[Second Edition.]

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Photo-electric Cell.

We, ARCTURUS RADIO TUBE COMPANY, a corporation of the State of Delaware, United States of America, of 260, Sherman Avenue, Newark, New Jersey, United States of America, Assignees of SAMUEL RUBEN, a citizen of the United States of America, of 83, Fourth Avenue, New York, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a photo-electrolytic cell. An object of the invention is the provision of a photo-electric cell which is both durable and low in cost of construction; another object is the provision of means to more efficiently operate this type of cell.

It is known in the art that with exposure to light rays the specific resistance of cuprous oxide varies according to the extent and nature of the exposure. Cuprous oxide has been used as the light-sensitive element in various photoelectric cells, one way being for instance, upon a device in which changes in the resistance of this material are employed to control an electron discharge.

According to the present invention the light-sensitive layer is not applied to the anode of the photo-electrolytic cell by a coating operation as is customary but is formed integrally on the anode in order to provide a non-porous, homogeneous layer of a compound of the base metal of which the anode is composed. By integrally formed layer as used in this specification is meant a layer formed by treating the anode itself so as to produce a surface chemical change.

With this electronegative material as a coating of an electrode immersed in a suitable electrolyte with a cooperating relatively electropositive electrode, a potential between the two is developed at their terminals. With the exposure of the cuprous oxide to light radiations the internal resistance of the cell varies in accordance with changes in the resistance of the cuprous oxide in contact with the solution and so exposed. For the operation of the cell, the oxide coating must have certain characteristics, such as non-porosity and homogeneity, and it must be an integral part of the base metal upon which it is formed. A cell having a layer of cuprous oxide on a copper metal electrode is capable of continuous operation with minimum chemical or physical change; but unless the layer is of a dense, crystalline, non-porous structure, the cell soon loses its photo-sensitivity and the layer flakes off, exposing the copper base to the action of the electrolyte.

When employed to generate its own potential by contact of the electrodes with an electrolyte, and the potential is varied through changes in the internal resistance of the cell by the effect of radiation upon the cuprous oxide surface so exposed and in contact with the solution, the cell loses its photo-sensitivity after continued exposure to light because of a film produced on the cuprous oxide surface, which appears to be one of copper and cupric oxide having an opaque black appearance.

We have found that this reduction of photo-sensitivity can be prevented by applying to the cell a potential of opposite polarity to that generated therein, preferably of equal or slightly greater potential; this might be called a depolarizing potential. This is of importance in respect to the commercial application of a cell employing the change of resistance of a cupric oxide electrode.

It is likewise important to use an electrolyte having the proper characteristics; also that the cooperating electrode material be as electropositive as practicable with respect to the other electrode. Such an electrode material we have found to be aluminum, although other metals, such as magnesium and zinc can be employed. The electrolyte which we have found to be most satisfactory in our experiments is a solution of cobalt chloride.

For certain applications it is desirable to have a cell in which there is no effective potential generated by the relation of the electrodes to the electrolyte. The effect of change of resistance of the cuprous oxide layer by the light radiation is then best used as a controlling means

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for an external source of potential. For cells of this type we prefer to use as the electro-positive electrode one composed of pure iron with a solution of sodium carbonate as the electrolyte. To most efficiently operate a cell of this control resistance type, the external potential is preferably adjusted to a value just below the decomposition potential of the electrolyte, so that a decrease in resistance of the electrode surface layer raises the potential at the cuprous oxide contact with the solution, to a point above the decomposition potential, with a resulting large increase in current flow.

For maximum cell efficiency the cuprous oxide electrode should be so constructed as to have a maximum absorption and minimum reflecting power, the surface should be serrated, that is, in a series of planes by a wedge-like arrangement, the adjacent plane surfaces being at an angle of seven degrees or less. Due to successive inter-surface reflections the electrode surface is then practically wholly non-reflecting.

The cuprous oxide layer is produced preferably by heating the copper electrode after thorough cleansing, for about three hours at a temperature of about 1000° C.; there is then established a thick fused adherent non-porous layer of cuprous oxide which has a ruby red color.

The resistance change of the cuprous oxide has been found to be in the order of twenty per cent, and the maximum sensitivity in the region of the ultra violet radiation is about 2800 A°.

The equilibrium potential change of the cell is in proportion to the square root of the light energy absorbed.

$Xe - K E^{\frac{1}{2}}$; Xe the equilibrium change of potential, E representing the amount of light energy and K a constant.

With a cell of the counter e.m.f. type, for example, one utilizing an aluminum cathode and a cuprous oxide anode in a cobalt chloride electrolyte, there was obtained an increase in potential across the output of the terminals of the cell of 50 milli-volts, with exposure to a forty candle power lamp at one foot distance.

For a better understanding of the invention, reference is made to the accompanying drawings representing one embodiment of my invention in which 1 represents a glass envelope having a rubber nipple 2, at the top, in which there is a small orifice 3, which permits the escape of excess gas but prevents the escape of the electrolyte. In the cobalt chloride electrolyte 5 is immersed curved copper electrode 4, having a dense, non-porous, homogeneous layer of cuprous oxide, integrally formed on the copper base, curved as shown, and having a serrated surface 4a, as described. Electrode 4 is mounted upon conductor 4b and support 4c. At 6 is the co-operating electrode of aluminium. In a cell not employing a counter e.m.f. as the major effect the electrolyte is a solution of sodium carbonate, the electrode 6 then being of pure iron.

The terminals of the cell are connected with an external source of potential, R1, being the potentiometer which is energized by the potential source B. The cell is also connected in series with the fixed resistance R, which is connected with the input terminals of the vacuum tube V, which provides for the amplification of any potential changes across R through the control of the electron stream in tube V, which affects translating device T. B2 is a battery for heating the filament of the tube V, as controlled by resistance R2. B1 is the accelerating potential for the electron discharge in the tube.

In operation the potentiometer is so adjusted that the potential across it and of opposite polarity, is equal to that generated in the cell.

So operated there is no potential drop across the resistance but when the light energy is absorbed by the cuprous oxide electrode due to the resistance change in the exposed cuprous oxide surface 4a, the internal resistance of the cell is changed and its potential is increased, overbalancing the depolarizing potential from the potentiometer with a resultant rise in potential across the resistance R. This potential in turn, causes a change in the plate current of the vacuum tube due to application to the grid element, with the operation of the relay, telephone receiver, or other translating device.

In view of the negative resistance coefficient of cuprous oxide it is desirable to maintain the temperature of the cell within definite limits. Otherwise the applied potential from the potentiometer must be adjusted. The type of cell described is found to be capable of response to audio frequency modulation of the exposed light.

While most satisfactory results have been obtained by the use of a copper anode having a layer of cuprous oxide thereon, other metallic anodes with a non-porous homogeneous layer of a compound of the metal of the anode can be used. As a further example of such anode we may mention an anode made of molybdenum and having a homogeneous layer of molybdenum sulphide thereon.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to

be performed, we declare that what we claim is :—

1. A photo-electrolytic cell having in an electrolyte, an anode with an integrally formed, non-porous, homogeneous layer of a compound of the metal of the anode, and a cooperating cathode composed of a material relatively electropositive with respect to said compound.

2. A photo-electrolytic cell having in an electrolyte, a copper anode with an integrally formed, non-porous, homogeneous layer of cuprous oxide, and a cooperating cathode composed of a material relatively electropositive with respect to the cuprous oxide.

3. A photo-electrolytic cell having in an electrolyte, a copper anode with an integrally formed, non-porous, homogeneous layer of cuprous oxide, and a cooperating cathode composed of aluminum.

4. A photo-electrolytic cell as hereinbefore claimed, including a transparent electrolyte of haloid salts.

5. A photo-electrolytic cell as hereinbefore claimed, in which the anode and the cathode are immersed in an electrolyte of cobalt chloride.

6. A photo-electrolytic cell as hereinbefore claimed, including means for balancing the potential between the cathode and the anode by applying an electromotive force of opposite polarity to that of said electrodes, and means for amplifying any differential potential there generated.

Dated the 23rd day of August, 1929.
For ARCTURUS RADIO TUBE COMPANY,
White, Langner, Stevens, Parry & Rollinson,
Chartered Patent Agents,
Jessel Chambers, 88—90, Chancery Lane, London, W.C. 2.,
and at
17, John Street, New York, U.S.A.

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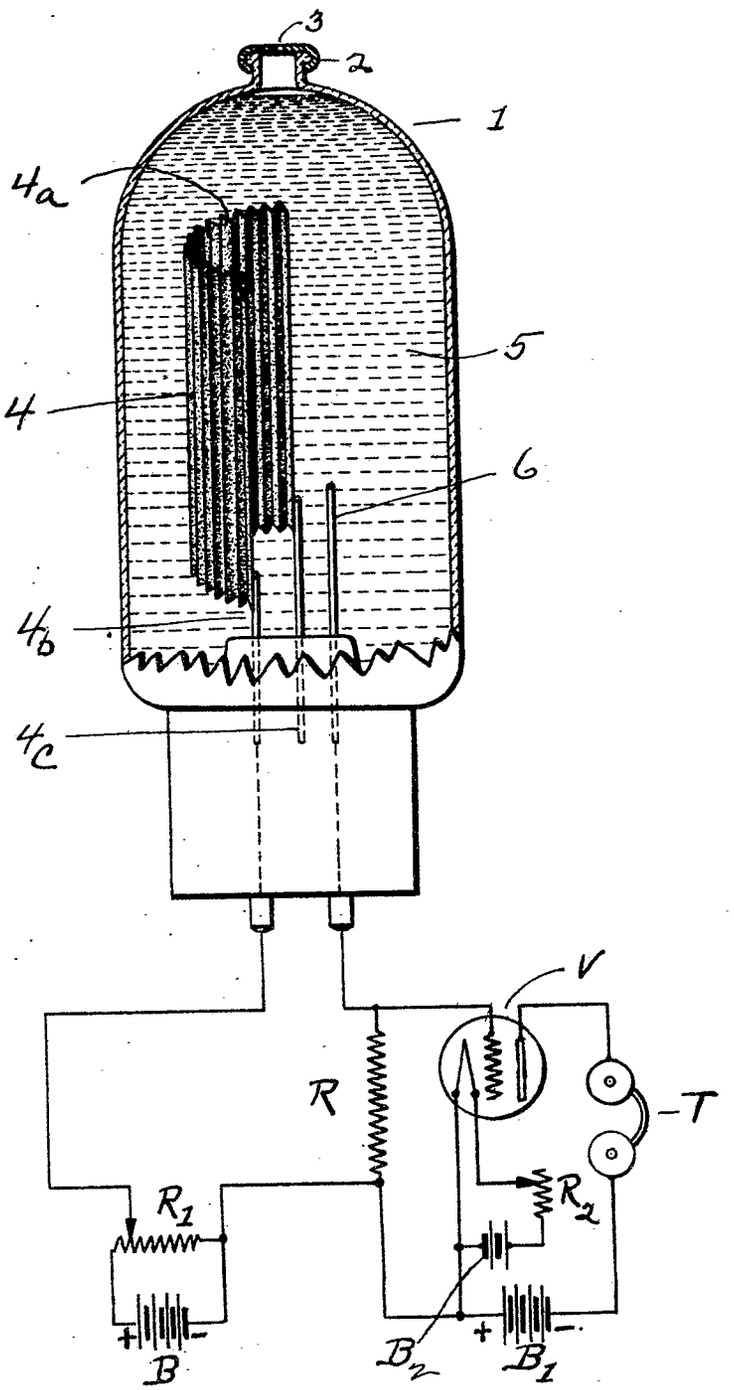

[This Drawing is a full-size reproduction of the Original]

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