

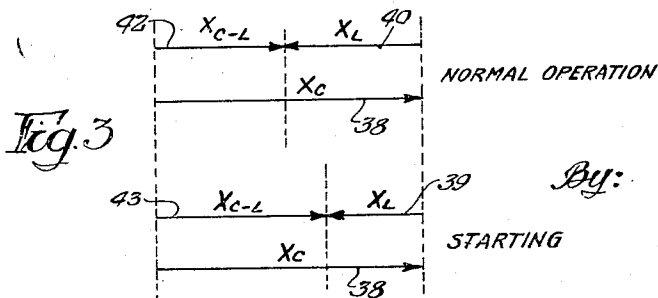
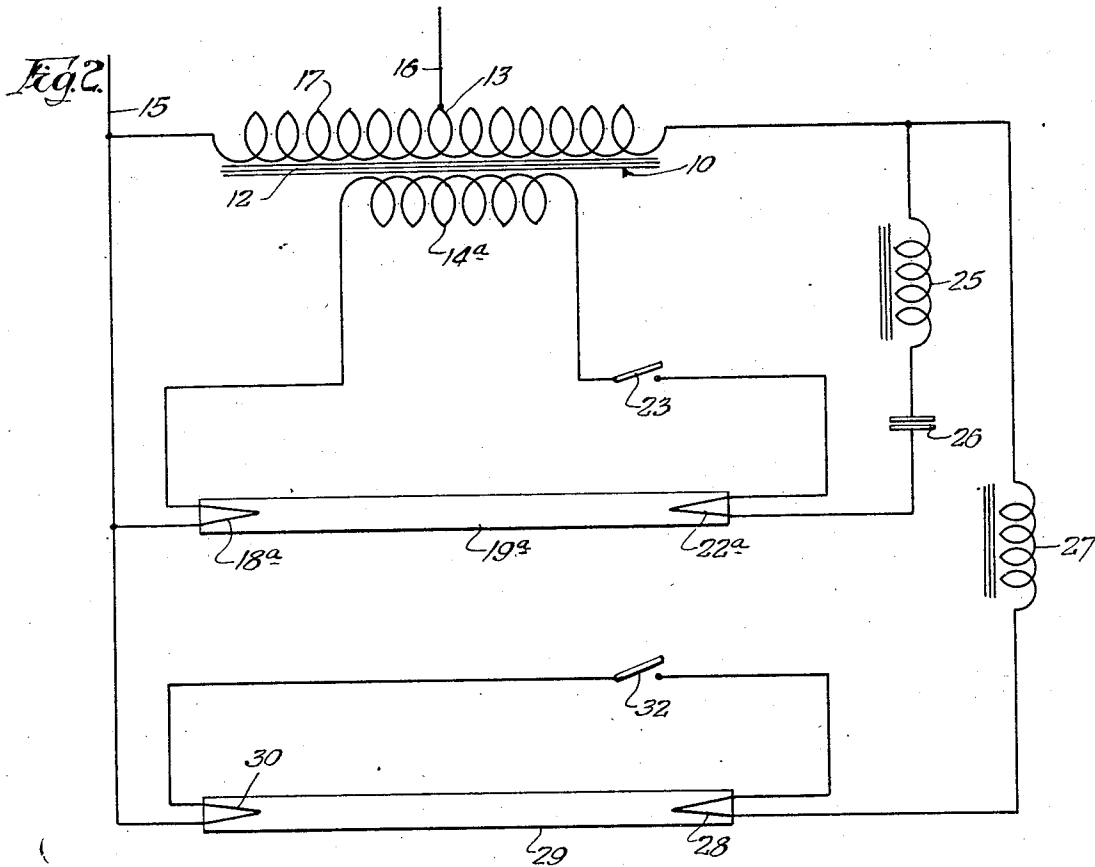
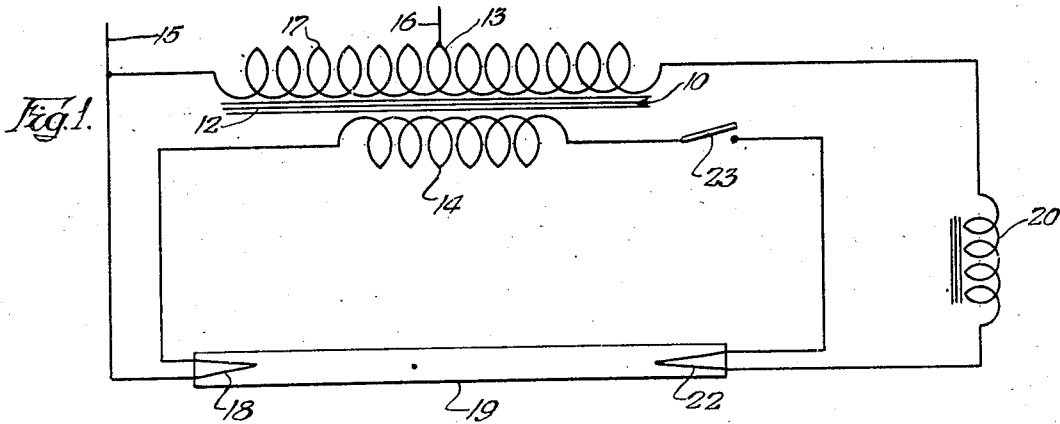
Oct. 19, 1943.

L. MAUERER

2,332,455

SYSTEM AND APPARATUS FOR OPERATING HOT CATHODE GAS DISCHARGE TUBES

Filed April 17, 1941



Inventor:
Leopold Mauerer,

By:

By:

Edmund Brewer
his Attorney

UNITED STATES PATENT OFFICE

2,332,455

SYSTEM AND APPARATUS FOR OPERATING
HOT CATHODE GAS DISCHARGE TUBES

Leopold Mauerner, Chicago, Ill., assignor to Jefferson Electric Company, Bellwood, Ill., a corporation of Illinois

Application April 17, 1941, Serial No. 338,974

8 Claims. (Cl. 176-124)

This invention relates to a system and apparatus for operating gas discharge tubes of the hot cathode type, and more particularly to a system and apparatus for providing proper values of cathode heating and operating current for starting and operating one or more gas discharge tubes of the hot cathode type.

In some instances, and particularly when the gas discharge tube is small, satisfactory regulation of cathode heating current and operating current is obtained through the use of only a single properly designed choke coil connected in series with the tube. However, in other instances, such as when larger tubes are used or when a condenser is connected in series with the tube, the regulation provided by the usual type of choke coil is not as satisfactory as it should be.

It is an object of this invention to provide a system and apparatus for starting and operating a hot cathode gas discharge tube which provides improved regulation of the cathode heating current of the tube.

Another object of this invention is to provide a system and apparatus for starting and operating one or more hot cathode gas discharge tubes which provides a greater range of control of the relation of starting and operating currents for the tube or tubes than can be accomplished by the use of only a choke coil for effecting the control.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred embodiment of the present invention is clearly shown.

In the drawing:

Figure 1 is a schematic circuit diagram disclosing a preferred embodiment of the present invention which is adapted to the operation of a single gas discharge tube;

Figure 2 is a schematic circuit diagram of a similar system adapted to the operation of a plurality of gas discharge tubes; and

Figure 3 is a diagrammatic representation utilized in the explanation of circuit operation.

Having particular reference to Figure 1, a transformer 10 has a core 12 and windings 13 and 14. The winding 13 is preferably an auto transformer winding, although it is understood that the primary and secondary portions thereof may be separated or segregated. The winding 14 is an auxiliary secondary winding. The winding 13 has a primary portion 17 which is connected to power supply line leads 15 and 16. The end or terminal of the winding 13 which is con-

nected to the power supply line lead 15 is also connected to one side of a cathode 18 of a gas discharge tube 19 which is preferably of the hot cathode type, such as a fluorescent lamp. The other end of the winding 13 which is the other output terminal thereof is connected through an iron core reactor or choke coil 20 to one side of another cathode 22 of the gas discharge tube 19. The other side of the cathode 18 is connected to one end of the auxiliary secondary winding 14. The other side of the cathode 22 is connected to a switch 23 and through that switch to the other end of the auxiliary secondary winding 14, when the switch is closed.

Referring to Figure 2, reference numerals similar to those previously used refer to like parts which operate similarly. In this circuit, an iron core reactor or choke 25 and a condenser 26 are connected in series and between one end or output terminal of the winding 13 and one side of the cathode 22a. A second choke coil or iron core reactor 27 is connected between the end or terminal of the winding 13 which is connected to the choke coil 25 and one side of a cathode 28 of a second gas discharge tube 29. One side of another cathode 30 of the gas discharge tube 29 is connected to the power supply line lead 15. The other sides of the cathodes 28 and 30 are connected to a switch 32, so that when the switch is closed the cathodes are connected in series.

In the operation of the circuit shown in Figure 1, the switch 23 is closed when the line circuit through the leads 15 and 16 is closed for starting the lamp. This completes a series circuit through the cathodes for effecting preliminary heating thereof. When this series heating circuit is closed, the potential drop across the reactor 20 is almost equal to the applied potential from the output terminals of the transformer winding 13, because the resistance of the cathodes is low. The reactance of iron core choke coils of the type utilized with gas discharge tubes becomes smaller for higher current values. If, due to saturation, the reactance of this choke becomes too small during the time it is connected in series with the low resistance cathodes, the resulting starting current will be too high and will shorten the cathode life. By connecting winding 14 into the starting circuit, as shown, the total applied voltage is reduced, because this winding is connected in such a way that it opposes or reduces the resultant voltage across the choke coil. By proper choice of the opposing voltage provided by the auxiliary

winding 14, a desired value of starting current is obtained. The switch 23 remains closed for only a short period, sufficient for the heating of the cathodes. When that switch is opened, mechanically, electrically or manually, the auxiliary winding 14 is disconnected from the circuit and the proper operating potential for effecting initial discharge is applied across the cathodes. After the commencement of the discharge, the reactance of the choke coil or reactor 20 assumes a value depending upon the current flow there-through during operation to limit the current flow through the gas discharge tube.

In the control of two fluorescent lamps or gas discharge tubes, as indicated in Figure 2, the switches 23 and 32 are closed at the time potential is initially applied by the closing of the circuit from the power supply line leads 15 and 16. As in the circuit shown in Figure 1, this closes a series heating circuits through the cathodes of the gas discharge tubes 19a and 29.

The circuit from the output terminals of the transformer winding 13 through the choke coil 27 to the gas discharge tube 29 is similar to the circuit shown in Figure 1, except that the auxiliary winding has been omitted from the series circuit between the tube cathodes. Such omission of the auxiliary winding from the cathode circuit can be accomplished when the characteristics of the choke coil 27 are such as to provide proper reactance characteristics, sufficiently to limit the heating current through the cathodes. In case, however, a choke coil having characteristics such as those assumed for the choke coil 20 of Figure 1 are encountered in the choke coil 27, a second auxiliary winding may be added to the transformer to make the circuit of the gas discharge tube 29 the same as the circuit provided in Figure 1 for the gas discharge tube 19.

The characteristics and operation of the circuit of the gas discharge tube 19 are somewhat different than the characteristics and operation of the circuits of the gas discharge tubes 19a and 29 of Figure 2, because of the addition of the condenser 26 which provides capacitive reactance in the circuit of the gas discharge tube 19a to improve the power factor of the combination of the circuits of the two lamps and to dephase the light pulses of the two lamps in the circuit. The reactance of the condenser 26 remains constant at the different current values encountered in the operation of the gas discharge tube, and is greater than the reactance of the choke coil 25. The preponderance of capacitive reactance is preferably equal to the inductive reactance of the choke coil 27, so as to provide power factor correction and maximum dephasing of the light pulses between the two lamps. The resultant reactance in the circuit including the condenser and choke coil consists of the capacitive reactance minus the inductive reactance. Since the capacitive reactance is constant and independent of current and the inductive reactance is inversely dependent upon the current, the resultant reactance increases with current.

Figure 3 is provided to clarify the explanation of the reactance values encountered in the branch of the circuit including the choke 25 and condenser 26. The actual value of the capacitive reactance of the condenser 26 is constant for either the starting or operating conditions and is indicated by the vector 38. During the starting or operation of the gas discharge tube, the reactance X_L of the choke coil 25 which is represented by the vector 39, being inductive, coun-

teracts a portion of the capacitive reactance of the condenser 26. For operation of the lamp, the desired reactance X_{c-1} , which is represented by the vector 42 is the difference between the capacitive reactance X_c and the inductive reactance X_L . For the starting condition, however, as shown in the diagram, the capacitive reactance remains unchanged, whereas the inductive reactance reduces somewhat due to an increase in current which results in a value of X_{c-1} which is represented by the vector 43 and is greater than the one obtained for the operating condition, represented by vector 42. Since this resultant reactance X_{c-1} for heating the cathodes is greater than for normal operation of the gas discharge tube, it results in a low starting current. A deficiency in cathode heating current is overcome by an additive voltage of sufficient magnitude to overcome the increased reactance and provide a proper value of starting current. This additional voltage is provided by the auxiliary winding 14a which, in the circuit of Figure 2, is additive with respect to the potential of the winding 13.

From the foregoing discussion and the diagram of Figure 3, it will be understood that even if a choke coil having constant reactance were used in the circuit which includes the condenser, and the values of both chokes were such as to provide proper operating current, the resultant reactance of the condenser circuit would be higher than the reactance of the inductive circuit which decreases during the cathode heating.

It is understood that a transformer having high reactance characteristics may be substituted for the transformer and choke coils which have been shown, and in the case of such a substitution an auxiliary winding on the transformer would be utilized to accomplish results similar to those pointed out with respect to the illustrated circuits.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is:

1. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, a gas discharge tube having therein two filament type cathodes each provided with a pair of end terminals, a power supply line, a transformer having an auto transformer winding and an auxiliary secondary winding, said auto transformer winding having input and output terminals, said input terminals being connected to the power supply line, one of said output terminals being connected to one of the end terminals of one of the cathodes, a reactor connected in series between the other output terminal and one terminal of the other cathode, switch means, and said auxiliary secondary winding being connected to the other end terminals of each of the cathodes through said switch means.
2. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, a gas discharge tube having cathodes therein which are adapted to be heated in operation, a power supply line, a transformer having an auto transformer winding and an auxiliary secondary winding, said auto transformer winding having input and output terminals, a reactor, said input terminals being connected to the power supply line, and said output terminals being connected across the cathodes through said reactor, switch means, and said auxiliary wind-

ing being connected across said cathodes through the switch means so that when the switch means is closed, the potential from the auxiliary secondary winding influences the cathode heating current.

3. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, a gas discharge tube having cathodes therein which are adapted to be heated in operation, a power supply line, a transformer having an auto transformer winding and an auxiliary secondary winding, said auto transformer winding having input and output terminals, a reactor, said input terminals being connected to the power supply line, and said output terminals being connected across the cathodes through said reactor, switch means, and means comprising said auxiliary secondary winding and switch means for supplementing the potential applied to said cathodes from the output terminals during the starting of operation of the illuminating devices.

4. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, a gas discharge tube having cathodes therein which are adapted to be heated in operation, a power supply line, transformer means having a plurality of secondary windings, switch means, and a reactor, said secondary windings, said reactor and said cathodes being connected in series with both secondary windings through the switch means to heat the cathodes when the switch means is closed, and said switch means being adapted to break the series circuit between the cathodes and one of the secondary windings during operation of the discharge tubes.

5. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, a gas discharge tube having cathodes therein which are adapted to be heated in operation, a power supply line, a transformer, a reactor, a switch, said transformer being connected to provide an operating potential across said cathodes through said reactor, and means connecting said cathodes in series for preliminary heating, the last mentioned means including said switch for breaking the series connection between the cathodes, and means which provides a supplementary potential to said cathodes only when the switch means is closed.

6. A system and apparatus for operating gas

discharge tubes of the hot cathode type comprising, in combination, a gas discharge tube having cathodes therein which are adapted to be heated by current flow therethrough prior to the commencement of normal operating discharge within the tube, a reactor, power supply means connected to the cathodes through the reactor, and means for temporarily connecting the cathodes in series for heating, the last mentioned means including a switch and an auxiliary source of potential providing a potential which is additive with the potential applied to the cathodes by said power supply means.

7. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, two gas discharge tubes having cathodes therein which are adapted to be heated in operation, a power supply line, a transformer for applying a proper potential across the cathodes of said discharge tubes from the power supply line, reactors having different reactance values in series with the cathodes of the tubes, means for temporarily connecting the cathodes of each of the tubes in series for heating, the last mentioned means for one of the tubes including an auxiliary source of potential providing an alternating current potential geometrically additive with the potential from said transformer when the cathodes of the said one of the tubes are connected in series.

8. A system and apparatus for operating gas discharge tubes of the hot cathode type comprising, in combination, two gas discharge tubes having cathodes therein which are adapted to be heated in operation, a power supply line, having a primary winding adapted to be connected to the power supply line and a plurality of secondary windings, choke coils, a condenser, one of said secondary windings being connected across the cathodes of one of the tubes through one of the choke coils and the condenser in series and across the cathodes of the other of the tubes through the other choke coil, two switches, the cathodes of the tube having the condenser connected thereto being connected in series for heating through the other of the secondary windings and one of the switches, and the cathodes of the other of said tubes being connected in series for heating through the other switch.

LEOPOLD MAUERER.