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ELECTRON DISCHARGE DEVICE

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This invention relates to the construction and operation of electron discharge devices and particularly to devices which are suitable for use as relays which may be started instantly by the application of a predetermined positive voltage to the grid and may be stopped suddenly the instant a certain critical negative potential is applied to the grid.

Thermionic devices which have the characteristic of starting into operation when a certain positive potential is applied to the grid and continuing to operate thereafter unaffected by the grid potential have now become well known and are in commercial use. The object of my present invention is to provide a thermionic current controlling device in which the plate current may not only be started instantly with substantially the maximum value and will continue to flow unaffected by fluctuations in the positive potential applied to the grid but which may be stopped suddenly by the application of a critical negative potential to the grid. A thermionic tube having these characteristics is applicable to conditions which cannot be fulfilled by prior devices.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its construction and mode of operation will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a longitudinal sectional view of a device embodying my invention; and Figure 2 is a diagram of a circuit arrangement in which my device may be utilized to advantage.

The device shown in Fig. 1 comprises an envelope 1 consisting of glass, quartz or the like, and containing a rare inert gas, a body of easily vaporizable monatomic metal 4, such as mercury or a mixture of them. The grid 5 is constructed of fine wire mesh and forms a closed cage completely enveloping the cathode filament 2, so that no electrons can pass from the cathode to the anode plate 3 without passing through the grid. It is in this feature that my invention is distinguished from prior devices. In certain prior thermionic devices in which the grid completely surrounds the cathode, as for instance in the thyatron type, after starting, the plate current attains its maximum value instantly and the grid has no further control, either to modulate, limit or extinguish it. The device of my present invention operates in the

same manner in regard to the instantaneous starting and continuous maximum flow in the plate circuit irrespective of fluctuations in grid potential so long as it remains positive, but it differs from the thyatron in that the plate current may also be stopped instantly by applying a critical value of negative potential to the grid. Herein lies the fundamental difference between the thyatron type and my present device.

The operation of my thermionic device having a grid-enclosed cathode is probably as follows: When the grid is made positive, there is a flow of electrons from the cathode through the small apertures in the grid to the anode. These electrons collide with the atoms of the gas, causing ionization and thereby starting the arc. As previously stated, the current continues to flow in the plate circuit unaffected by fluctuation in positive grid potential. If the grid is made negative by a certain critical value, positive ions collect and form a sheath of positive ions about the grid wires. This sheath acts like a layer of insulation. At the critical negative potential this sheath is made sufficiently thick to overlap between the small apertures of the grid and effectively block the ionic path through the grid. Since the cathode is completely enclosed or enveloped by the grid structure, the arc is stopped or extinguished and de-ionization takes place. The value of the critical negative voltage will depend, of course, upon the size of the apertures between the grid mesh wires. The coarser the mesh, the higher will be the critical negative voltage required. The thickness of the sheath of positive ions is a function of the negative grid voltage and also of the positive ion current. Hence a higher critical negative voltage will be required for a larger plate circuit current.

The thermionic tube or device of my invention may therefore be characterized as a gaseous controlled rectifier wherein the grid so completely encloses or envelopes either the cathode or the anode and is composed of a wire mesh of such dimensions that an arc can be started by applying positive potential to the grid and can likewise be extinguished by applying a critical negative potential thereto.

I have illustrated in Fig. 2, an example of a circuit arrangement particularly adapted for use with the thermionic tube of the present invention, this arrangement being claimed in my co-pending application, Serial No. 509,798, now Patent No. 1,944,888, Jan. 30, 1934.

I have indicated at 6, the output of an amplifier or magnifier of a telegraph receiving or repeating apparatus connected by conductor 7 with the continuous ring of a rotary repeater RR of the usual well-known construction. The segments *a*, *b*, *c*, etc. are connected alternately to the grids of two thermionic tubes *T*₁, *T*₂ of the construction described in which the cathodes are completely enclosed or enveloped by the fine mesh grids. The cathodes are connected in parallel to the other conductor 8 of the amplifier output through a conductor 9 and resistance *R*₁. The plates or anodes of the tubes are connected respectively through the actuating coils of the sending-on relays *SR*₁ and *SR*₂, through the conductor 10 and battery *BA* to the amplifier output conductor 8. The relay armatures *t*₁ and *t*₂ are normally biased to their left hand or negative polarity contacts by the biasing coils *bc*.

Let us assume that the received signaling impulses have a maximum of ten volts positive and a minimum of ten volts negative and that the amplifier output is normally biased to five volts positive so that there will be an available positive voltage of fifteen volts and an available minimum voltage of ten volts at the terminals of the amplifier. Also assume that there is a voltage drop of five volts across the resistance *R*₁ when current flows through one tube and a drop of ten volts when current flows through both tubes.

The illustration of the transmitted signal with square topped waves is of course, not attained in actual practice. The diagram of received signals shows that there is a lag between the transmission and the reception and also that the dots or impulses of unit length are too weak to be recorded. The diagram of repeated signals indicates that the regenerated signals repeated into the outgoing line or cable include the missing dot impulses and constitute a faithful reproduction of the original transmitted signals.

Let us examine the operation more in detail. When the brush *B*₁ is on the segment *b*, the received signal is at a maximum and hence there is a voltage of 15 positive at the terminals of the amplifier. At this instant current has been flowing through both tubes thereby causing a drop of 10 volts across resistance *R*, thus leaving 5 volts positive to be applied to the grid of tube *T*₂. This tube, therefore, continues to operate and holds its tongue or armature *t*₂ against its right hand contact. Consequently the tube *T*₂ will continue to operate and as the sending brush *B*₂ engages the segment *b'*, the repeated signal will continue as a maximum positive impulse from the tongue *t*₂.

When the brush *B*₁ engages the segment *c*, the received signal is at zero and the voltage at the amplifier output is 5 volts positive bias. Both tubes are still in operation and hence there is a drop of 10 volts across resistance *R*₁ to be subtracted, leaving a resultant of 5 volts negative which is applied to the grid of tube *T*₁. This stops the tube and the tongue *t*₁ of relay *SR*₁ is moved by its biasing coil to the left hand contact. As the sending brush now engages the segment *c'*, the repeated signal impulse transmitted to the outgoing line changes from maximum positive to minimum negative, as indicated by the diagram.

When the brush *B*₁ moves onto the segment *d*, the received signal is at a minimum 10 volts negative which is reduced by the 5 volts positive bias to 5 volts negative at the terminals of the

amplifier. Since the tube *T*₂ is still operating, there is a drop of 5 volts across the resistance *R*₁ giving a resultant of 10 volts negative to be applied to the grid of tube *T*₂. This stops tube *T*₂ and causes the tongue *t*₂ of sending-on relay *SR*₂ to move over to its left hand contact under the control of its biasing coil. Accordingly as the sending-on brush *B*₂ engages segment *d'* the negative impulse being transmitted to line is continued from tongue *t*₂.

When the brush *B*₁ has reached the pick-up segment *e*, the amplifier output has dropped to its "no signal" value, due to the fact that a series of single impulses are coming in and the attenuation of the cable is assumed to be so great that these signals are almost completely lost in transmission. The voltage at the amplifier output is 5 volts positive due to the positive bias. Since neither tube is operating, there is no drop at the resistance *R*₁ and hence the 5 volts positive is applied to the grid of tube *T*₁ which starts it into operation, thereby energizing the relay *SR*₁ and moving its tongue *t*₁ over to its right hand contact. As the sending-on brush *B*₂ engages the contact *e'*, the repeated signal impulse shifts from negative to positive as indicated.

This will suffice to explain the operation. It will be observed that the tubes are started and are also stopped by the received signal impulses, whereas when the thyatron tubes are employed, as in my prior applications, Ser. Nos. 335,963 and 343,109, now Patent No. 1,901,296, March 14, 1933, it is necessary to provide a special rotary distributor to stop the operation of the tubes. My present invention, therefore, greatly simplifies the apparatus required and consequently enhances the efficiency and permits of greater speed.

It will be obvious to engineers that my invention is applicable to the control of various arrangements of circuits and apparatus and that the application above described is merely illustrative for the purpose of making a clear and complete disclosure of the invention.

I claim:

1. The method of controlling the duration of an arc discharge in a gas which consists in rendering conductive the arc path between two electrodes, establishing in the arc path a negative electric field which completely envelopes one electrode and having a potential high enough to form a closed sheath of positive ions to thereby extinguish the arc.

2. The method of controlling the duration of an arc discharge in a gas which consists in rendering conductive the arc path between two electrodes, setting up in the arc path a negative electrostatic field which completely envelopes one electrode and is so disposed that at a critical value the resulting sheath of positive ions extinguishes the arc.

3. A thermionic device comprising an electron-emitting cathode, an anode, a grid element and an enclosing envelope, a gaseous medium within said envelope, said grid element consisting of a fine mesh wire structure completely enclosing said cathode, the apertures of said grid element having an area of such size that they are completely closed to the passage of electrons by a sheath of positive ions upon the application of a critical negative voltage to the grid element.

4. An electronic control switch comprising a receptacle having an ionizable medium therein, a solid electron emitting cathode and an anode element disposed in said receptacle and a control grid completely enclosing said cathode, compris-

ing in its entirety a metallic member provided with uniformly distributed small perforations of uniform size.

element disposed in said receptacle and a control grid completely enclosing said cathode, said grid being metallic throughout and having a plurality of small openings of uniform size.

5 5. An electron discharge device, comprising a receptacle having an ionizable medium therein, a solid electron emitting cathode and an anode

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