July 1, 1969 J. F. ENGLISH 3,453,476

HALOGEN REGENERATIVE CYCLE INCANDESCENT LAMP

Filed June 6, 1967

Fig. 1.

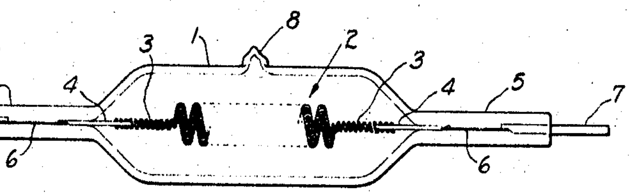


Fig. 2.

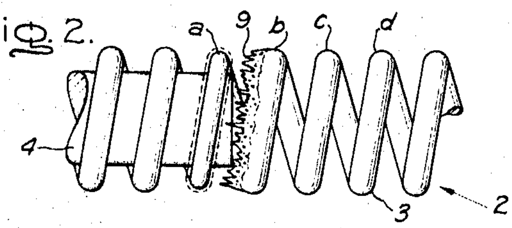


Fig. 3.

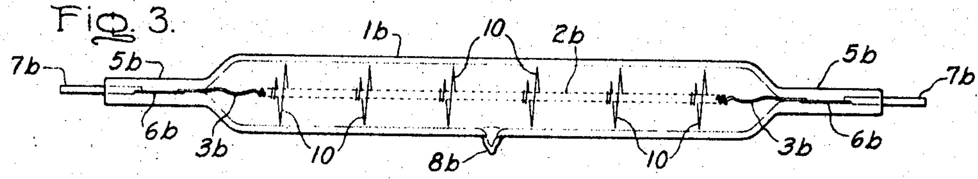
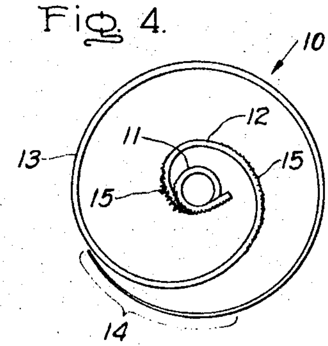


Fig. 4.



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3,453,476
HALOGEN REGENERATIVE CYCLE INCANDESCENT LAMP

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U.S. Cl. 313—176 4 Claims

ABSTRACT OF THE DISCLOSURE

A tungsten filament halogen regenerative cycle incandescent lamp containing both bromine and iodine as halogen.

FIELD OF THE INVENTION

The invention relates generally to electric incandescent lamps, and more particularly to tungsten filament lamps of the halogen regenerative cycle type.

BACKGROUND OF THE INVENTION

Several years ago the first practical halogen cycle lamp was introduced commercially in the form of a compact tubular envelope of quartz glass containing a tungsten filament and a filling of inert gas and a small quantity of iodine, and which operated with a minimum envelope wall temperature of 250° C. so that tungsten vaporized from the filament onto the envelope wall reacted with iodine to form a compound which returned to the vicinity of the filament where it was broken down and the tungsten redeposited on the filament, thereby keeping the envelope walls free from blackening by tungsten throughout a long, useful life. Such a lamp is more fully described and claimed in Patent 2,883,571 to Fridrich and Wiley.

More recently, it was found that lamps could be operated more or less successfully with bromine as the halogen. However, bromine attacks or etches the cooler portions of tungsten elements in the lamp, such as the cooler ends of the filament and cooler portions of tungsten support wire members which are used to support the filament from the envelope walls. In some cases, the bromine attack might be tolerated if the bromine content were reduced to a very small amount; however, in such cases there is a tendency for the bromine to be cleaned up and effectively removed from the lamp atmosphere if it is present in too small an amount. It was further found that the bromine attack could be reduced, although not entirely eliminated, by the addition of hydrogen, either separately or as a hydrogen-containing compound such as HBr, CH_3Br, CH_2Br_2, etc. There was thus made available a source or reservoir of bromine which could then be added in somewhat larger amounts, especially in lamp types, such as projection lamps, which operate at high filament temperature and efficiency for a corresponding relatively short life such as 50 to 150 hours or so, and which therefore are more likely to burn out in a normal manner before the bromine attack has destroyed the lamp.

In some cases it is possible to keep lamps clean with bromine which might tend to darken when containing iodine, for example lamps having filaments which are not of the best quality and which therefore contain various impurities. However, the attack or etching of cooler tungsten elements by the highly reactive bromine remains a problem.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a lamp containing bromine as a regenerative getter but in which the aforesaid bromine attack is greatly minimized or virtually eliminated.

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To that end, I have discovered that when iodine is added along with bromine to the lamp, the attack of the cooler portions of the tungsten filament and/or supports is greatly reduced.

Further features and advantages of the invention will appear from the following detailed description of species thereof and from the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side view of a form of lamp in which the invention may be embodied;

FIG. 2 is a fragmentary side view, on an enlarged scale, of the filament and the supporting lead-in wire or spud of the FIG. 1 lamp and illustrating the end attack of the filament in the absence of iodine in the lamp;

FIG. 3 is a side view of another species of lamp having supplementary filament support members; and

FIG. 4 is a side view, on an enlarged scale, of a filament support member illustrating the bromine attack thereof in the absence of iodine in the lamp.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 of the drawing, the lamp illustrated therein is of a double-ended type comprising a tubular envelope **1**, preferably of quartz glass or essentially fused silica, containing a tungsten filament **2**. In this case, the filament **2** is a helically coiled-coil of tungsten wire which extends axially of the envelope and which terminates in helically single-coiled ends or legs **3** which are fitted tightly over respective tungsten wire inner leads or spuds **4** which extend into respective flattened pinch seals **5** at the ends of the envelope where they are welded to respective molybdenum foils **6** which are hermetically sealed in the pinch seals **5** and which are, in turn, welded to respective outer lead wires **7** which may be made of molybdenum.

The envelope **1** is evacuated and filled with inert gas such as nitrogen, argon, krypton, xenon or mixtures thereof at a pressure of at least several hundred torr (mm. Hg) and preferably several atmospheres. In accordance with the invention, the envelope also contains both bromine and iodine for operation of the halogen regenerative cycle. The bromine may be used as such in small amounts, but it is preferred that hydrogen be present at a pressure at least equal to and preferably not more than five times the bromine pressure. The bromine and hydrogen may be provided in the form of hydrogen bromide or a hydrocarbon compound of bromine, for example. The iodine concentration should exceed that of the bromine. The envelope may be exhausted and filled with inert gas and halogen in known manner through an exhaust tube, the sealed or tipped-off residue of which is shown at **8**.

FIG. 2 illustrates a typical example of filament end attack or tungsten transfer which occurs when the lamp contains bromine alone as the halogen, with or without hydrogen. In this case, the last turn *a* of the filament leg **3** on the spud or lead-in wire **4** is attacked and etched down by transfer of tungsten up the temperature gradient to the first turn *b* which is off the spud **4**, as evidenced by the spikes **9** of tungsten crystal growth on turn *b*. In other lamps involving different filament temperatures, the turn *b*, or both turns *a* and *b* may be thinned down and the tungsten crystal growth appears on the next turn *c* or both turns *c* and *d*. The addition of iodine greatly minimizes or virtually eliminates such filament end attack. In some lamp designs having a longer coiled-coil filament **2**, the filament may be engaged at its midpoint by a supplemental support member in known manner, and in that case cooler portions of the support member are subject to attack by bromine which is minimized by addition of iodine.

The lamp shown in FIG. 3 is generally similar to that shown in FIG. 1, and parts corresponding to those in FIG. 1 are marked with the same numeral with the addition of the letter *b*. However, in this case the filament **2***b* is a helical single-coil of tungsten wire of extended length and it is connected to respective molybdenum foils **6***b* by leg portions **3***b* which are simply a generally straightened length of the wire at each end of the filament. To prevent the filament from sagging down against the envelope, when heated, it is supported by conventional tungsten wire support members **10** spaced evenly along its length. As better seen in FIG. 4, the support **10** comprises several turns **11** which are in intimate contact with the turns of the filament coil **2***b* and from which extends a spiral portion **12** which terminates in a circular portion **13** of at least one full turn which is adapted to engage the inner wall of the envelope **1***b*. A preferred form of such a support member is disclosed and claimed in Patent 3,168,670 to Levand.

As shown in FIG. 4, a typical case of attack or tungsten transfer caused by the use of bromine alone as the halogen, with or without hydrogen in the lamp, results in etching and thinning of a cooler portion of the outer turn **13**, as illustrated in the area at **14**, and deposits of crystalline spikes of tungsten on the spiral portion **12** nearer the filament, as shown at **15**. The thinning of the outer turn can, of course, lead to a failure or collapse of the support members with consequent sagging of the filament **2***b* toward the envelope wall. Such attack of the supports is minimized or virtually eliminated by the addition of iodine as a supplemental halogen.

It may be noted that in the particular end design of the filament shown in FIG. 3 wherein a few turns of the filament coil at each end thereof are simply pulled out to form the straightened legs **3***b*, the end attack by bromine on the filament turns is effectively reduced or eliminated due to the fact that there is a gradual temperature gradient along the filament end turns and the straight legs **3***b*, as contrasted with a sharp temperature gradient in the FIG. 2 design between the filament turns beyond the spud **4** and those turns enclosing the said spud. This is more fully described and claimed in my copending application Ser. No. 609,592, filed Jan. 16, 1967.

As pointed out above, the iodine concentration, by weight or by pressure, should exceed that of the bromine. Also, while bromine may be used in elemental form, it is preferably used as a hydrogen compound present in an amount equal to or up to about five times the bromine pressure. A compound such as CBr_4 may be used with free hydrogen added. However, the hydrogen preferably may be introduced as a compound with bromine, such as HBr, CH_3Br, CH_2Br_2, $CHBr_3$, etc. If more hydrogen is desired it may be introduced with the iodine as a compound which may be one corresponding to the stated bromine compounds. The proper or sufficient amount of hydrogen may be assured by proper selection of the bromine and iodine compounds such, for example, as CH_3Br with CHI_3, HI with HBr, etc.

The iodine may be present in the lamp in the range of about 0.02 to 1.5 micromoles per cc. of envelope volume, corresponding to about 0.006 to 0.4 milligram per cc. The bromine may be present in the range of about 0.002 to 0.5 micromole per cc. of envelope volume, corresponding to about 0.0004 to 0.09 milligram per cc.

Expressed as partial pressure (at ambient room temperature of about 24° C.), the bromine may be present in an amount ranging from about 0.05 to 10 torr, and the iodine at an "equivalent pressure" in the range of about 0.5 to 30 torr. The term "equivalent pressure" is one used in the art to designate a quantity of iodine which is actually solid at ambient temperature but which would have the indicated vapor pressure if it were all in vapor form at the ambient temperature. It is derived from the gas law formula

$$P=\frac{nRT}{V}$$

where P is pressure in torr, n is gram moles of iodine (or gram micromoles $\times 10^6$), R is a gas constant equal to 62,360, T is ambient temperature, absolute (24° C. plus 273.2=297.2° K.) and V is lamp envelope volume in cc. Thus, for a lamp of 3.8 cc. volume which is stated to contain an "equivalent pressure" of iodine of 20 torr (at an ambient temperature of 24° C.), the amount of iodine would be:

$$n=\frac{PV}{RT}=\frac{20\times 3.8}{62{,}360\times(273+24)}=4.1\times 10^{-6}\text{ moles}=4.1\text{ micromoles}$$

$$\text{micromoles/cc.}=\frac{4.1}{3.8}=1.08$$

The figure in milligrams per cc. is derived by multiplying the moles (4.1×10^{-6}) by the molecular weight of iodine (253.8), which equals 0.00104 gram total, or 1.04 milligrams divided by 3.8 cc. volume=0.273 milligrams per cc. of envelope volume.

By way of specific example, a lamp of the type shown in FIGS. 1 and 2 was made with an envelope of about 9.5 mm. inside diameter and volume of 2.5 cc. with a coiled-coil filament **2** of 500 watt rating at 120 volts. The envelope contained nitrogen at a pressure of 2000 torr, 3 torr of bromine and 3 micromoles of iodine. It was surprising to find that this lamp performed better than lamps filled with either bromine or hydrogen bromide, but no iodine. In particular, there was greatly reduced crystal activity or attack at the cooler ends of the filament, such as that illustrated in FIG. 2. The lamp burned in excess of 3200 hours without wall deposits and little filament end attack. On the other hand, similar coiled-coil filament lamps, including some of the single-ended type wherein the filament legs **3** and the lead-in conductors **4**, **6**, **7** both extend normal to the coiled-coil body portion of the filament and through a single pinch seal **5**, and containing only hydrogen bromide as the halogen, showed serious end attack where the filament coil joins the spuds or inner leads **4**.

Some 500 watt, 120 volt lamps of the type shown in FIGS. 3 and 4 were made in envelopes **1***b* of 8 mm. inside diameter and 3.8 cc. volume, with six supports **10** for use in applications where they are subjected to abnormal shock and vibration. Serious attack on the supports **10**, as shown in FIG. 4, occurred with either bromine or hydrogen bromide at concentrations around 3 torr pressure. With the addition of 3 micromoles of iodine, however, little, if any, support attack was observed at 1500 hours. Whether the main fill gas is nitrogen or argon seems to make little difference.

It appears that all or a large percentage of the initial hydrogen is retained within the quartz envelope in the presence of bromine. When stoichiometric quantities of hydrogen and bromine are introduced into the lamp along with nitrogen and/or argon, a definite yellow-brown bromine color is visible before the lamp is energized. Immediately after the lamp is lighted, colorless hydrogen bromide is formed. However, at no time afterward does the color return, even after several thousand hours of operation. Apparently the hydrogen is retained by the bromine before it can permeate through the quartz wall. This is in contrast to the case of colorless hydrogen iodide where the hydrogen permeates through the wall to the outside leaving behind a pink hue of molecular iodine vapor after an appreciable burning period of a few hundred hours. This color change is reversible, as can be demonstrated by inserting the pink lamps in a hydrogen oven and converting the iodine back to the colorless iodide.

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

1. An electric incandescent lamp of the halogen re-

generative cycle type comprising a compact sealed envelope of light-pervious material of high softening point containing at least one tungsten element including a tungsten filament and also containing a filling of inert gas and halogen which reacts with tungsten vaporized from the filament to form a tungsten-halogen compound which then breaks down in the vicinity of the filament to return tungsten thereto, wherein the halogen includes both bromine and iodine and the iodine concentration exceeds that of the bromine, said bromine tending to attack cooler portions of a said tungsten element, said iodine inhibiting the said attack of the tungsten elements, said bromine and iodine coacting in said regenerative cycle to maintain the envelope walls essentially free from blackening by vaporized tungsten.

2. A lamp as set forth in claim **1** wherein the iodine is present in the range of about 0.02 to 1.5 micromoles per cc. of envelope volume and the bromine in the range of about 0.002 to 0.5 micromole per cc. of envelope volume.

3. A lamp as set forth in claim **1** wherein the envelope also contains hydrogen at a pressure in a range equal to and up to about five times the bromine pressure.

4. A lamp as set forth in claim **3** wherein the iodine is present in the range of about 0.02 to 1.5 micromoles per cc. of envelope volume and the bromine in the range of about 0.002 to 0.5 micromole per cc. of envelope volume.

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U.S. Cl. X.R.

313—174, 222, 223