

Sept. 20, 1932.

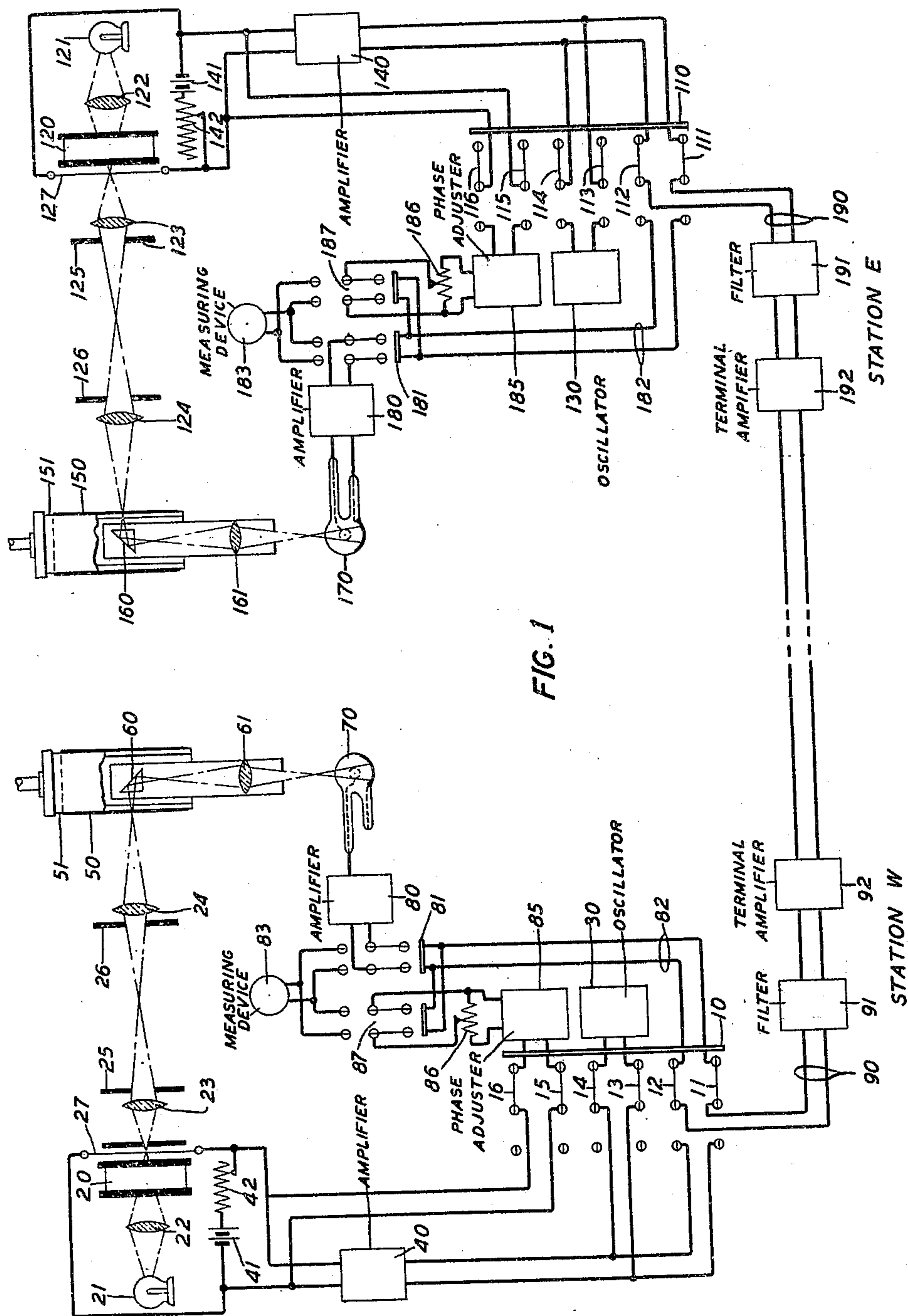
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1,878,711

ELECTROOPTICAL TRANSMISSION SYSTEM

Original Filed Feb. 18, 1927

2 Sheets-Sheet 1



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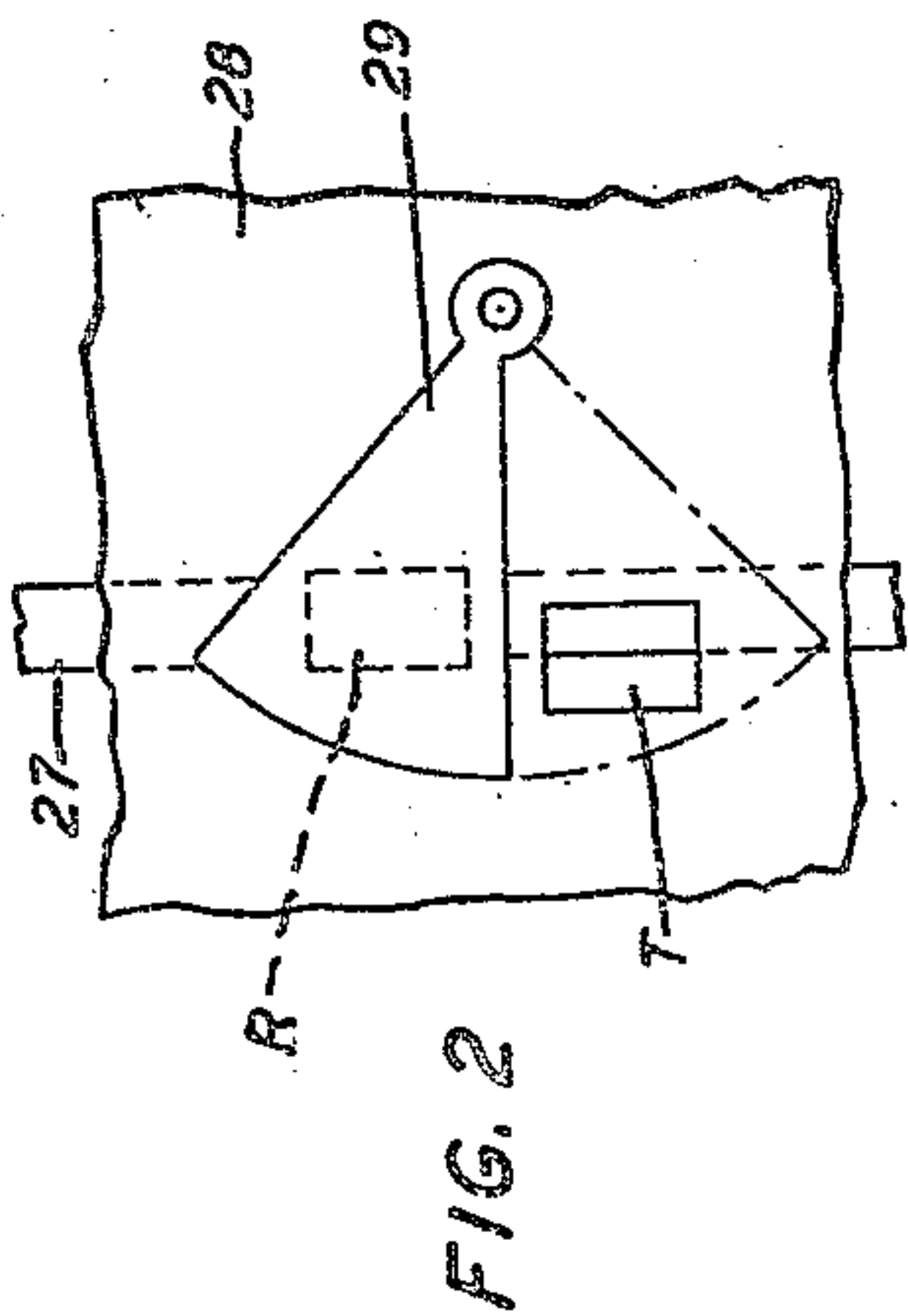


FIG. 2

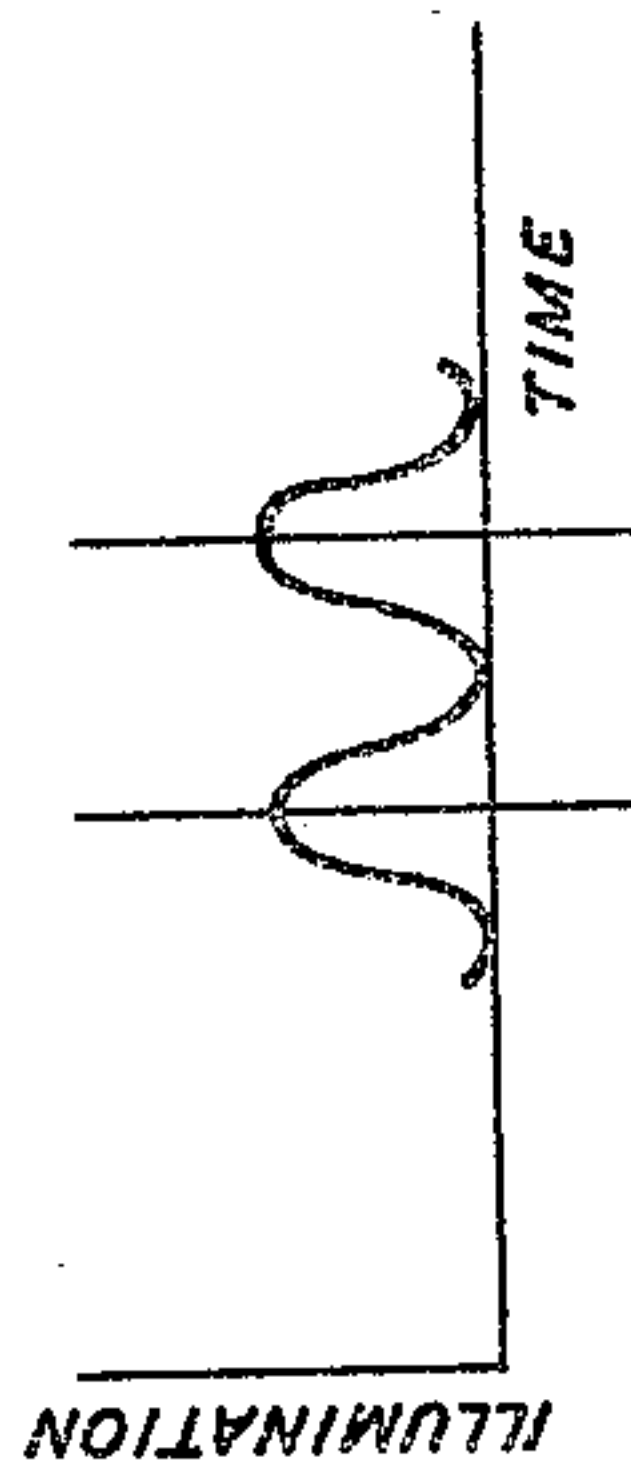


FIG. 3

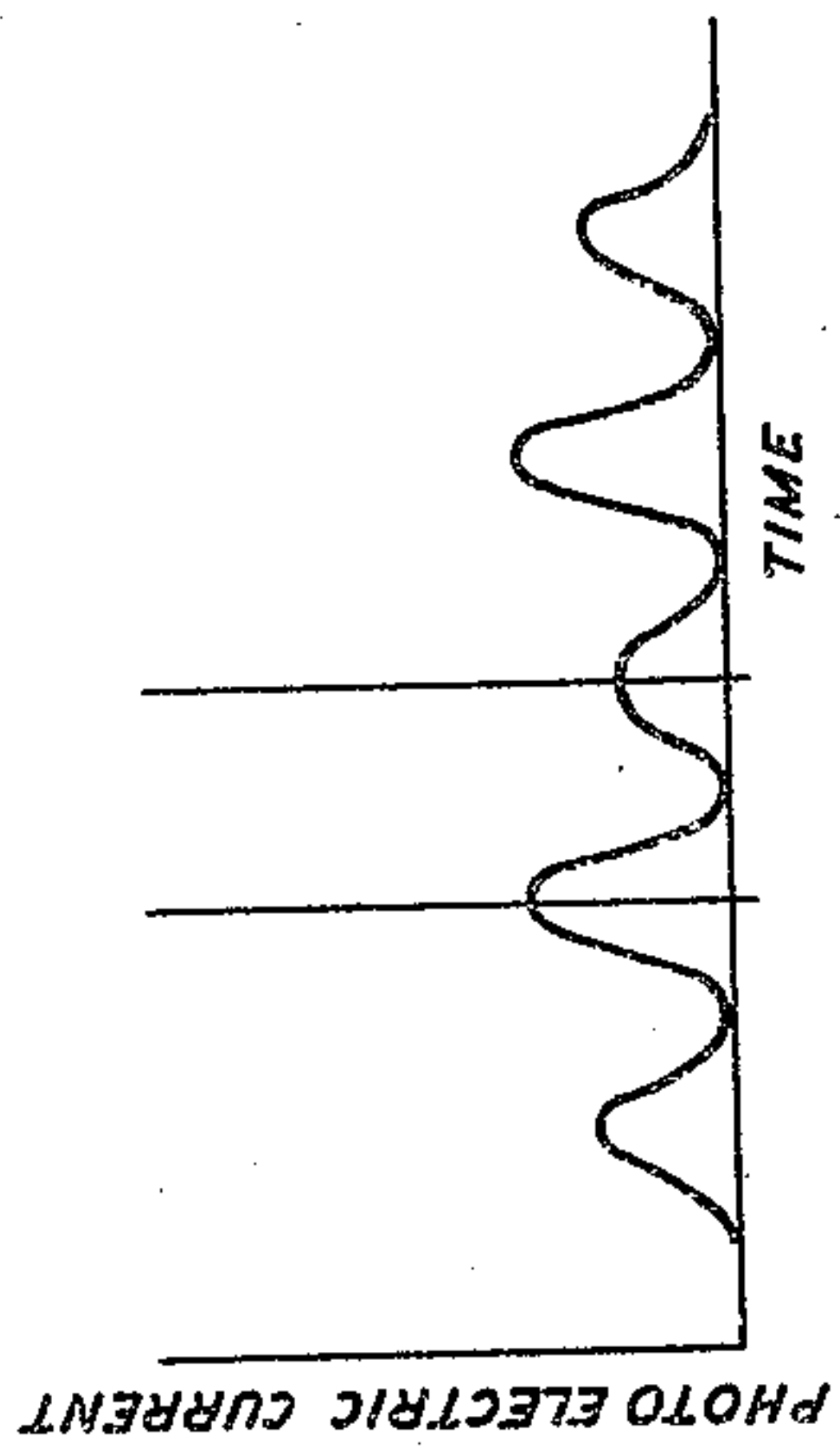


FIG. 4

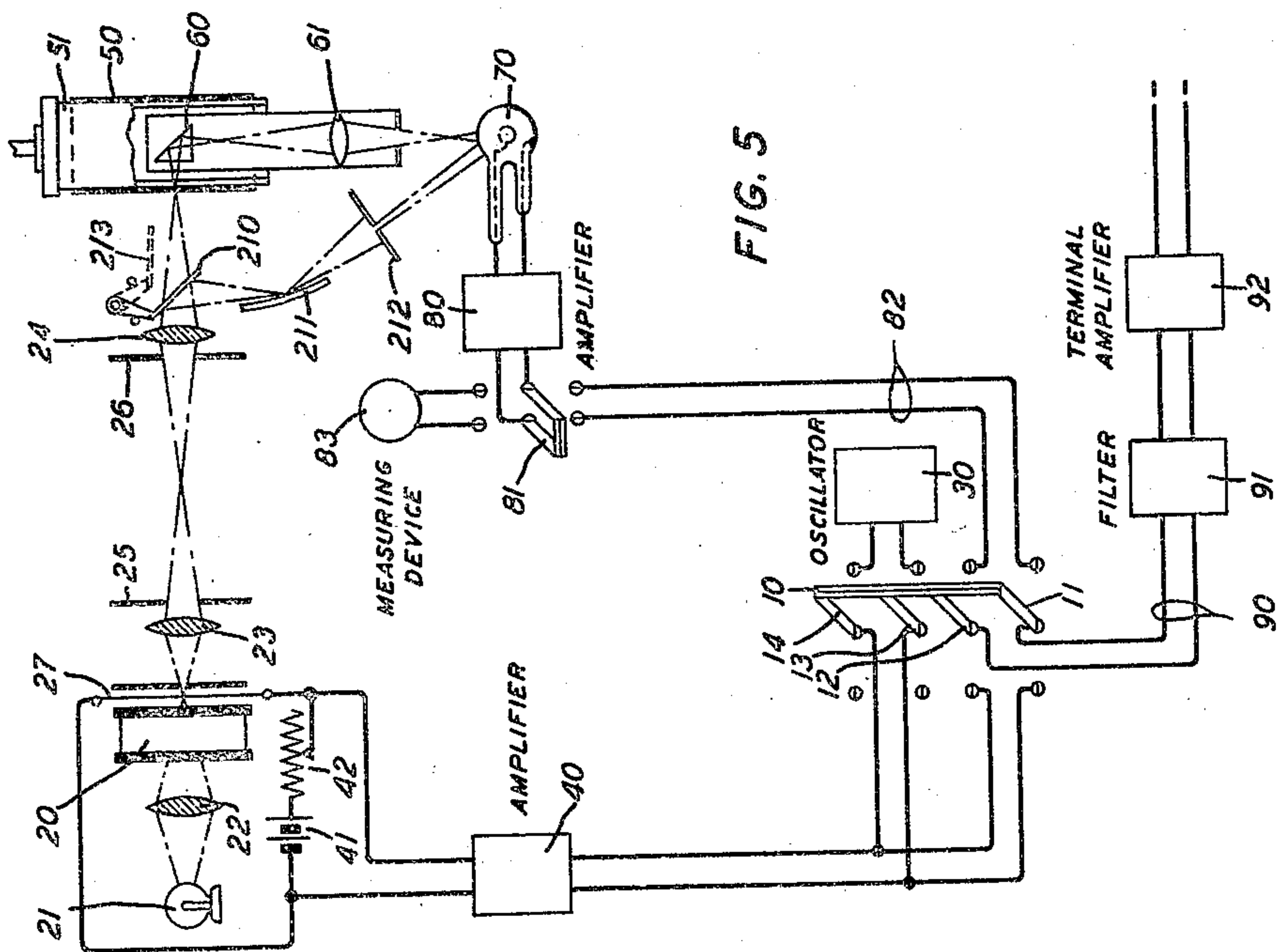


FIG. 5

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ELECTROOPTICAL TRANSMISSION SYSTEM

Original application filed February 18, 1927, Serial No. 169,322. Patent 1,773,119, dated August 19, 1930.
Divided and this application filed July 17, 1930. Serial No. 468,702.

This invention relates to electro-optical transmission and more particularly to a transmitting apparatus therefor and a method of operating such apparatus.

An object of the invention is to provide simple and efficient electro-optical apparatus and methods for producing a signal modulated carrier current.

In one aspect, certain elements of the apparatus may be used for either transmission or reception, and hence the invention serves to simplify the terminal equipment which is used for the transmission of pictures over telephone circuits.

In an embodiment of the invention selected for illustration a string or ribbon electromechanical light valve such as disclosed in Patent No. 1,667,805, May 1, 1928, of Herbert E. Ives, is positioned between a source of light and a holder for the transmitting or receiving film, depending upon whether transmission or reception is taking place. For picture transmission the light valve ribbon is vibrated by alternating current from a vacuum tube oscillator or other suitable source at a substantially constant frequency thereby generating a pulsating light beam which is hereinafter called a "carrier" light beam. This carrier light beam is modulated by the picture at the transmitter and is subsequently directed onto a photoelectric cell which in turn produces pulsating photoelectric currents representative of the light effects of the picture. By means of a transformer, these currents set up alternating current which constitutes the modulated carrier current for the line. For reception at the same terminal station, the oscillator is disconnected from the light valve and the incoming carrier picture currents are impressed upon this valve thereby causing to pass to the film holder, which now holds the receiving film, a varying beam of light corresponding to the light intensities of the elemental areas of the picture which is being transmitted from the distant station. The scanning at the terminals may be carried on in accordance with standard practice well known in the art. A suitable scanning system is disclosed in Patent No. 1,706,032, March 19, 1929 of M. B.

Long. The level of the line carrier currents may be raised at the transmitting terminal, to minimize the effect of disturbances entering by way of the line, by optically shunting some of the carrier light beam to the photoelectric cell.

This application is a division of an application filed February 18, 1927, which matured into Patent 1,773,119, Aug. 19, 1930.

A more detailed description of the invention follows and is illustrated in the accompanying drawings.

Figure 1 is a general schematic arrangement of a system comprising two interconnecting stations showing terminal apparatus which may embody this invention.

Fig. 2 is a detail, showing the light valve ribbon with relation to the light valve apertures when no current is flowing.

Fig. 3 is a curve, showing the variation in the intensity of the illumination of the picture at the transmitter with time.

Fig. 4 is a curve, showing the photoelectric current resulting from light modulation by the varying picture density plotted against time.

Fig. 5 is a general schematic arrangement of the terminal apparatus of one station, showing an embodiment of the invention comprising apparatus which may replace certain parts of the apparatus of Fig. 1.

Similar reference characters refer to similar parts of the apparatus.

In Fig. 1, in which two interconnected stations are shown, the terminal at the left, designated station W, will be described as a transmitting station and the switch 10 at this station is accordingly thrown to the right; while the terminal at the right, designated station E, will be considered as a receiving station and the switch 10 of that station is also thrown to the right, thus connecting the terminal apparatus of the two stations for transmission and reception, respectively.

At station W, light valve 20 is positioned in the path of light obtained from any suitable source 21. A suitable lens system 22, 23 and 24 and apertured members 25 and 26 cause a beam of light to pass through the

light valve and be focused on a small elemental area of the picture 50 where the light is modulated by the varying transparency of the elemental areas of the picture. The picture 50 is shown as a film of varying transparency mounted on a transparent drum 51 which is given a motion of rotation and of translation in accordance with standard practice in picture transmission systems, thereby causing the light beam to successively scan the elemental areas of the entire picture.

It is preferable to mount the light valve and the picture holding drum so that the axis of the light valve ribbon and the drum are at right angles to each other.

The light beam, after passing through the picture, is reflected 90° by a prism or mirror 60 and passed through a lens system 61 to the light sensitive cell 70. The light sensitive cell, upon being activated by the varying light, causes varying electric currents to be transmitted to the amplifier 80. The amplifier connects through the switch 81 to the circuit 82 which in turn connects through blades 11 and 12 of switch 10 to the outgoing circuit 90. The outgoing circuit 90 connects through the filter 91 and the terminal amplifier 92 with the transmission line leading to a receiving station.

The light beam activating the light sensitive cell 70 is a pulsating or carrier light beam, and the variation in the intensity of the beam is caused by the light valve 20. The ribbon 27 of the light valve 20 is energized by an oscillator 30 which generates a sinusoidal wave of the order of 1000 to 2000 or more cycles per second. The oscillator 30 transmits its currents through blades 13 and 14 of switch 10 and a connecting circuit to the amplifier 40 where the oscillating current is amplified and the output current of the amplifier passed through the ribbon 27 of the light valve thereby causing the light valve ribbon to oscillate at a substantially constant frequency. Movement of the light valve ribbon thus causes the light beam to rapidly vary in intensity in accordance with the frequency of the output current of the oscillator. The biasing battery 41 and the high resistance 42 afford means for adjusting the relation of the light valve ribbon with respect to the light valve aperture.

It has been found desirable in the transmission of pictures to provide for establishing a definite ratio between the maximum and minimum picture currents transmitted, and to provide for the transmission of a definite minimum carrier current at all times even when no light reaches the light sensitive cell. The purpose of this is to avoid overloading the transmission circuit apparatus such as repeaters and also to avoid inducing cross-talk in neighboring circuits, and to insure that the picture currents transmitted will be at an energy sufficient to avoid seri-

ous interference from noise currents. This may be accomplished as shown in Fig. 1 by using a part of the output current of the oscillator and adding it to the amplified picture currents, provision being made for adjusting both the phase and the magnitude of the former current with respect to the latter or vice versa. One way of adding a part of the oscillator output to the picture current is by means of the phase adjuster 85 and associated potentiometer 86, which connect the output side of the amplifier 40 through the circuit comprising the blades 15 and 16 of the switch 10 and the switch 87 to the circuit 82.

By means of the phase adjuster which may comprise a suitable network of variable impedances arranged in accordance with principles well known to the art, and the associated potentiometer, the output current of the oscillator can be phased with the picture current, and the necessary unmodulated carrier current of the proper amplitude impressed upon the transmission circuit. With such adjustment the shunted carrier and the variable picture currents add directly. The variations in light shades or tones of the picture are represented in this case by a current in the output circuit of the light sensitive cell 70, whose frequency is the frequency of the current impressed upon the light valve ribbon and whose amplitude at any instant is proportional to the light transmitted by the picture.

If the light valve is adjusted so that when there is no current flowing through its ribbon, the ribbon uncovers one-half of the light valve aperture, then the illumination will have a sinusoidal form represented by a constant added to a sine function, and at the same frequency as the current impressed upon the light valve ribbon, but with a phase displacement between its sine form component and the carrier of approximately 180° or multiple thereof. The width of the light valve ribbon should be equal to that of the light valve aperture and its maximum amplitude of vibration should be within one-half its width.

It is obvious that the amplified photoelectric current will add directly to the shunted output current of the oscillator if the phase of the latter current is adjusted relatively to the former. The phase adjuster 85 is adapted to bring about the necessary phase adjustment. This arrangement of the light valve in association with the light sensitive cell is such that the varying currents from the cell have the same frequency as the variations of the light transmitted by the light valve and also the same frequency as the current from the oscillator operating the light valve. This arrangement is important for if the light valve ribbon were differently adjusted with respect to the light valve aper-

ture with no current flowing through the ribbon, a double frequency in the light sensitive cell, for example, might be set up which would make it more difficult to add the desired carrier to the picture current.

In adjusting the apparatus for transmitting a picture it may be advantageous to ascertain the amount of current transmitted by the brightest and by the darkest portions of the picture and for determining this a measuring device 83 is arranged so that by throwing switch 81 to its upper closed position the output circuit of the amplifier 80 may be connected to this measuring device. Upon placing in the light beam various portions of the film 50, or any other object of varying transparency, its transparency at different spots may be measured and indicated by the measuring device 83 in such units as may be desired. For example, the measuring device may have a scale calibrated to read in per cent of the total light. When putting the apparatus in operation, the operator having ascertained the transparency of the lightest and the darkest portions of the picture may use this information in adjusting the apparatus for transmission.

The same measuring device 83, which may comprise a suitably arranged vacuum tube amplifier-detector unit, is also used for indicating when the phase difference between the photoelectric current and the shunted oscillator output current is zero. In making such a comparison, both the switches 81 and 87 are thrown into their upper closed position, thereby causing the output from both the light sensitive cell 70 and the phase adjuster 85 to be impressed simultaneously upon the measuring device 83. Also the ratio between the maximum and minimum picture currents, and the magnitude of the shunted oscillator output can be determined by the use of this measuring device 83 and proper manipulation of the switches 81 and 87 for connecting it to the two circuits. The magnitude of the picture current can be adjusted in a number of ways well known to the art, such as, by varying the voltage impressed upon the light sensitive cell.

The description so far has related primarily to the apparatus arranged for transmitting. When arranged for reception, a part of the same apparatus as is employed for transmission is used, and its connection is shown in the terminal station E at the right of Fig. 1. The switch 110 is thrown to the right and the relation of the light valve ribbon 127 with respect to the light valve aperture arranged so that with no current flowing through the ribbon the light valve is closed. When the switch 110 is thrown to the right blades 111 and 112 are operative to connect the circuit 190 with the amplifier 140 and the light valve ribbon 127. The other four blades 113, 114, 115 and 116 are inoperative

and hence the oscillator 130 and the phase adjuster 185 are disconnected from the operating circuit.

The proper relationship of the light valve ribbon to the light valve aperture may be established mechanically by adjusting the light valve jaws or electrically by means of the biasing battery 141 and the potentiometer 142. The incoming picture current is amplified by the terminal amplifier 192 and then passed through the filter 191, the amplifier 140 and the light valve ribbon to control its movement in a manner to reproduce the light effects of the distant picture and cause a light beam to be impressed upon the photo-sensitive film 150 on the cylinder 151, which is moved in synchronism and in phase with the picture at the transmitting station in accordance with standard practice well known in the art. Light from a steady source 121 is focused by the lens 122 on the light valve ribbon 127, and under control of the light valve is passed through the lenses 123 and 124 and the apertures 125 and 126 to the photo-sensitive film 150.

It is to be noted, as previously set forth, that the same apparatus units so far as may be required are employed for reception as are used for transmission and the principal adjustment necessary to put the terminal equipment into proper relationship for transmission or for reception are the circuit changes governed by the switches 10 and 110 at the terminals and the proper adjustments of the light valve ribbon with respect to the light valve aperture when no current is flowing. The interchangeability or dual use of the apparatus units for either transmission or reception simplifies the terminal equipment and its operation.

The relation of the light valve ribbon to the light valve aperture when no current is flowing is such that for transmission the light valve is half open and for reception the light valve is substantially closed as is shown at T and R, respectively, in Fig. 2. The primary reason for the half open position when no current is flowing when transmitting, as already explained, is to produce a varying illumination which when impressed on a light sensitive cell causes the latter to set up a varying photoelectric current of the same frequency as the current actuating the light valve. The closed position of the light valve when no current is flowing during reception is necessitated by the fact that the photoelectric current approaches zero when a dark portion of the picture is being transmitted and a maximum when the lightest portion of the picture is being transmitted.

Adjustment of the relationship between the light valve ribbon and the light valve aperture, as described in connection with Fig. 1, is effected by passing the proper biasing current through the light valve ribbon to

cause it to take up the proper position for transmission or for reception. This requires adjusting the biasing current when the light valve is changed from transmitting to receiving or vice versa.

In Fig. 2 is shown a mechanical means for making this change. Two light valve apertures T and R are used and permanently positioned in the apertured member 28 in proper relationship to the light valve ribbon. Only one of these apertures is open at a time. This may be mechanically effected by any suitable arrangement such as the opaque shutter 29 capable of being positioned in front of either aperture as shown in the drawings. However, even when the mechanical arrangement shown in Fig. 2 is used, the electrical biasing control would probably be advantageously employed for fine adjustments.

The illumination of the picture or film when plotted against time may be represented by a curve as indicated in Fig. 3. The illumination output of a light valve, properly adjusted, is approximately a linear function of the current input to the light valve ribbon so that the distortion from this source is negligible. This pulsating illumination has been described herein as producing a carrier light beam and as already explained it is impressed by means of a suitable optical system upon elemental areas of the picture whose image is being transmitted. One reason for employing a pulsating carrier light beam is to make possible the use of an alternating current amplifier, and thus use a photoelectric current under conditions which permit of its being amplified with ordinary voice frequency alternating current vacuum tube amplifiers. The employment of such apparatus permits its use on existing telephone or other transmission circuits.

The pulsating carrier light beam in passing through the picture at the transmitter is modulated in accordance with the light density of the elemental areas of the picture and the current variations resulting from the modulated light beam being impressed upon the photo-sensitive cell at the transmitting station may be represented by a curve having a substantially uniform fundamental frequency but of varying amplitude as shown in Fig. 4. The fundamental frequency of the photoelectric current as heretofore explained is the same as that of the illumination.

The unmodulated carrier current which is impressed upon the transmission circuit at all times, irrespective of the photoelectric current, may be obtained as described in Fig. 1 by shunting a part of the oscillator output current to the outgoing circuit.

In accordance with this invention an optical arrangement for supplying the modulated carrier is shown in Fig. 5. In this arrangement, a part of the carrier light beam is diverted by means of a partially transpar-

ent mirror 210, positioned in the path of the light beam, in such relation that it diverts a small percentage of the total light to the light sensitive cell 70. In the path of the light diverted to the light sensitive cell, is a plane or preferably a concave mirror 211 and an adjustable aperture 212 arranged for directing and controlling the diverted light. By such an optical arrangement the major portion of the carrier light beam passes through the mirror 210 to the picture, and a minor portion of the light is diverted to the light sensitive cell which is thereby actuated to produce unmodulated current of carrier frequency. When the apparatus is used for receiving, the semi-transparent mirror 210 is moved out of the path of the light beam into the position indicated at 213. The current produced in the light sensitive cell by the two parts of the light beam will be in synchronism and in phase and consequently add directly to each other. The magnitude of the carrier current produced by the deflected part of the light beam may be adjusted by means of the aperture 212.

The terminal apparatus shown in Fig. 5 with the exception of the omission of the electrical shunt and the substitution of the optical shunt, above described for impressing carrier current on the outgoing circuit, is the same as Fig. 1, and with the exception of these differences, the same description applies to both figures.

What is claimed is:

1. In an electro-optical system, a source of steady light, means to intermittently vary a beam from said source, means to further vary said beam in accordance with signals, means to produce a signal modulated carrier current from said beam, and means dependent upon the operation of said intermittent beam varying means to control the amplitude of the component of carrier frequency in said modulated carrier current.

2. In an electro-optical transmission system, a transmission circuit, a light beam, a light interrupter rapidly and regularly interrupting said beam at a substantially uniform frequency thereby producing carrier pulsations, a light modulating picture positioned in the path of the said light beam, a light sensitive element excited by the said light beam subsequent to the said picture modulating the said light beam, and an optical shunt passing pulsating light around the said light modulating picture for applying unmodulated carrier light pulsations produced by said light interrupter to the said light sensitive element.

3. An electro-optical system comprising a source of steady light, means for cyclically varying a light beam supplied by said source and for producing an auxiliary light beam therefrom, means for varying said first mentioned beam in accordance with signals, and

means upon which said signal varied and auxiliary beams are incident to produce signal modulated carrier current.

4. An electro-optical system comprising a source of steady light, means for cyclically varying a light beam supplied by said source, means for diverting light radiations from said beam to produce an auxiliary beam, means for varying said first mentioned beam in accordance with signals, and means upon which said signal varied and auxiliary beams are incident to produce signal modulated carrier current.

5. In an electro-optical transmission system, a transmission circuit, an analyzing light beam, a light interrupter in the path of said light beam, means for controlling the said light beam to produce a modulated carrier current in said circuit, and means acted upon by said analyzing beam to produce a second light beam for controlling the production of unmodulated carrier current to establish a minimum transmission level in said circuit.

6. In an electro-optical transmission system, a transmission circuit, an analyzing light beam, a light interrupter in the path of said light beam, a picture whose image is to be transmitted, means for controlling the said light beam to produce a modulated carrier current in said circuit varying according to the lights and shades of the said picture, and means acted upon by said analyzing beam to produce a second light beam for controlling the establishment of a definite ratio between the maximum and minimum current representing the darkest and lightest areas of said picture.

7. The method of carrier current signaling which comprises producing two beams of light from a single source of light which is modulated at carrier frequency, impressing a signal upon one only of said beams, and simultaneously utilizing said beams to set up a carrier current modulated in accordance with said signal.

8. A signaling system comprising a source of uniformly periodically varying light, means for modulating light in accordance with signals, means for directing light from said light source to said last mentioned means, light sensitive electric means receiving signal modulated light from said modulating means, and means for simultaneously impressing upon said last mentioned means light from said source which is not modulated in accordance with signals.

9. A signaling system comprising means for producing two uniformly periodically varying separate beams of light, the variations of said beams being in phase with each other, means for modulating one only of said beams in accordance with signals, and light sensitive electric means simultaneously receiving said signal modulated beam and said beam which is not signal modulated.

10. In an electro-optical system, means to produce a uniformly periodically varying beam of light, means to vary said beam in accordance with signals, means to produce a signal modulated carrier current from said beam, and means to control the amplitude of the component of carrier frequency in said modulated carrier current comprising light sensitive electric means and means for impressing thereupon a second beam of light having uniform periodic variations similar to and in phase with those of the first beam.

In testimony whereof, I have signed my name to this specification this 16th day of July 1930.

FREDERICK W. REYNOLDS.

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