

Jan. 30, 1951

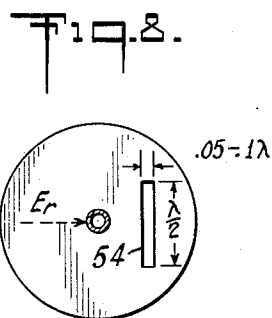
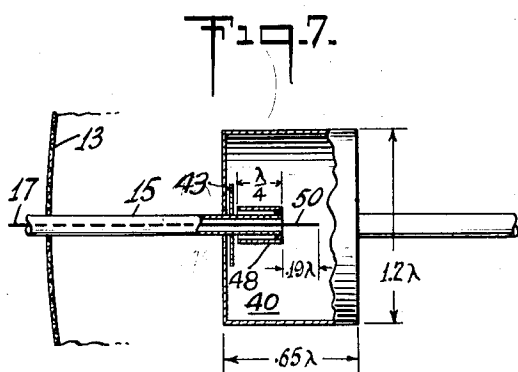
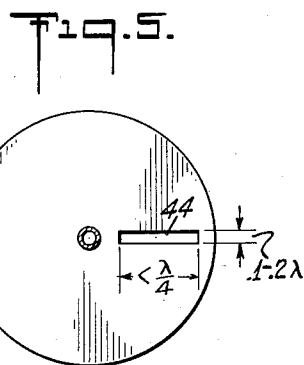
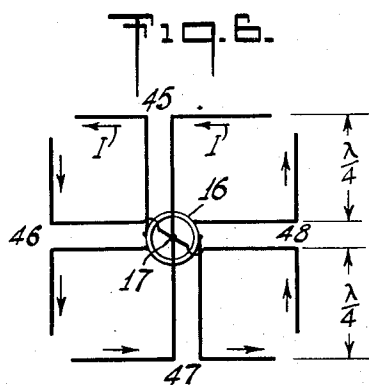
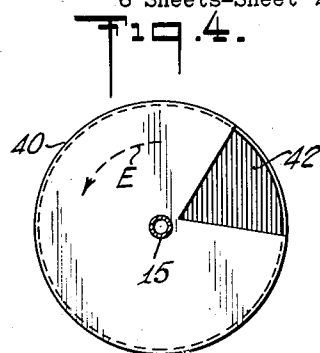
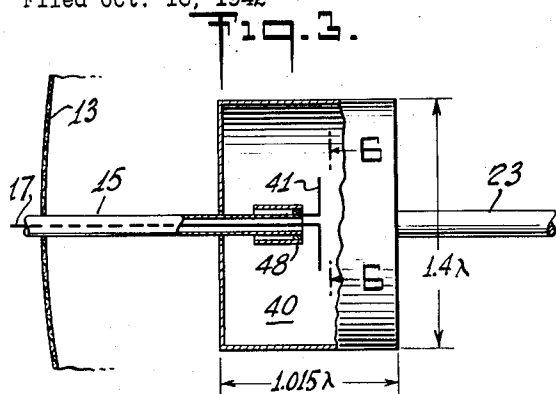
P. S. CARTER

2,539,657

PARABOLIC ANTENNA SYSTEM FOR RADIO LOCATORS

Filed Oct. 16, 1942

6 Sheets-Sheet 2



INVENTOR
PHILIP S. CARTER
 BY *H. S. Grover*
 ATTORNEY

Jan. 30, 1951

P. S. CARTER

2,539,657

PARABOLIC ANTENNA SYSTEM FOR RADIO LOCATORS

Filed Oct. 16, 1942

6 Sheets-Sheet 3

Fig. 9.

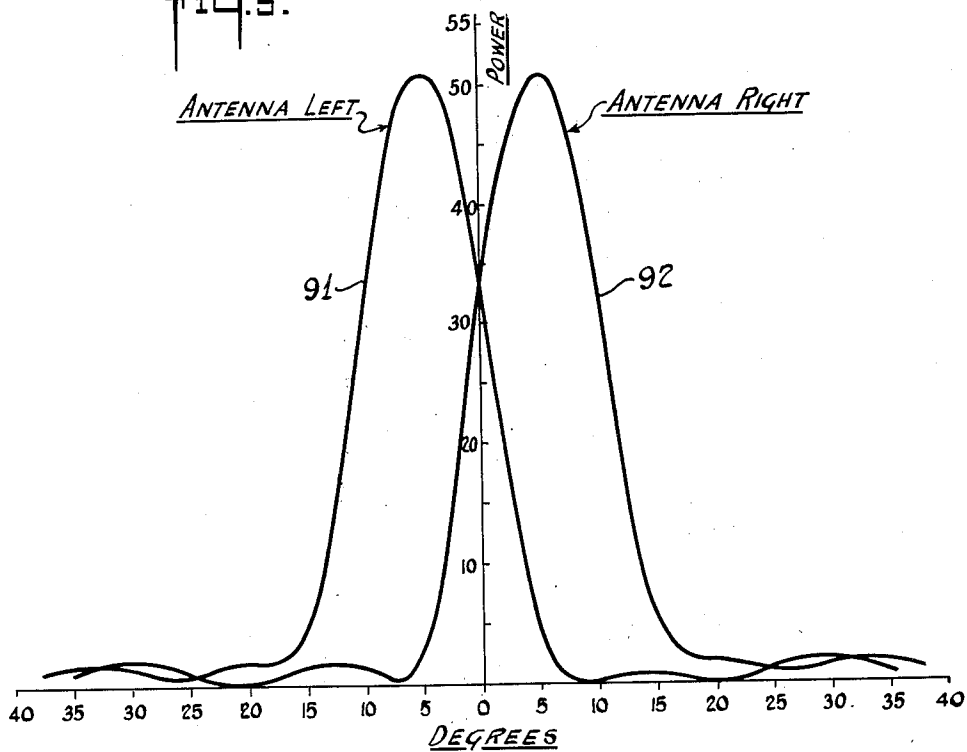
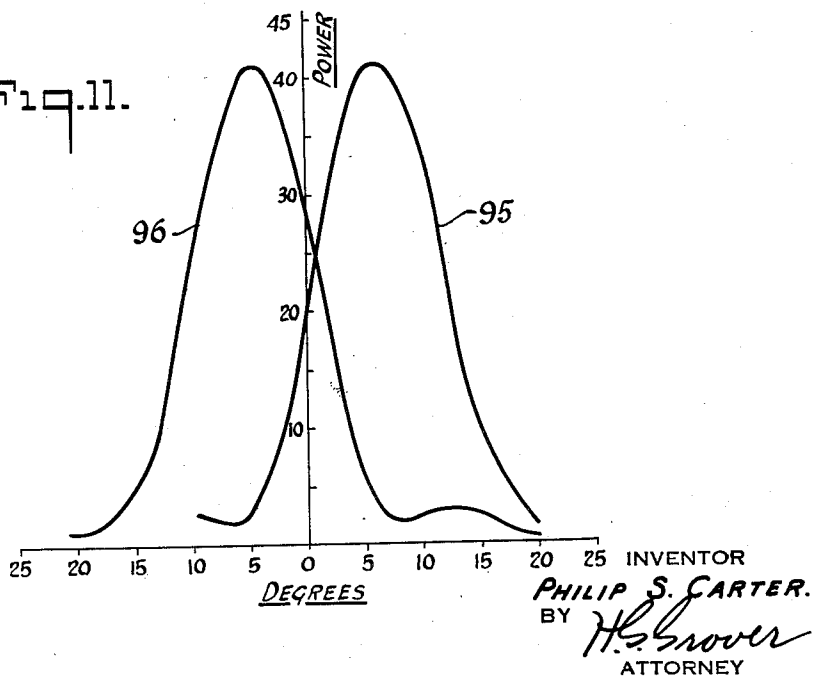


Fig. 11.



Jan. 30, 1951

P. S. CARTER

2,539,657

PARABOLIC ANTENNA SYSTEM FOR RADIO LOCATORS

Filed Oct. 16 1942

6 Sheets-Sheet 4

Fig. 10.

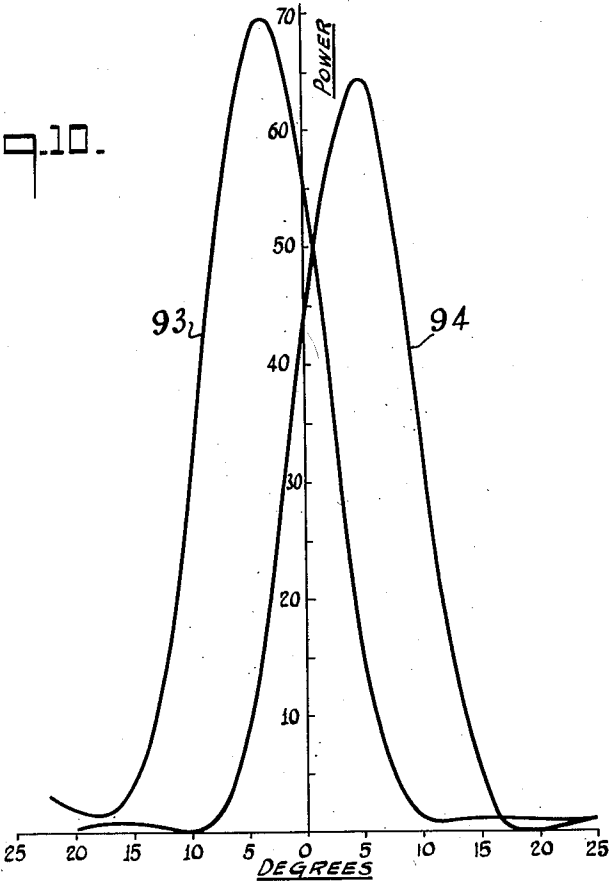
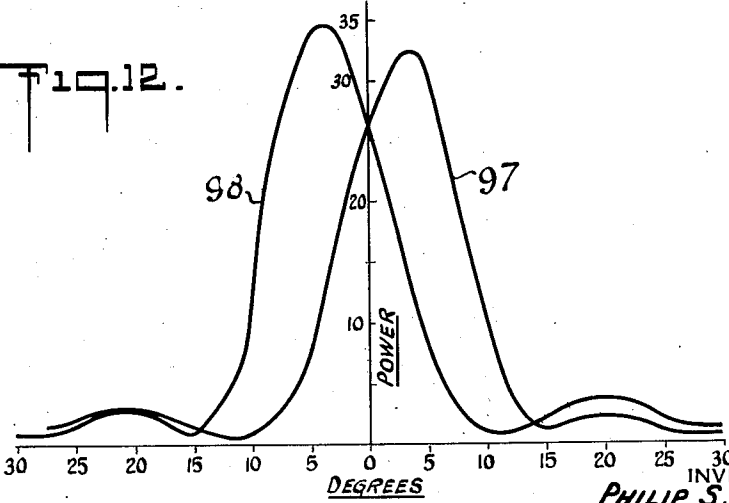


Fig. 12.



INVENTOR
PHILIP S. CARTER
BY *H. S. Brover*
ATTORNEY

Jan. 30, 1951

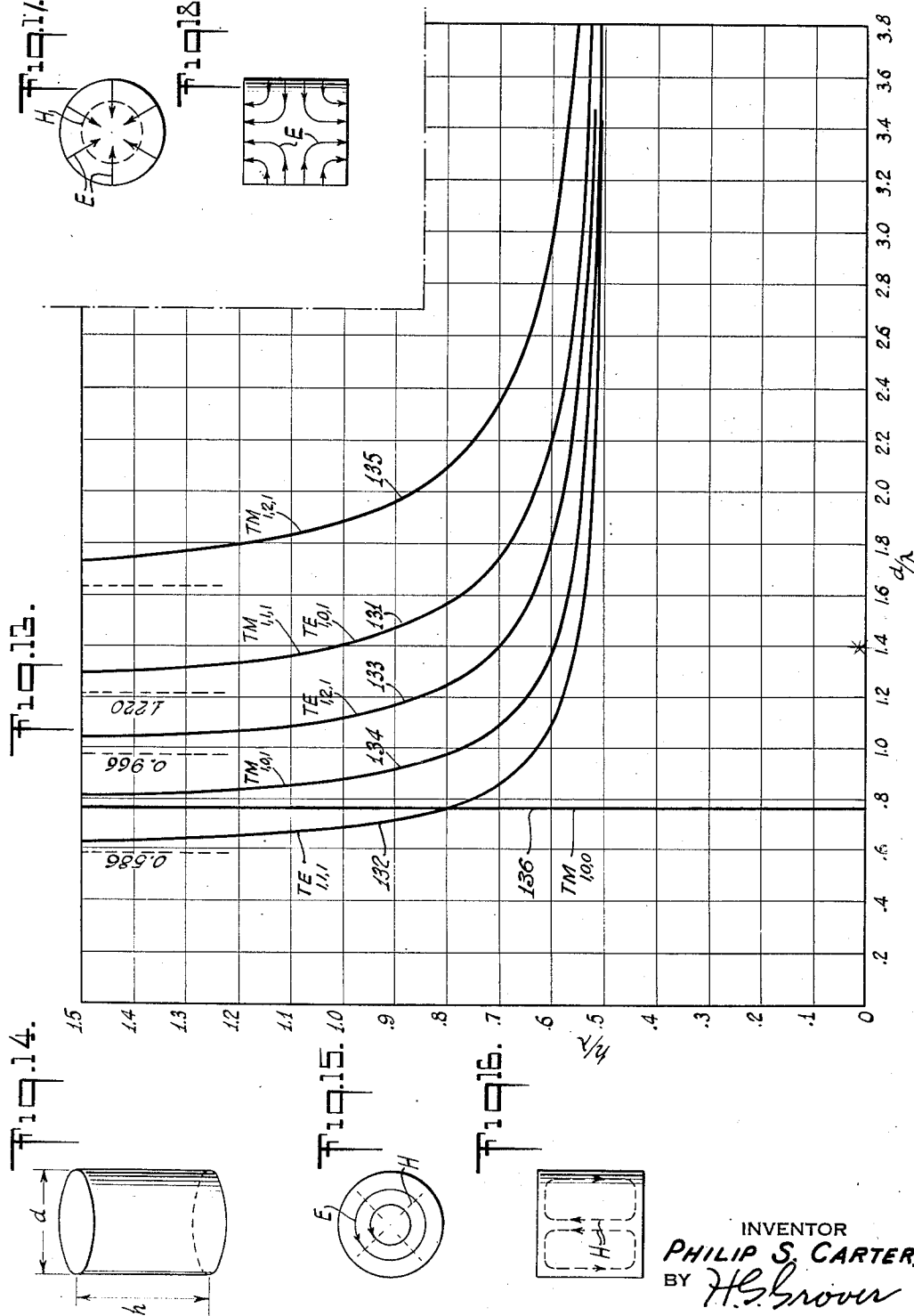
P. S. CARTER

2,539,657

PARABOLIC ANTENNA SYSTEM FOR RADIO LOCATORS

Filed Oct. 16, 1942

6 Sheets-Sheet 5



INVENTOR
PHILIP S. CARTER
 BY *H. S. Grover*
 ATTORNEY

Jan. 30, 1951

P. S. CARTER

2,539,657

PARABOLIC ANTENNA SYSTEM FOR RADIO LOCATORS

Filed Oct. 16, 1942

6 Sheets-Sheet 6

Fig. 27.

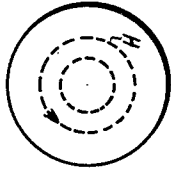


Fig. 28.

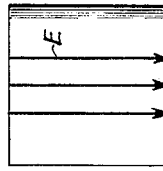


Fig. 29.

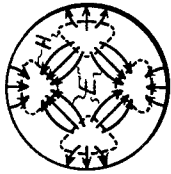


Fig. 26.

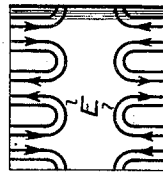


Fig. 23.

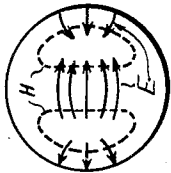


Fig. 24.

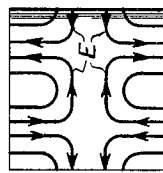


Fig. 21.

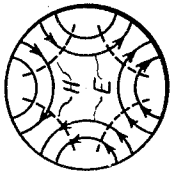


Fig. 22.

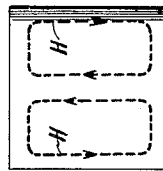


Fig. 19.

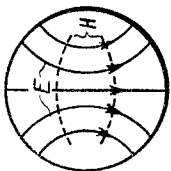
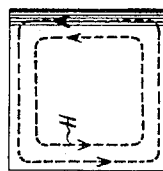


Fig. 20.



INVENTOR
PHILIP S. CARTER
BY *H. Schrover*
ATTORNEY

UNITED STATES PATENT OFFICE

2,539,657

PARABOLIC ANTENNA SYSTEM FOR RADIO LOCATORS

Philip S. Carter, Rocky Point, N. Y., assignor to
Radio Corporation of America, a corporation
of Delaware

Application October 16, 1942, Serial No. 462,251

14 Claims. (Cl. 250—33.65)

1

The present invention relates to antenna systems and, more particularly, to sharply directive antenna arrays for radio locator use.

In obstacle detection systems, sometimes known as radio locators, it has been proposed to cause a small deflection of a radio beam at regular intervals through the four quadrants of a circle which is perpendicularly located to the mean axis of the beam. This may be done by moving the antenna system as a whole or, in accordance with the principles of the present invention, by utilizing a fixed parabolic reflector with a radiating element associated therewith, positioned slightly off the center of the reflector. Thus, an unsymmetrical beam is radiated. The radiating element may then be revolved about the axis of the reflector so that the resultant radio beam is regularly deflected through the four quadrants of the circle perpendicular to the mean axis of the beam.

In accordance with the modification of the present invention, instead of revolving the radiating element itself, a cavity resonator with an eccentrically located slot therein may be revolved, or some deflecting element eccentrically located with respect to the center of the reflector may be used.

In a particular embodiment of the present invention it is contemplated utilizing a parabolic reflector of a foraminous or open mesh metallic construction so that the antenna may be placed over the face of a searchlight, for example, and project a radio beam having a mean axis aligned with the line of light from the searchlight. Due to the open mesh metallic construction of the reflector and the comparatively small size of the remainder of the elements of the antenna very little light is cut off from the searchlight beam. The antenna as thus described may be used with a transmitter for transmitting periodically repeated radio wave impulses of extremely short duration. Due to the high directivity of the antenna to which the transmitter is connected, pulses are returned from objects lying within a narrow range of angles with respect to the mean axis of the radio beam and, also, of course, of the searchlight. The transmitter may be generally of the type described in application, Serial #441,311, filed May 1, 1942, by Mr. N. E. Lindblad, now U. S. Patent 2,411,140, issued November 12, 1946. In this transmitter an oscillator is excited periodically through a spark gap switching device which is in series with the oscillator and a charging voltage source and to which is supplied at periodic intervals a voltage

2

of sufficient value to break down the gap. The copending application of C. W. Hansell, Serial #427,266, filed January 19, 1942, now U. S. Patent 2,455,673, issued December 7, 1948, also describes generally the principles of the radio locating system to which the present invention may be applied.

The radiating element of the antenna of the present invention which, as before stated, is eccentrically positioned with respect to the parabolic reflector, is preferably revolved by a two-pole synchronous motor at a rate of about 60 rotations per second. The entire system is designed to radiate a pulse of ultra-high frequency energy in each of the four quadrants of the circle travelled by the radiating element in each revolution. At a speed of 60 revolutions per second the pulses will be radiated 240 times per second, corresponding to a pulse for each quadrant position of the beam for each revolution of the antenna. The up and down beam firing positions of the radiating element determine the vertical position of the object to be detected, while the right and left beam firing positions of the radiating element determine the horizontal positions. The radiating patterns or lobes of the beam will, of course, be different for different quadrants of the circle as the radiating element revolves. However, the antenna system is so designed that the lobes of the radiation patterns overlap in the up and down beam firing positions and, also, in the right and left beam firing positions. The reflected pulses which are received are viewed on a pair of cathode ray oscilloscopes, one of which indicates the pulses received during the up and down positions of the revolving radiating element and the other of which indicates the pulses received during the right and left positions of the revolving radiating element. The impulses shown on each oscilloscope may thus easily be compared in amplitude.

Since the time interval between radiated pulses is quite long compared to the time of each pulse it will be understood that a pulse reflected by a remote object to be detected will be received at the receiver located adjacent to the transmitter during the same quadrant of revolution in which the original pulse was radiated. If pulses which are reflected from a remote object are radiated in the up and down positions of the revolving radiating element they will be received during the same up and down positions. If these received impulses are of equal intensity, it follows that the vertical plane of the antenna system is pointed

at the object. Likewise, if reflected pulses received during the right and left positions of the revolving radiating element are also of equal intensity it follows that the horizontal plane of the antenna system is also pointed at the object. Under these conditions the object is directly on the mean axis of the radiation patterns of the antenna system. Since the axis of the parabolic reflector of the antenna is coincident with the light beam from the searchlight with which it is associated, the searchlight will illuminate the object when turned on after locating the target. If the received pulses reflected from the objects are of unequal intensity it is an indication that the antenna and the searchlight is not pointing directly at the object but to one side of the object.

In the foregoing description it has been assumed, for convenience in description, that the system is so arranged that the axis of the beam is more or less horizontal. In actual practice, of course, the axis may be directed upwardly at angles nearly vertical so that there are in reality no actual up and down positions of the radiator. The operation, however, is the same.

In the system as so far described it is desirable that the feed lines to the antenna itself from the transmitter be fixedly located and, if possible, contain no sliding contacts which would tend to introduce difficulties in actual service.

An object, therefore, of the present invention is to provide a revolving radiator for an antenna system in which no sliding contacts are involved.

Another object of the present invention is the provision of a highly directive antenna system which may be placed over the face of a searchlight without obscuring a substantial amount of light therefrom.

A further object of the present invention is the provision of an antenna system for producing a sharply directive radio beam which is regularly deflected through four quadrants of a circle perpendicular to the main axis of the beam.

Still another object of the present invention is the provision of a novel means for energizing a directive antenna structure from a source of high frequency energy.

Still a further object of the present invention is the provision of an antenna system for radio locators.

The foregoing objects, and others which may appear from the following detailed description, are attained in accordance with the principles of the present invention by providing a radiating element which is eccentrically located with respect to the axis of symmetry of an open mesh parabolic reflector and providing capacitive coupling means between the revolving portions of the radiating element and a fixed transmission line.

In a modification of the present invention a rotating cavity resonator is employed, the said resonator having a slot therein eccentrically located with respect to the axis of symmetry of the parabolic reflector and serving in place of the radiating element.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which Figure 1 is a view in elevation and partly in section illustrating an embodiment of the present invention, while Figure 2 is a fragmentary view illustrating a modification of a portion of the structure of Figure 1, while Figures 3, 4, 5, 6, 7 and 8 illustrate further modifications of portions of the structure of Figure 1, Figures 9, 10, 11 and

12 are curves illustrating the directivity patterns obtained by the antenna structures of Figures 1 to 8, inclusive, in two diametrically opposed positions of the eccentrically located radiating element, Figure 13 is a group of curves useful in determining the dimensions of the cavity resonators, such as that shown in perspective in Figure 14, while Figures 15 to 28 are diagrams of the field distribution within the resonator of Figure 14 for certain modes of oscillation.

In the form of the present invention shown in Figure 1, a parabolic reflector 13 is shown. The reflector is preferably formed of an open metallic mesh construction so that a searchlight beam may be transmitted therethrough without substantial losses of light. Along the axis of symmetry of the reflector 13 is located a concentric transmission line 15 having an outer shell 16 and an inner conductor 17. The transmission line 15 is terminated near the focus of the reflector by a conductive disc 19 connected to the inner conductor 17. The outer conductor 16 is terminated just short of conductive disc 19, the space X between the end of the outer conductor 16 and the disc 19 being as small as possible. Coaxially located with respect to the transmission line 15 and disc 19 is a second disc 21 bearing at one point on its periphery a radiating element 22. The effective radius of radiating element 22 from the center of disc 21 to the extreme end is preferably of the order of .57 wavelength. The disc 21 is carried by a shaft 23 so that it may be rotated by motor 25. Motor 25 is supported in position by supporting rods 26 running from the edges of the reflector 13. Between motor 25 and radiating element 22 at a distance from the radiating element 22 of approximately a quarter wavelength is located a reflecting disc 27 having a diameter of a wavelength or more. The purpose of the reflecting disc 27 is to direct the radiation from radiator 22 primarily in the direction of the reflector 13, thus increasing the sharpness of the beam radiated from the antenna. The reflecting disc 27 may be conveniently supported in place by a sleeve 27', which surrounds shaft 23 and is attached at one end to disc 27 and at the other end to the shell of motor 25. Now it is apparent that if the transmission line 15 is energized by a source of high frequency energy and the radiator 22 is in the position shown a sharply directive beam will be radiated from the antenna, the axis of the beam being displaced slightly to one side of the axis of the reflector 13. A typical directivity is shown in Figure 9, curve 91. Now, if the shaft 23, bearing radiator 22, is rotated through 180 degrees, the beam will be oppositely displaced from the axis of the reflector as indicated by curve 92 in Figure 9. It will be seen that the two curves are symmetrically disposed with respect to the zero axis, crossing the axis at about two-thirds of the peak value. Thus, as the radiating element 22 is revolved through the four quadrants of the circle in which it travels the radiating beam will likewise be revolved about the axis of symmetry of reflector 13.

In order to prevent the flow of high frequency energy along the outside of conductor 16 of transmission line 15 a pair of conducting sleeves 28, and being spaced apart a half wavelength, each having a length equal to a quarter of the operating wavelength, are provided along outer conductor 16. These sleeves effectively present high impedance points along the outer conductor 16 so that the flow of high frequency energy therealong is greatly attenuated. Likewise, to atten-

5

uate the flow of high frequency energy between disc 21, and disc 27 a quarter wave isolating sleeve 29 is provided about the shaft 23.

In the modification shown in Figure 2 the motor 25 is located back of instead of in front of the parabolic reflector 13, of which only a part is shown. In this modification, the motor rotates the center conductor 37 of transmission line 15. A radiating element 32, having a length equal to .47 wavelength, is directly connected to and carried by the outer end of the inner conductor 37. High frequency energy from a source (not shown) is applied to the inner conductor 37 through the intermediary of a transmission line TL. The inner conductor 37 of line TL is connected to a sleeve 39 surrounding but not contacting inner conductor 37 while the outer shell 36 of the transmission line is directly connected to outer shell 16. Since the sleeve 39 is closely adjacent to but not in contact with conductor 37 only a capacitive connection exists between conductors 37 and 39 for the transference of the energy to be radiated. There are no sliding contacts involved and thus no possibility of wear introducing poor contacts, noise, etc. The point of connection of inner conductor 38 to sleeve 39 is placed a distance equal to a quarter of the operating wavelength from that end of transmission line 15 which is connected to motor 25. This quarter wave spacing prevents the metallic connection of conductor 37 to outer conductor 16 at the motor casing from short-circuiting the transmission line. Within the reflector, trap sleeves 28 are provided as described with reference to Figure 1.

The modification of the present invention, shown partly in section in Figure 3 and in an end view in Figure 4, utilizes the same relative positioning of the transmission line 15 and the motor as that of Figure 1. For the purposes of simplification only a fragment of reflector 13 is shown and the motor itself has been omitted. This modification, instead of rotating a condenser disc, differs from that of Figure 1 in that the shaft 23, rotates a cylindrical cavity resonator generally designated by reference character 40 about its axis of revolution. Cavity resonator 40 is entirely closed except for a central aperture for transmission line 15 and an output aperture 42 (Figure 4) in the end adjacent reflector 13, by means of which the electric field within the resonator is allowed to escape to form the radiated beam. The amount of loading of the resonator 40 may be adjusted to the desired value by a variation in the size of the aperture 42. Within the cavity resonator 40 the transmission line 15 terminates in a radiator assembly 41 for exciting the interior of the resonator with transverse electric waves of the mode where the electric force is in coaxial circles, as indicated by dotted arrow E (Figure 4). The field distribution is also shown in Figures 15 and 16. For cavity resonator 40 to be energized with a transverse electric wave of this type it is desirable that the radiator 41 be symmetrical about the rotational axis of resonator 40 and that the currents in radiator 41 flow circumferentially. These requirements may be met by utilizing a plurality of half wave dipoles 45, 46, 47 and 48 (Figure 6), arranged tangent to a common circle having its center coaxial with the center of resonator 40 and in a single plane. Each dipole is energized at its midpoint by connections to the conductors of transmission line such that alternate halves of the dipoles 45 to 48 are connected to inner con-

6

ductor 17 of transmission line 15 and the remaining halves are connected to the outer shell 16. So arranged and so energized, the currents at a given instant in the dipoles are all in the same direction, as shown by the arrows I.

In order to prevent stray uniformly distributed radiation caused by the escape of energy from resonator 40 around outer conductor 16, a trap sleeve 48 similar in construction and dimensions to trap sleeves 28 of Figures 1 and 2 may be provided within resonator 40. If such a trap is provided and the aperture through which line 15 passes is small enough very little stray radiation occurs. The dimensions of resonator 40 are so chosen that the interior space is resonant to the particular frequency used. Within limits, either the diameter or the length may be arbitrarily chosen and the other determined from the laws governing cavity resonance.

A family of curves is shown in Figure 13 giving the relationship between the diameter d and length h of a cylindrical cavity resonator 40, shown in perspective in Figure 14. Curves 131, 132 and 133 apply to a cavity resonator excited by a wave having a transverse electric component of the lowest or zero order, the first order and the second order, while curves 134, 131 and 135 apply to a cavity resonator excited by a wave having transverse magnetic components of several different orders. Each curve is also identified by the letters TE or TM indicating that the mode of oscillation is transverse electric or magnetic, respectively, and subscript numerals giving the harmonic orders of the wave in each coordinate. Thus the first subscript numeral gives the characteristic of the wave in the radial direction; the second subscript the characteristic in the direction of radiation and the third in the characteristic in the axial direction. For illustration in the (1,0,1) mode there would be a single half oscillation radially, no variation angularly and a half oscillation axially.

As an example of the application of the curves, suppose that the cavity resonator 40 is to be excited with the zero or lowest order of wave having a transverse electric component. The distribution of the field is indicated in Figures 15 and 16, Figure 15 indicating by closed circular arrows E the transverse electric field, and Figure 16 indicating by the closed loop arrows H the longitudinal magnetic field. If the ratio of the diameter to the wavelength is arbitrarily chosen as 1.4, then from curve 131 it may be seen that the ratio of height h to the wavelength is 1.015. In practice, the dimensions are somewhat modified by the size of the loading aperture. In the same way, curve 132 may be used for determining appropriate dimensions for oscillation with first order or TE_{1,1,1} waves having a field distribution, as indicated in Figures 19 and 20, while curve 133 applies to second order waves. The field distribution, both magnetic and electric, is indicated in Figures 21 and 22.

The directivity patterns for a parabolic reflector using a cavity resonator radiator for positions of the aperture to the right and left of the axis are given in Figure 10 by curves 93 and 94.

The slight dissymmetry appearing in the curves may be due to the center of rotation of the resonator being slightly off the axis of reflector 13. This may be corrected by appropriate adjustment and is therefore not serious. On the other hand, the presence of one or more large supplementary lobes in the patterns would be considered disad-

vantageous due to the possibility of an erroneous direction indication.

Under some circumstances it may be more desirable to utilize, instead of a triangular aperture, a narrow radial slot such as that shown at 44 in Figure 5. Extensive experimentation has established that the most satisfactory results may be obtained with radial slot 44 when the width is of the order of .1 to .2 wavelength and the radial length is of the order of a half wavelength, or slightly less. The radial slot results in directivity patterns to the right and left as indicated by curves 95 and 96 of Figure 11.

Figures 7 and 8 illustrate a further modification of the present invention also utilizing a cavity resonator. However, in this case the cavity resonator is arranged to be excited by a radial electric field, as indicated by dotted arrow E_r in Figure 8. This is accomplished by means of an extending portion 50 of inner conductor 17. The extending portion 50 preferably has a length of about .19 wavelength. With this type of energization of the cavity resonator 40 the loading slot must be arranged transverse to the radius of resonator 40, as indicated in Figure 3 wherein slot 54 is so arranged. The dimensions of slot 54 for optimum results are substantially the same order of magnitude as those for slot 44 of Figure 5.

The dimensions of the resonator 40 of Figure 7 are determined in the same general way as for that of Figure 3, but by a different law so that curves 134, 131 and 135 of Figure 13 apply.

Thus, if the cavity is to be excited by the lowest order transverse magnetic wave or $TM_{1,0,1}$ wave wherein the magnetic field distribution in a transverse plane is indicated by arrows H of Figure 17 and the electric field in a longitudinal plane by arrows E of Figure 18, curve 134 is used. Since it will be noted that the ratio of height to wavelength increases enormously for small ratios of diameter to wavelength, the latter is so chosen as to give a ratio of 1.2, then the ratio of height to wavelength becomes about .65.

Similarly, curves 131 and 135 may be used for higher orders of transverse magnetic waves. Curve 131 applies to the first order or $TM_{1,1,1}$ wave having a field distribution as indicated in Figures 23 and 24, while wave 135 applies to the second order or $TM_{1,2,1}$ wave wherein the electric and magnetic field components are described as indicated in Figures 25 and 26. Line 136 of Figure 13 applies to the $TM_{1,0,0}$ mode of oscillation wherein the field distribution is as shown in Figures 27 and 28. The electric field in this case extends from an end plate to the other and is independent of the length.

In Figure 7 I have shown an additional means which may be used for preventing the escape of radiation through the aperture for transmission line 15. A conductive disc 43 is fastened to the transmission line 15 just inside of the resonator 40. The radius of disc 43 and the spacing from the end is such that no energy escapes from cavity 40 except through slot 54. In many cases it will be found unnecessary to employ high impedance sleeves such as 48 when disc 43 is used. However, as a practical matter the disc is less convenient to use than the high impedance sleeve 48 when radial or sectoral loading apertures are used.

The radiation patterns for the structure of Figures 7 and 8 with the slot 54 in positions to the right and left of center are shown by curves 97 and 98 of Figure 12.

It should be noted that the power scales of

Figures 9 to 12 are not necessarily drawn to the same relative values so the figures cannot be compared one with the other.

While I have particularly shown and described several modifications of my invention, it is to be distinctly understood that my invention is not limited thereto but that improvements within the scope of the invention may be made.

I claim:

1. In an antenna system, a radiating member arranged radially with respect to and carried by a rotatable shaft at one end thereof and capacitive coupling means for connecting energy transducer means thereto.

2. In an antenna system, a radiating member arranged radially with respect to and carried by a rotatable shaft at one end thereof, a first condenser disc also carried by said end of said shaft, a second condenser disc concentric with said first disc and closely adjacent thereto and a transmission line having a conductor thereof connected to said second disc for coupling said radiator to a transducer means.

3. In an antenna system, a radiating member arranged radially with respect to and carried by a rotatable shaft at one end thereof, a first condenser disc also carried by said end of said shaft, a second condenser disc concentric with said first disc and closely adjacent thereto and a transmission line having an outer casing and an inner conductor arranged coaxially with respect to said shaft, said second disc being carried by said inner conductor and energy transducer means coupled to the other end of said transmission line.

4. In an antenna system, a radiating member arranged radially with respect to and carried by a rotatable shaft at one end thereof, a first condenser disc also carried by said end of said shaft, a second condenser disc also carried by said end of said shaft, a second condenser disc concentric with said first disc and closely adjacent thereto and a transmission line having an outer casing and an inner conductor arranged coaxially with respect to said shaft, said second disc being carried by said inner conductor and energy transducer means coupled to the other end of said transmission line, and means for preventing the flow of high frequency energy along the outside of said line.

5. An antenna system including a cylindrical cavity resonator adapted to be rotated about its longitudinal axis, said resonator having an eccentrically located aperture in one end wall thereof and means for introducing high frequency energy into said resonator, including a transmission line having an inner conductor and an outer shell coaxially arranged with respect to said resonator and passing through an end wall thereof.

6. An antenna system including a cylindrical cavity resonator adapted to be rotated about its longitudinal axis, said resonator having an eccentrically located aperture in one end wall thereof and means for introducing high frequency energy into said resonator, including a transmission line having an inner conductor and an outer shell coaxially arranged with respect to said resonator and passing through an end wall thereof, said inner conductor extending beyond said outer shell within said resonator a distance of the order of .2 wavelength whereby a radial electric field and circular magnetic field is set up within said resonator, said eccentrically located aperture being in the form of a narrow

slit having its length normal to a radius of said end wall.

7. An antenna system including a cylindrical cavity resonator adapted to be rotated about its longitudinal axis, said resonator having an eccentrically located aperture in one end wall thereof and means for introducing high frequency energy into said resonator, including a transmission line having an inner conductor and an outer shell coaxially arranged with respect to said resonator and passing through an end wall thereof, a plurality of dipoles arranged tangent to a common circle concentric with the axis of rotation of said resonator whereby a transverse electric field of the circular type is set up within said resonator.

8. An antenna system including a cylindrical cavity resonator adapted to be rotated about its longitudinal axis, said resonator having an eccentrically located aperture in one end wall thereof and means for introducing high frequency energy into said resonator, including a transmission line having an inner conductor and an outer shell coaxially arranged with respect to said resonator and passing through an end wall thereof, a plurality of dipoles arranged tangent to a common circle concentric with the axis of rotation of said resonator whereby a transverse electric field of the circular type is set up within said resonator, said eccentrically located aperture being sector-shaped.

9. An antenna system including a cylindrical cavity resonator adapted to be rotated about its longitudinal axis, said resonator having an eccentrically located aperture in one end wall thereof and means for introducing high frequency energy into said resonator, including a transmission line having an inner conductor and an outer shell coaxially arranged with respect to said resonator and passing through an end wall thereof, a plurality of dipoles arranged tangent to a common circle concentric with the axis of rotation of said resonator whereby a transverse electric field of the coaxial circle type is set up within said resonator, said eccentrically located aperture being in the form of a narrow radial slit.

10. In combination with a cylindrical cavity resonator, a concentric transmission line extending through an end wall of said resonator and arranged along the axis thereof, the inner conductor of said transmission line extending beyond the outer shell thereof to couple said transmission line to the interior of said resonator, and means for preventing current flow along the outside of said line, including a conductive disc connected to and surrounding said outer shell of said line and arranged closely adjacent to said wall of said resonator.

11. In combination with a cylindrical cavity

resonator, a concentric transmission line extending through an end wall of said resonator and arranged along the axis thereof, a plurality of dipole radiators arranged tangent to a circle about the end of said line and in a plane normal to the plane of said line, said radiators being so coupled to the conductors of said line that the instantaneous current flow is in the same direction in all of said dipoles.

12. In combination with a cylindrical cavity resonator, a concentric transmission line extending through an end wall of said resonator and arranged along the axis thereof, a plurality of dipole radiators arranged tangent to a circle about the end of said line and in a plane normal to the plane of said line, said radiators being so coupled to the conductors of said line that the instantaneous current flow is in the same direction in all of said dipoles, and means for preventing current flow along the outside of said line, including a quarter wave shell surrounding and connected to the end of said line.

13. An antenna system including a foraminous parabolic reflector adapted to be arranged over the face of a search light and radiating means associated therewith, said radiating means being eccentrically located with respect to the axis of said reflector whereby energy is radiated from said system at an angle to said axis and means for regularly moving said radiating means around said axis, said radiating means including a cavity resonator adapted to be revolved about said axis and having an aperture eccentrically located with respect to said axis and facing said parabolic reflector.

14. An antenna system including wave directive structure and radiating means including a cavity resonator associated therewith, said cavity resonator having an aperture eccentrically located with respect to the axis of and facing said wave directive structure, and means to revolve said resonator about said axis to radiate a beam of energy from said system having the maximum energy thereof projected at an angle to said axis.

PHILIP S. CARTER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,828,705	Kolster	Oct. 20, 1931
2,083,242	Runge	June 8, 1937
2,262,020	Llewellyn	Nov. 11, 1941
2,281,550	Barrow	May 5, 1942

FOREIGN PATENTS

Number	Country	Date
450,484	Great Britain	July 20, 1936