May 23, 1939. H. J. SPANNER 2,159,824

DISCHARGE DEVICE

Filed Nov. 6, 1937

Fig. 1.

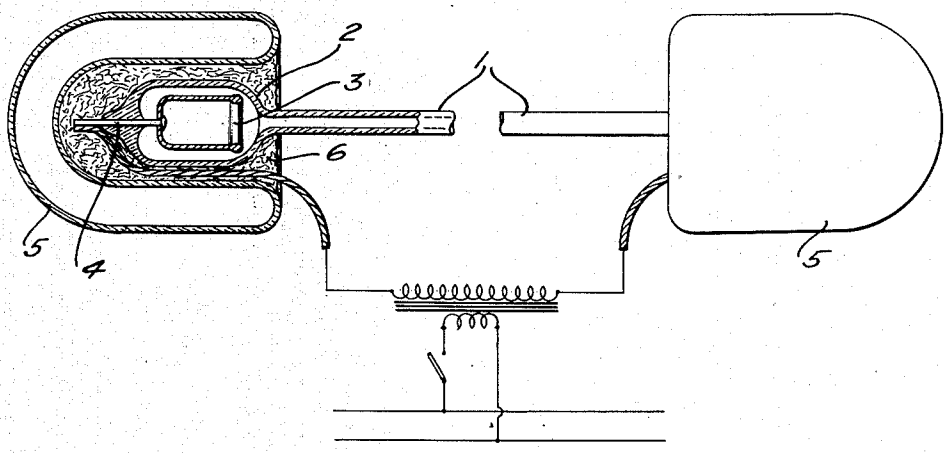


Fig 2.

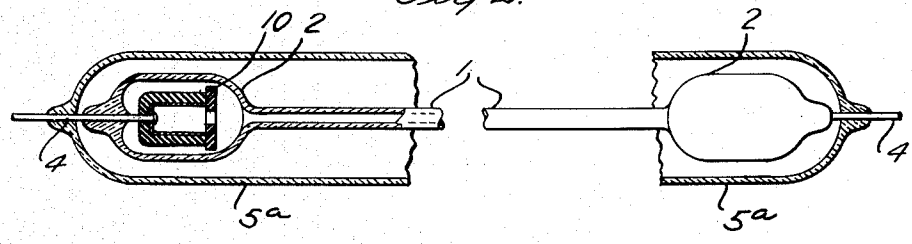
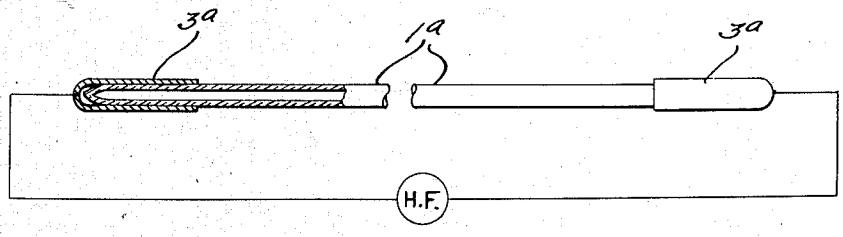


Fig. 3.



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DISCHARGE DEVICE

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5 Claims. (Cl. 176—124)

This invention relates to vapor discharge devices and more particularly to vapor discharge devices of the high pressure type in which the voltage consumption of discharge is increased after the discharge is initiated by vaporization within a confined space in which the discharge occurs.

Prior to my present invention it has become known that great improvement in efficiency and convenience of operation could be obtained in hot cathode discharge devices by vaporizing a material such as mercury within the confined space in which the discharge occurs and to such an extent that the voltage drop of the discharge is increased almost to the starting voltage. This is more fully described and claimed in the copending application of Edmund Germer, Serial No. 500,346, filed December 5, 1930. This invention has now gone into wide commercial use and is a commonplace in the art. Notwithstanding this it has not been considered practicable heretofore to apply the invention in so-called cold cathode or independent discharge devices such as are commonly referred to as Geisler tubes and are universally known and used in display lighting.

I have now discovered that it is possible to utilize this principle in tubes designed for independent discharge with relatively cool electrodes, i. e., electrodes which are adapted to sustain a discharge when cool, i. e., below incandescence by electrical potential applied to the gaseous atmosphere rather than by spontaneous emission of electrons from the electrode, (which for convenience I shall refer to as "cool electrode type devices"), and that such tubes utilizing the high pressure principle are possessed of important advantages as compared with the common low pressure tubes and, for some purposes, even as compared with the ordinary hot cathode high pressure tubes.

These cool electrodes may show some scintillations, but remain below incandescent temperatures and operate in general near the temperature of the vapor.

Tubes of my invention being essentially of the cool electrode type, necessarily operate at high voltage and relatively low current loading, e. g., of the order of milliamperes, for example from a fraction of a milliampere to several hundred milliamperes. Because of the relatively high voltage drop in the cool electrode it is important, if good efficiencies are to be obtained, that the tube should be relatively long in order that as large a proportion as possible of the total voltage consumption may occur in the discharge path rather than in the electrodes themselves. This consideration has been recognized in ordinary engineering practice in the construction of independent type tubes. In commercial practice, however, there are practical limitations to the length which can be given to any tube, and frequently it is necessary to be content with a lesser efficiency rather than to increase tube lengths. It is an advantage of my present invention that the tube lengths which are most convenient for practical reasons may nevertheless provide the desired high proportion of voltage consumption in the discharge path by increasing the voltage by vaporization in the tube after the discharge is started, and the efficiency is still further increased by raising the voltage to near the starting voltage. It is an advantage of the present tubes as compared with high pressure arc tubes that they may be used like ordinary low pressure display tubes, e. g., neon signs, by bending into designs, letters or words or to give a light distribution an extended area with relatively low wattage or intensity per unit length. If greater concentration of light is desired the tubes may be bent into spirals or other form as is known, e. g., for neon tubes.

It had not heretofore been thought possible to attain high pressure in the devices of the cool electrode type because of the low current loading and the large surface area resulting from their great lengths and from the fact that the electrode in order to have a satisfactory light must necessarily have a large surface area, thus requiring a relatively large tube diameter. I have now found, however, that a desired high pressure can be attained if the portion of the tube in which the discharge occurs is restricted to capillary dimension such that the current density in the discharge is sufficient to maintain a temperature on a tube wall about that which corresponds to the desired high vapor pressure while leaving the large diameter of the tube only in the electrode chamber where such diameter is necessary to accommodate the electrodes of the required surface area. The electrode chambers may then be thoroughly insulated so that the loss of heat from their relatively large surface is so far reduced that they also remain above the temperature corresponding to the desired vapor pressure.

It is important in such a lamp that the electrodes should not be allowed to heat up at any point so far that the glow discharge is converted to an arc. This I attain by making the electrode

with smoothly rounded and thick edges and without sharp corners, or projections and/or the result may be achieved by means of a ballast (choke, transformer, etc.) which is designed to limit the current to a value, e. g., about 10 milliamperes at which no arc can occur.

It is found, moreover, that the reduction of the diaemter of the portion of the tube in which the luminous discharge occurs further increases the voltage consumption of the discharge as compared with one occurring in a tube of larger diameter and thus permits a higher proportion of the voltage to be utilized in the luminous discharge as compared with the voltage consumption at the electrode.

The discharge produced in my novel devices is a luminous thread of high intensity with spectral distribution similar to that of the high pressure arc occurring in known high pressure vapor arc lamps. The thread of the discharge is, however, very much smaller than the luminous cord of the known high pressure arc and its light output may be smaller, although by use of sufficiently small tubing and sufficiently high vapor pressure the light output per unit of length may approach some of the lower intensity high pressure arc lamps.

It is thus possible to produce very striking display effects utilizing the fine delineation of the intensely luminous thread and to produce accurate light distribution, e. g., with lenses and reflectors, due to the extremely accurate positioning of the light source along a fixed axis of the tube. By limiting the heat dissipation, high pressure operation may be attained in lamps wherein the light comes from a glow at the surface of the electrode.

In the accompanying drawing, I have shown a preferred embodiment of my invention. This is given for purposes of illustration only and is not intended to be exhaustive or limiting of the invention but on the contrary is given for the purpose of instructing others in the principles of the invention and the best methods of embodying it in practical use in order that others may modify and adapt it to the conditions of each particular use.

In the drawing:

Fig. 1 is a view partly in elevation, partly in section and partly broken away of the tube embodying my invention; and

Figs. 2 and 3 are similar views of another embodiment of my invention.

The envelope indicated by the reference character 1 may be of quartz or refractory glass, or in general any material which is permeable to the desired radiation and refractory at least to the temperature corresponding to the desired vapor pressure. The tube between the electrode chambers ordinarily should withstand higher temperatures, being exposed directly to the discharge thread.

At the opposite ends of the tube are enlarged chambers 2 in which the electrodes 3 are mounted upon the lead-in wires 4 sealed through the ends of the tube. These electrodes as shown are made with smoothly rounded edges and ends to avoid the formation of an arc. The electrode may be activated as is well known for glow discharge electrodes, or other well known types of glow discharge electrodes may be used.

The electrodes 3 may be of design and dimension substantially similar to those used in ordinary low pressure cool cathode tubes and may be activated or unactivated as in the case of known cool electrodes.

The tube is filled with a starting gas, preferably one of the noble gases such as argon, neon, xenon, krypton and helium or mixtures of them, and is provided also with a vaporizable material, preferably one or more of the vaporizable metals, or metalloids such as arsenic or tellurium, or mixtures of these vaporizable materials. The vaporizable material is in amount sufficient to raise the vapor density within the envelope to a point at which the voltage consumption of the discharge will be increased substantially above that occurring immediately after the starting of the discharge and preferably sufficient to multiply the voltage consumption of the discharge several times. Thus, for example, in the case of mercury I have found it advantageous to operate with a vapor pressure of the order of several atmospheres, e. g., from about ½ atmosphere to 10 or even 20 atmospheres.

In order that the desired vapor pressure may be attained it is important to restrict the heat loss from the tube, and this I accomplish in the present instance by means of insulation over the ends of the electrode chambers and by reducing so far as practicable the size of the tube in which the luminous portion of the discharge occurs. As one example of insulation I have shown the electrode chambers mounted within the Dewar vessels 5 with a relatively heavy coat of asbestos or other insulating or heat intercepting material 6 between the electrode chamber and the Dewar vessel. It is also advantageous for the same purpose to provide a mirror heat reflecting surface either on the electrode chamber itself or on the Dewar vessel.

In the operation of such a device a high electrical potential, e. g., several thousand volts, is first applied to the electrodes, the exact potential required, of course, depending upon the length and diameter of the capillary tube and upon whether the electrodes are activated and the type of activation used. Upon the application of sufficient potential a glow discharge occurs through the gas between the electrodes and although the current loading of this discharge is low the heat generated therein has little opportunity to escape because of small dimensions of the capillary tube and the efficient insulation of the electrode chambers; and consequently the temperature is increased by the heat of the discharge with resultant vaporization of the mercury or other vaporizable material. As the vapor density increases the voltage consumption in the luminous discharge correspondingly increases until it has been raised nearly to the starting voltage, e. g., about ¾ of the maximum voltage at which an adequate operating current is available from the transformer or other current source, or to such lower or higher voltage at which the transformer or other current supplying means will operate most efficiently.

I have found also that a similar result can be attained in luminous discharge devices operating with high frequency currents with either outside or inside electrodes and in such case by use of outside electrodes a capillary tube may be used throughout. This device is of particular advantage in connection with ultra-violet irradiation for therapeutic purposes. High frequency devices are commonly available in hospitals, clinics, doctor's offices, etc., for therapeutic treatments and it has been common heretofore to utilize these high frequency generators for ex-

citing mercury vapor in low pressure containers of quartz or ultra-violet permeable glass. It is recognized, however, that the high pressure mercury arc is superior to these high frequency "cold quartz" tubes. I have now discovered that I can combine advantages of both types by a high pressure capillary tube of the type described above having no internal electrodes but operated by high frequency if these devices are provided with a sufficiently small discharge space providing a high current density and relatively small heat dissipating area.

In Fig. 2, I have shown a similar glow discharge lamp, but using typical isolantite electrodes having a hollow cylinder insulated outside with refractory insulation and having an annular disc shield 10 of insulation and, on the interior of the electrode, barium or other activation material.

In Fig. 3, I have illustrated another example designed particularly for high frequency use, in which a very small bore capillary quartz tube provided with the necessary amount of vaporizable material, e. g., mercury, and preferably a noble gas at low pressure, e. g., 1 to 10 or 20 mm. The ends of the tube are then sealed by fusing together over the ends of the tube and given as intimate contact with the glass as possible, e. g., by applying an electroplating or metal film directly to the surface of the tube which is in contact with the metal caps 3. These caps are connected to a suitable high frequency generator by which the atmosphere within the tube 1a is excited to luminous emission. At the same time a high frequency capacity current passes through the tube causing the desired evaporation therein of the vaporizable material.

In this tube as in the tube illustrated in Fig. 1, it is advantageous to provide a measured quantity of the vaporizable material such that the available material is all evaporated before the device reaches its normal equilibrium temperature.

What I claim is:

1. A high pressure vapor discharge device which comprises a plurality of cool electrodes, a sealed envelope having electrode chambers surrounding said electrodes and a narrow tube connecting them, a filling of material adapted during operation to provide an ionized atmosphere for the discharge and including a vaporizable material in amount sufficient to increase the voltage of the discharge and heat insulating means over the electrode chambers, whereby the temperature of the device during operation may be maintained within a range corresponding to a vapor pressure at which the voltage of the discharge is substantially increased.

2. A high pressure vapor discharge device which comprises a plurality of cool electrodes, a sealed envelope having electrode chambers surrounding said electrodes and a capillary tube connecting them, a filling of material adapted during operation to provide an ionized atmosphere for the discharge and including a vaporizable material in amount sufficient to increase the voltage of the discharge and heat insulating means over the electrode chambers, whereby the temperature of the device during operation may be maintained within a range corresponding to a vapor pressure at which the voltage of the discharge is at least doubled.

3. A high pressure vapor discharge device which comprises cool electrodes adapted to carry a discharge not dependent on thermionic emission, an envelope enclosing a discharge path between said electrodes, so closely fitted to the discharge as to maintain the walls of the tube above the vapor pressure as hereinafter defined, a filling in said envelope comprising a starting gas and a vaporizable material in amount adapted when vaporized in said container to increase the efficiency of operation and to increase the voltage drop of the discharge, and means for initiating and loading a discharge therein adapted to provide the discharge with a current of the order of milliamperes.

4. A device as defined in claim 3 in which the means for initiating and loading the discharge comprises a high frequency source.

5. A device as defined in claim 3, in which the electrode is formed with smooth surfaces free from fine projections and sharp edges and the means to provide current is adapted to limit the current to less than would sustain an arc from said electrode.

HANS J. SPANNER.