

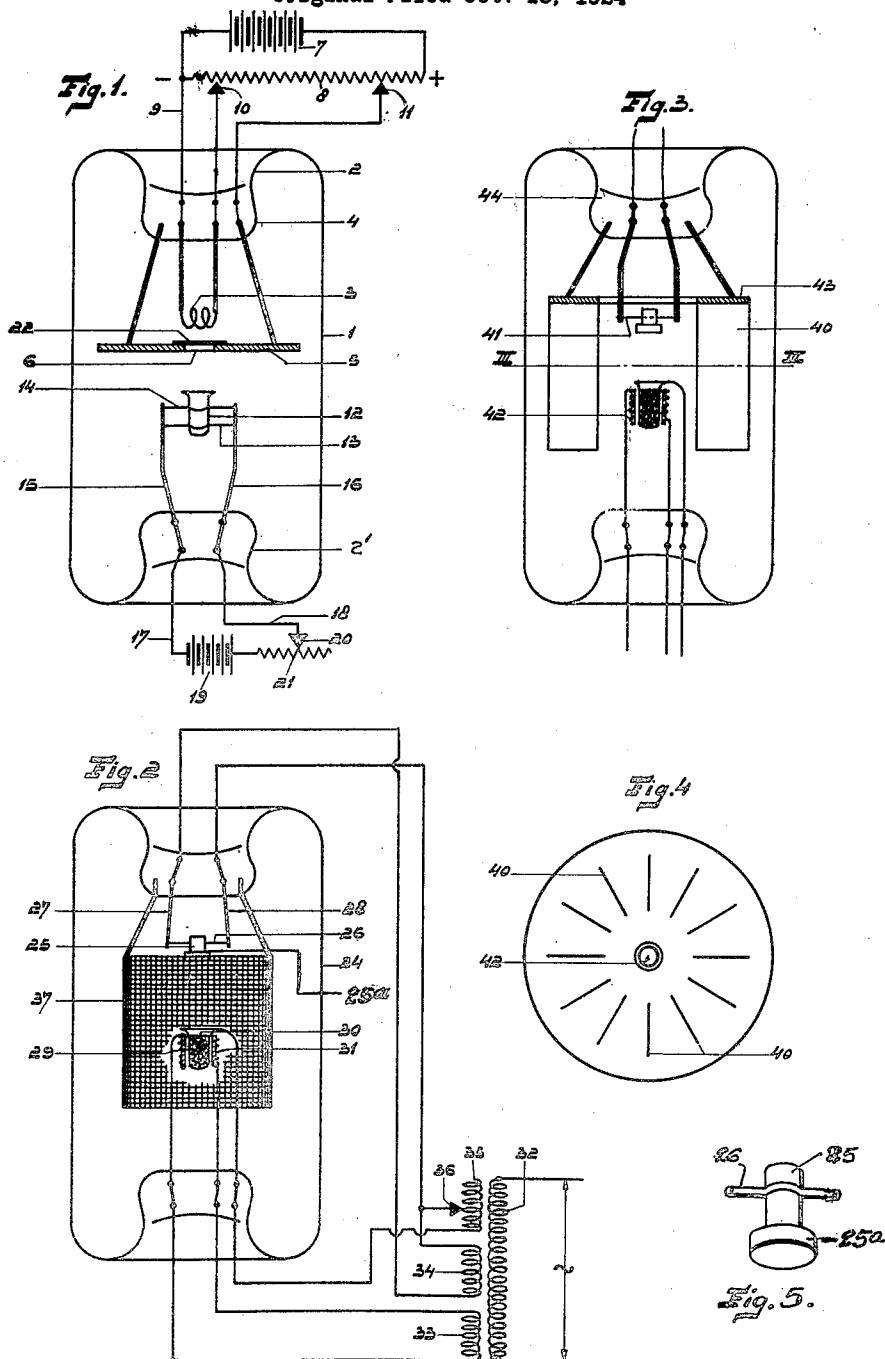
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G. L. HERTZ

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ELECTRIC DISCHARGE TUBE

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Inventor

Gustav Ludwig Hertz  
By E. T. & J. F. Branscum & Attorneys

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## ELECTRIC DISCHARGE TUBE

Gustav Ludwig Hertz, Eindhoven, Netherlands,  
 assignor, by mesne assignments, to General  
 Electric Company, a corporation of New York

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The invention has reference to a gasfilled electric discharge tube and has for its object the construction of a discharge tube of this kind, in which the light radiated in consequence of the electric discharge, principally shows the spectrum of a metal vapour, so that the spectrum of any metal can be examined and also light of any desired colour for illumination or other purposes can be obtained.

The discharge tube according to the invention is provided with a cathode, an anode, a gaseous filling consisting of one or more electro-positive gases and a device for developing metal vapour the density of which in the path of discharge attains such value that the light radiated as a consequence of the discharge substantially shows the spectrum of the vapour.

Among the electro-positive gases the rare gases may preferably be used for the gaseous filling; instead of the vapour of a single metal also a mixture of vapours may be developed.

By "path of discharge" that part of the interior of the discharge tube is meant in which the electric discharge is chiefly produced.

The discharge may be an independent one, for example an independent glow discharge; in this case the metal vapour is preferably developed in the positive column of the discharge. According to the invention, however the discharge tube is preferably provided with an incandescent cathode.

For example, a so-called oxide-cathode may be used; it may be constituted by a metal body that is coated on the active surface with a substance which easily emits electrons, and is suspended from one or more heating wires which make metallic contact with the said body and are capable of heating it to the required temperature.

According to the invention, means may be provided in order to prevent the volatilized metal from precipitating on the glass wall.

The device for developing the metal vapour may be used as the anode; according to the invention there may also be arranged between the cathode and the vessel developing the metal vapour a metal plate that serves as anode and has an opening provided with a grid for letting through the electrons emitted by the cathode.

According to the invention the device for developing the metal vapour may consist of a metal vessel which contains the metal to be volatilized and is carried by one or more heating wires which make metallic contact with the said vessel and

are capable of heating it to the required temperature.

The accompanying drawing illustrates, by way of example, some embodiments of the invention. In the said drawing:

Figure 1 shows a discharge tube, according to the invention, with its connections.

Figure 2 illustrates a modified construction of the discharge tube according to the invention, also with its connections. In this construction as well as in that shown in Figure 3 the device for developing the metal vapour acts as an anode. The constructions shown in the Figures 2 and 3 are identical except that the means provided to prevent the forming of a precipitate on the glass wall differ in the two cases.

Figure 4 is a cross section taken on the line III—III in Figure 3.

Fig. 5 represents the cathode structure of the discharge devices of Figs. 2 and 3 on an enlarged scale.

The discharge tube according to Figure 1 consists of a vessel 1 of glass or similar material in which stems 2 and 2' carrying electrodes are sealed. The stem 2 carries a cathode 3 and in the clamped portion 4 of the stem 2 leading-in wires 9 for the cathode are sealed. The stem 2 also carries a metal plate 5 having a central opening 6 on which a grid 22 is placed. A leading-in wire for the metal plate 5 that acts as an anode, is sealed in the clamped portion 4. A battery 7 is connected to a potentiometer 8, one end of which is connected to the leading-in wire 9 of the cathode 3 and along which the contacts 10 and 11 which are in connection respectively with the other end of the cathode 3 and with the anode 5, are slidable.

The temperature of the filament and the voltage of the anode can be regulated by sliding respectively the contact 10 and the contact 11.

The stem 2' carries a vessel 12 for developing the metal vapour. The said vessel makes metallic contact with heating wires 13 and 14, which are connected to conductive wires 15 and 16. The latter are in connection with leading-in wires 17 and 18, which are sealed in the clamped portion of the stem 2' and are connected respectively to one end of a battery 19 and to a contact 20, which is slidable along a resistance 21. With the aid of the contact 20 the temperature of the wires 13 and 14 and consequently, the temperature of the vessel 12 can be regulated. The said vessel should consist of a metal that transmits heat well and resists the temperature required for developing the vapour. If the said temperature is relatively

low, for example if sodium vapour has to be developed, copper may be used. If the temperature is higher for example molybdenum may be utilized for the construction of the vessel. The heating wires 13 and 14 are preferably of a material having a high specific resistance; for example nickel-chromium may be used.

The dimensions of the wires 13 and 14, the diameter of which may be small compared to the dimensions of the vessel 12, are such that it is not necessary to heat the wire to such an extent that detrimental results occur such as for example, the fusing of the wire. Preferably the wires 13 and 14 have a small length.

This device for heating the vessel 12 to the required temperature offers the advantages that a high temperature can easily be attained, that the required current can be feeble and that the thermal efficiency is rather high.

The conductive wires 15 and 16 may, as usual, be of nickel. The cathode 3 is preferably an oxide cathode, namely a wire coated with a metal oxide that emits electrons at a relatively low temperature, for example with oxide of barium.

The gaseous filling in the tube 1 consists of an electro-positive gas, preferably a rare gas or a mixture of rare gases. The pressure of the rare gas must be relatively low, for example of the order of magnitude of one centimeter or less in order that the gas shall be translucent for the spectrum radiated by the ionized vapor in the discharge.

Good results can be obtained with an argon filling having a pressure for example of about 1 mm.

During the operation of the tube the cathode 3 emits electrons which pass through the grid 22 at a certain velocity in consequence of the electric field between the cathode and the anode.

The vessel 12 is heated to the required temperature so that the metal vapour is developed, the molecules of which move amidst the molecules of the rare gas.

If the density of the metal vapour in the path of discharge has the correct value, the molecules of the vapour will be excited or ionized by the electrons, so that light is radiated having the spectrum of metal vapour.

It is not possible to mention determined values for the density of the metal vapour. The said density depends on the nature of the discharge, on the nature and the pressure of the rare gas and on the nature of the metal vapour.

In general it may be said that the density must have such value as to effect unelastic collisions between the electrons and the molecules of the vapour in a sufficient measure. By moving the contact 20 the density of the metal vapour can be regulated and, moreover, by changing the voltage between cathode and anode, the spectrum of the radiated light can be modified.

Sodium and thallium may be mentioned as examples of metals having a spectrum such that the discharge tube can be used for illumination purposes. With the discharge tube according to the invention however, spectra of any other metal, for example of copper or tin, can be obtained.

It may be observed that the rare gaseous filling chiefly serves to prevent the molecules of the vapour from precipitating immediately on the colder parts around the vessel 12. The plate 5, too can retain the molecules of the vapour so that they do not precipitate on the glass wall of the tube.

In the discharge tube according to the inven-

tion the metal vapour has only in the path of discharge such density that the light radiated in consequence of the discharge, principally shows the spectrum of the vapour. In the further interior space of the discharge tube the temperature is low and consequently the partial pressure of the metal vapour is practically equal to zero. In this the discharge tube according to the invention differs from the known metal vapour lamps as in the latter the discharge is so intensive and consequently the temperature in the tube so high, that the whole tube is filled with the vapour.

In the known metal vapour lamps the presence of the metal vapour is necessary for initiating the discharge, but in tubes according to the invention the discharge may also pass without depending on the vapour; when however vapour of the required density is developed, its molecules are influenced by the discharge so that light is radiated showing the spectrum of the vapour.

The discharge tube according to the invention may be constructed in such a manner that the discharge has the character of a low-potential arc (the potential depends on the nature of the metal vapour, it is of the order of magnitude of the potential of ionization of the metal vapour, in the case of sodium vapour, for example, the potential is only about 2.5 volts). The construction may also be such a one that the discharge shows a positive column; in this case the potential between the anode and the cathode is considerably higher.

The discharge tube shown in Figure 2 is substantially similar to the one shown in Figure 1. In this case the cathode does not consist of a helix but of a metal body which is traversed by a wire 26 which makes metallic contact with it and serves as a heating element. The wire 26 is fixed at its ends to conductive supporting wires 27 and 28. As regards the material and the dimensions of said wire, the same observations as those made in connection with the vessel 12 in Fig. 1 may be made. The metal body 25 is provided with a head 25a to the lower surface of which a substance may be applied emitting electrons at a comparatively low temperature. The device for developing the metal vapour comprises in this case a vessel 29 which contains the metal 30. A heating wire 31 is helically wound around the vessel 29 and is electrically insulated from the vessel 29 in any suitable manner.

Instead of employing continuous current as in Figure 1, the discharge tube may also be operated with alternating current. For this purpose in the construction shown in Figure 2 a transformer is arranged, the primary winding 32 of which is, for example, connected to the network of the town. Secondary windings 33 and 34 serve for heating respectively the heating wire 31 and the cathode 25 to the required temperature. A secondary winding 35 supplies the potential between the cathode and the vessel 29 that acts as an anode. This potential can be regulated by means of a contact 36. In order to prevent the metal vapour from precipitating on the wall of the vessel 24, the path of discharge is surrounded by a metal grid 37.

The discharge tube shown in the Figures 3 and 4 is similar to the one shown in Figure 2; only other means are provided to prevent the metal vapour from precipitating on the glass wall.

In this construction there are a number of metal plates 40 arranged, which are lying in different planes which pass through the axis of the discharge between the cathode 41 and the

vessel 42 that acts as an anode. At the top the said plates are attached to an annular plate 43, which is carried by a stem 44.

That which is said in connection with the construction shown in Figure 1 about the nature and the pressure of the gaseous filling, about the nature of the discharge and the density of the metal vapour may also be applied to the constructions shown in the Figures 2, 3 and 4.

The cathodes shown in the Figures 2 and 3 are so-called equipotential cathodes, all points of the surface having the same potential.

The use of such electrodes in discharge tubes according to the invention, offers special advantages, if one wishes to produce a determined spectrum, for example for spectral examination, as all the electrons leave the surface of the cathode at the same velocity.

What I claim is:

1. In combination with an electric discharge tube having two electrodes between which a discharge may occur and provided with a gaseous filling of at least one electro-positive gas, a device for developing metal vapor which has in the path of the discharge a density whereby the light radiated substantially shows the spectrum of the vapor, and a screen surrounding the path of the discharge for preventing the volatilized metal from precipitating on the tube wall, said screen consisting of a number of metal plates lying in different planes intersecting the axis of the path of the discharge.

2. In combination with an electric discharge tube having two electrodes between which a discharge may occur and provided with a gaseous filling of at least one electro-positive gas, a device for developing metal vapor which has in the path of the discharge a density whereby the light radiated substantially shows the spectrum of the vapor, said device consisting of a metal vessel which contains the metal to be volatilized and is carried by at least one heating wire making thermal contact with the said vessel.

3. An electric discharge device comprising a sealed envelope, a receptacle therein for holding a quantity of a substance to be vaporized, an electric heating device for heating said receptacle to vaporize said substance, and discharge means, said receptacle for holding the substance to be vaporized being mounted closely adjacent said discharge means to develop such a quantity of vapor in the discharge that the light radiated from the discharge device shows the spectrum of the vapor.

4. An electric discharge device comprising spaced electrodes, a vapor-generating receptacle and an electric heating device for heating said receptacle, said receptacle being mounted in the line of discharge between said electrodes whereby the vapor generated therein radiates light showing the spectrum of the vapor.

5. An electric discharge device comprising an envelope having spaced electrodes mounted

therein, one of said electrodes constituting a vapor-generating receptacle, and an electric heating device for heating said receptacle whereby the vapor generated therein has sufficient density in the path of the discharge to cause the light radiated by the discharge device to show the spectrum of the vapor.

6. An electric discharge device comprising a sealed envelope having a gaseous filling of at least one electro-positive gas at a relatively low pressure under operating conditions, means therein for holding a quantity of a substance to be vaporized, an electric heating device for heating said means to vaporize said substance, and discharge means, said means for holding the substance to be vaporized being mounted closely adjacent said discharge means to develop vapor in the discharge at such a high pressure relative to the pressure of the gas filling that the light radiated from the discharge device shows the spectrum of the vapor.

7. An electric discharge device comprising spaced electrodes, a receptacle in the line of discharge between said electrodes, a quantity of sodium in said receptacle and an electric heating device for heating said receptacle to liberate sodium vapor in the discharge path whereby the light radiated shows the spectrum of the vapor.

8. An electric discharge lamp comprising a sealed envelope, spaced electrodes therein adapted to support an electric discharge, means for supplying metal vapor to the discharge path at such rate that the light radiated shows the spectrum of the vapor and means in said envelope for preventing deposition of the metal vapor on the portion of the envelope wall through which the light is transmitted.

9. An electric lamp comprising a light-transmitting bulb, electrodes therein including a cathode comprising an electron emitting metal compound, a charge of rare gas having a pressure of the order of about one millimeter, and a quantity of vaporizable metal in said bulb, said lamp being constructed to operate with an arc discharge between said electrodes at a temperature at which the metal vapor in the path of said discharge has a sufficiently high density to cause the characteristic spectrum of said metal to predominate in light radiated by said lamp.

10. An electric lamp comprising a light-transmitting bulb, electrodes therein including a cathode comprising an electron emitting metal compound, a charge of rare gas having a pressure of the order of about one millimeter, and a quantity of sodium in said bulb, said lamp being constructed to operate with an arc discharge between said electrodes at a temperature at which sodium vapor in the path of said discharge has a sufficiently high density to cause the characteristic spectrum of sodium to predominate in light radiated by said lamp.

GUSTAV LUDWIG HERTZ.