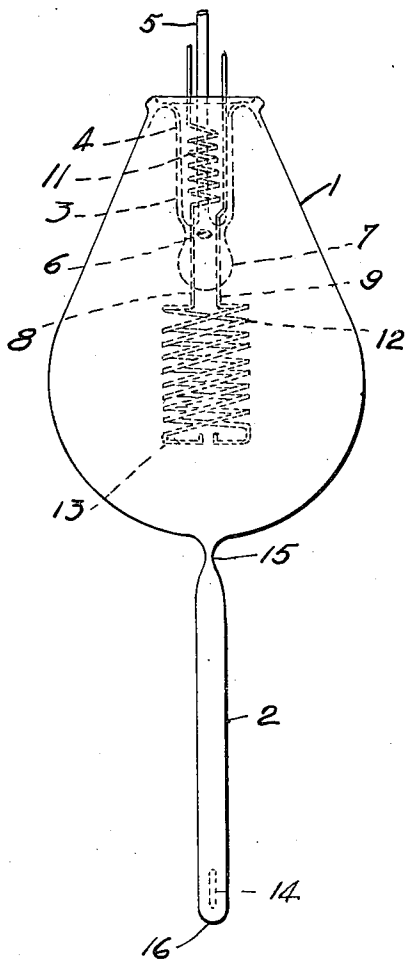


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C. C. VAN VOORHIS
GASEOUS DISCHARGE LAMP
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INVENTOR
CLETUS C. VAN VOORHIS
BY
J. J. Ebert
ATTORNEY

UNITED STATES PATENT OFFICE.

CLETUS CLINTON VAN VOORHIS, OF PRINCETON, NEW JERSEY, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA.

GASEOUS-DISCHARGE LAMP.

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This invention relates to electric lamps in which the light is generated by a discharge through inert rare gases and more particularly to such lamps designed especially for low voltages.

An object of my invention is the manufacture of glow-lamps in which electrodes composed of nickel, iron, aluminum or other suitable material coated with alkali metal are employed, enclosed in an atmosphere of a neon mixture, at such a pressure, and with the electrodes so spaced that the lamps may be operated on low voltages.

Another object of my invention is the construction of gaseous-conduction lamps designed to be operated on standard commercial voltages.

A further object of my invention is the manufacture of glow lamps, or lamps emitting light by an electric discharge through a rare gas mixture, of such construction that a minimum voltage is required therefor and they are adapted for uniform operating conditions.

A still further object of my invention is the development of a method for conveniently manufacturing gaseous-conduction or glow lamps, the starting potential of which has been materially decreased by using nickel electrodes coated with potassium, and operating in a mixture of rare gases of such composition and pressure, that the starting and operating voltages required therefor are reduced to a minimum.

Other objects and advantages of the invention will be disclosed more fully as the description proceeds.

Gaseous-discharge devices have long been known in the art, for example, the well known Geissler tube comprises a bulb or the like containing a plurality of electrodes in a gas at a low pressure and a glow discharge is produced therethrough by the passage of electric current. It is found, however, that light emitted from such a tube, as ordinarily constructed, is not uniform, as there are non-luminous regions designated first, with respect to the cathode as the Crookes dark space and beyond this is a second separate dark space known as the Faraday dark space. Such dark spaces become apparent because of the relatively-distant spacing of the electrodes and the character and pressure of the enclosed gas and such tubes require a relatively high potential for operating them.

Later developments along this line have resulted in substantially eliminating appreciable dark spaces in the electric discharge and have obviated the necessity of using such high voltages as were formerly required. However, such lamps heretofore have required a relatively high potential and have not been generally suitable for commercial lighting circuits of relatively low voltage, for example, 110 volts.

According to my invention, I provide a lamp in which the light is emitted by a glow discharge through an inert rare gas or mixture thereof and in which the voltage required is considerably reduced, over that formerly considered necessary, by constructing the electrodes of such material and spacing them apart such a distance and operating them in an atmosphere of such a character and pressure, that the voltage required to produce the desired discharge or glow therebetween, is reduced to less than 110 volts.

Briefly, my method of making such a lamp comprises constructing a lamp bulb or the like provided with two tubulatures or tubes for exhausting the same, that is, one tube may be provided in the regular location for lamps which are manufactured provided with a tip. The other tube for exhausting the lamp, may be provided extending through the stem thereof and connect to the interior of the lamp bulb through a small hole near the stem press.

Leading-in wires are provided extending through the stem press and join with electrodes which preferably take the form of helices, coiled together so as to provide a uniform spacing therebetween. Between the tubulature through the stem or such other exhaust tube as may be provided for lamps of the tipless type, and the surrounding stem portion or flare tube, a ballast resistance is preferably provided, in series with one of the leading-in conductors. A small amount of potassium, or other alkali metal, is preferably introduced into the regular tubulature opposite the stem and the end of said tubulature sealed. The bulb may then be exhausted through the stem or tipless tubulature.

While being exhausted, the bulb is preferably heated to eliminate moisture and other adsorbed gases and vapors therefrom, care being exercised not to heat the potassium in the tubulature. When thoroughly

exhausted, the bulb is allowed to cool sufficiently, so that potassium may condense thereon while the electrodes and stem are still fairly hot. The potassium may then be vaporized into the bulb from the tubulature by means of a hand torch or the like thus producing a uniformly distributed coating of potassium on the bulb. The tubulature formerly containing the potassium may then be tipped off and removed in the usual manner.

The bulb may then be filled with the rare gas or mixture thereof, which is preferably, mainly neon, after which the lamp is sealed off from the exhausting and filling system. The potassium may be localized by heating the bulb while a discharge is passed through the lamp and the stem is kept cool, so that the potassium vaporizes from the bulb and condenses on the stem. After this has been done, the glow from the electrodes is made uniform by running the lamp on a 110 volt circuit, with about 2000 ohms resistance in series, until the glow becomes uniformly distributed over the electrodes. The lamp may be seasoned, tested with a ballast resistance inserted in the stem and based in a manner as more fully described hereinafter.

My invention will better be understood by referring to the accompanying drawing, the single figure of which illustrates a side elevation shown partly diagrammatically, of a gaseous-discharge lamp constructed according to my invention.

Referring to the drawing, the bulb 1 is preferably provided with a regular tubulature 2 extending from that portion of the bulb where a tip is commonly formed. Into the opposite portion or neck of the bulb, is sealed a stem 3 comprising a flare tube 4, consolidated with a tubulature or exhaust tube 5, which connects with a small hole 6 through the flare tube and adjacent the stem press 7. Through the press 7 preferably extend leading-in wires 8 and 9. The bulb 1, flare tube 4, "tipless" exhaust tube 5 and the regular tubulature 2 are preferably made of glass which contains no lead oxide or oxide of other easily-reducible metal so that blackening of the glass will not be caused by the use of alkali metal thereon. Lime glass has been found to be satisfactory for this purpose.

The exhaust tube 5 should be of as small glass tubing as possible and the stem as large as possible, in order to give ample room for the insertion of a stabilizing resistance 11 in series with one of the leading-in wires as shown. For the electrode material, nickel in the form of 40 mil wire has proved very satisfactory. Electrodes 12 and 13 of such material are therefore preferably provided, coiled as helices and uniformly spaced concentrically as shown.

For use on alternating current circuits, the

electrodes should be of the same size and shape and a convenient arrangement is that of two intercoiled helices as illustrated, about one inch in diameter and one and one-half inches long, although I do not wish to be restricted to any specific arrangement, as the main spacing requirement is that the electrodes be disposed rather closely and uniformly. When operated on direct current, only the cathode is covered with the glow discharge and consequently the anode may be made much smaller than the cathode.

From measurements of starting potentials in helium, neon and argon under various conditions, I have found that in employing neon as the principal filling gas, the pressure thereof for minimum starting potential should be above 7 millimeters of mercury and the electrode distance such that the product of the pressure in millimeters of mercury and the distance between electrodes in millimeters, equals about 20. If these conditions are met, for at least one point along the electrodes, it will be sufficient, as the discharge will then start readily and immediately spread over the whole cathode, because the running or operating voltage is lower than the starting voltage and is practically independent of the distance between electrodes over a wide range of distances.

A pressure of 10 millimeters of mercury for the neon mixed with a small proportion of other rare gases, as pointed out later on, has been found satisfactory and consequently the distance between electrodes should be about 2 millimeters at one point at least. The low starting voltage, necessary for such lamps to operate on 110 volt commercial circuits, cannot be obtained with nickel or other metals suitable for making rigid electrodes, but such low starting voltages are to be secured by vaporizing thereon a small quantity of potassium or other alkali metal, thus getting the advantages of the low starting voltage of an alkali metal and the rigidity of the nickel electrodes.

Potassium seems to be the most suitable metal for the purpose, although other alkali metals would give similar results. Potassium gives a slightly lower starting voltage than sodium, has a considerably higher pressure at a given temperature and is therefore easier to introduce. Rubidium and caesium are very expensive and probably would have a greater tendency to darken the glass, although they would probably give lower starting voltages than potassium.

Since potassium is readily acted on by air and moisture, it is necessary to provide a method of introduction which will prevent contamination thereof, at least to a large extent. As potassium is ordinarily obtained on the market, it is kept under oil. In order to obtain the metal free from oil and absorbed gases, particularly hydrogen, and

also in order to get it into a condition in which it can be introduced into the lamp satisfactorily, it is preferably distilled a plurality of times in vacuo in a glass container, the final condensing channel being provided at the bottom with a long piece of thin-walled glass capillary tubing of about 1 millimeter bore. This capillary may be bent into a U shape and both ends attached to the evacuated system to facilitate the filling of the tube with potassium, which is melted in the final condensing chamber and runs down into the capillary tube, which is then sealed off and stored until needed.

Just before the lamps are to be exhausted, the capillary tube, filled with potassium, is cut up into sections, preferably four or five millimeters long. These sections containing three or four cubic millimeters of potassium, may then be dropped one into each regular tubulature of the lamps. The position of the lamps when this is performed, is preferably the reverse of that shown in the drawing, so that the tube of potassium will drop down the regular exhaust tube or tubulature 2 as far as the constriction 15 thereof. The end of the tubulature 2 may then be sealed at 16 and the position of the lamp reversed, so as to stand as shown in the drawing. When the lamps are thus treated, they are ready for the exhaust and filling processes and, for this purpose, the tipless tubulation or exhaust tube 5 may be inserted into connectors of rubber tubing, for connection with the exhausting pumps, as in ordinary lamp practice.

It will be seen that with the lamps in the position illustrated in the drawing, the potassium is at the extreme bottom of the regular tubulature which has been closed. A furnace is then placed around the lamps with only the extreme ends of the regular or bottom tubulature, where the potassium is located, sticking outside of the furnace. Thus the lamps may then be baked-out, without vaporizing the potassium. They are preferably thus heated at about 350° to 400° C. while being evacuated for about 10 minutes. Regular lamp exhaust pumps may be used for the evacuation process although, if desired, a better vacuum may be obtained. The furnace may then be removed and the potassium vaporized into the lamps as soon as the surfaces of the bulbs have cooled sufficiently to condense the potassium, but while the electrodes and stems are still fairly hot. This procedure may result in blackened electrodes which, however, give slightly lower starting voltages than bright ones.

The potassium in the regular tubulature may be vaporized into the bulb by means of a hand torch having a small flame or by any other convenient method of heating. The bulb, at this time, will be given

a purplish color by the vaporized potassium. The regular tubulature may then be tipped off in the usual manner and the lamps are then ready to be filled with a rare gas or mixture thereof.

A gas for filling lamps, according to my invention, preferably consists of a mixture of three to four parts of neon and one part of helium to which mixture is added about 1% of argon, all measurements being by volume. The addition of argon seems to give a more uniform product, although some lamps not containing it have given excellent results. For example, one lamp after running continuously for about 16 months had a starting voltage of only about 94 volts, alternating current. The gas pressure is preferably made about 10 millimeters of mercury, because much lower pressures would require higher starting voltages, while much higher pressures would cause the cathode glow to be concentrated more strongly and would not give as pleasing an appearance to the running lamp. However, as the pressure is increased, more current can safely be sent through the lamp and consequently more light obtained, so that in cases where it is desirable to obtain more light from the lamp, a higher pressure of the gas filling may be used with a smaller stabilizing resistance and the spacing of at least one part of the electrodes correspondingly less than 2 millimeters, so that the pressure in millimeters of mercury times the spacing in millimeters will still be about 20.

The rare gases used in filling the lamps are fairly pure, although an exceedingly high degree of purity is not necessary, as the potassium takes care of all deleterious impurities, if it is present in sufficient quantity. In order to provide a uniform filling for a large number of lamps, especially where a small amount of argon is to be used, the gases may be mixed in their proper proportions and purified by means of a direct-current discharge between calcium or magnesium electrodes. The charcoal and liquid air method of purification is likely to give varying proportions of neon and helium, and makes it necessary to add the argon after the purification of the other gases. After the gas filling is put into the lamps, they are tipped off in the regular manner for making tipless lamps and are then ready for the localizing of the potassium.

When the potassium is vaporized into a lamp, it condenses on the walls in a silvery or purplish deposit, which would greatly obstruct the light from the lamp if it were allowed to remain thereon. Hence, it is desirable to localize the potassium on some part of the lamp, where it will not interfere with the light given off. This may be ac-

complished by blowing a small stream of air inside of the stem 3 of the lamp, while a furnace applying a temperature of about 350° C. is placed over the lamp. While this is being performed, the lamp is preferably placed with its stem down, instead of up as shown in the drawing, so that the stem will not be heated as much by convection, as it would if in the position shown.

After heating from about 3 to 5 minutes, the potassium will be located principally on the stem, none being visible on the walls or even on the electrodes, although, due to the vapor pressure of potassium even at ordinary temperature, there will always be a small amount on the electrodes. During the life of the lamp, the potassium seems to disappear very slowly from the stem, but does not ordinarily become deposited on the walls.

While the localizing process is being conducted, and until the lamp becomes somewhat cooled, an electric discharge should be sent through the lamp. This may be done by connecting it to a 110 volt alternating current line through a resistance of about 2000 ohms. Running the lamp in this manner while the potassium is being localized, gives a starting potential about 30 volts lower than when it is not run during this process. For some purposes where the light needs to be non-obstructed for only a small solid angle, it may not be necessary to localize the potassium as above described, but would be sufficient to drive it off of only a small proportion of the wall, to allow a clear path for the light in the required direction. This procedure results in a lamp which may have a somewhat lower starting voltage, than that of a regularly treated lamp. Such lamps may start on potentials as low as 56 volts alternating current.

Usually, after the potassium has been localized, the glow will cover only a small part of the electrodes when the lamp is running, even though a rather small ballast resistance is used. To make the glow uniform over all the electrode surface, the lamp is preferably run on a 110 volt alternating current circuit with about 2000 ohms resistance in series and usually in from one to five hours the glow will be uniformly distributed and remain practically so.

After the glow has become uniform, the lamps are preferably seasoned with series resistances of from 6000 to 8000 ohms for about 50 hours after which the starting voltage is determined. Most of the lamps will then start on from 70 to 85 volts A. C. and, if fitted with the proper resistances, will probably run for more than 2000 hours before their starting voltage rises above 110 volts A. C. These figures apply to lamps whose electrodes are of nickel and whose dimensions are about as shown in the drawing.

The permanent resistances to be used should probably range from about 4000 ohms for lamps starting at about 85 volts to 7000 ohms for those starting at about 70 volts, although it may be possible to get a life of 1000 hours or more, with considerably smaller resistances. However, there is considerable likelihood of the lamps becoming blackened or of their starting voltages rising rapidly if too small a ballast resistance is used. Such a resistance, diagrammatically represented at 11, may be inserted in the stem or base in any desired manner, where care must be taken to insulate the leads thoroughly to prevent short-circuiting.

In some cases, it is better to have the resistance located in the socket and a special base placed on the lamp so that it can not be used in ordinary sockets, where it would immediately burn out without a stabilizing resistance in series.

The lamps may then be based in the manner in which ordinary incandescent electric lamps are based. After standing idle for some time, glow lamps made according to my invention almost invariably start on lower voltages than they do immediately after running for some time. Consequently, the life in intermittent service will probably be longer than in continuous service. Also, after standing idle, the glow for a short time after starting may not be uniform, but it usually becomes so in a few minutes.

If the discharge becomes flickery in a lamp at any time, it means that the resistance is too high to give a uniform glow over the whole cathode on the voltage available. Likewise, the discharge may be made to dance around over the electrodes by putting in a very high resistance. The stabilizing resistance and the internal conditions of the lamp should be such that a uniform glow over the electrodes is secured, without any appreciable warming up of the lamp wall taking place on continuous running. If there is any warming up, the lamp will probably have a short life.

The preferred current density of the electrodes should not exceed about 2 milliamperes per square centimeter of cathode surface, when the gas pressure is 10 millimeters of mercury.

Lamps manufactured according to my invention whose starting voltage has risen in service above 110 volts, may still have a long life on higher voltages, for example, on 220 volt circuits.

Although I have described what is now considered a preferred embodiment of my invention, it is to be understood that the same is merely illustrative and that I desire to be limited only by the spirit and scope of the appended claims.

What is claimed is:

1. The method of localizing an alkali

metal in a rare gas glow lamp comprising vaporizing said metal into the lamp to the walls of the bulb thereof, heating said bulb while maintaining an interior portion of the lamp cool, whereby the alkali metal is transferred from the bulb to said interior portion of the lamp and at the same time maintaining an electric discharge in said lamp to cause the starting voltage thereof to become reduced.

2. The method of reducing the starting voltage of rare-gas glow lamps comprising maintaining an electric discharge therein while vaporizing an alkali metal from one portion of a lamp to another.

3. The method of reducing the starting voltage of rare-gas glow lamps comprising vaporizing potassium from one portion of

the lamp to another portion while maintaining an electric discharge therein.

4. The method of introducing alkali metal into a device having a tubulature attached thereto comprising distilling said alkali metal in vacuo, collecting the same in a capillary tube, separating a portion of said tube containing the desired amount of alkali metal, placing said separated portion in said tubulature, sealing the end of said tubulature, heating the tubulature to vaporize the metal into the device and tipping-off the tubulature.

In testimony whereof, I have hereunto subscribed my name this eighteenth day of June 1923.

CLETUS CLINTON VAN VOORHIS.