

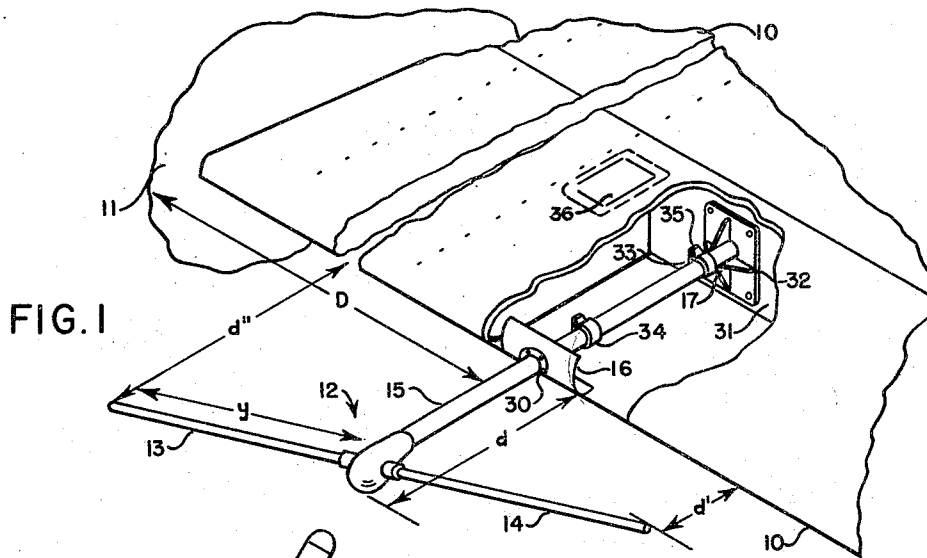
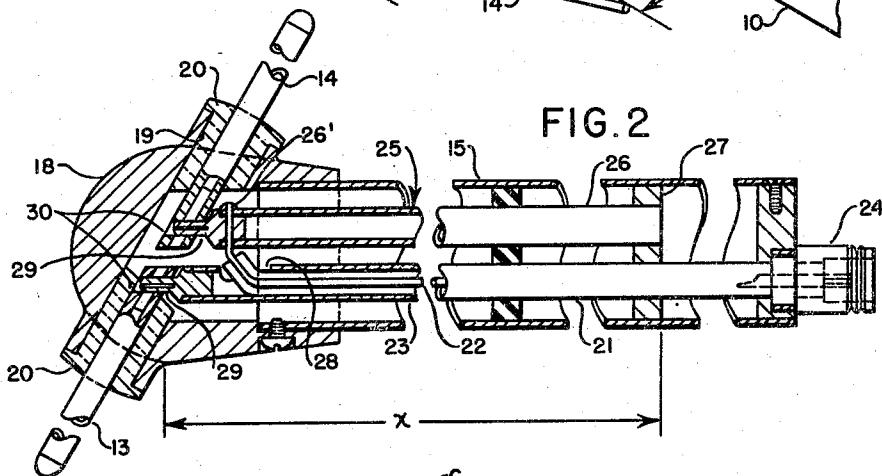
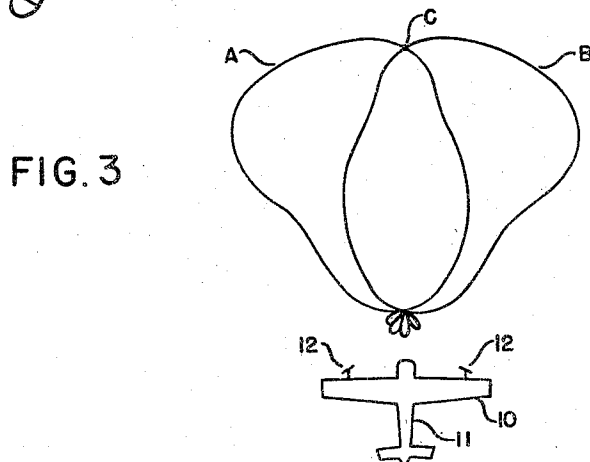
July 31, 1951

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2,562,296

ANTENNA

Filed June 21, 1946



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2,562,296

ANTENNA

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Application June 21, 1946, Serial No. 678,176

9 Claims. (Cl. 250—33)

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This invention relates to antenna systems for radiation and reception of high frequency electromagnetic energy. More particularly, the invention relates to a broad band antenna system for radio object locating systems such as for azimuth homing of aircraft.

In general, and as one of the objects, this invention contemplates utilizing a pair of broad band dipole antennas mounted in the leading edges of the wings of an aircraft wherein the antennas have radiation patterns each with a large forward lobe, high sensitivity at the cross-over point of the two patterns, and a high differential ratio for small angles from the cross-over point.

Another object of the invention is to provide a simple homing antenna system capable of operating over a frequency range of 2-1 or better, and suitable for use on high speed aircraft.

It is still another object of the invention to provide an antenna system designed for interchangeability of dipoles to thereby afford coverage over a broad range of frequencies.

For a better understanding of the invention together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, in which:

Fig. 1 is a broken away perspective view of a portion of an aircraft wing showing one antenna, according to the invention, with its mounting;

Fig. 2 is a longitudinal sectional view, partly broken away, of the antenna according to the invention; and

Fig. 3 is a diagrammatic view of an aircraft having an antenna, according to the invention, extending from the forward portion of each wing, and illustrating the approximate radiation patterns produced by the antennas.

In Fig. 1 there is shown a wing 10 extending from the fuselage 11 of an aircraft. Mounted in the leading edge portion of the wing 10 is an antenna 12 including the dipole members 13 and 14, the supporting element 15 and the mounting members 16 and 17. Preferably antenna 12 is mounted in the leading edge of each of the two wings of an aircraft and substantially equally spaced outwardly from the opposite sides of fuselage 11 as generally indicated in Fig. 3.

As shown in Fig. 2, the antenna 12 comprises the balanced dipole members 13 and 14 supported in aligned relation in a streamlined head member 18 secured to the free end of the supporting element 15 which is of generally tubular construction. The streamlined head member 18

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may be a casting of metallic material having a bore or socket 19 therethrough preferably disposed at an angle to the axis of supporting member 15. To prevent unwanted radiation losses or electrical connection between the dipole members 13 and 14 and the head member 18, a suitable dielectric material 20 is inserted in the bore 19 between the dipole members 13 and 14 respectively and the head member 18. Dielectric material 20 also serves to firmly secure dipole members 13 and 14 in position.

Energy for exciting dipole members 13 and 14 is fed thereto by means of a usual type of concentric or coaxial transmission line 21 having an inner conductor 22 and an outer concentric conductor 23, the inner end of which may be connected through a suitable RF connector 24 to a source of electromagnetic energy (not shown). Coupled to transmission line 21 is a line balance converter or balancing feedline transformer device generally designated 25. Balancing device 25 is similar to that described in the copending application of Clare Driscoll entitled "Electrical Apparatus," Serial No. 634,103, filed December 10, 1945, now Patent No. 2,530,048, granted November 14, 1950. This balancing device 25 comprises a conductor 26 which may be a hollow waveguide type transmission line extending in substantial parallel relation along a portion of the length of line 21 from the outer end thereof. Conductor lines 21 and 26 are preferably enclosed within the supporting element 15 which is in the form of a tubular sleeve or shield to prevent radiation and transmission losses. The end remote from the dipole of conductor 21 is electrically connected as by a shorting bar 27 to the outer conductor 23 and the inner conductor 22 is electrically connected to the conductor line 26 at the end nearer the dipole such as by bending the inner conductor 22 outwardly through an aperture 28 in outer conductor 23 and securing the end of inner conductor 22 as by soldering to the conductor line 26 near the outer end thereof as at 26' or by means of a strap member connecting the outer end of inner conductor 22 to the outer end of conductor 26. The dipole members 13 and 14 are connected to the outer ends of conductor lines 21 and 26 respectively, dipole member 13 being connected to the outer conductor 23 and dipole 14 being connected through conductor 26 to the inner conductor 22. To facilitate connection of dipoles 13 and 14 to conductors 21 and 26, the ends of the latter are each provided with or formed as plug elements 29 adapted to fit snugly within apertures or sockets 30 provided in and

near the inner ends of dipole members 13 and 14. This arrangement also facilitates interchangeability of the dipole members 13 and 14 for different frequencies of operation as desired, and also provides for ease of assembly and service of the dipole members or arms 13 and 14.

The length x of transformer or balancing device 25 from the shorting bar 27 to the connections to the dipoles 13 and 14 is preferably either a substantial fraction of or slightly more than a quarter wavelength of the center frequency at the desired frequency range of operation. The length y of each dipole member 13 and 14 should be greater than a quarter wavelength at this middle frequency of operation when the length x is less than a quarter wavelength or the dimension y should be less than a quarter wavelength when the length x is greater than a quarter wavelength. Thus, it will be understood that the balanced antenna comprises the two substantially identical dipole members or arms 13 and 14 which are adapted to be energized with equal and opposite voltages, the device 25 being adapted to transform the feeding concentric line which is normally unbalanced into a balanced line whereby the impedance of the feedline is matched to that of the dipoles and thereby affording operation over a wider band of frequencies than heretofore obtainable.

As hereinbefore described, dipole members or arms 13 and 14 are in aligned position and their common axis is preferably angularly related to the axis of the supporting tubular member 15, the latter being substantially perpendicular to the leading edge of the wing 10. The dipole members 13 and 14 preferably lie within the central horizontal plane of the wing 10. Thus, the common axis of the dipole members 13 and 14 is at an angle, preferably of substantially 30°, to the leading edge of wing 10, the dipole member 14 extending towards the wing tip being closer to the leading edge of wing 10 at a distance d' and the outer end of dipole member 13 (the end nearest fuselage 11) being at a greater distance d'' from the leading edge of wing 10. It is important that the position of the antenna 12 relative to the portions of the aircraft be properly determined in order that the desired function of the antennas may be achieved. Thus, it is desirable that the dimension D representing the distance from the fuselage to the point of mounting of the supporting element 15 in the wing 10, the distance d from the leading edge of the wing 10 to the end of head member 18 and the distance d' be calculated accurately in order that the combined radiation patterns of each of the two antenna elements mounted in the wings 10 of the aircraft may have the desired high sensitivity at the cross-over point C.

Antenna 12 is held in position in wing 10 by any suitable means. One means is shown in Fig. 1 where a metallic plate member 16 is shaped to fit the inner surface of the leading edge of wing 10. Plate 16 has a bearing aperture 30 there-through adapted to receive in a snug slidable fit the supporting element 15, a suitable aperture in the wing surface permitting entry of element 15. On an inner partition 31 of wing 10 is secured a terminal bracket or socket member 17 having a forwardly disposed extension 32 and bore 33 through the extension 32 and bracket 17 for slidably receiving the element 15. Suitable clamping means such as clamps 34 and 35 may be associated with or secured to the mounting plate and bracket member 16 and 17 for secur-

ing supporting element 15 against displacement which clamping means, when loosened, permit slidable movement inwardly and outwardly of element 15 to thereby permit adjustment of the dimension d . If desired a closable opening 36 may be provided in the surface of wing 10 to allow access to the mounting members 16 and 17. This arrangement also permits of removal and interchangeability of the antennas 12.

The principle of a homing antenna is illustrated by the radiation or field pattern shown in Fig. 3 which is a horizontal pattern of sensitivity as obtained when the aircraft is in level flight. The pattern of Fig. 3 is typical of operation at frequencies near the center of the frequency range of the antenna system. Such patterns are dependent both on the mounting position of the aircraft and on the characteristics of the antenna, not merely on the antenna characteristics alone. In general, three factors combine to produce the most desirable results; (1) the antenna balance, (2) the spacing and angular position in front of the wing 10, as indicated by the distances d and d' , and (3) the distance from the fuselage 11 (the distance D).

The dipole members 13 and 14 function as normal dipole antennas and are preferably designed to provide radiation patterns with large forward lobes. The position of each pair of dipoles 13 and 14 with respect to the leading edges of wing 10 and the nose of the aircraft produce two forward lobes A and B for the left and right antenna 12, respectively. The wing 10 behind each antenna 12 acts as a reflector thus increasing the forward sensitivity and it also shields the antenna from signal sources from the rear thus minimizing the back lobes of the radiation patterns. Thus, the backward energy is reflected by the antennas and is returned to reinforce the forward lobes. Due to the fairly close spacing between dipoles 13 and 14 and wing 10, wing 10 acts as a suitable reflector over a wide range of frequencies. As a result of the combined effect, in the plane of the antenna and the wing, of forward lobes, and the reflection from the wings, a front to back ratio of 20 to 25 db is obtainable and a forward gain of approximately 2 to 1 in voltage over that of a dipole antenna in free space is realized. Displacement of the forward lobes A and B to the left and right respectively from the centerline of the aircraft is due to the combined effect of the sweep back angle of the wings 10, the nose of the aircraft and the angular position of the dipoles 13 and 14 relative to the wing 10.

The fact that a signal from some source ahead of the aircraft will produce unequal amplitudes of signal input from each of the antennas 12 except when that signal source is dead ahead is utilized in the present invention. An approach indicator for a pointer operable from the signals received by the antennas may be utilized to give an indication of the signal source. This pointer may be moveable to the right or left to correspond to the antenna 12 which produces the stronger signal input. As the aircraft direction is changed to balance the pointer, the heading of the aircraft directs the cross-over point C of the radiation patterns at the signal source. The antenna system according to the present invention is adapted to provide an accuracy of + or - 3° over most of the normal frequency range; that is, the cross-over point C which is shown in Fig. 3 as exactly on the centerline of the aircraft may be 3 to 5° off

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the centerline near the extremes of the frequency range.

It will be understood that there are also cross-over points produced by the minor backward lobes which vary in number and direction with the frequency. Thus, the aircraft pilot is able to obtain information by a signal strength meter responsive to the signals received by the antennas. The forward to backward ratio of sensitivity as hereinbefore mentioned is in the order of 20 to 25 db., thus making the discrimination between forward and rear direction possible as the aircraft follows a particular course, including a circle course.

While the antenna system as hereinbefore described is utilized fundamentally as an indicator of azimuth direction only, it is possible to obtain a rough indication of elevation by putting the aircraft into a 45° position in flight while maintaining proper direction. A 45° clock-wise roll while heading in the course will produce a "right" deflection of the pointer if the source is at a lower elevation, or a "left" deflection if the source is above the aircraft.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention.

What is claimed is:

1. A broad band antenna system for airborne radio object-locating systems comprising, in combination, an antenna mounted on the leading edge portion of each of two wings of an aircraft, each antenna being substantially equally spaced from opposite sides of the aircraft fuselage, each antenna comprising a tubular supporting member mounted in the leading edge of a wing and projecting forwardly and substantially perpendicularly of said wing, a streamlined head member secured to the free end of said supporting member, a pair of aligned dipole arms of substantially equal length and each having one end secured within said head member with the dipole arms substantially lying in the plane of said supporting member and said leading edge, a coaxial conductor transmission line mounted in said tubular supporting member, one end of which is adapted to be connected to a source of electromagnetic energy, said dipole arms being electrically connected to the opposite end of said transmission line, one dipole arm being connected to the outer conductor and the other dipole arm being connected to the inner conductor, a transformer device comprising a hollow cylindrical member mounted within said tubular member coupled to and in substantially parallel relation with said transmission line, said device being adapted to transform the transmission line which is normally electrically unbalanced to a balanced line whereby said dipole arms are energized with equal and opposite voltages, each of said antennas thus being adapted to radiate energy with a large forward radiation pattern lobe, the positions of said antennas relative said wings and said fuselage being so determined that said two lobes overlap and have a cross-over point substantially on the centerline of said aircraft with high sensitivity at said cross-over point and a high differential ratio for small angles from said cross-over point.

2. An antenna system as claimed in claim 1 wherein each pair of dipole arms are disposed at an acute angle relative to said leading edge with the dipole arm extending toward the wing tip

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being closer to said leading edge than said other dipole arm.

3. An antenna system as claimed in claim 1 wherein the supporting elements of each said antenna are adapted to be removeable from their mountings in said wings and wherein said dipole arms are removeable from connection in said head member and from said transmission line thereby permitting interchangeability of said antennas and said dipole arms to afford operation of said antenna system over a wide range of frequencies.

4. An antenna system as claimed in claim 1 wherein each said supporting element is slidably mounted in said wing whereby the distance of said head member and said dipole arms in front of said leading edge is adjustable, means being provided for securing said supporting element in adjusted position.

5. In an antenna system for airborne radio object-locating systems, an antenna mounted on each of the wings of an aircraft at substantially equal distances from opposite sides of the aircraft fuselage, each said antenna comprising a tubular supporting member having one end mounted in the leading edge portion of said wing, a head member secured to the opposite end of said supporting member, a pair of aligned sockets in said head member, a dipole arm having one end mounted in each said socket, said dipoles lying substantially in the central plane of said wing which is parallel to the flat dimension thereof, a coaxial conductor transmission line mounted in said supporting member having one end adapted to be connected to a source of electromagnetic energy and its opposite end electrically connected with said dipole arms, an impedance matching device coupled to said transmission line for matching the impedance of said transmission line to that of said dipole arms, said leading edge portions of said wings acting as reflectors for energy radiated backward by said dipoles whereby said backwardly directed energy is reflected to reinforce the forwardly directed energy to provide large forward radiation pattern lobes, thereby affording high sensitivity at the cross-over points of the forward lobes radiated by each of said two antennas and affording a high forward gain.

6. In an antenna system for airborne radio object-locating systems, a pair of antennas mounted in the leading edge portions of the two opposite wings of an aircraft and equally spaced from opposite sides of the fuselage of said aircraft, each said antenna comprising a pair of aligned balanced dipole members, means for mounting and supporting said dipole members of each antenna at the same acute angle with respect to the leading edge of the wing on which said antenna is mounted, the dipole arm extending toward the wing tip being closer to said leading edge than the other dipole arm, means for feeding electromagnetic energy to said dipole members, and means for electrically balancing said feeding means to said dipole members, the positions of said antennas relative to said wings and said fuselage being so determined that the lobes of said pair of antennas overlap and have a cross-over point substantially on the centerline of said aircraft with high sensitivity at said cross-over point and a high differential ratio for small angles from said cross-over point.

7. An antenna system comprising a pair of spaced dipole antennas, means for mounting said antennas in the leading edge portions of the two wings of an aircraft at substantially equal dis-

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tances from opposite sides of the aircraft fuselage, means for mounting the dipoles of said antennas at the same acute angle with respect to said leading edge portions and at an obtuse angle with respect to each other, means for feeding energy to said antennas, and means for positioning said antennas with respect to said fuselage to radiate energy with large forward lobes, the lobes being in one plane and overlapping to provide a cross-over point substantially on a line perpendicular to the center of a line connecting said antennas.

8. An antenna system as claimed in claim 6 wherein said acute angle is substantially 30°.

9. A spaced dipole antenna structure comprising a tubular supporting member, a head member removably mounted on said supporting member, a coaxial transmission line within said supporting member, a hollow conductor within said supporting member and parallel to said coaxial line, the ends extending toward said head member of said hollow conductor and said coaxial line being formed as plugs, an aperture in the outer con-

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ductor of said coaxial line close to the plug end thereof, the center conductor of said coaxial line extending outwardly through said aperture and connected to the plug end of said hollow conductor, and a pair of aligned spaced dipole arms slidably mounted in said head member, each of said arms having a socket adapted to fit snugly over each of said plugs.

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