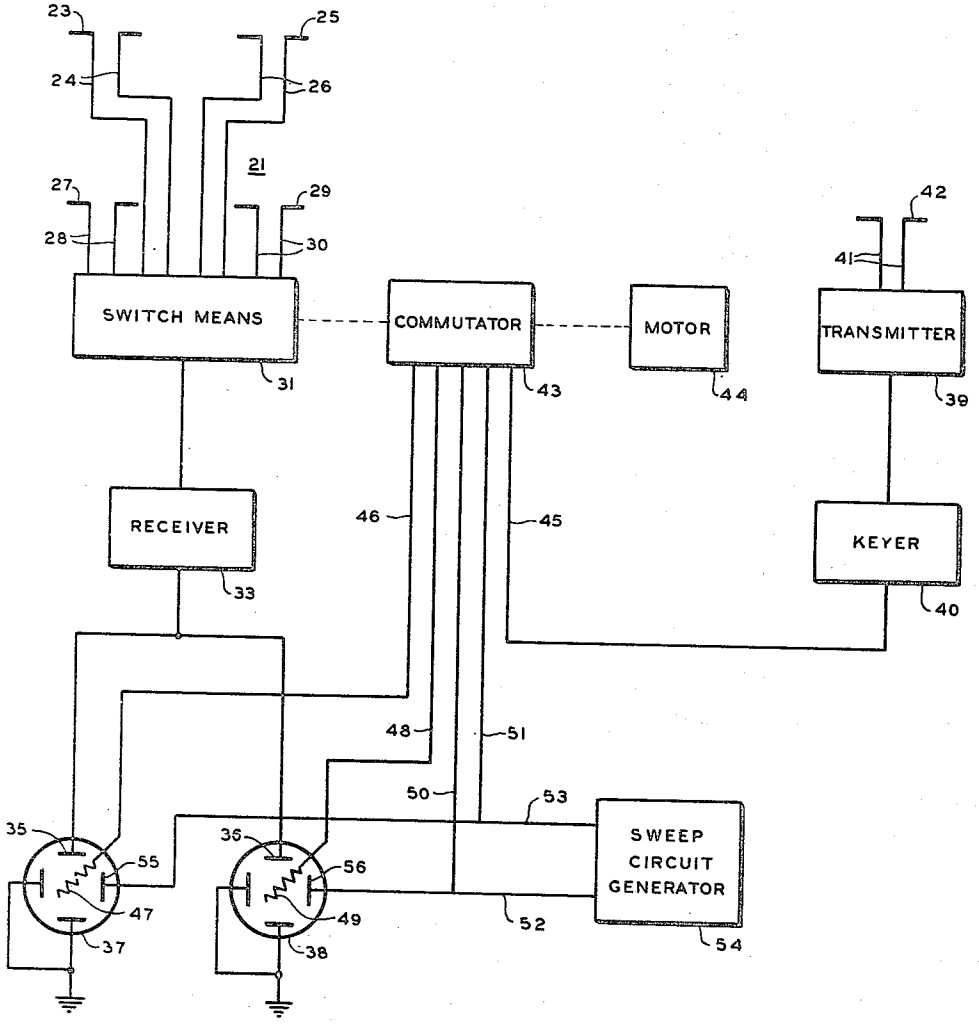
Aug. 23, 1949. J. R. MOORE ET AL 2,479,586

ANTENNA CONTROL SYSTEM

Filed June 28, 1944

3 Sheets-Sheet 1

FIG. 1.



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Filed June 28, 1944

3 Sheets-Sheet 2

FIG. 2.

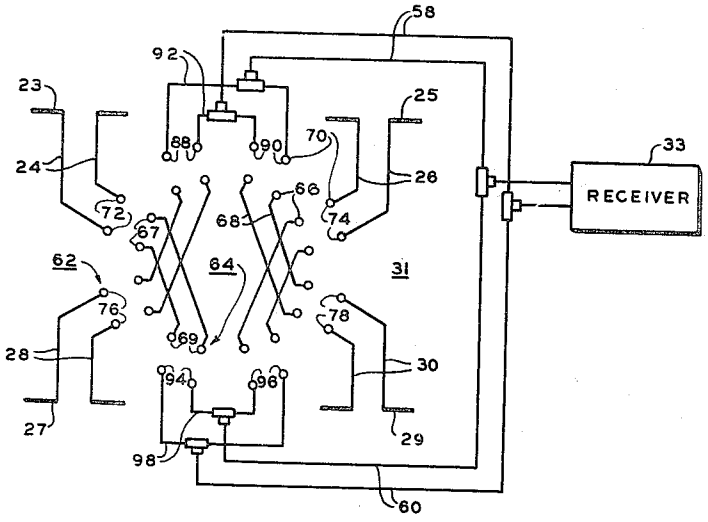


FIG. 3.

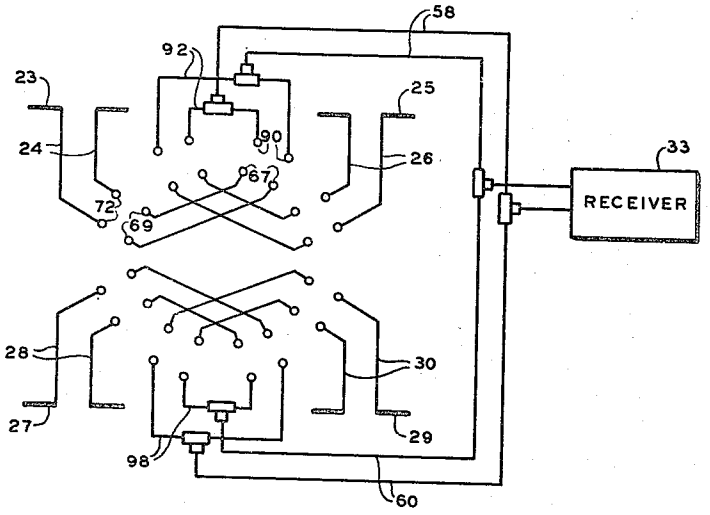
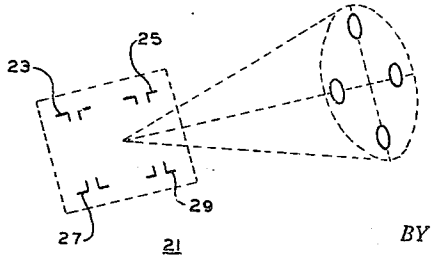


FIG. 4.



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ANTENNA CONTROL SYSTEM

Filed June 28, 1944 3 Sheets-Sheet 3

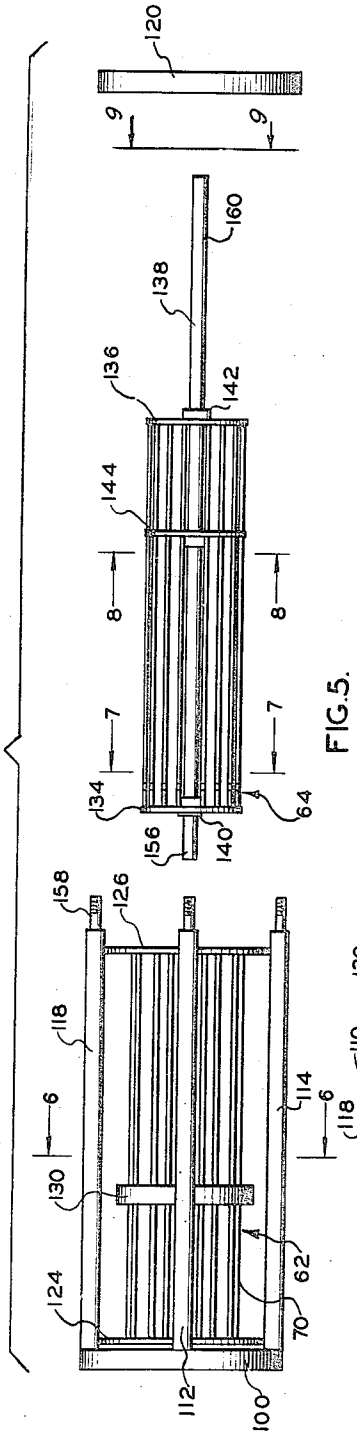


FIG.5.

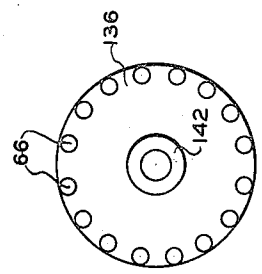


FIG.9.

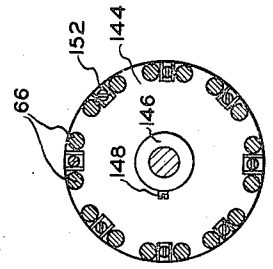


FIG.8.

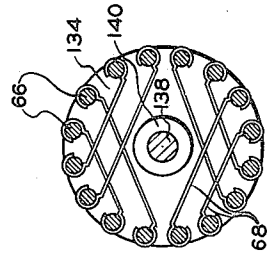


FIG.7.

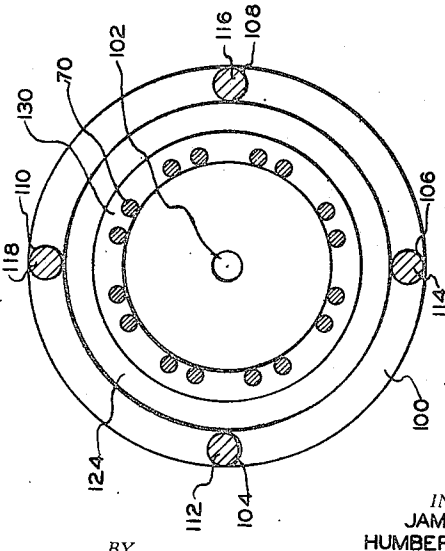


FIG.6.

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2,479,586

UNITED STATES PATENT OFFICE

2,479,586

ANTENNA CONTROL SYSTEM

James R. Moore, Dutch Neck, and Humbert P. Pacini, Asbury Park, N. J., assignors to the United States of America as represented by the Secretary of War

Application June 28, 1944, Serial No. 542,592

13 Claims. (Cl. 343—124)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

Our present invention relates to antenna control systems, and more particularly, to a method and means for lobe switching of directional antennas.

The location of objects by means of wave energy is known, one form of system therefor, the so-called pulse-echo system, including means for radiating exploratory pulses of high-frequency energy into space which, upon encountering some conducting object, are reflected or reradiated, the reflected or reradiated pulses being known as echoes and being utilized in many ways to inform the operator of the system of the location in space of the detected object. For example, said echoes may be utilized to provide a two-component visual image on a suitable indicator such as a cathode-ray oscilloscope. The components of the image may be produced by collecting the echo pulses on a multiple-element, directional antenna system, separate elements or units of which are de-phased and controlled so that the system possesses divergent and partially overlapping directivity patterns symmetrically disposed about the axis of the system, said axis being defined as the direction in which maximum antenna sensitivity is obtained when the elements thereof are in cophasal relationship to each other.

In systems of the character referred to, the relative sizes of the image components depend on the relative alignment of the antenna directivities with respect to the object's position. Thus, when the direction of maximum response of one portion of the system is more nearly in line with the object than is the direction of maximum response of the other, the image associated therewith is predominant, and when the directions of maximum response of the separate portions of the antenna are equiangularly or symmetrically disposed on opposite sides of the line of sight to the object, the energies received by each are equal and the components of the image corresponding thereto are likewise equal. Under such conditions the apparatus is said to be "on target"; otherwise, it is "off target." This method of object locating is referred to as "double tracking."

To determine the position of an object in space by pulse-echo methods, its azimuthal and elevational coordinates are obtained, ordinarily, by providing one receiving system having echo pulse collecting and indicating means preferentially

2

responsive to azimuthal variations in signal strength, and a second receiving system having similar means preferentially responsive to elevational variations in signal strength. This duplication of apparatus and the consequent operational problems involved have constituted a serious limitation on the practicability of certain earlier systems.

Furthermore, in known systems of the character referred to, for the purpose of electrical switching, or selecting separate portions or elements of the antenna array, various control means have been proposed including electromechanical switches having rotating contacts or brush switches. To obviate the use of contacts resulting therefrom, prior art systems frequently employed capacity type switches. This practice is disadvantageous for transmitter antenna systems in that a compromise must be made between the amount of capacitor plate separation to allow ample coupling capacity and the minimum separation where voltage breakdown occurs.

Accordingly, it is the principal object of our present invention to provide an antenna control system for use in locating objects by means of wave energy pulses wherein the directivity of the antenna system can be shifted in a plurality of senses.

Another object of our present invention is to provide an improved antenna system for locating objects by "double tracking."

Still another object of our present invention is to provide an antenna control system wherein antenna elements can be selectively coupled to radio apparatus without the use of contact or capacity type switches.

In accordance with our present invention, a novel system is provided which, to a considerable degree, simplifies the process of electrically interconnecting the separate elements of an antenna array in predetermined phase relationship for controlling the antenna directivity.

Further in accordance with our present invention, commutator means are provided for selectively coupling the antenna elements to a receiving system in such a manner that amplified signals or pulses are applied to indicating means for the purpose of producing desired visual or other directional indications from the collected signals.

For a better understanding of our present invention, together with other and further objects, attention is directed to the following description,

with reference to the accompanying drawings in which:

Figure 1 is a block-circuit diagram of a control system embodying our present invention as applied to a radio pulse-echo system for object detection;

Figures 2 and 3 are schematic circuit diagrams of an antenna control system illustrating two different instantaneous positions in the switching sequence thereof;

Figure 4 diagrammatically represents the operational relationship between elements of the antenna system and the composite positions of the directivity lobes;

Figure 5 is a side view, on a substantially reduced scale, of switch means for said system, constructed in accordance with our present invention and showing certain parts withdrawn one with respect to the other on a common operating axis;

Figure 6 is a cross-sectional view, on a greatly enlarged scale from that of Figure 5, of a stator element of said switch means, taken in the plane of the line 6—6 of Figure 5;

Figure 7 is a cross-sectional view, on the same scale as Figure 6, of a rotor element of said switch means, taken in the plane of the line 7—7 of Figure 5;

Figure 8 is a second cross-sectional view of said rotor element, also on the same scale as Figure 6, taken in the plane of the line 8—8 of Figure 5; and

Figure 9 is an end elevational view of said rotor element, also on the same scale as Figure 6.

Referring now more in detail to our present invention, with particular reference to Figure 1 of the drawings, the numeral 21 generally designates a directional receiving antenna array adapted for horizontal and vertical scanning movement. Said array comprises two vertically spaced banks or bays of half wave length dipole antennas, each of which bays are electrically divided in half, forming four antenna elements or units, designated by reference numerals 23, 25, 27, and 29. If desired, the antennas may be provided with parabolic reflectors, or with parasitically and/or independently energized reflectors in order to produce a well defined directive response pattern. Inasmuch as such reflectors and antenna arrays are well known and do not form part of this invention, the same are not shown.

Signal energy received or collected by antennas 23, 25, 27, and 29 is conveyed by means of transmission lines 24, 26, 28, and 30, respectively, through switch means 31 to a receiver 33, the output of said receiver being so divided that equal parts thereof are applied to the vertically deflecting plates 35 and 36 of a pair of cathode-ray oscilloscopes 37 and 38, respectively.

Pulses of radio-frequency energy from a transmitter 39, which is keyed into operation of a certain audio-frequency rate by suitable keyer means indicated at 40, are conveyed by means of a suitable transmission line 41 to a transmitting antenna indicated at 42, from whence said pulses are radiated in the general direction of the object or target of interest. The receiving means referred to above operates in response to echo signals reflected or reradiated from the target, as will hereinafter be more fully described.

To synchronize the reception of the echoes with the keying of the transmitter, commutator means, indicated at 43, is provided which is suitably coupled to the switch means 31 to operate therewith, as will also hereinafter be more fully described. The commutator means is driven by a suitable motor 44, and its output is substantially a rectangular voltage wave, a portion of which is conveyed to the transmitter keying means 40 by means of a suitable electrical connection indicated at 45. At 46 and 48 electrical circuit connections are indicated for conveying another portion of the commutator output to the intensity or control grids 47 and 49, respectively, of the oscilloscopes 37 and 38. At 50 and 51 suitable electrical circuit connections are indicated for conveying another portion of the commutator output to circuit connections 52 and 53, respectively, carrying a saw tooth voltage wave from a sweep circuit generator 54 and connected with the horizontally deflecting plates 55 and 56 of the oscilloscopes, whereby combined rectangular and saw tooth voltages are applied to said deflecting plates for a purpose that will later be more fully described.

Referring to Figure 2, the switch means, generally designated by the numeral 31, comprises a stationary or stator member, generally indicated by the numeral 62, and a rotary or rotor member, generally indicated by the numeral 64. It will later be apparent that the view here presented of said switch means is substantially a cross-sectional view of the preferred embodiment, the structure of which is shown in detail in Figures 5 and 7.

As will be hereinafter described in greater detail, the rotor member 64 comprises eight sets or tuned transmission trombones 66, alternate pairs of which, on each side of an arbitrary center line (not shown), are connected by suitable electrical conducting means 68, as shown.

The stator member 62 comprises a like number of sets of similarly tuned transmission trombones 70, the interconnections of which are as follows: four of the trombones, 72, 74, 76, and 78, are joined by means of the transmission lines 24, 26, 28, and 30 to the antenna elements 23, 25, 27, and 29 respectively. Two sets, 88 and 90, are joined together by the transmission line 92; the remaining two sets 94 and 96 being likewise joined together by the transmission line 98. The transmission lines 92 and 98 are joined to each other by means of the transmission lines 58 and 60, the latter named lines being slideably connected to the members 92 and 98 respectively. The receiver 33 is slideably tapped to the lines 58 and 60 at a position slightly displaced from the midpoint of the joined lines in such a manner that the electrical line length 58 is unequal to the electrical line length 60.

In Figure 3 there is shown the same electrical network as that disclosed in Figure 2, but the rotor member has been rotated through an angle of 90° from the position shown in Figure 2.

Referring to Figure 4, the quasi-conical rotation of the lobe of maximum response of the antenna array 21 is symbolically indicated, and this view will serve to more definitely indicate the real nature of our invention.

Referring to Figure 5, along with Figures 6, 7, 8, and 9, for a description of the details of the switch means, numeral 100 represents a substantially flat disc provided with a circular aperture 102 at the center thereof and four additional circular apertures 104, 106, 108, and 110, positioned in quadrature, near the peripheral edge thereof. The four outer openings receive a like number of rod-like members 112, 114, 116, and 118 which may be threadedly received therein or held by another suitable means. Another flat disc 120, of exactly the same size as the disc 100, is pro-

vided with apertures spaced collinearly with those of said disc 100. The four ends of the rods 112, 114, 116, and 118 at the extreme opposite of disc 100 are received in the outer openings of disc 120. When so disposed, the discs and rods form an assembly which serves as a support for the stator member which is generally indicated by the numeral 62.

Said stator member comprises a pair of annular rings 124 and 126 provided with a set of sixteen circular openings (not shown) disposed near the inner edge of said rings in perfect alignment with apertures formed in a third ring member 130 which is slideably disposed between the rings 124 and 126. Traversing each of said sets of aligned apertures is a cylindrical metallic rod 70, adjacent pairs of which constitute parallel transmission lines closed at each end. The electrical length of said lines may be variably controlled by the positioning of the intermediate ring 130 slideably mounted thereon. It will be apparent that the rods 70 may be held in position in the openings of the rings 124 and 126 by providing threaded ends on said rods and threading the openings, or by providing a tight machine fit, or by any other well known expedient.

For clarity of presentation, the means for coupling the antenna and receiving system transmission lines 24, 26, 28, 30, 92, and 98 to the stator trombones (Figures 2 and 3) is not shown in the drawings. The above said transmission lines can be slideably tapped to the appropriate trombones (Figures 2 and 3) in a manner well known in order to secure a point of proper impedance match. The expression "trombone," as used herein, shall be understood to include the expression "Lecher line" or any other expression indicating a two wire transmission line shorted at least at one end thereof and provided with a displaceable shorting bar.

The rotated member 64, or briefly, the rotor, comprises a pair of end plates 134 and 136 provided with 16 circular apertures (not shown) radially and equiangularly disposed near the periphery of said plates; said plates being also provided with a center aperture through which a cylindrical shaft 138 may be passed. The discs 134 and 136 are spaced and rigidly secured to said shaft 138 by means of collars 140 and 142, formed integrally with said discs, and each provided with a radial threaded opening in which a set screw may be engaged; said set screw being of conventional type and therefore not disclosed. Mounted on the shaft 138, and positioned between the discs 134 and 136, is a third disc 144 of the same general nature as the aforementioned discs 134 and 136, and also provided with a like number of apertures spaced, and in alignment with the apertures of the said discs. Disc 144 is also provided with a collar 146 which in turn has a threaded opening to receive a set screw 148 for rigidly fastening the disc to the shaft 138. When the openings of the plates 134, 136, and 144 are in alignment, rod-shaped members 66 may be passed therethrough, their opposite ends being tightly fixed in the apertures of the end plates 134 and 136. Just as in the stator member, the eight pairs of adjacent rods serve as tuned transmission lines, or trombones, closed at each end.

Referring to Figure 7, alternate pairs of trombones on each side of an arbitrary center line (not shown) are connected together by short cross-over transmission lines 68. Although not shown for reason of clarity in Figure 5, the cross-over connections are made at the end of the

trombones near the plate 134. The connections may be secured to the trombones by soldering, or by clips, so as to provide good electrical connections.

In Figure 8, it will be seen that the intermediate plate 144 is provided with substantially U-shaped spring clips 152 fastened to one face of the plate and so spaced that they occupy positions between pairs of apertures. As shown, the spring clips 152 are fastened to the plate by means of machine screws, but it is apparent that they could be fastened in any other way, as for example, by spot welding. In use, said spring clips bear tightly against pairs of rods 66 and assure good electrical connections therebetween.

Figure 9 is a view in elevation showing the end plate 136 of the rotor with the ends of the rods 66 secured therein.

In use, the rotor is inserted within the stator so that the short end 156 of the shaft 138 enters the aperture 102 of the disc 100, said aperture serving as a bearing. After the rotor has been so assembled within the stator, the cover plate 120 may be placed into position, adjusting the assembly by fitting said cover over the threaded ends 158 of the rods 112, 114, 116, and 118, and the long end 160 of the shaft 138 into suitable openings provided in the cover 120. The shaft 138 and rotor 64 are of course free to rotate as an integral unit. To enclose the unit, bolts (not shown) are provided to fit over the threaded end 158 of rods 112, 114, 116, and 118.

If difficulty in operation of intercoupling between trombone elements in the rotor or stator members arises, it can be minimized by providing shielding members (not shown) between adjacent trombones. It may also be helpful to substitute plastic plates in lieu of metal plates 124, 126, 130, 134, 136 and 144. When nonconducting plates are employed, shorting elements, similar to spring clips 152, can be employed for interconnecting adjacent pairs of rods so as to form tuned transmission trombones.

The operation of our invention in the double tracking of objects may be described as follows:

Referring to Figure 1, pulses of radio-frequency energy are projected into space as the keyer 40 trips the transmitter 39 into operation. Said pulses, when striking an object capable of reflecting or reradiating the same, will return a portion of the energy to the receiving antenna array 21. The direction of maximum response of the antenna array at any particular instant of reception may be determined from the following considerations:

Referring to Figure 2, and assuming that the array is oriented in a substantially vertical plane, and assuming further that the length of line 58 is somewhat shorter than that of the line 60, it will be apparent that the energy received by antenna 23 will be fed through transmission line 24 to the trombone 72 of the stator. By inductive coupling, said energy is transmitted to trombone 67 of the rotor, whence it is transmitted by a cross-over transmission line of the rotor to trombone 69 of the rotor, and then, again by inductive coupling, to trombone 94 of the stator. It is finally conducted by transmission lines 98 and 60 to the receiver 33. It will thus be seen that the energy received by the antenna 23 follows a long path for this particular orientation of the switch. The energy received by antenna 25 may be traced in a similar manner through transmission line 26 to the stator trombone 74, then, by inductive coupling, to a rotor trombone, whence,

by means of the cross-over transmission line and again by inductive coupling, the energy is passed to the stator trombone **96**. From this point, by means of the transmission lines **98** and **60**, the energy is carried to the receiver. Thus, it is apparent that the antenna **25** likewise feeds its energy through a long path to the receiver.

Considering now the antenna **27**, whose received energy is conducted by means of transmission line **28** to the stator trombone **76**, inductive coupling, crossover transmission line, and second inductive coupling, carry the energy to the stator trombone **88**, whence, by means of transmission lines **92** and **58**, the energy from antenna **27** is conducted by a short path to the receiver. And, finally, the energy picked up by the antenna **29** is transmitted by means of transmission line **30** to the stator trombone **78**, and, through inductive coupling, crossover transmission line, and second inductive coupling, said energy is delivered to the stator trombone **90**, whence, by means of transmission lines **92** and **58**, said energy is also delivered by means of a short electrical path to the receiver.

It is well known that in a plurality of jointly energized antennas, if the energy of a portion of said plurality of antennas is fed to a receiver through a transmission line of a given length, while the energy of the remainder of said plurality of antennas is fed to said receiver through a transmission line of a slightly different length, the net effect of the independent contributions from the two portions of the antenna will be a maximum if said contributions arrive at the receiver in phase, and will be a minimum if they arrive out of phase. The result, then, of such a combination of energies received from different antennas and fed to a receiver through unequal lengths of line, is to alter the direction of maximum response of said antenna from the normal direction, perpendicular to the plane of the array, to a direction inclined somewhat to said perpendicular, the direction of said inclination being toward those antennas whose energy is conducted to the receiver by means of the longer electrical path length. Only in this way can the energies from each portion of the antenna arrive in phase, assuming, of course, that the amount of the inclination is such that it will compensate for the difference in electrical path length.

Relating this to the problem at hand, and referring specifically to the situation as disclosed in connection with Figure 2, since the antennas **23** and **25** have their energy fed through a longer path length than the energies of the antennas **27** and **29**, it follows that the direction of maximum response of the gross antenna system will be changed from its normal orthogonal position relative to the plane of the array to a direction upwardly inclined from said orthogonal position, upwardly because the antennas **27** and **29** are disposed below the antennas **23** and **25** in the vertically oriented antenna array **21**.

Consider now what happens when the rotor is shifted through an angle of 90° in a clockwise direction. Figure 3 shows the instantaneous position of the rotor relative to the stator when such a rotation has been produced. It will be seen that the antenna **23** will have its energy conducted by the transmission line **24** to the stator trombone **72** and by inductive coupling to the rotor trombone **69**, whence, by crossover transmission line, said energy arrives at the rotor trombone **67**, from which point, by inductive coupling, the energy is led to the stator trombone **90**. The transmission lines **92** and **58** will then conduct this energy through the short path to the receiver **33**. Similarly, the energy picked up by antenna **25** will be conducted to the receiver through the rotor and the short path **58**. On the other hand, the antennas **27** and **29** have their energies transmitted through the rotor and, by means of the transmission lines **98** and **60**, through a long electrical path to the receiver.

It is thus apparent that as a result of the rotation of the rotor, those energies which, in the prior case described above, had been transmitted to the receiver by a long line are now transmitted by a short line, and vice versa. In the latter instance, since it is the energies of antennas **23** and **25** which are fed to the receiver by the short line and the energies **27** and **29** which are fed by the long line, the direction of maximum response of the antenna array will be bent from its normal position to a new position inclined downwardly therefrom.

It will be understood, of course, that in the intermediate position, that is, in the position between those shown in Figures 2 and 3, the antennas **25** and **29** will have their energies fed through the long line, while the antennas **23** and **27** will have their energies fed through the short line, with the resultant bending of the lobe to the right of the normal position, and in the situation immediately following that shown in Figure 3, the antennas **23** and **27** will have their energies fed through the long line, and the antennas **25** and **29** will have their energies fed through the short line, in which case the lobe will be shifted to the left. With continued rotation of the rotor in the same direction, it is clear that the direction of maximum response rotates in substantially the same direction, assuming positions disposed vertically above, horizontally to the right, vertically downward, and horizontally to the left of the normal position of said lobe.

Figure 4 graphically shows the positions of said lobes occupied when the coupling between the trombones of the rotor and those of the stator are "tightest." It has been found upon investigation that the tight coupling is obtained when said trombones are in direct opposition and that said tightness of coupling falls off very rapidly as the relative positions of the trombones approach and recede from the position of direct opposition. Consequently, while we have shown in Figure 4 the lobes' cross-sections to be independent of each other, in reality they are considerably wider and less well defined, with the result that there is partial overlapping of adjacent lobes. Showing these lobes as we have in Figure 4 was intended merely for the sake of clarity and not as a true representation of the phenomenon.

The problem of synchronizing the rate of transmission with that of lobe switching is satisfactorily solved by the use of a split segment commutator rotatively mounted on a common axis with that of the rotor of the switch means hereinbefore described. Said commutator provides a substantially square-wave output, which output is used for the purposes of, first, pulsing the keyer **40** into activity, second, instantaneously and alternately blanking the oscilloscopes, and third, applying a biasing voltage to the sweep circuit voltage obtained from the generator **54**. By a suitable adjustment in the phasal relation of the respective square-wave outputs of the commuta-

tor, it is possible to arrange matters so that at the instant of arrival of an echo from the object, the keyer is pulsed into activity, one of the oscilloscopes is blanked (or darkened), and the image produced on the screen of the other oscilloscope is split into a pair of partially overlapping traces.

Which of the two oscilloscopes is blanked, the other, of course, being in condition for reporting, is determined by the instantaneous position of the rotor of the switch. For example, if at the instant in question the rotor is in such a position that energy is being received from a direction vertically disposed from the normal, then it will be the "horizontal" indicating oscilloscope which is blanked. On the other hand, if it is the case that energy is being received from a direction horizontally disposed from the normal, then the "vertical" oscilloscope will be blanked. In this manner we have provided for the presentation of the electromagnetic responses to either one of the oscilloscopes, depending upon the direction whence the energy arrived.

While any of several methods known to the art for splitting the pulse image on an oscilloscope into a pair of overlapping traces may be employed in connection with this invention, the means indicated in Figure 1, namely, combining a square-wave voltage with the saw tooth sweep voltage and applying same to the horizontally deflecting plates, has been fully disclosed in the copending patent application of James R. Moore, entitled "Double tracking means for pulse echo systems," Serial Number 467,266. As we are principally concerned with the switching means herein, a complete disclosure of the indicating system is not given.

We have thus provided a means and a method for double tracking an object by the pulse-echo system, using a single antenna array coupled with a switch means, whereby the lobe of said antenna may be controlled so as to scan a solid angle in space. Wobbling the direction of maximum antenna response amounts to the same thing as having two independently energized antennas in which the lobe of response of one is warped in a vertical plane, while that of the other is warped in a horizontal plane. By receiving the energies from said antennas alternately into oscilloscopes, one for the horizontal direction and the other for the vertical direction as above described, it is possible to track the object, in such manner that information is provided the observer regarding the "on target" and the "off target" status of the apparatus. Further, if such "off target" status is obtained, information is provided regarding the fact of whether apparatus is off target to the right or to the left; also, whether the aim is too high or too low. The entire apparatus is mounted for complete rotation in azimuth and, at the same time the antenna is mounted for the required rotation in elevation.

In scanning space for targets of aerial natures, the apparatus may be continually rotated in azimuth and at the same time the antenna may be periodically oscillated through vertical displacements. When a target has been sighted, as evidenced by the appearance on either oscilloscope screen of a deflection of the time base, the motion of the apparatus is immediately restricted to a relatively small well-defined sector of the space, determined, of course, by the direction in which the apparatus was oriented at the instant of appearance of said indication. While

thus confined or restricted to this sector of space, the so-called double tracking process is carried out. Inasmuch as the process forms no part of this invention, the complete description thereof is not provided.

While separate antennas for transmitting and receiving have been illustrated and described in this specification, it will be apparent to those skilled in the art that one antenna can serve to perform both functions, provided, of course, that suitable means are employed to protect the receiving system during the period of transmission. Although we have shown and described certain specific embodiments of our invention, we are fully aware that many modifications thereof are possible and such modifications are intended to be covered in the appended claims.

We claim:

1. In a radio control system, in combination with a plurality of signal conveying transmission lines, switching means comprising: a plurality of spaced tuned Lecher lines; means connecting certain of said Lecher lines each with said transmission lines individually; means providing output connections for the remainder of said Lecher lines; means providing a corresponding number of spaced tuned Lecher lines in predetermined spaced relation to said first named Lecher lines; means providing connections between certain of said last named Lecher lines to provide signal transmission between said input and output means; signal responsive means; means connecting said output connecting means to said signal responsive means; and means for moving said last named Lecher lines in unison for effecting switching of the signal transmission between said transmission lines and said signal responsive means.

2. In an antenna control system, the combination of input means comprising a plurality of spaced Lecher line elements; output means comprising a corresponding number of spaced Lecher line elements; and switching means comprising a Lecher line element associated with each of said first named elements in spaced relation thereto and interconnected for transmission of energy between said input and output means; and means for moving said last named elements in relation to said first named elements for preferentially varying the phase of the energy transmitted therethrough.

3. A radio frequency switch to connect an antenna array to a receiver, said switch comprising a first plurality of Lecher lines connected to said antenna array, a second plurality of Lecher lines connected to said receiver, and a third plurality of Lecher lines to couple each Lecher line of said first plurality of Lecher lines to successive Lecher lines of said second plurality of Lecher lines.

4. The switch according to claim 3 where said first and second plurality of Lecher lines are arranged to define a hollow cylinder and said third plurality of Lecher lines is arranged to define a hollow cylinder coaxial therewith and rotatable therein.

5. The switch according to claim 4 wherein said first and second plurality of Lecher lines are tunable simultaneously by a common shorting bar and wherein said third plurality of Lecher lines is tunable by a second shorting bar.

6. A radio frequency switch comprising a stator and a rotor coaxial therewith, said stator and rotor each comprising a like plurality of Lecher lines.

7. The switch according to claim 6 and means to couple alternate pairs of rotor Lecher lines.

8. The switch according to claim 7 including first shorting bar means to tune simultaneously said stator Lecher lines and second shorting bar means to tune simultaneously said rotor Lecher lines.

9. A radio frequency switch comprising a stator and a rotor coaxial therewith, said stator comprising a pair of spaced, parallel annular members interconnected by a plurality of paired conductors, said rotor comprising a pair of spaced, parallel annular members complementary in diameter to said stator annular members and interconnected by a like plurality of paired conductors.

10. The switch according to claim 9 including means interconnecting alternate paired conductors of said rotor.

11. The switch according to claim 9 and annular members carried by said stator and rotor paired conductors, said members being longitudinally displaceable for tuning said paired conductors.

12. A radio frequency switch comprising an outer member including a plurality of Lecher lines and an inner member rotatable within said outer member and including a like plurality of Lecher lines, corresponding Lecher lines of said outer and inner members being inductively coupled to each other.

13. The switch according to claim 12 including means interconnecting alternate Lecher lines of said inner member, means to tune simultaneously the Lecher lines of said outer member, and means to tune simultaneously the Lecher lines of said inner member.

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