

Feb. 4, 1947.

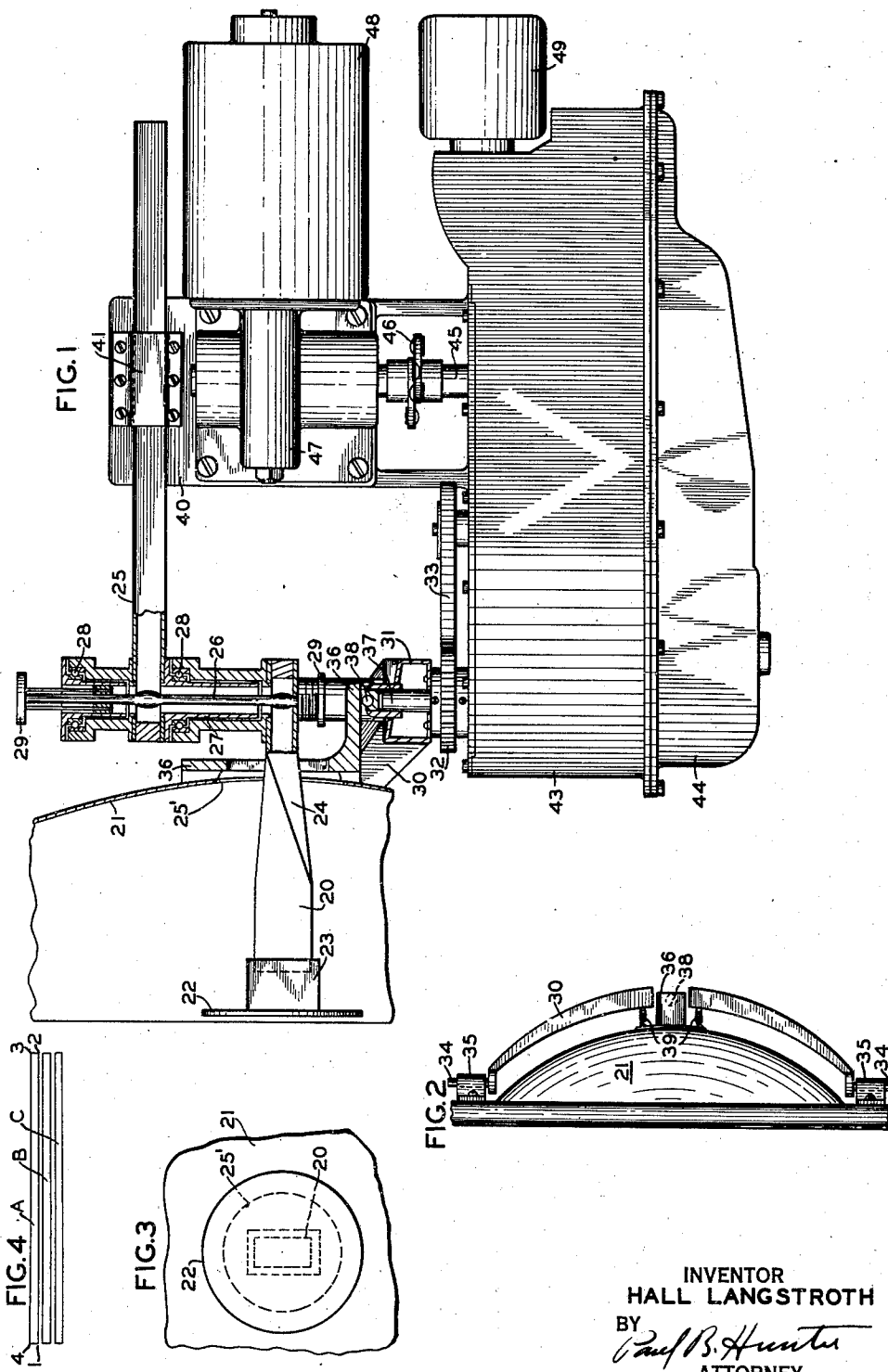
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2,415,103

DIRECTIVE ANTENNA STRUCTURE

Filed April 20, 1942

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

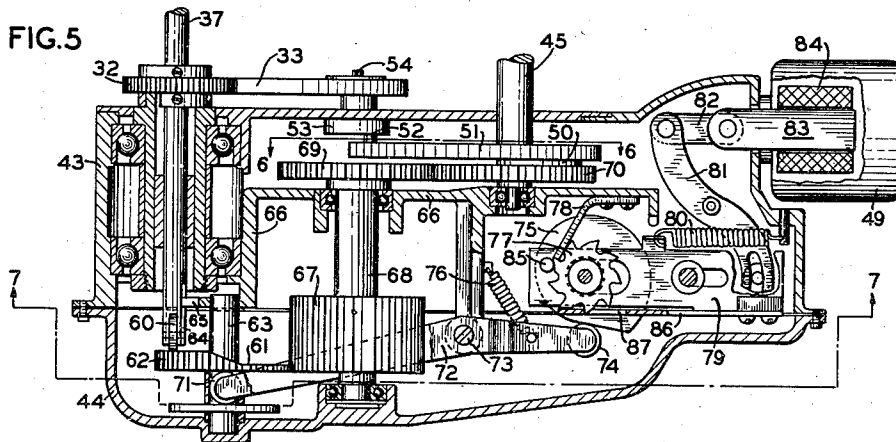


FIG. 6

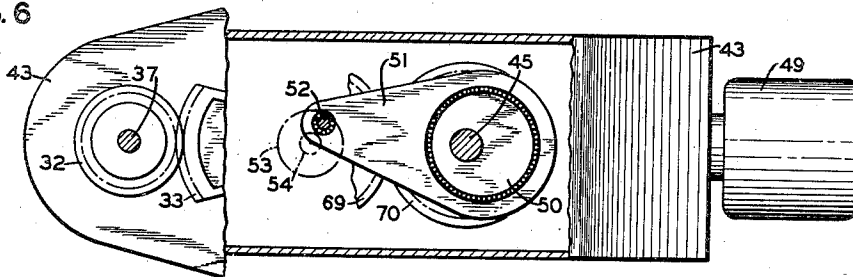
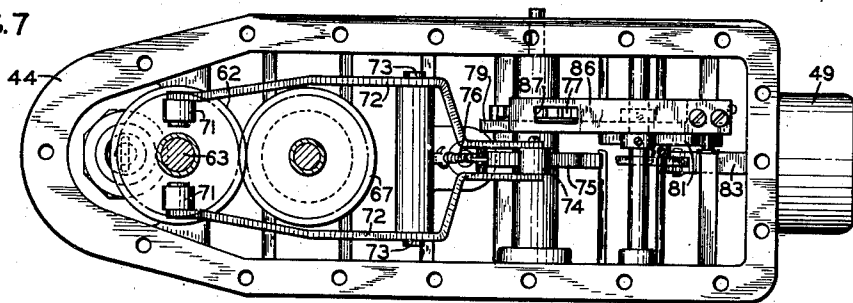


FIG. 7



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3 Sheets-Sheet 3

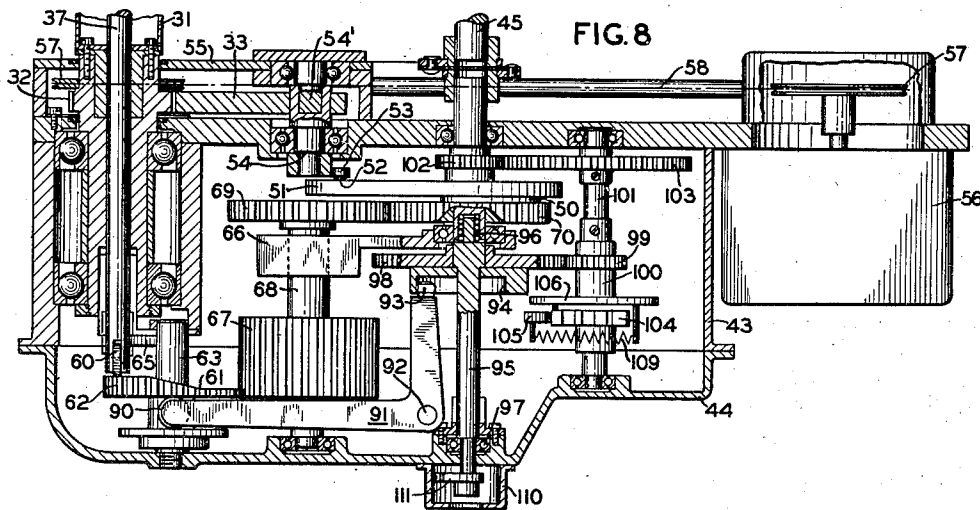


FIG. 8

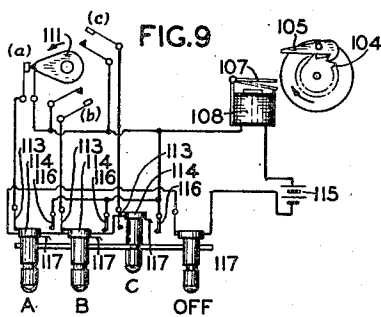


FIG. 9

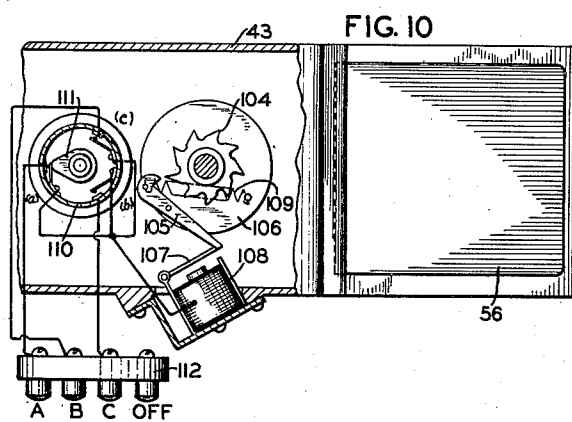


FIG. 10

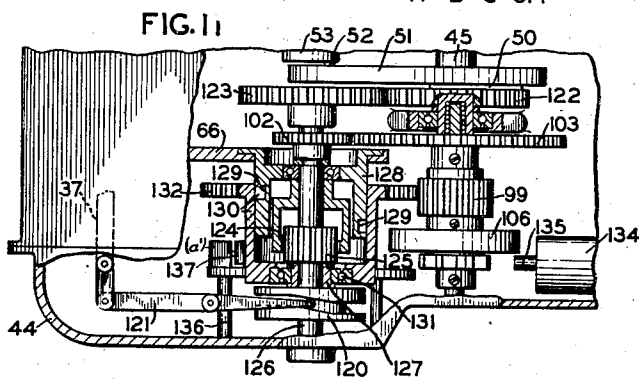


FIG. 11

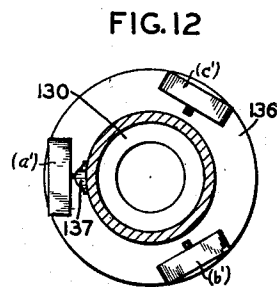


FIG. 12

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2,415,103

DIRECTIVE ANTENNA STRUCTURE

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Application April 20, 1942, Serial No. 439,708

15 Claims. (Cl. 250—11)

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This invention relates to radio scanning apparatus in the form of a directive antenna by which high frequency electromagnetic energy is either transmitted or received. More particularly the invention concerns the mechanism and structural arrangements provided for directing the antenna and causing the same to scan a cyclically repeated pattern in space of substantially rectangular cross-section.

In the embodiment of the invention shown in the drawings, the antenna structure or scanning apparatus includes a radiator of high frequency electromagnetic energy in the form of a wave guide and a reflector of the parabolic type which cooperates with the radiator. A suitable deflector is employed, in the instant case, to obtain the desired cooperation of the radiator and reflector. Other forms of radiators and reflectors may obviously be employed, however, without departing from the inventive concepts herewith disclosed. In accordance with the teaching of the invention the radiator and reflector of the apparatus are arranged to move together about a particular axis. The reflector is also arranged to move independently of the radiator about an axis at right angles to the axis about which both parts move. The extent of movement of the reflector of the structure about its independent axis defines the nod angle of the antenna and the height of the repeatedly scanned rectangular space pattern. The width of the pattern is defined by the length of the arc through which both the radiator and reflector move together.

One of the features of the invention resides in the arrangement of the radiator and reflector of the antenna by which the same are supported for movement about a common axis.

Another feature of the invention is contained in the provision of an intermittently effective means for changing the angle of nod of the reflector alone without interfering with the continuity of the joint movement of the reflector and radiator.

A further feature of the invention consists in the utilization of a separate control means for the reflector by which the apparatus scans a cyclically repeated space pattern of substantially rectangular cross-section at any of a number of different elevations.

Another feature of the invention is provided by a selective controlling means for positioning the antenna to scan at any desired one of the number of obtainable different elevations.

Other features and structural details of the invention will be apparent from the following de-

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scription when read in connection with the accompanying drawings, wherein

Fig. 1 is a side elevation assembly and part sectional view of a radio scanning apparatus constructed in accordance with the present invention.

Fig. 2 is a detail plan view reduced in scale of the reflector of the improved directive antenna.

Fig. 3 is a part front elevation of the reflector showing the deflector plate preferably included in the present antenna structure.

Fig. 4 is a transverse sectional view showing in a diagrammatic form the shape of the space patterns scanned by the improved apparatus.

Fig. 5 is a detail vertical cross-section showing the mechanism contained within the casing structure illustrated in Fig. 1.

Fig. 6 is a sectional view taken on line 6—6, in Fig. 5.

Fig. 7 is a sectional view taken on line 7—7, in Fig. 5.

Fig. 8 is a view similar to Fig. 5 showing a modified form of control mechanism for the antenna.

Fig. 9 is a wiring diagram and schematic view illustrating the selective means for positioning the antenna to scan at a particular one of the different scanning elevations at which it is operative.

Fig. 10 is a detail horizontal cross-section showing the arrangement of the relay illustrated in Fig. 9 in the casing of the apparatus.

Fig. 11 is a view similar to Fig. 5 illustrating a further modified form of the control mechanism of the present invention, and

Fig. 12 is a detail plan view of a portion of the mechanism illustrated in Fig. 11.

With reference to the drawings and particularly to Figs. 1 to 3, inclusive, the directive antenna illustratively shown therein includes a means for radiating high frequency electromagnetic energy in the form of a radiator 20 provided, in the instant case, by a tubular wave guide. Means are also provided to cooperate with the radiator 20 for the purpose of reflecting the energy issuing therefrom and directing the same into space with as little loss as possible. As shown in the drawings, a parabolic reflector 21 may be employed in this connection. To assist in the transfer of energy between the radiator and reflector, a deflector as designated at 22 may also be employed. Such an element, as shown in the drawings, may take the form of a conducting plate which is positioned at the approximate focal point of the reflector and shown

mounted on the projecting open end of the wave guide by means of a coupling piece 23 which is made of a suitable dielectric material. As shown, wave guide 20 is turned through an angle of 90° about its longitudinal axis as indicated at 24 for the purpose in the instant case of changing the plane of polarization of the electromagnetic energy from a vertical position to a horizontal position in which last named position the energy issues from the open end of the wave guide. In carrying out the provisions of the invention, it will be noted that the radiator 20 or wave guide projects through a circular opening 25' in the reflector 21 so that the parts may be mounted for relative movement with respect to one another as well as for joint movement with one another.

The supporting means for the reflector 21 includes a yoke 30 whose central portion 31 is suitably fixed to a driving gear 32 which is mounted to move or oscillate about a vertical axis. A sector gear 33 which meshes with gear 32 provides the means for sweeping the reflector about its vertical axis of support as hereinafter more particularly described. As shown in Fig. 2, the reflector is pivotally mounted about a horizontal axis by means of suitable trunnions 34 which extend from the respective ends of the yoke 30, the trunnions being journaled in bearing members 35 fixed to the rear frame of the reflector. The reflector is independently supported about its trunnion defined nod axis and is positioned thereabout by means of a cooperating bracket 36 and transversely movable rod 37 whose top portion is constructed to contain a thrust bearing member 38. The reflector is a paraboloid whose axis of symmetry is situated normal to its nod axis by the supporting or mounting means of the antenna. The focal point of the reflector is along its axis of symmetry. The inwardly disposed face of the bracket 36 rests on the bearing member 38 and is yieldingly retained against the member by means such as springs 39; Fig. 2. One end of the respective springs 39 employed is connected to the fixed yoke 30 and the other end is suitably secured to the rear face of the reflector 21. It will now be seen that the yoke 30 and reflector 21 are movable together about the axis of the gear 32 and that the reflector is movable relative to the radiator about an axis at right angles to the gear axis. In accordance with the teaching of the present invention, the reflector is arranged to move relative to the radiator about an axis that is normal to the vertical axis of the antenna and to the axis of symmetry of the reflector itself. The nod or horizontal axis of the reflector is situated in offset relation to the vertical axis of the antenna. Such axis is provided by trunnions 34 and movement about the same is obtained by means of the rod 37 which may be positioned at varying elevations as hereinafter more particularly described. Axial movement of rod 37 occurs along the vertical axis of the gear 32, both of these parts being coaxially arranged in carrying out the teaching of the present invention.

High frequency electromagnetic energy is fed to or withdrawn from the scanning apparatus by way of a fixed wave guide 25 having the same rectangular cross-sectional shape as the hereinbefore described wave guide 20 whose rearwardly extending end, as viewed in Fig. 1, is fixed to a portion of the yoke 31 so that it moves with the yoke and reflector as a unit about the vertical axis of the gear 32. A concentric line is employed; in the instant case, to transfer energy

between the movable guide 20 and the fixed guide 25. The concentric line includes an inner conductor 26 and an outer conductor 27, the same being arranged to transfer energy from one to the other of the wave guides 20 and 25. The inner conductor 26 of the concentric line is pivotally mounted by means of the spaced bearings 28 so that the same is coaxially positioned with relation to the gear 32 and rod 37. Fixed outer conductor 27 is suitably connected directly to the wave guide 25. Impedance matching plungers 29 are provided to match the impedance of the respective guides with the respective energy radiating or receiving portions of the concentric line. As shown, the rectangular wave guide 25 is fixed to a suitable mounting plate 40 by means of a bracket 41.

As shown in Fig. 1, the sector gear 33 and rod 37 are controlled by a mechanism enclosed within upper and lower connected casing parts indicated respectively at 43 and 44, the mechanism being driven by way of shaft 45, aligning coupling 46, a reduction gearing connection in housing 47 and driving motor 48. The motor 48 and housing 47 are suitably fixed in position on the side of the mounting piece 40. A housing for a solenoid control unit for the mechanism is indicated in this figure at 49.

With reference to Figs. 5, 6 and 7, the continuing rotative movement of shaft 45 is converted into oscillatory movement of sector gear 33 by means of an eccentric cam piece 50, a connecting plate 51, crank pin 52 and crank member 53 to which the gear 33 is directly connected by way of a suitably journaled stub shaft 54. It will be understood that the movement of sector gear 33 results in a corresponding movement of the driving gear 32 which in turn causes the reflector 21 and the radiator 20 to oscillate or sweep between predetermined limits about their common vertical axis of support. Substantially the same driving mechanism is employed to obtain this joint movement of the antenna parts in both modified forms of the invention shown in Figs. 8 and 11 and in which corresponding reference numbers are used to indicate the respective elements. In Fig. 8, both sector gear 33 and gear 32 are shown as covered by a protective housing 55 which in this instance is also utilized to provide a mounting for an extra bearing for a stub shaft 54' which is axially positioned with relation to stub shaft 54 and cooperates with the same. This view also includes an additional showing of the electrical arrangements provided by the improved scanner by which a potentiometer unit shown generally at 56 is controlled by a pulley and belt motion transmitting connection indicated at 57 and 58, the driving pulley of which is coaxial with and mounted to move correspondingly with the gear 32. The particularly described mechanism for obtaining the cooperative oscillatory motion of the radiating and reflector means of the scanner is illustrative only and other suitable mechanism may be employed for this purpose without departing from the concepts of the inventive subject matter herein disclosed.

With further reference to Figs. 5 and 7, the reflector 21 is positioned about its horizontal or nod axis by means of rod 37 whose inwardly disposed end is provided with a roller 60 which rests on a cam defining surface 61. The cam surface 61 is incorporated in the upper face of a pivotally mounted continuously rotating gear 62 which may also be moved axially along its fixed stub shaft 63. Rod 37 is confined to travel in an

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axial direction by means of a longitudinal slot 64 and a cooperating fixed tongue 65 which extends from a portion of a shelf 66 included in the upper casing 43. Gear 62 is rotated by means of the motor driven shaft 45 by way of a gear 67 which directly meshes with the same, the shaft 68 for gear 67 and the cooperating gears 69 and 70 which are situated just above the shelf 66. Cam 61 operates intermittently to change the elevation of rod 37 or the nod angle of the reflector twice during each revolution of gear 62. Such movements are timed to occur at the respective limiting positions of the oscillatory motion of the reflector and radiator as the same move together about their common vertical axis. The rod 37 is cyclically raised at one of the limiting positions of oscillatory motion and lowered at the other of such positions so that the antenna is adapted to scan a completed space pattern of substantially rectangular cross-section. The cam 61 is designed in the instant case to either raise or lower rod 37 sufficiently to obtain a change in the nod angle of the reflector by two degrees.

A complete cycle of operation of the scanning apparatus takes place in four successive steps and includes two separate movements about both the vertical and horizontal axis of support of the radiator and reflector. With reference to Fig. 4, the scanning movement of the antenna occurs as follows. Selecting position 1 in the scanning rectangle A as a starting point in the operation for example, the reflector 21 and radiator sweep about their common vertical axis under the control of the gear 32 and sector gear 33 and the described mechanism for driving the same until position 2 is reached. During this described first movement of the apparatus, the roller 60 is situated in the raised portion of the cam defining gear surface 61 as shown in Fig. 5. As the gear 32 changes its direction of movement, the cam 61 is effective to lower rod 37 and consequently raise the position of the reflector 21 about its independent horizontal axis. This directs the antenna to the approximate position shown at 3 in Fig. 4. A return movement similar to the described first movement occurs as the third step in the cycle of operation of the apparatus. When position 4 is reached, cam 61 is then effective to cause the reflector 21 to nod in a downward direction and restore the same to its original or starting position 1, the apparatus continuously repeating the described space pattern.

A separate mechanism is provided to control the antenna about the horizontal axis of the reflector so that scanning operations of the character described are effected at any of a desired number of different elevations. This mechanism may exert its control through the rod 37 and gear 62 so that as shown in Fig. 4 space patterns such as shown at B and C may also be scanned by the apparatus. In this connection, in Figs. 5 and 7, gear 62 is shown as moving upon two spaced rollers situated to either side of the fixed stub shaft 63. Rollers 71 raise or lower the gear 62 along the axis of shaft 63, the gear continuing to be driven by the elongated gear 67 with which it meshes. The rollers 71 are situated at one end of a bail 72 which is pivotally mounted at 73 on an extending part of the shelf 66 situated in the upper casing 43. A single roller 74 is provided at the other end of bail 72, the same engaging a rotatably mounted cam piece 75 and retained in engagement therewith by a spring 76. A ratchet wheel 77 is situated on the same shaft as cam 75 and these parts are prevented from moving in a

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clockwise direction, as viewed in Fig. 5, by means of a pawl 78. The actuating member for the cam 75 includes a reciprocatingly mounted slotted plate 79 which is moved against the retention of holding spring 80 by means of a rocker lever 81, crank connection 82 and the plunger or armature 83 of a solenoid coil 84 contained in the housing 49. A holding pin 85 which projects laterally from the plate 79 engages the respective teeth on the ratchet and in cooperation with pawl 78 positively positions cam 75 about its axis. In operation, the coil 84 is momentarily energized from a suitable current source and the plate 79 is moved to the left as viewed in Fig. 5 against the holding action of spring 80, the pin 85 moving correspondingly. The actuating piece for the mechanism is formed by a slotted resilient plate 86 connected at one end of the same to plate 79. Plate 86 is effective upon the return movement of the plate under influence of spring 80, the forward face of the slot 87 engaging the then adjacent tooth of the ratchet wheel 77 and moving the wheel one tooth space in a counterclockwise direction as viewed in Fig. 5. Cam 75 is moved correspondingly and positioned to locate the controlling gear 62. The cam 75 is designed in the instant case to effect axial movement of gear 62 from a lowermost position in which the same is shown in Fig. 5 to a central position in which rod 37 is elevated so that the nod angle of the reflector is changed three degrees. In the highest position the nod angle of the reflector is changed six degrees. Scanning patterns B and C, respectively, of the cyclically repeating type described result from this additional controlling mechanism. In operation, the described type of cam 75 changes the elevation of scanning areas in successive steps for example from pattern A to B to C to B and back to A. Obviously by altering the contour of the cam 75 various other systematic sequences and other elevations of the reflector may be obtained.

With reference to Fig. 8, a selective control mechanism is included to position gear 62 along its axis so that the reflector may be set at any one of its different elevations and the antenna positioned to scan a desired one of the patterns A, B or C shown in Fig. 4. In this figure, the driving means for continuously rotating gear 62 is similar to that hereinbefore described and shown in Fig. 5. The positioning mechanism for cam gear 62, in this instance, includes two rollers, one of which is indicated at 90 in Fig. 8, on which the bottom face of gear 62 rests. Rollers 90 are mounted at one end of a bell crank shaped yoke 91 which is pivoted at 92 in a suitable trunnion support located in the lower casing 44. The opposite end of the yoke includes a single roller 93 which engages the surface of an internal cam forming piece 94. Cam piece 94 is designed to have three positions of rest which through the yoke 91 elevate the gear 62 so that the antenna is adapted to scan either space pattern A, B or C shown in Fig. 4. Cam piece 94 is mounted upon a shaft 95 supported in upper and lower bearings 96 and 97, respectively and the shaft is independently positioned by means of a gear 98. Gear 98 is driven by a further gear 99 which meshes with the same. Gear 99 is mounted on a sleeve 100 mounted on a further shaft 101 which last shaft is directly driven by shaft 45 by way of the gears 102 and 103.

Also with reference to Figs. 9 and 10, a ratchet wheel 104 is mounted on shaft 101, this wheel continually rotating with shaft 101 being directly

driven by shaft 45. Motion is communicated from ratchet wheel 104 to the sleeve 100 and gear 99 by means of a pawl 105 which is pivotally mounted in a disc member 106 which forms a part of the sleeve. Pawl 105 is normally ineffective, being retained in an inoperative position by means of a resiliently mounted detent 107 which is controlled by an electromagnetic relay 108. When the relay is energized, the detent 107 is withdrawn from engagement with the pawl 105 which then engages the ratchet wheel 104 through the influence of the spring 109. A complete revolution of the ratchet mechanism is permitted before the pawl again engages its disabling detent 107. The selective control is obtained, in the present instance, by means of a control circuit by which the relay 108 is energized to permit more than one revolution of the ratchet wheel 104 in order to position the cam 94 as desired. In the position of the parts shown in Fig. 8, cam 94 and yoke 91 are in their lowermost position and consequently pattern A, in Fig. 4 is being repeatedly scanned by the directive antenna.

With particular reference to Figs. 9 and 10, an illustrative form of relay 108 controlling circuit is shown to include four normally closed push type switches indicated at A, B, C and OFF, the first three corresponding to the scanning patterns designated in like fashion in Fig. 4, and the OFF switch being included to completely disable the selective control mechanism when desired. Each of the switches except the OFF switch is grouped with a cam controlled resilient arm type of switch as shown at a, b and c respectively. These last named switches are contained in a switch box 110 fixed to the bottom casing 44 and are controlled by a cam 111 mounted on an extending portion of shaft 95. Due to the selected gear ratio between gears 98 and 99, shaft 95 rotates at one-third the speed of shaft 101, so that the switches a, b and c are contacted by the cam 111 each time the ratchet mechanism completes a revolution of its movement and the pawl 105 is at a position in which it cooperates with detent 107. The switch box 112 for the switches A, B, C, and OFF may be incorporated in the instrument casing or be entirely separate, as desired. As shown in the diagrammatic circuit diagram in Fig. 9, each of the push button type of switches utilized, when positioned outwardly, as are A, B and the OFF in the illustration, closes a series circuit which includes the closed contacts thereof, switches a, b or c, the relay 108 and a suitable source of electrical energy such as battery 115. Each of the switches A, B and C also includes two wipe contacts as shown at 116 and 117 which momentarily close a separate parallel circuit for the relay 108 and release pawl 105 to initiate the operation of the selective control. In describing the operation of the circuit, it will be assumed that the apparatus was initially set to scan pattern A, in Fig. 4, in which the parts are positioned as shown in Fig. 8. The operator desiring to have the apparatus scan pattern C, starts the controlling mechanism by pressing switch C inwardly to the position shown in Fig. 9. As contact 117 wipes past contact 116, the circuit for the relay is momentarily closed and detent 107 releases pawl 105 so that the motion of shaft 101 is communicated to gear 99 for at least one revolution. This motion results in corresponding movement of the shaft 95 which as noted travels at one-third of the speed of shaft 101. When cam 111, on shaft 95 has moved to close switch b, the pawl 105 has reached a detent 107 coop-

erating position. Due to the fact that switch B remains closed and switch b is closed by cam 111, the relay circuit through the respective switches is again completed and the detent 107 is withdrawn from its pawl engaging position. This permits a further movement of the gear 99 by the engaged ratchet mechanism which continues until a further full revolution of shaft 101 has been completed. When this point is reached, cam 111 closes the switch c. However, inasmuch as selector switch C is open, the circuit to the relay remains open and the detent then engages the end of pawl 105 and disengages the same from the ratchet wheel 104. Cam 94 has consequently been set in a position to raise cam gear 62 its maximum designed distance, in the instant case, in which the antenna scans pattern C in Fig. 4, as desired.

A modification of the selective controlling mechanism is shown in Figs. 11 and 12 in which a positive connection is utilized to position rod 37. The equivalent of gear cam 62 is provided in this instance by a cam plate 120 the movement of which is communicated to rod 37 by way of rocker arm 121. Cam plate 120 is rotatably mounted on a fixed stub shaft 126 and is driven by shaft 45 by means of gears 122, 123, internal gear 124, axially movable gear 125 which meshes with gear 124 and the sleeve 127 fitted on shaft 126 which connects gear 125 and cam plate 120. The mechanism for changing the axial position of cam plate 120, in this instance, includes a fixed tubular cam element 128 mounted on shelf 66, the cam surface of which consists of a spiral groove indicated at 129 contained in its circumferential surface. The follower for said tubular cam element 128 is provided by a rotatably positioned member 130 which fits telescopically over the element 128 and is movable axially with relation to the same. It will be understood that axial movement of member 130 is thereby communicated directly to gear 125 and cam plate 120 through bearing 131 to effect a corresponding movement of these parts. Cam follower member 130 includes a flanged portion which is constructed as a gear 132 and rotary movement of the member is derived from the gear 99 which meshes with the same and is controlled as hereinbefore described. As shown in this instance, relay 108 has been replaced by a solenoid 134 whose armature 135 provides the means for maintaining pawl 105 (not shown) normally disengaged from ratchet wheel 104. Also, circuit control switches a, b and c are provided by micro switches of the normally open type as shown generally at a', b' and c', in Fig. 12 which are mounted on a platform 136 situated in the lower casing 44 and situated in equidistantly spaced relation about the movable cam follower member 130. The movable plungers for each of the switches a', b' and c' are actuated by a rounded cam surface 137 fixed to the periphery of the member 130, the same functioning in the same type of controlling circuit hereinbefore described in connection with Fig. 9.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. The method of scanning a field of view with

a directive antenna which includes a relatively movable electromagnetic energy radiator and reflector therefor which consists in moving said radiator and reflector together about a first axis, moving said reflector alone about a second axis perpendicular to the first axis, moving said radiator and reflector together in a reverse direction about the first axis, and then moving the reflector alone in a reverse direction about the second axis to complete a scanning cycle of the antenna.

2. The method of scanning a field of view with radio apparatus including a relatively movable radiator and reflector which consists in sweeping said radiator and reflector together in one direction about a vertical axis, nodding said reflector alone about a horizontal axis, sweeping said radiator and reflector together in a reverse direction about the vertical axis, and then nodding the reflector alone in a reverse direction about the horizontal axis to complete a scanning cycle of the apparatus.

3. Radio scanning apparatus comprising a movable electromagnetic radiator, a reflector for said radiator having an axis of symmetry, means for mounting said reflector to move about a first axis with said radiator and to move about a second axis normal to the first axis relative to said radiator with the axis of symmetry of the reflector being situated normal to said second axis, means for moving said radiator and reflector together about said first axis, and automatic means, only effective intermittent of the movement of the radiator and reflector together, for moving said reflector alone about said second axis.

4. An apparatus as claimed in claim 3 in which said reflector is a paraboloid, the second axis of which is situated in offset relation to the first axis.

5. A directive antenna structure, as claimed in claim 11, including means for varying the position of the reflector about its horizontal axis, and means for selectively setting the reflector by said position varying means at a desired angle of nod.

6. A directive antenna structure comprising an electromagnetic energy radiator, a reflector for said radiator having an axis of symmetry, means for supporting said radiator and reflector for movement about a vertical axis, means for supporting said reflector for movement independent of the radiator about a horizontal axis situated in perpendicular relation to the axis of symmetry thereof, mechanism for oscillating said radiator and reflector together about said vertical axis and for intermittently nodding said reflector alone about said horizontal axis, means for varying the position of the reflector about its horizontal axis, and means for selectively setting the reflector by said position-varying means at a desired angle of nod.

7. Radio scanning apparatus comprising radiating means, reflecting means for said radiating means, means for oscillating said radiating means and reflecting means together about a first axis, and means automatically effective only at the respective reversing positions of the oscillating means for nodding said reflecting means relative to said radiating means about a second axis normal to the first axis.

8. A directive antenna structure comprising a reflector having an axis of symmetry, a wave guide for conveying electromagnetic energy to or from said reflector, deflector means positioned to

transfer energy between the guide and reflector, means for supporting said reflector and wave guide to oscillate together about a vertical axis and to oscillate relative to one another about a horizontal axis, said supporting means situating the axis of symmetry of the reflector normal to the horizontal axis thereof, means for oscillating said radiator and reflector together about said vertical axis, and intermittently effective means for oscillating said reflector alone about said horizontal axis.

9. Radio scanning apparatus comprising a movable electromagnetic radiator, a reflector for said radiator, means for mounting said reflector to move about a first axis with said radiator and to move about a second axis normal to the first axis relative to said radiator, intermittently operable means for moving said radiator and reflector together about said first axis, and automatic means effective only between the operations of said intermittently operable means for moving said reflector alone about said second axis.

10. Radio scanning apparatus comprising a movable electromagnetic radiator, a reflector for said radiator, means for mounting said reflector to sweep about a first axis with said radiator and to nod about a second axis normal to said first axis relative to said radiator, intermittently operable means for sweeping said radiator and reflector together about said first axis, and automatic means for nodding said reflector alone about said second axis between the operations of said sweeping means.

11. A directive antenna structure comprising an electromagnetic energy radiator, a reflector for said radiator, means for supporting said radiator and reflector for movement together about a vertical axis, means for supporting said radiator and reflector for movement relative to one another about a horizontal axis, mechanism for oscillating said radiator and reflector together about said vertical axis, and mechanism only effective upon reversal of the direction of operation of said oscillating mechanism for nodding said reflector relative to said radiator about said horizontal axis.

12. Radio scanning apparatus comprising radiating means, reflecting means for said radiating means, means for oscillating said radiating means and reflecting means together about a first axis, means effective at the respective reversing positions of the oscillating means for nodding said reflecting means relative to said radiating means about a second axis normal to the first axis, mechanism for varying the position of the reflector about its second axis, and means for selectively setting the reflector by said position-varying mechanism at a desired angle of nod.

13. High frequency scanning apparatus comprising radiating means, reflecting means for said radiating means, means for oscillating said radiating means and reflecting means together about a first axis, means operable upon reversal of direction of motion of said radiating means and reflecting means at one limit of travel thereof for moving said reflecting means relative to said radiating means about a second axis normal to said first axis and operable upon similar reversal of direction at the other limit of travel of said radiating means and reflecting means for moving said reflecting means relative to said radiating means about said second axis and in opposite direction, whereby said reflecting means and radiating means cyclically sweep out a rectangular pattern in space.

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14. Apparatus as in claim 13, further including means for adjusting the position of said pattern, including means for adjusting the average position of said reflecting means about said second axis.

15. Radio scanning apparatus comprising antenna means including reflecting means and radiating means relatively movable to one another, means for cyclically sweeping said antenna means over a rectangular pattern in space, and means for adjusting the position of said pattern in space, including means for adjusting the average position of said reflecting means relative to

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said radiating means during said cyclic sweeping.
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