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STARTING AND OPERATING CIRCUIT FOR HOT CATHODE
GASEOUS DISCHARGE LAMPS
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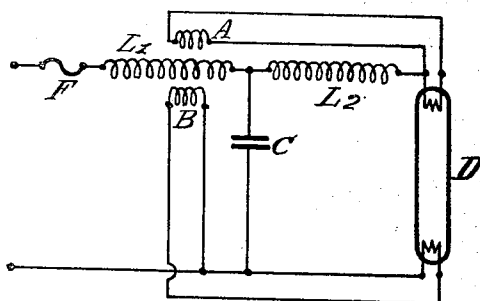


Fig. 1.

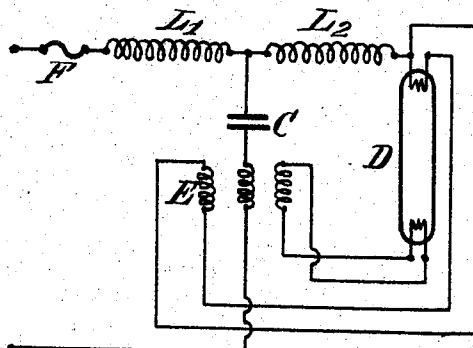


Fig. 2.

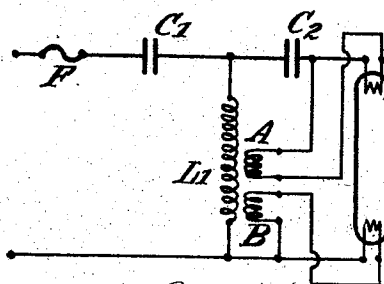


Fig. 3.

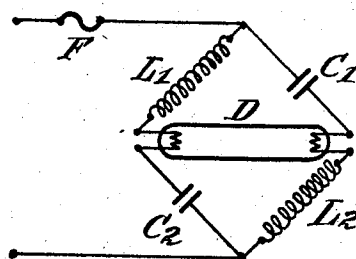


Fig. 4.

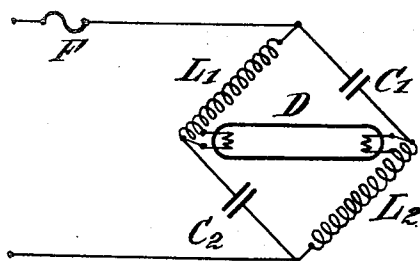
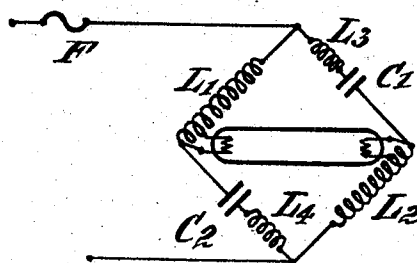


Fig. 5.



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STARTING AND OPERATING CIRCUIT FOR
HOT CATHODE GASEOUS DISCHARGE
LAMPS

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5 Claims. (Cl. 176—124)

The invention relates to an improved starting and operating circuit for hot cathode gaseous discharge lamps, in which it is necessary or desirable to preheat the cathodes to start the arc current, or discharge through the lamp, and in which it is necessary to regulate or control this current after the arc or discharge current has been started.

Most lamps of this character have what is known as negative voltage resistance characteristics, that is, it takes a lower voltage impressed across the terminals of the lamp to maintain a large current, than it does to maintain a small current. Some device or switch has to be used to preheat the cathodes, and this is then operated to apply voltage to the lamp to start the arc.

The present invention overcomes these objections and provides a quick means of starting these lamps. These lamps are inoperative on a constant voltage source, unless some series impedance or other method of controlling the current is used. The process of starting and operating is accomplished by coupling a hot cathode discharge lamp into a substantially constant current circuit. The invention consists in the means for the control of current through a discharge tube having two heated electrodes that alternately act as cathodes, by connecting same into a circuit which converts a constant potential source into a constant current in such a way by conductive or inductive coupling, the cathodes or filaments are heated quickly by the inrush of current, inherent in these constant current circuits when the output terminals are open-circuited that is before the arc discharge is started, and at the same time impressing a high voltage between these two electrodes or cathodes to start the flow of the normal arc current. By the nature of these circuits as soon as the output circuit is established, that is as soon as the arc current through the lamp starts, the inrush of current is reduced and the voltage applied to heat the filaments caused by the initial rush is also greatly reduced.

The principle of the invention having been set forth, the following embodiments thereof are described and shown to enable a man skilled in the art to reproduce the same.

In the accompanying drawing:

Figs. 1 and 2 are diagrammatic drawings of T circuits having series inductances and a shunt capacitor. They each show a different method of coupling the filament heating circuits into some part of the constant current circuit;

Fig. 3 is a similar drawing of a T circuit with

series capacitors and one shunt inductance. It shows a different method of coupling the filament heating circuits into the constant current circuits.

Figs. 4 and 5 are similar drawings showing "bridge" circuits each having two inductances and two capacitors. These two drawings show two methods differing slightly of coupling the filament heating circuits into the constant current circuit. In both of these circuits the inductances L_1 and L_2 are shown as separate units; but it is usually desirable to wind both coils on one iron core, insulated from each other but connected in such a way that the mutual inductance between the two coils adds to the self-inductance.

Fig. 6 shows another form of the bridge circuit similar to Fig. 5 but having two additional inductances L_3 and L_4 connected as shown. These two inductances may be wound on a common iron core but not on the same core as L_1 and L_2 . These small inductances prevent the circulating of any harmonic or other high frequency currents that may be generated by the lamp from flowing back to the supply line through condensers C_1 and C_2 .

Similar characters of reference indicate similar parts throughout the various views, where appropriate.

Referring to Fig. 1, the T circuit with series inductances L_1 and L_2 represent inductances of appropriate value to give the desired current through the lamp D when an alternating current voltage of given value and frequency is impressed across the input terminals. At the center of the drawing C is a capacitor of appropriate value. L_1 and L_2 inductances are coils wound on iron cores with an air gap in the magnetic circuit. Coils A and B are wound on the same iron core as L_1 , but are electrically insulated from L_1 . The terminals of A and B are connected respectively to the upper and lower electrodes or cathodes of the lamp D, which is a hot cathode discharge lamp. F is a fuse or other current interrupting device.

The method of operation is as follows:

In starting, alternating current voltage is applied to terminals. As L_1 and C are designed to be in resonance at the frequency of the alternating current used, a large current will flow from one line terminal through inductance L_1 , and capacitor C, as they are designed to be in resonance, (that is the reactive impedance of L_1 is equal to and of opposite sign to the capacitive impedance of C). This current is only limited by the resistance losses in L_1 and losses in C and

also by magnetic saturation in iron used in core of L_1 and can be given any desired value by the design of L_1 . This large current produces large voltage across L_1 and C but of nearly opposite phase relation. The large current through L_1 creates a large magnetic flux in core of L_1 which induces voltages in each of coils A and B which are applied to upper and lower cathodes of lamp D. Coils A and B are so designed that these voltages are of proper value to quickly heat the filaments to the desired temperature for starting of the lamp. At the same time the coils A and B supply heating current to the cathodes, a large voltage occurs across capacitor C. This high voltage in connection with the heated filaments starts the arc or discharge through lamp D. As soon as this discharge current has reached the value for which the circuit is designed the currents through L_1 and C are greatly reduced and the voltage across them is reduced proportionately. Also the voltage across coils A and B is reduced, thus reducing the heating current through the cathodes of lamp D.

L_2 is another inductance similar to L_1 , in series with lamp D to regulate the current through the lamp. (Inductance L_2 and lamp D could exchange places in the circuit without in any way affecting the operation of the circuit.)

F is a fuse or other circuit breaking device inserted in one supply line. This is so designed that it will not operate on the normal current the circuit is designed for, and so that it will carry for a short time the larger current necessary to start the lamp but would open the supply line in case this current was sustained for a length of time that would overheat or endanger the circuit, which would be the case if lamp D failed or was removed from the circuit.

Fig. 2 shows another method of coupling filament heating currents to a T circuit. This circuit has a three winding transformer E; one winding in series with capacitor C, one winding connected across upper filament of lamp D and the other winding across lower filament of lamp D. The large current through capacitor C in starting, and through the primary of E causes currents to flow through the two cathodes of lamp D at the same time that high voltage is impressed between the two cathodes. After arc or discharge current through lamp D is established, current through C, and primary of E, and consequently through secondaries of E and filaments, is reduced. F is a fuse or circuit breaking device as described for other circuits.

Fig. 3 shows a T circuit using two capacitors C_1 and C_2 and one inductance L_1 . The operation is similar to that described in connection with Figs. 1 and 2.

In starting the high current through capacitor C_1 and inductance L_1 , causes voltages to be generated in coils A and B which are inductively coupled to L_1 , which voltages cause currents to circulate in the two electrodes of lamp D to which they are respectively connected.

Fig. 4 shows a bridge circuit using two inductances L_1 and L_2 and two capacitors C_1 and C_2 connected as shown. The lamp cathodes are connected one in each side of the circuit. One between L_1 and C_2 , the other between C_1 and L_2 . Upon applying line voltage to terminals at left a large current will flow through L_1 lamp filament at left, (to heat this filament) and C_2 back to line. The same occurs through right side of circuit heating said filament of lamp. L_1 and C_2 , also C_1 and L_2 , are in resonance. The

voltage across L_1 and C_1 will be of nearly opposite phase so that a large voltage will be impressed across the two opposite filaments of the lamp, thus starting the arc discharge through the lamp, and as soon as this current is established the current through the filaments is greatly reduced. F is a fuse or other current limiting device in the supply line to protect circuit in case of failure of lamp to start. In this particular circuit no excess voltage or current can occur if the lamp is removed from circuit as the circuit will be opened at two opposite corners.

This particular circuit is suitable only for lamps where filament heating current is of proper value, the same as circulating current in bridge arms when this produces the proper voltage to start the lamp.

Inductances L_1 and L_2 may be wound on the same iron core and so connected as to be mutually additive in inductance.

Fig. 5 shows a modification of Fig. 4. This is the same as Fig. 4 except that inductances L_1 and L_2 are each tapped at the filament end so as to supply proper voltages across filaments where the simpler circuit of Fig. 4 does not furnish the proper heating current to these filaments. F is a fuse, as before described.

Fig. 6 is still another modification of Figs. 4 and 5. The modification consists in inserting in series with capacitor C_1 a self inductance L_3 and in series with capacitor C_2 a self inductance L_4 . These two inductances L_3 and L_4 may be wound on a common core. The advantage of this arrangement over the two previously described is that C_1 and C_2 can be made of smaller capacity and operated at higher voltage than in the other circuits. L_3 and L_4 also tend to prevent circulation of the harmonic and higher frequencies from line through C_1 , the lamp C_2 and back to other side of line. Additional coils L_3 and L_4 as shown in Fig. 6 may be used in the circuit of Fig. 4 where the circulating current is of proper value for heating filaments. These coils as above prevent circulation of undesired higher frequency currents. L_1 and L_2 can be wound on one core, which is desirable for saving of material.

Also in Fig. 6, L_3 and L_4 can be wound on the same core, but not on same core with L_1 and L_2 . In the circuits previously described, it is possible to substantially vary the power factor of alternating current supplied to the device and also the phase angle of the current through the lamp in respect to the supply voltage by changing the constants of the circuit (values of inductance of the coils and/or values of capacitors) without materially impairing other desirable features of the circuit.

I have shown various embodiments, but various changes can be made therein without departing from the principle of the invention.

What I claim is:

1. An electric circuit adapted to supply starting and operating voltages to hot cathode discharge lamps which comprises a bridge network having four bridge arms with a source of alternating current connected across two opposite conjugate points of the bridge and a hot cathode discharge lamp connected across the other two conjugate points, the bridge arms comprising condensative and inductive reactances of such values that a condition of resonance is established in the circuit including the source of current, one pair of opposite bridge arms including condensative reactances and the other pair

including inductive reactances of values such that the voltages at opposite ends of the lamp are in substantially opposite phase, whereby a starting voltage will be impressed across the lamp which is higher than the operating voltage.

2. In combination, a T circuit comprising series inductive reactances and at least one capacitive reactance, one of said inductive reactances being the primary of an induction coil which is provided with two secondary coils, said reactances being connected to a source of alternating current and having such values as to produce a condition of resonance in said series circuit, a second circuit comprising a series reactance and a hot cathode discharge lamp, having electrically heated filaments supplied with a heating current by the secondary coils of said transformer, said second circuit being connected in shunt across one of the reactances of said first circuit, whereby the starting voltage and filament heating current initially supplied to said lamp are substantially higher than the operating values.

3. An electric circuit adapted to supply starting and operating voltages to hot cathode dis-

charge lamps which comprises a bridge network having four bridge arms with a source of alternating current connected across two opposite conjugate points of the bridge and a hot cathode discharge lamp connected across the other two conjugate points, one pair of opposed bridge arms comprising inductive reactances and the other pair comprising inductive reactances in series with condensative reactances of values such that the voltages at opposite ends of the lamp are in substantially opposite phase, whereby a starting voltage will be impressed across the lamp which is higher than the operating voltage.

4. The electric circuit of claim 3 wherein the filaments of said discharge lamp are connected in the bridge network in series between the bridge arms at said other two conjugate points.

5. The electric circuit of claim 3 wherein the filaments of said discharge lamp are connected in shunt across portions of said inductive reactance in said bridge network in such manner that they are heated by the resulting induced currents.

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