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APPARATUS FOR AND METHOD OF OPERATING GASEOUS ELECTRIC DISCHARGE DEVICES

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Fig. 1

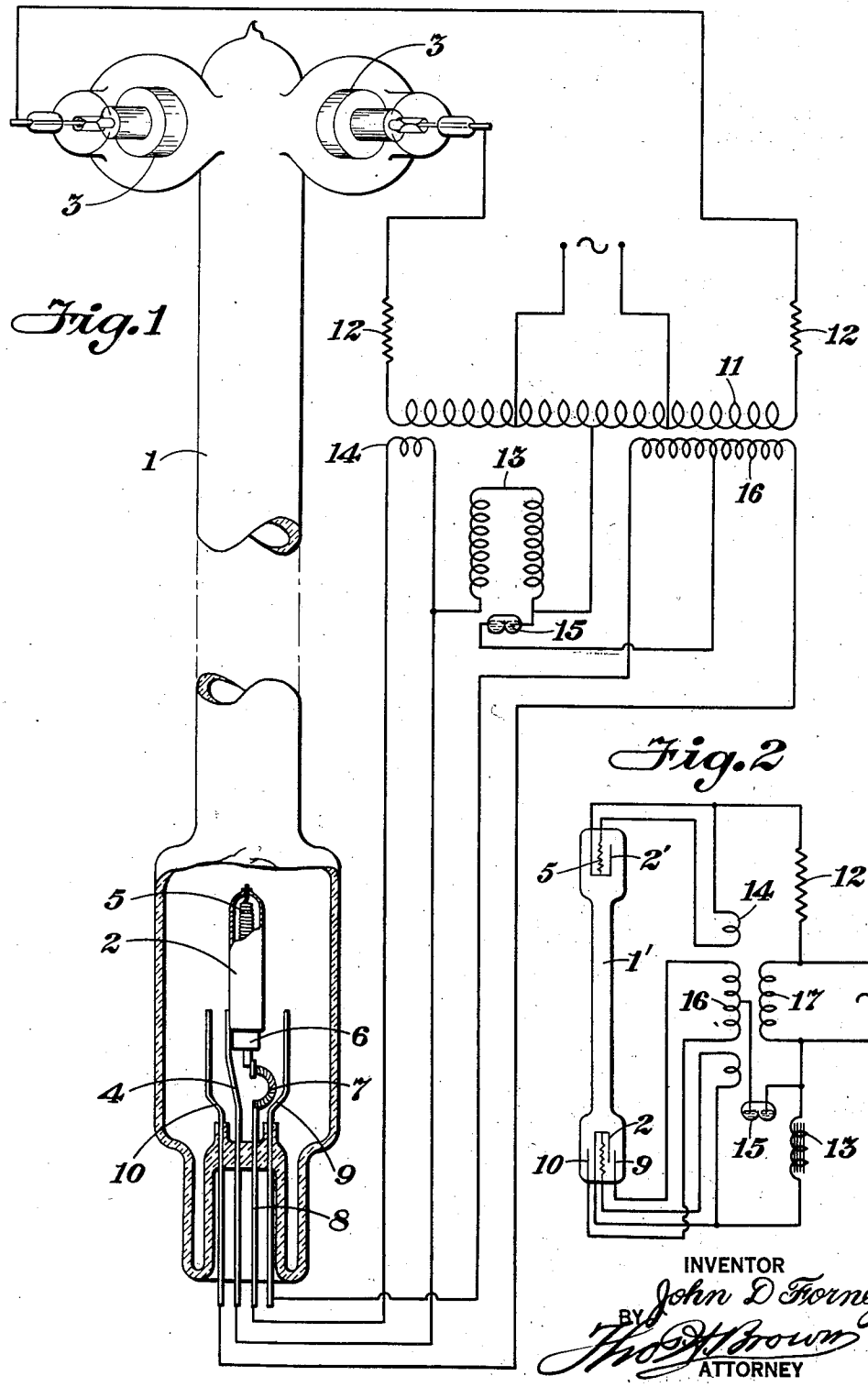


Fig. 2

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APPARATUS FOR AND METHOD OF OPERATING GASEOUS ELECTRIC DISCHARGE DEVICES

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4 Claims. (Cl. 176—124)

The present invention relates to electric discharge devices, and more particularly to alternating current gas or vapor discharge devices which operate with a hot cathode.

A particular object of the invention is to provide an improved method of and apparatus for starting and operating such devices. Another object of my invention is to provide a method of and apparatus for preventing operation of the said starting and operating apparatus if the discharge device has been damaged. Other objects and advantages of the invention will appear from the following detailed specification, or from an inspection of the accompanying drawing.

The invention consists in the new apparatus and in the new and novel methods of operation, as hereinafter set forth and claimed.

A well known type of electric gaseous discharge device utilizes a so-called hot cathode, which is usually coated with an active thermionic material such as barium, strontium, or compounds thereof, or mixtures of the aforesaid, to increase the thermionic emission therefrom, in order to eliminate the relatively high cathode fall which is characteristic of the ordinary gaseous discharge device. Due to the thermal capacity of these electrodes an appreciable interval, of say 15 to 45 seconds, is required at starting before the heating means usually provided can bring these cathodes to a temperature at which the thermionic emission therefrom will be sufficient to support the normal discharge current. The operating potential of these devices being ordinarily insufficient to initiate the discharge therein, an auxiliary starting means is commonly employed for this purpose. Experience has taught that actuation of this starting means must be delayed until the cathode has reached substantially operating temperature, for if the discharge is initiated before the cathode temperature is such as to provide sufficient electron emission the discharge will form a hot spot thereon which will seriously injure, if not destroy, the cathode. Various means of providing this delay have been suggested heretofore, but all have been open to the objection that they were based on the related functions of cathode temperature or time, rather than on the fundamental characteristic of electron emission, or that they were unduly destructive of the cathode in case they were responsive to the cathode emission. I have now discovered that by means of a novel structure the electron emission from the cathode may be directly availed of to actuate the discharge initiating means at precisely the right time regardless of ambient temperature, deterioration of the active surface, or variation in other factors which have adversely affected the operation of the delay means heretofore provided, without damaging the cathode surface in any way. According to my new invention two auxiliary anodes are provided adjacent to the cathode, and cooperate with said cathode and a suitable source of energy to form a full wave rectifier, the current from which is passed through an inductance which governs the initiation of the arc. The thermionic emission from the cathode is infinitesimal while the cathode is cold, but rapidly increases as said cathode approaches operating temperature, as is well known. Hence the full-wave rectified current flowing from said anodes, which is a direct function of said emission, likewise rapidly increases as the cathode approaches operating temperature. I have discovered that this current, which is thus a measure of the thermionic emission, can be utilized to energize the aforesaid inductance and thus to actuate the means by which the main arc is initiated. This means is so adjusted as to operate when the current flowing from the auxiliary anodes equals the normal discharge current. Since the impedance of the inductance is very low to the full-wave rectified current thus passed therethrough it is necessary to apply only a very low potential, of the order of 20–25 volts where neon is employed, between each anode and the cathode in order to obtain the desired current flow through this inductance when the cathode has reached its free electron emitting temperature. As a result of this extremely low potential difference there is virtually no destructive sputtering of the active surface of the cathode at any time during the starting operation, so that with this new circuit and structure the initiation of the arc is accurately delayed without in any way shortening the useful life of the device. I have found that in some cases the main discharge may be safely initiated as soon as the current from the auxiliary anodes is appreciable, say a third of the value of the normal discharge current. While it is probable that the initiation of the main discharge at this time momentarily results in an increased cathode fall, which assists in the heating of the cathode, it is an observed fact that no hot spot is formed thereby, hence this mode of operation is not only entirely satisfactory, but extremely desirable, since it results in cutting the delay period to the minimum, and such a mode of operation is contemplated, whereever possible. A further advantage of my new invention is found in the fact that if the dis-

charge device is damaged in any way which seriously reduces the thermionic emission, as by breakage of the envelope, the discharge initiating means is rendered inoperative, thus avoiding the production of electrical strains on the associated auxiliary apparatus. In order to reduce the demands on the cathode, and to increase the efficiency of the discharge device, the auxiliary anodes are preferably disconnected at the same time that the main discharge is initiated, a simple means being provided therefor.

For the purpose of illustration I have shown two embodiments of my invention in the accompanying drawing, in which

Fig. 1 is a diagrammatic representation, in part section, of a preferred embodiment of my invention, as applied to a self-rectifying device, and

Fig. 2 is a diagrammatic representation of the application of my invention to a full-wave, double end type of device.

In the drawing, with special reference to Fig. 1, there is shown a gaseous discharge device 1 of the Cooper Hewitt type, containing a suitable gas or vapor, such as neon or mercury vapor, at a pressure of say 0.5 to 4.0 millimeters of mercury, and employing a hot cathode 2 and anodes 3 of iron, graphite or the like. Said cathode, which is of nickel or other suitable material, is in the shape of a hollow cylinder, the exterior of which is preferably coated with a substance which will readily emit electrons when heated, such as barium or strontium or compounds thereof, or mixtures of the aforesaid. Said cathode is suitably supported at some distance from the pinch seal by the inlead 4, which is welded thereto. A heater 5 of tungsten or the like has one end thereof connected to said cathode while the other end passes through a loose fitting insulator 6 and is connected through a stranded conductor 7 of soft nickel, which permits unrestricted movement of said heater, to the inlead 8. A third inlead 9 terminates in a tungsten wire which extends to a point near said cathode 2, while a similar electrode 10 extends to a similar point on the opposite side of said cathode. Said inleads 9 and 10 each serve as an auxiliary anode during the starting of the device, and comprise with said cathode a full wave rectifier. Said inleads 9 and 10 may be enclosed within a glass sheath extending from the pinch seal to a point near the end thereof, if desired, in order to prevent any possible connection thereof to the other inleads by sputtered metal or the like.

An autotransformer 11 which is connected to a suitable source of alternating current has the ends thereof connected to the anodes 3 in the usual manner through the ballast resistances 12. The midpoint on said autotransformer 11 is connected through an inductance 13 to the inlead 4. Said inlead is also connected to one terminal of a low voltage secondary 14 which is in inductive relation to the autotransformer 11, the other end of said secondary being connected to the inlead 8. A connection is likewise made from a point between said inductance 13 and the midpoint of said autotransformer 11 through a mercury switch 15 of the type commonly called a shifter, to the midpoint of a secondary coil 16 which is in inductive relation to the autotransformer 11, while the ends of said secondary are connected to the inleads 9 and 10. Said switch 15, which is normally in a closed circuit position, has an armature connected thereto which is in magnetic relation to the inductance 13, whereby said switch is opened whenever a current of a desired value traverses said inductance. Where the normal arc current is 3.5 amperes this switch is usually set to open at an ampere.

In the use and operation of the device of Fig. 1 a suitable alternating current potential is first applied to the autotransformer 11. The secondary 14 is thereby energized, causing a current of several amperes to flow from said secondary 14 through inlead 8, heater 5, cathode 2, and inlead 4 back to said secondary. The gaseous content of the lamp 1 not being ionized, a discharge will not be produced between the anodes 3 and the cathode 2 at the relatively low potential available from the autotransformer 11, as is well known. Since the cathode 2 is cold the thermionic emission therefrom is infinitesimal, hence the discharge permitted thereby from either of the auxiliary anodes, which are maintained by the secondary 16 at a potential of only 20–25 volts higher than that of the cathode 2, will not exceed a few microamperes. To this there may be added a possible cathode glow discharge current of a few milliamperes. The inductance 13, which is in series with both the main and auxiliary discharge paths, will not, therefore, be traversed by any appreciable current at this time. As the cathode temperature rises under the influence of the heater 5 the thermionic emission therefrom will increase more and more rapidly, according to a well known law. The full-wave current flowing from either end of the secondary 16 to the auxiliary anodes 9 and 10, respectively, then through the gaseous atmosphere of the discharge device 1 to the cathode 2, and thence through inlead 4, and inductance 13 back to the midpoint of said secondary 16, being determined by said emission, varies in a like manner. After an interval of say 15 seconds this current equals an ampere in a device connected as shown and having a normal arc current of 3.5 amperes. The armature of the shifter 15 is thereupon attracted by the inductance 13, causing said shifter to open the circuit therethrough. Not only is the connection between the cathode 2 and the secondary 16 thereby disconnected, but the current carrying circuit through the inductance 13 is interrupted. As the magnetic field about said inductance 13 collapses a high potential surge is generated therein which momentarily so depresses the potential of the cathode 2 that a disruptive discharge occurs from an anode 3 to said cathode 2, due to the abnormally high potential difference therebetween. This discharge is then continued at the normal impressed potential in a well known manner. Current thereupon flows from the autotransformer 11 through one or the other of the anodes 3, the arc space of the discharge device 1, cathode 2, inlead 4 and inductance 13 back to said autotransformer. The inductance 13 thus maintains the shifter 15 in an open circuit position so long as the arc continues to operate. In case the arc is not initiated by the first "kick" of the shifter the circuit is again closed through said shifter 15, energizing said inductance 13 and thus again opening said shifter, with the attendant voltage surge as before, this cycle being automatically repeated until the main discharge has been initiated. While a discharge can be started in these devices, regardless of the polarity of the disruptive discharge, it is obvious that a discharge from either anode to the cathode will be most effective in this unidirectional type of device, since then the initial discharge will be in the same direction as that in which the arc is to be maintained. This

result is ensured with my new circuit, due to the fact that the inductance 13 is energized with direct current, so that the surge therefrom always makes the cathode highly negative. This also has the further advantage that the surge always assists the normally impressed potential, instead of bucking it, as occasionally occurred in the circuits heretofore employed, in which the inductance was energized by alternating current.

In Fig. 2 there is schematically shown a lamp 1' of the full-wave, double ended type. This lamp is identical with that of Fig. 1, except that the anodes 3 are replaced by a thermionic cathode 2' of the same type employed at the opposite end of the lamp, together with a heater 5 therefor. In this case the cathode 2 is connected to one side of a suitable alternating current line through the inductance 13, while the cathode 2' is connected to the other side of said line through a ballast resistance 12. The primary 17 of a transformer is also connected across said alternating current line. Two low voltage secondaries 14 of said transformer are connected to the heaters 5 in an obvious manner, identical with that shown in Fig. 1. Another secondary 16, having an overall voltage of about 45 volts, has the midpoint thereof connected through the shifter 15 to the line side of said inductance 13, while the ends of said secondary are connected to the auxiliary anodes 9 and 10, respectively.

In the use and operation of the device of Fig. 2 upon the application of potential thereto current first flows through the heaters 5, gradually raising the temperature of the cathodes 2 and 2'. As soon as there is appreciable emission from the cathode 2 a half-wave current flows alternately from opposite ends of the secondary 16 to the auxiliary anodes 9 and 10, thence through the discharge space to the cathode 2, where these currents combine to form a full-wave rectified current which flows through the inductance 13 and the shifter 15 back to the mid-point of said secondary. This current increases in value with increase in cathode temperature until it energizes the inductance sufficiently to attract the armature of the shifter 15, opening the circuit through said inductance. The collapsing magnetic field thereupon generates a voltage surge in said inductance which is impressed upon the cathode 2, depressing the potential thereof with respect to the cathode 2', with the result that a disruptive discharge occurs therebetween. This discharge ionizes the gas and permits the continuance of the desired arc discharge between said cathodes (each of which obviously serves alternately as an anode) by the normal applied potential. Thus the discharge is automatically initiated as soon as the cathodes are at the proper temperature. In some cases it may be desirable to make the thermal capacity of the cathode 2' somewhat less than that of the cathode 2, so as to ensure more rapid heating of the cathode 2'.

With either of these arrangements it is obvious that the discharge will be initiated with a minimum delay regardless of ambient temperature. Likewise, if the arc should be interrupted by momentary power failure it is apparent that the shifter 15 will be actuated immediately upon restoration of the line potential, provided the cathode 2 has not unduly cooled in the interval; and that even if it has appreciably cooled the delay will be only that fraction of the normal delay period which is necessary to restore the necessary emission. Furthermore, in case the active substance is partially destroyed, decreasing the emissivity of the cathode, it is obvious that my new apparatus provides proper compensation therefor. In case of breakage of the discharge device, or other accident which seriously impairs the emissivity of the cathode 2, so that it would be impossible to start the main discharge, my device automatically prevents the application of the repeated high voltage surges thereto, thereby saving the auxiliary apparatus the electrical strain to which it would otherwise be subjected.

By the use of two auxiliary anodes, connected with the cathode in a rectifying circuit, as here disclosed, a full wave current is passed through the inductance 13. The impedance of this inductance to such a full-wave current is very low with the result that where neon is used in the device I find it necessary to use only 20–25 volts between either auxiliary anode and the cathode. This potential varies, of course, with the gaseous atmosphere employed, being especially low with mercury, for example. As a result this auxiliary discharge produces virtually no sputtering of the active material of the cathode, and hence not only does not shorten the useful life of the device, but actually increases it. Moreover, with such a low impressed voltage all tendency toward establishment of a hot spot and premature establishment of the auxiliary discharge is avoided. The delay period may moreover be varied to produce the best starting conditions by minor changes in the potential applied, accompanied in some cases by change in the size of the auxiliary anodes or in their relationship to the cathode.

While I have described my invention by reference to discharge devices of particular types and to means for applying an inductive surge thereto to initiate a discharge therein, it is to be understood that it is not limited thereto, since the inductance energized by said full-wave rectifier may obviously be used to energize or control any other starting means, such as a high frequency oscillator. It is also to be understood that various changes, omissions and substitutions, within the scope of the appended claims, may be made therein, without departing from the spirit of my invention.

I claim as my invention:—

1. In combination, an electric gaseous discharge device having a cathode adapted to emit electrons when heated and another main electrode, a heater for said cathode, and two auxiliary anodes adjacent to said cathode, each auxiliary anode being connected to a terminal of a source of alternating current, said cathode being connected to an intermediate point on said source, and means responsive to the resulting full-wave rectified current to said cathode from said auxiliary anodes to initiate a discharge from said other main electrode to said cathode.

2. In combination, an electric gaseous discharge device having a cathode adapted to emit electrons when heated, a heater therefor, another main electrode and two auxiliary anodes adjacent to said cathode, said auxiliary anodes being connected to opposite ends of a low voltage transformer winding while said cathode is connected to the midpoint of said winding through an inductance, and means responsive to current flow through said inductance to create an abnormal voltage distribution within said device to initiate the main discharge in said device.

3. In combination, an electric gaseous discharge device having a cathode adapted to emit electrons when heated, a heater therefor, another main electrode, and two auxiliary anodes adja-

cent to said cathode, said auxiliary anodes being connected to opposite ends of a low voltage transformer winding while said cathode is connected to the midpoint of said winding through an inductance, and means responsive to current flow through said inductance to open the circuit between said inductance and said winding.

4. The method of starting and operating an electric gaseous discharge device which consists in applying the normal operating potential to the main electrodes of said device, applying potential of lower value to auxiliary anodes in operative relation to one of said electrodes as a cathode to initiate a rectifying discharge to said cathode, heating said cathode to increase the current in said rectifying discharge, and availing of the increased current to alter the voltage distribution in said device to initiate the discharge between the main electrodes.

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