March 23, 1965 I. S. WERNICK ETAL 3,175,219

CIRCULAR DIPOLE ARRAY WITH CENTRAL REFLECTOR AND SWITCHING SYSTEM FOR BEAM STEERING

Filed June 20, 1961 2 Sheets-Sheet 1

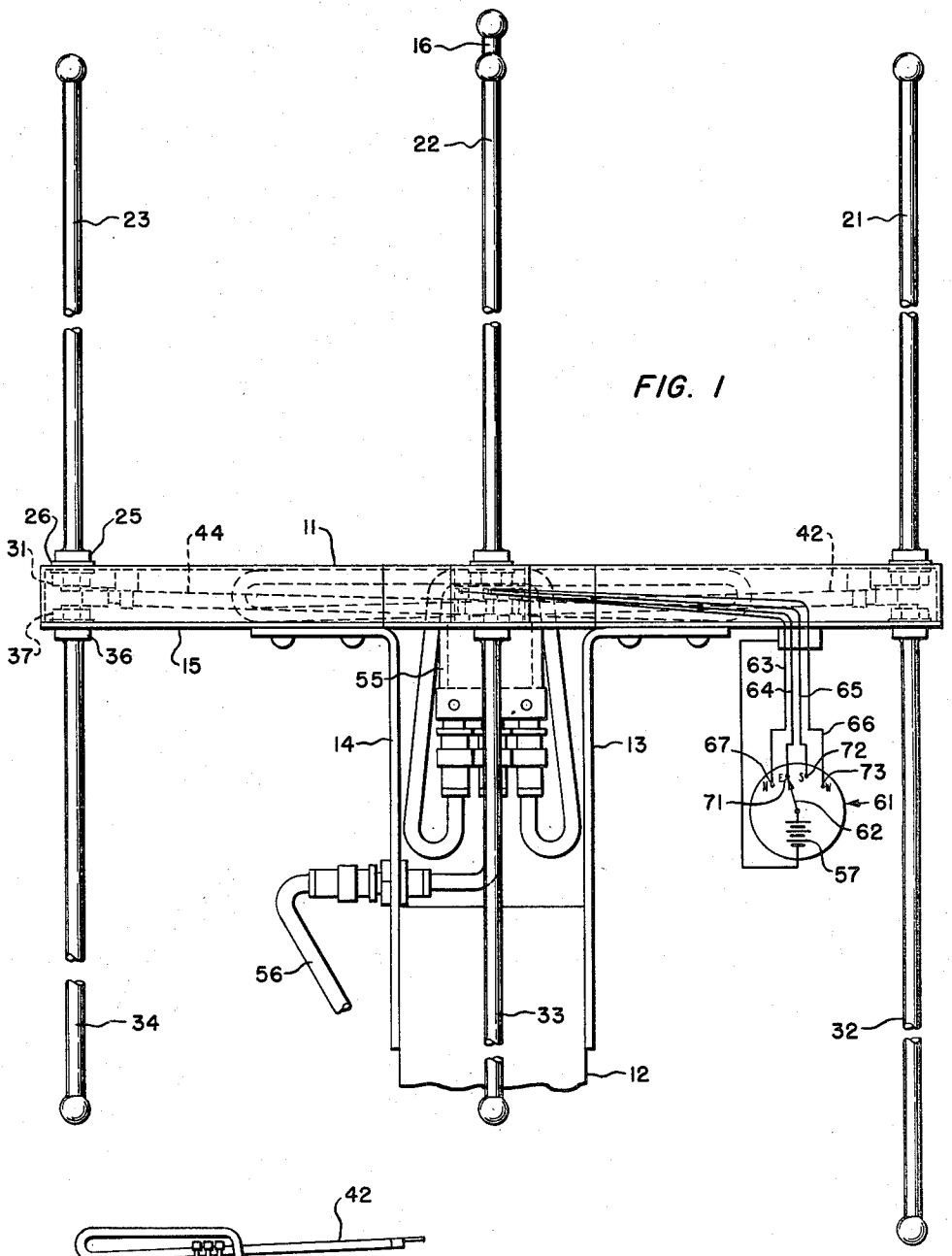


FIG. 1

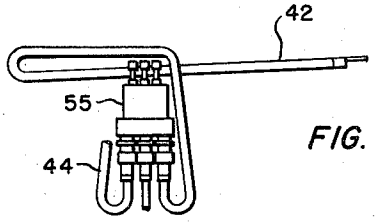


FIG. 4

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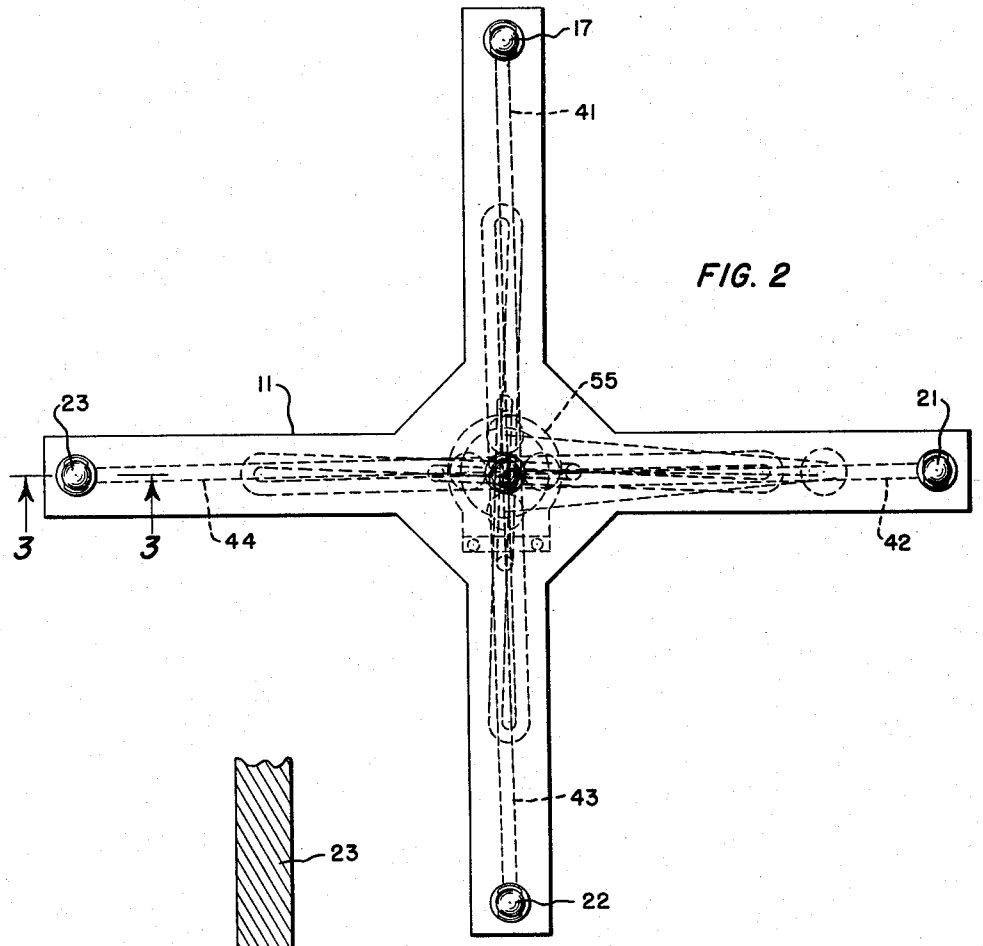


FIG. 2

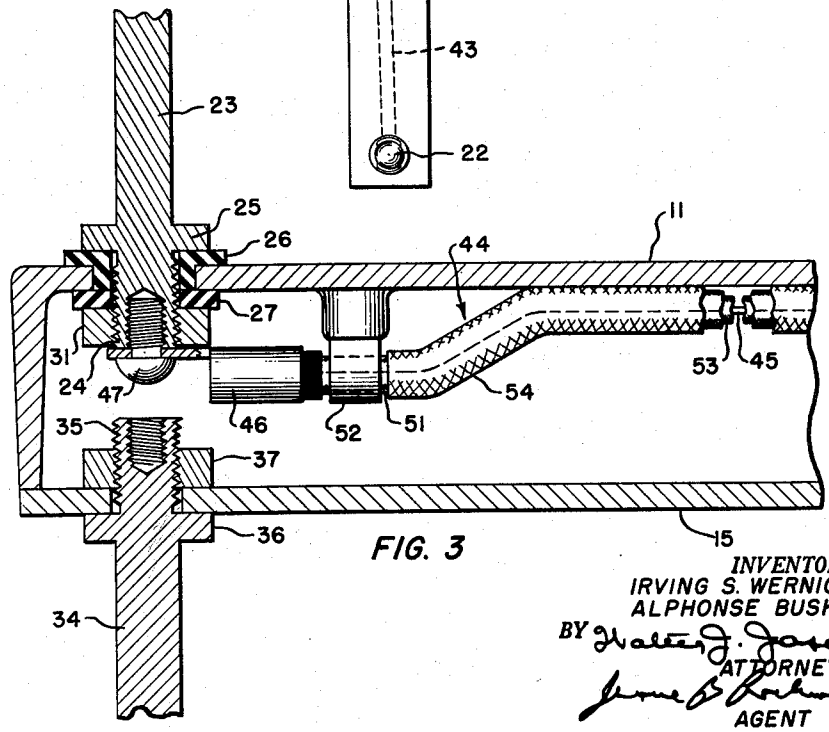


FIG. 3

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United States Patent Office 3,175,219 Patented Mar. 23, 1965

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CIRCULAR DIPOLE ARRAY WITH CENTRAL REFLECTOR AND SWITCHING SYSTEM FOR BEAM STEERING

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Filed June 20, 1961, Ser. No. 118,379
12 Claims. (Cl. 343—799)

This invention relates to antennas, and more particularly to a vertically polarized multi-directional array.

Many radio communications systems employ vertical polarization. Exemplarily, vehicular communications systems operating in the high, very high and ultra high frequency bands normally employ a vertical whip antenna on the vehicle carrying the mobile station, and an omnidirectional ground plane or coaxial antenna or the like at the base station. Such omnidirectional antennas ideally have a concentric circular radiation pattern about the antenna.

As will be apparent, such omnidirectional patterns result in a reduced range of communication with a given transmitter and receiver, or require a more powerful transmitter as compared with a directional antenna system. The directional antenna of the present invention enables communication between a mobile station and a base station at a considerably greater range than with omnidirectional antennas. In the antenna of the present invention, a central reflector element, grounded to a suitable conductive support, is surrounded by a plurality of driven elements. Suitable switching means are provided to disable all the driven elements except for the one element providing a radiation pattern aimed in the desired direction. Exemplarily, four driven elements are provided, spaced ninety degrees apart on the circumference of a circle. A single reflector element is placed at the center, equidistant from the four driven elements. A coaxial switch connects a selected drive element into circuit, and effectively grounds the other three driven elements. As a result, a radiation pattern is formed having a high gain in the desired direction.

It is, therefore, an object of this invention to provide a vertically polarized, steerable antenna.

Another object of this invention is to provide a remotely controlled electrically steerable antenna array.

Another object of this invention is to provide a physically fixed antenna which will provide a directional pattern aimed in a selected direction.

Another object of this invention is to provide a remotely controlled, steerable antenna having high gain which is rugged, reliable, simple and inexpensive to manufacture, and easy to install and use.

Other objects and advantages of the present invention will become apparent from the following specification and appended drawings, wherein:

FIGURE 1 illustrates a side view of a presently preferred embodiment of the antenna of the present invention;

FIGURE 2 illustrates a top view of the present invention;

FIGURE 3 is a section of a portion of FIGURE 2, taken at the end of one of the frame arms supporting the antenna elements; and

FIGURE 4 illustrates a suitable manner of arranging the transmission line elements between a coaxial switch and the various antenna elements.

Referring now to the drawings, a cruciform frame 11 is fastened to a non-metallic support or mast 12 by means of brackets 13 and 14 bolted or otherwise conveniently fastened to mast 12 and frame 11. Frame 11 is fabricated

of channel section metal, and is enclosed by a cover plate 15.

A reflecting antenna element 16 is mounted at the center of frame 11, and is grounded thereto. Antenna element 16 is longer than a quarter wavelength at the center frequency of the desired band of operating frequencies. In a presently preferred embodiment, element 16 is about 0.3 wavelength long. Four active antenna elements 17, 21, 22 and 23 are mounted adjacent the ends of the cross-arms of frame 11. Each of antenna elements 17, 21, 22 and 23 is substantially one-quarter wavelength long at the desired center frequency, and is placed at the circumference of a circle having a radius of about 0.15 wavelength, centered at reflecting antenna element 16.

Antenna elements 17, 21, 22 and 23 are insulated from frame 11. As illustrated by FIGURE 3, active antenna element 23, exemplary of active antenna elements 17, 21, 22 and 23, comprises a substantially cylindrical rod having a threaded end 24 and a flange 25. Element 23 is insulated from frame 11 by an extruded washer 26 of insulating material, and washer 27 of insulating material. A nut 31, cooperating with threaded end 24, secures the assembly including antenna element 23, extruded insulating washer 26 and insulating washer 27 to frame 11.

Cooperating with each of active antenna elements 17, 21, 22 and 23 is an image antenna element. Thus, image element 32 cooperates with active element 21, image element 33 with active element 22, image element 34 with active element 23, and an image element, not visible in the drawings with active element 17. Each image element is also substantially a quarter wavelength long, and is positioned opposite its corresponding active element. Each image element is grounded to metal cover plate 15 and frame 11.

The image elements are similar in size and shape to the active elements. Exemplarily, as illustrated in FIGURE 3, image element 34 comprises a substantially cylindrical rod having a threaded end 35 and a flange 36 integrally formed therewith. A nut 37, mated with threaded end 35 of element 34, secures element 34 to cover plate 15 both mechanically and electrically.

Each of active elements 17, 21, 22 and 23 is connected to the center conductor of one end of a half wave length section of coaxial cable. Active elements 17, 21, 22 and 23 are connected to coaxial cable lengths 41, 42, 43 and 44, respectively. The outer conductors of coaxial cable lengths 41, 42, 43 and 44 are grounded to frame 11 adjacent its associated antenna element. FIGURE 3 exemplarily illustrates connection of coaxial cable 44 to antenna element 23. The center conductor 45 of cable 44 is crimped or otherwise conductively fastened to lug 46, which is in turn fastened to antenna element 23 by means of screw. Outer conductor 51 is grounded to frame 11 by clamp 52, welded or otherwise suitably secured to frame 11. As is well known in the art, center conductor 45 is insulated from, and held concentric with outer conductor 51 by insulation 53, and outer conductor 51 is covered by an insulating protective layer 54.

The ends of coaxial cable lengths 41, 42, 43 and 44 remote from their respective antenna elements are connected to a coaxial switch 55. In addition, a feed coaxial cable 56 connected at one end to a radio transmitter or receiver, has the other end connected to coaxial switch 55, conveniently fastened to frame 11. A presently preferred coaxial switch is disclosed in U. S. Patent 2,926,318, issued February 23, 1960, to Donald H. Lanctot. As disclosed therein, such switch includes four output coaxial connectors which may be connected, either simultaneously or individually, to a central input coaxial connector. A relay coil is associated with each output coaxial connector. Normally, a metal reed connected to

the center conductor of the output coaxial connector shorts the center conductor to the outer conductor through frame of the switch. Upon energization of the appropriate relay coil, the reed is moved from contact with the switch frame to contact with the center conductor of the input coaxial connector. It will be apparent, therefore, that upon energization of the appropriate relay coil, one of coaxial cables 41, 42, 43 or 44 is connected to coaxial cable 56, while the other three are shorted at switch 55. Since coaxial cables 41, 42, 43 and 44 are electrically a half wavelength long between switch 55 and its associated active antenna element, those cables which are shorted effectively ground the associated active antenna element, as well known to those skilled in the art. Although the coaxial cables are a half wavelength electrically, they are physically shorter than a half wavelength in free space. Coaxial cables 41, 42, 43 and 44 may be conveniently folded within frame 11 as illustrated in FIGURE 4 for protection against damage.

Selection of the desired directional pattern is accomplished by energizing the appropriate relay coil. A battery or other power source 57 has one end connected to the relay coil by grounding to frame 11. A selector switch 61 has a movable contact 62 connected to the other side of battery 57. Conductors 63, 64, 65 and 66 are connected to fixed contacts 67, 71, 72 and 73, respectively. The other ends of conductors 63, 64, 65 and 67 are each connected to an individual relay coil.

In operation of the antenna of the present invention, coaxial cable 56 is connected to a radio receiver or transmitter. Assuming that the antenna is mounted so that active element 17 points north, and reception or transmission is desired in the eastern quadrant, movable contact 62 of switch 61 is moved to fixed contact 71. Battery 57 then actuates the relay coil in coaxial switch 55 connecting cable 56 to cable 42, and shorting cables 41, 43 and 44 to ground. Active antenna element 21 is thus connected to the transmitter or receiver. Image antenna element 32 serves to balance active element 21, forming a half-wave vertically polarized dipole, as is well known to those skilled in the art. The dipole so formed would normally have a circular pattern in the horizontal plane. However, grounded element 16, since it is spaced substantially 0.15 wavelength from active element 21, serves as a reflector, effectively limiting radiation and providing high gain to the selected east quadrant.

Many modifications within the scope and spirit of the present invention will occur to those skilled in the art. The present invention, therefore, is not to be thought of as limited to the particular embodiment set forth, but is to be limited only as defined in the appended claims.

What is claimed is:

1. An antenna system comprising a plurality of normally grounded substantially quarter wavelength active elements arranged on the periphery of a circle, a reflector element at the center of said circle, and a switch for selectively ungrounding and connecting said active elements to a transmission line.

2. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and arranged on the periphery of a circle, a reflector element connected to said conductive frame at the center of said circle, and a switch including means for selectively connecting said active elements to a transmission line and grounding the remainder of said active elements to said conductive frame.

3. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, a reflector element connected to said conductive frame at the center of said circle, a signal transmission line, and a switch including means for selectively connecting one of said active elements to said transmission line and grounding the remainder of said active elements to said conductive frame.

4. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, a reflector element conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said active elements to said coaxial transmission line and grounding the remainder of said active elements to said conductive frame.

5. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, a reflector element longer than said active elements conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said active elements to said coaxial transmission line and grounding the remainder of said active elements to said conductive frame.

6. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, an individual coaxial line connected to each of said active elements, a reflector element conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said individual coaxial lines to said coaxial transmission line and grounding the remainder of said individual coaxial lines to said conductive frame.

7. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, an individual coaxial line connected to each of said active elements, a reflector element longer than said active elements conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said individual coaxial lines to said coaxial transmission line and grounding the remainder of said individual coaxial lines to said conductive frame.

8. An antenna system comprising a conductive frame, a plurality of substantially quarterwavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, a plurality of substantially quarter wavelength image elements, each conductively connected to said conductive frame opposite a corresponding active element, a reflector element conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said active elements to said coaxial transmission line and grounding the remainder of said active elements to said conductive frame.

9. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, a plurality of substantially quarter wavelength image elements, each conductively connected to said conductive frame opposite a corresponding active element, a reflector element longer than a quarter wavelength conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selec-

tively connecting one of said active elements to said coaxial transmission line and grounding the remainder of said active elements to said conductive frame.

10. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, an individual coaxial line connected to each of said active elements, a plurality of substantially quarter wavelength image elements, each conductively connected to said conductive frame opposite a corresponding active element, a reflector element conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said individual coaxial lines to said coaxial transmission line and grounding the remainder of said individual coaxial lines to said conductive frame.

11. An antenna system comprising a conductive frame, a plurality of substantially quarter wavelength active elements mounted on said conductive frame and insulated therefrom, said active elements being arranged on the periphery of a circle, an individual coaxial line connected to each of said active elements, a plurality of substantially quarter wavelength image elements, each conductively connected to said conductive frame opposite a corresponding active element, a reflector element longer than a quarter wavelength conductively connected to said conductive frame at the center of said circle, a coaxial signal transmission line, and a switch including means for selectively connecting one of said individual coaxial lines to said coaxial transmission line and grounding the remainder of said individual coaxial lines to said conductive frame.

12. An antenna system comprising a cruciform conductive frame, a substantially quarter wavelength active element mounted on the end of each arm of said cruciform conductive frame and insulated therefrom, a substantially quarter wavelength image element conductively connected to the end of each arm of said cruciform conductive frame opposite a corresponding active element, a reflector element conductively connected to the center of said cruciform conductive frame, a coaxial signal transmission line, and a switch including means for selectively connecting one of said active elements to said coaxial transmission line and grounding the remainder of said active elements to said conductive frame.

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