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(72) Inventor: **Boroczki, Agoston**
1157 Budapest (HU)

(74) Representative: **Goode, Ian Roy et al**
GE LONDON PATENT OPERATION,
Essex House,
12/13 Essex Street
London WC2R 3AA (GB)

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(71) Applicant: **GENERAL ELECTRIC COMPANY**
Schenectady, NY 12345 (US)

(54) **Electrode arrangement for a discharge arc chamber**

(57) An electrode arrangement for a discharge arc chamber of a discharge lamp comprises a first electrode (24) and a second electrode (26) which are positioned at a predetermined distance (d) from each other along a connecting common axis (A). The electrodes each attached respectively to first (44) and second (46) metal

foils. The planes of the first and second foils are substantially parallel to the common axis, and the plane of the first foil (44) is perpendicular to the plane of the second foil (46). The invention also relates to a discharge arc chamber and a discharge lamp with the electrode arrangement.

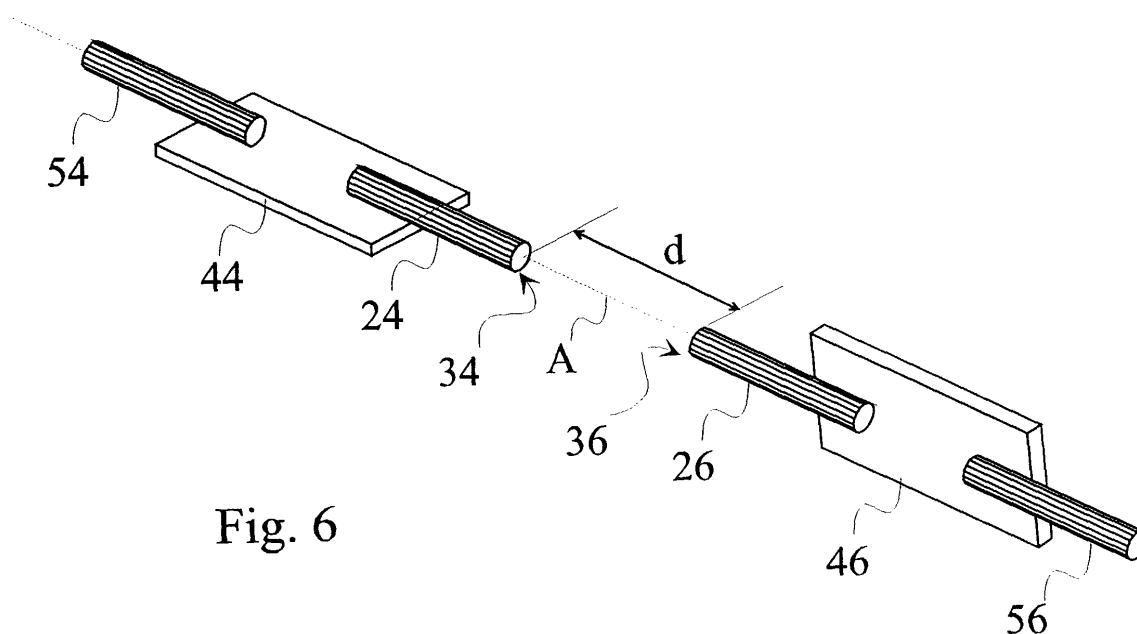


Fig. 6

Description

[0001] This invention relates to an electrode arrangement for a discharge arc chamber of a discharge lamp, and a discharge lamp and discharge arc chamber comprising the electrode arrangement.

[0002] U.S. Patent No. 5,993,279 discloses a double ended discharge arc chamber which comprises a first electrode and second electrode positioned at a predetermined distance from each other along a common axis connecting the electrodes. The first electrode is attached to a first plane metal foil, while the second electrode is attached to a second plane metal foil. The planes of the first and second foils are substantially parallel to the common axis connecting the electrodes, and the foils are also parallel to each other. The foil is made of molybdenum. The molybdenum foils are within a sealing portion of the arc chamber. The sealing portion is pinch sealed. The good sealing effect between the molybdenum and the fused silica arc chamber wall serves to maintain the necessary operating pressure in the arc chamber, and prevents the filling gas from escaping from the arc chamber. In this known arc chamber the plane of the first foil and the plane of the second foil are parallel to each other.

[0003] Further, U.S. Patent No. 5,142,195 teaches a double-ended, double-sided and pinch sealed discharge arc chamber which comprises two electrodes. The electrodes are attached to molybdenum foils, and the foils are disposed within the seal portion of the arc chamber. As above, the plane of the first foil and the plane of the second foil are parallel to each other.

[0004] This arrangement of the electrodes, or more specifically, the arrangement of the foils in the pinch poses certain problems. The operating voltage of discharge lamps is determined by the electric field distribution in the arc gap between the electrodes and the length of the arc gap. Since the performance characteristics of the lamp are significantly affected by the operating voltage, it is important to keep the length of the arc gap under tight control.

[0005] The length of the arc gap is primarily determined by the geometrical dimensions of the arc chamber and the length of the electrode assembly. Even if the geometrical dimensions determining the rated length of the arc gap are under tight dimensional control, the pinch or shrink seal process itself may cause variation in the final length of the arc gap due to the fact that the molybdenum foils are randomly bent during the sealing process.

[0006] A number of factors may cause the bending of the foils. Such factors are the unbalanced pinching forces exerted by the two pinch jaws, or by the flames compressing the melted glass inwards in the case of shrink seals. These forces may have a considerable component in the direction perpendicular to the plane of the foils, and thereby cause their bending. In addition, the foil can be bent prior to the pinch or shrink seal process,

e. g. because of gravitational forces acting on the electrode that is supported by the foil, or owing to other residual mechanical stress which arises during the mounting process of the electrode assembly.

[0007] This bending occurs basically in the direction perpendicular to the plane of the foil due to the much smaller stiffness of the foils in this direction. This foil bending may cause considerable variation of the arc gap length.

[0008] The result of the foil bending is illustrated with reference to Figs. 1-5. There is shown a prior art discharge arc chamber 2 in a first side view (Fig. 1) and a second side view (Fig. 2) rotated 90 degrees relative to the first side view. The arc chamber 2 comprises a first electrode 10 and a second electrode 12. The first electrode 10 is attached to a first molybdenum foil 14, and the second electrode 12 is attached to a second molybdenum foil 16 at one end thereof. Lead wires 18 and 20 are attached to the other end of the foils 14 and 16. A lead wire, foil and electrode together constitute an electrode assembly, and the two electrode assemblies are sealed at the two sealing portions 4, 6 of the arc chamber 2. The planes of the foils 14 and 16 are parallel to each other, and also to the longitudinal axis of the arc chamber 2.

[0009] Figs. 3-5 illustrate the result of the foil bending of the electrode assemblies of the prior art arc chamber 2. Fig. 3 shows the ideal case when no bending of the foils 14 and 16 occurs. In this case, the resulting arc gap d between the tip of the electrodes 10 and 12 is considered as the rated arc gap. In the case of a typical 70W metal halide discharge lamp with an arc chamber made of fused silica and a simple electrode assembly shown in Figs. 1-2, the rated arc gap length is 9.00 millimeters.

[0010] Fig. 4 illustrates the effect of the foil bending for the electrode arrangement of Fig. 3. In order to simplify the calculations, it may be assumed that foil bending occurs only in the plane perpendicular to the plane of the foils, and the effect of bending in other directions may be neglected. Considering an extreme angle value α of the foil bending, e. g. 8 degrees, the resulting arc gap length d may increase up to 9.18 millimeters, if the foils 14 and 16 bend in the same direction, e. g. upwards, as shown in Fig. 4. The bending of the foils in the figures is exaggerated for better visualization of the effect.

[0011] Fig. 5 shows the effect of the foil bending when each of the foils are bent with an extreme value of 8 degrees, but in opposite directions. In this case, the resulting arc gap length d may increase up to 9.51 millimeters.

[0012] Thus there is a particular need for an electrode arrangement with improved arc gap control.

[0013] In an exemplary embodiment of the invention, an electrode arrangement for the discharge arc chamber of a discharge lamp is provided. The electrode arrangement comprises a first electrode and second electrode positioned at a predetermined distance from each other along a common axis connecting the electrodes.

The first electrode is attached to a first metal foil having a principal plane, while the second electrode is attached to a second metal foil having a principal plane. The principal planes of the first and second foils are substantially parallel to the common axis connecting the electrodes, and the principal plane of the first foil is substantially perpendicular to the principal plane of the second foil.

[0014] This electrode arrangement effectively reduces the variation of the arc gap length between the electrodes by suppressing the effect of an unavoidable foil bending. Even if the extent of bending of the foils is unchanged, i. e. it is not reduced by any additional technological improvement in the pinch or shrink seal equipment or the geometrical arrangement of the seals themselves, the arc gap variation will be reduced using the proposed perpendicular orientation of the planes of the foils.

[0015] An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows a prior art discharge arc chamber in a first side view,

Fig. 2 shows the prior art discharge arc chamber of Fig. 1 in a second side view,

Figs. 3-5 show electrode assemblies of the prior art arc chamber of Figs. 1-2 in an enlarged side view,

Fig. 6 shows a perspective view of an electrode arrangement in which the present invention is embodied,

Fig. 7-8 show the effect of foil bending in the electrode arrangement, in which the present invention is embodied, in a perspective view,

Figs. 9-10 show a discharge arc chamber with the electrode arrangement of Fig. 6 in views similar to Figs. 1-2,

Fig. 11 illustrates a discharge lamp with the discharge arc chamber of Figs. 9-10 schematically.

[0016] Referring now to Fig. 6, there is shown an electrode arrangement for the discharge arc chamber of a discharge lamp. The electrode arrangement comprises a first electrode 24 and second electrode 26 which are positioned at a predetermined distance from each other along a common axis A connecting the electrodes 24 and 26. The distance between the ends 34 and 36 of the electrodes 24 and 26, respectively, is the arc gap. The electrodes 24 and 26 are made of tungsten wire, and the longitudinal axis of the wire substantially coincides with the common axis A. The first electrode 24 is attached to one end of a first metal foil 44. The first metal foil 44 is made of molybdenum. In the ideal case which

is shown in Fig. 6, the first metal foil 44 is straight, i. e. its surface corresponds to an ideal plane or flat surface which is termed as the principal plane of the first metal foil 44. This principal plane of the first metal foil 44 is substantially parallel to the common axis A connecting the electrodes 24 and 26.

[0017] It is understood that the first metal foil 44 may slightly deviate from this ideal principal plane due to the foil bending effect explained above. However, for the purposes of the following description, the ideally flat plane of the foil 44 will be considered as the principal plane of the foil even if the real surface of the foil 44 follows a slightly different form.

[0018] A lead wire 54 is attached to the other end of the foil 44. The lead wire is made of molybdenum, or other suitable metal. The lead wire 54 and the tungsten electrode 24 are spot welded onto the molybdenum foil 44, so that an electrically conductive connection is established between the lead wire 54 and the tungsten electrode 24. The lead wire 54, the foil 44 and the electrode 24 together constitute one of the electrode assemblies of an arc chamber.

[0019] The second electrode 26 of the electrode arrangement is attached to a second metal foil 46. The second metal foil 46 is also made of molybdenum, and its principal plane which is defined similarly as the principal plane of the first metal foil 44, is also parallel to the common axis A. Another lead wire 56 is attached to the other end of the foil 46. The second electrode 26, the second foil 46 and the lead wire 56 constitutes a second electrode assembly of the arc chamber. The two electrode assemblies are substantially identical, and together they constitute the electrode arrangement. It must be noted that the construction details of the lead wires 54 and 56 on the shown embodiments are given as an example only. Their design may be quite different in other embodiments of the present invention. The wires are not necessarily part of the electrode assembly, and other means of electrical contacting may be applied to the molybdenum foils, e. g. strips, plates or tubes of a suitable metal are also applicable.

[0020] The two electrode assemblies of the electrode arrangement are enclosed within two sealing portions of a discharge arc chamber (not shown in Fig. 6), so that the inner ends 34 and 36 of the electrodes 24 and 26 are within the volume enclosed by the arc chamber.

[0021] The principal plane of the first foil 44 is substantially perpendicular to the principal plane of the second foil 46. This is clearly illustrated in Fig. 6 where the first foil 44 has a horizontal principal plane, while the second foil 46 has a vertical principal plane.

[0022] Figs. 7-8 show how the foil orientation, in which the present invention is embodied, reduces the variations of the arc gap length d. Let us consider the rated and extreme cases of foil bending for a similar arc chamber design as shown in Figs. 3-5. Again, let us assume that foil bending only occurs in the plane perpendicular to the plane of the foils, and the electrode assembly, arc

chamber body and rated arc gap dimensions are the same as used with the prior art design shown in Figs. 3-5. As it will be apparent for those skilled in the art, if the planes of the foils 44 and 46 are perpendicular to each other, as shown in Fig. 6, and there is no foil bending, the resulting arc gap length will be the same as that shown in Fig. 3, that is 9.00 millimeters.

[0023] Let us now consider the situation when the foils 44 and 46 are bent with the extreme angle value of 8 degrees. The resulting position of the electrodes is shown in Fig. 7 where the foil 44 and the attached electrode 24 are bent upwards relative to the ideal plane of the foil 44 (the bending shown in the drawing is strongly exaggerated). At the same time, the other foil 46 and the attached electrode 26 is bent away from the viewer. The resulting arc gap length d is the maximal length of the arc gap. This length d did increase up to 9.26 millimeters. However, this value is significantly less than the maximum arc gap length of 9.51 millimeters which was demonstrated in Fig. 5.

[0024] Fig. 8 illustrates the situation where the foil 44 and the attached electrode 24 are bent upwards relative to the ideal plane of the foil 44, as in Fig. 7, but here the other foil 46 and the attached electrode 26 is bent towards the viewer. It will be appreciated that the resulting arc gap length d is again the maximal length of the arc gap, and its value is the same as before, i. e. 9.26 millimeters.

[0025] It is obvious for the skilled person that the same results for the maximum arc gap length will be obtained if the foil 44 is bent downwards. With other words, the maximal length of the arc gap does not exceed 9.26 millimeters in any combination of the bending of the foils 44 and 46.

[0026] It has been demonstrated that the maximum deviation in the arc gap length from its rated value is greater for the prior art parallel case than it is for the perpendicular case. Obviously, all the other gap length values resulting from random foil bending will be found between the rated (minimum) value and the extreme values calculated above. This means that the perpendicular foil orientation ensures lower maximum deviation from the rated arc gap length value, as well as smaller mean statistical variations of the rated arc gap length value. This allows improved arc gap control compared with the prior art design with the parallel foils.

[0027] A simple explanation of the results is the following. In the proposed case of perpendicular foil plane orientation, the random variations from the two foil bending directions are distributed between the two principal planes defined by the two foils. This results in the distribution of the arc gap lengths in a narrower range because the variations caused by the bending of the first foil is less related to the bending of the other foil, and errors caused by the bending do not add up.

[0028] In addition to the calculations above, Monte Carlo simulations were also performed to calculate the standard deviation of the arc gap length using different

design parameters. The angle of the foil bending was modeled with random values between the extreme values above. In order to produce reliable simulation results, several independent series of simulations were performed, each simulation series modeling the dimensions of different electrode arrangements with 1000 randomly selected bending angle values.

[0029] The average values obtained for the standard deviations of the arc gap length were compared for the case when the plane of the foils are parallel (prior art setup) and when they are perpendicular (setup in which this invention is embodied).

[0030] For a typical geometry of a standard discharge lamp, the parallel case resulted in a 0.008 millimeter standard deviation of the arc gap length while it was 0.005 millimeter for the perpendicular case. This is a 38% reduction in the standard deviation, i. e. the variation of the arc gap length. For a 70W metal halide lamp design, the parallel case resulted in a 0.173 millimeter standard deviation value of the arc gap length, while it was 0.128 millimeter for the perpendicular case. This is a 26% reduction. Both reductions are considerable and significant, thus confirm the advantage of the perpendicular foil plane orientation geometry.

[0031] Figs. 9-10 show a double ended discharge arc chamber 22 for a discharge lamp with an electrode arrangement embodying the present invention. Accordingly, the arc chamber 22 comprises a first electrode 24 and a second electrode 26 positioned at a predetermined distance from each other along a common axis A connecting the electrodes 24 and 26. The predetermined distance between the electrodes 24 and 26 corresponds to the rated arc gap length. As shown in Figs. 9 and 10, the first electrode 24 is attached to a first metal foil 44 where the latter is made of molybdenum. The principal plane of the first foil 44 is substantially parallel with the common axis A. The second electrode 26 is attached to a second metal foil 46, also made of molybdenum. The principal plane of the second foil 46 is also substantially parallel to the common axis A connecting the electrodes 24 and 26. The principal plane of the first foil 44 is substantially perpendicular to the principal plane of the second foil 46. 3. The arc chamber 22 is made of fused silica. The discharge arc chamber 22 comprises two pinch seal or shrink seal portions 28 and 30 around the metal foils 44 and 46. More precisely, the arc chamber 22 comprises outwardly extending lead wires 54 and 56 which are connected to the metal foils 44 and 46, and the seal portions 28 and 30 surround not only the metal foils 44 and 46, but also the ends of the lead wires 54 and 56, so that the ends of the lead wires 54 and 56 opposite to the metal foils 44 and 46 extend from the sealing portions 28 and 30. Similarly, the free ends of the electrodes 24 and 26 extend into the volume 32 enclosed by the arc chamber 22. It is clearly seen in Figs. 9 and 10 that the sealing portions 28 and 30 are substantially flat, and their principal planes are substantially perpendicular to each other in accordance with the

principal planes of the enclosed foils 44 and 46.

[0032] In other embodiments, where the sealing portions 28 and 30 are formed by a shrink seal process, the cross sections of these sealing portions 28 and 30 may be substantially circular while keeping the substantially perpendicular orientation of the principal planes of the metal foils 44 and 46 relative to each other.

[0033] Turning now to Fig. 11, there is illustrated a discharge lamp 60 which comprises a double ended discharge arc chamber 22 with a similar structure as the discharge arc chamber of Figs. 9-10. The discharge chamber 22 is disposed in the central region of a tubular outer jacket 62 made of vitreous material. The ends of the outer jacket 62 are closed with seals 64. Contact terminals 66 are enclosed in the seals 64, and the contact terminals 66 are connected to the metal foils 44, 46 of the arc chamber 22 through the lead wires 54, 56. The lead wires 54, 56 also provide the mechanical support of the arc chamber 22 within the outer jacket 62. The principal planes of the metal foils 44, 46 of the arc chamber 22 are substantially parallel to the principal axis of the outer jacket 62 and the arc chamber 22. This principal axis substantially coincides with the axis connecting the electrodes within the arc chamber 22, while the principal planes of the foils 44, 46 are substantially perpendicular to each other as explained with reference to Fig 6. and Figs. 9-10.

Claims

1. An electrode arrangement for a discharge arc chamber of a discharge lamp comprising
 - a first electrode (24) and a second electrode (26) positioned at a predetermined distance from each other along a common axis (A) connecting the electrodes (24, 26),
 - the first electrode (24) being attached to a first metal foil (44) having a principal plane, while
 - the second electrode (26) being attached to a second metal foil (46) having a principal plane, and the principal planes of the first and second foils (44, 46) being substantially parallel to the common axis (A) connecting the electrodes (24, 26), and
 - the principal plane of the first foil (44) being substantially perpendicular to the principal plane of the second foil (46).
2. A double ended discharge arc chamber for a discharge lamp, comprising
 - a first electrode (24) and a second electrode (26) positioned at a predetermined distance from each other along a common axis (A) connecting the electrodes (24, 26),
 - the first electrode (24) being attached to a first metal foil (44) having a principal plane, while
 - the second electrode (26) being attached to a second metal foil (46) having a principal plane, and the principal planes of the first and second foils (44, 46) being substantially parallel to the common axis (A) connecting the electrodes (24, 26), and
 - the principal plane of the first foil (44) being substantially perpendicular to the principal plane of the second foil (46).
3. The discharge arc chamber of claim 2 in which the metal foils (44, 46) are made of molybdenum.
4. The discharge arc chamber of claim 2 in which the discharge arc chamber is made of fused silica.
5. The discharge arc chamber of claim 2 in which the discharge arc chamber has pinch seal portions (28, 30) around the metal foils (44, 46).
6. The discharge arc chamber of claim 2 in which the discharge arc chamber has shrink seal portions (28, 30) around the metal foils (44, 46).
7. The discharge arc chamber of claim 2 in which the discharge arc chamber comprises outwardly extending lead wires (54, 56) connected to the metal foils (44, 46).
8. A discharge lamp comprising
 - a double ended discharge arc chamber, having a first electrode (24) and a second electrode (26) positioned at a predetermined distance from each other along a common axis (A) connecting the electrodes (24, 26),
 - the first electrode (24) being attached to a first metal foil (44) having a principal plane, while
 - the second electrode (26) being attached to a second metal foil (46) having a principal plane, and the principal planes of the first and second foils (44, 46) being substantially parallel to the common axis (A) connecting the electrodes (24, 26), and
 - the principal plane of the first foil (44) being substantially perpendicular to the principal plane of the second foil (46).

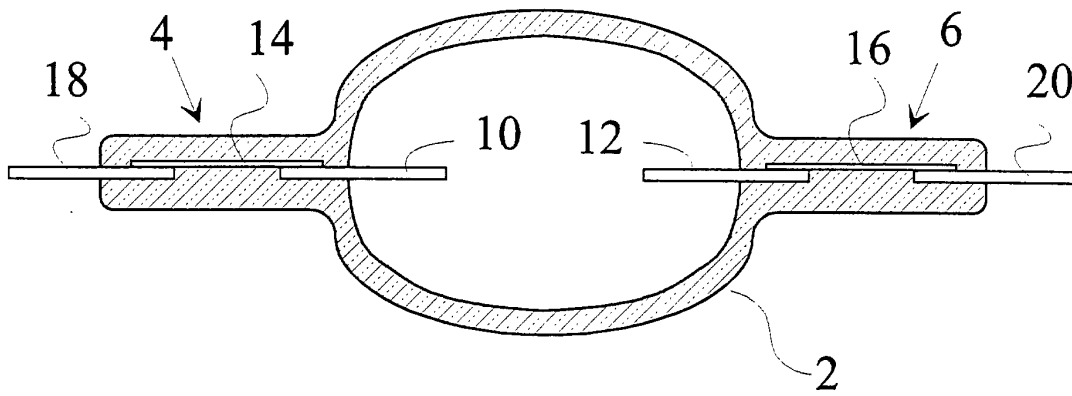


Fig. 1 (PRIOR ART)

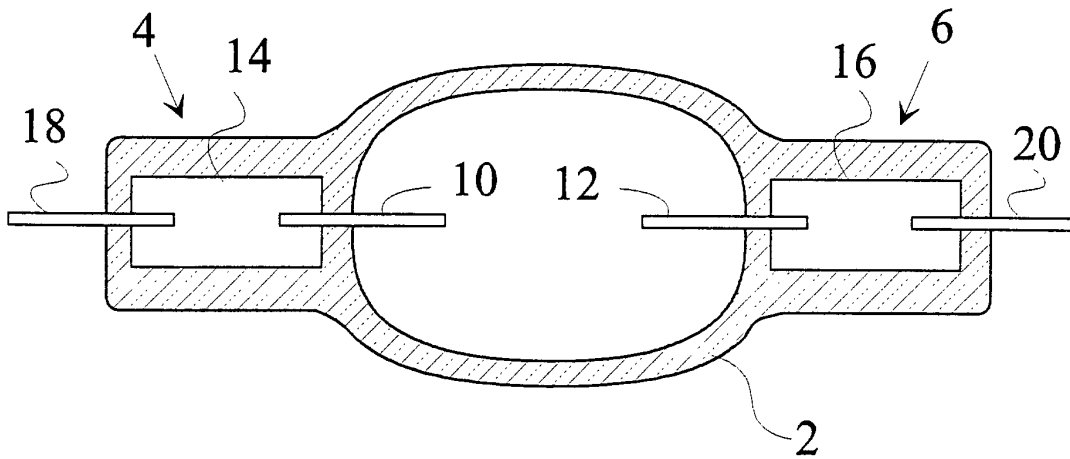


Fig. 2 (PRIOR ART)

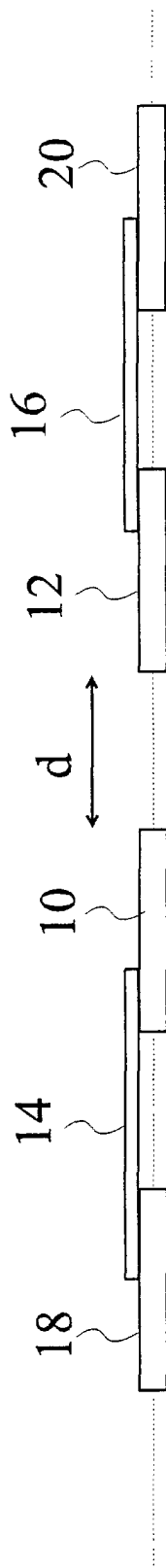


Fig. 3 (PRIOR ART)

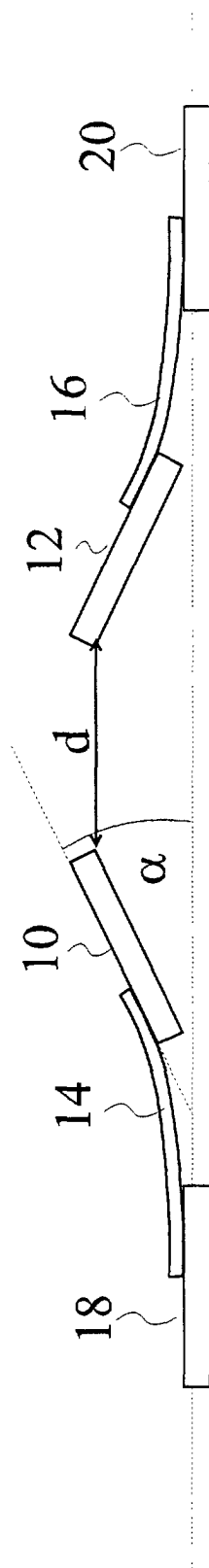


Fig. 4 (PRIOR ART)

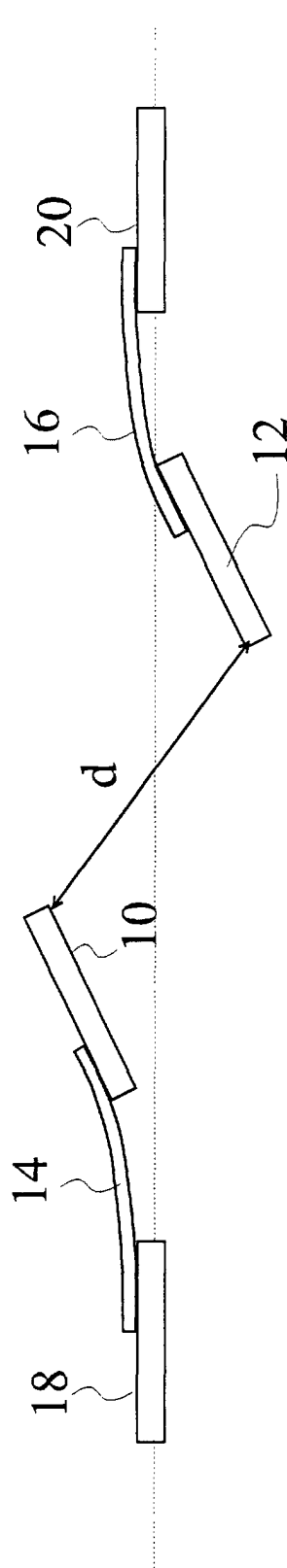


Fig. 5 (PRIOR ART)

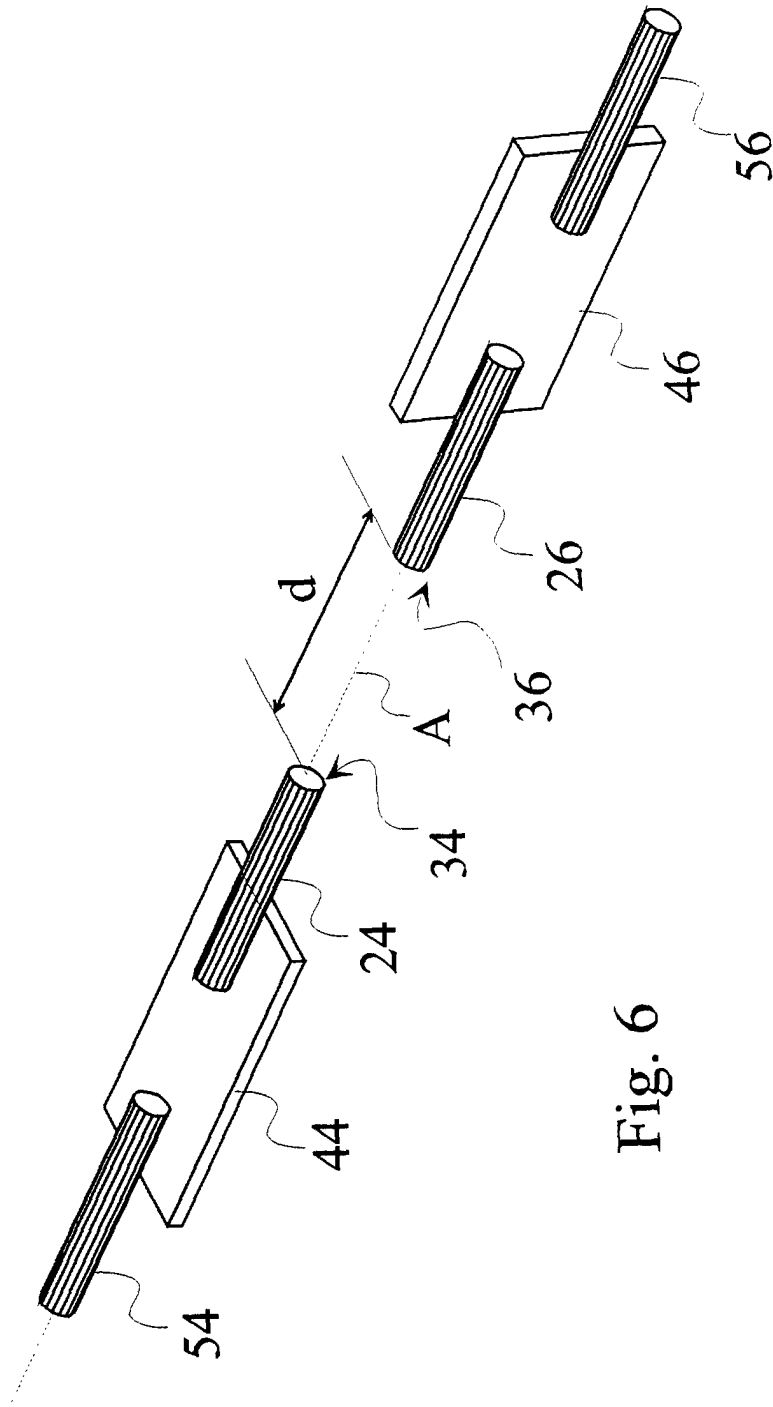
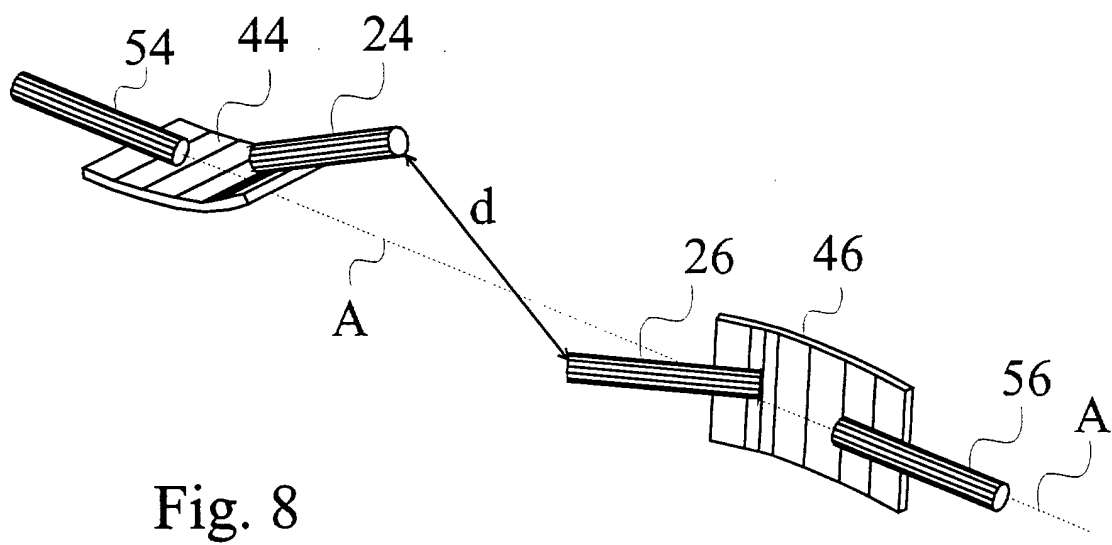
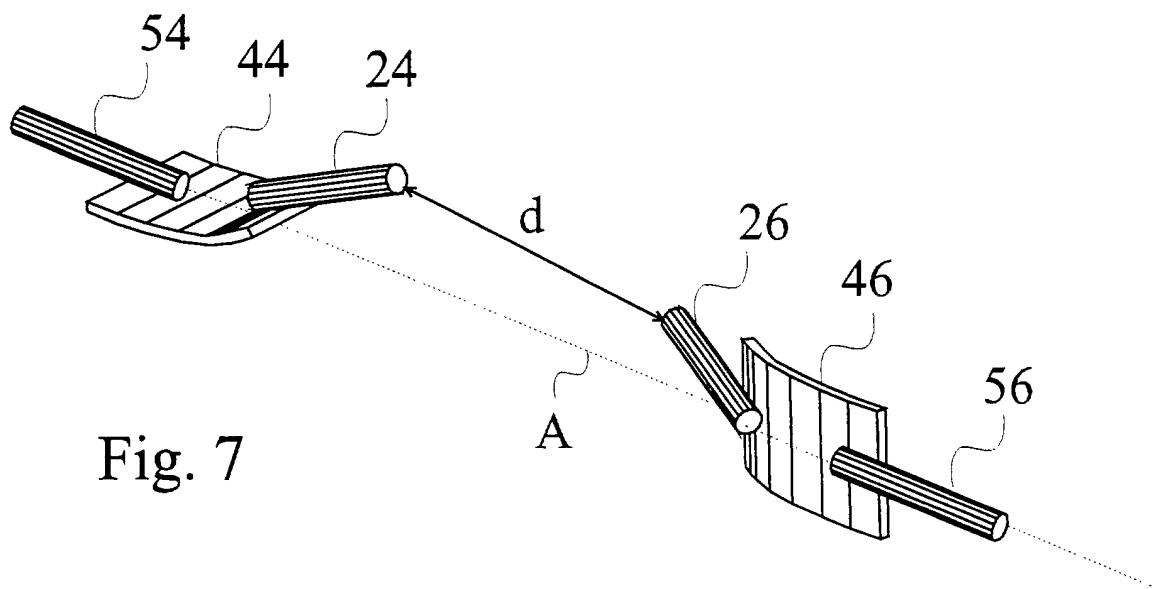


Fig. 6



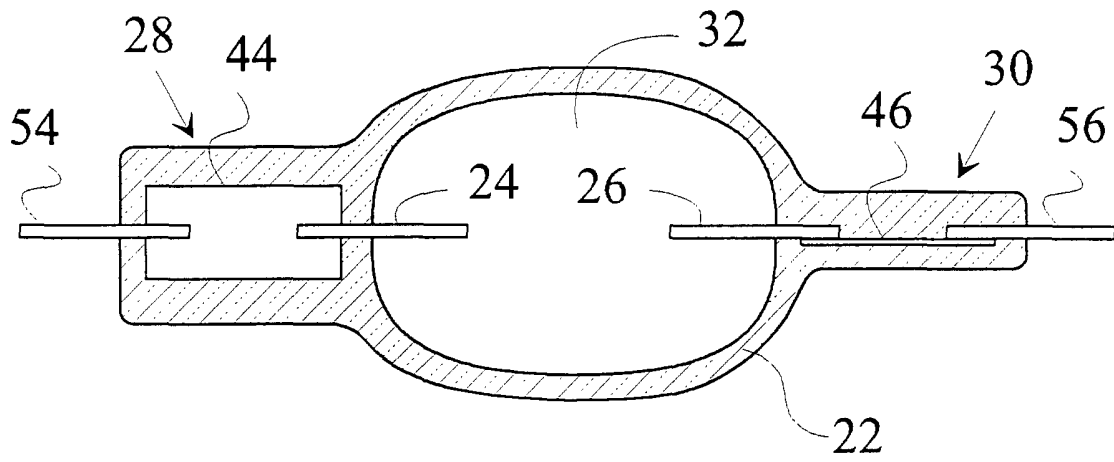


Fig. 9

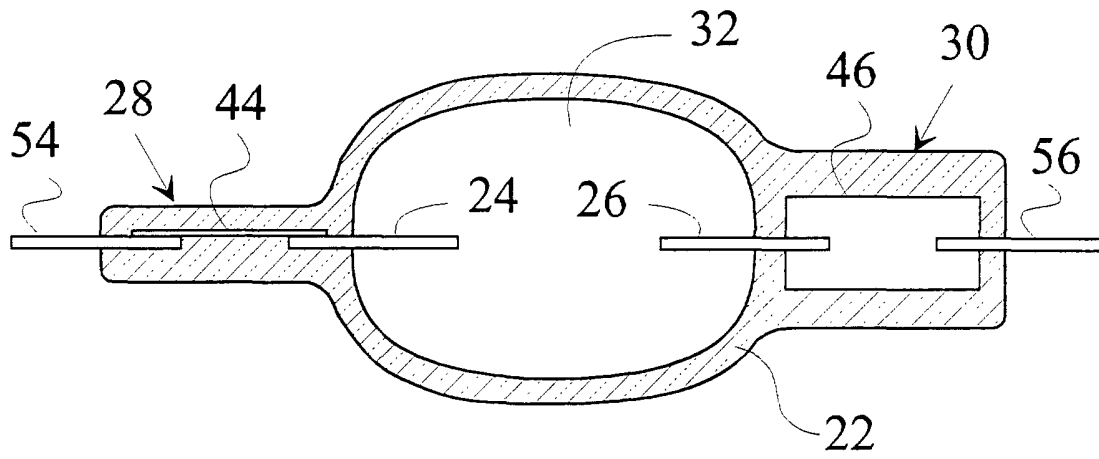
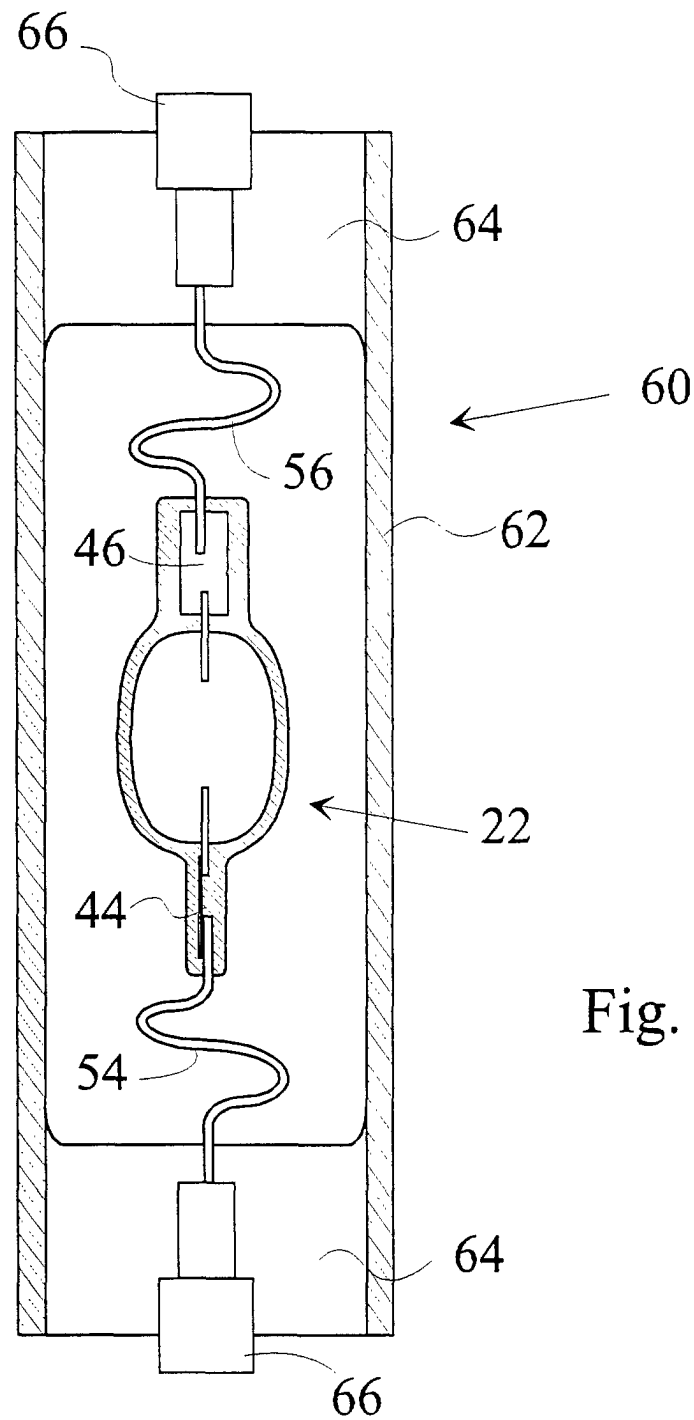


Fig. 10





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 8665

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