June 14, 1949. E. FUBINI ET AL 2,473,421

SEARCH ANTENNA ARRAY

Filed May 30, 1945 2 Sheets-Sheet 1

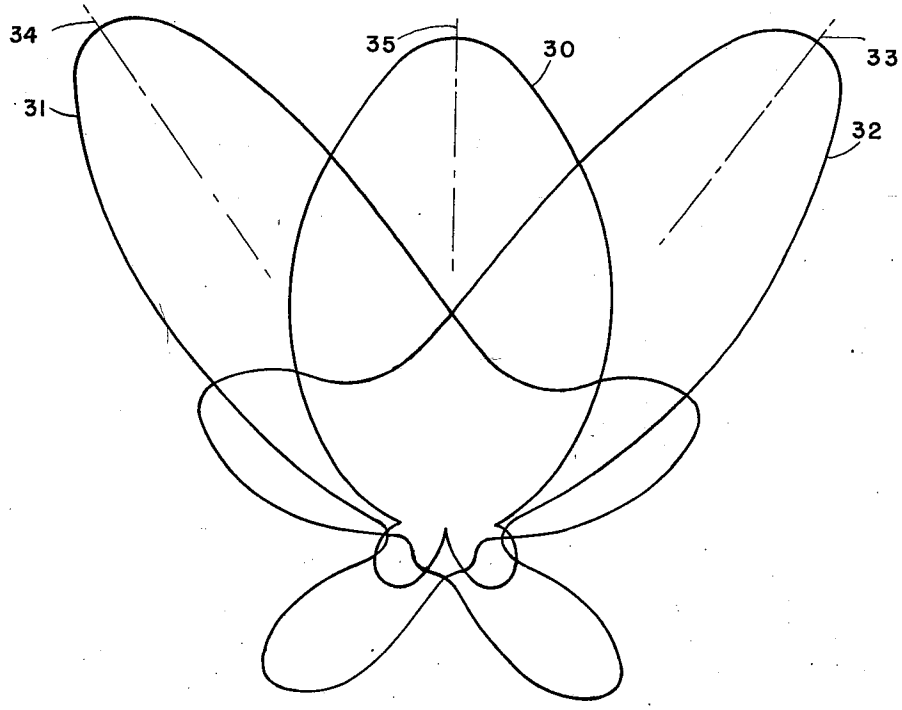


FIG. 2

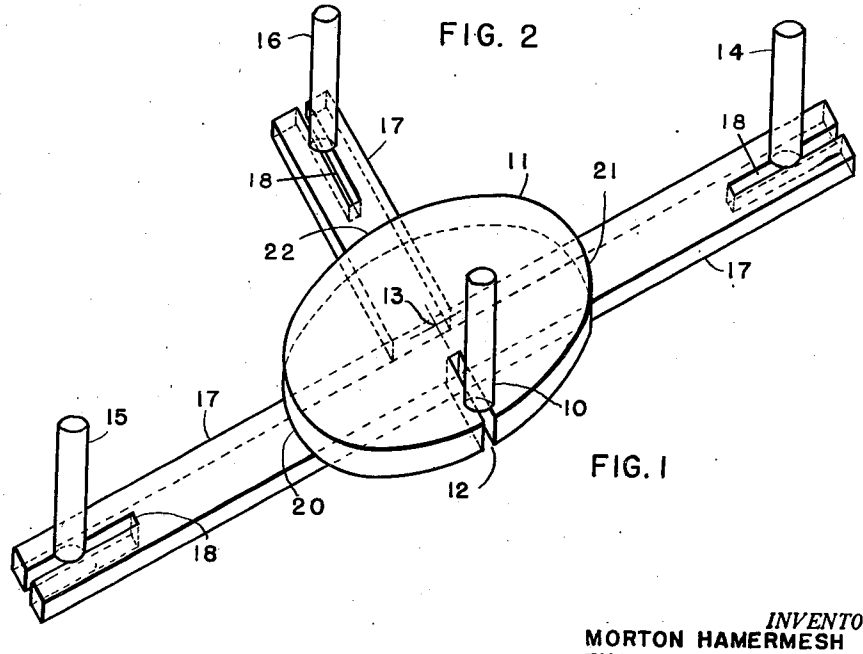


FIG. 1

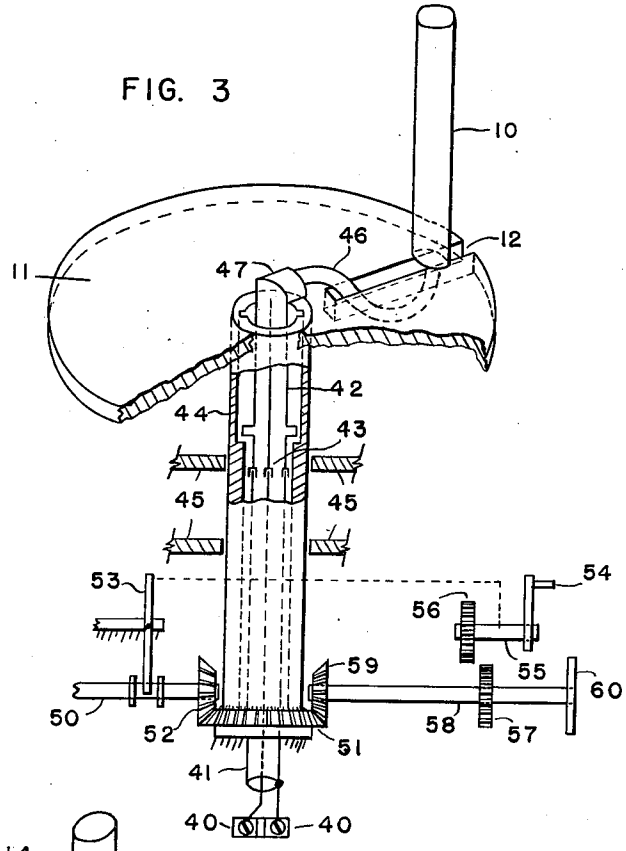
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FIG. 3



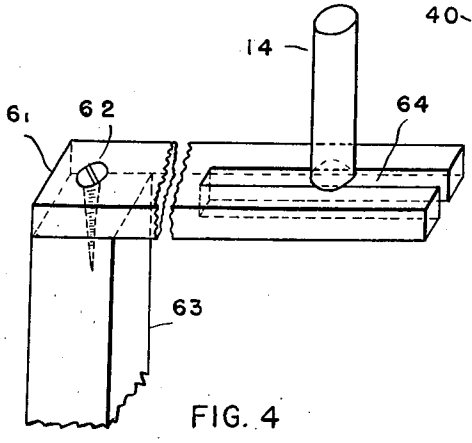


FIG. 4

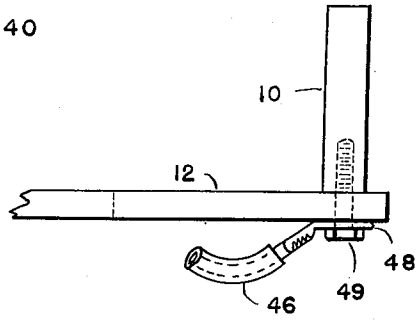


FIG. 3A

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SEARCH ANTENNA ARRAY

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9 Claims. (Cl. 250—33:65)

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This invention relates to an antenna system for radio signaling apparatus and is useful with both receiving and transmitting apparatus.

More specifically the present invention relates to an antenna array comprising at least one antenna electrically connected to the remainder of the apparatus and rotating about a center external to it and other antennas not electrically connected to the apparatus and adjustably arranged outside of the circle about which the connected antenna rotates.

When an array of antennas includes some antennas electrically connected to the receiving or the transmitting apparatus and others not connected thereto, the electrically connected antennas are normally designated in the art as driven antennas and those not electrically connected are ordinarily designated as parasitic antennas. Although in a receiver an antenna is not accurately speaking driven by the receiving apparatus, this usual terminology of the art will be used hereinbelow and is to be understood in accordance with the foregoing explanation. The performance of parasitic antennas is well known in the art. In a transmitter these parasitic antennas absorb power radiated by the driven antenna and reradiate it in a phase relation to the original radiation dependent upon their length and position with relation to the driven antenna, so that the fields add in one direction and subtract in the other producing a radiation pattern or radiation lobe having a definite direction of maximum radiation and a narrow angle of radiation.

It is one of the objects of the present invention to improve upon the conventional array of driven and parasitic antennas by producing a long and narrow lobe and to provide means for sweeping that lobe over a wide angle without being required to rotate the entire antenna array.

An object of this invention is to obtain over a wide range of frequencies a relatively narrow and sharp directive lobe which may be scanned continuously or intermittently at any desired rate of speed over a predetermined wide area of search. In the case where the antenna system of the present invention is used with receiving apparatus, this directive lobe represents a minimum area within which the antenna will pick up and deliver to the receiving apparatus signals of a predetermined minimum intensity, when attached to transmitting apparatus this lobe represents direction of radiation of equal minimum strength.

In a preferred embodiment of the invention, three parasitic antennas are used which are arranged in a semi-ellipse having its short axis along the major axis of wave propagation of the driven antenna and its long axis at right angles thereto. The center of this semi-ellipse coincides with the center around which the driven antenna rotates. It has been found for most satisfactory operation that the radius of rotation of the driven antenna should be a small fraction of the average fundamental wavelength covered by the array and that the parasitic antennas be spaced from the center of that circle at a distance no greater than a half of that wavelength.

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One advantage of the present invention is its use for navigational purposes on ships and aircraft for locating homing signals. Previously, it had been necessary, when searching for homing signals, to turn either the ship itself or the entire antenna array to locate the direction of the homing signals. Particularly on aircraft, the mechanical difficulties of rotating the entire array present serious obstacles.

Other advantages and novel features of this invention will become apparent to those skilled in the art from the following description of the invention taken in connection with the accompanying drawings in which:

Fig. 1 is a schematic representation of a preferred embodiment of the present invention;

Fig. 2 is a drawing of the patterns covered by the antenna array of the present invention for various positions of the driven antenna designated in Fig. 1;

Fig. 3 is a drawing partially in section and partially isometric showing a preferred mechanical arrangement for the mounting of the antenna array of the present invention;

Fig. 3a is a drawing showing details of the mounting of the driven antenna; and

Fig. 4 is a drawing showing details of the mounting of the parasitic antennas.

Referring to Fig. 1, the driven antenna 10 is fixedly mounted upon a rotatable disc 11 by any suitable means such as a slot 12. The driven antenna 10 is substantially perpendicular to the disc 11. The slot 12 provides means for adjusting the distance of the driven antenna 10 from the center 13 of the disc 11 which may be fastened in any desired position by any suitable device. The disc 11 may be rotated by any well known means such as a hand crank or driving motor, hereinafter shown. For most successful operation, it has been found that the radius of rotation of the driven antenna should be approximately one-tenth of the average fundamen-

tal wavelength of the signal to be transmitted or received by the antenna array.

The driven antenna 10 is preferably a dipole, that is, an antenna having an electrical length one-quarter the average fundamental wavelength of the signals to be transmitted or received.

The electrical length of the parasitic antennas 14, 15, and 16 are preferably one-quarter of a wavelength and are of sufficient thickness to permit a wide variation in the frequencies of the transmitted or received signals without adverse effect upon the efficiency of the array. Antennas 14, 15, and 16 are mounted to a rigid member 17 of insulating material with low dielectric loss. They are securely fastened to member 17 in slots 18 by any well known means, such as screws, which permit adjustment of their position along the member 17. The longitudinal axes of the parasitic antennas are substantially parallel to that of the driven antenna 10 and substantially perpendicular to the face of the rotatable disc 11. Antennas 14 and 15 are spaced one-half of the fundamental wavelength of the driven antenna 10 and antenna 16 one-quarter of that wavelength from the center 13 of the disc 11. The antennas 14 and 15 are centered on a straight line passing through the center 13, and the antenna 16 is centered on a line passing through center 13 and at a right angle to the line on which antennas 14 and 15 are centered.

In designing both the driven antenna and the parasitic antennas so that their effective electrical lengths are of proper dimensions, there should be taken into consideration the effect upon that length of the means employed to mount the antennas on the framework.

In order that an operator may determine the direction from which a signal is received, he will, upon reception of the signal, stop the rotation of the driven antenna 10. If the antenna is rotated by a motor or other mechanical means the driving means should be equipped with a fast operating brake so that when the rotating motor is cut off the driven antenna will come to an immediate stop. The direction from which signals are received may be determined by the angle between the axis 33, 34 or 35 (Fig. 2) of the lobe at the time of reception and a fixed axis, such as the longitudinal axis of a ship or airplane. This can be indicated by any usual means such as a dial and pointer.

With the driven antenna 10 in the position shown in Fig. 1, the antenna pattern for the system is indicated by curve 30 shown in Fig. 2. When the rotatable disc 11 is moved in a clockwise direction through an angle of 90° the driven antenna 10 will be at the position indicated by 20 on Fig. 1. Since the driven antenna 10 is now in a different position relative to the parasitic antennas 14, 15, and 16, the antenna pattern of the array will change in both direction and shape. The pattern obtained with the driven antenna 10 at the position 20 is that of the curve 31, Fig. 2. When the driven antenna is in the position 21, the antenna pattern will be that of curve 32, Fig. 2. Curves 32 and 31 are substantially congruent and the respective angles of their axes 33, 34 with the axis 35 of the antenna pattern for the original position of the driven antenna, are substantially equal. It is seen that the rotation of the driven antenna 10 results in a much wider coverage than that obtainable without rotating the driven antenna but for any given position of the driven antenna, the lobe is not widened. The angle of sweep for the arrangement hereinabove described has been found to approximate 70°.

For fixed dimensions of the driven antenna 10 and fixed dimensions and relative positions of the parasitic antennas 14, 15, and 16, the system will operate satisfactorily over a band of frequencies of ±25% of the center frequency, producing the fairly sharp unidirectional antenna patterns shown in Fig. 2. When it is desired to change the operating frequency to a greater extent than the above, the radius of rotation of the driven antenna 10, and the relative electrical distance from it of the parasitic antennas 14, 15, and 16 are adjusted to compensate for the change of frequency.

When the driven antenna 10 is rotated from the position 20, Fig. 1, through the position 22 to the position 21, the varying antenna pattern produced is not as narrow and contains a magnitude of range less than that for rotation through the other 180° of the circle. Hence, when desirable, only the more effective 180° of rotation is used. This may be accomplished by suitable switching of the driven antenna 10 from the operative to the inoperative state, and vice versa, as it passes through positions 20 and 21 during its rotation. Such an arrangement allows searching for one-half the time. An alternate arrangement is to provide conventional mechanical means to rotate the driven antenna 10 over only a semi-circle, from position 21, Fig. 1, through its original position to position 20 and likewise back through its original position to position 21. By this arrangement continuous searching over the predetermined area of space is accomplished.

The angular magnitude of the area of search may be altered by changing the angular positions of the parasitic antennas 14, 15, and 16 with relation to the driven antenna 10. Likewise, the width of the lobe may be varied by varying the number of parasitic antennas used.

A preferred form of mechanical construction for the mounting and operation of the antenna array of the present invention particularly suitable for aircraft is shown in Fig. 3. The input to the driven antenna 10 is introduced at terminal posts 40, 40 to a stationary coaxial line 41. In the case of a receiving antenna array terminals 40, 40 are the connections of the array to the receiver. Coaxial line 41 connects the receiving or transmitting apparatus to rotatable coaxial line 42 through electrically continuous joint 43. Rotatable coaxial line 42 is mechanically but not electrically connected to hollow rotatable shaft 44 surrounding stationary coaxial line 41. Rotatable shaft 44 may be grounded and is suitably supported along its length as at 45, 45, and mechanically connected to disc 11. Coaxial line 42 may be mechanically connected to rotatable shaft 44 by any well known means such as a locking key or tongue and groove that will provide electrical insulation between coaxial line 42 and shaft 44. A portion 46 of rotatable coaxial line 42 is continued at right angles by an adapter 47 in the proximity of rotatable disc 11 and follows under slot 12 in that disc. Its end is connected to driven antenna 10 by means of a conducting ring 48 (Fig. 3a) clamped in close contact with the base of antenna 10 by screw 49 (Fig. 3a) or other suitable means. Portion 46 of coaxial line 42 is flexible to provide for adjustment of antenna 10 in slot 12.

Shaft 44 is rotated by an electric motor or other driving means, not shown, through motor shaft 50 and a suitable gear train and clutch

mechanism to permit manual rotation when desired. One suitable arrangement of gearing is shown in Fig. 3. Assuming rotatable shaft 44 to be vertical, there is keyed to it at its bottom a bevel gear 51, meshing with bevel gear 52 on the end of motor shaft 50. Suitable clutch and clutch operating mechanism 53 is provided to disengage the motor drive for manual operation.

Manual operation is accomplished by turning crank 54 on shaft 55 also carrying gear 56 which, when the clutch is in manual operating position, engages gear 57 on shaft 58. Shaft 58 carries gear 59 which meshes with gear 51 on shaft 44.

Shaft 58 rotates both during motor and manual operation and therefore there may be conveniently placed on its free end a dial 60 by which the angular position of antenna 10 to a reference axis may be indicated.

Fig. 4 shows one method of mounting the parsitic antennas to permit the desired angular and linear adjustment. Each parasitic antenna is mounted on a stationary member 63 supported on the array structure or directly on the ship or aircraft carrying the array. A rigid non-conductive member 61 is attached to stationary member 63 by a screw 62 which provides adjustable means for the angular adjustment of member 61 with respect to driven antenna 10. The parasitic antennas 14, 15, and 16 are fastened to members 61 in any suitable manner. Slot 64 provides for variation of the distance between the parasitic antennas and the fixed position of vertical member 63. By utilization of the two above-described adjustments it is possible to place the parasitic antennas in any desired position with relation to the driven antenna.

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

What is claimed is:

1. An antenna array for radio signaling comprising a driven antenna arranged to travel along a substantially circular path in a horizontal plane, means for causing said travel, a pair of parasitic antennas fixedly mounted on the same horizontal plane and on a line representing an extended diameter of said circular path at points equidistant from the center of said circular path, and a third parasitic antenna fixedly mounted in the same horizontal plane at a point along an extended radius at right angles to the line on which said pair of parasitic antennas are mounted and at a distance from the center of said circular path substantially one-half the distance of each of the pair of parasitic antennas from said center.

2. An antenna array for radio signaling over a relatively wide working range of frequencies comprising a driven antenna adapted to travel on a horizontal plane along a substantially circular path having a radius of the order of one-tenth of the average wavelength of the working range of the array, means for causing the continuous travel of said driven antenna, a pair of parasitic antennas fixedly mounted in the same horizontal plane as said driven antenna, each of said pair being equi-distant from the center of said circular path on a line representing a continuation of a diameter of said circular path and at a distance of the order of half the average wavelength of the working range, and a third parasitic antenna mounted on the same horizontal plane at a point along an extended axis at right angles to the line on which said pair of parasitic antennas are mounted and at a distance of the order of a quarter of the wavelength of the working range.

3. An antenna array for radio signaling comprising a driven antenna arranged to travel along a substantially circular path in a horizontal plane, means to vary the radius of said circular path, means for causing said travel, a pair of parasitic antennas fixedly mounted on the same horizontal plane and on a line representing an extended diameter of said circular path at points equidistant from the center of said circular path, and a third parasitic antenna fixedly mounted in the same horizontal plane at a point along an extended radius at right angles to the line on which said pair of parasitic antennas are mounted and at a distance from the center of said circular path substantially one-half the distance of each of the pair of parasitic antennas from the center.

4. An antenna array for radio signaling comprising a driven antenna arranged to travel along a substantially circular path in a horizontal plane, means for causing said travel; a pair of parasitic antennas linearly adjustable on the same horizontal plane and on a line representing an extended diameter of said circular path at points equidistant from the center of said circular path, and a third parasitic antenna linearly adjustable in the same horizontal plane at a point along an extended radius at right angles to the line on which said pair of parasitic antennas are mounted and at a distance from the center of said circular path substantially one-half the distance of each of the pair of parasitic antennas from said center.

5. An antenna array for radio signaling comprising a driven antenna arranged to travel along a substantially circular path in a horizontal plane, means to vary the radius of said circular path, means for causing said travel; a pair of parasitic antennas linearly adjustable on the same horizontal plane and on a line representing an extended diameter of said circular path at points equidistant from the center of said circular path, and a third parasitic antenna linearly adjustable in the same horizontal plane at a point along an extended radius at right angles to the line on which said pair of parasitic antennas are mounted and at a distance from the center of said circular path substantially one-half the distance of each of the pair of parasitic antennas from the center.

6. An antenna array for radio signaling comprising a driven antenna arranged to travel along a substantially circular path in a horizontal plane, means for causing said travel, a pair of parasitic antennas fixedly mounted on the same horizontal plane and on a line representing an extended diameter of said circular path at points equidistant from the center of said circular path, and a third parasitic antenna fixedly mounted in the same horizontal plane at a point along an extended radius at right angles to the line on which said pair of parasitic antennas are mounted and at a distance from the center of said circular path substantially one-half the distance of each of the pair of parasitic antennas from said center, said parasitic antennas having sufficient cross-section to allow a change in operation frequency of plus and minus 25% without substantial adverse change in the resulting antenna pattern.

7. The device as set forth in claim 6 wherein said driven antenna and said parasitic antennas are substantially one-quarter wavelength in length with relation to the average operating frequency of the operating frequency range.

8. An antenna array for radio signaling comprising a driven antenna arranged to travel along a substantially circular path in a horizontal plane, means to vary the radius of said circular path, means for causing said travel, a pair of parasitic antennas linearly adjustable on the same horizontal plane and on a line representing an extended diameter of said circular path at points equidistant from the center of said circular path, and a third parasitic antenna linearly adjustable in the same horizontal plane at a point along an extended radius at right angles to the line on which said pair of parasitic antennas are mounted and at a distance from the center of said circular path substantially one-half the distance of each of the pair of parasitic antennas from said center, said parasitic antennas having sufficient cross-section to allow a change in operation frequency of plus and minus 25% without substantial adverse change in the resulting antenna pattern.

9. The device as set forth in claim 8 wherein said driven antenna and said parasitic antennas are substantially one-quarter wavelength in length with relation to the average operating frequency of the operating frequency range.

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