

Jan. 19, 1943.

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2,308,620

ELECTRONIC CONTROL CIRCUIT

Original Filed July 27, 1939

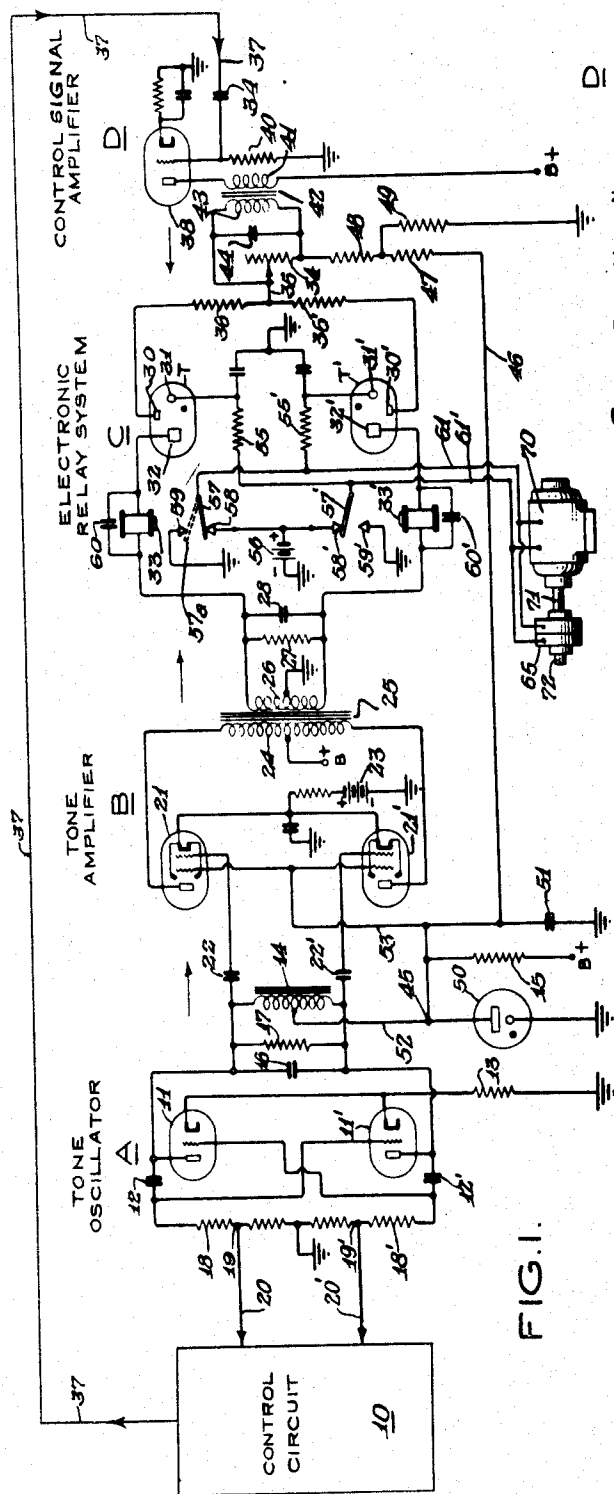


FIG. 1.

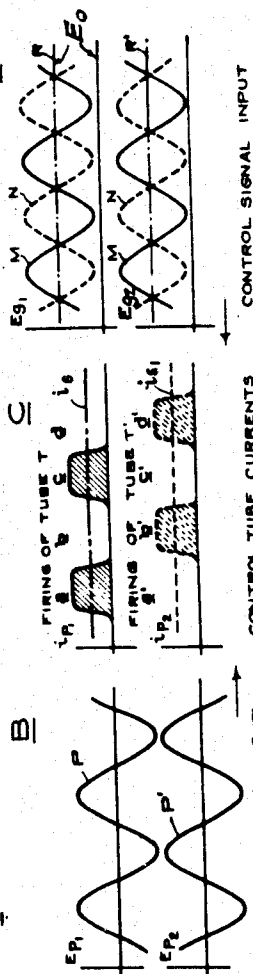


FIG. 2.

FIG. 3.

FIG. 4.

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ELECTRONIC CONTROL CIRCUIT

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Original application July 27, 1939, Serial No. 286,733. Divided and this application February 28, 1940, Serial No. 321,167

11 Claims. (Cl. 172-239)

This invention relates to relay systems and more particularly relates to novel electronic control systems for initiating reversible electrical actions. This application is a division of my parent case, Serial No. 286,733, entitled "Automatic radio direction indicator," filed on July 27, 1939.

In accordance with the present invention I provide an electronic relay control system comprising two oppositely phased electronic tubes rendered selectively conductive in accordance with the relative phase relation of a control signal impressed on both tubes. An alternating current signal or tone is continually impressed upon the oppositely phased tubes in 180° relation, serving as a reference condition for a control signal of the same frequency. The electronic tubes are each provided with a control or starter electrode, which, when suitably energized, causes the associated tube to conduct or fire. The magnitude and phase of the control signal are derived by determining factors in the system, as will be described.

Means are provided with the present invention to substantially increase the sensitivity of the selective firing action of the electronic tubes with respect to the control signal. Further means are provided to maintain the sensitivity and performance of the electronic relay circuit at a predetermined high level by insuring predetermined and constant biasing and anode supply voltages thereto. Further novel circuit arrangements are provided to substantially increase the sensitivity of firing by the unfired tube during the firing of the other one, whereby the unfired tube is made more highly responsive to a control signal of the opposite phase; resulting in the prevention of hunting of a reversible motor arrangement controlled thereby.

It is accordingly an object of my present invention to provide a novel electronic relay control system.

Another object of my present invention is to provide a novel electronic relay system selectively fired in accordance with the phase and magnitude of an alternating current signal.

Still another object of the present invention is to provide a novel electronic relay system giving uniform performance despite varying supply voltage conditions.

A further object of the present invention is to provide a novel electronic relay circuit of high sensitivity.

Still a further object of the present invention is to provide a novel electronic relay circuit with a selective sensitivity increase of firing action.

These and further objects of the present invention will become more apparent in the following description of a preferred embodiment of the invention illustrated in the drawing, in which:

Fig. 1 is a schematic electrical diagram of the electronic relay system and associated components.

Figs. 2, 3 and 4 are curves used in describing the electrical operation of the electronic relay system.

In accordance with my present invention, an audio frequency tone signal is provided from which a secondary control signal is derived to selectively control an electronic relay system. The tone frequency used is optional, a frequency being chosen which least interferes with other frequencies present in the associated radio or electrical circuits. Where speech or other audio frequencies are present, a very low or very high audio frequency is preferably chosen for the tone. A tone frequency of the order of 50, 100 or 150 cycles is satisfactory where non-interference with speech frequencies is desirable. An automatic radio directional finder system embodying the electronic relay system of my present invention is fully described in my copending patent application, Serial No. 286,733 referred to above. This direction finder system uses a control tone frequency of 102.5 cycles. It is to be understood that the electronic circuit of the present invention may be employed in conjunction with other types of radio or electrical systems where reversible relay action is indicated. A schematic "control circuit" is illustrated at 10 in Fig. 1, signifying optional associated circuit arrangements for the disclosed invention. The automatic direction finder of the application Serial No. 286,733 is to be understood to be an example of one of the many equivalent arrangements for "control circuit" 10, the present invention not being limited to any particular "control circuit."

The tone signal is electronically generated by local audio frequency oscillator A, comprising two opposed triodes 11, 11'. Other well known tone signal generator means may instead be used. The control grids of triodes 11, 11' are coupled to the anodes thereof by condensers 12, 12'. The cathodes of the oscillator triodes are connected together and to ground through biasing resistor 13. The anode supply for triodes 11, 11' is supplied through center tapped inductance 14 connected to the B supply by series resistor 15. A condenser 16 and resistance 17 are shunted across coil 14, to predetermine the frequency generated by oscillator A. Resistances 18 and 18' are coupled between

the grid electrodes of oscillator triodes 11, 11' and ground. Intermediate taps 18, 18' on respective resistors 18, 18' couple a portion of the available alternating tone energy from oscillator A to control circuit 10 through connection leads 20, 20'.

The output of tone oscillator A is amplified to a sufficiently high voltage value to properly actuate electronic relay system C in the manner to be described. Towards this end, a twin or push-pull amplifier B is provided, comprising oppositely connected amplifier tubes 21, 21'. Tubes 21, 21' are preferably a highly efficient amplifier type, such as electron beam power tubes, connected in a well known push-pull arrangement. The control grids of amplifier tubes 21, 21' are coupled to the output of tone oscillator A through coupling condensers 22, 22'. Direct current battery biasing is preferably used for tubes 21, 21', such as with the ships battery 23, to aid in stabilizing the action of amplifier B. The output of amplifier tubes 21, 21' is coupled to center-tapped primary winding 24 of step-down transformer 25. Secondary winding 26 of transformer 25 is center-tapped to ground, the outer terminals thereof being connected to the control tube anodes of relay system C, as will be described. Resistance 27 and capacitance 28 are shunted across secondary 26 of transformer 25 to cause selective transmission most efficient at the chosen tone frequency.

Electronic relay system C comprises two associated electronic control tubes T and T'. Electronic tubes T and T' may be high-vacuum triodes, mercury vapor relay tubes such as Thyratrons, or cold-cathode glow-discharge tubes with starter-anodes. I prefer to use the latter type as schematically indicated, containing starter-anodes 30, 30', cathodes 31, 41' and anodes 32, 32'. I have found such tubes, currently known as type OA4-G, suitable in practice for this purpose. The OA4-G tubes are designed so that a starter-anode voltage of the order of 110 volts between starter-anode and cathode, causes firing or breakdown in the tube to establish a current flow between the anode when energized and cathode thereof. In the illustrated circuit, anodes 32, 32' of relay tubes T and T' are energized by an alternating current signal at the tone frequency derived directly from oscillator A and amplifier B. The signal is applied to the anodes of tubes T, T' in push-pull relationship, i. e., in a 180° phase displacement relationship.

Fig. 2 illustrates the relative phase and form of a tone frequency signal input to anodes 32, 32' of the respective control tubes T and T'. Curves P and P' represent the relative phase and wave shape of the signal on anodes 32, 32', the signals P and P' being displaced by 180°. The signal magnitudes are equal, as is their frequency. Signal curve P diagrammatically represents the voltage input on anode 32 of tube T; curve P', displaced 180° with respect to curve P, to anode 32' of tube T'. The outer terminals of secondary winding 26 of step-down transformer 25 connects the output of tone amplifier B to anodes 32, 32' of respective tubes T, T' in the manner represented by curves P and P', through respective relay solenoids 33, 33'.

The control signal impressed across both starter-anodes 30, 30' is the same for both of these electrodes, being in-phase and applied to the anodes 30, 30' through a common variable tap 35 of potentiometer 34 through equal series resistors 36, 36'. The signal applied to starter-anodes 30, 30' controls the operation of tubes T and T' in a manner to be fully described. The

control signal for the starter-anodes is of the same frequency as the tone signal applied to the anodes 32, 32' of the tubes. The actual magnitude and relative phase relation of the control signal is derived in some characteristic manner, either manually or automatically, through control circuit 10. My patent application Serial No. 286,733 describes its derivation from and dependency upon the angular position of a rotatable loop antenna with respect to the radio station tuned to. Other applications are equally feasible. This derived control signal is applied to control signal amplifier D, through connection lead 37.

Control signal amplifier D comprises triode 38, the grid electrode of which is coupled to the connection lead 37 through coupling condenser 39. A grid resistor 40 connects the grid of tube 38 to ground. The output of amplifier D is derived from the anode of tube 38 through primary 41 of transformer 42 coupled thereto. Secondary winding 43 of transformer 52 is connected across potentiometer 34 having variable tap 35. The signals applied to amplifier D through connection lead 37 is predominantly of the signal frequency corresponding to the tone signal, extraneous frequencies being rejected by suitable filtering means in the control circuit 10, such as for example as disclosed in my patent application referred to above. An additional condenser 44 is shunted across secondary winding 43 of transformer 42 arranged for more efficiently passing the selected tone frequency to electronic relay system C.

Fig. 4 shows curves representing the control signal input to electronic relay system C, ordinates E_{e1} and E_{e2} , respectively representing the voltage applied to starter anodes 30 and 30' of tubes T and T'. Curve M is of the same frequency and wave shape with respect to axes R and R' as is reference curve P or P'. The magnitude of signal M depends upon the input to amplifier D from control circuit 10, which varies from zero to a substantially high value. Since both starter-anodes 30 and 30' are connected in common phase relationship, the signal represented by curve M is impressed on both at the same time, being of the same frequency, wave form, and magnitude for both E_{e1} and E_{e2} . Dotted curve N is identical with curve M, representing the signal impressed on starter-anodes 30, 30' but is displaced from signal M by 180°. The selective control action between tubes T and T' of relay system C is predicated upon such relative 180° displacement of the control signal impressed thereon as will be more fully described hereinafter. Control signals M or N also comprise an initial and steady direct current biasing potential to substantially increase the sensitivity of the firing by smaller control signals. This biasing potential is represented in Fig. 4 by E_0 , the supplementary axes R and R' indicating the level of the biasing or sensitivity, and is adjusted through variable tap 35 of potentiometer 34.

The biasing voltage for starter-anodes 30, 30' is supplied from constant B voltage potential point 45, through lead 46 and resistor network 47, 48 and 49 connected to potentiometer 34. The voltage at point 45 is held constant to maintain the sensitivity and performance of the relay system uniform, comprising an important feature of the invention. Potential point 45 is connected directly to the B supply terminal through series or limiting resistor 15. A voltage regulator device 50 is connected between point

45 and ground to hold the operating potential of point 45 constant over wide variations in the B potential supply. Series resistor 15 assists regulator device 50 in maintaining the unipotential value at point 45. A by-pass condenser 51 is connected between unipotential point 45 and lead 46 to ground. The biasing voltage E_0 for starter anodes 30, 30' is established by proper proportioning of resistor network 47, 48, 49 connected between potentiometer 34 and unipotential point 45. The anode potential for tone oscillator A is supplied from unipotential point 45 to lead 52, to insure stable operation of oscillator A. Lead 53 connects the screen grids of amplifier tubes 21, 21' to unipotential point 45.

A suitable voltage regulator device 50 is a cold-cathode, glow-discharge tube. In the practical embodiment thereof I employ a regulator tube 50 rated to maintain a voltage of 150 volts at point 45. Variation in the voltage supply to resistor 15 causes a variable voltage drop across the resistor 15, which is 2000 ohms in a chosen circuit. The current flow through regulator tube 50 varies in a well known manner to maintain the rated voltage, namely 150 volts, at point 45. It is to be understood that voltage regulator devices other than tube 50, or that a different voltage value or circuit connections may be used to maintain a constant voltage potential at point 45. Uniform, reliable and foolproof functioning of electronic relay system C depends upon the proper control of the biasing voltage therefor. Should the voltage rise unduly, the control tubes of electronic system C would fire and defeat any selective or automatic operation thereof. Should the voltage fall too low, the sensitivity of action of the control tubes T and T' would be impaired.

In the practical embodiment, the tone signal input P, P' is continually impressed upon anodes 32, 32' of the OAG-4 tubes T, T' by transformer 25, with a peak voltage of 140 to 150 volts for each anode with respect to ground. This anode voltage P, P' is kept substantially constant in magnitude, serving as a reference signal for relay system C as to phase relation for the control signal action. The voltage across the terminals of secondary winding 26 of transformer 25 is accordingly 280 to 300 volts peak value. Transformer 25 is preferably a step-down transformer, limiting the peak value of the voltage impressed upon the anodes of control tube T and T', and giving good current regulation for the transformer 25 despite the drawing of current by the anode circuit of the tubes upon firing. The peak voltage of the tone signal applied to anodes 32, 32' is kept below 150 volts per tube for the preferred arrangement, to avoid breakdown or firing of the tubes through the anode signal alone, and before a control signal of proper magnitude is applied to their starter-anodes 30, 30'. A step-down transformer 25, of 2:1 ratio is satisfactory, having a peak instantaneous signal voltage across the outside terminals of primary winding 24 of the order of 600 volts. Curves P and P' of Fig. 2 show equal magnitudes but a 180° phase displacement of the tone signals impressed upon anodes 32 and 32' respectively.

The initial positive bias, E_0 , upon starter-anodes 30, 30' is of the order of 85 volts with respect to ground in the preferred arrangement employing OA4-G tubes. Cathodes 31, 31' are here normally maintained at a positive 12 volt potential with respect to ground through respective cathode resistors 55, 55' connected to posi-

tive terminal of a 12 volt battery 56 through relay armatures 57, 57' and contacts 58, 58', respectively. The relative direct current potential of starter-anodes 30, 30' with respect to cathodes 31, 31' is thus 85 volts minus 12 volts, or 73 volts. When superimposed alternating current control signal M or N reaches a peak value of about 30 volts, it is just about sufficient to cause breakdown or firing of one of the control tubes T or T'. The peak positive value imparted to the starter-anodes 30, and 30' in this case is at least about 115 volts with respect to ground, being 103 volts or more with respect to cathodes 31, 31'. The phase relation of control signal M or N with respect to anode tone signals P or P' determines which of tubes T or T' will fire under these conditions.

In my copending patent application, Serial No. 286,733, where an automatic radio direction finder is the counterpart of control circuit 10, the position of rotatable loop antenna with respect to a radio transmitter, determines the magnitude and relative phase of the control signal impressed upon amplifier D. In the practical embodiment, a displacement of the rotatable loop antenna of about 1° from its null signal position produces a control signal component for signals M or N (Fig. 4) of about 10 to 15 volts peak value. A displacement of the loop antenna slightly more than the 1° brings the magnitude of the control signal to about 30 to 40 volts peak value, which signal is of sufficient magnitude to fire one of the tubes T, T' of system C. A further displacement, such as between 2 or 3 degrees brings the control signal component to its highest peak value of about 50 to 60 volts.

The limit of 60 volts peak or an equivalent limit for the control signal is in practice due to saturation of the control signal amplifier tube 38, or of preceding tubes in circuit 10 which must pass the alternating control signal to system C. The effect is to flatten the wave shape of the signal, maintaining the signal peak voltage at 60, or other predetermined value.

When the loop antenna or other device controlling the operation of circuit 10 is displaced on one side of its normal or null position, a resultant signal such as M of Fig. 4 is impressed upon the starter anodes 30, 30' of control tubes T, T'. As already described, anodes 32, 32' of the control tubes are continuously energized by oppositely phased control signals P and P', Fig. 2. Under these conditions, tube T will fire at alternate half cycles corresponding to the periods when anode 32 and starter anode 30 are at their positive half-cycle values. Tube T will accordingly break down or fire during half cycles a or c shown by firing current curves i_p in Fig. 3. It is to be noted that signal P' applied to anode 32' of tube T' is 180° out-of-phase, and negative when starter-anode signal M is positive, so that tube T' does not fire when tube T does.

Conversely, when the loop antenna or other controlling device is at the opposite position with respect to normal or null, the control signal impressed upon the starter-anodes 30, 30' is displaced 180° with respect to the previously described condition. The opposite phase control signal is represented by dotted curve N in Fig. 4, which signal is simultaneously impressed upon starter-anodes 30, 30'. In this latter condition with control signal N impressed upon tubes T, T' together with continuously impressed tone signals P and P', only tube T' will fire. This results due to the fact that the positive half-cycles

of these signals coincide only with curves P' and N in initiating the firing action. Current curve i_{p_2} of Fig. 3 shows that tube T' fires at the b' and d' half cycle periods, tube T being non-conductive during that time.

It will now accordingly be evident that selective firing of tubes T and T' takes place, dependent upon the relative phase relation of the control signal input to the control anodes 30, 30' of electronic relay system C, in turn dependent upon the operation at control circuit 10. One of the tubes, such as tube T, is arranged to fire when the phase of the control signal is at one condition, such as corresponding to the phase of tone signal M; and the other tube T' when the phase of the control signal is opposite thereto, corresponding to curve N. Condensers 60, 60' are respectively shunted across relay solenoids 33 and 33' for smoothing out pulsating current flow resulting from the interrupted firing action of relay tubes T and T'. A condenser of the order of one and one-half microfarads is satisfactory for flattening out the currents of solenoids 33 and 33', producing corresponding currents i_s and i_{s_1} as shown in Fig. 3. The average value of the solenoid currents is about 40 to 50 percent of the peak value of the control tube currents.

It is to be understood that in accordance with the present invention, only one or the other of solenoids 33 and 33' is energized at a given time, dependent upon the relative phase of the control signal input thereto corresponding to curves M and N, in turn dependent upon the displacement of a member of control circuit 10 with respect to its normal condition. Accordingly, when either tube is fired, an anode current will flow through the respective relay solenoid 33 or 33' of sufficient magnitude to energize it to attract its respective armature 57 or 57'. Solenoids 33 or 33' may each have a 2,000 ohm impedance in the present example. With such parameters an average current of 12 milliamperes flows through either solenoid.

The particular circuit connections for the gaseous control tubes T and T', such as the connections for the anode signals and control voltage signals impressed thereon, may assume different forms in practice. For example, the anodes may be connected in parallel or in-phase relation, and the starter-anodes connected in push pull or opposite-phase relation. Furthermore, high-vacuum triodes may be used for T and T', in place of the gaseous tubes described. However, the abrupt and large current changes of the gaseous control tubes permits the use of less sensitive relays 33, 33' for satisfactory service. The use of the gaseous control tubes T and T' instead of high-vacuum tubes results in an electronic relay system giving foolproof service in practice with highly sensitive control operation.

A reversible electric motor 70 is shown connected to electronic relay system C for direct control thereof, as an example of the application of the system in practice. It is to be understood that other control operations or elements may be initiated or effected by electronic relay system C, a motor being illustrative. Motor 70 is a direct current motor energized to normal operating condition when connected with battery 56. Any preferred type of reversible motor, such as a shunt-wound or permanent magnet field type may be used as motor 70. Leads 61, 61' connect motor 70 to armatures 57, 57' of the electromechanical relays of system C. Relay armatures 57, 57' are normally against their respective back contacts 58

58, 58' which are in turn connected to the positive terminal of direct current source 56, the negative terminal of which is grounded. Front contacts 59 and 59' of the relay armatures are connected to ground, and connect respectively to armatures 57 and 57' upon energization of corresponding solenoid 33 or 33'. An electromagnetic clutch 65 is preferably, though not necessarily, connected across the circuit of motor 70, and is coupled between the output shaft 71 of the motor and driven shaft 72 coupled to the load. Clutch 65 abruptly connects and disconnects motor shaft 71 from shaft 72 in correspondence with the energization and deenergization of the motor 70. Overrunning of the load is thus avoided when the motor is deenergized, as fully explained in the copending patent application referred to above, wherein the driven member is the loop antenna.

When solenoid 33 is energized due to the firing of tube T, armature 57 is connected with its front contact 59, and current flows to the motor 70 as follows: relay armature 57 (in the dotted position 57a), connection lead 61, motor 70 circuit, connection lead 61', relay armature 57', back contact 58', battery 56, and to ground back through front contact 59 and the relay armature 57. Where it is desired to conserve battery energy for operating motor 70, a permanent field magnet type of motor is used. When motor 70 is energized, the normally disengaged electromagnetic clutch 65 is thereupon also energized and couples driven shaft 72 with drive shaft 71 of motor 70. When the control signal condition impressed upon relay system C subsides or falls below a predetermined minimum value, e. g., 30 volts peak value, the firing of tube T stops and armature 57 returns to the back contact position 58, deenergizing motor 70 and immediately disconnecting driven shaft 72 from shaft 71 through the deenergization of clutch 65.

Conversely, when solenoid 33' is energized due to the firing tube T' instead of tube T in accordance with the control signal impressed upon system C, armature 57' is connected with its front contact 59'. Armature 57 remains in its neutral back contact position, and motor 70 is energized by the direct current source 56 in the direction opposite to that previously described. Driven shaft 72 is accordingly operated in the reverse direction during this condition, which continues until the control signal impressed upon starter-anodes 30, 30' falls below the predetermined firing magnitude. When motor 70 is deenergized, electromagnetic clutch 65 is simultaneously deenergized as previously described, disconnecting drive shaft 71 from driven shaft 72.

A further important feature of the present invention is the anti-hunting circuit provided for the operation of the electronic relay system C. Cathode resistors 55 and 55' are normally connected to the positive terminal of battery 56 through relay armatures 57' and 57 respectively, which in turn are connected to motor 70 through leads 61, 61'. Thus, cathode resistor 55 for tube T is connected to the relay armature 57' for the relay of the other tube T', and vice versa. When neither solenoid 33 or 33' is energized, corresponding armatures 57 or 57' are against their back contacts 58 and 58', normally biasing cathodes 31, 31' to the positive 12 volts (or any other desired voltage) value. The action of the positive 12 volt potential on cathodes 31, 31' is to reduce by a corresponding amount the effect of the positive biasing (E_0) on starter-anodes 30,

30'. Thus, the starter-anode biasing of the illustrated case, namely of the order of 85 volts, is reduced to an effective 73 volts with respect to the cathode. When either tube T or T' is fired due to a control signal of suitable magnitude being impressed upon the starter-anodes 30, 30', a corresponding armature 57 or 57' is attracted to its front position 59 or 59' respectively.

When tube T is energized in this manner, its relay armature 57 is attracted to front contact 59, away from back contact 58. The positive 12 volt bias on cathode 31' of opposite tube T' is thereupon removed, the cathode 31' being connected to zero or ground potential by grounded front contact 59. The removal of the 12 volt positive bias from cathode 31' increases by an equal amount the sensitivity of starter-anode of the opposite tube T', correspondingly enhancing the sensitivity of control tube T'. The bias increase by such action should be less than that which would directly cause firing of the tube. Unenergized tube T' is thereupon made more sensitive to a control signal with phase opposite to that of the firing tube T, and is thus more readily responsive to control the motor 70 into the opposite direction of rotation when such control signal of opposite phase reaches system C.

The unfired tube is thus rendered more sensitive to a control signal corresponding to an opposite direction to that causing the firing. Any tendency of driven shaft 72 together with its associated load (not shown but which may for example be a loop antenna or other device incorporated with control circuit 10 as previously indicated) to overshoot or overdrive with respect to the position it is intended to be driven to by motor 70, is thus readily counteracted by only a lower than normal control signal magnitude. Conversely, when tube T' is energized, attracting relay armature 57' to rotate the motor in the direction opposite to that of the above condition, cathode 31 of unfired tube T is grounded, increasing the firing sensitivity of tube T. A control for a motor drive or other reversible device is thus provided to prevent hunting or overshooting within rather close limits.

Such anti-hunting action is fully disclosed in my copending patent application, Serial No. 286,733 as applied to a rotatable directional antenna of an automatic direction finder. It is to be understood that the present invention has general applicability for equivalent uses, not being limited to a direction finder. Although I have disclosed a preferred arrangement for the circuits of the electronic relay system, it is to be understood that variations thereof may be made by those skilled in the art, falling within the broader spirit and scope of the present invention. Accordingly, I do not intend to be limited except as set forth in the following claims.

What I claim is:

1. A selective control system comprising a first electronic path, a second electronic path, a source of alternating potential in circuit connection with said electronic paths, means for impressing a control signal on said paths of the same frequency as said alternating potential, one of said paths firing when the impressed alternating potential and control signal are in substantial phase relation and the control signal is above a predetermined magnitude, and a relay in circuit with each of said paths individually actuated by the firing of its associated path, a reversible motor in circuit connection with said relays for energization in a direction in accord-

ance with the firing of said paths, and biasing means including circuit connections to said electronic paths for increasing the firing sensitivity of the unfired path to a control signal of proper phase, said biasing means being effective while the relay of the first path is actuated, whereby hunting by said reversible motor is inhibited.

2. A selective control system comprising a first electronic path, a second electronic path, a source of alternating potential in circuit connection with said electronic paths, means for impressing a control signal on said paths of the same frequency as said alternating potential and substantially in phase or one hundred and eighty degrees out of phase therewith, uni-directional biasing means including circuit connections to said electronic paths for substantially decreasing the magnitude required for firing a tube by the control signal and to predetermine the minimum control signal magnitude for firing said paths, said paths being selectively fired when the impressed alternating potential and control signal on a path are in substantial phase relation and the control signal is above said predetermined magnitude.

3. A selective control system comprising a first electronic path, a second electronic path, a source of alternating potential in circuit connection with said electronic paths, means for impressing a control signal on said paths of the same frequency as said alternating potential, one of said paths firing when the impressed alternating potential and control signal are in substantial phase relation and the control signal is above a predetermined magnitude, a relay in circuit with each of said paths individually actuated by the firing of its associated path, and biasing means including circuit connections to said electronic paths for increasing the firing sensitivity of the unfired path to a control signal of proper phase said biasing means being effective while the relay of the first path is actuated.

4. A selective control system comprising a first gaseous electronic tube having a cathode electrode, a second gaseous electronic tube having a cathode electrode, a source of alternating potential in circuit connection with said electronic tubes, means for impressing a control signal on said tubes of the same frequency as said alternating potential whereby one of said tubes is rendered conductive when the impressed alternating potential and control signal are in substantial phase relation and the control signal is above a predetermined magnitude, a relay in circuit with each of said tubes individually actuated by the conduction of its associated tube, an armature for each of said relays, and biasing means including circuit connections between the cathode of one tube and the armature associated with the other tube, whereby the conduction sensitivity of the non-conducting tube to a control signal of proper phase is substantially increased during the conduction period of the other tube by the disconnection of the biasing potential thereto.

5. A selective control system comprising a first gaseous electronic tube having cathode, anode and starter-anode electrodes, a second gaseous electronic tube having cathode, anode and starter-anode electrodes, a source of audio frequency current in circuit connection with the anodes of said tubes imparting alternating voltages thereto displaced by 180°, means including circuit connections to the starter-anodes of said tubes for impressing in substantial phase thereon a control

signal of the same frequency as said alternating voltage, the tube having the alternating voltage and control signal both impressed in substantial phase relation being rendered conductive when the control signal reaches a predetermined magnitude, a relay in circuit with each of said tubes, and biasing means including circuit connections to said tubes and said relays for increasing the firing sensitivity of the unfired tube to a control signal of proper phase while the relay of the fired tube is energized.

6. A selective control system comprising a first electronic path, a second electronic path, a source of alternating potential in circuit connection with said electronic paths, means for impressing a control signal on said paths of the same frequency as said alternating potential, biasing means including circuit connections to said electronic paths for increasing the firing sensitivity thereof by a control signal and predetermining the minimum control signal magnitude for firing said paths, one of said paths firing when the impressed alternating potential and control signal are in substantial phase relation and the control signal is above said predetermined magnitude, a common source of operating potential for said source of alternating potential and said biasing means, and a device for maintaining the potential of said common source substantially constant whereby the operating characteristics of the selective control system is maintained uniform.

7. A selective control system comprising a first gaseous electronic tube having cathode, anode and starter-anode electrodes, a second gaseous electronic tube having cathode, anode and starter-anode electrodes, a source of audio frequency current in circuit connection with the anodes of said tubes imparting alternating voltages thereto displaced by 180° , means including continuous circuit connections to the starter-anodes of said tubes for impressing in substantial phase thereon a control signal of the same frequency as said alternating voltage and substantially in phase or one hundred and eighty degrees out of phase therewith, means for biasing said starter-anodes with a substantial unipotential voltage to predetermine a substantially smaller magnitude for said control signal to render an electronic tube conductive, the tube having the alternating voltage and control signal both impressed in substantial phase relation being rendered conductive when the control signal reaches said predetermined magnitude.

8. A selective control system comprising a first gaseous electronic tube having cathode, anode and starter-anode electrodes, a second gaseous electronic tube having cathode, anode and starter-anode electrodes, a source of audio frequency current in circuit connection with the anodes of said tubes imparting alternating voltages thereto displaced by 180° , means including continuous circuit connections to the starter-anodes of said tubes for impressing in substantial phase thereon a control signal of the same frequency as said alternating voltage, the tube having the alternating voltage and control signal both impressed in substantial phase relation being rendered conductive when the control signal reaches a predetermined magnitude, a relay solenoid in circuit with each of said tubes and an armature for each of said relay solenoids for circuit connection with a device to be selectively controlled, and a substantial capacitance in shunt with each of said solenoids for smoothing currents therethrough to effect continuous control

of the device during interrupted current flow through the tube being selectively fired.

9. A selective control system comprising a first gaseous electronic tube having cathode, anode and starter-anode electrodes, a second gaseous electronic tube having cathode, anode and starter-anode electrodes, a source of audio frequency current in circuit connection with the anodes of said tubes imparting alternating voltages thereto displaced by 180° , means including circuit connections to the starter-anodes of said tubes for impressing in substantial phase thereon a control signal of substantially the same frequency as said alternating voltage, the tube having the alternating voltage and control signal both impressed in substantial phase relation being rendered conductive when the control signal reaches a predetermined magnitude, a relay solenoid in circuit with each of said electronic tubes, an armature for each of said relay solenoids, circuit connections between each of said armatures and the cathode of the opposite electronic tube, a source of biasing potential normally in circuit connection with said cathodes through said armatures, whereby the armature of the tube rendered conductive is actuated by the corresponding relay solenoid energized by the conductive tube to remove the biasing potential from the opposite or non-conducting tube and thereby increase the firing sensitivity of the non-conducting tube to a control signal of phase opposite to that causing the tube conduction.

10. A selective control system comprising a first gaseous electronic tube having a cathode electrode, a second gaseous electronic tube having a cathode electrode, a source of alternating potential in circuit connection with said electronic tubes, means for impressing a control signal on said tubes of the same frequency as said alternating potential whereby one of said tubes is rendered conductive when the impressed alternating potential and control signal are in substantial phase relation and the control signal is above a predetermined magnitude, a relay in circuit with each of said tubes individually actuated by the conduction of its associated tube, an armature for each of said relays, and biasing means including a resistor connecting the cathode of one tube with the armature associated with the other tube, a biasing battery the positive terminal of which is normally in common connection with said armatures, whereby the conduction sensitivity of the non-conducting tube to a control signal of phase opposite to that causing the conduction of the conducting tube is substantially increased during the conduction period of the other tube by the disconnection of the biasing potential thereto.

11. A selective control system comprising a first gaseous electronic tube having a cathode electrode, a second gaseous electronic tube having a cathode electrode, a source of alternating potential in circuit connection with said electronic tubes, means for impressing a control signal on said tubes of the same frequency as said alternating potential whereby one of said tubes is rendered conductive when the impressed alternating potential and control signal are in substantial phase relation and the control signal is above a predetermined magnitude, a relay in circuit with each of said tubes individually actuated by the conduction of its associated tube, an armature for each of said relays, biasing means including circuit connections between the cathode of one tube and the armature associated with

the other tube, and a direct current source normally in common connection with said relay armatures to normally bias said tubes whereby the conduction sensitivity of the non-conducting tube to a control signal of proper phase is substantially increased during the conduction period of the other tube by the disconnection of the biasing potential thereto, and a direct current re-

versible motor connected to said armatures for energization by said direct current source in a direction of rotation in response to and in accordance with the particular electronic tube rendered conductive, whereby hunting by said reversible motor is inhibited.

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