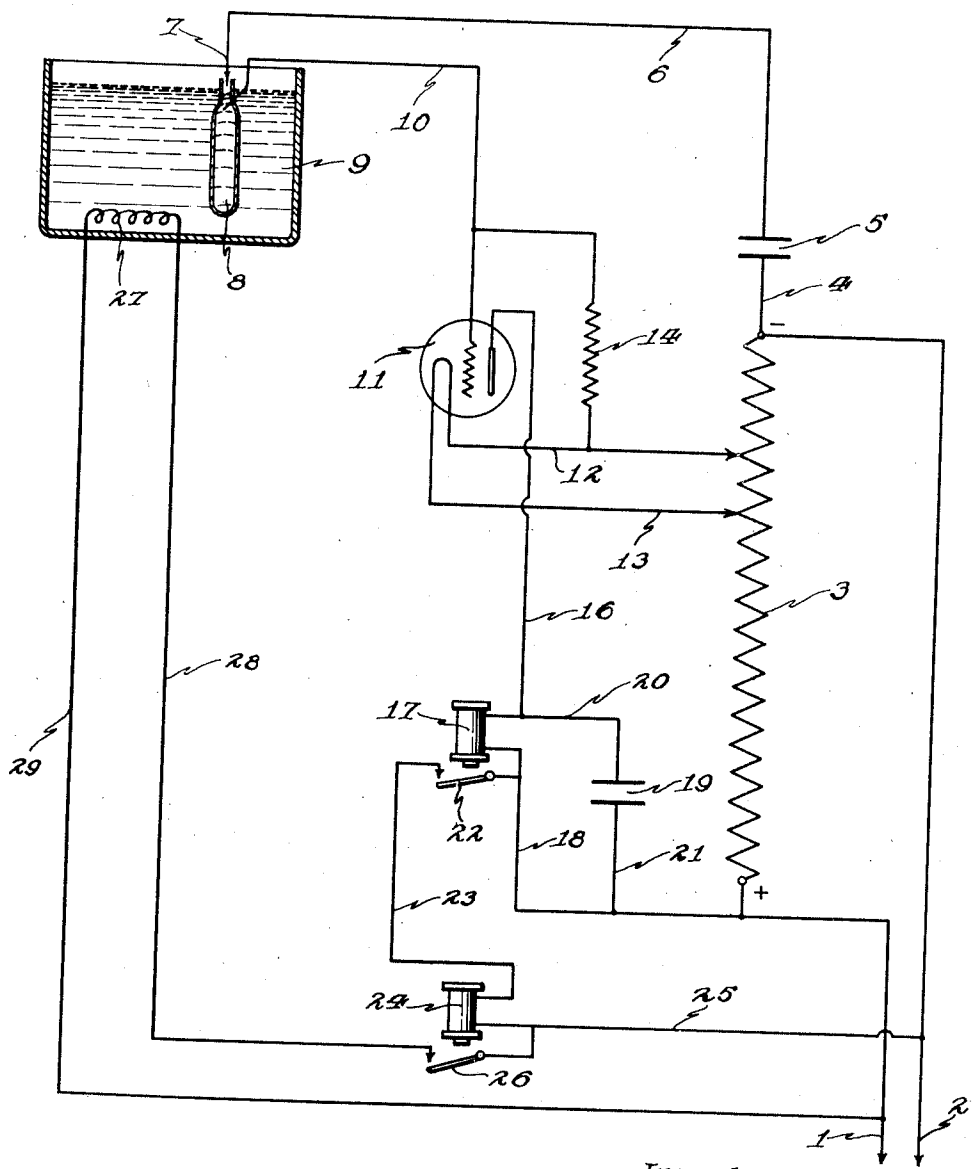
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POWER CIRCUIT

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POWER CIRCUIT

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5 Claims. (Cl. 219—20)

This invention relates to power circuits used under control of a thermostatic contact device. The precision which can be obtained in the electrical control of temperature or other loads by automatic regulators of various types is largely limited by the progressive deterioration of contacts which are required to carry any appreciable current. Mercury is frequently used as a contacting element but unless employed in a vacuum or inert gas is subject to oxidation and consequent deterioration as a contactor.

The main objects of this invention are to provide an improved form of thermostatic control circuit in which there is almost no appreciable flow of current through the thermally actuated contact and consequently no arcing and no oxidation of the mercury; to provide a circuit particularly adapted to give precision in automatic control of temperatures in thermal-bath apparatus; to provide an improved circuit giving precise thermal control independent of line voltage variations and uneven frequency characteristics; to provide a power tube circuit substantially independent of the operating efficiency of the electronic tube and having zero grid bias with open contacts and excessive grid bias with closed contacts to provide a regulator circuit having such a small current flow through the contacts that substantially a potential contact rather than a current contact is obtained and to provide a power circuit for thermal bath control which can be adapted to operate on any commercial service line.

A specific embodiment of this invention is illustrated in the accompanying drawing, which is a diagram showing the power circuit as it might be employed for heating a thermal bath under the control of a thermostat in which the temperature responsive element is mercury.

In our improved power circuit the main source of current is represented by the lines designated 1 and 2 and may be the usual 110 volt A. C. service lines. The line wires 1 and 2 are directly connected to a high resistance coil or potential divider 3, in which the fall of potential is substantially proportional to the length employed. One end of the potential divider 3 is connected by the lead 4 to a condenser 5 and thence by lead 6 to the contact 7 of the thermo-regulator device 8 which is located in the medium whose temperature is to be controlled, as for example, a thermal bath 9 of the type which is described in our copending applications for patents, Serial No. 18,698, filed April 27, 1935, on Thermo-regulators, and Serial No. 18,699, filed April 27, 1935, on Heater and circulator for thermostatic baths.

The mercury in the regulator 8 is electrically connected by the lead 10 to the grid of the electronic tube 11. The filament of the tube 11 is connected by leads 12 and 13 to selected points on the potential divider 3, and a high resistance grid leak 14 is connected between the lead 10 and the lead 12. The plate of the tube 11 is connected by lead 16 to a high resistance first stage relay 17 and thence by lead 18 to the main line 1. A condenser 19 is connected by leads 20 and 21 in parallel relation with the relay 17. The armature 22 of the relay is connected to close a contact with the lead 23 thence through the second stage relay 24 and lead 25 to the main line 2. The armature 26 of the second stage relay is arranged to close the circuit through the heating element 27 through leads 28 and 29 which are connected to the main line.

In the form of heating circuit shown, we employ a potential divider 3 of the resistance type for supplying filament, plate and grid bias voltages, which make easy the conversion for operation on direct current circuits. This is true because the action of the potential divider is the same on direct and alternating current.

In operation the electronic tube acts as a valve operating with high plate circuit resistance at zero grid potential with the thermo-regulator contacts in the grid circuit applying a sufficient negative bias when the contacts are closed to reduce the plate current substantially below the operating requirements of the first stage relay coil.

A three-element tube is satisfactory, but a variety of tubes may be applied in this application, the selection being determined by the performance characteristics at zero grid potential. Current drain in the plate circuit is held at a sufficiently low figure by first stage relay coil resistance to represent only a small fraction of the rated tube capacity and the tube therefore may be operated at lower voltages than those employed in audio circuits, thus providing a long life for the tube. The plate current operates the first stage relay whose contacts control the coil current in the second stage relay the contacts of which, if desired, may be of the mercury switch type. This circuit permits the use of alternating current as plate, filament and coil voltages, and eliminates any requirement for rectification of alternating current. The first stage relay may be either D. C. or A. C. design, provided only that its coil current be held well below the desirable continuous plate current calculated on a D. C. basis. Such relays have an armature response suffi-

ciently fast to open between the successive half waves delivered from an electronic tube to which alternating current is applied. In order to prevent relay chatter the condenser 19 is connected in parallel with the relay coil. The capacity of this condenser is determined by calculating the quantity in coulombs necessary to maintain the rated current through the relay coil for a period of one-half cycle. This quantity is then increased by a sufficient amount to compensate for the progressive voltage reduction between the condenser plates during discharge, this reduction resulting in a mean applied voltage of roughly one-half the line voltage measured across the coil terminals.

The effect of this condenser 19 is to fill in the half phase periods during which the tube plate is made negative with respect to the filament, the condenser being recharged at each reverse phase. This arrangement results in smooth and positive relay action regardless of whether D. C. or A. C. power is applied to the circuit.

In the application of alternating current to the electronic tube, alternate phases of reversal when the thermoregulator contacts are closed, closing the grid circuit, introduce the possibility of large grid currents. Half of each phase represents a difference in which the cathode is from 10 to 15 volts negative to the grid and the current flowing through the regulator contacts during such half cycle would be of a value corresponding to 15 volts divided by a resistance figure representing internal cathode to grid resistance plus the resistance of the circuit through the regulator contacts which circuit would be essentially zero. This current would rise to values in the milliampere range. Such currents are entirely eliminated by placing in the grid circuit, in series with the regulator contacts, a condenser of small capacity. By the use of this condenser the current flowing from the cathode to the grid in the half cycles referred to is limited by the capacity of the condenser. Theoretically, the correct capacity of this condenser would be one of the same order of magnitude as the capacity of the grid in which circumstance the grid would be freely charged and discharged to the limit of its capacity at impressed biased voltage and yet, excess current values originated by the flow of electrons from the cathode to the grid during the reverse phase would be held to the lowest possible quantity.

Assuming that such a condenser based upon the probable capacity of the grid were of a capacity one-ten thousandth of a microfarad, the grid bias fifteen volts and the frequency sixty cycles, it will be seen that charge, discharge and recharge of the grid circuit condenser would allow maximum currents in the grid circuit through the regulator contact points of no greater order of magnitude than 0.05 to 0.10 microampere. It will thus be seen that the amounts of current required to flow across the regulator contacts are minute and only in order of magnitude of grid capacity and it is only such current that is necessary to transfer a charge to and from the grid with the result that in a descriptive, rather than a quantitative sense, the thermoregulator or grid circuit closer makes a potential contact between its elements rather than a current contact.

A grid leak of high resistance value, such as approximately 10,000 megohms, has proved very satisfactory when used with a 12-A tube and a grid condenser of approximately 0.002 microfarad, to draw the accumulated electrons from the grid when the regulator contacts are opened.

With zero grid bias existing when the regulator contacts are open the plate current is limited only by the impedance of the first stage relay winding and therefore represents the full relay power requirement. When the regulator contacts close an excessive grid bias is applied producing an infinite tube resistance, thus reducing the plate circuit current to a practically zero value.

The excessive grid bias is permitted by the grid condenser 5 which prevents flow of current in the grid circuit in the phases which make the grid positive with respect to the cathode.

By the selection of adequate parallel condenser capacity and the imposition of an excessive grid bias, special adjustments are not necessary because the critical values for relay operation are not approached. With the grid circuit closed, the plate current is infinitesimally small, and with the grid circuit open the plate current is limited only by the impedance of the first stage relay winding which automatically fixes a more than adequate operating power for the relay.

The condenser 19 functions as a potential source for supplying current to the relay winding during the half phases in which no current is supplied through the electronic valve 11.

To employ this circuit for direct current, it is only necessary to eliminate the grid condenser 5 and to provide the corresponding coil windings in the second stage relay.

Although but one specific embodiment of this invention is herein shown and described, it will be understood that details of the construction shown may be altered or omitted without departing from the spirit of this invention as defined by the following claims.

We claim:

1. In an electric control circuit, a circuit closer, a condenser, an electronic tube having its grid connected to said circuit closer in series with said condenser, and a potential divider having a pair of taps connected to the filament of said electronic tube and one of said taps connected to the grid through a grid leak, whereby open contacts of said circuit closer give zero grid bias and closed contacts excessive grid bias.

2. In an electric control circuit, a thermal regulator having a pair of cooperating contacts, a condenser, an electronic tube having its grid connected to said regulator in series with said condenser, and a potential divider having a pair of taps connected to the filament of said electronic tube and one of said taps connected to the grid through a grid leak, whereby open contacts of said thermal regulator give zero grid bias and closed contacts excessive rigid bias.

3. An electric power circuit comprising a potential divider, a contacting element connected through a condenser to one end of said potential divider, an electronic tube having a grid connected to a second contacting element, said contact elements being arranged to cooperate with each other in a temperature responsive device, a filament in said tube connected to selected points on said potential divider, a grid leak connecting said grid to one of said filament leads, a first stage relay, a plate in said electronic tube connected through said first stage relay to the opposite end of said potential divider, a condenser shunting said first stage relay, electrical heating means positioned to influence said temperature

responsive device, and a circuit for said heating means controlled by said relay.

4. An electric power circuit comprising a circuit closer, an electronic tube, a grid circuit having a condenser in series with said circuit closer, a plate circuit including a relay, and a potential divider having a pair of taps connected to the filament of said tube and arranged to give through a grid leak zero grid bias on an open grid circuit and excessive grid bias on a closed grid circuit, all arranged whereby said circuit closer controls said relay and makes substantially a potential contact rather than current contact.

5. Apparatus of the class described, comprising a thermostatic circuit closer, an electronic tube, a grid circuit having a condenser in series with said circuit closer, a plate circuit including a relay, a potential divider having a pair of taps connected to the filament of said tube and arranged to give through a grid leak zero grid bias on an open circuit and excessive grid bias on a closed grid circuit, whereby said circuit closer controls said relay and makes substantially a potential contact rather than a current contact, electrical heating means positioned to influence said circuit closer, and a power circuit for said heating means controlled by said relay.

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CHARLES H. MILLER.

CERTIFICATE OF CORRECTION.

Patent No. 2,075,869. April 6, 1937.

PAUL SHERRICK, ET AL.

It is hereby certified that error appears in the printed specificatior of the above numbered patent requiring correction as follows: Page 2, second column, line 59, claim 2, for "rigid" read grid; and page 3, second column, line 6, claim 5, after the word "open" insert the word grid; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of June, A. D. 1937.

Henry Van Arsdale
Acting Commissioner of Patent:

(Seal)