July 28, 1931. D. McF. MOORE 1,816,690

GASEOUS CONDUCTION LAMP

Filed Nov. 7, 1924

Fig. 1.

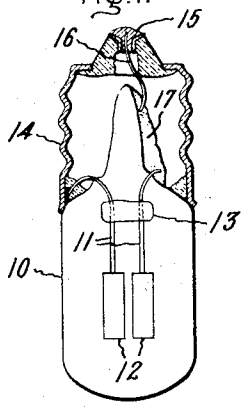


Fig. 2.

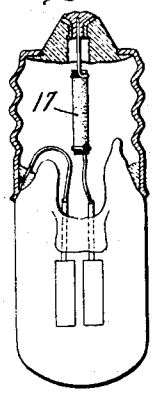


Fig. 3.

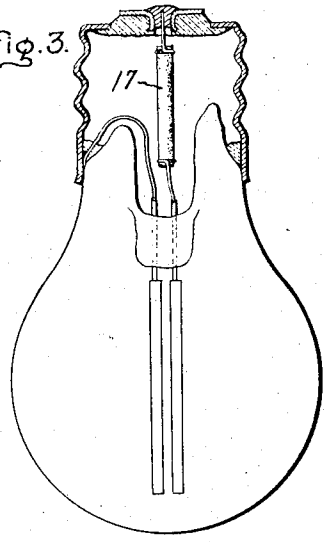


Fig. 4.

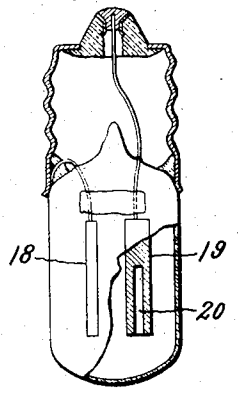


Fig. 5.

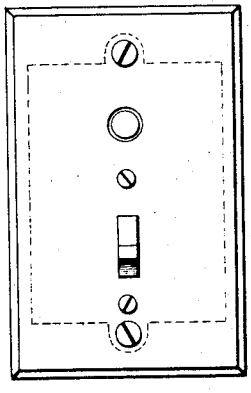


Fig. 6.

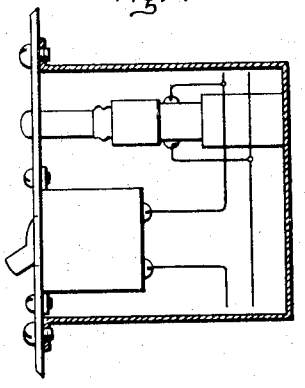


Fig. 7.

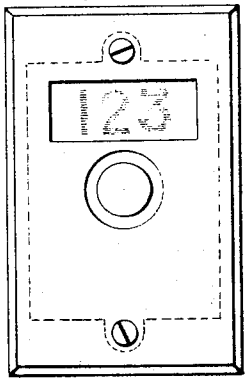
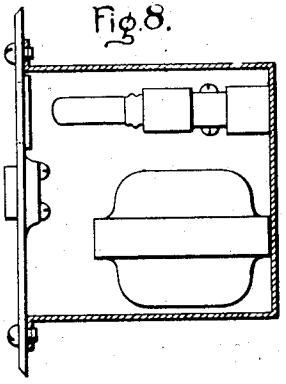


Fig. 8.



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Patented July 28, 1931

1,816,690

UNITED STATES PATENT OFFICE

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GASEOUS CONDUCTION LAMP

Application filed November 7, 1924. Serial No. 748,346.

My invention relates to gaseous conduction devices in which rarefied vapors or gases are rendered luminous by the passage of an electric current between electrodes, and more particularly to lamps of this type in which the luminosity is due to the negative glow discharge.

One object of my invention is to produce a very simple and rugged lamp of long life which operates at potentials of a few hundred volts or preferably at the potential of the usual lighting circuit, such as 110 volts, but is of much lower candle power than the smallest lamps used, with incandescent filaments which have been made commercially for such potentials, and is therefore of great use where only a small amount of light is required.

Another object is to produce a lamp which will have a very concentrated light source capable of responding instantly to voltage variations, even of very high frequency, and which is a desirable source of light where very quick response of the light to voltage variation is desirable, as in apparatus for transmitting facsimiles, photographs and motion pictures by wire or by radio.

In accordance with my invention light and sturdy electrodes parallel to each other and spaced apart a short distance are mounted directly on the wall of a small bulb which contains a gas of good conductivity, such as neon, at a pressure such that a negative glow discharge will occur between the electrodes at the voltage of the lighting circuit on which the lamp is to be used. A convenient way to mount these electrodes is to secure them to comparatively heavy wires, which may be the leading-in wires, embedded or sealed into the glass of the lamp stem or into the walls of the lamp bulb.

The flow of current through the lamp may be limited or controlled by a series resistance concealed in the base of the lamp, and preferably of novel construction. The resistance may, if desired, be great enough to limit the flow of current so that the energy consumption of the lamp may be very low, for example, a few hundredths of a watt, and the lamp will have a life of several thousand hours, although the amount of light is ample for many purposes.

To obtain a very concentrated light source the negative electrode in a lamp of this negative glow type is provided with a cavity or deep recess and the gas pressure is so chosen with relation to the dimensions of the recess and the voltage of the supply circuit that substantially all the discharge occurs in the recess in the electrode, producing a spot of intense light the size of the cross section of the recess, and variable in luminosity with variations of voltage on the supply circuit, even though those variations are of very high frequency.

My invention will best be understood in connection with the accompanying drawings in which Figure 1 is a view partly in section of one form of lamp constructed in accordance with my invention and suitable for use as an indicator; Fig. 2 illustrates a very rugged form of this lamp suitable for use where it is subjected to severe jars and shocks; Fig. 3 illustrates another form of this lamp in a larger size; Fig. 4 is a view partly in section of a lamp of this type suitable for use as a concentrated light source responsive to voltage variation; Figs. 5 and 6 are front and plan views of a wall switch provided with one of these lamps as an indicator and so connected that when the main switch is open the indicator lamp is in circuit to facilitate location of the switch, and Figs. 7 and 8 are plan and side views partly in section, of a push button and bell ringing transformer provided with a lamp for showing a house number.

In the particular form of lamp shown in Fig. 1 the bulb 10 is provided with short sturdy leads 11 sealed directly into the wall of the bulb and extending through the wall to act as leading-in conductors. Each of these leads is secured to or driven into the end of an electrode 12, preferably in the form of a cylindrical rod having a length several times its diameter. This particular lamp may be made conveniently and very cheaply by what is known as the butt seal method, illustrated in the U. S. Patent to Van Keuren No. 1,427,870, September 15,

1922. The bulb contains a gas of good electrical conductivity, preferably a rare gas, such as neon, or a mixture of neon and helium, at a pressure such that the voltage commonly used on commercial lighting circuits for incandescent lamps in multiple, such as a potential of 110 volts between the electrodes will produce a negative glow on the electrodes. The leads may be tied together if desired by an insulating bridge such as a glass bead 13. In the particular lamp shown the bulb is about 3/8 of an inch in diameter and about 3/4 of an inch long, and the electrodes are of magnesium rod .085 of an inch in diameter and 1/4 inch long, and spaced apart about 1/32 of an inch, the leads 11 being of any suitable metal.

The lamp is provided with a candelabra type base having a metal shell 14 and a center contact 15 connected through a short wire or connector 16 and a resistance 17 to one of the leads 11. The other lead 11 is connected to the shell 14 of the base.

To steady the light of the lamp and to control the amount of current flowing through it I provide a series resistance which may conveniently be concealed in the base of the lamp. Various forms of resistance can be used, but it is not easy to obtain the desired resistance in the space available with the types of resistance generally used in electrical work, and therefore, I prefer to use a resistance made by mixing some conducting powder, such as graphite, with an insulating cement, such as that ordinarily used for securing the bases of incandescent lamps to the bulbs. This cement consists essentially of powdered marble mixed with shellac and alcohol or with some material such as Bakelite which will harden when heated. By mixing with the dry powdered cement a small amount of powdered carbon or other conductor or by mixing with it some of the materially commercially known as Aquadag, which is graphite in a very finely divided form, the mixture can be made conducting to any extent desired. This resistance mixture may be applied to the bulb of the lamp to form a conducting bridge between one of the leads 11 and the connector 16 as shown in Fig. 1, and when subjected to a baking such as generally used for securing bases to incandescent lamps, the resistance mixture hardens and becomes firmly attached to the bulb forming a resistance 17 which may be made as high as 50,000 or 100,000 ohms. In some cases it is advantageous to anchor the connector 16 to the bulb by means of a small bead of glass although in many cases the resistance mixture will be so firmly secured to the glass that this anchor is not necessary.

To introduce the rare or good conducting gases into the bulb I prefer to exhaust the bulb on a high vacuum pump for about 10 minutes while heated to a temperature of about 400° C. I then admit a gas preferably a mixture composed of 75% neon and 25% helium to a pressure corresponding to 10 mm. of mercury, and apply 1000 volts alternating potential for about 1 minute and then remove the gas by the vacuum pump. This operation of flushing or washing out the bulb is repeated several times until the bulb is free from residual air. Sufficient argon gas then is admitted so that a pale blue discharge will be produced when a potential of 1000 volts is applied. The argon gas then is removed by the pump. Finally the mixture of neon and helium in the proportions above mentioned is admitted until a pressure corresponding to 30 m. m. of mercury is secured, whereupon the bulb is sealed off.

A lamp constructed as above described with the series resistance of about 50,000 to 100,000 ohms consumes about 1/100 of a watt when connected to a circuit of 110 volts potential, and the negative glow on the electrode is sufficient to give a light which is useful for many purposes. Such lamps have been made having a life of over 2000 hours with practically no lessening of the light or blackening of the bulb. If desired the resistance 17 may be decreased or omitted, causing more current to flow and more light to be produced, but also decreasing the life of the lamp to some extent.

If the electrodes 12 are of magnesium the glow will form at a potential about 20 volts less than if the electrodes were made of some other metal such as aluminum or iron although for some purposes the higher starting potential necessary when one or both electrodes are made of aluminum, iron or similar metals which melt or vaporize at higher temperatures than magnesium is not objectionable in view of the advantages obtained by using electrodes of such metals of higher melting point. Where the whole electrode is made of magnesium there is practically no blackening of the bulb if the current density is kept within suitable limits.

In Fig. 2 I illustrate a particularly strong and rugged lamp having electrodes like those shown in Fig. 1. Its electrodes are mounted on leads which are sealed into a stem of the usual construction and enclosed in a cylindrical bulb about 1 inch in diameter to which is secured a base of the standard or usual size. This lamp has no exposed tip and will withstand very rough treatment. The resistance in the base of the lamp may to advantage be of clay impregnated with graphite with the wire terminals let into grooves in the resistance.

Fig. 3 shows magnesium electrodes somewhat longer and larger than those shown in Figs. 1 and 2, mounted in a larger bulb which is provided with a standard base, this lamp being particularly suitable for use in the standard socket as a night light where only

a small amount of light is required all night. The resistance 17 can be so chosen that the light is sufficient to be useful but not bright enough to be objectionable while the current used is so small and the life of the lamp is so long that it is commercially feasible to operate the lamp all night.

Fig. 4 shows the lamp modified to produce a spot of intense light which is so responsive to voltage variations that it can be used as a source of light in apparatus for transmitting facsimiles, photographs or motion pictures by wire or by radio, where the light source must respond to voltage variations of a very high frequency. For this purpose the lamp is preferably made for direct current, has an anode 18, and is provided with a cathode 19 of magnesium iron, aluminum, or other similar metals in which there is a cavity or bore 20 about 1/8" deep produced with a number 50 or number 60 drill. This lamp does not usually have any series resistance in the base and the pressure of the gas preferably corresponds to about 40 mm. of mercury, while the wall of the bulb directly opposite the end of the tubular crater or electrode 19 may be flattened to prevent distortion of the light. The gas pressure is so adjusted with reference to the voltage at which the lamp operates that practically all of the luminous negative glow discharge occurs in the bore or crater 20 of the cathode 19. If the gas pressure is too high or the applied voltage is too low, the negative glow discharge may wander about on the surface of the electrodes, particularly the end of the cathode 19, but when the conditions are correct the negative glow discharge will be substantially absent from the outer surface or exposed end of the cathode 19 and will be confined almost entirely to the crater or cavity 20 of the cathode. The light thus obtained is quite intense, although the electrode is not heated to the point at which the magnesium or other metal of which the cathode is made vaporizes or spatters, and the light will vary instantly with variations in the potential applied to the lamp. Tubular electrodes of various metals such as iron, aluminum and similar metals may be used for the crater cathode, but I have obtained the best results with the tubular or crater electrode of magnesium constructed as above described.

Lamps constructed in accordance with this invention are useful for many purposes, particularly as indicator and signal lamps. One application of the lamps shown in Fig. 1 is illustrated in Figs. 5 and 6 showing a front and side view of a wall switch mounted in an outlet box in which there is a socket for a lamp such as shown in Fig. 1, and connections such that when the wall switch is open the potential of the circuit is applied to the indicator lamp which glows and shows clearly where the wall switch is located. The current consumption is so low and the life of the indicator lamp is so long that it is commercially feasible to use such lamps and to permit them to burn all the time that the wall switch is open.

A lamp such as that shown in Fig. 1 is also useful as a light source to be operated from dry batteries having a potential of 85 volts or over. The lamp when connected to such a battery will give sufficient light to act as a signal or indicator and will, in addition, indicate the condition of the battery because the lamp will go out when the voltage of the battery falls to about 85 volts.

Figs. 7 and 8 show another application of the lamp in which a lamp of the type shown in Fig. 1 is mounted beside a bell ringing transformer in a receptacle on which the push button for a door bell is mounted, the indicator lamp being connected to the high tension side of the transformer to show the location of the switch button at night, and to illuminate a translucent or transparent plate on which the street number of the house is shown.

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

1. A gaseous conduction lamp comprising a sealed vessel containing an atmosphere of good conductivity and a pair of parallel electrodes therein, one having in the end a hole deeper than its diameter, the pressure of said atmosphere being so chosen that at the operating potential substantially all the glow discharge appears in said hole.

2. A gaseous conduction lamp comprising a sealed vessel containing a rarefied atmosphere of good conductivity, a cylindrical electrode mounted in said vessel with one end exposed and having in said exposed end a cup with metal walls and bottom and of a depth greater than its diameter. and a second electrode out of axial alignment with said cup but so spaced with reference to said cylindrical electrodes that at the operating potential of the lamp a negative glow discharge appears in said cup.

3. A gaseous conduction lamp comprising a sealed vessel containing a rarefied atmosphere of good conductivity, an elongated electrode of solid conducting material secured at one end to the wall of the vessel and having in its free end a deep recess extending longitudinally of said electrode with a depth greater than its diameter, and a second electrode mounted out of alignment with but in such relation to said elongated electrode that the operating potential of the lamp causes a negative glow discharge which is concentrated in the recess in said elongated electrode.

4. A gaseous conduction lamp comprising a sealed vessel containing a rarefied atmosphere of good conductivity, an electrode of metallic magnesium having a recess in the

metal to form a deep cup with walls and bottom of magnesium, and a second electrode mounted out of alignment with but in such relation to said magnesium electrode that the operating potential of the lamp causes a negative glow discharge which is concentrated in the recess in said magnesium electrode.

5. A gaseous conduction lamp comprising a sealed vessel containing a rarefied gas of good conductivity, an anode and a cathode in such spaced relation to each other in accordance with the pressure of the gas that the operating potential of the lamp produces at said cathode a luminous discharge consisting of a negative glow, said cathode constituting a deep cup with metal walls and bottom, the internal diameter of said cup throughout at least a portion of its depth being of such magnitude relative to the depth of the negative glow that said cup throughout said portion is filled from wall to wall with said negative glow discharge at the normal operating potential of the lamp.

6. A gaseous conduction lamp comprising a sealed vessel containing an atmosphere of good conductivity, and a pair of electrodes therein spaced to produce a luminous discharge which consists solely of the negative glow, one electrode having a deep cavity with a bottom and substantially parallel walls of an alkali or alkaline earth metal, and a diameter such as to be substantially filled from wall to wall with said negative glow, the pressure of said atmosphere being such that at normal operating potential substantially all of the luminous negative glow discharge is confined to said cavity.

7. A gaseous conduction lamp comprising a sealed vessel containing a rarefied atmosphere of good conductivity, a cathode mounted in said vessel and having an open ended recess with substantially parallel walls considerably longer than the distance between said walls, and an anode adjacent said cathode but out of alignment with the longitudinal axis of said recess to leave its open end unobstructed along said axis, the spacing of said anode and cathode and the pressure of said atmosphere being so related that at the normal operating potential of said lamp a luminous discharge consisting solely of the negative glow appears in said recess and fills it from wall to wall.

In witness whereof, I have hereunto set my hand this sixth day of November, 1924.

DANIEL McFARLAN MOORE.