Oct. 20, 1953 R. J. HERBOLD 2,656,477

PHOTOELECTRIC CELL HAVING A LIGHT SENSITIVE ELECTRON EMISSIVE CATHODE

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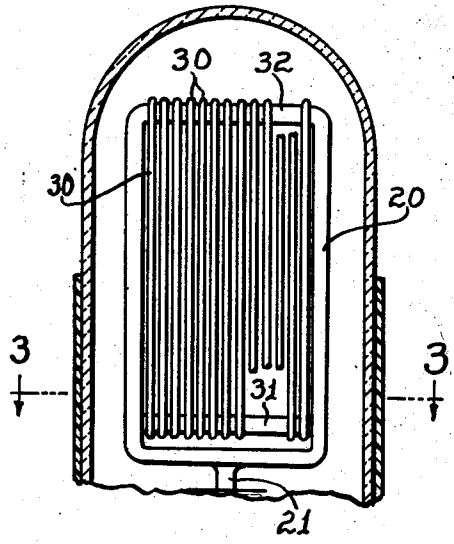
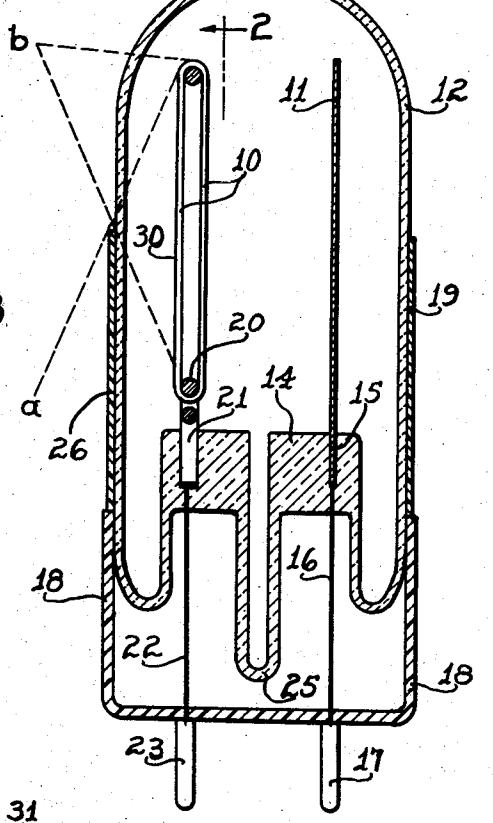


Fig. 2.

Fig. 1.



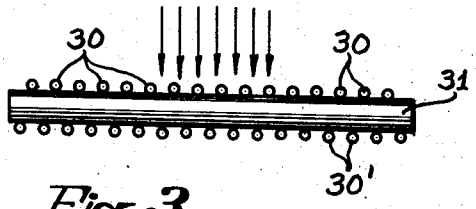


Fig. 3.

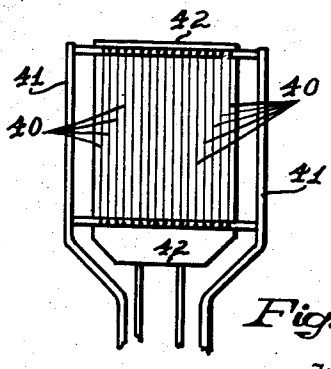


Fig. 5.

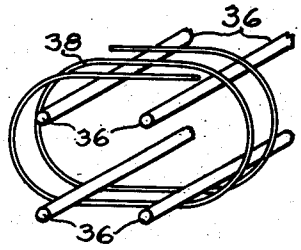


Fig. 4.

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PHOTOELECTRIC CELL HAVING A LIGHT SENSITIVE ELECTRON EMISSIVE CATHODE

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4 Claims. (Cl. 313—94)

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This invention relates to photoelectric cells having light sensitive electron emissive cathodes.

A photoelectric tube of the types shown in my prior Patents #2,489,220 and #2,489,222 of November 22, 1949, comprises a suitable anode associated with a cathode having a surface that is sensitive to light and capable of emitting electrons when light-activated. The emission of electrons from a saturated light sensitive cathode is proportional, other conditions being controlled, to the area of the sensitized surface which is activated by the light rays. These constructions also comprise an opaque shield or one made of a suitable light filtering medium so arranged in front of and spaced from the cathode that as the angularity of an impinging light ray is varied, the activated area of the cathode is varied, and thus the total electron emission is determined by the light angularity.

This type of photo cell, which has various uses as well as those defined in said patents, may depend for its accuracy upon the degree of uniformity of the light sensitive coating on the cathode. It, however, has been found that it is difficult to coat a cathode having an extensive flat or cylindrical surface with sufficient uniformity to give the desired accuracy, and standard procedures have resulted in some areas of the plate being less sensitive than others.

It is the primary object of this invention to provide a photo cell with a light sensitive electron emissive cathode which has a high degree of uniformity of light sensitivity throughout its effective area and which may be readily and economically manufactured and will provide a satisfactory photo action. Other objects will be apparent in the following disclosure.

In accordance with my invention, I make a cathode for a photo cell by coating a wire with a suitable light sensitive electron emissive material and form the required cathode area of this wire. Since the wire is small in diameter as compared with its length and the total cathode area, any variation in the uniformity of coating at a given point on the wire is negligible in its net result.

In the drawings illustrating one embodiment of this invention:

Fig. 1 is a central vertical sectional view through a photo sensitive tube;

Fig. 2 is a similar view, partly broken away, taken on the line 2 of Fig. 1;

Fig. 3 is an enlarged section through the cathode, taken on the line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic fragmentary perspective view of another form of wire cathode; and

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Fig. 5 is a fragmentary elevation of a modification having the cathode formed of separate wires.

One form of photo cell construction comprises my new cathode 10 associated with an anode 11 mounted within a glass tube or transparent casing 12 of suitable shape. This light transparent tube may comprise a base 14 of a soft lime glass or other suitable material which is integral with the cylindrical tube walls. The vertical anode wire 11, or a rectangular wire frame similarly used for the anode, may have a supporting wire portion 15 embedded in and projecting through the glass base 14, and it is connected within the glass to a suitable wire lead 16 which in turn connects with the metal prong 17 carried by the Bakelite or other insulating base 18 of the tube. Such tube and anode parts may be of suitable or standard constructions.

In the tube form shown, a shield 19 of a suitable opaque or light filtering medium is arranged in front of the cathode so as to shadow it. It extends half way, or otherwise as desired, up the length of the sensitized portion of the cathode 10. This shield, as described in my patents, may be an outside plate or tube spaced from the glass casing 12, or, as shown, a coating on the glass 12 which provides for shadowing a varying area of the cathode surface as a light ray moves angularly from the position *a* of zero illumination to the position *b* of full illumination of the cathode, as indicated in Fig. 1. The tubular shield 19 on the glass tube 12 may comprise a gelatin film, such as the Wratten gelatin filters identified commercially by the numbers 64, 65 and 67 which transmit light other than red and infrared. The transluscence of that filter to other light rays may be controlled by the addition of a dye or an opaque powder, such as dispersed graphite. Likewise, this shield may be made of other suitable light transmitting media, such as a nitrocellulose solution or cellulose acetate solution spread on the outside of the glass shell 12 and which contains a suitable light absorbing medium that will prevent the passage of selected wave lengths of light.

My cathode, in the form shown in Figs. 1 and 2, comprises a rectangular metal wire frame 20 of suitable size having a downwardly projecting centrally located metal support 21 formed preferably of the same type of wire. The support 21 in turn connects within the glass 14 with a lead-in wire 22 which terminates in the metal

prong 23 carried by the base. The cup-shaped insulating base 18 is suitably secured to the lower end of the glass tube 12 and holds it properly in place, as will be understood. The central hollow projection 25 of the glass tube 12 is for the purpose of exhausting the air from the inside of the tube after which the hole in the part 25 is sealed.

The primary feature of this invention comprises making the light sensitive portion of the cathode of a coated wire 30 mounted on the frame 20, or other support, such as a glass plate of rectangular or other desired shape. This wire is connected to the terminal 23 through the metal frame 20 or separately if mounted on insulating material. In the preferred form, this wire 30 is mounted on the wire frame 20 as a set of parallel sections, either spaced or in contact. It is preferred that the wire be continuous and arranged in vertical loops. The wire elements may, however, be formed of separate wires soldered or otherwise secured to the metal frame and suitably connected to the outside terminals. Where one wire section is back of another, it is preferred that the loops be vertical relative to the angular direction of the light movement, so that no material front portion of the wire will cast a shadow on any rear part of required use and thus affect the electron emission. As shown in Fig. 2, the cathode frame 20 may comprise a separate lower cross bar 31 and an upper cross bar 32. The sensitized wire, or a plurality of separate sections of wire, is secured to these two bars 31 and 32, such as by wrapping a single wire thereabout, as shown in Fig. 3, with the evenly spaced back wire elements 30 showing between the evenly spaced front wire elements. The spacing between the adjacent wire elements is preferably about equal to the diameter of the wire, so that no material amount of light (indicated by the arrows in Fig. 3) is lost by passage through the wire assembly. Various expedients may be adopted for wrapping a wire continuously around the frame and insuring that the light exposed elements are parallel and vertical.

The wire frame 20 with its cross bars 31 and 32 may be made of a suitable metal, such as nickel, platinum, tungsten or a tungsten molybdenum alloy, or other strong and electrically conductive material which will properly support the cathode wires. These wire elements 30 are preferably made of nickel coated with silver, and they may be suitably secured to the frame by a silver or other type of solder, or the frame may have locating ribs or depressions arranged to position the wire 30 and insure a definite spacing. A preferred light sensitive medium is formed of silver coated with caesium metal on a base of oxidized caesium which is so treated as to provide a sensitized surface in accordance with standard practice, so as to form a silver-caesium oxide-caesium element.

One suitable form of cathode may be made of a nickel wire electroplated lightly with copper and then with a coating of silver. The frame 20 may also be made of this same material. The silver-coated wire 30 may be oxidized and then coated with caesium and sensitized as described below before it is mounted on the frame 20. If it is to be sensitized after it is mounted in the tube 12, the silver plated wire may be wrapped around the frame 20 and the parallel loops of wires suitably soldered to the frame, such as by a silver solder. After the wire frame has been inserted in the glass tube with its lead wire connected thereto and in proper association with the anode, the gas in the tube made be exhausted by a vacuum system and other suitable procedure. Thereafter, oxygen may be admitted to the tube in sufficient amount so that when the cathode wire is electrically heated, the silver is suitably oxidized. Caesium is applied to this oxidized coating, such as by subliming the caesium metal derived from caesium trinitride on a magnesium ribbon or by decomposition of a pellet of caesium chromate and silicon that has been suitably mounted in the tube for the purpose. The application of heat decomposes the pellet and forms a vapor of caesium which reacts with the silver oxidized coating to form caesium oxide interspersed with the caesium metal when the wire is baked at about 200° C. or higher. Ultimately the tube may be exhausted to provide the necessary vacuum, or an inert gas, such as argon, may be added. This procedure forms a cathode having a threshold at about 14,500 Angstrom units and a selective maximum at 6,070 A. If the oxidized coating and caesium are applied to the wire before the latter is mounted on the supporting frame, suitable precautions are taken to insure that the sensitivity of the coating remains or is restored. In that case, the sensitized wire is preferably wrapped about the frame 20 but not soldered to it. It will also be appreciated that the other photo sensitive materials, such as other alkali metals or alkaline earth metals or combinations, such as antimony-caesium, may be appropriately provided and treated. The various sensitive coatings may be formed by suitable standard procedure.

If desired, as shown diagrammatically in Fig. 4, the cathode support may comprise parallel rods 35 having one or more sensitized wires 38 wrapped around it as a cylindrical helix or other shape, such as a hollow parallelopipedon or a flattened helix; and in such cases the anode may be arranged either within or outside of this cathode shell. If the cathode is made like a woven screen of preferably fine mesh, the two sets of substantially parallel wire elements of the weave will lie in contact where they cross. However, for uses set forth in my prior patents, the vertical wire arrangement without any cross wires is desirable, since the overlying portions of the crossed wires would throw shadows onto the underlying sensitized portions of the cathode, and the effect of these shadows would vary with changes in the directive angularity of the light. Also, for many purposes the elements of the loops of a single continuous wire wrapped around the frame 20 need not be in exact parallelism but may be arranged substantially in parallelism as a normally wrapped helix, whether cylindrical or flat, with an equal progressive spacing between the elements or loop portions of the helix. The size of the cathode wire elements and its supporting frame may be varied widely, as will be understood. A wire of 15 to 20 gauge will serve for the frame 20, and a wire of 20 to 50 gauge can be used for the silver caesium element. I have found that a cathode that is suitable for the purposes of said patents may be from ½ to 1 inch wide and from 1 to 3 inches long. The size and cross sectional shape of the wire 30 may be as desired. It is immaterial if the strands touch. In that case the effective portion of the cathode wire will be that part in front which is exposed.

Fig. 5 shows a construction in which the cathode wire elements are separate wires 40 soldered

or welded by spot or resistance welding to a rectangular metal frame 41 and arranged in parallelism. These wires may be closely spaced, or they may be in contact, so as to catch a desired proportion or substantially all of the light on the front exposed face portion of each wire element. Each of the wire elements is a single separate piece, and the elements are not wrapped around the frame, as shown in Figs. 2 and 4. The anode plate 42 is shown as a solid thin metal plate. It, however, may be made as a rectangular loop located outside of the path of the light rays towards the cathode wire elements. In such constructions where the anode plate has a considerable area and the cell could not be used for high frequency work due to its high capacitance, it is feasible to lower that capacity by the use of an opaque dielectric with its two vertical edges supported by anode wires which replace the all metal sheet shown in the Fig. 5 construction. Such an anode could be substituted for a central flat metal plate used in the Fig. 4 construction within the loop of the cathode wire. It will be appreciated that many modifications may be made in this construction within the scope of this invention.

The advantages, utility and operation of such constructions will be apparent. A cylindrical wire will give a maximum surface effect, and the cathode may be sensitized more uniformly for my purposes. If a spot on the wire is not properly coated, this will be immaterial because of the small percentage of the ineffective area relative to the total cathode surface. This cathode structure is such that the sum of the areas of the light sensitive coatings of the wire elements which are exposed simultaneously to the light constitute the effective activation area of the cathode, subject to the fact that the activation varies with the cosine of the angle of the impinging light. This activation is substantially uniform and equal in equal unit areas of the light exposed cathode, without regard to the location of the area, so that the electron emission varies according to the total area affected by the light. Since the preferred arrangement of Fig. 2 has the front wire elements 30 spaced by about the thickness of a rear element and staggered relative thereto, the assembly forms an apparently continuous surface that catches most of the impinging light.

It should be understood that these special wire cathode constructions need not be used with the light shield 19 above described, and that the wire cathode is of general utility in many types of cell and for general purposes where the angle of the light direction is otherwise varied.

I claim:

1. A light sensitive photo cell comprising a light transparent casing, a cathode having an extensive area of surface for light activation, an associated anode and terminals leading from the cathode and anode, and a shield terminating in an edge which is mounted to shadow an area of the cathode that varies in accordance with the directive angularity of light passing said edge, said cathode comprising a metal supporting frame and a plurality of substantially parallel wire elements mounted on the frame for exposure to said light throughout the major extent thereof and collectively connected to the cathode terminal, each wire element having a light sensitive electron emissive coating, and the sum of the areas of the light sensitive coating exposed to directional light impinging thereon constituting the effective activation area of the cathode.

2. A photo cell according to claim 1 in which the cathode comprises a metal frame having a continuous coated wire wrapped therearound in loops with the rear elements of the loop wire exposed to directional light passing between the front elements.

3. A photo cell according to claim 1 in which the cathode comprises a metal frame and a continuous light sensitive coated wire wrapped around the frame and forming substantially parallel closely arranged front and rear elements, the spacing between adjacent front elements being substantially the same as the width of a rear element and the front and rear elements being staggered so that the rear elements are exposed to directional light passing between the front elements, whereby the front and rear elements provide a light sensitive area substantially as large as the area of the frame and form an apparently continuous surface for light exposure.

4. A light sensitive photo cell comprising a light transparent casing, a frame mounted within the casing which has opposed supports bordering a light transmitting area, substantially parallel cathode elements of wire mounted on said opposed supports at closely spaced points and extending across said space, said wire having a light sensitive electron emissive coating throughout its exposed length within the frame and an extensive cylindrical surface providing an effective activation area which is the sum of the coating areas exposed to directional light, the electron emission from the cathode elements being substantially uniform and equal in equal unit areas of the entire light activated area, an anode associated with the cathode in the casing, electrical terminals leading from the anode and the coated cathode wire elements respectively, and means which shadows a varying area of the sensitized cathode wire elements in accordance with the directive angularity of the light.

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