May 31, 1960 A. TROOST 2,939,140

DIRECTIONAL ANTENNA SYSTEMS

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Fig. 1

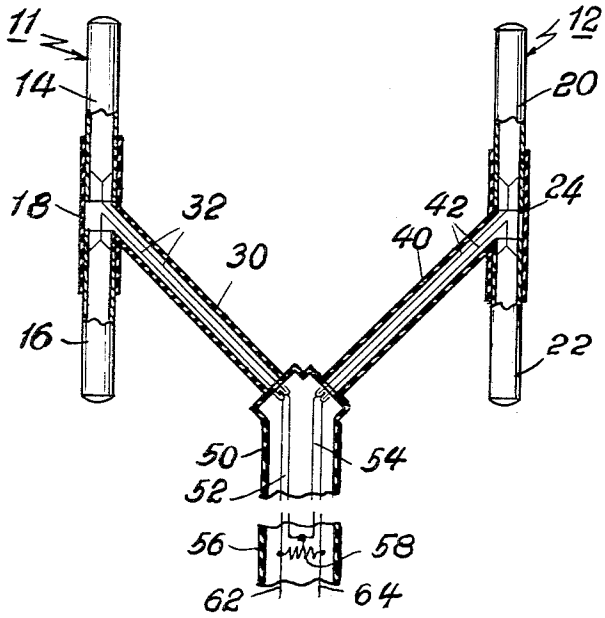
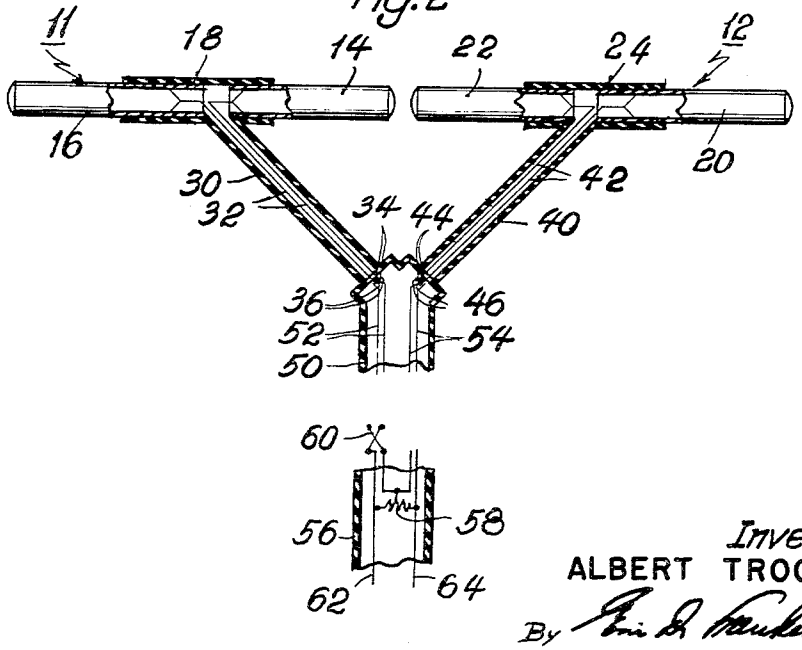


Fig. 2



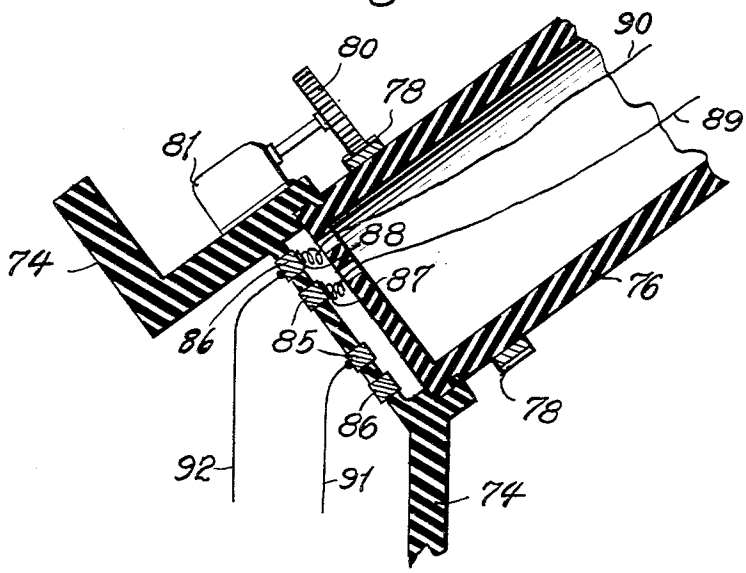
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Fig. 3



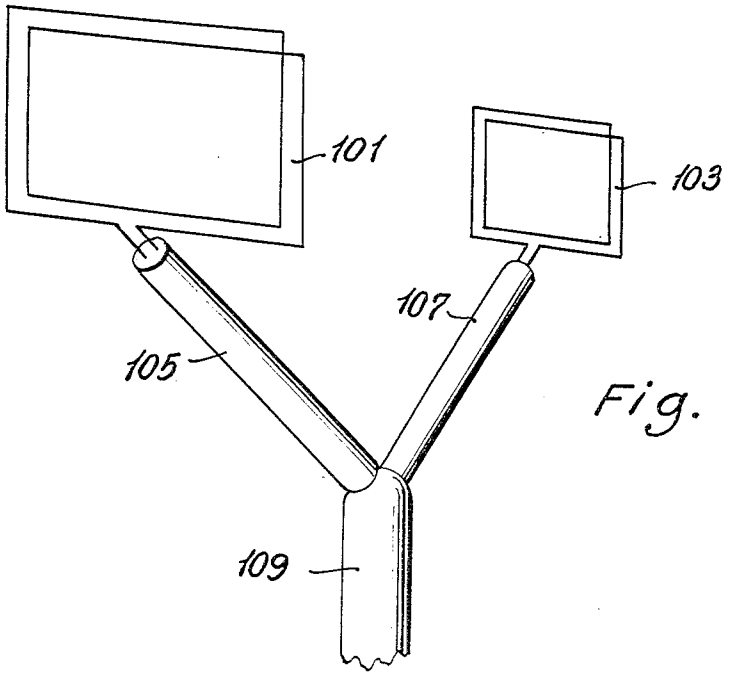


Fig. 4

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DIRECTIONAL ANTENNA SYSTEMS

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11 Claims. (Cl. 343—724)

The present invention relates to radio antennas and, more particularly, to antennas having highly directional characteristics suitable for use in radio direction finding equipment.

Transmitters of radio frequency energy, operating in the low or intermediate frequencies, usually transmit vertically polarized signals, due to the more suitable antenna structure which is obtained by such polarization. In other words, antennas of either low or broadcast band radio frequency energy are generally vertical towers which broadcast vertically polarized waves. In the very high and ultra-high frequencies, however, the antenna structures are much smaller and it is reasonably practicable to use horizontal polarization also. Therefore, radio and television transmitters operating in the ultra-high frequencies may use either vertical or horizontal polarization.

However, antennas which are to be used for direction finding equipment must, if the equipment is to be sensitive and accurate, be responsive to either form of polarization. The most versatile and most useful antennas for radio direction finding equipment would be those which respond equally well to both the vertical and the horizontal polarized radio waves but, in the past, except for the simple loop antennas, such composite directive antennas have proven impracticable.

In the prior art, there existed antennas which were positioned at right angles to each other. These antennas were generally adapted to be individually and selectively connected to a receiver and indicator circuit but, in such a system, the switching from one antenna to another usually also switched the response to the particular polarization. Thus, one antenna could quite properly respond to vertically polarized waves, while the other responded to horizontally polarized waves. This proved highly disadvantageous for the switching from one antenna to the other, because in addition to switching the sense of maximum polarization response, it also automatically varied the position of the antenna for minimum signal response.

In addition, dipole antennas have been used for direction finding antenna systems in which the antennas were arranged at a definite angle with respect to the vertical plane. Such dipole antennas were responsive to radio signals of both horizontal and vertical polarization, but one of the major disadvantages of this arrangement was the poor sensitivity of the final device and the wide angle of antenna movement for small changes in the indication registered.

Other antennas mounted for rotation about a generally horizontal axis have also been known. These antennas are rotated to vary the response to the different polarized radio signals, but they suffer disadvantages similar to the other mentioned antenna systems.

It is an object of this invention to provide a new and improved antenna system.

It is another object of this invention to provide a new and improved directional antenna system.

It is a further object of this invention to provide a

new and improved directional antenna system particularly suited for direction finders, which antenna system is sensitive to both horizontally and vertically polarized radio signals.

It is a still further object of this invention to provide a radio direction finder antenna which is adapted to selectively determine the direction of the sources of vertically or horizontally polarized radio signals.

It is another object of this invention to provide an improved direction finding antenna which more accurately determines the direction of minimum signal strength, regardless of the polarization of the received signals.

It is an additional object of the invention to provide novel direction finding antenna systems which are adapted to determine the horizontally and vertically polarized components of composite radio signals.

Briefly, the new antenna system of this invention comprises two rotatably mounted antennas connected in opposition to each other. These antennas are mounted for rotation on their supporting arms which are each inclined at an angle of 45° with the vertical. Means are provided for positioning the arms about their longitudinal axes, so that the antennas may be arranged at any time parallel to each other or perpendicular to each other in either the same plane or in different planes.

Still further objects and the entire scope of applicability of the present invention will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

In the drawings:

Figure 1 is a sectional view of an antenna system in accordance with this invention, said system being arranged for sensing vertically polarized signals only;

Figure 2 is a sectional view through the antenna system of Figure 1, in which the antennas are arranged to sense horizontally polarized components of radio signals;

Figure 3 is an enlarged sectional view through a portion of the antenna structure of Figure 1, and

Figure 4 is a perspective schematic illustration of a directional antenna system in accordance with this invention.

Referring now in more detail to the drawings and, more particularly, to Figures 1 and 2, the reference characters 11 and 12 designate a pair of dipole antennas. The dipole antenna generally designated by the reference character 11 comprises a pair of conductive tubes 14 and 16, each of which is a quarter wave length long at the midfrequency of the band of frequencies over which the antenna is operative, supported by a dielectric tube 18. The dipole antenna 12 is similarly constructed of two conductive tubular members 20 and 22, of the same length as the tubes 14 and 16, supported by a surrounding tube of dielectric material 24. The supporting tube 18 is mounted upon an arm 30 formed of insulating material and, in a similar manner, the insulating tube 24 of antenna 12 is mounted upon an arm 40 of dielectric material. The arms 30 and 40 are rotatably supported on a mast 50.

Two pairs of conductors 52 and 54 pass upwardly through the mast 50 and connect to conductors 32 and 42, respectively, in the arms 30 and 40. The ends of the conductors 32 are connected to the individual tubular members 14 and 16 of antenna 11, and the conductors 42 are individually connected to the tubular conductors 20 and 22 of the antenna 12. Connections made from the lines 52 to the conductors 32 of the rotatably mounted

arm 30 are by means of plugs 34 and jacks 36. In a similar manner, connections between the lines 42 and the lines 34 are made by means of plugs 44 and jacks 46. The plug and jack arrangement serves also as a mechanical support for each of the arms 30 and 40 as well as to make electrical connections with the wires passing therethrough.

The tubular radiators 14, 16, 20 and 22 of the antennas 11 and 12 are purposely made of relatively large diameter with respect to their length, so that the band of frequencies to which they respond is wide. The arms 30 and 40 are mounted in quadrature to each other, but symmetrically about the axis of the mast 50, so that each arm 30 and 40 forms a small interior angle of 45° with the longitudinal axis of the mast 50, which, generally, is mounted substantially vertically. In a similar manner, the tubular supports 18 and 24 are mounted so that their longitudinal axes form an angle of 45° with respect to the longitudinal axis of the arms 30 and 40, respectively, as is illustrated in Figure 1. With the dipoles 11 and 12 arranged as shown in Figure 1, the antenna system is responsive to vertically polarized energy. To render the antenna array sensitive to horizontally polarized energy, it is merely necessary to unplug the arms 30 and 40 from the mast 50, to rotate each of them through an angle of 90°, and to replug them into the mast 50. The arrangement of parts is then as shown in Figure 2, where the dipole antennas 11 and 12 are axially aligned and wherein the antennas are responsive to horizontally polarized energy.

For direction finding purposes, a means for determining the difference between the signals received from the two dipole antennas 11 and 12 is provided in another portion 56 of the mast 50. A resistor 58 contained therein is connected between the outside wires of the two pairs of wires 52 and 54, and the inside lines of the two pairs 52 and 54 are connected together and to a center tap on the resistor 58. The output signal is taken across the resistor 58 by means of lines 62 and 64. Since the rotation of the two arms 30 and 40 may result in signals which would become additive rather than subtractive when applied to the resistor 58, a means has been provided for reversing the polarity of the connections from one pair of leads. This is illustrated in Figure 2 as a reversing switch 60, said switch reversing the connections between the two leads of the pair 52 so that, if the received signals after rotation of the arms 30 and 40 to the position shown in Figure 2 result in producing across the leads 62 and 64 a sum of the signals received, the leads 52 from the antenna 11 may be reversed to produce an output which represents the difference between the two received signals. Since such summation circuits and switching means are normally maintained as close to the antennas as possible, the switch 60 may be operated when the antenna arms 30 and 40 are changed. It is not necessary to use the resistor 58 to accomplish the summation, but a transformer may be used if desired. In fact, any normal summation circuit may be used for this purpose and it is suggested that the circuit used be one which is particularly adapted for the range of frequencies over which the antenna system is intended to operate.

In addition to being able to manually change the orientation of the dipole antennas 11 and 12, as described above, it is within the purview of this invention to be able to automatically, either continually or selectively, vary the orientation of the antennas. In Figure 3, the reference character 76 designates a lower portion of one of the arms, such as the arm 40 shown in Figure 1. This arm is rotatably mounted within a properly formed bearing member on the mast 74, said mast corresponding to mast 50 of Figures 1 and 2. The other end of the arm 76 (to the right as shown in Figure 3) supports the antenna structure. The arm 76 has mounted on it close to the mast 74 a ring gear 78 which extends about

the circumference of the arm 76. The ring gear is engaged and driven by a gear 80 which is mounted upon the shaft of a suitable electric motor 81. The arm 76 is hollow and wires 89 and 90 pass therethrough to make connection with the two members of the dipole antenna. A spring-biased brush 87 is connected to the wire 89 and a similar spring-biased brush 88 is connected to the wire 90. The brushes 87 and 88 are carried by the arm 76 as it rotates and are arranged to make sliding contact with slip rings 85 and 86, respectively mounted in a panel of the mast 74. A wire 91 is electrically connected to the slip ring 85 and a second wire 92 is electrically connected to the slip ring 86 to convey signals received by the dipole antenna to appropriate receiving equipment. The spring-pressed brushes 87 and 88 and the slip rings 85 and 86 are provided to prevent unduly twisting the wires 89 and 90, causing them to break when the arm 76 is rotated in a single direction. However, if provision is made for repeatedly oscillating the arm 76 through a predetermined angle, stopping it and then turning it in a first direction, stopping it and then turning it in the opposite direction, the brushes 87 and 88 and the slip rings 85 and 86 may be considered unnecessary and may be replaced by suitably flexible conductors.

The device of Figure 3 may be used either as a continually rotating antenna system in which the two dipole antennas supported by the arm 76 and its companion arm (not shown) are continually rotated at a preselected speed to repeatedly become responsive to both the vertically and the horizontally polarized signals, or the device may be selectively operated. For selective operation, the orientation of the antennas may be maintained in a single plane until a signal is detected. At this time, the motor 81 may be energized to rotate the arm 76 changing the orientation of the antenans and, thus, determining whether the incoming signal is horizontally or vertically polarized. Of course, it is to be understood that, in the antenna array of this apparatus, there are two such arms 76, each of which has its own ring gear 78 and driving motor 81. The structure in Figure 3 is merely duplicated for the other arm. The motors 81 are preferably connected to be operated in synchronism, so that the orientations of the two antennas of a unit are changed simultaneously. However, such synchronous operation is not necessary in the inventive system and each antenna arm may be separately controlled if desired.

The prior discussions have described antenna structures which utilize dipole antennas, but the use of dipole antennas is not necessary and, in Figure 4, the general organization of an antenna system in accordance with the principles of this invention is shown, having loop antennas 101 and 103. The antenna 101 is mounted on an arm 105 and the antenna 103 is mounted on an arm 107, both arms 105 and 107 being supported by a mast 109, so that the longitudinal axis of each arm 105 and 107 forms an angle of 45° with the longitudinal axis of the mast 109. The mast 109 is preferably supported vertically and the planes of the antenna loops 101 and 103 are each arranged at an angle of 45° with the longitudinal axis of its respective arm. In this manner, by rotating the arms 105 and 107 through an angle of 180°, the planes of the loops of the antennas 101 and 103 may be positioned either vertically or horizontally. The arms 105 and 107 may be rotated manually by unplugging and replugging as described in the description of Figures 1 and 2, or the structure may be similar to that illustrated in Figure 3, where the arms are rotated by appropriate motor means.

This specification has illustrated and described new and improved antenna systems which have particular utility as highly directional antennas, such as those used in radio direction finding. The new antenna systems described herein are sensitive to both vertical and horizontal polarization of electromagnetic energy and are so

constructed that the type of polarization does not adversely affect the directional characteristics of the system.

What is claimed is:

1. A directional antenna system comprising a first antenna and a second antenna, a first arm supporting said first antenan, a second arm supporting said second antenna, said first and second arms being so arranged that their longitudinal axes are perpendicular to each other and at a 45° angle with the vertical, means to rotatably support said first and second antennas so that each is free to rotate about the longitudinal axis of its support arm, and means to connect said antennas with appropriate receiving equipment and including a summation means for differentially combining the signals from said first and second antennas.

2. The antenna system defined in claim 1, wherein further means are provided for oscillating each antenna about the longitudinal axis of its respective support arm through an angle of 180°.

3. The antenna system defined in claim 1, wherein said first and second antennas are dipole antennas.

4. The antenna system defined in claim 1, wherein said first and second antennas are loop antennas.

5. A directional antenna system comprising a first support arm mounted with its longitudinal axis at an angle of 45° with the earth, a second support arm mounted with its longitudinal axis at an angle of 45° with the earth and perpendicular to the longitudinal axis of said first arm, a first antenna mounted on said first arm, a second antenna mounted on said second arm, said first and second antennas being so mounted that they may be rotated about the longitudinal axes of their respective arms to a first position parallel with the earth and to a second position perpendicular to the earth, and means for differentially connecting said first and second antennas in each position with appropriate receiving means.

6. A direction finding antenna system comprising a support; two mutually perpendicular arms each connected to said support, the axes of the arms each lying in a

common vertical plane and disposed at an angle of 45° with respect to vertical; connection means connecting the inner end of each arm to said support; two antennas each having a plane of symmetry disposed normal to its direction of polarization; other connection means connecting the outer end of each arm to an antenna at an angle of 45° with respect to its plane of symmetry, at least one of said connection means on each arm comprising a rotatable joint; electrical conductor means connected with each antenna and extending inwardly along the arms and connected together in mutual opposition to differentially combine the signals from the two antennas.

7. The antenna system defined in claim 6, wherein the antennas each comprise a dipole.

8. The antenna system defined in claim 6, wherein the antennas each comprise a loop antenna.

9. The antenna system defined in claim 6, wherein drive gearing means is provided at the rotatable joint in each arm to rotate the arms about their axes.

10. The antenna system as defined in claim 9, wherein slip-ring connections are interposed in the conductor means coming from each antenna at the associated rotatable joint.

11. The antenna system defined in claim 6, wherein the arms are hollow and the conductor means from the antennas pass therethrough; and each rotatable joint comprising plug means and socket means joining an arm to the support and arranged in at least two quadrature locations at each joint whereby each arm may be rotated to orient the antenna to a desired polarization and then plugged into the support and retained by the selected plug and socket means.

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