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GRID CONTROLLED MERCURY ARC TUBES

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FIG. 1.

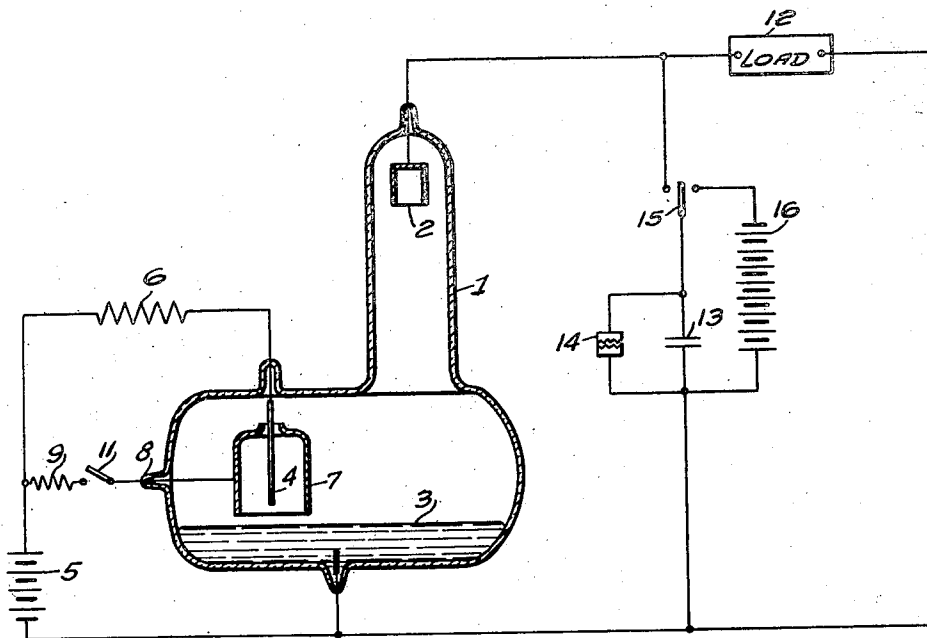
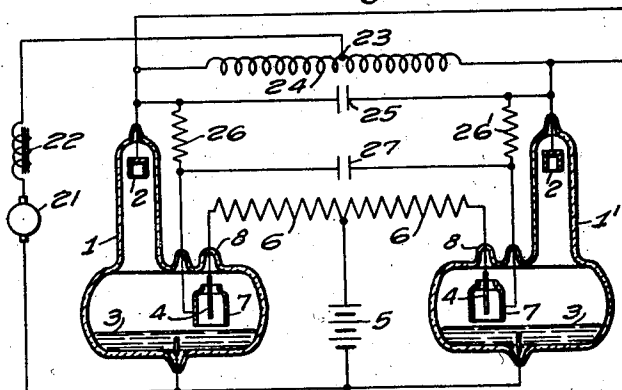


FIG. 2.



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GRID-CONTROLLED MERCURY ARC TUBE

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Application May 27, 1933, Serial No. 673,238

16 Claims. (Cl. 175—320)

My invention relates to vapor electric devices and in particular to methods of controlling current flow through such devices.

One object of my invention is to provide a continuously operating exciting arc in a vapor electric device with means for limiting its ionizing influence on the path of current flow between the vapor electric cathode and one or more cooperating anodes.

Another object of my invention is to provide means for employing a vapor electric arc to interrupt current flow in an electric circuit.

A further object of my invention is to provide a method of employing a gaseous discharge device having a continuously operating exciting arc for initiating and interrupting current flow at will through an electric circuit.

A further object of my invention is to provide a method for employing a device of the type described in the preceding paragraph for controlling the initiation and interruption of current flow through a direct-current circuit.

Other objects of my invention will become apparent upon reading the following description and drawing in which

Figure 1 illustrates a vapor electric device embodying my invention, together with a circuit of one type employing it for initiating and interrupting current flow, and

Fig. 2 illustrates a converter for translating energy between direct current and alternating current circuits.

In accordance with the prior art, vapor electric devices, of which the more common example is probably the mercury arc rectifier, have been provided with continuously operating exciting arcs, or side branches, in which current flows between an auxiliary anode and the vapor electric cathode. With such arrangements, current flow between this cathode and any main anode present in the container will be initiated as soon as a relatively small positive voltage relative to the cathode is impressed on such an anode; and this current flow will continue until the voltage of such main anode relative to the cathode falls to zero. However, for many purposes, such as the control at will of current flow in the circuit of a main anode, it would be desirable if the exciting arc could be kept continuously in operation without having the initiation of current flow from the main anode necessarily follow upon its assumption of a positive potential relative to the cathode. Thus, for example, it is frequently desired to prevent, for a predetermined period of time, the flow of current from the main anode, even after the latter has be-

come positive in potential relative to the cathode; and then without substantial change in this potential to permit the resumption of current flow from the anode. With the prior art arrangements this could be done by interrupting the flow of the exciting arc and only starting it when the resumption of current flow from the main anode was desired. However, restarting the exciting arc is not altogether easy to accomplish, particularly without a substantial delay in time; so the method of operation last described has been unsatisfactory for more practical purposes.

The above-described desired effects may be accomplished without the necessity of interrupting the flow of current in the exciting arc, if the latter is enclosed within a conducting member which extends within a short distance of the surface of the vapor electric cathode, this chamber being provided with arrangements so that the potential of its walls relative to the cathode can be controlled at will. If the walls of the chamber are electrically insulated from the remainder of the electrical system, or if they are not sufficiently positive relative to the cathode to cause an arc to strike with these walls as its anode, then the ionizing influence of the exciting arc is apparently confined to the immediate interior or vicinity of the chamber and a very considerable positive potential relative to the cathode may be imposed upon the main anode without causing substantial current flow therefrom. However, if the walls of the above-described enclosing chamber are given a sufficiently high positive potential so that an arc can operate between them and the vapor electric anode, the arrangement operates like the ordinary vapor electric device with an exciting arc as described above, and current flow takes place from the main anode even when it is only slightly positive relative to the cathode. Accordingly, by controlling the potential of the chamber walls above described, relative to the cathode, the ionizing influence of the exciting arc can be confined substantially to its immediate neighborhood or extended to substantially the entire discharge chamber, and current flow from the main anode controlled more or less independently of the potential of the latter.

These relations hold provided the cathode spot of the exciting arc stays within the chamber walls. If it passes outside the chamber walls, then the main anode may carry an arc with only a slight positive potential. It is to prevent the cathode spot of the exciting current arc from getting out that the lower edge of the chamber is placed as close as practicable to the mercury surface.

One specific use of the foregoing principle which I will describe is in connection with the use of a vapor electric device to interrupt and initiate current flow in a direct-current circuit in which its main anode and cathode are interposed. It being supposed that the exciting arc is in operation, current flow upon the main anode will take place once the chamber walls are made sufficiently positive. When it is desired to interrupt current flow through the main anode, a condenser or other device adapted to draw a large current when first connected across a circuit, but to cause such current draft to rapidly decrease to a relatively small value in a short time, is suddenly connected in shunt between the main anode and cathode of the vapor electric device. The rapid draft of current from the circuit of the main anode drops the potential of the latter to such a low value that, if the chamber walls enclosing the exciting arc are at a low potential, relative to the cathode, the arc between the main anode and the cathode is extinguished, and will not re-ignite when the potential of the main anode rises again to its high positive value. However, current flow from the main anode will restart when, in accordance with the desire of the operator of the tube, a sufficient positive potential relative to the cathode is impressed upon the aforesaid chamber walls.

Referring in detail to Fig. 1 of the drawing, a vacuum-tight container 1, which may be of glass, is provided in a conventional type of main anode 2 and a vapor electric cathode 3, such as mercury. The surface of the cathode 3 is preferably made of considerable extent and an exciting arc, or side branch electrode 4 is provided in co-operative relationship to it. The arrangements so far described are familiar to those skilled in the electrical discharge tube art, and may be of conventional type and provided with conventional auxiliary arrangements. Thus, a source of direct-current 5 and a resistor 6 may be connected to control current flow in an exciting arc between the anode 4 and the cathode 3.

In accordance with my invention, the anode 4 may be surrounded, except near its lower end, by the conducting walls 7 of an enclosing chamber, the walls 7 extending within a short distance, which may be about $\frac{1}{4}$ inch, of the surface of the cathode 3. The walls 7 may be insulated from the anode 4 by a collar of quartz or other insulating refractory, or they may be separated from it merely by a space which is small relative to the mean free path of an electron in the gas within the container; a distance of the order of a millimeter being satisfactory for most mercury arc devices. The container walls 7 are supported so as to be electrically insulated from the cathode and other electrodes of the container 1; and are provided with conducting connections leading through the walls of this container, such as the seal shown at 8. Any means may be provided for controlling the potential of the walls 7 relative to the other electrodes of the container, a simple resistance 9 and a switch 11 being shown in the drawing for this purpose.

For use in controlling initiation and interruption of current flow in a direct-current circuit, the anode 2 and the cathode 3 may be connected to the conductors of such a circuit, for example, in series with a load diagrammatically shown at 12. A condenser 13, which for many though not all purposes may be desirable to shunt with a lightning arrester 14, has one terminal connected to the cathode 3. The other terminal of the con-

denser is connected to a switch 15 which may be used to connect it to the negative end of a source of voltage 16. The switch 15 is arranged so that the connection just described may be broken and the terminal of the condenser then connected to the anode 2.

It is believed that the foregoing general description of the principles of my invention have sufficed to render the mode of operation of the circuits just described evident. It being assumed that the anode 2 is positive relative to the cathode 3 by reason of its connection in the circuit of the load 12, the exciting arc being in operation from the electrode 4 to the cathode 3 and the switches 11 and 15 open, no current flow will take place between the anode 2 and the cathode 3. When, however, the switch 11 is closed, current flow will start between the main anode 2 and the cathode 3, the magnitude of this current being, of course, determined by the characteristics of the load 12 and its connected circuit. Current flow will then continue until for any reason the voltage of the anode 2 falls substantially to zero relative to the cathode 3. If the switch 11 is still closed, current flow will resume as soon as the anode 2 rises again to a small positive potential relative to the cathode 3. On the other hand, if the switch 11 had been opened under the circumstances just outlined, current flow would not be resumed from the anode 2.

Supposing as another situation, that current is flowing from the anode 2 to the cathode 3 and the switch 15 is swung to the right, as shown, thus changing the upper plate of the condenser 13 to a negative potential. If then the switch 15 is swung to the left to connect the condenser 13 between the anode 2 and the cathode 3, the potential of anode 2 will fall to a low value relative to the cathode 3, but will quickly rise to its former positive potential as condenser 13 charges up. If the switch 11 was closed during the course of events just described, current flow from the anode 2 will not be interrupted except for a very short time, but will rise to its former value as soon as condenser 13 has charged up. However, if switch 11 had been opened, current flow would be interrupted between anode 2 and cathode 3 and would not be resumed when condenser 13 charged up. Current flow would not start again from anode 2 to cathode 3 until switch 11 was closed.

As a further illustration of the application of the principles of my broader invention, Fig. 2 illustrates an arrangement which may be employed for converting energy from a direct-current to an alternating-current circuit, or vice versa. Thus, a direct-current source 21 supplies current through a high inductance 22 to the mid-tap 23 of an inductance 24, which is preferably of the iron core type. The terminals of the inductance 24 are respectively connected to the conductors of an alternating-current circuit. If this circuit is not provided with any form of translating device which has a tendency to draw energy at a periodically varying rate, the inductance 24 may be shunted by a capacitance 25.

Between each terminal of the inductance 24 and the negative terminal of the source 21 is connected an electrical discharge device 1, 1' of the type described in connection with Fig. 1. Corresponding structural elements in Fig. 2 are given the same reference numerals as in Fig. 1 and function correspondingly, so they require no separate description except as follows. The container walls 7 of each discharge device of Fig. 2 are connected through a resistor 26, 26' to

their associated anodes; and a condenser 27 is connected between the container walls 7 of the respective devices 1, 1'. With such an arrangement alternating current will flow through the resistances 26, 26' and the capacitance 27, and this may be made to impress such voltages on the enclosing walls 7 of the respective discharge devices 1, 1' as to cause them to draw current from the source 21 through the inductance 24 in alternate periods, thereby setting up an alternating voltage across the terminals of inductance 24 and its associated alternating-current circuit.

From the preferred mode of operation of the above-described arrangement, the enclosing walls 7 should acquire a negative voltage relative to the cathode 3 slightly in advance of the time, in each cycle, when the voltage of the anode 2 relative to the cathode 3 becomes zero. Other circuit arrangements for causing gaseous discharge devices to convert energy between alternating-current and direct-current circuits are shown in my co-pending application Serial No. 680,396, assigned to the Westinghouse Electric & Manufacturing Company; and the control of the potential of enclosure walls 7 may be carried out by those elements in these arrangements which initiate and suppress current flow between the main anode and cathode by the agency of auxiliary discharges and electrode potentials.

I have described my invention as applied to a vapor electric device, but its principles are applicable also to a gaseous discharge device in which the cathode is of a heated (thermionically emissive) type. I have also described only one particular arrangement for controlling the potential of the enclosing walls 7, but it will be evident to those skilled in the art that any other arrangement for fixing and varying at will the potential of these walls may be substituted and may be more desirable in certain cases.

Likewise, I have described the enclosure 7 as substantially surrounding the exciting anode 4 but it will be evident to those skilled in the art that a shield or partition which substantially isolates the electrode 4 from the current path between the anode 2 and the cathode 3 may be substituted for a completely surrounding enclosure with satisfactory results in many cases.

Likewise, I have described the discharge tube as having only a single anode and a single cathode but it will be evident to those skilled in the art that a plurality of anodes which may be at different potentials can be controlled from a single cathode provided with an exciting arc of the type I have described. Furthermore, it will be evident that the second electrode with which the anode 4 cooperates within the shield 7 need not be a portion of the cathode 3 but may be a physically distinct electrode. Also, it will be evident that while I have described the battery 16 for charging the condenser 13 to a negative potential, the use of this battery is merely optional for most purposes; and likewise that the lightning arrester 14 is merely a desirable auxiliary device not absolutely essential to the operation of the condenser 13 as described.

Likewise, while I have shown how arcs in the device may be ignited and extinguished by applying suitable potentials to the chamber walls 7, by means of a switch, and by charging and discharging a condenser through a switch, it is not intended to limit the operation of my invention to the use of such switches, but varying potentials may be impressed upon the chamber

walls 7, in any other way, and the charging and discharging of the condenser may be effected in any other way. Thus two tubes such as described here may be connected to charge direct current power to alternating, where the ignition of the arc in one tube causes the extinguishing condenser discharge through the other. Arrangements in which an auxiliary anode discharging to an ordinary hot cathode instead of a keep-alive to a mercury cathode, enclosed by walls 7 are within contemplation of my invention.

While I have described my invention in connection with the particular embodiment here illustrated, it will be evident to those skilled in the art that many departures from the proposed structure and process of construction which I have described may be made without departing from the principles of my invention. I, therefore, desire that the terms of the claims shall be accorded their broadest reasonable signification excepting so far as limitations are expressly made or are imposed by the prior art.

I claim as my invention:

1. A vapor electric discharge device having a main anode, a cathode, an exciting anode to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, and means for controlling at will the potential of said shield relative to said cathode.

2. A vapor electric discharge device having a main anode, a cathode, an exciting anode to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, and means for controlling at will the potential of said shield relative to said cathode.

3. A mercury arc device having a main anode, a cathode and an exciting anode adapted to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, and means for controlling at will the potential of said shield relative to said cathode.

4. A mercury arc device having a main anode, a cathode, an exciting anode adapted to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, and means for controlling at will the potential of said shield relative to said cathode.

5. A vapor electric discharge device having a main anode, a cathode, and an exciting anode to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a work circuit including said main anode and said cathode, and means for shunting said main anode and said cathode with a device which draws a large current when first connected in said shunt, said current tending to decrease to a relatively small value after such connection.

6. A vapor electric discharge device having a main anode, a cathode and an exciting anode to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield

spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a work circuit including said main anode and said cathode, a condenser, and means to connect said condenser at will in shunt to said main anode and cathode.

7. A vapor electric discharge device having a main anode, a cathode, and an exciting anode to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a direct-current circuit including said main anode and said cathode, and means for shunting said main anode and said cathode with a device which draws a large current when first connected in said shunt, said current tending to decrease to a relatively small value after such connection.

8. A vapor electric discharge device having a main anode, a cathode, and an exciting anode to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a direct-current circuit including said main anode and said cathode, a condenser, and means to connect said condenser at will in shunt across said main anode and cathode.

9. A vapor electric discharge device having a main anode, a cathode, an exciting anode to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, means for controlling at will the potential of said shield relative to said cathode, a work circuit including said main anode and said cathode, and means for shunting said main anode and said cathode with a device which draws a large current when first connected in said shunt, said current tending to decrease to a relatively small value after such connection.

10. A vapor electric discharge device having a main anode, a cathode, an exciting anode to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, means for controlling at will the potential of said shield relative to said cathode, a direct-current circuit including said main anode and said cathode, and means for shunting said main anode and said cathode with a device which draws a large current when first connected in said shunt, said current tending to decrease to a relatively small value after such connection.

11. A vapor electric discharge device having a main anode, a cathode, an exciting anode to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, means for controlling at will the potential of

said shield relative to said cathode, a direct-current circuit including said main anode and said cathode, a condenser, and means to connect said condenser at will in shunt to said main anode and cathode.

12. A mercury arc device having a main anode, a cathode and an exciting anode adapted to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a work circuit including said main anode and said cathode, and means for shunting said main anode and said cathode with a device which draws a large current when first connected in said shunt, said current tending to decrease to a relatively small value after such connection.

13. A mercury arc device having a main anode, a cathode and an exciting anode adapted to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a work circuit including said main anode and said cathode, a condenser, and means to connect said condenser at will in shunt to said main anode and cathode.

14. A mercury arc device having a main anode, a cathode and an exciting anode adapted to cooperate with said cathode, a conductive shield insulated from said exciting anode and substantially enclosing said exciting anode except the portion adjacent said cathode, said shield spaced from said cathode by a small distance, means for controlling at will the potential of said shield relative to said cathode, a direct-current circuit including said main anode and said cathode, a condenser, and means to connect said condenser at will in shunt to said main anode and cathode.

15. A mercury arc device having a main anode, a cathode, an exciting anode adapted to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, means for controlling at will the potential of said shield relative to said cathode, a work circuit including said main anode and said cathode, a condenser, and means to connect said condenser at will in shunt to said main anode and cathode.

16. A mercury arc device having a main anode, a cathode, an exciting anode adapted to cooperate with said cathode and a conductive shield insulated from said exciting anode enclosing said exciting anode except in the region of said cathode, means for controlling at will the potential of said shield relative to said cathode, a direct-current circuit including said main anode and said cathode, and a condenser, and means to connect said condenser at will in shunt to said main anode and cathode.

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