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R. R. BRUNNER
DIRECTIONAL ANTENNA
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2,350,337

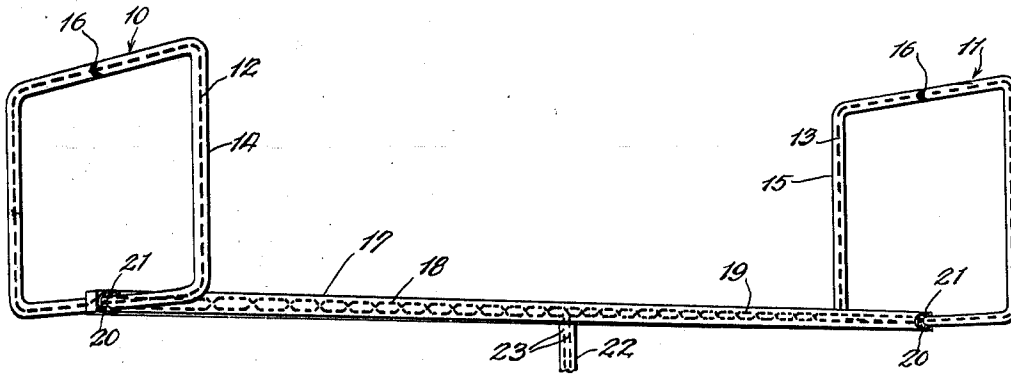


Fig. 1.

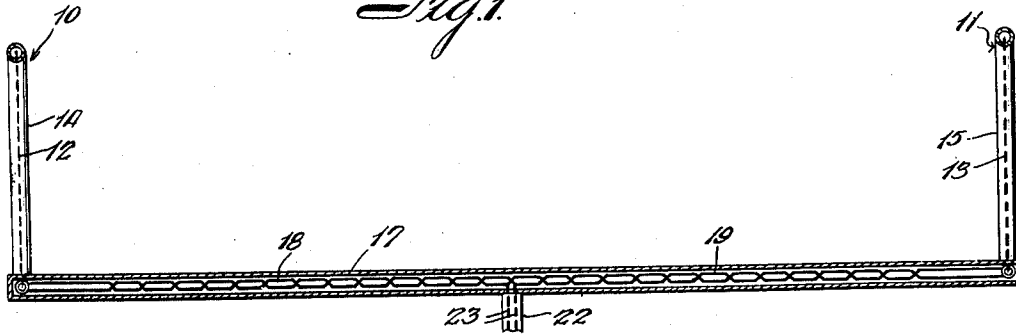


Fig. 2.

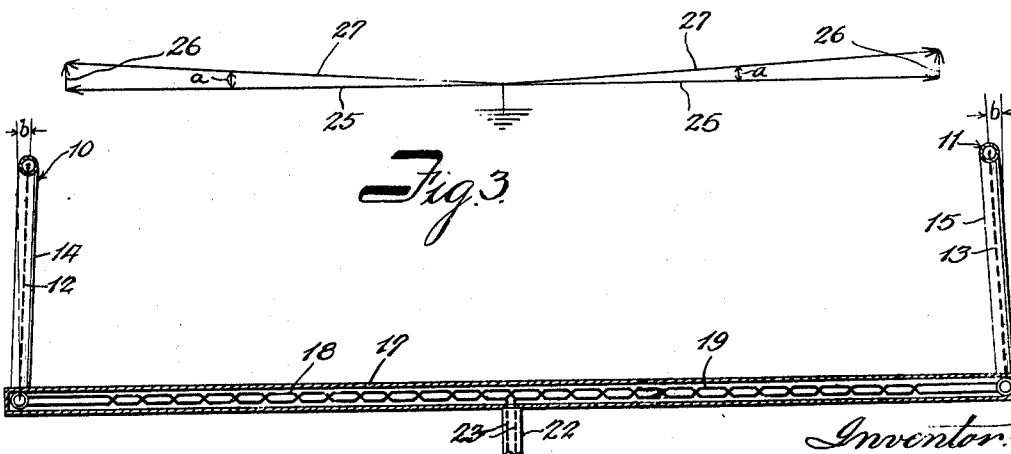


Fig. 3.

Fig. 4. Inventor:
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UNITED STATES PATENT OFFICE

2,350,337

DIRECTIONAL ANTENNA

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10 Claims. (Cl. 250—11)

This invention relates to directional antennas for radio direction finders, more particularly to directional antenna arrays and methods of eliminating undesirable components therefrom, and the invention has for an object the provision of apparatus and methods of the above character for rendering more accurate and reliable the bearing records obtainable by radio direction finders.

Radio direction finders utilizing an antenna array of the type to which this invention relates are described and claimed in a copending application of Peter C. Sandretto and Elmer P. Buckthal, Serial No. 403,802, filed July 24, 1941, entitled Radio direction finder, and in the present application only the antenna array itself will be described. It will be understood, however, that while antenna arrays embodying this invention are particularly applicable to the direction finder systems disclosed in the said Sandretto and Buckthal application, the invention is not limited thereto but may be employed in various other direction finder systems.

In antenna arrays comprising spaced loops disposed in substantial face-to-face or coaxial relation, the loops are preferably connected in opposed parallel relation with each other so that the voltages induced in the respective loops will cancel out regardless of variations in the induced voltages so long as the same variations occur in each loop. Cancellation and zero resultant voltage therefore occur, in so far as the loops themselves are concerned, regardless of variations in the inducing source. The spaced loops, as disclosed in the above referred to application, may be mounted on the opposite ends of a hollow horizontally disposed boom supported for rotation about a substantially vertical medial axis, and the connecting cables or transmission lines from the loops extend through this hollow boom. Voltages induced in these transmission lines by the received radio wave would not ordinarily be canceled out, however, and accordingly the boom is constructed of metallic material to form a shield for the transmission lines, and these lines are transposed so as to eliminate voltage errors which would otherwise appear in the output of the antenna array.

It is of course known, however, that certain components of the received radio wave will induce currents in a metallic boom of this character, and in order to avoid coupling between the currents flowing in the boom and the antenna loops, it has been proposed to mount the loops on the boom in coaxial relation to each other

with the plane of each loop at right angles to the boom. If the currents flowing in the boom itself were only horizontal, such a right angular relation would successfully eliminate all coupling, but as a matter of practical necessity the boom which forms the structural support for the loops must have a substantial vertical dimension, and with such a construction it has been found that eddy currents are set up which flow vertically in the boom and produce a resultant current flow at an angle to the horizontal. With the loops disposed in right angular relation to the boom, coupling of course results, and it is a further object of this invention to provide an antenna array in which the coupling, due to eddy current fields produced by the received radio wave, is eliminated, and to provide a simple and reliable method for insuring such elimination.

For a more complete understanding of this invention, reference should now be had to the drawing in which:

Fig. 1 is a somewhat diagrammatic perspective view of an antenna array embodying the present invention;

Fig. 2 is a diagrammatic elevational sectional view of the antenna array of Fig. 1 before adjustment in accordance with the present invention;

Fig. 3 is a vector diagram of the currents which are believed to be induced in the horizontal metallic boom of the antenna array of Fig. 1 by components of the received radio wave; and

Fig. 4 is a view similar to Fig. 2 but showing the antenna array as in Fig. 1 after it has been adjusted in accordance with this invention.

Referring now to the drawing, the invention is shown as embodied in an antenna array comprising a pair of spaced shielded loops 10 and 11 having suitable loop conductors 12 and 13 respectively enclosed within tubular shields 14 and 15 which are preferably formed of aluminum alloy tubing, the two halves of each shield being separated at the top as shown and suitably insulated as indicated by the reference numeral 16. As shown the loops 10 and 11 are mounted adjacent the respective opposite ends of a hollow horizontally extending boom 17 through which extend suitable transmission lines 18 and 19 for connecting the loop conductors 12 and 13 in opposed parallel relation. The boom 17 is preferably also formed of aluminum or aluminum alloys and not only provides the necessary mechanical support for the loops 10 and 11, but acts as a shield for the transmission lines 18 and 19 which, as shown, are suitably transposed to elim-

inate errors due to the voltage induced therein by the received radio wave.

While the loop shields 14 and 15 may be mounted on the boom 17 by various connecting means, they are preferably arranged, as shown diagrammatically in Fig. 1, to engage suitable apertures in the opposite side walls of the boom, and suitable flanges 20 and flange bolts 21 are provided by means of which the loops may be secured to the boom in the desired angular relationship thereto. As more fully explained in the above referred to Sandretto and Buckthal application, the boom 17 is supported at substantially its center on a rotatable post 22 by means of which the entire antenna array is rotated in a substantially horizontal plane, and the transmission lines 18 and 19 are connected by suitable conductors 23 to the direction finder receiver (not shown).

In Fig. 2 the antenna array is shown with the loops 10 and 11 disposed at right angles to the boom 17, and, as heretofore explained, with the loops in this position coupling will occur between the loops and the currents flowing in the boom itself due to the fact that components of the received radio wave induce voltages therein. In Fig. 3 there is shown a vector diagram illustrating the boom currents as comprising horizontal components 25 and vertical components 26. The resultants of the components 25 and 26 are illustrated by the arrows 27, and it will be observed that these resultants extend at an angle α with respect to the horizontal. Coupling with the loops 10 and 11 occurs due to the fact that the loops are not disposed in right angular relation to this resultant current, and in accordance with this invention substantially zero coupling is obtained by tilting the loops 10 and 11 to the respective tilted positions shown in Fig. 4, wherein the tilt angle is designated by the letter b . Although the loops 10 and 11 are shown in the drawing as being tilted inwardly, it will of course be understood variations in the eddy currents may necessitate that the loops be tilted outwardly instead.

In order accurately to determine the angle of tilt to be imparted to loops 10 and 11 so as to insure that substantially zero coupling with the boom currents will result, it has been found preferable to arrange the loops 10 and 11 in substantially the right angular position shown in Fig. 2 and to then energize the antenna array from a properly terminated two-wire transmission line directed substantially parallel to the boom 17. With the antenna array energized solely from this transmission line, the conductors 23 are connected to a suitable receiver, and the receiver output is observed either by visual or audible signal means. The loops 10 and 11 are then tilted with respect to the longitudinal axis of the boom 17 until the receiver output becomes substantially zero.

Zero receiver output indicates that the antenna array is so adjusted as to be free from any effect of eddy current fields produced by components of a received radio wave and, the tilt angle having thus been determined, the loops 10 and 11 are fixedly secured to the boom in the proper tilted position. While it may be possible, by trial and error during actual reception of a radio wave or by calculation, to determine the proper angle of tilt which must be imparted to the loops 10 and 11 in order to eliminate the effects of error-producing components, the above-described method has been found to be highly accurate and is considered the preferable method of insuring such

elimination of the error-producing components.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A directional antenna comprising a hollow metallic boom mounted in substantially horizontal relation for rotation about a vertical medial axis, a single pair of loops, said loops being positioned on opposite sides of said vertical axis in planes transverse to the longitudinal axis of said boom, means connecting said loops in opposed parallel relation to each other and means mounting said loops in predetermined oppositely tilted relation to said longitudinal axis.

2. A directional antenna comprising a hollow metallic boom mounted in substantially horizontal relation for rotation about a vertical medial axis, a single pair of loops, said loops being positioned on opposite sides of said vertical axis in planes transverse to the longitudinal axis of said boom, means connecting said loops in opposed parallel relation to each other and means mounting said loops on said boom in predetermined oppositely tilted relation to the plane of rotation of said boom.

3. A directional antenna comprising a hollow metallic boom mounted in substantially horizontal relation for rotation about a vertical medial axis, a pair of loops respectively positioned on opposite sides of said vertical axis in planes transverse to the longitudinal axis of said boom, and means mounting said loops on said boom with each loop in substantially zero coupling relation to the fields produced by the eddy currents induced in said hollow boom by received radio waves.

4. A directional antenna comprising a hollow metallic boom mounted in substantially horizontal relation for rotation about a vertical medial axis, a single pair of shielded loops disposed with one of said loops adjacent each end of said boom in a plane transverse to the longitudinal axis of said boom, means extending through said hollow boom connecting said loops in opposed parallel relation to each other, and means securing the lower side of each loop to said boom with the upper and lower sides of the loops at right angles to said axis and with the upper side of each loop offset from the vertical plane through the lower side thereof.

5. A directional antenna comprising a hollow metallic boom mounted in substantially horizontal relation for rotation about a vertical medial axis, a single pair of shielded loops each having a top portion, a bottom portion and connecting side portions, means mounting one of said loops adjacent each end of said boom with the top and bottom portions at right angles to the axis of said boom and the side portions of each loop in tilted relation to said axis, and means extending through said hollow boom connecting said loops in opposed parallel relation to each other.

6. A directional antenna comprising a hollow metallic boom mounted in substantially horizontal relation for rotation about a vertical medial axis, and a pair of shielded loops mounted on said boom with the top and bottom portions of each loop at right angles to the axis of said boom and the sides of each loop in tilted rela-

tion to said axis in substantially zero coupling relation to the eddy currents induced in said boom by received radio waves.

7. In a directional antenna array of the type comprising a pair of shielded loops disposed in spaced apart substantially face-to-face relation and connected in parallel circuit with each other by transposed transmission lines, the combination of a hollow metallic boom for containing said transmission lines in shielded relation and for supporting said loops for rotation about a medial axis, and means mounting said loops on said boom in such tilted relation thereto as to minimize coupling between said loops and said boom.

8. A rotatable directional antenna array comprising a pair of spaced apart shielded loops, transposed transmission lines connecting said loops in parallel circuit relation with each other, a hollow metallic boom through which said transmission lines extend in shielded relation, said hollow boom being mounted for rotation about a transverse medial axis, and means mounting said loops on said boom adjacent the respective opposite ends thereof and in such tilted relation thereto as to minimize coupling between said loop and said boom.

9. In a rotatable directional antenna array including spaced apart loops mounted in substantially face-to-face relation adjacent opposite ends

of a substantially horizontally extending metallic boom, the method of eliminating horizontal components which comprises energizing said antenna array solely from a transmission line disposed substantially parallel to said boom, determining the output of said antenna array, tilting said loops relative to the horizontal axis of said boom to positions in which said output is substantially zero, and securing said loops to said boom in said tilted positions.

10. The method of obtaining a sharp null in the energy received by a rotatable antenna array of the type including spaced apart loops supported on substantially the opposite ends of a rotatable horizontal boom formed of conducting material, which method comprises disposing said loops in substantially face-to-face relation, connecting said loops in opposed parallel circuit relation with each other by conductors extending through and shielded by said boom, transposing said conductors to cancel out the voltages induced therein, energizing said array solely from a transmission line disposed substantially parallel to said boom, determining the output voltage of said array due to said energizing, and tilting said loops to positions wherein said output becomes substantially zero.

REED R. BRUNNER.