Aug. 22, 1939. H. W. LORD 2,170,456

ELECTRIC DISCHARGE APPARATUS

Filed March 22, 1938

Fig.1.

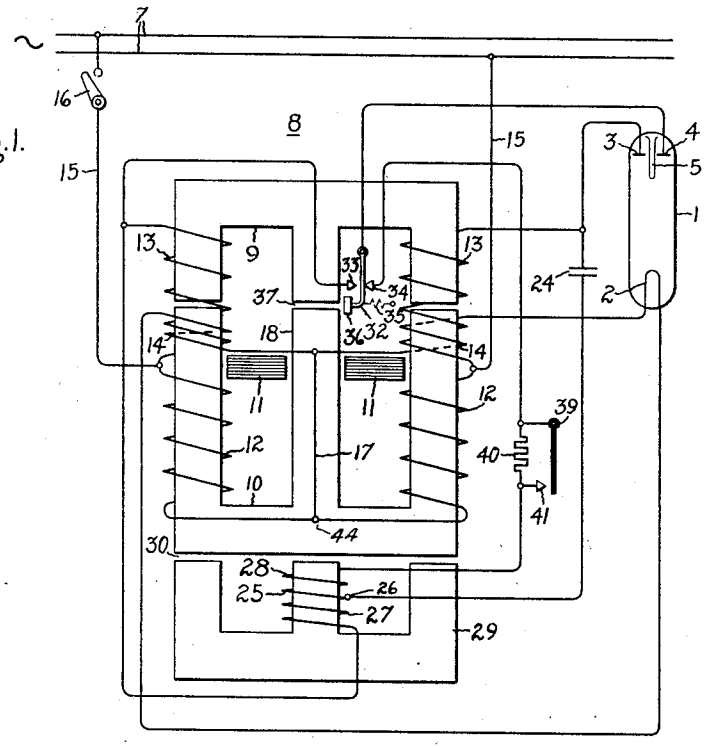


Fig.2.

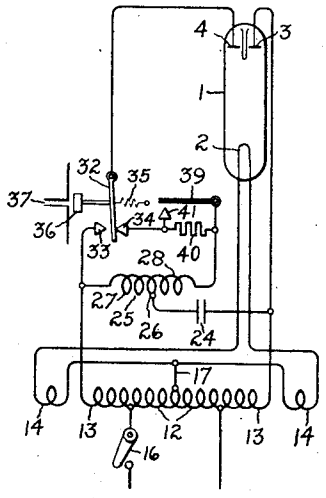
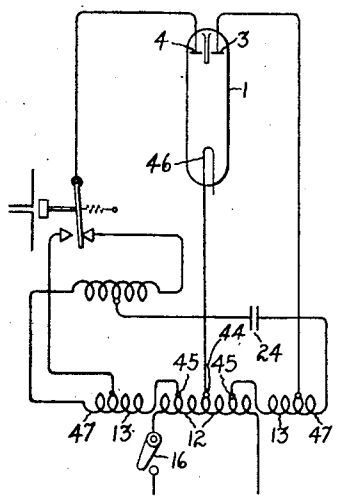


Fig.3.



Inventor:
Harold W. Lord,
by Harry E. Dunham
His Attorney.

Patented Aug. 22, 1939

2,170,456

UNITED STATES PATENT OFFICE

2,170,456

ELECTRIC DISCHARGE APPARATUS

Harold W. Lord, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application March 22, 1938, Serial No. 197,357

13 Claims. (Cl. 176—124)

My invention relates to gaseous electric discharge devices and apparatus employed in operating the same from alternating current circuits particularly when the discharge devices are used for the purpose of giving light, namely as lamps, and when their construction is such that they require the application of a higher voltage for starting than for their subsequent operation. My invention is a further development of that disclosed and claimed in the copending application Serial No. 197,526 for Electric discharge apparatus by Martin A. Edwards, filed March 22, 1938, and assigned to the same assignee as the present application.

One object of my invention is the provision of improved apparatus of the above mentioned character which will provide the voltage necessary to cause a discharge to start in the device without injury to the electrodes thereof and after starting has occurred will reduce automatically to the value required for the continued operation of the device thereafter. Another object is the provision of such starting apparatus which, in the event that the device fails to start or is removed from the circuit, will not cause an undesirable heating of any part of the apparatus and will not draw an objectionably large amount of energy from the source of supply. A further object of my invention is the provision of such apparatus wherein the same part will cooperate at the time of starting to produce the necessary starting voltage and subsequently during the operation of the device will function to improve the power factor of the energy drawn by the apparatus.

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 combined circuit diagram and diagrammatic side elevation of one embodiment of my invention; Fig. 2 is a simplified circuit diagram of the apparatus shown in Fig. 1, and Fig. 3 is a circuit diagram showing a modification.

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 where the devices 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. 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.

In Fig. 1, I have shown the electric discharge device or lamp 1 provided at one end with the thermionic cathode 2 and at the other end with the two similar anodes 3 and 4 preferably separated by the insulating partition 5. If desired, a well-known form of separately heated cathode may be employed instead of the directly heated cathode as shown.

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 110 volt circuit may require the application of approximately 450 volts between its anode and cathode to cause it to start. After it has started however the arc drop may be approximately only 100 volts.

The lamp 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 coil 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 and the midpoint 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 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 provides a return path for the uni-directional 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 unidirectional. 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.

It is well-known that a high reactance transformer produces a low power factor but that the power factor may be improved by the use of a capacitor across the primary or across another winding closely coupled therewith. A capacitor so used, however, is objectionable because of the current harmonics of large magnitude which it draws from the line when lamps of the arc discharge type are being operated by the apparatus and because the high current peaks due to such harmonics are found to be injurious to the electrodes of the lamp if allowed to continue for any appreciable length of time. With apparatus such as that disclosed by this application, should a capacitor be connected directly across the secondary for the purpose of improving the power factor it would be objectionable not only for the reasons mentioned above but for the additional reason that it would decrease the angle of commutation thereby off-setting to a certain extent the good effect of the high leakage reactance between the two halves of the secondary.

As in the aforesaid application of Martin A. Edwards I employ a capacitor shown at 24, across the secondary of the transformer to improve the power factor and also, as in that case, I avoid the objections which would arise from its being connected directly across the secondary by the insertion of a suitable amount of inductive reactance in series therewith. In the arrangement which I have devised the inductive reactance is furnished by the reactor or choke coil 25 which has the intermediate tap 26 dividing it into the two parts 27 and 28. As so constructed the reactor is adapted to function as an auto transformer. I connect the capacitor 24 and the reactor part 27 in series across the secondary terminals. As so arranged the capacitor serves to improve the power factor and the part 27 of the reactor in series therewith whose reactance is materially less than that of the capacitor, serves to smooth out the high current peaks and prevent any material decrease in the desired large angle of commutation.

As in the aforesaid application also the capacitor 24 and the reactor 25 thus bridged across the secondary performs the additional function of raising the voltage applied between the cathode and the anodes of the lamp. This is because the relative amounts of capacitative and inductive reactance in the closed circuit including those members and the leakage reactance between the primary and the secondary is such that a condition of partial resonance exists therein. 'A condition of actual or complete resonance is not desired, the natural resonance frequency of the circuit being somewhat higher than the supplied frequency. For example, if the supplied frequency is 60 cycles per second the natural resonance frequency of the circuit may be 65 cycles. For stability reasons it is desirable that the operating frequency shall be on the low frequency side of the resonance curve.

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.

In as much as the voltage applied between the cathode and either anode, namely the voltage of one-half of the secondary, plus that obtained by the above described bridge circuit, is not sufficient to cause a discharge to start in the lamp, I have provided the means now to be described for applying a higher voltage between the cathode and one anode to cause the discharge to start. In connection therewith I employ a time delay means whereby the high starting voltage is not applied to the lamp electrodes until the cathode has had time to become heated to the desired degree. Connected with the anode 4 is the electromagnetic switch 32 having the front contact 33 and the rear contact 34 against which it is biased by the spring 35. The switch is actuated by the small 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. The front contact connects directly with the secondary; the rear contact connects with the free end of part 28 of the reactor through the time delay apparatus shown as comprising the thermal switch 39 which may have a bi-metallic blade arranged to be heated by the resistance heater 40 and bent so as to touch the contact 41 thereby short circuiting the heater.

When the switch 16 is first closed to energize the lamp and the controlling apparatus therefor, a discharge does not immediately start in the lamp since the voltage applied thereto is not sufficient. Heating of the cathode by the auxiliary secondary, moreover, immediately starts. The switch 32 is held against the back contact since before the lamp starts there is substantially no flux in the middle leg of the transformer and the switch 39 being cool is open. The capacitor 24, the part 27 of the reactor and the main secondary form a circuit which is in partial resonance and as a result thereof a materially higher voltage appears across that secondary, across the capacitor and across the part 27 of the reactor. Since the reactor voltage is practically

in phase with that of the main secondary they add up with the arrangement shown and the sum is still further increased by the transformer action of the two parts 27 and 28 of the reactor. For example, the voltage at this time across each half of the main secondary may be 250 volts, across the part 27 it may be 100 volts, and across the part 28 it may be another 100 volts so that the total starting voltage available between the cathode and the anode 4 would be 450 volts. Until the cathode becomes heated to the proper temperature, however, the resistance of the heater 40 prevents the passage of enough current between the cathode and that anode to permit the formation of an arc therebetween. Cross currents nevertheless pass between the two anodes in a circuit including the entire main secondary whose voltage is augmented by the reactor as before and these currents cause the heater to operate the thermal switch 39 to short circuit the heater and thereby apply the starting voltage after the lapse of the desired time delay.

The discharge having started between the cathode and anode 4 is immediately picked up at the next half cycle by the other anode 3. The resulting uni-directional flux in the middle leg 18 of the transformer core operates the switch 32 to connect the anode 4 directly with the main secondary. That switch by so operating cuts out the time delay switch whereby it will cool off and return to its initial position ready for another starting of the lamp.

With the arrangement which I have shown and described, it will be seen that should the lamp for any reason fail to start or should the lamp be removed from the circuit only a small amount of energy is drawn by the apparatus from the source, hence, the apparatus, particularly the transformer, will not be overheated under such circumstances. Another advantage is that with my arrangement the same capacitor serves both for power factor improvement during the normal operation of the lamp and for obtaining a higher voltage for starting the lamp.

With apparatus such as I have shown and described where on each outer leg of the transformer the secondary winding has one part thereof closely coupled with the primary thereon and where the transformer has magnetic shunting means arranged to produce a high leakage reactance between another part of the secondary and the primary, the voltage of the part closely coupled with the primary is said to be fixed while the voltage of the other part is variable being dependent on the load. The total voltage applied between the cathode and an anode of the lamp is the sum of these two voltages. For the best results with such apparatus, I have found that that part of the voltage which is obtained from the closely coupled part of the secondary on one leg should have an average value which is approximately one-half of the average value of the arc drop voltage of the lamp. Exact equality between these voltages is in general not necessary as I have found that a difference between them up to 20% may occur and still stable operation of the lamp be obtained. The total open circuit secondary voltage applied between an anode and the cathode of the lamp should preferably be from two to three times the arc drop voltage of the lamp.

With that form of my invention illustrated by Figs. 1 and 2 it is assumed that the arc drop voltage of the lamp is approximately twice the average value of the voltage wave obtained from that part of the secondary winding which is common to one of the primary coils 12, hence is closely coupled therewith. Obviously the primary and secondary windings may be separate from each other if so desired.

If the lamp to be used has an arc drop of a materially lower voltage than that assumed above, I modify the circuit in the manner shown diagrammatically by Fig. 3. The secondary coils 13 in this case connect with the primary coils 12 at the intermediate points 45 thereof rather than at the ends of those coils, the points 45 being so spaced from each other that the average value of the voltage wave between each point and the middle point 44 to which the cathode connects is approximately equal to one-half of the arc drop of the lamp. Thus the total voltage applied between the cathode and an anode of the lamp comprises the voltage of a closely coupled part of the secondary, that is the part between point 44 and one point 45, and the voltage of a part 13 which is not closely coupled.

Fig. 3 shows not only the modification described above but also an arrangement including a lamp whose cathode 46 is not heated prior to the establishment of the arc. Since cathode heating current in this case is unnecessary the secondary coils 14 have been omitted, the cathode being connected directly with the mid-point of the transformer winding. When a lamp is employed having a low arc drop I have found it desirable to increase the voltage applied to the circuit of the capacitor. This may be done conveniently by extending the main secondary winding by adding a few additional turns to the coils 13 as shown at 47. It will of course be understood that Fig. 3 is purely diagrammatic and hence is not intended to show the several coils or parts thereof in their true proportions.

I have chosen the particular embodiment 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, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, power factor improving means connected across said transformer, and means responsive to the current in said means for increasing the voltage applied to said device by said secondary to start a discharge in said device.

2. In combination, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, a capacitor connected in closed circuit across said transformer, and means in said connection and cooperating with said capacitor for raising the voltage applied by said secondary between said cathode and one of said anodes.

3. In combination, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, a capacitative circuit connected across said secondary for improv-

ing the power factor, and means responsive to the current in said circuit for applying a higher voltage between the cathode and one of said anodes than that supplied by the secondary.

4. In combination, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, a capacitor and a reactor connected in series across said secondary and means connecting said reactor with one of said anodes for supplying between it and the cathode the sum of the voltage of said reactor and the voltage of the secondary supplied thereto at starting.

5. In combination, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, a capacitor and a reactor connected in series across said secondary, a switch connecting said reactor with one of said anodes for supplying between it and the cathode the sum of the voltage of the reactor and the voltage of the secondary supplied thereto at starting and means responsive to the starting of a discharge in said device for opening said switch.

6. In combination, an electric discharge device having a cathode and a plurality of anodes, a main transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, an auxiliary transformer, a capacitor connected in series with the primary of said auxiliary transformer across said secondary and means operable before a discharge starts in said device for adding the voltage of the secondary of said auxiliary transformer to that supplied between the cathode and one of said anodes by the secondary of said main transformer.

7. In combination, an electric discharge device having a cathode and a plurality of anodes, a main transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, an auto transformer, a capacitor connected in series with the primary of said auto transformer across said secondary, a switch arranged in one position to open the connection between one of said anodes and the secondary of said main transformer and to connect said one anode with the secondary of said auto transformer whereby the added voltage thereof is supplied between the cathode and said one anode and means responsive to the starting of a discharge in said device for operating said switch to close the first mentioned connection and to open the second mentioned connection controlled thereby.

8. In combination, an electric discharge device, a transformer having a secondary winding connected across said device and having means for increasing the leakage reactance between the primary and one portion of the secondary winding, and power factor improving means connected to be supplied by said secondary winding, another portion of the secondary winding being closely coupled with the primary and constructed to have a voltage approximately equal to one-half of the arc drop voltage of said device.

9. In combination, an electric discharge device, a transformer having a secondary winding connected across said device and having magnetic shunting means for increasing the leakage reactance between the primary and one portion of the secondary winding, and a capacitance connected to be supplied by said secondary winding, another portion of the secondary winding being closely coupled with the primary and constructed to have a voltage whose average value is within 20% of one-half of the arc drop voltage of said device.

10. In combination, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, a capacitor connected across said transformer and means in one of said anode connections and cooperating with said capacitor for raising the voltage applied between said one anode and said cathode.

11. In combination, an electric discharge device having a cathode and a plurality of anodes, a transformer having spaced points of its secondary arranged to be connected each with one of said anodes and an intermediate point thereof connected with said cathode, a capacitor connected across said transformer, a reactor having a portion thereof connected in series with said capacitor and means for inserting said reactor in series in the connection between one of said anodes and said secondary.

12. In combination, an electric discharge device, a transformer having a secondary winding connected across said device and having means for increasing the leakage reactance between the primary and one portion of the secondary winding and a capacitatively reactive circuit connected to be supplied by said secondary, another portion of the secondary winding being closely coupled with the primary, said one portion of the secondary being connected with said other portion thereof at a point intermediate its ends at which the voltage is approximately equal to one-half of the arc drop voltage of the device.

13. In combination, an electric discharge device, a transformer having a secondary winding connected across said device and having magnetic shunting means for increasing the leakage reactance between the primary and one portion of the secondary winding and a power factor correcting capacitor connected across said secondary, another portion of the secondary winding being closely coupled with the primary, said one portion of the secondary winding being connected with said other portion thereof at a point intermediate its ends at which the average value of the voltage is within 20% of one-half of the arc drop voltage of said device.

HAROLD W. LORD.