

July 24, 1951

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2,561,768

THERMIONIC CATHODE ACTIVATION

Filed April 10, 1950

Fig. 1

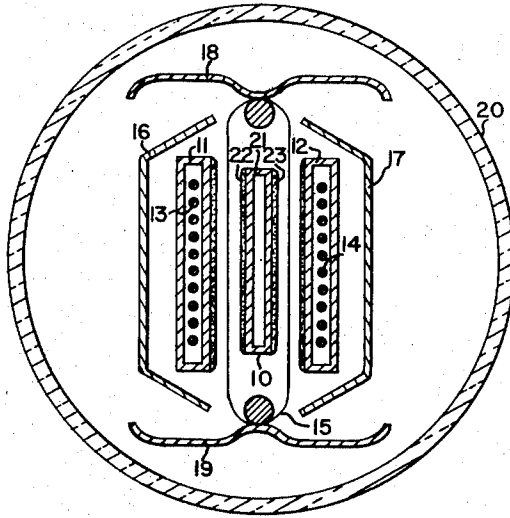
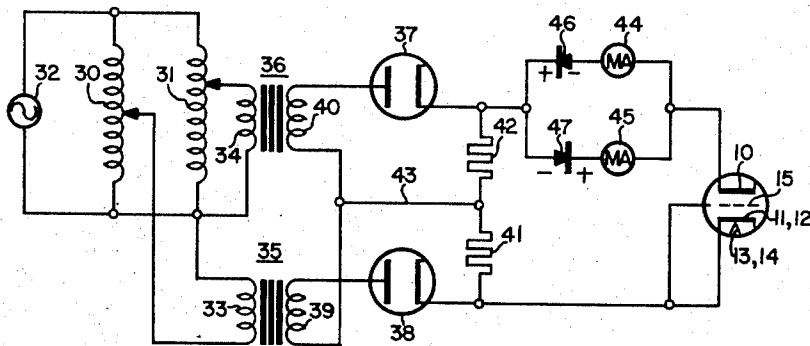


Fig. 2



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2,561,768

THERMIONIC CATHODE ACTIVATION

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Application April 10, 1950, Serial No. 155,049

9 Claims. (Cl. 316-13)

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This invention relates to the activation of thermionic cathodes and more particularly to a novel process for activating a thermionic cathode of the type which is not provided with an associated indirect-heater element.

In the copending application of Robert Adler, Serial No. 129,554, filed November 26, 1949, for "Electron-Discharge Device and Circuits," assigned to the present assignee, there is disclosed and claimed a novel type of bilaterally conductive electron-discharge device. In its preferred form, such a bilaterally conductive device may comprise a pair of thermionic cathodes with a control grid disposed therebetween, one of the cathodes being provided with a conventional resistance-type indirect-heater element and the other cathode being adapted to be energized in operation partially by heat radiation from the first cathode and partially by virtue of its own plate dissipation during portions of each operating cycle when it functions as an anode or a collector for electrons originating at the first cathode. A device of this type is especially useful in a simple circuit for the generation of sawtooth currents and finds particular application, for example, in the line-frequency scanning system of a television receiver or the like, as disclosed in detail in the above-identified copending application.

In the construction of conventional electron-discharge devices employing thermionic cathodes of the type utilizing indirect-heater elements for cathode energization, the process of rendering the cathode thermionically active is relatively simple of accomplishment. Such a cathode is usually prepared by coating a cathode base member with carbonates of barium, strontium, calcium, etc., heating the coated cathode member to a sufficient extent to cause breakdown of the carbonates, outgassing the broken-down carbonates to leave an oxide coating, and seasoning the oxide-coated cathode to improve the emissivity of the cathode surface. The seasoning step is readily accomplished, for example, by heating the oxide-coated cathode above normal emission temperature by means of the indirect-heater element and by simultaneously applying a suitable accelerating field until substantially full electron emission is obtained.

Such conventional seasoning methods are not possible, however, in the activation of a cathode which is not provided with an associated resistance-type indirect-heater element. Moreover, in a bilaterally conductive device of the type disclosed in the aforementioned Adler application, activation of two cathodes at opposite ends of a

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single electron-discharge path must be accomplished simultaneously. Thus, both cathodes must be heated considerably above normal emission temperature, and both must be subjected to suitable accelerating fields.

It is a particular object of the present invention to provide a novel process for activating a thermionic cathode.

A further object of the invention is to provide an improved process for activating a thermionic cathode of the type which is not provided with an associated indirect-heater element.

Yet another object of the invention is to provide a new and simple process for simultaneously seasoning a pair of thermionic cathodes disposed at opposite ends of a single electron-discharge path.

In accordance with the present invention, a new and improved process for activating a thermionic cathode comprises the steps of alternately heating the cathode by electron bombardment and subjecting the cathode to the influence of an accelerating field. The novel process comprises the further step of independently controlling the intensity of the electron bombardment and the strength of the accelerating field.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals indicate like elements, and in which:

Figure 1 is a cross-sectional view of a bilaterally conductive electron-discharge device constructed in accordance with the above-identified copending application and comprising a pair of thermionic cathodes disposed at opposite ends of a single electron-discharge path; and

Figure 2 is a schematic circuit diagram illustrative of one form of apparatus which may be used to carry out the novel cathode activation process of the present invention.

Figure 1 is a cross-sectional view of a bilaterally conductive electron-discharge device constructed in accordance with the above-identified copending application and comprising a thermionic cathode 10 of the type which is not provided with an associated indirect-heater element. Briefly, the device also comprises a second cathode, consisting of two parts 11 and 12 provided with associated indirect-heater resistance-type

elements 13 and 14 respectively. A control grid 15 is provided between cathodes 10 and 11, 12.

In operation the inner cathode 10 is adapted to be energized partially by heat radiation from outer cathode members 11 and 12. To this end, a pair of heat-reflecting members 16 and 17 are provided to concentrate reflected heat from outer cathode 11, 12 at inner cathode 10. In order to prevent overheating of control grid 15, heat-radiating fins 18 and 19 are affixed to the supporting rods for control grid 15. Preferably, the outer surfaces of fins 18 and 19 are blackened to provide efficient outward heat radiation, and the inner surfaces are polished to prevent substantial heat radiation inwardly toward the control grid. All of the elements are supported in any conventional manner within an evacuated envelope 20.

Since the inner cathode 10 is not provided with an associated indirect-heater element, it is readily apparent that conventional seasoning processes may not be employed in the activation of the inner cathode. In fact, in the preferred embodiment represented by Figure 1, the inner cathode may comprise a member 21 of conductive material such as nickel or the like which is provided with a pair of thermionically emissive coatings 22 and 23. No means are provided for heating the inner cathode 10 independently of the other electrodes of the tube.

In the processing of such a tube, the inner cathode 10 is provided with emissive surfaces 22 and 23 in a conventional manner, as for example, by applying suitable carbonate materials to the surfaces of cathode sleeve 21 and outgassing the carbonates to leave thermionically emissive oxide deposits on the sleeve. The outgassing operation comprises raising the temperature of the inner cathode, by induction heating or the like, to a sufficient extent to cause breakdown of the carbonates and drive off carbon dioxide which is then removed in the evacuation of the envelope. It has been found undesirable to raise the temperature of the inner cathode 10 during the outgassing process by electron bombardment from outer cathode members 11 and 12 since electron bombardment of the carbonate coating before the breakdown process is complete may result in poor emission characteristics. However, once the outgassing process is completed, the inner cathode may be subjected to electron bombardment without encountering detrimental effects of this type.

Following the outgassing process, the device is evacuated, gettered, and sealed in any conventional manner, and the inner and outer cathodes 10 and 11, 12 are subjected to the novel seasoning process of the present invention. Briefly, the seasoning process for inner cathode 10 comprises the steps of alternately heating the inner cathode by electron bombardment from the outer cathode 11, 12 and subjecting the inner cathode 10 to an accelerating field. In accordance with the invention, the intensity of the electron bombardment and the strength of the accelerating field are independently controlled during the seasoning process. The frequency of alternating between the electron bombardment and the application of the accelerating field is maintained at a sufficiently high value to render the inner cathode continuously electron-emissive. In other words, the inner cathode is preferably not permitted to drop at any time below the minimum temperature required for electron emission. In practice, it has been found that the thermal time

constant of the inner cathode may be of the order of one second or less; therefore, the frequency of alternation between electron bombardment of the inner cathode and application of the accelerating field at the surface of the inner cathode is preferably maintained at a value greater than one cycle per second. In practice, it has been found quite convenient to use an alternation frequency corresponding to the local power-line frequency, which is 60 cycles per second in most locations in the United States at the present time.

In other words, the process of activating the inner cathode comprises the steps of intermittently heating the inner cathode by electron bombardment during spaced time intervals, which intervals are preferably of sufficiently great time duration and of sufficiently high repetition frequency to maintain the cathode continuously in an electron emissive state, establishing an accelerating field at the surface of the cathode during intervening time intervals, and independently controlling the intensity of the electron bombardment and the strength of the accelerating field. The repetition frequency of the spaced time intervals during which the cathode is intermittently heated preferably has a period shorter than the thermal time constant of the inner cathode and may conveniently assume a value equal to the local power-line frequency.

As an additional feature of the invention, the outer cathode 11, 12 may be seasoned at the same time as the inner cathode 10. Preferably, the seasoning process is accomplished by applying an alternating voltage between the inner and outer cathodes and changing the amplitudes of the positive and negative half-cycles at different rates, so that the intensity of electron bombardment of the inner cathode 10 and the strength of the accelerating field formed adjacent emissive surfaces 22 and 23 of inner cathode 10 are independently controlled. The seasoning process is continued until substantially full electron emission is obtained and until the emissivity of the inner and outer cathodes is substantially uniform over the respective emissive surfaces.

Merely by way of illustration and in no sense by way of limitation, there is illustrated in Figure 2 a schematic diagram of one form of apparatus which has been found suitable for performing the novel process provided by the present invention. In the apparatus of Figure 2 a pair of continuously variable alternating-current transformers 30 and 31 are connected in parallel across a suitable alternating-voltage source 32, which may for example constitute a conventional 115 volt-60 cycle A. C. power line. The variable outputs of transformers 30 and 31 are differentially applied to the primary windings 33 and 34 of a pair of transformers 35 and 36 respectively. A pair of rectifier devices 37 and 38 are differentially connected in circuit with the secondary windings 39 and 40 of transformers 35 and 36 respectively; as shown, rectifier devices 37 and 38 may conveniently comprise thermionic diodes, the anodes of which are connected with oppositely polarized terminals of secondary windings 39 and 40. Of course, any type of unilaterally conductive device may be used in place of diodes 37 and 38. A pair of load resistors 41 and 42 are connected in series between the cathodes of diodes 37 and 38, and a connection 43 is provided between the junction of resistors 41 and 42 and the free ends of secondary windings 39 and 40.

The device of Figure 1 is connected in parallel

with series-coupled resistors 41 and 42, the inner cathode 10 being coupled to the cathode of diode 37 and the outer cathode 11, 12 being connected to the cathode of diode 38. During the seasoning process, the control grid 15 is connected to outer cathode 11, 12, and indirect-heater elements 13, 14 associated with outer cathode 11, 12 are connected to a suitable energizing current source (not shown). In order to provide separate indications of the respective currents drawn from the inner and outer cathodes, a pair of oppositely-polarized direct-current milliammeters 44 and 45, respectively connected in series with oppositely-polarized rectifier devices 46 and 47, are connected in parallel between inner cathode 10 and the cathode of diode 37.

The apparatus of Figure 2 constitutes a convenient circuit for providing independent control over the intensity of electron bombardment of the inner cathode 10 and the strength of the accelerating field produced adjacent the inner cathode. Essentially, the apparatus of Figure 2 operates to apply an alternating voltage between the cathodes 10 and 11, 12 so that the inner cathode 10 is alternately bombarded by electrons from the outer cathode 11, 12 and subjected to an accelerating field or positive potential gradient which tends to draw current from the inner cathode. The amplitudes of the positive and negative half-cycles of the alternating voltage applied between the cathodes are independently controllable by means of the variable taps associated with variable A. C. transformers 30 and 31. Thus, variable transformer 31 controls the intensity of electron bombardment of the inner cathode 10 by controlling the amplitude of the positive half-cycles of the alternating-voltage wave from source 32, while variable transformer 30 controls the strength of the accelerating field produced adjacent inner cathode 10 by controlling the amplitude of the negative half-cycles of the alternating-voltage wave from source 32. Milliammeters 44 and 45 indicate respectively the magnitudes of the emission currents drawn from outer cathode 11, 12 (the bombarding current) and from inner cathode 10 (the emission current).

The operational details of the circuit of Figure 2 are straightforward and immediately apparent to anyone skilled in the art, and this circuit is illustrated only as an example of one form of apparatus which may be used to carry out the novel seasoning process of the present invention. A detailed description of the operation of the circuit is therefore believed unnecessary.

With the apparatus of Figure 2, the seasoning process may be carried out as follows. Heater elements 13, 14 are energized to raise outer cathode 11, 12 considerably above normal emission temperature. Variable transformer 31 is adjusted to provide sufficient emission current from outer cathode 11, 12 during the positive half-cycles of the supply voltage to maintain inner cathode 10 above its normal emission temperature. Variable transformer 30 is then adjusted to provide a relatively small accelerating field adjacent inner cathode 10 during the negative half-cycles of the supply voltage from source 32.

The seasoning process is completed by gradually increasing at different rates the peak amplitudes of the positive and negative half-cycles of the alternating voltage from source 32 by means of variable transformers 31 and 30 respectively; generally, it has been found most desirable to increase the emission current from inner cathode 10 at a slower rate than the bombarding

current from outer cathodes 11, 12, and it may even be desirable to decrease the bombarding current slightly toward the end of the seasoning process. Of course, it is contemplated that the changes in the peak amplitudes of the positive and negative half-cycles, and hence the changes in the bombarding and emission currents, may be effected either continuously at different rates or in unrelated steps until the emissivity of both cathodes is uniform and complete.

In the particular application of the activation process of the present invention to the manufacture of bi-directional switch tubes of the type disclosed in the above-identified copending application and illustrated in Figure 1, particularly good results are obtained by maintaining the control grid 15 and the outer cathode 11, 12 at a common potential throughout the seasoning process, as by a galvanic circuit connection therebetween.

When the grid is so connected, the amount of bombarding current from the outer cathode 11, 12 required to keep the inner cathode 10 at the desired seasoning temperature is maintained at a low value, since the device functions as a grounded-grid triode. Consequently, during such intervals when the inner cathode 10 serves as an anode or collector, plate dissipation at the inner cathode 10 is obtained with high voltage and low current, and the current-collecting capacity of the inner cathode is not exceeded. However, when the device is conductive in the opposite direction, from inner cathode 10 to outer cathode 11, 12, the control grid 15 is connected to the electrode which instantaneously serves as the anode, and the device functions as a diode. In the reverse direction, therefore, a relatively high emission current is drawn from the inner cathode 10 at a low voltage. Thus, maximum emission current may be drawn from the inner cathode without incurring excessive plate dissipation at the outer cathode.

Thus, the invention provides an important new process for activating a thermionic cathode of the type which is not provided with an associated indirect-heater element. The invention provides a simple and reliable method of seasoning a cathode of this type and is particularly useful in connection with the processing of a bilaterally conductive electron-discharge device of the type disclosed and claimed in the above-identified copending application.

While a particular embodiment of the present invention has been shown and described, it is apparent that various changes and modifications may be made, and it is therefore contemplated in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. The process of activating a thermionic cathode which comprises: alternately heating said cathode by electron bombardment and subjecting said cathode to an accelerating field; and independently controlling the intensity of said electron bombardment and the strength of said accelerating field.

2. The process of activating a thermionic cathode which comprises: alternately heating said cathode by electron bombardment and subjecting said cathode to an accelerating field; and changing the intensity of said electron bombardment and the strength of said accelerating field at different rates until substantially full electron emission from said cathode is obtained.

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3. The process of activating a thermionic cathode which comprises: alternately heating said cathode by electron bombardment and subjecting said cathode to an accelerating field; and gradually increasing the strength of said accelerating field independently of the intensity of said electron bombardment until substantially full electron emission from said cathode is obtained.

4. The process of activating a thermionic cathode which comprises: intermittently heating said cathode by electron bombardment during spaced time intervals to maintain said cathode continuously in an electron-emissive state; establishing an accelerating field at the surface of said cathode during intervening time intervals; and independently controlling the intensity of said electron bombardment and the strength of said accelerating field.

5. The process of activating a thermionic cathode which comprises: intermittently heating said cathode by electron bombardment during spaced time intervals occurring at a frequency greater than one cycle per second to maintain said cathode continuously in an electron-emissive state; establishing an accelerating field at the surface of said cathode during intervening time intervals; and independently controlling the intensity of said electron bombardment and the strength of said accelerating field.

6. The process of activating a pair of thermionic cathodes disposed at opposite ends of a single electron-discharge path within an evacuated envelope which comprises: impressing an alternating voltage between said cathodes; and independently controlling the peak amplitudes of the positive and negative half-cycles of said alternating voltage.

7. The process of activating a thermionic cathode of the type adapted to be energized in sub-

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sequent operation at least partially by heat radiation from a second cathode which comprises: alternately bombarding said first-mentioned cathode with electrons originating at said second cathode to heat said first cathode, and establishing a positive potential gradient at the surface of said first cathode to draw emission current therefrom; and changing the value of said positive potential gradient, without affecting the intensity of said electron bombardment, until substantially full electron emission from said first cathode is obtained.

8. In the manufacture of an electron-discharge device of the type comprising a pair of thermionic cathodes arranged at opposite ends of a common electron-discharge path and having a control grid intermediate said cathodes, the process of activating one of said cathodes which comprises: maintaining said control grid and the other of said cathodes at a common potential; impressing an alternating voltage between said cathodes; and independently controlling the peak amplitudes of the positive and negative half-cycles of said alternating voltage.

9. In the manufacture of an electron-discharge device of the type comprising a pair of thermionic cathodes arranged at opposite ends of a common electron-discharge path and having a control grid intermediate said cathodes, the process of activating one of said cathodes which comprises: galvanically connecting said control grid to the other of said cathodes; impressing an alternating voltage between said cathodes; and independently controlling the peak amplitudes of the positive and negative half-cycles of said alternating voltage.

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No references cited.