

Oct. 22, 1935.

C. E. HUFFMAN
ELECTROOPTICAL SYSTEM

2,017,901

Filed Oct. 18, 1930

2 Sheets-Sheet 1

Fig 1.

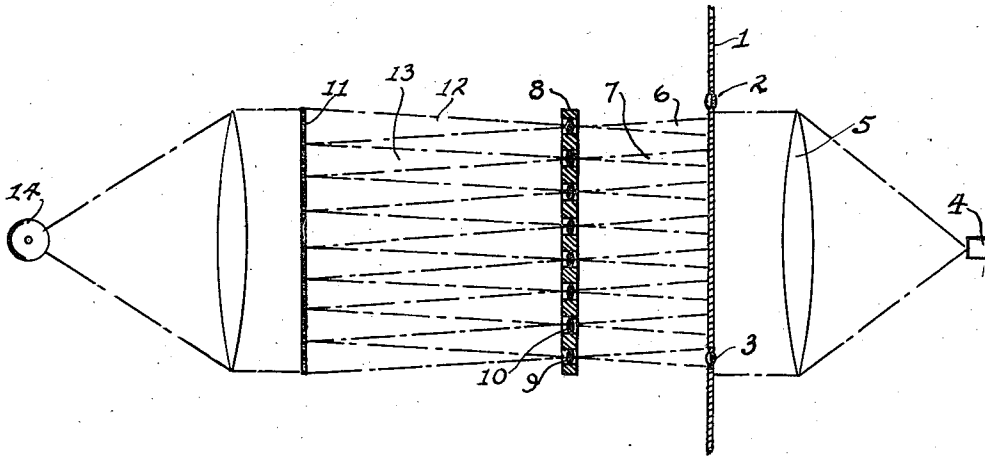
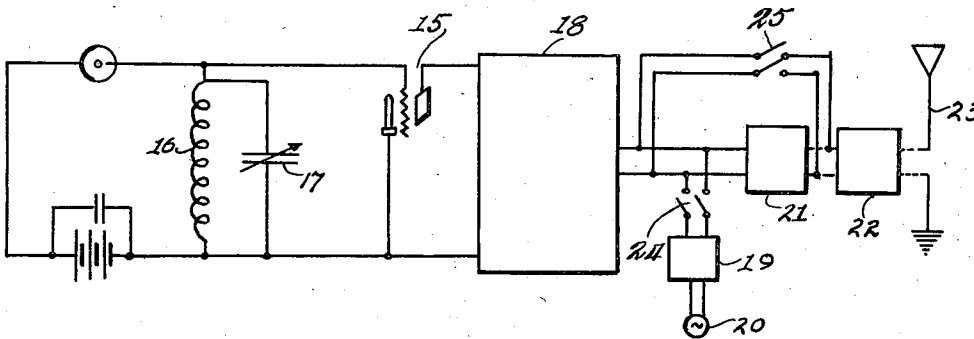


Fig 2



Charles E. Huffman ^{Inventor}
By his Attorneys
Darby Darby

Oct. 22, 1935.

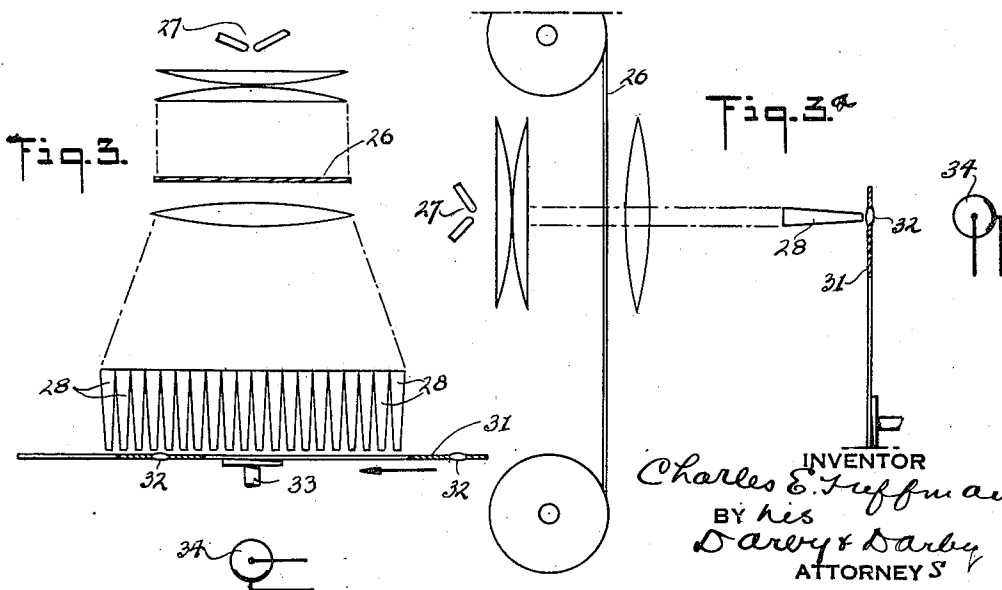
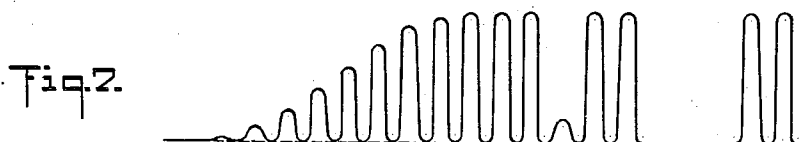
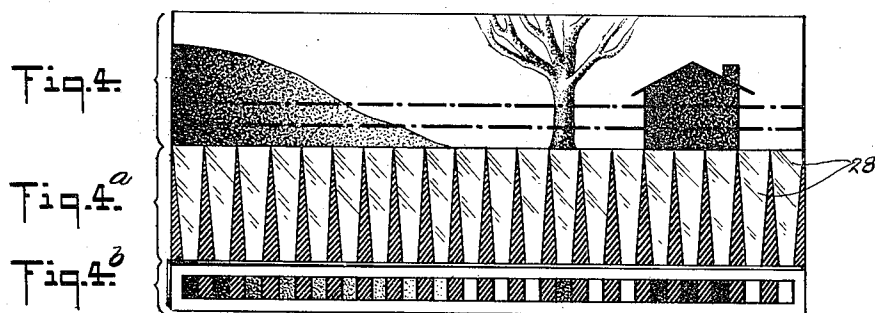
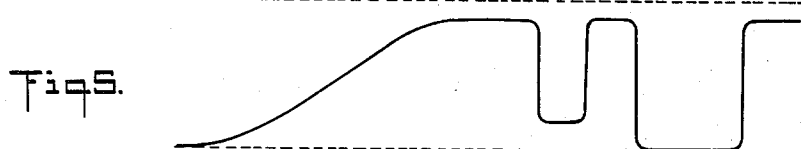
C. E. HUFFMAN

2,017,901

ELECTROOPTICAL SYSTEM

Filed Oct. 18, 1930

2 Sheets-Sheet 2



INVENTOR
Charles E. Huffman
BY his
Darby & Darby
ATTORNEYS

UNITED STATES PATENT OFFICE

2,017,901

ELECTROOPTICAL SYSTEM

Charles E. Huffman, Montclair, N. J.

Application October 18, 1930, Serial No. 489,503

1 Claim. (Cl. 178—6)

This invention relates to electro-optical systems and with particularity to methods and means for transmitting images or visual representations.

One of the principal objects of the invention is to provide a method of scanning whereby image currents are produced having an extremely narrow frequency spectrum.

As is well known in the customary type of television system the image, object or other visual representation is scanned in a continuous process with the result that at any given instant the image current possesses frequency components corresponding not only to each adjacent elemental area but also to varying proportions of each set of adjacent areas. In other words the light beam after leaving the object or image possesses almost an infinite variety of frequency components, and when intensity is plotted against time the resultant curve is one of a very complex character. Therefore, an amplifier having an exceptionally wide frequency amplifying characteristic must be employed if faithful reproduction is to be achieved. Furthermore such an amplifier must have a substantially uniform "frequency-gain" characteristic over the complete spectrum to be amplified.

In accordance with the present invention it is proposed to employ a scanning method whereby the image currents have a restricted frequency range whereby a so-called tuned amplifier may be employed. The expense of building such an amplifier is of course considerably less than in the case of the broad or untuned amplifiers usually employed, and greater effective detail may be achieved in both analysis and reproduction since the width of the wave band required is independent of the degree of detail required.

The scanning light spot is projected for a predetermined time interval upon each elemental area of the representation before passing to the next area. While any given elemental area is being scanned the quantity of light projected thereon may be varied preferably in a sinusoidal manner. In other words the scanning spot is modulated while scanning a given area, independently of the shade characteristics of said area. Consequently the response of the light cell is in the form of a regularly recurrent wave of sinusoidal form, each wave having an amplitude corresponding to the shade characteristics of a particular area of the representation, and having a single frequency determined by the time the

scanning spot dwells on each elemental area before passing to the next.

Inasmuch as the size of the scanning aperture or lens must be sufficiently large to pass the proper amount of light, it is inevitable that some detail of the visual representation is lost due to the integrating effect of the aperture. In addition, since the aperture moves in a continuous manner from one end of an elemental area to the next, there is a continuous overlapping which exhibits itself in the form of a complex current wave for each elemental area of the picture. In accordance with the present invention it is proposed to overcome these disadvantages by "averaging" the light from each elemental area, and causing the scanning mechanism to scan these "averaged" elemental light spots instead of the original image. Thus considering a picture divided into elemental areas of 0.01 square inches, in many cases each elemental area will exhibit complex shade variations from edge to edge. By the present invention this variation in shade of the elemental area is averaged and the picture or image at the transmitter is translated into a picture or image having uniform elemental areas each area, having uniform shade characteristics over its complete area.

Therefore it is one of the principal objects of the invention to provide methods and means for translating a picture, image or visual representation to be transmitted into a similar picture having elemental areas of uniform dimensions, and with each area preferably, although not necessarily, having uniform shade or light qualities within its boundaries.

Another object of the invention is to provide methods and means for translating a picture or image into a similar picture or image but with the elemental areas thereof spaced from one another.

In the ordinary type of television transmitting system further "distortions" are produced, rendering the transmitted image current waves more complex, as a result of what may be termed "fatigue" of the light and sensitive device. Thus even in the fastest known photo-electric cell while the output may be in phase with the incident light, nevertheless after a period of use the sensitivity of the cell decreases. For example, when the cell is first excited by light of a given intensity the response will have a certain strength, but after a period the response for the same given light intensity will decrease. It has been found that by allowing the cell a time to recover be-

tween successive light impulses the sensitivity is restored to its normal value.

Accordingly it is another object of this invention to provide a scanning method whereby the photo-sensitive device is only intermittently illuminated, and is allowed to "recover" during the dark intervals.

A further object is to so time the intermittent illumination that the photo-sensitive device produces a current which is in the form of a regularly recurrent wave of simple wave form with each wave having its amplitude varied in exact correspondence with the incident light.

As a result of this object the scanning apertures or elements may be so related to the scanning light source that the actual scanning spot builds up and decays in a simple and regular manner preferably sinusoidally.

A still further object is to provide a scanning method whereby the image currents are in the form of a series of regularly recurrent waves having a single or extremely restricted wave band or frequency spectrum.

A feature of the invention resides in the means whereby an object or image may be scanned in successive elemental areas so that the scanning spot is moved in a step-by-step fashion from one elemental area to the next, instead of in a continuous line according to the prior art.

Another feature relates to a television scanning system whereby the response of the photo-sensitive device is allowed to "build-up" and "decay" in regularly recurrent waves each corresponding in amplitude to the light value of an elemental area of the image, object or visual representation.

Another feature relates to a television scanning system whereby a tuned coupling circuit may be provided between the photo-sensitive cell and the amplifier.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following description and the appended claim.

While the invention will be described as employing known types of apparatus it will be understood that other apparatus may be used without departing from the spirit and scope of the invention.

Referring to the drawings—

Figure 1 shows in schematic form a television analyzing system according to the invention;

Fig. 2 is a schematic wiring diagram to be used with the system of Fig. 1;

Fig. 3 illustrates a modified manner of visually preparing or translating the picture or image prior to scanning;

Fig. 3A is another view of the apparatus of Fig. 3;

Fig. 4 is a portion of a picture or view to be transmitted;

Fig. 4A shows how the picture appears when "translated" according to the present invention;

Fig. 5 is a curve of the "shade" or light transmission or reflection characteristics of Fig. 4;

Fig. 6 is a curve of the photo-electric currents produced by the prior art scanning methods;

Fig. 7 is a curve and representation of the photo-electric currents corresponding to Figs. 4 and 5 produced according to the invention;

Fig. 8 shows how the current of Fig. 7 is reproduced after rectification or detection.

Referring to Fig. 1, the numeral 1 represents a scanning disc of known construction having a plurality of equally spaced scanning or analyzing elements or apertures 2, 3, etc. preferably ar-

anged at equal distances from the center of the disc. It is also preferred to mount a lens in each of the analyzing apertures. Light from a source 4 of relatively high and constant intensity is projected by a suitable optical system 5 upon the disc 1, preferably in the form of a narrow band. Thus as disc 2 rotates there is produced by means of the lenses 2, 3, etc., a moving spot of light successive positions of which are represented by numerals 6, 7, etc. Situated on the side of disc 1 opposite to the source 4 is a baffle strip 8 having a plurality of apertures in each of which is mounted a lens 9, 10, etc.

The strip 8 is stationarily mounted adjacent disc 1 and in alignment with the path of movement of the disc lenses 2, 3. Consequently as the disc rotates the light which reaches the moving film 11 is regularly interrupted since the beams 6, 7, etc. alternately strike the apertured portions of strip 8, and the opaque portions thereof. It will be understood that there are as many apertures in the strip 8 as there are elemental areas in each linear element of the film. For example, in one known type of system it is customary to divide the picture into 48 linear elements; consequently in such a system there would be provided 48 spaced apertures in strip 8. As shown in Fig. 1 the light beam which passes through the baffle strip is projected in the form of a beam whose width is equal to the width of the elemental areas of the picture. Thus each linear element of film 11 may be considered as made up of 48 successive elemental areas of square light boundary. Under this assumption the apertures in strip 8 are also square. However, due to the diverging character of the beams 6 and 7 after leaving the strip 8, each emergent beam 12, 13 etc. exactly illuminates each elemental area of the film; notwithstanding that the apertures in strip 8 are spaced apart.

In effect, therefore, the light from source 4 completely illuminates each and every elemental area of film 11 for a definite time interval which is determined by the number and size of the apertures in strip 8 and the speed of disc 1. In like manner as the beam 6 encounters the opaque portion of strip 8 it is regularly interrupted at the same rate. The net result is that the light spot moves over each strip of film 11 in an interrupted step-by-step fashion, dwelling on each elemental area for a definite time, and being extinguished (so far as film 11 is concerned) for an equal length of time.

In this connection it may be noted that the light spot actually "builds-up" so far as each elemental area of film 11 is concerned. Thus the shape of the apertures 9, 10, etc. may be such with respect to the cross section of beams 6, 7, etc. that the light spot on each elemental area of the film "builds-up" preferably in the form of a sine wave.

The purpose of thus interrupting the light beam is two-fold, first so that the response from the photo-sensitive device 14 may have a regular and fixed frequency characteristic (determined by the number of apertures in strip 8, and the speed of disc 1), and also the light cell being energized in an intermittent fashion is enabled to recover after each light impulse is projected thereon. Indeed it is preferred to so proportion the interval of illumination to the interval of darkness so that the current may build-up and decay within the cell in its normal manner, thus allowing the cell to restore to its normal degree of sensitivity for each light impulse.

From the foregoing it will be seen that the photo-electric currents have a relatively simple wave form which has a fixed frequency. Consequently such currents may be amplified by means of a so-called "tuned" amplifier. A system of this character is shown in Fig. 2 wherein the photo-electric currents are impressed on the input circuit of amplifier tube 15 through a tuned circuit comprising the inductance 16 and the variable condenser 17. It will be understood that the condenser coil coupling is tuned to the frequency of illumination of cell 14. As hereinabove described this adjustment is preferably such that the cell 14 is enabled to follow its natural rate of response and decay for each impulse of light, allowing it to completely restore between successive light impulses.

The amplified output of tube 15 is further amplified by an amplifier 18 also tuned to the characteristic frequency. If the signals are to be transmitted over a radio channel, the amplified photo-electric currents may be applied to an oscillator-modulator device 19, 20 of known construction. The modulated carrier is then preferably passed through well-known apparatus 21 for "suppressing" the carrier and one of the side bands. The other side band is amplified by device 22, and applied to the transmitter 23.

As shown in Fig. 2 the oscillator modulator 19, 20 is connected to the output of amplifier 18 through a switch 24, while another switch 25 is provided for connecting the amplified output directly to the transmitter. Thus if the picture is scanned in areas of 0.01 square inches and there are fifteen pictures per second to the inch and assuming a one-hundred line picture, then the amplified output from device 18 may be used directly for radiation, in which case switch 25 is closed and switch 24 is opened. With this latter arrangement the increased frequency band arising from modulation, etc. is avoided and the frequency of the carrier is determined either by varying the speed of disc 1, by increasing the size of the scanning spot, or in the case of a motion picture film changing the speed of the film.

Referring to Figs. 3 and 3A there is shown a modification of the invention wherein the numeral 26 represents a motion picture film or other visual representation to be transmitted. Positioned on one side of film 26 is a source of light 27 such as an arc lamp or the like. Positioned on the opposite side of film 26 is a series of light confining rods 28 such as quartz, glass, or the like. In the case of a moving film these rods are arranged side by side in a straight line, corresponding to a linear element of the film. Thus by means of a suitable optical system 29, 30, a magnified image of each linear element of film 26 is projected upon the ends of the rods 28, as the film moves. As shown, the rods 28 are tapered and disposed with the large ends nearest the film 26, it being understood that each large end corresponds to an elemental area of film 26. Thus if the picture is to be scanned in one hundred adjacent linear elements (lengthwise of the film) then there will be provided one hundred light rods 28 with the enlarged ends adjacent each other. As a result of the tapering of the rods, each linear strip (across the width of the film) is translated into a similar linear strip but with the elemental areas spacially separated and of reduced size as will be evident from Fig. 3. Positioned in front of the small ends of rods 26 is a scanning disc 31 similar to disc 1 (Fig. 1) and preferably with

lenses 32 arranged equally distant radially from the axis 33. A photo-sensitive cell 34 is positioned on the other side of disc 33 to receive the light passing through rods 26 and disc 31. In order that the photo-cell may have an opportunity to "restore" after each light impulse it is preferred to design the rods 26 so that the width of the small ends is equal to the separation between adjacent small ends. Thus the photo-cell instead of scanning the film across a linear element in a continuous manner as is done in the prior art, scans the linear elements in areas of uniform size and in a step-by-step manner, since the cell is cut off from light when the lenses 32 therein are passing over the spaces between the small ends of rods 26. Furthermore, because of the integrating effect of rods 26, the light that actually reaches the photo-cell (corresponding to a given elemental area of the film) is collected and uniformly distributed through the small ends of the rods. In effect therefore the photo-cell scans a "translated" picture which is made up of elemental areas which are spacially separated, are of uniform light boundary and with each area having a uniform light distribution over its area, notwithstanding that the original picture may have a highly complex shade distribution over each elemental area.

Referring to Fig. 4 there is shown another manner of illuminating the object, image or visual representation in a step-by-step manner. Parts of this figure, which are similar to those of Fig. 1, bear the same designations, thus numeral 11 represents a transparency such as a motion picture film or the like, which is adapted to be illuminated by a scanning light 4, the lens 5 and an analyzing disc 6 are provided for the purpose of moving the scanning beam relatively to the film 11. Positioned between the film and the disc 6 are a plurality of light confining channels such as quartz rods 24 or any other elements capable of confining light within a sharp boundary. As shown in Fig. 4, the rods 24 are tapered and are positioned with their wide ends adjacent to each other, and with their narrow ends separated. Each of the ends 25 corresponds to an elemental area of the film 11, thus if the film is to be scanned in areas of the order of one-hundredth of an inch square then the ends 25 will likewise be of the same dimensions. From this figure it will be seen that as the lenses move past the ends of rods 28 the cell 34 is illuminated for definite intervals, but while the lenses are traveling between the spaced ends of the members 28 there is no light projected upon the cell, thus producing substantially the same effect that is produced with the optical system of Fig. 1. It will be understood that the disclosures of Figs. 1 and 3 are merely illustrative, and that other equivalent optical arrangements may be employed for illuminating the object in the manner described.

In order more clearly to explain how the scanning method may be carried out, there is shown in Fig. 4 a portion of a view to be transmitted or analyzed. For the purpose of explanation it will be assumed that the view is being scanned at the instant along the linear element between the dot-dash lines. Fig. 4A shows a plan view of the light confining rods 28 positioned in front of the picture, which for clarity is shown in the same plane as the rods 28. Actually the rods will be perpendicular to the picture, as shown in Fig. 3A. Fig. 5 shows how the density or light characteristics of the view vary over the said linear element, the abscissae representing distance of travel (or time) of the scanning aperture, and

ordinates representing intensity of light transmission, light reflection, as the case may be. Fig. 6 shows how the photo-electric current produced according to prior art methods would vary according to the "shade" curve of Fig. 5. This photo-electric curve it will be seen is highly irregular, and when analyzed possesses an infinite number of frequency components. Furthermore, due to photo-electric fatigue the current does not follow the shade characteristics. Fig. 4B shows how the linear element of Fig. 4 appears when viewed from the smaller ends or the light confining rods, while Fig. 7 shows the photo-electric currents produced, when the strip shown in Fig. 4B is scanned. From an inspection of Fig. 7 it will be seen that the photo-electric response is in the nature of a regular wave having a definite frequency and wherein each elemental area of the picture is represented by a wave of corresponding amplitude. Furthermore, as a result of the interruptions provided by the spaces between the reduced ends of rods 28 (Fig. 4A) or the opaque portions of member 8 (Fig. 1) the photo-cell is "blanked-off" at regular intervals thus allowing it to restore to its normal sensitivity between successive light impulses. Fig. 8 shows how the response of Fig. 7 is reproduced after detection or rectification at the receiving station. From this latter curve, which may also represent intensity of the reproducing light, it will be seen that the original shade curve (Fig. 5) is more faithfully followed than is attainable with the curves of Fig. 6, wherein the dotted curve represents the signals after being modulated with a carrier and detected at the receiver.

As a result of the foregoing arrangement the picture variations which usually vary in a continuous and complex manner are directly translated into a photo-electric current having a simple and uniform wave shape and of a fixed frequency, and any distortions due to photo-electric fatigue are avoided. Furthermore, the production of a "single frequency" photo-electric current enables a less costly amplifier to be used and one that has its maximum efficiency at the "characteristic" frequency.

While the invention has been described as applied to a system for scanning a moving film, it will be understood that it is equally applicable to the scanning of opaque or other objects. Thus the apertures in member 8 may be long and narrow and the disc 4 may have the lenses arranged spirally in the well-known manner. Similarly the film of Figs. 3 and 3A may be advanced intermittently and a bank of rows of rods 28 may be provided together with a "spiral" scanner of known type.

What is claimed is:

A television transmitting system comprising a source of light, a scanning disc, a film to be scanned, a light sensitive device, and a screen having alternate lenses and opaque sections for projecting said light upon said device through said film, so that the device is affected intermittently by light projected through contiguous non-overlapping elemental areas of said film.

CHARLES E. HUFFMAN.