May 21, 1946. N. E. LINDENBLAD 2,400,867

ANTENNA

Filed June 27, 1942 2 Sheets-Sheet 1

Fig. 1.

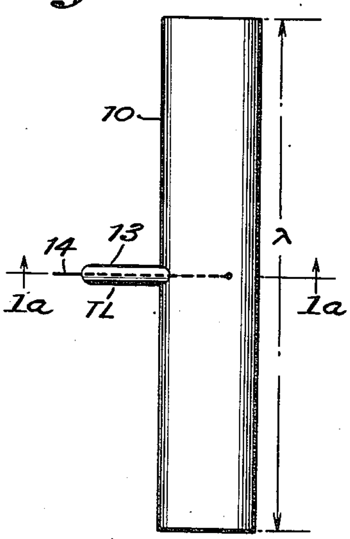


Fig. 2.

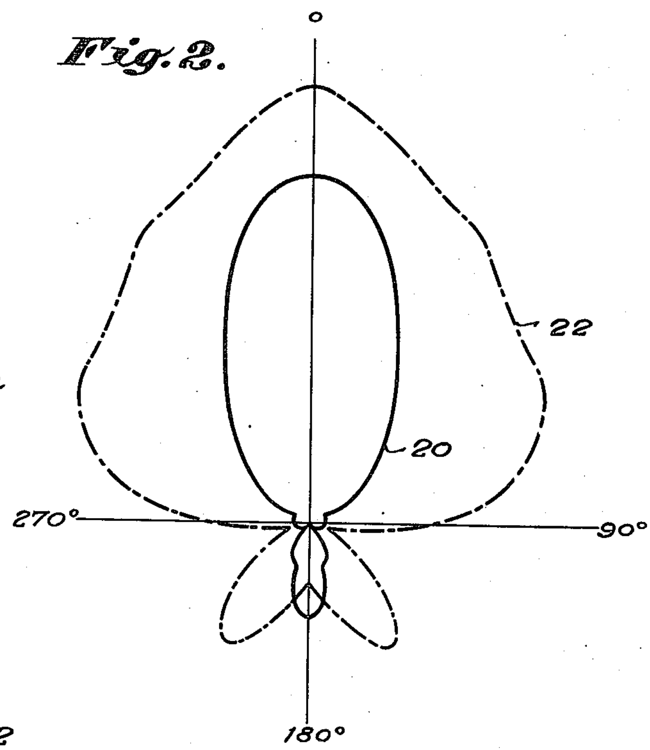


Fig. 1a.

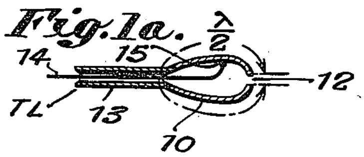
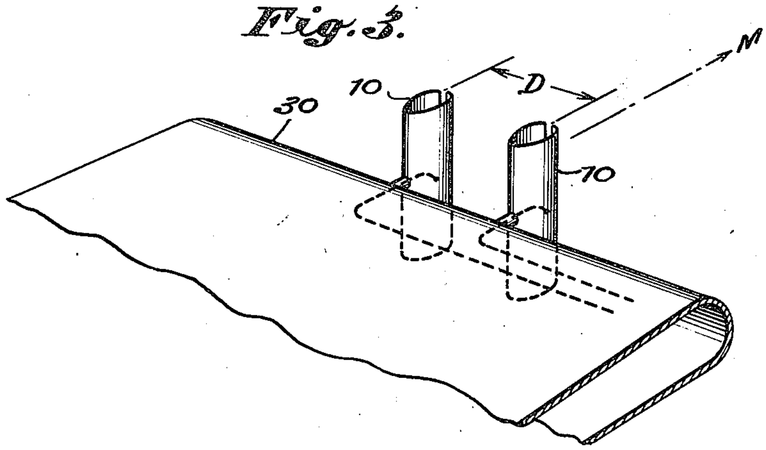


Fig. 3.



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

May 21, 1946. N. E. LINDENBLAD 2,400,867

ANTENNA

Filed June 27, 1942 2 Sheets-Sheet 2

Fig. 4.

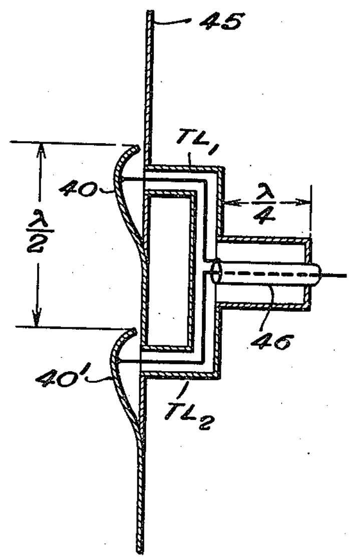
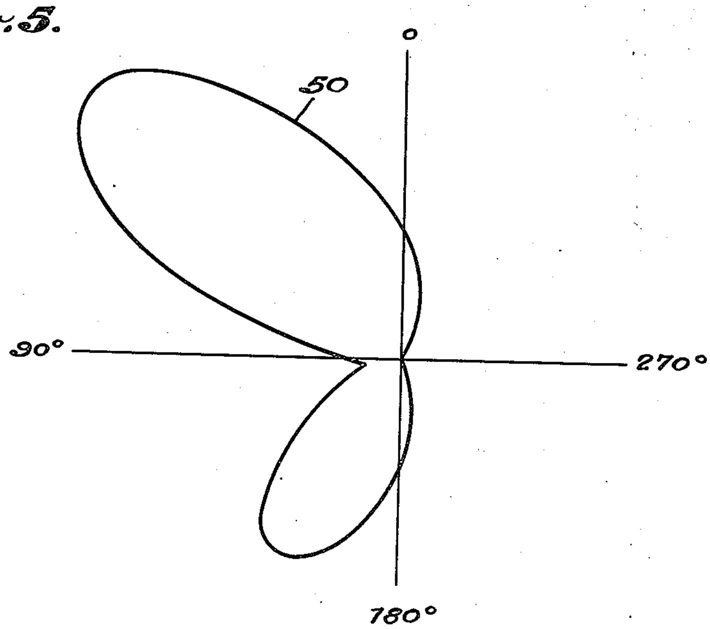


Fig. 5.



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

Patented May 21, 1946 2,400,867

UNITED STATES PATENT OFFICE

2,400,867

ANTENNA

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

Application June 27, 1942, Serial No. 448,744

11 Claims. (Cl. 250—33)

The present invention relates to directive antennas and, more particularly, to such antennas which are particularly adaptable to use on airplanes with a minimum disturbance of the aerodynamics of the supporting structure.

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

Another object of the present invention is the provision of an antenna, as aforesaid, which is streamline in form and is adapted to be mounted externally on the supporting structure.

A further object of the present invention is the provision of a compact directive antenna structure.

Still another object of the present invention is the provision of a simple, mechanically sturdy, directive antenna for use on an airplane.

The foregoing objects, and others which may appear from the following detailed description, are attained by the provision of an antenna in the form of a conductive tube having a tear drop cross-section, said tube being slotted along its blunt edge. The slot may be covered by plastic or other insulating material having good dielectric characteristics. The tube is fed transversely at one point and is of such dimensions that a phase velocity within the antenna is obtained which is of a higher order than the velocity of light. The radiator thus radiates energy polarized in the plane of its transverse cross-section. The radiation pattern obtained is of the figure 8 type with the frontal lobe in the direction of the blunt edge much greater than the rear lobe. The pattern in the plane of the axis of the tube and of the slot is a function of the length of the tube.

The present invention will be more fully understood by reference to the following detailed description, which is accompanied by drawings in which Figure 1 illustrates a side view of an embodiment of the invention, while Figure 1*a* is a cross-section taken along lines 1*a*, 1*a* of Figure 1, and Figure 2 illustrates diagrammatically the directivity patterns obtained with the antenna of Figure 1; Figure 3 is a modification of the form of the antenna shown in Figure 1, while Figure 4 is a further modification, and Figure 5 is a directivity pattern for the modification of Figure 4.

In the following detailed description for convenience the operation of the invention will be considered as a transmitting antenna only. However, it must be clearly understood that, if desired, the invention is equally adaptable to the reception of radiant energy waves.

In Figure 1 there is shown an antenna 10 in the form of an elongated somewhat cylindrical tube having a streamline cross-section. The cross-section is somewhat in the form of a tear drop as shown in Figure 1*a*. The tube is provided with a narrow slot 12 running longitudinally along its blunt edge. While not so shown, the slot may be filled in or covered with an insulating material of good dielectric characteristics. Any of the recently discovered plastics, such as polymerized styrene, may be used. The slotted tube is fed by high frequency oscillatory energy from a source of such energy (not shown) by means of a transmission line TL. The transmission line TL may conveniently be of the concentric type having an outer sheath 13 and an inner conductor 14. The outer sheath is, of course, electrically connected to the tube while the inner conductor 14 is connected to a predetermined point 15 within the tube. The point of connection 15 of conductor 14 to the interior of tube 10 is so chosen that the impedance of the antenna is matched to the impedance of the transmission line TL, thus avoiding reflection of energy back into the transmission line.

In Figure 1 the radiator 10 has been indicated as having a length approximately equal to one wavelength for the energy with which it is energized. Of course, the length may be made greater, if desired. However, if the length is increased very greatly it may be desirable to energize the antenna at several points along its length in order to prevent random phase irregularities along the length of the radiator 10. Since the circumferential dimensioning of tube 10 has been so chosen that a phase velocity along the length of the tube 10 is of a higher order than the velocity of light, energy in all sections of the cylinder is substantially in phase if the length does not greatly exceed one wave length. The radiation from the antenna is polarized in a plane of the cross-section of Figure 1*a*. The radiation pattern obtained in this plane, which is usually the horizontal plane, is of the figure 8 type with the frontal lobe in the direction of the blunt edge, much greater than the rear lobe. A typical directivity pattern in the horizontal plane is shown by curve 20 of Figure 2. The radiation pattern in the plane of the axis of the tube 10 and the slot is a function of the length of the cylinder. For the particular length shown in Figure 1, the radiation pattern in this plane, the vertical, is shown by curve 22 of Figure 2. This directivity pattern will be somewhat affected by the amplitude distribution along the length of cylinder 10 which, in turn, depends on the termination of the ends of the cylinder of the tube. If the ends are closed by conductive sheets the distribution will approach the sinusoidal from end to end. The vertical directivity pattern will then be somewhat broader but more free from secondary lobes.

In Figure 3 is shown an application of the radiator of Figure 1 to the front of an airplane wing 30. A pair of radiators 10 and 10′ are vertically mounted at the front edge of the wing a distance D one from the other. The radiators are energized by a pair of transmission lines, such as TL of Figure 1. In order to provide a maximum response along line M, normal to the edge of wing 30, the currents in radiators 10 and 10′ should be in phase, where the distance D between the radiators is a half wavelength as shown in Figure 3, and the feed lines run parallel to the edge of wing 30. There is effectively a half wave difference in length of the lines. Thus, to insure the correct energization of the radiators, the feed lines may be energized in a push-pull or phase-opposing relationship. Due to the half wave difference in distance that the energy is required to travel over the feed lines, when the energy arrives at the radiators 10 and 10′, they will be energized in an in phase or co-phasal relationship. If a maximum of the radiation pattern is desired along some other line with the distance D remaining constant the phase relationship of energy applied to radiators 10, 10′ may be varied by using different lengths of matched lines feeding the different units. The phase difference must then be such that combined with space difference in the desired direction the radiation from the various units adds in an in phase relationship.

A further modification of the present invention is shown in Figure 4 in which half sections 40, 40′ of a radiator structure such as that shown in Figure 1, are mounted on a conductive sheet 45 which may, for example, be the side wall of the fuselage or body of an airplane. The half sections 40 and 40′ may be spaced a distance equal to a half wave length along a horizontal line on the sheet 45. The half sections are energized by means of transmission lines TL_1 and TL_2, which are energized in a push-pull or phase opposing relationship from a source of radiant energy waves (not shown), through the phase inverting network 46. The phase inverting network 46 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, other means of applying push-pull energy to transmission lines TL_1 and TL_2 being equally adaptable thereto, the phase inverting network 46 will not be further described here. A more complete understanding of the construction may be had by reference to the aforesaid patent.

The radiation pattern obtained by an antenna structure as shown in Figure 4 is shown by curve 50 of Figure 5. It will be noted that due to the closeness of all parts of the antenna to conductive sheet 45 a deviation effect is obtained which is of considerable magnitude. Within the practical limits of dimensions of sheet 45 the deviation is of such magnitude that the antenna system shown in Figure 4 may be used only where a directivity pattern having a maximum considerably off the longitudinal axis of the plane is desired. For this reason the antenna of Figure 4 would not ordinarily be used for the "homing" type of direction finding, except as a pair mounted near the nose of the plane where the side walls converge rather sharply.

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

I claim:

1. An antenna including a section of conductive tube having a narrow longitudinal slot therein, the circumference of said tube from one edge of said slot to the other being of the approximate order of half of the operating wavelength and means for so energizing said antenna as to radiate energy polarized in a plane normal to the length of said tube.

2. An antenna including a section of conductive tube having a narrow longitudinal slot extending from end to end thereof, the circumference of said tube from one edge of said slot to the other being of the approximate order of half of the operating wavelength and means for energizing said antenna, including a concentric transmission line having an outer sheath and an inner conductor, said outer sheath being connected to said tube at a point diametrically opposite to said slot and said inner conductor being connected to the inner surface of said tube at such point that the impedance of said antenna is substantially equal to the impedance of said transmission line.

3. An antenna including a plurality of tubes as set forth in claim 2, said tubes being arranged with their slots parallel and facing in the same direction and means for energizing said tubes in a predetermined relationship.

4. An antenna including a plurality of tubes as set forth in claim 2, said tubes being arranged side by side with their slots parallel and facing in the same direction and means for energizing said tubes in an in phase relationship, the spacing between said tubes being such that a maximum of the radiated field occurs normal to a line joining said tubes.

5. An antenna including a plurality of tubes as set forth in claim 2, said tubes being arranged one behind the other with their slots parallel and facing in the same direction, said tubes being spaced apart a distance equal to one-half of the operating wavelength, a flat conductive sheet forming one side of both of said tubes and extending beyond said tubes a substantial ditsance in all directions.

6. An antenna including a plurality of curved plates arranged one beside the other on a conducting sheet, one edge of each of said plates being in electrical contact with said sheet and the other spaced a short distance therefrom to form an elongated slot, corresponding parts of said plates being so spaced apart and so energized that a directivity pattern is formed having a pronounced maximum inclined from a line perpendicular to said sheet.

7. An antenna including a plurality of elongated curved plates arranged one beside the other on a conducting sheet, one longitudinal edge of each of said plates being in electrical contact with said sheet and the other spaced a short distance therefrom to form an elongated slot, said slots facing in the same direction, corresponding parts of said plates being spaced apart a distance equal to a half of the operating wavelength, said plates being energized in a push-pull relationship from a source of high frequency energy so that a directivity pattern is formed

having a pronounced maximum inclined from a line perpendicular to said sheet.

8. An antenna including a section of conductive tube having an arrow longitudinal slot therein, the circumference of said tube from one edge of said slot to the other being substantially equal to one half of the operating wavelength, said tube having an overall length substantially equal to one wavelength, and means for so coupling transducer equipment to said antenna that said antenna is operative with electromagnetic wave energy polarized in a plane normal to the length of said tube.

9. An antenna including a section of conductive tube having a narrow longitudinal slot therein, the circumference of said tube from one edge of said slot to the other being of the approximate order of one half of the operating wavelength, means for so energizing said antenna as to radiate energy polarized in a plane normal to the length of said tube, said tube having a streamlined cross section.

10. An antenna including a section of conductive tube having a narrow, longitudinal linear slot therein, the circumference of said tube from one edge of said slot to the other being substantially equal to one half of the operating wavelength and a high frequency transmission line connected to coupled points on said tube lying in a plane normal to the longitudinal axis of said tube whereby said antenna has a maximum response to electro-magnetic wave energy polarized in a plane normal to the length of said tube.

11. An antenna including an elongated curved plate on a flat conductive sheet, one edge of said plate being in electrical contact with said sheet and the other spaced at a distance therefrom to form an elongated slot, the width of said curved plate being substantially equal to one quarter of the operating wavelength and means for connecting a conductor of a transmission line to said curved plate at a point substantially midway between the ends of said plate.

NILS E. LINDENBLAD.