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P. A. GUARINO ET AL
ANTENNA SWITCHING SYSTEM

2,607,008

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2 SHEETS—SHEET 1

Fig. 1

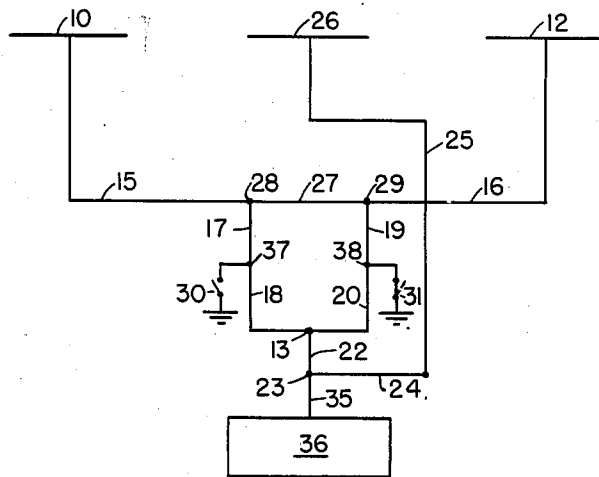
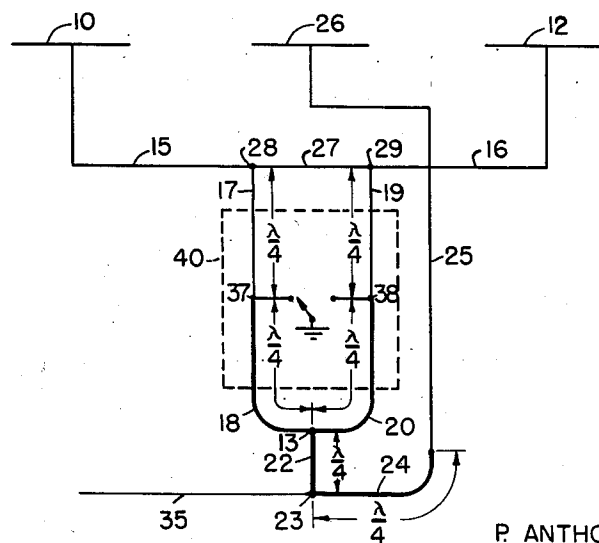


Fig. 2



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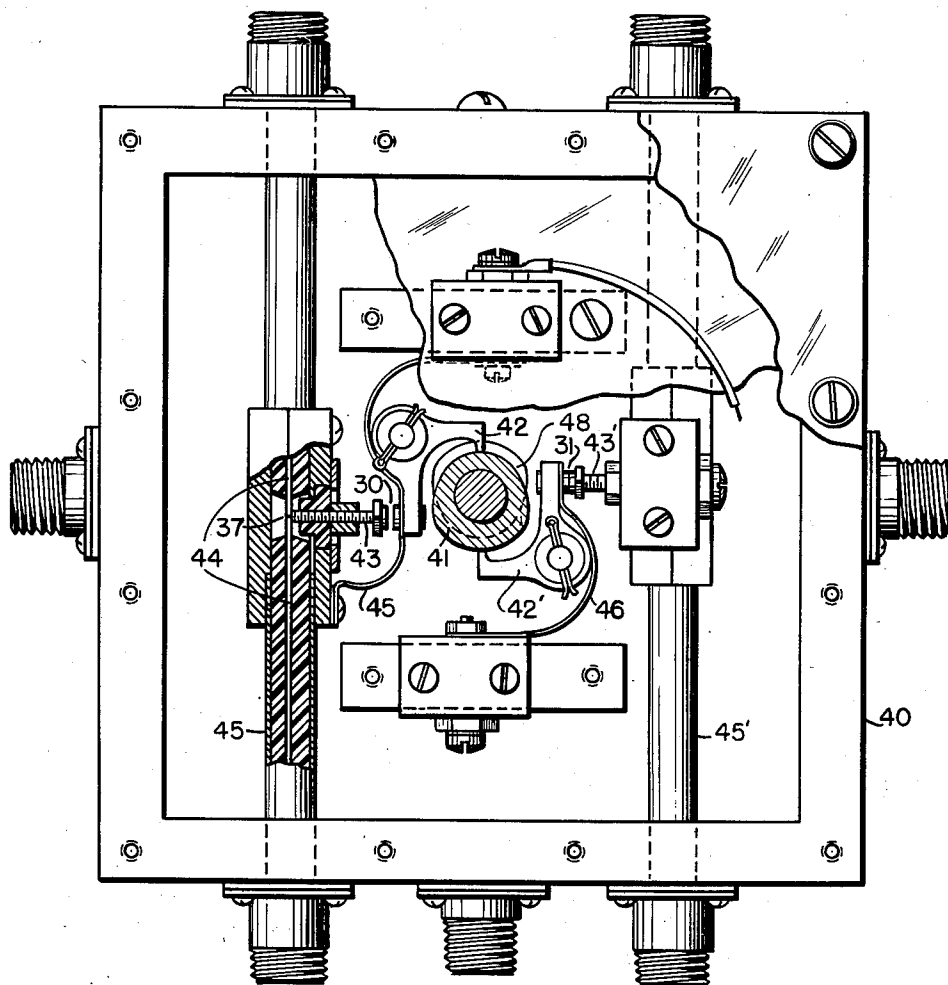
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FIG. 3



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ANTENNA SWITCHING SYSTEM

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1

This invention relates to a high-frequency directive antenna system consisting of a plurality of individual radiators and, in particular, to a method of and apparatus for switching the primary lobe of the beam pattern of such an antenna system some angular distance to one side or the other of a given line of bearing.

An object of this invention is to provide a simple means of angularly deflecting the beam of such an antenna system pattern.

It is another object of the present invention to provide a satisfactory division of the radio frequency power among the elements of an antenna system formed of three radiators.

A further object of the invention is to provide an antenna lobe-switching system of simple and inexpensive construction which can be assembled with a minimum number of circuit components, and without the use of expensive and specially designed apparatus.

It is well known that the direction of the main beam of a directive antenna array depends upon the phase relation of the currents flowing in the several radiators comprising the antenna system. Various methods have been proposed hitherto for feeding the different radiators of an antenna array with currents having the desired phase variation. The common practice depends upon feeding all the radiating elements from a single feed line through paths of different electrical lengths.

According to the present invention an antenna comprising three vertical dipole radiators is used to alternately transmit and receive radio-frequency signals. The center radiator is fed by a line whose length remains unchanged. The electrical length of the feed line to each of the outer two radiators is alternately made shorter then longer than the length of the feed line to the center radiator. By this means the radio-frequency currents are phased so that the phase of the currents in the center radiator lies between the phases of the currents present in the outer radiators with first one then the other of the outer radiators being ahead in phase. In this way the beam is made to deflect first to one side, then to the other of a normal line of bearing.

The alternation of the order of the phases of the currents in the radiators is accomplished by means of a switch mechanism including two pairs of contact points which are alternately operated to cause one or the other of two short sections of transmission line to be electrically grounded so that when thus connected it is effectively removed from the circuit. The details of the cir-

2

cuit arrangement for effecting these desirable results will be hereinafter described in greater detail in the more specific description which subsequently follows:

5 A better understanding of the objects, features and advantages of this invention will be had from the particular description of a preferred embodiment thereof made with reference to the accompanying drawing, in which:

10 Figure 1 is a schematic diagram of one embodiment of the invention;

Figure 2 shows a modified form of the invention; and

15 Figure 3 is a perspective view of the mechanical switching device, shown partially in section, and constructed in accordance with the invention.

Referring now to Fig. 1 of the drawing, the outer radiators 10 and 12 may comprise vertical dipoles which are respectively connected electrically to two transmission line sections 15 and 16 of equal length. The radiator 10 is connected to a junction point 13 through the sections of transmission line 15, 17 and 18. The other outer radiator 12 is connected to the point 13 through the sections of transmission line 16, 19 and 20. The impedances of the sections 15 and 16 are matched to the radiators 10 and 12. The sections 17 and 19 each are quarter-wave transformers of the same characteristic impedance, Z_0 , as the transmission line sections 15 and 16. The sections 18 and 20 each are a quarter-wave length also and the characteristic impedance of each is approximately equal to $Z_0\sqrt{2}$. It will be observed that standard 52 and 75 ohm coaxial lines will meet these impedance requirements. A third quarter wave section of transmission line designated as line 22, of this latter characteristic impedance, $Z_0\sqrt{2}$, connects the junction point 13 with the branch point 23. Another quarter-wave transformer 24 of characteristic impedance $Z_0\sqrt{2}$, is used between this branch point 23 and the line 25 leading to the central vertical dipole radiator 26. Line 25 is of characteristic impedance, Z_0 , and is matched to the radiator 26. A short phasing section of line 27 of impedance Z_0 , is bridged between the points 28 and 29, thereby connecting the outer radiators together through the lines 15, 27 and 16. The length of this phasing section may be of the order of one hundred twenty-five (125°) electrical degrees. The exact length required depends upon the phase difference desired between the currents in the two outer radiators. The length of the line 25 and the transformer 24 taken as a unit is equal to

3

the electrical length of line from point 23 through the lines 22, 20, 19 and 16 to the radiator 12 plus one half the length of the phasing section 27. Contact points 30 and 31 are provided for grounding alternately the midpoints of the half-wave sections of line made up of the quarter-wave length pairs 17, 18 and 19, 20. From the branch point 23 a line 35 of impedance Z_0 is run to the transmitter and/or receiver 36.

In Figure 3 there is shown one practical form of lobe switch which comprises a metallic shield or box 40 housing a rotatable cam 41 which upon rotation by a motor (not shown) alternately makes and breaks the pairs of contact points 30 and 31, one of each pair being movable and carried by the cam-actuated rocker arms 42 and 42' respectively. The stationary contact point of each pair is electrically connected by means of the respective adjustable screw-threaded conductors 43 and 43' to the inner conductor 44 of the associated short coaxial line sections 45 and 45' at the respective junction points 37 and 38 thereof. Restoring springs 46 of flat conductive strip material complete the connection of the movable contacts to ground, the length of these springs being taken into account when adjusting the lengths of the quarter-wave pairs of lines 17, 18 and 19, 20 of the antenna system.

Mounted on the same shaft but within a separate compartment is another cam 48 which actuates therein similar pairs of contact points (not shown), the operation of which correctly channels to the visual indicating device, the signals received when the beam is deflected to one side whereby they will be readily distinguishable from any signals received when the radiated beam is deflected to the other side.

It is to be understood that all $\lambda/4$ sections of line may be any odd number of quarter-wave lengths, and that all $\lambda/2$ sections may be any integral number of half-waves. However, if the antenna lobe switching system is to operate successfully over a band of frequencies, the lengths specified are preferable.

During operation of the beam switching circuit the half-wave section comprising the lines 17 and 18 is grounded through the set of contact points 30 following which the set of contact points 31 is opened. Thereafter because of the ground connection made through contact point 30, the impedances at points 13 and 28 looking toward the grounding contacts are quite high; hence, for all practical purposes, the half-wave section between the points 13 and 28 may be regarded as being out of the circuit so that radio-frequency currents entering the line 22 would go by way of sections 20 and 19 to the junction point 29 where they would divide. The currents going by way of the phasing section 27 through line 15 to radiator 10 will lag the currents in radiator 12 by an amount essentially equal to the electrical length of section 27. As was pointed out above the path from point 23 to radiator 26 is longer than the path from point 23 to radiator 12 by way of sections 22, 20, 19 and 16. This difference in length causes the currents in radiator 26 to be phased substantially half-way between the currents in radiators 10 and 12. Operation of the switching system to close the points 31 and open the points 30 serves effectively to remove the sections 19 and 20 from the circuit by making the points 13 and 27 points of high impedance. Currents entering the section of line 22 are then obliged to take the path through sections 18 and 17 to the junction point 28. Under these circum-

4

stances the currents in radiator 10 lead the currents in radiator 12. Therefore, the currents in radiator 26 now lag the currents in 10 and lead the currents in 12.

If we assume the contact points 30 open and points 31 closed, the impedance seen at junction 28 looking toward the radiators will be

$$\frac{Z_0}{2}$$

The quarter-wave transformer 17 of impedance Z_0 will transform this impedance to $2Z_0$ at point 31. Since sections 18 and 22 are each quarter-wave sections of line comprising together a half-wave transformer, the impedance at point 23 looking toward point 13 is likewise $2Z_0$. The impedance at point 23 looking toward radiator 26 is $2Z_0$, being transformed from Z_0 by the quarter-wave transformer 24 of impedance $Z_0/\sqrt{2}$. The impedances looking toward the radiators are paralleled at the junction point 23 and therefore will match the line 35 of impedance Z_0 .

It will be noted that the impedances of the outer radiators as seen from point 28 when the contacts 31 are closed or from point 29 when the contacts 30 are closed are each Z_0 . Therefore, the radio-frequency power leaving points 28 or 29 will be divided approximately equally between these radiators. Now, since the impedances looking into lines 22 and 24 from point 23 were each equal to $2Z_0$, the power leaving point 23 will be equally divided. The center radiator therefore receives the same power as the outer two radiators combined.

The power division thereby obtained plus the phasing of the radiator currents provided by the switching system herein described produces a beam of moderate width whose axis is shifted through a small angle as the phase order of the radiator currents is reversed.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a directive antenna system, a central set of radiators and two side sets of radiators, a transmission line joining said side sets of radiators, a pair of transmission lines electrically an integral number of half-wave lengths long having one pair of ends thereof connected at different points on said transmission line equally distant from said side sets of radiators and the other pair of ends thereof joined at a common junction point, a feed line, a quarter-wave line connecting said common junction point to said feed line, a pair of grounding contacts in each line of said pair of transmission lines located an odd number of quarter-wave lengths from said common junction point, means for alternately rendering each pair of grounding contacts effective and ineffective so that the pair of transmission lines are alternately rendered conductive and non-conductive to passage of radio frequency energy, a transmission line joining the central set of radiators to said feed line through impedance transformer means connected to the junction point of said quarter-wave line and said feed line, and impedance transformer means included in the portion of each line of said pair of transmission lines between said grounding contacts and said common junction point.

2. In a directive antenna system, a central set of radiators and two side sets of radiators, a

5

transmission line matched to said side sets of radiators, a first pair of quarter-wave transmission lines having characteristic impedances corresponding to the characteristic impedance of said transmission line connected at different points on said transmission line equally distant from said side sets of radiators, a second pair of quarter-wave transmission lines each having characteristic impedances equal to the product of the square root of two and the value of said characteristic impedance connecting said first pair of transmission lines to a common junction point, a feed line having a characteristic impedance corresponding to said characteristic impedance, a quarter-wave line having a characteristic impedance corresponding to the characteristic impedance of said second pair of quarter-wave transmission lines connecting said common junction point to said feed line, a transmission line matched to the central set of radiators, a quarter-wave line having characteristic impedance corresponding to the characteristic impedance of said second pair of quarter-wave transmission lines connecting the last-named transmission line to said feed line at the junction point thereof with said quarter-wave line, and means alternately grounding the mutually connected ends of the transmission lines of said first and second pair of quarter-wave transmission lines.

3. In a directive antenna system, a central set of radiators and two side sets of radiators, a transmission line joining said side sets of radiators, a pair of transmission lines electrically an integral number of half-wave lengths long having one pair of ends thereof connected at different points on said transmission line equally distant from said side sets of radiators and the other pair of ends thereof joined at a common junction point, a feed line, a quarter-wave line connecting said common junction point to said feed line, a trans-

6

mission line joining the central set of radiators to said feed line through impedance transformer means connected to the junction point of said quarter-wave line and said feed line, impedance transformer means included in each line of said pair of transmission lines, and means for alternately rendering said pair of transmission lines conductive and non-conductive to passage of radio frequency energy, the last-named means including two adjustable stationary contact points, an electrical connection between a selective point on one of said pair of transmission lines and one of said stationary contact points, an electrical connection between a selective point on the other of said pair of transmission lines and the other of said stationary contact points, one movable contact in cooperating relationship with the said one of said stationary contact points, a second movable contact in cooperating relationship with the other of said stationary contact points, two rocker arms carrying said movable contact points, a cam for operating said rocker arms, restoring springs for said rocker arms in contact with said cam, and means for rotating said cam.

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