

Aug. 1, 1939.

A. M. SKELLETT

2,168,047

ELECTRO-OPTICAL SYSTEM

Filed Dec. 24, 1936

3 Sheets-Sheet 1

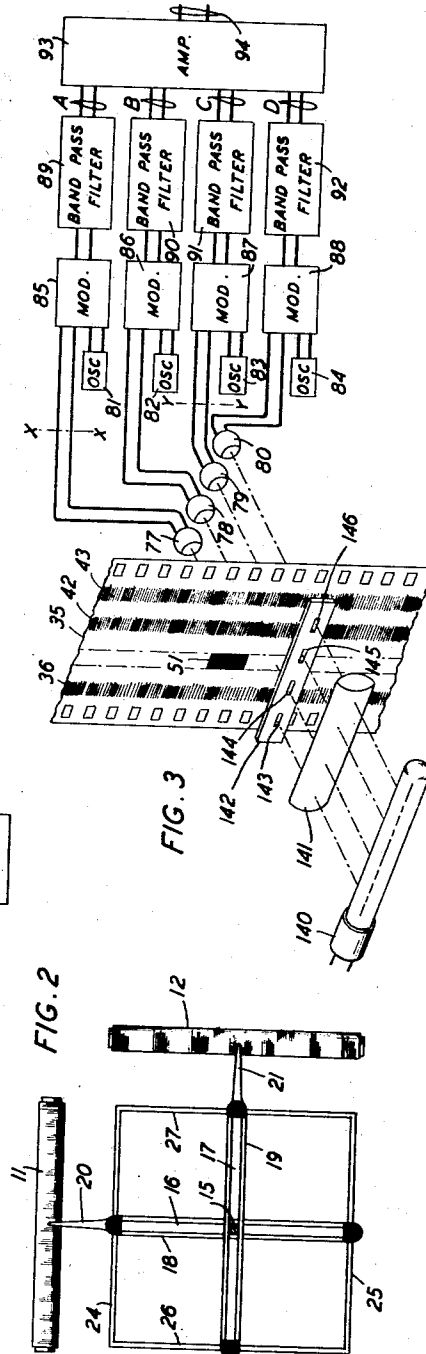
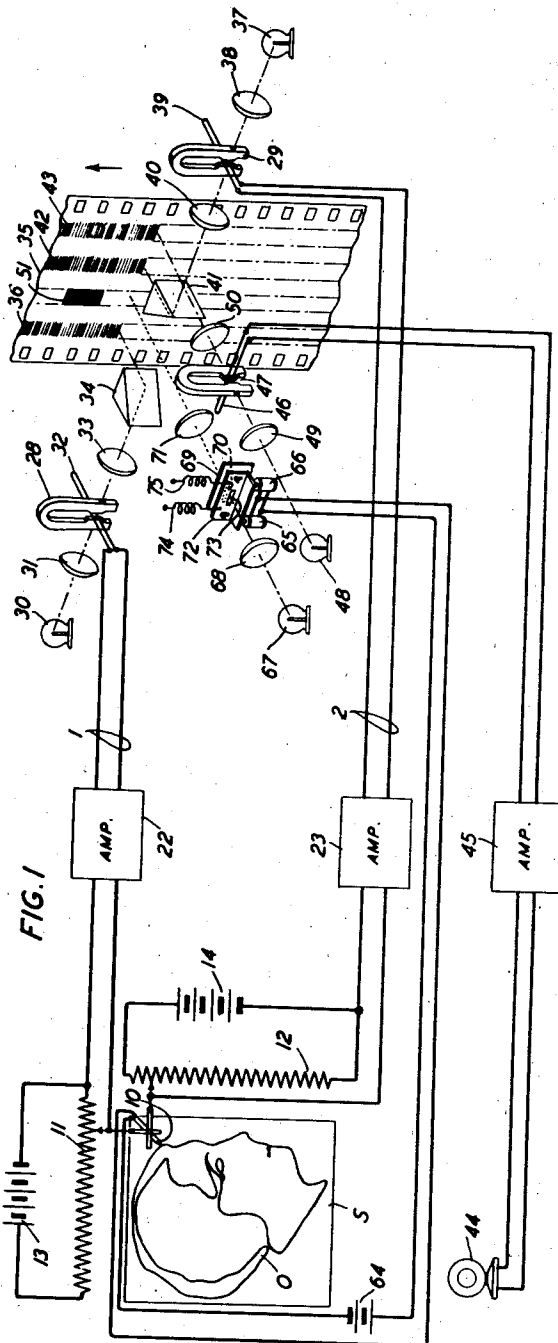
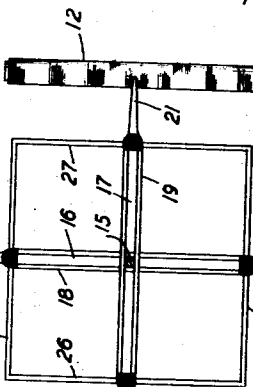


FIG. 3



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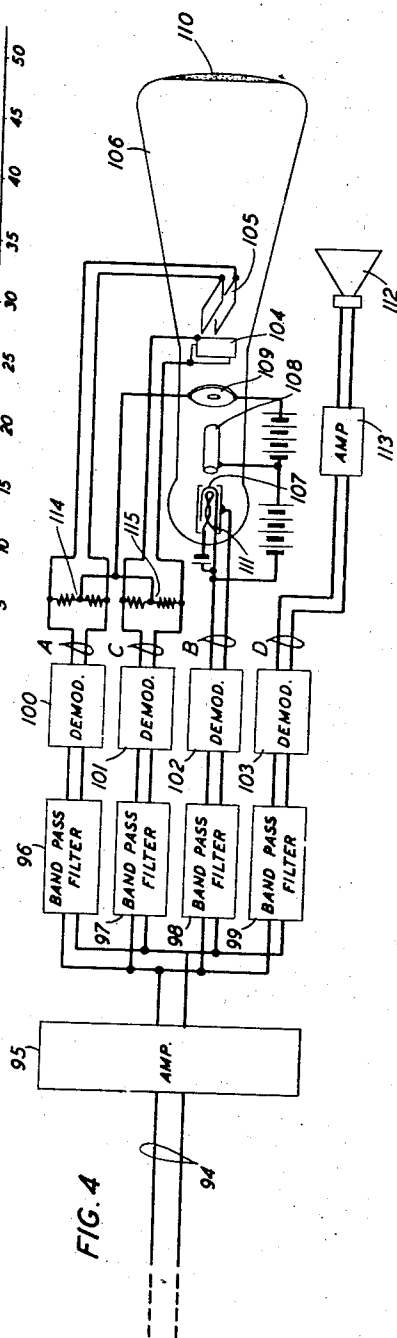
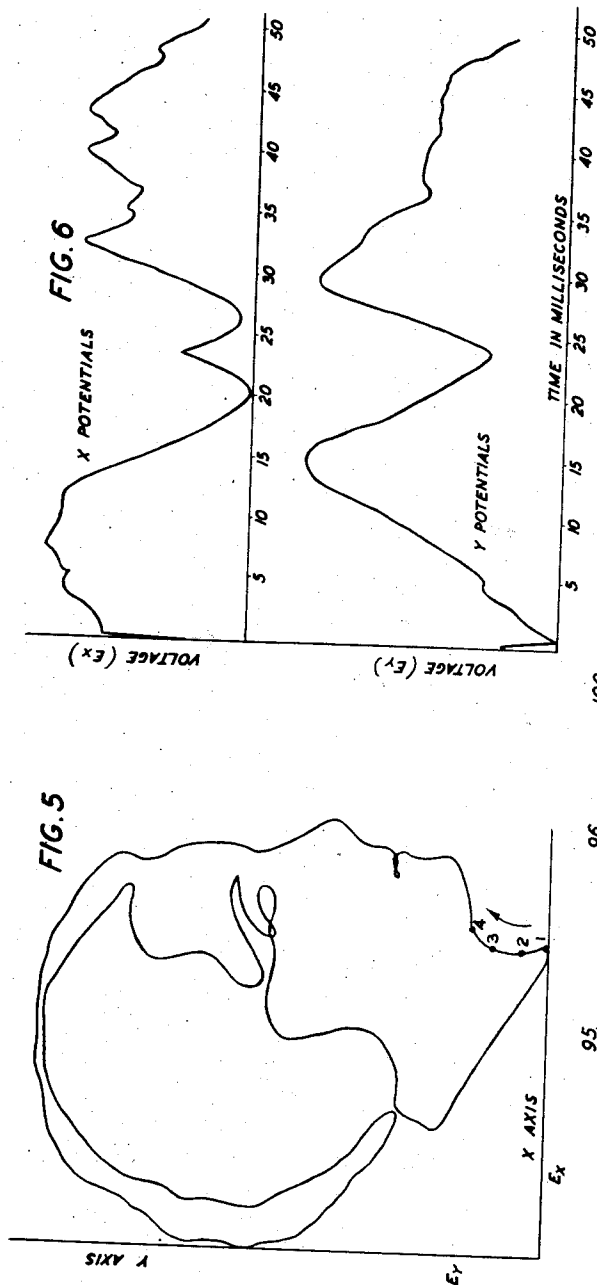
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3 Sheets-Sheet 2



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2,168,047

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FIG. 7

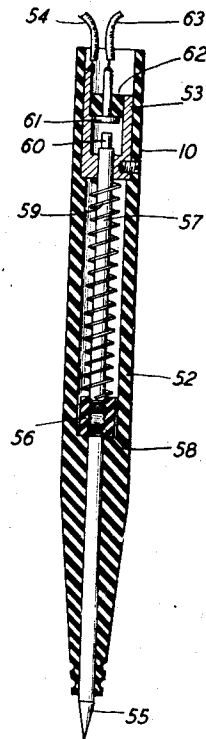
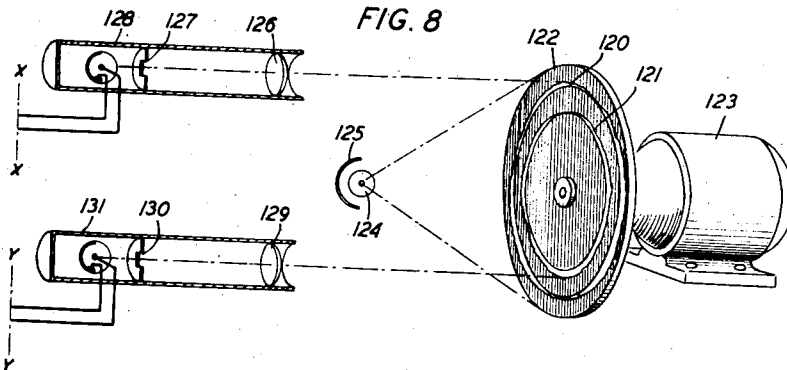


FIG. 8



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2,168,047

ELECTRO-OPTICAL SYSTEM

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Application December 24, 1936, Serial No. 117,521

22 Claims. (Cl. 178-19)

This invention relates to electro-optical systems and more particularly to the electrographic transmission of images or facsimiles.

It is an object of this invention to provide a novel electro-optical system resembling a television system in which a comparatively narrow frequency band is required for transmission.

It is a feature of this invention that a pictorial or graphic representation is traced rather than scanned.

At the present time, so far as known, the trend in the development of television transmission systems in which scanning is used appears to be toward the use of higher and higher frequency band widths in order to have satisfactory entertainment value. Some known systems require band widths of a million cycles and upward and band widths of such magnitude require carriers of ultrahigh frequency. A feature of the present invention is that, inasmuch as the subject is traced rather than scanned, the required frequency transmission band is so narrow that one or two channels in the radio broadcast range may be used as the carriers. Some subjects, such as cartoons and sketches may be satisfactorily transmitted in this manner and still have much entertainment value.

In one embodiment of this invention shown by way of example for purposes of illustration, a graphic or pictorial representation such as a writing, drawing, diagram, painting, picture, map, printing, sketch, cartoon or the like, is traced by a stylus arranged so as to continuously vary two resistances at right angles to each other in such a manner that as the stylus moves over the lines or boundaries of areas of distinctive tone values of said representation varying voltages are produced at the resistances corresponding to the X and Y coordinates of the stylus point as it progresses with respect to a pair of coordinate axes. The areas of distinctive tone value may be no more than lines in some cases. These voltages are recorded as tracks on a suitable record member, such as a film, and the tracks are used to generate signal currents which are transmitted to a receiving station and there used to deflect the cathode ray beam in a cathode ray tube in accordance with the successive values of the coordinate voltages. A contact mechanism may be provided for recording a cut-off signal on the film whenever the stylus is lifted from the subject and this cutoff signal may be transmitted to the receiver and there applied to a control electrode in the cathode ray tube to cut off the beam during this period. A

sound track may also be applied to the film and transmission made from this track by well-known means to a loud-speaker at the receiving station.

In order to produce a continuous image on the screen of the cathode ray tube, transmission is made from the record over and over again in order to take advantage of the phenomenon of persistence of vision. The drawings or cartoons may be animated by changing slightly the voltages in any appropriate way for each successive tracing of the stylus as by tracing consecutively sketches which differ slightly from each other. In the case of animated subjects image currents are generated only once from the tracks of each sketch, but image currents generated from twenty such sketches are transmitted every second in order to make the image animated. The time allowed for transmission does not in any way limit the time allowed for tracing a representation with the stylus as the record may be made in advance of the transmission time. As a modification the tracks may be recorded on a circular member and this record placed on a shaft rotating twenty times per second but this modification is not so suitable for animated subjects.

The invention will be more readily understood by referring to the following description, taken in connection with the accompanying drawings forming a part thereof in which:

Fig. 1 is a schematic diagram of the transcriber of this invention;

Fig. 2 is a detail view of apparatus for forming the coordinate voltages;

Fig. 3 shows the apparatus for reproducing from the record member;

Fig. 4 shows the receiving system;

Fig. 5 shows a method of tracing the subject with a stylus;

Fig. 6 is a representation of the X and Y coordinate voltages produced by tracing the subject of Fig. 5;

Fig. 7 is an enlarged cross-sectional view of a stylus; and

Fig. 8 shows a modified transmitter.

Referring more particularly to the drawings, Fig. 1 shows a schematic diagram of apparatus for converting the movements of a stylus into a record of coordinate voltages which apparatus will be designated a transcriber. In general the transcriber comprises means such as a stylus for tracing the lines or boundaries of distinctive areas of a subject O, means for translating the movement of the stylus into X and Y coordinate voltages, and suitable means for recording these coordinate voltages on a suitable record

member, such as, for example, a photographic film.

For producing the two coordinate voltages, a device similar to a telautograph may be used. Stylus 10 may be connected to two resistances 11 and 12 arranged at right angles to each other so that as the stylus is moved over the representation O, which is mounted on a suitable support, voltage drops are produced across the resistances which vary with the X and Y coordinates of the stylus point as it progresses with respect to a pair of coordinate axes. Connected in circuit with the potentiometer resistances 11 and 12, respectively, are batteries 13 and 14 which cooperate with the varying resistances 11 and 12 to produce voltages which vary respectively with the X and Y coordinates of the successive positions of the stylus point. For a more complete description of the resistances and their control means, reference will now be made to Fig. 2 which shows a detail view of the apparatus involved. The stylus 10 is placed in the intersection 15 of the slots 16 and 17, respectively, of the control bars 18 and 19 which are made of insulating material. As the stylus 10 is caused to move over the surface of the subject or representation O, sliders 20 and 21 of conducting material attached to the control bars 18 and 19 vary the resistances 11 and 12 in the input circuits of amplifiers 22 and 23 which may be, for example, of the multi-stage type. In some cases, the amplifiers 22 and 23 may not be necessary. The control bars 18 and 19 are guided in their paths by means of rails 24, 25, 26 and 27. The speed at which the stylus is moved over certain portions of the representation will determine the brightness of that portion at the receiving station. For example, if a line is quickly traced the image of the line will be very faint. After amplification by the amplifiers 22 and 23, the image currents in channels 1 and 2 are caused to vary the illumination of light from suitable sources 30 and 37 through light valves 28 and 29, respectively. The optical system for the light valve 28 comprises a light source 30, a lens 31 for focussing the light upon the light valve 28, moving ribbon 32 of the light valve 28, lens 33 and a prism 34 for directing the light passing through the light valve 28 upon a moving film 35 to form a track 36 thereon corresponding at all times to the X position of the stylus. The track 36, and also the other tracks, on the film 35 have been shown as of the variable density type, but it is obvious that the optical system may be so arranged as to form variable area tracks instead. The method of forming the tracks on the moving film 35 is similar to the well-known sound track recording technique. The optical system for the light valve 29 comprises the light source 37, lens 38 for focussing the light from the source 37 upon the aperture of the light valve 29, ribbon 39 for controlling the passage of light through the light valve, lens 40 and prism 41 for directing the light upon the film 35 to form a variable density track 42 thereon. The use of the prisms 34 and 41 makes it possible to displace the light valves 28 and 29 from each other more than would otherwise be possible.

The film 35 may also have a track 43 to record the sound accompaniment. The schematically shown system for this sound accompaniment comprises a microphone 44 for generating currents corresponding to the desired sound accompaniment, and an amplifier 45 for amplifying these currents which are then used to control the

movement of the ribbon 46 of a light valve 47. The optical system for the light valve 47 comprises a light source 48 and lenses 49 and 50 on opposite sides of the light valve.

While the drawings illustrate the sound accompaniment being recorded at the same time as the other tracks, it may be desirable in some instances to record it at a different time. For example, if the coordinate tracks are made on the film at a speed different from the speed of the film during transmission from these tracks to a receiving station, it is advisable to have a sound track made on a film moving at the same speed as that used in transmitting the sound. The sound track may be made on a separate film and this film developed and a positive made. A positive is also made of the developed film containing the tracks corresponding to the coordinate positions of the stylus and the two films are combined, both picture tracks and sound tracks being printed to give the master negative. If desired, the sound track may be displaced with respect to the corresponding image track on the film as in the usual sound motion picture practice.

The moving film 35 may also contain a fourth track. Since each drawing transmitted must be resolved into a single line it is obvious that for some drawings this line must not be continuous if all details are included. For example, if it is desired to transmit two circles, one inside the other, there must be a break in the line at the completion of one circle as the spot goes over to the other circle. This may be done either by a modulating voltage which cuts off the electron beam of the receiving cathode ray tube as it traverses the unwanted path, or by moving the spot over the unwanted path so quickly that the line is too faint to be seen. The track 51 on the film 35 is representative of the time the stylus 10 is lifted from the surface of the object O and is thus used to control the electron beam at the receiver. In order to better understand the control means for producing this track, reference will now be made to Fig. 7 which shows a detail view of the stylus 10.

The stylus 10 comprises a casing 52 of any suitable material, such as for example, black micarta, at the butt end of which is secured an inner sleeve member 53 of conducting material. A tracing member 55 of any suitable material, such as for example, steel, is adapted to be moved in an axial direction within the casing 52 when the stencil is pressed down against the surface of the subject O. As the tracing member 55 is attached by means of a micarta spacing member 56 to a rod 57, the rod 57 also moves in an axial direction with respect to the casing member 52. The micarta spacing member 56 is prevented from moving in a downward direction by a shoulder 58 on the casing member 52, it being caused to rest against this shoulder because of the action of the spring 59 surrounding the rod 57 and pressing against the sleeve 53. The top end of the rod 57 has a contact point 60 of contact metal which is adapted to contact a second contact point 61 which is held in a stationary position within the conducting sleeve 53 by means of the spacing member 62, which is of insulating material. Fastened to the contact member 61 is an electrical lead connection 63 and fastened to the sleeve 53 is a lead connection 54. When the stylus 10 is tracing the outline of the subject O, the spacer 56 is raised from the shoulder 58 against the action of the spring 59 thereby causing contact member 60 to come into electrical contact with

the member 61 and close a circuit comprising battery 64 and electromagnets 65 and 66 connected in parallel (see Fig. 1). The electromagnets 65 and 66 are adapted to control an apparatus for recording the track 51 representing the cut-off signal on the moving film 35.

This recording apparatus comprises a light source 67, a lens 68, an opaque mask 69 having an aperture 70 therein, a lens 71 and means represented generally by the plate 72 having an aperture 73 therein for preventing light from the light source 67 from reaching the aperture 70. The apertures 73 and 70 are so arranged with respect to each other that when there is no flow of current through the electromagnets 65 and 66 (as when the stylus 10 is raised from the surface of the subject O), light from the source 67 will pass through both of them and generate a track 51 on the film 35. When the circuit through the electromagnets 65 and 66 is closed, however, (as by the stylus resting on the subject O) the plate 72 is drawn down against the action of the springs 74 and 75 so as to cover up the aperture 70 in the plate 69, thus producing no track on the film 35. The track 51 thus represents the period or periods of time when the stylus 10 has been lifted from the outline of the subject O and may be used to control the generation of a signal which may be used to modulate the beam of a cathode ray tube used at the receiver in such a manner as to cut off the beam during the period of time that the stylus is lifted from the outline of the subject O being traced at the transmitter. It should be, of course, understood that any other suitable means for producing a cut-off signal may be used instead of the one described above which is merely for the purpose of illustration.

After the film 35 has been developed, fixed and dried in accordance with well-known photographic technique, the tracks on the film are used to control the generation of signal currents for transmission to a receiving station. Fig. 3 is a schematic representation of apparatus for transmitting from the film 35. Light from an elongated light source 140 is focussed upon the film by means of a suitable optical system represented generally by lens 141 and is projected through apertures 143, 144, 145 and 146 of a mask 142 to illuminate respectively the tracks 36, 51, 42 and 43 of the film 35. It is to be understood that the lens 141 may comprise four different lens systems, if desired. The light passing through the film 35 falls upon photoelectric cells 77, 78, 79 and 80 located directly behind the film and as close thereto as is practical. (For convenience of illustration these cells are shown at a considerable distance from the film.) These cells generate signal currents respectively proportional to the density of the particular portions of the tracks 36, 51, 42 and 43 respectively opposite the apertures 143, 144, 145 and 146. If desired, the photo-cells 77, 78, 79, and 80 may be spaced farther apart than shown, any suitable optical arrangement being used to separate the rays from the respective tracks.

The signal currents generated by the photoelectric cells 77, 78, 79 and 80 are then used to modulate carrier waves generated by means such as, for example, oscillators 81, 82, 83 and 84, the modulators 85, 86, 87 or 88 being used to perform this modulation. Band-pass filters 89, 90, 91 and 92 are preferably used to exclude all frequencies except those of the desired band width. The currents in channels A, B, C and D are then amplified by the amplifier 93, which may comprise a num-

ber of stages, and transmitted over suitable wire or radio lines 94 to the receiving system shown in Fig. 4. If desired, the amplifier 93 may comprise four separate units.

The receiving system shown in Fig. 4 comprises a suitable amplifier 95, four band-pass filters 96, 97, 98 and 99 for selecting the appropriate channels, and demodulators 100, 101, 102 and 103 for demodulating the received signals in the various channels. The signals in channels A and C are then applied to two pairs of deflecting plates 104 and 105 of a cathode ray receiving tube 106; those in channel B are used to cut off the beam in the tube at times when the stylus 10 is lifted from the subject; and those in channel D are used to produce sound effects.

The cathode ray tube 106 comprises a means such as a cathode 107 and an anode 108 for producing a beam of electrons and a second anode 109 for accelerating this beam toward a fluorescent screen 110. The voltages from the channels A and C create electrostatic fields between the deflecting plates 104 and 105, respectively, which deflect the beam to positions corresponding to the successively traced positions of the stylus at the transmitting station. The voltages across the deflecting plates are balanced with respect to the anode 109 by means of the high resistances 114 and 115, the mid-points of which are connected to the anode 109. By making the film 35 a continuous belt and transmitting from it anywhere from 12 to 30 times a second an apparently continuous steady image may be formed on the fluorescent screen 110 of the cathode ray receiving device 106 which corresponds to the subject O at the transmitting station. The length of the continuous belt corresponds to one complete tracing of the subject.

The drawings or cartoons may be animated by changing slightly the voltages in any appropriate way for each succeeding tracing. This introduces no added requirements of any kind in the transmission. Drawings differing slightly from each other may be successively traced by the stylus and in this manner an animated motion picture may be produced on the fluorescent screen 110. It is thus possible to transmit by this method animated cartoons.

The signals in channel B (cut-off signal) are applied to a control or modulating electrode member 111. The negative voltage applied between the cathode 107 and the modulating member 111 causes the cathode ray beam to be cut off, thus producing no line or trace on the screen 110 when the stylus 10 is lifted from the subject O.

The signals in channel D may be conducted to any suitable loud-speaker arrangement 112 through any appropriate amplifying means 113. The observer thus sees a moving picture and hears the sound accompaniment.

In order to fully understand the operation of the image or facsimile transmission system shown in Figs. 1, 3 and 4, some of the theory of this system will now be considered. It is inherent in well-known systems in television that high definition must at all times be realized no matter how simple the transmitted image may be. Many useful and entertaining images, however, do not contain a great amount of detail and in transmitting them large blank areas on the available field are wastefully transmitted. The animated cartoon is an example of such a simple image. By making it possible to transmit the figure and line background without the blank areas a great simplification can be brought about. The system

of this invention was designed to take advantage of this fact.

By the application of proper potentials to the receiving plates 104 and 105 of the cathode ray tube 106, the cathode ray beam of the tube may be made to traverse any path desired. Furthermore, if the spot is made to follow a certain path, such as that shown in Fig. 5, over and over, approximately twenty times a second, this trace will appear on the end of the tube as a stationary image.

Two potentials, each varying in intensity with time, are needed to properly actuate the spot. They are applied, one across the horizontal set and one across the vertical set of deflecting plates of the cathode ray tube 106. They are directly proportional, respectively, to the X and Y coordinates of the points of the figure, that is, points 1, 2, 3, 4, etc. of Fig. 5, taken along the path of the spot in the direction in which it moves. These potentials for the image of Fig. 5 are shown in graph form in Fig. 6.

Any method of recording the X and Y potentials may be used as, for example, photographic film. The film 35 of Fig. 1 is an example of this method of recording. They may be recorded or plotted, as a modification, as a circular track either of the variable area or variable density type, the former being illustrated in Fig. 8. Each of the image tracks, that is, the area between each curve and its base circle is made contrasting with the background and the disc 122 containing the curved image tracks 120 and 121 is mounted on the shaft of a motor 123 which is adjusted to run at a speed of, for example, twenty revolutions per second. The disc is brightly illuminated by light from a source 124 which is reflected by a curved mirror 125. A lens 126 and a radially oriented slit 127 are arranged in such a manner that a portion of the image of the track 120 falls across the slit 127. Behind the slit 127 is a photoelectric cell 128 which receives the illumination passing through the slit to generate therefrom signals which may be used to modulate a carrier such as that of channel A of Fig. 3. Thus the output of the photoelectric cell 128 is directly proportional to the X coordinate of the stylus position at any instant of time. The apparatus to the left of the line X—X in Fig. 8 may be the same as the apparatus to the right of the line X—X for channel A in Fig. 3 with the possible addition or subtraction of one amplifying stage in the case where the area between each coordinate curve and its base circle is made white and the background black.

A similar set-up comprising a lens 129, a radially oriented slit 130, and a photoelectric cell 131 may be used to produce potentials which are proportional to the Y coordinates of the successively traced points of the subject O. Auxiliary apparatus for channel C which may be connected on the left of the line Y—Y in Fig. 8 may be similar to that shown to the right of the line Y—Y in Fig. 3 with the addition or subtraction of one amplifying stage if the image track is white rather than black as shown in Fig. 3.

For the simplest type of image in which the drawing may be resolved into a single unbroken line, e. g., the object in Fig. 5, the total frequency spectrum of band width needed for accurate reproduction of the sketch will consist of the sum of the band widths needed to transmit accurately the X and Y potentials. These may be assumed to be equal. The band widths may then be determined by the analysis of the X (or Y) potential

variations of a single trace by means of harmonic analysis.

The magnitude of this potential E may be expressed as a function of time by a Fourier equation with an infinite number of terms.

$$E = f \int_0^{1/f} E dt + \sum_{n=1}^{\infty} A_n \sin(\theta + \phi_n) \quad (1)$$

where f is the fundamental or trace frequency (about twenty per second) and A_n and ϕ_n are the amplitude and phase angle of the n th harmonic.

However, an infinite number of terms is of no value here because of the limitations of the eye and of the cathode ray tube 106. All components above a certain value of n would add so little to the reproduced image that it would be impossible to distinguish the difference due to their absence. For any subject, therefore, the problem becomes that of determining the highest value of n needed for satisfactory reproduction. The band width will be that included between f_1 and the frequency of this n th component.

In general, the three kinds of detail which will suffer most by the elimination of high order terms are straight portions, sharp kinks, and small bends, i. e. bends of small (approximate) radius of curvature. This is true for the straight portions simply because it is easier for the eye to distinguish a small deviation from a straight line than to detect the difference between two curvatures which are slightly different. A "steep front" such as often arises in wave analysis and which requires relatively high order terms will not appear in the problem considered here, because of the assumption that the spot moves with uniform speed.

A certain degree of departure from the linearity of the straight portions and from the exact form of the various curvatures and also a certain amount of waviness may be tolerated. These are the defects in the image which will be occasioned by the elimination of the terms of the series above the n th. Furthermore, such defects will be more detrimental the smaller the detail, since enough terms will always be transmitted to give a good overall shape and good form to the larger details. Now it is much more important to reproduce correctly the general overall form of the image than the smaller details. Thus the band width is largely determined by the fidelity of small detail desired.

Suppose therefore that the smallest detail, in the form of a small bend or kink in the curve of a potential function, is picked out and a small portion of the curve in which this detail occurs is analyzed harmonically. For the purpose at hand only a small number of terms or harmonics need be considered. The results of the analysis may be written in the form of an equation of the usual Fourier type and the term having the largest coefficient will, in general, be the most important one in contributing to the shape of the desired detail. In any case this "most important" term may be determined by graphically synthesizing the terms. A little experience in harmonic analysis will enable one to determine it, in most cases, by inspection alone.

If the band width extends up to and includes the frequency of this term, the detail in the image which gave rise to that in the potential curve will in general be reproduced in approximate form. The band width determined in this manner may therefore be taken as that neces-

sary for satisfactory reproduction. A rough check was obtained on the adequacy of this approximate method by equivalently shortening the band width of the apparatus used in the reproduction of the figure shown in Fig. 5. The total band width determined as above for this figure was two thousand cycles. The bands passed by the amplifiers were equivalently reduced to 1300 cycles each and no marked change in the image occurred.

The first term of the series of Equation 1 for each component curve is of importance for centering the image in the field. It is

$$F \int_0^{1/f} Edt. \quad (2)$$

This is simply the total area between the voltage curve and the line representing zero voltage over one cycle of period f divided by the length of the base line

$$\left(\frac{1}{f}\right)$$

It thus represents the mean distance of the curve from the zero axis. If this mean distance, which can be considered a direct current component, is eliminated from the image signal current, the shape of the component curve and hence also of the image would not be altered but the centering of the image would vary as the figures move around in the field. As an example of the effect of this, suppose that the image consists of a central human figure and a very simple background. As the figure starts to walk from the center to the side of the field, the absence of the transmission of this centering component holds the figure near the center and the background slides away in the opposite direction, an effect which is sometimes desired. This component would be eliminated by ordinary alternating current amplifiers or other apparatus incapable of passing direct or low frequency currents but if the image frequencies are used to modulate a carrier or carriers, the frequency band may be made to extend to zero on the low frequency end and this component will then be included in the transmission even when amplifiers or other apparatus like that just mentioned is employed. If a carrier is not used the problem is similar to that encountered in ordinary television when the components representative of average brightness are suppressed. As in systems of that kind, voltage components correspond to those suppressed may be inserted at the receiving station. See for example the patent to Ives and Gray, 2,037,471 April 14, 1936.

A possible application of this system will be considered here, namely, the transmission of sketches, writing, and particularly animated cartoons by way of radio broadcasting stations purely for entertainment or educational purposes. With most modern broadcasting stations definitely transmitting an audio band 7500 cycles wide and attempting to transmit one up to 10,000 cycles (a total transmitted band width of 20,000 cycles) in the interest of high quality music, it is apparent that by proper engineering, animated cartoons of a degree of complexity of definite entertainment value plus a sound accompaniment of at least 3000 cycles may be transmitted from a modern radio broadcasting station. This may be accomplished as follows: Let it be assumed that the band width for each component image potential is 5000 cycles and for the sound band is 3000 cycles. Each of these will be used to modu-

late a separate carrier as in Fig. 3 and by proper filters one side-band of each will be discarded. There will be left for transmission three carriers and their single side-bands (if a cut-off signal is transmitted there will be an additional carrier). The carriers will have been chosen so that the sound channel falls in the center of the transmitted band of the broadcast transmitter with the image channels on either side of it and with a spacing between channels of several hundred cycles. The carriers for the image channels will be placed near the sound band so that the higher frequencies will be at the edges of the transmitted band (one channel has the upper and the other the lower side-band). Thus the total transmitted band will be somewhat less than 14,000 cycles wide, which is equivalent to transmitting an audio range of 7000 cycles by the usual method (transmitting both side-bands). It is possible therefore to transmit images of even greater complexity than that of Fig. 5 from a modern radio broadcasting station having filter circuits, etc., arranged for high fidelity sound broadcasting. By this arrangement the higher frequencies, which, in general, have decreasingly lower amplitudes, are placed at the outside of the band and interference between stations will not be materially greater than it is now with high fidelity radio transmission.

It will thus be observed that this system will produce visual programs of high entertainment value without requiring band widths any larger than those of the ordinary high fidelity radio transmitting stations of today.

Various modifications may be made in the invention as above disclosed, the scope of which is indicated by the appended claims. The expression "along the boundaries of distinctive areas" used in the claims is intended to be inclusive of the case where a distinctive area is a line. The two parallel boundaries of a line area are for practical purposes coincident so that a stylus tracing the line is in effect tracing each boundary of the line area; that is, tracing both boundaries of the line area simultaneously. This term, "along the boundaries of distinctive areas", is also intended to be inclusive of the case where the areas are distinguishable by differences in elevation as, for example, a figure cut from cardboard and placed or mounted upon a flat support having the same or different tone value or an element of wax forming a field in which a line drawing, figure or design of any kind is produced by indentations in the wax, thus forming depressed line areas.

What is claimed is:

1. A method of image production comprising the steps of tracing the boundaries of distinctive areas of a subject lying substantially in a plane, simultaneously generating by said tracing two potentials the values of which at each instant are respectively proportional to the distances from the boundary element then being traced to two coordinate axes, making two records corresponding respectively to the variations of said two potentials, transmitting within the period of persistence of vision from said records potentials corresponding to a complete tracing of said subject, and immediately repeating said last step.

2. In combination a support for a subject, a stylus for tracing the boundaries of distinctive areas of said subject, means for generating potentials representative of the changing location of said stylus with respect to coordinate axes, means for recording said potentials, and means for re-

peatedly transmitting from said recording sets of signals each set representative of a complete tracing of said subject and each in a time interval within the period of persistence of vision.

3. A transcriber comprising a stylus for tracing boundaries of distinctive areas of a subject, means controlled by the raising of said stylus from said subject for generating a signal, means for recording said signal, and means for utilizing said recording to control the intensity of a cathode ray beam.

4. In combination, a stylus for tracing the outline of a subject at a transmitting station, a record member at said station, means for directing a beam of light to said record member, and means operable upon the lifting of said stylus from said representation for controlling the intensity of said light beam.

5. In combination, means for generating signals varying with the location of successively traced points on the boundaries of distinctive areas of a complete subject, means for transmitting said signals to a receiving station, a cathode ray tube at said receiving station, said cathode ray tube having means for generating a beam of electrons, two sets of electrostatic deflecting plates, and a fluorescent screen, means for applying to the sweep plates of said cathode ray tube potentials which continuously vary in accordance with the signals received at the receiving station so that said beam traces on said screen an image of said object, and means for retransmitting at predetermined intervals within the period of persistence of vision signals similar to said first signals representing a completely traced subject so that an apparently steady and continuous image is formed on the screen of said cathode ray tube.

6. In combination, means for converting the motion of a stylus along the boundaries of distinctive areas of a subject into two potentials continuously varying in accordance with successive positions of the stylus, a circular disc for recording said potential variations corresponding to a complete subject in polar coordinates along the complete circumference of two coaxial circles on said disc, means for rotating said disc so that a complete revolution is made within the period of persistency of vision, and means for transmitting these potential variations from said record member to a receiving station.

7. A method of producing variations in density of the received image in the cathode ray tube of an electrograph system in which the boundaries of distinctive areas of a subject at a transmitting station are traced by a stylus comprising tracing lines of the subject at the transmitting station of less density with greater speed than lines of greater density.

8. A method of image production comprising the steps of tracing the boundaries of distinctive areas of a series of successive representations of a subject, each representation in the series differing from its preceding representation by an extent corresponding to a difference in time within the period of persistence of vision, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, recording the potential variations, and transmitting signals from said recording at such a rate that the signals corresponding to a complete tracing of one of the representations of said subject occurs within the period of persistence of vision.

9. A method of image production comprising

the steps of tracing the boundaries of distinctive areas of a subject, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, recording these potential variations as two tracks coaxially arranged on a circular disc, turning said circular disc at such a speed with respect to a pick-up device that signals corresponding to a complete tracing of said subject are generated within the period of persistence of vision, and retransmitting from said disc signals corresponding to complete tracings of said subject at intervals within the period of persistence of vision.

10. A method of image production comprising the steps of tracing the boundaries of distinctive areas of a subject, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, photographing these potential variations as parallel tracks on a sensitive film, developing, fixing and drying said film, transmitting from the tracks on said film within the period of persistence of vision signals corresponding to a complete tracing of said subject, and repeatedly transmitting from said film signals from the tracks thereon corresponding to complete tracings of said subject, each within the period of persistence of vision.

11. A method of image production comprising the steps of tracing the boundaries of distinctive areas of successive representations of a subject, each representation in the series differing from its preceding representation by an extent corresponding to a difference in time within the period of persistence of vision, simultaneously generating by said tracing two potentials varying in accordance with the positions of successively traced elements of said boundaries with respect to coordinate axes, photographing these potential variations as two parallel tracks on a sensitive film, developing, fixing and drying said film, and successively transmitting signals from the tracks on said film corresponding to successive complete tracings of representations of said subject, each transmission of a representation being completed within the period of persistence of vision.

12. A method of image production comprising the steps of tracing the boundaries of distinctive areas of a subject, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, recording these potential variations, generating from said recording two signals varying in accordance with the positions of the successively traced points of the subject at such a rate that the signal corresponding to a complete tracing of said subject is generated within a time interval within the period of persistence of vision, modulating separate carrier waves with said signals, and transmitting said modulated carriers to a receiving station.

13. A method of image production comprising the steps of tracing the boundaries of distinctive areas of a subject, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, recording these potential variations, generating from said recording two signals varying in accordance with the positions of the successively traced points of the subject at such

a rate that the signals corresponding to a complete tracing of said subject are generated within a time interval within the period of persistence of vision, modulating separate carrier waves with said signals, transmitting said modulated carriers to a receiving station, demodulating said modulated carriers at said receiving station, and applying the signals resulting from said demodulation to a receiving member to form thereby an image of said subject.

14. A method of image production comprising the steps of tracing the boundaries of distinctive areas of a subject, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, recording these potential variations, generating from said recording two signals varying in accordance with the positions of the successively traced points of the subject at such a rate that the signals corresponding to a complete tracing of said subject are generated within a time interval within the period of persistence of vision, modulating separate carrier waves with said signals, filtering said modulated carrier waves to remove one side-band of each, transmitting the remaining side-bands to a receiving station, filtering the received side-bands to divide them into their respective channels, demodulating the resulting signals in the respective channels, and applying the signals resulting from said demodulation to a receiving member to form thereby an image of said subject.

15. A method of transmitting signals for the production at a receiving station of an image of a subject at a transmitting station comprising the steps of tracing the boundaries of distinctive areas of said subject, simultaneously generating by said tracing two potentials varying in accordance with the positions of the successively traced elements of said boundaries with respect to a coordinate system, generating a third potential variation whenever the tracing member is lifted from the boundaries of said subject, recording all three of these potentials, generating from said recording two signals varying in accordance with the positions of the successively traced points of the subject at such a rate that the signals corresponding to a complete tracing of said subject are generated within a time interval within the period of persistence of vision and a third signal corresponding to the period of time the tracing member is lifted from the surface of said subject, and transmitting all three of said signals to a receiving station where they cooperate to form an image of said subject.

16. A method of controlling from a transmitting station a cathode ray beam in a receiving device, said device being used to produce an image of a subject the boundaries of distinctive areas of which are traced at said transmitting station which comprises the steps of generating potentials when the tracing member at the transmitting station is moved from the plane of the subject, recording said potentials, reproducing potentials from said recording, transmitting said reproduced potentials to said receiving station, and applying said received potentials to the control means for said cathode ray beam in such a manner that said beam is substantially extinguished when the tracing member is moved from the plane of the subject.

17. A method of transmitting signals for producing at a receiving station an image of a subject at the transmitting station with sound accompaniment comprising the steps of tracing the boundaries of distinctive areas of said subject, the complete subject being traced within a period of time much greater than the period of persistence of vision, simultaneously generating by said tracing two potentials continuously varying in accordance with the positions of the successively traced elements of said boundaries with respect to coordinate axes, recording these potentials as two parallel tracks on a first film member as they are generated, developing, fixing and drying said film member, making a positive from said first film member, recording the sound accompaniment as a track on a second film member moving at the usual sound recording speed, which speed is the same as the reproducing speed, developing, fixing and drying the second film member, making a positive of said second film member, and combining the two positives to form a single master positive having three tracks thereon, printing a master negative from said master positive, and moving said master negative with respect to pick-up apparatus at the speed at which said sound accompaniment was recorded, said speed being such that the tracks corresponding to a complete tracing of said subject pass the pick-up apparatus within the period of persistence of vision.

18. Means for making a record member for controlling the production of an image of a subject comprising means for generating two potentials continuously varying in accordance with the positions of the successively traced elements of the boundaries of said subject with respect to coordinate axes, a film, means for moving said film, a pair of light valves, a light source associated with each light valve, means including said light valves for modulating the light from said sources in accordance with the changes in said two varying potentials, and means for projecting said modulated light upon said moving film to expose said film in two tracks parallel to each other.

19. Means for making a record for controlling the production of an image of a subject comprising means for simultaneously generating, by tracing the boundaries of the distinctive areas of a subject, two potentials continuously varying in accordance with the positions of the successively traced elements of said boundaries with respect to coordinate axes, a film member, means for moving said film member, a pair of light valves, a light source associated with each light valve, means for modulating the light from each of said sources in accordance with the changes in the two varying potentials, means for projecting said modulated light beams upon said moving film to form thereon two parallel tracks, a third light valve, a source of light associated with said third light valve, means for controlling said third light valve in accordance with the lifting of the tracing member from the surface of said subject, and means for projecting the light through said third light valve as a third track on said film parallel to said first two tracks.

20. A cathode ray device comprising means for generating a beam of electrons, two pairs of electrostatic deflecting plates for giving the beam a motion having components at right angles to each other, a fluorescent screen on which said beam impinges, said screen being of such material that it emits light only a relatively short time after being impulsively energized by said beam, such period of time being much shorter than the period of persistence of vision, and

means for impressing upon said pairs of deflecting plates, respectively, varying trains of potentials representative of successively traced positions, with respect to coordinate axes, along the boundaries of distinctive areas of a subject the image of which is to be produced, the varying trains of potentials corresponding to a complete tracing of said subject being impressed upon said plates within the period of persistence of vision, and means for repeatedly impressing upon said pairs of deflecting plates varying trains of potentials each train representative of complete successive representations of said subject.

21. A cathode ray device comprising means for generating a beam of electrons, two pairs of electrostatic deflecting plates for giving the beam a motion having components at right angles to each other, a fluorescent screen on which said beam impinges, said screen being of such material that it emits light only a relatively short time after being impulsively energized by said beam, such period of time being much shorter than the period of persistence of vision, and

means for impressing upon said pairs of deflecting plates, respectively, varying trains of potentials representative of successively traced positions, with respect to coordinate axes, along the boundaries of distinctive areas of a subject the image of which is to be produced, the varying trains of potentials corresponding to a complete tracing of said subject being impressed upon said plates within the period of persistence of vision, and means for suppressing the beam for a period after each of the boundaries corresponding to a complete image has been traced.

22. As an article of manufacture, a record for controlling the production of an image comprising three separate tracks adapted to be simultaneously separately read, two of said tracks being representative of the positions, with respect to a system of coordinates, of elemental portions of an object the image of which may be produced from said record, and the third of said tracks being representative of a termination of a series of said elemental portions.

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