Feb. 11, 1947. G. A. HOYT 2,415,680

ANTENNA

Filed March 27, 1943 2 Sheets-Sheet 1

Fig. 1.

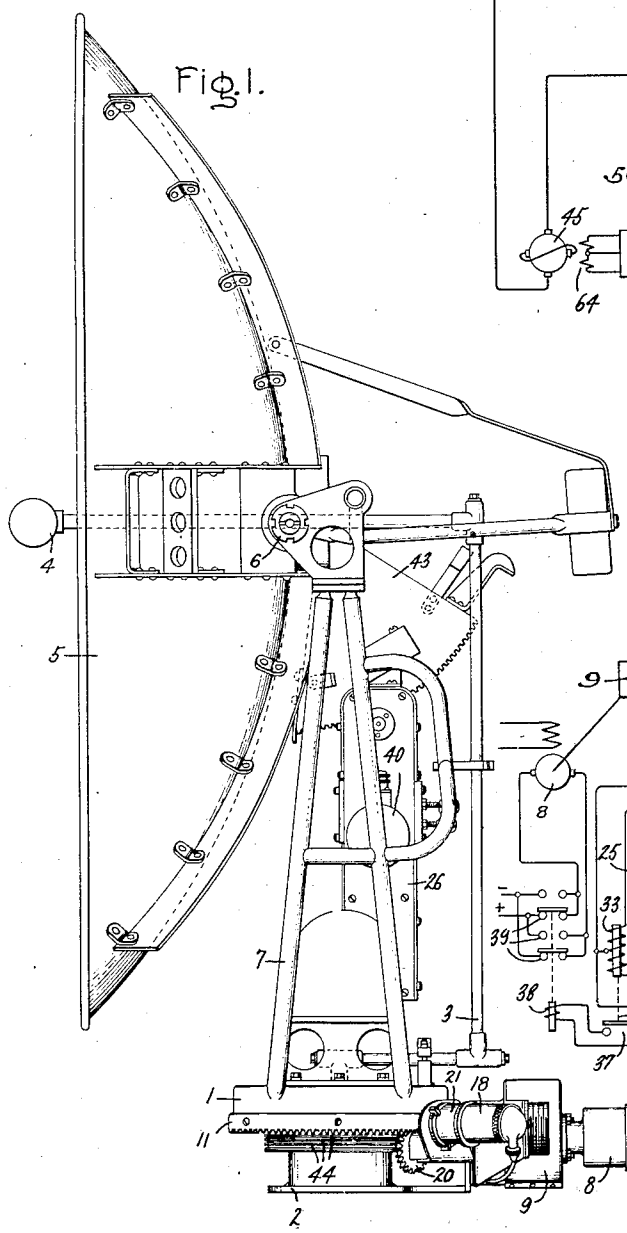


Fig. 2.

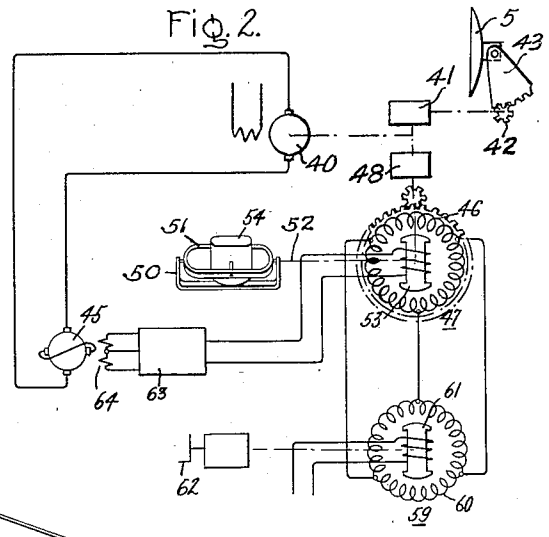
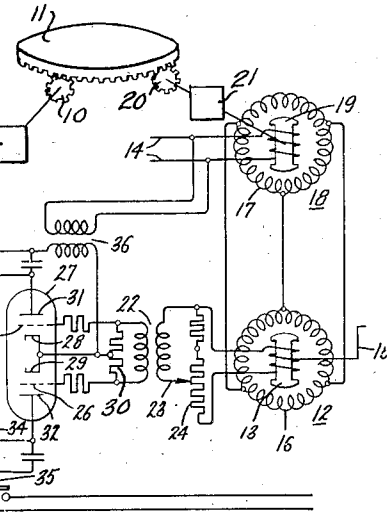


Fig. 3.



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Fig. 4.

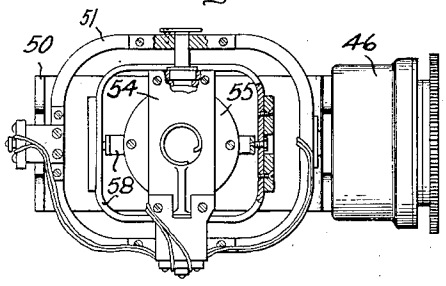


Fig. 5.

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UNITED STATES PATENT OFFICE

2,415,680

ANTENNA

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Application March 27, 1943, Serial No. 480,803

6 Claims. (Cl. 250—11)

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The present invention relates to directional antennas of the type known as scanners or spinners, and is particularly concerned with an arrangement for causing the antenna to scan a sector in azimuth of adjustable width. Such antennas are primarily used with radio locating equipment for scanning the horizon or zones at a small elevation from the horizon to obtain information as to the location of remote objects.

The object of my invention is to provide a directive antenna with an improved arrangement for controlling the antenna so as to cause it to scan a sector of adjustable width and median direction.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 is a side elevation of an antenna embodying my invention; Fig. 2 is a diagram of the elevation control; Fig. 3 is a diagram of the azimuth control with the adjustable sector scan; Fig. 4 is a top plan view of the gyroscope; and Fig. 5 is a sectional elevation of the elevation drive.

Referring to the drawings, there is shown a scanner mounted on a turntable 1 journaled for rotation on a vertical axis in a base 2. Fixed on the turntable is a transmission line 3, the lower end of which is connected to a rotating joint (not shown) at the axis of the turntable and the upper end of which extends through a clearance opening in a parabolic reflector 5 and terminates in a radiator 4. The radiator and reflector constitute an antenna having a directive axis determined in the relative position of the radiator and reflector. The reflector is supported for tilting relative to the turntable on a horizontal axis perpendicular to the axis of the reflector by trunnions 6 at the upper ends of standards 7 fixed to the turntable. The directive axis of the antenna is shifted in azimuth by rotating the turntable and in elevation by tilting the reflector relative to the turntable. Due to reflection, the directive axis is shifted in elevation through twice the angle between the radiator 4 and the axis of the reflector.

The turntable is rotated in azimuth by a motor 8 through reduction gearing 9 which drives a pinion 10 meshing with a crown gear 11 fixed to the outer edge of the turntable. The position

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of the directive axis of the antenna in azimuth, which corresponds to the position of the turntable, is controlled by a Selsyn 12 (which may be located in a control box remote from the antenna) having its rotor 13 rotatable by a hand-crank 15 and having its stator 16 connected to the stator 17 of a Selsyn 18 on the base 2. The rotor 19 of the Selsyn 18 is energized from an A.-C. supply 14 and is driven from the crown gear 11 through a pinion 20 and reduction gearing 21 so its position at all times corresponds to the azimuth of the antenna. Whenever the position of the rotor 19 does not exactly correspond to the position of the rotor 13 of the Selsyn 12, a displacement voltage is induced in the rotor 13 which corresponds in magnitude with the magnitude of the displacement and in phase with the direction of the displacement.

The displacement voltage is fed to the primary of a transformer 22 through an adjustable tap 23 on a shunt resistance 24. The secondary of the transformer 22 is connected across the grids 25 and 26 of a push-pull amplifier tube 27 having cathodes 28 and 29 connected to the mid-point of a resistance 30 shunting the secondary of the transformer 22 and having anodes 31 and 32 connected in series with coils 33 and 34 of a relay 35. The mid-point of the relay coils 33 and 34 and the mid-point of the resistance 30 are connected through a transformer 36 to the alternating current supply 14. When the displacement voltage is of such polarity that grid 25 becomes positive at the same time anode 31 is positive, a current flows in the relay coil 33 proportional to the magnitude of the displacement voltage. When the displacement voltage is of such polarity that grid 26 becomes positive at the same time that anode 32 is positive, a similar current flows in the relay coil 34. At predetermined currents, the relay coils 33 and 34 are arranged to respectively open and close contacts 37 in series with a relay 38 controlling a reversing switch 39 in series with the armature of the motor 8. The relay 35 is of the type which remains in the position to which it is moved until moved in the opposite direction while the relay 38 is of the type which moves to one position when energized and to the opposite position when deenergized.

When the relative displacement of the rotors 13 and 19 produces a displacement voltage in such phase that grid 26 is positive when anode 32 is positive and the azimuth motor 8 is running in the direction to increase this displacement voltage, a current proportional to the magnitude of the displacement voltage flows through the coil

34 and, at a predetermined magnitude determined by the characteristics of the relay 35, operates the relay 35 to close the contacts 37 and energize the relay 38 which reverses the azimuth motor and causes it to run in the direction to decrease the displacement voltage. The relays 35 and 38 remain in this position until the displacement voltage in the rotor 13 decreases to zero and builds up in an opposite phase. When the displacement voltage reaches a magnitude determined by the characteristics of the relay 35 and the adjustment of the tap 23, sufficient current flows through the coil 33 to open the contacts 37, deenergizing the relay 38 which drops out, reversing the switch 39 and causing the azimuth motor to move in the reverse direction (the direction to cause relative displacement in the opposite direction of the rotors 13 and 19).

During the operation of the azimuth control, the directive axis of the antenna is continually shifted back and forth to opposite sides of a median position determined by the setting of the handcrank 15 and through an angle determined by the setting of the tap 23.

The handcrank determines the median position of the antenna and the tap 23 determines the width of the sector scanned. Either may be adjusted at any time without interrupting the continuous scanning of the antenna. While there may be slight variations in the width of the sector scanned due to variations in the operation of the relay 35, the median position of the antenna remains at the value set by the handcrank 15.

The directive axis of the antenna is shifted in elevation by a motor 40 through reduction gearing 41 having a pinion 42 meshing with a gear sector 43 fixed to the back of the reflector 5. The motor 40 is energized from a generator 45 through slip rings 44 on the turntable. The connections to the other electrical apparatus carried by the turntable are also made through the slip rings 44. The motor also drives the stator 46 of a Selsyn transformer 47 through reduction gearing 48 having half the reduction of the gearing 41 driving the reflector so the angular position of the stator 46 corresponds to the elevation of the directive axis of the antenna which is shifted by twice the angle the reflector is moved. The stator 46 is journaled in a housing 49 fixed to a U-shaped frame 50 bolted to the turntable. Journaled in the frame 50 on a horizontal axis perpendicular to a vertical plane including the directive axis of the antenna is a frame 51 having a shaft 52 fixed to the rotor 53 of a Selsyn transformer 47. The frame 51 is held horizontal in a plane along the directive axis of the antenna by a gyroscope stable vertical carried in a frame 54 pivoted to the frame 51 on a horizontal axis along the directive axis of the antenna. The gyroscope consists of an induction motor having its stator fixed to the frame 54 and a rotor 55 surrounding the stator. At the lower end of the rotor is a spherical eddy current damper 56 cooperating with a permanent magnet 57 supported by a universal pendulous suspension 58 from the frame 54. The magnet, which is free to swing in any direction, has a very short period and its average position over an interval of a few seconds is true vertical. If the axis of the rotor 55 differs from true vertical, the drag due to eddy currents in the damper 56 causes the gyroscope to precess toward true vertical. So long as the gyroscope is in true vertical, the frame 51 is horizontal in a vertical plane along the directive axis of the antenna although the frame may be inclined in a perpendicular vertical plane.

The elevation of the antenna is controlled by a Selsyn 59 (which may be located in a control box remote from the antenna) having a stator 60 connected to the stator 46 of the Selsyn transformer 47 and a rotor 61 connected to an alternating current supply. The rotor 61 is positioned to the desired elevation angle in any suitable manner, for example by a handcrank 62. Whenever the position of the rotor 53 of the Selsyn transformer does not correspond to the position of the rotor 61, a displacement voltage is induced in the rotor 53 which corresponds in magnitude to the magnitude of the displacement and in phase to the direction of the displacement. In apparatus indicated at 63, the displacement voltage is amplified and rectified and supplied to the fields 64 of the generator 45 which generates a control voltage for the motor 40 of magnitude and polarity such that the motor drives the stator 46 (and the antenna) in the direction to decrease the displacement.

In the use of the antenna, the base 2 may be fastened to a support, such as a platform on a ship, and the control box, containing the Selsyns 12 and 59 and the associated control equipment, may be located at some convenient point remote from the antenna. When used on a ship, the platform supporting the antenna is usually located at as great a height as possible so radio waves along the directive axis of the antenna will encounter a minimum of obstruction. Since the elevation of the antenna is indicated by the Selsyn 59, the median azimuth of the antenna is indicated by the Selsyn 12 and the width of the sector scanned is indicated by the adjustment of the tap 23; the control box is usually located at the place at which this information is used.

The operator, by the handcrank 15, determines the median position of the directive axis of the antenna in azimuth, by the adjustment of the tap 23 determines the width of the sector to be scanned, and by the handcrank 62 determines the position of the directive axis of the antenna in elevation. Through displacement voltages induced in the Selsyn 12, the anntena is rotated in azimuth back and forth on opposite sides of a median position determined by the setting of the handcrank 15 so as to scan a sector of a width determined by the adjustment of the tap 23 which from one aspect can be considered as an adjustment of the gain of the amplifier 27. Through displacement voltages induced in the Selsyn 47, a voltage is generated by generator 45 of magnitude and polarity such as to cause the motor 40 to shift the directive axis of the antenna in elevation by tilting the reflector 5 to a position corresponding to the elevation indicated by the positions of the handcrank 62. As the ship pitches and rolls, the components of the pitch and roll along the directive axis of the antenna are compensated by the gyroscope 54 which holds the frame 51 horizontal in a vertical plane along the directive axis of the antenna. This holds the rotor 53 of the Selsyn transformer 47 in a horizontal position and causes the stator 46 to assume a position relative to the rotor 53 corresponding to the relative position of the rotor 61 and the stator 60. The directive axis of the antenna, which corresponds to the position of the stator 46, is accordingly held at the elevation angle corresponding to the setting of the handcrank 62. Since the elevation of the directive axis of the antenna is with reference to the horizontal frame 51, the elevation is not affected by tilting of the base due to pitch or roll. The pitch and roll are

compensated only along the directive axis of the antenna. When the directive axis is lengthwise of the ship, the compensation is solely for pitch of the ship since the roll of the ship does not affect the azimuth or elevation of the directive axis. When the directive axis is crosswise of the ship, the compensation is solely for roll since pitch does not affect the azimuth or elevation of the directive axis. At intermediate points, the compensation is solely for the components of pitch and roll along the directive axis since the components of pitch and roll at right angles have very little effect on the accuracy of the overall system.

The arrangement for compensating for pitch and roll is being claimed in application Serial No. 480,802, filed March 27, 1943.

While I have shown particular embodiments of my invention, it will be understood that many modifications may be made without departing from the spirit thereof, and I contemplate by the appended claims to cover any such modifications as fall within the true spirt and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a rotatable directional antenna, a reversible drive for rotating the antenna, a Selsyn positionable in accordance with the instantaneous position of the directive axis of the antenna, a Selsyn positionable in accordance with the desired median position of the directive axis of the antenna and interconnected with the first Selsyn so as to result in the production of a displacement voltage proportional to the displacement of the directive axis of the antenna from said median position, and means responsive to a predetermined value of said displacement voltage for reversing the antenna drive.

2. In combination, a rotatable directional antenna, a reversible drive for rotating the antenna, means producing a voltage proportional to the displacement of the directive axis of the antenna from a predetermined position, and means responsive to a predetermined value of said voltage for reversing said drive.

3. In combination, a rotatable directional antenna, a reversible drive for rotating the antenna, a control for the drive having relatively movable parts and provisions for producing voltages in magnitude and sense proportional to the magnitude and direction of the relative displacement of parts, one of said parts being postionable in accordance with the desired median position of the directive axis of the antenna and the other of said parts being positionable in accordance with the instantaneous position of the directive axis, and means responsive to predetermined magnitude of said voltages for reversing the antenna drive.

4. In combination, a rotatable directional antenna, a reversible drive for rotating the antenna, a control having parts respectively positionable in accordance with the instantaneous and desired median position of the directive axis of the antenna, means producing a voltage proportional in magnitude and phase to the magnitude and direction of the relative displacement of said parts, an amplifier for said voltage, a relay responsive to the magnitude and phase of the voltage for reversing the drive at predetermined points on opposite sides of said median position, and means varying the gain of the amplifier to vary the displacement at which the drive is reversed.

5. In combination, a directional antenna, means supporting the antenna for tilting about a horizontal axis perpendicular to its directive axis, a turntable rotatable on a vertical axis carrying said supporting means, a frame on the turntable pivoted on a horizontal axis perpendicular to a vertical plane including said directive axis, a gyroscope on said frame holding said frame horizontal in a direction along said directive axis, means responsive to the elevation angle between said frame and the directive axis of the antenna for rotating the antenna on its horizontal axis to maintain said angle at a predetermined value, a reversible drive for rotating the turntable in azimuth, means producing a voltage proportional to the displacement in azimuth of the directive axis of the antenna from a predetermined position, and means responsive to a predetermined value of said voltage for reversing said drive.

6. In combination, a directional antenna for mounting on a support subject to pitch and roll, drives for shifting the directive axis of the antenna in azimuth and elevation relative to the support, a frame journaled on the support on an axis perpendicular to the plane of the azimuth and elevation of the directive axis of the antenna relative to the support, a stable vertical for holding the frame horizontal in a plane perpendicular to said first plane, means responsive to the elevation angle in said first plane between the directive axis of the antenna and the frame for controlling the elevation drive to maintain said angle at a predetermined value, a control having parts respectively positionable in accordance with the instantaneous and desired median azimuth of the directive axis of the antenna, means producing a voltage proportional in magnitude and phase to the magnitude and direction of the relative displacement of said parts, an amplifier for said voltage, a relay responsive to the magnitude and phase of the voltage for reversing the azimuth drive on opposite sides of said median azimuth, and means varying the gain of the amplifier to vary the displacement at which said azimuth drive is reversed.

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