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ELECTRON DISCHARGE DEVICE SWITCHING SYSTEM
WITH AUTOMATIC VOLTAGE COMPENSATION
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FIG. 2

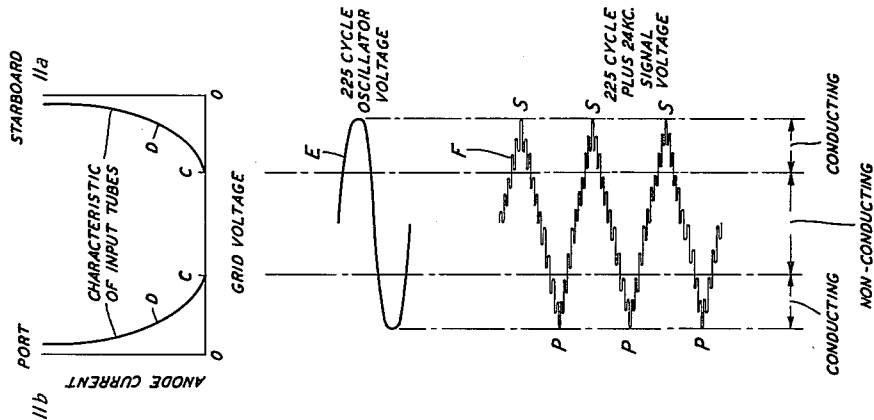
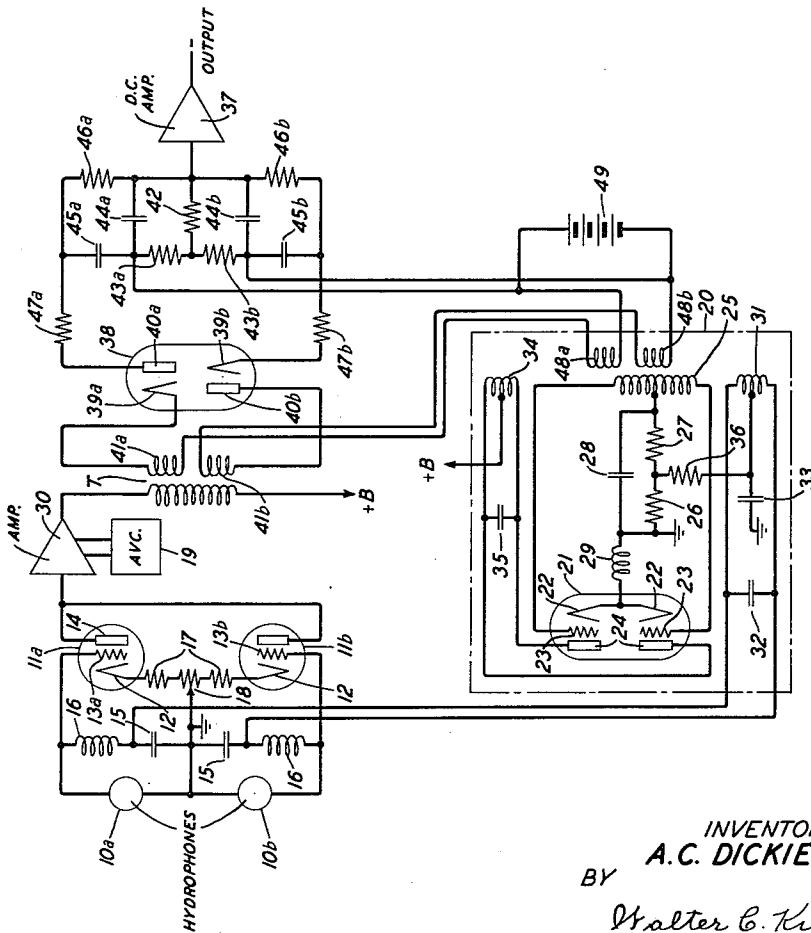


FIG. 1



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ELECTRON DISCHARGE DEVICE SWITCHING SYSTEM WITH AUTOMATIC VOLTAGE COMPENSATION

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This invention relates to electronic signal translating circuits and more particularly to electronic switching circuits especially suitable for use in signal controlled steering systems for moving bodies, such as, for example, sonically controlled steering systems for torpedoes, of the general organization disclosed in the application Serial No. 491,795, filed June 22, 1943, of Donald D. Robertson.

In steering systems of the general organization disclosed in the above-identified application, a pair of hydrophones are connected alternately in operative relation with an amplifier and the amplifier output is supplied to a pair of translating elements alternately and in synchronism with the operative association of the hydrophones to the amplifier. The translating elements operate to resolve the input thereto into a signal for controlling suitable steering apparatus in accordance with signals received by the hydrophones. The alternate connection of the hydrophones to the amplifier can be effected by way of electron discharge devices cooperatively associated with the hydrophones, these devices being controlled to perform the desired connection of the hydrophones to the amplifier.

One object of this invention is to simplify switching systems for effecting alternate connection of a pair of signal translating devices, such as hydrophones, to a circuit element, such as an amplifier.

Another object of this invention is to assure proper operation of switching systems wherein the switching is effected by way of electron discharge devices, despite substantial variations in the supply sources for the devices during the operating life thereof.

A further object of this invention is to obtain a substantially constant relation between the biasing potential and the switching potential applied to the control element of an electron discharge device intended to be rendered conductive cyclically in accordance with the overcoming of the biasing potential by a signal or switching potential.

In one illustrative embodiment of this invention, a signal translating circuit comprises an amplifier, a pair of signal translating devices, such as hydrophones, a pair of electron discharge devices each cooperatively associated with a corresponding one of the signal translating devices, e.g. hydrophones. The electron discharge devices have their output electrodes connected in common to the amplifier and each comprises a control electrode the potential of which is varied in accordance with the output of the corresponding hydrophone. Means are provided for biasing the control electrodes normally at or beyond cut-off. The bias on these electrodes is overcome cyclically to associate the hydrophones with the amplifier in alternation.

In accordance with one feature of this invention, both the biasing and switching potentials applied to the control electrodes noted are derived from a common circuit element constructed and arranged so that a substantially constant relation obtains between the magnitudes of the two potentials.

More specifically, in accordance with one feature of this invention, the biasing and switching potentials are derived from an electronic oscillation generator the grid

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circuit of which includes a grid leak and an oscillating coil. The switching potential is obtained from the grid circuit as by a coil coupled to the oscillating coil and connected across the control electrodes of the electron discharge device. The biasing potential is obtained by way of a potentiometer arrangement including a part of the grid leak resistance and associated with the coupling coil.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

FIG. 1 is a circuit diagram of a signal translating system including an electronic switching circuit illustrative of one embodiment of this invention; and

FIG. 2 is a diagram illustrating the character and relation of the several potentials applied to the control electrodes of the discharge devices associating the signal translating devices with the amplifier in the system shown in FIG. 1.

Referring now to the drawing, the signal translating system illustrated in FIG. 1 comprises a pair of substantially identical hydrophones 10a and 10b, which may be mounted on opposite sides, e.g. port and starboard or top and bottom, of a torpedo so that the relative intensities of the signals thereat are dependent upon the position of the signal source with respect to the torpedo. The hydrophones 10a and 10b have associated therewith electron discharge devices 11a and 11b respectively, each of which comprises a cathode 12, a control electrode or grid 13a or 13b respectively, and an output electrode or anode 14. The two anodes 14 are connected in common to the input of an amplifier 30 provided with automatic gain control 19. Advantageously, the hydrophones 10 are designed to be especially responsive to the signals of a particular frequency, for example 24 kilocycles per second, and the amplifier and the input and output circuits of the discharge devices 11 are tuned to this frequency.

The input circuits for the two discharge devices 11 are balanced and each includes one of the hydrophones 10, a condenser 15, an inductance coil 16, a biasing resistance 17 and a portion of the potentiometer resistance 18, the common connection to this resistance 18 being grounded and adjustable as shown to establish balance in the two input circuits.

The electron discharge devices 11 are controlled by an oscillator, designated generally by the reference numeral 20, to operatively associate the two hydrophones 10 with the amplifier 30 alternately. The oscillator 20 comprises an electron discharge device 21 including two substantially identical electrode units each having a cathode 22, a control electrode or grid 23 and an anode 24, the two electrode units being associated in push-pull relation. Advantageously, the oscillator frequency is low in comparison with the frequency to which the hydrophones 10 are particularly responsive. For example, if the hydrophones are tuned to 24 kilocycles per second, the oscillator frequency may be of the order of 225 cycles per second.

The grid circuit of the oscillator comprises the coil 25 connected across the control electrodes or grids 23, the mid-point of the coil 25 being connected to the cathodes 22 by way of resistances 26 and 27 bridged by a condenser 28, and a suitable inductance 29. The cathode end of the resistance 26 is grounded as shown. Coupled to the coil 25 is a second coil 31 which is connected across the condensers 15 in the input circuits of the discharge devices 11 and has in parallel therewith a tuning condenser 32. The mid-point of the coil 31 is connected to ground by way of a by-pass condenser 33 and is connected also to the grid leak 26, 27, and condenser 28 in

the grid circuit of the oscillator by way of resistance 36. The anode circuit of the oscillator is coupled to the grid circuit by way of the coil 34 which has a tuning condenser 35 associated therewith.

When the oscillator 20 is operating, a direct current potential appears across the resistances 26 and 27 because of grid current flow. A portion of this potential is impressed upon the control electrodes or grids 13 of the discharge devices 11, the circuit being traced from ground through resistances 26 and 36 to the mid-point of the coil 31 and thence to the grids 13, the cathodes of the devices being connected to ground through the resistances 17 and 18 as shown, whereby a negative bias is applied to the grids 13. The parameters of the circuit noted are made such that the bias applied to the grids 13 is beyond the cut-off point whereby, in the absence of other potentials in the grid circuits, the devices 11 are blocked or non-conducting.

The oscillator 20 supplies also to the grids 13 of the devices 11 a low frequency switching potential which is of sufficient amplitude to overcome the grid bias noted and thus to render the two devices 11a and 11b conducting alternately, the switching potential being supplied by way of the coil 31. Hence, the hydrophones 10a and 10b are operatively associated alternately with the amplifier 30. The operation is indicated diagrammatically in FIG. 2 for a system wherein the hydrophones 10a and 10b are on the starboard and port sides of the moving body or torpedo. The discharge devices 11 have grid voltage-anode current characteristics of the general form indicated at D, and, as noted above, the grids of these devices are biased beyond the cut-off points, indicated at C. The switching potential supplied by the oscillator, which is of the general form indicated by E, is of sufficient amplitude to overcome the grid bias and, as is apparent, renders the devices 11a and 11b conductive alternately. The 24 kilocycle outputs of the hydrophones 10 and 10b are impressed upon the respective grids 13a and 13b so that the 225 cycle potentials impressed upon the grids of the devices 11 are modulated in accordance with the respective 24 kilocycle signal as indicated at F. In the interest of simplicity of illustration in FIG. 2, the outputs of the two hydrophones 10 have been assumed to be equal. Thus, the input to the amplifier 30 is composed of 225 cycle pulses of 24 kilocycle signals, one group of alternate pulses being related in amplitude to the signal intensity at the hydrophone 10a and the other alternate pulses being related in amplitude to the signal intensity at the hydrophone 10b. Because of the action of the automatic gain control 19, a substantially constant gain is established for the amplifier 30 and, therefore, the output of the amplifier, similarly to the input, is composed of two groups of pulses each of which is proportional in amplitude to the signal intensity at a corresponding one of the hydrophones.

It will be noted that the direct current bias supplied to the grids 13a and 13b is proportional to the grid currents in the oscillator 20 and that the switching potential applied to these grids also is proportional to these currents. Consequently, the switching potential always is of sufficient amplitude to overcome the grid bias, and render the devices 11 conducting, even though the characteristics of the device 21 vary, as for example due to changes in the source, such as a battery, supplying potential to the anodes 24 or to changes in the emission characteristics of the cathodes 22. Stated in another way, a substantially fixed ratio is obtained between the bias and switching potentials supplied to the grids 13a and 13b so that permanent blocking of the devices 11a and 11b and consequent failure of the switching of the hydrophones to the amplifier 30 are prevented.

In a typical circuit, the control grids 13 may be biased normally at a potential of 7 volts negative with respect to the cathodes 12 and the peak value of the switching potential may be normally of the order of 5 volts. The resistances 26 and 27 may be equal and of the order of

50,000 ohms each and the condenser 28 may have a capacitance of the order of 0.1 microfarad. The resistance 36 may be of the order of 0.1 megohm.

The output of the amplifier 30 is resolved into a direct current potential proportional to the difference in the signal intensities at the two hydrophones 10, which is impressed upon the input element of a direct current amplifier 37. The resolution is effected by a network which includes a rectifier 38 having two substantially identical electrode units each of which includes a cathode 39a or 39b and an anode 40a or 40b, the two units being connected in parallel opposing relation and energized alternately, as described hereinafter, by way of circuits including balanced secondary windings 41a and 41b of a transformer T, the primary winding of which is included in the output circuit of the amplifier 30.

Associated with the rectifier 38 is a differential network which comprises a resistance 42 connected to the mid-point between two equal resistances 43, and two equal condensers 44a and 44b bridged across the resistance 42 and one of the resistances 43. The differential network includes also substantially identical end sections associated with a corresponding one of the condensers 44, each end section comprising a condenser 45 and resistances 46 and 47, the condensers and resistances being identified in the drawing by the same letter as the respective condenser 44. Included in the rectifier circuits are balanced coils 48a and 48b coupled to the oscillator and constructed and arranged to have equal voltages induced therein by the oscillator.

The circuit for the rectifier unit 39a, 40a may be traced from the cathode 39a, through windings 41a and 48a, through resistances 42 and 43a, in shunt with condenser 44a, and thence through resistances 46a and 47a to the anode 40a. The circuit for the rectifier unit 39b, 40b may be traced in like manner as is apparent.

A battery 49 is connected across the resistances 43a and 43b so that a biasing potential is impressed between each cathode 39 and the associated anode 40, the battery and resistances in the rectifier circuits being correlated so that each rectifier unit is biased beyond the cut-off point. The coils 48 are constructed and arranged so that the potentials supplied thereby to the respective rectifier units are of slightly less peak amplitude than the direct current bias supplied by the battery 49.

As noted heretofore, the output of the amplifier 30 is composed of pulses one group of which is related to the signal intensity at the hydrophone 10a and another group of which is related to the signal intensity at the hydrophone 10b, the pulses of the two groups being in alternate relation. These pulses are of such amplitude that when superimposed upon the potentials supplied by the oscillator to the rectifier circuits the resultant is sufficient to overcome the direct current bias upon the rectifier units. Hence, as will be apparent, the two rectifier units are rendered conductive in alternate relation and in synchronism with the alternate connection of the two hydrophones to the amplifier 30. When each rectifier unit becomes conducting, a charging current is supplied to the condenser 44 in the circuit thereof and as a result, a potential appears across the resistance 42. The two condensers 44 are charged in opposite directions relative to the resistance 42. Each condenser 44 receives its charging current from the corresponding rectifier unit and the input to each unit by way of the respective winding 41a is proportional to the signal intensity at the corresponding hydrophone. Consequently, the potential appearing across the resistance 42 at any time is related in polarity and amplitude to the relative signal intensities at the two hydrophones, being proportional in amplitude to the difference of the signal intensities and having the polarity associated with the hydrophone having the greater output.

The direct current amplifier 37 may be operated in accordance with the potential appearing across the resistance 42, as described in the aforementioned application of D. D.

Robertson, to control the deflection of a rudder of a moving body.

Although a specific embodiment of this invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A signal translating circuit comprising a pair of electron discharge devices each having a cathode, a control electrode and an output electrode, an output element to which the output electrodes of said devices are connected in common, separate input circuits for said devices each including the control electrode of the respective device, an electronic oscillation generator having a grid circuit, means for biasing the control electrodes of said devices proportionately to the grid circuit current of said oscillation generator, and means coupling said input circuits to said grid circuit for impressing between said control electrodes alternating potentials proportional to said current.

2. A signal translating circuit comprising a pair of electron discharge devices each having a cathode, a control electrode and an output electrode, an output circuit connected to the output electrodes of said devices, separate input circuits for said devices and each connected to the control electrode of the respective device, and means for controlling said input circuits comprising an electronic oscillation generator having an oscillating circuit including a coil and a resistance, a second coil inductively coupled to said first coil and connected between the control electrodes of said devices, and a direct current connection between said resistance and an intermediate point on said second coil.

3. A signal translating circuit comprising a pair of electron discharge devices each having a cathode, a control electrode and an output electrode, an output circuit connected to the output electrodes of said devices, separate input circuits for said devices and each including the control electrode of the respective device, and means for controlling said input circuits comprising an electronic oscillation generator having a resistance in its grid circuit, means for biasing the control electrodes of said devices proportionately to the potential across said resistance, and means coupled to said grid circuit for applying an alternating potential to said control electrodes.

4. A signal translating circuit comprising a pair of similar electron discharge devices each having a cathode, a control grid and an anode, an output circuit connected to the anodes of said devices, separate input circuits for said devices each including the control grid of the respective device, and means for controlling said input circuits to render said devices conductive in alternate relation, said

means comprising an electronic oscillation generator having a cathode and another electrode, an oscillatory circuit connected between said cathode and electrode of said oscillation generator and including a resistance, a coil coupled to said oscillatory circuit and connected between said control grids, a direct current connection between said resistance and the mid-point of said coil, and means connecting all of said cathodes to one another.

5. A signal translating circuit comprising a pair of electron discharge devices each having a cathode, a grid and an anode, an output circuit connected to the anodes of said devices, separate input circuits for said devices, an electronic oscillation generator the grid circuit of which includes a leak resistance, means including said resistance for biasing the grids of said devices at a potential beyond cut-off and proportional to the potential across said resistance, and means including a coil inductively coupled to said grid circuit and connected between said grids for impressing an alternating potential upon said grids of sufficient amplitude to overcome said biasing potential.

6. A signal translating circuit comprising a pair of similar electron discharge devices each having a cathode, a grid and an anode, an output circuit connected to the anodes of said devices, separate balanced input circuits for said devices, an electronic oscillation generator including two similar electrode units connected in push-pull relation and each having a grid, the grid circuit for said units including a leak resistance, means coupled to said grid circuit for impressing an alternating potential between the grids of said devices, and means including said resistance for impressing a biasing potential upon said grids of said devices.

7. A signal translating circuit comprising a pair of similar electron discharge devices each having a cathode, a control grid and an anode, a common output element connected to the anodes of said devices, separate balanced input circuits for said devices and each including the control grid of the respective device, an electronic oscillation generator including a pair of electrode units each having a grid, and connected in push-pull relation, the grid circuit of said oscillation generator including a leak resistance, a direct current connection between the cathodes of said devices and a point on said resistance, a coil coupled to said grid circuit and connected across the control grids of said devices to impress alternating potentials upon said control grids, and a direct current connection between the mid-point of said coil and another point on said resistance.

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