

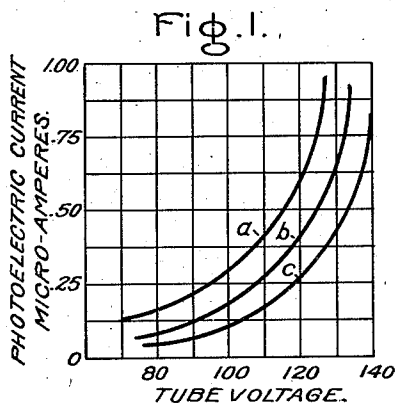
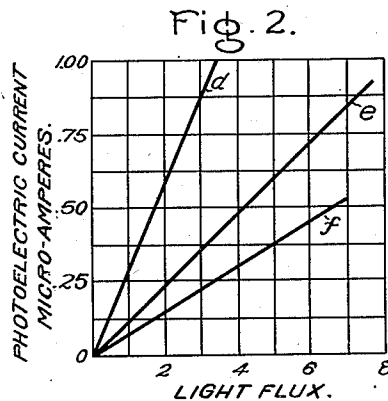
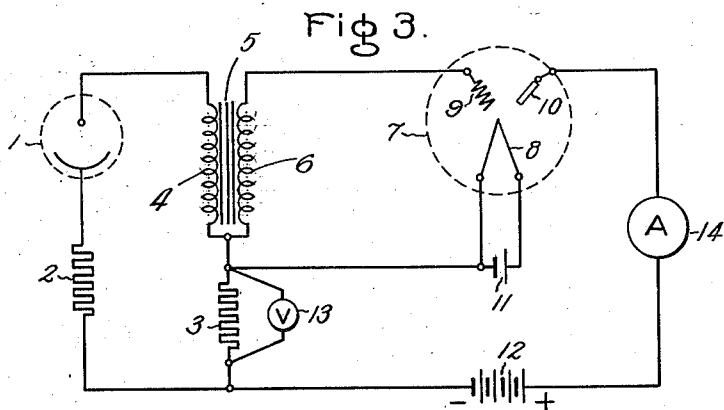
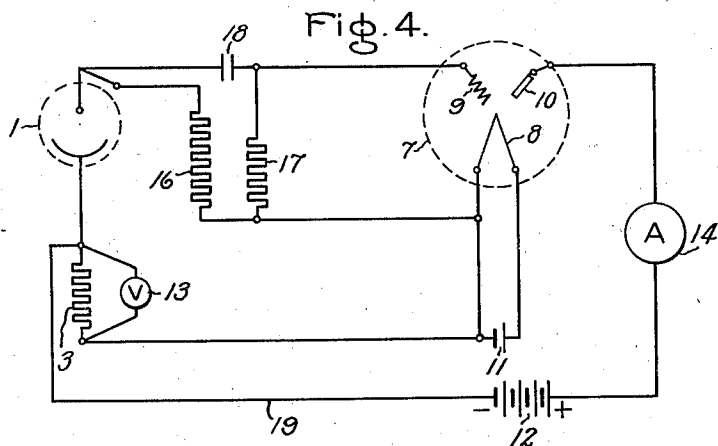
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FEEDBACK AMPLIFYING CIRCUIT FOR LIGHT SENSITIVE DEVICES

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FEEDBACK AMPLIFYING CIRCUIT FOR
LIGHT SENSITIVE DEVICESRaymond R. Haugh, Chicago, Ill., assignor to
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3 Claims. (Cl. 250—41.5)

This invention relates to a feedback amplifying circuit for light sensitive devices for use in connection with talking moving pictures, television and various other industrial and scientific devices.

It is definitely known that the output current of light sensitive devices, such as the current output of a photo-electric cell, is not large. It is sometimes necessary therefore, when such a device is used and additional power is needed, to employ many stages of amplification in order to increase the power output to the desired amount. Amplifiers of this type are now used to produce sufficient power for talking motion pictures, television and the like.

An amplifier of this type is objectionable because of resultant microphonic tube noises, complicated wiring, electrical pick-up, distortion, cost and various other factors.

Among the objects of my invention is to overcome these disadvantages by providing a simple, practical and efficient feedback amplifying circuit for light sensitive devices of one or more tubes that will take the place of the above mentioned amplifier or amplifiers.

Another object of my invention is to amplify the output of a photoelectric cell or the like without consequent distortion.

A further object is to provide a feedback amplifying circuit for light sensitive devices for the purpose of regenerating the photo-electric tube or its equivalent. This regeneration may be positive or negative.

A further object is to provide a working circuit whereby light which reaches a photo-electric tube controls the oscillation of a vacuum tube circuit.

A further object is to produce a working circuit that will be economical in construction, practical of installation and having a long life without the necessity of constant repair, replacement and their consequent inconveniences.

This application is a continuation-in-part of my prior application, Serial No. 394,941 filed September 25, 1929, and entitled "Feedback amplifying circuits for light sensitive devices".

The improved system utilizes a photo-electric tube connected in the input circuit of a thermionic amplifier and has a feedback or regenerative connection between the output circuit of the amplifier and the photo-electric tube. The regenerative circuit is arranged in such a manner that the undulations derived from the amplifier are fed back to the photo-electric tube in the proper phase relation so as to add their effect to the electrical variations in the light-sensitive device. The invention will be better understood

when reference is made to the following description and the accompanying drawing in which Fig. 1 shows the relation between the photo-electric current in micro-amperes and voltage when a constant source of illumination is applied to a photo-electric tube useful in the practice of my invention. Curves *a*, *b*, and *c* are for different values of illumination. Fig. 2 depicts the change in photo-electric current produced by a variation in the light flux at the different voltage levels *d*, *e*, and *f*; Fig. 3 is an exemplary circuit diagram embodying the principles of my invention; while Fig. 4 illustrates a modification of the improved system.

Referring more particularly to Fig. 3, numeral 1 designates a photo-electric tube, gas-filled or vacuum, having a rising volt-ampere characteristic for a light flux of average value. This tube is connected in series with a relatively high resistance 2 and a relatively low resistance 3, also with a primary 4 of a transformer 5. The secondary 6 of the transformer is connected in the input circuit of a thermionic amplifier 7 of any standard and well known type, and containing a filamentary cathode 8, a control electrode 9 and an anode 10. The filament is energized by a source of electromotive force 11, and the anode, by a source 12. The cathode is connected to one end of the resistance 3 and to the primary and secondary windings of the transformer. A volt meter 13 may be shunted across the resistance 3 to determine the voltage drop under operating conditions; a microammeter 14 may be inserted in the plate circuit of the amplifier to measure the output current.

The operation of the circuit arrangement is substantially as follows: A voltage drop is produced in the resistance 3 because the latter effectively is in the output circuit of the amplifier and this voltage provides energy for the photo-electric tube. When a light source (not shown) activates the light sensitive member, the impedance of the latter changes in accordance with the variations of light and sets up current pulsations in the primary 4. The electrical undulations induce voltage changes across the terminals of windings 6 and if these changes are poled correctly the amplifier will respond by way of increased or decreased amplification, as desired, exactly in accordance with the change in the light source. For example, assume that the coils 4 and 6 are wound in the same direction, then as the light flux is increased the current through coil 4 increases and causes the grid 9 to go more positive, hence increases the plate current in the meter 14. This increase in

plate current produces a greater voltage drop in resistance 3 which in turn causes a greater voltage to be applied to the photo-electric tube 1 and produces an amplified series of current undulations in primary 4, corresponding faithfully to the original variations.

The effect of increasing the voltage applied to the photo-electric tube in this manner is clearly shown in the graphs of Figs. 1 and 2. In Fig. 1, curves *a*, *b*, and *c* represent different values of illumination and depict the relation between the current flowing through the light-sensitive device and the voltage measured across the device, the latter having a substantial rising volt-ampere characteristic. It will be understood however that my invention is not limited to any particular form of photo-electric tube or tube characteristic. In fact, the tube may be vacuum or gas-filled, provided that there is at least a slight rise in the tube volt-ampere characteristic and further, that in the case of a vacuum tube, the latter is operated substantially below saturation.

It will be evident from the curves of Fig. 1 that the direct result of the increase in tube voltage is the production of a marked increase in tube current. Fig. 2 illustratively expresses the same idea when the three voltage curves *d*, *e*, and *f* are considered with respect to the ordinate current values. The regenerative effect obtained by the improved circuit is limited almost entirely by the current-carrying capacity of the various elements, also by the energy capacity of the battery 12, so that the effect of losses invariably present in a circuit operating without regeneration, can be substantially reduced by the feedback connection. The high resistance 2 is provided in series with the photo-electric tube to limit the current flowing through the latter, in case a gas type of tube is employed and the amount of regeneration is such as ordinarily to cause cumulative ionization in the absence of the resistance.

It will occur to those skilled in the art that the regenerative action of the improved circuit may be employed, if desired, to obtain an augmented decrease of plate current for an increase of light in the photo-electric tube, in other words, the reverse effect to that previously explained, by simply reversing the winding 6. The turn ratio of transformer 5 preferably is such that the impedance of the photo-electric circuit substantially matches that of the amplifier input circuit in order to obtain the optimum efficiency of energy transferred from one circuit to the other, although it will be understood that all satisfactory turn ratios, voltage step-up or step-down come within the purview of my invention.

Fig. 4 shows a modified circuit in which the resistances 16, 17 are employed to transfer the photo-electric current variations to the thermionic device 7. In addition to these resistances

there is a condenser 18 arranged in the grid circuit of the amplifier and connected between the resistances, which cooperates with the latter to shift the phase of the output current delivered by the amplifier so that the charge on the grid will be of proper polarity to facilitate regeneration and if desired, to sustain oscillation. It will be noted that the feedback connection 19 is joined between the plate battery 12 and the point intermediate the photo-electric tube and resistance 3. This manner of connection serves to produce a voltage drop in the resistance 3, in such a direction that when combined with the voltage drops across the condenser 18, and the resistances 16, 17 in addition to the capacitive voltage drop across the photo-electric tube 1, the charge on the grid is of the proper polarity to effect regeneration. It is evident that the circuit is designed for operation principally in connection with a light source of a continually varying character so that the condenser 18 is periodically charged and discharged. It is also apparent that for the maximum efficiency of operation the condenser 18 should be relatively small or rather, its reactive impedance large in order to obtain phase shift of voltage in the grid circuit with respect to plate current of sufficient amount to permit regeneration, and oscillation, if desired.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, an amplifier having input and output circuits, a photo-electric device, electrical connections between said input circuit and said device, a source of electrical energy for said output circuit, and a resistance connected to said source, included in the circuit of said device and so arranged as to energize said device and simultaneously feed back a portion of the amplifier output energy to said device.

2. In combination, an amplifier having input and output circuits, a photo-electric device, electrical connections between said input circuit and said device, a source of electrical energy for said output circuit, and a resistance connected in both said output circuit and the circuit of said device, so arranged as to energize said device and simultaneously feed back a portion of the amplifier output energy to said device.

3. In combination, an amplifier having input and output circuits, a photo-electric device, a resistance connected across said input circuit, a resistance connected across said device and a condenser connected between said resistances, a source of electrical energy for said output circuit, and a resistance connected to said source, included in the circuit of said device and so arranged as to energize said device and simultaneously feed back a portion of the amplifier output energy to said device.

RAYMOND R. HAUGH.