June 20, 1950 N. C. FULMER 2,512,146

PHOTOELECTRIC DEVICE

Filed Oct. 3, 1946

Fig. 1.

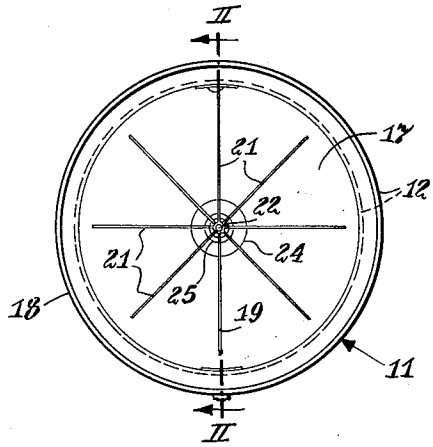


Fig. 2.

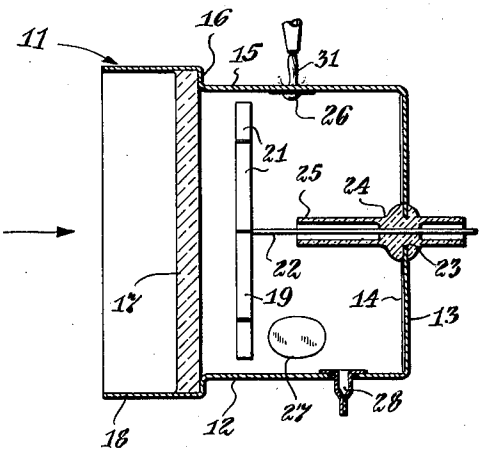


Fig. 3.

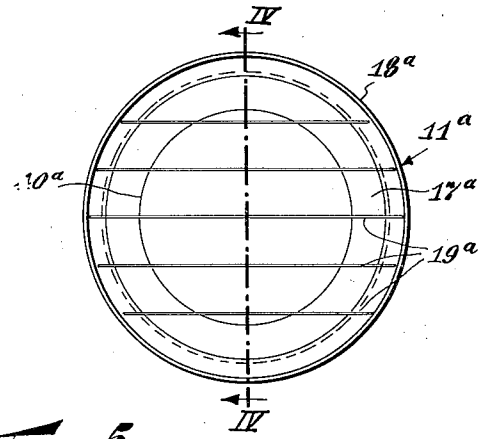


Fig. 4.

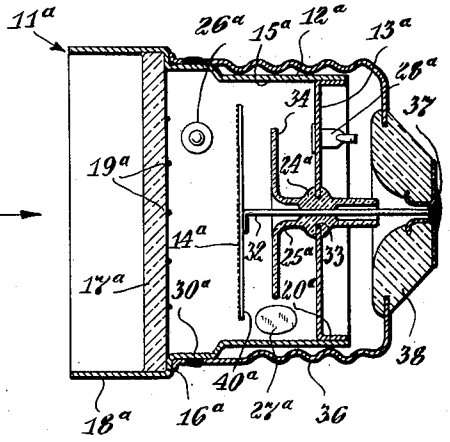


Fig. 5.

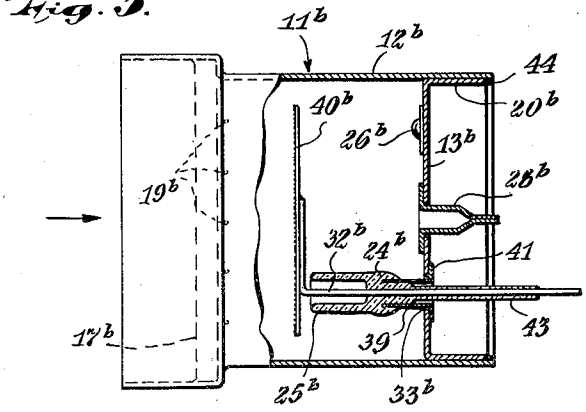
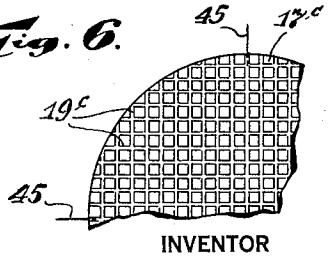


Fig. 6.



INVENTOR
N. C. FULMER
BY
ATTORNEY

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2,512,146

PHOTOELECTRIC DEVICE

Norman C. Fulmer, Montclair, N. J., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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16 Claims. (Cl. 250—165)

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This invention relates to photoelectric devices and, more particularly, to such constructed of metal or other non-frangible material.

The principal object of my invention, generally considered, is to produce photoelectric devices or phototubes in which the body of each is ruggedly constructed, as by being made of metal or other non-frangible material, as distinguished from glass as usually employed.

Another object of my invention is to produce phototubes in which the light-sensitive material for the cathode of each is applied to the inside of the bottom of a rugged metal shell, a vane-like anode being supported by a lead passing through and insulated from said shell.

A further object of my invention is to produce phototubes in which the sensitive surface is carried on a rugged metal portion thereof, a lead passing through said sensitive surface portion and insulated therefrom, and a glass tube extending from the insulating portion around said lead to form a long leakage path.

A still further object of my invention is to produce phototubes in which the casing of each is formed as a cup or shell of metal or other rugged material, which is sealed by a glass window serving to admit light, or other radiation, to the cathode surface therein.

An additional object of my invention is to produce phototubes, each comprising a rugged metal shell enclosing a cathode formed as a metal disk coated with photo-sensitive material, said shell being closed by a window for admitting radiation to the cathode surface, the anode being formed as conducting strips or wires underlying said window and attached to the metal shell at a distance from the cathode surface.

Another object of my invention is to produce a phototube comprising a rugged shell closed by a glass window sealed thereto directly adjacent a structure formed to function as an anode, the open end of said shell being extended beyond the window to form a light shield, and in which said shell may be provided with a screw-threaded base, as by threading the shell or an extention thereof for connection with a receptacle.

Other objects and advantages of the invention will become apparent as the description proceeds.

Referring to the scale drawing:

Figure 1 is a plan of a phototube embodying my invention.

Figure 2 is an axial sectional view of the line II—II of Figure 1, in the direction of the arrows, parts being shown in elevation.

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Figure 3 is a plan corresponding to Figure 1, but showing another embodiment of my invention.

Figure 4 is an axial sectional view on the line IV—IV of Figure 3, in the direction of the arrows.

Figure 5 is a view corresponding generally to Figure 4, but showing another embodiment of my invention.

Figure 6 is a plan of the combination window and anode of another embodiment of my invention.

Phototubes, as now generally constructed, are fragile devices consisting of an anode and a cathode enclosed within a glass envelope. Because of their fragility, such tubes are usually housed in a protective metal box which has an aperture in one side to allow light or other radiations to enter and impinge on the photoelectric surface of the cathode. Conventional phototubes also generally contain within their glass envelopes considerable space not needed for tube operation.

In accordance with my invention, I propose a phototube which, unlike those of present construction, is compact and rugged. The shell of the tube is constructed of non-frangible material, such as metal, and is cylindrical in shape with a transparent window at one end through which light may enter.

Referring to the drawing in detail, like parts being designated by like reference characters, and first considering the embodiment of my invention illustrated in Figures 1 and 2, there is shown a phototube 11 comprising a generally cylindrical shell or housing 12 which may be of metal, such as "Kovar," steel, copper, nickel, or silver. Said shell desirably has a circular end wall 13, integral or separately formed and attached, as shown in one of the figures, the inner surface of which carries a photosensitive material forming the cathode 14. A cylindrical wall 15 extending therefrom, desirably has an annular shoulder 16 providing a seat for holding a glass window 17 parallel to the end wall 13, and continuing at enlarged diameter beyond said window, as indicated at 18, to provide a light shield.

In the present embodiment the anode 19 is of a vane-type construction, with narrow metal strips or wires 21 radiating from a lead 22 which passes through a hole 23 in the end wall 13 of the metal shell. The anode lead 22 is supported and insulated from the shell by a glass seal 24, which closes the hole 23 in the shell bottom wall 13. Integral with the glass seal 24, is a glass tubing insulator 25, surrounding the anode lead 22 inside of the tube shell for the purpose of provid-

ing a long leakage path between the anode 19 and cathode 14. Such an insulating sleeve prevents material deposited in forming the cathode 14, from making a leakage path to the anode 19. The vane-type of anode construction allows light to easily reach the cathode, and also provides a large area to collect electrons released by the action of light on the sensitive surface of the cathode 14. The glass window 17 may be sealed to the metal shell in any desired manner, as by induction heating.

The sensitive surface of the cathode 14 may be produced in a conventional manner, as by deposition of alkali metal, such as cesium, on an oxidized silver surface. Thus, the shell 12, if not made of silver, may have the inner surface of its bottom wall 13 silver plated before the sensitizing or "getter" capsule 26 supported on the cylindrical part of the shell 12, is activated. The silver surface is in any event desirably carefully cleaned and then etched to provide an enlarged area and allow finely-divided silver particles to remain to mix with oxygen and cesium at a later step in the process. After the getter capsule 26 has been positioned, the shell may have the window 17 placed, sealed thereto, and the enclosed portion of the shell exhausted through tube 28, positioned as shown in one of the figures, while baking to purify the glass and metal parts. Then some purified oxygen at low pressure, say about 3 millimeters, may be admitted through said tube 28. The silver plating on the surface of the bottom wall 13 may then be oxidized as by a glow discharge at from 450 to 500 volts D. C. until the cathode is bright emerald green in color. The remainder of the oxygen is removed by evacuating through tube 28.

The getter capsule 26 may contain cesium-generating means, such as a mixture of cesium dichromate and a reducing agent such as silicon. The cover of the capsule may be of iron or nickel. On a part of the shell 12, such as on the cylindrical surface, is an absorbent for excess cesium, such as a coating 27 of tin oxide. The cesium capsule, being on the cylindrical surface, may be activated as by a flame or other convenient heating means, directed at the adjacent part of the cylindrical portion 15 of the shell.

This activation results in deposition of cesium on the oxidized silver surface of the cathode 14, as well as other parts of the tube. As an alternative, cesium vapor may be distilled into the shell 12 through the exhaust tube 28. The shell is then baked on exhaust in order that the deposited cesium may react with the silver oxide to form a highly light-sensitive surface. This baking also removes the cesium from the walls of the housing 12 and the window 17. It also removes all but a very thin layer from the cathode 14. An indication of when to stop is the brown color of the cathode.

The so-called "activating" of the cathode is done by running a glow discharge at about 400 volts in argon at a pressure of about 100 microns. A faint yellow sputtered film on the window is generally an indication of sufficient "activation." Excess cesium in the shell is absorbed by the tin oxide during the baking and "activation" operations. The housing is then evacuated or filled with a desired gas, if a gas tube is to be made, and the exhaust tube 28 sealed, as illustrated.

Referring now to the embodiment of my invention illustrated in Figures 3 and 4, there is shown a phototube 11ª comprising a generally cylindrical shell or housing 12ª, which may be of metal such as "Kovar," steel, copper, nickel, or silver. One end of said shell is desirably closed by a circular shell bottom wall portion 13ª, having an outstanding flange 20ª secured to said shell 12ª in any desired manner, as by welding, brazing, or soldering. The cylindrical shell portion 15ª, extending therefrom, is desirably outwardly offset, as indicated at 30ª, and then desirably provided with an annular shoulder 16ª, forming a seat for a glass window 17ª, and continued at an enlarged diameter beyond said window, as indicated at 18ª, to provide a light shield.

In the present embodiment, the cathode 40ª is formed as a flat thin metal disk, coated with light-sensitive material 14ª on the side facing the window 17ª. This cathode is supported on a lead 32 which passes through a hole 33 in the circular portion 13ª. The lead 32 is supported on, and insulated from, said circular portion by a glass seal 24ª which closes the hole in the bottom wall portion 13ª. Integral with said glass seal 24ª, is a glass tubing insulator 25ª, surrounding the lead 32 inside of the shell 12ª, for the purpose of providing a long leakage path between the electrodes. In the present embodiment, the sleeve is shown flared to form a circular disk portion 34 parallel to the cathode 40ª, thereby making it possible to shorten the shell 12ª in this and other embodiments without decreasing the length of the leakage path between the electrodes.

Such an insulating sleeve prevents material deposited in sensitizing the cathode 40ª from making a leakage path to the anode 19ª. The latter, in this instance, may be formed by a series of conducting strips or wires, attached electrically and mechanically to the metal shell at a desired distance from the cathode, preferably directly adjacent the window 17ª, or as silver stripes or a silver grid 19ᶜ plated on the inner surface of the glass window 17ᶜ, as illustrated in Figure 6. In the latter case, flexible or "catwhisker" means 45 may extend from the shell to make electrical connection with said anode 19ᶜ. As a further alternative, a translucent or semi-transparent silver film may be provided on the inner surface of the window, to be sensitized like the member 14 and function as the cathode, the other electrode functioning as the anode. Said translucent film may, if desired, be superimposed on a grid, like that designated 19ᶜ, thereby increasing the conductivity of the cathode formed. The glass window 17ª may be sealed to the metal shell in any desired manner, as by induction heating.

The sensitive surface 14ª on the cathode 40ª may be produced in a conventional manner, as by deposition of alkali metal, such as cesium, on an oxidized surface. Thus, if the cathode disk is not made of silver, it may have the surface, which faces the window 17ª, silver plated and treated as described in connection with the first embodiment, before the sensitizing means, such as the getter capsule 26ª supported on a cylindrical part of the shell 12ª, is activated. After the getter capsule 26ª has been positioned, the shell may have the window placed and sealed thereto, and the enclosed portion of the shell exhausted through tube 28ª. Then some oxygen at low pressure, say about 3 millimeters, may be admitted through said tube 28ª. The silver surface of the cathode disk may be oxidized as previously described in connection with the first embodiment, or in a conventional manner, the remainder of the oxygen being removed by exhaustion through tube 28ª.

The getter capsule 26ª may contain cesium-

generating means, as in the preceding embodiment. The shell of the capsule may be of iron or nickel, and fastened on a part of the shell, 12a, such as the cylindrical surface of enlarged part 30a. An absorbent for excess cesium, such as a coating 27a of tin oxide may be on the cylindrical surface. The getter may be activated by a flame, or other convenient heating means, directed at the adjacent part of the cylindrical portion 30a of the shell. This heating results in a deposition of cesium on the oxidized silver surface of the cathode 40a, as well as other parts of the tube. As an alternative, cesium vapor may be distilled in the shell 12a through the exhaust tube 28a. The shell is then baked on exhaust in order that the deposited cesium may react with the silver oxide to form a highly light-sensitive surface. Said baking also acts as described in connection with the first embodiment, after which "activation" of the cathode is effected as previously described, the excess cesium being absorbed by the tin oxide. The tube is then completed, as before.

In the present embodiment the completed phototube is, as an example, shown with a conventional base applied thereto, as by fitting a threaded shell portion 36 thereover until the free edge engages the surface of the shoulder 16a opposite that on which the window 17a is positioned, and securing the free edge thereof to the offset portion 30a of the shell 12a, in any desired manner, as by soldering or welding. This threaded portion 36 is thus connected to the anode. A center contact 37, insulated from the threaded portion by glass or other insulator 38, is connected to the lead 32 in a conventional manner, as by soldering.

Referring now to the embodiment of my invention illustrated in Figure 5, there is shown a phototube 11b which may correspond with the tube 11a of the preceding embodiment, except that the lead 32b does not pass through the center of the member 13b, said center being occupied by the exhaust tube 28b, secured thereto, as in the preceding embodiments, by passing through a hole in the shell and having an inner peripheral flange secured to said shell, as by soldering or welding. Besides this, the insulator 25b is not flared, as in the second embodiment, but rather extends cylindrically as in the first embodiment. The glass insulator portion 24b is shown sealing the lead 32b to a metal eyelet 39, having a flange 41 secured to the circular portion 13b around an aperture 33b therethrough as by soldering or welding, rather than fused directly in said aperture. The glass of said insulator portion 24b is shown extending through the eyelet and out of the tube around the lead 32b, as indicated at 43. Except for the different positioning of the getter capsule 26b, and the fact that there is no offset corresponding with that designated 30a in the preceding embodiment, the anode members 19a and the window 17b being the same, the tube 11b may correspond with that of the preceding embodiment. A conventional base, however, is not illustrated.

Instead of making the shell complete with bottom wall and supported electrode and then applying the glass window 17b, I may, as an alternative, apply the glass window 17b and electrode strips 19b to the cylindrical portion 12b and then after assembly of the cathode 40b with the bottom wall member 13b and the associated parts, said bottom wall member may be secured in place as by fitting in the open end of the shell 12b and securing its flange 20b to said shell as by soldering or welding, as indicated at 44.

From the foregoing, it will be seen that I have provided a phototube comprising an enclosing shell which is rugged, as by being formed of metal rather than glass, and in which the cathode-sensitizing material is applied to a portion of the shell, or to a surface on a disk, for example, insulated and spaced from said shell. A glass tube or flared insulator may be provided around the stem of the electrode which is separated from the shell, to form a long leakage path between electrodes. A glass window, which may be plated, with or without subsequent treatment to also function as the cathode or anode, seals the metal shell after the application of the spaced electrode, and if not plated is desirably disposed adjacent the anode, whereby the size of the structure is kept small. In embodiments in which the anode consists of wire or conducting strips adjacent, touching, or embedded in the glass window, the material of such is "Kovar" or other material whose expansion coefficient corresponds sufficiently with that of the tube housing and glass, so that effective sealing results.

The Lempert et al. Patent No. 2,279,831, dated April 14, 1942, is referred to for the formula of "Kovar."

Although preferred embodiments of my invention have been disclosed, it will be understood that modifications may be made within the spirit and scope of the appended claims.

I claim:

1. A non-frangible photoelectric device comprising a non-frangible main container portion having a bottom wall member, an extension of section different from that of said main container portion and providing a shoulder adjacent its junction therewith, a lead passing through said wall member and insulated therefrom, an electrode member in said container and supported on said lead in spaced relation with respect to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, and a glass window sealed to said extension adjacent said shoulder to admit light to said sensitive material.

2. A photoelectric device comprising a non-frangible container having a generally flat bottom metal wall member, a lead passing through said wall member and insulated therefrom, an electrode member in said container, disposed generally parallel to said bottom wall member, and supported on said lead in spaced relation with respect to said wall member, the metal wall member carrying photo-sensitive material to function as a cathode, and a glass window sealing said container in position to admit light to said sensitive material.

3. A photoelectric device comprising a non-frangible container with a metal end wall portion, a lead passing through said end wall portion and insulated therefrom, a thin metal disk inside said container and supported on said lead, a glass window closing the other end of said container and positioned to admit light to said disk, photo-sensitive material on the surface of said disk facing said window, and conducting portions traversing said container adjacent said window to function as an anode.

4. A photoelectric device comprising a metal container having a generally flat bottom wall member, a lead passing centrally through said bottom wall and insulated therefrom, an elec-

trode member in said container and supported on said lead in spaced generally parallel relation with respect to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, and a glass window sealing said container and positioned to admit light to said sensitive material.

5. A photoelectric device comprising a metal container having a generally flat metal bottom wall member, a lead passing through said wall member, an insulator formed as a tube surrounding said lead to provide for a long leakage path, said insulator also serving to secure said lead to said container, an electrode member in said container, disposed generally parallel to said bottom wall member, and supported on said lead in spaced relation with respect to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, and a glass window sealing said container and positioned to admit light to said sensitive material.

6. A photoelectric device comprising a non-frangible container having a bottom wall member, a lead passing through said wall member, an insulator closing a hole in said wall member and through which said lead passes, an electrode member in said container, said insulator being extended towards said electrode member and flared to provide a long leakage path disk adjacent thereto, said electrode member being supported on said lead in spaced relation with respect to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, and a glass window sealing said container in position to admit light to said sensitive material.

7. A photoelectric device comprising a metal container having a generally flat metal bottom wall member, a lead passing through said wall member and insulated therefrom, an electrode member in said container and supported on said lead in spaced generally parallel relation to said bottom wall member, a getter capsule device mounted on the inside of said container in a position convenient for activation by external heat for supplying photo-sensitizing material to cause one of the members to function as a cathode, and a glass window sealing said container and positioned to admit light to said cathode.

8. A photoelectric device comprising a metal container having a generally flat bottom wall portion, an exhaust tube extending through approximately the center of said portion, an aperture between said exhaust tube and the rim of said bottom wall member, an eyelet having a flange secured to said wall member around said aperture and a cylindrical portion extending inwardly from said wall member, a lead passing through said eyelet, insulating material sealing said lead in said eyelet, an electrode member in said container and supported on said lead in spaced relation to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, and a glass window sealing said container in position to admit light to said sensitive material.

9. A photoelectric device comprising a metal container having a bottom wall member, a lead passing through said wall member and insulated therefrom, a vane-type anode member supported in said container by said lead and spaced with respect to bottom wall member, said bottom wall member having an inner oxidized silver surface and carrying a photo-sensitive material to function as a cathode, and a glass window sealing said container and positioned to admit light to said cathode.

10. A photoelectric device comprising a metal container having a metal bottom wall member, a lead passing through said wall member, an insulator between said lead and wall member and including a tube portion around the former to provide a long leakage path, an electrode member in said container and supported on said lead in spaced relation with respect to said bottom wall member, said lead-supported electrode having a surface of oxidized silver facing away from said bottom wall member and coated with photo-sensitive material to function as a cathode, an anode structure traversing said container over said cathode, and a glass window sealing said container and disposed directly adjacent said anode structure.

11. A generally cylindrical photoelectric device comprising a metal container having an annular shoulder and continuing at enlarged diameter beyond said shoulder, a metal bottom wall member closing one end of said container, a lead passing through said wall member and insulated therefrom, an electrode member in said container and supported on said lead in spaced relation with respect to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, and a glass window sealing said container, seated on said shoulder, and positioned to admit light to said sensitive material, the wall of said container which extends beyond said shoulder and supported window, forming a light shield.

12. A photoelectric device comprising a generally cylindrical metal container having a generally circular bottom wall member at one end and flanged adjacent its other end to provide a shoulder, a lead passing through said wall and insulated therefrom, an electrode member in said container and supported on said lead in spaced relation with respect to said bottom wall member, one of said members carrying photo-sensitive material to function as a cathode, a glass window sealing said container and positioned on said shoulder to admit light to said cathode, and a base comprising a threaded shell in which said container fits and a center contact, the free edge of said shell engaging the surface of said shoulder opposite that on which the window is positioned, and means securing said container to said shell and said lead to said center contact.

13. A photoelectric device comprising a non-frangible container formed with an annular ledge and having a bottom wall member, a lead passing through said wall member and insulated therefrom, an electrode member in said container and supported on said lead in spaced relation with respect to said bottom wall member, and a flat glass window member with its edge seated on said ledge and sealing said container, one of said members carrying photo-sensitive material to function as a cathode and said glass window member serving to admit light to said photo-sensitive material.

14. A photoelectric device comprising a non-frangible container having a metal bottom wall member, a lead passing through said wall member and insulated therefrom, an electrode member in said container and supported on said lead in spaced relation with respect to said bottom wall member, said electrode member carrying photo-sensitive material to function as a cathode, a glass window sealing said container and positioned to admit light to said photo-sensitive ma-

terial, and a conductive grid formed on the inner surface of said window and electrically connected to said container to function as an anode.

15. A photoelectric device comprising a nonfrangible container having a metal bottom wall member, a lead passing through said wall member and insulated therefrom, an electrode member in said container, disposed generally parallel to said bottom wall member, and supported on said lead in spaced relation with respect to said bottom wall member to function as an anode, a glass window, disposed generally parallel to said bottom wall member, sealing said container, a very thin translucent film of silver on the inner surface of said window, the inner surface of said film being treated and coated to form a photosensitive surface functioning as a cathode, and means connecting said surface to said container.

16. A radiant energy device comprising a container having a main enclosure portion, a cylindrical extension of different diameter from said

main portion, providing an annular shoulder adjacent the junction between said main and extension portions, a lead passing through one wall of said container and insulated therefrom, an electrode member in said container and supported on said lead, and a glass element sealing said container and seated on said shoulder.

NORMAN C. FULMER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,881,521	Gstyr et al.	Oct. 11, 1932
1,885,819	Geffcken et al.	Nov. 1, 1932
1,900,577	Moore	Mar. 7, 1933
2,029,414	De Boer et al.	Feb. 4, 1936
2,306,376	Beuchon	Dec. 29, 1942
2,444,915	Cade	July 13, 1948