

Feb. 13, 1945.

J. C. BARNES

2,369,206

PICTURE TRANSMISSION SYSTEM

Filed Jan. 28, 1943

2 Sheets-Sheet 1

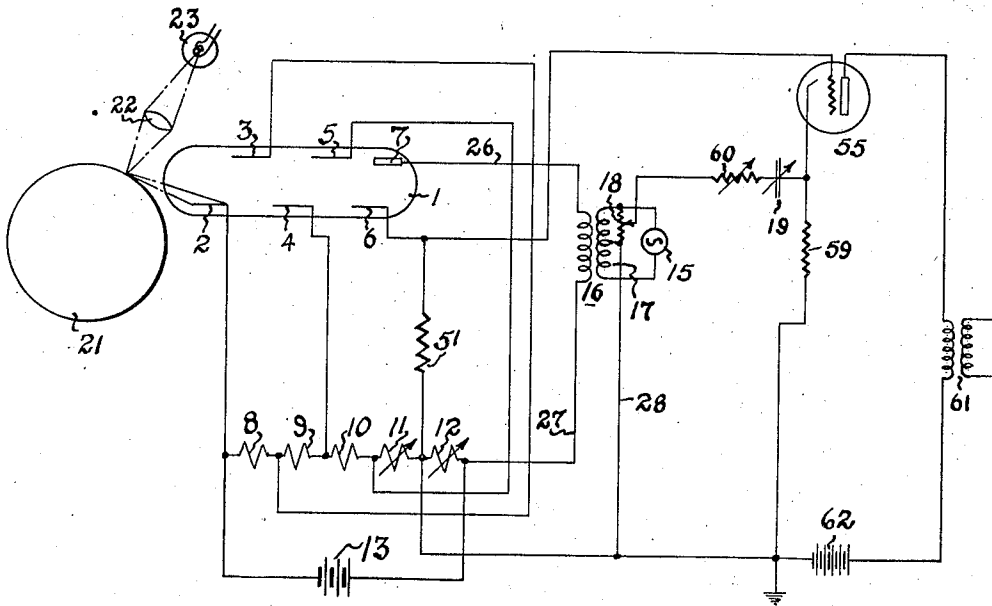


Fig. 1

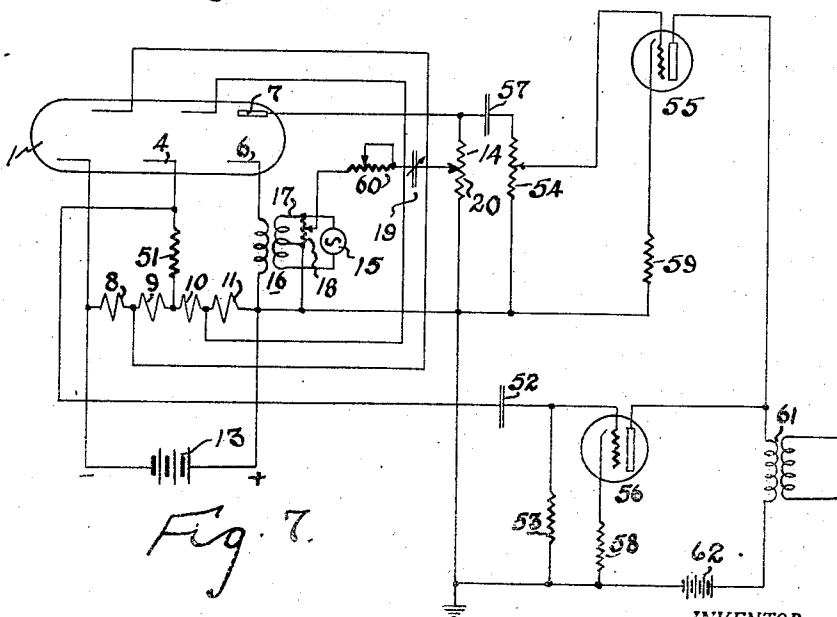


Fig. 7

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2 Sheets-Sheet 2

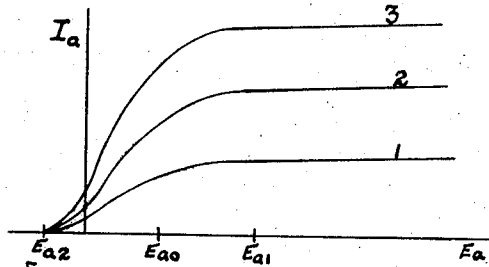


Fig. 2.

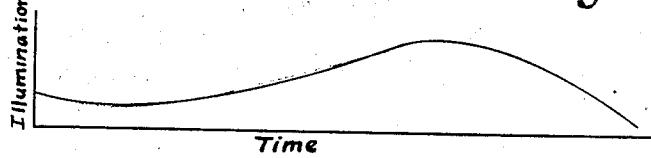


Fig. 3.

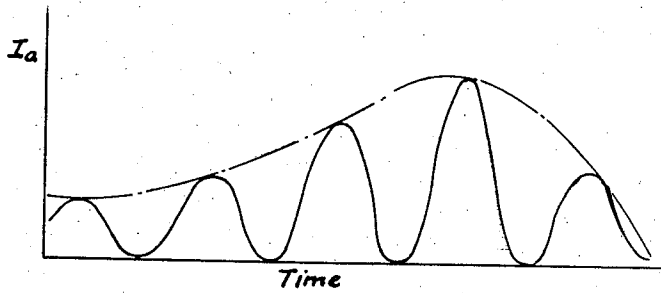


Fig. 4.

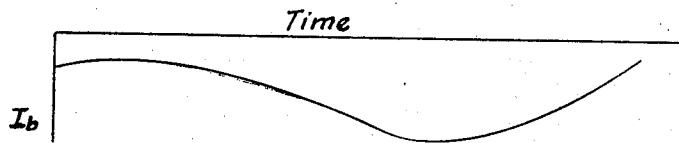


Fig. 5.

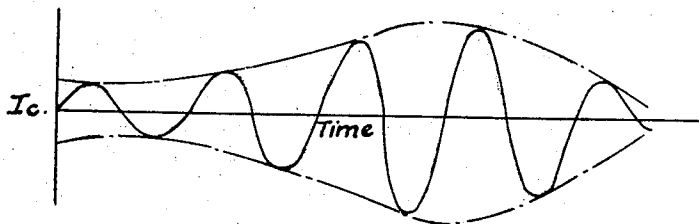


Fig. 6.

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PICTURE TRANSMISSION SYSTEM

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Application January 28, 1943, Serial No. 473,789

22 Claims. (Cl. 179—171.5)

This invention is directed to improvements in that portion of a picture transmission system which is employed for converting the elemental areas of a scene such as a photographic negative or print into corresponding electrical variations for transmission to a receiving point.

The broad object of the invention is to provide an assemblage of devices by means of which a carrier signal modulated in accordance with the representative light produced by the usual scanning devices is simply and efficiently produced.

A specific advantage of the invention herein disclosed lies in producing the modulated carrier substantially free of any component which is not related to the carrier. In circuits which produce a carrier modulated by the light obtained by scanning the scene there may be present in the output carrier, side bands, and a component related to the illumination from the scanned picture but not related to the carrier. The latter will be referred to as the signal component. The signal component occupies a frequency band from nearly zero frequency to a frequency depending upon the transmission speed and definition. It represents a distortion of the modulated carrier. It is desirable, of course, to eliminate the signal component and the most common procedure has been that of making the carrier frequency sufficiently high so that a band pass filter or a high pass filter or other frequency selective circuit can be used to pass the carrier and side bands while attenuating the signal component. However, when the speed or definition is high the carrier becomes so high to permit filtering of the signal component that it cannot be transmitted over the ordinary telephone talking circuit commonly used in picture transmission systems. This requires a second modulation to produce a lower carrier frequency for transmission. Accordingly, it is an advantage where high speed or high definition is required to use a modulator whose output does not contain the signal component.

Another advantage of the invention is found in the method of applying the carrier signal voltage to the electron multiplier, whereby the current saturation characteristics of its output circuit are advantageously employed, and where a comparatively small carrier voltage supply is required.

Other advantages of the novel system herein disclosed will be best appreciated by a brief reference to several solutions heretofore proposed.

This application is a continuation in part of my copending application Serial No. 426,813, filed

January 15, 1942, and likewise entitled "Picture transmission system."

This invention resides substantially in the combination, construction, arrangement and relative location of parts, as will be described in detail below.

In the accompanying drawings,

Figure 1 is a diagrammatic illustration of that portion of a picture transmission system to which the invention herein disclosed has been applied;

Figure 2 are curves of current and voltage relationship for the output circuit of the electron multiplier;

Figures 3, 4, 5 and 6 comprise characteristic curves representing light and current variations with respect to time involved in the operation of the system; and

Figure 7 is a diagrammatic illustration of an arrangement like that of Figure 1 involving certain modifications of this invention as will hereinafter be fully explained.

As illustrated, the circuit of this invention employs an electron multiplier of the type having preferably a photo-electric cathode and having more than one stage of secondary electron emission amplification. In Figure 1 of the drawings such a device has been diagrammatically illustrated at 1. Within a properly evacuated vessel is disposed the photo-electric cathode 2 which is the primary source of electrons released by the scanning light beam when impinged thereon. In accordance with the usual practice this light signal is produced from a suitable light source 23, the light from which is focused by a suitable optical system 22 to a point upon the rotatable cylinder 21. As is well known, this cylinder serves as a support for the picture to be transmitted and relative motion in accordance with the usual practice is effected between the picture surface and the focused scanning light so that the light-spot progressively scans the entire picture, and therefore successively traverses the entire area thereof by tracing a helical path from one end to the other.

Light is reflected from each point or elemental area illuminated by the focused light point as it scans the picture to the photo-electric cathode 2 in varying intensity in accordance with the variations in the light reflecting ability of the surface being scanned, which ability, of course, varies with the variations in the tonal value of the picture. The electrons released from the cathode 2 are focused in accordance with established principles upon the secondary emitter 3 where they in turn release electrons which are focused upon the secondary emitter 4, and so on to the

final emitter 6; the quantities of electrons released being progressively increased in accordance with one function of such a device. Electrons released by the emitter 6 are caused to impinge upon the anode 7 of the multiplier. A voltage divider comprising the serially connected and properly proportioned resistors 8, 9, 10, 11 and 12, is connected between the cathode 2 and one terminal of the secondary of transformer 16 by the wire 27. The high voltage source 13 is connected across the terminals of the voltage divider. The anode 7 is connected by a wire 26 to the other terminal of the secondary. As illustrated, the secondary emitters 3, 4, 5 and 6 are connected successively to the voltage divider at points of increasing positive potential. These connections, of course, may be varied to determine the proper relative operating voltages for these electrodes. The junction point of resistors 11 and 12, both of which are variable, as illustrated, is connected by a grounded wire to the negative terminal of a suitable high voltage current supply source 62. The primary 17 of the transformer 16 is connected to a suitable alternating carrier current source 15 such as a vacuum tube oscillator, with the result that the carrier voltage is applied in series with the anode 7 and the voltage supply source 13. A potentiometer 18 is connected across one-half of the primary winding 17 and the mid-point of the secondary is grounded by wire 28, as shown. The movable contact of the potentiometer is connected through a variable resistor 60 and a variable capacitor 19 to the cathode of a triode 55. The cathode of the triode is also connected to ground through the resistor 59. The grid electrode of this triode is connected as shown to the electrode 6 of the multiplier. The anode of the triode is connected in series with the primary of the output transformer 61, and the current source 62. From a study of this circuit it will be seen that the electrode 6 is coupled to the grid cathode circuit of the triode 55 by means of resistor 51 which acts as a coupling resistance. It may be noted that suitable combinations of resistance, inductance and capacity may be substituted for the resistor 51 to give the desired frequency characteristics to the circuit. The output of the circuit thus described may be supplied through the transformer 61 to any suitable work circuit such as a transmission line.

The operation of this circuit and the manner in which the signal component previously referred to is eliminated from the output current will be described by reference to Figures 2 to 6 inclusive. In Figure 2 the anode current I_a is plotted on the ordinate of the graph while the voltage E_a between last secondary emitter 6, and the anode 7 is plotted along the abscissa of the graph. The curves marked 1, 2 and 3 in Figure 2 are those resulting from different light values employed to energize the multiplier 1, and are of increasing intensity in that order. It is to be noted that the corresponding curve for the condition of no illumination is a straight line coincident with the abscissa E_a . The current flowing in the anode circuit and the multiplier is proportional to the light impinging upon the photo-electric cathode 2 for a constant value of E_a . It will be seen that for any particular light value as E_a becomes negative, the anode current falls to zero at the point E_{a2} . As E_a becomes increasingly positive the anode current increases rapidly at first but ultimately flattens off to an almost constant value. The carrier voltage impressed upon the anode 7 causes a periodic variation in E_a about an average value

determined by the direct current voltage drop across the resistor 12. This average value may be adjusted by varying the value of the resistor 12, but upon adjustment for a particular working condition this adjustment may be made permanent if desired. This periodic variation in E_a produces a periodic variation in the anode current which depends on both the instantaneous light value and the carrier voltage supplied through the transformer 16. For example, it follows that if the illumination varies with time as shown in Figure 3, the anode current I_a will vary with time as shown in Figure 4. It may be seen from Figure 4 that I_a includes a signal component as well as carrier and side bands.

The current in electrode 6 to which the output is coupled may be regarded as the algebraic sum of the anode current consisting of secondary emission electrons going to the anode plus the current consisting of electrons coming from the preceding electrode 5. These currents are opposing. The current from the preceding electrode is proportional to the illumination and is not modulated and therefore consists entirely of signal component. The ratio of the secondary emission current to the current from the preceding electrode 5 may be controlled by the polarizing voltage across resistor 11. By adjusting the value of the resistor 11 so that the current from the preceding electrode 5 equals the signal component of the anode current the signal components cancel so that only the carrier and side band currents flow in the coupling resistor 51, in series with the electrode 6. In the example of Figure 5, I_b is the current flowing from electrode 5 to electrode 6 and is proportional to the illumination reaching the electron multiplier tube 1. The total current in electrode 6 is shown as I_c in Figure 6 and is a modulated carrier without a signal component. This is the type of output desired and secured by the circuit of Figure 1.

The current in electrode 6 flows through the resistor 51 and therefore produces a corresponding voltage drop across it. This voltage drop is applied to the grid of the triode 55, and of course appears in the anode circuit thereof suitably amplified for application to the work circuit through the coupling transformer 61. It will at once be apparent that the amplifier may comprise more than one vacuum device depending upon the requirements and the conditions under which the apparatus must operate. It is, of course, apparent that the source 62 provides the operating voltage to the anode of the triode 55 and the resistor 59 in the cathode circuit of the triode provides a proper grid bias. This resistor is also included in a circuit for introducing a balancing voltage, as will be described.

Thus, in addition to the carrier voltage drop across resistor 51 produced by the emission current as described above, there will be an undesired carrier voltage component which will result from current flowing in the circuit comprising the secondary of transformer 16, the inherent capacity between the anode 7 and electrode 6, conductor 26, resistor 51, resistor 12, and conductor 27. This voltage component can be balanced out or opposed by introducing a part of the carrier voltage properly phased across the resistor 59 through the variable capacitor 19 and variable resistor 60 which by the proper choice of values thereof will substantially neutralize this undesired alternating voltage component or undesired carrier voltage component. As a result a greater percentage of modulation is produced by

changes in the scanning light intensity actuating the cathode 2.

The effect of fluctuations of the carrier voltage amplitude may be minimized by having the carrier voltage cause a change in E_a from a value less than E_{a2} where the current is zero, to a value greater than E_{a1} where the current has reached an almost constant value. The average voltage E_{a0} is preferably selected so as to correspond to a point on the curve half way between E_{a1} and E_{a2} . In other words, the voltage drop appearing across the resistor 12 of the voltage divider is represented by the voltage E_{a0} of Figure 2 for proper operating conditions.

There is illustrated in Figure 7 another circuit arrangement for accomplishing elimination of the signal component. In this circuit, as illustrated, the scanning mechanism has been omitted for the sake of simplicity.

The electron multiplier 1 is similar to that previously described as well as the primary operating circuits therefor. In this circuit, however, the secondary of transformer 16 is connected between electrode 6 and the high voltage current supply source 13, as appears in Figure 7. The primary of this transformer is connected to the carrier current source 15 as before, and the potentiometer 18 employed as before has its contact connected through the variable resistor capacitor combination 60-19 to a movable contact which divides a resistor into the parts 14 and 20. The resistor combination 14-20 is connected in series between the anode 7 and the high voltage source 13. The grid of the triode 55 is connected to the movable contact of a resistor 54 connected between the anode 7 and ground through a capacitor 57. The resistor 59 as before connects the cathode of the triode 55 to ground as shown. The grid of another triode 56 is connected to the electrode 4 through the conventional resistance-capacity network consisting of the resistors 53 and 51 and the capacitor 52. The resistor 58 connects the cathode of the triode 56 to ground. It will be seen that the voltage source 62 supplies the operating potentials for the anode circuits of both triodes 55 and 56. The primary of the coupling transformer 61 is connected in the output circuits of both triodes 55 and 56. As a result of the connection through the variable resistor 60 and the variable capacitor 19 a properly phased voltage may be made to appear across the resistor 20 which will oppose the voltage drop across resistors 14 and 20, resulting from the current flowing due to the inherent capacity between the electrode 6 and the anode 7.

In the operation of this circuit the current in the anode circuit, as previously shown, will have the form illustrated by the curve in Figure 4. The current in electrode 4 will have the form illustrated by the curve in Figure 5, but of a lower amplitude than the current in the circuit of anode 7. Its direction is such that the voltage across the resistor 51 will be in the opposite direction to the signal component of the voltage across resistors 14 and 20. Therefore, by applying a portion of the voltage across resistors 14 and 20 to the grid of the vacuum tube of the triode 55 the signal component in the plate circuit of triode 55 will be cancelled by the current in the plate circuit of triode 56. The current in electrode 4 is of too low a value for direct use as a neutralizing current, and therefore, the amplifier 56 is employed to amplify it to the proper value. Adjustment of potentiometer 54 also aids in this effect by controlling the value of the volt-

age applied to the grid of the amplifier 55. As a result no signal component will appear in the secondary transformer 61. Thus by means of this circuit both the undesired signal components and the undesired carrier voltage component due to the inherent capacity between the electrode 6 and anode 7 of the multiplier are eliminated.

From the above description it will be apparent to those skilled in the art that the subject matter of this invention may be embodied in other circuit arrangements, and I do not, therefore, desire to be strictly limited to the disclosure as given therein in an illustrative sense, but rather by the scope of the claims granted me.

What is claimed is:

1. In a system for converting light variations to a modulated alternating current, the combination including an electron multiplier having a cathode and a plurality of secondary emitters and an anode arranged so that electrons travel from the cathode to the secondary emitters and anode in succession, a circuit including said anode and the secondary emitter from which it receives electrons, means for impressing an alternating carrier voltage on said circuit, a circuit including the secondary emitter cooperating with the anode and the secondary emitter from which it receives electrons, means for impressing operating potentials upon said secondary emitters and anode, said two circuits having a common connection, an impedance in said connection and an output circuit connected across said impedance.

2. In the combination of claim 1, the means for impressing operating potentials upon said secondary emitters and anode including adjustable resistors for varying the potentials applied to the two secondary emitters specifically mentioned.

3. In the combination of claim 1, said impedance comprising a resistor.

4. In the combination of claim 1, said means for applying operating potentials to the secondary emitters specifically mentioned comprising a pair of adjustable resistors and said impedance comprising a resistor.

5. In the combination of claim 17, said impedance comprising a resistor.

6. In the combination of claim 17, said means including adjustable resistors.

7. In the combination of claim 17, said impedance comprising a resistor and said means including a pair of resistors.

8. A system which converts light variations to a modulated alternating current including an undesired signal component comprising a photo-electric multiplier having a photo-electric cathode, a plurality of secondary emitters and an anode associated with one of said emitters, means for supplying operating potentials to said emitters and anode, means for impressing an alternating carrier voltage upon the emitter associated with the anode, an output circuit for said multiplier including its anode, a vacuum tube amplifier having an input and an output circuit, means for coupling said input circuit to the output circuit of said multiplier, and means connected to an emitter preceding the emitter associated with the anode of the multiplier for applying a properly phased neutralizing current to the output circuit of said vacuum tube amplifier to cancel the signal component therein.

9. In the combination of claim 8, said last means comprising a vacuum tube amplifier having an input circuit and an output circuit, the

connection from said preceding emitter being to its input circuit.

10. A system which converts light variations to a modulated alternating current including an undesired signal component comprising a photo-electric multiplier having a photo-electric cathode, a plurality of secondary emitters and an anode associated with one of said emitters, means for supplying operating potentials to said emitters and anode, means for impressing an alternating carrier voltage upon the emitter associated with the anode, a vacuum tube amplifier having an input and an output circuit, means for coupling said input circuit to the output circuit of said multiplier, means connected to an emitter preceding the emitter associated with the anode of the multiplier for applying a properly phased neutralizing current to the output circuit of said vacuum tube amplifier to cancel the signal component therein, and means including a variable impedance for applying a portion of the carrier voltage properly phased to the input circuit of the vacuum tube amplifier coupled to the output circuit of said multiplier.

11. In a system for converting light variations to a modulated alternating current, the combination including an electron multiplier having a cathode and a plurality of electrodes and an anode arranged so that electrons travel from the cathode to the electrodes and anode in succession, a circuit including said anode and the electrode from which it receives electrons, means for impressing an alternating carrier voltage on said circuit, a circuit including the electrode cooperating with the anode and the electrode from which it receives electrons, means for impressing operating potentials upon said electrodes and anode, said two circuits having a common connection, an impedance in said connection, an output circuit connected across said impedance, and an impedance connection from said carrier voltage means to said output circuit properly phased for neutralizing the carrier voltage component therein due to the flow of current through the inherent capacity between the electrode cooperating with the anode and the anode of the multiplier.

12. In the combination of claim 11, said last impedance comprising an adjustable series resistor-capacitor combination.

13. In a system for converting light variations to a modulated alternating current, the combination including an electron multiplier having a cathode and a plurality of electrodes and an anode arranged so that electrons travel from the cathode to the electrodes and anode in succession, a circuit including said anode and the electrode from which it receives electrons, means for impressing an alternating carrier voltage on said circuit, a circuit including the electrode cooperating with the anode and the electrode from which it receives electrons, means for impressing operating potentials upon said electrodes and anode, said two circuits having a common connection, an impedance in said connection, a vacuum tube having at least a cathode and a grid, a circuit for connecting said impedance across said cathode and grid, and an impedance connection from said carrier voltage means to said cathode properly phased for neutralizing the carrier voltage component therein due to the flow of current through the inherent capacity between the electrode cooperating with the anode and the anode of the multiplier.

14. In the combination of claim 13, said last

impedance comprising an adjustable series resistor-capacitor combination.

15. In a system for converting light variations to a modulated alternating current, the combination including an electron multiplier having a cathode and a plurality of emitter electrodes and an anode arranged so that electrons travel from the cathode to the emitter electrodes and anode in succession, a circuit including said anode and the emitter electrode from which it receives electrons, means for impressing an alternating carrier voltage on said circuit, a circuit including the emitter electrode cooperating with the anode and the emitter electrode from which it receives electrons, means for impressing operating potentials upon said emitter electrodes and anode, said two circuits having a common connection, an impedance in said connection, a vacuum tube having at least a cathode and grid across said impedance, a resistor in series with said cathode, and an impedance connection from said carrier voltage means to said cathode properly phased for neutralizing the carrier voltage component therein due to the flow of current through the inherent capacity between the emitter electrode cooperating with the anode and the anode of the multiplier.

16. In the combination of claim 15, said last impedance comprising an adjustable series resistor-capacitor combination.

17. A system for converting light variations into a modulated alternating current including an electron multiplier having a cathode and a secondary emitter positioned to receive electrons therefrom and a plurality of additional electrodes for receiving electrons in succession from said emitter, means for applying operating potentials to all of said electrodes, means for applying an alternating carrier voltage to one of said additional electrodes, both of said means including a common connection to another of said additional electrodes, an impedance in said common connection, a vacuum tube amplifier having input and output circuits, and means for connecting the amplifier across said impedance.

18. In the combination of claim 17, means for applying a neutralizing voltage component of the carrier voltages to said amplifier.

19. In the combination of claim 17, means for applying a neutralizing voltage component of the carrier voltage to the input circuit of said amplifier.

20. In the combination of claim 17, means for applying a neutralizing voltage component of the carrier voltage to the output circuit of said amplifier.

21. A system for converting light variations into a modulated alternating current including an electron multiplier having a cathode and a secondary emitter positioned to receive electrons therefrom and a plurality of additional electrodes for receiving electrons from said emitter, means for applying operating potentials to all of said electrodes, a circuit including a source of carrier current connected to a pair of said additional electrodes in which circuit both the signal modulated carrier and signal currents flow, a second circuit connected to another pair of said additional electrodes in which the signal current alone flows, and a work circuit interconnecting said two circuits so as to substantially neutralize the signal current in the work circuit.

22. In the combination of claim 21, amplifying means in said second circuit.

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