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### (54) Yttrium oxide based gas mantle

(57) The present invention relates to incandescent pre-formed low-pressure gas mantles useful for fixed fuel-burning lanterns, such as stationary lamp posts or patio lights (typically at gas pressures of 2.7KPa). The pre-formed low-pressure gas mantle has a body comprising: (A) 77.1 to 85.3 mol% yttrium oxide as the predominant

metal oxide, (B) 1.4 to 3.1 mol% of at least one lanthanide oxide, (C) 2.2 to 5.0 mol% of at least one of magnesium oxide and aluminium oxide, and (D) 11.1 to 14.8 mol% of calcium oxide, based on the total molar content of (A), (B), (C) and (D). Such a mantle is non-radioactive, durable and provides good illumination.

**Description**

**[0001]** The present invention relates to incandescent low-pressure gas mantles useful for fixed fuel-burning lanterns, such as stationary lamp posts, patio lights or wall-bracket mounted lights. Typically, such mantles are used with gas pressures of about 2.7 KPa (280mm H<sub>2</sub>O gauge). More particularly, the present invention relates to pre-formed (hard) gas mantles.

**[0002]** The successful commercial development of an incandescent gas mantle depends on a number of factors. Of primary importance is the illumination provided by the mantle (illuminating power and colour), both in absolute terms and in respect of the amount of fuel consumed. Also important is the durability of the mantle both in terms of its physical strength and period of useful light output.

**[0003]** Traditionally, incandescent gas mantles have been made from thorium oxide with small quantities of cerium oxide and magnesium oxide and are known as Welsbach mantles (see, for example, US 563524). Thorium is radioactive and decays to give, *inter alia*, thoron-220 (radon-220) and lead. Although the quantity of thorium used in each mantle is small and may be considered to present an insignificant health risk in the finished article, the industrial production of gas mantles uses large quantities of thorium which require careful and expensive handling procedures. Thus, there is a potential health and environmental hazard at manufacturing sites. In addition these compositions are brittle and so may require an additional hardening procedure during manufacture. This involves coating the head of the mantle with a solution of (usually) aluminium nitrate. It cannot be applied to the body of the mantle because the hardening metals are not luminescent. As a result, these mantles often break on the body of the mantle just below the attachment head.

**[0004]** EP 0082062 discloses non-radioactive mantles based on zirconia which contain calcium oxide (10 to 25 mol%), aluminium oxide and magnesium oxide (0 to 5 mol% total), and oxides selected from iron, manganese, praseodymium and cerium (0 to 1 mol% total). Calcium oxide is used to promote a cubic zirconia crystal structure which is desirable for resistance to mechanical and thermal shocks.

**[0005]** EP(UK) 0159212 discloses mantles based on those described in EP 0082062 in which the calcium oxide is replaced partially or completely by yttrium oxide as the cubic zirconia stabiliser. Yttrium oxide is present in the range of 5 to 20 mol%, with magnesium oxide/aluminium oxide (2 to 15 mol%) and one or more of the oxides of iron, chromium, manganese, praseodymium and cerium (0.01 to 1.0 mol% total).

**[0006]** EP 0101086 discloses gas mantles comprising a host metal oxide (eg. yttrium, thorium, zirconium or rare earth metal oxide), a rare earth metal oxide (different to the host metal oxide) as a radiation modifying dopant, and a strengthening dopant (eg. an oxide of aluminium, magnesium, beryllium or calcium).

**[0007]** GB 2145811 discloses an yttrium oxide based gas mantle mainly for use in portable lanterns which are supplied with high pressure gas from a bottle or cylinder. The mantle contains cerium oxide to improve the illuminating power and a small amount of a crystal growth inhibitor such as magnesium oxide and/or aluminium oxide. To obtain satisfactory illuminating power, a critical amount of cerium oxide of 1.8 to 3.8 parts per 100 parts of yttrium oxide by weight is essential. This corresponds to a maximum range of 2.3 to 4.8 mol% of the total composition. The disclosed quantity of magnesium oxide and aluminium oxide, 0.1 to 2.0 parts per 100 parts of yttrium oxide by weight, corresponds to 0.54 to 9.9 mol% magnesium oxide and 0.21 to 4.2 mol% aluminium oxide of the total composition. However, the only composition specifically disclosed is unsatisfactory for low pressure gas mantles because it has inadequate light output characteristics and tensile strength (see Table 1).

**[0008]** The expression "pre-formed" is used herein to describe a mantle which has been burnt off by the manufacturer of the mantle before sale, the mantle usually being tied onto a ring prior to the burning off.

**[0009]** The object of the present invention is to provide a low pressure pre-formed gas mantle having good light output, tensile strength and durability.

**[0010]** According to a first aspect of the present invention, there is provided a pre-formed low pressure gas mantle having a body comprising: (A) 77.1 to 85.3 mol% yttrium oxide as the predominant metal oxide, (B) 1.4 to 3.1 mol% of at least one lanthanide oxide, (C) 2.2 to 5.0 mol% of at least one of magnesium oxide and aluminium oxide, and (D) 11.1 to 14.8 mol% of calcium oxide, based on the total molar content of (A), (B), (C) and (D).

**[0011]** The above ratio of components (A), (B), (C) and (D) is critical in obtaining a low-pressure gas mantle which is of high illuminating power and produces a light of satisfactory colour. More particularly, the durability (*i.e.* length of time over which the mantle can be burnt without significant deterioration of the light output) of mantles according to the present invention is good. In addition, mantle bodies having this composition are of a sufficient strength that a hardening procedure to avoid rupture of the mantle is not required.

**[0012]** Preferably said body consists only of components (A), (B), (C) and (D).

**[0013]** Preferably component (B) consists of at least one of cerium oxide, praseodymium oxide and erbium oxide and more preferably is cerium oxide.

**[0014]** Component (C) is preferably magnesium oxide.

**[0015]** A preferred molar composition range is:

yttrium oxide 78.7 to 83.2 %;  
 cerium oxide 1.7 to 2.9 %;  
 magnesium oxide 3.3 to 4.8 %;  
 calcium oxide 12.6 to 14.2 %.

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**[0016]** A highly preferred molar composition is:

yttrium oxide 80.4 %;  
cerium oxide 2.55 %;  
magnesium oxide 4.00 %;  
calcium oxide 13.05 %.

**[0017]** According to a second aspect of the present invention, there is provided a process for the preparation of a pre-formed low pressure gas mantle, including the steps of:-

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- (i) impregnating a combustible reticulated material with an aqueous solution of metal salts;
- (ii) converting said salts to the corresponding metal hydroxides; and
- (iii) converting the metal hydroxides to the corresponding oxides so as to form a body comprising: (A) 77.1 to 85.3 mol% yttrium oxide as the predominant metal oxide, (B) 1.4 to 3.1 mol% of at least one lanthanide oxide, (C) 2.2 to 5.0 mol% of at least one of magnesium oxide and aluminium oxide, and (D) 11.1 to 14.8 mol% of calcium oxide, based on the total molar content of (A), (B), (C) and (D).

[0018] Step (ii) may be achieved using ammonia vapour, aqueous ammonia solution, an amine and/or a caustic alkali solution. The use of an amine, such as triethanolamine, results in a soft, flexible impregnated material which is easy to shape, although it has been found that after step (iii) mantles so prepared contain less magnesium oxide and cerium oxide than expected. It is thought that this may be due to selective dissolution of magnesium and cerium in the triethanolamine, thereby leaching these components from the knitted mesh. Preferably, step (ii) is effected using an aqueous KOH solution (25% by weight) at room temperature, when such loss does not occur.

[0019] The combustible reticulated material may be any woven combustible filamentary material. Such filamentary material preferably has a fineness of about 220 to 350 Dtex, with a Dtex of about 330 being particularly preferred. Preferably said material is rayon.

**[0020]** Preferably, the concentration of the metal salts in step (i) is 25 to 50 % by weight. The metal salts are preferably nitrates. It has been found that, at lower concentrations, there is a risk that insufficient metal salt may be absorbed into the reticulated material, resulting in weak mantles. At higher concentrations, the conversion step (ii) tends to be less efficient, which can lead to uneven conversion. In addition, the impregnated material tends to be stiff and it becomes progressively more difficult to achieve the required mantle shape without breakage.

[0021] The present invention will now be described in further detail in the following examples:-

### Example 1

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**[0022]** Knitted tubes of rayon mesh (330 Dtex) are soaked in an impregnating solution of metal nitrates having the following composition:

30 Kg  $\text{Y}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 0.5 Kg  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 0.54 Kg  $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.5 Kg  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$   
 72.46 Kg  $\text{H}_2\text{O}$

50 On saturation, the mesh tubes are removed from the solution, drained and dried. The metal nitrates which are now absorbed onto the mesh are converted to the corresponding hydroxides by immersion in an aqueous solution of aqueous KOH (25% by weight) at ambient temperature. The hose is then washed and dried.

**[0023]** When dry, the mesh tubes are cut and the mantles shaped in a manner known per se. Since no hardening procedure is necessary, the mantles are now tied to ceramic rings by means of a non-combustible yarn, eg. an aramid or asbestos, for health reasons an aramid is preferred.

**[0024]** The rayon is then burnt off, to leave a hard lattice of metal oxides. This is done in a manner known per se, with a powerful flame having a high flow of an air and gas mixture.

**[0025]** The mantles thus prepared have a molar composition of:-

80.4 % yttrium oxide  
 4.0 % magnesium oxide  
 2.55 % cerium oxide  
 13.05 % calcium oxide.

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**Example 2**

**[0026]** The same method is employed as for Example 1, using the following impregnating solution:

30 Kg  $\text{Y}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 0.6 Kg  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 0.5 Kg  $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.3 Kg  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$   
 72.6 Kg  $\text{H}_2\text{O}$

15

**[0027]** The mantles thus prepared have a molar composition of:-

81.32 % yttrium oxide  
 4.86 % magnesium oxide  
 2.39 % cerium oxide  
 11.43 % calcium oxide.

**Example 3**

**[0028]** The same method is employed as for Example 1, using the following impregnating solution:

30 Kg  $\text{Y}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 0.35 Kg  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 0.51 Kg  $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.4 Kg  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$   
 72.74 Kg  $\text{H}_2\text{O}$

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**[0029]** The mantles thus prepared have a molar composition of:-

82.23 % yttrium oxide  
 2.86 % magnesium oxide  
 2.46 % cerium oxide  
 12.45 % calcium oxide.

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**Comparative Example 1 (C1):**

**[0030]** The same method is employed as for Example 1 above, using the following impregnating solution:

29.5 Kg  $\text{Y}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.0 Kg  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 0.54 Kg  $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.5 Kg  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$   
 72.46 Kg  $\text{H}_2\text{O}$

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**[0031]** The mantles thus prepared have a molar composition of:-

77.02 % yttrium oxide  
 7.80 % magnesium oxide  
 2.48 % cerium oxide  
 12.70 % calcium oxide.

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**Comparative Example 2 (C2):**

[0032] The same method is employed as for Example 1 above, using the following impregnating solution:

5      30 Kg  $\text{Y}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.5 Kg  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 0.2 Kg  $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 1.5 Kg  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$   
 71.80 Kg  $\text{H}_2\text{O}$

10     [0033] The mantles thus prepared have a molar composition of:-

15     75.57 % yttrium oxide  
 11.29 % magnesium oxide  
 0.89 % cerium oxide  
 12.25 % calcium oxide.

**Comparative Example 3 (C3):**

20     [0034] The same method is employed as for Example 1 above, using the following impregnating solution, which has the same molar composition as that disclosed in GB-B-2145811:

25     286.9 g  $\text{Y}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 5.85 g  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$   
 7.3 g  $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$   
 166.7 g  $\text{H}_2\text{O}$

30     [0035] Denitration was effected with ammonium vapour rather than caustic alkali solution. The mantles thus prepared have a molar composition of:-

35     90.43 % yttrium oxide  
 5.41 % magnesium oxide  
 4.06 % cerium oxide.

40     [0036] The properties of mantles 1 to 3 and C1 to C3 are indicated in Table 1 below.

TABLE 1

Sample	Average Light Output (Lux)	Tensile Strength <sup>1</sup>	Light Quality <sup>2</sup>	Durability (200hrs) <sup>3</sup>	Durability (2000hrs) <sup>3</sup>
1	38	pass	good	pass	pass
2	32	pass	good	pass	pass
3	35	pass	good	pass	pass
C1	36	fail	good	pass	fail
C2	20	fail	poor	pass	fail
C3	15	fail	poor	pass	fail

45     <sup>1</sup>Ability to withstand at least 800 bumps on a shock treatment machine (pass), such as is available from Messrs. Alexander Wright & Co., Ltd, London.

50     <sup>2</sup>Qualitative assessment made by experienced workers in the field of mantle production. The light should not be unduly yellow (good).

55     <sup>3</sup>Light output is substantially unchanged after indicated number of hours continuous burning (pass).

[0037] As can be seen from Table 1, Examples 1 to 3 are superior to Comparative Examples 2 and 3 in terms of average light output, light quality, tensile strength and durability. Examples 1 to 3 are comparable to Comparative Example 1 in terms of average light output and light quality, but superior in terms of tensile strength and durability.

**Claims**

1. A pre-formed low pressure gas mantle having a body comprising: (A) 77.1 to 85.3 mol% yttrium oxide as the predominant metal oxide, (B) 1.4 to 3.1 mol% of at least one lanthanide oxide, (C) 2.2 to 5.0 mol% of at least one of magnesium oxide and aluminium oxide, and (D) 11.1 to 14.8 mol% of calcium oxide, based on the total molar content of (A), (B), (C) and (D).

5 2. A mantle as claimed in claim 1, wherein said body consists only of components (A), (B), (C) and (D).

10 3. A mantle as claimed in claim 1 or 2, wherein component (B) consists of at least one of cerium oxide, praseodymium oxide and erbium oxide.

15 4. A mantle as claimed in claim 3, wherein component B is cerium oxide.

5 5. A mantle as claimed in any preceding claim, wherein component (C) is magnesium oxide.

10 6. A mantle as claimed in any preceding claim wherein the molar composition range is:

20 yttrium oxide (A) 78.7 to 83.2 %;

cerium oxide (B) 1.7 to 2.9 %;

magnesium oxide (C) 3.3 to 4.8 %;

calcium oxide (D) 12.6 to 14.2 %.

25 7. A mantle as claimed in claim 6, wherein the molar composition is:

20 yttrium oxide 80.4 %;

cerium oxide 2.55 %;

magnesium oxide 4.00 %;

calcium oxide 13.05 %.

30 8. A process for the preparation of a pre-formed low pressure gas mantle, including the steps of:-

35 (i) impregnating a combustible reticulated material with an aqueous solution of metal salts;  
 (ii) converting said salts to the corresponding metal hydroxides; and

35 (iii) converting the metal hydroxides to the corresponding oxides so as to form a body comprising: (A) 77.1 to 85.3 mol% yttrium oxide as the predominant metal oxide, (B) 1.4 to 3.1 mol% of at least one lanthanide oxide, (C) 2.2 to 5.0 mol% of at least one of magnesium oxide and aluminium oxide, and (D) 11.1 to 14.8 mol% of calcium oxide, based on the total molar content of (A), (B), (C) and (D).

40 9. A process as claimed in claim 8, wherein step (ii) is achieved using ammonia vapour, aqueous ammonia solution, an amine and/or a caustic alkali solution.

10. A process as claimed in claim 9, wherein step (ii) is effected using an aqueous KOH solution at room temperature.

45 11. A process as claimed in any one of claims 8 to 10 in which the combustible reticulated material referred to in step (i) is a woven combustible filamentary material having a fineness in the range of about 220 to 350 Dtex.

12. A process as claimed in claim 11, in which the woven combustible reticulated material has a fineness of 330Dtex.

50 13. A process as claimed in any one of claims 8 to 12, in which the concentration of the metal salts in step (i) is 25 to 50 % by weight.

14. A process as claimed in any preceding claim, in which the metal salts are nitrates.