June 1, 1954 R. L. HAMMETT 2,680,223

ANTENNA SCANNING APPARATUS

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FIG. 1

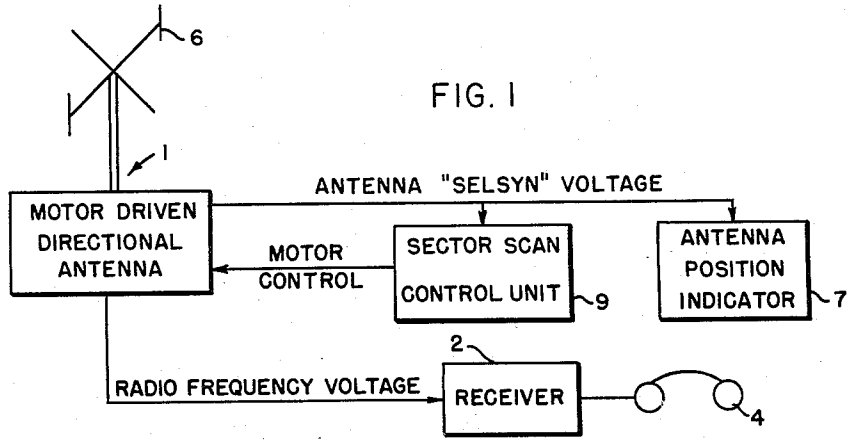
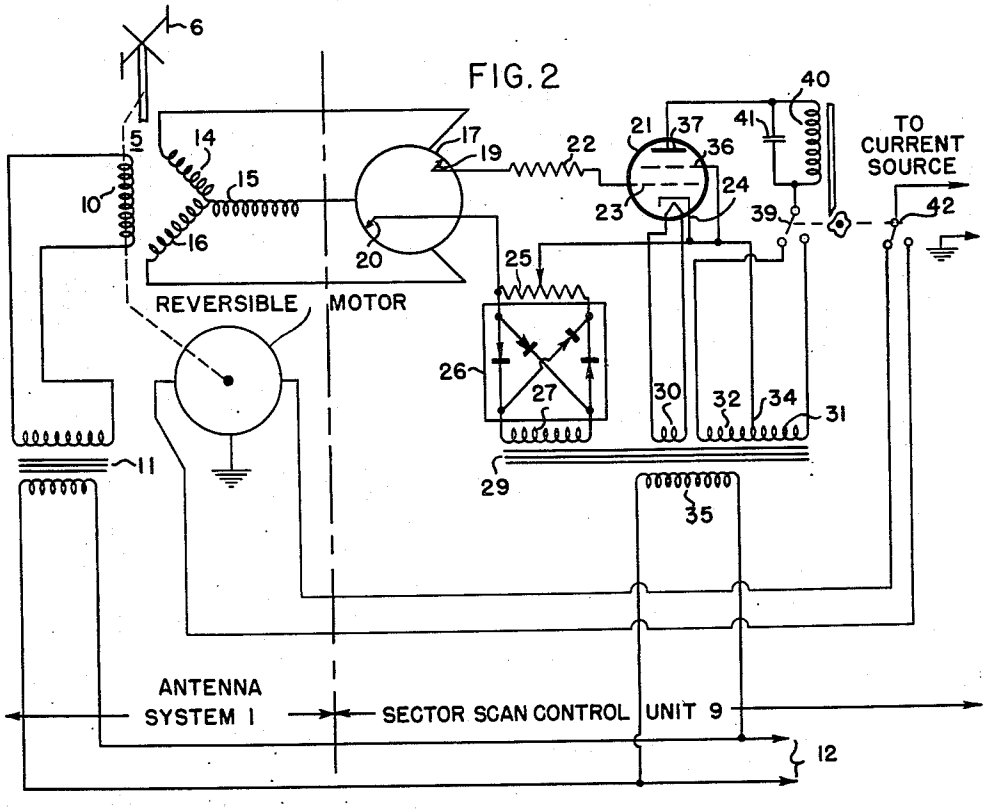


FIG. 2



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ANTENNA SCANNING APPARATUS

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13 Claims. (Cl. 318—28)

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This invention relates to sector scanning mechanisms for use with radio direction finding systems, and particularly to means for automatically scanning a desired sector continuously.

The invention is intended primarily for use with direction finding equipment arranged for manually controlled scanning, and will permit continuous back and forth sweeping of a desired sector without the attention of an operator. The direction finding system may be of any type, but is shown here adapted to radio operation. The same principles could be utilized with sonic, supersonic, infra-red, or radar operation, as will be apparent to those skilled in the art from the following disclosure.

In brief, the operation is effected by utilizing a voltage obtained from a "Selsyn" generator linked to the antenna, applying this voltage to the control grid of a gas tube, and controlling the direction of an antenna drive motor through a relay connected in the output circuit of the gas tube.

The primary object of the invention is to make possible automatic scanning of a sector by an otherwise manually controlled direction finding equipment.

Another object is to provide for automatic scansion of a sector of any desired angular width.

Still another object is to improve the operation of direction finding equipment.

The invention is illustrated in the accompanying drawing, in which:

Fig. 1 is a schematic diagram showing the components of a radio direction finding set utilizing the invention; and

Fig. 2 is a circuit diagram of the invention.

Referring now to the drawing from a detailed description of the invention, in Fig. 1 is shown schematically a motor driven directional antenna system 1 from which radio frequency energy is delivered to a receiver 2 having suitable indicating means such as a telephone headset 4.

A transmitting "Selsyn" 5 (Fig. 2) mechanically coupled to the antenna array 6 and forming a part of antenna system 1, supplies properly phased A.-C. voltage to an antenna position indicator 7, not shown in detail, which includes a conventional receiving "Selsyn" to actuate the indicating elements.

Transmitting "Selsyn" 5 also supplies A.-C.

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voltage to the sector scan control unit 9 which returns motor controlling voltages back to system 1 to effectuate the desired automatic scansion.

The transmitting "Selsyn" 5 is energized by A.-C. current fed to the rotor winding 10 (Fig. 2) by a transformer 11 connected to a suitable power source 12. "Selsyn" stator windings 14, 15 and 16 are connected equi-angularly to a ring potentiometer 17 tapped by diametrically opposed sliding contacts 19 and 20. The potential between contacts 19 and 20, which is the single phase resultant of the three phase potentials induced in the stator windings, is used to control the input circuit of a gas tube 21.

Since the rotor 10 is mechanically coupled to the antenna array 6, the voltages induced in stator windings 14, 15 and 16 will be dependent on the angular position of the antenna array. For any position of array 6, a position may be found for sliding contacts 19 and 20 in which the resultant potential across them will be zero. This position determines the mid-sector or zero position of the antenna scan. As the array 6 rotates in either direction from this position, potential will build up across contacts 19 and 20, and when it turns through the zero position, the polarity of the potential will reverse.

The potential across contacts 19 and 20 is applied through a current limiting grid resistor 22 across control grid 23 and cathode 24 of the gas tube or "Thyratron" 21, together with a pulsating D.-C. grid biasing voltage obtained by tapping a resistor 25 connected across a bridge rectifier 26. The position of the tap on resistor 25 is variable, and as will hereinafter appear, may be used to determine the angular limits of the sector to be scanned. The rectifier is fed by a grid bias winding 27 on a transformer 29. Transformer 29 also supplies power to heat cathode 24 through a heater winding 30, and provides anode potential from anode windings 31 and 32 having a center tap 34. The primary 35 of transformer 29 is fed by the same A.-C. power source as is the "Selsyn" energizing transformer 11, so that the currents flowing through the "Selsyn" 5 and the potentials applied to the tube 21 will have the desired frequency and phase relationships.

The anode return from center tap 34 to cathode 24 may be connected to shielding grid 36,

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although the shielding grid 36 may be omitted in some cases, as will be understood by those skilled in the art. Anode potential is applied to the anode 37 through a reversing switch 39 associated with an impulse relay 40, the latter being shunted by a capacitance 41. Relay 40 is arranged to actuate anode potential reversing switch 39 and antenna motor drive reversing control switch 42 simultaneously.

Assume now that potentiometer contacts 19 and 20 have been adjusted for zero potential for a given position of antenna array 6 and the phases of the applied grid and anode voltages are the same. Rotation of the array by the motor element, not shown in detail, of antenna system 1, will cause an alternating potential to be applied to control grid 23, increasing in amplitude as the angle through which it is turned increases. As soon as the amplitude of the applied alternating potential exceeds the cutoff bias on the grid supplied by the bridge rectifier 26 through resistor 25, since the anode voltage maxima are in phase with the applied alternating grid potential, tube 21 will become conducting.

The current flow actuates relay 40 which in turn actuates reversing switch 39, first cutting off and then reversing the applied anode potential. Relay 40 also actuates the reversing control 42 for the antenna drive motor, reversing the direction of antenna scan.

The tube 21 will immediately cease conducting as soon as the anode potential is cut off, and will continue in that state, since the anode potential maxima will occur 180° out of phase with the positive grid maxima. As soon as the antenna 6, rotating in the opposite direction, passes through zero position, the alternating grid potential will reverse and begin to build up in phase with the anode potential, until the positive maxima again exceed the pulsating negative bias supplied through resistor 25 and tube 21 becomes conducting, operating relay 40, and repeating the cycle.

It will be apparent that the size of the arc or sector through which the antenna swings can be controlled by varying the bias resistor 25, since this will determine the bias voltage which must be overcome to render the tube conducting, and hence the angle through which the "Selsyn" rotor 10 must swing to produce such a potential.

The particular sector to be scanned will be determined by the setting of potentiometer contacts 19 and 20, since this determines the mid-sector position of the array 6.

It will be obvious that the same principles may be used to effect automatic sweeping through an angular range in a vertical plane, or any other desired plane, as well as through an azimuthal plane.

It will be apparent that the system described will produce a controllable, automatic sweeping of an antenna over a sector of any desired angular size, and will relieve the operator of the necessity for continuous or frequent manual adjustments. It is applicable to radar and radio direction finding systems of any type utilizing a highly directional antenna which must be mechanically traversed to explore a desired area in space. It is also applicable to the control of rotating apparatus of many other types, as will be apparent to those skilled in the art, in which a movable element is to be reciprocably rotated through a controllable angle.

What is claimed is:

1. In a direction finding system, the combination, with a highly directional antenna array, of motor means arranged to turn said array about an axis, and means for effecting continuous back and forth sweeping of a desired sector, comprising a rotary transformer having rotor and stator windings, means mechanically coupling said rotor to said array, means for energizing said rotor from a source of alternating current, a potentiometer connected to said stator, and means for deriving a resultant voltage from said potentiometer, a gas tube having at least an anode, a cathode, and a control grid, means for applying said resultant voltage to said control grid, means for applying a bias potential to said control grid, means including a center-tapped transformer secondary winding for deriving alternating potentials from said source of alternating current, means for applying said alternating potentials to said anode, a relay in circuit with said anode, switching means operable by said relay arranged to supply said anode from opposed ends of said center-tapped secondary winding, and motor reversing control means operable by said relay simultaneously with said switching means.

2. The combination, with a directional antenna array, of motor means arranged to rotate said array about an axis, and means for causing continuous back and forth sweeping of a desired sector by said array, comprising a rotary transformer having rotor and stator windings, means rotating said rotor in synchronism with the rotation of said array, means for energizing said rotor from a source of alternating current, adjustable potentiometer means connected to said stator, means for deriving a resultant potential from said potentiometer, a gas tube having at least a cathode, an anode, and a control grid, means for energizing said gas tube from said alternating current source, means for applying said resultant potential to said control grid, means for applying an adjustable bias voltage to said control grid, a relay connected between said anode and said cathode, means actuable by said relay for shifting by 180° the phase of the alternating current energizing said gas tube, and means simultaneously actuable by said relay for reversing the direction of rotation of said motor means.

3. A system for oscillating a rotatable element about its axis through a given angle relative to a given reference position, comprising drive means for rotating said rotatable element, a rotary transformer comprising a primary coil having a single winding across which an alternating potential is impressed and a secondary coil having three windings, said three windings being equiangularly displaced relative to each other and interconnected to provide a three terminal output circuit from which a three phase potential output is derived, means rotating one of said coils relative to the other in synchronism with the rotation of said rotatable element, a thermionic tube having at least an anode, cathode and control grid, means for impressing said alternating potential on said anode, means for impressing a bias potential on said grid, a ring potentiometer, connections from said three terminals, respectively, to three points on said potentiometer spaced at 120° intervals, a pair of taps on said potentiometer separated by 180°, one of said taps being coupled to said grid and the other to said cathode, a relay in circuit with said tube and energized by current flow therethrough, and means actuated by said relay for simultaneously reversing the direction of rotation of said drive

means and shifting by 180° the phase of the alternating potential impressed on said anode.

4. The system as set forth in claim 3, further including means to adjust the size of said given angle, comprising means for adjusting the bias potential impressed on said grid.

5. The system as set forth in claim 3, further including means to change said given reference direction, comprising means for adjusting the position of said taps on said ring potentiometer while maintaining their 180° separation.

6. The system as set forth in claim 5, further including means to adjust the size of said given angle, comprising means for adjusting the bias potential impressed on said grid.

7. The combination, with an antenna arranged to be rotated about an axis by motor means, of means for sweeping said antenna back and forth through a controlled arc comprising, a rotary transformer having rotor and stator windings, means rotating said rotor in synchronism with the rotation of said antenna, means for supplying an alternating potential of fixed phase to said rotor, means for deriving a single phase resultant voltage from said stator varying in sense depending on the direction of motion of said antenna from the mid-point of said arc, a gas tube having at least an anode, a cathode and a control grid, means for applying said resultant voltage to said control grid, an alternating voltage source connected in the anode circuit of said tube, biasing means arranged in the non-conductive condition of said tube to render said tube momentarily conductive when said resultant voltage reaches a limiting value toward which it is driven in either direction from the mid-point of said arc, and a relay having the coil thereof connected in the anode circuit of said tube and having first and second pairs of contacts respectively adapted upon conduction of said tube to reverse said motor and to simultaneously reverse the phase of the alternating potential applied to the anode of said tube.

8. A system for oscillating a rotatable element back and forth through a given angle about a reference position comprising, a reversible motor coupled to said element, a voltage source having a movable element driven in synchronism with said motor for varying the output voltage in one sense or another depending on the direction of motion of said rotatable element from said reference position, a gas tube having at least an anode, a cathode and a control grid, means for applying said output voltage to said control grid, an alternating voltage source connected in the anode circuit of said tube, biasing means coupled to said alternating voltage source and arranged in the non-conductive condition of said tube to render said tube momentarily conductive when said output voltage reaches a limiting value towards which it is being driven in either sense, and means connected in the anode circuit of said tube and operable by momentary conduction of said tube simultaneously to reverse said motor and to reverse the phase of the alternating potential applied to said anode.

9. The system as set forth in claim 8 further including means to adjust the size of said given angle comprising means for adjusting said biasing means to change the bias potential applied to said grid.

10. A scanning system comprising a source of voltage having a movable element, a reversible motor arranged to displace said element in either of two directions for varying the output voltage in one sense or another, respectively, an electron tube having at least a control grid, a cathode and an anode, means connecting the grid and cathode of said source across the output of said source, an alternating voltage source connected in the anode circuit of said tube, biasing means arranged in the non-conductive condition of said tube to render said tube momentarily conductive when said output voltage reaches a controllable value toward which it is being driven in either of said two directions, and a relay having the coil thereof connected in the anode circuit of said tube and having a first pair of contacts adapted upon conduction of said tube to reverse said motor and having a second pair of contacts adapted simultaneously to reverse the phase of the alternating potential applied to the anode of said tube.

11. A system for scanning a rotatable element back and forth through a given angle about a mid-position comprising, a reversible motor having its armature connected to said element, a gas tube having at least an anode, a cathode and a control grid, an alternating potential source connected in the anode circuit of said tube, means coupled to said alternating potential source for applying a controllable bias voltage to said grid, means responsive to the rotation of said motor for producing a voltage having a sense depending on the direction of motion of said element from said mid-position, means for applying said last-mentioned voltage to said control grid for counteracting said bias voltage to render said tube momentarily conductive when said rotatable element is driven to either extremity of said given angle, and switching means responsive to the momentary conduction of said tube for simultaneously reversing said motor and reversing the phase of the alternating potential applied to the anode of said tube.

12. An electrical system for causing the armature of a motor to oscillate through an arc comprising, first switching means for reversing the direction of movement of armature, a thermionic tube having at least an anode, a cathode and a control grid, a source of alternating potential, a relay for actuating said first switching means having the coil thereof connected in the anode circuit of said tube and including second switching means for selectively connecting said source of alternating potential to said anode circuit in opposite phase, means for applying a controllable bias voltage, and means responsive to the rotation of said armature for counteracting the bias voltage on said grid.

13. A system for causing the armature of a motor to oscillate back and forth through a given angle about a mid-position comprising, a gas tube having at least an anode, a cathode and a control grid, a source of alternating potential, a center tapped transformer coupled to said alternating potential source and connected in the anode circuit of said tube, means including a rectifier coupled to said alternating potential source for applying a controllable bias voltage to the grid of said tube, a source of voltage having a movable element movable in synchronism with said armature for producing an output voltage having a sense depending on the direction of motion of said armature from said mid-position and a magnitude proportional to the amount of motion from said mid-position, means for applying said output voltage to the control grid of said tube for counteracting said bias voltage to render said tube momentarily conductive when said

output voltage is driven to a limiting magnitude in either direction, means connecting the center-tap of said transformer to the cathode of said tube, and a relay having the coil thereof connected in the anode circiut of said tube and having first and second pairs of contacts adapted upon momentary conduction of said tube to simultaneously reverse the direction of movement of said armature and reverse the connection of said transformer to the anode of said tube whereby the phase of the alternating potential applied to the anode of said tube is reversed.

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