Feb. 11, 1941. H. W. LORD 2,231,584

ELECTRIC DISCHARGE APPARATUS

Filed May 27, 1939

Fig. 1.

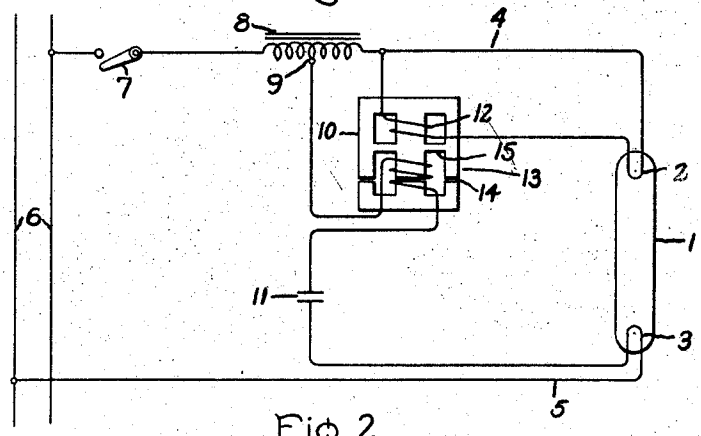


Fig. 2.

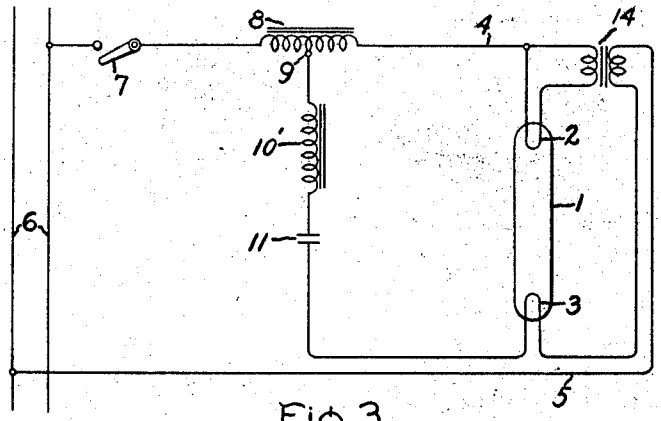
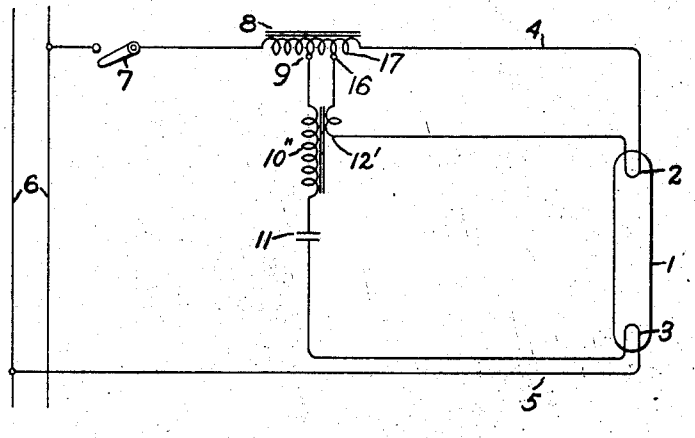


Fig. 3.



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ELECTRIC DISCHARGE APPARATUS

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3 Claims. (Cl. 176—124)

My invention relates to gaseous electric discharge devices and apparatus for operating them 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 and is a further development of the apparatus disclosed and claimed in the copending application of Martin A. Edwards Serial No. 197,529 entitled Electron discharge apparatus and filed March 22, 1938.

In that apparatus one electrode or cathode was initially heated to an electron emitting temperature the other electrode or cathode being heated only by the discharge between the electrodes after it had started. It has been found that because of the deterioration at starting of the electrode which is not initially heated it is highly desirable to preheat both electrodes. It is the object of my invention therefore to provide an improved apparatus of this character whereby both electrodes are heated to an electron emitting temperature before the discharge starts.

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 Figs. 1, 2 and 3 are circuit diagrams showing various forms of my invention.

While my invention like that of the aforementioned Edwards application 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 both of which are initially heated to an electron emitting temperature 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. This circuit comprises the reactor or choke coil 10 whose inductance, for example, may be 1.45 henries, the capacitor 11 whose capacitance, for example, may be 3 mfd., and the electrode 3, the reactor, the capacitor, and the electrode 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.

The reactor 10 is of special construction being provided with the additional winding 12 of a few turns in which a voltage is induced for initially heating the electrode 2. A preferred form of the reactor comprises the three legged core 13 having the gaps 14 and having the main and additional windings mounted on different portions of the middle leg. Arranged between the two windings and extending between the middle and each

side leg are the narrow shunting portions 15 which readily saturate. One end of winding 12 connects with the lead 4 and the other end connects with the free end of electrode 2.

When the switch 7 is closed to energize the lamp that part of the reactor 8 which comprises the primary together with the reactor 10, the capacitor 11 and the electrode 3 constitute a circuit which is in a condition of partial resonance, i. e. the inductance and the capacitance of the circuit are such that the circuit is partly tuned but is not in exact resonance at the frequency of the source of supply, or, in other words, is operated off the resonance peak. The electrode 3 is heated by the current traversing the branch circuit and the electrode 2 is heated by the current supplied by the winding 12 which is a maximum since at this time the portions 15 of the reactor are saturated. The voltage applied between the electrodes 2 and 3 is the vector sum of that of the source and the voltage induced in the reactor 8 due to the leading current drawn through the branch circuit. The resultant voltage applied between the heated electrodes of the lamp is sufficient to cause a discharge to start therein after the electrodes have been sufficiently heated for electron emission. Having started, the lamp continues to operate with the reactor 8 in combination with the 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 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. By reason of the reduction of the current in the branch circuit the sections 15 of the reactor no longer saturate hence the heating current supplied by the winding 12 is very materially reduced with a corresponding reduction in heat losses. It has been 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 above described circuit the current peaks arising from the action of the capacitor in the branch circuit at the beginning of each half cycle of current conduction 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 a simple reactor 10' of well known form is employed and the electrode 2 is supplied with current for the initial heating thereof by being connected with the secondary of the transformer 14 whose primary is arranged in series in the branch circuit comprising the reactor 10', the capacitor 11 and the electrode 3.

In the modification disclosed by Fig. 3 the reactor 10'' in the branch circuit is of well known form like the reactor 10' in Fig. 2 except that it has an additional winding 12' thereon. The reactor 8 has not only the intermediate tap 9 as in Figs. 1 and 2 but a second tap shown at 16. One end of the winding 12' connects with the tap 16 and the other end connects with the free end of the electrode 2 thereby forming a series circuit comprising the winding 12', electrode 2 and the right end portion 17 of the reactor 8, the connection being such that the voltage applied to the electrode 2 is the vector sum of the voltages of the winding 12' and the portion 17.

During starting, that is before the discharge starts in the lamp, the voltages across the reactors 8 and 10'' are substantially in phase and since the windings 12' and 17 are so connected that their voltages are additive the electrode 2 receives the maximum current at that time for the rapid heating thereof. During running, that is after the discharge has started in the lamp, the voltage across the reactor 10'' is considerably reduced as already explained, and the phases of the voltages across 12' and 17 differ by a considerable angle. By a proper selection of the ratio of the voltages 12' and 17 it is possible to cause the voltage across the electrode 2 to vary as much as 4 to 1 between starting and running conditions. This is ample to reduce the running losses in the electrode to a satisfactory low level.

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

1. In combination, an electric discharge device having connections by which it is arranged to be supplied from a source of alternating current and having an electrode constructed to be initially heated to an electron emitting temperature, a transformer having its secondary included in one of said connections, a branch circuit connected to be supplied from said source and including the primary of said transformer, a reactor and a capacitor connected in series and a heating circuit for said electrode including a winding inductively related to said reactor and a portion of said secondary.

2. In combination, an electric discharge device having connections by which it is arranged to be supplied from a source of alternating current and having electrodes between which a discharge takes place constructed to be initially heated to an electron emitting temperature, a transformer having its secondary included in one of said connections, a branch circuit connected to be supplied from said source and including the primary of said transformer, a reactor, a capacitor, and one of said electrodes connected in series and a heating circuit for the other of said electrodes including a winding in inductive relation to said reactor and a portion of said secondary connected in series.

3. In combination, a source of alternating current, an electron discharge device having connections by which it is supplied therefrom and having electrodes between which a discharge takes place constructed to be initially heated to an electron emitting temperature, a reactor having a plurality of taps included in one of said connections, a second reactor having thereon an additional winding, a capacitor, a branch circuit connected between one of said taps and the free end of one of said electrodes and including said second reactor and said capacitor, and means including said additional winding connecting the other of said taps with the free end of the other of said electrodes.

HAROLD W. LORD.