Nov. 22, 1927. 1,650,092

A. POULSEN ET AL

DEVICE FOR CONVERSION OF LIGHT VARIATIONS INTO ELECTRICAL CURRENTS

Filed April 30, 1924

Fig. 1.

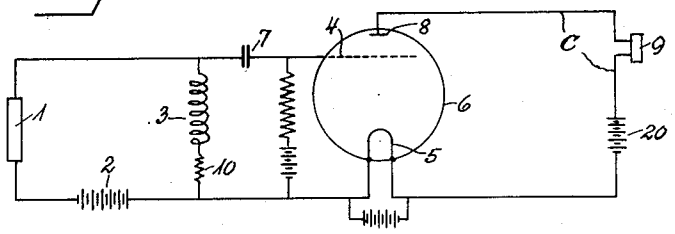


Fig. 2.

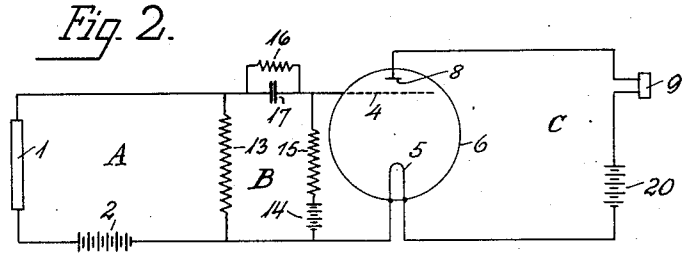


Fig. 3.

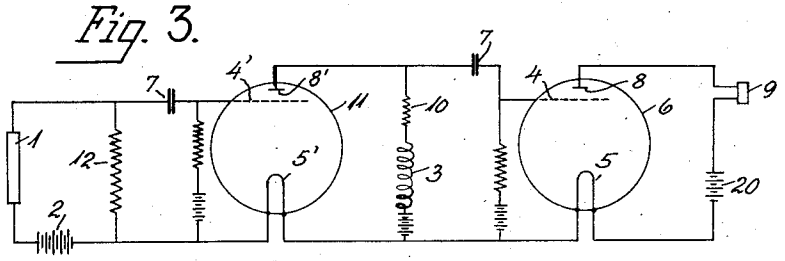
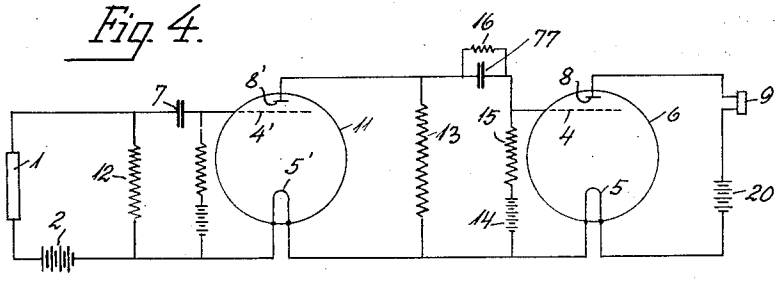


Fig. 4.



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DEVICE FOR CONVERSION OF LIGHT VARIATIONS INTO ELECTRICAL CURRENTS.

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As is well known, light-variations may be converted into electrical currents by allowing the former to actuate certain light-sensitive substances inserted, in suitable known manner, in the electric circuits. These light-sensitive substances may be divided into two classes, namely, substances the electrical conductivity of which is altered by action of light, the best known substance of this nature being selenium, and substances having a tendency to emit electrons, when actuated by light, and which may be found especially among the alkali metals. If the first mentioned substances are inserted as resistances in an electrical circuit in series with a battery, an electric current will flow in the circuit varying with the variations of light. And when the last mentioned substances are used as cathode in a closed glass tube, while a metal wire forms the anode, they will give off electrons, when exposed to light, and thereby a weak electrical current will be generated varying proportionally to the intensity of light.

While the last mentioned ones of these light-sensitive cells, the so-called photo-electrical cells, operate absolutely without sluggishness, i. e. in such a manner that the current in the electrical circuit is at any time proportional to the entering amount of light, such is not the case for the first mentioned cells, hereinafter called selenium cells. Such cells are sluggish, that is to say a certain time will pass before a variation of light has exerted its full action. Photo-electrical cells would therefore in this respect be preferable, but as the current variations produced by these cells are very weak, selenium cells have frequently been preferred in spite of the drawbacks due to their sluggishness.

This sluggishness is especially prominent in cases when selenium cells are used to convert rapidly changing light into electrical currents, for instance in the case of light-telephony where the sluggishness manifests itself in that the alternating currents produced by a periodic variation of light will decrease very much by increasing periodicity and, thereby, cause a very marked distortion of the speech reproduced.

The present invention is now built up on the basis of the recognition of the law according to which the conductivity of the selenium is modified when the selenium is actuated by periodical light variations of varying periodicity, and the invention has for its object, on the basis of the said recognition, to compensate the distortion caused by the sluggishness.

It has been shown that as soon as the light-variations are tolerably fast, for instance a few hundred variations per second, then with a practically sufficient approximation the variations of conductivity caused thereby will be inversely proportional with the frequency of the light variations.

According to the invention the sluggishness of selenium cells is compensated in that the current variations produced in the circuit of the selenium cell are caused to produce variations of an electrical potential resting on the grid in a thermionic tube, in such a manner that the said variations will be proportional to the frequency, when the latter exceeds a certain value, for instance 150 to 200. In the anode circuit of the thermionic tube, current variations will then be produced which are proportional to the said variations of potential, and the latter will then vary with the light variations, independently of the frequency of the latter.

The drawing represents diagrammatically two constructions of the invention,

Figs. 1 and 2 showing two different wiring diagrams for a circuit comprising a selenium cell and one single thermionic tube, and

Figs. 3 and 4 wiring diagrams for a cirsuit comprising a selenium cell and two thermionic tubes coupled in cascade.

Referring to the drawing, 1 is a selenium cell, 2 a battery and 3 a self-induction coil connected in series with the battery and the selenium cell (Fig. 1).

By exposure of the selenium cell 1 to light of varying intensity, for instance light varying proportionally to a telephone current, current variations will be produced in the circuit of the selenium cell, which current variations will produce variations of the potential difference existing between the ends of the self-induction coil. These variations of potential are proportional to the current variations and the frequency of the latter. Now, as the intensity of the current variations, besides being proportional to the intensity of the light-variations, is also inversely proportional to the frequency of these variations—as long as the said frequency, as mentioned above, exceeds a few hundred periods per second—it will be seen that the said va-

riations of potential in the self-induction coil 3 will vary proportionally to the light-variations, independently of the frequency of the latter, provided that the alternating-current resistance of the self-induction coil for the periodicities considered is slight relatively to the resistance of the selenium cell and relatively to the resistance between the grid 4 and the cathode 5 in a thermionic tube 6, into the grid circuit of which the self-induction coil 3 is inserted in series with an arresting condenser 7. In the circuit C of the anode 8 of the thermionic tube 6, current variations will then be generated, which will be proportional to the current variations of the self-induction coil 3, and, consequently, proportional to the light-variations.

The speech concerned will then, without any distortion, be reproduced by a telephone 9 in the circuit C of the anode 8, which circuit in known manner comprises a battery 20.

As the sluggishness of the selenium cell does not decrease indefinitely at very low periodicities, but approximates a certain definite value, it will be necessary—in view of the possibility of the occurrence of current variations of very low periodicity—to insert a resistance 10 in series with the self-induction coil 3. The most suitable value of this resistance is easily calculated by means of an empirically determined curve showing the sensitiveness of selenium as a function of the frequency.

Instead of causing the current variations in the circuit of the selenium cell to produce potential variations in a self-induction coil 3, the said current variations may be caused to produce other current variations which are proportional to the frequencies of the former ones, and occur in another circuit in which they produce potential variations in an ohmic resistance inserted in parallel to the grid in a thermionic tube. Fig. 2 shows an arrangement of this kind. The varying currents in the circuit A of the selenium cell 1 produce current variations in the circuit B, which comprises a condenser 17, a resistance 13, a battery 14 and a resistance 15. If the impedance of the condenser 17, at the periodicity considered, is high in relation to all the resistances 13, 15 inserted, then current variations will be produced in the circuit B which are proportional to the frequency, and in the resistance 15 there will then be produced a potential variation which is equally proportional to the frequency of the current variations in the circuit A of the selenium cell. Out of regard to the lower frequencies the condenser 17 is shunted with a resistance 16. The grid circuit of the thermionic tube 6 is connected to the circuit B as shown.

If the selenium cell is used in connection with several thermionic tubes connected in cascade, for instance as shown in Fig. 3 in connection with a thermionic amplifier 11 inserted in the circuit of the selenium cell and connected with the thermionic tube 6, then a compensation of the sluggishness of the selenium cell may also be attained by causing the current variations produced in the circuit of the selenium cell to produce proportional current variations in an ohmic resistance 12, which is inserted in series in the grid circuit of the amplifier 11, while a self-induction coil 3, Fig. 3, corresponding to the self-induction coil 3 in Fig. 1, or a condenser 77, Fig. 4, corresponding to the condenser 17 in Fig. 2, is inserted in the grid circuit of the thermionic tube 6 or—if more than two thermionic tubes are used—in the grid circuit of one of the following thermionic tubes. The impedance of the self-induction coil 3, however, should in this case be slight relatively to the internal resistance in the anode circuit of the amplifier 11 as well as relatively to the resistance of the grid circuit of the thermionic tube 6.

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 device for compensating for the sluggishness of selenium cells used for the conversion of light variations into electric currents, comprising, in combination with a selenium cell; a thermionic tube having an anode circuit, a grid circuit including in series a grid, a grid resistance, a source of potential and the filament of the thermionic tube, and a local circuit which includes in series the selenium cell and a current source and which is interconnected to the said grid circuit across the grid-resistance and the source of potential; and connections between the grid circuit and the local circuit including an impedance which varies with the frequency of the current variations generated in the circuit that includes the selenium cell and which causes the said current variations to influence the grid-potential independently of the frequency of the said current variations.

2. An impedance for causing the current variations in the circuit of a selenium cell to influence the grid potential in a thermionic tube, such tube having its grid circuit connected across the circuit of the selenium cell so as to cause the magnitude of said potential, and thereby the strength of the current in the anode circuit of the thermionic tube, to vary independently of the frequency in the circuit of the selenium cell; said impedance comprising an inductance connected across the grid circuit.

3. An impedance for causing the current variations in the circuit of a selenium cell to influence the grid potential in a ther-

mionic tube, such tube having its grid circuit connected across the circuit of the selenium cell so as to cause the magnitude of said potential, and thereby the strength of the current in the anode circuit of the thermionic tube, to vary independently of the frequency in the circuit of the selenium cell; said impedance comprising an inductance and an ohmic resistance connected in series across the grid circuit.

In testimony whereof we affix our signatures.

ARNOLD POULSEN.
AXEL CARL GEORG PETERSEN.