Oct. 17, 1933. A. A. SHOUP 1,930,541

PHOTOCELL AND CIRCUIT

Filed Feb. 15, 1929 3 Sheets-Sheet 1

Fig. 1.

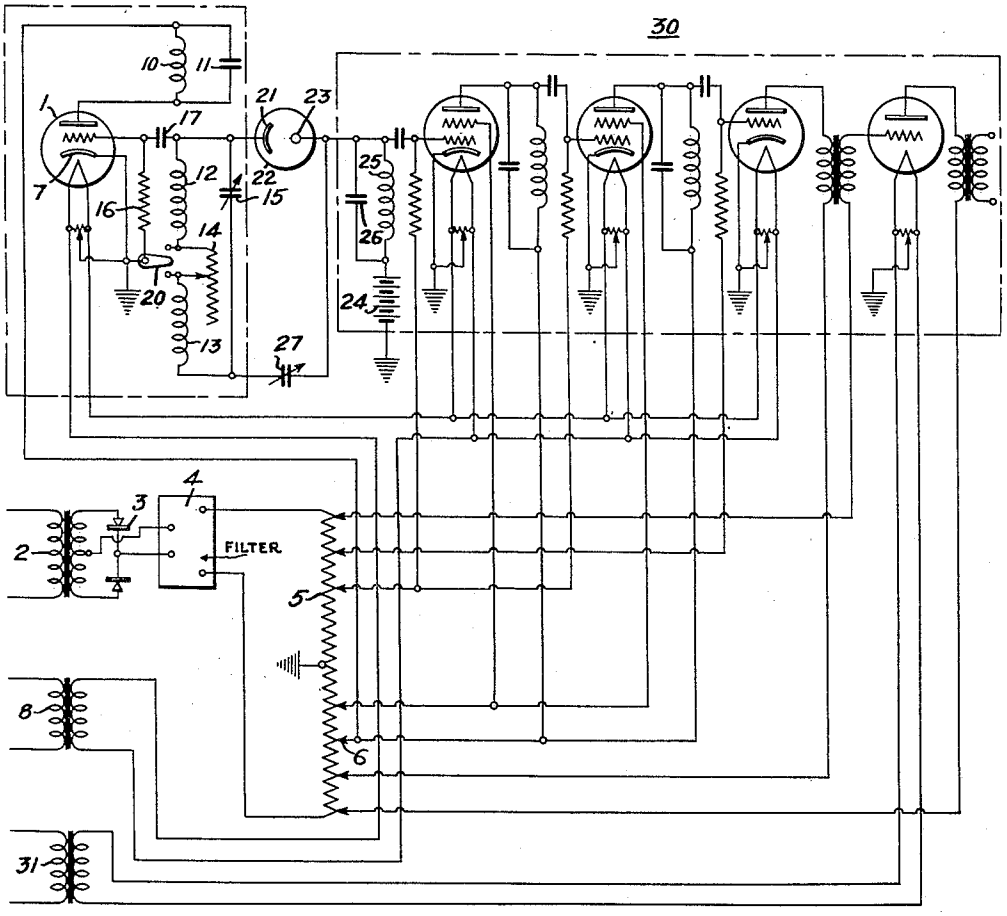
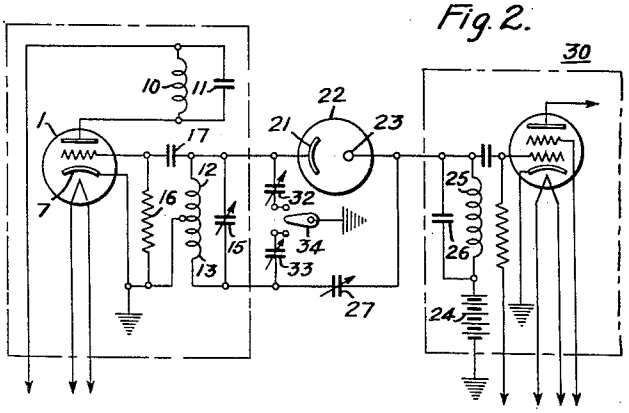


Fig. 2.



INVENTOR
Allen A. Shoup.
BY
Wesley G. Carr
ATTORNEY

Oct. 17, 1933. A. A. SHOUP 1,930,541

PHOTOCELL AND CIRCUIT

Filed Feb. 15, 1929 3 Sheets-Sheet 2

Fig. 3.

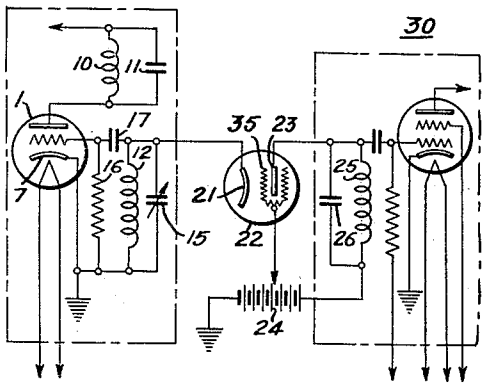


Fig. 4.

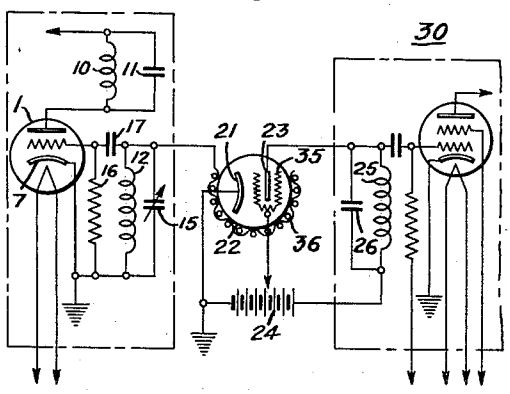


Fig. 5.

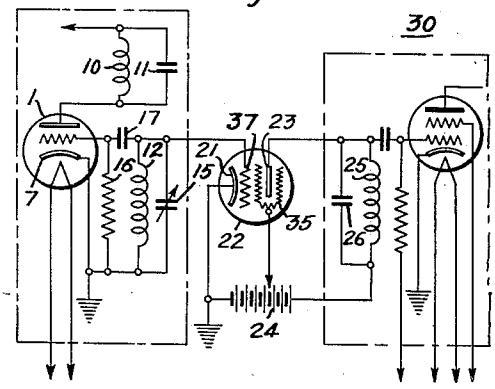
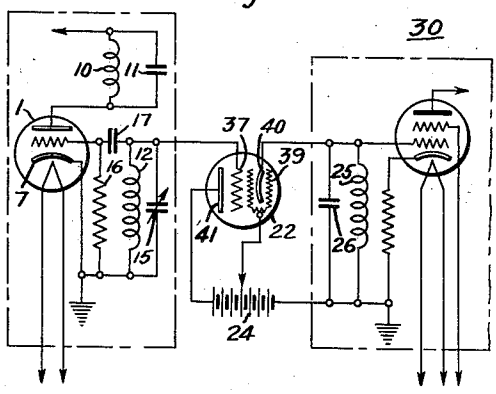


Fig. 6.



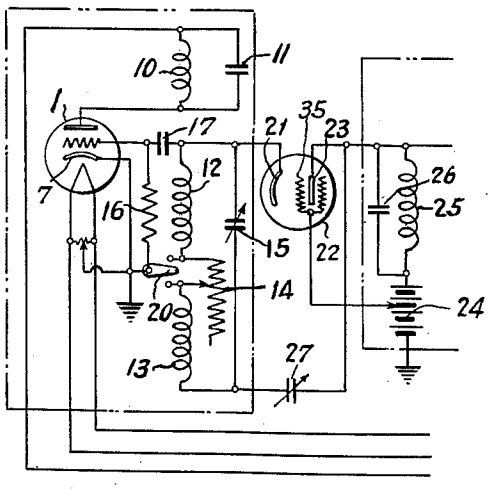


Fig. 15.

INVENTOR
Allen A. Shoup.
BY
Wesley G. Carr
ATTORNEY

Oct. 17, 1933. A. A. SHOUP 1,930,541

PHOTOCELL AND CIRCUIT

Filed Feb. 15, 1929 3 Sheets-Sheet 3

Fig. 7.

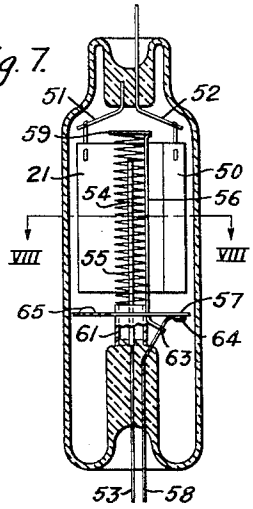


Fig. 9.

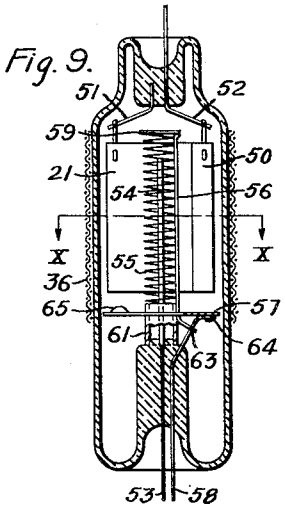


Fig. 11.

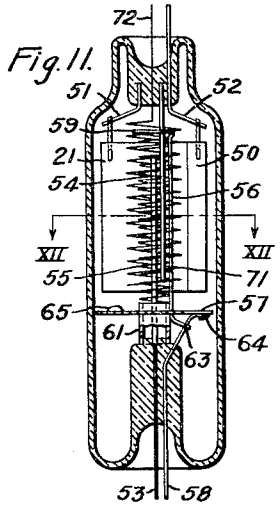


Fig. 8.

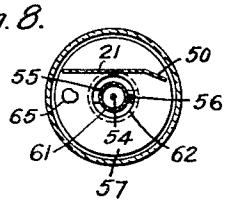


Fig. 10.

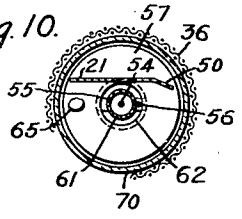


Fig. 12.

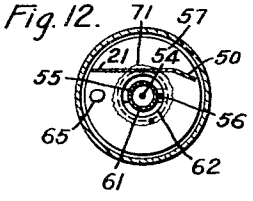


Fig. 13.

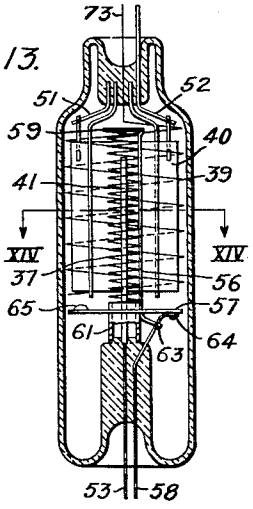
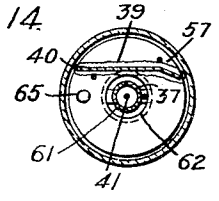


Fig. 14.



INVENTOR

Allen A. Shoup.

BY

Wesley G. Carr

ATTORNEY

Patented Oct. 17, 1933 1,930,541

UNITED STATES PATENT OFFICE

1,930,541

PHOTOCELL AND CIRCUIT

Allen A. Shoup, Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company, a corporation of Pennsylvania

Application February 15, 1929. Serial No. 340,314

4 Claims. (Cl. 250—41.5)

This invention relates to photocells and particularly to photocells intended for use in picture transmission or television.

It has been proposed to supply high-frequency alternating current to a photo-electric cell in order to obtain a high-frequency carrier current modulated by the changes in the illumination of the cell for delivery to the amplifying and transmitting apparatus. Attempts to do this have met with difficulty, caused by the capacity between the electrodes of the photocell. When the carrier current is of sufficiently high frequency, this capacity may cause sufficient current to pass through the photocell to overload some of the tubes of the amplifier, and render the system inoperative.

Neutralizing circuits for the photocell may be used to avoid this result, but they require very exact adjustment in order that the neutralization shall be sufficient to prevent overloading the amplifier as just mentioned.

It is an object of this invention to provide means whereby the effect of the capacity of the photocell in the output circuit may be avoided.

It is a further object of this invention to provide an adjusting device for the neutralizing circuit which will facilitate exact adjustment for balancing the circuit.

It is a further object of my invention to provide a shielding grid by means of which the capacity effect between the electrodes of the photocell may be nullified to such a degree that the neutralizing circuit is unnecessary.

Other objects of the invention and details of the constructions used will be clear from the following description and the accompanying drawings, in which;

Figure 1 is a diagram of one form of circuit which may be used either with the photocell proposed herein or with an ordinary photocell,

Fig. 2 is a diagram illustrating a modification of a portion of the circuit shown in Fig. 1,

Fig. 3 is a circuit diagram illustrating the arrangement used when a photocell having a shield electrode is employed,

Fig. 4 illustrates the arrangement used with a photocell having a shield electrode, and an external control grid,

Fig. 5 illustrates the circuit arrangement for a photocell with both a shield electrode and a control grid,

Fig. 6 illustrates a modification in which the shield electrode shields the cathode,

Fig. 7 is an axial section and Fig. 8 a transverse section of that form of photocell illustrated in Fig. 3,

Fig. 9 is an axial section and Fig. 10 a transverse section of that form of photocell illustrated in Fig. 4,

Fig. 11 is an axial section and Fig. 12 a transverse section of that form of photocell illustrated in Fig. 5, and

Fig. 13 is an axial section and Fig. 14 a transverse section of that form of photocell illustrated in Fig. 6.

Fig. 15 is a view illustrating a circuit embodying a combination of the circuits of Fig. 1 and Fig. 3 to obtain cooperating internal and external neutralizing effects.

In the circuit illustrated in Fig. 1, the vacuum tube 1 is associated with circuits which cause it to operate as an oscillator. Current for the tube is supplied from an alternating-current source through a transformer 2, a double-wave rectifier 3 and a filter 4. The filter delivers current to the resistor 5 of a potentiometer. The central point of this resistor is grounded and an adjustable tap 6 on the potentiometer supplies plate current potential for the tube 1.

The cathode 7 of the tube 1 is connected to ground, the potential difference between the point 6 and the ground is, therefore, impressed upon the tube 1. The tube is energized by a heater to cause the cathode to emit electrons. Heating current is supplied through the transformer 8 which may, if desired, be operated from the same source as transformer 2, or an additional winding on said transformer 2 may be used.

The circuits which cause the tube 1 to generate oscillations include a plate coil 10 in parallel with a condenser 11. The grid coil is in two parts 12 and 13, connected by an adjustable resistor 14 and shunted by an adjustable condenser 15. The grid leak 16 and grid condenser 17 are usual features of such an oscillator.

The oscillations may be maintained by inductive coupling between the coil 10 and the coil 12—13, or by electrostatic coupling between the electrodes of the tube 1. A switch 20 is provided by which the ground and the grounded end of the grid leak 16 may be connected to the coil 12—13 on either side of the selected portion of the resistor 14 at will.

The condenser 15 is adjustable to control the frequency generated by the oscillator 1, although this frequency is intended to be adjusted through only narrow limits.

The condenser 26 and the inductor 25 together

constitute the impedance for an impedance coupling of the photocell to the first tube of an amplifier 30 which is of familiar form and need not be described in detail. All of the tubes of this amplifier, except the last, are of the indirectly-heated type and the heating current for each of them is supplied from the transformer 8. The last tube is a power tube and operates from a directly-heated filament which is energized through the transformer 31 from any suitable source, which may, if convenient, be the source which supplies the transformer 2. Tubes of other types can be used, if desired, and other coupling may be used as well.

In the modification shown in Fig. 2, the circuit differs from that described in Fig. 1, only in that the adjustable resistor 14 and switch 20 are omitted, the midpoint of the coil 12—13 being permanently connected to ground and two condensers 32 and 33 being added. The current-supply system and most of the amplifier have been omitted from all figures except Fig. 1, to avoid repetition.

The coil 12—13 in Fig. 2 is shunted by the condenser 15 in parallel with two adjustable condensers 32 and 33. A switch 34 serves to ground either of said two condensers and simultaneously disconnect the other.

The adjustable resistor 14 and the adjustable condensers 32 and 33 are not shown in the succeeding diagrams of circuits employing shield-electrode photocells. The oscillator may have the same associated circuits in any of the figures from Figs. 3 to 6, inclusive, including either the resistor 14 or the condensers 32 and 33, to supplement the effect of the shielding electrode when desired.

The photocell structures illustrated in Figs. 3 to 14 are intended to render the condenser 27 and associated connections unnecessary. If the shielded-electrode photocell structure of itself, or the balanced circuit of itself, incompletely nullify the effect of inter-electrode capacity, the two may be used together to complete the prevention of the undesired results of said capacity.

In Fig. 3 the output of the oscillator tube 1 is connected, as in Fig. 1, to the cathode 21 of the photocell 22. The anode 23, in the photocell shown in Fig. 3, instead of being directly exposed to the cathode, is separated therefrom by a shield grid 35. The battery 24, between the anode 23 and ground, has an intermediate point connected to the shield grid 35.

In the form illustrated in Fig. 4, the output of the oscillator tube 1 is connected to a grid 36 which is wrapped about the outside of the photocell 22. In this cell, the cathode 21 is connected to ground, the anode 23 being connected, as before, through a tuned impedance 25—26 and a battery 24, to ground and an intermediate point of this battery is connected to the shield grid 35.

In the form illustrated in Fig. 5, the cathode 21 is connected to ground and the anode 23 and shield grid 35 are connected as in Figs. 3 and 4. The output of the oscillator tube 1 is connected to a control grid 37, inside of the tube, between the cathode and the shield grid.

In the form shown in Fig. 6, the output of the oscillator tube 1 is connected to the grid 37 between the anode 41 and the shield grid 39. The shield grid 39 is, in this modification, placed between the control grid 37 and the cathode 40. The anode 41 is connected, through the battery 24, to ground and the shield grid 39 is connected to an intermediate point of this battery.

In each of the figures from Fig. 1 to Fig. 5, inclusive, the anode of the photocell is connected to the input circuit of the amplifier 30, but in Fig. 6, the cathode 40 is connected to said input circuit and the anode 41 is connected only to the battery 24. For this reason, the battery 24 is drawn in Fig. 6 with the positive pole toward the left, but in the other figures, with the negative pole to the left.

Figs. 7 and 8 show in detail the mechanical structure of the photocell diagrammatically illustrated in Fig. 3. The cathode 21 is in the form of a flat sheet coated with photo-sensitive material. In order that the light may be received with minimum obstruction from the metallic bodies in front of the cathode 21, one portion 50 thereof is disposed at an angle to the plane of the main body of the cathode.

The cathode is supported upon two standards 51 and 52 which enter the press at the top of the tube. The standard 52 extends through said press and affords the connection through the wall of the tube by which the cathode is supplied with high-frequency current from the oscillator.

A press at the bottom of the tube is traversed by a conductor 53 which extends to, and affords support for the anode 54. The anode is a small straight rod disposed axially in the tube. The shield grid 35 comprises a helix 55 of wire, much finer than the rod 54. The helix is supported by a rod 56 which extends through an opening in the metallic disc 57, secured to a second conductor 58 through the press at the bottom of the tube.

The rod 56 supports a disc 59 at the top of the helix. The diameter of the disc is approximately equal to that of the helix. At the lower end of the helix, a metallic cylindrical sleeve 61, of the same diameter as the helix 55, is fitted over a circular projection constituting part of the top of the press. The disc 57 surrounds the sleeve 61 and is provided with a central opening 62 to accommodate the sleeve and the rod 56.

The conductor 58 emerges from the press into the tube at an angle, in order to afford a brace to support the disc 57. The rod 56 and the conductor 58 are soldered together as shown at 63 and the conductor 58 is soldered to the disc 57, as shown at 64. A body 65, of material which will be vaporized upon heating, is deposited upon the disc 57. This material includes a compound of caesium, preferably the bichromate. It may also include magnesium or other getter material if desired.

The tube shown in Figs. 4, 9 and 10 is like the tube shown in Figs. 7 and 8, except for the addition of an exterior grid 36. This grid incompletely surrounds the tube, leaving a portion 70 of the glass uncovered in order that the light may readily be admitted.

The tube shown in Figs. 11 and 12 corresponds to the tube shown diagrammatically in Fig. 5. It contains all the elements described in connection with Figs. 7 and 8 and, in addition, a second helical grid 71 surrounding the grid 55 and the rod 56. The helix 71 is made of finer wire and wider pitch than the grid 55. This helix 71 constitutes the grid 37 of Fig. 5 and, at the upper end, the wire of the helix 71 extends through the press, as shown at 72, to afford the connection to the grid 37 shown in Fig. 5.

The tube shown in Figs. 13 and 14 is the tube represented in Fig. 6. The cathode 40 is surrounded by a grid 39, while the anode 41 is

surrounded by the grid 37. A conductor extending through the press at the upper end of the tube, as shown at 73, affords the connection represented in Fig. 6, from the grid 39 to the midpoint of the battery 24, while the conductor 52, which assists in supporting the cathode 40, affords the connection from the cathode 40 to the input of the amplifier.

The conductor 58 extending through the press at the bottom of Fig. 13 is the connection through the wall of the tube by which the grid 37 is connected to the output of the oscillator 1. Similarly, the conductor 53 at the bottom of the tube is the connection through the wall of the tube, shown in Fig. 6, by which the anode 41 is connected to the battery 24.

It will be readily seen that in all of the tubes represented in Figs. 7 to 14, inclusive, the anode is surrounded by a grid which is made to serve as either the shield grid or the control grid, whichever the circuit connected to the photocell requires.

The shielding of the anode, effected mainly by the helix (55 in Figs. 7 to 12, 37 in Fig. 13) is completed by the disc 59 at the top of the helix and the combination of disc 57 and sleeve 61 at the bottom. The sleeve 61, being connected through the helix to the rod 56 and thence to the disc 57, assists in completing the enclosure of the anode. The opening between the inner edge of the disc 57 and the sleeve 61 is no greater than the openings between successive whorls of the helix.

In the operation of the device, as shown in Fig. 1, the oscillator 1, impresses an alternating potential upon the cathode 21 of the photocell 22. The photocell is electrically equivalent to a capacity, which is independent of the illumination, and a resistance, which is dependent upon the illumination, in parallel therewith. The resistance is unidirectional because electrons may escape from the cathode 21 when illuminated, but not from the anode 23.

In order that the photocell 22 may still conduct when electromotive force from the oscillator 1 is in the direction in which the photocell is nonconductive, the biasing battery 24 is of sufficient voltage to insure that the direction of electromotive force through the cell is not reversed. The action of the oscillator 1 is, therefore, to superpose a carrier-frequency current upon the direct current supplied by the battery 24.

The condenser 27 is of such size and preferably is so adjusted that its capacity equals the capacity of the photocell. Under these conditions, the current conducted through the photocell 22 by its capacity will be neutralized by the current conducted through the condenser 27 and the only resultant high-frequency current impressed upon the input of the amplifier will be that which passes through the photocell because of its action as a resistance. That is to say, when the photocell is dark, no carrier-frequency potential is delivered thereby to the amplifier.

When the photocell is illuminated, the amplitude of the high-frequency current delivered through it to the amplifier will be dependent upon the illumination. As long as the photocell is not caused to carry currents beyond that for which it is designed, and is not illuminated with too bright a light, this amplitude will be proportional to the illumination. Because of the neutralizing action of the condenser 27 and the circuits associated therewith, the current delivered to the amplifier does not include current passing through the cell by the action of its electrostatic capacity.

In this way a truly proportional effect is obtained and in this way also, the overloading of the amplifier by current conveyed through the electrostatic capacity of the photocell is avoided.

It is not possible to completely avoid the effect of the inter-electrode capacity of the photocell by adjusting the condenser 27. This adjustment is exceedingly critical, but even when the capacity of condenser 27 is exactly equal to the inter-electrode capacity of the photocell, the neutralizing is incomplete. The leakage resistance of the condenser 27 will not, ordinarily, balance the leakage resistance of the photocell, even when the photocell is dark. Differences of phase will arise between the potential impressed upon the input of the amplifier, through the coil 12 and the photocell on the one hand and the coil 13 and the condenser 27 on the other. These differences in phase will cause some carrier-frequency current to be impressed upon the input of the amplifier even when the condenser 27 has been adjusted very exactly to the capacity of the photocell 22.

To avoid this, a resistor 14 is provided which may be made to add an adjustable amount of resistance, either to the coil 12 or to the coil 13, according to the position of the switch 20. When the whole circuit is in correct adjustment, not only the magnitudes but the phases of the currents delivered over the two paths to the amplifier are such as to completely neutralize each other and no high-frequency current is delivered to the amplifier except when the photocell is illuminated.

The current delivered when the tube is illuminated is the current conducted by the action of the photocell as a unidirectional resistor. It does not include any component caused by the capacity effect of the photocell. For this reason, the amplifier is not overloaded and the carrier-frequency current delivered to it is proportional to the illumination.

Except for the structural changes needed to adapt the amplifier to indirectly-heated tubes having a shield-electrode, the amplifier is of usual construction. The first stages have impedance coupling and the output of the detector is transformer-coupled to a power tube having a directly-heated cathode. The impedances, for the stages preceding the detector, are tuned to the carrier frequency.

The transformer following the detector must be designed for the particular use intended. For example, if the modulation of the light is by a photographic record of sound, the transformer must be designed for audio frequencies. If the light-changes are of such great variety in frequency that amplification after detection is not practical, as is the case in some systems for the reproduction of visual effects, the transformer stage is omitted and more stages of carrier-frequency amplification may be used if necessary.

An alternative method of neutralizing the capacity of the photocell 22 is illustrated in Fig. 2. In this figure, the coil 12—13 is shown as one continuous coil and a connection is made from the center thereof to the ground. If the exact center of the coil is not found when making this connection, or if the condenser 27 does not exactly match the photocell, both as to capacity and as to leakage resistance, proper positioning of the switch 34 and correct adjustment of the

condenser 32 or 33 connected to the switch will compensate for these matters.

I have found from experiment that, unless the centering of the ground connection is very accurate, the condensers 32 and 33 must be inconveniently large, but, when the ground connection is to the exact center of the coil 12—13, condensers of the capacity ordinarily used for neutralizing vacuum tube circuits will serve.

In Fig. 2, the condenser 15 is intended to cooperate with the inductor 12—13 to constitute a circuit resonant to the frequency which the oscillator is intended to deliver. If the condenser connected to the switch 34 is large enough to affect the tuning, readjustment of the condenser 15 will be necessary, but, with the small condensers which I have been able to use, the effect upon the tuning is negligible.

After the adjustments illustrated in Fig. 2 are correct, the operation is essentially similar to that in Fig. 1. In both Figure 1 and Figure 2, although the capacity effect of the photocell 22 has been neutralized, current through the photocell is not zero, even in the dark, but a certain current flows therein which is compensated by an equal and opposite current through the condenser 27. The connection through the wall of the cell 22, either to the cathode 21 or to the anode 23 carries current, in addition to the photo-electric current controlled by the illumination, in both of these embodiments of the invention.

In the form of the invention illustrated in Figs. 3, 7 and 8, the carrier-frequency current conveyed by the capacity within the photocell 22 does not emerge through the connection between the anode 23 and the outside of the cell. The capacity between the grid 35 and the cathode 21 is one member of a shunt circuit by which the alternating current is diverted, through the left-hand portion of the battery 24 and the ground, to the oscillator from whence it started.

The circuit from the oscillator 1, through cathode 21 and anode 23 in series, to the impedance 25—26, includes the capacity just mentioned in series with the capacity between shield-grid 35 and the anode 23. The impedance of two capacities in series is large compared with the impedance of one of them alone. Moreover the impedance 25—26 is very large for the carrier frequency. Consequently, substantially all the current of this frequency is diverted and does not reach the anode 23. Therefore, substantially no current carried by capacity effect is present in the connection from the anode through the wall of the tube.

The grid 35 is strongly positive relative to the cathode 21. Electrons emitted from the cathode 21, therefore, approach the shield with sufficient velocity to cause a considerable, although limited, number of them to pass through the meshes of the grid 35. The electrons which pass through the grid 35 are influenced by the difference of potential, established by the right-hand part of the battery 24, between the grid 35 and the anode and, therefore, arrive at the anode.

Regarding the grid 35 as the source of a limited and varying number of electrons, the difference of potential impressed by the right-hand part of the battery 24 is sufficient at all times to produce the corresponding saturation-current in the space between shield 35 and anode 23.

The number of electrons which pass the grid 35 is influenced not only by the illumination of the cathode 21, but also by the difference of potential between the cathode 21 and the shield 35. They, therefore, produce in the output from the anode 23, a current which comprises a direct-current component corresponding to the constant potential from the battery 24 and an alternating-current component corresponding to the potential impressed by the oscillator 1. In addition to these components, the current possesses a modulation corresponding to the changes in illumination, because the number of electrons liberated at the cathode 21 changes with the light.

The direct-current component produces no effect upon the amplifier but the alternating-current component impresses upon the amplifier a frequency corresponding to that of the oscillator 1, and upon this carrier current there is imposed a modulation corresponding to the changes in illumination.

On the other hand, no alternating-current is impressed upon the input of the amplifier as a consequence of the capacity between the electrodes, this capacity effect being nullified by the presence of the shield 35.

The difference of potential between the cathode 21 and the system composed of anode 23 and shield 35 is varied in Fig. 3 by the potential impressed from the oscillator 1. The electrostatic field between the cathode 21 and the shield 35, therefore, changes at the frequency of the oscillator. In Fig. 4, the cathode 21 is not connected to the oscillator and a constant difference of potential exists between the cathode and either the shield 35 or the anode 23. A variation in the electrostatic field between the electrodes 21 and 35 is obtained by connecting the oscillator to the external grid 36. Electrons emitted from the cathode 21 are accelerated, retarded, or diverted, according to the direction and strength of the field imposed upon the interior of the tube by the difference of potential between the grid 36 and the ground, because the cathode 21 is connected to the ground.

The corresponding change in the velocity of the electrons, either in magnitude or direction, produces a change in the number of electrons which pass through the shield 35 and arrive at the anode 23. A variation in the current emerging from the anode 23, at the frequency of the oscillator, is thus produced, but the capacity between the anode 23 and the grid 36 is not the cause of this carrier-frequency component of the current in the output of the photocell. The capacity between the grid 36 and the shield 35 is effective in shunting alternating current in the same way as the capacity between the cathode 21 and shield 35 in Fig. 3.

The output of the photocell in Fig. 4 has, therefore, as in Fig. 3, a direct-current component, an alternating current component at the frequency of the oscillator and a modulation corresponding to the illumination.

In Fig. 5, the control grid 37 produces a high-frequency field within the tube which corresponds in function to the high-frequency field produced by the grid 36 in Fig. 4. The position of the grid 37 in Fig. 5, directly between the cathode 21 and the system comprising anode 23 and shield 35, enables the impressed field to act mainly by changing the magnitude of electron flow without producing much change in the direction thereof. The shielding action of the

grid 35 in eliminating capacity effects and the production, in the output, of a current comprising a direct-component, a high-frequency alternating component, and the modulation is the same as already discussed in connection with Figs. 3 and 4.

In connection with Fig. 6, the capacity effect to be eliminated is the capacity between the control grid 37 and the cathode 40. The shield 39 provides a shunt path for the carrier-frequency current from the oscillator 1, which may be traced from the control grid 37, by capacity effect to the shield 39, thence through the right-hand part of the battery 24, as illustrated in Fig. 6, to the ground and from the ground back to the oscillator.

The constant direct-potential difference between the cathode 40 and the shield grid 39 produces a high velocity of the electrons from the cathode 40, in consequence of which some electrons pass through the shield 39. The difference of potential between the shield 39 and the anode 41, caused by the left-hand portion of the battery 24, causes such electrons as emerge from the shield 39 to go to the anode 41. The flow of these electrons is controlled by the grid 37 in a familiar way.

The number of electrons emitted by the cathode 40 and, therefore, the number emerging from the shield 39, is controlled by illumination. The two controls, by the illumination and by the grid 37, respectively, produce an alternating component in the output of the photocell which is modulated in accordance with the illumination. The energy impressed upon the amplifier, in the case of Fig. 6, is, therefore, like that in the other cases.

In Fig. 15, I have disclosed a circuit incorporating the neutralizing features of both the circuit of Fig. 1 and that of Fig. 3. This general type of circuit embodying both an internal and external neutralizing feature is desirable under the condition heretofore set forth.

In preparation of the photocell, photo-sensitive material such as caesium, and a getter, which may be magnesium is deposited upon the disc 57, as illustrated at 65 in Figs. 7 to 14. After the cell has been pumped and sealed off, a high-frequency alternating field is impressed transverse to the disc 57. Eddy currents are thus set up in the disc, which heat it, with the result that some of the material 65 is vaporized and will deposit upon the cooler parts of the tube.

The helices present closed conducting paths, of the same position, relative to the field, as the disc 57 but not of as great conductivity. These portions of the tube are, therefore, heated, although not as much as the disc 57. The cathode 21, being almost entirely sheet material parallel to the alternating field, is heated very little. The vaporized material, therefore, condenses upon the cathode which is thereby rendered photo-sensitive. If an undesirably large amount of the photo-sensitive material is deposited upon the glass wall of the tube, it can be driven off by supplemental heating which will be insufficient to materially disturb the deposit upon the cathode. Moreover, the quantity of material vaporized by the heating of the envelope is too small to make any undesirable deposit upon the other electrodes.

Although I have illustrated and described several embodiments of my invention, many other modifications will occur to those skilled in the art and that the description is confined to a small number of variations is not to be construed as a limitation. The only intended limitations are those expressed in the claims, or required by the prior art.

I claim as my invention:

1. A photocell, having a plurality of electrodes, one of which is light-sensitive, means for impressing a high-frequency potential difference between two of said electrodes, means for substantially preventing the electrostatic capacity between said two elements from conveying current, and means associated with said last-mentioned means for obtaining fine adjustment of said means.

2. A photocell having a plurality of electrodes, means for substantially neutralizing the capacity effect normally existing between certain of said electrodes and means for more accurately determining the neutralizing effect of said neutralizing means.

3. A photocell having a plurality of electrodes, means for substantially neutralizing the capacity effect normally existing between certain of said electrodes and means external of the photocell for more accurately determining the neutralizing of said capacity effect.

4. A photocell having a light-sensitive cathode, an anode, means external of the photocell for controlling the flow of current through said cell and means within the cell electrostatically associated with said external control means for substantially eliminating the flow of current through said cell by reason of capacity effect normally existing between certain of said electrodes.

ALLEN A. SHOUP.