United States Patent [19]

Richardson

[11] **3,900,753**

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[54] **HIGH PRESSURE SODIUM VAPOR LAMP HAVING LOW STARTING VOLTAGE**

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[52] **U.S. Cl.** **313/198**; 313/201; 313/225; 313/226; 313/229

[51] **Int. Cl.** **H01j 61/54**

[58] **Field of Search** 313/198, 201

[56] **References Cited**

UNITED STATES PATENTS

3,721,845 3/1973 Cohen et al. ..... 313/17 X

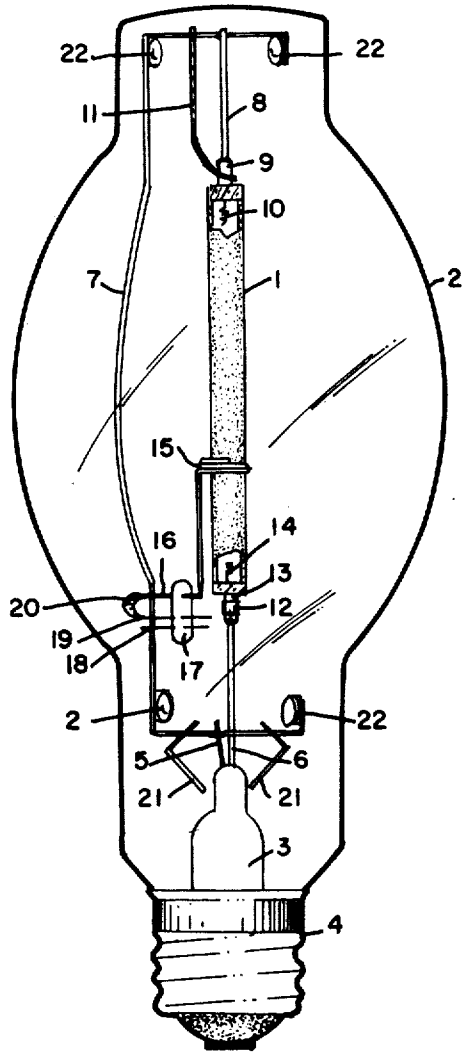
3,721,846 3/1973 Cohen ..... 313/17 X

Primary Examiner—R. V. Rolinec
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[57] **ABSTRACT**

The alumina arc tube of a high pressure sodium arc discharge lamp contains a Penning mixture gaseous filling and also has an encircling wire ring starting aid, in order to reduce lamp starting voltage. A temperature actuated circuit breaking device is in series with the starting aid in order to electrically remove it from the circuit after the lamp starts.

5 Claims, 3 Drawing Figures



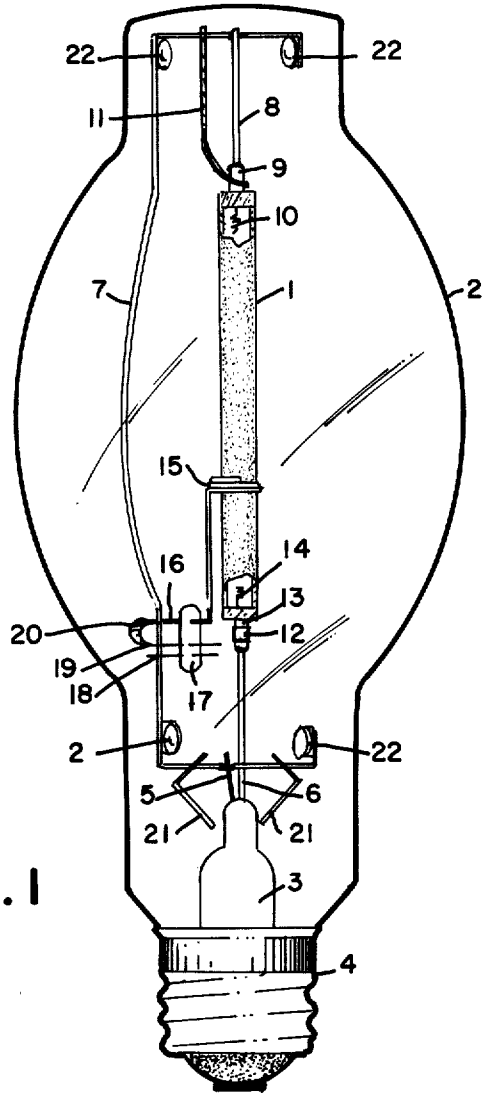


FIG. 1

FIG. 2

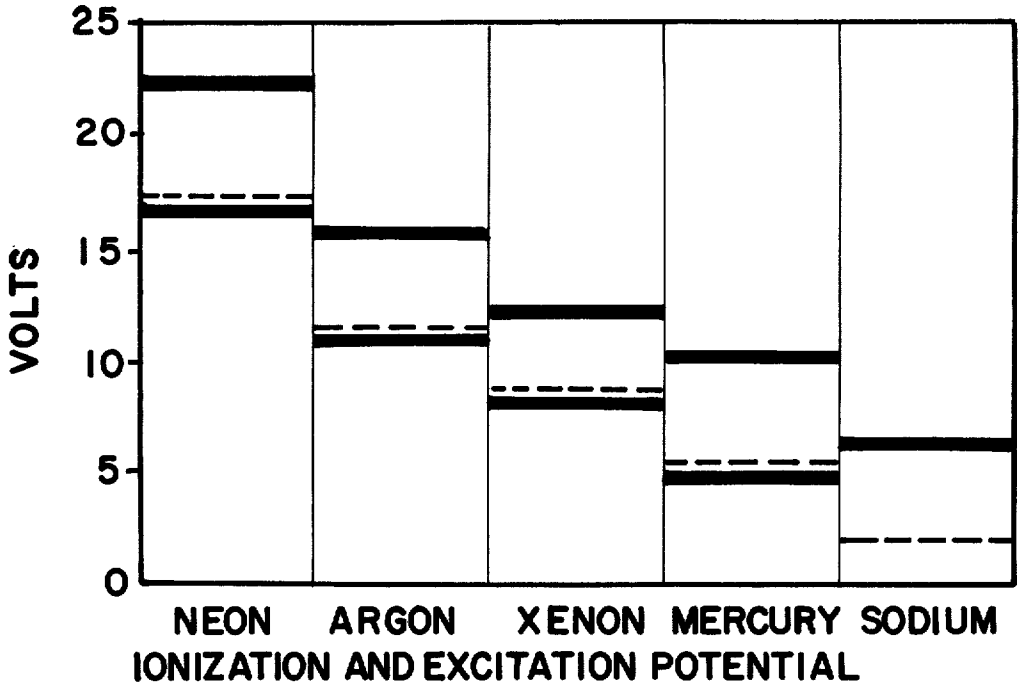
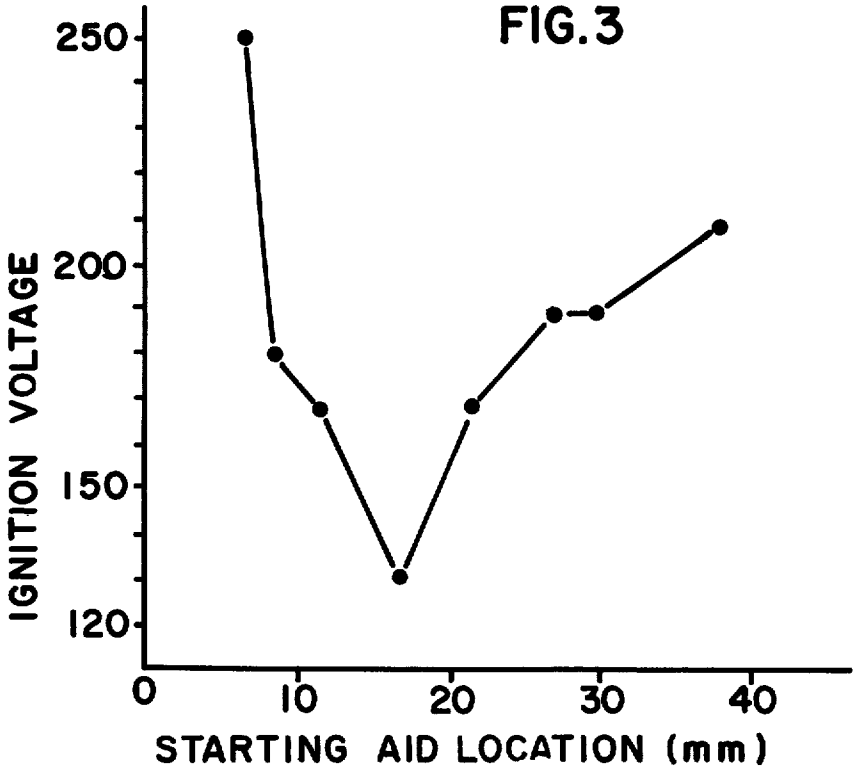

25
20
15
10
5
0
VOLTS
NEON
ARGON
XENON
MERCURY
SODIUM
IONIZATION AND EXCITATION POTENTIAL

FIG. 3


250
200
150
120
IGNITION VOLTAGE
0
10
20
30
40
STARTING AID LOCATION (mm)

HIGH PRESSURE SODIUM VAPOR LAMP HAVING LOW STARTING VOLTAGE

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This invention relates to arc discharge lamps and, in particular, to high pressure sodium vapor lamps.

2. Description Of The Prior Art

Within the past few years, high pressure sodium vapor lamps have become commercially useful, especially for outdoor lighting applications, because of their high efficiency. The sodium operating vapor pressure in such lamps can vary from several millimeters to about 1,000 millimeters Hg.

Such lamps are called high pressure in order to distinguish them from low pressure sodium vapor lamps in which the sodium operating vapor pressure is in the order of a few microns. Low pressure sodium lamps have been in use for about 35 to 40 years, but, although efficient, they produce an unattractive monochromatic yellow light. The color of light from high pressure sodium lamps is considerably improved over that from low pressure sodium lamps.

High pressure sodium lamps generally comprise an alumina ceramic arc tube and an arc tube fill of sodium, mercury and an inert gas, usually xenon. Examples of such lamps are shown in the following U.S. Pat. Nos: 3,248,590, 3,721,846 and 3,746,914.

One of the problems of high pressure sodium arc discharge lamps relates to the starting thereof. Such lamps require a considerably higher starting voltage to initiate an arc discharge than do other types of arc discharge lamps, such as fluorescent, mercury or metal halide. This higher starting voltage requirement necessitates the use of a special ballast for high pressure sodium lamps.

It is an object of this invention to provide a high pressure sodium vapor lamp having a reduced starting voltage, thereby eliminating the high voltage requirements of the ballast. Thus, a simpler more economical ballasting arrangement becomes quite precticable and, in fact conventional mercury lamp ballasts can often be used. Such lamps having reduced starting voltage are shown in U.S. Pat. Nos. 3,721,846 and 3,746,914, where the arc tube is heated in order to reduce the starting voltage. The instant invention presents an alternate approach to a low voltage starting lamp which is simpler and less expensive to manufacture.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an elevational view, partly broken away, of a high pressure sodium arc discharge lamp in accordance with this invention.

FIG. 2 is a chart showing the lowest metastable potential, the lowest excitation potential and the ionization potential for gases commonly used in arc discharge lamps.

FIG. 3 is a graph showing the relationship between starting aid location and ignition voltage for a lamp in accordance with this invention.

THE INVENTION

A high pressure sodium vapor arc discharge lamp in accordance with this invention has an alumina arc tube which contains a fill including sodium, mercury and a Penning mixture starting gas. In addition, the arc tube has an encircling wire ring starting aid and a temperature actuated circuit breaker in series with the starting aid.

F. M. Penning discovered in the 1920's that certain critical mixtures of gases had lower starting voltages than either of the gases separately. This effect has taken his name and Penning mixtures are used in mercury, fluorescent and low pressure sodium lamps.

In order to explain the Penning effect, the terminology and some basic physics concepts concerning gas atoms are reviewed.

Let us first consider an atom in the ground state. This is the normal state of the atom with a full complement of electrons whirling about the nucleus in their normal orbits.

If sufficient energy (the excitation potential) is applied to the atom, an electron will remove itself to a higher energy level or orbit. This is known as the excited state of an atom. An atom in the normal excited state tends to return to the ground state rather quickly. In so doing, it gives up energy in the form of radiation or light.

At specific energy levels (the metastable potential), an atom will become excited but tend to "hang up" in this state. It can actually have an excited life as much as 1000 times as long as the normally excited state. This is known as the metastable state. Metastable atoms tend to lose their energy by collision with other atoms rather than by radiation.

As higher potentials are applied to atoms, electrons will remove themselves completely from the atom. The atoms become charged ions. The atom will then be in the ionized state and the energy level or potential necessary to form ions is known as the ionization potential.

FIG. 2 is a chart comparing the lowest metastable potential, the lowest excitation potential and the ionization potential of different gases or vapors commoly used in arc discharge lamps,, namely, neon, argon, xenon, mercury and sodium. The lower solid line represents the lowest metastable potential. The dashed line represents its lowest excitation potential. The upper solid line denotes the ionization potential of the gas.

In order for a Penning effect to take place certain conditions must be satisfied:

1. A major and minor constituent of the gas mixture must exist;
2. The lowest excited state of the major constituent must be a metastable one;
3. The metastable potential of the major constituent must be greater than the ionization potential of the minor constituent.

Considering the fact that we can select an optimum relationship of the major and minor constituents, it can be observed from FIG. 2 that several Penning mixtures are possible. Among them is argon as the major constituent with mercury. This mixture is used in fluorescent and mercury lamps.

Another possibility is neon as a major constituent with argon. This is the mixture of starting gases selected for the Penning start high pressure sodium lamp. Typical Penning mixtures of neon-argon gases contain argon as approximately 0.1 to 1% of the mixture. Thus we can expect from 100 to 1000 times the number of atoms of neon as compared with the number of argon atoms.

Let us consider random electrons being accelerated down an arc tube containing the above neon-argon mixture. The probability of collisions with neon atoms

is much greater than with argon atoms due to their sheer relative number of atoms. It is very probable that some electrons will be able to accelerate to a velocity equivalent to 16.6 volts of kinetic energy before collision with neon atoms. They would thus give up their energy to the neon atoms and cause them to be in the metastable state. Since this is the lowest excited state of the major constituent, it is very probable that this condition will occur in adequate numbers. The neon atoms tend to remain in their excited metastable state until collision. When tye collide and impart their energy to argon atoms, the argon atoms will become ionized. This of course is because the energy imparted by the neon atom will be higher than the 15.8 volts required to ionize argon atoms. This process will continue until the gas becomes ionized and current flows, thereby starting the lamp.

The Penning mixture substantially reduced the starting voltage from that of the conventional xenon filled high pressure sodium lamp. It was still not sufficiently reduced to provide satisfactory starting with mercury ballasts. In order to design lamps capable of starting at voltages provided by mercury ballasts, a starting ring is wrapped around the arc tube. The starting ring, which is near one electrode, is at the potential of the opposite electrode. Thus the full open circuit voltage would exist between the starting ring and the nearest electrode. Ionization is initiated to the starting ring and then tends to avalanche to the opposite electrode.

A lamp in accordance with this invention, as shown in FIG. **1**, comprises a hermetically sealed alumina arc tube **1** disposed within an outer glass jacket **2** which is sealed at the bottom to the flare of the usual stem press **3** and has the usual metal threaded base **4**. Lead-in wires **5** and **6** are supported in stem press **3** and are connected to base **4** in the usual manner.

Support rod **7** is welded to lead-in wire **5** and extends roughly from the bottom to the top of the lamp. The upper end of arc tube **1** is supported by a rod **8** which is welded between support rod **7** and niobium tube **9**. Tube **9** is sealed through the upper end of arc tube **1** and supports electrode **10** within arc tube **1**. Electrical connection to electrode **10** is provided by metal strap **11** which is welded between rod **7** an niobium tube **9**.

The lower end of arc tube **1** is supported by metal strap **12** which securely encircles lower niobium tube **13** and is welded to lead-in wire **6**. Tube **13** is sealed through the lower end of arc tube **1** and supports electrode **14** within arc tube **1**.

Encircling arc tube **1**, the closer to the lower end than to the upper end thereof, is wire ring starting aid **15**. Wire ring **15** is welded to a support wire **16** which is embedded in a quartz rod **17**. Quartz rod **17** is supported by another support wire **18** which is embedded thereon and is welded to support rod **7**. Another wire **19** is embedded in quartz rod **17** and is also welded to rod **7**. A U shaped bimetallic switch **20** is welded to wire **19** and makes pressure contact, at room temperature, with wire **16**. Thus, when the lamp is initially energized, wire ring **15** has the same voltage as electrode **10**. Wire ring **15** is electrically removed from the circuit by the opening of switch **20**, which occurs after a few seconds or minutes when switch **20** is heated to its actuating temperature, for example 105°C, by the heat generated by the lamp. Removal of wire ring **15** from the circuit is necessary in order to avoid electrolysis, during normal operation, which could draw sodium in the arc tube through the walls thereof.

Disposed at the lower end of the lamp, supported on rod **7**, are two getters **21**. Spring fingers **22**, disposed at both ends of the lamp and mounted on rod **7**, engage the inner wall of jacket **2** and aid in positioning arc tube **1**.

Arc tube **1** contains sodium, mercury and a Penning mixture gaseous filling, for example, neon and argon.

The location of wire ring starting aid **15** is critical for attainment of lowest ignition voltage.

The effect of the location of wire ring **15** upon the starting of a particular 150 watt lamp is shown in FIG. **3**. The arc length of the lamp was approximately 69 mm. The starting aid location shown in FIG. **3** is the distance between wire ring **15** and electrode **14**. The optimum location in this example was about 17 mm.

Optimum starting aid location is dependent on the pressure and composition of the Penning gas mixture. For example, in an arc tube having a 69 mm arc length and containing 99% neon - 1% argon at 14 torr, the minimum starting voltage of 160 volts was attained at a starting aid location of 24.1 mm. For a Penning mixture of 99.7% neon - 0.3% argon at 34 torr, the location of the starting aid to obtain minimum starting voltage was 16.2 mm.

I claim:

1. A high pressure sodium arc discharge lamp comprising an alumina arc tube disposed within an outer jacket, the arc tube having an electrode at each end and containing a fill including sodium, mercury and a Penning gas mixture; a wire ring starting aid encircling the arc tube, more proximate one electrode than the other, and electrically connected to said other electrode through a temperature actuated switch which is normally closed at room temperature and which is open during normal lamp operation, thereby electrically disconnecting the wire ring starting aid.

2. The lamp of claim **1** wherein the gas mixture comprises neon and argon.

3. The lamp of claim **2** wherein the gas mixture comprises at least 99% neon.

4. The lamp of claim **1** wherein said arc tube has an arc length of 69 mm, said Penning gas mixture is 99% neon and 1% argon and said wire ring starting aid is 24.1 mm from said more proximate one electrode.

5. The lamp of claim **1** wherein said arc tube has an arc length of 69 mm, said Penning gas mixture is 99.7% neon and 0.3% argon and said wire ring starting aid is 16.2 mm from said more proximate one electrode.

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