Aug. 28, 1934. D. McF. MOORE 1,971,916

GASEOUS DISCHARGE LAMP

Filed Dec. 31, 1930

Fig. 1

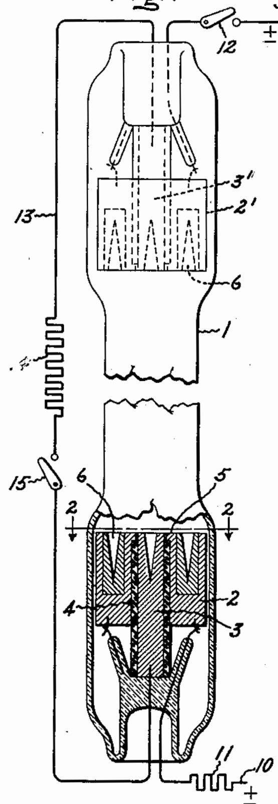


Fig. 3.

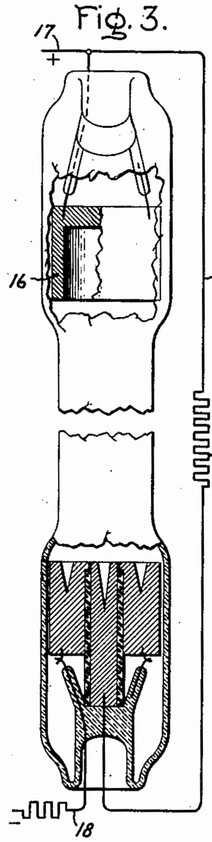


Fig 4-A

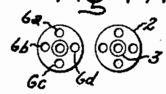


Fig. 4.

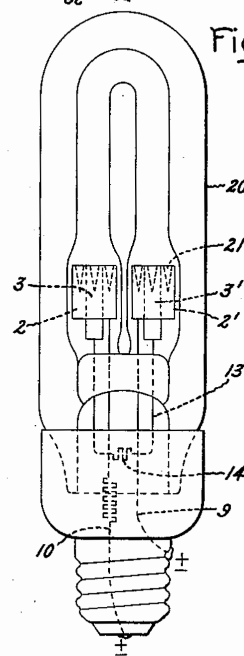


Fig. 2.

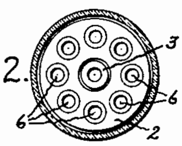
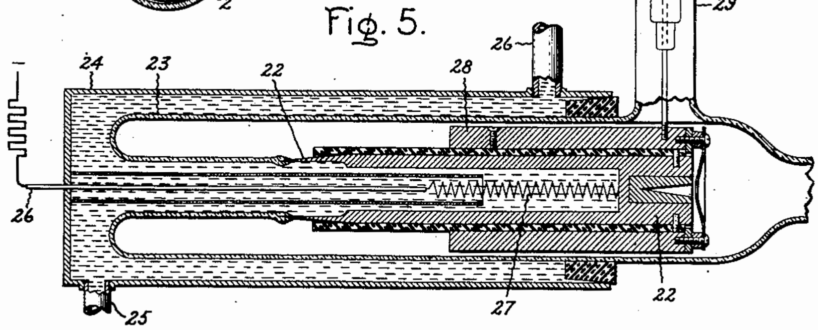


Fig. 5.



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UNITED STATES PATENT OFFICE

1,971,916

GASEOUS DISCHARGE LAMP

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4 Claims. (Cl. 176—126)

The present invention relates to gaseous electric discharge devices of the positive column type, such for example, as lamps in which a luminous discharge is produced in a column of attenuated gas.

When an electric discharge is produced in a gas at low pressure under conditions producing luminosity in a column of gas between the electrodes of the discharge the fall of potential at the cathode depends largely on the production of electrons at the cathode. If electrons are only produced by the discharge between the main electrodes, a relatively high fall of potential occurs at the cathode. In luminous discharge lamps, such as used commonly for display lighting, provided with non-thermionic cathodes, the fall of potential at the cathode is of the order of several hundred volts. Such a high fall of potential is wasteful of energy and renders such lamps unsuitable for operation at commercial lighting voltages.

As a consequence of my present invention I have provided gaseous discharge devices in which an abundant supply of electrons for a positive column gas discharge is generated by an auxiliary discharge, rendering such lamps operable with a cathode fall of potential of about 90 volts. Positive column lamps embodying my invention are operable at commercial distribution voltages without the starting devices heretofore required.

The novel features of my invention will be described in greater detail in connection with the accompanying drawing in which Fig. 1 is a longitudinal section of an alternating current lamp embodying my invention; Fig. 2 is an end view of the electrode structure for one terminal of the lamp shown in Fig. 1; Fig. 3 is a similar view of a direct current lamp; Fig. 4 is a side view partly in section of a modification; Fig. 4A is an end view of the electrodes of Fig. 4; and Fig. 5 is a longitudinal section of a modified water-cooled cathode structure.

The lamp shown in Fig. 1 comprises an elongated envelope 1 consisting of glass, or like material. It has been shown as broken, as ordinarily it is of greater length than can be illustrated on the scale of drawing which has been adopted. It should be understood, however, that the benefits of my invention are obtainable also in lamps having a short positive column.

The envelope contains a suitable filling of gas or a gaseous mixture in which a desired luminous discharge may be produced. For example, the gas charge may consist of neon, preferably admixed with about 3/8% argon, and the gas preferably should be at a pressure within the range of about 10 to 20 millimeters of mercury. In the preparation of the lamp the envelope and electrodes should be freed from deleterious gases in accordance with the known technique. In general, the preparation and nature of the gaseous filling should follow the practice now well understood in the art.

The electrode structure shown at opposite ends of the lamp is a substantial duplicate, hence the structure for but one end will be described, the same reference numerals primed being applied to the structure at the opposite end. The electrode structure at opposite ends comprises an electrode 2 consisting of tungsten, iron, aluminum, copper, magnesium or other suitable metal and encloses an electrode 3 of somewhat greater length, which can also be made of aluminum or copper or tungsten or magnesium or other suitable metal. The two electrodes are separated by a layer 4 of electrical insulation, which may consist of fired magnesium silicate, mica, alumina, or the like. The exposed ends of the electrodes 2, 3 are flush with one another. The inwardly projecting flange 5 of the electrode 2 is separated by a narrow gap or moat from the electrode 3 which preferably is so narrow that no visible discharge occurs in it. Preferably the width of this gap is within the dimensions of the Crookes dark space. Both electrodes are provided with funnel-shaped craters whereby the emission of electrons is facilitated. Only two craters are shown in the sectional view, Fig. 1, in electrode 2, but usually there are eight such craters in a circle as shown in Fig. 2, or four such craters in each electrode, as shown in Fig. 4A, at 6^a, 6^b, 6^c, and so on. The craters may be formed either in the body of the electrode, or in an insert consisting of material of higher electron emissivity than the main portion of the electrode. For example, to facilitate low break down voltage and copious electron emission such insert may consist of, or the walls of the crater may be coated with, an alkaline earth metal, such as magnesium, or barium, or barium azide, or caesium, or a rare earth metal, such as thorium, or cerium, or an alloy such as ferrocerium, or Mischmetal. However when both electrodes 2 and 3 are completely made of such specially selected metal, there is gained the additional advantage that material of the opposing walls of the moat or electron gap assist in current flow at minimum potentials. The craters for most purposes may have a muzzle diameter of about 4/100 to 6/100 of an inch and a depth of about $\frac{7}{16}$ inch.

The electrodes 2 and 2′ at opposite ends of the tubular envelope 1 are connected by the conductors 9, 10 to a suitable source of alternating current, through a suitable series resistance 11, and a switch 12 is shown in the circuit. The electrodes 3, 3' are connected to one another by a conductor 13 containing a resistor 14, or other suitable impedance device, and a switch 15. The two gaps between the electrodes 2, 3 and 2', 3' respectively are connected through the circuit 13 in series across the line when the switch 15 is closed, causing a current of low value to flow over the two electron gaps in series with each other.

The lamps illustrated in the drawing have been shown merely as illustrative of my invention but my invention is broader than the lamps illustrated in the drawing. In general, it may be said that the luminous efficiency of such lamps depends largely on the ratio of the length to the diameter of the positive column formed in the discharge tube connecting to two electrode envelopes. The light production and efficiency in general varies directly with this ratio. For example, with an impressed voltage of 220 volts the maximum efficiency is obtained by using a discharge tube that is as long as practicable and of as small a diameter as practicable for starting and operation at this voltage. The following is one example of such a lamp operable at 220 volts embodying my invention, although a great many modifications may be employed. Such a lamp for alternating current use may be constructed as shown in Fig. 1 the distance between the opposite sets of electrodes being about 12½ inches and the glass discharge tube between them being ⅝ inch in diameter. The diameter of the duplex electrode in the electrode envelope at each end of the lamp is about $1\frac{7}{32}$ inches, the diameter of the inner electrode being about ¼ inch.

No current will flow through the lamp of Fig. 1 when switch 12 is closed until switch 15 in the auxiliary circuit 13 is also closed. The current then flowing across the gaps between the paired electrodes at opposite ends of the lamp produce an emission of electrons sufficient to start and carry the main discharge in the ⅝'' glass discharge tube, although the current through this auxiliary circuit 13 is only about .013 ampere, the resistance 14 being relatively high, for example, about 1000 ohms. Assuming the series line resistance 11 to be about 45 ohms, current through the positive column will be about 0.8 ampere. With a gas filling consisting mainly of neon the resulting positive column discharge gives a brilliant light.

The number of amperes flowing through this positive column of given length and diameter can be regulated by varying either the amount of the series resistance 11 in circuit with the main electrodes or the amount of the resistance 14 in series with the electron-emission gaps at the electrodes. If no resistance is provided in this auxiliary circuit 13 and if the areas of the electrodes exposed in the gaps are too large, then too much current will flow across the gaps, thus deflecting undue amounts of energy from the positive column. In general, it may be said that the current in the auxiliary circuit, the size and shape of the electrodes, and the number of craters in the cathodes should be so chosen that the main current through the positive column is properly maintained.

The direct current lamp illustrated by Fig. 3 differs from the lamp shown in Fig. 1 by the provision of an ordinary anode 16 consisting of nickel, carbon, tungsten, or other suitable conducting material, unprovided with craters or other means for independently emitting electrons. The main electrode 16, 2 of this lamp are connected to a direct current source respectively by the conductor 17, and the conductor 18. In the circuit 13 connecting the electrodes 16 and 3 is a resistor 14.

In the alternating current lamp illustrated in Fig. 4 the discharge tube in which the positive column discharge is produced is bent into the form of a U and is mounted within an outer envelope 20. The craters in the electrodes are shown above the main figure. Four craters are indicated at 21 in the outer electrode 2 but a different number may be employed according to circumstances. The inter-electrode auxiliary circuit 13 and its resistor 14 are embodied within the lamp structure. If the gaps between the two sets of electrodes are suitably proportioned to the rest of the lamp the resistor 14 may be made small and even may be omitted entirely. The electrodes 3, 3' of Fig. 4 may be connected to a suitable alternating supply circuit by the conductors 9, 10 which are shown connected to a conventional lamp base.

Fig. 5 illustrates an electrode structure of a lamp of higher current-carrying capacity which is provided with means for artificially cooling the crater electrodes. The discharge tube has been shown broken away.

The structural features of the cathode shown in Fig. 5 in many respects are similar to the structural features already described in connection with the other figures. It will be noted, however, that the lower end of the cathode 22 terminates in a sharpened rim or edge which is sealed directly to the tubular glass envelope 23. Surrounding the electrode chamber is an outer jacket 24 through which the cooling fluid such as water is circulated through inlet tube 26 and outlet tube 25. An electrical connection to the cathode 22 is made through conductor 26 which terminates in compressible spring 27, the outer end of which makes electrical contact with the electrode 22. Contact to the anode 28 is made through a side arm 29 by anode conductor 30. The glass electrode chamber or envelope 23 is jointed at its right hand end to a tube which is shown broken away and through which the brilliant positive column discharge occurs. A similar structure may be employed at opposite ends of the positive column when alternating current operation is desired and the electrical connections will correspond to those of Fig. 1. Otherwise an ordinary anode, such as shown at 16, Fig. 3, is employed in connection with such a water-cooled cathode on a direct current circuit and the electrical connections will correspond with Fig. 3.

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

1. An electric lamp comprising an envelope, a luminosity-producing gas therein, a main anode, a main anode provided with one or more craters and a cooperating auxiliary cathode located closely adjacent said crater cathode, said auxiliary anode also being provided with one or more craters.

2. An electric lamp comprising an elongated envelope, a discharge-conducting gas therein, cooperating main electrodes at opposite ends of said envelope for supporting a discharge through said gas, one of said electrodes being provided with a crater and an auxiliary electrode also provided with a crater spaced closely adjacent said main crater electrode and electrical connections for said respective crater electrodes whereby in-

dependently of said main discharge an auxiliary discharge may be produced which fills said crater with luminosity.

3. A gas conduction device comprising a closed envelope containing an attenuated gas of good conductivity, a main anode, a main cathode spaced apart a sufficient distance to produce a long positive column discharge therebetween, said main cathode having one or more funnel-shaped indentations in the surface thereof, a third electrode spaced from said main cathode a distance substantially equal to the Crookes dark space and a circuit connected electrically in parallel to the gas space between said electrodes for producing a luminous discharge between said main cathode and said third electrode emanating from one or more of said craters.

4. The combination in an electrical discharge device of a unitary structure comprising an elongated envelope, a plurality of electrodes at one end of said envelope, each having a funnel-shaped crater formed therein, material of high electron emissivity lining the walls of said crater, means for electrically insulating said electrodes from one another, separate leading-in conductors for said electrodes, and another electrode at the opposite end of said envelope.

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