

April 24, 1945.

D. E. HENRY

2,374,287

PHOTOELECTRIC DEVICE

Filed Nov. 19, 1941

2 Sheets-Sheet 1

Fig. 2.

Fig. 1.

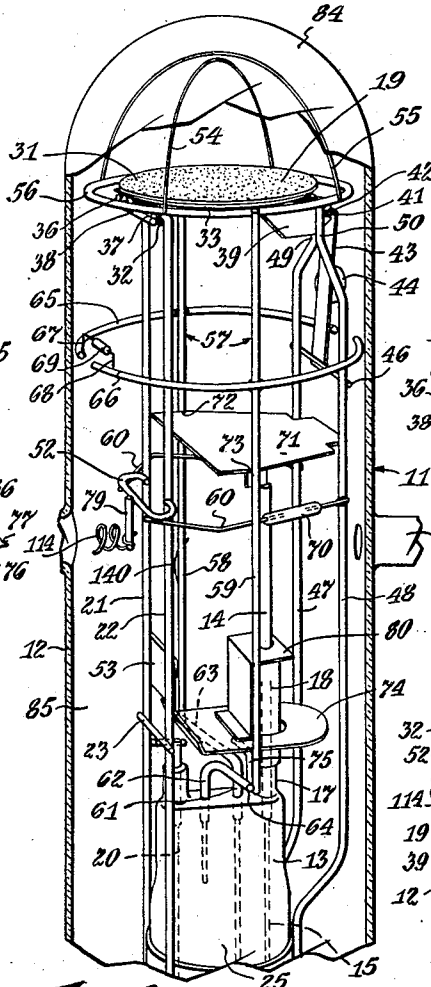
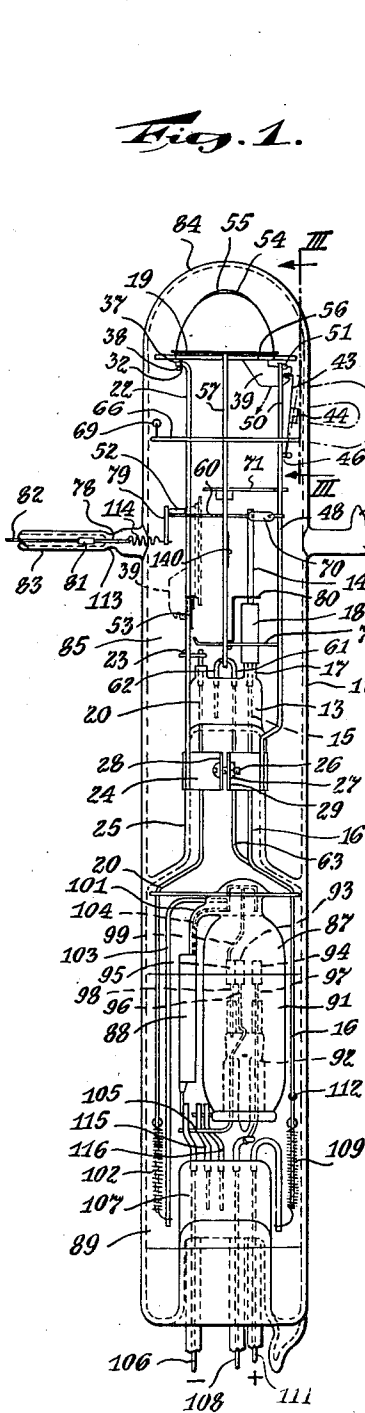


Fig. 4.

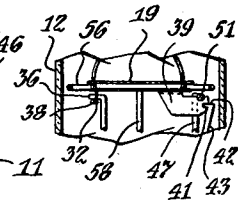


Fig. 5.

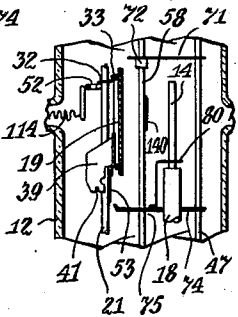
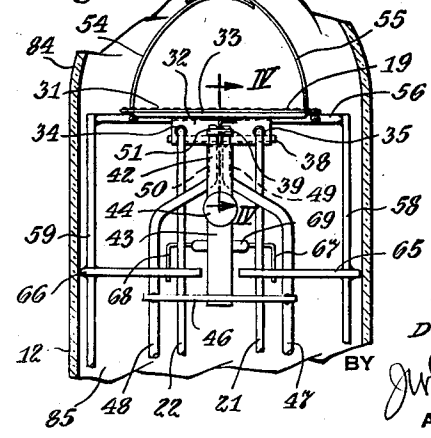


Fig. 3.



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2 Sheets-Sheet 2

Fig. 6.

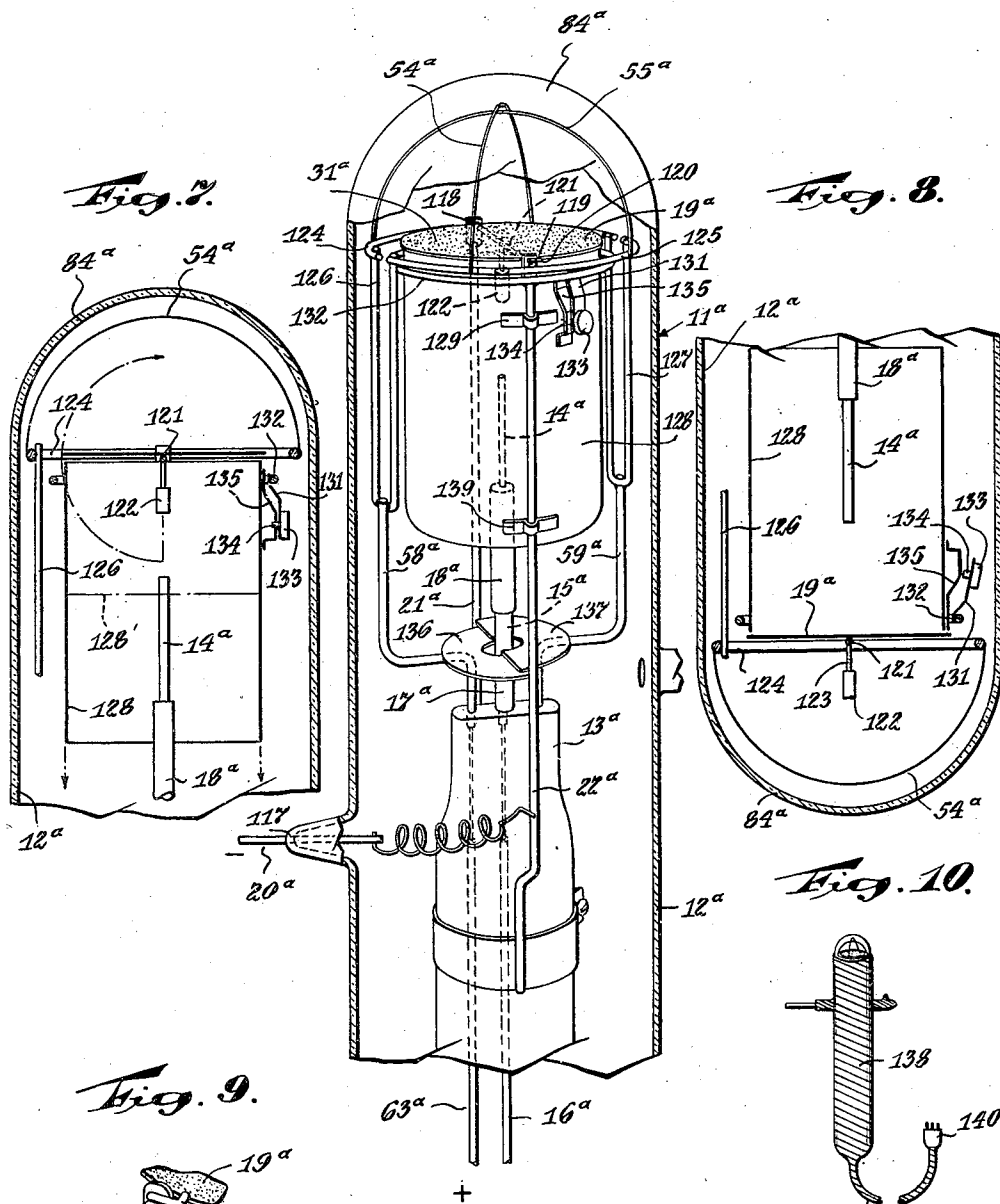


Fig. 7.

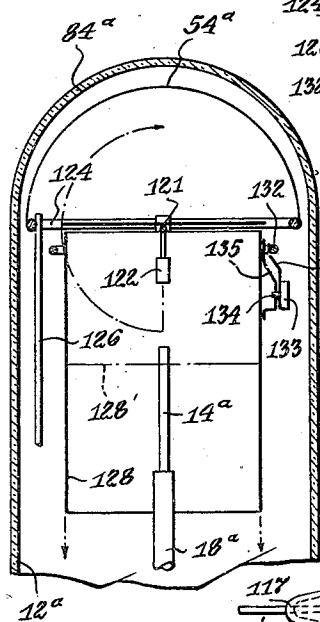


Fig. 8.

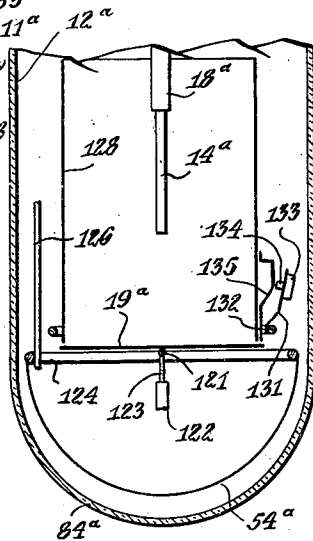


Fig. 10.

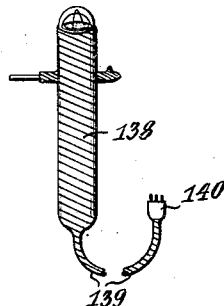
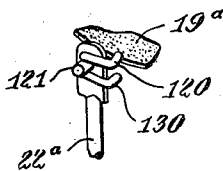


Fig. 9.



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2,374,287

PHOTOELECTRIC DEVICE

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Application November 19, 1941, Serial No. 419,667

16 Claims. (Cl. 250—165)

This invention relates to photo-electric devices and, more particularly, to such adapted to record radiations from all directions above the cathode plane.

The principal object of my invention, generally considered, is to provide a photo-electric tube with a light-sensitive cathode in the form of a flat plate, said cathode being sensitizable from an electrode normally disposed inwardly thereof when swung to inoperative position, and means for swinging the same after sensitization so as to face outwardly and co-operate with an operating anode.

Another object of my invention is the provision of a photo-electric tube having a flat cathode adapted to swing parallel to an electrode in the form of a wire or rod of metal for sensitizing the surface of said cathode, and then swing outwardly for co-operation with another electrode.

A further object of my invention is the provision of a photo-electric tube consisting of a sensitized cathode having a flat surface, and means for localizing the sensitizing film on the cathode lead portions which are disposed relatively remote from the radiation to be measured.

A still further object of my invention is the provision of a photo-electric tube with a hinged cathode, whereby said cathode may be sensitized when in one position and then moved to operative position by tipping the bulb, with means for locking said cathode in operative position.

An additional object of my invention is the provision of a photo-electric tube with a hinged cathode which is movable from one position to another, whereby it may be activated in one position by sputtering from an inwardly disposed electrode formed of a material to be used as the sensitizing agent and then moved to operative position for co-operation with an operating anode.

Another object of my invention is the provision of a photo-electric tube having a cathode in the form of a flat plate movable from sensitizing to operating positions, a shield carried in the enclosing envelope to protect the cathode leads adjacent the operative position of the cathode, and another shield for shading the supporting press to protect the leads from short-circuits.

Other objects and advantages of the invention, relating to the particular arrangement and construction of various parts, will become apparent as the description proceeds.

Referring to the drawings:

Figure 1 is an elevational view of a photo-electric tube embodying my invention.

Figure 2 is a perspective view of the upper portion of the tube shown in Figure 1 with portions broken away.

Figure 3 is an enlarged sectional view of the upper portion of the tube on the line III—III of Figure 1, in the direction of the arrows.

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

Figure 5 is a fragmentary view showing a portion of the tube illustrated in Figure 1, but with the light sensitive cathode in position to be activated.

Figure 6 is a perspective view corresponding to Figure 2, but showing a modification.

Figure 7 is an axial sectional view of the upper portion of the tube shown in Figure 6, with the cathode in operative position.

Figure 8 is a view corresponding to Figure 7, but showing the cathode reversed with respect to the tube and the whole device transposed into position to be activated or sensitized.

Figure 9 is an enlarged perspective view of the cathode "stop" arrangement.

Figure 10 is a small scale view showing one of my phototubes finished by application of an extension cord and protective tape.

The cathode of a phototube, for recording radiations from all directions above its plane, should not be obstructed in any way, as by a shield, base, or vaporized or sputtered material, which would interfere with radiation falling on the sensitized surface. For long continued measurements such a tube should be very stable.

In accordance with my invention I have provided a phototube in which a metal plate to form the cathode thereof is arranged to face, and preferably hang parallel to, the rod or wire of sensitive material to be sputtered thereon during the sensitizing operation, at the same time making it possible to localize the deposit on the cathode leads toward the lower part of the tube, or relatively remote from the operative position of the cathode. This type of construction also lends itself better to the sensitizing of the cathode by vaporizing material from an oxide-coated filament or electrode, in which process the sensitivity must be tested frequently by shining a light on the cathode after or during the depositing.

Referring now to the drawings in detail, and first considering the embodiment of my invention illustrated in Figures 1 to 5, inclusive, there is shown a phototube 11 provided with an envelope 12 desirably composed of a material such as Corning No. 974, high transmission ultra-violet glass, if the tube is to measure ultra-violet radia-

tions. If the tube is to measure other than ultra-violet radiations, it is, of course, formed of material pervious to the type of radiations to be measured. Other materials suitable for the transmission of ultra-violet radiations are quartz, high silica glass, Corning No. 791 and Corex glass. For measuring the radiations in the bactericidal range, Corning No. 972 glass is particularly appropriate and the tube of the present embodiment is especially adapted for that purpose.

Within the main or upper portion of the envelope 12 is provided a press 13 on which is mounted a rod-shaped electrode 14. This electrode may be composed of titanium, if the tube is to be used like that of the Rentschler Patent #1,955,608 of April 17, 1934, for the measurement of ultra-violet radiations between about 2500 and 3200 Angstrom units, or for the measurement of such in sunlight between 3200 A. U. and the atmospheric cut-off. If, however, the tube is to be used for the measurement of bactericidal radiations, or those having wave lengths of 3000 Angstrom units and shorter, then I preferably employ tantalum as the material forming the electrode 14. The electrode 14, which is used to supply the photo-sensitive material is, therefore, subject to change in accordance with the type of radiations to be measured. Thus it may be formed of zirconium, vanadium, tungsten, uranium, or other photo-electric material, if the tube is to be used for measuring radiations of other wave lengths.

The electrode 14 is mounted upon a lead-in conductor 15 extending through the press 13 to an external conductor 16. The conductor 15 is desirably enclosed in a dielectric shield member 17 constructed of glass or similar material. The upper portion of the shield member 17, and the joint between the electrode 14 and the lead-in conductor 15 is also desirably enclosed in a shield member 18, preferably formed of lavite or similar insulating material fitting the member 17 and having an aperture in its upper end through which the electrode 14 extends, thereby restricting the active area of said electrode to the exposed end portion which for this reason is the only part of the electrode that need be formed of titanium or the photo-electric material selected.

The active portion of the cathode comprises a film of titanium or other photo-electric material. Such a film is desirably deposited upon an electrical conductor, preferably formed as a sheet of nickel 19 which is electrically connected to leading-in conductor 20 passing through the press 13, as illustrated.

A framework, consisting of two parallel longitudinally extending wires 21 and 22 and a bracing cross wire 23, is mounted above the press 13, as by means of a carrying collar 24, frictionally engaging the flare tube 25 on which the press 13 is formed, as by being clamped thereon by means of a bolt 26 and nut 27, the former of which passes through overlapping flanges 28 and 29 on said collar.

Movably supported on said framework, as by means of an angular plate 32, is a preferably circular flat nickel sheet 19 carrying a sensitive cathode surface 31. One flange of the plate 32 is secured to a circular reinforcing ring 33 on the plate 19 and the other flange is apertured as indicated at 34 and 35, to receive the wires 21 and 22, thereby providing a hinged connection therebetween. The upper or free ends of said wires are bent outwardly, as indicated at

36 and 37, and connected by bracing wire 38 also forming a stop for the hinge member 32 of the plate 19.

That portion of the reinforcing ring 33 remote from the angular plate 32 has secured thereto a keeper member comprising a plate 39 depending therefrom and having a notch 41 to receive the flanged or angular end portion 42 of a spring latch 43. To the latch is secured an iron armature 44, adapted for operation by an external magnet 45, shown dotted in Figure 1. The latch 43 is supported on a bracing wire 46, which extends between two longitudinally extending wires 47 and 48, desirably supported from the same carrying collar 24 as the wires 21 and 22. The upper or free end portions of said wires are bent toward one another and then extended generally parallel while disposed close together, thereby providing a guide for the keeper member 39, as indicated at 49 and 50. The ends of said wires are desirably connected by a stop wire, indicated at 51. The cathode plate 19 is, therefore, movable from the position shown in Figure 2, as upon release of the latch 43 by the magnet 45 shown in Figure 1, to swing and slide down the wires 21 and 22 until stopped by the bracing wire 52 and bracing plate 53, where it then hangs parallel to the electrode 14, with its normally outer surface facing towards said electrode for application of the sensitive surfacing 31. Bracing wires 60, including insulating beads 70, also desirably connect the wire 52 to the wires 47 and 48. The plate 53 also functions as a shield to prevent sensitizing the keeper 39.

The electrode to function as an anode for association with the cathode 19 is, in the present embodiment, formed as a pair of arc-shaped fine wires 54 and 55 with their ends supported from the upper circular member 56 of a wire frame 57 consisting of wires 58 and 59 respectively extending longitudinally from a lead 61 and a spud 62, projecting from the press 13 and with their upper ends bent outwardly, as indicated respectively at 63 and 64, and secured to the lower ends of the wires 58 and 59, respectively, portions of the wires 58 and 59 adjacent the ring 56 having curved wire sections 64 and 66, respectively, secured thereto. The adjacent ends of said wires 65 and 66, opposite to that where the latch member 43 is located, are desirably braced together as by means of short wires 67 and 68 welded thereto and projecting therefrom, with their adjacent ends imbedded in a glass connector 69.

The wires 58 and 59 also desirably serve to support a plate forming a shield 71 therebetween, as by means of welds 72 and 73 at the engaging points, whereby material being sputtered from the electrode 14 is prevented from getting on the cathode leads adjacent the normal position of the cathode as shown in Figure 2. A plate forming a shield 74, desirably carrying an angular shield 80, is desirably supported from the spud 62, as by means of connecting wire 75, thereby "shading" the press, preventing a short-circuiting deposit of sputtered material thereon, and preventing a possible contamination of the sputtered coating by the insulator 18.

In order to obtain the photo-sensitive surface 31 on the cathode plate 19, the electrode assembly is sealed in the envelope. The plate 19, if not already in the position shown in Figure 5, is allowed, with the latch 43 released by the magnet 45, as indicated in Figure 1, and the pho-

totube in the position illustrated in the figures, to slide from the position shown in Figures 1 to 4, inclusive, to where it lies parallel and close to the activating electrode 14, that is, from the full to the dotted line position of Figure 1. The whole is then baked out and exhausted in the usual manner heretofore employed to obtain high vacua, with the parts degasified by heat produced by high frequency induction, for example. A filling of a gaseous medium such as argon, neon or helium, preferably argon at a pressure of from 1 to 6 mm., is then introduced into the envelope in any desired manner, as through the exhaust tube 76. The envelope is then sealed off as indicated at 77. A glow discharge is then produced to effect positive ion bombardment of the electrode 14 from the electrode 19, with a sputtering or electrical vaporization of the material or titanium of the electrode 14 to the sheet 19 of nickel, until a uniform cathode surface having the proper spectral sensitivity is formed.

A direct current discharge is employed, with the rod 14 serving as a cathode and the sheet 19 of nickel as the anode for the discharge. In this instance the connection to the cathode may be effected by lead-in conductor 78 connecting with brace wire 52 by means of conductor 79. Temporary connection with this lead-in conductor is desirably effected in the present instance by having an internally threaded socket 81 in the outer end of said conductor 78 with which a correspondingly threaded current carrying lead 82 may be joined in the outstanding tube 83.

I find it preferable to continue the discharge for about twenty hours, the exact length of time depending upon conditions. The sputtered material, other than that deposited upon the sheet of nickel 19, mainly collects on the shields 71 and 74 and the glass of the envelope between the planes of said shields, as well as the leading-in conductor and brace wires in that neighborhood. The shield 74 so covers or "shades" the press 13 that clear glass areas are maintained between the lead-in conductors, thereby preventing short-circuits therebetween. On account of the remoteness from the spherical end portion 84 of the envelope 12, no deposit is produced which would tend to absorb the radiations to be measured.

After the cathode 19 has been coated with the sputtered sensitizing material, the envelope 12 is reversed, allowing the plate 19 to slide back to the ends of the wires 21 and 22 and swing to the position illustrated in Figures 2, 3 and 4, the latch 43 being moved outwardly and springing back into the locking notch 41, as shown in Figures 1 to 4, inclusive, thereby holding the now sensitized cathode 19 in operative position.

The main portion 85 of the envelope 12 may then be finally exhausted, without opening to the atmosphere, by a method formerly used. If argon was used as a gas filling, said main portion desirably had apparatus connected to it, like the tube 20 shown in Patent #2,167,777, dated August 1, 1939, and could be finally exhausted by means of activated charcoal in liquid air to make a vacuum phototube and finally tipped off as indicated at 86.

If desired, a relay tube 87 and condenser 88 may be housed in the neck or extension 89 of the envelope 12, as illustrated most clearly in Figure 1, in a manner as described and claimed in Patent #2,242,483, dated May 20, 1941. The relay tube 87 is desirably formed as described and claimed in Patent #2,079,362, dated May 4, 1937,

except that it is not necessary to base it. That is, the tube comprises an envelope 91 of glass or the like and three electrodes supported from the flare tube 92 thereof, the electrode 93 being desirably formed of thorium and functioning as a cathode, electrode 94 as a main anode and electrode 95 as a starting or auxiliary anode.

Although all of these electrodes are supported from the stem or press 92 as by means of support wires 96, 97 and 98, the starting anode 95 has its outside connection desirably made by means of lead-in conductor 99 extending from the end portion of the envelope 87 opposite to that to which the flare tube 92 is secured. Before sealing the relay tube 87 and the condenser 88 into the extension 89, both are desirably coated with insulating material 101, such as the sealing wax shown, in order to prevent surface leakage. As alternatives, the envelope 91 of the relay tube 87 may be painted with a light-absorbing coating or formed of red or green glass, which is sufficiently light-absorbing, as the thorium cathode is not photo-sensitive to wave lengths much longer than 3650 A. U., while the other parts from which the leads extend are coated with sealing wax or other insulating material.

The condenser and relay tube do not have to be covered with sealing wax if the leakage during calibration is negligible, as moisture due to sealing-in can be removed during the exhaust.

The connections between the electrodes 14, 19 and the anode wires 54 and 55 in the phototube compartment proper and the leads to the relay tube and condenser in the extension or auxiliary tube 89 are as shown in Figure 1. The cathode 19 is connected by means of lead-in conductor 20, coil spring 102 and lead 103 to the lead 104 which connects one pole of the condenser 88 to the lead-in conductor 99 from the starting anode 95. The other pole of the condenser is connected by means of lead 105 to cathode 93 and a lead 106 from said connection extends through flare or press 107 of extension 89 out of the envelope 12, forming one of the terminals of the combination photo-tube illustrated in Figure 1.

Another terminal of the tube connects with the main anode 94 of the relay tube 87 by means of lead 108 extending through the same press 107, while the third terminal connects with the anode wires 54 and 55 of the photo-electric tube proper through supporting wires 58 and 59, lead 63, coil spring 109 and lead 111 through the same press 107.

After the main portion 85 of the envelope 12 has been finally exhausted and before the relay tube 87 and condenser 88 are inserted, the leads 63 and 16 are connected together, as by welding at 112, so that the single lead 111 connects with both the activating electrode 14 and the anode wires 54 and 55. Such a connection is desirable to make it impossible for the electrode 14 to act as a photo-electric cathode, and permissible because said electrode is supposed to be inoperative and never used after the cathode 19 has been activated and disposed in the position shown in Figure 2. When the cathode 19 is being activated from the activating electrode 14 functioning as a cathode, the anode wires 54 and 55 are not energized.

It will thus be seen that the anode wires 54 and 55 of the radiation-responsive device disclosed are, when assembled for use, as diagrammatically shown in Figure 4 of Patent #2,242,483, referred to, connected through lead 111, and that designated 62 in said figure, to the positive terminal

of a source of potential; for example, a battery of cells there designated 63. The negative terminal of said source of potential is connected by means of a lead, there designated 60, to one side of condenser 88 through lead 106, while the other side is connected to the cathode 19 by means of leads 104, 103 and 20, as well as the starting anode 95 of the relay tube by means of leads 104 and 99. The cathode 93 of the glow relay tube 87 is also connected to said negative pole of the battery by means of conductors 105, 106, and lead designated 60 in said patent, thereby completing the input circuit to said relay tube 87 in accordance with Patent #2,037,925, previously referred to.

The output circuit of the system is also shown in Figure 4 of Patent #2,242,483, previously referred to, and comprises a fixed or variable resistance, there designated 64, of appropriate value, having one end thereof connected to the positive terminal of one of the cells of the battery, there designated 63, and the other end of which is connected to one terminal of a recording device, there designated 65, and one pole of a condenser, there designated 66. The other pole of the condenser is connected to the negative pole of the battery, one pole of the other condenser 88 and the cathode 93 of the relay tube. The other terminal of the recording device is connected to the anode 94 of the relay tube 87, as by means of lead-in conductor, designated in Figure 4 of said patent by the reference character 59, through lead 108.

From the foregoing disclosure it will be seen that all the parts of the input circuit shown in the diagram of said Figure 4, except the energizing battery, are enclosed in the extended evacuated envelope portion 89, and thereby kept moisture-free and protected from leakage. The operation of the device for measuring radiations is as described and claimed in the Rentschler Patent #2,037,925, previously referred to except that, by virtue of enclosing the parts of the input circuit for protection against leakage due to moisture, the accuracy of the measurement is greatly increased.

It will be seen that the main difference in the photo-electric portion of the combined device is that the lead 20 from the cathode 19 goes through the stem or lower part of the envelope portion 85, rather than through the upper portion. In order, however, to test the photo-electric portion of the device separately from the associated condenser 88 and relay tube 87, after the parts are assembled as a unit, I desirably also provide a lead 78 extending through the side of the envelope portion 85, and having a screw-threaded socket 81, for making a temporary connection therewith by means of the wire 82 having a screw-threaded inner end portion. That portion of the lead 78 between the seal 113 and the connecting wire 79 is desirably a coil of soft wire 114 to prevent strain in said seal and allow the lead 78 to be properly positioned when sealing-in. After testing the photo-electric portion, the lead 82 may be unscrewed and the tubular extension 83 closed off, as by sealing the end in a flame, to prevent surface leakage.

In manufacturing a combined meter device, such as heretofore disclosed, the photo-electric tube portion 85 is exhausted, the argon admitted, the electrode 14 sputtered to provide the sensitive cathode surface, and the envelope re-exhausted, as previously described. The tube is then tested for the spectral position of the energy cutoff,

after which it may be exposed to radiations from a suitable source with the lead 20 connected to the top of the relay tube 87 in a regular meter circuit and the lead 63 connected to the positive side of a battery. Arrangements should be made so that the condenser 88 between the top of the relay tube 87 and the negative side of the battery can be changed at will, until one is found of such capacity that the energy unit indicating clicks of the recorder, designated 65 in Figure 4 of Patent #2,242,483, previously referred to, come at the desired intervals.

When a condenser having the proper capacity is found, it and the relay tube are mounted on the flare 107, as shown in Figure 1. Springs 102 and 109 are welded to the leads 20 and 16-63, respectively, coming from the photo-electric portion, in such a manner that the ends can be pulled past the end of the extended envelope portion 89. The relay tube 87 and condenser 88, mounted on the flare 107, using supporting spuds 115 and 116 for the relay tube 87, are pushed up into the portion 39, but the flare held far enough out so that the springs 102 and 109 can be pulled down and respectively welded to the leads 103 and 111.

Positions in making the foregoing assembly are illustrated in Figures 5 and 6 of the Patent #2,242,483, which is again referred to for a complete description of the manner of assembly.

Referring now to the embodiment of my invention illustrated in Figures 6, 7, 8 and 9, there is shown a phototube 11^a provided with an envelope 12^a, desirably composed of material like the envelope 12 of the preceding embodiment. Within the main or upper portion of the envelope 12^a, if a combined device is being made, I provide a press 13^a on which is mounted a rod-shaped electrode 14^a, composed of material like the electrode 14 of the preceding embodiment. Said electrode is mounted upon a lead-in conductor 15^a extending through the press 13^a to an external conductor 16^a. The conductor 15^a is desirably enclosed in a dielectric shield member 17^a, as in the preceding embodiment. The upper portion of the shield member and the joint between the electrode 14^a and the lead-in conductor 15^a are also desirably enclosed in a shield member 18^a, preferably formed of lavite or similar insulating material, as in the preceding embodiment.

The active portion of the cathode 19^a comprises a film of titanium or other photo-sensitive material, as in the preceding embodiment. Such a film is desirably deposited upon an electrical conductor preferably formed of a sheet of nickel 19^a, which is electrically connected to leading-in conductor 20^a, passing through a seal 117 in the side of the envelope 12^a, through supporting wires 21^a and 22^a, the upper ends of which are apertured, as indicated at 118 and 119, to receive a pivot wire or axle 121 secured to the cathode plate 19^a and having a counterweight 122 secured thereto as by means of a wire connector 123, the ends of which are respectively welded to said counterweight and axle. One end of the axle 121 desirably has angular lugs 120 and 130 welded thereto, as shown in Figure 9, to facilitate positioning the parts by preventing more than 180° of rotation. This manner of supporting the cathode plate 19^a makes it possible to reverse its position by reversing the position of the envelope 12^a, as the counterweight 122 is heavy enough to overbalance the plate 19^a. The plate is shown locked in its operative position in Figures 6 and 7

and unlocked in position to be activated in Figure 8.

The electrode to function as an anode for association with the cathode 19^a is, in the present embodiment, formed as a pair of arc-shaped fine wires 54^a and 55^a with their ends supported from the upper arc-shaped members 124 and 125 which, in turn, have their adjacent ends supported respectively on U-shaped longitudinally extending wire members 126 and 127, which function as resistance in circuit with the members 124 and 125 and prevent overheating during treatment, the lower or uniting portions of which project from support wires 58^a and 59^a extending from the press 13^a, and at least one connecting with lead 63^a extending through said press.

In order to protect the light-transmitting semispherical end portion 84^a of the envelope from an obscuring deposit during activation of the cathode, by sputtering from the electrode 14^a as described in connection with the preceding embodiment, for example, a generally cylindrical shield 128 is provided having metal loops 129 and 139 on the sides thereof, allowing it to slide along the support wires 21^a and 22^a from the position shown in Figure 6 to a lower position, permitting rotation of the cathode 19^a. Said shield 128 may be locked in uppermost position, as shown in Figures 6 and 7, when the cathode 19^a is in operative position, by means of a resilient latch member 131, the upper portion of which is secured as by welding to a metal ring 132 fastened to the supports 21^a and 22^a adjacent their upper ends but below the apertures 118 and 119, said latch carrying an iron armature 133 and a prong 134, which latter element fits in a corresponding aperture in a keeper member 135 on the cylindrical shield 128 for holding it in uppermost position until released by action of an external magnet, corresponding to the magnet 45 of the preceding embodiment, on the armature 133 to withdraw the prong 134 from the keeper 135 and permit the shield 128 to descend and release the cathode 19^a for swinging to the desired position.

The support wires 58^a and 59^a also carry shield members 136 and 137 for "shading" the press 13^a, like the shield 74 of the preceding embodiment.

The phototube of the present embodiment may otherwise be manufactured like that of the preceding embodiment, that is, the sensitized cathode surface 31^a is applied like the surface 31 of the preceding embodiment, when device is reversed and the cathode swung to the "unlocked" position shown in Figure 8, from the activating electrode 14^a as by electrical bombardment therebetween on direct current, with the electrode 14^a functioning as a cathode.

When sufficiently activated, the device is turned to the normal position shown in Figures 6 and 7, the shield 128 allowed to slide down to its lowest position represented by the dotted line 128', and the cathode 19^a reversed to the position shown in said figures. The shield may then be returned to the "locked" position illustrated in Figures 6 and 7, in accordance with the following procedure. The tube is turned on its side and inclined at an angle, with the top pointing diagonally upward. By revolving the tube on its axis the plate 19^a can be made to swing around, due to the counterweight 122, until it faces the top. If the tube is now maneuvered properly the lug 120 or 130 will prevent the plate from swinging any farther even when the tube is tipped at an angle with its top pointing diagonally down-

ward. In this position, the shield 128 can be tapped or worked down to engage the plate, and finally locked in the position shown in Figures 6 and 7. A slightly different but similar procedure will also place the plate 19^a and the shield 128 in the position shown in Figure 8. The phototube may be employed like the phototube 11 of the preceding embodiment, either with or without vacuum-enclosed relay tube and condenser connected to the lower or other end portion of the envelope as in the preceding embodiment.

The stops 120 and 130 make it possible to conveniently effect and control rotation of the cathode plate 19^a. The counterweight 122 may, if desired, be made of magnetizable material, such as iron or steel, for operation from the outside.

After the devices 11 and 11^a are completely assembled and tested, the envelopes are desirably covered with light obscuring tape 138, except at the active or convex ends 84 and 84^a, as shown in Figure 10, and provided with operating cords and plugs 139 and 140. The film of activating material which forms on the glass during the sputtering operation is desirably prevented from photo-emission during operation of the device by connection with the anode, as by means of a flexible wire 140 extending from an anode lead into engagement with the sputtered portion of the envelope, as shown in Figure 2.

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 photoelectric device comprising an elongated envelope, one end of which is closed by an outwardly convex portion and the other by a flare tube, a plate electrode therein having a flange extending from one surface thereof and formed with apertures, a pair of support wires extending through said apertures with their end portions at an angle to the main portions thereof, and connected by a stop for said plate electrode, an activating electrode in the form of a rod of photosensitive material extending generally parallel to said support wires and disposed inwardly thereof, an operating electrode beyond the angular ends of said support wires, and lead-in conductors extending through said press to said electrodes, whereby said movable electrode may be sensitized from said activating electrode when swung inward and slid downward along its supporting wires, and then slid back to a position transverse to the axis of said envelope to face said operating electrode.

2. A photoelectric device comprising a generally cylindrical envelope, a movable plate electrode therein to act as a photosensitive cathode, support wires for said plate electrode, an activating electrode in the form of a rod of photosensitive material extending generally parallel to said support wires and disposed inwardly thereof, an operating electrode disposed therebeyond toward an end of said envelope, and means supporting said operating electrode comprising wires extending directly from a portion of the envelope and continuing longitudinally thereof, the free ends of said wires being connected by a generally circular bracing wire to which said operating electrode is secured.

3. A photoelectric device comprising an elongated envelope, one end of which is closed by an outwardly convex portion, and the other by a flare tube, support wires extending longitudi-

nally of said envelope toward said convex end portion, a plate electrode having an apertured flange extending from one surface thereof, a pair of said support wires extending through said apertures to their end portions at an angle to the main portions thereof, and connected by means forming a stop for said plate electrode, whereby the latter is swingable and slidable along said support wires, an operating electrode in the convex end portion of said envelope beyond the angular ends of said support wires, other support wires extending longitudinally of said envelope, the free ends of said other wires being connected by a generally circular bracing wire, said operating electrode being connected to said bracing wire, and lead-in conductors extending through said press to said electrodes.

4. A photoelectric device comprising an elongated envelope, one end of which is closed by an outwardly convex portion and the other by a flare tube, support wires extending longitudinally of said envelope from said flare tube toward said convex end portion, a plate electrode having a flange formed with apertures and flange extending from one surface thereof, a pair of said support wires extending through said apertures with their end portions extending at an angle to the main portions thereof, and connected by means of a bracing wire, another portion of said plate electrode carrying an outstanding flange with an edge portion notched forming a keeper, a resiliently mounted latch member with a flanged end portion receivable in said notch for locking said plate electrode in position, an operating electrode in the convex end portion of said envelope, and lead-in conductors extending through said press to said electrodes.

5. A photoelectric device comprising an elongated envelope, one end of which is closed by an outwardly convex portion and the other by a flare tube, a collar gripping said flare tube, support wires extending from said collar longitudinally of said envelope toward said convex end portion, a plate electrode having a flange formed with apertures and flange extending from one surface thereof, a pair of said support wires extending through said apertures, with their end portions at an angle to the main portions thereof, and connected by a wire forming a stop for said plate electrode, an operating electrode in the form of wires curved outwardly into the convex end portion of said envelope beyond the angular ends of said support wires, and lead-in conductors extending through said press to said electrodes, whereby said movable electrode may be sensitized when swung inward and slid downward along its supporting wires, and then slid back to a position transverse to the axis of said envelope to face said wire electrode for operation.

6. A photoelectric device comprising a generally cylindrical envelope, one end of which is closed by a generally hemispherical portion and the other by a flare tube providing a re-entrant portion terminating in a press, a collar gripping said flare tube, support wires extending from said collar longitudinally of said envelope toward said hemispherical end portion, a generally circular plate electrode having an apertured flange extending from one surface thereof, a pair of said support wires extending through said apertures with their end portions at an angle to the main portions thereof, and connected by a wire forming a stop for said plate electrode, an activating electrode in the form of a rod of photosensitive material extending generally parallel to

said support wires and disposed inwardly thereof, an operating electrode in the form of wires curved outwardly into the spherical end portion of said envelope beyond the angular ends of said support wires, and lead-in conductors extending through said press to said electrodes, whereby said movable electrode may be sensitized from said activating electrode when swung inward and slid downward along its supporting wires to face said activating electrode, and then slid back to a position transverse to the axis of said envelope to face said wire electrode for operation.

7. A photoelectric device comprising a generally cylindrical envelope, a movable plate electrode therein, an activating electrode, an operating electrode in the form of wires disposed outwardly thereof, and means supporting said operating electrode comprising a flare tube terminating in an inwardly disposed press and closing one end of said envelope, support wires extending directly from said press and continuing longitudinally of said envelope, the free ends of said wires being connected by a generally circular bracing wire to which the ends of said electrode wires are secured.

8. A photoelectric device comprising a generally cylindrical envelope, a movable plate electrode therein, an activating electrode, an operating electrode in the form of wires disposed outwardly thereof, means supporting said operating electrode comprising a flare tube terminating in an inwardly disposed press and closing one end of said envelope, support wires extending directly from said press and continuing longitudinally of said envelope, the free ends of said wires being connected by a generally circular bracing wire to which the ends of said electrode wires are secured, and a plate extending transverse to the axis of said envelope and secured to said support wires between said activating electrode and bracing wire to shield the end portion of said envelope and contents from sputtered material.

9. A photoelectric device comprising a generally cylindrical envelope, a movable plate electrode therein, an activating electrode, an operating electrode in the form of wires disposed outwardly thereof, means supporting said operating electrode comprising a flare tube terminating in an inwardly disposed press and closing one end of said envelope, conductors extending from said press, support wires extending directly from said conductors longitudinally of said envelope, the free ends of said wires being connected by a generally circular bracing wire to which the ends of said electrode wires are secured, and a plate mounted on said leads for shading said press from sputtered material.

10. A photoelectric device comprising an elongated envelope, one end of which is closed by an outwardly convex portion, and the other by a flare tube, a collar gripping said flare tube, support wires extending from said collar longitudinally of said envelope toward said convex end portion, a plate electrode having an apertured flange extending from one surface thereof, a pair of said support wires extending through said apertures with their end portions at an angle to the main portions thereof and connected by means forming a stop for said plate electrode, whereby the latter is swingable and slidable along said support wires, an operating electrode in the form of wires curved outwardly into the convex end portion of said envelope beyond the angular ends of said support wires, other support wires extending from said press longitudinally of said

envelope, the free ends of said other wires being connected by a generally circular bracing wire, said operating electrode wires having their ends connected to said bracing wire, and lead-in conductors extending through said press to said electrodes, whereby said movable electrode may be sensitized when swung inward and slid downward along its supporting wires and then slid back to a position transverse to the axis of said envelope and encircled by said bracing wire to face the curved electrode wires for cooperation therewith.

11. A photoelectric device comprising an elongated envelope, one end of which is closed by an outwardly convex portion and the other by a flare tube, a collar gripping said flare tube, support wires extending from said collar longitudinally of said envelope toward said convex end portion, a plate electrode having a flange formed with apertures and flange extending from one surface thereof, a pair of said support wires extending through said apertures with their end portions extending at an angle to the main portions thereof and connected by means of a bracing wire, another portion of said plate electrode carrying an outstanding flange with an edge portion notched to form a keeper, a resiliently mounted latch member with a flanged end portion receivable in said notch for locking said plate electrode in position, an operating electrode in the form of wires in the convex end portion of said envelope, and lead-in conductors extending through said press to said electrodes, whereby said movable electrode may be sensitized when swung inward and slid downward along its supporting wires and then slid back to a position transverse to the axis of said envelope, where its keeper is engaged by said latch to hold in that position to face said wire electrode for operation.

12. A photoelectric device comprising a generally cylindrical envelope, a movable plate electrode therein, a resiliently mounted latch for holding said electrode in operative position, a magnetizable armature on said latch to allow it to be operated from outside said envelope, an operating electrode in the form of wires disposed outwardly of said plate electrode when the latter is in operative position and held by said latch, and means supporting said operating electrode comprising a flare tube terminating in an inwardly disposed press closing one end of said envelope, support wires extending directly from said press and continuing longitudinally of said envelope, the free ends of said wires being connected by curved bracing wire means to which the ends of said electrode wires are secured.

13. A photoelectric device comprising an envelope consisting of a main portion defined at one end by a generally semi-spherical end portion and at the other by a flare tube terminating in a press, a neck portion extending beyond said flare tube, photoelectric elements supported from said press in said main portion, said elements comprising a movable plate electrode, a rod electrode adapted to activate said plate electrode when in one position to function as a cathode when moved to operative position adjacent said semi-spherical end portion, wires disposed in said spherical end portion to function as an anode with respect

to said plate electrode when in operative position, leads extending through said press and connected with said electrodes, the leads from said wires and activating electrode being connected together in said extension, springs respectively connected to said connected leads and other lead, a condenser and a relay tube mounted on another flare tube and electrically connected to said plate electrode by one of said springs, another of said springs being connected to a lead extending through said other flare tube, said springs allowing for connection outside of said extension and subsequent insertion therein, whereby after insertion said second-mentioned flare tube may hermetically seal the outer end of said extension.

14. A photoelectric device comprising an envelope, a plate electrode therein, supporting means for said electrode, means pivoting said plate electrode to said supporting means, said plate electrode also having a counterweight for swinging it through 180° about said pivoting means, an activating electrode in said envelope, a shield mounted and longitudinally movable in said envelope for housing or exposing said activating electrode, an operating electrode disposed in said envelope outwardly of said pivoted electrode to function as an anode with respect thereto, and means in said envelope for locking said shield in position adjacent said pivoted electrode to hold it with one side or the other facing said operating electrode.

15. A photoelectric device comprising an envelope, a plate electrode therein and provided with pivoting means extending therefrom, supporting wires mounted in said envelope and receiving said means for pivotally supporting said plate electrode, said plate electrode also having a counterweight for swinging it through 180° about said pivoting means, an activating electrode in said envelope, a generally cylindrical shield slidable on said supporting wires for housing said activating electrode, other support wires in said envelope extending outside of said shield and terminating in arc-shaped bracing wires extending across said envelope, fine wires curved longitudinally from said bracing wires and lying in said envelope outwardly of said pivoted electrode to function as an anode with respect thereto, and means in said envelope for locking said shield in position adjacent said pivoted electrode so as to hold it with one side or the other facing said fine wires.

16. A photoelectric device comprising an envelope consisting of a main portion and another portion, a cathode disposed in said main portion and sensitive to radiations to be measured, anode means disposed outward thereof, said other portion containing auxiliary equipment connected to said cathode, and means for making a temporary connection with said cathode independent of said auxiliary equipment comprising a lead extending through a seal at the side of said envelope and terminating in a socket carrying interior threads, said socket being protected by a tubular extension beyond said seal, and a conductor having an end portion provided with exterior threads fitting the threaded socket.

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