Aug. 22, 1939. M. A. EDWARDS 2,170,449

ELECTRIC DISCHARGE APPARATUS

Filed March 22, 1938

Fig. 1.

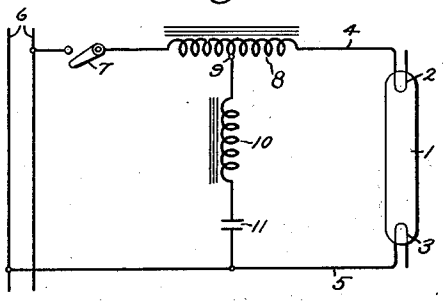
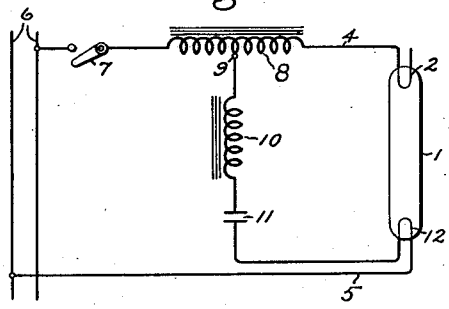


Fig. 2.



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ELECTRIC DISCHARGE APPARATUS

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9 Claims. (Cl. 176—124)

My invention relates to gaseous electric discharge devices and apparatus for operating the same from alternating current circuits. It relates particularly to electric discharge devices which require the application of a higher voltage for starting them than for the subsequent operation thereof. Certain forms of apparatus of this character which have been constructed heretofore and which have included capacitors for obtaining the required higher starting voltage have not been entirely satisfactory for various reasons; the cathodes of the devices often have been damaged by the high current peaks produced by the capacitors employed, and the apparatus has not had as good operating characteristics as desired.

One object of my invention is the provision of improved apparatus of the above mentioned character which employs simple means including capacitors by which the desired starting voltage may be obtained without danger of damage to the cathodes. Another object is the provision of improved apparatus of this character which will operate with high efficiency and good stability, which will not be critical to reasonable variations in line voltage and whose construction will be simple and inexpensive to manufacture.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 is a circuit diagram illustrating one embodiment of my invention in which an electric discharge device is employed having non-thermionic electrodes, and Fig. 2 is a circuit diagram showing a modification thereof in which the discharge device is provided with one thermionic electrode and with one non-thermionic electrode.

While my invention is applicable to apparatus employing various forms of electric gas discharge devices it is of particular interest and has been especially developed for use in connection with low pressure discharge devices which are employed to give light. A preferred form of such device is a lamp of the positive column type comprising a tubular envelope having electrodes at its ends and containing a gaseous atmosphere such as a few millimeters of a rare gas, for example argon, and a small quantity of a vaporizable metal, such as mercury. Preferably the envelope is coated internally with a suitable fluorescent material in order that the electric discharge, which in itself may be scarcely visible, shall produce the desired high degree of illumination. The coating may also contain a suitable material to cause the lamp to continue to give light during the intervals of current reversal therein. In the description to follow therefore I shall refer to the discharge devices as lamps. It is well known that to start a discharge in such a lamp by the application of a voltage to its electrodes a higher voltage must be employed than that required to maintain the discharge after it has been started.

Referring to Fig. 1, I have shown the electric discharge device or lamp at 1, the same being provided at its ends with the thermionic electrodes 2 and 3 which are heated by the discharge which takes place between them rather than being previously heated to an electron emitting temperature as, for example, by passing a current through them. Before starting, the lamp has a high resistance and may require a voltage considerably higher than that of the circuit from which it is supplied to start a discharge therein. A lamp for example that is adapted to operate on a 115 volt circuit may require the application of approximately 300 volts between its electrodes to cause it to start. After it has started, however, the arc drop will be approximately only 65 volts but a voltage somewhat greater than that is required to maintain the discharge. This required voltage has been found to be of the order of the

$$\sqrt{2}$$

times the voltage of the arc drop. In the circuits now to be described the difference between the voltage of the source of supply and the arc drop voltage is absorbed by the ballast employed.

As shown by Fig. 1 the lamp is connected through the connections 4 and 5 with the source of supply 6 of alternating current which for example may be a 60 cycle, 110 volt lighting circuit. These connections include the switch 7 and the ballast reactor or choke coil 8 whose inductance for example may be 1.3 henries. At a point intermediate the ends of this reactor, shown by way of example as the mid-point thereof, is the tap 9 and connected between this tap and the other lamp connection is a branch circuit constructed to have a leading power factor and comprising the reactor or choke coil 10 whose inductance, for example, may be 1.45 henries and the capacitor 11 whose capacitance for example may be 3 mfd., the reactor and capacitor being arranged in series. The reactor 8 thus constitutes a step-up auto transformer of which that part of the reactor winding between the switch and the

point 9 is the primary and the entire winding is the secondary.

When the switch 7 is closed to energize the lamp that part of the reactor winding which comprises the primary together with the reactor 10 and the capacitor 11 constitute a circuit which is in a condition of partial resonance, that is, the inductance and the capacitance of the circuit are not such that the circuit is tuned or is in exact resonance at the frequency of the source of supply but rather is only partly tuned or, in other words, is operated off the resonance peak. The voltage then applied to the electrodes 2 and 3 is the vector sum of that of the source and the induced voltage of the reactor 8 due to the leading current drawn through the branch circuit comprising the reactor 10 and capacitor 11. The resultant voltage applied to the electrodes of the lamp is sufficient to cause a discharge to start therein. Having started, the lamp continues to operate with the reactor 8 in combination with reactor 10 and capacitor 11 as the effective ballast. The lamp together with that part of the reactor 8 between the tap 9 and the electrode 2 now form a shunt around the branch circuit comprising the reactor 10 and the capacitor 11 so that the current therein is very materially reduced but, nevertheless, is of such a value that the capacitor exerts a beneficial effect by raising the power factor to such an extent that with apparatus having the values mentioned above the current drawn from the supply circuit 6 is but slightly lagging.

I have found that when a capacitor is employed in circuit with such a lamp the high current peaks due to the capacitor often seriously injure the cathodes of the lamp if the lamp is allowed to continue in circuit therewith for any appreciable length of time. In the circuit which I have devised and have just described the current peaks arising from the action of the capacitor in the branch circuit during the starting of the lamp are dissipated and sufficiently smoothed out by the reactor 10 in series therewith so that no harmful results are apparent in the electrodes of the lamp.

In the modified form of my invention illustrated by Fig. 2, the electrode 12 is initially heated to an electron emitting temperature by passing a current through it. The said electrode is connected in series with the branch circuit comprising the reactor 10 and capacitor 11 whereby the current traversing that circuit will pass through and heat that electrode at the time of starting. After the discharge in the lamp has started however the electrode 12 may be kept hot partly by the current in the branch circuit and partly by the cathode spot formed thereon. As in the form illustrated by Fig. 1 the lamp after being started operates with inductive ballast but the capacitor 11 very materially improves the power factor of the apparatus. Moreover, the high current peaks originating in the capacitor are smoothed out by the reactor in series therewith.

While in Fig. 1 I have not shown any means for initially heating the electrodes, it will be understood that the electrodes may be heated in any desired and well known manner. Also, the electrode 2 of Fig. 2 may, if desired, be heated in any desired and well known manner.

Moreover the lamp may be provided with a well known form of indirectly heated electrode in which case the member 12 would constitute the heater therefor, the electrode and the heater being electrically connected together.

I have chosen the particular embodiments described above as illustrative of my invention and it will be apparent that various other modifications may be made without departing from the spirit and scope of my invention which modifications I am to cover by the appended claims.

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

1. In combination, a source of alternating current supply, an electric discharge device, connections between the electrodes of said device and said source, a transformer having its secondary included in one of said connections, and a branch circuit including a reactor and a capacitor arranged in series and connected to be supplied from said source through the primary of said transformer.

2. In combination, a source of alternating current supply, an auto-transformer, a circuit connected to be supplied from said source including the primary of said transformer, a reactor and a capacitor arranged in series, an electric discharge device and means connecting said device to be supplied from said source in series with the secondary of said transformer.

3. In combination, a source of alternating current supply, an electric discharge device having electrodes, connections between the electrodes thereof and said source, a transformer having a winding in the connection to one of said electrodes and a circuit including a reactor and a capacitor in series connected between another of said electrodes and an intermediate point of said winding.

4. In combination, a source of alternating current supply, an electric discharge device, one of the electrodes thereof being electron emitting, connections for supplying energy from said source to said device, a transformer having its secondary in one of said connections, and a branch circuit including the primary of said transformer, a reactor, a capacitor and said one electrode arranged in series.

5. In combination, a source of alternating current supply, an auto-transformer, an electric discharge device, one of the electrodes thereof being electron emitting, connected in series with the secondary of said transformer to be supplied from said source, and a circuit including a reactor and a capacitor arranged in series with said one electrode and the primary of said transformer.

6. In combination, a source of alternating current supply, an electric discharge device, connections between the electrodes thereof and said source, a reactor all portions of whose winding are constructed to produce flux in the same direction arranged in one of said connections, and a branch circuit including a capacitor and a second reactor in series permanently connected between an intermediate point of the first mentioned reactor and the other of said connections.

7. In combination, a source of alternating current supply, an electric discharge device having a starting voltage higher than the voltage of said source, connections between said device and said source, a transformer having its secondary arranged in one of said connections and a branch circuit arranged permanently between said connections including a capacitor, a reactor and the primary of said transformer in series.

8. In combination, a source of alternating current supply, an electric discharge device having a starting voltage higher than the voltage of said source, connections between said device and said source, a transformer having its secondary arranged in one of said connections and a branch

circuit having capacitative reactance permanently connected between an intermediate point of said secondary and the other of said connections whereby the voltage across said branch circuit is augmented by transformer action to effect the starting of the device.

9. In combination, a source of alternating current supply, an electric discharge device having a starting voltage higher than the voltage of said source, connections between said device and said source, a transformer having its secondary arranged in one of said connections and a capacitatively reactive branch circuit permanently connected between an intermediate point of said secondary and the other of said connections, the amount of inductance in the circuit comprising the transformer primary and the branch circuit being materially greater than that required to produce a condition of resonance therein.

MARTIN A. EDWARDS.