

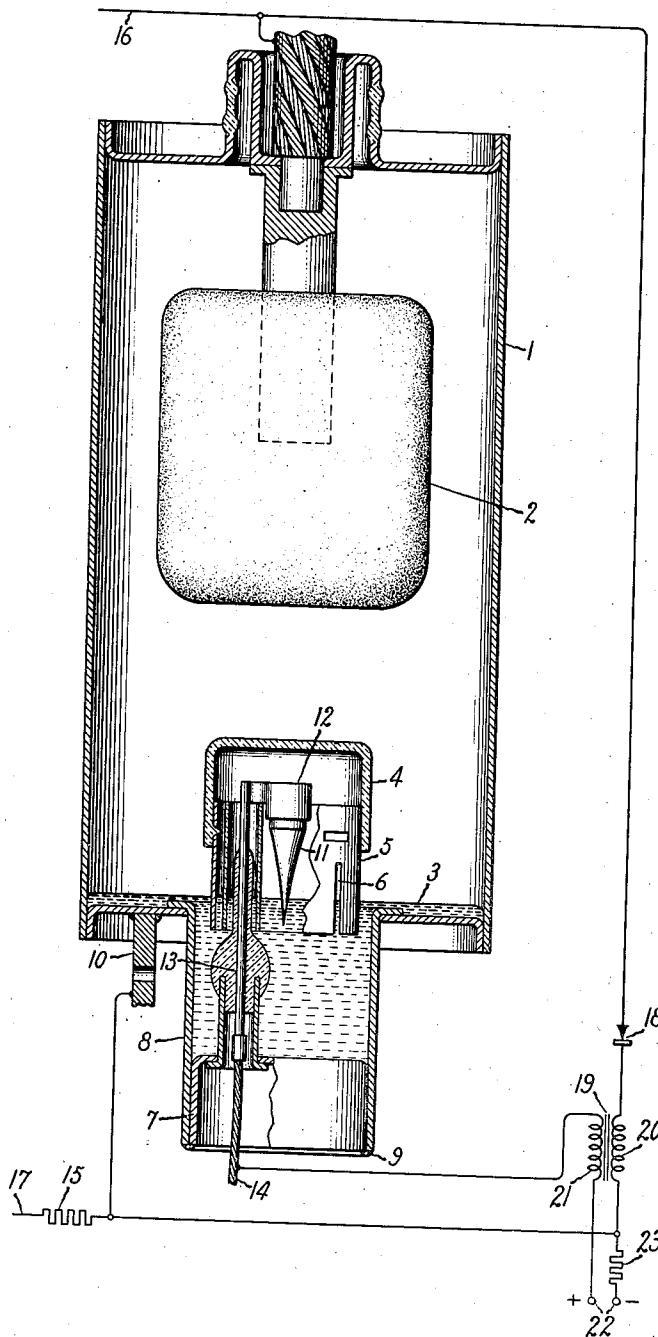
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L. D. MILES

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ELECTRIC DISCHARGE APPARATUS

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ELECTRIC DISCHARGE APPARATUS

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9 Claims. (Cl. 250—27.5)

My invention relates to electric discharge apparatus or electric valve means and more particularly to circuits for controlling the operation of apparatus of this nature.

It has been proposed heretofore to initiate arc discharges between the anode and the cathode of electric valve means by employing an immersion-ignitor or make alive control member which is associated with a pool type cathode, such as a mercury pool cathode. The term "pool" as used herein and in the appended claims is not limited to liquid metals such as mercury but is intended also to include solid substances which are capable of analogous use. Particular examples of such solid substances are cadmium and bismuth. The initiation of the arc discharge between the cathode and the anode is effected by transmitting to the control member current of a magnitude sufficient to establish on the surface of the cathode a potential gradient of a value which initiates the establishment of a cathode spot. The make-alive electrode is preferably constructed of a material, such as boron-carbide or silicon-carbide, having a specific electrical resistivity large compared with that of the associated pool cathode. Due to the nature of the materials which have been found most effective in the initiation of arc discharges, it is important to relieve as much as possible the duty imposed on the material by requiring the control member to conduct current only until the arc discharge is initiated and to interrupt or decrease substantially immediately thereafter the current conducted by the control member. In this manner, the life of the control member and the life of the electric valve means are materially increased. It has also been appreciated heretofore that it is desirable to limit or substantially eliminate the magnitude of the negative or inverse voltage which is impressed across the control member and the cathode. An appreciable inverse voltage and consequential inverse current have been found to have a deleterious effect upon the life of the control member. In accordance with the teachings of my invention disclosed hereinafter, I provide new and improved apparatus for effectively controlling an electric valve means of the pool type employing make-alive or immersion-ignitor control members, and which relieves the duty imposed on the control member so that the life of the electric valve means is substantially increased.

It is an object of my invention to provide new and improved electric discharge apparatus.

It is another object of my invention to provide a

new and improved control system for electric valve apparatus.

It is a further object of my invention to provide new and improved control or excitation circuits for electric valve means of the type employing an ionizable medium and having a pool cathode.

It is a still further object of my invention to provide a new and improved arc-initiating and arc-maintaining circuit for electric valve means of the type employing a mercury pool cathode and an immersion-ignitor control member.

Briefly described, in accordance with the illustrated embodiment of my invention, I provide a new and improved control circuit for an electric valve means of the type employing an ionizable medium, such as mercury vapor, and including a mercury pool cathode and an associated immersion-ignitor control member. The excitation or control system transmits a relatively large impulse of current through the control member to the cathode to initiate an arc discharge, and apparatus is provided to maintain an arc discharge within the electric valve means after the initiation of the discharge, thereby relieving the duty imposed on the control member and increasing the life of the apparatus.

For a better understanding of my invention, reference may be had to the following description, taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims. The single figure diagrammatically illustrates an embodiment of my invention as applied to a mercury-pool electric discharge device having a make-alive or an immersion-ignitor type control member.

Referring particularly to the single figure of the accompanying drawing, I have chosen to represent my invention as applied to an electric discharge device or an electric valve means comprising a metal envelope 1 forming an enclosed discharge space within which are arranged an anode 2 and a pool cathode 3, such as a mercury pool cathode, forming with the anode 2 appropriate discharge terminals. The electric discharge device may incorporate some of the features disclosed and claimed in U. S. Letters Patent No. 2,152,201 granted March 28, 1939, upon my application and which is assigned to the assignee of the present application. One of these features may be the apparatus there shown for confining the cathode spot within a limited desired region on the surface of the mercury pool. This confining means may comprise a shield 4 of cylindrical configuration and constructed of a refractory

material adapted to withstand the effects of an arc discharge. The lower portion 5 of the shielding member is also preferably of a refractory metal or a ceramic material. In order that the cathode spot maintained within the shielding member may be effective to initiate a discharge upon the application of suitable voltage differences between the anode 2 and the cathode 3, at least some communication must be provided with the inner chamber of the shielding member and the main arc discharge path. The shielding member, therefore, is provided with a plurality of longitudinal slots or openings 6 formed in the shielding member. These slots 6 preferably extend normally or perpendicularly from the cathode surface to a point appreciably above the surface.

It is possible, of course, to arrange the cathode construction in a number of ways. However, I prefer an arrangement such as that shown in the figure wherein the assembly as a whole is mounted on a demountable header 7 which is positioned within a conforming cylinder 8 extending from the bottom of the envelope 1. The header is secured in place by an externally accessible fillet 9 of appropriate sealing material such as glass or fused metals which may be removed or broken away to permit replacement or repair of a header whenever necessary. The power or cathode terminal of the electric valve means may consist of a suitable metal connection 10 in electrical contact with mercury pool cathode 3.

To initiate an arc discharge within the electric valve means or more particularly within the inner chamber of the shielding member 4, I employ a control member 11 of the make-alive or immersion-ignitor type having an extremity thereof extending below the surface of the mercury pool cathode 3 and being constructed of a suitable material having an electrical resistivity relatively large compared with that of the associated mercury of the cathode 3. This material may be boron-carbide or silicon-carbide, as stated above, or any other suitable material of this nature. I provide a holding structure or support 12 for maintaining the immersion-ignitor control member 11 in operative relation with the cathode 3. The support 12 is arranged not only to act as a mechanical supporting structure for the control member 11, but is also arranged or adapted to operate as a holding anode to maintain an arc discharge between itself and the cathode 3 upon the initiation of an arc discharge by the transmission of a suitable current through the control member 11. The support 12 may be constructed in cylindrical form to support the upper portion of the control member 11, and is preferably constructed of a material such as tungsten, molybdenum or graphite capable of withstanding an arc discharge without appreciable disintegration. A terminal connection for permitting the make-alive electrode and the support 12 to be energized is shown at 13. This stem-like construction may extend downwardly and is attached to a terminal 14 which is arranged to effect transmission of arc-initiating current and arc-holding current to the control member 11 and to the support 12, respectively.

In order to illustrate in simplified form a circuit application for the electric discharge device, I have chosen to show the discharge device connected for energizing a load 15 from an alternating current supply circuit comprising conductors 16 and 17. Unidirectional current is transmitted to the load 15 through the electric discharge device.

I provide a control or excitation system for transmitting to the immersion-ignitor control member 11 an impulse of current of sufficient magnitude to establish an arc discharge within the electric valve means. More particularly, an impulse of current is transmitted through the control member 11 to the cathode 3 to establish within the chamber provided by the shielding member 4 an arc discharge. This excitation circuit is arranged to decrease substantially the energization of the immersion-ignitor control member 11 as soon as an arc discharge is initiated. I provide a control or excitation circuit responsive to the voltage applied across the anode and cathode of the electric valve means to effect energization of the control member 11. This circuit is responsive not only to the magnitude of the anode-cathode voltage, but is also responsive to the polarity of the anode-cathode voltage so that energization of the control member is effected only when the polarity of the voltage is suitable for initiating an arc discharge between the anode and the cathode. Furthermore, the control or excitation circuit operates to maintain an arc discharge within the inner closure of the shielding member 4 after the initiation of the discharge. In the event the arc discharge is not maintained within the closure, the circuit becomes effective to cause re-energization of the control member 11 to initiate another discharge.

Referring more particularly to the arrangement shown in the drawing, I provide a control or excitation circuit comprising a suitable unidirectional conducting device, such as a copper-oxide rectifier 18 disclosed and claimed in U. S. Letters Patent No. 1,640,335, granted August 23, 1927 upon an application of Lars O. Grondahl. I also provide a suitable inductive device, such as a transformer 19 having a primary winding 20 and a secondary winding 21. The primary winding 20 is connected in series relation with the copper-oxide rectifier 18 across the anode 2 and the cathode 3 through terminal 10 of the electric valve means. One terminal of the secondary winding 21 is connected to terminal 14 associated with the control member 11 and the support 12. The other terminal of the secondary winding 21 is connected to a suitable source 22 of unidirectional current for maintaining an arc discharge within the closure of the shielding member 4 after the initiation of the discharge. The voltage of circuit 22 is unidirectional and of a value substantially less than the magnitude of the voltage impressed upon the control member 11 to effect initiation of the arc discharge. I have found that the source of voltage 22 may have a value of substantially 20 or 30 volts. The source 22 applies to the support 12 a suitable unidirectional voltage through secondary winding 21 of transformer 19, so that the support 12 operates as a holding anode once the arc discharge is established within the shielding member 4. Due to the ebullition of the cathode during the time when it is supporting a cathode spot, there is a tendency for the current transmitted to the support 12 to vary substantially. As a means for stabilizing or limiting this current, I provide a stabilizing means such as a stabilizing resistance 23 connected in series relation with the support 12 and the source 22. Instead of a resistance as a stabilizing means, I of course may use an inductance.

The operation of the embodiment of my invention shown in the single figure of the drawing will be explained by considering the system

when the electric valve means is operating to transmit unidirectional current to the load 15 from the alternating current supply circuit 16, 17. Upon energization of the alternating current circuit 16, 17, no arc discharge is present within the electric valve means. During the first positive half cycle of applied anode-cathode voltage, the control or excitation circuit operates to transmit an impulse of unidirectional current to the immersion-ignitor control member 11. The control or excitation circuit, since it is responsive to the polarity of the anode-cathode voltage due to the presence of the copper-oxide rectifier 18, effects energization of the control member 11 only during the positive half cycles of anode-cathode voltage, during which half cycles it is possible to transmit current through the electric valve means. Of course, an arc discharge will not be initiated within the closure of the shielding member 4 until the anode-cathode voltage increases to a value which is sufficient to transmit the desired or required value of current to the control member 11. When this value of anode-cathode voltage is attained, an impulse of current will be transmitted through the control member 11 and the mercury pool cathode 3 to establish an arc discharge within the closure of the shielding member 4. Immediately thereafter, the anode-cathode voltage of the electric valve means will substantially decrease from its initial value to the valve voltage drop due to the fact that an arc discharge will be established between the main anode 2 and the cathode 3. The voltage then impressed across the primary winding 20 of the transformer 19 and the copper-oxide rectifier 18 will be the arc drop of the electric valve means. It will be understood that the application of a positive voltage to the main anode 2 establishes within the vicinity thereof a strong positive electrostatic field which draws electrons from the cathode spot within the closure of the shielding member 4 through the slots 6. That is, the electrons are drawn through the slot 6 to establish a cathode spot outside the shielding member 4 and in turn to establish a main arc discharge between the anode 2 and the cathode 3.

After the cathode spot is initiated within the shielding member 4, due to the application of the unidirectional voltage to the support 12 and the relatively larger resistance of the control member 11, the arc discharge is transferred from the control member 11 to the support 12 which acts as a holding anode. The magnitude of the voltage applied to the control member 11 to initiate the arc discharge is in the vicinity of two hundred or three hundred volts, whereas the arc discharge may be maintained by a much smaller voltage, such as twenty or thirty volts, after the initiation of the discharge.

It is to be understood that after an arc discharge has been initiated within the shielding member 4, it is maintained therein by the support 12 which operates as a holding anode. Circuit 22 supplies the holding current. During each positive half cycle of applied anode-cathode voltage, current will be conducted between the anode 2 and the cathode 3. The exact point in the positive half cycle at which anode-cathode current begins to flow, of course, depends upon the instantaneous value of the anode-cathode voltage. As soon as the voltage reaches that value where the field provided by the anode 2 is sufficient to draw more than the critical number of electrons through the slots 6 into the

region of the main discharge path, a discharge will be initiated in that path and current will flow.

The excitation circuit which I provide prevents the application of a negative voltage to the control member 11 for two reasons. In the first place, the small value of reverse or inverse current which flows through the copper-oxide rectifier 18 during the negative half-cycles of anode-cathode voltage is absorbed as exciting current in the transformer 19 and this value of exciting current is ineffective to build up an appreciable secondary voltage. In the second place, there is impressed on the control member 11 a positive voltage at all times by the unidirectional voltage source 22. Another of the principal advantages of my invention is the manner in which the excitation system relieves the duty imposed on the control member by effecting deenergization of the control member as soon as an arc discharge is established between the anode 2 and the cathode 3. Moreover, the absence of inverse voltage also materially increases the life of the control member and the discharge device.

While I have shown and described my invention as applied to a particular system of connections and as embodying various devices diagrammatically shown, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode, means for supplying to said control member a voltage sufficient to initiate an arc discharge between said anode and said cathode, and means for supplying to said support a voltage of a magnitude insufficient in itself to initiate an arc discharge but sufficient to maintain an arc discharge within said electric valve means after an arc discharge has been established by the energization of said control member.

2. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode, means for supplying to said control member a voltage sufficient to initiate an arc discharge between said anode and said cathode when said electric valve means is non-conductive, and means for supplying to said support a unidirectional voltage of a magnitude insufficient in itself to initiate an arc discharge but sufficient to maintain an arc discharge within said electric valve means after an arc discharge has been established by the energization of said control member.

3. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode, means responsive to the voltage appearing between said anode and cathode for supplying to said control member an

impulse of voltage to initiate an arc discharge between said anode and said cathode, and means for supplying to said support a unidirectional voltage of a magnitude insufficient in itself to initiate an arc discharge but sufficient to maintain an arc discharge within said electric valve means after an arc discharge has been established by the energization of said control member.

4. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode and adapted to operate as an auxiliary holding anode, means responsive to the voltage appearing between said anode and said cathode for initiating an arc discharge between said anode and said cathode, and means comprising a source of unidirectional voltage of a magnitude insufficient in itself to initiate an arc discharge but sufficient to maintain an arc discharge between said support and said cathode after an arc discharge has been established by the energization of said control member.

5. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode and being adapted to operate as a holding anode, means responsive to the magnitude and polarity of the voltage appearing across said anode and said cathode to initiate an arc discharge therebetween by effecting energization of said control member and comprising a transformer having a primary and a secondary winding and a unidirectional conducting device connected in series relation with said primary winding across said anode and cathode, and a source of direct current for impressing on said support a unidirectional arc-maintaining voltage through said secondary winding.

6. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode and being adapted to operate as a holding anode, means for transmitting to said control member an impulse of current to establish an arc discharge between said anode and said cathode, and means for maintaining an arc discharge within said electric valve means between said support and said cathode after the initiation of a discharge by the energization of said control member comprising a source of unidirectional current for maintaining said support at a potential positive with respect to said cathode.

7. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode and being adapted to operate as a holding anode, means responsive to the magnitude and polarity of the voltage appearing across said anode and said cathode to initiate an arc discharge therebetween by effecting energization of said control member, means comprising a source of unidirectional current for energizing said support to maintain an arc discharge between said support and said cathode, and a stabilizing resistance connected in circuit with said support and said source to assure the transmission of a substantially constant unidirectional current between said support and said cathode.

8. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode and a support for maintaining said control member in operative relation with said cathode and being adapted to operate as a holding anode, means for supplying to said control member an impulse of voltage sufficient to initiate an arc discharge between said anode and said cathode, and means for supplying to said support a unidirectional voltage of a value relatively small compared to the magnitude of said first mentioned voltage to maintain an arc discharge between said support and said cathode.

9. In combination, an electric valve means having an anode, a cathode of the pool type, a control member of the immersion-ignitor type associated with said cathode, a support for maintaining said control member in operative relation with said cathode and being adapted to operate as a holding anode and a shielding member for substantially enclosing said control member, and said support for confining the cathode spot upon a localized area of said cathode and having openings therein for permitting the establishment of an arc discharge between said anode and said cathode upon the application of a positive voltage to said anode, means for transmitting to said control member an impulse of current for initiating an arc discharge within said shielding member, and means for supplying to said support a voltage of a magnitude insufficient in itself to initiate an arc discharge but sufficient to maintain an arc discharge within said shielding member after the initiation of the arc discharge.

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