Nov. 23, 1965 D. W. YOUNG ETAL 3,220,006

GROUND PLANE VHF ANTENNA COMPRISING BLADE-TYPE DIPOLE CONFIGURATION OBTAINED BY REFLECTING MONOPOLE IN GROUND PLANE

Filed June 5, 1961

2 Sheets-Sheet 1

FIG. 1.

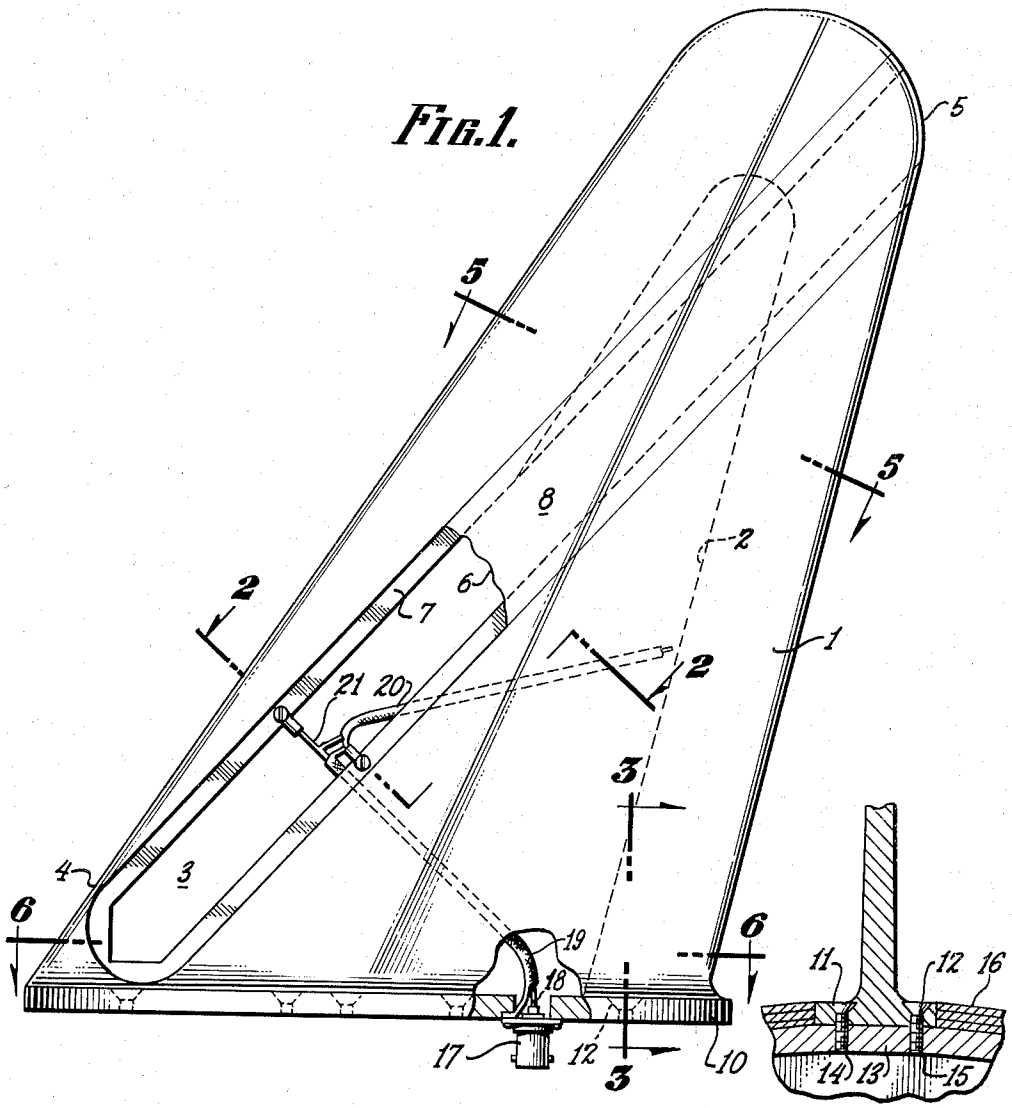


FIG. 3.

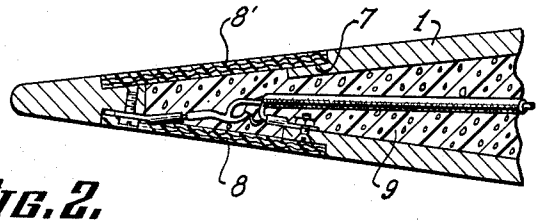


FIG. 2.

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FIG. 4.

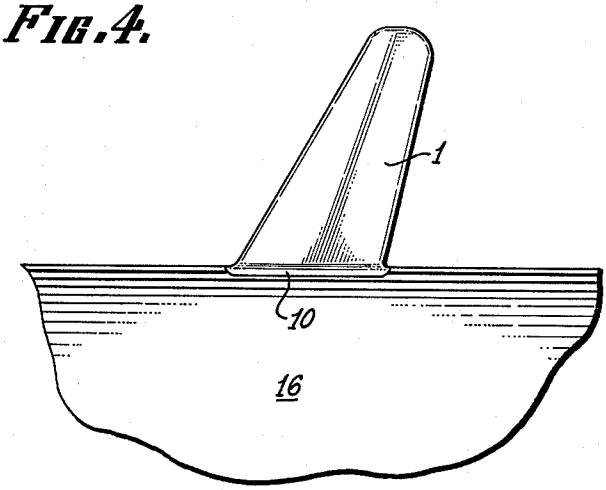


FIG. 5.

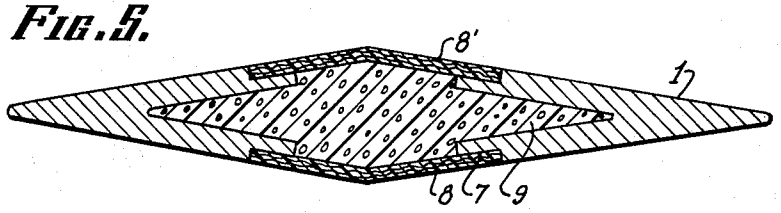
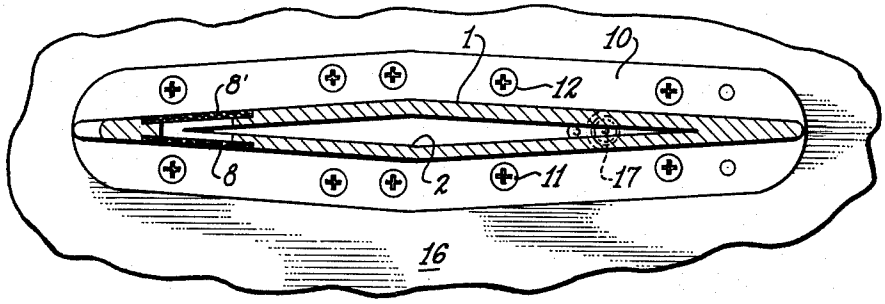


FIG. 6.



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3,220,006

GROUND PLANE VHF ANTENNA COMPRISING BLADE - TYPE DIPOLE CONFIGURATION OBTAINED BY REFLECTING MONOPOLE IN GROUND PLANE

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14 Claims. (Cl. 343—708)

This invention relates to antennas and more particularly to very high frequency antennas suitable for use on high-speed aircraft and the like.

VHF antennas for use with aircraft radios have, generally, been of the streamlined stub type, sleeve-stub type, or the so-called blade type. With increased flying speeds of airplanes, as is especially evident in the case of jet aircraft, these prior antennas have suffered from certain shortcomings which render them unsuitable for high-speed aircraft. Specifically, their mechanical strength is inadequate for the aerodynamic stresses applied thereto since certain portions, directly exposed to the airstream, are fabricated from dielectric materials having structural characteristices which are not commensurate with those of the metal portions. Ideally, an antenna exposed directly to the airstream of a high speed airplane should be of all-metal construction in order to have the desired strength and resistance to erosion. Lacking an all metal design, all leading edges of the antenna should be metal. Even this alternative has not been met by prior designs.

Another shortcoming of prior antennas is the difficulty with which they are adapted to provide adequate lightning protection. Ideally, there should be a very low resistance path, having high current carrying capacity, extending from the outermost end of the antenna to the ground plane or frame of the aircraft. For example, a typical blade antenna of the prior art involves a base section attached to the skin of the aircraft and surmounted by a dielectric section which in turn is capped with a second metal section. The strength of the antenna is impaired by the center dielectric section which, in addition to having to support the metal cap section, also comprises a portion of the leading edge of the blade. The dielectric section exposed at the leading edge is subject to abrasion from the high speed airstream. There is provided by the present invention a streamlined blade antenna having an all-metal leading edge and which offers simple and highly effective lightning protection. Additionally, the antenna according to the present invention, has great mechanical strength, low drag and excellent radiation characteristics. The inherent strength of this design results in an external blade antenna assembly which is ideally suited for the VHF communication system of modern high-speed jet aircraft.

It is therefore a principal object of the invention to provide an antenna for airborne communications equipment which has improved mechanical strength, and superior lightning protection characteristics, over that available heretofore.

It is another object of the invention to provide an antenna for airborne communications equipment capable of radiating high-power RF energy with improved efficiency.

Yet another object of the invention is to provide an airborne antenna having an all-metal leading edge and improved aerodynamic characteristics.

Another object of the invention is to provide an aircraft antenna which is adapted to be heated by warm air to prevent icing of the exterior surfaces.

Still another object of the invention is the improvement of aircraft antennas generally.

These and other objects of the invention will become more readily apparent upon consideration of the following specification taken in conjunction with the following drawings in which:

FIGURE 1 is a side elevation view, of a preferred embodiment of the invention, partially broken away to show detailed features thereof.

FIGURE 2 is a fragmentary sectional view taken along line 2—2 of FIGURE 1.

FIGURE 3 is a fragmentary transverse sectional view taken along line 3—3 of FIGURE 1.

FIGURE 4 is a side elevational view illustrating the manner of installation of the antenna of the invention on an airframe.

FIGURE 5 is a sectional view taken along line 5—5 of FIGURE 1.

FIGURE 6 is a sectional view taken along line 6—6 of FIGURE 1 and illustrates the antenna attaching means.

There is shown in FIGURE 1 a preferred embodiment of the invention which, mechanically, comprises a blade-type antenna and which, electrically, comprises a VHF dipole in a ground plane. A dipole configuration is achieved by reflecting a monopole in the ground plane to form a mirror image. This results in predominant vertical polarization and the radiation pattern in the horizontal plane is essentially omnidirectional. Radiation in the horizontal plane, of the embodiment described hereinafter, will not depart from an omnidirectional pattern more than ±3 db in relation to the average energy level represented.

The design of aircraft antenna systems has been largely based on experimental data concerning antenna impedance and pattern characteristics. This is so because the airframes of modern aircraft constitute very complicated grounds for the antenna to work against, and because areodynamically suitable antennas are very often quite different in construction and essential dimensions from those which would be used at identical frequencies in ground installations. In addition to aerodynamic considerations, the antenna must be mechanically constructed to operate satisfactorily under conditions of extreme vibration and noise, such as are encountered during high-speed flight.

Conventional antennas meeting desired electrical requirements would have a large cross section such as a cylinder, cone or ellipse. Examination of the aerodynamic characteristics of such structures shows that the excessive air drag proves them impractical, and even a streamlined airfoil section of the required dimensions would result in an air drag of perhaps 75 to 100 pounds at modern aircraft speeds. The problem then becomes one of selecting an antenna with the necessary electrical qualities without unfavorable aerodynamic characteristics. A typical construction of the present invention will have an aerodynamic drag which is less than 4 pounds at 25,000 feet altitude at a speed of Mach 0.85. The main body 1 of the antenna comprises a blade-like member which may be cast from aluminum, magnesium or the like. The interior of the casting may be hollow, in which instance, dotted outline 2 illustrates the extent of the cored hole. A slot 3 extends from near the lower forwardmost edge 4 of the blade to the upper rearwardmost edge 5. The lower end of the slot 3 is terminated in a U-shaped closure while the upper end is open and extends through the edge of body 1. This slot may be filled with a solid dielectric, as shown extending upward from broken line 6, or in the simplest case, the dielectric may be air. The use of a solid dielectric in slot 3 increases the structural rigidity and mechanical strength of the antenna. To facilitate installation of a dielectric in the form of a laminated fiberglass sheet 8, the slot 3 may be provided with a recessed edge or step 7 to serve as a support and

attachment surface for the sheet. Since the interior of body **1** is hollow, two dielectric sheets (**8** and **8'**) are required (see also FIGURE 5). Sheet **8** may be adhesively bonded to step **7** or attached thereto by any other suitable fastening means. The outer surface of sheet **8** is flush with the exterior surface of the main body **1** as is clearly shown in FIGURE 2.

Additionally, the hollow interior of body **1** may be filled with a cellular plastic dielectric **9** or rigid plastic foam.

If desired, the interior of body **1** may be left hollow so that heated air may be forced therethrough in order to heat the surface of the antenna and thereby prevent ice from forming on the exterior surface during freezing weather.

To provide the desired aerodynamic characteristics compatible with high speed aircraft, the antenna body **1** is streamlined and tilted to provide a sweep-back of 35 degrees to its mounting base **10**. This also results in a radiation pattern that is free from dip nulls through a 180° sector and accordingly, permits more uniform coverage than would be available if the antenna axis were normal to the base **10**.

Looking now at FIGURE 3, the base end of the antenna body **1** is provided with a flared portion having the form of an external pressurized flange mounting. Base **10** contains a plurality of holes adapted to receive fastening screws such as **11** and **12** or other means of attaching the antenna to the airframe. In a typical installation, screws **11** and **12** are threadedly attached to an airframe support member **13** having tapped holes **14** and **15** therein for receiving the screws. The skin **16** of the aircraft is provided with a receiving opening to accommodate the base **10** portion of the antenna permitting a flush installation wherein the surface of the antenna base is faired into the surface of the aircraft skin **16**.

The skin **16** and the support member **13** of the aircraft are provided with apertures through which connector **17** may pass for interconnection with a coaxial cable (not shown) leading to the related radio equipment. The installed antenna appears as shown in FIGURE 4. Since the exterior surface of dielectric sheets **8** and **8'** are flush with the exterior surface of body **1**, the antenna may be painted to have a uniformly solid appearance as shown in FIGURE 4.

Electrical connection between the antenna and a transmission line (not shown) is made via cable connector **17** which may be of any well-known type suitable for interconnection with coaxial cable or the like. In a typical application, the transmission line may comprise a 52 ohm coaxial line. The center conductor **18** of cable **19** is attached to the shielded conductor of connector **17** and its opposite end terminates at a point on the edge of slot **3** nearest the leading edge of antenna body **1** and at a distance approximately one quarter of the way from the base **10**. The shield conductor of cable **19** is connected to the shell of connector **17**, which is grounded to the base of body **1**. The opposite end of the shield conductor of cable **19** terminates at a point on the edge of slot **3**, opposite from the connection of conductor **2**, as shown in FIGURE 1.

If an antenna is fed by a transmission line, then it follows that the antenna impedance should match the line. However, this is very seldom the case, especially over a range of frequencies, so that it becomes necessary to transform the antenna impedance by use of pure reactive networks for maximum power transfer. To provide a better impedance match between the antenna and the transmission line, and to reduce the standing wave ratio, various matching means may be employed, as is well known to those skilled in the art. In the embodiment shown in FIGURE 1, the impedance matching means comprises stub **20**. This stub comprises a short length of coaxial cable, the center conductor of which connects to center conductor **21** of cable **19** and the shield conductor of which connects to the shield conductor of cable **19**. The opposite end of the matching stub **20** is left open and may extend backward, away from the leading edge of the antenna. This stub is physically located within the hollow core section of body **1**. Alternative means for matching or terminating the line may be employed such as lumped constants in the form of capacitors, inductors, etc. The antenna terminated in the manner of the preferred embodiment discussed above will match a 52 ohm line with a voltage standing wave ratio which is less than 2:1 over the VHF frequency range of 116 to 156 megacycles.

As is apparent from the foregoing, the major exterior surfaces of the antenna are all metal and the main body is grounded directly to the mounting structure. The all-metal leading edge results in minimum erosion and also serves as an efficient lightning arrester.

Thus, there is provided an antenna meeting the objectives set forth hereinbefore and which is readily installed and maintained and may be made highly weather resistant.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated may be made by those versed in the art. For example, the particular outline along the major axis and the streamlined shape along the minor axis may be altered in accordance with specified aerodynamic parameters, and the slot extended diagonally along the maximum linear dimension may extend along other lines of increased or decreased slope, dependent only on electrical and mechanical design requirements. Such modifications may be made without departing from the spirit of the invention; therefore, it is intended to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. An antenna comprising an upwardly extending blade-like member having a flanged base portion, a leading edge, and a trailing edge, and having a length several times the width, said leading and trailing edges being tilted backwardly at an angle with respect to said base portion, said leading edge being an uninterrupted conductor throughout its length; an elongated slot passing entirely through the width of said member and extending diagonally from adjacent the leading edge and said base portion upwardly through the trailing edge, said slot containing a dielectric material; and a two-conductor transmission line, one of the conductors of said line being connected to one side of said slot and the other conductor of said line being connected to a side of said slot opposite said one side.

2. An antenna as defined in claim **1** wherein said dielectric material in said slot comprises a solid insulating sheet, the exterior surfaces of said sheet being flush with the exterior surfaces of said member.

3. An antenna as defined in claim **1** including transmission line terminating means comprising a relatively short length of two-conductor coaxial cable having its inner-conductor electrically connected to said one side of said slot and its outer-conductor electrically connected to said other side of said slot.

4. An antenna as defined in claim **1** wherein said base portion is mounted on a conductive ground plane extending outwardly in a generally perpendicular plane to said member.

5. An antenna comprising a monopole reflected on a ground plane, said monopole consisting of a pair of coplanar blade-shaped metal elements connected to and extending upwardly and rearwardly from a ground plane comprising a metal conductor substantially perpendicular to said elements, and a two-conductor transmission line, one of the conductors of said line being attached to one

of said elements and the other conductor of said line being connected to the other of said elements.

6. An antenna as defined in claim 5 having a solid dielectric sheet filling the space between said pair of elements.

7. An antenna comprising an element reflected on a ground plane, said element comprising a hollow blade-shaped member of conductive material lying in a plane perpendicular to said ground plane, said member having a pair of diametrically opposed elongate dielectric sheets defining opposite wall-portions of said member, each of said sheets extending diagonally from adjacent said ground plane along the maximum linear surface dimension of said member and through an edge thereof, and a two-conductor transmission line, one conductor of which is connected to a point on said member adjacent one edge of one of said sheets and the other conductor of which is connected to another point on said member adjacent another edge of said one sheet opposite said one edge.

8. An antenna as defined in claim 7 wherein the interior of said hollow member is filled with a plastic foam dielectric.

9. An antenna comprising an element reflected on a ground plane, said element consisting of a hollow member having a length several times the width and lying in a plane perpendicular to said ground plane, the leading and trailing edges of said member being tilted backwardly at an angle with respect to said ground plane, a pair of spaced apart co-extensive elongated slots passing entirely through the walls of said member and extending diagonally from adjacent the leading edge through the trailing edge along the greatest possible linear surface dimension, said slots each containing a dielectric material.

10. An antenna as defined in claim 9 wherein said dielectric material in said slots comprises solid dielectric sheets defining opposite wall portions of said member.

11. An antenna as defined in claim 9 having a passage through said ground plane communicating with the hollow interior of said member and adapted to permit heated air to be forced therethrough and thereby prevent

ice from forming on the exterior surfaces of said antenna.

12. An antenna as defined in claim 11 having transmission line terminating means comprising a two-conductor coaxial cable passing through said passage, one conductor of said cable being electrically connected to an edge of said member bordering on said slot and the other conductor of said cable electrically connected to another edge of said member bordering on said slot and located opposite from the connection of said one conductor.

13. An antenna comprising an upwardly extending blade-like member having a flanged base portion, a leading edge, a trailing edge, and having a length several times the width, the said leading and trailing edges being tilted backwardly at an angle with respect to said base portion, and an elongated slot passing entirely through the width of said member and extending diagonally from adjacent the leading edge through the trailing edge along the greatest possible linear surface dimension, said slot containing a dielectric material.

14. An antenna as defined in claim 12 having impedance matching means, comprising a matching stub located within said hollow member, connected to said co-axial cable.

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