March 28, 1950 C. G. SMITH 2,502,236

GASEOUS DISCHARGE DEVICE

Filed Sept. 12, 1945

FIG. 2.

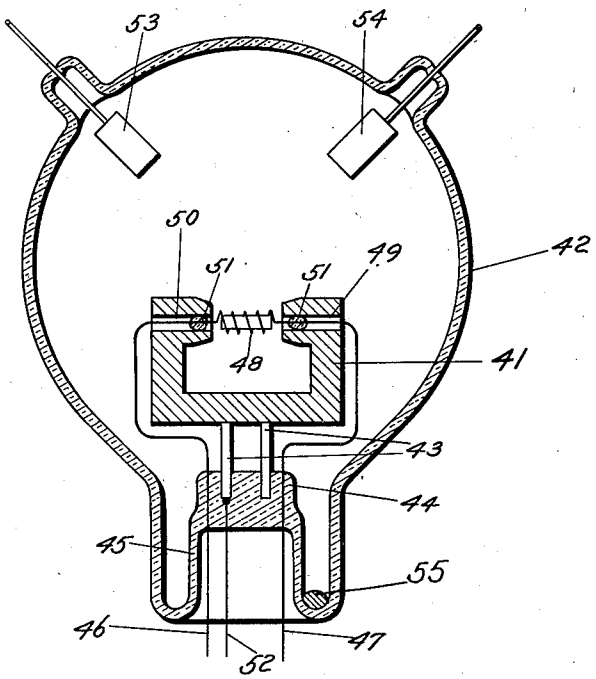
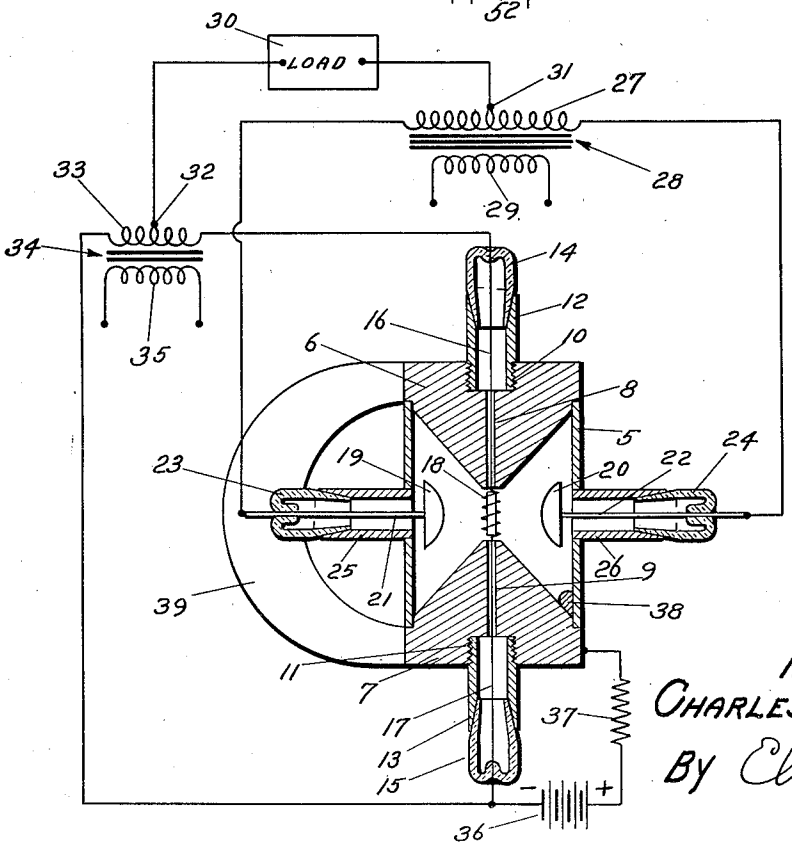


FIG. 1.



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GASEOUS DISCHARGE DEVICE

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6 Claims. (Cl. 250—27.5)

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This invention relates to gaseous electrical discharge devices, and more particularly to gaseous discharge devices of the hot cathode type.

The current carrying capacity of hot cathode gas filled tubes of the type to which the invention relates is limited in practice by the fact that the oxide coated cathods disintegrate rapidly under positive ion bombardment when the ion velocity exceeds a critical value. The ionization potentials of some of the noble gases and of mercury vapor are sufficiently lower than the disintegration voltage to make it possible to design hot cathode arc discharge tubes in which the cathode does not disintegrate, but this requires that the average anode current be kept below the value corresponding to the electron emission from the cathode.

It is among the objects of this invention to provide a hot cathode gaseous discharge device which will carry large currents at moderately low voltages and have long life although the gas or vapor in the tube is at a relatively low pressure.

To these ends the invention contemplates a construction in which the positive ion space charge near the cathode is greatly increased over that which is present in conventional constructions. This end is achieved by the provision of a magnetic field of high intensity in the region immediately surrounding the cathode so that electrons flowing in this region follow a much longer path than they would if the field were not present. The voltage drop between the cathode and the surrounding ionized gas therefore occurs in a very minute space. Voltage gradients of one thousand volts per centimeter or higher are thus obtained.

The above and other objects and features of the invention will be made fully apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawing in which:

Fig. 1 is a sectional view with parts in side elevation of a discharge device embodying the invention together with the circuit diagram thereof; and

Fig. 2 is a sectional view of another embodiment of the invention.

Referring to the drawing and first to Fig. 1 thereof, reference numeral 5 indicates an envelope which, in the instance shown, is a tubular member of non-magnetic material such as copper. The ends of the tubular member 5 are closed by a pair of pole pieces 6 and 7, each having axial passages 8 and 9 extending there-

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through. The passages 8 and 9 are enlarged at the outer ends thereof providing internally threaded portions 10 and 11 to receive the externally threaded pipes 12 and 13 which are hermetically sealed therein. The outer ends of the pipes 12 and 13 are sealed by glass seals 14 and 15. Cathode lead-in conductors 16 and 17 are sealed through the glass seals 14 and 15 and extend through the axial passages 8 and 9 to provide lead-in conductors and supports for the cathode 18. The cathode 18 is of the permanently energized type and may be constructed, for example, of a coil of tungsten wire surrounding a section of thorium. The pole pieces 6 and 7 are provided with truncated conical portions projecting inwardly into the tubular member 5 to points in close proximity with the cathode 18 in order to provide a strong magnetic field, which field is highly concentrated in the annular space immediately surrounding the filament 18. A pair of main anodes 19 and 20 are positioned within the tube 5 in the annular space adjacent the cathode 18, and are supported by lead-in conductors 21 and 22 which extend through pipes 25 and 26 sealed in openings through the tube 5. The outer ends of the pipes 25 and 26 are sealed by glass seals 23 and 24 through which the lead-in conductors and supports 21 and 22 are sealed. The anode lead-in conductors 21 and 22 are connected to the end terminals of the secondary winding 27 of a power supply transformer 28 having a primary winding 29. A load 30 is connected between a center tap 31 on the transformer 28 and a center tap 32 on the secondary winding 33 of a transformer 34 having a primary winding 35. The outer ends of the secondary winding 33 of the transformer 34 are connected to the lead-in conductors 16 and 17 of the cathode 18 for supplying an energizing current to said cathode. A battery 36 having its positive terminal connected through a current-limiting resistor 37 to the tube 5 and its negative terminal connected to one of the cathode lead-in conductors, in this instance 17, is provided in order to bias the pole pieces 6 and 7 positive relative to the cathode 18. In the instance shown, a small quantity of mercury 38 is provided in the envelope 5 sufficient when vaporized to provide a gas filling within the envelope having a pressure of the order of 10 microns more or less. A filling of a permanent gas may be used in conjunction with the mercury, or such gas may be used alone where desired.

In the operation of the device described in

the foregoing, when the cathode 18 is heated to a temperature at which there is appreciable thermionic emission, a small ionizing current flows between the ends of pole pieces 6 and 7 and the cathode 18, due to the potential difference applied therebetween by the battery 36. The pole pieces 6 and 7 thus function as an auxiliary starting electrode. When an alternating voltage is supplied to the anodes 19 and 20 from the transformer 28, a large current is drawn through the device between the cathode 18 and one or the other of the anodes 19 and 20 depending on which ever of these anodes is positive. Thus, on alternate half cycles, the current flows from the left-hand side of the secondary winding 27 to the anode 19, and thence by way of the cathode 18, the center tap 32 of the secondary winding 33 of the transformer 34, the load 30, to the center tap 31 of the secondary winding 27. On the next succeeding alternation, the current flows through the right hand side of the secondary winding 27 to the anode 20 and thence to the cathode 18 and through the load 30 in the same direction as when the voltage is applied to the anode 19.

The magnetic field between the adjacent ends of the pole pieces 6 and 7 has the effect of causing the electrons in the space immediately surrounding the cathode 18 to follow much longer paths in flowing from the cathode to the anode than they would follow if the field were not present. This results in a much greater ionization of the gas or vapor present in this region. An intense glow is produced in the region immediately surrounding the cathode even when the pressure is very low. The voltage drop between the cathode and the surrounding ionized gas occurs in a very minute space. One thousand volts per centimeter and much higher gradients are possible. An atom of thorium attempting to leave the region will in general be ionized and immediately drawn back to the cathode. Thus the magnetic field so increases the degree of ionization and the voltage gradient that the loss of active cathode material is greatly reduced. Thus much higher currents may be drawn without destroying the cathode than are otherwise practical. Furthermore, auto-electronic emission becomes appreciable at the higher current densities and higher magnetic field strengths. Thus, at moderate intensities of the magnetic field, the cathode is operative in regions of lower pressure than normally expedient. Where the field is of high intensity, the cathode is operative under conditions of greater emissivity than normally practical.

In operating with a very intense magnetic field I prefer to use a bare tungsten or tantalum cathode which can be operated at higher temperature than is normally practical and the voltage gradient at the emitting surface makes possible additional thermionic emission, with a resulting discharge giving an apparently unlimited cathode emission or causing an approach to such conditions.

The magnetic field may be derived from a permanent magnet such as 39 connecting the outer ends of the two pole pieces 6 and 7. Obviously, instead of a permanent magnet, an electromagnet may be utilized. It will be understood that where the device is to be utilized as a half wave rectifier rather than a full wave rectifier, only one main anode 19 or 20 and its corresponding connections need be provided.

In some instances I prefer to dispose the magnet within the evacuated space of the envelope. In Fig. 2 a permanent magnet 41 is disposed within the envelope 42 being positioned by support 43 in a press 44 of a reentrant stem 45. The lead-in conductors 46 and 47 sealed through the press 44, supply the cathode 48 with energizing current. In order to support the cathode 48 in a position coaxial with the magnetic field provided by the magnet 41, the pole pieces of said magnet may be provided with longitudinal bores 49 and 50 through which the lead-in conductors 46 and 47 extend to support the cathode 48. In order to maintain the lead-in conductors 46 and 47 in spaced relation to the interior walls of the bores 49 and 50, one or more glass beads 51—51 or equivalent spacing devices may be provided in each of the bores 49 and 50. In order to supply a positive potential to the magnet 41 relative to the cathode 48, a lead-in conductor 52 is provided, which conductor is sealed within the press 44 and connected to one of the supports 43 for the magnet 41. Anodes 53 and 54 are positioned in the envelope 42 in the space outside of the field of the magnet 41. A small quantity of mercury 55 provides an ionizable medium of relatively low pressure within the envelope 42 when the tube is in normal operation. As in the construction previously described, other ionizable mediums may be utilized.

It will be understood that the external circuit of the form of the device shown in Fig. 2 may be identical with the circuit shown in Fig. 1, and when so connected the operation of the device as a rectifier will be the same as the operation previously described in conjunction with Fig. 1. It will be understood that instead of functioning as a rectifier, either tube may be utilized as an oscillator, or for other purposes.

While there have been herein described certain preferred embodiments of the invention, other embodiments within the scope of the appended claims will be apparent to those skilled in the art from a consideration of the embodiments shown and the teachings hereof. Accordingly, a broad interpretation of the appended claims commensurate with the scope of the invention within the art is desired.

What is claimed is:

1. A gaseous conduction device comprising an envelope containing an ionizable medium, a cathode of the heated type having an electron emissive surface in said envelope, a main anode spaced from said cathode and providing an electron path therebetween, and means, for returning to said cathode surface electron emissive material thrown off therefrom, comprising a magnetic field concentrated in the space immediately surrounding said cathode surface, said field extending transversely to the normal direction of electron flow between said cathode and said anode.

2. A gaseous conduction device, comprising an envelope containing an ionizable medium, a pair of pole pieces mounted within said envelope and separated by a gap, a cathode of the heated type positioned in said gap, and means for returning electron emissive material thrown off from said cathode surface to said cathode surface comprising means for establishing a magnetic field between said pole pieces across said gap, and a main anode in said envelope spaced from said cathode and from said pole pieces and providing an electron path between said cathode and said anode, said field having its greatest intensity in the space immediately surrounding said cathode and

extending transversely to the normal direction of electron flow between said cathode and said anode.

3. A gaseous conduction device comprising an velope containing an ionizable medium at a pressure of the order of ten microns, a pair of pole pieces mounted within said envelope and separated by a gap, a cathode of the heated type positioned in said gap, and means for forcing material thrown off from said cathode surface back to said cathode surface, comprising means for establishing a magnetic field between said pole pieces across said gap, and a main anode in said envelope spaced from said cathode and from said pole pieces and providing an unimpeded electron path between said cathode and said anode, said field having its greatest intensity in the space immediately surrounding said cathode and extending transversely to the normal direction of electron flow between said cathode and said anode, said pole pieces cooperating with said cathode to maintain an auxiliary discharge in the normal operation of said device.

4. An electron discharge device comprising an envelope containing a cathode of the heated type having a surface comprising electron emissive material, an anode spaced from said cathode, and means, for returning atoms of material vaporized from said cathode to said cathode surface, comprising means for applying a magnetic field across the space surrounding said cathode in a direction transverse to the direction of normal electron flow, and an ionizable medium surrounding said cathode.

5. An electron discharge device comprising an envelope containing a cathode of the heated type having an electron emissive surface, an anode spaced from said cathode, means for applying a potential between said anode and said cathode, and means, for returning to said cathode material vaporized from said cathode, comprising means for applying a magnetic field across the space surrounding said cathode in a direction transverse to the direction of normal electron flow,

and an ionizable medium surrounding said cathode, for increasing the potential gradient surrounding said cathode, whereby electrons emitted from said cathode are accelerated at an increased rate, and ionized particles of vaporized material from the cathode are forced back to said cathode.

6. An electron discharge device comprising an envelope containing a cathode of the heated type and an anode spaced therefrom, means for producing the ionization of material vaporized from said cathode comprising means for applying a magnetic field across the space surrounding said cathode in a direction transverse to the direction of normal electron flow, whereby said electrons are retained in the area surrounding the cathode for an increased length of time and the probability of their striking material emitted from the cathode and ionizing same is greatly increased, means for increasing the electrostatic force between material vaporized from said cathode and ionized by said electrons comprising an ionizable material surrounding said cathode for increasing the potential gradient in the area surrounding said cathode.

CHARLES G. SMITH.

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