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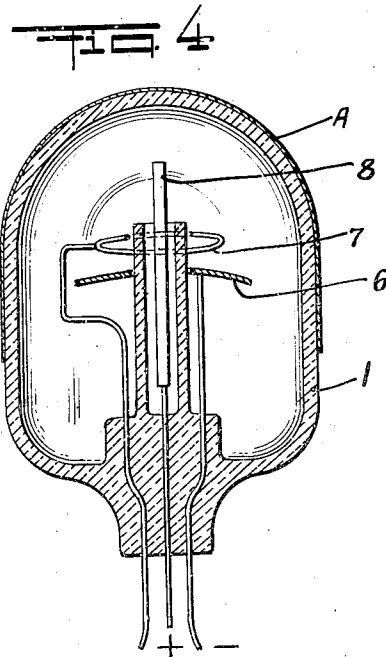
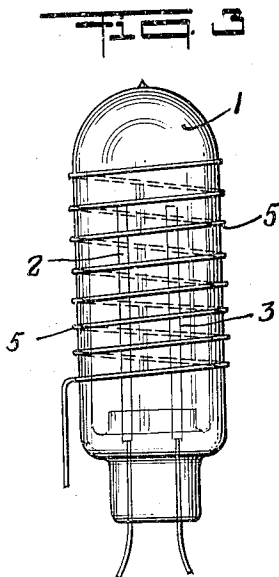
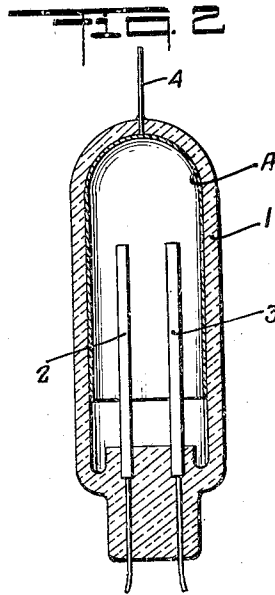
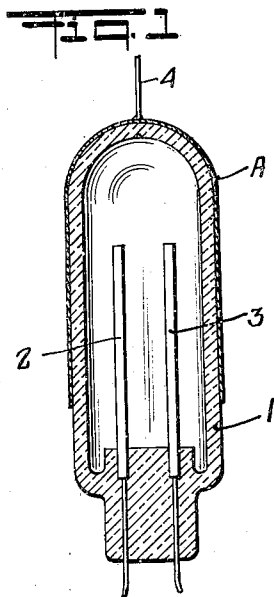
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COLD CATHODE GASEOUS DISCHARGE TUBE

Filed Nov. 23, 1943

2 Sheets-Sheet 1



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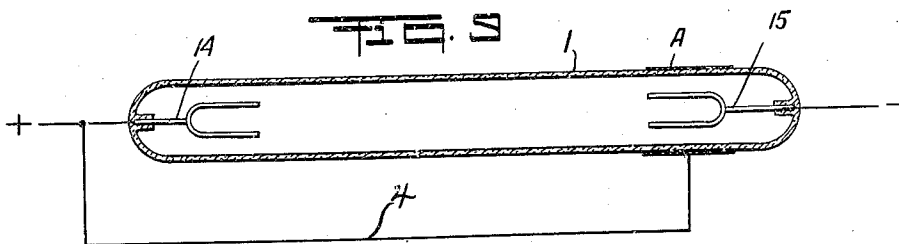
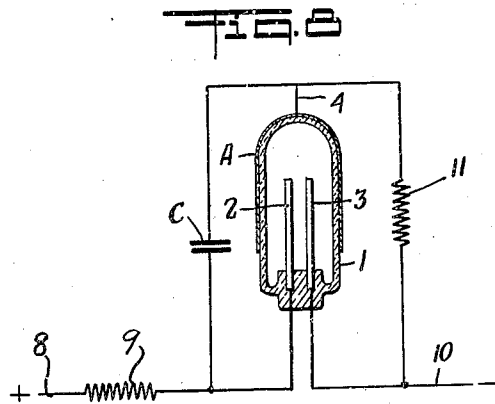
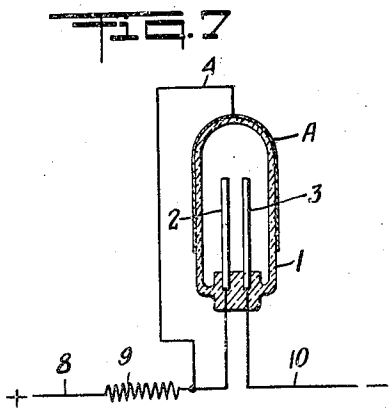
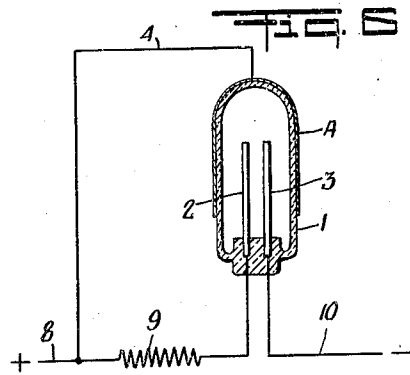
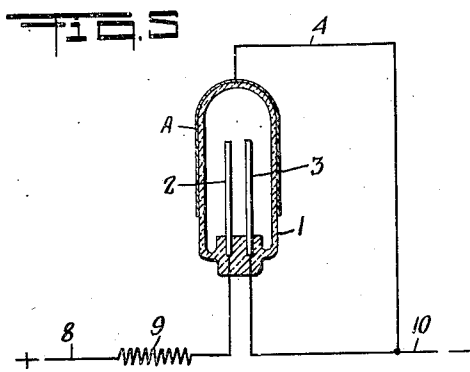
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COLD CATHODE GASEOUS DISCHARGE TUBE

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2 Sheets-Sheet 2



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COLD CATHODE GASEOUS
DISCHARGE TUBE

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1 Claim. (Cl. 250—27.5)

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Our invention relates to improvements in gaseous discharge tubes of the cold cathode type.

The invention relates particularly to cold-cathode gaseous discharge tubes in which the cathode is not independently heated in order to emit electrons. Such tubes have outer walls or envelopes which are made of glass or other material which is either insulating, or which has low conductivity. Such cold-cathode discharge tubes include glow discharge lamps and photoelectric tubes, in which the current is conducted between internal electrodes by ionization.

According to our invention, we apply an auxiliary or wall electrode to the inner or outer face of the non-conductive or poorly conductive envelope of the cold-cathode gaseous discharge tube, and we maintain said wall electrode at a predetermined selected potential, which may be zero or plus or minus.

Numerous additional advantages and objects of our invention will be stated in the annexed description and drawings, which illustrate preferred embodiments thereof.

Fig. 1 is a vertical axial section which shows an imperforate external wall electrode applied to a cold-cathode gaseous discharge tube or glow lamp, of the type which is largely used in switches, relays, in the transmission of pictures by wire and radio, and for many other purposes.

Fig. 2 is a similar section, which shows an imperforate internal wall electrode.

Fig. 3 is a similar section, which shows an external wire electrode. This wire electrode is an example of a perforate wall electrode.

Fig. 4 is a similar section, which shows an external wall electrode which is applied to a grid glow tube. The wall electrode is imperforate.

Figs. 5-8 inclusive, are respective diagrammatic views of respective circuits which embody our invention.

Fig. 9 shows our invention applied to an elongated glow lamp, of the type which is used for illumination.

The glow lamp 1 has an envelope which is made of transparent or translucent glass or other material which is non-conductive or which has low conductivity. The material of said envelope need not be light-permeable.

Said envelope has an internal filling of neon, argon, etc., at suitable low pressure, and cold electrodes 2 and 3. Said electrodes are designated as cold electrodes, because they are not

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heated, save by the heat of the discharge through the gaseous filling. Such glow lamps operate at low temperature.

Without limiting the invention to any details stated herein, the height of the envelope of the glow lamp which is shown in Figs. 1-3, is about 20 millimeters, and the cold electrodes 2 and 3 are made of nickel. The gaseous filling consists of 99% of neon and 1% of argon. At normal temperature of about 20° C.-25° C., the pressure of said gaseous filling is about 20 millimeters of mercury. Each electrode 2 and 3 is a solid nickel cylinder, whose height is 12 millimeters. The diameter of each electrode is 1 millimeter.

The width of the space between said parallel electrodes 2 and 3, is about 2-3 millimeters.

The usual discharge current through such a glow lamp is about one milliampere.

Since such lamps cannot be made with absolute uniformity, the striking voltage will vary with respective lamps.

In an ordinary commercial glow lamp of this type, the striking voltage exceeds the operating voltage by about 15 volts. In order to strike the glow lamp, it is necessary temporarily to apply an overvoltage, which exceeds the striking voltage.

In such a glow lamp, if the overvoltage of about 5 volts is applied after the lamp has been shielded from external light, the striking period may vary between 0.01 second and 0.001 second.

The cold electrodes 2 and 3 suffer little or no disintegration in the glow discharge of such lamp, due to the low discharge current. Such discharge current is kept at a suitable low value by external resistance.

Figs. 1-3 are substantially to scale. The wall electrode may be perforate or imperforate, in any of the embodiments of our invention.

Fig. 1 shows an external auxiliary electrode A, which is imperforate, and which makes tight and air-free contact with the external wall of the envelope, so that there is no air space between electrode A and said wall. Electrode A can be made of metal or of any conductive material. It can be a conductive lacquer or adhesive composition, which contains finely divided particles of graphite, such as "Aquadag." Wire 4 is connected to electrode A.

Fig. 2 shows an internal auxiliary electrode A, which is more expensive to apply, but which is more effective than the external electrode. This contacts tightly with the interior wall of the envelope.

Fig. 3 shows an external auxiliary wire electrode 5, which can consist of a helix of wire, which makes said tight and air-free contact with the external wall of the envelope.

Fig. 4 shows the external auxiliary electrode A applied to a grid glow tube, which has a cylindrical anode 8, which extends through a bore of the cathode 6. Said grid glow tube has a grid or auxiliary internal anode 7. The details of construction of such grid glow tube are not shown, since such tube is well-known.

In Fig. 5, the electrode 3 is the cathode, and it is connected to negative lead 10, to which the auxiliary electrode A is connected by wire 4. Fig. 5 also shows the positive lead 8, and the resistor 9.

In Fig. 6, the auxiliary electrode A is connected by wire 4 to positive lead 8, anterior resistor 9.

In Fig. 7, the wire 4 connects auxiliary electrode A to positive lead 8, succeeding the resistor 9. This is more efficient than the circuit of Fig. 6, because it makes the striking voltage lower after short idle periods.

Fig. 8 shows wire 4 connecting auxiliary electrode A to positive lead 8, succeeding the resistor 9, through capacitance C. The electrode A is also connected to negative lead 10, through resistor 11. As an example, the value of resistor 9 is 10^4 ohms, and the value of resistor 11 is 10^7 ohms, and the capacity of condenser C is 0.001 microfarad. Hence the product CR of the capacity of the condenser and the resistance of the resistor 11, is in the order of 0.01 second.

Fig. 9 shows an elongated glow discharge tube 1, of the familiar "neon" type, which is used on advertising signs, etc. This tube 1 has anode 14, cathode 15 and an imperforate and external wall electrode A which is connected to anode 14, externally of the tube. This electrode A also makes direct and close contact with the external wall of the envelope of the tube 1.

The cylindrical wall electrode A surrounds substantially the entire cathode 15, and it also extends longitudinally beyond each end of said cathode 15. Cathode 15 can be wholly or partially enclosed by wall electrode A.

In Figs. 1-3, the electrode A encloses more than half of the electrodes 2 and 3. This can be varied. We can use an internal or external wall electrode, in any of the embodiments.

In a cold-cathode gaseous discharge tube whose envelope is made of glass or other material which is substantially non-conductive or poorly conductive, said envelope may acquire a definite electric charge, either during a discharge period of the tube, or by slow accumulation of electric charges between discharge periods.

When such tube is not being operated during an idle period, the electric field in the space between the electrodes, and in the space which surrounds the electrodes, is greatly influenced by the amount and distribution of electric charge on the insulating or poorly conductive wall of the envelope. This charge on said wall of the envelope may vary, and said charge influences the striking voltage of the tube. Hence, said striking voltage depends upon many variable factors. Said factors include the intensity of previous discharges, the idle period since the last discharge, the voltage which is applied to the electrodes before the tube is struck, and electrical leakage on the outer surface of the envelope, which varies with the humidity of the surrounding atmosphere.

We have discovered that the substantial and non-uniform effect of accumulated electric charge

on the wall of the envelope may be eliminated or minimized by means of an auxiliary electrode. We thus eliminate or minimize the effect of said accumulated electric charge on the striking voltage, and also to a less extent, on the functioning of the gaseous discharge tube.

The auxiliary electrode is designated as a wall electrode. It may abut the inner face or the outer face of the envelope, in the zone which surrounds the main electrodes of the tube, between which the discharge takes place. The wall electrode may be continuous, such as an imperforate coating, or it may consist of separated lines or points, as by using a conducting grid or by means of suitably distributed metal wire.

The auxiliary electrode can be optionally permanently electrically connected either to the cathode or to the anode of the gaseous discharge tube, or it may be electrically connected directly or indirectly to any point of the circuit of the main electrodes. Such electrical connection may be by means of resistors, capacitances, etc.

The wall electrode stabilizes the striking voltage, especially if the gaseous discharge tube is shielded from external light during idle periods, so that it receives no light during idle periods between successive discharges thereof. In addition, by means of said wall electrode, the striking voltage is lowered, and there is an increase in sensitivity and regularity of striking, especially when the tube is struck by applying an overvoltage thereto during a short period. If the overvoltage only slightly exceeds the striking voltage, the wall electrode diminishes the delay in striking the tube, when such small overvoltage is applied.

Said auxiliary wall electrode is not merely an electric shield which protects the tube from external electric influences, because the close and preferably air-free contact of said auxiliary electrode with the insulating or poorly conductive wall of the envelope is essential, or at least, highly desirable.

When the auxiliary electrode contacts with the external face of the envelope, it can remove or neutralize any charge on the envelope, including any charge on the interior face of the envelope, by reason of the conductivity of the envelope, even though such conductivity is small. The inner face of the envelope may collect a charge from the gaseous ions. A sharp change in the applied voltage of the auxiliary electrode can neutralize such interior charge, due to the capacity between said inner face and the external wall electrode.

The striking voltage of a gaseous discharge tube or lamp is diminished by a few volts, below the normal striking voltage which is ordinarily required if no wall electrode is used, if the wall electrode is connected to the anode of the lamp. Such striking voltage is lower than if the wall electrode is connected to the cathode of the lamp. Hence we prefer to apply a positive biasing voltage to the wall electrode, although the invention is not limited to this feature.

When a gaseous discharge tube is kept in darkness during an idle dark period of several hours between consecutive discharges, the required striking voltage is increased. When a wall electrode which is connected to the anode is used, such increase of striking voltage which results from an idle dark period is diminished.

As an example, in the tube illustrated in Fig. 1 herein, the striking voltage is increased from about 75 volts to 95 volts, if said tube is shielded from light during an idle dark period of fifteen

hours between consecutive discharges, if the wall electrode is omitted. By using a wall electrode which is connected to the anode, the increase in striking voltage during said dark period is from about 75 volts to about 80 volts.

The striking voltage of a gaseous discharge tube which has a wall electrode, is not completely determined by the voltage which is applied to the wall electrode at the time of striking. The voltage which was applied to the wall electrode, at the previous striking, also has an important effect.

For example, the striking voltage of a tube of the type of Fig. 1 may be 77 volts if the wall electrode was connected to the cathode during the next preceding discharge. If the wall electrode was connected to the anode during the next previous discharge, the striking voltage is 94 volts.

If the lamp is struck by a sharp overvoltage, while simultaneously sharply increasing the positive potential of the wall electrode, the delay in the striking period is diminished, and the required striking voltage is also diminished. This makes it possible to strike the lamp, even after a long idle dark period, by means of a very slight overvoltage.

The invention also applies to gaseous photoelectric tubes, which have a small amount of gaseous filling. Since such photoelectric tubes are well-known, specific illustration in the drawings is not necessary.

A photoelectric tube has a light-sensitive cathode, which may be a coating on the inner face of the glass envelope, or which may be spaced internally from said inner face. Said photoelectric tube also has an anode which is spaced from the cathode. The light is transmitted through the glass envelope to the cathode.

The internal resistance of a photoelectric tube varies generally in accordance with the intensity of the light-energy which is received by the cathode.

We provide the external face of the glass envelope, in a location near the cathode, including a position in front of the cathode, with a wall electrode.

If such wall electrode is applied in the path of the light which energizes the cathode, such wall electrode is perforate, like the wall electrode in Fig. 3 herein.

Such wall electrode, if positively biased, makes the photoelectric tube more sensitive, so as to produce a larger current flow for the same intensity of received light-energy, and it causes the current of said photoelectric tube to be closer in phase to the energizing light, if the energizing light is modulated or interrupted.

Our invention therefore applies to any tube of the cold-cathode gaseous conduction type, including photoelectric tubes.

The wall electrode should cover sufficient area, substantially to prevent the accumulation of electric charge on the wall of the envelope.

When we refer to a biased wall electrode, we refer to an electrode which has a positive, nega-

tive or zero electrical bias. Said wall electrode may be at zero potential.

Our invention is particularly useful in operating glow discharge lamps which are enclosed in light-impermeable boxes or casings, as in various types of relay devices.

Our invention applies to a glow discharge lamp or other cold-cathode gas discharge lamp which is operated by alternating current, in addition to a glow discharge lamp which is operated by direct current.

In operating the circuits disclosed herein, by means of direct current, we can ground either the plus terminal or the negative terminal of the source of direct or unidirectional current.

If we wish sharply to increase the positive voltage of the wall electrode, we use the circuits of Figs. 6-8. For example, in Figs. 6 and 7, the wall electrode is connected to the positive side of the power supply. We can also use the circuits of Figs. 6-8, in operating the lamp by alternating current. If the lamp is operated by alternating voltage, it acts as a rectifier to some extent, because the striking voltage will be smaller during the half-cycle in which the voltage of the wall electrode is positive. It is well-known to ground one of the supply mains of an electric power circuit, especially a circuit which delivers alternating current.

We have described preferred embodiments of our invention, but it is clear that numerous changes and omissions and additions can be made without departing from its spirit.

We claim:

A cold cathode discharge tube which has an internal anode and an internal cathode, a positive lead connected to said internal anode, a resistor located in said positive lead external to said tube, a wall electrode upon the wall of said tube, said wall electrode being connected to said positive lead at a point between said resistor and said anode.

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