

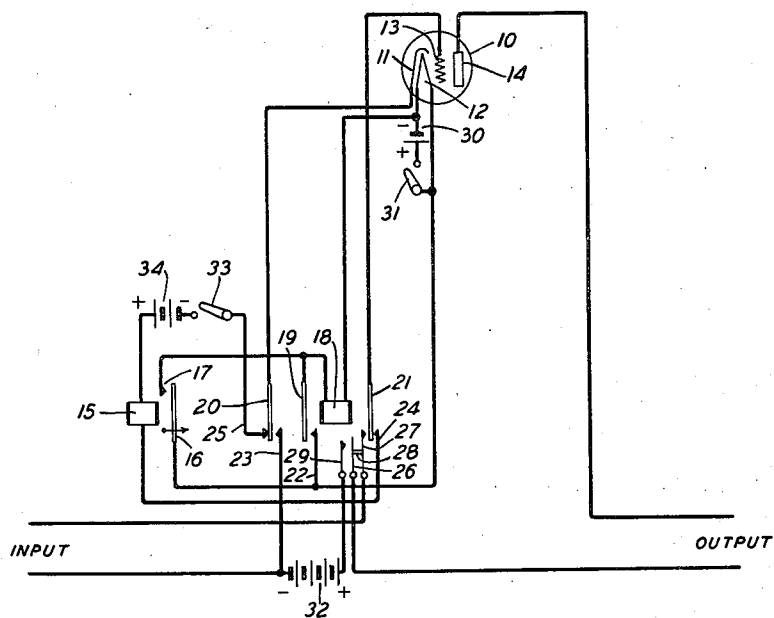
Nov. 9, 1937.

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2,098,310

CIRCUITS FOR SPACE DISCHARGE DEVICES.

Filed Oct. 8, 1935



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2,098,310

CIRCUIT FOR SPACE DISCHARGE DEVICES

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Application October 8, 1935, Serial No. 44,062

10 Claims. (Cl. 250—27)

This invention relates to circuits for space discharge devices and more particularly to circuits for gaseous discharge devices having an incandescent cathode.

5 In gaseous discharge devices having an incandescent cathode, it is desirable that no space current be drawn unless the cathode is at the temperature at which it is intended to be operated, in order that the cathode will not be subjected
10 to positive ion bombardment with a resultant disintegration of the thermionic cathode material and shortening of the operating life of the cathode. Such deleterious bombardment occurs principally during the initiation of the operation of
15 gaseous discharge devices and during the periods in which the cathode heating circuit may be interrupted temporarily, as by failure of the supply source.

One general object of this invention is to prevent positive ion bombardment of the cathode in space discharge devices.

More specifically, objects of this invention are to prevent the drawing of space current in gaseous discharge devices while the cathode is below
25 its normal operating temperature and to insure the rapid application of the anode potential when the cathode has reached its operating temperature so that the period allowed for heating of the cathode to this temperature is very short.

30 One circuit illustrative of this invention comprises a gaseous discharge device including a cathode, a heater element therefor, a control electrode, and an anode, a heater circuit for the heater element, an input circuit connected to the
35 cathode and the control electrode, and an output or load circuit connected to the cathode and the anode, the input and output circuits including circuit controlling members which are actuable by
40 a control relay having a winding adapted to be connected in the heater circuit.

In accordance with a feature of this invention, an auxiliary circuit including a relay, having a contact for closing the circuit through the winding of the control relay, and adapted to operate
45 only on the current desired in the output circuit, is provided for applying an auxiliary starting voltage between the cathode and the control electrode. The starting voltage is below that at which destructive positive ion bombardment of
50 the cathode will occur. For example, if the discharge device utilizes argon as the ionizable medium, the auxiliary or starting voltage upon the control electrode should be less than 50 volts positive with respect to the cathode.

55 When the heater and auxiliary circuits are

closed, the control electrode draws space current the magnitude of which increases gradually as the temperature of the cathode rises. Inasmuch as the potential upon the control electrode is below the critical value, deleterious positive ion
5 bombardment of the cathode will not occur. When the cathode reaches its normal operating temperature, the current to the control electrode will be of the magnitude of the output current desired for the device and the relay in the auxiliary
10 circuit will operate to close its contact and thereby connect the control relay in shunt with the heater element for the cathode. The control relay is thus energized and actuates the circuit controlling members to close the input and output
15 or load circuits. Simultaneously, the control relay actuates another circuit controlling member to open the auxiliary circuit whereby the relay in this circuit releases.

In the event of an interruption in the heater
20 circuit, the control relay will be deenergized and released so that the input and output circuits are opened. Hence, no space current will flow to the anode and the cathode will be protected against
25 positive ion bombardment. When the heater circuit is closed again, the relay in the auxiliary circuit controls the reapplication of the anode potential as described above.

The invention and the various features thereof will be understood more clearly and fully from
30 the following detailed description with reference to the accompanying drawing in which the single figure illustrates a circuit for space discharge devices, illustrative of one embodiment of this invention.

As shown in the drawing, the space discharge device may comprise an enclosing vessel 10 having an ionizable atmosphere, such as a rare gas or mercury vapor, therein, a cathode 11, a heater element 12 for the cathode, a control electrode or
40 grid 13, and an anode 14. Associated with the space discharge device are a starting relay having a winding 15, an armature 16, and a contact 17, and a control relay having a winding 18, and three armatures 19, 20, 21. The starting relay
45 is designed to operate upon the flow through the winding 15 of a current equal to the desired output current of the space discharge device. Each of the armatures of the control relay has a contact 22, 23 and 24, respectively, thereadjacent
50 and the armature 20 has also thereadjacent another contact 25. Disposed in cooperative relation with the armature 21 are a pair of spring contacts 26 and 27 which are mechanically connected and insulated from each other by an insulating
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member 28, the spring contact 26 being adapted to engage a fixed contact 29.

The heater element 12 may be connected to a suitable source, such as a battery 30, through a circuit including a controlling member such as a switch 31. A load, which may be, for example, one or more space discharge devices, may be connected between the cathode 11 and anode 14 through an output circuit including cathode 11, armature 20, contact 23, a suitable source such as a battery 32, contact 29, and spring contact 26. An input circuit may be connected between the cathode 11 and control electrode through a path including cathode 11, armature 20, contact 23, spring contact 27, armature 21 and grid 13.

The winding 18 of the control relay is adapted to be connected in shunt with the heater source 30 through the armature 16 and contact 17 of the starting relay. The winding 15 of the starting relay is adapted to be connected between the cathode 11 and control electrode 13 through an auxiliary circuit including cathode 11, armature 20, contact 25, a switch 33, a source such as a battery 34, winding 15, contact 24, armature 21, and control electrode 13. The source 34, it will be apparent is adapted to impress a positive potential upon the grid 13 relative to the cathode, the potential being below that at which deleterious positive ion bombardment of the cathode 11 will occur upon the flow of space current to the control electrode. For example, if the ionizable medium in the vessel 10 is argon, the potential applied to the control electrode 13 by the source 34 should be less than 50 volts.

When the space discharge device is not in operation, the positions of the armatures of the starting and control relays are as shown in the drawing so that the input and output or load circuits are open. In order to place the device in operation, the heater and auxiliary circuits are closed through the switches 31 and 33, and as the control electrode 13 is then positive with respect to the cathode 11 a space current will flow to the control electrode. This current will increase gradually in magnitude as the temperature of the cathode 11 rises and will reach a value equal to that desired in the output or load circuit. When this value of current is reached the starting relay operates so that the armature 16 engages the contact 17 and the winding 18 of the control relay is thereby shunted across the heater source 30 and the control relay operates.

Operation of the control relay causes the armature 19 to engage contact 22 so that a circuit is established through the source 30, winding 18, contact 22 and armature 19. Substantially simultaneously armature 20 leaves the contact 25, so that the auxiliary circuit is interrupted, and engages contact 23 whereby the cathode 11 is connected to the negative terminal of the source 32. Preferably the starting relay is of the slow release type so that the armature 16 will not leave the contact 17 until the winding 18 has been shunted across the source 30 through the armature 19 and contact 22. If the starting relay is not of the slow release type, the control relay should be so designed that armature 19 engages contact 22 before armature 21 leaves contact 24.

Operation of the control relay also causes armature 21 to leave contact 24, so that the control electrode 13 is disconnected from the source 34, and to engage the contact 27 whereby the control electrode 13 also is connected to the negative terminal of the source 32 through the input circuit. Simultaneously the contact spring

26 engages contact 29 whereby the anode 14 is connected through the load to the positive terminal of the source 32 and the output or load circuit is completed.

From the foregoing, it will be clear that the anode potential is not applied until the cathode 11 has attained its normal operating temperature so that destructive positive ion bombardment of the cathode 11 is prevented. Furthermore, it will be apparent that the delay between the time when the cathode reaches its normal operating temperature and the completion of the output or load circuit is relatively short.

If the heater circuit for the heater element 12 should be interrupted as by failure of the source 30, the winding 18 becomes deenergized so that the control relay releases and the input and output or load circuits are interrupted and the auxiliary circuit is completed through armature 21, contact 24, and armature 20 and contact 25. When the heater circuit is reestablished the sequence of operations described hereinabove is repeated and the output and input circuits are reclosed only when the cathode 11 again has reached its normal operating temperature. It will be noted that in the event of an interruption in the heater circuit, the time elapsing before reapplication of the anode potential is directly dependent upon the period of interruption; that is, the longer the period of interruption, the greater will the temperature decline in the cathode be, and hence the longer will be the period before the cathode will emit sufficient electrons to produce the space current to the control electrode requisite to operate the starting relay. Hence, the output circuit will remain open until the cathode has reached its normal operating temperature and deleterious positive ion bombardment of the cathode is thereby prevented.

Although a specific circuit has been shown and described it will be understood that this circuit is but illustrative of this invention and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims. For example, although the cathode 11 has been shown as of the type having a separate heater element, it may be of the self-heating filament type. Likewise, although the heater 12 has been shown as supplied from a direct current source, it may be supplied from an alternating current source. Also, it will be appreciated that the auxiliary circuit may be connected to an electrode other than the control electrode. For example, in devices having a heat shield adjacent the cathode and electrically separate therefrom, the auxiliary circuit may be connected to the cathode and to the heat shield.

What is claimed is:

1. In combination, a space discharge device comprising a cathode, an anode, and a third electrode, a heater circuit for said cathode, a normally open output circuit connected to said cathode and said anode, and means including an auxiliary circuit connected to said cathode and said third electrode responsive to the attainment of a cathode temperature after closing of said heater circuit sufficient to enable the passage of a desired space current to said anode, to close said output circuit, said auxiliary circuit including a source for applying a constant positive potential to said third electrode.

2. In combination, a space discharge device comprising a cathode, an auxiliary electrode, and

an anode, a heater circuit for said cathode, an output circuit coupled to said cathode and said anode, an auxiliary circuit including a relay connected to said cathode and said auxiliary electrode and a source for applying a constant positive potential to said auxiliary electrode, means for closing said heater circuit, and means controlled by said relay for closing said output circuit, said relay being operable only in response to the flow of a current in said auxiliary circuit substantially equal to the current in said output circuit when said cathode has reached its normal operating temperature after closing of said heater circuit.

3. In combination, a space discharge device comprising a cathode, an anode, and an auxiliary electrode, a heater circuit for said cathode, a normally open output circuit coupled to said cathode and anode and including a source for applying a positive potential to said anode, a circuit including a relay and a source for applying a fixed constant positive potential to said auxiliary electrode, connecting said auxiliary electrode and said heating circuit, said relay being operable in response to the flow of a predetermined space current between said cathode and said auxiliary electrode, and means operable upon operation of said first relay to close said output circuit.

4. In combination, a space discharge device comprising a cathode, a control electrode, and an anode, a heater circuit for said cathode including a source of current, an output circuit coupled to said cathode and said anode, a circuit controlling member in said output circuit, means for actuating said circuit controlling member, said means being associated with said heater circuit source and adapted to be energized thereby, and an auxiliary circuit including a relay connected to said cathode and said control electrode, said relay having a contact for connecting said means to said heater circuit.

5. In combination, a space discharge device comprising a cathode, a control electrode, and an anode, a heater circuit for said cathode, an output circuit coupled to said cathode and said anode, a relay having a normally open contact in said output circuit, a winding adapted to be connected to said heater circuit, and a normally closed contact, and an auxiliary circuit connected to said cathode and said control electrode including said normally closed contact, a source for applying a positive potential to said control electrode, and a relay having a contact in circuit with said first winding, said relay being operable in response to the flow of a predetermined current in said auxiliary circuit to close its contact whereby said first winding is connected to said heater circuit and said first relay operates to close said normally open contact and open said normally closed contact.

6. In combination, a gaseous discharge device comprising a cathode, a control electrode, and an anode, an output circuit coupled to said cathode and said anode, an input circuit coupling said cathode and said control electrode, a heater circuit for said cathode, an auxiliary circuit including a relay and a source for applying a positive potential to said control electrode, connecting said cathode and said control electrode, said relay being operable in response to a predetermined flow of space current between said cathode and said control electrode, a relay having a wind-

ing adapted to be connected in said heater circuit when said first relay operates, said second relay having a plurality of contacts adapted to be closed when said second relay operates to close said input and output circuits and having a contact adapted to open said auxiliary circuit.

7. In combination, a space discharge device comprising an enclosing vessel having an ionizable medium therein, a cathode, a heater element for said cathode, a control electrode, and an anode, a heater circuit for said heater element, an output circuit coupled to said cathode and said anode, an input circuit coupled to said cathode and said control electrode, a control relay having a winding adapted to be connected in shunt with said heater element, a normally open contact in said output circuit, a normally open contact in said input circuit, and a normally closed contact, and an auxiliary circuit connected between said cathode and said control electrode including said normally closed contact, a relay, and a source for applying a potential less than that at which deleterious positive ion bombardment of said cathode occurs, between said cathode and said control electrode, said second relay having a normally open contact in series with said winding and said heater circuit, and said second relay being operable in response to the flow of a predetermined space current between said cathode and said control electrode to close its contact whereby said control relay is energized from said heater circuit.

8. In combination, a space discharge device comprising a cathode, an anode and an auxiliary electrode, a heater circuit for said cathode, a load circuit connected to said cathode and said anode, an auxiliary circuit connected to said cathode and said auxiliary electrode, an input circuit connected to said cathode and said auxiliary electrode, and means for closing said load and input circuits in response to the flow of a predetermined current in said auxiliary circuit.

9. In combination, a space discharge device comprising a cathode, an anode and an input electrode, a heater circuit for said cathode, an input circuit connected to said cathode and said input electrode, an output circuit connected to said cathode and said anode, circuit controlling means in said input and output circuits, and an auxiliary circuit connected to said cathode and said input electrode including means responsive to the attainment by said cathode of its normal operating temperature by energization through said heater circuit, to actuate said controlling means to close said input and output circuits.

10. In combination, a space discharge device comprising a cathode, an anode and an auxiliary electrode, a heater circuit for said cathode, an output circuit connected to said cathode and said anode and including a source for applying a positive potential to said anode, and means including an auxiliary circuit connected to said cathode and said auxiliary electrode for closing said output circuit only in response to the flow of a current in said auxiliary circuit commensurate with the desired space current between said anode and said cathode, whereby said positive potential is applied to said anode only after said cathode has been heated to its operating temperature through said heater circuit.