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(54) Cold cathode type discharge lamp apparatus.

(57) A cold cathode type discharge lamp apparatus of the invention is composed of a discharge lamp tube, a cathode electrode member in nearly cylindrical form made of a semiconductor porcelain and including an apex made a discharge surface, a sealing support member for sealing and supporting the cathode electrode member within the tube, and a lead wire connected to the cathode electrode member. In such discharge lamp apparatus, since an electron emission material is not used in the cathode electrode but the semiconductor porcelain is used, chemical reaction due to heating is not used, thereby blackening of the light emission tube is prevented and the life becomes long.

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COLD CATHODE TYPE DISCHARGE LAMP APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to discharge lamp apparatuses, and more particularly to a cold cathode type discharge lamp apparatus.

A mercury lamp is known as a cold cathode type discharge lamp apparatus. In cathode of the mercury lamp, when a switch is turned on at cold cathode state, glow discharge is started and transferred immediately to arc discharge thereby the cathode is transferred from cold cathode state to hot cathode state so as to perform the hot cathode emission.

Such cathode of the mercury lamp is produced in process that oxide of alkaline earth metal and other oxide having heat-resistant property are mixed, thereby electron emission material is produced and filled in a storage portion of a coil-like electrode, and then burning is applied thereto.

In the electrode of the mercury lamp, however, when the lamp is stabilized in the complete hot cathode state as above described, the electron emission material in the storage portion of the electron is subjected to chemical reaction due to heat and varied into material liable to evaporation, and the evaporated material is adhered to the tube wall of the light emission tube during the lighting for a long time, thereby the light emission tube is blackened and the luminous flux of the lamp is deteriorated and the life of the lamp is decreased.

SUMMARY OF THE INVENTION

As above described, the prior art has problems in the chemical reaction of the material on the electrode surface due to heat, the blackening of the light emission tube and decrease of the tube life.

In order to solve above-mentioned problems, an object of the invention is to provide a cold cathode type discharge lamp apparatus wherein a tube wall of a light emission tube is prevented from being blackened, and the life of the tube becomes long.

In order to attain the above object, a cold cathode type discharge lamp of the invention is composed of a discharge lamp tube, a cathode electrode member in nearly cylindrical form made of a semiconductor porcelain and having a discharge surface on an apex, a sealing support member for sealing and supporting the cathode electrode member within the tube, and a lead wire connected to the cathode electrode member.

In such a discharge lamp apparatus, since an electron emission material is not used in the cathode electrode but a semiconductor porcelain is used, chemical reaction due to heating is not produced and the light emission tube is prevented from being blackened and the life of the tube becomes long.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a is a sectional view of main part of a discharge lamp apparatus as an embodiment of the invention;

FIG. 1b is a plan view of a cathode electrode member in FIG. 1a;

FIG. 2 is a schematic illustration of an experiment device for the cathode electrode of the invention;

FIG. 3 is a graph illustrating experimental data of the cathode electrode;

FIG. 4a is a sectional view of main part of a discharge lamp apparatus as another embodiment of the invention;

FIG. 4b is a sectional view of an end portion of a cathode electrode member in FIG. 4a;

FIG. 5 is a sectional view of main part of a discharge lamp apparatus as another embodiment of the invention;

FIG. 6a is a sectional view of main part of a discharge lamp apparatus as another embodiment of the invention;

FIG. 6b is a sectional view of main part of a cathode electrode member in FIG. 6a illustrating another example of lead wire connection structure;

FIG. 7a is a sectional view of main part of a discharge lamp apparatus as another embodiment of the invention;

FIG. 7b is a perspective view of a cathode electrode member in FIG. 7a;

FIG. 8 is a sectional view of main part of a discharge lamp apparatus as another embodiment of the invention;

FIG. 9 is a sectional view of main part of a cathode electrode member in FIG. 8 illustrating another example of lead wire connection structure;

FIG. 10a is a sectional view of main part of a discharge lamp apparatus as another embodiment of the invention;

FIG. 10b is a plan view of a cathode electrode member in FIG. 10a;

FIG. 10c is a sectional view of an end portion of FIG. 10a illustrating an example of lead wire connection structure; and

FIG. 10d is a sectional view of an end portion of FIG. 10a illustrating another example of lead wire connection structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the invention will now be described in detail referring to FIG. 1a.

A discharge lamp electrode shown in FIG. 1a is composed of a tube 1 for discharge lamp, a cathode electrode member 2 using a semiconductor porcelain and arranged within the tube 1, a sealing support member 3 which seals and supports the cathode electrode member 2 within the tube 1 and near an end portion 1a of the tube 1, and a lead wire 4 which is connected to the cathode electrode member 2 and extends to outside through the sealing support member 3.

As shown in FIG. 1b, the cathode electrode member 2 is made of a semiconductor porcelain, and comprises a semispherical discharge surface 2a on one end portion and a base 2b of nearly cylindrical form. Center portion of the discharge surface 2b becomes an apex 2c most projecting from the base 2b. Thus the cathode electrode member 2 is in cylindrical form.

The sealing support member 3 is arranged penetrating the end portion 1a of the tube 1, and the lead wire 4 is sealed and supported at the end portion 1a and an end portion 4a of the lead wire 4 at inside of the tube is wound on outer circumference of the base 2b, thereby the cathode electrode member 2 is supported within the tube 1 in vertical arrangement to the end portion 1a and other end portion 4b of the lead wire 4 is projected to outside from the end portion 1a of the tube 1.

A semiconductor porcelain as a raw material for the cathode electrode 2 will now be described in detail.

For example, a valency compensation type semiconductor porcelain may be mentioned as the semiconductor porcelain. A typical example of the valency compensation type semiconductor porcelain is that using barium titanate.

The valency compensation as known well consists in that metal ion having valency different by value ±1 from that of constitution metal ion of metal oxide is added as an impurity, and increase or decrease of the charge quantity produced by introduction of the impurity is compensated by the number of valency of the constitution metal ion.

The valency compensation semiconductor forming agent can be exemplified by Y, Dy, Hf, Ce, Pr, Nd, Sm, Gd, Ho, Er, Tb, Sb, Nb, W, Yb, Sc, Ta or the like. These can be used together for adding. Adding amount of the adding agent is preferably 0.01 ~ 0.8 mol %, particularly 0.1 ~ 0.5 mol %.

On the other hand, a raw material to constitute the cathode electrode made of the semiconductor porcelain in the embodiment is preferably titanates. In addition to the above-mentioned barium titanate, strontium titanate, calcium titanate or lanthanum titanate may be used. Composite material of these may be used. Further, titanic acid in the titanates may be replaced by at least one of zirconic acid, silicic acid and stannic acid.

The semiconductor porcelain for the discharge electrode in the invention may be a forced reduction type semiconductor porcelain. This can be obtained by method of reducing the semiconductor porcelain for the cathode electrode as above described, and further by method of reducing without adding the semiconductor forming agent if the sufficient reducing condition is supplied. Reduction in this case may be performed in the reducing atmosphere of N_2 or H_2 and preferably in the temperature condition of 700°C or more, particularly in 1,200 ~ 1,450°C.

The electrode may be formed by using the valency compensation type and the forced reduction type together. Modes of the concurrent use are as follows:

(a) A semiconductor forming agent is added, and a molding body of a valency compensation type semiconductor porcelain is formed.

(b) The molding body in (a) is directly reduced and burned, or a sintering porcelain in air burning is further reduced and burned, thereby a semiconductor porcelain in concurrent use of valency compensation type and forced reduction type can be obtained.

A concrete experiment example will now be described.

Top end of a valency compensation type semiconductor porcelain was ground into conical form of about 60°, and specific resistance of the obtained semiconductor porcelain was 9.9 Ωcm.

Further, the H_2 density was made 20 % in the reducing atmosphere of H_2 + N_2, and the semiconductor porcelain was reduced and burned at 1,250°C and the stabilizing time 2 Hr. Specific resistance of the burned porcelain was 0.90 Ωcm.

Similar results were obtained in other titanates. Results are summarized in Table 1.

Table 1

Specific Resistance of Various Semiconductor Porcelains for Discharge Electrode

No.	Composition	before reduction (Ωcm)	after reduction (Ωcm)
(1)	$BaTiO_2$ - Y_2O_3 0.15 mol% - SiO_2 0.6 wt%	9.9	0.90
(2)	$SrTiO_3$ - Dy_2O_3 0.3 mol% - SiO_2 0.6 mol%	0.50	0.048
(3)	$SrTiO_3$ 62 wt% - La_2O_3 $3TiO_2$ 10 wt% - $CaTiO_3$ 27.7 wt% - Nb_2O_5 0.3 wt%	0.35	0.032

Similar results were obtained when titanic acid in the titanates was replaced by at least one of zirconic acid, silicic acid and stannic acid.

In order to study the easiness of electron emission, the electric field emission intensity was measured regarding the above-mentioned specimens No. 1 through No. 3. For comparison, the measurement was performed also regarding Al, Cu, Fe having the work function being relatively low. Results are shown in FIG. 3. In FIG. 3, discharge generating voltages in a polyethylene container (kV) are taken in ordinate, and specimen cathodes are arranged in abscissa. The specimen cathodes are Cu, Al, Fe as comparison examples and the specimens No. 1 ~ No. 3 arranged in Table 1. A device shown in FIG. 2 was used in the experiment. The device comprises a polyethylene container 5 of 15 cm in width, 5 mm in length and 10 mm in height, and silver paste 6 is applied to the bottom surface of the container 5. A specimen electrode 2′ was arranged above the bottom surface and an AC power source 7 was connected between the specimen electrode 2′ and the silver paste 6. Radius R at the top end arc-shaped portion of the specimen electrode 2′ is made 20 μm, and distance D between the top end portion of the specimen electrode 2′ and the silver paste 6 is made 4 mm. The starting voltage was 10 kV, and the voltage was increased in 1 kV per minute.

As a result, characteristics as shown in FIG. 3 were obtained. As clearly seen from FIG. 3, in any of the specimens in the experiment, the discharge is easily generated even at low generating voltage in comparison to conventional examples.

According to the results, it is understood that the semiconductor porcelain for the cathode electrode in the embodiment has equivalent or more excellent characteristics in comparison to metals.

Consequently, the cathode electrode 2 made of the semiconductor porcelain in the embodiment can obtain the stabilized discharge characteristics and the manufacturing cost can be decreased.

Next, various modifications of the discharge lamp apparatus using the above-mentioned cathode electrode will be described in sequence.

A second embodiment of the discharge lamp apparatus as shown in FIG. 4a comprises a discharge lamp tube 11, a cathode electrode 12 using a semiconductor porcelain and including a top end portion disposed within the tube 11, a base 12b penetrating an end portion 11a of the tube 11 and other end portion 12d projecting, a sealing support member 13 for sealing and supporting the penetrating portion of

the base 12b of the cathode 12 to the end portion 11a of the tube 11, and a lead wire 14 with an end portion 14a embedded to a screw body 15 threadably engaged with the projecting end portion 12d of the cathode electrode 12. The lead wire 14 is connected to a power source (not shown), thereby the power is supplied. As shown in FIG. 4b, the cathode electrode member 12 may be connected to the lead wire 14 through a conductive cap 16.

FIG. 5 shows another embodiment of the invention. In FIG. 5, a discharge lamp apparatus comprises a tube 21, a cathode electrode member 22 made of a semiconductor porcelain and arranged within the tube 21, and a lead wire 24 including one end wound on the cathode electrode member 22 and other end penetrating an end portion 21a of the tube 21 and projecting to outside. A conical discharge surface 22a is formed on top end portion of a base 22b of the cathode electrode member 22, and a projecting end portion is made an apex 22c. Numeral 23 designates a sealing support member.

In both FIG. 6a and FIG. 6b, a cathode electrode member 22 with form shown in FIG. 5 is used. However, both are different from each other in mounting structure and connection structure of a lead wire 24. In FIG. 6a, a base 22b of the cathode member 22 is sealed and supported through a penetrating hole provided on an end portion 21a of a tube 21, and a lead wire 24 is connected through a screw body 25. In FIG. 6b, the lead wire 24 is connected to the cathode electrode member 22 through a conductive cap 26.

FIG. 7a shows another embodiment of the invention. An apparatus shown in FIG. 7a comprises a tube 31 for discharge lamp, a cathode electrode member 32 using a semiconductor porcelain and arranged within the tube 31, and a sealing support member 33 for sealing and supporting the cathode electrode member 32 within the tube 31 and near an end portion 31a of the tube 31. As shown in FIG. 7b, the cathode electrode member 32 is made of the semiconductor porcelain, and is composed of one end surface formed in a circular discharge surface 32a and a base 32b.

The sealing support member 33 is arranged penetrating the end portion 31a of the tube 31, and a lead wire 34 is sealed and supported at the end portion 31a. An end portion 34a of the lead wire 34 at inside of the tube 31 is wound on outer circumference of the base 32b, thereby the cathode electrode member 32 is supported within the tube 31 and the circular discharge surface 32a is arranged in parallel to the end portion 31a, and other end portion 34a of the lead wire 34 is projected from the end portion 31a of the tube 31 to outside.

In both FIG. 8 and FIG. 9, a cathode electrode member 32 in FIG. 7a is used. However, both are different from each other in mounting structure and connection structure of a lead wire 34. In both embodiments, a base 32b of the cathode electrode member 32 is supported penetrating an end portion 31a of a tube 31. However, in FIG. 8, a screw body 35 is threadably engaged with a bottom surface 32c of the cathode electrode member 32, and one end of the lead wire 34 is embedded to the screw member 35. In FIG. 9, the lead wire 34 is connected through a conductive cap 36.

FIG. 10a shows another embodiment of the invention. An apparatus in FIG. 10a comprises a discharge lamp tube (e.g., made of glass) 41, a cathode electrode member 42 using a semiconductor porcelain and arranged within the tube 41, and a sealing support member 43 for sealing and supporting the cathode electrode member 42 within the tube 41 and near an end portion 41a of the tube 41. As shown in FIG. 10b, the cathode electrode member 41 is in nearly cylindrical form and provided at intermediate position with a swelling portion 42c having outer diameter slightly less than diameter of an inner wall of the tube 41. A projecting base 42b in cylindrical form having outer diameter less than that of the swelling portion 42c is projected upwards from the center of an upper surface of the swelling portion 42c, and a circular discharge surface 42a is formed on an end surface of the projecting base 42b. A tube fitting portion 42d having diameter less than that of the swelling portion 42c is projected downward from the center of a lower surface of the swelling portion 42c. On outer circumferential portion of the swelling portion 42c abutting on the tube 41, that is, portion abutting on end portion 41a and a side wall portion 41b of the tube 41, is formed a sealing layer 44 made of the same material as that of the tube 41 (e.g., made of glass) by means of painting or baking. The cathode electrode member 42 is sealed within the tube 41 through the sealing layer 44 thereby the sealing member 43 is found. In this case, both the tube 41 and the sealing layer 44 may be made of glass, thereby the sealing process can be facilitated and the air tightness can be improved. An electrode member 45, e.g., made of silver, is formed on a projecting end portion 42e of the tube fitting portion 42d. The electrode member 45 is connected to a power source (not shown), thereby the cathode electrode member 42 is energized. FIG. 10c shows a modification of lead wire connection structure in FIG. 10a. In FIG. 10c, a screw 47 holding a lead wire 46 is threadably engaged with the projecting end portion 42e. FIG. 10d shows another example of lead wire connection structure. In FIG. 10d, a cylindrical cap 48 holding the lead wire 46 is fitted, thereby the cathode electrode member 42 is energized.

According to the cold cathode type discharge lamp apparatus of the invention as above described in detail, since an electron emission material is not used in the cathode electrode but the semiconductor porcelain is used, chemical reaction due to heating is not produced, thereby blackening phenomenon of the light emission tube can be prevented and the life of the discharge lamp apparatus becomes long. Also, since the semiconductor porcelain is cheap, cost of the apparatus is reduced. Further, since the semiconductor porcelain may be formed in any shape, shape of the semiconductor may be selected corresponding to the use object so as to obtain required characteristics.

Claims

1. Cold cathode type discharge lamp apparatus, comprising:
a tube for discharge lamp;
a cathode electrode member in nearly cylindrical form made of a semiconductor porcelain and including an apex made a discharge surface;
a sealing support member for sealing and supporting the cathode electrode member within the tube; and
a lead wire connected to the cathode electrode member.

2. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the semiconductor porcelain is a valency compensation type semiconductor porcelain or a forced reduction type semiconductor porcelain or a semiconductor porcelain in concurrent use of both.

3. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the semiconductor porcelain has main constituent being one or two or more selected from oxides of titanium, barium, strontium, calcium, lanthanum and tin.

4. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the semiconductor porcelain has adding agent of valency compensation semiconductor forming agent being one or two or more selected from Y, Dy, Hf, Ce, Pr, Nd, Sm, Gd, Ho, Er, Tb, Sb, Nb, W, Yb, Sc and Ta.

5. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the sealing support member penetrates an end portion of the tube, and the lead wire is sealed in the end portion and an end portion of the lead wire at inside of the tube is wound on a portion of the cathode electrode member at opposite side to the discharge surface.

6. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the sealing support member seals the cathode electrode member with the discharge surface penetrating an end surface of the tube.

7. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the sealing support member has the lead wire projecting to outside of the tube and connected to an end portion of the cathode electrode member.

8. Cold cathode type discharge lamp apparatus as set forth in claim 1, wherein the cathode electrode member in nearly cylindrical form comprises a circular discharge surface on an end surface, a swelling portion abutting on the inner wall of the tube, and a tube fitting portion projecting out of the tube.

9. Cold cathode type discharge lamp apparatus as set forth in claim 1 or claim 8, wherein a glass layer formed on outer circumference of the swelling portion is sealed by a tube made of glass so as to constitute the sealing support member.

10. Cold cathode type discharge lamp apparatus as set forth in claim 1 or claim 8, wherein the tube fitting portion of the cathode electrode member has an electrode for external connection.

FIG. 1a

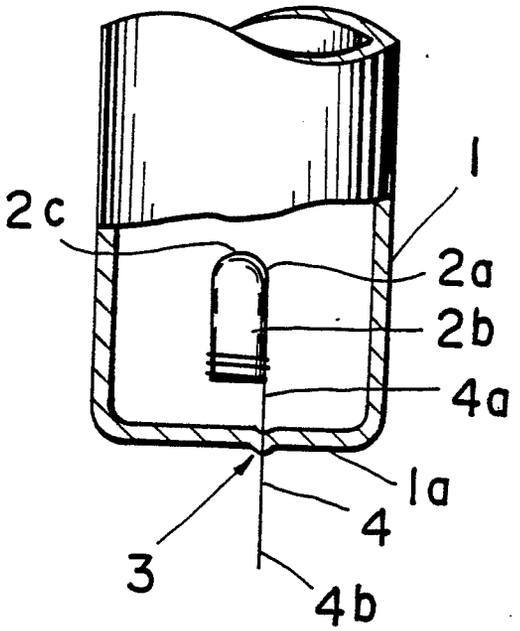

FIG. 1b

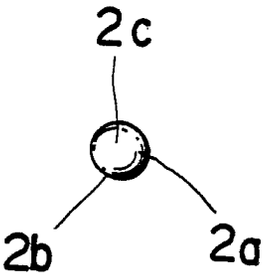

FIG. 2

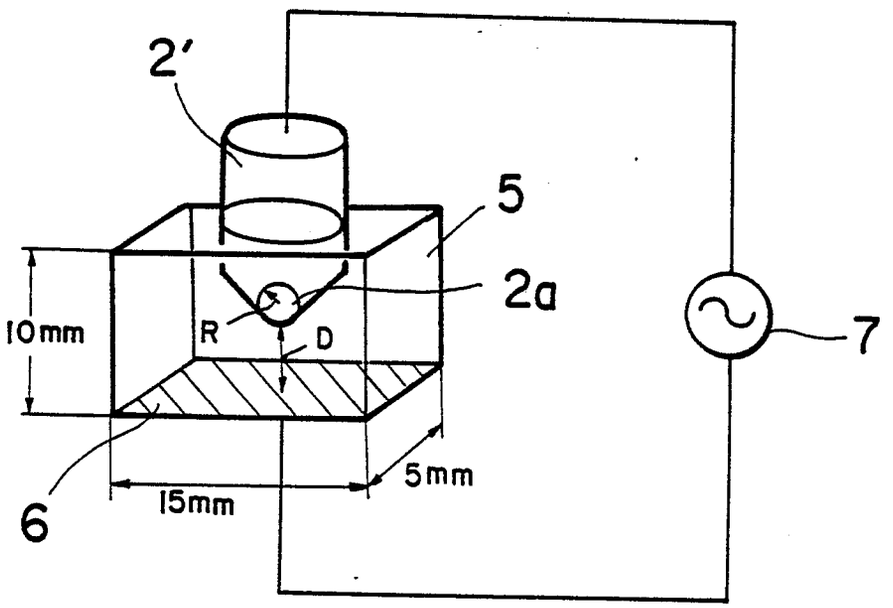

FIG. 3

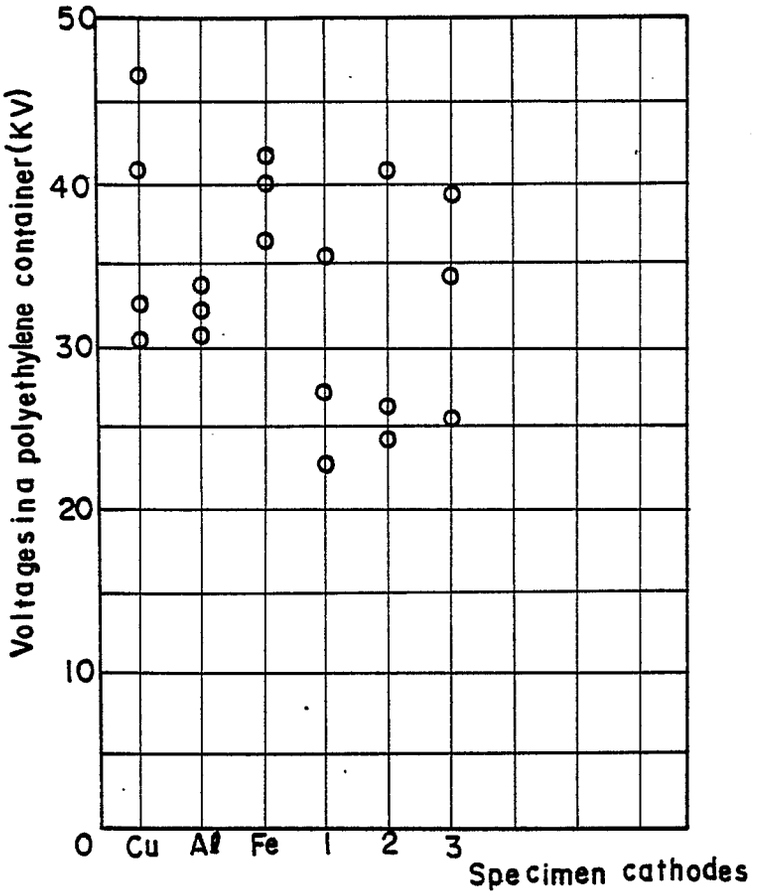

FIG. 4a

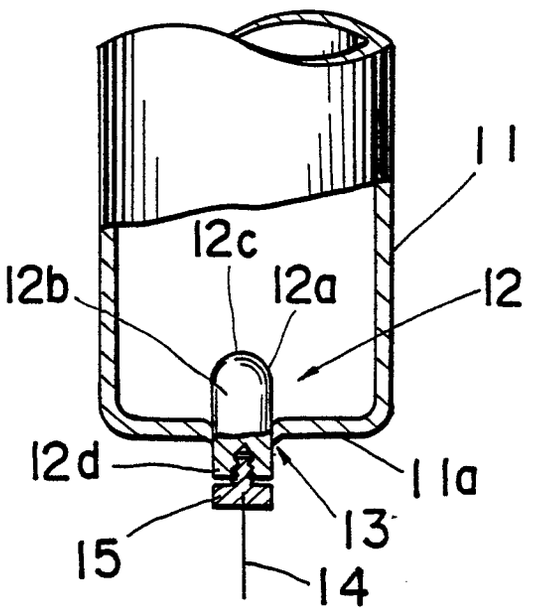

FIG. 4b

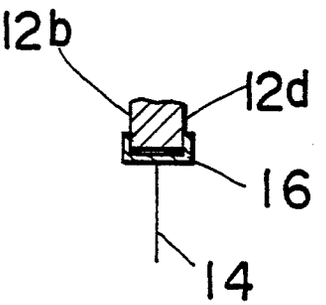

FIG.5

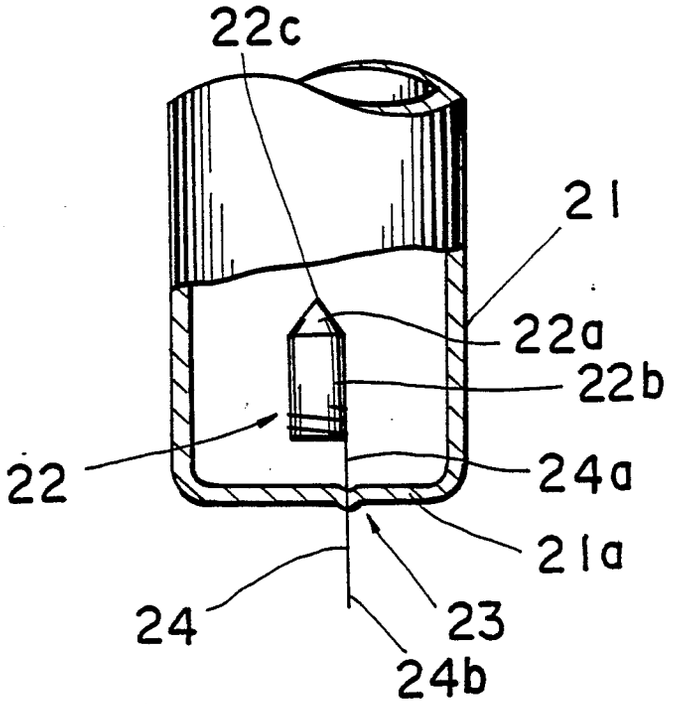

FIG.6a

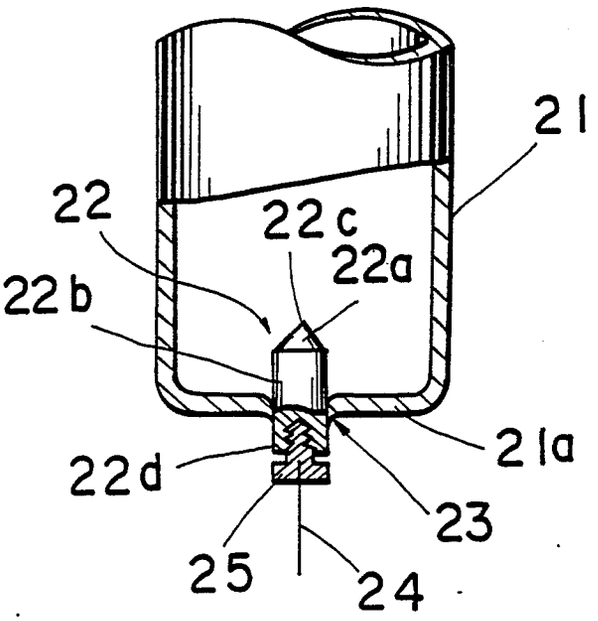

FIG.6b

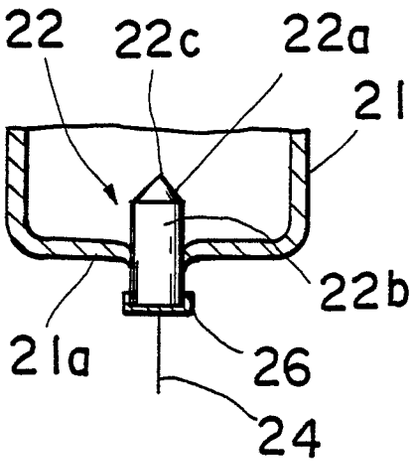

FIG.7a

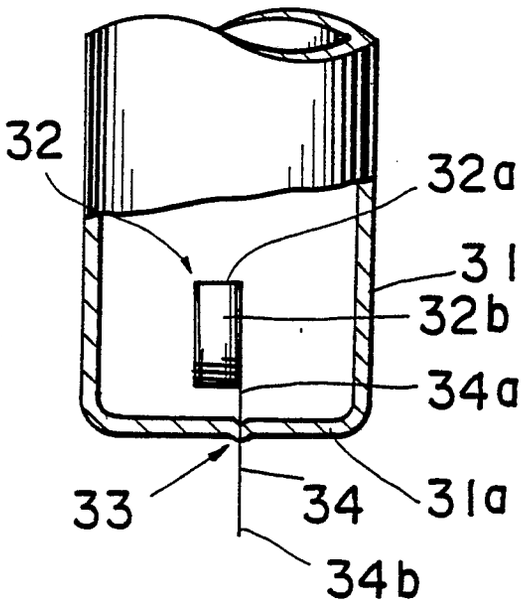

FIG.7b

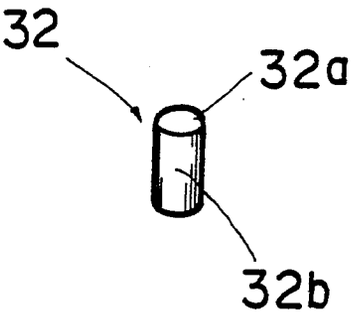

FIG.8

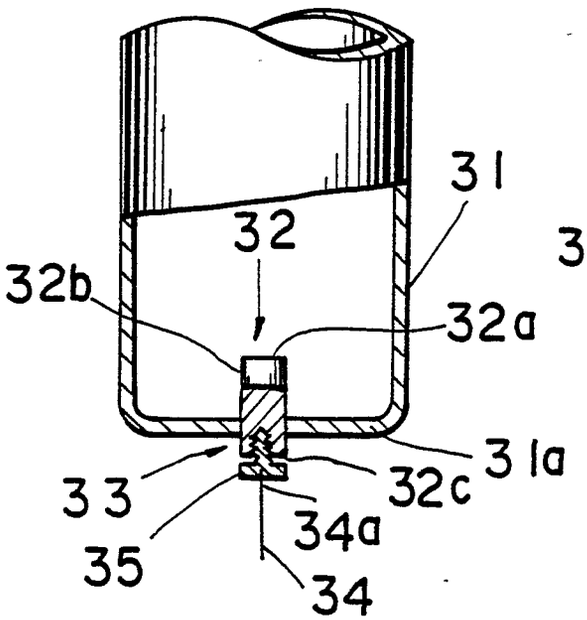

FIG.9

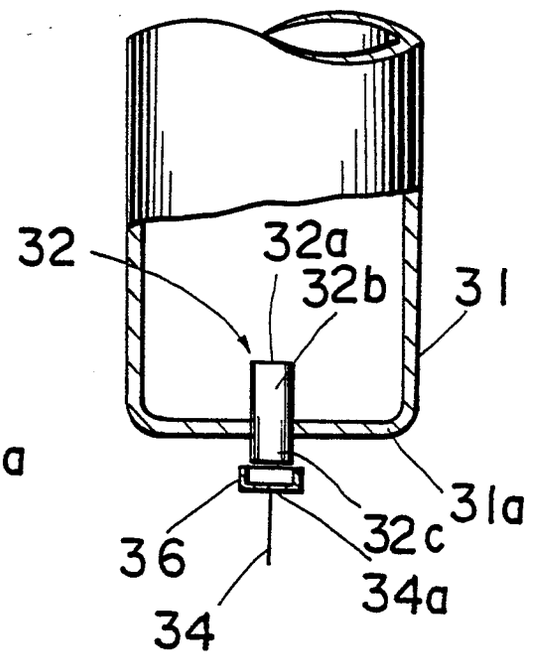

FIG.10a

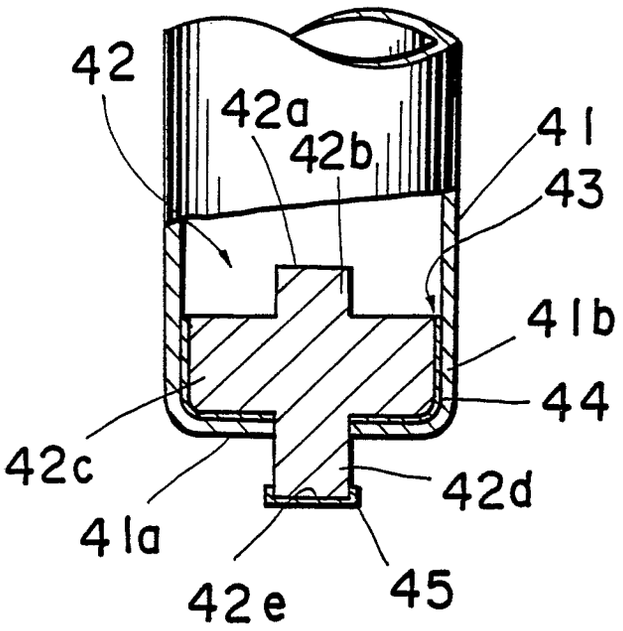

FIG.10b

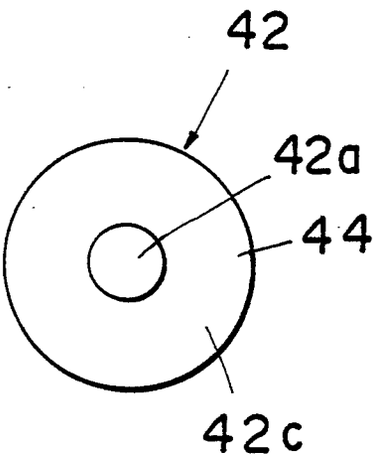

FIG.10c

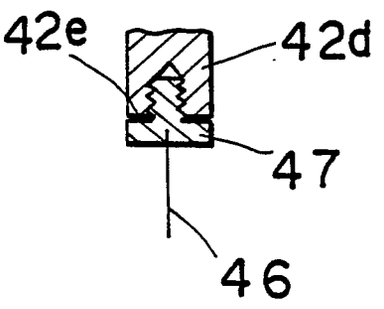

FIG.10d