

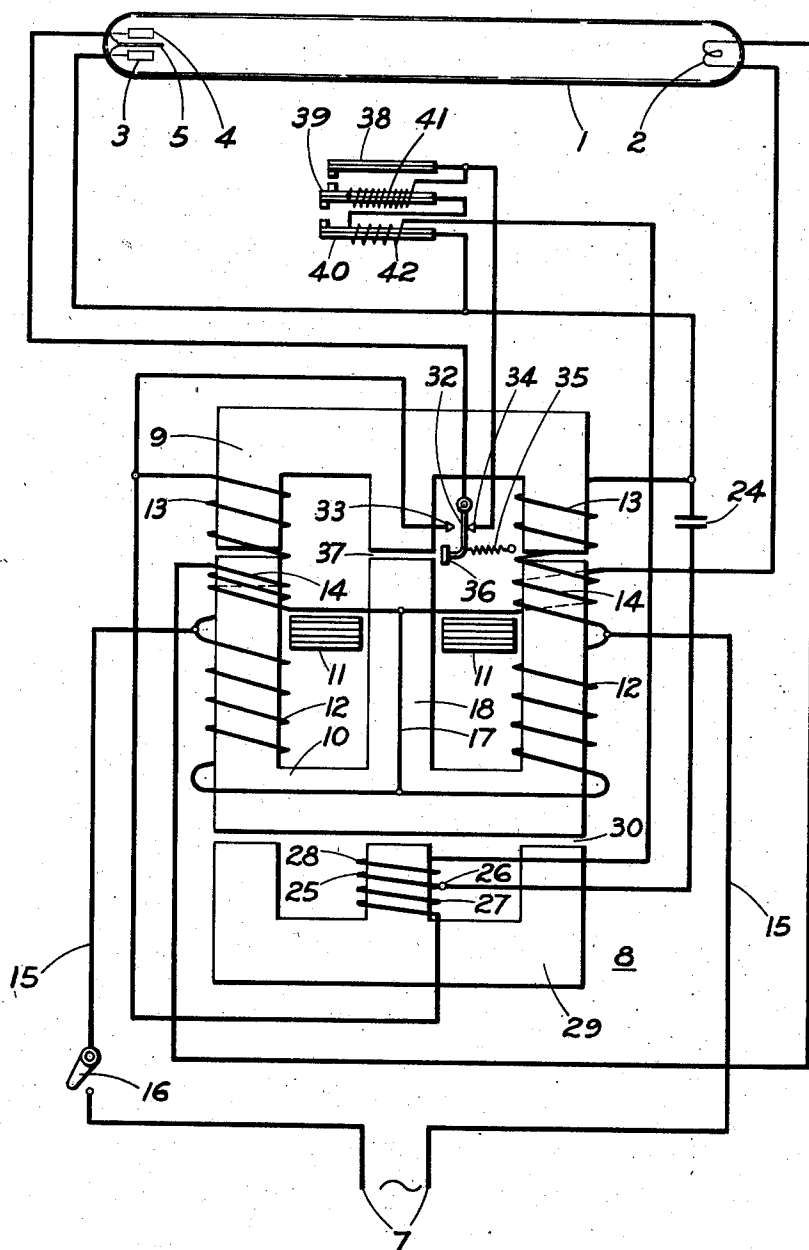
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ELECTRIC DISCHARGE APPARATUS

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ELECTRIC DISCHARGE APPARATUS

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4 Claims. (Cl. 176—124)

The present invention relates to electric gaseous discharge devices generally and in particular to devices having starting means of the resonance type.

5 A particular object of the invention is to provide a novel means for throwing a resonance or semi-resonance starting circuit out of resonance if the gaseous discharge does not start within a predetermined time after said starting circuit has been energized. A further object of the invention is to minimize the energy consumed by such a device while the circuit is thus deresonated by my novel means. Another object of my invention is to prevent recurrent opening and closing of switches connected with the starting circuit when the discharge device is inoperative for any reason. Still other objects and advantages of my invention will appear from the following detailed specification, or from an inspection of the accompanying drawing.

10 The invention consists in the new and novel combination of elements hereinafter set forth and claimed.

15 An extremely desirable and effective starting and operating circuit for gaseous electric discharge devices of the full-wave rectifying type has recently been devised by Harold W. Lord. This circuit, which is disclosed in his pending application, Serial No. 197,357, filed March 22, 1938, provides means of the semi-resonance type to raise one of the anodes to a much higher potential than the other anode above the cathode potential, whereby the discharge is initiated between the first of these anodes and the cathode. The difference in anode potentials which is thus produced results in a cross-current discharge between these anodes which is availed of, where a time delay is desired to permit heating up of the cathode, to operate a time delay mechanism of the thermostatic type. Switching means operated by the main rectified discharge current is ordinarily provided to disconnect this high voltage from the one anode as soon as the discharge to the cathode is started. In some cases, as where the lead to the cathode becomes accidentally disconnected, or where the cathode has become deactivated, so that the discharge to the cathode cannot start, this switching means obviously does not function, and hence the high voltage discharge between the anodes continues so long as the lamp circuit is energized. These cross currents produce undesired voltage surges every half cycle, as the current reverses. Also, since partial resonance exists during this starting period the current drawn from the line is

materially greater than that required during normal operation of the lamp, and the heating of the various elements of the circuit is thus relatively high, so that some means of reducing the wattage input to the device if the main discharge does not start within a reasonable time is eminently desirable. Where a time delay device, such as a resistance which is adapted to be short circuited by a thermostat, is included in the anode discharge circuit in order to keep the cross-current discharge between the anodes down to a very small value, and at the same time to reduce the anode potential to a value insufficient to initiate the main discharge until the cathode has had an opportunity to reach a desired electron emitting temperature, failure of the main discharge to start at the desired time upon short circuiting of this resistance results in the recurrent opening and closing of the thermostatic shunt in the anode discharge circuit. The repeated interruption of this shunt circuit produces unnecessary wear and tear on the contacts of the delay mechanism, and also produces undesired voltage surges. Hence under these circumstances it is desirable to provide means to lock out the delay mechanism in case the main discharge does not start within a reasonable time.

20 I have discovered that all of these desired results are produced by the use of an additional delay mechanism which completes a circuit adapted to deresonate the means by which the high potential for the one anode is created, this new circuit preferably providing its own holding circuit, whereby when once closed it will not reopen without manual intervention. Where a time delay mechanism is provided for the protection of the cathode this novel circuit also preferably short circuits or otherwise locks out this delay mechanism to prevent repeated useless operations thereof, and the timing of the two delay means is also preferably so coordinated that the circuit is deresonated, in case the main discharge is not earlier initiated, prior to the reopening of the shunt in the anode circuit after the first closing thereof. Due to this novel means for throwing the circuit out of its semi-resonance condition, the total impedance of the lamp circuit is materially increased, and the line current is correspondingly decreased, with a resultant decrease in the heating of the various components of the circuit. Furthermore the wear and tear which would otherwise result from useless intermittent openings of the cross-current circuit is entirely eliminated.

For the purpose of illustrating my invention,

I have shown a schematic diagram of a preferred embodiment thereof in the accompanying drawing.

As shown in this drawing the electric gaseous discharge device or lamp 1 comprises a tubular sealed envelope having an activated thermionic cathode 2 at one end thereof and two similar anodes 3 and 4, of carbon or the like, the latter being preferably separated by a baffle 5. The lamp which has thus been schematically shown is conveniently of the type disclosed in my co-pending application, Serial No. 149,707, filed June 22, 1937, wherein the lamp contains mercury vapor and a starting gas, such as argon, and wherein the lamp envelope is coated with a fluorescent material.

Before starting, such a lamp has a high resistance and ordinarily requires a voltage considerably higher than that of the circuit from which it is supplied to start a discharge therein. Thus a lamp that will operate with a drop of the order of 100 volts in the arc may require as much as 450 volts between the cathode and an anode to ionize the gas and initiate the arc discharge. The auxiliary apparatus shown is especially designed to give this starting voltage and to ballast the discharge in an extremely efficient manner. The circuit shown is essentially that disclosed by Lord in his co-pending application, referred to hereinbefore, with the addition of a second delay element whose action is coordinated with the action of the original delay element in a novel manner.

In this circuit the lamp 1 is supplied from the source 7 of single phase alternating current which for example may be a 60 cycle, 110 volt lighting circuit, through the unitary structure represented at 8 and comprising a combined high reactance transformer and smoothing reactor. The core of the structure comprises two E-shaped members 9 and 10 reversely arranged with respect to each other and with corresponding legs spaced from each other to form magnetic gaps. In the drawing these gaps are shown for simplicity as air gaps but as the apparatus is manufactured they comprise a suitable non-magnetic material against which the two members are clamped. Between the legs of the member 10 are magnetic shunts shown at 11 thereby increasing the flux leakage to provide a higher leakage reactance.

On each of the outer legs of the core structure is a primary winding consisting of the coil 12, a main secondary winding consisting of the coil 13 plus the coil 12 thereby constituting an auto transformer and a separate auxiliary secondary winding comprising the coils 14. The ends of the primary, thus composed of the two coils 12, are connected by the leads 15 and switch 16 with the opposite sides of the source 7. The opposite ends of the main secondary, composed of the two coils 12 and the two coils 13, connect with the two anodes 3 and 4, one directly and the other through a relay which will be described hereinafter, and the mid-point thereof connects with the cathode 2. The latter connection includes the conductor 17 and the auxiliary secondary, made up of the two coils 14, the purpose of which is to supply heating current to the lamp cathode.

As shown by the drawing the magnetic shunts 11 are arranged adjacent the upper ends of the primary coils and extend between the outer legs of the core structure and the middle leg 18 thereof, said shunts being spaced from those legs by magnetic gaps which preferably comprise a suitable non-magnetic material. It will be seen that by

this arrangement the amount of leakage of the primary flux is greatly increased since the shunts provide a relatively low reluctance leakage path, with the result that the leakage reactance between the primary and the secondary is accordingly increased. The middle leg 18 also provided a return path for the unidirectional component of the flux in each of the two outer legs during the operation of the lamp, such a component being present by reason of the fact that since the lamp acts as a full wave rectifier the secondary current is uni-directional. By reason of the middle leg, moreover, an exceptionally high reactance is obtained between the two halves or coils of the secondary winding because of the magnetic shunt effect thereof, whereby they are virtually isolated from each other.

A capacitor 24, which is used among other purposes to improve the power factor of the unit, is connected across the secondary of the transformer in series with a suitable reactance which not only prevents undesired harmonics but also avoids an undesired decrease in the angle of commutation. In the arrangement shown, which is identical with that of the aforementioned Lord application, this inductance is furnished by the reactor or choke coil 25 which has the intermediate tap 26 dividing it into the two parts 27 and 28, whereby it can function as an autotransformer. The portion 27 is connected in series with the capacitor 24 across the secondary of the main transformer. The relative amounts of capacitive inductance in the closed circuit including these members and the leakage reactance between the primary 12 and secondary 12 and 13 of the transformer is such that a condition of partial resonance is produced therein, with the natural resonance frequency of this circuit preferably slightly higher than the frequency of the supply circuit, as in the ratio of 65 to 60 cycles, for example. This semi-resonance condition results, of course, in a relatively large voltage drop across the coil 27, and in the production of a still higher voltage, by transformer action, across the entire coil 25, and also in an increased potential across the secondary of the main transformer.

The reactor 25 may have any desired core provided it is not the same as the transformer core. It may, however, be of a form that constitutes an incomplete magnetic circuit in itself but, for purposes of economy, may be arranged adjacent to a part of the transformer core which part thereby serves to complete its magnetic circuit. Such a core construction is shown by the E-shaped member 29 separated from the transformer core by magnetic gaps 30.

Inasmuch as the voltage applied between the cathode and either anode, namely the voltage of one half of the secondary, even when augmented by the semi-resonant condition described, is insufficient to initiate a discharge in the lamp, a special starting means is provided, wherein at starting the anode 4 is connected to the extended winding 28 of the coil 25, whereby a high potential difference, sufficient to initiate the discharge, is produced between the anode 4 and cathode 2. This starting connection is provided by an electro-magnetic switch 32 which is normally biased against the contact 34 by the spring 35. This switch is adapted to be moved away from the starting contact 34 and into engagement with the running contact 33 by the armature 36 attached thereto in response to a predetermined value of the uni-directional flux passing the air gap 37 in the middle leg of the transformer core, this run-

ning contact 33 being directly connected to the opposite end of the transformer secondary from that connected to the anode 3.

Included in the circuit between the contact 34 and the coil 28 is a novel time delay mechanism comprising three bimetallic blades 38, 39 and 40, so arranged as to permit electrical contact between the free ends of adjacent pairs, and the heating coils 41 and 42. The heater 41 is wound on or otherwise suitably associated with the blade 39, while the heater 42 is similarly associated with the blade 40. Heater 41 is of relatively high resistance, of the order of 9000 ohms, while heater 42 is of relatively low resistance, of the order of 30 ohms. These elements are so connected that the heaters 41 and 42 are in series in the circuit from the contact 34 to the coil 28, with the heater 41 nearer said contact 34. One end of the heater 41 is connected to the blade 38 and the other end thereof is connected to the blade 39, whereby this heater is short circuited by contact between the blades 38 and 39. It may be noted that the blade 38 is merely used to compensate for changes in ambient temperature, and may be replaced by a fixed contact where such compensation is not required. The end of the coil 42 which is more remote from the coil 28 is also connected to the blade 39, while the blade 40 is connected directly to the same end of the transformer secondary which is connected to the anode 3. Thus upon establishment of a contact between blades 39 and 40 a by-pass including the coil 28 and heater 42 is established across the condenser 24 which de-resonates the starting circuit, and at the same time provides sufficient current in heater 42 to keep the blades 39 and 40 in contact.

When the switch 16 is first closed to energize the lamp and the controlling apparatus therefor, a discharge does not immediately start, due to the inclusion of the high resistance of the heater 41 in the circuit to the anode 4. Heating of the cathode 2 by the secondary 14, however, is immediately started. During the interval while the cathode is heating up to the desired temperature cross currents pass between the anodes as a result of the high voltage existing therebetween. These cross currents flow through the heater 41, which limits them to a small value, of the order of 20 milliamperes, and the heater 42 in series. The heat produced by this small current flowing through the low resistance heater 42 is negligible, and hence the blade 40 is substantially unaffected thereby but this same current flowing through the high resistance heater 41 produces enough heat to cause the associated blade 39 to move upwardly into contact with the blade 38, after a predetermined time interval of the order of 5 seconds has elapsed, this interval being made equal to that required to heat the cathode to the desired starting temperature. The heater 41 is thereupon short circuited, whereby the high resistance which has prevented the starting of the main discharge is removed, and the high voltage existing between the cathode and the anode 4 starts the main rectified discharge, provided the cathode is in operative condition. This discharge thereupon causes a uni-directional flux to pass through the gap 37, attracting the armature 36, and thus moving the switch 32 against the running contact 33, whereby the anode 4 is connected to the free end of the transformer secondary. Under this normal operation the switch 32 opens the circuit through the heater 42 before it has functioned.

In case the discharge does not start imme-

diately, however, it is evident that after a definite time interval, determined by the thermal lag of the blade 39 and heater 41, the blade 39 will move away from the blade 38, reinserting the heater 41 in the circuit, tending to cause a recurrence of this cycle of operation. This action of the blade 39 is undesirable, since once the heater 41 has been short circuited the cross currents increase to the order of .9 ampere, and the opening of this circuit by the thermostatic blade 39 is not only destructive of the contacts but also tends to produce undesired voltage surges in the inductive circuits. This action is, however, eliminated with my novel circuit, since the increased cross currents, of the order of .9 ampere, flow through the heater 42 and provide sufficient heat to move the blade 40 toward the blade 39, actual contact being made, in case the main discharge is not earlier initiated, before the blade 39 has cooled sufficiently to open the shunt across the heater 41. When the blades 39 and 40 are thus in contact the anodes 3 and 4 are short circuited and a circuit is created from the end of the winding 28 through the heater 42, blade 39 and blade 40 to the end of the transformer secondary of opposite polarity. This connection throws the circuit entirely out of resonance, thus reducing not only the voltage applied to the lamp 1 but also materially decreasing the wattage drawn from the energy source 11 to a value of the order of one third of that drawn initially, with a corresponding reduction in the heating of the various coils. A current of the order of 0.4 ampere still flows through the heater 42, however, which is sufficient to keep the blades 39 and 40 in contact, especially as the blade 39 cools and moves toward the blade 40. Since the anodes 3 and 4 were short circuited by the simultaneous contact of the blades 38, 39 and 40 the cross currents were eliminated, and hence the later opening of the contact between the blades 39 and 40 does not open a current carrying circuit and hence is of no effect and unobjectionable. This setting of the various elements of the circuit then continues until the switch 16 is manually opened and the tube 1 replaced, or the cause of the difficulty otherwise eliminated.

While so far I have discussed only the case of a lamp having cathodes of the type requiring pre-heating, it is to be understood that my invention is also applicable to devices using other types of thermionic cathode. Thus where no time delay is required to protect the cathode, the heater 41 may be permanently short circuited, or as an alternative the thermostatic blade 39 and its associated heater 41 may obviously be eliminated from the circuit, in which case the blade 40 would make contact with the blade 38 after a predetermined time if the discharge in the tube 1 had not started in that interval, whereupon the unit would be thrown out of resonance, and the wattage input and heating likewise reduced, as before. Hence my novel arrangement is eminently desirable, regardless of the type of cathode employed. When such a cathode only requires a single inlead it would of course be connected directly to the center tap of the windings 12.

Likewise, while I have shown the delay mechanisms as being of the thermostatic type it is to be understood that various other types of time delay mechanism can be substituted therefor without invention. It is also to be understood that various other changes, omissions and substitutions, within the scope of the appended claims, may also be made in the structure illus-

trated without departing from the spirit of my invention.

I claim as my invention:

5 1. In combination, an electric gaseous discharge device having at least two electrodes, a circuit connected with said device to create a high voltage between said electrodes by series resonance at a commercial frequency, switching means operative only after the elapse of a given time interval after energization of said circuit to deresonate said circuit at said frequency, and means responsive to the discharge current through said device to render said switching means inoperative upon initiation of a discharge between
10 15 said electrodes.

2. In combination, an electric gaseous discharge device having a cathode and a pair of anodes, a transformer having its ends connected to said anodes and a midpoint connected to said cathode, the connection between one end of said transformer and its associated anode including means responsive to a commercial frequency to produce a high voltage by resonance which increases the potential difference between that
20 25 anode and the cathode, switching means operative only after the elapse of a predetermined interval after energization of said transformer to deresonate said first mentioned means, and means responsive to the discharge current through said device to render said switching means inoperative upon initiation of a discharge between said cathode and anodes.

3. In combination, an electric gaseous discharge device having a cathode and a pair of
30 35 anodes, a transformer having its ends connected to said anodes and a midpoint connected to said cathode, the connection between one end of said transformer and its associated anode including means responsive to a commercial frequency to

produce a high voltage by resonance which increases the potential difference between that anode and the cathode, switching means responsive to the flow of cross currents between said anodes to deresonate said first mentioned means after flow thereof for a predetermined time interval, and means responsive to the discharge current through said device to render said switching means inoperative upon initiation of a discharge between said cathode and anodes.

4. In combination, an electric gaseous discharge device having a cathode and a pair of anodes, a transformer having its ends connected to said anodes and a midpoint connected to said cathode, the connection between one end of said transformer and its associated anode including means responsive to a commercial frequency to produce a high voltage by resonance which increases the potential difference between that anode and the cathode and between said anodes, whereby cross currents are caused to flow between said anodes, a high resistance in the circuit traversed by said cross currents, thermostatic means responsive to the heat produced by the flow of said cross currents through said high resistance to short circuit said resistance after a predetermined time interval, switching means responsive to the flow of said cross currents thereafter to short circuit said anodes and to deresonate said voltage producing means at a predetermined time after said thermostatic means has functioned and before said thermostatic means opens the short circuit across said resistance, and means responsive to the flow of the main discharge current through said device to render said switching means inoperative upon initiation of a discharge between said cathode and anodes.

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