Oct. 2, 1928. 1,686,355

E. C. WENTE

TRANSLATING DEVICE

Filed March 22, 1924

Fig. 1.

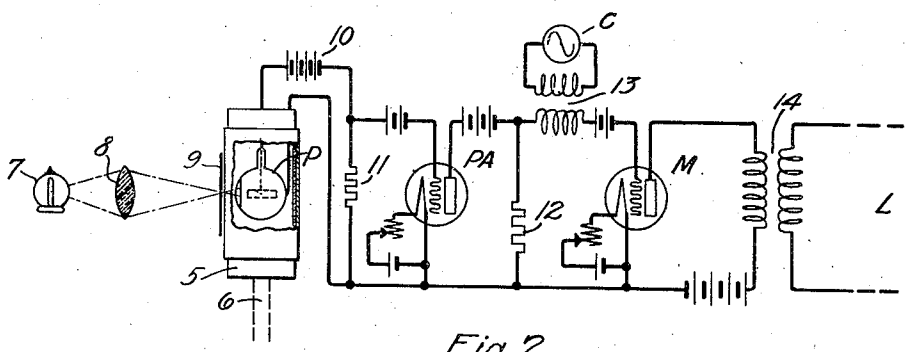


Fig. 2.

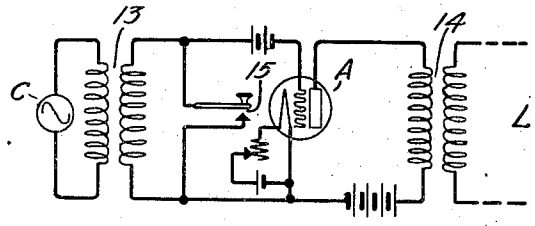


Fig. 3.

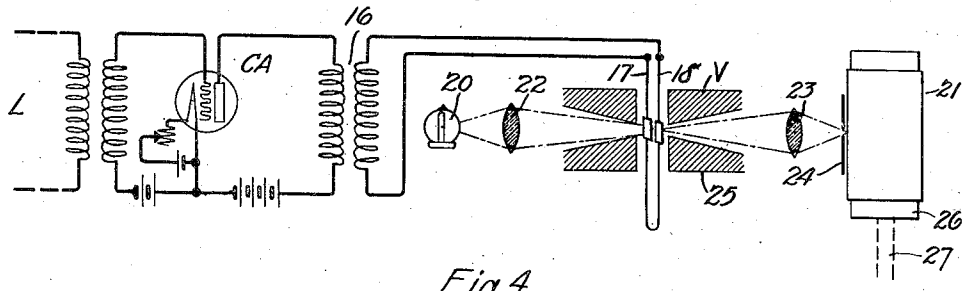
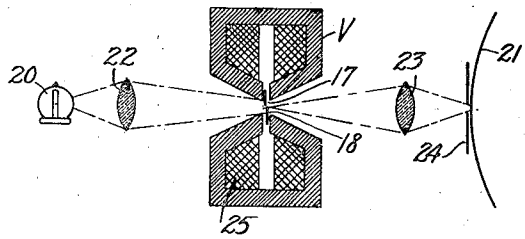


Fig. 4.



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UNITED STATES PATENT OFFICE.

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TRANSLATING DEVICE.

Application filed March 22, 1924. Serial No. 701,016.

This invention relates to translating devices and more particularly to an electromagnetic device for converting alternating current of varying amplitudes into a light record, the tone values of the successive elemental areas of which correspond to the envelope of the successive instantaneous amplitudes of the alternating current.

In applicant's Patent No. 1,638,555, Aug. 9, 1927, Serial No. 635,886, filed May 1, 1923 an arrangement is disclosed for obtaining a light record, the successive tone values of which are a function of the instantaneous amplitudes of an impressed current of any desired wave form, such as that of a wave corresponding to speech. It is often found desirable to transmit current of such a wave form as modulations of a carrier wave of higher frequency. In such case it has been customary to obtain the light sensitive record from the modulated carrier wave in two steps. The carrier wave is first demodulated to product current of wave form identical with that of the modulating wave form which current is then used to operate an electromagnetic device or light valve to produce the light record.

An object of this invention is to accomplish both these steps in the light valve by means of a novel adjustment thereof.

This object may be attained by providing in combination with a light source, a light valve comprising a pair of electrical conductors arranged in planes at right angles to a magnetic field so as to define under certain circumstances an aperture through which light is transmitted. Electrical waves of varying amplitude are supplied to the conductors to cause movement thereof relatively to each other. The separate conductors are arranged in adjacent planes so that each conductor may move independently of the other. The conductors are so adjusted that when the electrical waves are of zero amplitude the slot is just closed and no light can pass. Consequently, the light which is allowed to pass is proportional to the envelope of the waves of varying amplitude.

The novel features which are considered characteristic of this invention are set forth with particularity in the appended claims. The invention both as to its organization and method of operation together with other objects and advantages thereof will be understood from the following description having reference to the accompanying drawing consisting of the following figures.

Fig. 1 is a diagrammatic showing of an arrangement for modulating carrier waves in accordance with the tone values of elemental areas of a transparency of a picture to be transmitted by electricity.

Fig. 2 is a diagrammatic showing of an arrangement for transmitting telegraph signals by means of carrier waves.

Fig. 3 is a diagrammatic showing of a light record producing arrangement for use with either Fig. 1 or Fig. 2.

Fig. 4 is a cross section of the optical system of Fig. 3 on a plane at right angles to the paper.

Referring now to Fig. 1, a modulator M is supplied with carrier waves from a source C and with picture current from a photoelectric cell P and picture amplifier PA. Modulated carrier waves from the modulated M are impressed upon the transmission line L. The photoelectric cell P is located within a transparent drum 5 which is driven in any suitable manner by shaft 6. Mounted on the drum 5 is a transparency of the picture to be transmitted. Light from a source 7 is focussed by means of lens 8 upon the transparency of the picture through an aperture in a screen 9. The intensity of the light affecting the photoelectric cell P is determined by the tone value or density of the elemental area of the transparency of the picture which is, at any instant, adjacent to the aperture in the screen 9 at the focal point of the light beam. The intensity of the light within the photo-electric cell P in turn determines the amount of current flowing from the battery 10 through the photoelectric cell P and resistance 11 and consequently the potential drop through the resistance 11 which potential is impressed upon the input circuit of the picture amplifier PA. The amplified picture current is impressed upon the modulator M by resistance 12 simultaneously with carrier current from the source C by transformer 13. Modulated carrier waves from the modulator M are then impressed upon the line L by means of transformer 14.

Another arrangement for impressing carrier waves modulated in accordance with signals upon the line L is shown in Fig. 2. Carrier waves from the source C are impressed

upon the input circuit of amplifier A by means of transformer 13. Amplified carrier waves in the output circuit of amplifier A are then impressed upon the line L by means of transformer 14. The input circuit of amplifier A may be short circuited by means of key 15 to interrupt the transmission of carrier waves to the line L. Consequently, by manipulating key 15 in accordance with a message code, impulses of carrier waves may be impressed upon the line L corresponding to said code.

A receiving arrangement is shown in Fig. 3. Modulated carrier waves from the line L are amplified in the amplifier CA and impressed by means of transformer 16 on the conductors 17, 18 of light valve V. The general features of light valve V are identical with the light valve described in applicant's Patent No. 1,638,555, supra. The arrangement of the conducting wires is specifically different as will be explained hereinafter.

Referring to Fig. 4, it is seen that the conductors 17, 18 according to the preferred arrangement of the present invention are mounted in adjacent planes so that they may move independently of one another. Under "no-current" conditions they are so adjusted that the light passage from the light source 20 to the recording blank 21 is just closed by the conductors 17, 18. By "no-current" condition is meant broadly the condition when the amplitude of the carrier wave is zero. It is not necessarily the condition when no current is flowing in the movable conductors of the light valve. Light from the source 20 is directed by means of lens 22 upon the conductors 17, 18. The source 20 is so arranged with respect to the lens 22 and conductors 17, 18 that the conductors are intensely and uniformly illuminated over a surface at least as wide, in a direction transverse to the conductors, as the maximum opening of the valve, that is, the maximum separation of the conductors 17, 18 and sufficiently wide in the direction of the conductors 17, 18 to expose the width of the trace on the record blank 21 in the direction of rotation. The width of the trace is determined by the width of the aperture in the screen 24. An image of the aperture formed by a small section of the conductors 17, 18 is projected upon the light sensitive record blank 21. The magnetic field within which the conductors 17, 18 are mounted is set up by a coil 25.

Referring again to Fig. 3, the record blank 21 is mounted on a drum 26 which is driven in suitable manner by a shaft 27.

With the conductors 17, 18 mounted, as shown in Fig. 4 so that no light is transmitted when no current is traversing conductors 17, 18, the valve will operate as a demodulator when actuated by modulated carrier waves. The passage of carrier waves through conductors 17, 18 will cause the strips to vibrate and the valve will open to allow transmission of light for one-half of each cycle and remain closed during the other half.

If the adjustment is made as just explained so that the light is cut off with the strips in normal position, the light transmitted during each alternate half cycle is directly proportional to the amplitude of motion of the conductors. If the motion of the conductors follows the current amplitude the transmitted light impulses follow the envelope of the impressed modulated carrier wave. As a result of the movement of the light sensitive record blank 21, in a direction at right angles to the conductors 17, 18, that is, in the direction of their movement, the record is in the form of a trace of varying brightness corresponding to the envelope of the carrier wave.

In order to have the motion of the conductors follow the instantaneous value of the current as accurately as possible it is important that the damping of the conductors be sufficiently large. The frequency of the modulations that may be recorded by the device is largely determined by this quantity. To make this point clear an example is given for the transmission of a 4 x 5 inch picture with a carrier wave of 1200 cycles per second with the equipment of Figs. 3 and 4.

The valve will transmit 1200 light impulses per second to the recording blank 21, which may be a photographic film. If the film is run sufficiently fast it will after development show 1200 dots in the space the image traversed in 1 second. If the picture is to have one hundred dots per linear inch—a value which obtains in a good grade of news paper half tone—the drum runs at a linear speed of 12 inches per second. If the drum is 2 inches in diameter, the revolutions per second should be 12 divided by 2Π. For the 4 x 5 inch picture 400 revolutions would be required so that the time required for transmitting this picture would be

$$400 \times 2\Pi = 210 \text{ seconds or } 3\tfrac{1}{2} \text{ minutes.}$$

With the arrangement so far described 100 dots are recorded per inch but the exposure given by each light impulse will not be proportional to the envelope of the carrier wave at each instant unless the damping of the vibrating system has been suitably chosen. The response to changes in current amplitude will be most exact if the system is made aperiodic; this condition, however, means lower sensitivity and a damping so large is in general not necessary or advisable. If the amplitude drops to one tenth of its initial value in going from one dot to the next when the current is suddenly interrupted, satisfactory results will be obtained. This condition would require a damping constant

of 2800 (the damping constant is here defined as the reciprocal of the time required for a displacement to drop to $\frac{1}{2.718}$ of its initial value when the impressed force is removed). This value of damping may be obtained by shunting the valve with a suitable resistance.

In order to obtain a continuous trace of varying brightness the drum would need to run at a much lower linear speed, so that successive impulses of light would expose overlapping surfaces. In a modified arrangement the drum is rotated in a direction at right angles to the movement of the conductors 17, 18. The speed of rotation could be the same as that given hereinbefore as an example. The record with this arrangement would be in the form of dots having uniform dimensions in the direction of the trace and lengths at right angles to the trace corresponding to the envelope of the modulated carrier wave. By slowing down the speed of rotation of the recording drum the record could be obtained in the form of a continuous line of varying width corresponding to the envelope of the modulated carrier wave.

In the preferred embodiment of the invention the natural frequency of the valve strips is made the same as the frequency of the carrier waves. This is desirable not only because it increases the sensitivity of the valve but also because it reduces the effect of disturbing currents of different frequency which may find access to the valve under actual operating conditions.

For the transmission of pictures by electricity the arrangement of Fig. 1 is combined with that of Fig. 3 by connecting the lines L together. The drums 5 and 26 are driven in synchronism by any suitable arrangement such, for example, as that shown in the copending application of M. B. Long, Serial No. 681,347 filed December 18, 1923. They not only rotate in synchronism but are also moved axially relatively to the shafts. As the drum 5 rotates, carrier current modulated in accordance with the varying tone values of the successive elemental areas of the picture is transmittd over line L and impressed in amplified form upon the conductors of light valve V. The movement of these conductors relatively to each other allows more or less light from the source 20, depending upon the amplitude values of the envelope of the modulated waves, to affect the elemental areas of the light sensitive record blank 21 on the drum 26. It is thus evident that the reproduction of the picture from the modulated carrier waves is effected in a single step by means of the light valve V and its associated optical apparatus.

For the reception of telegraph signals originating in the arrangement of Fig. 2 by means of the arrangement of Fig. 3, no synchronizing apparatus is required. The impulses of carrier current corresponding to the message code are transmitted over the line L and cause an intelligible light record on record blank 21 providing that drum 26 is rotated at a uniform speed.

An important feature of this invention is the transformer coupling between the amplifier CA and the light valve V. In any practical recording or reproducing system amplification is essential and the necessary amplification is best accomplished by the use of electron discharge devices. In systems of this kind heretofore known, this required the direct connection of the light valve to the electron discharge device, as exemplified in the copending application of M. B. Long, supra. Since the light valve V has an impedance of only a few ohms, while the discharge device has an impedance of several thousand ohms, such direct connection is necessarily inefficient and necessitates a large amount of amplification. By this invention alternating currents are supplied directly to the light valve and an efficient coupling transformer 16 is used between the electron discharge amplifier CA and the light valve V. The transformer 16 is a step-down transformer and matches the high output impedance of the amplifier CA to the low impedance of the valve V.

Two embodiments of the invention have been specifically described. The scope of the invention, however, is not so limited, but is defined by the appended claims.

What is claimed is:

1. An electro-optical system comprising a passage through which light is transmitted, a source of modulated carrier waves, and vibrating means comprising two members movable in separated but parallel planes to vary the amount of light passing through said passage in accordance with only half of the envelope of the amplitudes of said modulated waves.

2. In a light recording system, a light valve comprising a movable conductor located in a magnetic field, a light passage normally closed by said conductor and opened only during one direction of movement thereof, means to supply electric current of varying amplitude and direction to said conductor to cause movement thereof, and means to obtain a record of the amount of light allowed to pass through said passage.

3. In an optical arrangement, a light valve comprising a movable conductor located in a magnetic field, a light passage normally closed by said conductor and only opened during one direction of movement of said conductor, a source of light for said passage, and means to supply electric current of varying polarity to said conductor to cause movement thereof whereby light is allowed to pass

through said passage when current of one polarity only is passing through said conductor.

4. In an electro-optical system, a directed beam of light, an aperture on which said beam is focussed, an electrically controlled movable screen comprising a conductor located in a magnetic field normally closing said aperture, a source of modulated carrier waves, and means for moving said screen by passing current from said source through said conductor whereby the amount of light traversing said aperture varies in accordance with the envelope of the amplitudes of the carrier waves from said source.

5. In a system for the transmission of pictures by electricity, a source of carrier waves, means to modulate carrier waves from said source in accordance with the tone values of the elemental areas of the picture to be transmitted, an electromagnetic light valve comprising a movable conductor located in a magnetic field actuated by varying current in said conductor corresponding to modulated carrier waves from said modulating means, a source of light for said light valve, and a light sensitive record blank exposed to light from said source under the control of said light valve for reproducing the picture.

6. In a system for the transmission of pictures by electricity, a source of carrier waves, a source of picture current comprising a photoelectric cell and a movable element for effecting changes in said cell in accordance with the tone values of the elemental areas of the picture, a modulating device whereby carrier waves from said source of carrier waves are modulated by picture currents from said picture current source, an electromagnetic light valve comprising a movable conductor located in a magnetic field actuated by varying current in said conductor corresponding to modulated carrier waves from said modulator, a source of light, and a second movable element for effecting the reproduction of the picture by means of light from said source controlled by said light valve.

7. In an electro-optical system, a light valve having movable conducting members, defining a variable aperture, means to transmit light through said aperture, a light sensitive recording blank exposed to said transmitted light, a source of alternating current modulated in accordance with a record to be reproduced, an electron discharge amplifier for amplifying current from said source and a transformer for efficiently coupling said amplifier to the conducting members of said light valve.

8. In an electro-optical recording system, a light valve having two movable members defining a variable aperture, a source of light, a lens for forming an image of said source of light in the plane of said aperture, a lens for forming an image of said aperture upon a light sensitive record blank, and means to vary said aperture in accordance with impulses of one polarity only of an alternating current wave.

9. In an electro-optical system, a light valve having an aperture therein, a source for directing a beam of light upon said aperture, a movable conductor normally closing said aperture, and means for generating and transmitting through said movable conductor an alternating current, said conductor vibrating in response to said current in such a manner that the aperture is opened only while said current is flowing in a given direction.

10. In an optical system, a light valve having an aperture therein, a source for directing a beam of light upon said aperture, a movable conductor normally closing said aperture, a source of alternating current, means to modulate said current in accordance with the characteristics of a picture, and means for applying the modulated current to said conductor, said conductor responding to said current in such a manner that the aperture is opened only while current is flowing in a certain direction.

11. In an optical system, a light valve having an aperture therein for the passage of light, a screen normally closing said aperture and comprising two separate elements arranged to vibrate toward and away from each other, a source of alternating current, and means responsive to said current for causing said elements to vibrate such that when the current is of one polarity said elements are separated to open the aperture and when the current is of the opposite polarity the elements are brought together to maintain the aperture closed.

12. An electro-optical system comprising a passage through which light is transmitted, a source of modulated carrier waves, and vibrating means comprising two members movable in separated but parallel planes to vary the amount of light passing through said passage in accordance with the envelope of the amplitudes of said modulated waves.

13. In an optical system, a light passage, a source for supplying light to said passage, a movable screen controlling the amount of light passing through said passage from said source, means for observing the amount of light allowed to pass through said passage, means to supply alternating electric current to move said screen to vary the amount of light passing through said passage and to cut off substantially all light during a portion of each cycle of the alternating current, and means to cause relative movement between the observing means and the light passage at such a rate that discrete portions of the observing means are acted upon by the light passing through said passage during successive cycles of the alternating current.

14. The method of transmitting a picture,

which consists in sending current impulses corresponding to the degree of shade of successive picture elements, applying these current impulses to operate a light valve, and moving a sensitive film at a definite rate with respect to the rate of operation of said light valve to produce on said film discrete halftone dots in area corresponding to the magnitude of the respective current impulses.

15. In combination, means to generate current impulses corresponding to the degree of shade of successive elements of a picture, means to apply said currents to operate a light valve, and means to move a sensitive film under said light valve at such a speed that its openings will record discrete halftone dots to make the received picture.

In witness whereof, I hereunto subscribe my name this 14th day of March, A. D., 1924.

EDWARD C. WENTE.