March 1, 1966 P. J. KAYATT 3,238,408

FLICKER GLOW LAMPS

Filed Sept. 27, 1962

FIG. 1

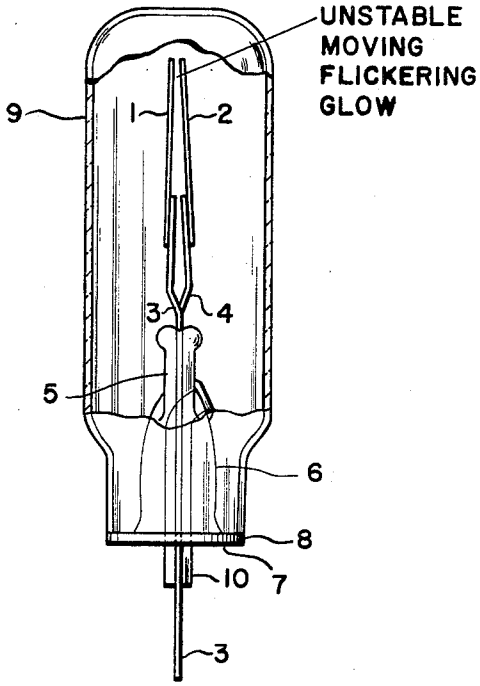
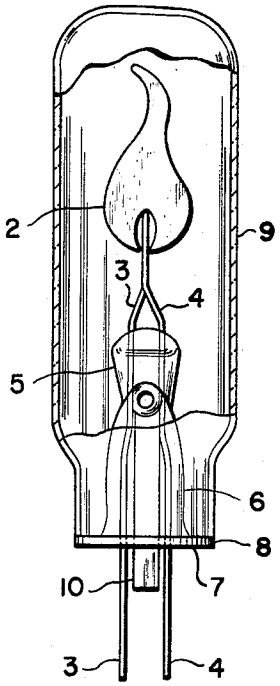


FIG. 2



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FLICKER GLOW LAMPS

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This application is a continuation-in-part of my co-pending application Serial No. 50,482, filed on August 18, 1960, and now abandoned.

The present invention relates to flickering glow lamps of the gas discharge type and to methods for making the same.

The invention provides methods by means of which cathode glow lamps may be produced which will throughout their entire useful lives, exhibit an unstable glow which covers only a portion of the cathode at any particular instant. The glow flickers and shifts its position and intensity or both in turbulent and random, yet cyclic, manner. The repetition rate of the flickering is such that it is readily followed by an observer. In operation, the flickering glow will simulate the flame of a candle, for example. This candle-like flickering effect is not in any way related to the continuous line frequency flicker which is inherent in any glow lamp which is energized by a source of alternating current.

In applying one method, a barium azide coated electrode is heated to partially decompose the barium azide, the evolved nitrogen being carried away by a vacuum pump. The heating is discontinued during and prior to completion of the final evolution of nitrogen so that a small predetermined amount, hereinafter referred to as a trace amount, of nitrogen remains within the coating.

An alternative method is to carry the evolution of nitrogen to completion and thereafter to introduce the small predetermined amount or trace of nitrogen by means of a metering operation.

As a variation of the alternative method, nitrogen may be mixed with the final filling gas so that the trace of nitrogen and the filling gas are simultaneously introduced into the lamp in a single metering operation.

Both the methods and the lamps produced by these methods are the subject matter of the present invention.

The invention will be better understood by reading the following specification with reference to the accompanying drawing forming a part hereof.

Referring to the drawing:

FIGURE 1 is a side elevational view, partly broken away and shown in section, showing a lamp embodying the invention, the base and usual current limiting resistor being omitted.

FIGURE 2 is a view similar to FIG. 1 showing a face view of one of the electrodes.

The electrodes are preferably formed of sheet metal of the ferrous group, of which iron, nickel or ferrous alloys of various types all seem to operate with especial efficiency, and I am not limited to the employment of any particular metal or alloy, but I prefer to use iron having plated upon the surface thereof a layer of nickel, the thickness of the layer being immaterial, provided that it is sufficient to remain undamaged during the mechanical operations involved in the production of the lamp, without unduly exposing the base metal. As to the thickness of the sheet metal of the electrode, this again is not critical, but I have found that a thickness of about 0.005 to 0.006 of an inch and lends itself to ready working. The sheet metal is stamped or otherwise formed into the desired shape and is then thoroughly degreased.

The electrodes 1 and 2, are secured, as by spot welding to separate lead wires 3 and 4, respectively. The lead wires 3 and 4 extend through a metal-to-glass seal

in the pressed portion 5 of a glass stem or base 6. The stem 6 comprises a lower skirt portion 7 provided with a peripheral lip 8 which is fused to the mating lower circumferential edge of an enclosing envelope 9.

The stem 6 is provided with the usual downwardly extending exhaust tube 10 for connection in conventional manner to suitable exhausting and filling apparatus, as is well known in the art.

The mounted and degreased electrodes 1 and 2 are boiled in a dilute aqueous solution of an alcohol such as isopropanol for a short interval. The purity of the alcohol is not critical provided that it leaves no appreciable quantities of solid residues on the electrodes. After the treatment with alcohol, the electrodes are thoroughly rinsed in warm water followed by a rapid drying in heated air. Preferably, the drying is in an oven with freely circulating air at a temperature of about 150° C.

After the stem-mounted electrodes are dry, it will be found that an oxide of iron will have formed upon the edges, or wherever the base metal beneath the nickel plating is exposed. This oxide is not detrimental.

In the manufacture of these lamps it has been found that a larger amount of emissive material, usually barium azide, must be used, than has hitherto been the practice in cathode glow lamp manufacture and the manner in which this relatively heavy deposit is obtained is now described in detail.

I prefer to use barium azide in a commercial degree of purity readily available on the market. I use a strong or saturated solution of barium azide in water, of about 15% as available in commerce. This solution is employed at full strength in the coating of the electrodes. Preferably, both electrodes are coated, in order that the lamp shall operate satisfactorily with alternating current energization, when each electrode functions alternately as the cathode of the lamp.

The azide solution is applied to the electrode, by brushing, spraying, dipping or other convenient method. I have found that the emission ultimately obtained is not adversely affected by the presence of iron oxide on the edges or surface of the electrode. This first coating of barium azide is thoroughly dried in air at not greatly over 110° C., temperatures between 80° and 100° being preferred. Higher temperatures are detrimental to the azide coating.

In order to increase the total amount of barium azide upon the electrode, a series of successive coats of the azide solution are applied. These additional coats are suitably applied each separately over an underlying coat of dried azide solution. A thorough drying between successive coats is required. I have found that a minimum of two coats is needed, and in most cases I find it very advantageous to use four or more coats of azide for the best results in securing the desired moving glow or flicker effect, i.e., exhibiting a cathode glow which continually changes its position upon the electrode in a random manner simulating the flame of a candle.

The mutual spacing of the electrodes is critical. The proper operation of the flickering lamp is dependent upon several factors, such as the surface area of the electrodes, the gas used, the filling pressure, the amplitude of the voltage applied and the minimum spacing between the electrodes. For example, if all other factors are suitable and the electrodes are spaced closest at their upper ends, e.g., one millimeter apart, then the movement of the flickering glow will be downward from the top and inwardly from the sides to the center of the largest portion of the electrodes 1 and 2. There usually will be a moving dark spot, generally rounded in shape, which will ordinarily rock or shift from side to side.

If the closest point between the electrodes 1 and 2 is at the bottom of the electrodes, then the glow will move upwardly and the moving dark spot will be at or near the top or moving upwards. In other words, the glow will start from the point of minimum spacing and move to the more widely spaced portions of the electrodes 1 and 2. If all other factors are suitable and the desired movement of the glow is a rocking or shifting motion at the widest part of the electrodes, I space the electrodes at the top, usually 0.5 mm. to 2.0 mm. apart and about 1.0 to 4.0 mm. apart at the bottom. The mounted electrodes 1 and 2 are now ready for sealing into the envelope 4. This is accomplished in conventional manner, special care being taken not to overheat the electrodes or the azide coating to a temperature which may cause the coating to disintegrate or change its characteristics or otherwise be detrimental to the proper functioning of the completed lamp.

The lamp, sealed except for the exhaust tubing, is now ready for evacuation and further processing. It is connected to a vacuum pump, which should be of reasonably high efficiency so that it will exhaust the gases as quickly as possible as they are evolved when the electrodes are heated. First the lamp is evacuated at room temperature until all traces of air are removed and the exhaust connection is subsequently maintained. A suitable gas or electrically heated oven is set to operate in the range from 350°–400° C., and after the air has been removed from the lamp, the oven, later to be described, is lowered thereover. The temperature to be used will depend, among other factors, upon the pumping rate. The starting temperature of the oven will drop from about 400° C. to about 350° C. because of the initial coolness of the lamp and then begin to rise to its normal operating temperature. Almost within a few seconds after application of a 350°–400° C. oven, the first evolution of nitrogen commences and in a few minutes more, as the first evolution is being completed, a second evolution takes place which is also completed within a few minutes. This nitrogen is evolved during the course of progressive decomposition of the barium azide coating of the electrodes which is caused by the oven heat. After the second evolution has been completed, which may be determined by a high frequency test coil, there seems to be a third evolution of gas, the exact nature of which has not been verified, although the high frequency test coil indicates that it includes hydrogen, the source of which is uncertain. The third evolution seems to occur with an oven temperature in the 350°–365° C. range. This third evolution is not as voluminous as the first two evolutions of nitrogen and is completed in about a minute or so.

Progress of the three evolutions may be checked by means of a "Tesla" type high frequency test coil which is well known in the art. Placing the energized test coil near the lamp causes any appreciable amount of ionizable gas within the envelope 9 to glow. The color of the glow is indicative of the indentity of the gas and the brilliance of glow depends upon the gas pressure.

The oven consists of two spaced rows of gas heaters or electrical heating elements. The oven is suspended by a counterbalanced arrangement so that it may be easily lowered over or raised above a row of lamps which is being processed. During heating, the lamps are located between the two rows of heating elements. The oven temperature is measured by means of a mercury thermometer the bulb of which is centrally located in the oven. The top of the oven is at least partially closed. The heating elements acquire a temperature of incandescence which heats the electrodes through the glass envelope by thermal radiation. The mercury thermometer temperatures given above have not been correlated with corresponding optical pyrometer temperatures for the heating elements. While the mercury thermometer temperature is not an accurate measure of the electrode temperature, it serves as a reliable guide during production. The desired electrode temperatures are those which produce the evolutions of gas, as herein described, from the barium azide coatings. It has not been found practicable to measure the actual temperature of the electrode coatings during heating. The evolved gases must be rapidly removed by the vacuum pump so that heating may be terminated before the metal of the electrodes becomes hot enough to emit occluded gases or other substances which might contaminate or poison the electrode coatings.

In accordance with one method, the predetermined small amount or trace of nitrogen may be permitted to remain within the coatings by quickly removing the oven immediately after completion of the second evolution and during the progress of the third evolution. The lamp is thereupon filled with the desired gas in an amount sufficient to attain a predetermined gas pressure within the lamp, whereafter the exhaust connection is permanently sealed off. If the oven be allowed to remain for an extended time after the completion of the second gas evolution, there will be an apparent change in the barium surface, which may be caused by evaporation or reformation of the barium or possible undesirable contamination thereof. If the oven be removed before the second evolution of nitrogen has been completed, the barium surface may reabsorb an excessive amount of nitrogen and the flickering operation of the lamp will be adversely affected. Even though precautions are taken to remove all of the excess nitrogen and at least part of the third evolution of gas, the predeterminted small trace amount of nitrogen must be permitted to remain. This correct small quantity will be absorbed by the electrode coatings. In combination with other factors described below, the correct small quantity of nitrogen will provide the desired flickering operation. An excess of nitrogen, as indicated by the "Tesla" coil, will adversely affect the flickering operation and color of glow.

Alternatively, the third evolution may be carried to completion as shown by a "Tesla" coil indication that the lamp is substantially free of gas while still hot. The heating is thereupon discontinued and the predetermined small amount of nitrogen is introduced into the lamp by means of a metering operation. For this purpose, a predetermined volume of commercially pure nitrogen at a suitable pressure is admitted into the lamp upon termination of the heating and while the vacuum pump connection is maintained. This may be readily accomplished by means of a length of glass tubing or other receptacle of suitable predetermined volumetric capacity having an inlet valve and an outlet valve. The inlet valve is connected to the supply of nitrogen which is at a suitable pressure. The outlet valve is connected to the vacuum or exhaust connection of the lamp or row of lamps. The inlet valve is opened with the outlet valve closed while the receptacle is filled with nitrogen until the desired pressure is reached. The inlet valve is then closed and the outlet valve thereafter opened so that the predetermined volume of nitrogen is fed to the row of lamps being processed.

As a gas filling, neon or helium or a mixture of both is used because of their high ionization potentials. The preferred pressure for the desired flickering effect is from 70 to 120 millimeters of mercury absolute. An excellent flickering lamp is obtained with pure neon at a pressure of about 100 mm.

If the gas pressure is appreciably decreased, the glow may extend to the entire surface and not move, resulting in an undesired steady glow. If the gas pressure is appreciably increased, an increased operating voltage will be required. Variations in gas pressure may be compensated to some extent by changing the inter-electrode spacing, by changing the operating voltage, by changing the resistance of the external current limiting resistor, or by combinations of such changes. Using neon at a pressure of 100 mm. with an inter-electrode spacing of 1.0 mm., the lamp should produce a good flickering operation when energized with 100 to 120 volts A.C. With an

electrode having the candle flame configuration of FIG. 2 and a face area of about 2 square centimeters, a series resistor having a resistance between 1800 and 4500 ohms will provide good flickering operation. A larger flickering lamp having face area of 6 square centimeters and a series resistor of 900 ohms draws about 50 milliamperes when energized with 120 volts at 60 cycles, the current density being about 8.3 milliamperes per square centimeter of electrode area.

The addition of a small amount of hydrogen (about 2%) will change the color of the glow from that of pure neon, and seems to improve the motion of the glowing spot, but this addition is not essential.

It will be appreciated that nitrogen may be mixed with the filling gas in a certain proportion such that admission of the filling gas into the envelope simultaneously introduces the correct small predetermined amount or trace of nitrogen in a single metering operation.

To summarize, there are two methods of obtaining the desired final condition of the electrodes. With either method, there is a predetermined small trace amount of nitrogen which remains in the coatings of the electrodes. It is this trace amount of nitrogen which produces the desired flickering operation.

Using the first method, the heating is discontinued during the course of and prior to completion of the third evolution of gas so that the required trace amount of nitrogen remains unevolved from the coatings of the electrodes.

With the second method, the heating is not discontinued until after the third evolution has been completed. The small predetermined trace amount of nitrogen is thereafter metered into the envelope after completion of the third evolution. This introduction of the required trace of nitrogen may constitute a separate operation prior to the filling with the desired gas. Alternatively, nitrogen may be mixed with the filling gas in such a proportion that the required small predetermined trace quantity of nitrogen is introduced into the envelope along with the filling gas in a single metering operation.

In any event, the small predetermined amount or trace of nitrogen is sufficiently small so that it is substantially completely contained within the decomposed barium azide coatings of the electrodes. The small amount of nitrogen is such that the pressure of the trace of nitrogen as a free gas within the envelope cannot be detected by a test coil after the lamp has cooled to room temperature. The trace amount of nitrogen in the electrode coatings must be sufficiently large, however, to produce the desired flicker effect.

By carrying the third evolution to completion and subsequently introducing the trace amount of nitrogen as a metered quantity of nitrogen, errors in timing are avoided which may occur if the heating is to be discontinued within the short time interval during and prior to completion of the third evolution, or during the second evolution, as the case may be.

It is to be understood that conventional automatic lamp making machinery may be used. The lamps will then be conveyed automatically through heating zones of appropriate temperatures, the evacuation and filling operations being likewise automatically performed.

While I have shown and described what I believe to be the best embodiments of my invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A gas discharge lamp comprising: a plurality of spaced electrodes, at least one of said electrodes being coated with at least partially decomposed barium azide; a rigid gas-tight transparent envelope spaced from and enclosing said electrodes; circuit means connected to said electrodes and extending exteriorly of said envelope for energizing said electrodes; an inert gas consisting essentially of neon at a pressure in the range from 70 to 120 millimeters of mercury absolute enclosed within said envelope and surrounding said electrodes; and a trace amount of nitrogen contained in said decomposed barium azide, whereby energization of said circuit means will cause said electrodes to emit an unstable flickering glow which simulates a flame.

2. A lamp according to claim **1**, wherein the pressure of said neon is substantially 100 millimeters of mercury absolute.

3. The method of producing a gaseous discharge glow lamp which comprises the steps of: coating a plurality of spaced electrodes a series of successive coats of a metallic azide of the Formula XN_n wherein X is a metal selected from the first two columns of the Periodic Table and *n* is an integer not exceeding 6; enclosing the coated electrodes in an at least partially transparent envelope in fixedly spaced relationship; evacuating said envelope; heating the enclosed electrodes to at least partially decompose the metallic azide coating; continuing said evacuating step during the heating of the electrodes to remove nitrogen as it is evolved during decomposition of said coatings; causing a trace amount of nitrogen to remain within said coatings; admitting a predetermined amount of an inert ionizable gas into the envelope; and sealing off the envelope, whereby said electrodes, when energized, will emit an unstable flickering glow which simulates a flame.

4. The method according to claim **3**, wherein the decomposition of said metallic azide is accompanied by at least two successive evolutions of nitrogen, and in which said heating step is discontinued during the course of and prior to the completion of an evolution subsequent to the first evolution to cause said trace amount of nitrogen to remain within said coating.

5. The method according to claim **4**, wherein the decomposition of said metallic azide is accompanied by three successive evolutions of gas, and in which said heating step is discontinued during the course of and prior to the completion of the third evolution to cause said trace amount of nitrogen to remain within said coating.

6. The method according to claim **3**, wherein the decomposition of said metallic azide is accompanied by three successive evolutions of gas, and in which said heating step is discontinued after completion of the third evolution, said step of causing said trace amount of nitrogen to remain within said coating being performed by introducing said trace amount of nitrogen into said envelope after completion of said third evolution.

7. The method according to claim **3**, wherein said heating step is performed using an oven heated to a temperature higher than 350° C., by relatively positioning the evacuated envelope and the oven to heat the electrodes enclosed within the envelope.

8. In combination, a plurality of spaced electrodes, a coating consisting essentially of a metallic azide covering at least a portion of one of said electrodes, said azide having the Formula XN_n wherein X is a metallic element selected from the first two columns of the Periodic Table and *n* is an integer not exceeding 6, said coating being at least partially decomposed, said coating including a trace amount of nitrogen, a gas impervious envelope surrounding said electrode, an inert ionizable gas, and circuit means connected for energization of said electrodes, whereby energization of said circuit means will cause said electrodes to emit an unstable flickering glow which simulates a flame.

9. The combination according to claim **8**, wherein said inert gas consists essentially of neon at a pressure within the range from 70 to 120 millimeters of mercury absolute.

10. The combination according to claim **8**, wherein

said inert gas consists essentially of neon at a pressure of the order of 100 millimeters of mercury absolute.

11. A cold cathode glow lamp comprising two spaced electrodes, each electrode having an exposed surface formed of a metal of the ferrous group, an emitting coating of barium on the exposed surface of the cathode, said emitting coating including a trace amount of nitrogen, the inter-electrode spacing being within the range from 0.5 to 4.0 millimeters, a gas-tight envelope surrounding said electrodes, and a gaseous medium confined in said envelope and surrounding said electrodes, said medium consisting essentially of gases which are members of the zero valence group at a pressure within the range from 70 to 120 millimeters of mercury, the electrodes of said lamp being energizable at a current density in the range from 5 to 30 milliamperes per square centimeter of conducting electrode area to produce an electrical discharge through said medium which exhibits a flickering flame-simulating glow effect.

12. A cathode glow lamp according to claim **11**, in which the electrodes are elongated and confront each other, said inter-electrode spacing being greater near one end of said electrodes than near the other end thereof, said discharge moving repeatedly from said other end toward said one end to produce said flickering glow effect.

13. A cathode glow lamp according to claim **11**, in which said gaseous medium includes a major portion of neon and a minor portion of helium.

14. A cathode glow lamp according to claim **11**, in which said gaseous medium includes a major portion of neon and a minor portion of hydrogen.

15. A glow lamp according to claim **11**, wherein nitrogen is effectively excluded from said gaseous medium.

16. A gas discharge lamp comprising: a plurality of spaced electrodes, at least one of said electrodes being coated with substantially decomposed barium azide, said

decomposed barium azide containing a trace amount quantity of nitrogen; a rigid and at least partially transparent gas-tight envelope spaced from and enclosing said electrodes; circuit means connected to said electrodes and extending exteriorly of said envelope for energizing said electrodes; and an inert gas selected from the group consisting of neon and helium and mixtures thereof enclosed within said envelope and surrounding said electrodes, whereby said electrodes, upon energization of said circuit means, emit an unstable flame-simulating cathode glow.

17. A gas discharge lamp according to claim **16**, further comprising but not exceeding about 2 percent of hydrogen mixed with said inert gas.

18. In combination, an atmosphere consisting essentially of an inert gas of zero valence; means confining said atmosphere a first electrode substantially completely surrounded by said atmosphere; a coating on said electrode in contact with said atmosphere, said coating consisting of Ba, BaN_n and a trace amount of N, where n is an integer from 1 to 6 inclusive; and a second electrode in said atmosphere spaced from said first electrode, whereby an unstable electrical discharge through said atmosphere and between said electrodes is produced when said electrodes are connected to an energizing circuit.

References Cited by the Examiner

UNITED STATES PATENTS

1,291,209	1/1919	Skaupy	313—185 X
1,852,826	4/1932	Skaupy	316—17
1,965,588	7/1934	Foulke	313—185 X
2,804,911	6/1937	Kayatte	316—17

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