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(71) Applicant : **GE LIGHTING LIMITED**
Lincoln Road
Enfield, Middlesex EN1 1SB (GB)

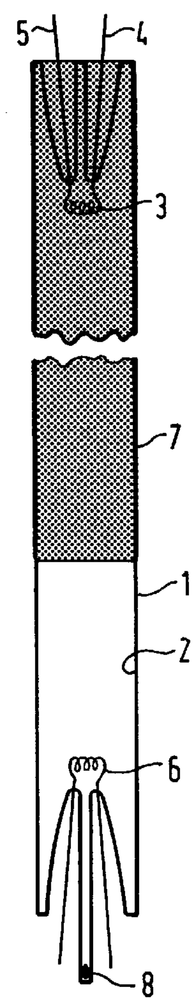
(72) Inventor : **Stocks, John Alan**
76 Cambridge Street
Leicester LE3 0JP (GB)
Inventor : **Tambini, Antony John**
7 Maitland Avenue
Mountsorrel, Leicester LE2 7DU (GB)

(74) Representative : **Pratt, Richard Wilson et al**
London Patent Operation G.E. Technical Services Co. Inc. Essex House 12/13 Essex Street
London WC2R 3AA (GB)

(54) **DC fluorescent lamps.**

(57) In order to counteract the migration of mercury ions from the anode (6) to the cathode (3) of a DC fluorescent lamp (1), a temperature gradient is established between the cathode (3) and the anode (6). The cathode (3) region is made hotter than the anode (6) region causing the mercury ions to recirculate in the lamp.

FIG. 2



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The present invention relates to DC fluorescent lamps.

These lamps are based on a discharge arc which is generated in a clear tube containing a low pressure mixture of mercury vapour and a rare gas. The tube, usually of glass, is coated on its inner surface with a layer of phosphor. This layer is necessary because the arc discharge, although producing some blue and green radiation, mainly generates ultra-violet radiation. The phosphor layer converts the ultra-violet radiation into visible light by the process of fluorescence. The inert gas normally used in fluorescent lamps is a mixture of argon and krypton.

In lamps of this kind the mercury exists in the lamps as a small liquid dose: during operation of the lamp the mercury condenses at the coolest part of the lamp body, this part being known as the cool spot. An amount of mercury determined by the temperature of the cool spot is then evaporated into the gas phase. During operation of the lamp mercury atoms are ionised and if the arc is DC generated the resultant positive mercury ions migrate to the (negative) cathode. This one-way transport of mercury is known as cataphoresis and its result is that in a DC operated fluorescent lamp all the mercury will in a short time of typically around 10 hours have been transported to the cathode region. This in turn results in the light output falling to around 40% of its original value. It is because of this that commercial fluorescent lamps are operated from A.C. where the 50Hz switching of electric field direction prevents cataphoresis. However there are many situations where it would be desirable to operate fluorescent lamps from DC sources if the mercury transport problem could be overcome. In particular the control gear for a DC lamp tends to be both cheaper and less bulky than that for A.C. operated lamps and this could be of particular advantage in compact fluorescent lamps.

In the last few years there have been attempts to produce compact fluorescent lamps in which the unwanted effects of cataphoresis are controlled so that the lamps can be run from a DC source. For example European Patent Specification No. 0 152 264 in the name of Matsushita Electronics Corporation discloses a compact fluorescent lamp in which it is claimed that cataphoresis is prevented by placing an amalgam forming material such as BiIn, In or BiPbSn adjacent to an electrode of the lamp and running the lamp from a DC supply so that the electrode adjacent to the amalgam is the anode. In Japanese Patent Specification 63037554, also in the name of Matsushita Electronics Corporation, there is described a compact fluorescent lamp of the kind having four parallel light-emitting tubes linked by short bridging tubes to provide a single discharge path between a pair of electrodes. Such lamps are known as quads. In this specification it is claimed that cataphoresis can be controlled by ensuring that the tips of two of the tubes are kept at a different temperature from the corresponding tips of the other two tubes so as to provide cold spots along the length of the discharge path. This temperature difference is achieved by positioning the bridging tubes at different distances from the tips of the light-emitting tubes. There is some doubt as to whether the arrangement proposed by Matsushita in this Japanese specification will work as it seems that at least one of the light-emitting tubes will be affected by cataphoresis.

Furthermore the concept of this prior specification is only applicable to quad-type compact fluorescent lamps.

Another patent specification concerned with the prevention of cataphoresis in fluorescent lamps is US patent specification No. 3,117,248. This patent discloses the use of link tubes to transport mercury from the cathode end to the anode. Experiments have shown that this system does not provide an adequate answer.

Accordingly the present invention is concerned with the provision of a fluorescent lamp which can be operated from DC but which does not suffer from the restricted operational life which results from mercury transportation. Furthermore the invention is not solely concerned with quad-type compact fluorescent lamps but with all types of fluorescent lamps.

Thus in accordance with the present invention there is provided a DC fluorescent lamp comprising a phosphor coated tubular lamp body housing a gas fill which includes a dose of mercury, the lamp body having a cathode electrode at one end thereof and an anode electrode at the other end thereof so that when a discharge is initiated in the gas fill by the electrodes, the phosphor coating converts the discharge into visible light, and wherein means are provided to maintain, in operation of the lamp, a temperature differential between the cathode region of the lamp and a cool spot located adjacent the anode region of the lamp, the temperature at the cathode region being kept sufficiently high to prevent condensation of mercury at the cathode region, and the temperature gradient between the cathode region and the cool spot being sufficient to counterbalance cataphoretic migration of mercury ions from the anode region to the cathode.

In accordance with a feature of the invention the cool spot of the lamp is located in operation of the lamp outside the line of the path of the arc between the electrodes.

In order that the invention may be more readily understood various embodiments thereof will now be described by way of example and with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic section through a known linear fluorescent lamp,

FIGURES 2, 3 and 4 are diagrammatic views showing three alternative embodiments of linear fluorescent lamps according to the invention, and

FIGURE 5 shows a compact fluorescent embodiment.

Referring now to FIGURE 1 of the drawings this shows a known linear fluorescent lamp operable from an AC current supply which is not shown and having a main glass lamp body 1. This body 1 is coated with an internal layer of phosphor 2 which can be one of many known types and also contains a standard gas fill which includes a mercury dose. Each end of body 1 houses an electrode one (the cathode) of which is shown at 3. The electrodes are connected to lead wires one pair of which is shown at 4 and 5. If the lamp as so far described is operated from a DC source mercury transportation would occur from whichever of the electrodes functioned as the anode to the cathode electrode. As a result of this the lamp would in a relatively short time cease to function properly.

FIGURE 2 of the drawings shows a first embodiment of a DC fluorescent lamp according to the present invention. In this embodiment, as in the embodiments of FIGURES 3 and 4 integers which are common to the embodiment of FIGURE 1 have been given the same reference numerals. In the embodiment of FIGURE 2 the main body 1 is provided with an additional coating layer 7 which reflects the bulk of infrared radiation from the lamp discharge back into the interior of the lamp. This area layer 7 covers the shown shaded in FIGURE 2 at 7 and in the present embodiment consists of a layer of fluorine doped Tin Oxide (FTO). The effect of layer 7 is to maintain the interior of the body surrounded by it at an elevated temperature and in particular that the cathode 3 region of the lamp remains at a sufficiently high temperature to prevent mercury condensation within the region 7. A typical temperature gradient within the lamp which would prevent cataphoresis is a temperature of around 85°C at the cathode region, between 59 and 69°C at the central region and 25°C at the cool spot 8. Thus during operation of the lamp mercury ions are transported to the cathode region by cataphoresis but the heating effect of the layer 7 prevents its condensation. Additionally the temperature gradient created by the raised temperature at the cathode region together with a concentration gradient forces the mercury back across the main body 1 where it re-condenses behind the anode 6 at the cool spot 8 which is located in the anode tubulation 9. This concentration gradient is caused by the depletion of mercury at the anode region by cataphoresis. The processes just described mean that the mercury dose is continually re-circulated around the main body 1 of the lamp. The forced recirculation of the mercury in turn means that the lamp just described does not suffer from a loss of mercury at the anode region and as a result can be run from DC with substantially constant light output.

Figures 3 of the drawings shows a variant of the embodiment of Figure 2 and in this embodiment the cathode region of the lamp is enclosed by a moulded resistor 10 which forms part of the ballast of the lamp. The heating effect generated by this moulded resistor is such that the temperature at the cathode region is sufficiently high to prevent mercury condensation and to ensure re-circulation of the mercury within the main body 1 to the coolspot 8.

FIGURE 4 shows a further way in which the required raised temperature at the cathode region can be achieved and in this embodiment a resistive wire 12 is coiled around the cathode region.

It will be appreciated that the linear lamp shape shown in FIGURES 2, 3 and 4 of the drawings is by no means the only lamp shape to which the concept of having an elevated temperature at the cathode region for the return of mercury can be applied. The concept can be used with any shape of fluorescent lamp an example of which would be the well-known U-tube type. In lamps such as the U-type where the anode and cathode regions are close together it may be advantageous to provide a narrow tube or tubes linking the two regions, the tubes being of sufficiently narrow diameter to prevent the arc striking them rather than through the main body. In such a case temperature elevation at the cathode region can be obtained in any of the ways described with reference to FIGURES 2, 3 and 4 of the drawing.

FIGURE 5 of the accompanying drawings shows a compact fluorescent lamp in which the discharge tube 51 is bent at 52 and 52' through 90° to form three sides of a rectangle, in the present example a square. The tube 51 is further bent at 53,53' through 180° so that the ends 54 of the discharge tube are re-entrant to the square formed thereby. Inside the square formed by the folded tube 51 is a lamp support housing 55 into which the ends of the discharge tube 51 are fitted. The housing 55 contains starter components and electrical connections and is formed with two hollow arms 56 which each grip the centre section of discharge tube 51 to give it structural support. Within the housing 55, which may be formed in two press-fit halves of thermoplastics material, is located appropriate circuitry 59 for starting the lamp and converting an AC mains power supply to DC. The circuitry 59 is connected to a printed circuit board 60 and the lamp has an anode electrode 61 and a cathode electrode 62. As can be seen the anode electrode 61 is located outside the housing 55 for cooling purposes whilst the cathode electrode 62 is located within the housing 55 so that the cathode region of the lamp will be relatively hotter than the anode region. Additionally the exhaust tube 65 of the anode end 54 of the discharge tube 51 is extended so it projects out of the housing 55 and into one of the hollow arms 56. Thus the cool spot 66 of the lamp where the mercury dose tends to collect will be external of the housing 55. In this way the necessary temperature gradient is maintained during operation of the lamp to counterbalance the effects of cataphoresis and to allow the lamp to be operated in a DC mode. Additional cooling can be provided for the extended exhaust tube by utilising a heat sink attached to the exhaust tubulation 65 of the anode.

It will also be appreciated that whilst the embodiments of FIGURES 2, 3 and 4 all show different ways in which a raised temperature can be achieved at the cathode region that it is possible to combine the reflecting layer 7 of FIGURE 2 with, for example the moulded resistor 10 of the embodiment of FIGURE 3.

Claims

1. A DC fluorescent lamp comprising a phosphor (2) coated tubular lamp body (1) containing a gas fill which includes a dose of mercury, the lamp body having a cathode (3) electrode at one end thereof and an anode (6) electrode at the other end thereof so that when a discharge is initiated in the gas fill by the electrodes, the phosphor coating (2) converts the discharge into visible light, and characterized in that means are provided to maintain, in operation of the lamp, a temperature differential between the cathode (3) region of the lamp and a cool spot (8) located adjacent the anode (6) region of the lamp, the temperature at the cathode region being kept sufficiently high to prevent condensation of mercury at the cathode region, and the temperature gradient between the cathode region and the cool spot being sufficient to counterbalance cataphoretic migration of mercury ions from the anode region to the cathode.

2. A lamp according to claim 1, wherein the said means to maintain a temperature differential comprises means (10,12) for heating the cathode region of the lamp body.

3. A lamp according to claim 2, wherein the heating means comprises a resistive heater (10,12) at the cathode region.

4. A lamp according to claim 3 wherein the resistive heater (10) is arranged for connection with, and to form part of, a ballast for the lamp.

5. A lamp according to claim 3 wherein the resistive heater comprises a resistive wire (12) coiled around the cathode region of the lamp body.

6. A lamp according to claim 1 wherein the said means to maintain a temperature differential comprises means (7) for reflecting infra-red radiation from the said discharge into the interior of the cathode region of the lamp body.

7. A lamp according to claim wherein the lamp body has exhaust tubulation at the anode region of the lamp and the said cool spot (8) is located in the said exhaust tubulation.

8. A lamp according to claim 1, wherein: the lamp body (51) is bent (52,52',53,53') so that the cathode and anode regions (54) are adjacent; the lamp comprises a housing (55) into which the said regions (54) extend; the cathode electrode (62) is located inside the lamp body and within the housing (55); the anode electrode (61) is located inside the lamp body and outside the housing (55); the lamp body has exhaust tubulation (65) at the anode region, the exhaust tubulation extending outside the housing (55); and the cool spot (66) is located in the tubulation outside the housing.

9. A lamp according to claim 7, further comprising means for cooling the said exhaust tubulation.

10. A lamp according to claim 1 in combination with a DC ballast (59,60) .

FIG.1

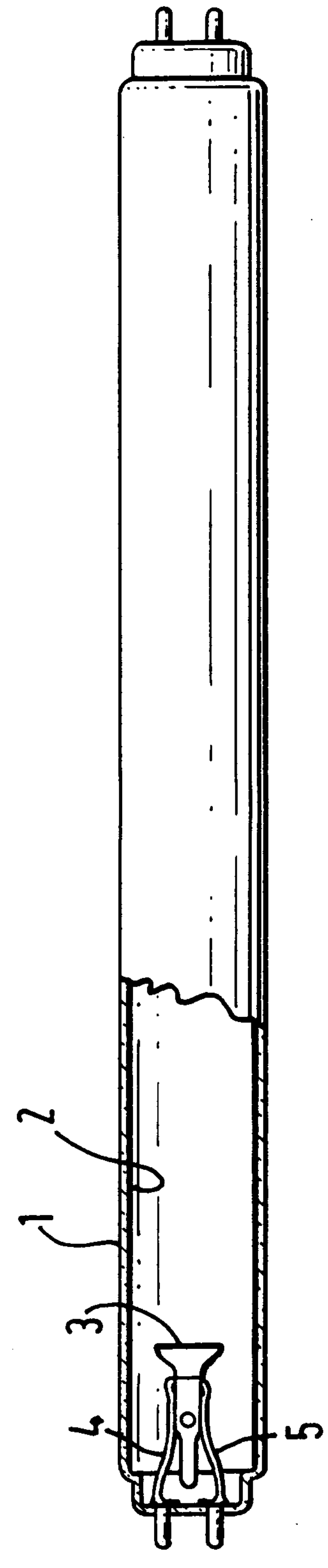


FIG. 2

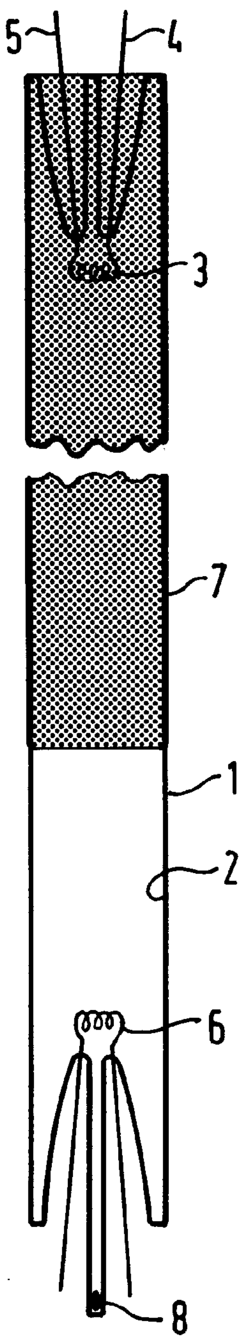


FIG. 3

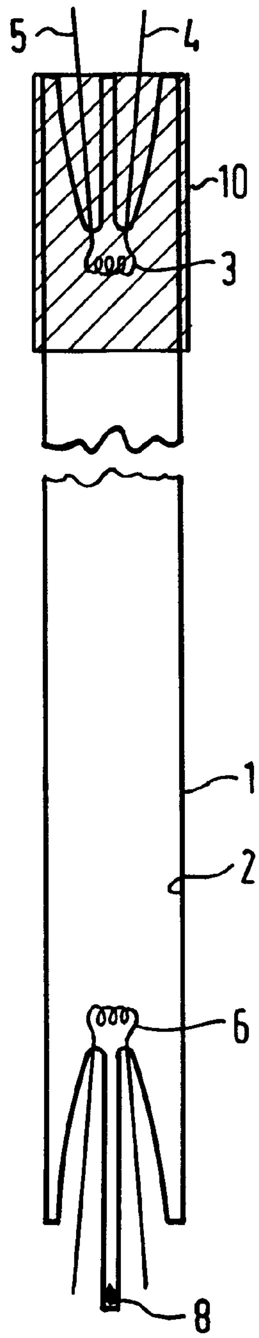


FIG. 4

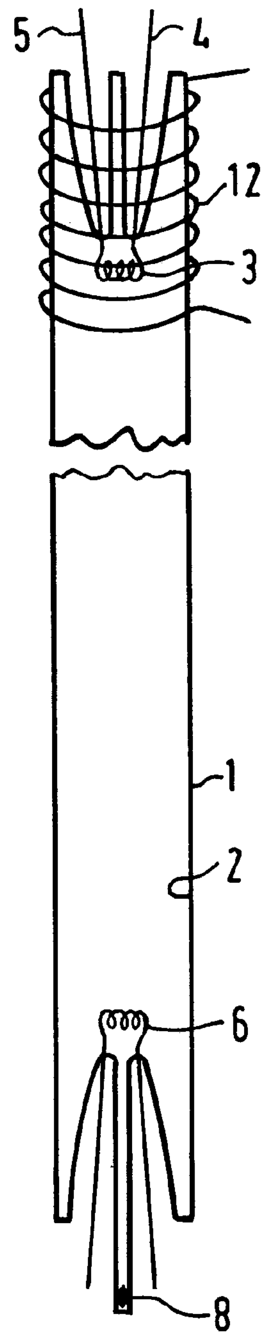
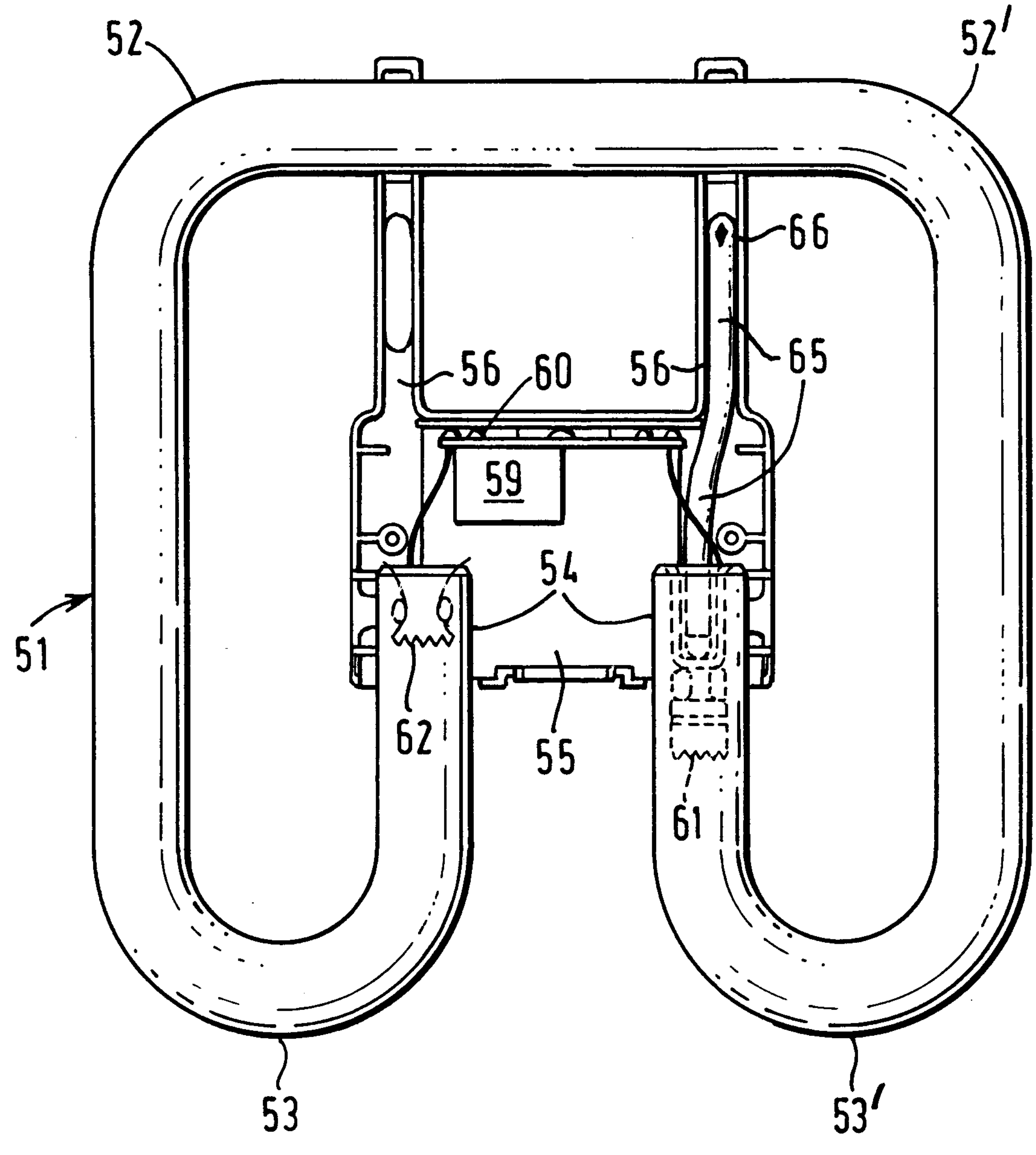


FIG. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 5015

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	US-A-3 714 492 (W.ROCHE) 30 January 1973 * column 1, line 11 - line 39 * * column 1, line 50 - line 53 * * column 1, line 60 - column 2, line 7 * * column 4, line 23 - line 25 * * column 4, line 31 - line 42 * * column 5, line 7 - line 18; figures 2,3 *	1-5,10 1,6	H01J61/72 H01J61/52 H01J61/33
Y	US-A-4 071 798 (T.HAMMOND) 31 January 1978 * column 2, line 1 - line 8 * * column 2, line 20 - line 34 * * column 2, line 38 - line 39; figure *	1,6	
A	EP-A-0 152 264 (MATSUSHITA) 21 August 1985 * page 6, line 17 - page 7, line 2; figure 2 *	1,7,8	
	-----		TECHNICAL FIELDS SEARCHED (Int. Cl.5) H01J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 OCTOBER 1993	ROWLES K.E.G.

CATEGORY OF CITED DOCUMENTS

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