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POLARIZED LAYER IN COPPER OXIDE PHOTOVOLTAIC CELL

Original Filed May 8, 1935

Fig. 1.

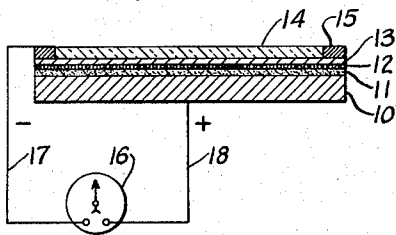


Fig. 2.

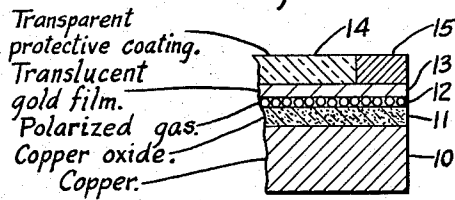


Fig. 3.

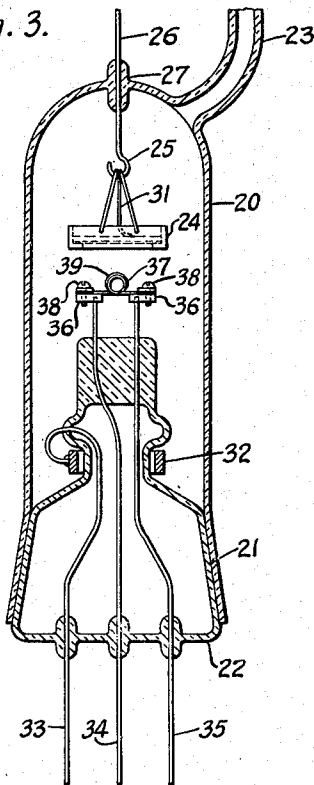


Fig. 4.

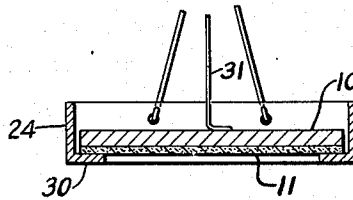
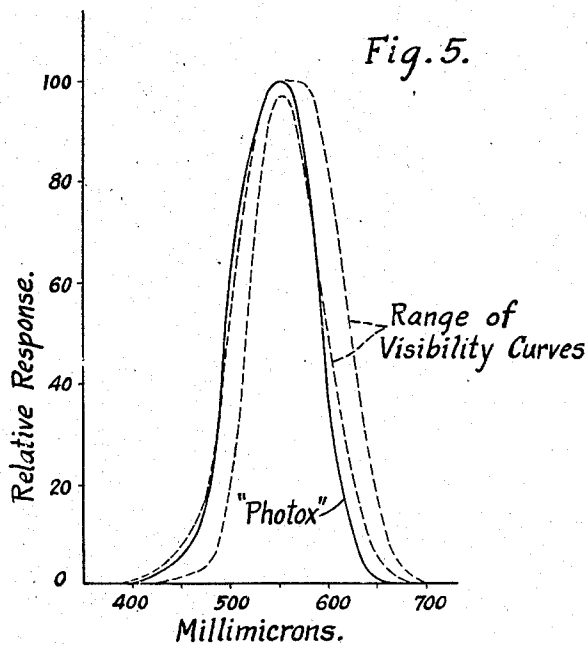


Fig. 5.



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POLARIZED LAYER IN COPPER-OXIDE
PHOTOVOLTAIC CELL

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Application May 8, 1935, Serial No. 20,362
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7 Claims. (Cl. 136—89)

This application is a continuation in part of my
copending applications Serial No. 578,399, filed
December 1, 1931, and Serial No. 4,285, filed Jan-
uary 31, 1935.

5 My invention relates to photo-sensitive devices
and it has particular relation to photo-sensitive
devices of the dry photo-voltaic type.

In the prior art, photo-sensitive devices have
been constructed of a translucent film of cuprous
oxide upon copper. Contact has been made to
the oxide and to the copper by mechanical pres-
sure or other equivalent means. Light passing
through the copper oxide caused the electrons to
pass across the juncture between the oxide and
the copper. While such a cell was responsive to
light, yet its sensitivity was not of a very high
order. It was found that the sensitivity of such
a cell was limited to the red portion of the visible
spectrum, namely, the range from about 650
millimicrons to 700 millimicrons, and that the
cell was not sensitive to green light, which has a
position in the visible spectrum to which the
human eye is most sensitive. Such a device,
furthermore, had to be very carefully manufac-
tured and assembled in view of the necessarily
thin delicate coating of transparent copper oxide.

It is an object of my invention to utilize the
photo-electric properties of copper oxide, but to
avoid all of the above-mentioned difficulties of
the copper-copper oxide cell just described.

It is another object of my invention to provide
a photo-sensitive device having a copper oxide
layer upon a copper base, and to provide the elec-
tron discharge device from the copper oxide to
another metal instead of to the copper, as in the
prior art devices.

Another object of my invention is to provide
such a photo-sensitive device that has its maxi-
mum relative response in the central portion of
the visible spectrum.

More specifically stated, it is an object of my
invention to form a photo-sensitive device by
oxidizing copper, and forming a layer of polarized
gas on the copper oxide covered with a layer of
translucent metal whereby the copper oxide and
metal are electrodes bounding a discharge path
across the polarized layer of gas.

Other objects of my invention will become evi-
dent from the following detailed description
taken in conjunction with the accompanying
drawing, in which:

Figure 1 is a schematic view with parts of the
photo-sensitive device in cross-section and a
meter in elevation;

Fig. 2 is an enlarged view in cross-section of

the extreme right-hand portion of the photo-
sensitive device of Fig. 1;

Fig. 3 is a cross-section view with some parts
in elevation of a preferred type of apparatus for
forming the layer of polarized gas and translu-
cent metal film on the copper oxide;

Fig. 4 is an enlarged view in cross-section with
some parts in elevation of the copper-copper
oxide disc carrying member of Fig. 3; and

Fig. 5 is a curve showing the relative spectrum
response of my photo-sensitive device manufac-
tured under the trade name "Photox" with the
range of visibility of 125 human eyes.

The completed preferred form of my photo-
sensitive device is disclosed in Fig. 1 with a por-
tion at the extreme right enlarged in detail in
Fig. 2. As disclosed in these figures, the form of
this photo-sensitive device is preferably that of
a disc in which the base is a thick disc of copper
10. Upon this layer of copper is a layer of copper
oxide 11, preferably of a thickness to be opaque
to prevent any light passing through to the cop-
per and also of a thickness to withstand rough
treatment without cracking through to the cop-
per. On the surface of the copper oxide is a
layer of polarized gas 12. This layer of polarized
gas is very much enlarged and out of proportion
for the sake of illustration. Upon this polarized
gas is a translucent metallic film 13. This film
can be of any suitable conducting material, but
I prefer one of the noble metals and especially
either gold or silver. Upon the central portion
of the translucent film, I prefer to place a trans-
parent protective coating 14 and also to provide
a ring of conducting material 15 to make contact
with the gold film.

The cell as I have described it and as dis-
closed in these two figures is a generator of elec-
tricity in response to light passing through the
translucent film and polarized gas to the oxide.
A meter 16 with its negative lead 17 connected
to the contact member 15 and its positive lead
18 connected to the copper will register a varying
amount depending upon the intensity of il-
lumination of the light.

A preferred type of apparatus for performing
the electron discharge elements of my photo-
sensitive device is disclosed in Fig. 3. A disc of
copper is oxidized at a temperature preferably
of the order of 1000° C., and has formed upon its
surface a thick layer of cuprous oxide. The disc
is then preferably vacuum treated at 800° C., and
then the oxide surface is cleaned with acid, pref-
erably nitric acid. Any of the black cupric oxide
is, of course, removed in this process, and the

copper disc 10 has the red layer of cuprous oxide upon one surface. This disc is then placed within the container 20, preferably of a somewhat bell-shaped design, and having a ground glass fit 21 with a suitable base 22. The atmosphere of the container 20 can be removed or changed or varied through a suitable outlet 23 connected to a pump. In the upper portion of the container is a holder 24 for the disc, and this container is suspended from a suitable support 25 having an electrical connection 26 passing through the container wall at 27.

The holder 24 is more clearly disclosed in Fig. 4 and preferably consists of a cylindrical container with a slight intumed rim 30 on its underside for holding the edge of the copper-copper oxide disc. The disc is placed with the oxide surface 11 facing downward. A connection 31 makes contact between the back of the copper and the connection 26 passing to the exterior of the container 20.

In the bottom of the container is an electrode 32 with a lead 33 passing through the base to the exterior. Two connections 34 and 35 also preferably extend through the base to a position just below the holder 24 and have any suitable wire supporting means 36 upon their upper ends. A wire, preferably in the form of a coiled filament, 37 is supported by these supports 36 and secured thereto as by the screws 38. The filament 37 is of suitable resistance and material to produce the electric current passing therethrough. On this wire is placed a material 39, of which the translucent or transparent film 13 is to be composed. This, as previously mentioned, is preferably of gold or silver.

The chamber within the container 20 is evacuated and then filled to about 30 microns of pressure with any suitable gas such as argon or air. If air is used, the pressure is merely reduced to this amount. A discharge is then passed from the electrode 32 to the disc with the disc negative. The electrons within the gas in the container will travel towards the electrode 32 and will collide with atoms of the gas, and the collision will create positively charged ions as well as other electrons. These ions of gas will travel to the surface of the copper oxide 11 and impinge thereon and create a polarized layer of gas over the surface. This layer of polarized gas may be of the order of one or a few atoms thick. Nevertheless, I believe that this polarized gas with its positive charge will place the electrons in the copper oxide under tension. I believe that the orbits of the polarized gas and the electrons just within the surface or on the surface of the copper oxide are interlinked, so that while the tension is not sufficient to pull the electrons out of the copper oxide, yet the tension is sufficient to materially reduce the amount of work necessary to actually pull the electrons out of the copper oxide surface.

An atom or molecule of gas is said to be polarized when the electronic orbits are so perturbed that an effective electrical dipole results. Two charges of opposite sign separated by a finite distance constitute an electric dipole.

After the discharge between the electrode 32 and the disc has formed a polarized layer of gas on the copper oxide, the chamber is again evacuated and a current passed through the conductors 34 and 35 heating up the silver or gold 39 on the filament 37 and evacuating it upon the surface of the copper oxide and polarized layer of gas. The amount of evaporation is controlled so that

this layer is merely a translucent film or even may be thin enough to be practically transparent. The cell is then removed and I preferably add the transparent protected coatings 14 and the contact rim 15 on the surface of the translucent gold or silver film. The resulting cell is capable of delivering more than 10 microwatts per square inch at an illumination of 50 footcandles from an ordinary incandescent lamp.

One of the great advantages of my photo-sensitive device, which is known under the trade name "Photox", is that it has a relative spectrum response comparable to that of the human eye. This feature is graphically illustrated in Fig. 5 showing the maximum response of the "Photox" in the green portion of the visible spectrum. The dotted lines in Fig. 5 represent the spectrum range of visibility curves for 125 human eyes.

While I have described the polarized gas layer and the translucent film as being deposited upon the copper oxide surface in separate steps, yet it is possible to produce the polarized gas and metal film by a simultaneous discharge and transfer of material. The discharge, in such case, has to be strong enough to insure a sufficient layer of polarized gas, as otherwise the cell will not be sensitive.

I desire to emphasize that the discharge provides the conductive medium for the gold or silver films to act as electrodes in receiving the ions from the copper oxide. The polarized gas, as previously explained, places the electrons in the copper oxide under a tension. The light energy passing through the translucent film 13 strikes the copper oxide and provides the additional energy necessary to haul these electrons out of the copper oxide and across the gas to the translucent film. This light energy accordingly generates a current that will pass through the conductors 17 and 18 and register on the microammeter 16.

If the layer 13 is placed upon the copper oxide layer 11 without a prior glow discharge or a simultaneous glow discharge, then there will be no appreciable electron discharge from the copper oxide to this translucent film. This is true with the cells of the prior art. As previously pointed out, these cells depend upon the light striking the junction between the copper oxide 11 and the copper 10 so that the discharge device takes place from the copper oxide to the copper, and the direction of current is reversed from that of my device.

While I have used the term gas throughout yet this term is to include vapors such as water vapors, alcohol, acetane which I have found to be effective. Numerous other vapors may be used especially those having a high vapor pressure at room temperature which are obviously more convenient to use.

I also contemplate using polarized solid insulators or semi-conductors for the polarized layer. The substances would include waxes, resins, oils, sulphur and poorly conducting metallic oxides and compounds.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible, such as the shape, arrangement and materials of the elements of both the photo-sensitive device and the apparatus for constructing it. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art.

I claim as my invention:

5 1. The method of forming a photo-sensitive device which comprises oxidizing copper, bombarding the surface of the oxidized copper with positive gaseous ions and depositing a layer of a metal which is substantially inert photo-electrically and which is thin enough to be translucent on said oxide.

10 2. The method of forming a photo-sensitive device which comprises oxidizing copper, exposing said copper oxide to a glow discharge to form a polarized gas layer thereon, and evaporating a layer of a noble metal thin enough to be translucent on said polarized layer.

15 3. The method of forming a photo-sensitive device which comprises oxidizing copper, placing the oxidized copper in a container with a gaseous medium, passing a discharge through the gaseous medium with the copper oxide as a cathode surface to form a polarized layer of gas thereon, and evaporating a metal which is substantially inert photo-electrically and depositing a thin film of said metal on said polarized layer and oxide.

20 4. A light-sensitive device comprising copper, 25 a layer of copper oxide on said copper, a polarized layer of gas on said oxide and a layer of conductive metal which is substantially inert photo-electrically on said gas and oxide, said oxide and conductive metal being electrodes bounding a

discharge path across said polarized layer of gas made conductive by light.

5 5. A light-sensitive device comprising copper, a layer of copper oxide on said copper, a polarized layer of gas on said oxide and a layer of conductive material on said oxide and said polarized gas, said oxide and said conductive material being electrodes bounding a discharge path across said polarized layer made conductive by light, said conductive material being the negative electrode and said oxide the positive electrode. 10

6. The method of forming a photo-sensitive device which comprises oxidizing copper, cleaning the oxidized copper with acid, bombarding the surface of the oxidized copper with positive gaseous ions and depositing a layer of metal which is substantially inert photo-electrically and which is thin enough to be translucent on said oxide. 15

7. The method of forming a photosensitive device which comprises oxidizing copper, heat treating said oxidized copper in a vacuum, bombarding the surface of the oxidized copper with positive gaseous ions and depositing a layer of metal which is substantially inert photo-electrically and which is thin enough to be translucent on said oxide. 20 25

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