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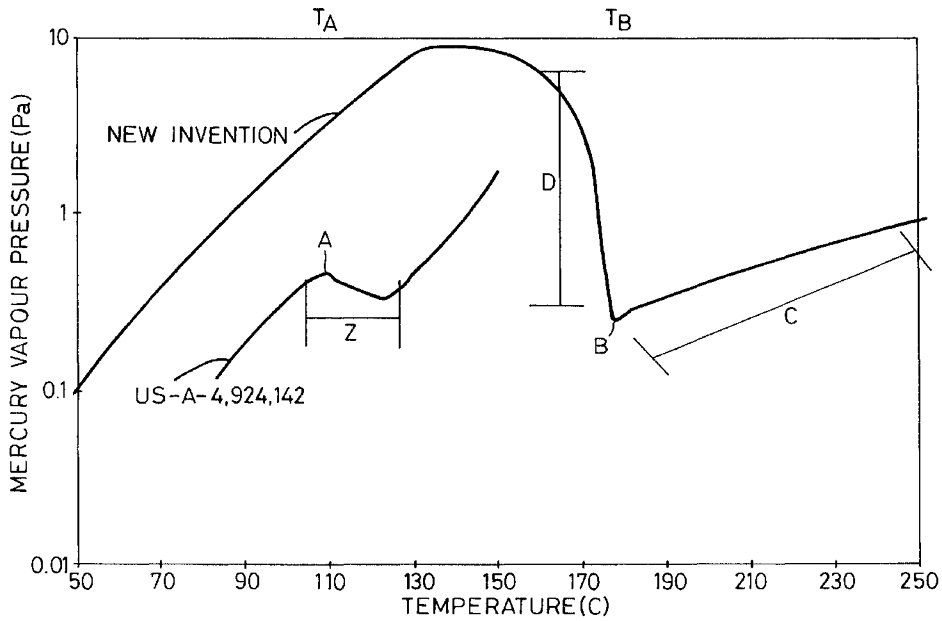
(54) **Mercury vapour discharge lamp including an amalgam**

(57) A mercury discharge lamp includes an amalgam for controlling the mercury vapour pressure within the lamp, the amalgam being selected and positioned within the lamp to provide a substantially optimum vapour pressure of mercury at the temperature of the amalgam corresponding to the maximum rated operating power of the lamp. The optimum vapour pressure is close to a minimum (B) at the temperature corresponding to maximum operating power, and adjacent a region (D) of steeply rising mercury vapour pressure with falling temperature. By operating the lamp in this region, a reduction in the operating power of the lamp causes a fall in temperature and hence an increase in the vapour pressure of the mercury to effect dimming of the lamp.

FIG. 2



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Description

This invention relates to gas discharge lamps, and in particular to fluorescent lamps employing a mercury low pressure discharge. The invention is useful with both electroded and electrodeless discharge lamps but is particularly applicable to compact electrodeless fluorescent discharge lamps.

In a mercury low pressure discharge lamp, high energy free electrons collide with neutral mercury gas atoms, raising a proportion of them to an excited state. The excited atoms can relax to a lower energy state by a number of routes but the route of particular interest is the one which results in the emission of electromagnetic radiation. The radiation produced by the lowest radiative excited state of the gas atoms is called the resonance radiation and is generally the most efficiently generated by the discharge gas.

The resonance radiation of mercury has a wavelength of 253.7 nm which, in a fluorescent lamp, is converted to visible light on striking phosphors coating the inside of the envelope of the lamp. The efficacy of the lamp, that is the ratio of the visible light power output to the electrical power input, is dependent to a large degree on the vapour pressure of the mercury within the lamp, the optimum pressure being approximately 0.8 Pa.

If the mercury vapour within the lamp is obtained by introducing an excess of pure mercury the vapour pressure is determined by the lowest temperature within the lamp, the lamp's cold spot, the optimum vapour pressure being obtained when the cold spot is approximately 40°C. Such lamps and their fixtures are therefore designed so that during operation at normal ambient temperatures the cold spot is at the design temperature of about 40°C.

Flexibility in lamp design can be achieved by introducing the mercury into the lamp in the form of an amalgam. As is well known in the prior art, the use of an amalgam allows the optimum pressure of the mercury vapour within the lamp to be obtained at a higher temperature than with pure mercury. The amalgam can therefore be physically located at a particular position within the lamp whose operating temperature is selected to suit the amalgam rather than having to ensure that the cold spot of the lamp is at 40°C.

It is also known in the prior art that an amalgam can provide a stable region in which the vapour pressure of the mercury is relatively insensitive to changes in temperature. A discussion of this effect can be read in an article by J Bloem et al., Journal of the Illuminating Engineering Society, April 1977, pages 141-146 entitled "Some New Mercury Alloys For Use in Fluorescent Lamps". In such prior art systems the amalgam is formulated such that the stable region corresponds to a mercury vapour pressure of about 0.8 Pa, the amalgam being positioned such that the amalgam is heated within a range of temperatures during operation which corresponds to the region of stable mercury vapour pressure.

Such amalgams have proved to be particularly useful with compact mercury discharge fluorescent lamps which have a relatively high power density associated with correspondingly higher operating temperatures. Discharge lamps generally operate in the arc discharge region which has a steeply negative voltage/current characteristic and such lamps have to employ a ballast component to prevent current runaway. The supply voltage must be kept above a maintenance voltage below which the operation of the lamp will become unstable and the discharge may be extinguished. Usual designs allow a maximum of about a 15% drop in the supply voltage before such extinction occurs. Attempts to dim pure mercury discharge lamps by changing the operating power of the lamp to reduce its efficacy are therefore relatively ineffective, both because the change in efficacy is not very great, and because of the need to retain some safety margin to prevent extinguishing during normal voltage excursions in operation of the lamp.

In the case of low pressure mercury discharge lamps employing an amalgam, the stabilisation of the vapour pressure with temperature by the amalgam further reduces the degree of dimming that can be obtained by reducing the power input to the lamp.

The present invention seeks to provide a mercury discharge fluorescent lamp having enhanced dimming characteristics. Accordingly, the present invention provides a mercury discharge lamp which includes an amalgam for controlling the mercury vapour pressure within the lamp, the amalgam being selected and positioned within the lamp to provide a substantially optimum vapour pressure of mercury at the temperature of the amalgam corresponding to the maximum rated operating power of the lamp, the optimum vapour pressure being close to a minimum at said temperature, and adjacent a region of steeply rising mercury vapour pressure with falling temperature, such that a reduction in the operating power of the lamp causes a fall in temperature and hence an increase in the vapour pressure of the mercury to effect dimming of the lamp.

Preferably, a rate of increase of mercury vapour pressure in the range 0.1 to 0.5 Pa per degree Centigrade fall in temperature is sustained over a temperature range appropriate to the level of dimming required and tailored to the thermal characteristics of the lamp to effect dimming of the lamp.

By selecting a suitable amalgam, a small reduction in the temperature of the amalgam, obtained by reducing the input power to the lamp, results in a relatively large increase in the mercury vapour pressure in the lamp. As the vapour pressure increases, the number of mercury atoms in an excited state increases with a consequential increase in the probability that these excited mercury atoms will undergo non-radiative transitions, so decreasing the efficacy of the lamp by such a degree that effective dimming is obtained.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic graph of the mercury vapour pressure above an amalgam suitable for a fluorescent lamp according to the prior art; and
Figure 2 is a schematic graph of the mercury vapour pressure above a preferred amalgam for a fluorescent lamp according to the present invention.

Figure 1 shows the variation of mercury vapour pressure above a typical amalgam as a function of temperature. In prior art mercury discharge fluorescent lamps the amalgam is selected such that the maximum A is at or near the optimum operating pressure for a mercury discharge lamp of 0.8 Pa. The lamp is then designed such that the amalgam is positioned within the lamp so that when it is operating at its rated input power the amalgam is heated to the temperature T_A corresponding to the desired operating mercury vapour pressure. As described above, this provides relatively stable operation of the lamp as the vapour pressure is relatively insensitive to changes in temperature of the amalgam.

In the present invention, as shown in the upper curve of Figure 2, the amalgam is selected such that the minimum B corresponds to the optimum operating pressure of 0.8 Pa and the amalgam is suitably positioned within the lamp so that it is near the corresponding operating temperature T_B, corresponding to this optimum pressure, during operation of the lamp. In this case, however, the mercury vapour pressure is more sensitive to temperature changes of the amalgam and in particular to reduction in its temperature. Reducing the operating temperature of the amalgam by a small amount results in a relatively large increase in the mercury vapour pressure as compared to that obtainable with comparable temperature drops in the prior art lamps and hence provides enhanced dimming over previously known lamps.

The present invention is applicable to both electroded and electrodeless fluorescent lamps and in particular to compact fluorescent lamps.

In an electroded lamp, the amalgam can be located near the cathode at the point which reaches the desired operating temperature TB because of the heated cathode. Reducing power to the lamp reduces the temperature of the amalgam and so results in the required dimming of the lamp. For an electrodeless fluorescent lamp this is of particular significance as a large power reduction will lead to extinction of the lamp.

Electronic control circuits able to provide control over the input power to a mercury discharge lamp of the present invention are well known in the art and will not be described in detail in this application. Referring again to Figure 2, it is preferable that the local minimum, B, of the mercury vapour pressure to which the amalgam is heated during full rated operation of the lamp has a region of mercury vapour pressure stability bordered by a steeply rising vapour pressure with falling temperature. This rising vapour pressure with falling temperature is preferably in the range 0.1 to 0.5 Pa per degree Centigrade, and optimally is approximately 0.28 Pa per degree Centigrade. This characteristic can be achieved, in general by reducing the proportion of mercury in the lamp relative to the quantity of the base alloy. The effect of reducing the mercury in this way is to lower the section C, Figure 1, of the vapour pressure curve downwards so deepening the minimum as shown in section C of Figure 2.

Although not essential to the operation of the present invention, it is preferable that the proportion of the mercury to the base alloy is less than about 1 atomic percent. This allows an amalgam to be selected which has a minimum in the mercury vapour pressure curve near the desired optimum pressure with fine tuning of the minimum obtained by adjusting the atomic percent of mercury relative to the base alloy.

A further advantage of the present invention is that the preferred low percentage of mercury reduces the potential adverse environmental impact of such lamps once their useful life is finished.

Examples of suitable amalgams are, in mole fractions:

a) $Pb_{0.47}\ Sn_{0.47}\ Ag_{0.06}$ with 0.2 atomic percent Hg
b) $Pb_{0.48}\ Sn_{0.48}\ Ag_{0.04}$ with 0.1 atomic percent Hg
c) $Pb_{0.24}\ Sn_{0.74}\ Ag_{0.02}$ with 0.1 atomic percent Hg.

Example (b) is currently preferred. These and other suitable amalgams are described in more detail in our copending PCT/GB 96/02345.

Figure 2, in the upper curve, marked "New Invention", shows the pressure/temperature diagram of an example using the amalgam $Pb_{0.47}\ Sn_{0.47}\ Ag_{0.06}$ with 0.2 atomic percent Hg. That amalgam has a region of stability C around the optimum vapour pressure of mercury of 0.8 Pa over the temperature range 170 to 240°C. This amalgam is useful, for example, in electrodeless fluorescent lamps where the operating temperature is in that range. By reducing the power to the lamp, the temperature of the amalgam enters the region of steeply changing mercury vapour pressure, zone D. The vapour pressure of mercury in zone D increases steeply with reducing temperature resulting in dimming of the lamp.

The amalgam is suitable for providing dimming by virtue of its pressure/temperature characteristic. This amalgam produces in zone D a 40% to 50% dimming for a reduction of 5 to 6 watts in a 23 watt fluorescent lamp.

The curve denoted "US-A-4,924,142" is for a prior art amalgam known from that patent. Such an amalgam provides less dimming by virtue of its smaller range of increasing mercury vapour pressure with reducing temperature and the much smaller slope in range Z.

Claims

1. A mercury discharge lamp including an amalgam for controlling the mercury vapour pressure within the lamp, the amalgam being selected and positioned within the lamp to provide a substantially optimum vapour pressure of mercury at the temperature of the amalgam corresponding to the maximum rated operating power of the lamp, the optimum vapour pressure being close to a minimum at said temperature, and adjacent a region of steeply rising mercury vapour pressure with falling temperature, such that a reduction in the operating power of the lamp causes a fall in temperature and hence an increase in the vapour pressure of the mercury to effect dimming of the lamp.

2. A mercury discharge lamp including an amalgam for controlling the mercury vapour pressure within the lamp, the amalgam being selected and positioned within the lamp to provide a substantially optimum vapour pressure of mercury at the temperature of the amalgam corresponding to the maximum rated operating power of the lamp, the optimum vapour pressure being close to a minimum at said temperature, and adjacent a region of steeply rising mercury vapour pressure with falling temperature, such that a reduction in the operating power of the lamp causes a fall in temperature and hence a rate of increase of mercury vapour pressure in the range 0.1 to 0.5 Pa per degree Centigrade fall in temperature sustained over a temperature range appropriate to the level of dimming required and tailored to the thermal characteristics of the lamp to effect dimming of the lamp.

3. A mercury discharge lamp as claimed in Claim 2 wherein said rate of increase of mercury vapour pressure is approximately 0.28 Pa per degree Centigrade.

4. A mercury discharge lamp as claimed in any one of Claims 1 to 3 in which the concentration of mercury in the lamp relative to the parent alloy of the amalgam is less than 1 atomic percent.

5. A mercury discharge lamp as claimed in any one of Claims 1 to 4, the lamp being an electroded lamp.

6. A mercury discharge lamp as claimed in any one of Claims 1 to 4, the lamp being an electrodeless lamp.

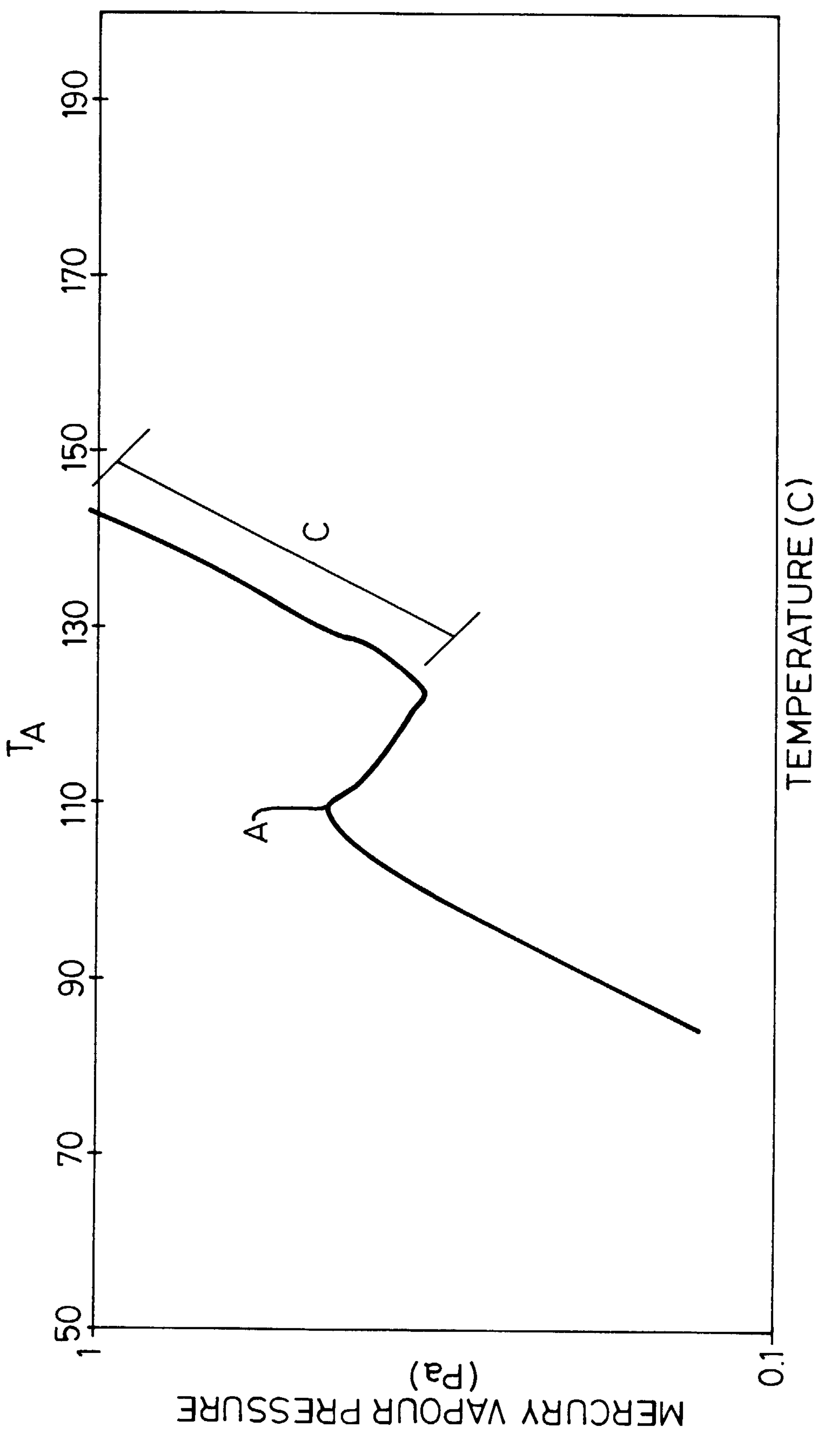
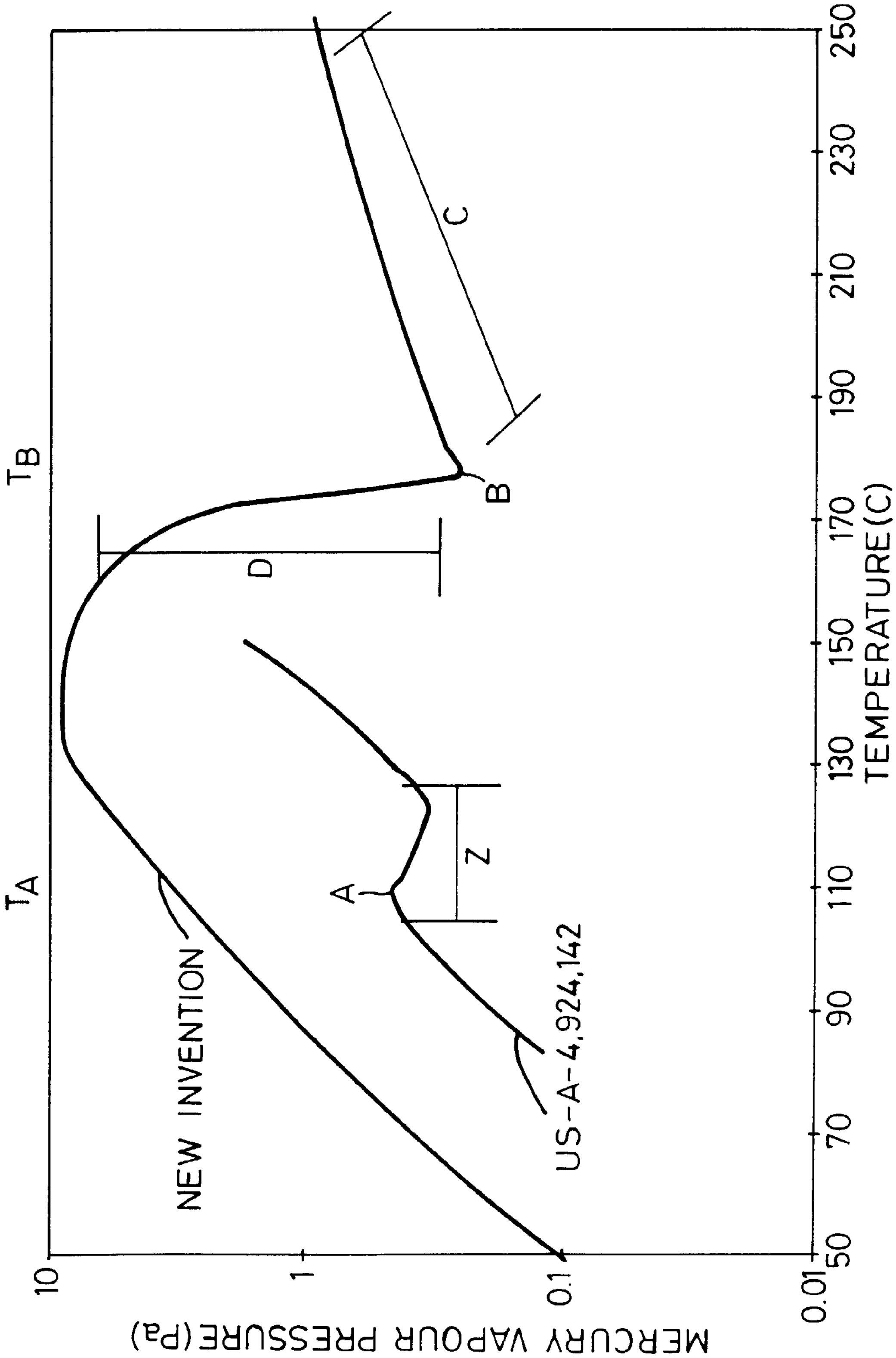

T_A
190
170
150
130
110
90
70
50
C
A
TEMPERATURE (C)
1
0.1
MERCURY VAPOUR PRESSURE
(Pa)

FIG. 1

FIG. 2


MERCURY VAPOUR PRESSURE (Pa)
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0.1
0.01
TEMPERATURE (C)
50
70
90
110
130
150
170
190
210
230
250
T_A
T_B
NEW INVENTION
US-A-4,924,142
A
B
C
D
Z

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 2183

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.6)
A	US 5 598 069 A (VAN OS RON ET AL) 28 January 1997 * column 10, line 22 - column 10, line 26 *	1-6	H01J61/28 H01J61/20 H01J61/12 H01J61/70 H01J61/72 C22C7/00 C22C13/00
D,P,A	WO 97 13000 A (GEN ELECTRIC ;FORSDYKE GRAHAM MALCOLM (GB); MUCKLEJOHN STUART ALBE) 10 April 1997 * page 3, line 37 - page 4, line 8 *	1-6	
D,A	BLOEM J ET AL: "SOME NEW MERCURY ALLOYS FOR USE IN FLUORESCENT LAMPS" JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY, vol. 6, no. 3, April 1977, pages 141-147, XP000615021	1-6	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H01J
C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	13 July 1998	Zuccatti, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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