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2,653,313

ANTENNA DIRECTION INDICATOR

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FIG. 1

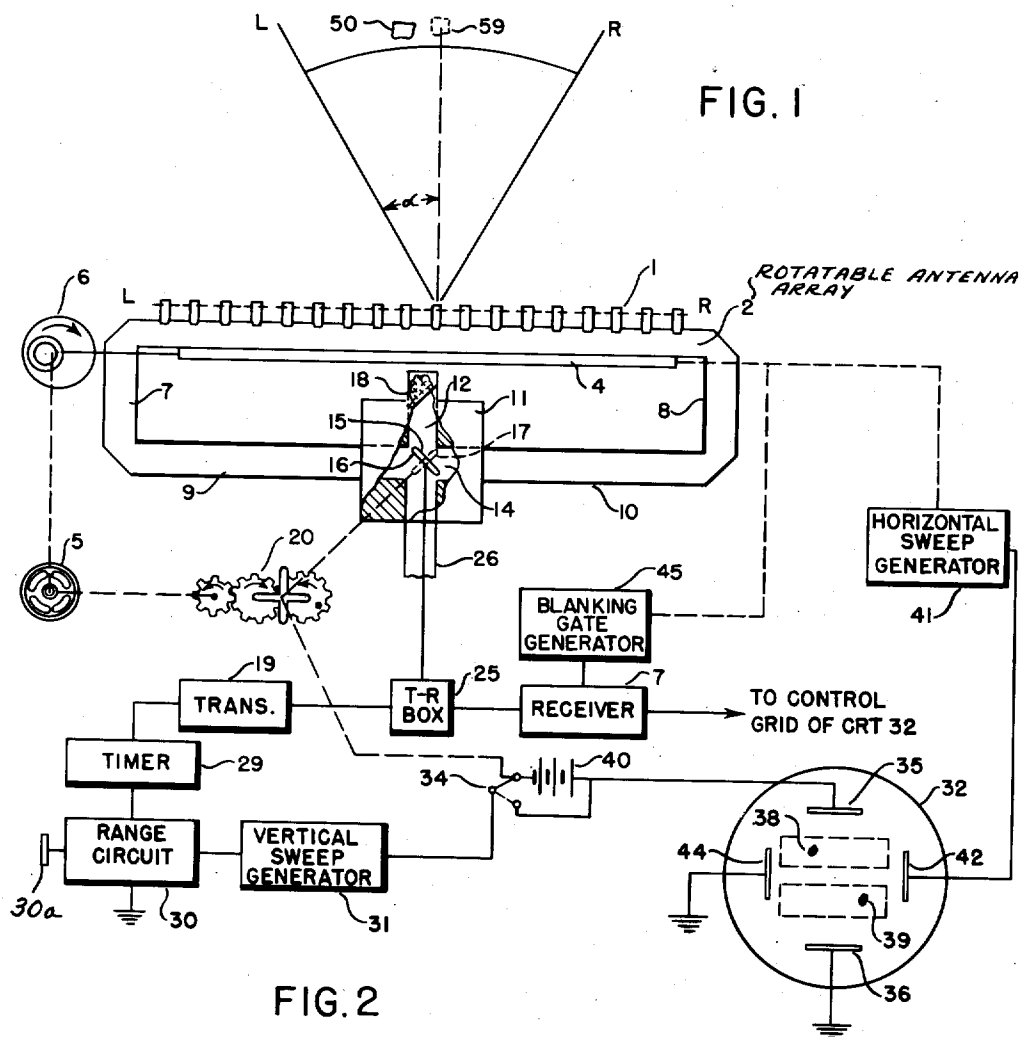
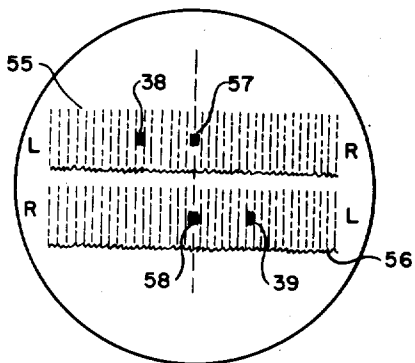


FIG. 2



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ANTENNA DIRECTION INDICATOR

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7 Claims. (Cl. 343-11)

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This invention relates to radio object locating (radar) apparatus for indicating the position of a target relative to the axis of a directional antenna system, and particularly to such an apparatus adapted to be used with a scanning linear antenna array of the variable width wave guide type.

Antenna arrays of the type with which my invention is concerned are described in the pending application of Jack H. Irving entitled "Antenna System," Serial No. 560,975, filed October 30, 1944, now Patent No. 2,480,189, and in the two co-pending applications of Luis W. Alvarez, entitled "Antenna System with Variable Directional Characteristics," Serial No. 509,790, filed November 10, 1943, now Patent No. 2,605,413, and Serial No. 542,287, filed June 27, 1944, issued as Patent No. 2,480,208, entitled "Radio Distance and Direction Indicator."

In the co-pending applications referred to, a linear antenna array is shown arranged for alternate feeding from opposite ends. This array consists of a series of aligned dipoles mounted on a rectangular wave guide having a movable wall, and having a suitable reflector arranged to direct substantially all of the radiated energy in one general direction. The radiation pattern of such a linear array would be fan shaped, with the narrow dimension of the fan parallel to the array and the wide dimension in a plane perpendicular to the array, if the dipoles were fed in phase. If the phasing is varied (as can be done by changing the width of the feed wave guide), the pattern remains fan shaped, but assumes an oblique angle relative to the array. When the direction of feeding is reversed, the fan shaped pattern assumes an equal oblique angle on the opposite side of the normal to the array.

In Patent No. 2,480,208, referred to above, a simple system is illustrated for cyclically scanning a sector in space by changing the long dimension of the wave guide by motor-driven means, producing, when used with alternate-direction feeding, a scanning movement of the beam to cover a sector which may extend substantially 30° on either side of the normal to the array.

Since thermal expansion of the wave guide structure and other mechanical factors understood by those skilled in the art may result in frequency changes which will shift the beam in its angular relation to the antenna, it is desirable to provide indicating means whereby the harmful effects of such changes are substantially eliminated.

The present invention provides such an indi-

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cating means by utilizing B-scan presentation in a novel and effective manner. As is well known, a B-scan presentation is defined as one using beam intensity control and showing range information along one rectangular axis of the oscilloscope screen, usually the vertical, and azimuth information along the other rectangular axis. The term B-scan, as used hereinafter in the specification and claims, shall be construed in the light of this definition. In this invention, the screen is divided into two portions, one above the other, and B-scan presentation is provided in each. One portion indicates targets located during the part of the scan when the antenna is fed from one end, while the other portion indicates targets located when the antenna is fed from the other end. In both portions, the azimuth (horizontal) sweeps move the electron beam in the same direction, for example, left to right.

With this arrangement, one B-scan presentation portion is a mirror reversal of the other. When a given target is not on a line normal to the antenna array, its indication image will appear on one portion displaced a certain distance from the center of the presentation, and on the other portion substantially the same distance on the other side of the center. If the target is on a line normal to the center of the array, its two indication images will appear in exact vertical alignment on the two scope presentations. Thus, any deviation of the target from a line normal to the antenna array may be corrected by rotating the array to bring the two indication images into vertical alignment. This indication will be substantially independent of frequency variations, since the azimuth sweeps on the scope are the same in both cases and are controlled simply by the mechanical position of the scanner mechanism.

The invention is thus adapted to be used with any type of radio object locating equipment in which accurate directional indications are necessary, as for example, in supplying position data to a gun director or gun-laying equipment for fire or searchlight control. It is equally adapted to use on the ground or in aircraft.

It will be understood that the preferred embodiments shown are illustrative of the invention, and that other applications may be made without departing from the spirit of the invention or the scope of the appended claims.

In the drawings:

Fig. 1 is a schematic circuit diagram showing my invention incorporated in a radar system shown partially in blocks;

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Fig. 2 represents an oscilloscope screen on which are shown the two vertically displaced B-scan presentations and indicated target images.

Referring now to the drawings, I have shown in Fig. 1 a simple schematic diagram of a radar circuit including a rotatable antenna in which a linear array of dipoles 1 is mounted on a rectangular wave guide 2. A reciprocating member 4, associated with wave guide 2 to effect variation in its wide dimension is driven by a motor mechanism 5 through eccentric 6. Variation of the wave guide dimension effects the scanning action more fully described in the referred to co-pending applications, so that the beam is swept through an angle α of substantially 30° on each side of the normal to the array.

Wave guide 2 forms with left and right side sections 7 and 8 and left and right elongated portions 9 and 10 a closed circuit. The juncture between elongated portions 9 and 10 is preferably a coupling block 11 having wave guide channels 12 and 14 intersecting at right angles therein to form chamber 15. Within chamber 15, a high frequency reflecting member 16 is pivotally disposed, arranged to deflect energy into left elongated portion 9 when in the position shown, and into right elongated portion 10 when in its alternate position as indicated in dotted lines at 17. Any unreflected energy returning through right side section 8 and right elongated portion 10 impinges on the reverse side of reflecting member 15 and is deflected toward a filler 18 of high impedance material which absorbs it completely. Suitable material may be, for example, sawdust or finely divided carbon particles. This coupling, reflecting, and absorbing mechanism is described in detail in the Alvarez applications referred to above, and need not be explained further here.

In position as shown, the output of transmitter 19 is fed into the wave guide 2 from the left end when reflecting member 16 is rotated to alternate position 17 by such means as the Maltese cross drive 20, shown and described in Patent No. 2,480,208, the energy is fed into the wave guide 2 from the right end. The Maltese cross arrangement 20, driven by motor 5 to thus provide proper synchronism with the scanning antenna, is designed to turn the reflecting member 16 rapidly through 90° , and after a suitable interval to return it rapidly to the original position through the same 90° angle.

Energy is delivered from the transmitter 19 to coupling block 11 through a conventional transmit-receive (T-R) box 25, shown on page 205 of "Radar Systems Fundamentals," Bureau of Ships, Navy Department, 1944, and wave guide 26. Box 25 is also arranged to provide connection between the antenna array and a receiver 27 except during the time a pulse is being sent out by transmitter 19. At this time receiver 27 is effectively disconnected from the antenna to prevent damage until the end of the pulse.

A timer 29 is provided to synchronize the system. Timer 29 controls the pulsing rate of transmitter 19 and has a range circuit 30 and a vertical sweep generator 31 associated therewith to supply a delayed sawtooth sweep voltage to the vertical deflection plates 35 and 36 of a cathode ray tube 32.

Range circuit 30 provides a time delay between each pulse of transmitter 19 and the initiation of the next following sawtooth voltage generated by vertical sweep generator 31, and may consist of a delay multivibrator, such as shown in Fig. 224, "Radio Systems Fundamentals," supra. The

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length of the time delay may be controlled by a manual adjustment 30a which is calibrated in range. The adjustment may be varied to select targets lying at a predetermined range from the system. Thus the vertical sweep deflections applied to the tube 32 correspond only to the predetermined range interval. The range to a selected target may be determined from the reading of the manual adjustment plus the additional distance measured from the base line (X-axis) of one portion of the tube indication to the position of the target indication on that portion.

The output of the vertical sweep generator 31 may be applied as a potential relative to ground through a bias control switch 34 to one of a pair of vertical deflection plates 35 and 36, the other of which may be grounded.

The reflected energy received back from a particular target 59 lying within the fields of scan but not on a line normal to the center of the array is conducted to receiver 27 in accordance with usual radar practice and is presented on one portion of the B-scan scope 32 as indication 38 when wave guide 2 is fed from the left. When the guide 2 is fed from the right, the presentation is reversed along the X-axis and shifted vertically to the other portion and is shown as indication 39.

This vertical shift may be accomplished by adding a constant D.-C. bias derived from a battery 40 or equivalent source. The single pole double throw switch 34 is mechanically linked to the Maltese cross arrangement 20 and operated simultaneously therewith to cut the bias source 40 into or out of the deflection circuit of the indicating tube. Other equivalent means for shifting the presentation vertically will be obvious to those familiar with oscilloscope circuits.

A conventional sweep or deflection voltage generator 41 may be used to produce the horizontal deflecting potential applied to one plate 42 of a pair of X-deflection electrodes in the cathode ray tube 32. The other plate 44 of the pair may be grounded. As will be understood, the horizontal sweep moves the electron beam in accordance with the comparatively slow scan of the antenna radiations in space.

Proper synchronization of the horizontal deflection voltage with the sweeping of the beam of antenna radiation may be obtained by linking the sweep generator 41 with the movable element 4 of the wave guide.

Fig. 2 is an enlarged view of the screen of the indicator tube shown in Fig. 1. The two portions of indication are shown at 55 and 56. Images 38 and 39, above mentioned, which indicate a target lying at a point displaced from a line normal to the antenna, are shown. Images 57 and 58 which are in vertical alignment (but not necessarily in the center of the indication), show the indication of the same target when the antenna system has been rotated in azimuth so that the target now lies on a line normal to the array, as shown by dotted target 59 in Fig. 1.

In the particular system above described, only one half of each cycle of antenna scan is utilized. That is, when the antenna is fed from the left end, for example, the scanning beam of radiation is used only during its travel from left to right across the scanned sector. Correspondingly, when the antenna is fed from the left, the scanning beam is used only during its travel from right to left. The system is suitably blanked during the return travel of the beam. For this purpose, a blanking gate generator 45 mechani-

cally associated with the scanning antenna, is provided. Generator 45 is shown connected to perform its blanking action on receiver 21, although, if desired, the generator could be connected to cause blanking in the transmitter, or other components of the system. It will be apparent that the system could readily be modified to utilize the full cycle of antenna scan if desired.

What is claimed is:

1. In a pulsed radio object locating system having a scanning linear antenna array of the variable width wave guide type and means for alternately feeding said array first from one end and then the other whereby a beam of radiant energy respectively traverses a field of scan first in one direction and then the other, a system of target indication including means for selecting a target lying within a predetermined range interval, a cathode ray tube having a data presenting screen, means for intensity modulating said tube to provide target indicating spots on said screen, means for sweeping the electron beam of said cathode ray tube across said screen at a rate corresponding to the scanning rate of said beam of radiant energy and in a direction that is the same for both directions of radiant energy scan, said sweeping means having circuit means connected therewith to provide a displacement between the sweeps corresponding to the two directions of radiant energy scan, said displacement being at right angles to the direction of the sweeps, said two sweeps each commencing from a common base line on said scope screen, and means synchronized by the pulse repetition frequency for sweeping the electron beam in a direction normal to the first mentioned sweeps, said system of indication thereby providing two portions of B-scan presentation, one portion being a mirror image of the other portion whereby a target lying within the predetermined range interval is indicated by a spot in each portion of B-scan presentation, said spots lying on a line normal to the direction of said first mentioned sweeps when the target is on a line normal to the axis of said antenna array.

2. In a micro-wave radio object locating system utilizing a directional linear antenna array arranged to be fed through a wave guide of periodically varying width for scanning a given angular field; a system for determining the normal position of said antenna relative to a beam radiated from said antenna to a particular target comprising means for feeding said antenna in a first direction through said guide, a cathode ray tube indicator, means for producing a first B-scan presentation of radiation echoes from such feeding on said indicator, means for feeding said antenna in a reversed direction, and means for producing a B-scan presentation of radiation echoes from such reversed feeding on said indicator over the same time base as said first B-scan presentation, but laterally displaced therefrom.

3. A radio-object locating system comprising an antenna for radiating pulses in a directional beam and for receiving echoes reflected from a reflecting object, means for alternately sweeping said beam clockwise and counterclockwise about a mean position in a given plane, display means, means for presenting a first indication on said display means in response to echoes reflected from said object and received by said antenna during the clockwise sweeps of said beam, means coordinated with said beam sweeping means for displacing said indication from a given position on said display means in a given direction as a function of the angle of said object with respect

to the starting position of said clockwise sweeps, means for presenting a second indication on said display means in response to echoes reflected from said object and received by said antenna during the counterclockwise sweeps of said beam, means coordinated with said beam sweeping means for displacing said second indication from said given position in said given direction as a function of the angle of said object with respect to the starting position of said counterclockwise sweeps, and means for rotating in said given plane said mean position of beam sweeping, whereby when said mean position passes through said object, said first and second indications are aligned.

4. A radio-object locating system comprising an antenna for radiating pulses in a directional beam and for receiving echoes reflected from a reflecting object, means for alternately sweeping said beam clockwise and counterclockwise through a given sector in a given plane, display means, means for presenting a first image on said display means on a first two-coordinate range and angle display in response to echoes reflected from said object and received by said antenna during the clockwise sweeps of said beam, means synchronized with said beam sweeping means for displacing in a given direction said image along said angle coordinate as a function of the angle of said object with respect to the starting position of said clockwise sweeps, means for presenting a second image on said display means on a second two-coordinate angle and range display in response to echoes reflected from said object and received by said antenna during the counterclockwise sweeps of said beam, the angle coordinate of said second two-coordinate display being spaced from and parallel to the angle coordinate of said first two-coordinate display, means synchronized with said beam sweeping means for displacing in said given direction said second image along said second angle coordinate as a function of the angle of said object with respect to the starting position of said counterclockwise sweeps, and means for rotating in said given plane said given sector of sweeping, whereby when the bisector of said given sector passes through said object, said first and second indications are aligned.

5. In a radio-object locating system comprising an antenna for radiating pulses in a directional beam and for receiving echoes reflected from a reflecting object, means for alternately sweeping said beam clockwise and counterclockwise about a mean position in a given plane, cathode ray tube display means including a screen and a deflectable electron beam, means synchronized with said beam sweeping means for deflecting said electron beam in a given direction from a given position on said screen in synchronism with the clockwise sweeps of said directional beam, whereby the angle of deflection of said electron beam is a function of the angle of said directional beam with respect to the starting position of said clockwise sweeps, and means synchronized with said beam sweeping means for deflecting said electron beam in said given direction from said given position on said screen in synchronism with the counterclockwise sweeps of said directional beam, whereby the angle of deflection of said electron beam is a function of the angle of said directional beam with respect to the starting position of said counterclockwise sweeps.

6. In a radio-object locating system comprising an antenna for radiating pulses in a directional beam and for receiving echoes reflected

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from a reflecting object, means for alternately sweeping said beam clockwise and counterclockwise through a given sector in a given plane, a cathode ray tube indicator including a screen and a deflectable electron beam, means synchronized with said beam sweeping means for deflecting said electron beam in a given direction from a given position on said screen in synchronism with the clockwise sweeps of said directional beam and for intensifying said beam to form a first image on said screen in response to echoes reflected from said object and received by said antenna during the clockwise sweeps of said directional beam, whereby the displacement of said image from said given position is a function of the angle of said object with respect to the starting position of said clockwise sweeps, means synchronized with said beam sweeping means for deflecting said electron beam in said given direction from said given position on said screen in synchronism with the counterclockwise sweeps of said directional beam and for intensifying said beam to form a second image on said screen in response to echoes reflected from said object and received by said antenna during the counterclockwise sweeps of said directional beam, whereby the displacement of said image from said given position in said given direction is a function of the angle of said object with respect to the starting position of said counterclockwise sweeps, and means for rotating in said given plane said given sector, whereby when the bisector of said given sector passes through said object, said first and second images are aligned.

7. In a radio-object locating system comprising an antenna for radiating pulses in a directional beam and for receiving echoes reflected from a reflecting object, means for alternately sweeping said beam clockwise and counterclockwise through a given sector in a given plane, cathode ray tube indicator means including a

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screen and a deflectable beam, means synchronized with said beam sweeping means for displaying a first B-scan image presentation on said screen in response to echoes reflected from said object and received by said antenna during the clockwise sweeps of said beam, whereby the angle coordinate of said image is a function of the angle of said object with respect to the starting position of said clockwise sweeps, means synchronized with said beam sweeping means for displaying a second B-scan image presentation on said screen directly below and parallel to said first B-scan image presentation and having an angle presentation which is displaced in the same direction as the one of said first B-scan image presentation in response to echoes reflected from said object and received by said antenna during the counterclockwise sweeps of said beam, whereby the angle coordinate of said second image is a function of the angle of said object with respect to the starting position of said counterclockwise sweeps, and means for rotating in said given plane said given sector of sweeping whereby when the bisector of said given sector passes through said object, said first and second images on said first and second B-scan image presentations are aligned.

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