Jan. 14, 1947. M. S. GLASS ET AL 2,414,099

SPACE DISCHARGE DEVICE

Filed April 2, 1942

FIG. 1

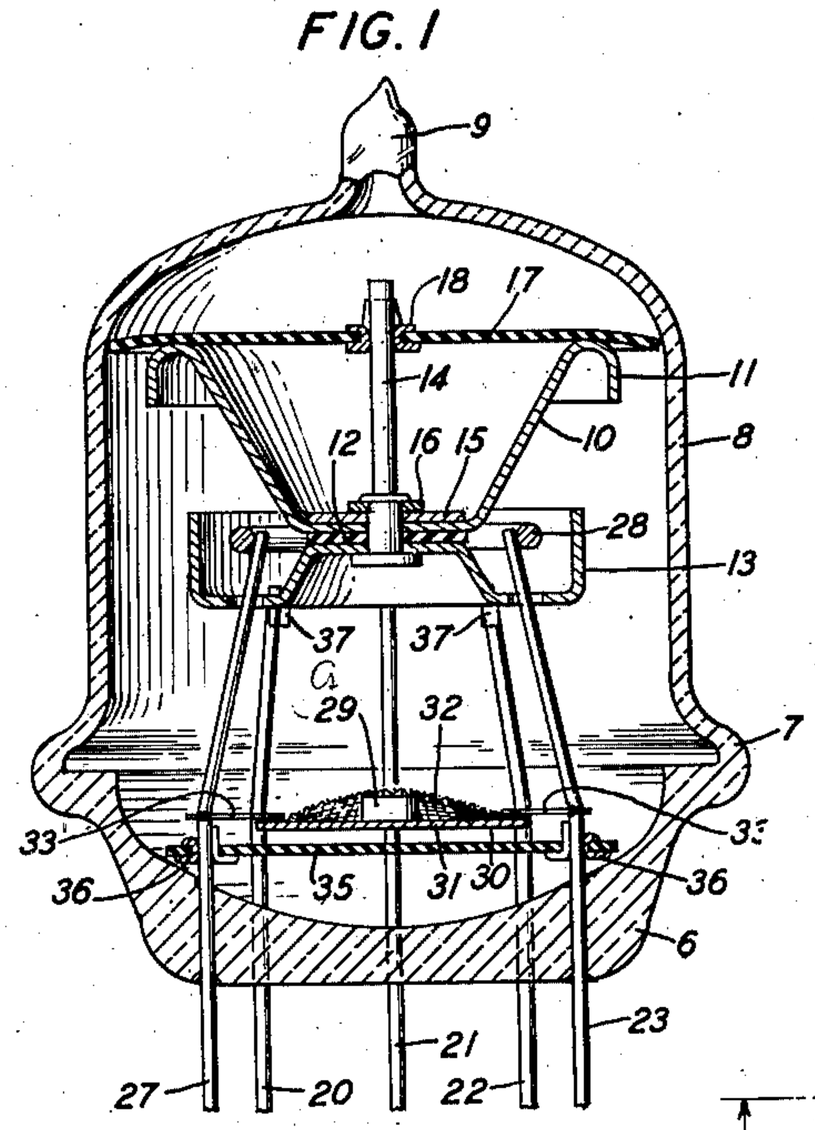


FIG. 3

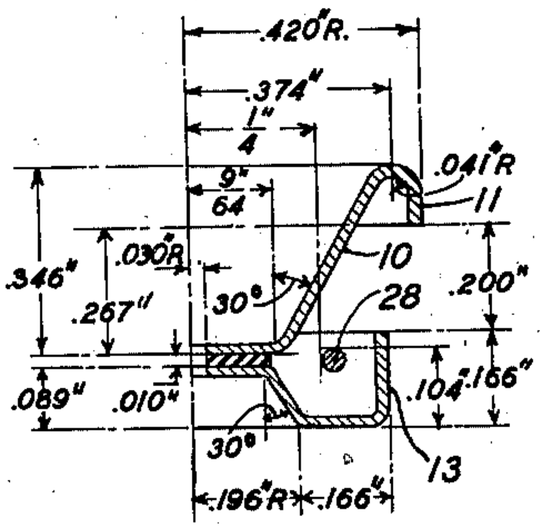
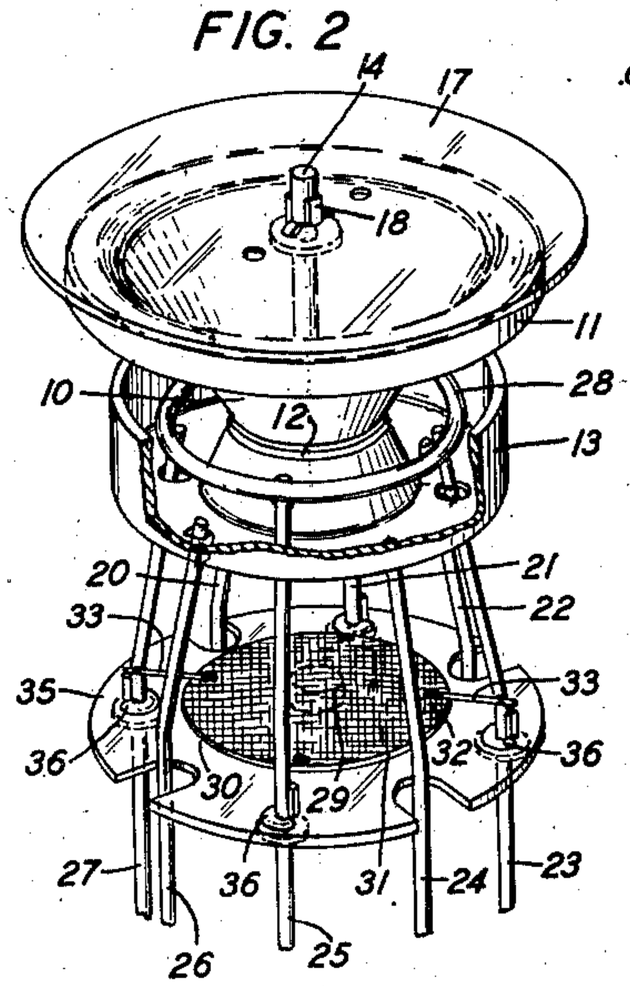


FIG. 2



INVENTORS: M. S. GLASS
V. L. RONCI
E. J. WALSH

BY Stanley B. Kent

ATTORNEY

Patented Jan. 14, 1947 2,414,099

UNITED STATES PATENT OFFICE

2,414,099

SPACE DISCHARGE DEVICE

Myron S. Glass, West Orange, N. J., Victor L. Ronci, Brooklyn, N. Y., and Edward J. Walsh, Jersey City, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 2, 1942, Serial No. 437,392

18 Claims. (Cl. 250—165)

1

This invention relates to space discharge devices and more particularly to photoelectric tubes.

An object of the invention is to provide an improved space discharge device, an example of which is a photoelectric tube.

A feature of the invention is a photoelectric tube having a cathode, an anode and a metallic shield in cooperative relationship with the cathode to focus upon the anode electrons emitted from the cathode.

Other features of the invention will appear from the description which follows.

In an example of practice illustrative of the invention, a compact photoelectric tube having a conical cathode and surrounding ring anode is provided with an electron focussing shield to direct the emitted electrons to the anode thus preventing the accumulation of electron charges on the glass walls of the container and other insulating members within the container. The cathode and shield are conductively connected by a metallic rivet but are separated by a mica washer to minimize the heat transfer therebetween during the flashing of the caesium pellet. The cathode is supported through the intermediary of the shield from four lead-in wires circularly arranged and sealed in a dished stem, while the anode is supported from four other lead-in wires also sealed in the stem and located on the same circle as the cathode support wires but respectively midway therebetween. The caesium pellet holder is supported from two of the anode support wires close to the stem but separated therefrom by a heat protective mica disc. This device constitutes a highly efficient, compact photoelectric tube which is remarkably free during operation from noise due to vibration, accumulated electronic charges or other causes.

This invention will now be described in more detail, having reference to the accompanying drawing.

Fig. 1 is a longitudinal section of one embodiment of the invention in a photoelectric tube.

Fig. 2 is a perspective showing the relative location of the elements within the container of Fig. 1.

Fig. 3 shows the dimensions used in an embodiment of the invention.

Like reference characters are used to refer to identical elements in the several figures.

The embodiment of the invention illustrated in Figs. 1 and 2 is a photoelectric tube comprising a generally cylindrical container formed in two parts. A molded dished stem 6 below the glass ring seal 7 carrying the electrode assembly constitutes one part, and the cylindrical portion 8

2

above the ring seal 7 with the exhaust tabulation 9 constitutes the other part. This container in a practical tube embodying this invention is approximately 1⅛ inches in diameter and 1⅝ inches long.

The cathode 10 is formed advantageously from substantially pure silver in the shape of a hollow truncated cone, the large end of the cone being spun-over to form a focussing and shielding rim 11. The conical surface of the cathode 10 in the completed tube is treated to make it photoelectrically sensitive. The small end of the cathode 10 is turned in to fit against one surface of a mica washer 12, the other surface of which fits against an annular metallic shield 13. The cathode 10, washer 12 and shield 13 are held together by a long shank rivet 14, nickel washer 15 and a nickel clamping washer 16. The washer 16 is forced over a bevelled section of the shank of rivet 14 thereby providing a tight fit and a portion of the bevelled section is sheared down and forced over the washer 16 by the riveting tool. A mica disc 17, provided with a center eyelet 18, rests on the spun-over end of cathode 10, the shank of rivet 14 passing through the eyelet 18 and being welded thereto. The shield 13 is supported on four lead-in conductors 20, 22, 24 and 26 which are sealed through the dished stem 6 at positions equally spaced on a circle centered at the center of the stem.

The anode 28 is a nickel ring of circular cross section supported on four lead-in conductors 21, 23, 25 and 27 also sealed through the dished stem 6 at positions on the same circle as conductors 20, 22, 24 and 26 and midway between those conductors, respectively. The anode 28 is so positioned with respect to the cathode 10, shielding rim 11 and shield 13 that the electrons emitted from the surface of the cathode 10 are focussed on the anode 28 and prevented from accumulating on the glass walls of the container 8 and other insulating surfaces to cause noise during the operation of the tube. The shape of the cathode 10 and shield 13 is such as to facilitate focussing. The shape shown in the drawing is particularly effective.

Caesium for sensitizing the cathode is preferably produced by chemical reaction of a mixture of ingredients in the form of a so-called caesium pellet 29. This pellet is mounted in a holder 30 comprising a nickel disc 31 and a nickel gauze disc 32 welded together at four equally spaced positions around the periphery of the discs, two of these welds at diametrically opposed positions including support wires 33. The gauze disc 32 is

resilient and when welded to the disc 31 holds the pellet 29 firmly against the disc 31. Support wires 33 are welded respectively to the anode support wires 23 and 27 transversely to the axis of the tube and a small distance from the dished stem. When the chemical reaction of the caesium pellet takes place during the process of sensitizing the cathode 10, a large amount of heat is generated. In order to keep the length of the container as small as possible the pellet holder is located very close to the dished stem. In fact, it is placed so close that the stem would be injured if means were not provided to prevent such injury. For this purpose, another mica disc 35 is positioned intermediate the nickel disc 31 of the pellet holder 30 and the stem 6. This mica disc 35 is supported from the anode support wires 21, 23, 25 and 27 through the intermediary of eyelets 36 through which the support wires are passed and to which they are welded. The cathode support wires 20, 22, 24 and 26 pass through notches in the edge of disc 35 and do not touch the disc.

The several elements of the illustrated photoelectric tube are assembled as follows:

The dished stem 6 with the eight lead-in wires 20 to 27, inclusive, is placed in a suitable jig. The mica disc 35 with the assembled eyelets 36 is positioned with the wires 21, 23, 25 and 27 passing through the eyelets, respectively. The eyelets are then welded to the support wires. Pellet holder 30 is then secured above and close to the mica disc 35 by welding support wires 33 to lead-in wires 23 and 27, respectively. Next, the shield 13 is slipped over all of the upstanding lead-in wires 20 to 27, inclusive, to a position somewhat below its final position, sufficiently low to expose the upper ends of anode support wires 21, 23, 25 and 27. The support wires 20, 22, 24 and 26 pass through holes in the shield 13 which holes have dependent metal tabs formed of the metal punched downward to form the holes. The anode support wires pass through other holes in the shield 13 provided for that purpose. By means of a jig the anode 28 is then welded to its support wires 21, 23, 25 and 27 at the proper distance from the stem 6 and concentric with the axis of the stem 6. The shield 13 is then raised to its proper location with respect to the anode 28 and held by means of a jig while the tabs 37 are welded to the respective support wires 20, 22, 24 and 26. The shank of rivet 14 is inserted through the center aperture of shield 13 and mica washer 12, cathode 10, nickel washer 15 and nickel clamping washer 16 are assembled over the shank of rivet 14 in the order named. Pressure is then applied between the head of rivet 14 and washer 16 by suitable tools to force this washer over a bevelled section of the shank 14 and shear down a portion of the bevelled section which is forced over the washer 16 to firmly secure all of these elements together. Mica disc 17 with its eyelet 18 is then mounted on the rim 11 of cathode 10 with the shank of rivet 14 passing through the eyelet 18 to which eyelet the shank is welded. The cylindrical portion 8 of the glass container is then placed over the disc 17 in the sealing machine and sealed to the dished stem 6 at the ring seal 7 so that the disc 17 is in pressure contact at its periphery with the inside of the portion 8. The exhaust tubulation 9 has not yet been sealed. The assembled tube is now ready for sensitization.

This structure is compact, relatively simple and particularly rigid so that jolts and jars cause practically no relative movement between the cathode and anode. Thus noise due to vibration in the completed tube is minimized. Furthermore, this tube is not injured by exceedingly rough handling.

The cathode may be sensitized in any well-known manner after the tube structure has been fabricated. A preferred method is very similar to that described in Patent 2,178,227, of M. S. Glass, patented October 31, 1939. The method therein described is modified to take into account the difference in sizes of the cathodes, the fact that in the photoelectric tube illustrated the caesium pellet holder and the conical cathode 10 are coaxial and the additional fact, that the cathode 10 and shield 13 are concentric and both composed of metal.

Briefly described, the preferred method of sensitizing the cathode is as follows:

The tube is baked in an oven at about 400° C. to remove occluded gas from the bulb but this heating does not cause any chemical reaction in the caesium pellet. Oxygen is admitted into the container and the cathode is subjected to ionic bombardment in such a way as to produce a heavy layer of silver oxide on the convex surface of the conical cathode 10. The residual oxygen is then pumped out and the cathode inductively heated by means of a high frequency coil surrounding the container to reduce the heavy layer of silver oxide. The cycle of oxidation and reduction is repeated. This treatment leaves the convex surface of the cathode clean and slightly rough so that it has a uniform matte surface. The surface of the nickel shield 13 remains unchanged. A fresh charge of oxygen is admitted and by a succession of discharges of fixed amount of electricity from condensers the convex surface of the cathode is oxidized to an amount depending upon the amount of caesium to be introduced. The mica disc 17 functions to prevent discharges to the inner surface of the cone 10 and thus facilitates the oxidation of the convex surface thereof. The caesium pellet is then inductively heated to effect a chemical reaction which produces caesium vapor. This is commonly called flashing the caesium. The high frequency coil used for inductively heating the caesium pellet holder 30 is positioned around the stem 6 with the upper end of the coil at approximately the level of the holder 30. In order to protect the cathode 10 from induced currents, a short-circuiting turn in the form of a short length of copper tubing is placed around the cylindrical portion 8 of the container with the lower end at the level of the shield 13. A certain amount of heating of the shield 13 takes place nevertheless but such heating is prevented from injuring the cathode 10 by the mica disc 12 which greatly reduces the conduction of heat from the shield 13 to the cathode 10. Caesium vapor produced by the chemical reaction condenses primarily on the inner walls of the glass container and is prevented from directly striking the oxidized surface of the silver cathode 10 by the shield 13. The shield 13 is of such diameter that an annular space is provided between the periphery of the shield and the glass bulb for the uniform migration of the caesium to the cathode surface. The mica disc 17 also prevents the passage of any appreciable amount of caesium vapor into the upper end of the container. The container is then heated in a stream of hot air to a temperature of about 225° C. until the cathode has reached the desired sensitivity. Argon or other suitable gases may be admitted at low pressure to obtain

the benefits of gas amplification. Another method of sensitization may be used in which argon is admitted immediately after flashing the caesium and the tube sealed off. A subsequent heat treatment, dissociated from the pump station, completes the sensitization.

Other materials may be used for the cathode and further modified treating methods may be employed. The cathode may consist of copper, the convex surface being silver-plated. The cathode may also consist of bimetallic sheet metal of nickel and silver so formed that the silver forms the outer convex surface of the cathode 10. The cathode 10 because of its form may be outgassed by inductive heating. The heavy layer of silver oxide formed during the roughening of the cathode 10 might be reduced by ionic bombardment but reduction by inductive heating is preferred in the embodiment hereinbefore described to prevent sputtering of silver on the inner surfaces of the bulb and nickel shield 13. Other materials and modified methods are described in the Glass Patent 2,178,227 noted hereinbefore. Suitable ingredients of the caesium pellet are those disclosed in that Glass patent, namely, caesium chromate, chromic oxide and powdered aluminum. These ingredients are carefully prepared, finely pulverized and thoroughly mixed in proper proportions before being formed into pellets. The electrode structure may be supported in any other convenient manner to effect rigidity, shielding and focussing.

A great advantage of the specifically described tube is that practically no insulating surfaces are exposed to electrons produced during the operation of the tube. Most such surfaces are directly shielded by the rim 11 and the shield 13 while the exposed section of glass wall in front of the cathode 10 is protected by the focussing action of the cathode 10 including the rim 11 and the focussing shield 13.

In order to facilitate the practicing of this invention physical dimensions of the cathode, anode and focussing shield of one embodiment of the invention are given in Fig. 3. The silver sheet of which the cathode 10 and rim 11 is made, is .005 inch thick. The nickel sheet of which the focussing shield 13 is made, is .010 inch thick. The anode is made of nickel wire .030 inch in diameter, and the anode ring is one-half inch inside diameter and located coaxially with aspect to the cathode 10 and shield 13. It is to be understood, however, that these dimensions are merely illustrative and that other structures may be used which also embody the invention as defined in the appended claims.

What is claimed is:

1. A photoelectric tube comprising a container, a photoelectric cathode in the form of a truncated cone and within said container having an electron emitting surface adapted to receive light from all directions in a plane transverse to said cathode, an anode in said container in the form of a metallic ring surrounding said cathode near the smaller end thereof and transverse to the axis of said cathode, and additional electron focussing means in said container for focussing electrons emitted from said cathode on said anode, said additional focussing means having the form of a cup open toward said electron emitting surface and located with said anode within the cup near the rim of said cup but out of contact with the cup.

2. A photoelectric tube comprising a container, a photoelectric cathode in said container having an electron emitting surface in the form of a surface of revolution, said surface being convex in planes normal to the axis of and intersecting said surface, an annular shaped anode in said container surrounding said axis and symmetrically positioned with respect to a transverse elemental section of said electron emitting surface, and means in said container including said cathode and additional focussing means outside of said electron emitting surface and concentric therewith for focussing electrons emitted from said cathode on said anode.

3. A photoelectric tube comprising a container, a conical photoelectric cathode in said container, an anode in said container surrounding said cathode, and an annular metallic shield in said container conductively conected to said cathode to focus electrons emitted from said cathode on said anode.

4. A photoelectric tube comprising a hollow conical photoelectric cathode, an anode surrounding said cathode, and a mica disc in contact with and closing the large end of said cathode.

5. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a cup-shaped metallic shield supported by certain of said wires in a position transverse of said container, a photoelectric cathode in the shape of a truncated cone supported at its small end on said metallic shield and having its large end closely adjacent the end of the container away from the sealed wires, and an anode supported by other of said support wires.

6. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a metallic cup-shaped shield supported from certain of said wires in a position transverse of said container, a photoelectric cathode in the shape of a truncated cone supported on its small end on said shield and having its large end closely adjacent to the end of the container away from the sealed wires, an anode supported by other of said support wires, and a caesium pellet holder also supported from said anode wires on the side of the shield opposite from said cathode with the emitting surface of said holder toward said shield, said holder having held a mixture which gave caesium vapor when heated.

7. An electron discharge device comprising an evacuated container, a cathode at one end of said container, an anode adjacent to said cathode, a support for cathode sensitizing material at the other end of said container, a metallic focussing- and heat-resisting shield supported intermediate said cathode and said support, and a second heat-resisting shield intermediate the said support and the adjacent end of the evacuated container.

8. A photoelectric tube comprising an evacuated container, a photoelectric cathode at one end of said container, an anode adjacent to said cathode, a support for light-sensitizing material at the other end of said container, a metallic heat-resisting and focussing shield supported intermediate said cathode and said support, a second heat-resisting shield intermediate the said support and the adjacent end of the evacuated container, and an exhaust tubulation connected to said container at the end adjacent to said cathode.

9. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a metallic focussing shield supported from certain of said wires in a position transverse of said container, a photocathode in the shape of

a truncated cone supported at its small end on said shield and having its large end closely adjacent to the end of the container away from the sealed wires, an anode supported by other of said support wires, a pellet holder supported from said anode support wires on the side of the shield opposite from said cathode with the emitting surface of said holder turned toward said shield, said holder having held a mixture which gave caesium vapor when heated, and a mica disc support between the said pellet holder and the adjacent end of the container but out of contact with both.

10. A photoelectric cathode assembly comprising a truncated cone of sheet metal, the convex surface of which is silver for serving as photoelectric cathode support, a metallic shield approximately as large as the base of said cone, a rivet securing the small end of the said cone to the center of said shield, a glass stem, a plurality of wires sealed in said stem, and means supporting said shield from a plurality of said wires.

11. A photoelectric electrode assembly comprising a truncated cone of sheet metal, the convex surface of which is silver for serving as cathode support, a metallic focussing shield approximately as large as the base of said cone, conductive means securing the small end of said cone to the center of said shield, a glass stem, a plurality of wires sealed in said stem, means supporting said shield from some of said plurality of wires, a holder positioned on the side of said shield opposite to said cone and supported by wires secured to others of said plurality of wires, said holder containing a reactive mixture for giving light-sensitive material.

12. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a metallic shield supported from certain of said wires in a position transverse of said container, a photocathode in the shape of a truncated cone supported at its small end on said shield and having its large end closely adjacent to the end of the container away from the sealed wires, an anode supported by others of said support wires and a metallic holder supported from said anode support wires on the side of the shield opposite from said cathode with the opening of the holder toward said shield, said holder holding a mixture for giving caesium vapor when heated.

13. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a metallic electron focussing shield supported from certain of said wires in a position transverse of said container, a photocathode in the shape of a truncated cone supported at its small end on said focussing shield and having its large end closely adjacent to the end of the container away from the sealed wires, an anode supported by other of said support wires, a metallic disc also supported from said anode support wires on the side of said shield opposite from said cathode and parallel to said shield, an elastic wire gauze disc overlying said metallic disc on the side toward said shield welded at a plurality of points near the edges of said over-lying discs, and a pellet of a mixture which produces light-sensitive material in the form of vapor when heated pressed between said over-lying discs.

14. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a cup-shaped metallic shield supported by certain of said wires in a position transverse of said container, a photoelectric cathode in the shape of a truncated cone supported at its small end on said metallic shield, and an anode supported by other of said support wires.

15. A photoelectric cathode assembly comprising a truncated cone of sheet metal, the convex surface of which serves as photoelectric cathode support, a metallic shield approximately as large as the base of said cone, metallic means securing the small end of said cone to the center of said shield, a glass stem, a plurality of wires sealed in said stem, and means supporting said shield from a plurality of said wires.

16. A photoelectric cathode assembly comprising a truncated cone of sheet metal, the convex surface of which serves as photoelectric cathode support and the large end of which is turned over outwardly forming a focussing rim, a cup-shaped metallic focussing shield approximately as large as the base of said cone, metallic means securing the small end of said cone to the center of said shield, an insulating disc covering the large end of said cone in substantially fixed relationship thereto and extending beyond the turned over rim, a glass stem, a plurality of wires sealed in said stem, and means supporting said shield from a plurality of said wires.

17. A photoelectric tube comprising a glass container, a plurality of support wires sealed through a restricted portion of said container, a cup-shaped metallic shield supported by certain of said wires transverse of said restricted portion of said container, a photoelectric cathode in the shape of a truncated cone supported at its small end on the inside surface of the bottom of said metallic shield, a shielding and focussing rim secured to the large end of said cone, an insulating disc covering the large end of said cone in substantially fixed relationship thereto and extending beyond the turned over rim, the periphery of said disc pressing against the inside of said container, and an anode in cooperative relationship with said cathode supported by other of said support wires.

18. A photoelectric tube comprising a glass container of generally cylindrical shape, a plurality of support wires sealed through one end of said container, a cup-shaped metallic shield supported by certain of said wires in a position transverse of said container with the bottom of the cup-shaped shield facing the wire seals, a photoelectric cathode in the shape of a truncated cone supported at its small end on the inside bottom surface of said cup-shaped shield, and an anode surrounding said cone coaxially therewith and located within the cup-shaped shield.

MYRON S. GLASS.
VICTOR L. RONCI.
EDWARD J. WALSH.