

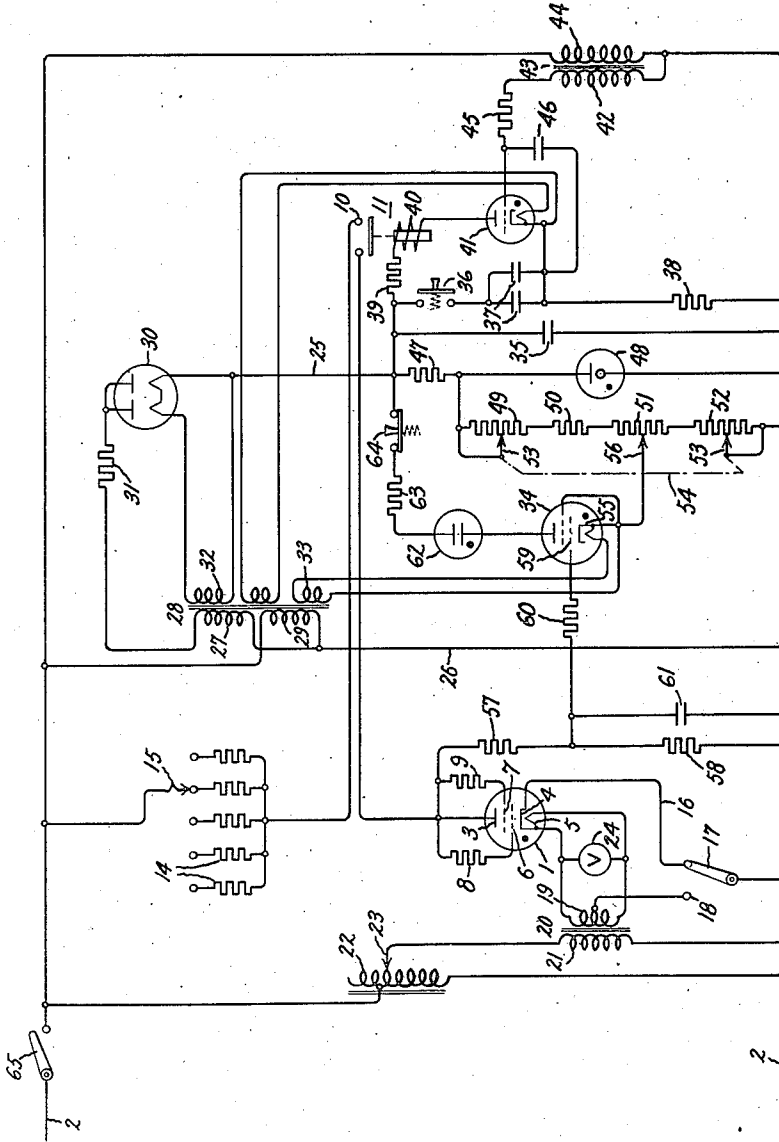
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ELECTRIC CONTROL CIRCUITS

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ELECTRIC CONTROL CIRCUITS

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Our invention relates to electric control circuits and more particularly to an improved control circuit for effecting the closing and opening of an alternating current circuit during cycles of voltage of predetermined polarity.

While not limited thereto, we have applied our invention successfully to a testing circuit for electric discharge devices of the gas or vapor-filled type in which the anode-cathode circuit of the device to be tested is established for a half cycle or predetermined number of half cycles by closure of an electromagnetic switching device connected in series with the anode-cathode circuit and controlled synchronously with the voltage of the alternating current supply so that all operations of the switching device are accomplished during half cycles of negative voltage of the supply circuit.

It is an object of our invention to provide a new and improved electric circuit.

It is another object of our invention to provide a new and improved switching circuit.

It is a still further object of our invention to provide a new and improved electric control circuit particularly adapted for establishing a circuit including a unilaterally conductive device and a source of alternating voltage during half cycles of the voltage during which the unilateral device is nonconductive.

Further objects and advantages of our invention will become apparent as the following description proceeds, reference being had to the accompanying drawing, and its scope will be pointed out in the appended claims. In the drawing, the single figure is a schematic representation of a tube testing circuit embodying our invention.

Referring now to the drawing, we have shown our invention embodied in a control circuit for measuring the arc drop of an electric discharge device 1 during predetermined half cycles of voltage of an alternating current supply circuit 2. The electric discharge device 1, as illustrated, is of the type utilizing an ionizable medium, such as a gas or vapor, and including within the envelope an anode 3, a cathode 4, a heater element 5, a control grid 6 and a screen grid 7. As illustrated in the drawing, the control and screen grids are connected with the anode through resistors 8 and 9, respectively. The anode is adapted to be connected to one side of the alternating current supply circuit through the normally open contacts 10 of an electromagnetic relay 11 and one of a plurality of resistors 14 which are selectively connected in the

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circuit by a switch 15. The cathode of the device 1 is connected with the other side of the alternating current circuit by conductor 16 and a manual switch 17. As illustrated, the switch 17 may be moved to engagement with a contact 18 connected with the midpoint of the secondary winding 19 of a filament transformer 20 for the purpose of completing the anode-cathode circuit for devices designed to operate with the cathode circuit established through the midpoint of the secondary winding of the heater supply transformer. As illustrated, the end terminals of the transformer secondary winding 19 are connected with the heater element 5. The primary winding 21 of transformer 20 is energized from the alternating current supply circuit 2 by means of an auto-transformer 22 having an adjustable tap 23. A voltmeter 24 may be connected across the heater circuit for use in adjusting the heater voltage to rated value.

In accordance with an important feature of our invention, the relay 11 is energized synchronously with respect to the voltage of the alternating current supply circuit 2 to close the anode-cathode circuit of the discharge device 1 during a negative half cycle of the supply circuit voltage, and to maintain the circuit closed for one or more positive half cycles of this voltage, and to open the circuit during a negative half cycle of voltage. The control circuit for accomplishing this end is in the nature of a single-tube inverter and is energized from a suitable source of direct current voltage including conductors 25 and 26 which may to advantage be energized from the output of a rectifier circuit connected between the alternating current supply circuit 2 and the conductors 25 and 26. As illustrated, this circuit includes the secondary winding 27 of a transformer 28 having the primary winding 29 thereof energized from the alternating current supply circuit 2 and a full wave electric discharge device 30. A suitable current limiting resistor 31 is connected between the transformer winding 27 and the anode-cathode circuits of the device 30. As illustrated in the drawing, the transformer 28 also includes a secondary winding 32 for supplying heating current to the cathodes of the discharge device 30 and a further winding 33 for energizing the cathode heater of an electric discharge device 34 which, as will be described later in the specification, forms a part of a measuring circuit for indicating the peak voltage drop across the anode-cathode circuit of the discharge device 1 which is under test.

The direct current voltage provided by conductors 25 and 26 is filtered by a shunt capacitor 35 and impressed on a series circuit including a normally open push button switch 36, capacitors 37 connected in parallel and a charging resistor 38. It will be apparent that the capacitors 37 charge from the direct current voltage of conductors 25 and 26 upon closure of the switch 36 at a rate dependent upon the magnitude of the charging resistor 38. The circuit including switch 36 and capacitors 37 is shunted by a series circuit including a resistor 39, an operating coil 40 of the relay 11, and the anode-cathode circuit of an electric discharge device 41 which may to advantage be of the gas-filled type. This latter circuit including the discharge device 41 controls the discharge of capacitors 37 and the duration of each period of energization of the operating coil 40 of the relay 11. In order to synchronize the initiation of conduction by electric valve 41 with the voltage of the alternating current supply circuit 2, the circuit of the control member thereof is completed from the cathode of the device, through resistor 38 which provides a negative bias having a magnitude dependent upon the condition of charge of capacitors 37, and the secondary winding 42 of a peaking transformer 43 having the primary winding 44 thereof energized from the alternating current supply circuit 2. The secondary winding 42 is connected with proper polarity so that the voltage peaks tending to render the control member of valve 41 positive with respect to the cathode occur during half cycles of the supply circuit voltage during which the anode 3 of discharge device 1 is negative. The circuit of the control member of valve 41 also includes a series current limiting grid resistor 45 and a shunt transient suppressing capacitor 46 in accordance with practice well established in the art.

The conductors 25 and 26 also provide a source of direct current voltage for a peak voltage measuring circuit for indicating the voltage drop across the anode-cathode circuit of the discharge device 1 which is undergoing test. The voltage of conductors 25 and 26 is regulated by a circuit including a series resistor 47 and a glow discharge device 48 of the type having a critical minimum ionizing potential connected in series across these conductors. The constant voltage appearing across the terminals of the discharge device 48 is impressed on a circuit including, in series, the resistors 49—52. Resistors 49 and 52 are provided, respectively, with adjustable taps 53 which are arranged to short out variable portions of resistors 49 and 52 and which are mechanically interlocked, as indicated at 54, so that as resistor 49 is shorted out, resistor 52 is inserted, so that the total resistance of the circuit including resistors 49—52, inclusive, remains constant. The adjustment of the contacts 53 is, therefore, effective to adjust the direct current voltage level of any point upon the resistors connected between these contacts 53. The cathode 55 of the electric discharge device 34 is connected to an adjustable contact 56 on the resistor 51 to establish a reference voltage with which the arc drop voltage of discharge device 1 is compared as a result of the connection between the grid circuit of device 34 and the anode cathode circuit of device 1. As illustrated, a voltage dividing circuit including resistors 57 and 58 is connected across the anode-cathode circuit of device 1 and the control grid 59 of discharge device 34 connected with the common point of these resistors through

a current limiting resistor 60. In order to control the response of the control member 59 to the anode-cathode voltage of device 1, and particularly to render it insensitive to the initial steep wave front of voltage at the instant of initiation of conduction, a capacitor 61 is connected across voltage dividing resistor 58. This capacitor tends to by-pass this steep wave front voltage and to render the control circuit responsive to the voltage occurring during the remaining portion of the conducting half cycle of device 1.

The anode-cathode circuit of device 34 is completed from the anode of the device, to the conductor 25, through an electric discharge device 62 which may be an indicating tube such as a neon lamp, a current limiting resistor 63 and a resetting push button switch 64 which is, as illustrated, normally biased to the closed position.

A brief description of the operation of the system described above will serve to emphasize the features and advantages of our invention as well as to point out the manner in which the quality of the discharge device under test is determined. It should be indicated here that the test is particularly designed to determine the adequacy of the emission from the cathode of the device 1. With the switch 17 in the position illustrated in the drawing, the system is energized by closing a line switch, designated by numeral 65. After a brief interval, the cathodes of electric discharge devices 1, 30, 34 and 41 are at proper operating temperature and the system is ready for operation. It will be noted that the control members of discharge device 1 are connected with the anode so that the device will conduct for the full positive half cycle of the supply circuit voltage. The switch 15 is moved to include that one of the resistors 14 in the anode-cathode circuit having the proper magnitude for limiting the discharge current to the desired value. When it is desired to close the relay 11, push button switch 36 is closed and capacitors 37 charged from the direct current voltage conductors 25 and 26 through resistor 27. As the capacitors become charged, the negative biasing voltage of resistor 38 decreases in accordance with the decrease in charging current and after a short interval, determined by the charging rate of capacitors 37, the positive voltage peak produced by transformer 42 renders electric discharge device 41 conductive to discharge capacitors 37 through device 41, the relay coil 40 and the resistor 39. As previously stated, the transformer winding 42 is poled in such a manner that conduction of current occurs during a negative half cycle of the anode voltage of discharge device 1, so that when contacts 10 are closed no current flows immediately. The period during which the relay remains closed is determined by the constants of the circuit including capacitors 37 of discharge device 41, relay coil 40 and resistor 39. For purposes of the present application, the relay is maintained closed for one cycle so that it opens again during the next negative half cycle of the supply circuit voltage, after which it is closed to maintain the anode-cathode circuit of the device under test established for one positive half cycle. The resistor 39 is included so that the damping of the relay circuit is controlled to minimize bouncing of the contacts of the relay 11.

It will be apparent that during the next positive half cycle of voltage of the supply circuit 2 after the contacts of relay 11 are closed the electric discharge device 1 will conduct current and the voltage which appears across the anode-cathode cir-

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cuit of the device will be dependent upon, among other things, the emission of the cathode 4. This voltage is impressed on the control member 59 of discharge device 34 and, as a result of the connection of the cathode with a suitable point on resistor 51, is compared with the regulated voltage appearing between the tap on resistor 52 and the contact 56 of resistor 51. If the voltage impressed on control member 59 of valve 34 exceeds a predetermined magnitude determined by the voltage of the tap 56, valve 34 conducts to ignite the indicating lamp 62 and in this way indicates excessive arc drop in the device under test as the result of inadequate emission from the cathode. It will be understood that the voltage indicating circuit may be reset by opening the push button switch 64. It will also be apparent that the adjustable contacts 53 and 56 provide an arrangement for adjusting the operation of the voltage measuring electric valve 34 to render the indicating lamp 62 conducting on the occurrence of a predetermined arc-drop across the device. As previously mentioned, the capacitor 61 is included in the circuit of control member 59 for the purpose of by-passing the initial steep wave front voltage occurring upon establishment of conduction in discharge device 5. This is necessary since this first voltage is not indicative of the adequacy of emission from the cathode, and it is the subsequent peak arc discharge voltage which it is desired to measure.

For purposes of the present invention, it is desired to maintain the anode-cathode circuit of the device closed for only one-half cycle at a time since under this condition heating of the cathode due to the arc current is negligible. The arc drop is then determined by the electron emission of the cathode at the operating temperature produced by the heater when energized with normal heater voltage. It will be apparent that by adjustment of the constants of the circuit including discharge device 41, the relay 11 may be maintained closed for different periods of time. By utilizing a circuit which opens and closes the relay contacts during negative half cycles of voltage of anode 3 of device 1, the contacts of the relay are relieved of all current making and breaking functions. Thus the relay 11 may be of small current interrupting capacity.

While we have shown and described a particular embodiment of our invention, it will be apparent to those skilled in the art that changes and modifications may be made without departing from the features of our invention, and we, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

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

1. In combination, an alternating current supply circuit, a unilaterally conducting device, an electromagnetic switching device having a contact connecting said device to said alternating current circuit for energization therefrom, elec-

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tric valve timing means including peaked voltage producing means for initiating operation of said timing means, means impressing a voltage derived from said alternating current circuit on said timing means to effect operation of said switching device during half cycles of voltage of said supply circuit during which said device is nonconductive as a result of its unilaterally conductive characteristic, a capacitor, and a circuit completed by operation of said peaked voltage producing means for effecting operation of said switching device to open position a predetermined time after circuit closing operation thereof.

2. In combination, an alternating current supply circuit, an electric discharge device including an anode, a cathode, an electromagnetic switching device having a normally open contact connecting the anode-cathode circuit of said discharge device to said alternating current circuit for energization therefrom, timing means, means for deriving a voltage from said alternating current circuit and impressing it on said timing means to effect closing and opening operation of said switching device during half cycles of voltage of said supply circuit which are negative with respect to the anode of said electric discharge device, and means connected to respond to the anode-cathode voltage of said discharge device to measure the arc drop voltage of said discharge device during conduction.

3. In combination, an alternating current supply circuit, an electric discharge device including an anode, a cathode, an electromagnetic switching device having a contact connecting the anode-cathode circuit of said discharge device to said alternating current circuit for energization therefrom, timing means, means for deriving a voltage from said alternating current circuit and impressing it on said timing means to effect closing and opening operation of said switching device during half cycles of voltage of said supply circuit which are negative with respect to the anode of said electric discharge device, means for establishing a present voltage and means including an electric discharge device connected to said last-mentioned means and to the anode-cathode circuit of said device for comparing the arc drop voltage of said device with a preset voltage.

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