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[54] **FILL GAS MIXTURE FOR GLOW LAMPS**

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[52] **U.S. Cl.** **313/226,** 313/210
[51] **Int. Cl.** **H01j 61/16**
[58] **Field of Search** 313/210, 226; 315/358

[56] **References Cited**

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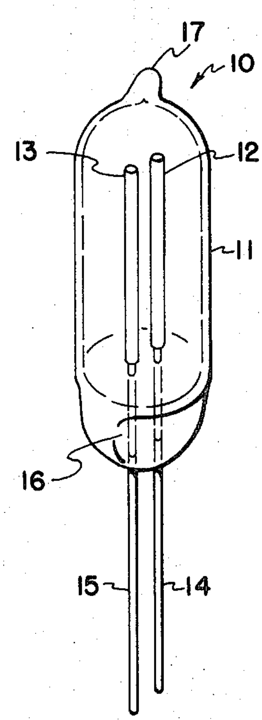
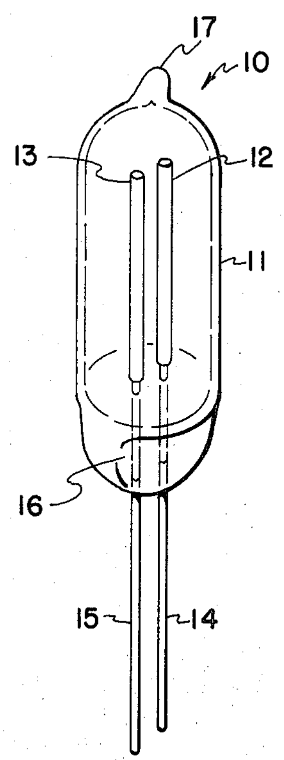
[57] **ABSTRACT**

A glow lamp for use as a circuit component or indicator lamp comprising an envelope, electrodes, lead-in wires connected to the electrodes and sealed in said envelope, the envelope contains a Penning mixture of neon and xenon with the xenon varying from 0.001 percent to 1.0 percent by volume. The use of the xenon-neon Penning mixture increases the life of the lamp without substantially increasing breakdown voltage.

5 Claims, 1 Drawing Figure

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FILL GAS MIXTURE FOR GLOW LAMPS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to discharge devices with particular gas or vapor fillings. More particularly, the invention relates to a discharge device containing two rare gases, namely, neon and xenon.

2. Description of the Prior Art

In a glow lamp, current will flow between electrodes after a certain potential is applied to the electrodes. This voltage is known as the breakdown voltage. An elementary explanation of this phenomenon is that the gas between the electrodes becomes ionized at a certain voltage and will therefore conduct current.

Different gases such as neon or argon require differing amounts of voltage to become ionized and conduct current. The breakdown potential required to ionize pure neon gas, with a pressure and molybdenum electrode spacing product of 2 cm-torr, is approximately 160 volts and for pure argon gas is approximately 170 volts. It has been known that a mixture of two gases, such as neon and argon, in which the ionization potential of the added gas, argon, is less than the metastable level of the parent gas, neon, will have a breakdown voltage lower than the breakdown potential of either gas. This combination of gases is called a Penning mixture.

In addition to having a low breakdown voltage, it is desirable to have a glow lamp in which the breakdown voltage is relatively stable during the usable life of the device. Breakdown voltages have a tendency to gradually increase over the life of the lamp until the increased breakdown voltage exceeds the operating voltage of the circuit. This renders the glow lamp useless for the particular circuit application even though it may still function at a higher voltage.

According to prior art theories, the best Penning mixture would be one using neon as a parent gas and argon as the added gas. Neon has a metastable level of 16.6 electron volts, and argon has an ionization potential of 15.7 electron volts, a difference of 0.9 electron volts. This small energy difference would allow the rapid ionization of argon atoms through the Penning reaction. Other gases such as Krypton and xenon (with ionization potentials of 14.0 and 12.1 electron volts respectively) have much greater energy differences, and therefore the probability of the Penning reaction occurring would theoretically be greatly reduced. Accordingly, it was believed that the addition of xenon, having the greatest energy difference, would increase the breakdown voltage to a point where the benefit of the Penning effect was marginal if it existed at all.

The rise in breakdown voltage and the decrease in lamp life is believed to be caused by the gradual erosion of emission materials, such as barium strontium oxide, from the cathode. This erosion is dependent upon the sputtering yield, namely, the number of atoms of material which leave the electrode surface under the bombardment of positive ions of certain kinetic energy. Prior art data shows that for a given electrode material, such as copper, the sputtering yield increases as atomic weight increases. Much of this data, for example, pages 126 and 127, "Cold Cathode Discharge Tubes", G. F. Weston, is for ion energy above 100 electron volts. However, there was no reason to believe that less than 100 electron volts, the ion energy range relevant to glow lamps, would produce results which differ from those between 100 to 1,000 electron volts. Therefore, since argon has the second lowest sputtering rate and xenon the highest, it would be expected that a neon lamp containing an argon additive would have a longer life.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to make a glow discharge device containing a fill gas which will increase the life of the discharge device. Another object of the invention is to design a discharge device containing a fill gas which will extend useful lamp life and at the same time lower the breakdown voltage to a value less than that of the constituent gases.

The objects of the invention are accomplished through the use of a particular fill gas containing neon and xenon. A lamp, comprising an envelope containing two electrodes and lead wires connected to the electrodes and sealed in the envelope, is filled with a particular mixture of neon and xenon. It has been found that the percentage of xenon which acts as a Penning additive and extends the life of a glow discharge device is from 0.001 percent to 1.0 percent, with the remainder of the fill gas being neon by volume.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is an elevation view of a glow discharge device utilizing the fill gas of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in the drawing, glow lamp **10** is comprised of envelope **11**, electrodes **12** and **13**, lead-in wires **14** and **15**, and stem press **16**. The lamp of the invention is filled with a unique fill gas of neon and xenon at a predetermined pressure and the envelope is closed and tipped off as shown at **17**. Electrodes **12** and **13** are coated with an emission mix material such as barium strontium oxide or barium azide. These emission mix materials are high in electron yielding particles and therefore facilitate the discharge between electrodes into the gaseous atmosphere of the lamp.

Electrodes **12** and **13** are spaced from one another a predetermined distance, and the envelope is filled with a gas at a certain pressure. Various adjustments in the distance between electrodes and the pressure of the fill gas cause variations in breakdown voltage. Plots of the breakdown voltage versus the product of gas pressure and electrode spacings for particular gases are known as Paschen curves.

Electrodes **12** and **13** may be nickel or nickel-coated steel. Both nickel and nickel-plated steel have a tendency to emit electrons at a greater rate than most other metals although other metals may be used. The electrodes **12** and **13** are connected to lead-in wires **14** and **15** which are usually made of the wire known as Dumet. Lead-in conductors **14** and **15** are hermetically sealed in the envelope at pinch seal **16**. The fill gas of the invention is then added to the envelope at a pressure of between 20 to 150 millimeters of mercury, and the envelope is closed or tipped as shown by residue **17**.

Breakdown voltage can be defined as the voltage between electrodes **12** and **13** at which the fill gas will become sufficiently ionized to allow a current generally of the value of milliamperes to be conducted through the lamp. As lamps continue to burn, after their initial aging or seasoning of approximately 75 to 100 hours, they begin to resist the passage of current. Accordingly, as time goes on, the breakdown voltage becomes higher and higher until it reaches a point where the circuit using the glow lamp or gas discharge device can no longer energize the lamp. An example of this would be an indicator lamp used in a 120-volt household circuit. If the range of breakdown voltages for a household circuit indicator lamp were from 100 to 105, as time went on and the lamp aged, the breakdown voltage would gradually increase and exceed 120 volts thereby rendering the lamp inoperable in the particular circuit.

The phenomena of increased breakdown voltage and the useful life of the gaseous discharge lamp have been studied in an attempt to determine ways to increase the life of the lamp by retarding the steady increase of breakdown voltage. It is believed that erosion or sputtering of the emission mix material on the cathode is largely responsible for the increase in breakdown voltage. Results of mass spectrometric studies show that this erosion is caused by ions striking the cathode and, further, that these ions are predominantly the atomic ions of the Penning additive in the gas mixture.

As indicated earlier, the available data concerning sputtering yields demonstrated that the sputtering yield of xenon is greater than that of argon for a given electrode material. This data was gathered for energy levels between 100 and 1,000 electron volts. An extrapolation of this data would lead one skilled in the art to believe that the sputtering yield, at energy levels less than 100 electron volts, would be larger for xenon than for argon and therefore give a shorter life lamp using xenon. Contrary to this hypothesis, it was found that the sputtering yield for a xenon plus ion is smaller than that for either a krypton plus ion or an argon plus ion. Because of this reduced sputtering yield, the emission mixture is eroded away at a slower rate and, in turn, the rise in breakdown voltage is slowed and the life of the lamp is increased.

Another unexpected result of the addition of xenon to form a Penning mixture is the magnitude of increase in the breakdown voltage of a neon-xenon-filled lamp compared to a neon-argon-filled lamp. The magnitude of the breakdown voltage is dependent upon, in part, the difference between the ionization potential and the mestastable energy level of the parent gas, in this case neon (pages 18 and 19, "Cold Cathode Discharge Tubes", G. F. Weston). The difference between neon and argon is 0.9 electron volts and between neon and xenon is 4.6 electron volts.

Comparing the difference between argon and xenon, it can be seen that one is more than five times greater than the other. Even though the relationship between breakdown voltage and gas type is not completely linear, it was believed, heretofore, that the use of xenon would raise the breakdown voltage to such an extent that the mixture would approach that of a pure gas with no additive which, of course, would be contrary to the main purpose of having a Penning mixture.

As was found by experiment, a lamp using neon and 0.1 percent argon had a breakdown voltage ranging from 70 to 80 volts, and a lamp using neon and 0.1 percent xenon had a breakdown voltage of only 75 to 85 volts. The other variables which affect breakdown voltage such as fill gas pressure and electrode spacing were held constant in the above experiments.

Glow lamps presently marketed usually are used in circuits of 120 volts or less. Certain lamps are used as indicator lamps for household appliances such as the General Electric C2A neon glow lamp which may have a breakdown voltage as high as 120 volts or less. The C2A lamp has an electrode spacing of 0.7 millimeters and is filled at a pressure of 38 torr and was made up using a Penning gas mixture containing neon and xenon with the xenon being 0.01 percent of the mixture by volume. This particular mixture of xenon increased the life of the C2A lamp and also gave a narrower range of breakdown voltage.

Another type of lamp, the General Electric 5AH–B lamp, is used as a circuit component with less emphasis placed upon light output and more emphasis placed upon the lamp life and breakdown voltage. The 5AH–B lamp has an electrode spacing of 1.1 millimeters and is filled with the Penning mixture at a pressure of 120 torr. The particular mixture which was most effective to increase the life of the lamp and stabilize the range of breakdown voltages was one containing neon and 0.1 percent xenon by volume. On the basis of these and other experiments, it is believed that an improved Penning mixture containing neon and between 0.001 percent and 1.0 percent xenon by volume may be used effectively to increase lamp life while maintaining a reduced breakdown voltage level for various types of gas discharge devices.

Comparative test data of the 5AH–B lamp filled with Penning mixtures of neon plus 0.1 percent argon, neon plus 0.1 percent krypton, and neon plus 0.1 percent xenon indicated that the life of the test group containing argon was 1,265 hours, containing krypton 2,440 hours and that containing xenon was 2,600 hours. As can be seen from the results of this test, the use of xenon almost doubled the expected life of the lamp compared to a lamp filled with argon and increased the lamp life by approximately 10 percent over a lamp filled with krypton. The initial breakdown voltage of the lamp containing xenon increased to 75 to 85 volts as compared to a range of 70 to 80 for a lamp filled with krypton.

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

1. A glow discharge device comprising: an envelope, electrodes, lead-in wires connected to the electrodes, said lead-in wires extending through and hermetically sealed in said envelope, said envelope containing a Penning mixture fill gas of neon and xenon wherein said xenon may vary between 0.001 percent to 1.0 percent by volume.

2. A glow discharge device as claimed in claim **1** wherein said xenon may vary between 0.001 percent to 0.1 percent by volume.

3. A glow discharge device as claimed in claim **1** wherein said xenon may vary between 0.01% to 0.1 percent by volume.

4. A glow discharge device as claimed in claim **1** wherein said xenon equals 0.1 percent by volume.

5. A glow discharge device as claimed in claim **1** wherein said xenon equals 0.01 percent by volume.

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