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ANTENNA POSITIONING SYSTEM

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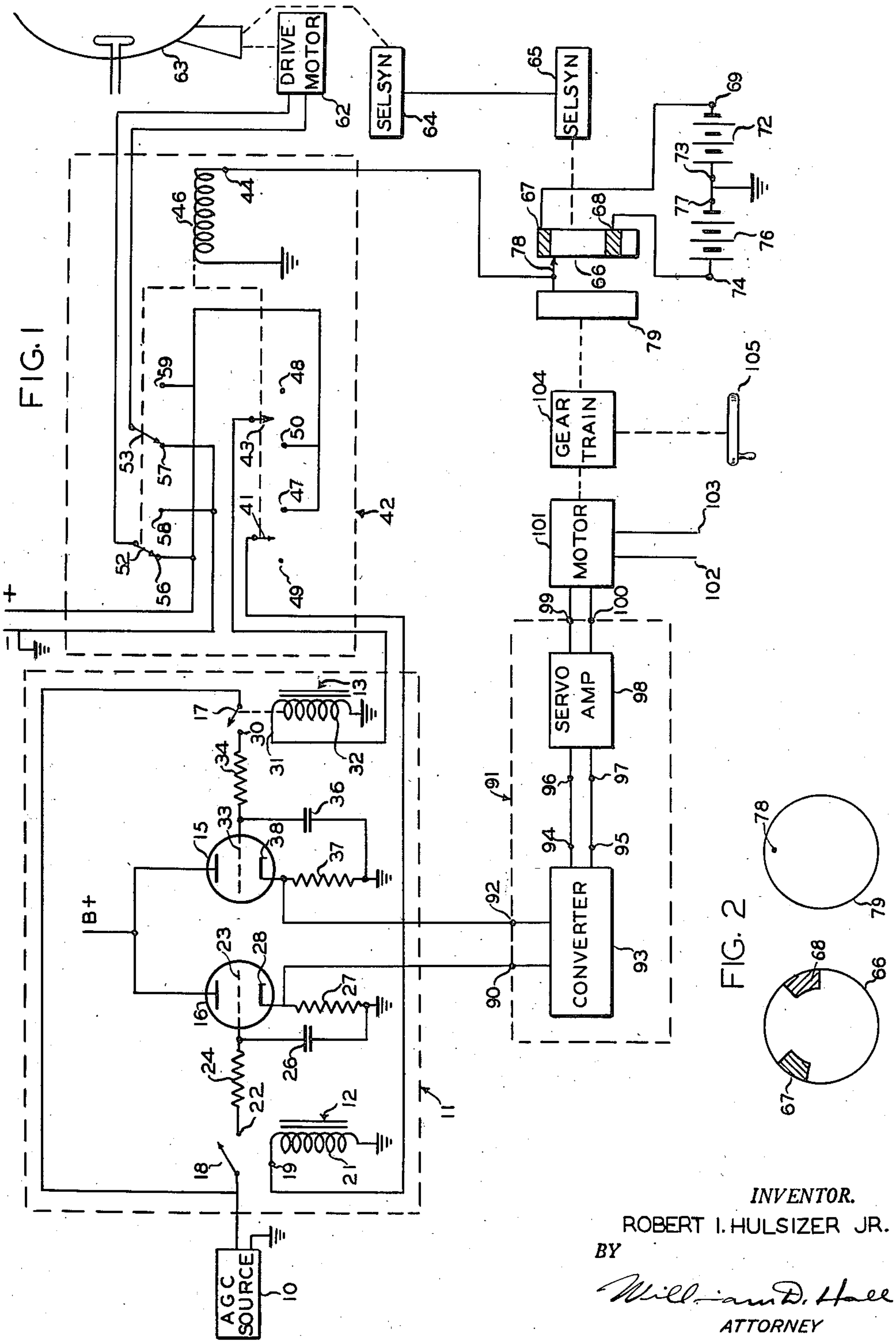

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ANTENNA POSITIONING SYSTEM

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This invention relates to electrical control means particularly as employed in radio object-locating systems.

In some radio systems the antenna array is made to move back and forth through a small angle in azimuth. In many systems known in the prior art the sector scanned by the antenna may be selected by suitable controls on the radio set. This selection is done manually by the operator of the radio set.

In many applications it would be desirable to have the antenna move automatically in azimuth so that the sector scanned is centered about the target once the antenna array has been positioned so that the sector scanned contains the selected target.

It is an object of the present invention, therefore, to present a system for automatically centering the sector scanned by an antenna array on a selected target.

In accordance with the present invention there are provided energy radiating means and means for causing said radiating means to oscillate through a predetermined angle. The amplitude of the angle of oscillation is determined by suitable control means associated with the means for causing the radiating means to oscillate. Means are provided in said control means for causing the radiating means to oscillate at an angular position with respect to a given reference indicated by information derived from the signals from a selected target.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of the invention; and

Fig. 2 is a detail view of a commutator and a cam shown in Fig. 1.

Referring now more particularly to Fig. 1 of the drawing, there is shown a source of automatic gain control or AGC voltage 10, connected to a selector means 11. In this embodiment of the invention the selector means 11 comprises relays 12 and 13, and vacuum tubes 15 and 16 connected as cathode followers. The input from AGC source 10 is applied to contact arm 17 of relay 13 and contact arm 18 of relay 12. Relay 12 has a winding 21, and when a voltage is applied to terminal 19 of this winding, contact arm 18 of the relay engages the contact point 22. When no voltage is applied to terminal 19, there is no connection between contact arm 18 and

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point 22. Point 22 is connected to grid 23 of vacuum tube 16 by means of resistor 24. A capacitor 26 is connected from grid 23 to ground. Resistor 27, connected between cathode 28 of tube 16 and ground, serves as the cathode load for the cathode follower circuit of tube 16. Relay 13 is similar to relay 12 in that contact arm 17 engages the point 30 when a voltage is applied to terminal 31 of the winding 32. When no voltage is applied to terminal 31, there is no connection between contact arm 17 and point 30. Point 30 is connected to grid 33 of tube 15 by resistor 34. A capacitor 36 is connected from grid 33 to ground. Resistor 37 is connected from cathode 38 of tube 15 to ground and serves as a cathode load for the cathode follower circuit of tube 15.

Terminal 19 of relay winding 21 is connected to contact arm 41 of a relay 42, and terminal 31 of relay winding 32 is connected to contact arm 43 of relay 42. Relay 42 is so constructed that when a voltage of a given polarity is applied to terminal 44 of coil 46, contact arms 41 and 43 will make contact with points 47 and 48, respectively. When a voltage of polarity opposite to the above mentioned polarity is applied to terminal 44, contact arms 41 and 43 make contact with points 49 and 50 respectively. When no voltage is applied to terminal 44, contact arms 41 and 43 remain in a neutral position so that no contact is made. Points 47 and 50 of relay 42 are returned to a source of positive potential represented by the plus sign in Fig. 1. No connection is made to terminals 49 and 48 of relay 42.

Relay 42 has a second set of contact arms 52 and 53. Relay 42 is so constructed that contact arms 52 and 53 engage the contact points 56 and 57 respectively when the above mentioned voltage of given polarity is applied to terminal 44 of coil 46. When this voltage is removed from terminal 44, contact arms 52 and 53 remain in engagement with contact points 56 and 57. When a voltage of a polarity opposite to the given polarity is applied to terminal 44, contact arms 52 and 53 make contact with terminals 58 and 59 respectively. When that voltage is removed from terminal 44, contact arms 52 and 53 remain in contact with points 58 and 59. Points 56 and 59 are returned to a point of positive potential represented by a plus sign in Fig. 1, and points 58 and 57 are returned to a point of negative potential represented by a minus sign in Fig. 1. Contact arms 52 and 53 are connected to terminals of a motor 62. Drive motor 62 is mechanically connected to antenna structure 63. A "Selsyn" generator 64 or other suitable angular position transmitter is mechanically connected to antenna structure 63. A "Selsyn" motor 65 or suitable angular position receiver is electrically connected to "Selsyn" generator 64. Commutator 66 has two conducting segments 67 and 68, more clearly shown in Fig. 2. Segment 67 is connected to the negative terminal 69 of a source of direct-current potential 72. Positive terminal 73 of source 72 is maintained at ground potential. Segment 68 is connected to the positive terminal 74 of a source of direct-current potential 76. The negative terminal 77 of source 76 is maintained at ground potential.

A contact 78 mounted on cam 79 makes contact with a segment 67 or 68 when cam 79 and commutator 66 are in certain relative positions. Contact 78 is connected to terminal 44 of relay coil 46.

Cathode 28 of tube 16 in the selector means 11 is connected to terminal 90 of a controlled power supply means 91, and cathode 38 of selector means 11 is connected to terminal 92 of controlled power supply means 91. In this embodiment of the invention terminals 90 and 92 are the input terminals of a converter 93. This converter is preferably of the type known to the art as a Brown converter. Output terminals 94 and 95 of converter 93 are connected to input terminals, 96 and 97, respectively of a servo-amplifier 98. The output terminals 99 and 100 of servo-amplifier 108 are connected to a motor 101. Motor 101 has a second set of input terminals 102 and 103, the purpose of which will be explained presently. Motor 101 is mechanically connected to cam 79 through gear train 104. A control handle 105 is mechanically coupled to a suitable differential in gear train 104.

In the operation of the system motor 62 rotates the antenna 63, the direction of rotation of motor 62 being controlled by the polarity of the energy supplied to motor 62. With relay contact arms 52 and 53 in the positions shown in Fig. 1, contact arm 52 is at a positive potential, and contact arm 53 is at a negative potential. It will ba assumed that this causes antenna 63 to rotate in a clockwise direction when viewed from the top. As antenna 63 rotates, "Selsyn" generator 64 which is mechanically coupled thereto also rotates. "Selsyn" motor 65 rotates in synchronism with "Selsyn" generator 64, and in so rotating it causes a segment, for example segment 68, on commutator 66 to come in contact with contact 78 on cam 79. A positive potential is now applied to terminal 44 of relay coil 46, causing the contact arms 52 and 53 to move so that they make contact with points 58 and 59, respectively. Contact arm 52 is now at a negative potential, and contact arm 53 is at a positive potential. The direction of rotation of motor 16 is thus reversed so that antenna 63 rotates in a counterclockwise direction when viewed from the top. The direction of rotation of "Selsyn" motor 65 is also reversed so that commutator 66 is driven in the opposite direction to bring contact 78 into engagement with segment 67 on commutator 66. Terminal 44 of relay coil 46 is now at a negative potential, and contact arms 52 and 53 are actuated to make contact with points 56 and 57, respectively. This causes motor 62 to again reverse direction, and the cycle will be repeated. Thus, it will be seen that antenna 63 oscillates through an angle jointly determined by the spacing of segments 67 and 68 on commutator 66, the ratio of the movement of "Selsyn" generator 64 to the movement of antenna 63, and the ratio of the movement of "Selsyn" motor 65 to the motion of commutator 66.

The location of the sector scanned is determined by the position of contact 78 on cam 79. The position of cam 79 is controlled by motor 101, which turns cam 79 through the medium of a reduction gear train 104. The direction in which motor 101 turns, and hence the direction in which contact 78 on cam 79 moves, is controlled by selector 11, controlled power supply 91 and relay 42.

Automatic gain control source 10 produces an automatic gain control or AGC voltage in any manner well known in the art. This AGC voltage is a direct-current potential that has an amplitude dependent on the strength of the signals received by the AGC generator. In the usual system this AGC voltage is applied to a receiver in such a manner that the amplitude of the output signals are constant even though the amplitude of the input signals are varying. It should be understood, however, that an AGC voltage may be produced without actually applying this voltage to a receiver. As is well understood in the art, the signals received by a directional antenna array such as antenna 63 are of maximum strength when the axis of the array is pointed at the source of the received signals. This source may be a reflecting object which returns echoes of the pulses transmitted by antenna array 63, or it may be any signal source emitting signals of constant amplitude. When the axis of the antenna is moved away from the source of the received signals, the amplitude of the signals at the input of the receiver is reduced, requiring that the AGC voltage change in order to maintain the signals in the output of the receiver constant. In the present embodiment of the invention it will be assumed that the AGC voltage produced in source 10 becomes more positive as the received signal decreases in amplitude and becomes less positive as the received signal increases in amplitude.

AGC source 10 is connected in parallel to contact arms 18 and 17 in selector 11. With relay 42 in the normal or unenergized position the AGC voltage is not applied to relay contact 22 nor is it applied to relay contact 30. Continuing the original assumption that antenna 63 is rotating clockwise, contact arms 41 and 43 will make contact with points 47 and 48, respectively, when relay coil 46 is energized by contact 78 coming in contact with segment 68. Since antenna 63 has inertia, it will take a small time interval for contact 78 to move off segment 68 in the ensuing reversal of rotation. During this time interval contact arm 41 is connected to a source of positive potential through point 47. Coil 21 of relay 12 is now energized, and contact arm 18 connects the AGC voltage source to point 22. Resistor 24 and capacitor 26 act as a smoothing filter so that the potential on grid 23 is the average value of the pulses of AGC voltage applied to point 22 every time relay 12 closes. Relay 13 remains open when contact 78 is in contact with segment 68 because point 48 is open. However, when commutator 66 moves so that contact 78 touches segment 67, relay 13 will then be closed; and relay 12 will be released. Resistor 34 and capacitor 36 act as a smoothing filter for the pulses of AGC voltages applied to point 30. It will be noted that each of relays 12 and 13 is closed for only a short time interval and that this time interval occurs at the moment when motor 62 is reversing its direction of rotation.

The converter 93, which may be of the type known as a Brown converter, is a type of vibrator circuit that produces a square wave output of a predetermined repetition frequency. The vibrator is so designed that the polarity of the output is determined by the relative polarity of the input terminals. Referring now to the converter shown as unit 93 in Fig. 1, if terminal 92 is at a higher direct-current potential than terminal 90, the output at terminals 94 and 95 will be a square wave of a first polarity. If, on the other hand, terminal 90 is at a higher potential than terminal 92, the output at terminals 94 and 95 will be a square wave having a polarity exactly opposite to the first polarity. If terminals 90 and 92 are at equal potentials, the output at terminals 94 and 95 is zero. The output of converter 93 is fed to servo-amplifier 98. Amplifier 98 is any of the types of amplifiers well known to the art that will produce a substantially sine wave voltage wave form at terminals 99 and 100 when a square wave is applied to input terminals 96 and 97. The output at points 99 and 100 is either of two sine waves that differ in phase by 180° depending on the polarity of the square wave at points 96 and 97. It is understood that the output at points 99 and 100 will be zero when the input at points 96 and 97 is zero. Motor 101 in this embodiment of the invention is a two-phase alternating current motor. One field of motor 101 is energized by amplifier 98, and the second is energized by an alternating voltage applied to terminals 102 and 103 that is of the same frequency as the output of amplifier 98. The phase of the voltage at points 102 and 103 differs by ninety electrical degrees from the phase of either output of amplifier 98. It can be seen that the direction of rotation of motor 101 will be determined by the phase of the output of amplifier 98 and hence by the relative polarity of terminals 90 and 92. It is also obvious that motor 101 will not rotate if terminals 90 and 92 are at the same potential.

As will be apparent to those skilled in the art, the controlled power supply 91 may be a type of differential amplifier and motor 101 may be a type of direct-current motor without affecting the operation of the invention.

Suppose now the center line of the sector scanned by antenna 63 contains the source of received signals. The axis of the array will be displaced by an equal angle from the direction of the target at each end of the sector, and, therefore, the pulses of AGC voltages applied to points 22 and 30 will be of equal magnitude. Since the time that relay 12 is closed is substantially equal to the time relay 13 is closed, the average voltage at point 22 will be the same as the average voltage of point 30, so grid 23 will be at the same potential as grid 33. Since the two cathode follower circuits containing tubes 15 and 16 have substantially identical characteristics, cathode 28 will be at the same potential as cathode 38 when grid 33 is at the same potential as grid 23. Since cathode 28 is at the same potential as cathode 38, no field exciting voltage will be supplied to motor 101 by amplifier 98; hence, motor 101 will not rotate.

Suppose now the center line of the scanned sector is off center with respect to the target. The axis of the antenna array will make a smaller angle with the target line at one end of the sector than it does at the other. This would mean that the magnitude of the AGC voltage pulses applied to points 22 and 30 would not be equal, and, therefore, the potential of grid 23 will not be equal to the potential of grid 33. Controlled power supply 91 is designed so that the output at points 99 and 100 will be such that motor 101 will move cam 79 in a direction to place the center of the scanned sector on the target.

Using the assumed directions of motion of antenna 63 and commutator 66, that is, when antenna moves clockwise when viewed from the top, commutator 66 moves clockwise when viewed from "Selsyn" motor 65, assume further that the target or source of the received signals lies to the left of the center of the scanned sector as viewed from the antenna. When relay 12 closes, the axis of antenna 63 will make a greater angle with the line to the target than it will when relay 13 closes. This means that grid 23 will be at a higher potential than grid 33. Controlled power supply 91 now furnishes motor 101 with energy of such a polarity that it will move cam 79 in a counterclockwise direction when viewed from "Selsyn" 65. Moving cam 79 in this direction will move the center of the scanned sector back to the target line. It will now be apparent that if the target is on the right side of the center of the scanned sector, grid 33 will be at a higher potential than grid 23 and controlled power supply 91 will furnish energy of such a phase that cam 79 is moved in a clockwise direction by motor 101.

When searching for a target, the sector scanned may be selected by turning control handwheel 105 which moves cam 79 through a suitable differential mechanism in gear train 104. It may be convenient in some embodiments of the invention to make the connection to segments 67 and 68 through slip rings so that antenna 63 may be rotated continuously if desired.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention.

What is claimed is:

1. An antenna positioning system, comprising a directional signal receiving antenna having a beam pattern adapted to scan thru an angle in a given plane sector, a motor for driving said antenna, a source of energizing potential for said motor; a relay, having contacts in the circuit between said motor and said source, for controlling the polarity of the potential with respect to said motor; a second source of energizing potential, a circuit including a rotatable commutator connecting said second source and said relay, an angular position transmitting device connecting said antenna and said commutator, a contact controlling the connection between said commutator and said relay, a cam for controlling the position of said contact, motor means for displacing said cam to effect a shift in the position of said contact; an automatic gain control circuit for supplying a signal, the relative value of a given polarity of which is inversely proportional to the intensity of the signals received thereby, a circuit for periodically transducing signals from said gain control circuit including actuating means therefor, circuit control means for said actuating means controlled by said relay; and

means for converting the output of said transducing means into a sine wave, the presence and relative phase of which depends on the comparative polarity of said output, said last named means being connected to energize said second motor.

2. An antenna positioning system, comprising a directional antenna having a beam-like pattern adapted to scan a sector having a given angle, a driving motor for said antenna to normally effect an oscillation thereof thru said angle, a source of energizing potential for said motor, means to effect a reversal in the polarity of said source with respect to said motor connected to said potential source and said motor, means for controlling said reversal effecting means as a function of the angular position of said antenna; a source of signals the amplitudes of which are a function of the centering of said scanning sector with respect to a point in a given direction within said sector, means for periodically supplying a signal which in respect to sign and amplitude is a function of the difference of the extreme values of said signal amplitudes connected to be supplied from said signal source, and means connected to be energized from said signal difference supplying means for effecting a shifting of said controlling means by an amount in accordance with said signal difference.

3. An antenna positioning system, comprising a directional receiving antenna having a beam pattern, means for effecting an oscillatory movement of said antenna in a given plane through a sector having a given angle, means for shifting the direction of said scanning sector connected with said last named means, and means including a source of signals the sign and amplitudes of which are a function of the centering of said scanning sector with respect to a point in a given direction within said sector for controlling said shifting means; wherein said means for controlling said shifting means includes a normally inoperative motor and said means for controlling said last named motor includes an automatic gain control circuit for supplying a signal, the relative value of a given polarity of which is inversely proportional to the intensity of the signals received thereby, means for periodically transducing signals from said gain control circuit in synchronism with the extreme limits of the oscillatory movement of said antenna, and means for converting the said transduced signals into a sine wave the presence and relative phase of which depends on the comparative polarity of said two transduced signals, and means for applying said sine wave signal to said shifting motor.

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