

Oct. 19, 1948.

D. D. HINMAN

2,451,830

STARTING ARRANGEMENT FOR ELECTRIC DISCHARGE DEVICES

Filed Nov. 21, 1944

FIG. 1.

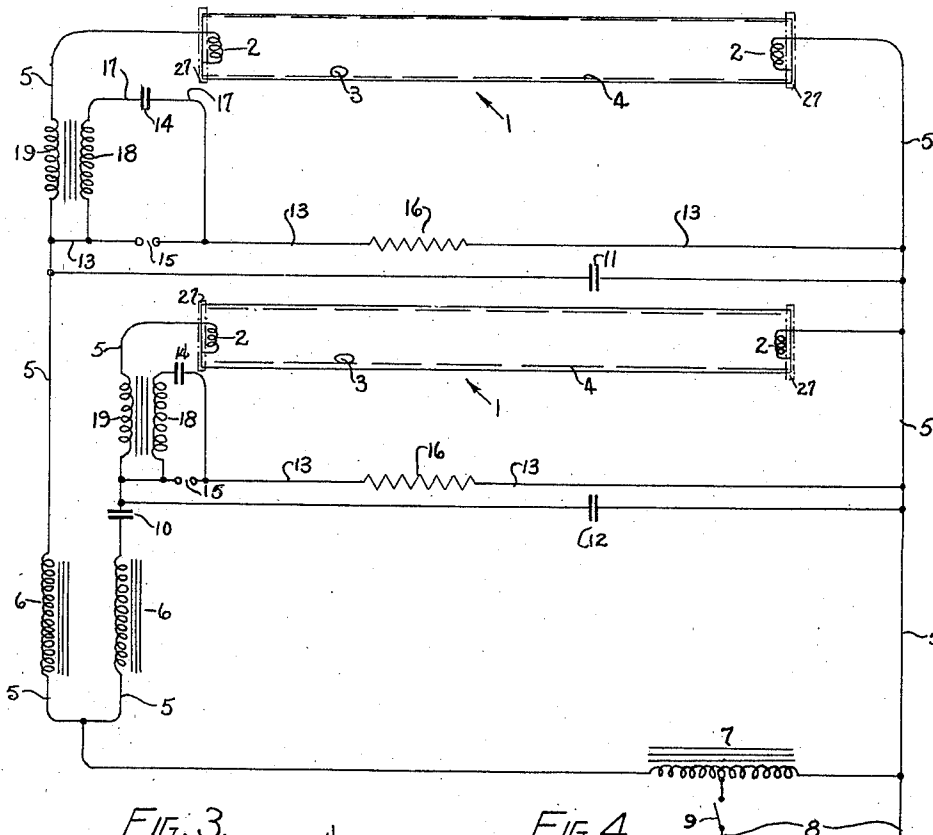


FIG. 3.

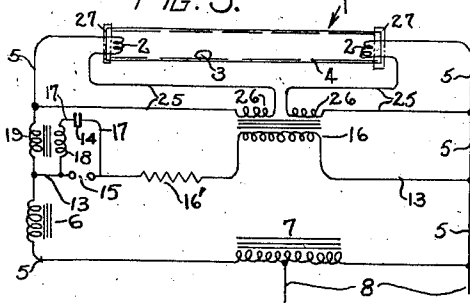


FIG. 4.

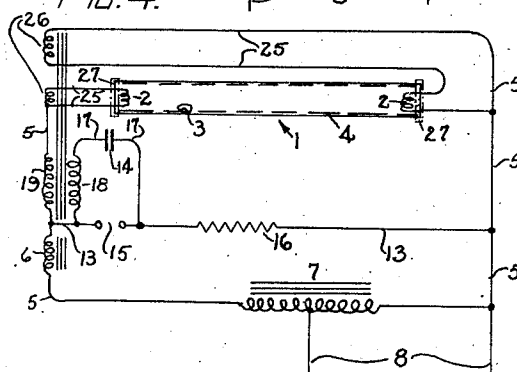
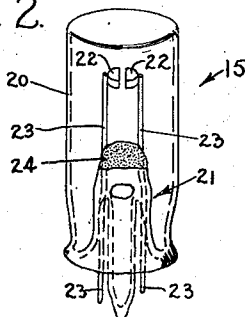


FIG. 2.



INVENTOR:
DONALD D. HINMAN
By *John H. Anderson*
HIS ATTORNEY

UNITED STATES PATENT OFFICE

2,451,830

STARTING ARRANGEMENT FOR ELECTRIC DISCHARGE DEVICES

Donald D. Hinman, Cleveland Heights, Ohio, assignor to General Electric Company, a corporation of New York

Application November 21, 1944, Serial No. 564,479

7 Claims. (Cl. 315-96)

1

This invention relates to the starting control of electric discharge devices, and is very useful for fluorescent tubes of positive column discharge type, as well as for various other discharge devices. The invention is especially adaptable for starting discharge devices quickly, without the delay usually entailed by preheating their cathodes.

As is well known, the voltage required to start a discharge through an ionizable atmosphere (gas or vapor, or both) is considerably higher than that required to maintain it after it has started. Even this operating voltage is often different from ordinary lighting supply circuit voltages, so that a transformer is generally interposed between the supply circuit and the discharge circuits of an installation, to give the required voltage. In any case, current-limiting chokes or ballasts are commonly interposed in the discharge circuits. Such ballasts usually have inductance, and may also include capacitance. Very commonly, the ballast is structurally built into the transformer. In the case of D. C. discharges, means other than transformers are employed to give the desired voltage, but resistive or reactive ballasts are still used to control the discharge current.

Most fluorescent lamps of positive column low pressure discharge type are at present "hot-starting," with flow of heating current through their cathodes to preheat them before discharge is initiated. For this purpose, a starting circuit with an automatic switch therein is connected across the discharge circuit, in parallel with the discharge gap of the lamp and through heating means embodied in the cathodes. The automatic switch passes current through the cathode-heating means long enough to bring the cathode(s) of a lamp up to an adequate emissive temperature, and then suddenly opens the starting circuit, giving rise to a high voltage "kick" between the electrodes (due to the inductance in the discharge circuit, and much higher than the operating voltage of that circuit) which generally suffices to initiate the discharge.

The time required to preheat the cathodes to the operating temperature of adequate thermionic emission is appreciable, so that at best an undesirable brief interval elapses between the closing of the wall switch or other manual switch controlling an installation and the actual lighting up of the lamps. Moreover, the action of starters in common use is often irregular, so that the lapse of time between closing the control switch and lighting up all the lamps may often amount to a quarter of a minute, more or less. These drawbacks have heretofore been unavoid-

2

able in practice, because starting of lamps "cold," without cathode preheat, resulted in rapid disintegration of the cathodes and blackening of the lamps.

5 Recently, cathodes have been evolved which stand cold starting so much better that it would seem feasible to do away with hot starting and with starting switches, so that fluorescent lamps would light instantly (or practically so) when the controlling switch is closed, just like incandescent lamps. For this purpose, a leakage-reactance transformer may be used between the lighting supply circuit and the discharge circuits, to give high open-circuit voltage for initiating discharge, 10 followed by suitably lower voltage for ordinary operation.

While this arrangement is generally successful, it has the disadvantage of requiring larger and more expensive transformers than those now in use for hot-starting installations, in order to assure starting with certainty under unfavorable atmospheric conditions of very high humidity. For example, 40-watt fluorescent lamps of tubular, low-pressure, positive column type may require 20 as high as 800 volts or more to insure starting under the most adverse conditions, as against a voltage of some 110 volts (more or less) in subsequent operation. The size and cost of the auxiliaries for such voltages would be well-nigh prohibitive. 30

I have devised starting arrangements which afford ample voltage to assure starting under the most adverse conditions, without necessity for large or expensive auxiliaries, and without the irregularity of starting that is almost characteristic of certain much-used types of starting switches. This I accomplish by induced high voltage generated and applied in a novel way, which is applicable to discharge lamps operating on D. C., as well as to A. C. systems. For generating and applying the high voltage, I employ a capacitor or condenser, an electric valve (e. g., a thyatron, spark-gap, or other auxiliary discharge device), and an inductive coupling to a circuit connected to the main discharge electrodes. My invention allows of preheating the cathodes, if desired, without entailing long or irregular delays in starting, as well as of virtually instantaneous cold starting without preheat. Various other features and advantages of the invention will appear from the description of a species or form of embodiment, and from the drawings.

In the drawings,

Fig. 1 is a circuit diagram showing starting and operating arrangements for discharge lamp(s) 55

operating on A. C.; and Fig. 2 is a tilted view of one form of spark-gap device that is suitable and convenient for use in the starting circuits illustrated in Fig. 1.

Figs. 3 and 4 illustrate modifications of the Fig. 1 type of circuit to provide for cathode preheat.

Figs. 1 and 2 illustrate the application of the invention to a discharge device 1 such as the low pressure positive column fluorescent lamp exemplified in U. S. Patents No. 2,294,203 to Peters, 2,330,161 to Townsend, and 2,306,925 to Aicher, heretofore ordinarily started "hot" after a period of cathode preheat. As shown in Fig. 1, the tubular radiation-transmitting envelope of the device 1 has spaced-apart activated thermionic cathodes 2, 2 in its ends. These electrodes 2, 2 may be of the usual coiled or coiled-coil tungsten filament type, coated or charged with activating oxides such as a mixture including barium and strontium oxides. The envelope may contain a low-pressure atmosphere of ionizable starting gas, such as argon at a pressure of 2 to 4 mm. of mercury, or other inert rare gas(es) at a corresponding pressure, and also a vaporizable and ionizable working substance or metal such as mercury, of which a surplus supply (exceeding what will vaporize during operation of the device) is indicated by a mercury droplet 3 inside the envelope. An internal coating of fluorescent material or phosphor 4 on the envelope walls is also indicated.

The discharge device is shown connected across a discharge circuit 5 including the inductive ballast 6. For energizing it, the discharge circuit 5 is shown connected across the secondary of an autotransformer 7 whose primary is connected across a voltage source such as an ordinary 60 cycle A. C. lighting circuit 8 of some 110 to 120 volts, for example. The usual make-and-break wall or other control switch 9 is shown in the circuit 8. To illustrate usual conditions of operation, two similar discharge devices 1, 1 are shown connected across the transformer secondary in parallel lead and lag circuits 5, 5. As usual, the lead circuit 5 includes a condenser 10, which besides other functions also serves as ballast to limit the discharge current. Condensers 11 and 12 are shown connected across the lag and lead circuits 5, 5 to prevent radio interference, as well understood in the art. I find that the lag circuit condenser 11 also facilitates starting, though it is not essential for this purpose. The transformer 7 is of course chosen to give or assure the desired voltage across each of the discharge circuits 5, 5. Once the discharge has started, the voltage across each device 1 is regulated or reduced by its ballast 6 to a favorable value for the operation of the device 1, which may be the closed circuit voltage on which the device would be operated in present hot-starting practice.

For the purposes of my invention, a starting circuit 13 is shown connected across the discharge circuit 5 of each of the discharge devices 1, 1. Each circuit 13 is provided with means for generating high voltage oscillations and applying them across the discharge gap between the electrodes 2, 2 of the corresponding device 1, such means comprising a capacitor or condenser 14 and an auxiliary electric discharge device 15 in shunt with one another in said circuit 13, with an inductive coupling between one side of the shunt and one side of the discharge circuit 5 to the device 1, and, as shown, an impedance 16 in series with the shunt-connected condenser and auxiliary discharge device or spark-gap. In other

words, the circuit 13 here shown includes a loop circuit 17 in which the condenser 14 and spark-gap 15 are connected in parallel, so as to be in series with the rest of circuit 13 including impedance 16; and this loop 17 also includes a primary 18 in inductive relation to a secondary 19 in the circuit 5, in series with the discharge device 1. Specifically, the inductive primary 18 is shown connected to the circuit 13 between the spark-gap 15 and the connection of said circuit 13 to the discharge circuit 5; and the secondary 19 is interposed in said circuit 5 between said connection of circuit 13 to circuit 5 and the discharge device 1, in series with the latter. It makes no difference whether the impedance 16 is connected in said circuit 13 at one side of the parallel-connected condenser 14 and spark-gap 15 or at the other side thereof. Nor is it very important which of the direct connections between condenser 14 and spark-gap 15 includes the primary 18, or which end of this primary is connected to the condenser, and which to the spark-gap.

The discharge device(s) or spark-gap(s) 15 should have a break-down voltage less than the open-circuit voltage across the secondary of transformer 7, and, therefore, less than the break-down voltage of any device 1 which the transformer cannot start unaided. The device 15 should preferably show a large difference between break-down and maintaining voltages; but the maintaining voltage should preferably be higher than the voltage on said device 15 during ordinary operation of the discharge device(s) 1, so as to assure cessation of the discharge in device 15 during the ordinary operation of said discharge device(s) 1, as hereinafter explained. One suitable device 15 is of moderately low-pressure gaseous discharge type, resembling a glow-lamp in general construction, but showing opposite characteristics: i. e., an unstable glow-discharge which is sustained largely by field emission and tends to hot-spot. Such a device 14 is illustrated in Fig. 2 as comprising a sealed vitreous envelope 20 containing a flare and stem press type of mount 21, with a pair of flat electrodes 22, 22 (resembling halves of a circular disc) suitably spaced apart, and carried by inward-extending leadwires 23, 23 sealed through the press. These electrodes 22, 22 may have a thickness of about $\frac{1}{16}$ inch and a semicircle diameter of about $\frac{1}{8}$ inch. They may consist, for example, of an emissive nickel-tungsten composition activated with barium, which may be mainly in the form of barium oxide, BaO. They may be prepared from a batch mixture of finely divided ingredients comprising by weight:

	Parts
W (325 mesh grains) -----	80
NiO -----	10
BaCO ₃ -----	10

This mixture is pressed into the desired shapes in a pill machine, and these are fired for 20 to 30 minutes at 1453° to 1510° C. in hydrogen to render them coherent. In accordance with U. S. Patent 2,332,809 to Peters, the inner end of the stem press 21 is painted with aluminum paint 24 in contact with both leads 23, 23, to obviate "dark effect" alterations of break-down voltage of the device.

A mode of operation of the system shown in Fig. 1 is that when the switch 9 is closed to turn on the lamps 1, 1, A. C. voltage is applied in each discharge circuit 5 and in each starting circuit 13, charging the corresponding condenser 14 through the corresponding resistance 16, and also tending to "break down" the corresponding discharge de-

vice or spark-gap 15. When the device 15 breaks down or becomes conducting, the condenser 14 discharges through it, producing in the "oscillating" loop circuit 17 and in the primary 18 a current surge or surges, or a series of high frequency electrical oscillations. Such break-down may occur once or several times during each 60 cycle or other A. C. wave in the circuits 8, 5. The rapidly changing current in primary 18 induces in secondary 19 a high voltage which appears across the discharge gap in the discharge device or lamp 1; and since there is no return path or shunt for this high voltage in 19 except the path through the device 1, its full effect is felt in the device 1. When such a voltage impulse coincides with a corresponding impulse due to the A. C. supply in circuit 8, or occurs in such phase relation thereto that the algebraic sum of the voltages suffices to break down or render conductive the discharge atmosphere in the device 1—which happens in a fraction of a second after switch 9 is closed—discharge in the device 1 is successfully initiated. Moreover, the high frequency from 19 after a glow discharge has started in the device 1 helps to change this over into a positive column or arc discharge.

When the discharge starts, the resistance of the device 1 falls off to a minor fraction of its value before breakdown (which is of the order of megohms), and the voltage across the spark-gap 15 (as limited by the impedances 7, 6, 16, 14, 18 when current is flowing through them) decreases so much that the device 15 drops out and ceases to carry current. During ordinary operation, therefore, current flow in the circuit 13 is limited by the impedances 16, 14, 18 to a trifling value which may be no more than a couple of milliamperes, representing an energy loss that is inappreciable.

Because of the high frequency of the electrical oscillations produced as above described in the primary 18, the number of turns that are needed in the secondary 19 to produce the desired starting voltage is far less than it would be for ordinary commercial frequencies of 60, 50, or 25 cycles, so that this secondary and the inductive device or transformer embodying it may be relatively small in size and weight. For oscillations of sufficiently high frequency, the transformer 18, 19 may be of air-core type, offering only negligible impedance to the current due to the 60 cycle or other A. C. in circuit 8. In this case, the primary and secondary circuits may or may not be tuned or adjusted to the same resonant frequency. If the transformer 18, 19 has an iron core, its corresponding impedance may or may not be negligible; and in the latter case it becomes part of the operating ballast for the discharge device 1. However, an iron core makes for smaller dimensions, with less copper, and lower secondary resistance.

For the convenience of persons wishing to practice my invention, I will now give specific details of design for a system such as shown in Fig. 1; but these are to be understood as illustrative, and not as limiting or defining the invention. For starting and operating 40-watt fluorescent lamps of the present T-12, 48 inch tubular, positive column, low-pressure type, the open-circuit voltage produced by the transformer 8 across the discharge circuit(s) 5 may be 300 volts, which may obviate the underwriter's requirement of special lampholders and wiring with present standard auxiliaries that give an open-circuit voltage of some 450 volts. The condenser 10 may be of 2.1 microfarad capacity, and the condensers 11 and

12 of 0.03 microfarad each. The condensers 14 may be of 0.05 microfarad each, and the resistances 16 of 20,000 ohms each. The transformer(s) 18, 19 may be of auto type, or may have separate primary and secondary windings. In general, their design is not at all critical. One satisfactory autotransformer consists of 218 turns of #26 enameled copper wire having a 1½ inch square air core and provided with a primary tap at the fifth turn. In the case of an iron core, the iron should preferably have high permeability and show low hysteresis loss at high frequencies. One satisfactory transformer of this character has separate primary and secondary windings, the secondary consisting of 650 turns of #26 enameled copper wire wound on and next to a ¼ inch square core 1¾ inches long consisting of 4-mil thick lamina of transformer iron, and the primary consisting of 20 turns of the same wire wound over the secondary. The particular iron used in this core is that known commercially as "DX8," though any good transformer iron of the character above indicated is suitable. To minimize capacitance effects in such a transformer(s) 18, 19, the end of the secondary winding(s) 19 next the core should be connected to the device 1, and the other end to the ballast 6 through the condenser 10.

For use with a 40-watt fluorescent lamp starting system embodying the particulars above set forth, the gap between the electrodes 22, 22 may be about 15 to 20 mils, and the gas filling in the envelope 20 may be argon at a pressure of about 100 to 200 mm. Thus constructed, the device 14 shows a break-down voltage of about 250 volts R. M. S., and the voltage across it becomes negative during part of each cycle of the discharge voltage in the circuits 8, 5.

Fig. 3 illustrates a modification of the system shown in Fig. 1 to provide for preheat of the cathodes 2, 2 at starting. In this figure, only a single discharge circuit 5 is shown, and the condenser 10 which differentiates lead and lag circuits is omitted, as well as the condensers 11, 12. For preheating purposes, the connection of each side of the discharge circuit 5 to one end of a cathode 2 is supplemented with an auxiliary circuit connection 25 from the other end of said cathode 2 back to the same side of the circuit 5, between said cathode and the secondary 19. In each circuit 25 is included a secondary 26 in inductive relation to a primary that is traversed by current flowing in the circuit 5, this primary being as shown a current-limiting impedance 16 of inductance type in the starting circuit 13. For each electrode 2, therefore, there is a heating loop circuit which may be traced as including part of circuit 25, secondary 26, the rest of circuit 25, and the part of circuit 5 extending from circuit 25 back to said electrode 2, and which is energized from circuits 5 and 13. In practice the coils 16 and 26, 26 may conveniently be embodied in a single transformer with double secondaries. In any case, there should be only a low capacitance between the secondary 26 that is connected to the side of circuit 5 which includes the secondary 19 and the inductively associated parts constituting the rest of the transformer 16, 26, 26. If for any reason it is not desired to give the primary 16 as much impedance as is wanted in the circuit 13, additional impedance 16' may be included in said circuit 13.

In the operation of this system, each cathode 2 is preheated by the current flow in its heating loop from the moment when switch 9 is closed

until the discharge is successfully started in the device 1. While this may often be too short a time to bring this cathode 2 up to full operating temperature and emission, experience has shown that even a relatively small amount of preheat greatly reduced deterioration of a cathode in starting. When the discharge in the device 1 has been started and the device 15 has dropped out, the current flow in the circuit 13 and in the heating loops of the cathodes 2, 2 is reduced to an insignificant value, so that during ordinary operation the energy consumption in these loops is trifling.

Besides and because of giving cathode preheat, this system allows of employing the same transformers 8 and ballasts 6 that are now in use in present preheating systems, which give an open circuit voltage of the order of 200 to 220 volts across the secondary of a transformer 7, instead of requiring a special transformer 7 with a secondary voltage of some 300 volts on open circuit, as is the case with the Fig. 1 system.

The modification illustrated in Fig. 4 differs from Fig. 3 in that the secondaries 26, 26 in the preheating loops for the cathodes 2, 2 are inductively associated with the primary 18 of the inductive coupling 18, 19, instead of with the current-limiting impedance 16. Practically, the primary 18 and the secondaries 19, 26, 26 may all be embodied in a single triple-secondary transformer. In this case, the current-limiting impedance 16 may preferably have a lower value than is preferred in Fig. 1, such as some 10,000 ohms, for example.

In Figs. 3 and 4, various parts and features are marked with the same reference characters as those corresponding in earlier figures, in order to dispense with repetitive description.

In D. C. systems involving my invention, the means for providing the desired voltage across the discharge circuit will of course be different from the transformer 7 here illustrated; the lead and lag circuit features will of course be omitted; and the discharge-controlling ballast 6 may be purely resistive instead of inductive or capacitive, or both. However, the starting circuit 13 and the condenser 14, discharge device or spark-gap 15, transformer 18, 19, and current-limiting impedance 16 may be essentially the same as shown in Fig. 1.

Figs. 1, 3, and 4 of course assume equipment of each discharge circuit 5 with any suitable means (such as sockets diagrammatically represented at 27 in dot and dash lines) for electrically connecting it to the electrodes 2, 2 of each discharge device 1, which may be equipped with corresponding bases or other means, not shown.

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

1. The combination with an electric discharge device containing an ionizable atmosphere and coating electrodes, and a discharge circuit connected to said electrodes, of a starting circuit energized from said discharge circuit independently of discharge between said electrodes, including a loop circuit responsive to the voltage supplied to said discharge device and a current-limiting impedance in series with said loop, a capacitor and an auxiliary electric discharge device connected in said loop in parallel with one another with respect to said impedance, said auxiliary discharge device having a break-down voltage less than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation

of the first-mentioned discharge device, and an inductive coupling between said loop and a portion of said discharge circuit which is in series with the first-mentioned discharge device.

2. The combination with an electric discharge device containing an ionizable atmosphere and coating electrodes, and a discharge circuit connected to said electrodes, of a starting circuit responsive to the voltage supplied to said discharge device and connected across said discharge circuit in parallel with the discharge gap between said electrodes, including a capacitor and a spark-gap in shunt with one another, said spark gap having a break-down voltage less than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation of said discharge device, and a current-limiting impedance in series with said shunt-connected condenser and spark-gap, and a transformer comprising a primary winding connected in the shunt and a secondary winding connected in said discharge circuit in series with said discharge device, between the latter and the corresponding connection of said starting circuit to said discharge circuit.

3. The combination with an electric discharge device containing an ionizable atmosphere and coating electrodes, and a discharge circuit connected to said electrodes, of a starting circuit energized from said discharge circuit independently of discharge between said electrodes, including a loop circuit responsive to the voltage supplied to said discharge device and a current-limiting impedance in series with said loop, a capacitor and an auxiliary electric discharge device connected in said loop in parallel with one another with respect to said impedance, said auxiliary electric discharge device having a break-down voltage lower than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation of the first-mentioned discharge device, and a transformer comprising a primary winding connected in said loop and a secondary winding connected in said discharge circuit in series with the first-mentioned discharge device, between the latter and the corresponding connection of said starting circuit to said discharge circuit.

4. The combination with an electric discharge circuit and means for connecting it to coating electrodes of an electric discharge device containing an ionizable atmosphere, of a starting circuit responsive to the voltage supplied to said discharge device and connected across said discharge circuit in parallel with its aforesaid connecting means, and including a loop circuit and a current-limiting impedance in series with the loop, a capacitor and an auxiliary electric discharge device connected in said loop in parallel with one another with respect to said impedance, said auxiliary discharge device having a break-down voltage less than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation of the first-mentioned discharge device, and an inductive coupling from said loop to a portion of said discharge circuit which lies between its aforesaid connecting means and its corresponding connection to the starting circuit.

5. The combination with an electric discharge circuit and means for connecting it to coating thermionic electrodes of an electric discharge device containing an ionizable atmosphere, of a starting circuit responsive to the voltage supplied

9

said discharge device and connected across said discharge circuit in parallel with its aforesaid connecting means, and including a loop circuit and a current-limiting impedance in series with the loop, a capacitor and an auxiliary electric discharge device connected in said loop in parallel with one another with respect to said impedance, said auxiliary discharge device having a break-down voltage less than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation of the first-mentioned discharge device, an inductive coupling from said loop to a portion of said discharge circuit which lies between its aforesaid connecting means and its corresponding connection to the starting circuit, means forming a heating loop circuit for a thermionic electrode aforesaid, and an inductive coupling from said heating loop to one of the other circuits aforesaid.

6. In combination, an electric discharge device employing an ionizable medium and comprising a pair of thermionic electrodes, a discharge circuit connected to said electrodes, a starting circuit energized from said discharge circuit independently of discharge between said electrodes and including said starting circuit responsive to the voltage supplied to said discharge device, a loop circuit and a current-limiting impedance in series with said loop, a capacitor and an auxiliary electric discharge device connected in said loop in parallel with one another with respect to said impedance, said auxiliary discharge device having a break-down voltage less than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation of the first-mentioned discharge device, and an electrode heating transformer comprising a primary winding connected in series relation with said impedance and having a pair of secondary windings each connected to a different one of said electrodes, and an inductive coupling between said loop and a portion of said discharge circuit which is series with the first-mentioned discharge device.

10

7. In combination, an electric discharge device employing an ionizable medium and including a pair of filamentary electrodes, a discharge circuit connected to said electrodes, a starting circuit energized from said discharge circuit independently of discharge between said electrodes and including a loop circuit and a current-limiting impedance in series with said loop, said starting circuit being responsive to the voltage supplied to said discharge device, a capacitor and an auxiliary electric discharge device connected in said loop in parallel with one another with respect to said impedance, said auxiliary discharge device having a break-down voltage less than the supply voltage in said discharge circuit and having a maintaining voltage higher than the voltage thereon during operation of the first-mentioned discharge device, and means for coupling said loop and a portion of said discharge circuit which is in series with the first-mentioned discharge device comprising a transforming means having a primary winding connected in circuit with said auxiliary discharge device and said capacitor and including a secondary winding connected to one of said electrodes, said transforming means also comprising a pair of electrode heating windings each connected to a different one of said electrodes.

DONALD D. HINMAN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,555,547	Bethenod	Sept. 29, 1925
1,976,645	Westendorp	Oct. 9, 1934
2,008,514	Peterson	July 16, 1935
2,050,135	Tour	Aug. 4, 1936
2,302,213	Hall	Nov. 17, 1942
2,326,597	Abernathy	Aug. 10, 1943
2,358,810	Karash	Sept. 26, 1944