

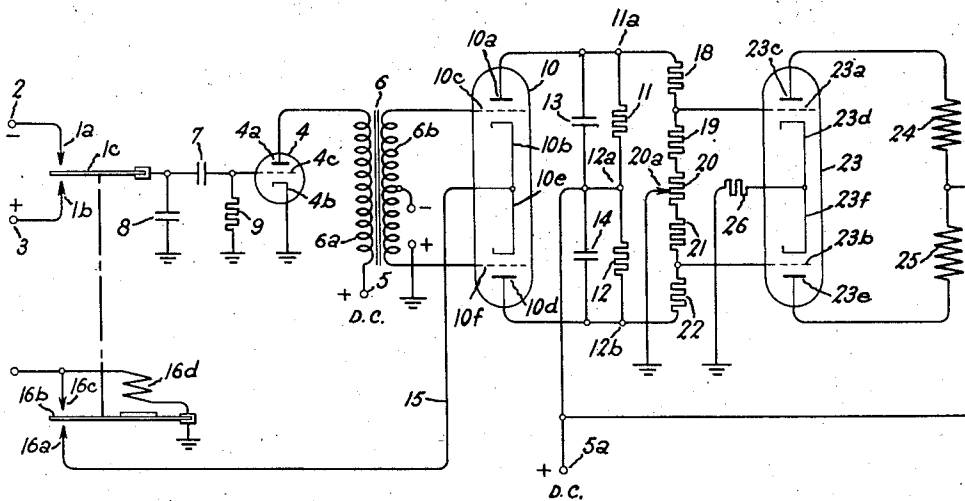
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ELECTRONIC DIRECT CURRENT CONTROL SYSTEM

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ELECTRONIC DIRECT-CURRENT CONTROL SYSTEM

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This invention relates to control systems, more particularly to electric valve control systems and it has for an object the provision of a simple, reliable, inexpensive and improved control system of this character.

Still more specifically the invention relates to a control system for amplifying a direct signal voltage of either polarity by converting the direct voltage to a square wave periodically varying voltage and amplifier, and a further object of the invention is the provision of a control system of this character which is self-synchronous and which requires no contacts to be driven in synchronism with an A.-C. line voltage.

In carrying the invention into effect in one form thereof, a direct signal voltage is supplied to the input terminals of a vibrator unit having a pair of main vibratory contacts by means of which the signal voltage is chopped and converted into a square wave periodically varying voltage. This voltage is amplified by means of an A.-C. amplifier and the amplified voltage is supplied to the input circuit of a discriminator stage comprising a pair of electric valves which are connected push pull and each of which is provided with an anode, a cathode, and a control grid. An auxiliary vibratory contact of the vibrator unit is connected in circuit between the cathodes of the discriminator stage valves and one terminal of the discriminator's source of supply. This auxiliary contact is mechanically connected with the main contact of the vibrator unit and is arranged to complete its circuit only in one of the two contact making positions of the main vibratory contact. The voltage at the output terminals of the discriminator stage is uni-directional and its magnitude reverses with reversals in polarity of the direct signal voltage at the input terminals.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawing of which the single figure is a simple, diagrammatical sketch of an embodiment of my invention.

Referring now to the drawing, a vibratory contact unit having stationary contacts 1a and 1b and a vibratory contact 1c is provided with input terminals 2 and 3. The vibratory contact 1c is connected by means of a capacitive coupling to the input circuit of an A.-C. amplifier comprising the electric valve 4 and associated control circuits. This valve is provided with an anode 4a, a cathode 4b, and a control grid 4c. It is supplied from a suitable source of direct voltage of which the

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positive terminal is represented by the conductor 5 and the negative terminal is connected to ground.

As shown, the anode 4a is connected through the primary winding 6a of a coupling transformer 6 to the positive terminal 5 and the cathode is connected to ground. The control grid 4c is connected through the coupling capacitor 7 to the vibratory contact 1c. A capacitor 8 is connected between the vibratory contact 1c and the cathode 4b, and a resistor 9 is connected between the grid 4c and the cathode. Normally, with no signal voltage applied to the grid 4c, the valve 4 is conducting in mid range.

The discriminator stage comprises two electric valves which are preferably included within a single envelope 10. One of the valves comprises the anode 10a, cathode 10b and control grid 10c and the other comprises anode 10d, cathode 10e and control grid 10f. These valves are preferably connected push pull. As shown, the anodes 10a and 10d are respectively connected through resistors 11 and 12 to the positive terminal 5a of a source of direct voltage of which the negative terminal is connected to ground. Capacitors 13 and 14 are connected in parallel with resistors 11 and 12 respectively. Cathodes 10b and 10e are connected by means of a conductor 15 to the negative side of the source. An auxiliary pair of vibratory contacts 16a and 16b is connected between the cathodes and the negative side of the source. The auxiliary vibratory contact 16b is mechanically connected by suitable means to the main vibratory contact 1c so that the contacts 1b and 16a are made and broken synchronously. Direct voltage for operating the vibrator is supplied to the terminals of the operating coil 16d. A stationary contact 16c cooperates with the vibratory contact 16b to short circuit the coil to provide the vibratory action of the reeds which carry the vibratory contacts.

The grids 10c and 10f of the discriminator stage are connected to opposite terminals of the secondary winding 6b of the transformer 6 and the midpoint of the secondary winding is connected to a negative terminal of the source. A suitable source of a biasing potential is included in this connection. The magnitude of this bias is such that with no signal voltage being supplied to the grids, both valves of the discriminator are conducting in approximately mid range.

When either of the valves of the discriminator stage is conducting, it produces a uni-directional voltage drop across the corresponding resistor 11 or 12. During the nonconducting half cycle of

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the valve which is conducting, the voltage drop across the resistor 11 or 12 is maintained as a result of the charge on the capacitor 13 or 14 which is connected in parallel therewith.

A plurality of resistors 18, 19, 20, 21 and 22 are connected in series relationship across the resistors 11 and 12 and thus constitute a voltage divider of the output circuit voltage of the discriminator stage. The resistor 20 is provided with a sliding contact 20a which is adjusted as necessary to secure a balanced output with zero signal input.

A portion of the output circuit voltage of the discriminator stage which is obtained from this voltage divider is supplied to the input circuit of a power amplifier which comprises a pair of electric valves connected in push pull. Preferably these electric valves are included within a common envelope 23. These valves are supplied from a source of direct voltage which is preferably the same source as that from which the discriminator stage is supplied. As shown, the anodes of the power amplifier stage are connected through coils 24 and 25 to the positive terminal 5a of the source and the cathodes are connected through a resistor 26 to the negative terminal of the source. Coils 24 and 25 may be the operating coils of relays or they may be opposed field windings of a dynamo-electric machine such as a motor, a generator, or an amplidyne exciter.

With the foregoing understanding of the elements and their organization, the operation of the system will be readily understood from the following description: It is assumed that the terminals of the coil 16d of the vibrator are connected to a source of direct voltage and that the vibrator is operating. A signal voltage is applied to the input terminals 2 and 3 of which the polarity at the terminal 3 may be assumed to be positive.

The main vibrator contacts 1a, 1b and 1c chop this direct signal voltage into a square wave periodically varying voltage which is amplified by the amplifier 4. As a result, a periodically varying voltage of the same frequency is induced in the secondary winding 6b of the transformer 6. The transformer windings are so poled that the polarity of the voltage at the lower terminal of the secondary winding is positive when the contact 1c is in engagement with the stationary contact 1b and the current in the primary winding is increasing. At this same instant, the vibratory contact 16b is in engagement with the stationary contact 16a, thereby completing the cathode circuit of the discriminator stage. The positive voltage of the lower terminal of the transformer secondary is impressed on the grid 10f and consequently current flows from the positive terminal 5a of the source through resistor 12 and from anode 10d to cathode 10e and thence through conductor 15 and contact 16a to the negative terminal of the source. As a result of this current flow, a voltage drop appears across the resistor 12 of which the polarity at the center terminal 12a is positive. This voltage drop charges the capacitor 14.

During this same period when contacts 16a and 16b are engaged there is a negative voltage impressed on grid 10c. If the magnitude of this voltage is less than the critical value above which no plate current can flow, current will flow from 5a through 11, 10a, 10b, 16a and 16b to ground. However, the magnitude of this current will be less than that flowing through resistor 12 and the

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voltage appearing across 11 will be less than that across 12.

During the succeeding half cycle the movable contact 1c is in engagement with the stationary contact 1a. Consequently the polarity of the voltage at the secondary terminals of the transformer is reversed, i. e. the voltage at the upper terminal is positive and the voltage at the lower terminal is negative. However, there is no conduction from the anode 10a to the cathode 10b because the auxiliary stationary contact 16b is out of engagement with the stationary contact 16a when main contact 1c is in engagement with stationary contact 1a. During this half cycle in which there is no conduction through either valve of the discriminator stage the voltage drop across the resistor 12 is maintained by the charge on capacitor 14 and the voltage drop across resistor 11 is maintained by the charge on capacitor 13. Thus, there is maintained across the resistors 12 and 11 uni-directional voltages of which the magnitude is proportional to the magnitude of the signal voltage which is impressed on the input terminals 2 and 3.

If the polarity of the signal voltage is reversed, the voltage at the lower terminal of the secondary winding 6b will be positive when the main vibratory contact 1c is in engagement with the stationary contact 1a. However, when the contact 1c is in engagement with the contact 1a the auxiliary contact 16b is out of engagement with the stationary contact 16a. Consequently the cathode circuit of the discriminator stage is interrupted and although a positive voltage is applied to the grid 10f there is no conduction between the cathode 10b and 10e. However, during the next half cycle when the main vibratory contact 1c is in engagement with the stationary contact 1b which is connected to the now negative input terminal, the polarity of the voltage at the upper terminal of the secondary winding 6b is positive. During this half cycle the auxiliary vibratory contact 16b is in engagement with the stationary contact 16a, thereby completing the cathode circuit of the discriminator stage, and current flows from the positive terminal of the source 5a through resistor 11, and from anode 10a to cathode 10b within the valve and thence by conductor 15 and by the auxiliary contacts 16a and 16b to the negative terminal of the source. As a result, a voltage drop appears across the resistor 11 of which the polarity at the center terminal 11a is positive and the polarity at the end terminal 11b is negative. This voltage drop charges the capacitor 13 so that during the succeeding half cycle, when neither valve of the discriminator stage is conducting, the voltage across the resistor 11 is maintained.

Thus, the voltage appearing across resistor 11 is either greater or less than the voltage appearing across resistor 12 depending upon the polarity of the D. C. input voltage and the magnitude of each voltage depends upon the magnitude of the input voltage.

The voltage across resistor 11 is divided by resistors 18, 19 and part of 20 and the voltage across resistor 12 is divided by resistors 22, 21 and part of 20. These voltages are divided in order to provide the proper operating grid voltages on grids 23a and 23b. With no signal input on terminals 2 and 3 the voltages of the grids 23a and 23b are equal and the currents flowing through windings 24 and 25 are equal. With an input signal of the proper polarity i. e. the terminal 2 positive and the terminal 3 negative,

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the voltage across 11 increases the current through winding 24 decreases and the voltage across 12 decreases the current through 25 increases. With an input voltage of reversed polarity, the reverse action occurs.

Thus, from the foregoing, it is seen that the magnitude and polarity of the voltage at the output terminals of the discriminator stage corresponds to the magnitude and polarity of the direct signal voltage at the input terminals 2 and 3.

Although in accordance with the provisions of the Patent Statutes this invention is described as embodied in concrete form and the principle thereof has been explained together with the best mode in which it is now contemplated applying that principle, it will be understood that the elements shown and described are merely illustrative and that the invention is not limited thereto since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of this invention or from the scope of the annexed claims.

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

1. A control system comprising a pair of input terminals adapted to be connected to a source of direct voltage, vibratory contacts with terminals for deriving from said direct voltage a square wave periodically varying voltage, means for amplifying said square wave voltage comprising an electric valve provided with an input circuit connected to said vibratory contacts and an output circuit, a discriminator stage having an output circuit and having an input circuit connected to the output circuit of said amplifier comprising a pair of electric valves connected push pull and each having an anode, a cathode, and a control grid, connections for energizing said anodes and cathodes from a source of direct voltage, auxiliary vibratory contacts included in said cathode connection, and means for mechanically connecting said auxiliary vibratory contacts with said first mentioned contacts for interrupting and completing said cathode connection synchronously with said square wave voltage thereby to provide a rectified voltage at the terminals of the output circuit having a polarity that reverses with the polarity of the voltage at said input terminals.

2. A control system comprising a vibrator having a pair of input contacts arranged and adapted to be connected to a source of direct voltage, a cooperating vibratory contact, an auxiliary stationary contact and auxiliary vibrating contact cooperating with said auxiliary stationary contact, means for operating said vibratory contacts synchronously, an amplifier comprising an electric valve having an anode, a cathode and a control grid coupled to said first vibratory contact, a discriminator stage comprising a pair of electric valves connected push pull and having an input circuit coupled to the output circuit of said amplifier stage, an output circuit network for said discriminator stage comprising a pair of resistors connected across the anodes of said discriminator stage valves and a separate capacitor connected in parallel with each of said resistors, a connection from an intermediate point of said resistors to the positive terminal of a source of direct voltage and a connection including said auxiliary contacts from the cathodes of said discriminator stage valves to the opposite terminals of said source for increasing the conductivity of one of said discriminator stage valves

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for one polarity of said input voltage and for increasing the conductivity of the other of said discriminator stage valves for the opposite polarity of said input voltage.

3. A control system comprising a discriminator stage having an input circuit and an output circuit and comprising a pair of push pull connected electric valves each provided with an anode, a cathode and a control grid, a pair of input terminals adapted and arranged to be connected to a source of direct voltage, vibratory contacts connected to said terminals for deriving from said direct voltage a square wave periodically varying voltage, an electric valve alternating current amplifier for amplifying said square wave voltage and supplying the amplified voltage to said input circuit, connections from the anodes and cathodes of said discriminator valves to a source of direct voltage for energizing said push pull valve, an auxiliary pair of vibratory contacts included in said cathode connection, and means mechanically connecting said auxiliary contacts with said first mentioned contacts for interrupting and completing said cathode connection in synchronism with said square wave voltage for selectively rendering said discriminator valves conducting thereby to provide at the terminals of said output circuit a uni-directional voltage varying in polarity with the polarity of the voltage at said input terminals.

4. A control system comprising a discriminator stage having an input circuit and an output circuit and comprising a pair of push pull connected electric valves each provided with an anode, a cathode and a control grid, a pair of input terminals adapted and arranged to be connected to a source of direct voltage, vibratory contacts connected to said terminals for deriving from said direct voltage a square wave periodically varying voltage, an electric valve alternating current amplifier for amplifying said square wave voltage and supplying the amplified voltage to said input circuit, connections for energizing the anodes and cathodes of said discriminator valves from a source of direct voltage, an auxiliary pair of vibratory contacts included in said cathode connection, means mechanically connecting said auxiliary contacts with said first mentioned contacts for interrupting and completing said cathode connection in synchronism with said square wave voltage for selectively rendering said discriminator valves conducting thereby to provide at the terminals of said output circuit a uni-directional voltage varying in polarity with the polarity of the voltage at said input terminals, a power amplifier stage having an input circuit and an output circuit divided into two portions comprising a pair of electric valves connected push pull and having its input circuit connected to the output circuit of said discriminator stage, and a pair of electromagnetic devices having coil windings connected differentially in said portions of said output circuit.

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