Feb. 18, 1947. K. RATH 2,416,215

TRANSLATION SYSTEM FOR BLOCKING LAYER PHOTOVOLTAIC CELLS

Filed July 6, 1944

Fig. 1.

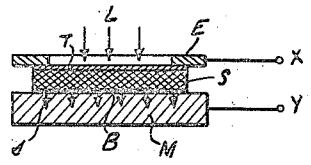


Fig. 2.

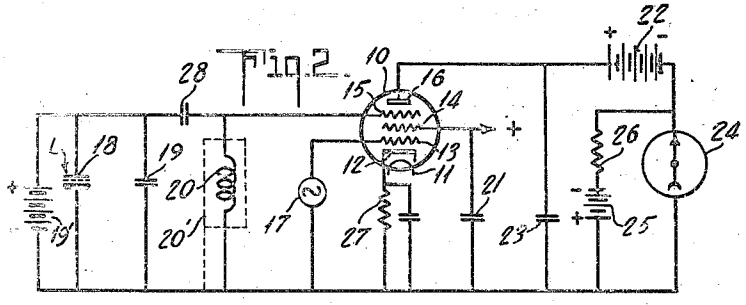


Fig. 3.

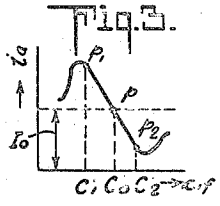


Fig. 4.

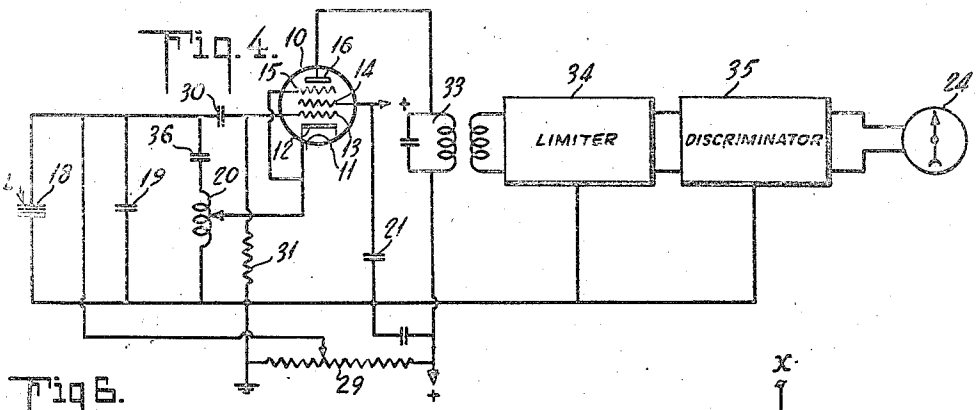


Fig. 6.

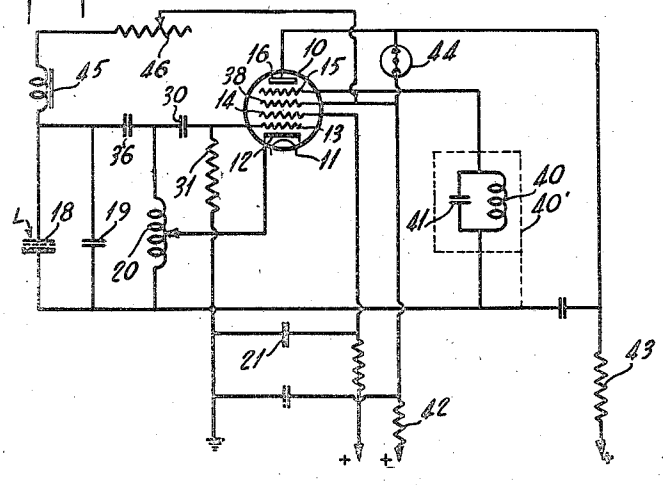
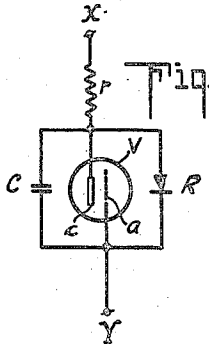


Fig. 5.



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UNITED STATES PATENT OFFICE

2,416,215

TRANSLATION SYSTEM FOR BLOCKING LAYER PHOTOVOLTAIC CELLS

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Application July 6, 1944, Serial No. 543,659

13 Claims. (Cl. 250—41.5)

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My invention relates to means for and a method of translating and amplifying the response of barrier or blocking layer photovoltaic cells such as those of the selenium or cupreous oxide type at present being known and used in the art.

As is well known, the standard vacuum tube amplifier, being basically a potential operated device, is not suited for direct amplification of the voltage or potental obtainable from photovoltaic or self-generating light-sensitive cells of the type mentioned above, the output voltage of such devices being of extremely low value of the order of .01 to .20 volts.

In order to amplify the weak current supplied by a photovoltaic cell, direct coupled amplifiers or other elaborate arrangements such as automatically balanced potentiometric indicators or recorders were required in the past in order to obtain a sufficiently amplified output current. Direct coupled amplifiers which are capable of amplifying the weak output current generated by a photovoltaic cell are both troublesome to build and operate and suffer greatly from an inherent tendency to instability due to drift and other causes. Other means and methods such as the periodic interruption of the controlling light beam to obtain an alternating output current for amplification by means of an audio frequency amplifier are also undesirable in many cases, especially where compactness and simplicity of the apparatus are required.

The present invention has for its object to provide a new method of and system for translating and amplifying the response of a blocking layer type of photovoltaic cell and with this object in view the invention proposes to utilize the variation of the inherent capacity of a cell of this type to derive an amplified output current or potential in a most simple and efficient manner.

It has already become known that barrier or blocking layer devices constructed similarly to a photovoltaic cell, such as dry rectifiers, have a capacity which may be varied by an adjustable electrical biasing potential impressed upon the devices in the current blocking direction.

The present invention is based on the recognition and fact that light of varying intensity impinged upon the sensitive surface of a photovoltaic cell results in a corresponding release of electrons entering the microscopic barrier or boundary space at the junction between the metallic and semi-conducting layers or elements, whereby to cause a variable space charge within the boundary space which in turn causes a variation

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of the inherent or blocking layer capacity in proportion with the impinging light intensity. This capacity variation is translated into substantial current changes by varying the tuning or resonating frequency of a frequency discriminator or conversion device to obtain a substantial output current change in a most simple and efficient manner.

This and further objects and novel aspects of my invention will become more apparent from the following detailed description taken in reference to the accompanying drawing forming part of this specification and wherein:

Figure 1 is a schematic cross-section through a barrier layer photovoltaic cell of known construction and shown for purposes of explanation and better understanding of the invention;

Figure 2 shows a simple translation circuit for a photovoltaic cell embodying the principles of the invention;

Figure 3 is a graph explanatory of the function and operation of Figure 2;

Figure 4 shows a modified translation circuit for a photovoltaic cell in accordance with the invention;

Figure 5 is a diagram showing the equivalent electrical circuit of a photovoltaic cell; and

Figure 6 illustrates still another modification of a photovoltaic cell translation circuit according to the invention.

Like reference characters identify like parts in the different views of the drawing.

Referring more particularly to Figure 1, I have shown schematically the construction of a standard barrier layer photovoltaic cell such as of the selenium-on-iron type known in the art, with the thickness and other dimensions of the electrodes and layers being shown greatly exaggerated for the sake of clarity of illustration. Item M is a metallic base electrode in the form of a plate or disk of iron, copper or the like and having applied thereto a light-sensitive semi-conducting layer S such as crystalline selenium or cupreous oxide, respectively, for the base metals mentioned. The light sensitive layer S is in turn coated with a thin translucent metallic covering layer T, which may consist of multiple layers of different metals well known in the art and to which in turn is applied a contacting metal electrode E in the form of a metal ring or frame held by spring pressure or in any other suitable manner.

If a cell of this type is illuminated by light rays indicated by the arrows L and passing through the translucent covering layer T, electrons will be freed or released from the layer S

and will enter the microscopic boundary space B in the direction indicated by the arrow *s*. This release of electrons by the layer S may be assisted by an electric potential difference applied between the electrodes of the cell, such as the inherent contact potential or an outside potential source. If the latter is an alternating potential, the device acts as a rectifier due to the unilateral electron emission in the manner indicated and well known in the art.

In entering the so-called boundary or barrier space B of microscopic thickness between the layers M and S which constitutes the equivalent of the evacuated space between the cathode and anode of a high vacuum phototube, the electrons produce a space charge cloud or sheath at varying distances from the electrode M and of varying charge density depending upon the exciting light intensity. This in turn results in a corresponding variation of the inherent capacity between the layer S and the electrode M.

By the proper design of the covering electrode T, electron emission to the latter from the layer S or a barrier layer effect (back effect) between the latter and the layer T can be avoided or reduced to a negligible minimum, whereby the layer T and the electrode E serve as mere contacting members for conducting the electric current to and from the layer S. Accordingly, the variable capacity of the cell will be substantially limited by the effects taking place within the main barrier or boundary space B.

However, due to the somewhat involved physical construction and the phenomenon taking place in a blocking layer photovoltaic cell, a number of precautions and special circuit arrangements are required to enable the full utilization of the varying capacity in a practical and efficient manner and to prevent undesirable interference with or complete impairment of the function as a pure capacity.

In Figure 5 there is shown the equivalent electric diagram of a barrier layer photovoltaic cell which comprises a high vacuum phototube V having a light sensitive cathode *c* and an anode *a* and provided by the barrier or boundary space B. This gaseous or, for practical purposes, high vacuum type photocell is in series with a variable conductance type selenium cell presented by the light-sensitive layer S and having a resistance *r*. In parallel to the high vacuum phototube there is connected a rectifier R representing the rectifier action and a condenser C equivalent to the internal capacity to be utilized in accordance with the present invention. The terminals of the cell as indicated at X and Y in the drawing.

The presence of the rectifier R and resistance *r* makes it necessary to prevent any steady or direct voltage produced by rectification, if the cell is inserted in a circuit carrying alternating or high frequency current as proposed by the invention.

In Figure 2 there is shown a simple translation circuit utilizing a space charge type discriminator or frequency converter of known design for converting the capacity variations of a photovoltaic cell into substantial output current changes. The circuit shown comprises an electron discharge tube 10 provided, in the example shown, with a heater 11, an equipotential cathode 12, a first or inner control grid 13, an accelerating or screen grid 14, an outer control grid 15 and an anode or plate 16, all arranged substantially in the order named. Various electron tubes available on the market in the form of pentodes, penta-grid converters, etc., having the above electrode arrangement, may suitably be used for the purpose of the invention.

The inner control grid 13 near the cathode is excited by a high frequency potential of substantially constant frequency which is supplied by any suitable source 17 such as a crystal-controlled oscillator or any other known highly stabilized source of electrical oscillations. Accordingly, the electron current emitted from the cathode 12 and passing to the screen grid 14 and anode 16, will be subjected to continuous fluctuation at a frequency equal to the frequency of the source 17.

The outer control grid 15 located near the anode 16 is connected to the cathode 12 through a tuned or resonant circuit comprising the capacity of a photovoltaic cell 18 in parallel to a fixed or adjustable condenser 19 and an induction coil 20. The latter is carefully shielded or exteriorly decoupled from the remaining parts of the circuit by a metallic shield 20' and other means well known in the art.

In the example shown the resonant circuit 18—19—20 is of the parallel tuned or anti-resonant type, that is, the photovoltaic cell 18, the condenser 19 and the induction coil 20 are connected in parallel. Alternatively, a series tuned circuit may be employed for the purpose of the invention. The screen grid 14 is connected in a known manner to the positive pole of a high tension source indicated by the + sign and bypassed for high frequency current to ground or cathode through bypass condenser 21. The anode 16 is connected to the positive pole of a suitable space current supply source such as a storage battery 22 and is also bypassed to ground or cathode for high frequency current through condenser 23. The anode circuit includes a suitable output for translating device 24 in the form of an indicator, recorder, relay, etc., which may be shunted by a compensating battery 25 in series with a resistance 26 for balancing the normal steady plate current through the indicator 24.

Item 27 is a condenser-shunted biasing resistance in the common cathode return lead for the grid and plate circuits to produce suitable negative operating bias potential for the control grids 13 and 15. If desired, however, the grids 13 and 15 may be separately biased by individual biasing sources. If the circuit is designed for operation from an A. C. source, a double diode rectifier may be used, one section of which serves to supply the screen and plate operating potentials, while the other section supplies the balancing voltage for the indicator or recorder 24.

There is furthermore provided a blocking condenser 28 in the upper connecting lead of the condenser 19 and the induction coil 20. Furthermore, the photovoltaic cell 18 is shown shunted by a source 19' of direct current in the form of a battery or the like and connected to the cell in the current blocking direction. The function of the blocking condenser 28 and biasing source 19' will be further understood from the following.

In a circuit of the aforedescribed type, the direct or steady anode current i_a varies substantially as indicated by the curve shown in Figure 3 as a function of the frequency *f* of the source 17 or of the capacity *c* of the photovoltaic cell 19 and condenser 18 in case the source 17 supplies a constant frequency. More particularly, if the resonating frequency of the circuit 18—19—20 is equal to the frequency of the source 17 (combined capacity C_0 of the cell 18 and condenser

19, the anode current i_a will have a normal mean value I_0 corresponding to the current if the tuned circuit 18—19—20 were removed or disconnected from the grid 15. As the resonating frequency of the circuit 18—19—20 varies in either sense from the frequency of the source 17, or as the tuning capacity varies in either sense from C_0 due to intensity variations of light impinged upon the cell 18 and indicated by the arrow L, the electron current to the anode 16 will increase or decrease, in a substantially linear relation with respect to the normal current I_0 in the manner shown by the characteristic curve in Figure 3.

As pointed out, in the latter the abscissa represents the capacity of the photovoltaic cell 18 and the ordinates represent the steady or direct plate current i_0. For a capacity C_0 corresponding to a given illumination, the circuit 18—19—20 is assumed to resonate with the frequency of the source 17 in such a manner as to result in a steady anode current I_0 or an operating point p substantially in the center of the straight line portion of the operating characteristic. As the capacity of the photovoltaic cell increases or decreases in accordance with the intensity of the impinging light beam L, the output current I_a varies substantially linearly with a range p_1—p_2 corresponding to a lower and upper capacity of the resonant circuit C_1 and C_2, respectively.

There is thus provided a most simple and efficient circuit for directly translating light intensity variations into corresponding substantail current changes by means of a photovoltaic cell and associated electron discharge tube. The slope of the operating curve between points p_1 and p_2 depends upon the "Q"

$$\left(\frac{\omega L}{R}\right)$$

of the resonant circuit 18—19—20 and in order to obtain a high conversion sensitivity, a sufficiently high operating frequency may be used to result in a desired conversion sensitivity of the system.

It has been found that the functions of the control grids 13 and 15 may be interchanged, that is, the source 17 may be connected to the grid 15 and the resonant circuit including the photovoltaic cell may be connected to the grid 13 without substantially affecting the operation of the system, the only difference being a reversal of the phase or slope of the operating chaarcteristic. It has furthermore been found that the steady output current of the screen grid 14 is subject to a variation similar to that of the plate current as shown in Figure 3, the difference again being a reversal of the phase or slope of the characteristic. Accordingly, according to a further feature of the invention, the output or translating device such as the indicator 24 may be inserted in the screen grid circuit or may be connected differentially between the screen and plate circuits for balancing the normal output current I_0 as shown and described in more detail in connection with Figure 6.

The function of the discriminator or translating circuit of Figure 2 is based on the effect of a variable electron space charge adjacent to the outer control grid 15 and exciting the resonant circuit 18—19—20 by electrostatic induction to cause a potential to be developed upon the grid 15 of varying phase relation to the potential on grid 13 in direct proportion to the variations of the natural or resonant frequency of the circuit 18—19—20, i. e., in proportion to the capacity of the photovoltaic cell 18. This will be further understood from the following.

Electrons emitted from the cathode 12 and initially accelerated towards the screen grid 14 will in part pass through the meshes of the latter and travel to the plate 16, and in part become decelerated by the negative electric or braking field produced by the grid 15 which is at cathode potential or a potential negative with respect to the cathode due to the action of the biasing resistance 27. As a result of this deceleration, a dense electron cloud or concentrated space charge will be formed adjacent to the grid 15, said space charge having a density fluctuating at the rate of and substantially in phase with the operating potential applied to the control grid 13. This variable space charge causes a corresponding current to be induced electrostatically in the outer circuit connected to the grid 15. This current in turn causes a potential at operating frequency on the grid 15 determined by the potential drop through the circuit 18—19—20. The phase of the potential on grid 15 depends upon the impedance or resonating frequency of the circuit 18—19—20 and accordingly determines the amplitude of the plate or screen current in cooperation with the potential upon the inner grid 13.

More particularly, if the circuit 18—19—20 is in tune with the frequency of the source 17, the potential on grid 15 will be 90° out of phase or in quadrature with the potential on grid 13 due to the fact that under this condition the circuit 18—19—20 offers purely resistive impedance to the induced current which, being proportional to the rate of change or derivative of the exciting space charge fluctuations, lags the latter and in turn the potential on grid 13 by 90°. As the circuit 18—19—20 is detuned relative to the operating frequency in one of the other sense by the capacity changes of the photovoltaic cell 18, the phase relation between the potentials on the grids 13 and 15 will become greater or less than 90° respectively, whereby to result in a corresponding variation of the average electron current in the plate or screen grid circuits in the manner shown in Figure 3. In order to insure stability of the operation, it is necessary that the tuned circuit 18—19—20 be carefully decoupled from the remaining portions of the system and be excited solely by internal space charge coupling with the electron discharge stream in the manner described. Accordingly, careful precautions should be taken to prevent exterior couplings such as by efficient metallic shielding and other means commonly known for this purpose.

In a system of the type described above, the high frequency current passing through the photovoltaic cell 18 will be partly rectified due to the rectifier action of the cell, resulting in a direct current voltage being developed across the series resistor r (see Figure 5). The function of blocking condenser 28 is to prevent a direct current path through the cell and inductance 20 and to eliminate the possibility of a continuous conduction current from passing from the light-sensitive layer S to the electrode M and interfering with the proper function of the tube as a pure capacity varying in accordance with the impinging light intensity variations.

For the same purpose, the photovoltaic cell is connected to a biasing source 19' applied in the current blocking direction, whereby to completely eliminate any continuous conduction current, even if the alternating or oscillating currents

have a substantial amplitude. As a result, the electrons released from the light-sensitive layer by the energy of the impinging light rays will be confined at all times in the boundary space B and cause a pure capacitative or displacement current to be induced in the outer circuit by the variable space charge effect in the manner pointed out. In this manner the cell acts as a pure condenser having a capacity which varies to a substantial degree in proportion to the electron emission from the light sensitive layer or in turn to the impinging light intensity. Any other means to prevent the establishment of a direct or induction current through the photovoltaic cell due to rectification or during the positive cycles of the alternating or oscillating current may be employed for the purpose of the invention to insure a substantially pure capacity action in the manner described.

According to a modification of the invention, the capacity variations of the photovoltaic cell are utilized to directly frequency modulate a high frequency carrier oscillation which is then demodulated in any known manner by means of a frequency discriminator supplying an output current sufficient to operate a suitable output device such as a meter or indicator.

A system of this type is shown in Figure 4. In the latter, the resonant circuit 18—19—20 forms the tank circuit of a regenerative oscillator of well known type by connecting the cathode 12 to a tap point of the inductance 20 and connecting the lower potential side of the circuit to the screen grid 14 serving as the oscillator output electrode by way of bypass condenser 21. A grid condenser 30 and grid leak resistance 31 serve to produce proper grid operating bias in a manner well known.

The frequency modulated oscillations transmitted to the anode or plate circuit by electron coupling are applied by way of a resonant coupling circuit 33 to an amplitude limiter 34 to remove undesirable spurious amplitude modulations. The output of the limiter is applied to a frequency discriminator 35 of any known type to produce an output current varying in proportion to the capacity changes of the photovoltaic cell 18 and serving to operate a suitable output device such as a meter or indicator 24.

Condenser 36 is series with the tank circuit inductance 20 acts to block any rectified direct current through the cell 18. In addition, the cell is biased or pre-polarized by a constant potential applied in the current blocking direction and obtained, in the example shown, by connecting the upper or covering electrode of the cell with a variable tap point of a potentiometer resistance 29 placed across the source of plate current supply such as a storage battery or a rectifier power supply if the system is operated directly from an A. C. network. The bias on the photovoltaic cell by a suitable constant potential in the blocking direction serves to eliminate any possibility of a conduction current through the cell and to confine its operation substantially to the electron space charge effect within the barrier or boundary space. Consequently, the photovoltaic cell acts as a pure capacity in the manner described and explained in detail hereinabove.

Any other type of frequency modulated oscillator and demodulator or discriminator known in the art for translating the capacity changes of the photovoltaic cell in response to light intensity changes may be employed for the purpose of the invention.

Referring to Figure 6, there is shown a further modification of the invention utilizing a single discharge tube acting both as oscillator and discriminator and embodying negative feed-back means for frequency stabilization and to obtain other advantages and effects.

The oscillator circuit including the photovoltaic cell 18 and associated with the cathode 12, control grid 13 and screen grid 14 is similar to the circuit according to Figure 4. A space charge type discriminator is directly embodied in the tube and comprises a fixedly tuned circuit constituted by an induction coil 40 shunted by a capacity 41 and connected directly between the suppressor or outer control grid 15 and ground. Circuit 40—41 being carefully shielded from the remaining parts of the circuit by a shield 40' is tuned to the normal or center frequency of the oscillator, whereby to result in a normal or steady plate current I_0 which varies in substantially the same manner as shown in Figure 3 as a result of variations of the oscillating frequency or capacity of the photovoltaic cell.

In order to prevent interaction between the oscillator and discriminator circuits, a further screen grid 38 maintained at a suitable positive potential and bypassed to ground for radio frequency current is interposed between the oscillator grid 14 and the outer control grid 15. The electron current to the grid 38 undergoes a similar variation as the plate current but in a sense opposite to that shown in Figure 3 as pointed out hereinabove.

The resonant discriminating circuit 40—41 may be of the series tuned type instead of a parallel tuned circuit as shown or it may be replaced by any other resonant impedance such as a piezo-electric crystal shunted by a high ohmic resistance or choke coil. When using a crystal, the slope or steepness of the operating characteristic or conversion sensitivity of the capacity changes into corresponding output current changes may be greatly increased due to the high "Q" of the piezo-electric crystal. In this manner considerable output current changes may be obtained by using a simple discharge tube.

The screen grid 38 and anode 16 are loaded by suitable resistors 42 and 43, respectively, to obtain screen and plate potential variations for operating the indicator 44 directly connected between the screen 38 and anode 16. Since the screen and anode currents vary in an opposite sense as pointed out, a suitable design of resistors 42 and 43 will result in a balance of the normal current I_0 through the indicator 44, whereby to dispense with the separate balancing source 25 shown in Figure 2.

According to a further improvement, as shown in Figure 6, the output potential changes are fed back upon the photovoltaic cell 18 in inverse phase for the purpose of stabilizing the oscillating frequency and/or providing a certain amount of inverse feed back for the signal frequencies to improve the fidelity of translation, to reduce noise, and for other purposes. The potential of the grid 38 is applied for this purpose to the upper or covering electrode of the photovoltaic cell 18 through a choke coil 45. Blocking condenser 36, in addition to preventing a rectified current through the photovoltaic cell has the further function of preventing a short circuit of the screen voltage through the coil 20.

As previously mentioned, the capacity of the photovoltaic cell may be varied by a biasing po-

tential applied to the cell in the current blocking direction. In Figure 6 the potential fed back from the screen 38 acts in the blocking direction and in a manner to provide an inverse feed back effect in the input oscilator circuit.

Thus, assuming an increase of the light intensity, this will result in an increased electron emission into the boundary space B. This increased electron emission causes a greater space charge effect and accordingly a reduced capacity or increased oscillating frequency. The increased oscillating frequency, on the other hand, results in an increase of the average current in the circuit of screen grid 38 varying in a sense opposite to the average plate current i_a as shown in Figure 3. This increased screen current in turn causes a decrease of the potential on screen 31 and accordingly a decrease of the biasing potential in the blocking direction of the photovoltaic cell. This, in turn, results in an increase of the capacity of the cell. This increased capacity thus counteracts the initial capacity decrease, whereby to result in a negative or inverse feed back effect, as is understood.

While the explanation above given accounts for the effects taking place under varying light intensities and biasing potentials applied in the current blocking direction, other phenomena taking place in a photovoltaic cell may result in a variation in a sense opposite from that given. However, in any case, the output current variation i_a can be caused to have a proper sense by using either the plate or screen currents for producing the feed back potential in such a manner as to obtain a desired negative or inverse feed back or degenerative effect in the manner pointed out.

By the proper design of the choke coil 45, the feed back may be adjusted for any desired frequency or range of frequencies to obtain special effects such as the elimination of disturbing frequencies or frequency bands.

In an alternative arrangement the choke coil 45 may be designed so as to limit the inverse feed back to relatively slow variations of the oscillating frequency due to drift and other causes of instability. In this case, the system represents a most simple and efficient means for stabilizing the center or carrier frequency, resulting in increased accuracy and efficiency of conversion of the light intensity variations into corresponding output current changes.

Thus, if the center or carrier frequency of the oscillator deviates from its proper value determined by the natural or resonating frequency of the discriminating circuit 40—41, which latter is advantageously replaced by a piezo-electric crystal element bypassed by a high ohmic resistance or choke coil, the corresponding variation of the potential on the plate 16 will result in a biasing change of the photovoltaic cell 18 in such a manner as to vary the capacity of the cell and to restore the proper oscillating frequency. More particularly, a slight increase of the oscillating or carrier frequency will result in an increase of the steady current to the screen grid 38. This in turn causes a decrease of the screen potential and consequently of the negative biasing potential impressed on the photovoltaic cell 18. Consequently, the capacity of the cell will be increased so as to counteract the assumed initial rise of carrier frequencies. A similar effect takes place in the opposite direction if the carrier frequency decreases from its assigned value.

An adjustable resistance 46 inserted in the feed back path serves to control the normal or steady bias potential applied to the photovoltaic cell for manually adjusting the center or carrier frequency in relation to the frequency of the discriminating circuit 40—41.

As pointed out, the feed back circuit may be connected to the plate 16 and if no feed back is desired the covering electrode of the photovoltaic cell may be connected to the opposite end of either of the resistors 42 or 43 through the adjustable resistance 46.

According to a further modification of the invention, the capacitance variations of the photovoltaic cell may be utilized to phase-modulate a carrier oscillation of constant frequency and translated into current amplitude changes by a suitable phase modulation detector known in the art. Such a system may, for instance, be obtained by stabilizing the frequency of the oscillator in Figure 4 in a known manner by a piezo-electric crystal or the like and replacing the discriminator 25 by a suitable phase modulation detector of any type known in the art.

The inverse or degenerative feed back as shown in Figure 6 may be such as to substantially counteract the oscillating frequency changes from the assigned center or carrier frequency caused both by drift and due to the variations of the capacity of the photovoltaic cell in response to light intensity fluctuations. In other words, the feed back potential derived from the screen 14 and applied to the photovoltaic cell 18 is of such a value to counteract initial capacity changes of the photovoltaic cell to leave only a relatively small differential necessary for the continuous operation of the circuit in such a manner as to maintain the oscillating frequency at a substantially constant value determined by the tuning frequency of the discriminating circuit 40—41 or equivalent resonating impedance. The discriminating current variations in the screen and plate circuits are then proportional to the capacity changes of the photovoltaic cell and may be utilized for operating an output device in the manner shown. A self-balancing system of this type has the advantage of great stability and freedom from noise and other interference, which in turn results in increased accuracy and sensitivity of the circuit.

While I have shown and described a few desirable embodiments of my invention, it is to be understood that this disclosure is for the purpose of illustration and that various changes in the circuits and arrangement of parts may be made without departing from the spirit and scope of the invention as defined in the appended claims. The specification and drawing are accordingly to be regarded in an illustrative rather than a restrictive sense.

I claim:

1. A translation system comprising a blocking layer photoelectric cell, an electron discharge tube comprising a cathode, a first control grid, a screen grid, a second control grid and an anode, a regenerative oscillating circuit operatively connected to said first control grid and said screen grid to generate sustained oscillations, said circuit including said cell as an effective tuning element, whereby to vary the oscillating frequency in accordance with the inherent capacity changes of said cell in response to light intensity fluctuations, an output circuit connected to said tube, resonant impedance means having a predetermined resonating frequency and connected to said other control electrode, whereby to cause

output current changes in proportion to said light intensity fluctuations, means for biasing said cell by constant uni-directional potential applied in the current blocking direction, blocking condenser means to prevent continuous current flow through said cell due to rectifying action thereof, and translating means in the output circuit of said tube.

2. A translation system comprising a blocking layer photoelectric cell, an electron discharge tube comprising a cathode, a first control grid, a screen grid, a second control grid and an anode, a regenerative oscillating circuit operatively connected to said first control grid and said screen grid to generate sustained oscillations, said circuit including said cell as an effective tuning element, whereby to vary the oscillating frequency in accordance with the inherent capacity changes of said cell in response to light intensity fluctuations, load resistance means connected to both said anode and said screen grid, an output circuit connected between said anode and said screen grid, resonant impedance means having a predetermined resonating frequency and connected to said other control electrode, whereby to cause current variations in said output circuit in proportion to said light intensity fluctuations, means for biasing said cell by constant uni-lateral potential applied in the current blocking direction, blocking condenser means to prevent continuous current flow through said cell due to rectifying action thereof, and translating means in the output circuit of said tube.

3. A translation system comprising a blocking layer photoelectric cell. an electron discharge tube having a cathode, a first control grid, a screen grid, a second control grid and an anode, a regenerative oscillating circuit operatively connected to said first control grid and said screen grid to generate sustained oscillations, said circuit including said cell as an effective tuning element, whereby to vary the oscillating frequency in accordance with the inherent capacity changes of said cell in response to light intensity fluctuations, an output circuit connected to said tube, resonant impedance means having a predetermined resonating frequency connected to said second control grid, whereby to cause output current variations in proportion to said light intensity fluctuations, blocking condenser means to prevent continuous current flow through said cell due to rectifying action thereof, and further means to apply uni-lateral feed back bias potential from said output circuit to said cell in the current blocking direction, and translating means in the output circuit of said tube.

4. A translation system comprising a blocking layer photoelectric cell, an electron discharge tube comprising a cathode, a first control grid, a screen grid, a second control grid and an anode, a regenerative oscillating circuit operatively connected to said first control grid and said screen grid to generate sustained oscillations, said circuit including said cell as an effective tuning element, whereby to vary the oscillating frequency in accordance with the inherent capacity changes of said cell in response to light intensity fluctuations, an output circuit connected to said tube, resonant impedance means having a predetermined resonant frequency connected to said control electrode, whereby to cause output current fluctuations in proportion to said light intensity fluctuations, blocking condenser means to prevent a continuous current flow through said cell due to rectifying action thereof, and further means

to apply uni-directional feed back potential from said output circuit in the current blocking direction to said cell, to vary the inherent capacity of said cell in response to relatively slow variations of and to counteract oscillating frequency variations from a predetermined assigned value.

5. A translation system comprising a blocking layer photoelectric cell, an electron discharge tube having a cathode, a first control grid, a screen grid, a second control grid and an anode, a regenerative oscillating circuit operatively connected to the first control grid and the screen grid to generate sustained oscillations, said circuit including said cell as an effective tuning element, whereby to vary the oscillating frequency in accordance with the inherent capacity changes of said cell in response to light intensity fluctuations, a load resistance connected to said screen grid, resonant impedance means having a predetermined resonating frequency and connected to said second control electrode, whereby to cause output current variations in the screen grid and anode circuits in proportion to said light intensity fluctuations, a feed back path from said screen grid to said cell to apply uni-lateral screen potential to said cell in the current blocking direction, and blocking condenser means to prevent continuous current flow through said cell due to rectifying action thereof, and translating means in the anode circuit of said tube.

6. The combination with a blocking layer photoelectric cell having a base electrode, a light sensitive layer and a translucent covering electrode intimately connected with each other, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said light sensitive layer through said covering layer; of a conversion circuit comprising an oscillation generator for generating a high frequency current; a frequency discriminator connected to said generator, said discriminator including a resonant impedance means and adapted to produce an output current proportional to the relative frequency departure between the oscillation frequency and the resonating frequency of said impedance means; circuit connections between said cell and said circuit for controlling the frequency departure between said generator and said discriminator; a translating device energized by said output current, and further means for biasing said cell by a constant uni-directional potential difference applied in the current direction thereof.

7. The combination with a blocking layer photoelectric cell having a base electrode, a light sensitive layer and a translucent covering electrode intimately connected with each other, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said light sensitive layer through said covering layer; of a conversion circuit comprising an oscillation generator for generating a high frequency current; a frequency discriminator connected to said generator, said discriminator including a resonant impedance means and adapted to produce an output current proportional to the relative frequency departure between the oscillation frequency and the resonating frequency of said impedance means; circuit connections between said cell and said circuit for controlling the frequency departure between said generator and said discriminator; a translating device energized by said output current; blocking condenser means to prevent a continuous current flow through said cell due to rectification thereby of high frequency current, and further means for biasing said cell by a

constant uni-directional potential difference applied in the current direction thereof.

8. A photoelectric system comprising a resonant circuit; a blocking-layer photoelectric cell having a base electrode, a light-sensitive layer and a translucent covering electrode intimately connected with each other, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said light-sensitive layer through said covering electrode; said cell being connected in said circuit to form an effective tuning element thereof; means to establish a high frequency current in said circuit; further means for translating the tuning frequency variations of said circuit with respect to the frequency of said current into corresponding output current amplitude changes; a translating device energized by said output current; and further means for biasing said cell by a constant uni-directional potential difference applied in the current blocking direction thereof.

9. A photoelectric system comprising a resonant circuit; a blocking-layer photoelectric cell having a base electrode, a light-sensitive layer and a translucent covering electrode intimately connected with each other, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said light-sensitive layer through said covering electrode; said cell being connected in said circuit to form an effective tuning element thereof; means to establish a high frequency current in said circuit; a frequency discriminator connected to said circuit for translating the tuning frequency variations of said circuit into corresponding output current amplitude changes; a translating device energized by said output current; blocking condenser means to prevent a continuous current flow through said cell due to rectification thereby of high frequency current; and further means for biasing said cell by constant uni-directional potential applied in the current blocking direction thereof.

10. A photoelectric system comprising an oscillator including a resonant circuit having a frequency determinative of the oscillation frequency; a blocking-layer photoelectric cell having a base electrode, a light-sensitive layer and a translucent covering electrode intimately connected together, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said layer through said covering electrode; said cell being connected in said circuit to form an effective tuning element thereof; a frequency discriminator connected to said oscillator for converting the oscillation frequency variations into corresponding output current amplitude changes; a translating device energized by said output current; and means for biasing said cell by a constant uni-directional potential difference applied in the current blocking direction thereof.

11. A photoelectric system comprising an oscillator including a resonant circuit having a frequency determinative of the oscillation frequency; a blocking-layer photoelectric cell having a base electrode, a light-sensitive layer and a translucent covering electrode intimately connected together, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said layer through said covering electrode; said cell being connected in said circuit to form an effective tuning element thereof; a frequency discriminator connected to said oscillator for converting the oscillation frequency variations into corresponding output current amplitude changes; a translating device energized by the output current of said discriminator; blocking condenser means to prevent a continuous current from passing through said cell due to rectification thereby of high frequency current; and further means for biasing said cell by constant uni-directional potential difference applied in the current blocking direction.

12. A photoelectric system comprising a blocking-layer photoelectric cell having a base electrode, a light-sensitive layer and a translucent covering electrode intimately connected together, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said light-sensitive layer through said covering electrode; an electron discharge tube including a cathode, a control grid and an anode; an output circuit connected between said cathode and said anode; means to cause the electron stream of said tube to fluctuate according to a substantially constant operating frequency; means to produce a concentrated electron space charge adjacent to said control grid; a resonant circuit connected between said control grid and cathode and including said cell as an effective tuning element thereof; a translating device arranged to be energized by the steady current through said output circuit; and means for biasing said cell by a constant uni-directional potential difference applied in the current blocking direction thereof.

13. A photoelectric system comprising a blocking-layer photoelectric cell having a base electrode, a light-sensitive layer and a translucent covering electrode intimately connected together, whereby said cell has an inherent capacity subject to the intensity of light impinged upon said light-sensitive layer through said covering electrode; an electron discharge tube including a cathode, a control grid and an anode; an output circuit connected between said cathode and anode; means to cause the electron stream of said tube to fluctuate according to a substantially constant operating frequency; means to produce a concentrated electron space charge adjacent to said control grid; a resonant circuit connected to said grid electrode and including said cell as an effective tuning element; a translating device arranged to be energized by the steady current through said output circuit; blocking condenser means to prevent a continuous current flow through said cell due to rectification thereby of high frequency current, and further means for biasing said cell by a constant uni-directional potential difference applied in the current blocking direction thereof.

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