July 1, 1947. N. E. LINDENBLAD 2,423,150

LOBE SWITCHING ANTENNA

Filed Dec. 10, 1943 2 Sheets-Sheet 1

Fig. 2.

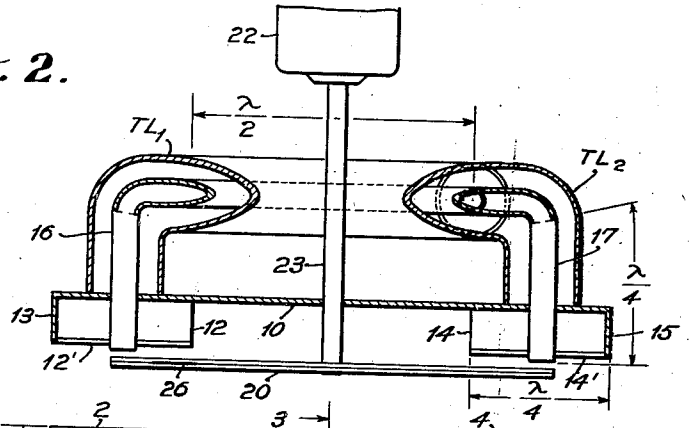
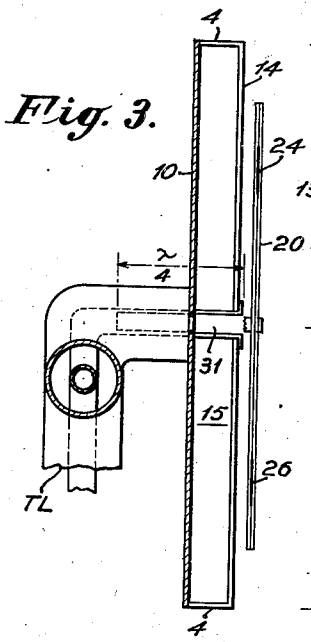


Fig. 3.



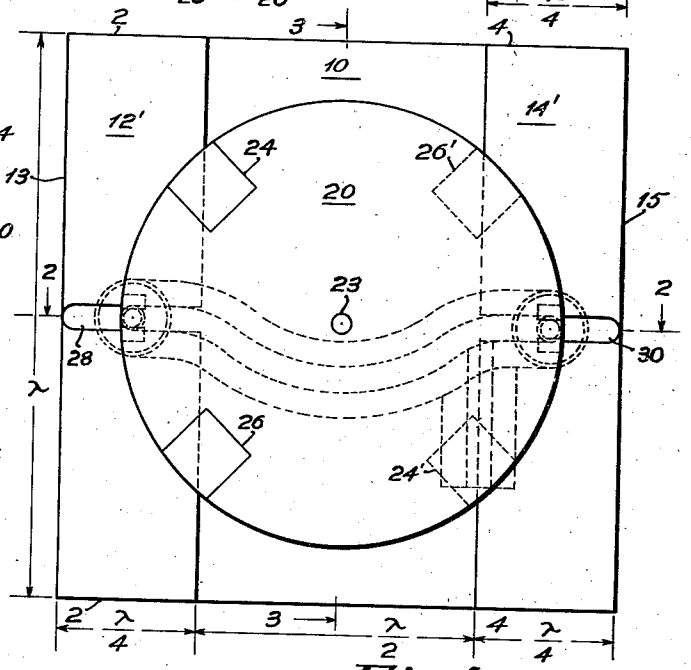
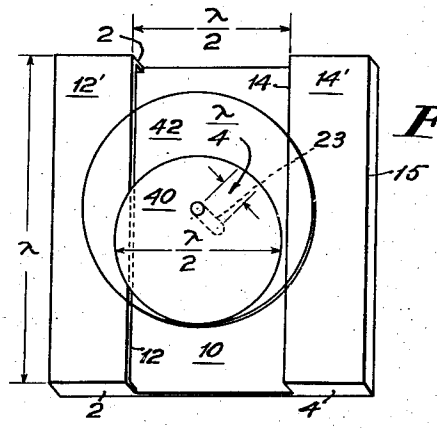


Fig. 1.

Fig. 4.



INVENTOR
Nils E. Lindenblad
BY H. E. Grover
ATTORNEY

July 1, 1947. N. E. LINDENBLAD 2,423,150

LOBE SWITCHING ANTENNA

Filed Dec. 10, 1943 2 Sheets-Sheet 2

Fig. 5.

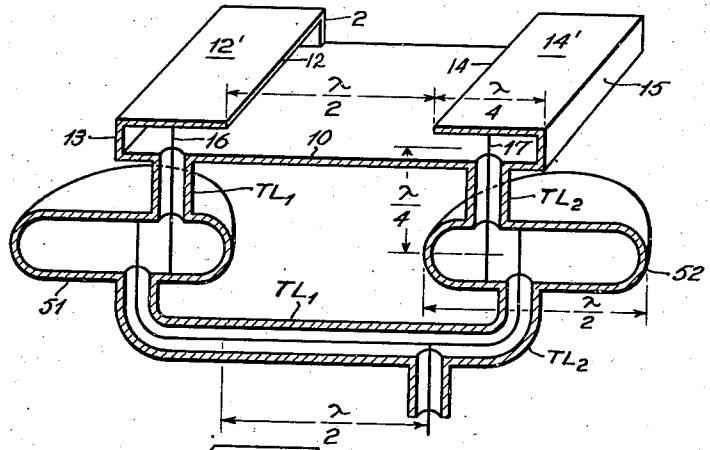


Fig. 6.

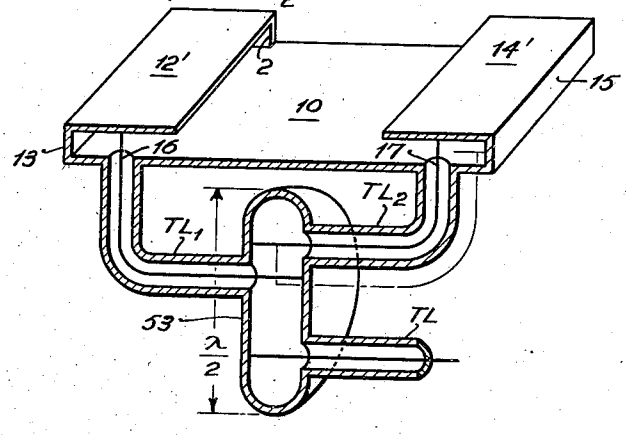


Fig. 7.

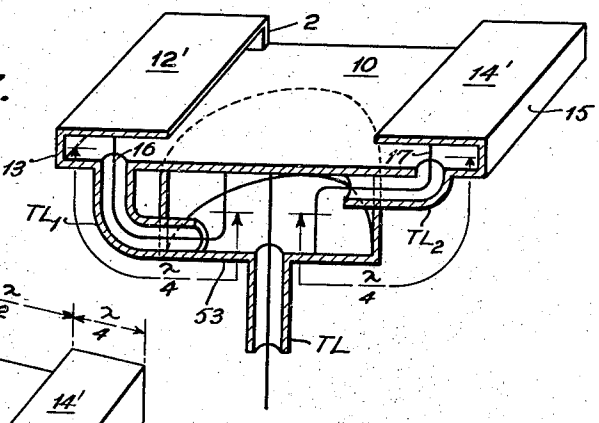
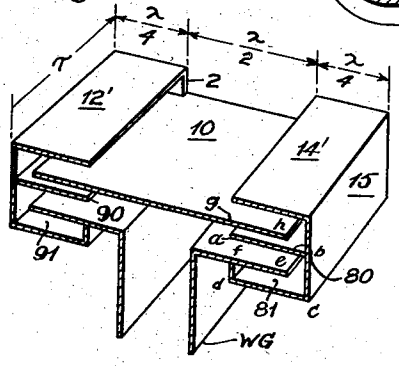


Fig. 8.



INVENTOR
Nils E. Lindenblad
BY H. S. Grover
ATTORNEY

Patented July 1, 1947

2,423,150

UNITED STATES PATENT OFFICE

2,423,150

LOBE SWITCHING ANTENNA

Nils E. Lindenblad, Rocky Point, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application December 10, 1943, Serial No. 513,691

31 Claims. (Cl. 250—11)

1

The present invention relates to antenna structures for radio detecting and ranging systems and, more particularly, to a lobe switching antenna structure for use at the focus of a parabolic reflector.

An object of the present invention is the provision of a focus antenna for use with a parabolic reflector.

Another object of the present invention is the provision of a directive antenna which permits lobe switching of the beam of radiated energy without shifting the plane of polarization of the radiated energy.

Still another object of the present invention is the provision of a lobe switching antenna which involves no cumbersome or delicate junctions between stationary and moving portions of the associated transmission line structure.

A further object of the present invention is the provision of a surface current antenna having no slots in the surface conductor.

Still a further object of the present invention is the provision of a lobe switching antenna in which the rotating parts are mechanically balanced.

Still a further object of the present invention is the provision of reactance compensation for reactance variations with changes in frequency in the surface current antenna.

The foregoing objects, and others which may appear from the following detailed description, are attained in accordance with the principles of the present invention by utilizing an antenna structure in the form of a conductive sheet of suitable dimensions within a reactive trench. The area isolated from the rest of the structure by means of the reactive trench may then be energized and serves as a radiator. This type of antenna exhibits the very desirable characteristic of a maximum radiation in a direction normal to the plane of the sheet and of decreasing radiation as directions parallel to the plane of the conductive sheet are approached. The radiation falls to zero in all directions parallel to the plane of the sheet and there is no back radiation. The antenna may be simplified by so constructing the portion surrounding the conductive sheet so that the radiating area is surrounded by a quarter wave wide pocket moulding of which the outer edge is attached to the sheet and the edge facing the radiating area is free. The height of the moulding may be made a small fraction of a wavelength, that is, 5 percent, or so. The height is determined primarily by voltage considerations. For a given amount of radiated power the voltage

2

gradients developed in this type of antenna are lower than in heretofore known types of antennas. If desired, the radiating area and the surrounding mouldings may be enclosed by a window of insulating material extending between the facing edges of the moulding, thus protecting the structure from damage by the weather. The antenna is preferably energized by transverse line connections inside the moulding cavities at proper matching distances from the free edge of the moulding.

The antenna as so far described may then be located at the focus of a parabolic reflector, facing the reflector. In order to obtain a uniform progression of the beam of radiated energy about the axis of the parabolic reflector, either one of two systems of lobe switching may be used. Thus, a displacement of the center of the total radiation for lobe switching may be achieved by means of a pair of non-resonant shading patches mounted on an insulating disc rotating parallel and close to the edges of the mouldings. The shading patches may consist, for example, of thin conductive foil cemented on an insulating disc and angularly displaced 90 degrees from each other. As the disc rotates, the two patches successively assume positions wherein they both protrude over one edge of the same moulding and wherein one protrudes over the edge of each moulding. Thus four quadrant lobe switching is obtained. It will be noticed that all antenna components including the lobe switching structure are at substantially the same distance from the parabolic reflector with which it is contemplated the present antenna be used. Thus the characteristic low radiation in the plane of the antenna structure itself is not affected.

Alternatively a conductive disc of a diameter somewhat smaller than required for diametric half wave tuning may be located at a distance of the order of a quarter wave in front of the primary radiating area. It thus acts as a director component. Since the disc is parallel with the primary radiating area, rotation of the disc about its center would not in any way affect the electrical characteristics of the antenna. However, if the disc is mounted to spin eccentrically with reference to the central axis of the primary radiating area, a progressive displacement of the total radiation about the axis of the antenna is obtained. The eccentrically located conductive disc should, of course, be mechanically balanced and may also be aero-dynamically balanced by enclosing it within a circular insulating envelope rotating about its geometric center.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which Figure 1 illustrates in front elevational view an antenna constructed according to the principles of the present invention, while Figure 2 is a transverse section of Figure 1 taken along the lines 2, 2 of Figure 1, and Figure 3 is another transverse section of the antenna shown in Figure 1 taken along lines 3, 3, while Figure 4 is a view in perspective of a modified form of the present invention, while Figures 5, 6 and 7 illustrate in perspective, and partly in section, modified antenna systems in which any reactance introduced into the transmission line as the frequency applied to the antenna varies, is counterbalanced by reactance stubs connected to the transmission line at appropriate points, and Figure 8 is a further modification particularly adapted to be used with wave guide energizing means.

In Figures 1 to 3, inclusive, reference numeral 10 indicates, generally, the radiating portion of a conductive sheet antenna. The radiating portion is isolated from the rest of the structure of the antenna by means of pocket mouldings 12 and 14.

These pocket mouldings each include bottom wall portions 13 and 15 attached to the sides of radiating sheet 10 and face portions 12' and 14' lying in a plane parallel to the sheet 10. The ends of pocket mouldings 12 and 14 may be closed by end plates 2, 2 and 4, 4 or they may be left open as desired. The width of the face portions 12' and 14' of the pocket mouldings is so chosen as to be equal to one-quarter of the operating wavelength. Since the voltage gradients developed across radiating sheet 10 are comparatively low even for high radiated power, the width of mouldings 12 and 14, that is, the widths of bottom walls 13 and 15 need only be a small fraction of a wavelength, that is, 5% or so. Preferably, the radiating area 10 of the antenna has an overall length of about 1 wavelength and a free width between the free edges of mouldings 12 and 14 of approximately one-half of the operating frequency. The antenna is energized from a suitable source of high frequency energy (not shown) by means of concentric transmission line TL which is split into two branches, TL1 and TL2, having inner conductors 16 and 17. The center conductors 16 and 17 each cross the space enclosed by one pocket moulding and are connected to faces 12' and 14', respectively. Transmission line branch TL1 has its length so chosen as to be a half wave longer than transmission line branch TL2, the energy appearing across pocket mouldings 13 and 15 is in an opposing phase relationship. Thus, at any given instant the potential gradient across the half wave dimension of radiating sheet 10 will vary from, for example, a maximum positive value opposite the free edge of moulding 12 to a maximum negative potential opposite the free edge of moulding 14. The potential distribution along the length of the radiating area 10 is substantially uniform. The points of connection of the inner conductors 16 and 17 to the faces 12' and 14' of the edge mouldings is so determined as to insure an impedance match between the antenna and the transmission line.

The antenna as so far described has a radiation pattern characterized by a maximum radiation in a direction normal to the plane of sheet 10 and which uniformly decreases in all directions as the plane of the sheet 10 is approached.

The radiation is substantially zero in all directions parallel to the plane of the sheet 10 and in all directions to the rear of the sheet. Now, in order to provide a continuous progression of the beam of radiated energy about a central axis normal to the plane of sheet 10, a lobe switching structure is provided in the form of an insulating disc 20 rotated by motor 22 having a shaft 23 passing through sheet 10 at substantially its midpoint and normal to the plane of the sheet. The insulating disc 20 carries on its edge at points angularly displaced by 90 degrees a pair of shading patches 24 and 26. The patches may be thin aluminum or other conductive foil, cemented between two thin sheets forming disc 20. Now, as disc 20 is rotated the shading patches successively assume the following effective positions: first, both patches 24 and 26 overlap the edge of face 12' of pocket moulding 12; then, as the rotation is continued in a clock-wise direction, shading patch 24 overlaps the edge of face 14' of pocket moulding 14 and patch 26 overlaps the edge of face 12'; next, both patches overlap the edge of face 14' of pocket moulding 14, as indicated by dotted outlines 25' and 24', and patch 24 overlaps the edge of face 12', while patch 26 overlaps the edge of face 14'. Thus, as the shading disc 20 successively assumes the four positions outlined above, the direction of maximum response of the antenna is successively deflected into four quadrants about an axis normal to the plane of sheet 10.

In practice, the antenna may be placed at the focus of a parabolic reflector and in such position that the front surface of sheet 10 faces the reflector.

It will be noted that as the beam of radiant energy is caused to progress about the axis of the parabolic reflector, all of the radiating components maintain the same distance from the parabolic antenna. Since there is no potential viariation along the axis of the antenna there is substantially no radiation in directions parallel to the plane of sheet 10. In order that the displacement of the radiation center caused by shading one of each moulding by the shading patches may be of comparable magnitude to the effect occurring when both patches shade one moulding, it is desirable to split each moulding at its midpoint from the free edge to the bonded edge. These splits are shown at 28 and 30. Now, since the split portions are each substantially a quarter wave deep, the upper and lower halves of the pocket mouldings are substantially isolated one from the other. Since the inner conductors 16 and 17 of transmission lines TL1 and TL2 must be connected to the pocket mouldings 12 and 14 at their midpoints, the inner conductors must likewise be split for a distance of a quarter wave in order to isolate the halves of the moldings. This is indicated at 31 in the side view, Figure 3. This split should, likewise, be one quarter wave long.

The modification of the invention shown in Figure 4 utilizes the same construction for the radiating sheet and pocket mouldings, as heretofore described, and therefore the same reference numerals are applied as far as they are appropriate. This form of lobe switching does not require the division of the quarter wave pocket mouldings 12 and 14 at their midpoints and the splits 28 and 30 of Figure 1 are therefore not shown here. The lobe switching is obtained in this modification by providing a director component in the form of a conductive disc 40 lo-

cated at a distance of a quarter wave in front of the primary radiating sheet 10. The disc 40 is mounted eccentrically on shaft 23 to wobble about the central axis of the primary radiator 10. A continuously progressive displacement of the total radiation in an orbit about the central axis of sheet 10 is thus caused. The eccentrically rotating disc 40 should, of course, be mechanically balanced and it is preferable that it be aerodynamically balanced by enclosing it within a concentrically rotating insulating envelope 42, formed, as described with reference to disc 20 of Figure 1, of a pair of thin sheets cemented together. Eccentric disc 40 may be a comparatively thin conductive foil in the point between the sheets forming the envelope 42.

Under some certain circumstances it may be desirable to utilize the antenna of the present invention for a wide band of frequencies. In such cases, as the wave applied to the antenna departs from the mid frequency of the band, it will be noted that the quarter wave mouldings on either side of the antenna introduce reactances into the transmission line of a magnitude and sign varying with the magnitude and sense of departure of the wave from the midband frequency. In order to compensate for this within reasonable limits, a modified form of the invention shown in Figures 5, 6 and 7 may be used. The antenna structure in each of these figures is the same as has been heretofore described, and will not therefore be described.

In the modification shown in Figure 5, resonant chambers 51 and 52 are associated with transmission lines TL1 and TL2. Chamber 51 acts as a shunt resonant circuit across transmission line TL1 and resonant chamber 52, across transmission line TL2. These resonant chambers are coupled to the transmission lines each at a distance equal to one-quarter of the mean operating wavelength from the point of connection of the transmission lines to the reactive mouldings 12 and 14, respectively. Now, if the frequency departs in one direction from that for which the antenna is designed, resonant chamber 51, for example, will introduce a reactance equal in magnitude and sign to that introduced into transmission line TL1 by moulding 12. Similarly, resonant chamber 52 will introduce into transmission line TL2 a reactance equal in magnitude and sign to that introduced by moulding 14. The impedance reversing characteristic of the quarter wave line sections between the chambers and the antenna couplings causes an exact neutralization of the reactance introduced by the departure in frequency. The resonant chambers 51 and 52 are shown in Figure 5 as having such diametral dimension as to be resonant to the mean operating frequency and they are coupled to the transmission lines TL1 and TL2 by the central conductors 16 and 17 passing through the resonant chambers and in the direction of the electric field. It is, of course, not necessary that resonant chambers be used in these positions as any equivalent form of resonant circuit may be used if desired, such as quarter wave line sections short-circuited at one end and suitably coupled to the inner conductor of the transmission lines.

In the modification shown in Figure 6 only a single resonant chamber 53 is used. Transmission lines TL1 and TL2 in this modification each have an overall length equal to one quarter of the operating wavelength and transmission line TL is coupled directly into resonant cavity 53. Since it is essential that energy applied to the mouldings 12 and 14 be in an operating phase relationship, transmission lines TL1 and TL2 enter the resonant chamber 53 from opposite sides, thus performing the phase reversing function. The reactance compensation occurs as described above with reference to Figure 5.

The modification shown in Figure 7 differs from that shown in Figure 6 only in that the resonant chamber 53 lies with its diametral dimensions in a plane parallel to the plane of radiating sheet 10 instead of at right angles thereto as shown at Figure 6. The transmission lines TL1 and TL2 enter the side walls of resonant chamber 53 in this modification and are connected to opposite phases of the resonant chamber in order to obtain the phase reversing function.

Figure 8 illustrates a modification of the present invention particularly adapted for use with wave guide coupling means between the antenna and the desired transducer equipment.

The antenna itself is the same as described in the previous embodiments and will, therefore, not be again described here. Obviously the lobe switching structure of either Figure 1 or Figure 4 may be employed with this antenna if desired.

The antenna is coupled to the transducer equipment by a wave guide WG. If the dimension of the wave guide in a direction parallel to the long dimension of the free area of sheet 10 is chosen to be equal to or greater than one half of the operating wavelength, a transverse electric wave of the lowest order may be propagated through the guide. Since the dimension of the guide perpendicular to the last mentioned dimension determines the characteristic impedance of the line, it is chosen in accordance with the operating characteristics desired.

As wave guide WG approaches the antenna, it is split into two branches one of which terminates in the space between moulding 12' and sheet 10, and the other between moulding 14' and sheet 10. At a given instant the direction of the electric field from 12' to 10 may be in a downward direction while at the same instant the direction of the electric field will be from 10 to 14' at the other edge of the radiating sheet 10. Thus, sheet 10 is caused to radiate in the same manner as in the previously described modifications.

One of the branch wave guide sections defined by the space between *g*—*h* of plate 10 and *a*—*b* of plate 80, it will be noticed, has a length in the direction of wave travel of one quarter of the operating wavelength. At one end it is coupled to the antenna, and at the other end it is coupled to a half wave compensating cavity 81 constituted by the space between one wall outlined by *a*, *b*, *c*, *d* and another outlined by *f*, *e*, *d*. Thus, any variation in impedance introduced by the antenna into one branch by a variation in frequency is compensated for by similar variations introduced across the line by the compensating cavity a quarter wave away.

Similarly, the other branch wave guide is provided with a quarter wave section defined by plate 90 and sheet 10 having a similar compensating cavity 91 coupled to one end.

While I have illustrated a particular embodiment of the present invention, it should be clearly understood that it is not limited thereto since many modifications may be made in the several elements employed and in their arrangement and it is, therefore, contemplated by the appended claims to cover any such modifications as fall within the spirit and scope of the invention.

What I claim is:

1. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges and means for coupling a transducer to said antenna including conductor means crossing the space within said mouldings.

2. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance equal to one-quarter of the operating wavelength and means for coupling a transducer to said antenna including conductor means crossing the space within said mouldings.

3. A surface current antenna including a plane conductive sheet one wavelength at the operating frequency in length and width and having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance such that the open area of said plane sheet has a width equal to one-half of the operating wavelength.

4. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter of the operating wavelength, the open surface of said plane sheet having a width equal to one half of the operating wavelength and an overall length of one wavelength.

5. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter of the operating wavelength, the open area of said plane sheet having a width equal to one half of the operating wavelength and means for coupling a transducer to said antenna including conductor means crossing the space within said mouldings.

6. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter of the operating wavelength, the open area of said plane sheet having a width equal to one half of the operating wavelength and a pair of transmission lines each having a conductor crossing the space within said mouldings and connected to said mouldings.

7. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter of the operating wavelength, the open area of said plane sheet having a width equal to one half of the operating wavelength and a pair of transmission lines each having a conductor crossing the space within said mouldings and connected to said mouldings and a circuit resonant at the operating frequency connected across each of said transmission lines at a distance equal to an odd multiple including unity of a quarter wavelength from said mouldings.

8. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter of

the operating wavelength, the open area of said plane sheet having a width equal to one half of the operating wavelength and a pair of transmission lines each having a conductor crossing the space within said mouldings and connected to said mouldings, the distance from the point of each connection to the bottom wall of said mouldings being so chosen that the characteristic impedance of said antenna matches the impedance of said transmission lines.

9. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings substantially midway along their lengths.

10. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance equal to one quarter of the operating wavelength and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to the moulding substantially midway between its ends.

11. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter wavelength, the open area of said plane sheet having a width equal to one half of the operating wavelength, a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to the moulding substantially midway between its ends, and a circuit resonant at the operating frequency connected across each of said transmission lines at a distance equal to an odd multiple, including unity, of a quarter wavelength from said mouldings.

12. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings at substantially their midpoints, said transmission lines having a differential length equal to half the operating wavelength and being connected in a parallel relationship to energy transducer means.

13. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance equal to one-quarter of the operating wavelength and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings at substantially their midpoints, said transmission

lines having a differential length equal to half the operating wavelength and being connected in a parallel relationship to energy transducer means.

14. An antenna system including a radiating member in the form of a flat conductive sheet so energized as to provide a radiation pattern having a maximum intensity along a desired line of directivity and uniformly decreasing intensity with increasing departure from said line, and means for progressively displacing said maximum intensity in an orbit about said line.

15. An antenna system including a radiating member characterized by a radiation pattern having a maximum intensity along a desired line of directivity and uniformly decreasing intensity with increasing departure from said line, and means for progressively displacing said maximum intensity in an orbit about said line, including an eccentrically rotatable disc mounted in front of said radiating member a distance one-quarter of the operating wavelength, the diameter of said disc being of the order of one-half of the operating wavelength.

16. An antenna system including a sheet radiator and means for progressively displacing the region of maximum radiation in an orbit about a line normal to said sheet, including an eccentrically rotatable disc mounted in front of said sheet radiator a distance one-quarter of the operating wavelength, the diameter of said disc being of the order of one-half of the operating wavelength.

17. An antenna system including a sheet radiator and means for progressively displacing the region of maximum radiation in an orbit about a line normal to said sheet, including a pair of inductive shading patches on an insulating disc arranged for rotation in front of and closely adjacent said sheet radiator, said shading patches being so placed on said disc as to successively overlap the edges of said sheet radiator.

18. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one-quarter wavelength, the open area of said plane sheet having a width equal to one-half of the operating wavelength and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings at substantially their midpoints, said transmission lines having a differential length equal to half the operating wavelength and being connected in a parallel relationship to energy transducer means.

19. A surface current antenna including a plane conductive sheet one wavelength at the operating frequency in length and width and having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance such that the open area of said plane sheet has a width equal to one-half of the operating wavelength and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line.

20. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said

opposite edges a distance of one-quarter of the operating wavelength, the open area of said plane sheet having a width equal to one-half of the operating wavelength and a pair of transmission lines each having a conductor crossing the space within said mouldings and connected to said mouldings and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line.

21. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings substantially midway along their lengths and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line.

22. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance equal to one quarter of the operating wavelength and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings at substantially their midpoints, said transmission lines having a differential length equal to half the operating wavelength and being connected in a parallel relationship to energy transducer means, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line.

23. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance of one quarter of the operating wavelength, the open area of said plane sheet having a width equal to one half of the operating wavelength and a pair of transmission lines each having a conductor crossing the space within said mouldings and connected to said mouldings, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means including an eccentrically rotatable disc mounted in front of said sheet a distance one-quarter of the operating wavelength, the diameter of said disc being of the order of one-half of the operating wavelength.

24. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings substantially midway along their lengths, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means

including an eccentrically rotatable disc mounted in front of said sheet a distance one-quarter of the operating wavelength, the diameter of said disc being of the order of one-half of the operating wavelength.

25. A surface current antenna including a plane conductive sheet having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance equal to one quarter of the operating wavelength and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings at substantially their midpoints, said transmission lines having a differential length equal to half the operating wavelength and being connected in a parallel relationship to energy transducer means, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means including an eccentrically rotatable disc mounted in front of said sheet a distance one-quarter of the operating wavelength, the diameter of said disc being of the order of one-half of the operating wavelength.

26. A surface current antenna including a plane conductive sheet one wavelength at the operating frequency in length and width and having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance such that the open area of said plane sheet has a width equal to one-half of the operating wavelength, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means including a non-conductive rotatable disc mounted in front of said sheet, the diameter of said disc being of the order of one-half of the operating wavelength, said disc carrying a pair of conductive shading patches arranged to progressively overlap a free edge of each of said mouldings and each to overlap a free edge of one of said mouldings.

27. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings substantially midway along their lengths, and means for displacing the region of maximum effectivness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means including a non-conductive rotatable disc mounted in front of said conductive sheet, the diameter of said disc being of the order of one-half of the operating wavelength, and carrying a pair of conductive shading patches arranged to progressively overlap a free edge of each of said mouldings and each to overlap a free edge of one of said mouldings.

28. A surface current antenna including a plane conductive sheet one wavelength at the operating frequency in length and width and having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance such that the open area of said plane sheet has a width equal to one-half of the operating wavelength, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means including a pair of conductive shading patches arranged to progressively overlap a free edge of each of said mouldings, said shading patches being carried on an insulating disc mounted for rotation about the center of said plane conductive sheet and in a plane parallel thereto and closely adjacent said mouldings, said patches being angularly spaced 90 degrees on said disc.

29. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings substantially midway along their lengths, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet about said line, said means including a pair of conductive shading patches arranged to progressively overlap a free edge of one of said mouldings, said shading patches being carried on an insulating disc mounted for rotation about the center of said plane conductive sheet and in a plane parallel thereto and closely adjacent said mouldings, said patches being angularly spaced 90 degrees on said disc.

30. A surface current antenna including a plane conductive sheet one wavelength at the operating frequency in length and width and having hollow conductive mouldings along a pair of opposite edges, the free edges of said mouldings extending inwardly from said opposite edges a distance such that the open area of said plane sheet has a width equal to one-half of the operating wavelength, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet about said line, said means including a pair of conductive shading patches arranged to progressively overlap a free edge of each of said mouldings and each to overlap a free edge of one of said mouldings, said shading patches being carried on an insulating disc mounted for rotation about the center of said plane conductive sheet and in a plane parallel thereto and closely adjacent said mouldings, said patches being angularly spaced 90 degrees on said disc, each of said mouldings having a quarter wave split at substantially its midpoint.

31. A surface current antenna including a plane conductive sheet having a hollow conductive moulding along a pair of opposite edges and a pair of transmission lines each having an outer shell and an inner conductor, said outer shells being connected to said plane conductive sheet and said inner conductors each crossing the space within one of said mouldings and connected to said mouldings substantially midway along their lengths, and means for displacing the region of maximum effectiveness of said antenna from a line normal to said plane conductive sheet in an orbit about said line, said means including a pair of conductive shading patches arranged to progressively overlap a free edge of each of said mouldings and each to overlap a free edge of one of said mouldings, said shading patches being carried

on an insulating disc mounted for rotation about the center of said plane conductive sheet and in a plane parallel thereto and closely adjacent said mouldings, said patches being angularly spaced 90 degrees on said disc, each of said mouldings having a quarter wave split at substantially its midpoint.

NILS E. LINDENBLAD.

REFERENCES CITED

The following references are of record in the file of this patent:

FOREIGN PATENTS

Number	Country	Date
450,484	Great Britain	July 20, 1936