

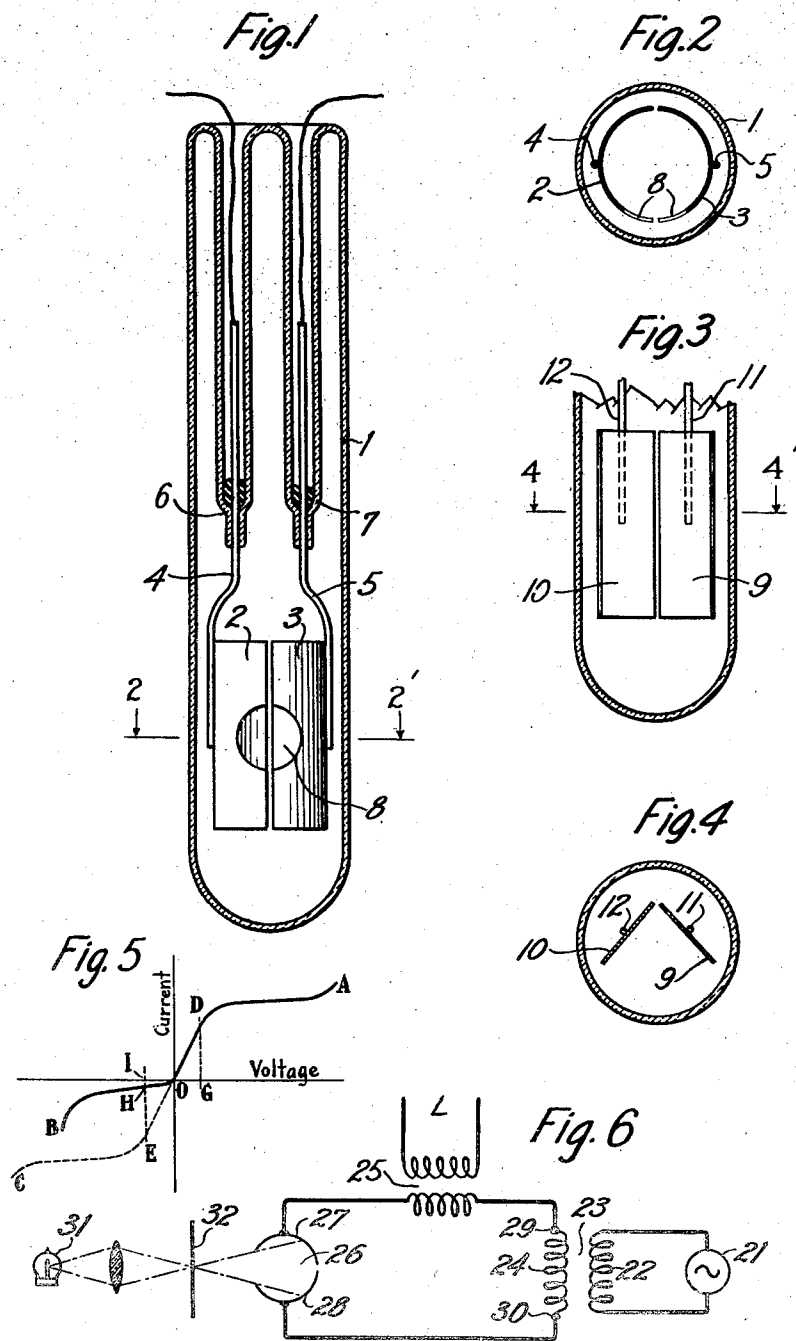
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SIGNALING APPARATUS

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## UNITED STATES PATENT OFFICE

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## SIGNALING APPARATUS

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This invention relates to electro-optics and more especially to modulating electrical oscillations in accordance with light waves.

An object of the invention is to provide improved means and method for controlling alternating electric energy with light waves.

Another object is to provide for efficiently modulating an alternating electric potential in accordance with signals.

10 In the embodiment of the invention which is herein shown and described for the purpose of illustration, the output of a source of electrical oscillations is connected in series with the primary winding of a line transformer and in series with the terminals of a photoelectric cell. Signals in the form of light waves of varying intensity are focused equally upon the elements of the light cell. The impinging of the waves upon the cell elements, each of which acts alternately as an anode and as a cathode correspondingly affects the impedance of the circuit including the source of carrier current, the primary winding of the line transformer and the light cell. The amplitude of the current flowing through this circuit is a direct function of the light which impinges upon the photoelectric cell elements, and as a result of the applied alternating potential an alternating photoelectric current is produced.

Referring to the drawings, Fig. 1 shows a photoelectric cell with symmetrical light sensitive elements.

Fig. 2 is a cross sectional representation of the elements shown in Fig. 1 and is taken across the line 2-2'.

Fig. 3 shows a cell with a modified form of symmetrical cell elements.

Fig. 4 is a cross sectional showing of the elements of Fig. 3 taken along the line 4-4'.

Fig. 5 is a diagram showing the manner in which the photoelectric current varies with the value of the impressed voltages, both in a cell constructed according to the prior art,

and a cell constructed to embody the invention.

Fig. 6 is a circuit diagram showing one manner of utilizing the cells shown in Figs. 1 and 3 to directly modulate an oscillating current.

Referring to Fig. 1 there is shown a photoelectric cell embodying the present invention. The cell proper consists of an evacuated glass vessel 1 in which the elements 2 and 3 are supported. The drawings show these elements supported by rods 4 and 5 which also serve as lead-in wires through the sealing in portions 6 and 7, respectively. However, it is to be understood that any other well known means for supporting and connecting with the elements may be employed without departing from the spirit of the invention.

As shown in Figs. 1 and 2, elements 2 and 3 are plates of semi-cylindrical shape, each plate having a portion cut away from one of its edges. The plates may be of any suitable material, such as nickel, silver or platinum. The cut-out portions of the plates are symmetrical with respect to each other and provide a circular opening 8 through which incident light rays may be equally dispersed over both of the plates.

The plate elements may each be coated with any light sensitive substance. The manner of coating and the material of which the coating consists does not form a feature of the present invention, and accordingly any substance which under the influence of light causes electrons to be emitted may be employed. However, it has been found that a hydride of an alkali metal produces highly efficient results.

A preferred method of coating the elements consists in vaporizing a supply of an alkali metal until the interior of the tube as well as the electrodes themselves are coated. Subsequently the tube surface is heated sufficiently to drive the deposit of metal there-

from, but not enough to displace the coating on the electrodes. Hydrogen may then be introduced and the tube subjected to a glow discharge resulting in the formation of a film of the metal hydride on the plates. After the evacuation process has been completed an inert gas such as argon or helium may be introduced for purposes well known in the art.

Fig. 3 shows a cell similar to the cell shown in Fig. 1, but the elements in this case consist of flat plates 9 and 10 supported by leading in wires 11 and 12, respectively. The plates 9 and 10 are positioned at an angle toward each other as is shown in Fig. 4, which represents a cross section of the cell shown in Fig. 3 and is taken along the line 4-4'. The angle of opening between the plates 9 and 10 may be such as to provide maximum photoelectric effects as determined by the characteristics of the cell. In this modification the light rays may be projected upon the plates in any manner to provide an equal dispersion of said rays thereover.

Heretofore where the output circuit of a photoelectric cell has been employed for modulating an alternating signaling current it has been the practice to employ separate batteries to provide the necessary electromotive force to draw the electrons from the light-sensitive cathode to the anode. This necessitated a source of potential which must at all times be constant, since a slight variation of anode potential produces a disproportionately greater change in the photoelectric current. By means of applicant's cell such sources are eliminated and the varying impedances of the cell itself under the influence of light rays cause the alternating current to be modulated directly. The potential of the alternating current itself serves as the anode potential for the cell as will appear hereinafter.

In Fig. 5 the curve BOA represents the manner in which the photoelectric current varies with the impressed voltage in a cell constructed according to the prior art. When, for example, a positive voltage of value OG is applied to the anode of such a cell, the resultant current for a given light intensity is GD. When an equal and opposite voltage OI is impressed, the resultant current is IH. This necessarily follows from the asymmetrical arrangement of the electrodes, and from the fact that in the process of coating the cathode surface the anode, which is usually much smaller in size, is unintentionally also coated with a certain amount of the light sensitive substance. On the contrary with a cell constructed according to Fig. 1 or Fig. 3 the current produced by a negative voltage is of the same value but of opposite sign to that produced by an equal positive impressed voltage, since each plate, being of the same size is intentionally coated with an equal amount

of light sensitive material. Curve COA shows this relation and it may be seen that both halves of the curve are truly symmetrical.

Accordingly should an alternating voltage be impressed upon a cell with a characteristic represented by the curve BOA, there will be produced an alternating photoelectric current with half waves asymmetrical both as to form and amplitude. On the other hand when an alternating voltage is impressed upon a cell constructed according to Fig. 1 or Fig. 3, the resultant photoelectric current is symmetrical both as to form and amplitude. It will be noted that the portion EOD of the curve COA is substantially a straight line. Therefore, if an alternating voltage of maximum value OG is impressed upon the terminals of the cell of Fig. 1, the resultant photoelectric current will be an alternating current of the same wave shape as that of the impressed voltage.

Under certain conditions it may be desirable to use a signaling current of distorted wave form but having symmetrical half waves. In such a case the maximum value of the impressed voltage should be greater than value OG.

Referring to Fig. 6 there is shown one method of employing a cell according to Fig. 1 or Fig. 3 as a modulator. The source of carrier current 21 is connected to the primary winding 22 of transformer 23, and the secondary winding of this transformer is connected in series with the primary winding of line transformer 25 and in series with the elements of cell 26. Thus elements 27 and 28 act each alternately as a cathode and as an anode in accordance with the change in sign of the impressed carrier current.

When the light from source 31 is completely screened from cell 26 the impedance of said cell is of the order of infinity. Assuming light rays of constant intensity to be focused upon plates 27 and 28 and assuming that the instantaneous potential of the terminal 29 is positive with respect to that of terminal 30, then plate 27 acts as an anode and attracts the electrons emitted from plate 28 as a result of the light waves impinging thereon. In accordance with well established laws the value of the current flowing from the plate 27 to plate 28 is therefore in proportion to the instantaneous difference of potential between the terminals 29 and 30. When, however, the current passes through the opposite half wave to that above considered, terminal 30 is at a higher potential than terminal 29 and accordingly plate 28 acts as an anode with respect to plate 27. Thus a current of magnitude determined by the intensity of the light rays and in a form determined by the wave shape from the source 21 flows through the primary winding of transformer 25 and induces in the secondary

winding of said transformer a similar current wave which may be utilized for any species of signaling.

It will be seen from the foregoing that if the source 21 generates an alternating current of characteristic wave form, such as is commonly used for carrier signaling, then under the influence of light rays of varying intensity from a source 31 the amplitude of the photoelectric current flowing through the cell 26 and transformer 25 is correspondingly affected.

The varying intensity of the light from source 31 may be controlled by appropriate signals, such for example as the elemental characteristics of a picture film 32, thus causing the carrier current from source 21 to be directly modulated in accordance with the tone values of said elemental areas, or other signals employed to control the light source.

It is to be understood that the invention is not limited to the specific structure above described by way of example. Details of construction of the cell and to modes of preparation hereinbefore described may be modified. For example, the coating upon the electrodes may be simply an alkali metal without treatment by the hydrogen glow discharge or even without the introduction of an inert gas. Also the manner of projecting the light upon the cell elements to obtain symmetrical modulation of the electric waves applied thereto is immaterial so long as equal amounts of light are incident upon said elements. The invention, however, is not to be construed as limited to the use of signaling waves or to any particular form of impressed electric waves or variations of the light waves, the scope of the invention being defined by the appended claims.

What is claimed is:

1. In combination, a source of signaling current, a light sensitive cell having electrodes each of which is adapted to act both as an anode and as a light sensitive cathode, means comprising said source of current for rendering each of said electrodes alternately an anode and a cathode, and means for controlling the amplitude of the photoelectric current in said cell in accordance with light rays of varying intensity.

2. In combination, a photoelectric cell having electrodes each of which comprises the same light sensitive substance and each of which is adapted to act as both an anode and a light sensitive cathode, and means for applying an alternating electromotive force to said electrodes to render each electrode alternately an anode and a cathode to produce an alternating current of symmetrical wave form in said cell.

3. In combination, a light sensitive cell comprising two light sensitive electrodes each adapted to act as both an anode and a light sensitive cathode, a source of light, means for

directing light from said source upon both of said light sensitive electrodes simultaneously, and means comprising said source of light and a source of signaling electromotive force to act upon said electrodes for rendering each alternately an anode and a cathode for producing in said cell an alternating photoelectric current of symmetrical wave form.

4. The method of producing alternating photoelectric current by means of a photoelectric cell having a pair of similar light sensitive electrodes each adapted to act both as an anode and as a light sensitive cathode, which method comprises directing a beam of light on both of said electrodes simultaneously and applying an alternating electromotive force to said electrodes for rendering each of said electrodes alternately an anode and a cathode.

5. In combination, a photoelectric cell having electrodes each comprising the same light sensitive substance and each adapted to act as both an anode and as a light sensitive cathode, means for directing a beam of light upon said electrodes simultaneously, and means for applying an alternating electromotive force to said electrodes for rendering each electrode alternately an anode and a cathode to produce an alternating photoelectric current of symmetrical wave form.

6. In combination, a light sensitive cell comprising two light sensitive electrodes each adapted to act as both an anode and as a light sensitive cathode, a source of varying light, means for directing light from said source upon both of said light sensitive electrodes simultaneously, and means comprising said source of light and a source of electromotive force to act upon said electrodes for rendering each alternately an anode and a cathode for producing in said cell an alternating photoelectric current of symmetrical wave form having variations corresponding to the variations of light from said source.

7. In combination, a light sensitive cell comprising two light sensitive electrodes each adapted to act as both an anode and a light sensitive cathode, a source of light, means for modulating light from said source in accordance with a signal, means for directing said modulated light upon both of said light sensitive electrodes simultaneously, and means comprising said source of light, said modulating means and a source of electromotive force to act upon said electrodes for rendering each alternately an anode and a cathode for producing in said cell an alternating photoelectric current of symmetrical wave form having variations corresponding to said signal.

8. The method of producing alternating photoelectric current having variations corresponding to a signal by means of a photoelectric cell having a pair of similar light

sensitive electrodes, each adapted to act both  
as an anode and as a light sensitive cathode,  
which method comprises generating a beam  
of light, modulating said light beam in ac-  
cording with a signal, directing said modu-  
lated light beam on both of said electrodes  
simultaneously, and applying an alternating  
electromotive force to said electrodes for ren-  
dering each electrode alternately an anode  
and a cathode.

In witness whereof, I hereunto subscribe  
my name this 15th day of August, A. D. 1925.

HERBERT E. IVES.

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