

Jan. 14, 1947.

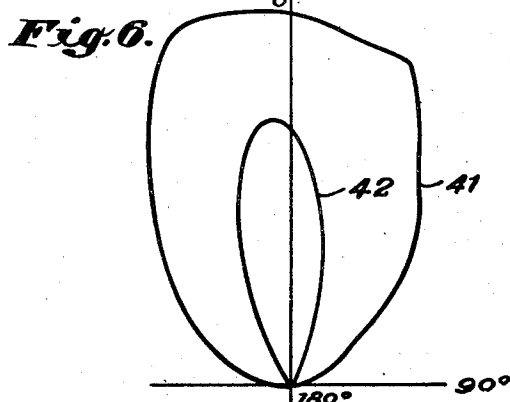
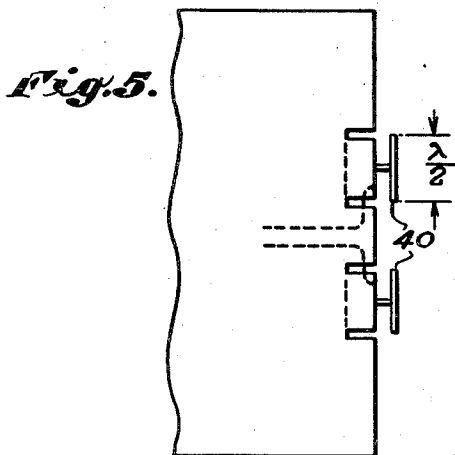
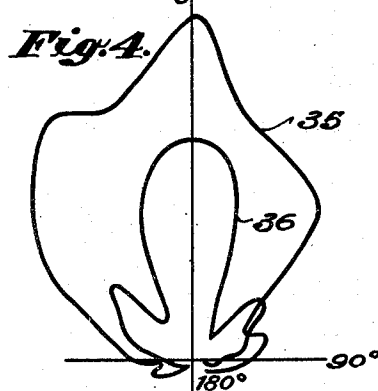
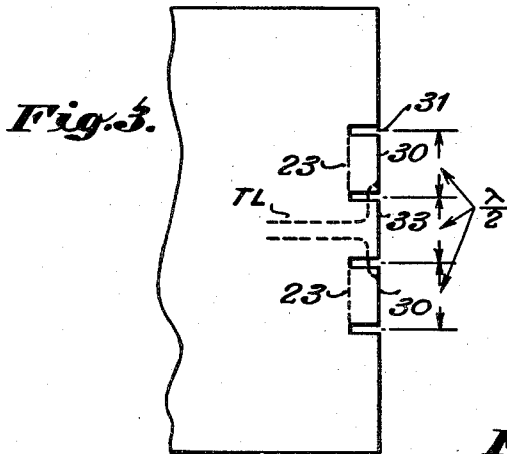
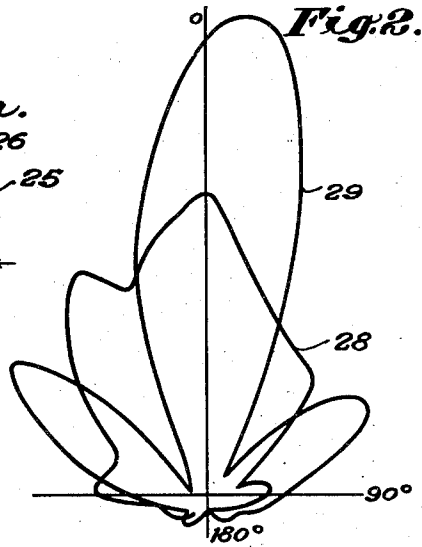
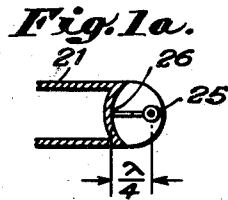
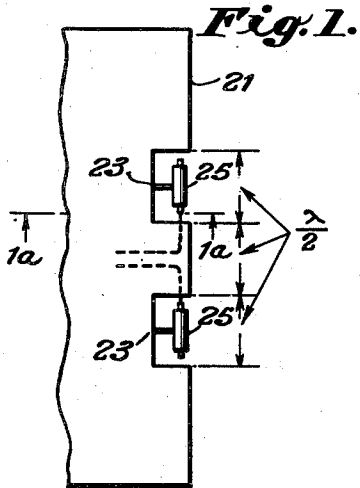
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2,414,266

ANTENNA

Filed June 27, 1942

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

**Fig. 7.**

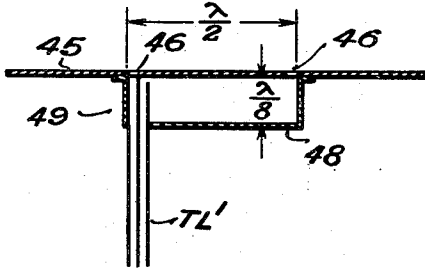


**Fig. 8.**

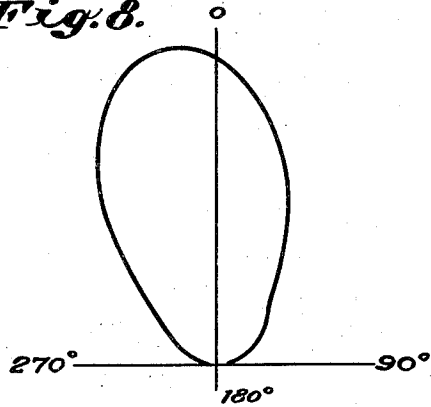


**Fig. 9.**

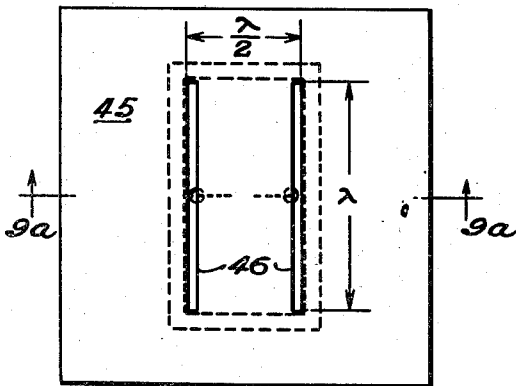


**Fig. 9a.**

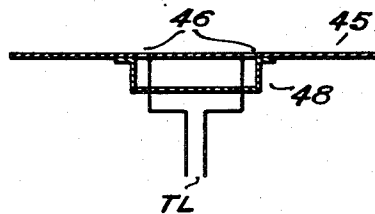


**Fig. 12.**

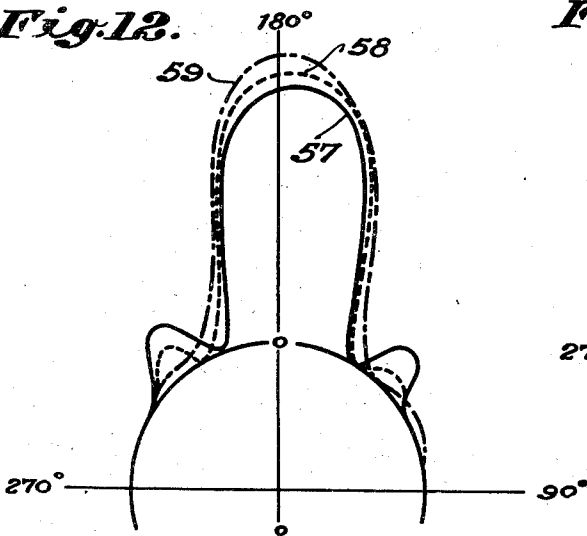
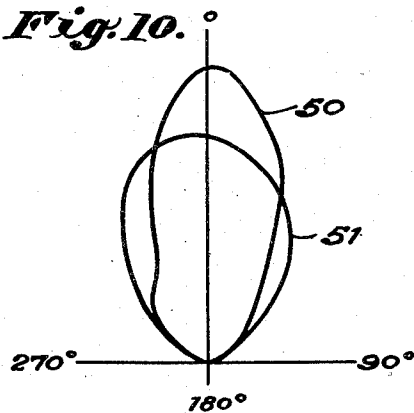


**Fig. 10.**



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Fig. 11.

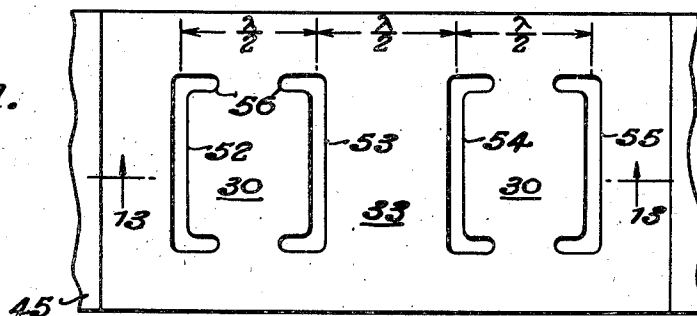


Fig. 13.

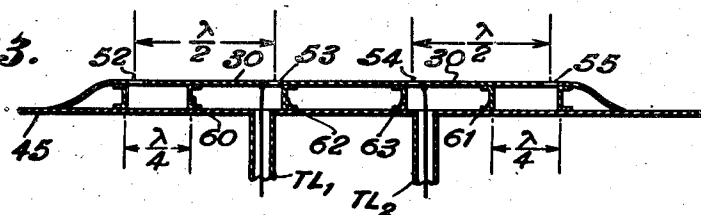


Fig. 14.

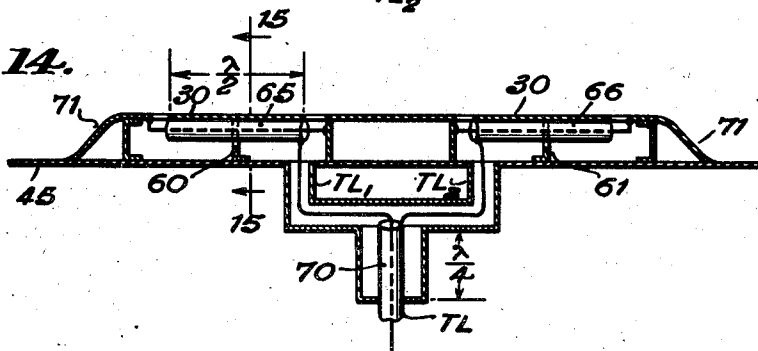


Fig. 16.

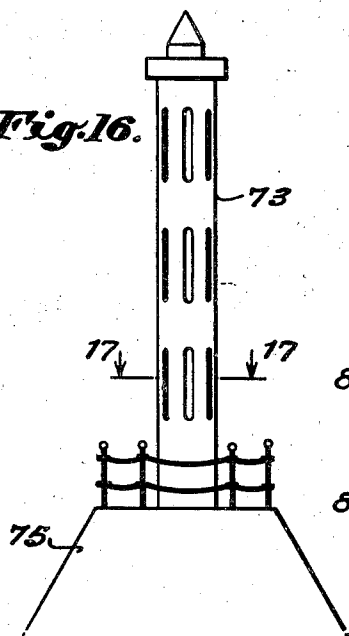


Fig. 15.

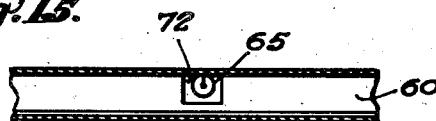
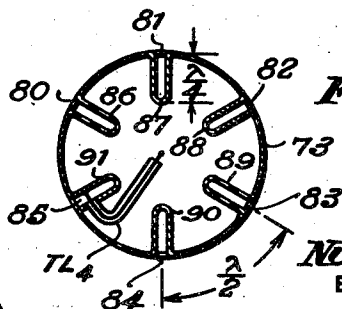


Fig. 17.



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*Fig. 18.*

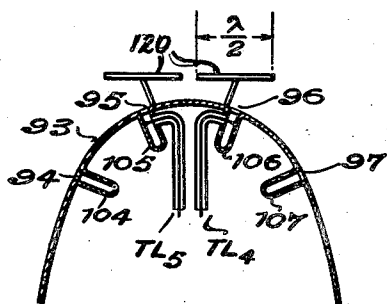


*Fig. 19.*

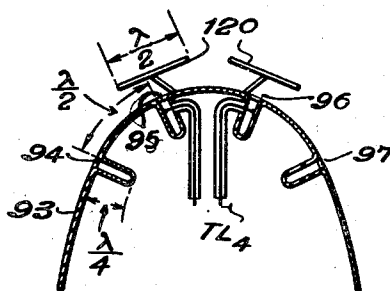
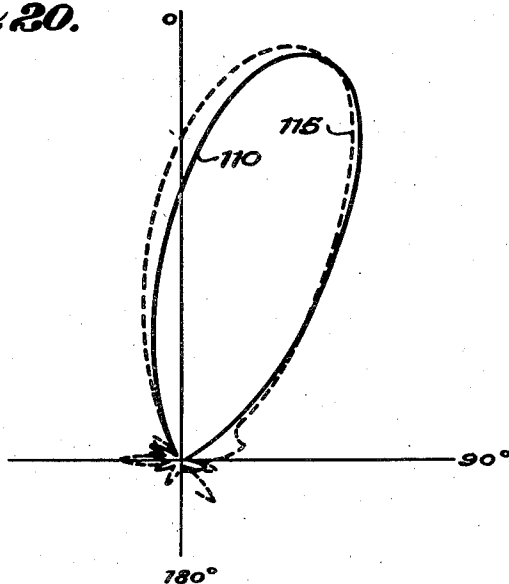


*Fig. 20.*



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## UNITED STATES PATENT OFFICE

2,414,266

## ANTENNA

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Delaware

Application June 27, 1942, Serial No. 448,743

31 Claims. (Cl. 250—33)

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The present invention relates to directive antennas and, more particularly, to such antennas which may be used on airplanes with a minimum adverse influence upon the aerodynamics of the supporting structure.

An object of the present invention is the provision of a directive antenna for use in airplanes.

Another object of the present invention is the provision of a highly directive antenna having substantially all of its response pattern concentrated in a single lobe without supplementary ears.

A further object of the present invention is the provision of a directive antenna which has a minimum influence upon the aerodynamics of an airplane upon which it may be used.

Still a further object of the present invention is the provision of a directive antenna which may be concealed in the structure of an airplane.

The foregoing objects, and others which may appear from the following detailed description, are attained by providing one or more cavities in the outer surface of the plane and installing the radiant element within the cavities so formed. The cavity may be covered by a sheet of plastic insulating material. Thus, the body of the plane after the antenna is installed is as smooth as before. In a modification of the invention the aperture in the surface or window itself may be caused to act as the radiator. In this case the material closing the aperture or window in the surface of the plane is made of the same metal as the body of the plane and the radiator in effect becomes an integral part of the surrounding structure, being separated therefrom by only such narrow insulating portions as may be necessary to confine the radio frequency currents in a desired pattern.

The present invention will be more completely understood by reference to the following description which is accompanied by drawings in which Figure 1 illustrates in plan view an embodiment of the present invention; Figure 1a is a vertical section view of the structure shown in Figure 1, taken along the line 1a, 1a, while Figure 2 illustrates the directivity characteristics of the antenna shown in Figure 1; Figures 3 and 5 illustrate, in plan view, modifications of the form of the invention shown in Figure 1, while Figures 4 and 6 are directivity patterns for the antennas of Figures 3 and 5; Figure 7 illustrates in transverse section a further modification of the present invention, while Figure 8 is a directivity pattern of the modification of Figure 7; Figure 9 illustrates in elevation a further modification of the

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present invention, while Figure 9a is a transverse sectional view of the modification shown in Figure 9, taken along line 9a, 9a; Figure 10 is a directivity pattern of the antenna shown in Figure 9; Figure 11 illustrates in elevation a further modification of the form of the invention shown in Figure 9, while Figure 13 is a section of the modification of the figure shown in Figure 11, taken along line 13, 13; Figure 12 is a directivity pattern of Figure 11; Figure 14 illustrates in transverse section a further modification of the invention, while Figure 15 is a section of the modification shown in Figure 14, taken along line 15, 15 and Figure 16 is a view in elevation illustrating the application of the principles of the present invention to a broadcast antenna, while Figure 17 is a view in horizontal section of the modification shown in Figure 16, taken along line 17, 17; while Figures 18 and 19 are transverse sectional views illustrating further modifications of the present invention and Figure 20 is a directivity pattern of the modification shown in Figures 18 and 19.

Referring, now, to Figure 1 there is shown a portion of the front edge of an airplane wing, identified by reference character 21. Along the leading edge of the wing are provided cavities 23, 23 in which half wave dipoles 25, 25 are located. The cavities 23 are preferably formed in the shape of a somewhat parabolic reflector at their rear portions, as indicated by reference character 26. The depth of the cavities 23 is preferably such that dipoles 25 may be mounted a quarter of the operating wave length in front of the reflector portion 26. The cavities 23 are, by way of example, spaced substantially a half wave apart and may be covered by plastic insulating sheets of the same curvature as that of the leading edge of the wing. Thus, the combined antenna and wing structure has the same aerodynamic efficiency as the wing alone would have.

The curves of Figure 2 show the directivity characteristics of the system shown in Figures 1 and 1a, curve 28 being the directivity pattern in a vertical plane, that is, perpendicular to the plane of the wing, while curve 29 is the directivity pattern in the horizontal plane, that is, the plane of the wing.

The modification shown in Figure 3 differs from that shown in Figure 1 in that the radiator 25 of Figure 1 is expanded into a conductive sheet covering cavities 23. That is, the cavities 23 are each covered with a bent metal sheet 30 having a width somewhat less than a half of the oper-

ating wavelength. Thus, a narrow elongated slot 31 remains on each of two opposing sides of the sheet while the other two opposing sides of the sheet are electrically bonded to the edges of the cavity. The bent metal sheet 30 is thus conductively continuous with the remainder of the wing structure at the two last mentioned opposing sides of the sheet. The narrow slots 31 may, if desired, be closed by insulating material in order to avoid aerodynamic disturbances. An important advantage here is, of course, that the radiator is an integral part of the surrounding structure. Furthermore, smaller amounts of insulating material may be used in weatherproofing the antenna. Simplicity and ruggedness are also further advantages. The depth of the cavities 23 is, in this modification, of very little importance, a depth of an inch or so being adequate. This form of antenna is energized by a transmission line TL carrying push-pull energy, the conductors of transmission line TL being connected to the most closely adjacent edges of a pair of sheets 30. Thus energized the radiating sheets 30, as well as the intervening space 33, at any given instant all carry currents in the same direction. The assembly, therefore, radiates in the same manner as a collinear stack of cophasally energized dipole radiators. It will be readily apparent that this means of energizing the radiator is very simple. Furthermore, the system as a whole lacks delicate tuning features, although it is preferable to give resonance dimensions to the cavity formed inside of the surfaces.

The curve 35 of Figure 4 shows the directivity pattern obtained in a plane perpendicular to the longitudinal axis of the wing, while curve 36 shows the directivity pattern in the plane of the wing. The simple system shown in Figure 3, as will be noted from the directivity pattern of Figure 4, has a very desirable radiation characteristic but it was discovered that the addition of parasitic radiators 40 in front of each radiating sheet 30, as shown in Figure 5, has a very important effect. The addition of these two parasitic radiators, at a distance of about one-eighth of a wavelength from the front edge of the radiators 30, results in the radiation patterns shown in Figure 6, wherein curve 41 indicates the directivity perpendicular to the plane of the wing and curve 42 is the directivity in the plane of the wing. It will be noted that high directivity without the presence of side ears has been attained in both planes. The directivity pattern in the plane perpendicular to the longitudinal axis of the wing has also been particularly slenderized and freed from secondary lobes or ears. A power gain in the forward direction of about  $2\frac{1}{2}$  times over that obtained with the structure of Figure 3 is obtained, the greater portion thereof being apparently mainly due to the fact that ears or side lobes have been so completely eliminated. The position and dimensions of the parasitic radiators 40 are not particularly critical and are best determined by trial since it is extremely difficult to accurately calculate the electrical center of the curved radiator plates 30. However, as above indicated, a spacing of the order of one-eighth of the wavelength from the surface has proven satisfactory.

Under circumstances where it may be undesirable to utilize parasitic radiators because of complexities introduced by the necessity of placing de-icing structures on the front edge of the wing, it may be desirable to use an antenna structure which is incorporated in the body wall of the plane. Such a structure incorporating the prin-

ciples of the present invention is shown in Figure 7, and modifications thereof in later figures.

In the structure shown in Figure 7 the antenna is effectively a part of the side wall of the body of the plane and forms a continuity path for the currents originating in the inside cavities and thus in no way affects the operation of the plane. The side wall of the plane, identified by reference numeral 45, has therein at least a pair of slots 46, each having a length of about one wavelength and spaced a half wavelength apart. These slots are preferably arranged vertically so that a horizontally polarized wave is radiated. Covering the back of the slotted portion of the body of the plane is a shallow pan 48. The depth of this pan is not particularly critical, a dimension of the order of one-eighth of the operating wavelength being ample. The side walls 49 of pan 48 are preferably immediately adjacent the edges of slots 46. To the free edge of one of the slots 46 is connected the central conductor of a concentric transmission line TL' which is energized from a transmitter or other source of high frequency energy. The radiation pattern obtained from the antenna of Figure 7 is shown in Figure 8. It will be noted that a high degree of directivity is obtained with, at the same time, an entire absence of side ears. However, the direction of maximum response is not truly vertical to the plane of the wall 45, it being inclined about 10 degrees toward the slot which is directly energized. This inclination may be overcome by energizing the radiator along the edges of both slots 46, as shown in Figures 9 and 9a, Figure 9a being a section along the lines 9a, 9a of Figure 9. The individual conductors of two wire transmission line TL are connected to adjacent edges of slots 46. With this exception the structure of Figures 9 and 9a is similar to that of Figure 7. Thus energized, the antenna has a maximum, in the directivity pattern in the plane parallel to the length of slots 46, which is truly vertical to the plane of the side wall 45, as shown by the curve 50 of Figure 10. The directivity in the plane perpendicular to the length of slots 46 is shown by curve 51. It will be apparent that there are no side ears to either directivity pattern.

Under some circumstances it may be desirable to increase the vertical directivity of the antenna by vertical stacking of a plurality of radiators. If two or more antennas as shown in Figure 9 are stacked vertically, the height of the structure may become excessive. Furthermore, not all of the expected gain may be realized. This will be understood when it is considered that the radio frequency voltage difference between the two slot edges of the antenna of Figure 9 is a maximum at the center of the slots and decreases toward each end. Therefore, the portions of the radiator at the extreme ends of slot 46 contribute very little to the operation of the antenna while, at the same time, necessitating a large spacing between adjacent radiators. The effectiveness of the array may be increased by turning inwardly the ends of the slots of each bank of radiators as shown in Figure 11 at 56. It will be apparent that if a second radiator structure similar to that of Figure 11 is stacked above the one shown, the high voltage portions of the two structures may be more closely adjacent. While the length of the turned inward portions 55 is not particularly critical as far as the radiation from the antenna array is concerned, it has been discovered that the impedance of the antenna may be altered somewhat by a variation of the length of the turned-in-portions. Thus, a very convenient

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way of matching the impedance of the antenna to the associated transmission line is provided. Merely increasing or decreasing the depth of the turned-in portions 56, as required, will result in a perfect match of the antenna to the transmission line.

Figure 12 illustrates the effect of variation in slot spacing in the antenna of Figure 11 upon the directivity pattern of the antenna. It should be particularly noted that in this figure the zero point of the scale is not at the center of the figure but has been moved outwardly to considerable extent in order to more clearly separate extremely small lobes which would not be apparent if the zero point were at the center of the diagram. Curve 57 shows that slight supplementary ears are formed in the directivity pattern when the spacing between the central slots 53, 54 is slightly greater than a half wavelength. Curve 58 shows that the supplementary ears are reduced when a half wave spacing is employed between each of the slots 52, 53, 54, 55, while curve 59 shows that supplemental ears are almost entirely destroyed when the spacing between slots 53, 54 is made slightly less than a half wavelength.

A manner of energizing the antenna of Figure 11 is shown in Figure 13. A pair of concentric transmission lines TL<sub>1</sub> and TL<sub>2</sub> have their inner conductors connected to the adjacent edges of radiating plates 30 at slots 53 and 54. The outer conductors of the transmission lines are connected to conductive sheet 45. Midway between the edges of the slots 52 and 53 is provided a dividing wall 60 while a second dividing wall 61 is provided midway between slots 54 and 55. The electrical distance, therefore, from one edge of any slot to the opposite edge of the same slot is substantially one half of the wavelength, thus preventing any phase irregularities due to difference in phase velocity inside and outside of the structure. Both edges of central plate 33 along slots 53 and 54 are connected to the conductive sheet 45 by means of walls 62 and 63.

A further modification of the structure of Figure 13 is shown in Figure 14. Here concentric line sections 65 and 66 are provided to couple the outer edge of slot 52 to the inner edge of slot 53 and the outer edge of slot 55 to the inner edge of slot 54. Thus, the phase relationships between potentials at these edges are rigidly controlled instead of depending upon the energy distribution through the radiating portions of the antenna. An aperture 72 (Figure 15) is provided in each of the dividing walls 60 and 61 for the passage of transmission lines 65, 66.

In the modification of the invention shown in Figure 14 the transmission lines TL<sub>1</sub> and TL<sub>2</sub> are connected to a main transmission line TL by means of a phase reversing network 70 which is constructed according to the principles set forth in my prior Patent #2,238,904, granted April 22, 1941. Since this construction is not an essential part of the present invention it will not be more completely described here but a more complete understanding thereof may be had by reference to the said patent.

While the antenna structure of Figures 13 and 14 is shown as being mounted outside of a conductive sheet 45, such as the wall of the body of the plane, it is, of course, within the scope of my invention to so arrange the structure that the outer radiating surface, as constituted by sheets 30, 33, 30, is flush with wall 45. However, in the case of planes already built it may be preferable to provide structure as shown in Figure 14

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which may be directly mounted on the outside wall. In order to strengthen the structure and avoid disturbance of the aerodynamics of the plane, the edges of the radiating structure are faired into the wall 45 by means of sloping side wall portions 71.

The modification of the present invention shown in Figure 16 is particularly adapted for the broadcast transmission of short wave radiant energy. Its operation may be more clearly understood by considering it to be constituted of a group of antennas, such as shown in Figures 11 to 14, stacked vertically one above the other to form an array. The array is then bent around a vertical axis of symmetry to form a cylinder. A simple, sturdy structure electrically at ground potential and thoroughly protected against wind, weather and lightning damage is thus provided. The structure is particularly adapted for installation on the top of a tall building, or tower such as that indicated by reference character 75. Some details of construction of this modification are perhaps more clearly shown in Figure 17 which is a cross-section of Figure 16 viewed in the direction of arrows 17, 17. Herein are distinctly shown slots 80, 81, 82, 83, 84 and 85, each of the slots being spaced from the next a distance equal to a half of the operating wavelength measured around the circumference of the cylinder 73. Each of the slots 80 to 85 is closed on the interior of the cylinder 73 by pockets 86 to 91, inclusive, each pocket or cavity having a depth equal to a quarter of the operating wavelength. In this way the shunting effect of the cavity across the slot is small since the slot end impedance of such a cavity is very high. The antenna is energized by a plurality of transmission lines, only one of which, TL<sub>1</sub>, is shown by Figure 17, the others being omitted in the interests of clarity. The outer conductor of transmission line, TL<sub>1</sub>, is connected to one side wall of pocket 91 with the central conductor passing across slot 85 and connected to its opposite edge. All of the transmission lines energizing slots 80 to 85, inclusive, may be connected in parallel to a main transmission line which is adapted to be energized from a suitable source of high frequency energy. Impedance transformation can also be obtained by adjustment of the distance away from the slot at which the transmission lines are connected across the cavity.

In certain types of installation of radio direction finding equipment in airplanes it is particularly desirable to obtain alternately a pair of directivity patterns which are symmetrically disposed about a common axis along the line of flight of the plane and which overlap to a considerable extent along said axis. This may be done with separate antennas or with a single antenna array alternately energized in two different ways. This effect may be obtained by utilizing the principles separately set forth with reference to the previously discussed modifications of the present invention. For example, an antenna structure such as shown in Figure 18 may be provided. The curved surface 93 may be considered to be the nose of the body of a two or four motored plane. It is here shown as though in horizontal cross-section. Symmetrically arranged about a center line are vertically disposed slots 94, 95, 96 and 97 spaced a half wave apart. The slots are closed by pockets 104, 105, 106, 107, each having a depth equal to a quarter wavelength.

Now, if this antenna structure is unsymmetri-

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cally energized, such as through transmission line TL<sub>4</sub>, a directivity pattern is obtained which has its maximum to the right of the axis of symmetry of the figure. Energization of the structure through transmission line TL<sub>5</sub> results in a second directivity pattern which is the mirror image of the first, having its maximum at the left of the axis of symmetry. Suitable transducer equipment alternately connected to transmission lines, TL<sub>4</sub> and TL<sub>5</sub>, may thus be used to determine more accurately the true direction of the axis of symmetry of the structure. If desired, the directivity pattern of the antenna may be sharpened somewhat by providing parasitic half wave radiators 120 symmetrically disposed about the axis of symmetry of the antenna. They may be either closely adjacent as shown in Figure 18, or more widely spaced so as to be bisected by the center lines of slots 95, 96 as shown in Figure 19. Curve 110 of Figure 20 illustrates the directivity pattern of the antenna shown in Figure 18, as energized by transmission line TL<sub>4</sub>, while curve 115 shows the directivity pattern of the antenna of Figure 19 similarly energized.

For the sake of convenience, the foregoing description has been predicated on the assumption that the antennas of the present invention are to be used for transmission of radiant energy waves. It is to be clearly understood, however, that by connecting suitable receiving equipment to the transmission lines associated with the antennas, reception of radiant energy waves may be accomplished.

While I have shown and particularly described several embodiments of my invention, it is to be distinctly understood that my invention is not limited thereto but that modifications within the scope of my invention may be made.

I claim:

1. An antenna including a conductive sheet having a slot or a plurality of parallel slots therein and means forming at least one conductive walled cavity associated therewith, and means for so introducing high frequency energy into said cavity that said sheet is energized by continuity currents from within said cavity.

2. An antenna including a conductive sheet having a number of slots therein, means forming at least one conductive walled cavity back of said slots and means for energizing said sheet with radio frequency energy, including a transmission line terminating within said cavity.

3. An antenna including a conductive sheet having parallel slots therein and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced apart a distance equal to substantially half the operating wavelength.

4. An antenna including a conductive sheet having parallel slots therein and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced apart a distance equal to substantially half the operating wavelength, the length of said slots being of the order of one wavelength, the end portions of said slots being turned toward each other, the length of the end portions being so adjusted as to match the impedance of said antenna to said energizing means.

5. An antenna including a conductive sheet forming the front edge of an airplane wing and having a number of parallel slots therein normal to the plane of said wing and means for energizing said sheet between said slots with radio frequency energy.

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6. An antenna including a conductive sheet forming the front edge of an airplane wing and having a number of parallel slots therein normal to the plane of said wing and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced a half wave apart.

7. An antenna including a conductive sheet forming the front edge of an airplane wing and having a number of parallel slots therein normal to the plane of said wing and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced a half wave apart and parasitic radiators in front of said sheet and in the plane of said wing between at least one pair of slots.

8. An antenna including a conductive sheet forming the front edge of an airplane wing and having a number of parallel slots therein normal to the plane of said wing and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced a half wave apart and parasitic radiators in front of said sheet between at least one pair of slots and in the plane of said wing, said radiators being spaced from said sheet a distance of the order of one-eighth of the operating wavelength.

9. An antenna including a conductive sheet having at least a pair of parallel slots therein, a shallow pan covering said slots on one side of said sheet and means for energizing said sheet between said slots with radio frequency energy.

10. An antenna including a conductive sheet having at least a pair of parallel slots therein, a shallow pan covering said slots on one side of said sheet and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced apart a distance equal to substantially half the operating wavelength.

11. An antenna including a conductive sheet having at least a pair of parallel slots therein, a shallow pan covering said slots on one side of said sheet, and means for energizing said sheet between said slots with radio frequency, said slots being spaced apart a distance equal to substantially half the operating wavelength, the length of said slots being of the order of one wavelength, and dividing walls between said slots so arranged that the interior distance from one edge of each slot to the other edge of the same slot is substantially equal in electrical length to one half wavelength.

12. An antenna including a conductive sheet having at least a pair of parallel slots therein, a shallow pan covering said slots on one side of said sheet, and means for energizing said sheet between said slots with radio frequency energy, said slots being spaced apart a distance equal to substantially half the operating wavelength, the length of said slots being of the order of one wavelength, the end portions of said slots being turned toward each other, the length of the end portions being so adjusted as to match the impedance of said antenna to said energizing means.

13. An antenna including a conductive sheet having a plurality of pairs of parallel slots therein, the spacing between the slots of each pair being of the order of a half of the operating wavelength, a second conductive sheet parallel to said first sheet and spaced therefrom a short distance, walls between said sheets dividing the space therebetween into a plurality of chambers, one chamber being in communication with each slot.

14. An antenna including a conductive sheet

having a plurality of pairs of parallel slots therein, the spacing between the slots of each pair being of the order of a half of the operating wavelength, a second conductive sheet parallel to said first sheet and spaced therefrom a distance of the order of one-eighth of the operating wavelength, walls between said sheets dividing the space therebetween into a plurality of chambers, one chamber being in communication with each slot.

15. An antenna including a conductive sheet having a plurality of pairs of parallel slots therein, the spacing between the slots of each pair being of the order of a half of the operating wavelength, a second conductive sheet parallel to said first sheet and spaced therefrom a short distance, walls between said sheets dividing the space therebetween into a plurality of chambers, one chamber being in communication with each slot, and having a dimension transverse to said slot substantially equal to a quarter of the operating wavelength.

16. An antenna including a conductive sheet having a plurality of pairs of parallel slots therein, the spacing between the slots of each pair being of the order of a half of the operating wavelength, a second conductive sheet parallel to said first sheet and spaced therefrom a short distance, walls between said sheets dividing the space therebetween into a plurality of chambers, one chamber being in communication with each slot, and having a dimension transverse to said slot substantially equal to a quarter of the operating wavelength, and means coupled to at least one edge of each of said slots for energizing said antenna with radio frequency energy.

17. An antenna including a conductive sheet having a plurality of pairs of parallel slots therein, the spacing between the slots of each pair being of the order of a half of the operating wavelength, a second conductive sheet parallel to said first sheet and spaced therefrom a short distance, walls between said sheets dividing the space therebetween into a plurality of chambers, one chamber being in communication with each slot, and having a dimension transverse to said slot substantially equal to a quarter of the operating wavelength, and means coupled to at least one edge of each of said slots for energizing said antenna with radio frequency energy, said last means including a concentric transmission line having its outer shell connected from an edge of one slot to the adjacent edge of the next slot and its inner conductor connected between the remaining edges of said slots.

18. An antenna including a conductive sheet having a plurality of pairs of parallel slots therein, the spacing between said slots being a half of the operating wavelength, and means for so energizing said sheet between said slots with radio frequency energy that the instantaneous current direction between each pair of slots is in the same direction.

19. An antenna including a conductive sheet having a plurality of pairs of parallel slots therein, the spacing between said slots being a half of the operating wavelength, and means for connecting a source of push-pull radio frequency energy to opposite edges of each pair of adjacent parallel slots.

20. An antenna including a conductive sheet having an aperture therein, means forming a conductive walled cavity back of said aperture and radiator means within said aperture and in the plane of said conductive sheet.

21. An antenna including a conductive sheet having an aperture therein, means forming a conductive walled cavity back of said aperture and radiator means within said aperture and in the plane of said conductive sheet, said means including a dipole.

22. An antenna including a conductive sheet having an aperture therein, means forming a conductive walled cavity back of said aperture and radiator means within said aperture, said radiator means including a conductive plate over said aperture and spaced from a pair of opposing sides of said aperture to form a pair of parallel slots, said slots being spaced apart a distance substantially equal to one-half of the operating wavelength and means for applying radio frequency energy to at least one free edge of said plate.

23. An antenna including a conductive sheet having an aperture therein, means forming a conductive walled cavity back of said aperture and radiator means within said aperture, said radiator means including a conductive plate over said aperture and spaced from a pair of opposing sides of said aperture to form a pair of parallel slots, said slots being spaced apart a distance substantially equal to one-half of the operating wavelength and means for applying radio frequency energy to at least one free edge of said plate, the other edges of said plate being conductively continuous with said conductive sheet.

24. An antenna including a conductive sheet having an aperture therein, one pair of opposing sides of said aperture being spaced apart a distance of the order of one-half of the operating wavelength, means forming a conductive walled cavity back of said aperture and radiator means within said aperture including a conductive plate over said aperture and spaced from said sides which are spaced one-half wavelength thus forming a pair of free edges and means for applying said radio frequency energy to at least one edge of said plate, the other edges of said plate being conductively continuous with said sheet.

25. An antenna including a conductive sheet having an aperture therein, one pair of opposing sides of said aperture being spaced apart a distance of the order of one-half of the operating wavelength, means forming a conductive walled cavity back of said aperture and radiator means within said aperture including a conductive plate over said aperture and spaced from said sides which are spaced one-half wavelength thus forming a pair of free edges and means for applying said radio frequency energy to at least one edge of said plate, the other edges of said plate being conductively continuous with said sheet, said sheet being curved in the direction along the length of said free edges.

26. An antenna including a conductive sheet having an aperture therein, one pair of opposing sides of said aperture being spaced apart a distance of the order of one-half of the operating wavelength, means forming a conductive walled cavity back of said aperture and radiator means within said aperture including a conductive plate over said aperture and spaced from said sides which are spaced one-half wavelength thus forming a pair of free edges and means for applying said radio frequency energy to at least one edge of said plate, the other edges of said plate being conductively continuous with said sheet, said sheet being curved in the direction along the

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length of said free edges to form the leading edge of an airplane wing.

27. An antenna including a conductive sheet having an aperture therein, means forming a conductive walled cavity back of said aperture and radiator means within said aperture and in the plane of said conductive sheet, said means including a conductive plate over said aperture and spaced from a pair of opposing sides of said aperture to form a pair of parallel slots, said slots being spaced apart a distance substantially equal to one-half of the operating wavelength, and means for applying radio frequency energy to at least one free edge of said plate.

28. An antenna including a conductive sheet having an aperture therein, means forming a conductive walled cavity back of said aperture and radiator means within said aperture and in the plane of said conductive sheet, said means including a conductive plate over said aperture and spaced from a pair of opposing sides of said aperture to form a pair of parallel slots, said slots being spaced apart a distance substantially equal to one-half of the operating wavelength, and means for applying radio frequency energy to at least one free edge of said plate, the other edges of said plate being electrically connected to said conductive sheet.

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29. An antenna including a conductive sheet having an aperture therein, one pair of opposing sides of said aperture being spaced apart a distance of the order of one-half of the operating wavelength, means forming a conductive walled cavity back of said aperture and radiator, means within said aperture including a conductive plate of said aperture, and spaced from two sides which are spaced one-half wavelength apart thus forming a pair of free edges, and means for applying said radio frequency energy to at least one of said edges, said plane being electrically connected to said conductive sheet.

30. A short wave antenna including a conductive sheet having an aperture therein, said aperture having a width of the order of one half of the operating wavelength and conductive radiator means within said aperture and substantially in the plane of said conductive sheet.

31. A short wave antenna including a conductive sheet having an aperture therein, said aperture having a width of the order of one half of the operating wavelength and conductive radiator means within said aperture and substantially in the plane of said conductive sheet, said radiator means including a half wave dipole.

NILS E. LINDENBLAD.