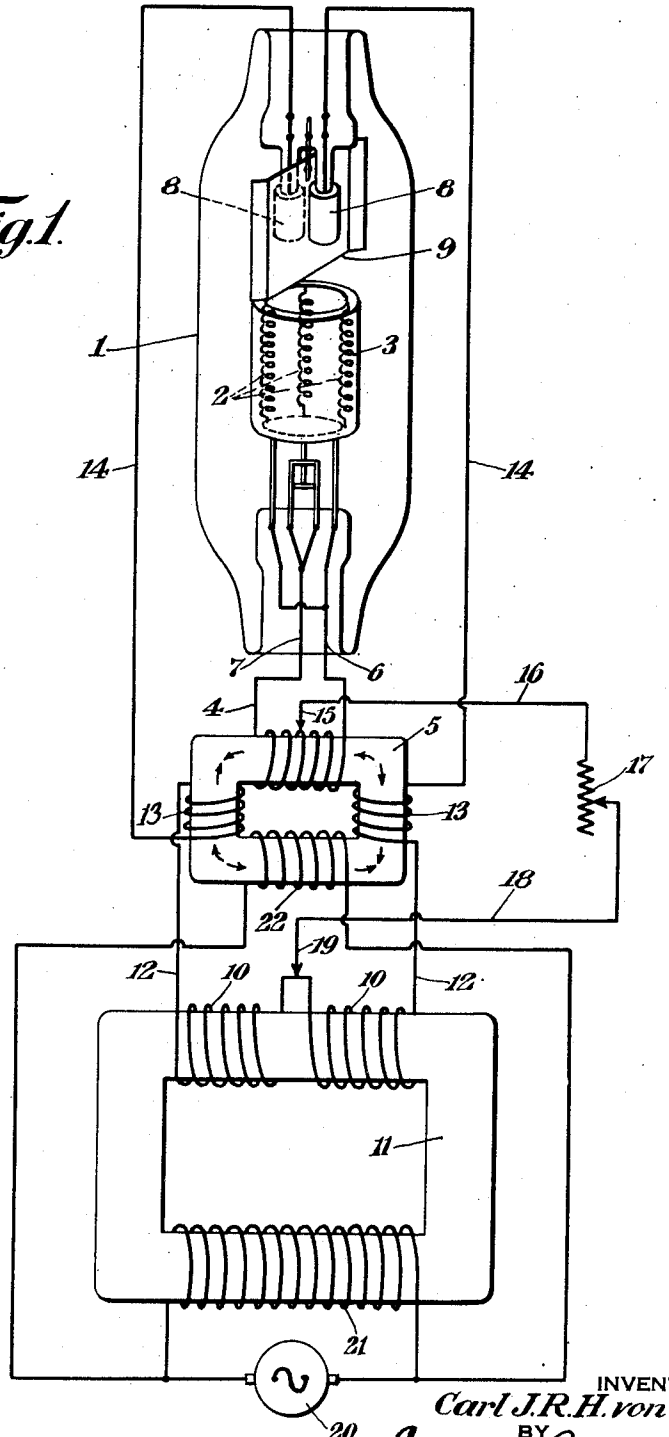
Dec. 10, 1935. C. J. R. H. VON WEDEL 2,023,453

CIRCUIT FOR DISCHARGE TUBES

Filed April 2, 1931 2 Sheets-Sheet 1

Fig. 1.



INVENTOR
Carl J.R.H. von Wedel
BY
Edwards, Bower & Pool.
ATTORNEYS

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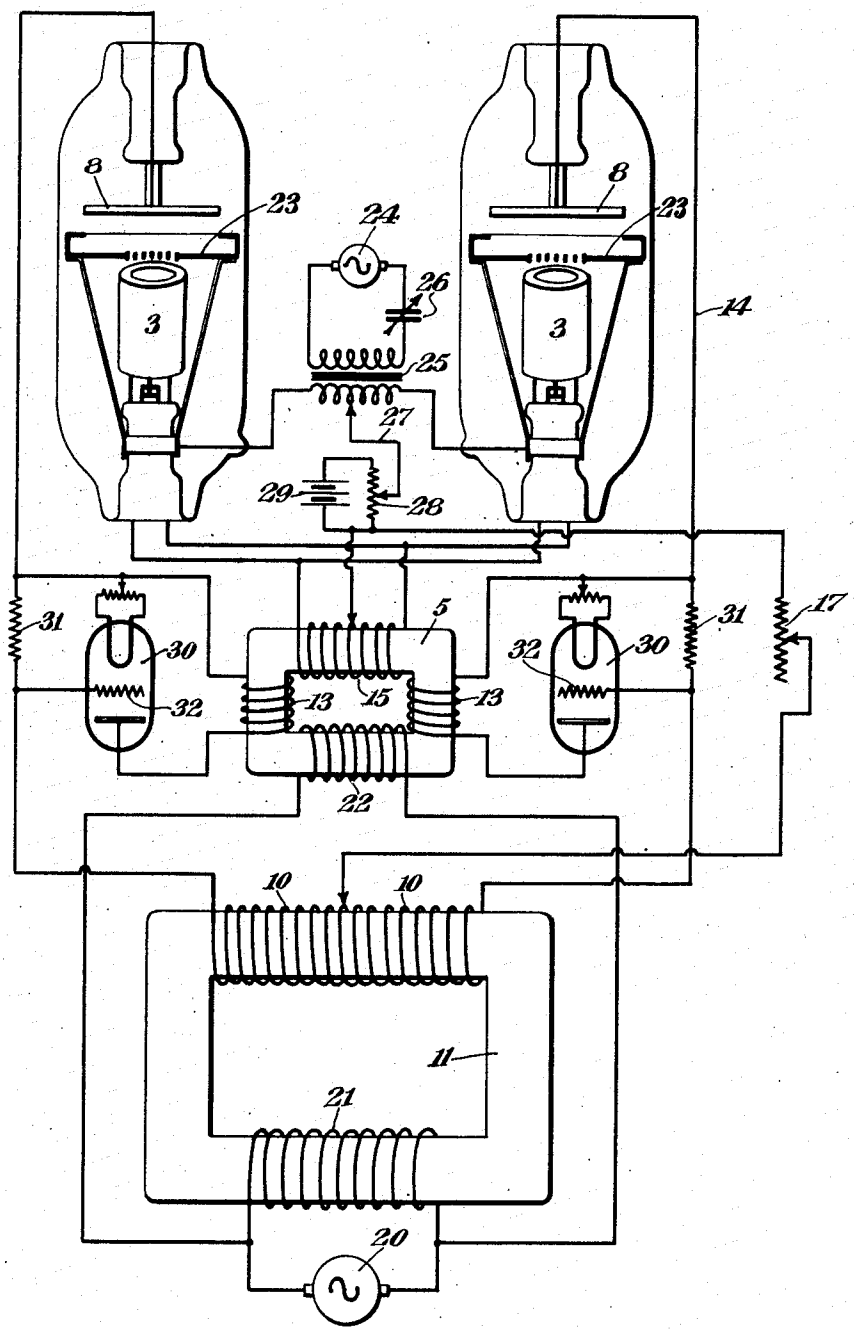


Fig. 2.

INVENTOR
Carl J.R.H. von Wedel
BY
Edwards, Bower & Pool.
ATTORNEYS

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CIRCUIT FOR DISCHARGE TUBES

Carl J. R. H. von Wedel, Newark, N. J., assignor to Electrons, Inc., a corporation of Delaware

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10 Claims. (Cl. 175—363)

This invention relates to discharge tube circuits and has particular reference to circuits for discharge tubes of the gaseous type employing oxide coated cathodes. In the operation of tubes of this character due to various causes, such for example as where used in circuits tending to cause an abnormal rise in the discharge current, as for instance, by reason of surges or change in load, or in some cases by reason of the presence in the tube of structural parts preventing heat radiation, the rise in temperature caused by the rise in discharge current tends to cause a corresponding rise in temperature of the cathode or heater. In certain types of rectifiers, for example those employing the enclosed type of cathode, the rise in temperature thus caused may be a very substantial percentage increase over the normal cathode temperature. Such abnormal rises in cathode temperature tend to cause more or less rapid destruction of the oxide coated cathode, irregularity in starting, or loss of control, or irregularity of control if the tube be of the grid controlled type of rectifier.

The object of the present invention is to protect the oxide coated cathode from overheating due to increase in value of the discharge current. The invention will be described with reference to the embodiments thereof shown in the accompanying drawings, in which

Fig. 1 illustrates one embodiment of the invention, and

Fig. 2 illustrates a modification.

Referring to Fig. 1, 1 represents the outer shell of a discharge tube containing a gaseous medium, preferably argon, although mercury or a mixture of argon and mercury may be employed. The cathode comprises one or more heater coils 2, 2, 2, coated with a suitable electron emissive coating. I prefer a coating of the type comprising a mixture of an alkali earth metal, such as barium oxide, and one or more of the oxides of metals of the amphoteric group less acid than titanic acid, such for example as aluminum oxide, zirconium oxide or the like, the mixture being heated in a vacuum to form an emissive coating highly resistive to ionic bombardment. The cathode also preferably comprises the enclosing can or shield 3 which in this case is cylindrical in form, surrounding the cathode, the upper ends of the coils 2 being connected to the upper circumference of the can 3. The heating circuit includes the secondary coil 4 of a transformer 5, conductor 6 connecting the transformer secondary with the can and conductor 7 connecting the coils 2 with the secondary 4, thereby forming a complete heating circuit.

In the form shown the rectifier is of the full wave type. The anodes are indicated at 8, 8 separated by a shield 9, one of the anodes being shown in dotted lines by reason of being behind the shield 9. The anodes may be of suitable construction although I prefer hollow carbon cylinders. The anodes are energized by coils 10, 10 of transformer 11, the circuit of the anodes being from coils 10, 10 by way of wire 12 through coil 13, wire 14 to anode 8, thence to the cathode and from the midpoint 15 of the cathode heating coil 4 by way of wire 16 to the load, which in this instance is represented as a variable resistance 17, and wire 18 to the midpoint 19 of the coils 10, 10 on transformer 11. An alternating current source of supply 20 is connected to the primary 21 of transformer 11 and to the primary 22 of transformer 5.

The primary and secondary voltages of the transformers will be designed to give the desired heating and discharge voltages, and currents. As an example, in a normal case the coil 4 would be designed to carry a normal heating current of about 16 amperes at 2½ volts, heating the cathode coating to about 850° centrigrade. The coils 10, 10 of the main transformer will be designed to give a maximum peak voltage of about 180 volts and to carry current commensurate with the normal load of the tube of ten amperes.

The coils 13, 13 on the transformer core 5 are wound to oppose the coils 15 and 22 whereby the magnetic flux created by coils 13, 13 will oppose that created by coil 22, as indicated by the arrows in the drawings. The coils 13, 13 are so designed that at low load of the tube the opposition to the coil 22 will be so balanced that the normal heating current is permitted in coil 15, but upon rise of current in the anode circuits, they will oppose any increase of current in coil 15 and hence oppose further increase in temperature of the emitting surface of the cathode due to the combined heating current and discharge effects.

In the operation of the tube the values of the several coils of transformer 5 are adjusted to give the normal cathode heating current. If now the load increases, or for other reason, the plate circuit draws more current, tending to give rise to a larger current value in the discharge, the rise of current in coils 13 will oppose the current in the heating coil 15 and so hold the cathode at its normal temperature.

The heating transformer being separated from the main discharge transformer may be designed for only relatively small power, for example, about 40 watts, as compared with about 1250 watts for the main discharge transformer. Therefore, only a very small fraction of the discharge energy is required to regulate the heating current, and the output potential of the tube will be reduced by a negligible degree only. Where it is not desired to reduce the heating effect, but to maintain the same constant, upon increase of load, the heating transformer may be designed so that under full load conditions it operates near the upper bend of the saturation curve of the iron core. In this case the coils 13 should be so wound that the current induced in them by coil 22 will add to the discharge voltage of transformer 11. Then, if the discharge current increases, the transformer 5 automatically will cause a drop in voltage across the heating coil 15, so that the combined heating effect of the discharge current and the heating current on the cathode 3 can be maintained constant without materially affecting the output of the discharge tube. This also permits the use of a low loss type of transformer 11 which will be able to take care of over loads without diminishing the output voltage of the tube.

In the modification shown in Fig. 2, the rectifiers are of the grid controlled type. In this case, two single wave rectifiers are shown. In each rectifier, 3 represents the cathode, preferably of the same construction as that before described. 8 is the anode and 23 is the grid. The cathodes, as in the case shown in Fig. 1, are energized from coil 15 of transformer 5. The anodes are energized from coils 10, 10 of transformer 11, and both transformers are excited from a source of alternating current 20. The grids are controlled in any suitable manner. I prefer the arrangement shown in the drawings in which 24 is a source of alternating current of the same frequency as that of generator 20. It may be derived from generator 20 if preferred. This frequency is impressed upon the grids by means of a transformer 25 and may be adjusted to be out of phase with the main current. For this purpose a variable condenser 26, or other suitable means, may be employed. The grids are connected to the midpoint of coil 15 by conductor 27 leading through a variable resistance 28 and battery 29, whereby a direct current voltage is superimposed upon the out of phase alternating current and thereby the starting point of the tubes is determined.

By this arrangement the discharge current indirectly, through the relays 30, controls the heating current of the main discharge tubes, and the output current is not affected by the control of the heating current. Preferably the heating transformer 5 is of the saturated core type before mentioned. The coils 13 are shunted by variable resistances, shown as tubes 30 in this case. In the plate circuits 14 of the rectifiers are included suitable impedances 31, which are also connected between the cathodes and grids 32 of the tubes 30. In case the discharge current of the main rectifiers increases, then the grids 32 become more positive and the tubes 30 have less resistance, causing more current to flow in the coils 13 of transformer 5. In this way the transformer will automatically drop its heating coil voltage and the heating current for the main rectifiers will be reduced with increasing main discharge current.

If preferred, similar grid controlled rectifiers 30, 30 may be employed to control the current passing through coils 13, 13.

By suitably proportioning the several coils only a very small percentage change in the discharge current may be made to produce a large percentage change in the cathode heating current; and since in the types of rectifier above described the heating current for the cathode normally may be relatively small compared to the operating discharge current, it will be seen that the average cathode heating current may readily be controlled within very narrow limits. Thus the cathode heating current is controlled without noticeably affecting the load current.

The arrangement in Fig. 2 will render the heating current completely ineffective to affect the load current, because of the negligible energy required to control the grid of the control tube and because of the unidirectional conductivity of the control tube.

While I have shown one method of using a low loss relay connection to so control the heating transformer that it will reduce the heating current with increasing discharge current of the main rectifiers without materially affecting the output potential, other arrangements may be used without departing from the spirit of the invention.

I claim:—

1. In combination, a gaseous discharge tube, a main discharge circuit, a low-loss transformer for energizing said circuit, a heating transfomer, the primaries of said transformers being connected in parallel, a cathode heating circuit supplied from the secondary of the heating transformer, and an auxiliary winding on said heating transformer, the said auxiliary winding being connected in the main discharge circuit and opposing the flux in the heating transformer.

2. A circuit for gaseous discharge tubes comprising one or more discharge tubes, a main discharge transformer for the plate current, a separate heating transformer with a heater winding and an auxiliary winding on the same core, the auxiliary winding being connected to the main discharge circuit in such a way that increasing discharge current decreases the voltage across the heater coil to such extent that the cathode temperature is maintained at a temperature below disintegration and whereby the plate voltage on the discharge tubes is substantially maintained.

3. A circuit for gaseous discharge tubes comprising one or more discharge tubes, a main discharge transformer for the plate current, a separate heating transformer having a heater winding and an auxiliary winding on the same core, the auxiliary winding being connected to the main discharge circuit in such a way that increasing discharge current decreases the voltage across the heater winding to such extent that the cathode temperature is maintained below volatilization of the cathode coating and the plate voltage on the discharge tubes remains substantially constant, said core of the heating transformer being operated near saturation under heating current load.

4. In combination, a gaseous discharge tube, a main discharge circuit, a transformer, a cathode heating circuit supplied from the secondary of said transformer, an auxiliary winding on said transformer opposed to said cathode heating circuit, a grid controlled rectifier, the plate filament circuit of which is connected to the said auxiliary winding and the grid filament circuit of which is controlled by the said main discharge circuit.

5. A rectifier adapted to maintain substantially constant output voltage with varying load resistance, comprising a rectifier tube having relatively low internal resistance, a main transformer for supplying the discharge current the secondary voltage of which is substantially constant under varying loads, a cathode heating transformer the secondary voltage of which decreases with increased load, and an auxiliary coil on the heating transformer connected in series with the secondary of the main transformer and arranged to load the heating transformer thereby reducing the heating energy and increasing the discharge energy.

6. A rectifying system comprising a grid controlled gaseous rectifier tube, a discharge circuit, a control grid circuit and a cathode heating circuit connected to said tube, means in said grid circuit for controlling the starting point of the discharge current in said tube and means for varying the energy in the heating circuit inversely according to the discharge current and thereby maintain the said starting point independent of said discharge current.

7. In combination, a gaseous discharge tube having a thermionic cathode, said tube operating with substantially constant discharge drop with varying discharge currents, a main discharge circuit, a cathode heating circuit, means for energizing the discharge circuit, and means responsive to an increase in the main discharge current to decrease the cathode heating current, the said latter means supplying energy to the discharge circuit in addition to the said energizing means.

8. In combination, a sealed envelope containing an anode, a thermionic cathode of the type heated by electrical currents, and an ionizable atmosphere surrounding said cathode and anode, a magnetizable core, a primary winding on said core adapted to be connected to a suitable source of alternating current, a secondary winding on said core connected to said cathode and adapted to furnish heating current thereto, a load circuit connecting said cathode and anode, and an auxiliary winding on said core included in said load circuit, said core being designed so as to become saturated when the current flowing through said auxiliary winding reaches a certain predetermined value.

9. In combination, a gaseous discharge tube containing an anode and a heatable cathode, a heating transformer having primary and secondary windings, the latter supplying the heating current for said cathode, a main discharge circuit for said tube including a source of anode potential which is independent of said heating transformer, and means responsive to the current in said main discharge circuit for varying the magnetic coupling between said primary and secondary inversely with respect to the main discharge current.

10. A discharge tube system comprising a gaseous discharge tube including a starting control electrode therein, a control circuit for said electrode, a main discharge circuit, a cathode heating circuit, means in said control circuit for controlling the starting of the discharge current in said tube, and means for varying the energy in the heating circuit inversely according to the discharge current and thereby maintain the starting of said tube independent of said discharge current.

CARL J. R. H. VON WEDEL.