March 29, 1960 W. H. LAKE ET AL 2,930,873

GLOW SWITCH

Filed March 25, 1957

Fig. 1.

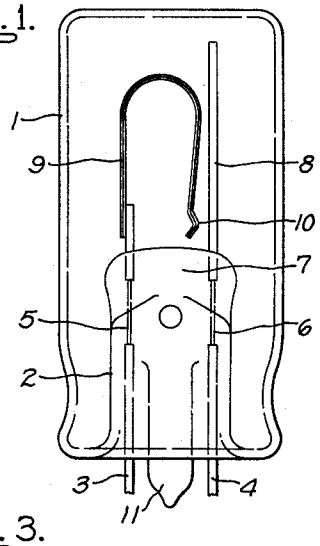


Fig. 2.

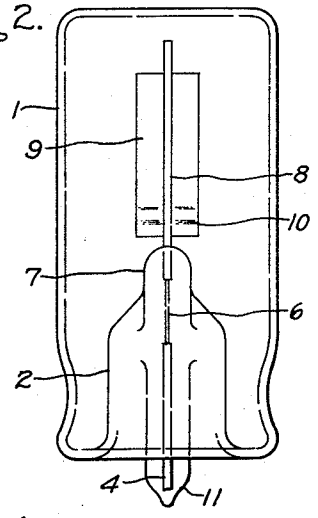


Fig. 3.

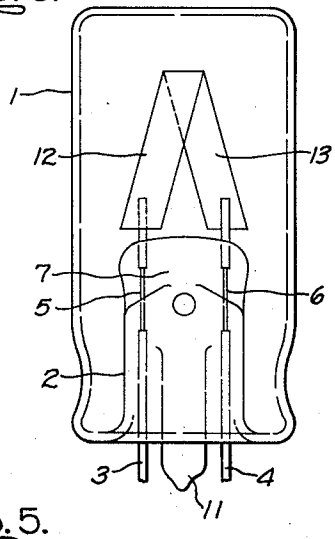


Fig. 4.

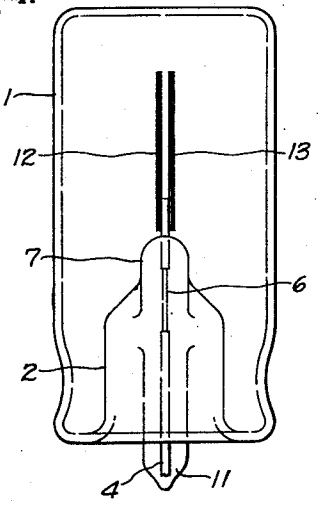
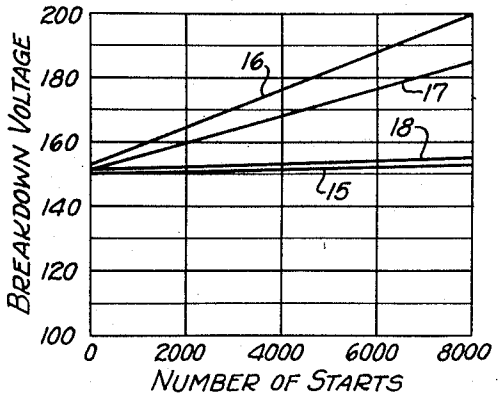


Fig. 5.



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United States Patent Office 2,930,873
Patented Mar. 29, 1960

2,930,873

GLOW SWITCH

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Application March 25, 1957, Serial No. 648,280

6 Claims. (Cl. 200—113.5)

This invention relates to thermal switches of the glow type used for starting elongated low-pressure discharge lamps such as fluorescent lamps.

In switch-start fluorescent lamp circuits, a glow switch is connected in shunt with the discharge path through the lamp and in series with the electrodes. The switch comprises a pair of normally spaced-apart electrodes, at least one of which is heat-deformable, within a small glass envelope containing an ionizable gaseous atmosphere. The heat-deformable electrode, generally a thermally responsive bimetallic strip, is positioned to flex toward and engage the other electrode when heated.

At starting, the open circuit voltage of the ballast exceeds the breakdown voltage of the switch and starts a glow discharge therein which heats the thermally responsive electrode and causes it to engage the other electrode in the switch. The closure of the switch effectively short circuits the lamp electrodes in series across the ballast; thereupon the increased current flow through the electrodes raises them rapidly to an electron-emitting temperature. Simultaneously, the glow discharge through the switch is extinguished and the switch electrodes begin to cool. After a time, the thermally responsive electrode in the switch breaks contact with the stationary electrode and produces a transient voltage surge or kick due to the inductance in the ballast. This surge impressed across the lamp normally starts the main discharge between the lamp electrodes; if the lamp fails to start, the cycle is repeated until starting is achieved. After the main discharge through the lamp has started, the voltage drop thereacross is less than the breakdown voltage of the switch so that the switch does not develop a glow discharge and its electrodes remain disengaged.

Glow switches, like glow discharge devices in general, are subject to an effect commonly known as dark effect, whereby the breakdown voltage of the glow discharge in the switch is higher in the dark than in the light. This effect results in delay at starting and erratic operation. Various expedients have been resorted to for eliminating it. One expedient widely used is to provide a coating of uranium oxide on the inner surface of the end wall of the glass envelope of the switch, as disclosed in U.S. Patent No. 2,324,907—Clack. Another expedient which has been widely used is to provide a coating of a conductive material such as aluminum paint on the inner end of the stem and extending onto the lead-in wires at the points where they emerge from the press, as disclosed in U.S. Patent 2,332,809, Peters. These dark effect neutralizing expedients add substantially to the cost of the glow switches and complicate the manufacturing process. Also, in the case of the aluminum stem paint particularly, the effectiveness thereof decreases during the life of the switch, thereby rendering the operation of the switch erratic and terminating its useful life.

An object of the invention is to provide an improved glow switch which is simpler and more economical to manufacture.

Another object of the invention is to provide an improved glow switch in which the ionization conditions remain extremely stable throughout the life of the device.

In accordance with the invention, the dark effect remedial expedients of the prior art are replaced by the introduction into the gaseous filling of the switch of a trace of tritium in sufficient concentration to provide enough radioactivity to overcome dark effect. However, we have discovered that the addition of tritium alone in the concentration required to eliminate dark effect at the beginning of the life of the switch will not assure the desired mode of operation throughout life. Increasing the concentration of tritium in the switch does not offer a practical solution due to the cost factor involved and other complications. In accordance with the invention, a solution to the problem is provided by adding to the gaseous filling of the switch a carrier gas consisting of hydrogen.

For further objects and advantages and a better understanding of the invention, attention is now directed to the following description and accompanying drawing. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

In the drawing wherein like numerals denote corresponding parts in the various figures:

Figs. 1 and 2 are front and side elevations respectively of a glow switch embodying the invention.

Figs. 3 and 4 are front and side elevations respectively of another glow switch embodying the invention.

Fig. 5 is a graph showing the breakdown characteristics of glow switches as affected by the presence of hydrogen in addition to tritium.

Referring to Figs. 1 and 2, there is shown a glow switch comprising a tubular glass bulb **1** having its upper end closed and its lower end peripherally sealed to a glass stem tube **2**. Lead-in wires **3**, **4** extend through the stem and have intermediate portions **5**, **6** of copper clad nickel-iron alloy wire commonly known as dumet sealed through the press **7** of the stem. Lead wire **3** projects beyond the dumet portion as a metal rod **8**, for instance a nickel rod. Lead wire **4** has welded to its inwardly projecting end a bimetallic element **9** which is bent over into a U-shape, as shown, so that the free end thereof is proximate to rod **8**. Bimetallic element **9** consists of two strips of metal having different linear coefficients of expansion welded together. For instance, the side of lower expansion may consist of nickel-iron alloy and the side of higher expansion of chrome-iron alloy. The side of higher coefficient of expansion is on the inside curve of the U so that the bimetallic element opens out and engages electrode **8** when heated. Preferably the free end of the bimetallic element to provide with an outwardly projecting embossment or curved portion **10** to insure that contact with electrode **8** is always made at the same point after flexure of the bimetallic element through a predetermined distance. The stem **2** is provided with an exhaust tube **11** through which the envelope is exhausted of air and filled with the desired ionizable gaseous atmosphere during manufacture of the switch, as explained hereinafter.

Figs. 3 and 4 illustrate another embodiment of the invention wherein similar reference numerals indicate corresponding parts. In this switch, thermally responsive bimetallic strips **12**, **13** are welded to the inwardly projecting ends of the lead-in wires and are angled toward each other in order to overlap at their upper ends. Each bimetallic strip consists of two strips of metal having different linear coefficients of expansion welded together as in the case of the U-shaped bimetallic element of Figs. 1 and 2. The twostrips are mounted in such fashion that the sides of lower coefficient of expansion face inwardly, that is are in confronting relation. Thus when the elec-

trodes become heated, they bend inwardly towards each other and make contact at their upper ends.

The switch of Figs. 1 and 2 corresponds to the type designated commercially GS4 and intended for the operation of 30 and 40-watt standard switch-start fluorescent lamps. In order to eliminate dark effect in this switch, it has been the practice to paint the upper portion of the stem 7 and also the lead-in wires at the points where they emerge from the press with a conductive material such as an aluminum paint consisting of aluminum metal powder in a nitrocellulose lacquer. The switch envelope may contain a filling of an inert gas such as helium or neon or argon or a mixture of neon and argon at a low pressure, depending upon the breakdown voltage desired for the switch. For a GS4 switch intended for the operation of 30 and 40-watt lamps and required to have a minimum breakdown or closure voltage of 128 volts R.M.S., the filling may consist of argon at approximately 25 millimeters pressure. It has also been the practice to coat the bimetallic electrode in this switch with a low melting point metal such as zinc or magnesium and to subject the switch to a seasoning operation in order to reduce and stabilize the breakdown voltage.

The switch of Figs. 3 and 4 corresponds to that designated commercially GS4A and likewise intended for the operation of standard 30 and 40-watt switch start lamps. This switch, as described in Patent 2,740,861—Lake, makes use of electrically symmetrical electrodes and a gaseous filling of neon with 10 to 20 percent argon at a total pressure in the range of 45 to 70 millimeters in order to reduce instant starting of lead lamps in lead-lag circuits. In this switch, it has been the practice to eliminate dark effect by the provision of a coating of uranium oxide on the inner surface of the end wall of the envelope.

In accordance with the present invention, the dark effect resulting in rise of the breakdown voltage in these switches where the ionizable medium is argon or neon or mixtures thereof at a low pressure not exceeding approximately 100 millimeters of mercury, is eliminated by the provision of a minute proportion of radioactive tritium $_1H^3$. Tritium is a radioisotope of hydrogen having a half-life of 12.5 years and emits beta rays with a maximum energy of .019 mev., (million electron-volts). The production of ions by a radioisotope is directly dependent upon the number of disintegrations per second occurring. Accordingly, the quantity of radioisotope required is most conveniently stated in terms of its activity expressed in curies, a curie by definition consisting of 3.7×10^{10} disintegrations per second. Generally, an activity no less than 0.1 millicurie per liter of filling gas measured at atmospheric pressure is necessary for overcoming dark effect and activity in excess of 10 millicuries per liter provides no additional benefits. For the switches described herein, an activity of one millicurie per liter in the filling gas measured at atmospheric pressure eliminates substantially all dark effect. However, it is desirable to have some excess radioactivity inasmuch as some of the radioisotope may be absorbed on the walls of the switch and be covered by sputtered metal from the electrodes. Accordingly, it is preferred to use a radioactivity of approximately 5 millicuries per liter in the filling gas measured at standard temperature and pressure. Such a minute quantity avoids any radiation hazards.

While the addition of tritium to the switch filling in the proportion specified is sufficient to eliminate dark effect at the beginning of life of the switch, we have found that in the absence of further measures, the cure is not permanent. With increasing life, there is a gradual rise in the breakdown voltage as illustrated in Fig. 5 wherein the ordinate represents breakdown voltage and the abscissa represents the number of starts. It will be appreciated that each start may represent several cycles of closure of the switch, up to 20 for instance, depending upon the facility with which the lamp starts. Curve **15** represents the breakdown characteristic of prior art switches using for instance uranium oxide to compensate for dark effect as in my Patent 2,740,861. Curves **16** and **17** are typical of the breakdown characteristic of the switches discussed herein where tritium alone is added to the gaseous filling to compensate for dark effect, the curves illustrating the effects of the addition of ⅛ millicurie per liter and 5 millicuries per liter respectively.

In accordance with the invention, the gradual rise in the breakdown voltage with increasing life is avoided by the addition of a minor proportion of hydrogen, for instance in the range of 3 to 10 percent by volume, to the switch filling. Such addition stabilizes the breakdown characteristic with life and results in a substantially flat characteristic as illustrated by curve **18**. The explanation for the stabilizing effect of hydrogen is believed to be that in the absence of hydrogen, the chemically highly active tritium reacts with traces of impurities present in the switch and is deposited on the inner surface of the envelope. Continued action of the glow switch produces sputtering of metal through arcing during cyclic opening and closing of the switch contacts, and this sputtered or evaporated metal is deposited on the switch envelope over the tritium previously absorbed on the envelope wall. Since the range of the tritium beta radiation is small and the evaporated bimetallic material layer is of the order of magnitude of this range, the radiation from the tritium is absorbed in increasing degree. As a result, the ionizing effect of the tritium gradually disappears and the breakdown voltage of the switch increases with time.

While it is realized that the loss of ionization discussed above may be offset by greatly increasing the concentration of tritium initially introduced into the switch, this does not offer a practical solution due to the expense involved and also due to the excessive activity at the beginning of life. However, the addition of hydrogen as a carrier gas offers a practical solution. Since hydrogen is similar to tritium in chemical activity, the preferential deposition of tritium on the envelope wall is greatly reduced. We have found that the addition of hydrogen in a proportion between 3 and 10 percent assures that a concentration of tritium providing an activity in the range of 0.1 to 10 millicuries per liter in the filling gas measured at atmospheric pressure, provides adequate ionization to eliminate dark effect throughout the useful life of the switches.

As examples of switches embodying the invention, in a switch corresponding to that designated commercially GS4 having the physical configuration illustrated in Figs. 1 and 2, the proportions of the constituent gases in the filling may be in the following ranges:

Principal constituent—argon, 90 to 97%.
Radioisotope—tritium, 0.1 to 10 millicuries per liter measured at atmospheric pressure.
Carrier gas—hydrogen, 3 to 10%.
Filling pressure—20 to 30 millimeters of mercury.

The preferred proportions are approximately 93% argon, 5 millicuries per liter of tritium, and 7% hydrogen, the filling pressure for the mixture being approximately 25 millimeters of mercury.

For a switch corresponding to that designated commercially GS4A and having the physical configuration illustrated in Figs. 3 and 4 with electrically symmetrical electrodes for the elimination of instant starting in lead circuits, the proportions of the constituent gases in the filling may be in the following ranges:

Principal constituent—neon containing up to 20% argon, 90 to 97%.
Radioisotope—tritium, 1 to 10 millicuries per liter, measured at atmospheric pressure.
Carrier gas—hydrogen, 3 to 10%.
Filling pressure—45 to 70 millimeters of mercury.

The preferred proportions are approximately 95% neon, 5 millicuries per liter of tritium, and 5% hydrogen, the filling pressure for the mixture being approximately 60

millimeters of mercury. Curve 18 in Fig. 5 is representative of a switch of the GS4A type having these preferred proportions of filling gases.

While certain specific embodiments of the invention have been shown and described in detail, these are intended primarily as illustrative and not as limitative of the invention. Various modifications for adapting the switches to different sizes of lamps and to the operation condition provided by various ballast circuits will readily suggest themselves. The appended claims are intended to cover any such modifications coming within the true spirit and scope of the invention.

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

1. A glow switch comprising a sealed envelope containing a pair of cooperating electrodes at least one of which is deformable by heat into engagement with the other and an ionizable gaseous atmosphere in said envelope containing for the major part an inert gas from the group consisting of argon and neon and mixtures thereof at a pressure not exceeding 100 millimeters, a trace of radioactive tritium in a concentration providing sufficient activity to overcome dark effect, and a minor proportion of hydrogen in a percentage not exceeding 10 percent to serve as a carrier for the tritium.

2. A glow switch comprising a sealed envelope containing a pair of cooperating electrodes at least one of which is deformable by heat into engagement with the other, an ionizable gaseous atmosphere in said envelope at a pressure in the range of 20 to 30 millimeters of mercury comprising 90 to 97 percent argon, radioactive tritium at a concentration in the range of 0.1 to 10 millicuries per liter measured at atmospheric pressure and providing sufficient activity to overcome dark effect, and a minor percentage of hydrogen not exceeding 10 percent to serve as a carrier for the tritium.

3. A glow switch as defined in claim 2 wherein the ionizable gaseous atmosphere is at a pressure of approximately 25 millimeters of mercury and consists of approximately 93 percent argon, radioactive tritium at a concentration providing an activity of approximately 5 millicuries per liter measured at atmospheric pressure, and approximately 7 percent hydrogen to serve as a carrier for the tritium.

4. A glow switch comprising a sealed envelope containing cooperating electrically symmetrical electrodes at least one of which is deformable by heat into engagement with the other, and an ionizable gaseous atmosphere in said envelope at a pressure in the range from 45 to 70 millimeters of mercury and comprising 90 to 97 percent of a principal gas consisting for the major part of neon and containing not over 20 percent argon, a trace of radioactive tritium in a concentration providing sufficient activity to overcome dark effect, and 3 to 10 percent hydrogen to serve as a carrier for the tritium.

5. A glow switch comprising a sealed envelope containing cooperating electrically symmetrical electrodes mounted in confronting relation, said electrodes consisting of iron alloy bimetals devoid of any plating of low melting point metal and being spaced apart at room temperature and deformable by heat into mutual engagement, and an ionizable gaseous atmosphere in said envelope at a pressure of approximately 60 millimeters of mercury and comprising approximately 95 percent neon, 0.1 to 10 millicuries per liter of radioactive tritium measured at atmospheric pressure to provide sufficient activity to overcome dark effect, and approximately 5 percent hydrogen to serve as a carrier for the tritium.

6. A glow switch as defined in claim 5 wherein the concentration of tritium provides a radioactivity of approximately 5 millicuries per liter measured at atmospheric pressure.

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