Dec. 2, 1930. A. WEAVER 1,783,321

ELECTRICAL TRANSMISSION OF PICTURES

Filed March 26, 1924 3 Sheets-Sheet 1

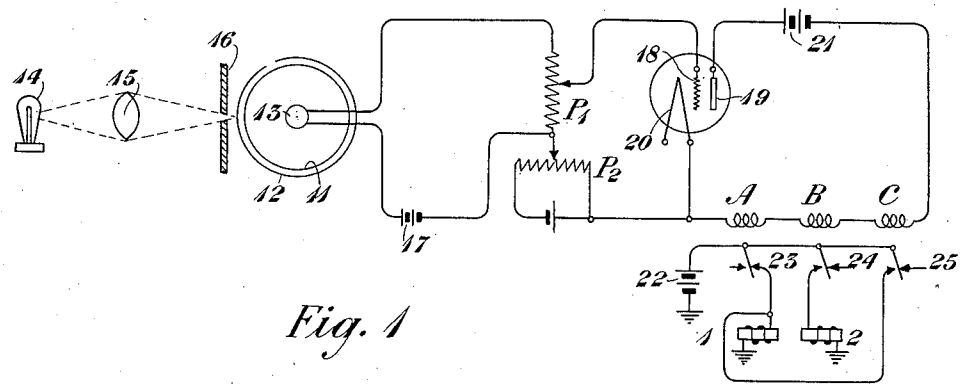


Fig. 1

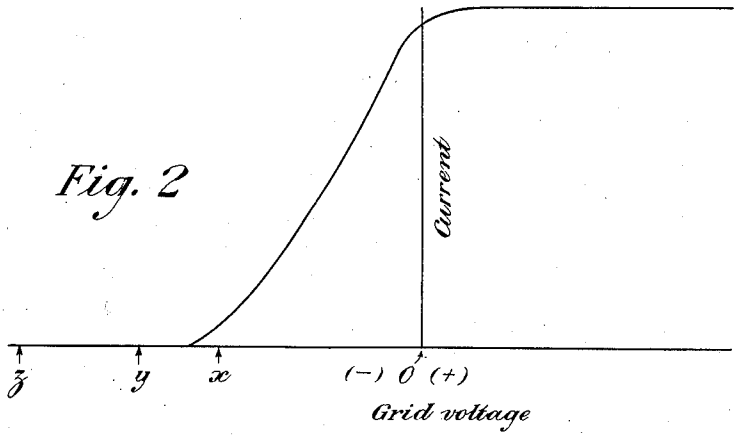


Fig. 2

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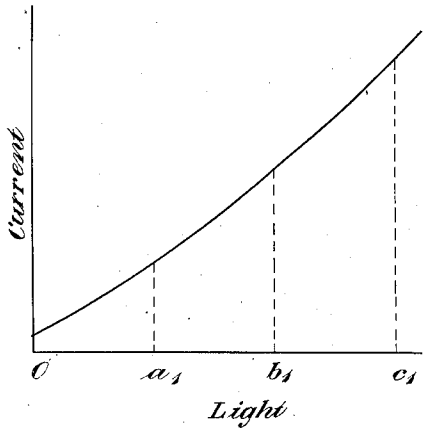


Fig. 3

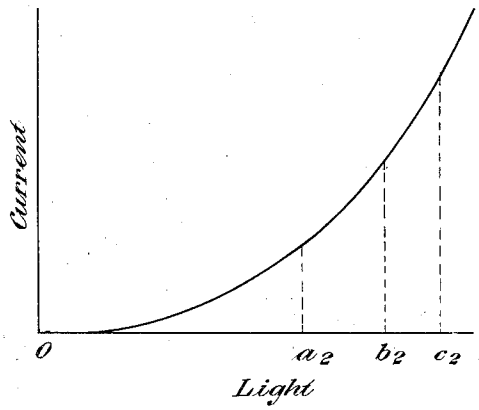


Fig. 4

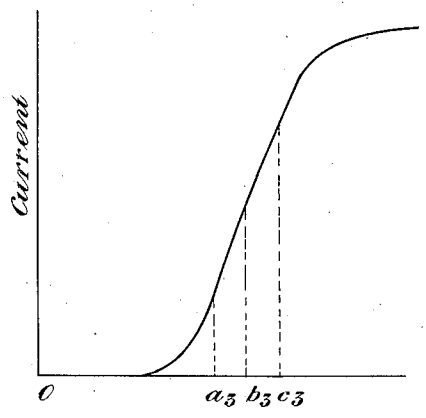


Fig. 5

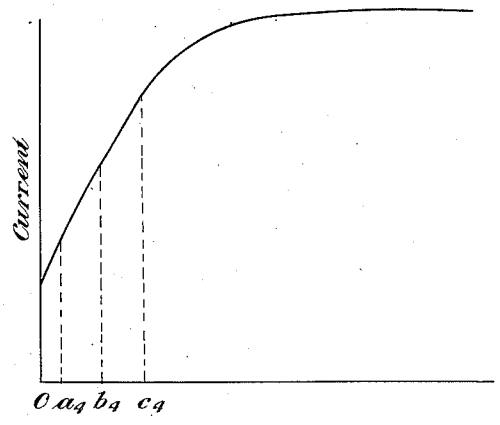


Fig. 6

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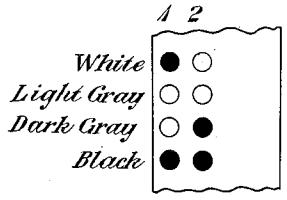


Fig. 7

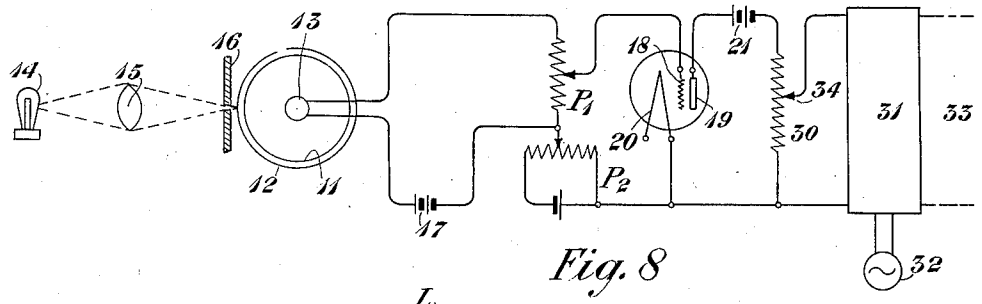


Fig. 8

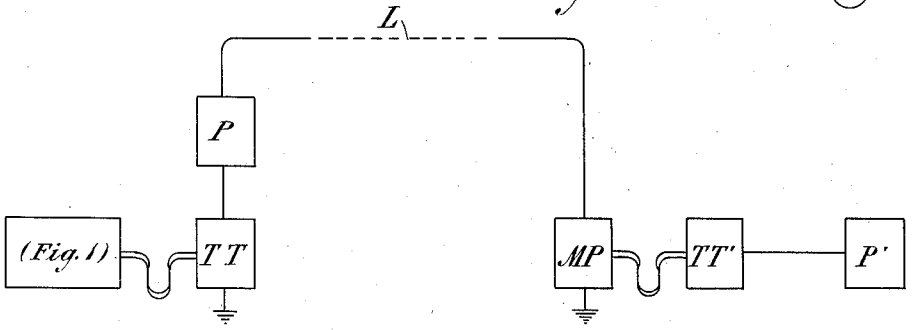


Fig. 9

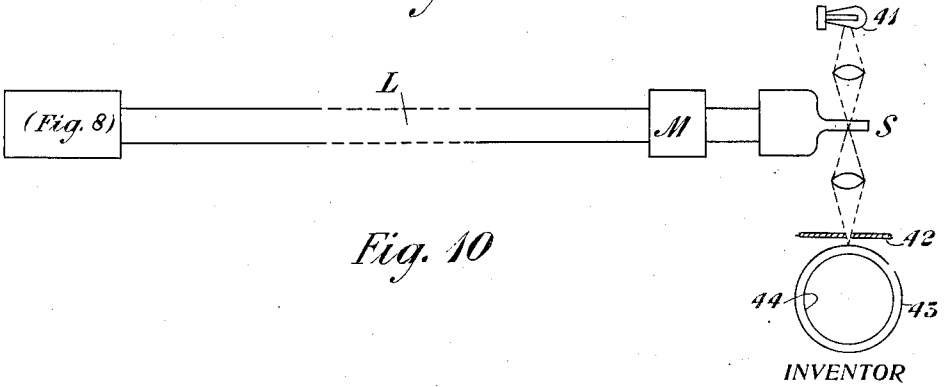


Fig. 10

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Patented Dec. 2, 1930 1,783,321

UNITED STATES PATENT OFFICE

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ELECTRICAL TRANSMISSION OF PICTURES

Application filed March 26, 1924. Serial No. 702,109.

The principal object of my invention is to provide a new and improved method and apparatus for the transmission of a picture electrically. Another object of my invention is to provide for adjusting a picture transmitting system in accordance with the character of the picture representation from which the transmission is made. Another object is to provide for adjustment between a light-sensitive element and an amplifier in a picture transmitting system so as to adapt the system for successful transmission whether the film be over-exposed or under-exposed and whether its contrasts be slight or marked. These and various other objects of my invention will become apparent on consideration of a limited number of examples of embodiments of the invention which I will discuss in the following specification. It will be understood that this disclosure will relate to these particular examples and that the invention will be defined in the appended claims.

Referring to the drawings, Figure 1 is a diagram illustrating a picture transmitting system embodying my invention; Fig. 2 is a characteristic curve for the plate current as a function of the grid voltage in a three-electrode vacuum tube amplifier; Figs. 3, 4, 5 and 6 are curves showing the amplifier output current as a function of the transmitted light with various adjustments in my system; Fig. 7 shows a punched tape embodying the code for my system; Fig. 8 is a diagram of apparatus alternative to that shown in Fig. 1; and Figs. 9 and 10 are general symbolic diagrams of the entire systems of which the apparatus of Figs. 1 and 8 respectively, are parts.

The glass drum 11 is rotated slowly on its axis and traversed lengthwise in the meantime, so that the spot underlying the opening in the screen 16 describes a helical course relatively to the drum 11. Wrapped about the drum 11 is a picture representation in the form of a semi-transparent film 12. The lamp 14 has its light focused by the lens 15 at tne opening in the screen 16 and this light shines through the film 12 and the drum 11 on the photoelectric cell 13.

This cell 13 is in circuit with the battery 17 and according to well-known principles, the current in this circuit will vary in dependence on the light that passes through the underlying spot of the film 12 to the cell 13.

The grid 18 of a three-electrode vacuum tube or audion has its circuit completed to the filament 20 through an adjustable portion of the resistance of the potentiometer P_1, the entire resistance being comprised in the circuit of the photoelectric cell 13. The electromotive force normally applied to the grid 18 is determined by the potentiometer P_2. As the current through the cell 13 increases, the potential drop in the portion of the potentiometer resistance P_1 comprised in the grid circuit increases, and vice versa; thus the current in the cell 13 determines a corresponding voltage on the grid 18.

The plate circuit of the audion comprises the battery 21, the plate 19 and the filament 20 and the windings of three marginal relays A, B and C. These are adjusted so that for a certain small amount of light in the cell 13, none of them picks up; for a limited increase of the light, A only picks up; then with more light, A and B pick up and with still more light, A, B and C pick up.

The armatures of the relays A, B and C control the circuits of the two selector magnets 1 and 2.

Referring to Fig. 7, this shows a tape with a transverse row of positions for holes to be punched for each successive picture element in the film 12. In Fig. 7, a solid black circle means a hole punched in the tape and an open circle merely indicates a position at which a hole might have been punched. At any position of the tape a hole in the column marked 1 will be punched when the magnet 1 is energized, and similarly, for the column marked 2 and the magnet 2. In accordance with what has been said, the code indicated in Fig. 7 can readily be verified.

Fig. 2 shows a curve giving the relation of the output current to the grid voltage in a three-electrode vacuum tube amplifier such as that shown in Fig. 1. Fig. 2 presupposes a certain constant voltage in the plate circuit as given by the battery 21.

For a good ordinary film, in order to actuate the marginal relays A, B and C with defi-

niteness, a desirable relation between the light falling on the photoelectric cell 13 and the current in the output circuit of the amplifier will be as given by Fig. 3. The quantity of light to produce enough current to cause the relay A to pick up is given by the abscissa Oa_1. An increase in the quantity of light to Ob_1 gives enough current to cause the relay B also to pick up, and an increase in the quantity of light to Oc_1 causes the relay C in addition to pick up. Such a characteristic as that shown in Fig. 3 can readily be obtained by adjustment of the potentiometers P_1 and P_2 in Fig. 1. The potentiometer P_2 is adjusted to give the negative voltage Ox (in Fig. 2) on the grid, when the light on cell 13 is zero.

Assume that the film 12 is lighter than the usual film,—that is, that it may have been under-exposed but still possesses sufficient contrast. In this case a suitable relation between light and current will be that given by Fig. 4. It will be seen that here no current will flow in the plate circuit until the light reaches a comparatively large value, and not until the light reaches the amount given by the abscissa Oa_2 will the current rise to a sufficient value to pick up the first marginal relay A. Further increments in the light will then cause the additional relays B and C to pick up in succession. This kind of a characteristic will be obtained with the apparatus in Fig. 1 by making P_1 a proper value and by adjusting the potentiometer P_2 until the normal grid potential corresponding to zero light on the cell 13 is at the negative value indicated by the abscissa Oy in Fig. 2.

Again, suppose the film 12 has very little contrast, such as might be obtained when the original view has insufficient contrast. A suitable current-light characteristic will then be as shown in Fig. 5. This will be obtained by adjusting the potentiometer P_2 to give a strong normal negative voltage on the grid 18 as indicated by the abscissa Oz in Fig. 2 and by adjusting the potentiometer P_1 so as to include a large part of its resistance in the grid circuit. This latter adjustment makes a small change of current in the circuit of the cell 13 produce a large change of voltage on the grid 18 and a large change of current in the circuit of the plate 19, all as shown in Fig. 5. With the explanation that has gone before it will be readily apparent how adjustments may be made for an over-exposed film, corresponding to Fig. 6.

Fig. 8 shows a modification which is the same as in Fig. 1 from the source of light 14 to the vacuum tube amplifier 18—19—20. Instead of having marginal relays in the plate circuit as for Fig. 1, the plate circuit in Fig. 8 comprises the battery 21 and a resistance 30. The adjustable tap 34 enables one to apply as input to the modulator 31 any desired fraction of the voltage drop through the resistance 30. At 32 is a source of alternating current which is put into the modulator 31 and modulated from the input circuit last mentioned and the modulated current is put on the line 33.

In this modification the amplitude of the modulated carrier for any amount of light falling upon the light sensitive element is represented by the corresponding ordinates of the curves of Figs. 3, 4, 5 or 6. When the system is operated according to the condition represented by Fig. 3 the relation between light transmitted through the picture representation and the amplitude of the modulated carrier current is seen to be approximately linear. The picture formed at the receiving station will then be an approximate reproduction of the picture representation at the sending station.

When the system is operating according to the condition of Fig. 5 for instance, the relation between light and modulated carrier current is non-linear. The curve is now such that the high lights will be made lighter and the shades darker. The received picture will therefore possess more contrast than the picture representation at the sending station.

The perforated tape produced by the apparatus of Fig. 1 is fed to a tape transmitter TT as shown in Fig. 9. This tape transmitter and the remaining elements of Fig. 9 here to be mentioned are devices commonly used and well-known in text message printing telegraphy, hence they are shown only symbolically in the figure and are described only briefly here. The tape transmitter TT determines the sending of code current impulses on the line L, which are received in the machine perforator MP, which perforates a tape at the receiving end corresponding to that at the sending end. The tape from the machine perforator MP goes to a tape transmitter TT′, which controls the operation of the printer P′. This printer P′ prints a blank for the shade white in the picture, a small dot for light gray, a medium dot for dark gray and a large dot for black. Thus it will be seen that the sheet produced by the printer P′ is a half-tone reproduction of the picture corresponding to the picture representation 12 of Fig. 1.

Each time the edge of the film 12 passes the opening in the screen 16, a special code combination is punched in the tape. The corresponding currents sent over the line L and recorded in the tape at the receiving end determine the carriage return and line feed functions in the printer P′.

The currents from the tape transmitter TT also determine the operation of a printer P at the sending station, so that the sending station will have a copy of the picture in the same style that it is reproduced by the printer P′ at the receiving station.

When the transmitting apparatus of Fig.

8 is employed, the entire system will be as shown in Fig. 10. The modulated carrier currents put on the line L at the sending station go to detecting and demodulating apparatus M at the receiving station. The output current from the apparatus M controls a light valve S which determines the quantity of light from a source 41 to the spot of the sensitive surface 43 that underlies the opening in the screen 42. The surface 43 is on a drum 44 which is rotated and traversed in synchronism with the drum 11 at the sending station. Accordingly the exposure of the surface 43 to the light from the source 41 corresponds to the shade of the film 12 and when the surface 43 is developed, it will give a representation of the picture.

I claim:

1. A picture representation, a light-sensitive element, an electric circuit connected with said light-sensitive element to be controlled thereby, amplifying means associated with said circuit, means to test the elements of said picture representation in succession and actuate said light-sensitive element accordingly, and means associated with said amplifying means adapted to be adjusted to obtain a suitable functional relation between the current in said circuit and the quantity of light incident on said light-sensitive element.

2. The method of transmitting pictures which consists in establishing a current as an increasing function of the light transmitted by successive elements of a picture representation and adjusting for the character of the picture representation from which transmission is effected, increasing the light value at which the current becomes appreciable for a comparatively transparent picture representation, and decreasing the light value for a comparatively opaque picture representation.

3. The method of transmitting pictures which consists in establishing a current as an increasing function of the light transmitted by the successive elements of a picture representation, and adjusting to make the curve of current as a function of light steep for a picture representation of slight contrast and less steep for one of sharp contrast of light and shade.

4. In combination, an electric circuit, means to govern a current therein in accordance with the light and shade of successive elements of a picture representation, an element with a sensitized surface, means to cause the reproduction of said picture on said surface, and adjustable means to govern the average contrast of the reproduced picture independently of the current in said circuit.

5. In combination, a three-electrode vacuum tube, a light-sensitive element, circuit connections to the grid of said tube from said element, means to excite said element by light transmitted through successive elemental areas of a picture representation, and means to adjust the circuit connection from the sensitive element to the grid, so as to secure a desired functional relation between the plate current of the tube and the light transmitted through the elemental areas of the picture to the light-sensitive element.

6. In combination, a three-electrode vacuum tube, a light-sensitive element, circuit connections therefrom to the grid of the tube, means to transmit light through successive elemental areas of a picture representation to said light-sensitive element, means to adjust the ratio of the effect on the grid as compared with the current output of the light-sensitive element, and means to adjust the normal grid voltage whereby the characteristic curve or plate current in relation to light can be displaced laterally in respect to the zero point.

In testimony whereof, I have signed my name to this specification this 24th day of March, 1924.

ALLAN WEAVER.