Dec. 24, 1940. D. K. LIPPINCOTT 2,226,436

SYSTEM OF PICTURE TRANSMISSION

Filed Aug. 26, 1932 2 Sheets-Sheet 1

Fig. 1.

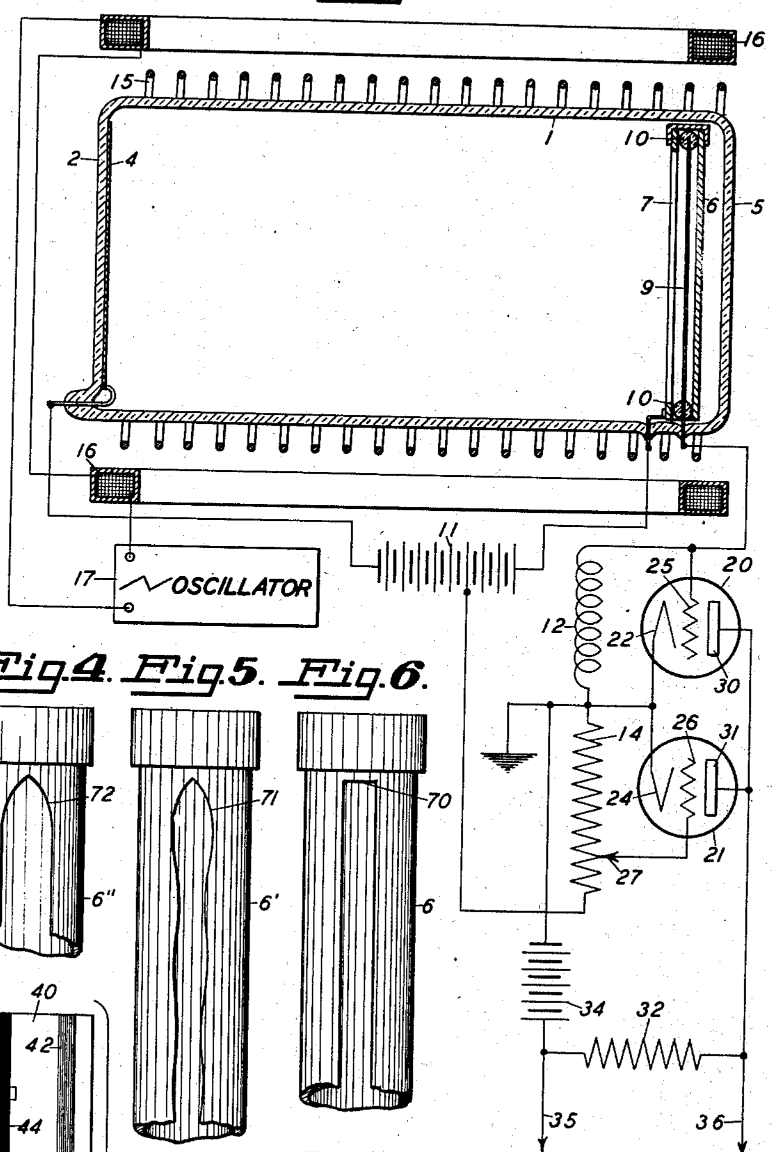

Fig. 2.

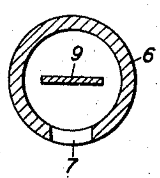

Fig. 3.

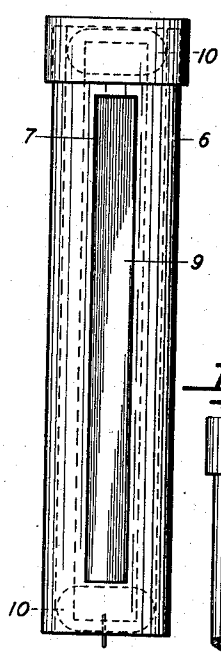

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 8.

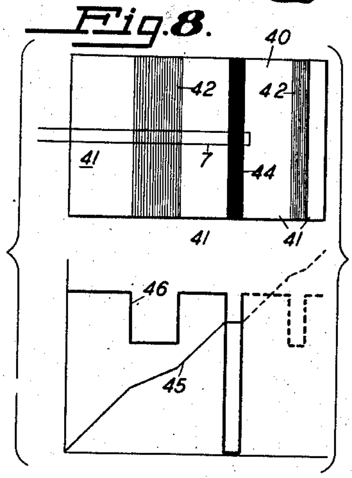

Fig. 7.

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Fig. 9.

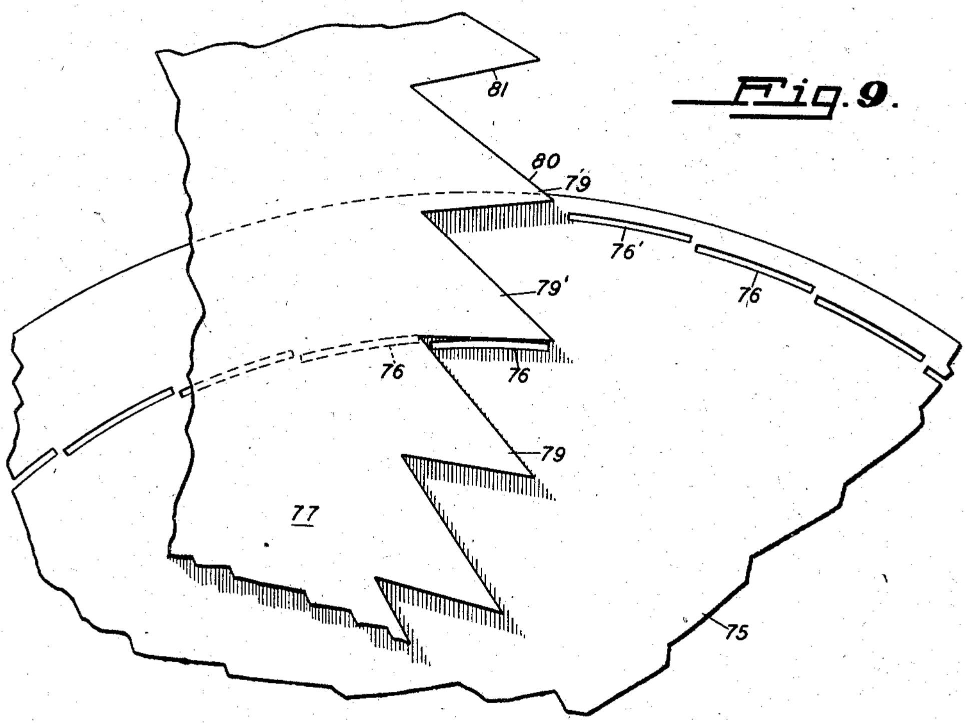


Fig. 10.

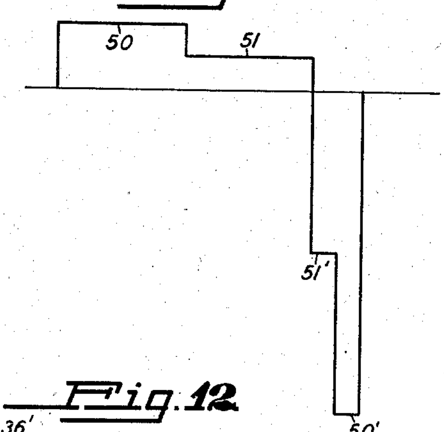


Fig. 11.

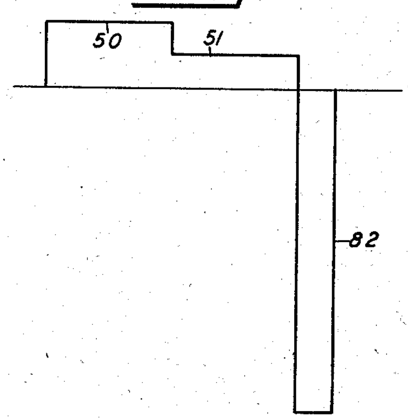
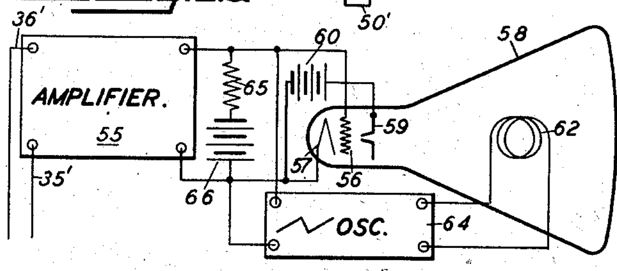


Fig. 12.



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Patented Dec. 24, 1940 2,226,436

UNITED STATES PATENT OFFICE

2,226,436

SYSTEM OF PICTURE TRANSMISSION

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Application August 26, 1932, Serial No. 630,524

14 Claims. (Cl. 178—6)

My invention relates to systems of electrical picture transmission, such as television, photo telegraphy, and the like, and particularly to systems wherein the picture field is scanned in order to dissect it into elementary units, which are represented by signals transmitted over a single communication channel.

The customary method of scanning is to traverse the picture field with an aperture of "elementary area," in accordance with a predetermined pattern, the illumination of successive elementary areas of the picture field, acting on a light-sensitive element, serving to graduate a current which is passed through a resistor. The finite size of the aperture causes what is known as "aperture distortion," that is, a sudden change in illumination from point to point of the picture field is represented by a current which increases gradually during the time required by the aperture to pass across the change, so that sharp lines are inevitably blurred in the measure of the aperture width. A further, similar blurring occurs at the receiver, thus doubling the effect. One of the objects of this invention is to eliminate this aperture distortion effect at the transmitter, thus reducing the total distortion of this character to one-half.

In the usual method of transmission, the average or mean illumination of the picture field is represented by a direct-current component. This component is difficult to transmit, particularly in radio transmission systems, and even in wire transmission systems it is usually avoided. It is customary, therefore, merely to transmit the fluctuations of illumination around this mean density, the average level of illumination being re-established at the receiver either arbitrarily or, in some cases, automatically by the use of a separate channel. Another object of my invention is to provide a method of transmitting the mean level of illumination, together with illumination fluctuations from point to point, on the same channel and without the use of complicated equipment.

In general, changes in illumination over a picture field occur abruptly, and are truly represented by square-fronted waves or pulses, occurring at random, that is, without any defined periodicity. P. T. Farnsworth, in his co-pending application, Serial No. 500,092, filed December 4, 1930, and entitled "System of pulse transmission," and now United States Patent No. 2,026,379, issued Dec. 31, 1935, has shown that the picture may be reproduced if only a portion of the Fourier component frequencies of these pulses are transmitted, and a proper restoring network is used at the receiver. That this may be accomplished satisfactorily, requires that the pulses be filtered to remove the high-frequency components, and that these filters be practically without phase distortion. Such filters are difficult to construct, and another object of my invention is to provide a scanning system whereby either square-fronted waves, or waves resulting from the removal of certain definite frequencies from such square-fronted waves, may be generated without the use of filters or other auxiliary apparatus.

Among the other objects of my invention are: to provide a scanning system which may be applied with any type of scanning mechanism, whether cathode ray, oscillating mirror, or scanning disk, and with either beam scanning (the so-called flying spot) or image scanning; to provide a scanning system wherein synchronizing pulses are automatically generated without the use of additional equipment; to provide a system wherein the entire picture transmission is accomplished on a single wave, the positive portions of the wave carrying the picture, while the negative portions accomplish the synchronizing; and to provide a scanning system wherein variations in scanning speed, over the various portions of the picture field, do not result in departures from the true illumination level as long as the transmitting and receiving scanning apparatus travel at the same velocity.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 is a simplified schematic diagram illustrating my invention as applied to a cathode ray television transmitter.

Figure 2 is a transverse sectional view, on a larger scale, of the anode and shield used in the transmitter tube of Figure 1.

Figure 3 is a view of the anode shield, showing the elongated scanning aperture.

Figures 4, 5 and 6 are fragmentary views of anode shields, showing apertures of various types.

Figure 7 is a graph indicating the wave form produced by the scanning generator or oscillator of Figure 1.

Figure 8 is a schematic view of an idealized picture field, together with graphs indicating the current and voltage waves produced by scanning such a field in accordance with this invention.

Figure 9 is a fragmentary view of a pair of scanning disks, illustrating the adaptation of this invention to mechanical scanning.

Figure 10 is a simplified graph of a wave form produced in a single scanning cycle by the apparatus of Figure 1.

Figure 11 is a similar graph showing the wave form as produced by the apparatus of Figure 9.

Figure 12 is a simplified schematic diagram showing receiving equipment for use with this invention.

Scanning systems of picture transmission, as distinguished from non-scanning systems wherein separate channels are required for each elementary area of the picture field, all operate in accordance with the same basic principles, although they vary widely in detail. Thus, all use a photosensitive element which controls the signal currents, and all traverse the picture field with an aperture of elementary size in order to limit the graduation of current at any instant to that produced by the light from a particular elementary area of the pictured surface. In this statement, the term "picture field" is used in its broadest sense, since the actual position of the aperture, relative to the object and to the photosensitive element, differs greatly in different systems. Thus in the simplest form of the Nipkow disk, an image of the object to be pictured is focused on the rim of the moving disk, which carries the aperture. In a more highly developed form of the same scanning equipment, a beam of light is projected through lenses in the moving disk upon the object itself, and light from this beam is reflected from the object to the photosensitive cell. In the Farnsworth cathode ray system, an electrical image is formed, which is moved across the scanning aperture, the latter in this case not affecting the light itself, but, instead, the electron stream initiated by the light. The same principle is even adhered to in the more primitive methods of picture transmission in which photosensitive cells are not used, but wherein an electrical feeler or contact traverses conducting and non-conducting portions of a specially prepared picture or print. In each of these cases, however, the flux through the aperture, whether that flux be light, free electrons, or electric current in the usual sense, determines the current flowing, and the aperture is moved in some manner relative to the picture field.

Considered broadly, my system comprises the use of an aperture of elementary width, but whose length is substantially equal to that of the path it describes across the picture surface. The end of this aperture is traversed across the field, in the direction of the aperture length, to disclose a varying area of the field. The area embraced by the aperture is thus constantly changing, disclosure and occultation of the aperture occurring alternately and preferably at different rates. Whether the disclosure be gradual and the occultation sudden, or whether the reverse be the case, is purely a matter of choice.

This produces a current which is at a minimum (usually zero) when the aperture is fully occulted, at a maximum when maximum area of the picture field is disclosed, and which, between these conditions, varies at a rate which depends upon the illumination of the particular portion of the picture field which is being traversed by the advancing end of the aperture. The aperture may therefore be said to integrate the effect of the illumination upon the entire area of the picture surface which it embraces.

The current thus produced is passed through an inductance coil, across which it produces a voltage which is proportional to its rate of change. During the period of the disclosure, the voltage pulses produced are all of one sign, while during the period of occultation the voltage pulse or pulses will be of opposite sign. If the disclosure is gradual and the occultation sudden, it is preferred to use the disclosure pulses as the picture pulses, which may arbitrarily be denominated "positive" pulses, while the "negative" occultation pulse is used as a synchronizing pulse. If occultation is gradual and disclosure sudden, the occultation pulses become "positive" pulses.

A rectifier is used at the receiving end, so that the illumination of the received picture field is proportional to the intensity of the positive pulses, while the negative pulses, occurring between the scanning sweeps of the field, have no effect upon the picture illumination. The receiving aperture, it may be noted, is of the usual type, since the scanning system of the present invention is one of the few which are not directly reversible for transmission and reception.

If the advancing end of the aperture be rectangular, the voltages generated across the inductance coil will be true "square-front" waves, but by shaping the end of the aperture so that it represents a curve of a desired wave form, that is, a wave having any particular desired frequency distribution, the pulses generated by the advance of the aperture across a discontinuity in illumination will have this wave form, and hence it is unnecessary to provide a filter to remove undesired frequency components therefrom.

The nature of the invention may be understood more fully by reference to the accompanying drawings. A preferred embodiment, as applied to the system of television described in the above-mentioned patent of Philo T. Farnsworth, is shown in Figure 1. A cylindrical evacuated envelope 1, usually of glass, has at one end a flat surface 2 upon which is deposited a photoelectric cathode coating 4. At the opposite end of the tube is a plane window 5, immediately within which is mounted a cylindrical shield 6, having a narrow elongated aperture 7 formed in the side facing the photosensitive cathode.

Mounted within the shield is the anode or target 9, which is supported at its ends by glass beads 10. The shield 6 connects through a battery or other potential source 11 with the cathode 4. The anode 9 is connected through an inductor 12 and a resistor 14 to an intermediate point on the battery 11.

An image of the pictured area is projected by a suitable lens system on the cathode 4, liberating electrons which are drawn forward to the anode by the potential of the battery 11. These electrons are focused to form an electrical image in the plane of the aperture by direct current flowing through the solenoid 15, which surrounds the tube 1. The details of this are not shown in the present drawings since they are fully disclosed in the above-mentioned Farnsworth patent, and since they relate only indirectly to the present invention.

Positioned on each side of the tube 1 are coils 16, which are connected in series with an oscillator 17, preferably adapted to generate currents of the slope or saw-tooth wave type, the wave form being substantially that shown in Figure 7. The flux generated by these currents in the coils 16 deflects the electrical image across the aperture 7, and in the direction of its length. This deflection is so adjusted that when maximum current flows in one direction in the deflecting coils the image is removed entirely from the aperture, that is, the aperture is fully occulted as regards the image. At the peak of current in the other direction the aperture crosses the entire width of the image, receiving electrons from an area thereof which corresponds to the entire width of the picture field but of elementary height.

In the preferred method of using this equipment, the electrons from the image, which enter the aperture 7, liberate secondary electrons from the target 9 by their impact, these secondary electrons being drawn back to the shield 6, owing to its higher potential. This causes current to flow through the resistor 14 and inductor 12, causing voltage drops therein.

A vacuum tube 20 is connected across the inductor 12, and a second tube 21 across the resistor 14. The cathodes 22 and 24 of these tubes both connect to the junction between the resistor and the inductor, the grid 25 of tube 20 connecting at the opposite end of the inductor, while the grid 26 of tube 21 connects to a variable contact 27 on the resistor 14.

The plates 30 and 31 of the two tubes are connected in parallel to a resistor 32, which in turn is connected through a voltage source 34 to the cathodes and ground. The output leads 35 and 36 may connect to any suitable amplifier or line along which it is desired to transmit the resulting signal.

The object of this arrangement of vacuum tubes is to neutralize or cancel out the effect of any voltage drop which may exist in the coil 12 due to its resistance, for since the elements 12 and 14 are in series, a proportional voltage drop will occur in the latter element, the drops in the two elements being impressed upon the grids of the tubes in opposite phase. The contact 27 is adjusted so that, with a constant current flowing through the two elements, the total current in the two parallel plates is the same as when no current flows. As a result of this arrangement, the current in the resistor 32 will be directly proportional to the voltage due to the inductance only of the coil 12.

A similar cancellation of the resistive drop due to the picture current could, of course, be accomplished by coupling the tube 20 to the photocell circuit by means of a transformer. Owing to the difficulty in eliminating phase and frequency distortion due to leakage reactance in a transformer, however, the arrangement shown is preferred.

The operation of the system is illustrated in Figure 8, wherein the rectangle 40 represents a simplified picture field, the areas 41 representing maximum illumination, while the areas 42 and 44 indicate various degrees of shade. The outline 7 of the aperture is shown as progressing across this field from left to right. During this process the electrons through the aperture will increase at a rate depending upon the illumination of the portion of the field which is being traversed by the leading edge of the aperture. The resulting current is shown by the curve 45 of Figure 8, starting at zero where the aperture first starts to traverse the field, and climbing at a constant, steady rate during the traversal of the areas 41, at a lesser steady rate during the traversal of the areas 42, and remaining constant during the period of the traversal of the area 44, which is assumed to have zero illumination.

The inductive voltages produced by this current are proportional, not to its intensity, but to its rate of change, or, expressed mathematically, $E=L\,di/dt$. This voltage is shown by the curve 46 of Figure 8, the dotted portions of both curve 45 and curve 46 indicating potions of the curve not yet traversed by the advancing aperture. It will be seen that these changes are abrupt, and that aperture distortion effect in the direction of the motion of the aperture has been eliminated.

At the end of the scanning sweep the aperture traverses the field in the opposite direction, the current decreases continuously, and the voltages produced across the inductance coil 12 are reversed both in time and in sense. This condition is shown in Figure 10, which represents the voltages produced by scanning a field having but two variations in illumination. The first, or greater illumination, is indicated on the scanning half of the cycle by the portion 50 of the curve, while the second or lesser illumination is shown by the portion 51. The return sweep, where a scanning wave of the type shown in Figure 7 is used, occurs with much greater speed. As a result, a more intense negative voltage 51′ is produced while the end of the aperture scans the portion of the field represented on the direct sweep by the portion 51, and a still more intense portion 50′ occurs while the end of the curve occults the brighter portion of the field. The height of the curve varies directly with the speed of scanning, so that the area beneath portion 50 is equal to that beneath the portion 50′, while the same is true of the portions 51 and 51′. The wave may therefore be transmitted as a true alternating-current wave, whose zero axis indicates zero illumination.

It is a mathematical characteristic of waves of this character, both sides of which carry equal energies, that they contain no frequencies lower than their own period, that is, the line frequency, whereas the waves generated by the ordinary elementary aperture contain all frequencies down to zero.

A receiver for this wave is shown schematically in Figure 12. The incoming leads 35′ and 36′ may be the leads 35 and 36 of Fig. 1, or any other carrying an equivalent signal. These leads are connected to an amplifier 55, whose output terminals connect respectively to the grid 56 and cathode 57 of an oscillight or cathode ray receiving tube 58.

The anode 59 of this tube connects through a battery or other source of potential 60 to the cathode, and serves to generate therewith a beam of cathode rays which may be focused in any accepted manner on the fluorescent screen 61 formed on the end of the tube 58. This beam is deflected by currents flowing in the coil 62, and generated by an oscillator 64, which produces currents of the same wave form as those produced at the transmitter by the oscillator 17. The oscillator 64 is, however, provided with input terminals which are connected between the grid 56 of the tube 58 and its cathode 57.

We will first consider the case where the grid 56 is so biased that the maximum negative pulse is required to reduce the illumination, produced on the screen 61 by the cathode ray beam, to zero. Assuming that the transmitting and receiving oscillators are exactly in step, and that the illumination of the screen is directly proportional to the voltage on the grid, no picture would be produced. The portion 50 of the curve of Fig. 10 would produce a certain level of illumination while it was being traversed, but this illumination would be effectively cancelled by the portion 50′, effective on the return sweep of the scanning spot. Only about one-fifth of the time would be required for this return sweep as for the effective sweep, but its effect would be five times as intense, and the eye would therefore integrate the two results to produce complete cancellation. The same would also be true of the portions 51 and 51′ of the curve, since the effect produced at the transmitter will always be proportional to the product of light intensity and scanning speed. It is to be noted that this is a valuable feature, since, with the transmitter and the receiver in step, variations in intensity due to varying speed of scanning will always cancel out.

The grid 56 is, however, biased through a resistor 65 by a battery or other potential source 66, and this bias is so adjusted that the spot is reduced to zero for zero level of the incoming signal. For this reason, although the positive portion of the incoming wave can produce increases in illumination, the negative portion of the wave is without effect, since in this instance negative illumination has no meaning.

One method of adjusting this bias on a received signal is merely to adjust the picture field for maximum contrast. If the bias be too far positive, the negative half of the incoming wave will cancel out portions of the positive half, tending to reduce the picture to a common mean level of illumination. If the bias be too far negative, the positive portion of the wave cannot produce its full effect, and therefore the contrast will be decreased. For the proper adjustment, contrast will be a maximum, and at the same time the true picture effect, as relates to the average illumination of the picture compared with its variations in illumination, will be preserved.

It will be noted that this condition corresponds to a complete rectification of the picture wave. The positive half of the wave produces the picture, while the negative half has no effect thereon. A separate rectifier may be used to accomplish this if desired, but the use of the receiving oscillight itself as the rectifier is to be preferred.

The negative half of the wave is not, however, without its use. The control terminal of the oscillator 64 is connected directly to the grid of the oscillight, and the negative pulses will therefore hold the oscillator in step, without the intervention of any auxiliary apparatus for this purpose. Furthermore, no portion of the picture wave can swing as far negative as the reverse half of the wave always swings, and therefore there is no tendency on the part of the oscillator 64 to pull into step with the dark portions of the picture.

It will further be noted that it is unnecessary, in case the picture wave is modulated upon a carrier for radio transmission, to transmit the entire negative half of the wave. The modulating equipment may be so set that the zero axis of the curve of Fig. 10 represents perhaps 25 or 34% of the mean carrier amplitude. The negative portion of the wave of Figure 10 would therefore produce far greater than one hundred per-cent modulation, but since this can merely reduce the carrier to zero, and not beyond, the full synchronizing effect will be obtained, while all of the effective picture amplitude will be transmitted.

Thus far in the present discussion it has been assumed that the end of the scanning aperture 7 is rectangular, as shown in detail in Figure 6 and indicated by the reference character 70. In his above-mentioned patent, Philo T. Farnsworth has shown that the removal of high-frequency components from a square-fronted wave produces a wave form which rises in a manner approximating a sine curve to a maximum, and then oscillates with decreasing amplitude about the final value of the wave. In Figure 5, there is shown a shield 6′ wherein the aperture is shaped with an outline 71 corresponding to this type of curve. As shown, the curve is repeated on each side of the median line of the aperture, but one-half of the aperture could be used if desired. An aperture of this character, crossing a discontinuity in illumination, would produce a current change corresponding to the area under the curve, and this current wave will be differentiated by the inductance coil 12 to produce a voltage wave whose form is represented by the outline 71 of the aperture. There will thus be produced a wave whose form is that of a square-front wave which has been passed through an ideal filter, without phase distortion, and this result is achieved without the introduction of any additional apparatus. The effect may be modified by forming the aperture substantially as that shown by the reference character 72 in Figure 4. In this case the outline of the aperture is shaped in conformity with the wave form of a square-front wave wherein the cut-off is less abrupt than in the case of the aperture 71, that is, the high-frequency components are attenuated proportionately to frequency.

The use of an aperture of this character is advantageous in that multiple images are not produced when the wave is passed through a restoring network.

Figure 9 illustrates the application of my invention to disk scanning. In this figure only portions of the scanning disks are shown, since this method of scanning is well known and the purpose of the showing is merely to indicate the generality of the present invention. The disk 75 has the usual spirally arranged apertures 76, but in place of being square or round, each of the apertures is elongated, being of elementary width and of a length equal to the transverse dimension of the picture field.

A separate disk 77 is mounted on an axis parallel to that of the disk 75, and its circumference is provided with serrations 79, these serrations being formed like saw teeth whose depth is equal to the width of the apertures 76, and whose spacing is substantially equal to the other dimension of the picture. In the present instance, the rotation of the disk 75 is presumed to be counter-clockwise, while the rim of the disk 77 moves down. It will be seen that the final or inner aperture of the spiral is about to be occulted suddenly by the advance of the tooth 79′. The aperture 76′ will next traverse the picture field, the portion 80 of the advancing serration retreating before the aperture as it advances until it, in turn, is suddenly occulted by the advance of the tooth 81.

The wave form produced by this arrangement is shown in Figure 11, where the same field is supposed to be scanned as in the case of Figure

10. The advancing aperture 76' will trace out the portions 50 and 51 of the curve, but in this case the occultation is not performed in the same direction as the scanning, and the negative half of the wave, although encompassing the same area as the positive half, will be a different shape, probably practically square as is shown by the portion 82.

Reversal of the direction of rotation of the two disks will merely reverse the wave, and have no further effect. In other words, in this case the disclosure will be sudden and the occultation gradual, but the wave form and the effect produced will be exactly the same as before. In this case, as before, the receiver will be adjusted to give maximum contrast in the received picture, which corresponds with proper mean illumination thereof. Similar methods are available for use in any of the scanning systems thus far proposed, the application of this invention being perfectly general.

Although it is preferable that the disclosure and occultation of the picture field take place at very different rates of speed, this is not an essential of the system. Thus, if desired, every alternate aperture 76 could be omitted from the scanning disk, and the disk 77 eliminated. In this case, the two halves of the wave could be symmetrical, but the time required to transmit each image would not be so economically used.

It will be seen, moreover, that the ends of the aperture 76 may be shaped to produce a desired wave form, in exactly the same manner as are the ends of the apertures 70 and 71.

I claim:

1. The method of scanning an area to be electrically pictured which comprises disclosing and then occulting successive complete lines across said area, said disclosure and occultation being at different rates.

2. In a method of picture transmission wherein a current flow is graduated by traversing successive lines of more than elementary length across the picture field with an aperture, the step of alternately increasing and decreasing the area of the field embraced by said aperture, the rates of said increase and said decrease being materially different.

3. In a method of picture transmission wherein a current flow is graduated by traversing the picture field with an aperture, the step of alternately increasing and decreasing the area of the field embraced by said aperture to vary said current flow, inducing with the controlled current a voltage having a wave whose sign is dependent on the sign of the change in said area, and utilizing one half of said wave to reconstruct the picture and the other half of said wave to synchronize the transmitting and receiving operations.

4. In an electrical picture transmitter including a current source having a light-actuated current-controlling element and a picture circuit connected thereto, scanning means including an elongated aperture of a length sufficient to extend across the picture field and means for alternately disclosing and occulting portions of said field as related to said current-controlling element with said aperture, one of the disclosing and occulting operations of each cycle of operation being effected by the traversal of an end of the aperture across said field in the direction of its length and the other of said operations in each cycle being effected at a different speed, and means responsive to the rate of change of the current controlled by said element for impressing a signal on said picture circuit.

5. In combination, means for forming an electrical image of a field to be pictured, a shield having an aperture therein substantially in the plane of said image, said aperture being of elementary width and substantially equal to the dimension of said image in length, a target protected by said shield positioned to receive the portion of said electrical image passing through said aperture, and means for deflecting said image across said aperture in the direction of the length thereof.

6. In combination, means for forming an electrical image, a shield having an aperture therein substantially in the plane of said image, said aperture being of elementary width and substantially equal to the dimension of said image in length, a target protected by said shield positioned to receive the portion of said electrical image passing through said aperture, means for deflecting said image across said aperture in the direction of the length thereof, an inductance coil connected in series with said target, and an amplifying tube connected across said coil.

7. In combination, means for forming an electrical image, a shield having an aperture therein substantially in the plane of said image, said aperture being of elementary width and substantially equal to the dimension of said image in length, a target protected by said shield positioned to receive the portion of said electrical image passing through said aperture, means for deflecting said image across said aperture in the direction of the length thereof, an inductance coil connected in series with said target, an amplifying tube connected across said coil, and means for neutralizing the effect of the voltage drop due to the resistance of said coil.

8. In combination with a scanning system comprising means for integrating a current flow in accordance with the illumination of a linear area of a picture field, an inductance coil connected to pass said current, a resistor connected in series with said coil, and a pair of vacuum tubes having control electrodes connected across said coil and said resistor respectively and in opposed relation so that resistive drops due to said current flow will produce opposite effects on the current flow in said tubes, the output electrodes of said tubes being connected in parallel.

9. In combination, means for forming an electrical image of a field to be pictured, a shield having an aperture therein substantially in the plane of said image, said aperture being of elementary width and substantially equal to the dimension of said image in length, a target protected by said shield positioned to receive the portion of said electrical image passing through said aperture, means for deflecting said image across said aperture in the direction of the length thereof, the rates of deflection in opposite directions being unequal.

10. In combination, means for forming an electrical image of a field to be pictured, a shield having an aperture therein substantially in the plane of said image, said aperture being substantially equal to the dimension of said image in length and of varying width such that the outline of said aperture corresponds to a predetermined wave form and means for traversing said aperture across said image in the direction of the length of the aperture.

11. In combination, means for forming an

electrical image of a field to be pictured, a shield having an aperture therein substantially in the plane of said image, said aperture being substantially equal to the dimension of said image in length and of varying width such that the outline of said aperture corresponds to the form of a wave having a predetermined frequency spectrum.

12. In combination, means for forming an electrical image of a field to be pictured, a shield having an aperture therein substantially in the plane of said image, said aperture being substantially equal to the dimension of said image in length and of varying width such that the outline of said aperture corresponds to the form of the wave resulting from the attenuation of a predetermined band of high frequencies from a square-front wave.

13. In a scanning system, a movable scanning element having linear apertures therein, each aperture being substantially equal in length to a line to be scanned thereby across the picture field, means for traversing said apertures across said field in the direction of their length, and means for suddenly occulting said apertures.

14. In a scanning system, a first movable scanning element having linear apertures therein, each aperture being substantially equal in length to the line to be scanned thereby across the picture field, and a second movable scanning element having serrations formed thereon and so mounted relatively to said first element that said serrations suddenly occult said apertures upon relative motion of both of said elements.

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