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DECOUPLED HORIZONTALLY AND VERTICALLY POLARIZED ANTENNA

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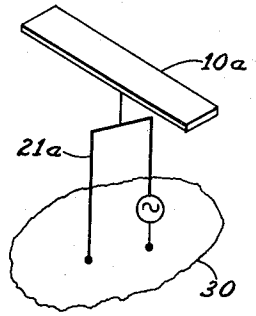


FIG 1

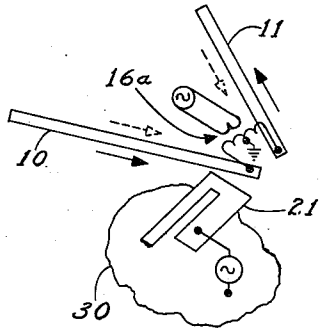


FIG 2

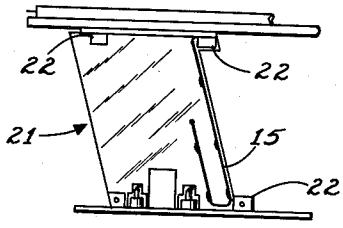


FIG 4

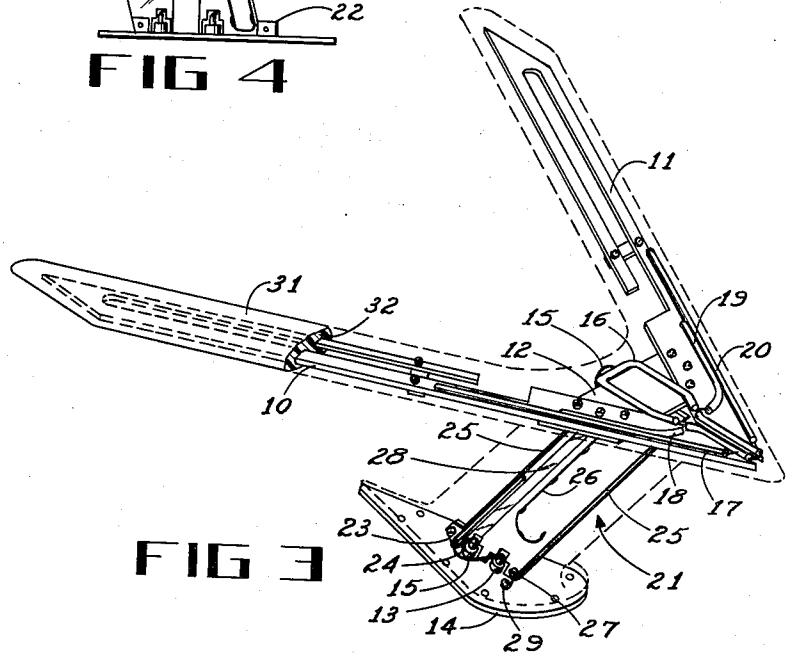


FIG 3

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DECOUPLED HORIZONTALLY AND VERTICALLY POLARIZED ANTENNA

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This invention pertains to radio antennas and particularly to antenna systems comprising a plurality of antennas in a balanced configuration for permitting simultaneous non-interfering broadcasting and receiving of electromagnetic waves that are in the same frequency range and that have polarizations that are normal to each other. Antennas constructed according to this invention are particularly applicable to aircraft for reducing the number of antenna structures that are required for providing the several radio systems normally employed. Obviously, a reduction in the number of antenna structures simplifies installation and reduces aerodynamic drag at the increasingly higher velocities of newly designed aircraft.

An object of this invention is to combine in a single structure antennas for vertically and for horizontally polarized signals in a configuration that provides effective decoupling between the respective signals on the antennas.

The following description and the appended claims can be more readily understood with reference to the accompanying drawings, in which:

FIGURE 1 is a simplified schematic diagram of the vertical polarized antenna of a combination of non-interfering antennas;

FIGURE 2 is a simplified schematic for showing the relative positions of the antennas and their input feed terminals;

FIGURE 3 is an oblique top view of the combined antennas with the molded supporting structure removed; and

FIGURE 4 is a side elevation view of the combined antennas with the supporting structure removed.

The top portion of the antenna structure of FIGURE 3 is a dipole swept back from its center to form a V-shaped antenna which provides omnidirectional operation. The V shape is chosen for its appearance and its aerodynamic characteristics. Other symmetrical configurations suitable for reception of horizontally polarized signals may be used, for example, a loop or a delta configuration. The vertical portion of the antenna system that is contained in the mast is a folded monopole for receiving and transmitting vertically polarized electromagnetic signals. In addition to being a dipole, the top portion of the antenna functions as a loading element for the vertical monopole. The dipole is symmetrical with respect to the monopole even to the point of installing unused coaxial line on one arm of the dipole. The dipole is connected to a connecting terminal through a balanced coaxial line coupler such that the signal induced into the dipole from the monopole is very effectively balanced out.

In FIGURE 3 the dipole elements **10** and **11** are mounted on an insulated mounting plate **12** so that the elements form a V in which the ends at the vertex are separated slightly. Terminal **13** that is mounted on base **14** is connected through coaxial line **15** to the balanced-to-unbalanced coaxial line transformer **16**. The coupler or transformer includes matching stubs **17** and **18** that comprise lengths of coaxial lines which have their outer conductive braid soldered along a portion of dipole element **10**. These stubs **17** and **18** have corresponding lengths **19** and **20** of coaxial line that are placed on dipole element **11** in positions corresponding to those of lines **17** and **18** on element **10**. The center conductors of the dummy stubs **19** and **20** remain unconnected but the outer conductor or braid serves to balance out any signal induced into the outer conductor of lines **17** and **18** by induction from the vertical monopole antenna. The balanced terminals of transformer **16** are connected to respective adjacent ends of dipole elements **10** and **11**. In the model shown in the accompanying drawings, the outer conductors of the coaxial lines that are used for the transmission lines for both of the antennas are soldered at close intervals to the copper plate which is used for the folded monopole antenna. The particular layout of the lines as shown provides the necessary length as required for matching in the specific application of the antenna system.

The vertical portion **21** of the antenna system is fabricated from a metal clad insulating board such as a copper clad epoxy fiberglass sheet. On the one side of the vertical assembly as shown in FIGURE 4, the only conducting portion is that portion to which the outer conductor of line **15** is soldered. The folded monopole is formed by etching a slot **28** into the copper plate that adheres on that side of the vertical insulating member shown in FIGURE 3. The copper plate has sufficient thickness for providing the necessary conductivity to keep resistance losses to a minimum and the insulating sheet has sufficient strength so that the antenna can be handled without damage until the surrounding supporting material is applied.

The base **14** and the insulating mounting plate **12** for supporting the dipole antenna are mounted at opposite ends of the vertical monopole structure normal to the plane of the monopole. In the instant example, small phenolic blocks **22** and screws are used to fasten the elements together. The monopole assembly is mounted on the axis of mounting plate **12** about which the horizontally polarized antenna is symmetrical, for example, the bisector of that angle formed by the dipole elements **10** and **11**. The lower end **23** of one leg or element of the monopole is connected to plate **14** whereas the lower end **27** of the other leg is insulated from the plate. The connection from the radio equipment to the monopole is completed through connector **24** and coaxial line **25**. A matching stub **26** connected to line **25** may be used as required to match the line from the radio equipment to the antenna. The outer conductor of coaxial line **25** is connected at intervals to the copper plate that forms the monopole and the inner conductor of line **25** is connected to terminal **29** on base **14** so that signal from the line is applied between the lower end **27** of one leg of the monopole and the base **14** which is ordinarily mounted to a large conductive surface. The top center portion of the monopole is connected to the dipole antenna which functions as a top loading plate for the monopole antenna. The connection between the two antennas is completed by the outer conductor of line **15** which is connected at the intervals to the proper plate of the monopole and is also connected to the dipole elements **10** and **11** at a point about which the dipole elements are electrically balanced.

The antenna is encased in a fiberglass streamlined housing **31** that is molded in three sections, the three sections being cemented together with epoxy resin. After the sections are cemented together about the antenna, the housing is filled through openings provided for this purpose with an epoxy or plastic foam **32** for supporting the antenna.

The operation of the vertically polarized folded monopole antenna is apparent from the simplified schematic diagram of FIGURE 1. A source of signal is applied between one end of the monopole and conductive surface

30 to which the base 14 of the antenna is attached. The monopole is top loaded by dipole elements 10 and 11 which are shown as plate 10*a* connected to the top portion of the monopole. Application of signal to the monopole antenna 21 induces into dipole elements 10 and 11 current flow which has opposite directions in the different elements as indicated by dotted lines in FIGURE 2. The coaxial line transformer 16 of FIGURE 3 may be represented by a balanced-to-unbalanced transformer 16*a* in which the oppositely induced currents cancel so that signal is not applied to the transmission line which is connected to the dipole elements. This balanced state is obtained for configurations in which the horizontally polarized antenna is symmetrical and the vertically polarized antenna is positioned on the normal plane through the bisector of the angle subtended by the dipole elements. The balanced antenna structure of this invention has been applied very successfully to aircraft installations in which the top dipole section is used for receiving omni-range directional signals and the vertical monopole is used for both reception and transmission on the communication bands. The isolation between the antennas is so effective that the horizontally polarized omni-range directional signals of a particular frequency may be received without interference from the transmission of vertically polarized signals in the communication band even though the omni-range and communication bands are adjacent.

Although this invention has been described with respect to a particular embodiment thereof, it is not to be so limited, as changes and modifications may be made therein which are within the full scope and spirit of the invention as defined by the appended claims.

What is claimed is:

1. The combination of horizontally polarized and vertically polarized decoupled antennas, means for mounting said vertically polarized antenna in a vertical plane, said horizontally polarized antenna being symmetrical about a horizontal central axis and being mounted with said axis in said vertical plane, the planes containing said antennas being normal, said horizontally polarized antenna being provided with two electrically balanced

points representing image positions on opposite sides of said vertical plane, balanced transformer means for connecting antenna terminals of radio equipment between said two points, means for connecting antenna terminals of other radio equipment to said vertically polarized antenna, and said balanced transformer means being arranged with said image positions of said horizontally polarized antenna to substantially mutually decouple said antennas.

2. An antenna system as described in claim 1 in which said horizontally polarized antenna is connected to said vertically polarized antenna at the intersection of the planes of said antennas, whereby said horizontally polarized antenna functions as a top loading element for said vertically polarized antenna.

3. An antenna system having a grounding plate, a dipole, and a monopole, said monopole being folded to form first and second legs, said grounding plate and said dipole being mounted at opposite ends of said legs in planes normal to the plane passing through said legs, one leg of said monopole being connected directly to said grounding plate, means for connecting the antenna circuit of radio equipment between the other leg of said monopole and said grounding plate, said dipole being symmetrical to said plane of said monopole, said dipole being balanced by symmetry for presenting a pair of points that are images relative to said plane of said monopole, balanced transformer means for connecting the antenna circuit of radio equipment between said pair of points of said dipole, means for connecting said dipole to the central adjacent portion of said monopole, the connection to said dipole being at a point about which said dipole is electrically symmetrical relative to said plane of said monopole, and said dipole being connected as a loading element for said monopole, said dipole being balanced relative to said monopole for substantially eliminating radio frequency wave coupling between said dipole and said monopole.

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