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METHOD OF BORESIGHTING

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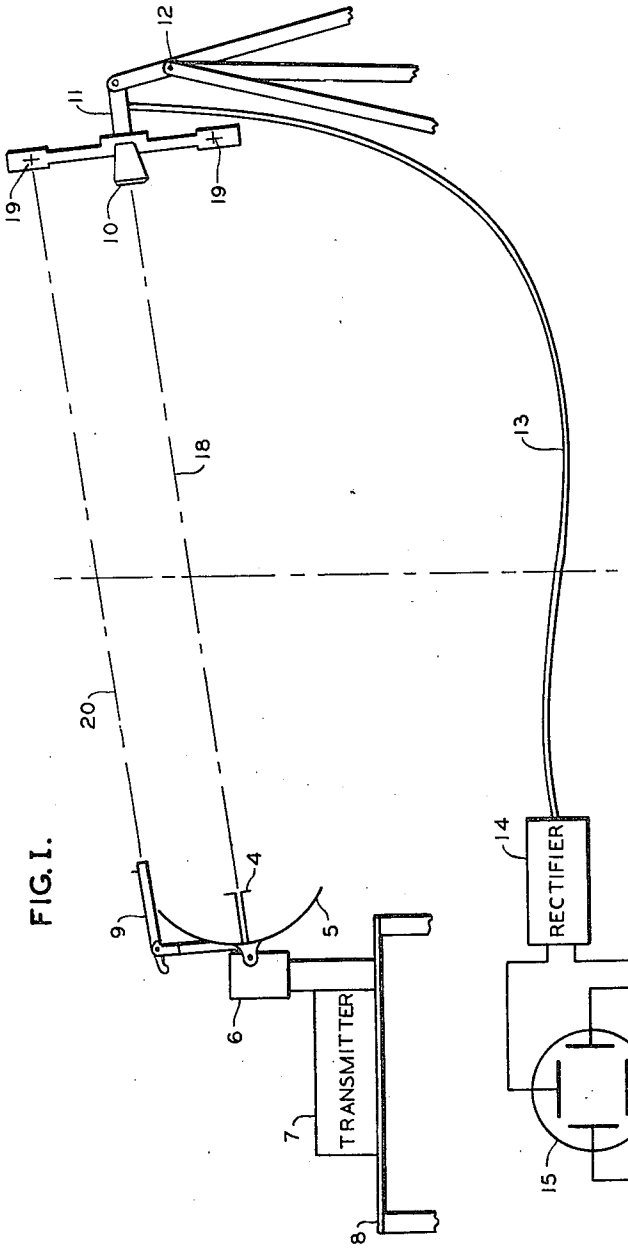



FIG. 1.

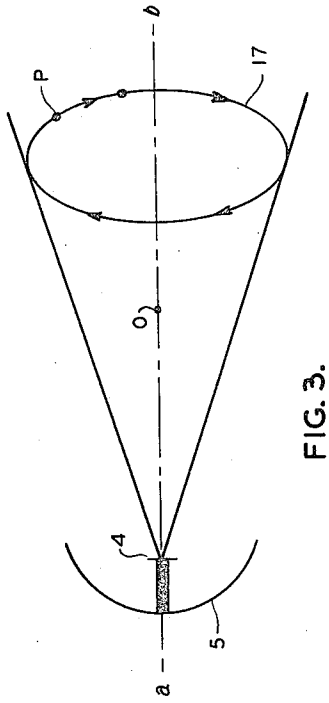



FIG. 3.

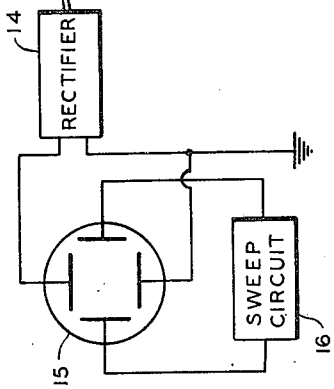



FIG. 2.

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## METHOD OF BORESIGHTING

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

The present invention relates to the boresighting of directive antenna assemblies and relates more particularly to a method for ascertaining the electrical axis of a radiation pattern produced by conical scanning.

Conical scanning finds important applications in the art where it is desired to have a directed beam of high frequency radio energy sweep a given sector in space. This may be accomplished in a variety of ways. For example, if a dipole is employed as the radiating member it may be mechanically rotated at some relatively low frequency, say 30 times per second, around the geometric axis of an associated parabolic reflector. If such a rotating dipole is offset from the geometric axis of the reflector, a directive beam of energy will be projected into space, rotating in such manner as to describe a cone. A similar effect can be achieved by rotating the parabolic reflector eccentrically about its geometric axis. Such a "wobbling dish" can be used conveniently where the operating frequency is high and the size of the reflector is relatively small.

In most systems employing conical scanning it is desirable to know the electrical axis of the conic radiation pattern with a high degree of accuracy. This is particularly true in radar systems associated with gun turrets in such manner as to provide proper orientation of the guns with respect to a desired target. While the electrical axis of a conical radiation pattern substantially coincides with the geometric axis of the reflector assembly, in most cases there is enough variance to make necessary the alignment of associated apparatus by electrical methods. Such associated apparatus may include, for example, an optical sight and gun directing mechanisms, which, when properly related to the axis of the radiation pattern, will insure that the radar system and the gun pointing apparatus will track accurately on a given target.

It is, accordingly, a major object of the present invention to provide a simplified method of accurately ascertaining the axis of a radiation pattern produced by conical scanning.

It is a further object of the present invention to provide improved boresighting means whereby associated apparatus may be properly oriented with respect to the electrical axis of a conical radiation pattern.

These and other objects and advantages of the

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present invention will become apparent to those skilled in the art from the following detailed description, taken in connection with the accompanying drawings wherein like components are referred to by like reference characters and in which

Figure 1 is a view in elevation of a directive antenna system and associated target assembly;

Figure 2 is a diagrammatic representation of an indicator which may be used in connection with the target assembly of Figure 1; and

Figure 3 is an illustration of a conical radiation pattern useful in explaining the invention.

Referring now particularly to Figure 1, a directive antenna assembly is shown, comprising a dipole 4, a reflector 5, and a suitable gear box 6, by means of which the assembly may be accurately adjusted in azimuth and in elevation. The entire unit together with a transmitter 7 is firmly mounted on an elevated platform 8. An optical sight 9 is provided and is connected to the reflector unit in such manner as to be adjustable with respect to the axis of the antenna assembly. The dipole 4 may be rotated as heretofore explained to produce a rotating beam which describes a cone in space. It should here be noted that the invention applies to any of the particular methods of producing a conical radiation pattern.

A receiving horn 10, terminating in a wave guide section 11, is mounted on a suitable support, shown for example as a tripod 12. Radio energy picked up by the horn 10 is applied through a cable 13, which may be of the coaxial type, to a rectifier 14, which forms a part of the indicator circuit of Figure 2. The rectified output voltage is applied to one pair of deflecting plates of a cathode ray tube 15, while a suitable sweep voltage from sweep circuit 16 is applied to the other pair of deflecting plates.

Referring now to Figure 3, it can readily be seen that at any arbitrary point P, off the axis *a—b*, there will be a periodic change in field intensity as the directive beam from dipole 4 is rotated as indicated by the line 17 to define a conical radiation pattern. This change in field intensity will occur at the same rate as the scanning speed, which may be, for example, 30 rotations per second. However, at any arbitrary point 0, on this axis *a—b*, there will be substantially no periodic field intensity variation due to the conical scanning of the beam from the dipole 4. This fact forms the basis of operation of the present invention.

Referring again to Figure 1, the horn target

assembly on the tripod 12 is so placed as to be relatively close to its proper position, namely, near the electrical axis 18 of the directive antenna assembly. By mechanical means in the gear box 6, the reflector 5 and the dipole 4 are oriented in azimuth and in elevation until substantially no modulation signal appears on the cathode ray tube 15 in Figure 2. The sweep voltage frequency is preferably lower than the scanning rate so that several cycles of field intensity variation will appear for observation on the screen of the cathode ray tube 15.

The operator adjusts the directive antenna system until substantially no modulation of the rectified radio-frequency energy appears on the screen of cathode ray tube 15. When such condition of zero or minimum modulation is obtained, it is apparent that the pick-up horn 10 lies on the electrical axis 18 of the conical radiation pattern. An optical target 19 is affixed to and extends a predetermined distance from the center of the horn 10. While maintaining the adjustment of the directive antenna assembly which produced substantially no modulation, as outlined above, the optical sight 9 is adjusted in azimuth and in elevation to bear upon one of the optical targets 19. If the optical sight is trained on the target 19 which lies on the same side of the axis 18 as does the sight 9, the desired parallel relationship will be achieved between the optical sighting axis 20 and the electrical axis 18. In this manner the orientation of associated apparatus, such as guns and the like, with respect to the radar axis may be achieved with great accuracy.

It should be understood that the boresighting method herein described is not limited to the specific apparatus shown by way of illustration. For example, the pick-up horn 10 may take the form of a dipole or any other pick-up device, the choice depending largely upon the frequency of the radiated energy. Furthermore, the indicator circuit shown in Figure 2 may include a suitable meter, transducer, or other device whereby the operator can measure the rectified voltage from rectifier 14 and the degree to which it is modulated. In some applications it may be more convenient to move the target until it lies on the electrical axis, while the directive antenna assembly is kept in a fixed position.

It has been found in practice that the null point which appears when the target is on the electrical axis is exceedingly sharp, and enables the operator to accurately boresight the particular apparatus being adjusted. By means of cable 13, the indicator may be placed on the platform 8, thus enabling one man to perform the entire operation.

While a specific embodiment to carry out the method of the present invention has been shown, it is obvious that modification within the spirit and scope of the invention as defined by the appended claims may occur to persons skilled in the art.

What is claimed is:

1. The method of ascertaining the axis of a cone described in space by conically scanning a directive beam of radio energy comprising the steps of directing said beam toward a fixed pick-up target, altering the orientation of said beam until substantially no periodic field intensity variations exist at said pick-up target, and with said beam so altered optically sighting between a predetermined point fixedly offset from the element radiating said beam and a predetermined point similarly fixedly offset from said target.



2. The method of ascertaining the axis of a cone described in space by conically scanning a directive beam of radio energy comprising the steps of directing said beam toward a pick-up target, moving said target until substantially no periodic field intensity variations exist at said target, and optically sighting between a predetermined point fixedly offset from the element radiating said beam and a predetermined point similarly fixedly offset from said target.

3. Test apparatus for ascertaining the axis of a cone described in space by conically scanning a directive beam of radio energy, comprising in combination, a target horn positioned to pick up unreflected energy directed at it by said beam, means for altering the spatial position of said horn with respect to the source of said radio energy, and means for measuring the modulation component of the radiated field produced at said target horn by said scanning.

4. A device for ascertaining the axis of a cone described in space by conically scanning a directive beam of radio energy, comprising in combination, a target positioned to pick up unreflected energy directed at it by said beam, means for altering the spatial position of said target with respect to the source of said radio energy, means for measuring the modulation component of the radiated field produced at said target by said scanning, and means for establishing the bearing of said target from the source of said radio energy.

5. An apparatus for boresighting firing equipment coupled to a directive antenna having a conically scanned radiation pattern, comprising in combination, a target positioned to pick up unreflected radio energy from said antenna, means for altering the bearing of said target relative to said antenna, means to indicate periodic field intensity variations at said target, and optical means coupled to said antenna for aligning said firing equipment with said target.

6. A method for fixedly adjusting the orientation of a target sighting device with respect to the scanning axis of a scanning apparatus in which a directive beam of energy is generated and caused to be projected to scan symmetrically about a mean axis, comprising directing said scan toward a predetermined fixed target, receiving a portion of said energy at said target, obtaining a sensory indication of variations in said received energy, adjusting the mean axis of said scan until said variations are a minimum, and, with the mean axis so adjusted, optically sighting by means of said device from a predetermined point fixedly offset from said mean axis to a predetermined point equally fixedly offset from the center of said target to orient said device along a line having a predetermined relationship with said mean axis.

7. A method as in claim 6 wherein said directive beam is caused to scan conically about said mean axis.

8. In a gun firing system in which a target is tracked in the axis formed by a beam of energy conically scanning a target and in which an optical sight for said system is fixedly mounted on the scanning apparatus and offset a predetermined distance from the radiating element of said apparatus, a method for boresighting the gun system with respect to said axis, comprising scanning a predetermined fixed target, receiving a portion of the energy at said target, obtaining an

indication of variations in said received energy, adjusting the scanning axis until said variations are a minimum, and, while maintaining said adjustment constant, adjusting the orientation of said sight to sight at a fixed point offset from the center of said target by said predetermined distance to orient said sight along a line parallel to said axis.

9. In combination with a radio object-locating system having means for generating a directive beam of energy and means for projecting said beam to scan symmetrically about a mean axis; an optical sight affixed to said latter means and offset therefrom by a predetermined distance, a target antenna positioned to be energized directly by said beam, an optical target in the same plane as said sight, said optical target being affixed to and offset from the center of said target antenna by said predetermined distance and in the same direction as said sight, means for rectifying the energy received by said target antenna, means for indicating variations in said received energy, means for orienting said mean axis until said variations are a minimum whereby, when said optical sight is aligned with said optical target, said sight is positioned in parallel with said mean axis.

10. In combination with a radio object-locating system having means for generating a directive



beam of energy and means for projecting said beam to scan symmetrically about a mean axis; an optical sight affixed to said latter means and offset therefrom by a predetermined distance, a target antenna positioned to be energized directly by said beam, an optical target affixed to and offset from the center of said target antenna, means for rectifying the energy received by said target antenna, means for indicating variations in said received energy, means for orienting said mean axis until said variations are a minimum whereby, when said optical sight is aligned with said optical target, said sight is positioned along a line having a predetermined relationship with said mean axis.

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