

July 8, 1930.

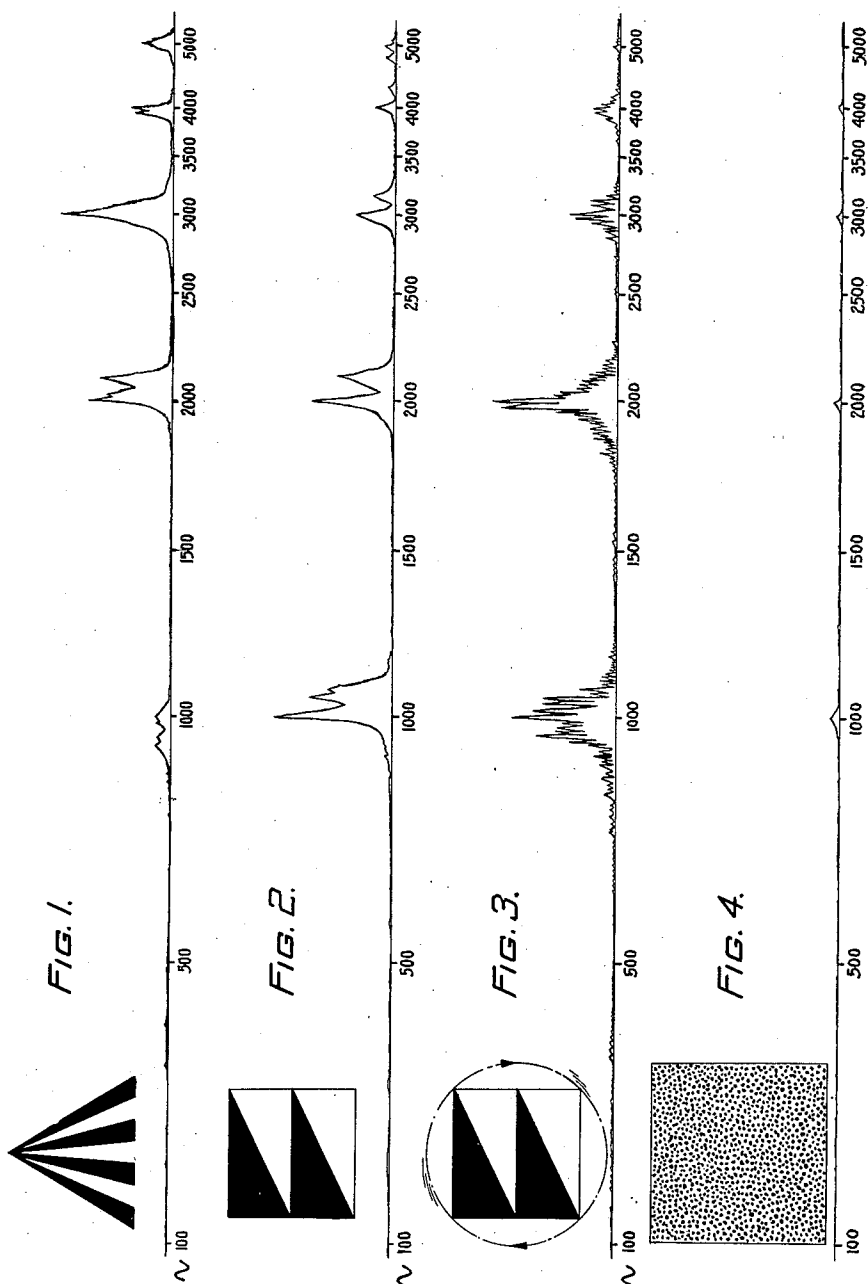
F. GRAY ET AL

1,769,918

ELECTROOPTICAL TRANSMISSION SYSTEM

Filed Feb. 2, 1929

4 Sheets-Sheet 1



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FIG. 5.

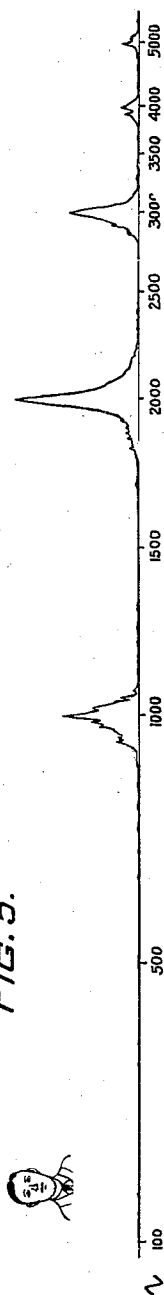


FIG. 6.

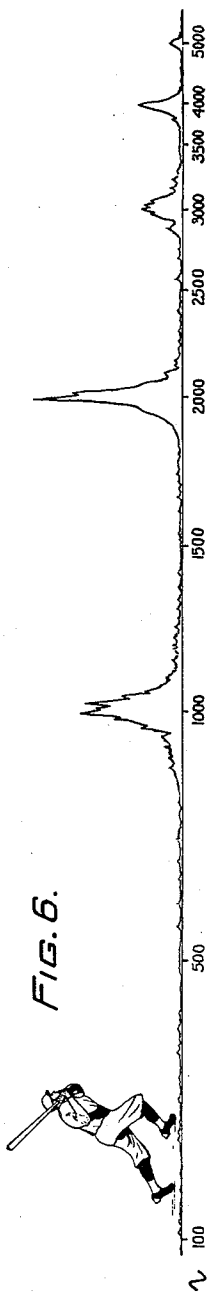
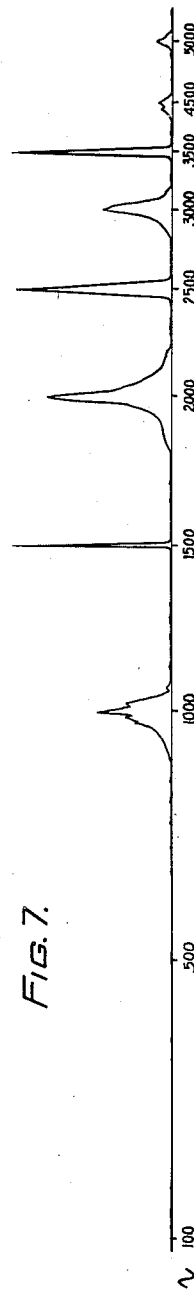


FIG. 7.



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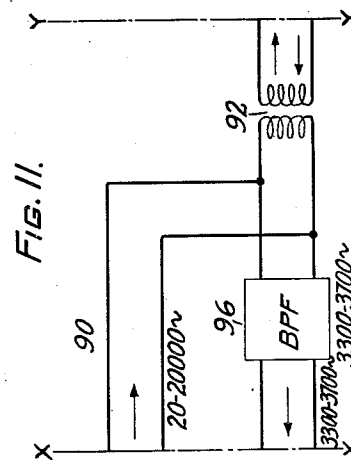
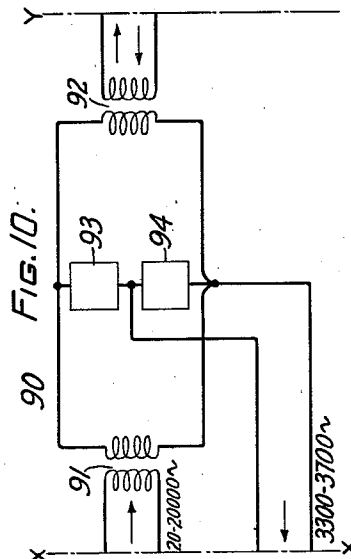
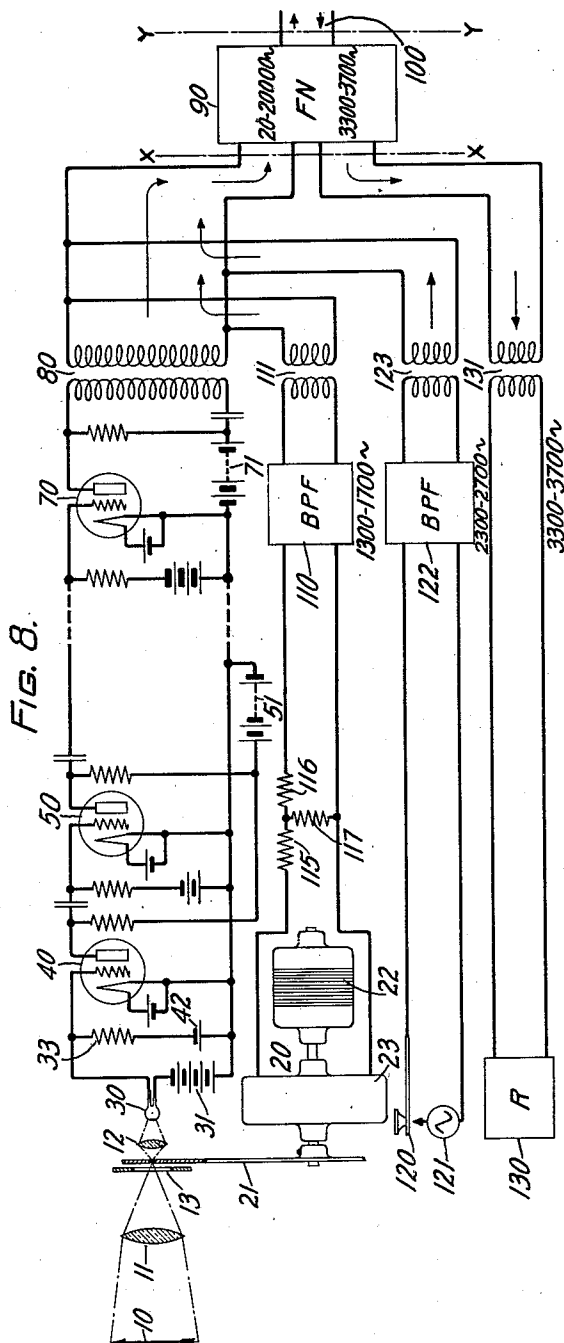
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4 Sheets-Sheet 3



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Fig. 9.

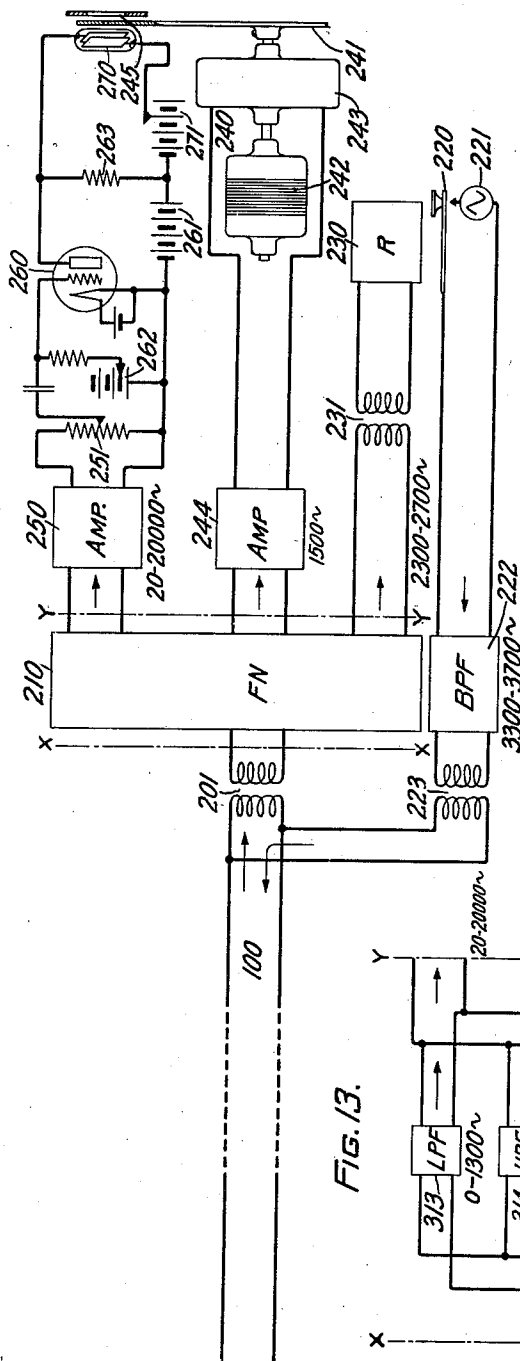


FIG. 12.

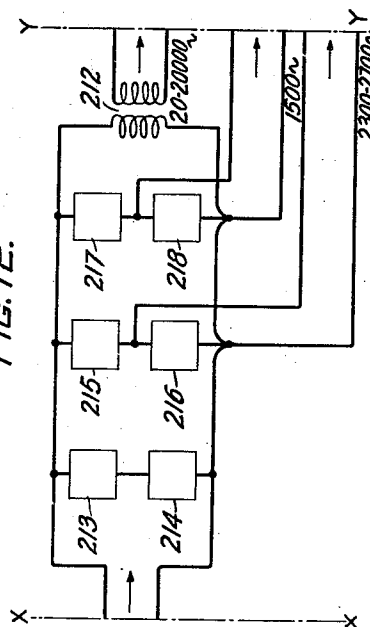
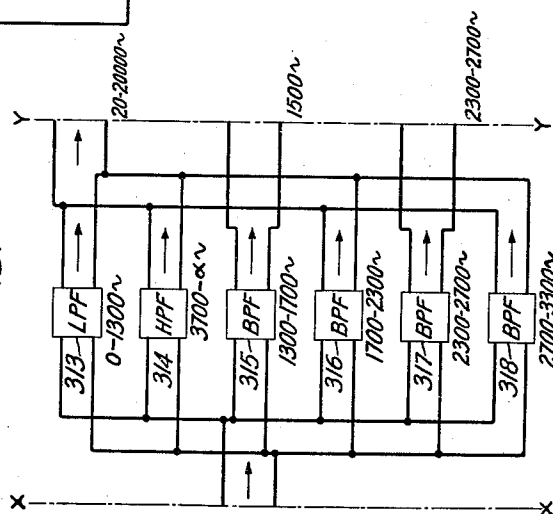


FIG. 13.



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UNITED STATES PATENT OFFICE

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ELECTROOPTICAL TRANSMISSION SYSTEM

Application filed February 2, 1929. Serial No. 337,132.

This invention relates to signaling and more particularly to television and high speed picture transmission and composite signal transmission.

5 An object of the invention is to improve the utilization of the frequency transmission band involved in signaling for such types of transmission as television and high speed picture transmission.

10 This invention is the result of the discovery that when an object or field of view is periodically scanned in a series of parallel lines and the light tone values of elemental areas are translated into electric current variations the
15 energy is largely concentrated in a number of distinct bands of frequencies between which there is very little useful energy, and the position of the bands in the frequency spectrum is dependent upon the field scanning frequency and upon the line scanning frequency. The energy concentrations resulting from scanning an ordinary field occur
20 in the regions of the field scanning frequency and some of the lower harmonics thereof and in the regions of the line scanning frequency and the lower harmonics thereof. These latter bands are made up of a plurality of frequencies the prominent ones of which differ by approximately the field scanning frequency. The bands may, for example, have
25 a band width of approximately 20% of the line scanning frequency, in which case the low energy intervening gaps or valleys have a frequency band width of about 80% of the
30 line scanning frequency.

This invention provides means for utilizing the above mentioned gaps or valleys for other purposes, such for example, as the transmission of synchronizing current, or other signals, etc. The transmission of the various
35 signal currents may be over the same medium and in the same direction or in opposite directions. In accordance with one form of this invention, means are provided for producing and for simultaneously transmitting
40 over a single circuit or medium a photoelectric current generated by scanning an object whose image is electrically produced and other signal currents having frequencies falling
45 within the low energy gaps of the photo-

electric current, such as, for synchronizing and for telegraphing.

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

55 Figs. 1, 2, 3, 4, 5 and 6 show current-frequency curves resulting from periodically scanning in a series of adjacent parallel lines, a fan-shaped diagram, a double wedged diagram, a double wedged diagram rotating at
60 about two revolutions per second, a gray background, a human face, and a human subject making rapid motions with the head and hands, respectively.

Fig. 7 is a typical current-frequency curve
65 resulting from scanning in a series of adjacent parallel lines an ordinary object and of three other interwoven superimposed currents of relatively narrow frequency range.

Fig. 8 is a general schematic representation
70 of transmitting terminal apparatus in a television system arranged in accordance with the invention for simultaneously transmitting the television current and a number of additional signal currents over the same trans-
75 mission circuit.

Fig. 9 is a general schematic representation of the receiving terminal apparatus in a television system arranged in accordance with the invention for simultaneously receiving
80 the television current and a number of additional signal currents over the same transmission circuit from a transmitting terminal equipped for example as shown in
85 Fig. 8.

Fig. 10 is a detail circuit diagram of the filter network FN of Fig. 8 used to connect the terminal apparatus with the transmission line.

Fig. 11 is an alternative arrangement of a
90 filter network for that shown in Fig. 10.

Fig. 12 is a detail circuit diagram of the filter network FN of Fig. 9 used to connect the terminal apparatus with the trans-
95 mission line.

Fig. 13 is an alternative arrangement of a filter network for that shown in Fig. 12.

The current-frequency curves in Figs. 1 to 6 inclusive show the magnitude of response at different frequencies over a frequency band
100

or spectrum ranging from approximately 100 to 5000 cycles per second of the photoelectric current generated in scanning ordinary objects such as geometric figures or human subjects. These curves do not show the band of frequencies which occurs, near the scanning frequency, since it has been well understood that frequencies in this region must be present. Current strength is indicated by the ordinate and frequencies on a logarithmic scale by the abscissa. A sketch to indicate the nature of the object scanned is shown at the left in each figure. Figs. 3 and 6 relate to objects in motion while the other four figures relate to objects at rest. Fig. 3 is a double wedged diagram rotating about two revolutions per second and Fig. 6 is a human subject making rapid motion with the head and hands. The first three geometric objects were black on white background to obtain two distinctive tones. Fig. 4 is a plain field which is of uniform tone throughout so far as the eye can detect. The energy concentrations for ordinary objects as these figures show occur in narrow frequency bands having substantially the same position and width in the entire frequency spectrum irrespective of whether the object is at rest or in motion. These current-frequency curves were experimentally obtained and are typical for ordinary objects either still or moving when periodically scanned in a series of 50 parallel lines repeated at the rate of approximately 20 times per second thereby producing energy concentrations at or very near the fundamental line scanning frequency of 1000 cycles per second, and harmonics of 2000, 3000, etc., cycles per second. If with the same apparatus the scanning rate is increased from 20 to say 30 times per second, the fundamental line scanning frequency is 1500 cycles per second and the harmonics are 3000, 4500, etc., cycles per second at which points the energy concentrations occur. The curves obtained from actual experiment in scanning the object at approximately 20 times per second have a band width, at the frequencies around which energy concentrations occur, which is a small proportion of the line scanning frequency which results in the low energy intervening gaps or valleys having a relatively wide frequency band wherein the photoelectric energy is comparatively small. It appears that each of these bands is probably made up of separate very narrow bands each having an energy peak at a frequency which is a multiple of the field scanning frequency. Thus the bands in the general region of 1000, 2000, 3000, etc., cycles per second when the line scanning frequency is 1000 and the field scanning frequency is 20 cycles, may be made up of narrow bands having their maxima removed from 1000, 2000, or 3000, as the case may be, by multiple of 20. These narrow bands widen somewhat when

there is motion of the objects scanned. There may be greater energy at one of these points removed from the line scanning frequency, or a multiple thereof by 20 or a small multiple thereof, than at 1000 or a multiple thereof.

This invention employs the intervening wide gaps or valleys of low energy in the photoelectric current for the simultaneous transmission of other signals such as synchronizing and telegraphing, and Fig. 7 shows a typical current-frequency curve of a photoelectric current resulting from scanning an ordinary object and three other currents occupying gaps in the spectrum of the photoelectric current. At the 1500 cycle position occurs a synchronizing current occupying a very narrow band and at the 2500 and the 3500 cycle positions occur telegraph channels approximately 200 cycles wide for operating simultaneously in both directions. Each of the added currents is preferably positioned at approximately the midpoint of one of the gaps between energy concentrations in the photoelectric current. By keeping the added frequency bands of the proper width and symmetrically positioning them in the gaps or valleys of low energy in the photoelectric current the different currents may be transmitted and separated at the receiving station without interfering with one another, and because of this the transmission capacity of the transmission medium is decidedly increased. Means which may be employed for carrying out the principles of operation illustrated in Fig. 7 are shown in Figs. 8 and 9.

The television transmitting station shown in Fig. 8, in general comprises terminal apparatus consisting of television scanning apparatus, current amplifying apparatus for the photoelectric current, and telegraph communication apparatus for both sending and receiving, all of which are connected with the transmission line through suitable electrical filter networks. An illuminated object 10 whose image is to be transmitted is periodically scanned in a series of parallel lines by the scanning apparatus 20. An image of the object is focused upon the viewing field of the scanning apparatus by means of a suitable objective lens system 11 and light from elemental areas of the image thus formed is directed by means of the lens system 12 upon the light sensitive cell 30. The scanning arrangement may comprise any suitable device such as a rotating scanning disc 21 having a row of apertures spirally arranged. An opaque member having an aperture 13 is positioned between the lens 11 and the scanning disc and limits the size of the image field upon the scanning disc so that just one aperture in the scanning disc is exposed at any instant, the angular width of the aperture 13 being equal to the angular pitch of the apertures in the scanning disc. The scanning disc is driven at suitable speed by means of

a driving motor 22. For generating a synchronizing current to control the speed of the receiving apparatus, an alternating current generator 23 is mounted upon the same shaft as the scanning disc 21. The photoelectric current generated in the light sensitive element 30 is amplified by suitable vacuum tube amplifiers 40, 50, and 70. The output circuit of the light sensitive cell 30 contains batteries 31 and 42, and resistance 33. Battery 31 causes a current to flow through the resistance 33 which is varied by the changing excitation of the light sensitive cell. This results in a varying potential across the resistance 33, one side of which is connected to the grid and the other to the filament of the vacuum tube of the amplifier 40. Polarizing battery 42 is adjusted to apply a proper negative bias to the grid of the vacuum tube. The output of amplifier 40 is impressed upon the intermediate amplifier 50 whose output is in turn impressed upon succeeding amplifiers. Battery 51 supplies space current for these amplifiers. Any suitable number of stages of amplification may be employed. The amplified photoelectric current on passing through the last amplifier stage 70, which is supplied with space current by the battery 71, is transmitted through repeating coil 80, and the filter network 90 designed to pass currents covering the entire range of the photoelectric current frequency band, to the transmission line 100.

In this invention, as shown in Fig. 7, some of the intervening frequency bands wherein the photoelectric current is of relatively small amplitude are utilized for sending other signaling current. One of these gaps is used for the synchronizing current which is generated by the alternating current generator 23. The gap between the photoelectric current concentration bands in the neighborhood of 1000 cycles and in the neighborhood of 2000 cycles may be selected for this purpose and a current of 1500 cycles employed for synchronization. This synchronizing current is transmitted through a band pass filter 110, repeating coil 111 to the circuit leading to the filter network 90 and from there to the transmission line 100. A network comprising resistances 115 and 116 in the series arm and a resistance 117 in the shunt arm is connected to the output leads of the synchronizing current generator 23 and to the input leads of the band filter 110 for properly matching and adjusting the impedances of these elements. An order wire telegraphic communication channel is provided for communicating in each direction between the transmitting and the receiving stations. Two other gaps in the photoelectric current are selected for transmitting the telegraph signaling current substantially mid-way between the photoelectric current concentration bands in the neighborhood of

2000 and 3000, and of 3000 and 4000 cycles, respectively. A carrier current of 2500 cycles is used for the outgoing telegraph channel and a carrier current of 3500 cycles is used for the incoming telegraph channel at this station. The telegraph transmitting apparatus is represented by the key 120 which controls the output circuit from the oscillator 121 which generates a carrier current of approximately 2500 cycles. This current is passed through the band-pass filter 122, designed to pass the 2500 cycle carrier current and side bands of sufficient width for telegraph signals. The outgoing telegraph signals are next transmitted through the repeating coil 123 to the circuit leading to the filter network 90 and from there to the transmission line 100. The incoming telegraph signals are received by the telegraph receiving apparatus 130 which is connected by means of the repeating coil 131 with the filter network 90. The filter network 90 is arranged to pass to the receiver telegraph signals having a frequency band of approximately 3300 to 3700 cycles, a frequency band which has practically no significance in the transmission of the photoelectric current under consideration. The filter network 90 is arranged to transmit outgoing signals of the order of 20 to 20,000 cycles which is ordinarily sufficient for the transmission of the frequencies significant in the transmission of the photoelectric current under consideration, the synchronizing current, and the telegraph currents.

The terminal apparatus at the receiving station shown in Fig. 9 is connected with the transmission line 100 by the repeating coils 201 and 223. The filter network 210 passes all frequencies of the order of 20 to 20,000 cycles with the exception of a band of the order of 3300 to 3700 cycles which is the frequency used for telegraphing from this television receiving station to the television transmitting station. The incoming television. The incoming television photoelectric current is passed by the filter network 210 to the amplifier 250 and suitable control circuits to the receiving lamp 270. The output of the amplifier 250 is shunted by the potentiometer 251 to permit adjustment of the intensity of the photoelectric current supplied to the receiving lamp. It is necessary to so arrange the circuits that the current through the glow discharge receiving lamp is at all times proportional to the illumination at the transmitting station in view of the well established linear relation between the intensity of the illumination resulting from the glow discharge and the current. The photoelectric signal wave as transmitted through the various amplifier circuits differs fundamentally from the initial current generated in the light sensitive cell in that the direct current component has been eliminated. This

direct current component must be restored before the changes in light intensity at the receiving station will follow those at the transmitting station. The amplifier 260 provides means for making the necessary adjustment. The incoming photoelectric signal current whose intensity is adjusted by means of the potentiometer 251 is impressed upon the grid of the vacuum tube of the amplifier 260. The space current which is provided by the battery 261 is adjusted by the grid biasing voltage of the battery 262. Instead of connecting the glow discharge lamp and the vacuum tube directly in series, a resistance 263 is shunted across the output of the circuit of the vacuum tube across which is set up a potential proportional to the current through the resistance. The receiving lamp 270 is shunted across this resistance. In order to confine the operation of the vacuum tube of the amplifier 260 to the linear part of its characteristic the biasing battery 271 is connected in series with the lamp so that current through the lamp will go to zero even when a finite current is flowing through the vacuum tube of the amplifier 260 and it is still on the linear part of its characteristic. For any strength of the alternating current television current determined by the potentiometer 251 the direct current component of the television current may be restored by adjusting the grid biasing battery 262 to such a value that the proper direct current flows through the receiving lamp 270. The viewing field in front of the receiving lamp is defined by the aperture 245 in an opaque plate positioned in front of the scanning disc 241 and in line with the receiving lamp 270. The angular width of the aperture 245 is such that just one aperture in the scanning disc appears at any instant, the angular width of this aperture being equal to the angular pitch of the apertures in the scanning disc. The scanning discs at the transmitting and receiving stations are driven by the direct current motors and held in synchronism and in phase by the alternating current machines in accordance with well established practice. The incoming synchronizing current of approximately 1500 cycles is passed by the filter network 210 to the amplifier 244 which in turn is connected with the synchronous motor 243 associated with the receiving scanning apparatus 240. The energy for driving the scanning disc 241 is supplied by a driving motor 242 but synchronism is maintained by synchronous motor 243 whose input current is transmitted from the television transmitting station. A typical synchronizing arrangement is shown in the patent of H. M. Stoller et al. No. 1,763,909, issued June 17, 1930. The incoming telegraph signals having a frequency band within 2300 to 2700 cycles are passed by the filter network 210 and transmitted through the repeating coil 231

to the telegraph receiver 230. The telegraph transmitting apparatus 220 controls the output circuit of the oscillator 221 which generates a carrier current of approximately 3500 cycles. This current is passed through the band-pass filter 222 designed to pass the 3500 cycle carrier and side-bands of sufficient width for telegraph signals. Outgoing signals are next transmitted through the repeating coil 223 and from there to the transmission line 100.

The arrangement of the elements of the filter network 90 shown in Fig. 8 is disclosed in further detail by two alternative arrangements shown in Fig. 10 and in Fig. 11. The dot-dash lines X—X and Y—Y in each of these three figures indicate the points of connection of the input and output circuits. Fig. 10 is a simple network designed to directly pass all of the outgoing photoelectric current, the synchronizing current, and the telegraph signals in the most direct manner. Only one incoming current need be considered, namely, the telegraph signal having a channel with a frequency band of approximately 3300 to 3700 cycles. Any branch of the filter network 90 designed to pass this band does not transmit any of the outgoing signal currents as such a frequency band is not a part of any of the outgoing signals. The network is connected to the various outgoing signal circuits by the repeating coil 91 and with the transmission line by repeating coil 92. The incoming telegraph signals are taken off from the network by means of shunt impedance 93 and 94 shunted across the series arms of the filter network, one side of the receiving telegraph circuit being connected to one of the series arms of the filter network and the other side between the two impedances. In the region of 3300 to 3700 cycles the total impedance of the impedances 93 and 94 is so small in comparison with the impedance of the output side of the repeating coil 91 or the input side of the repeating coil 92 that this band is drained out of the circuit. In a specific case impedances 93 and 94 may comprise inductance and capacity elements, respectively. In operation the signals originating at the transmitting station are directly transmitted through the filter network 90 to the transmission line and the incoming telegraph signals are drained by the network directly to the telegraph receiving apparatus 130. The alternative arrangement shown in Fig. 11 provides an equally direct path for the outgoing signals and a branch containing a band-pass filter 96 passes a frequency band of from 3300 to 3700 cycles to the telegraph receiving apparatus 130. As the frequencies generated by the transmitting apparatus do not fall within this band only the incoming telegraph signals are passed by the band-pass filter 96. Connection with the transmission

line 100 is made for both the outgoing and incoming signals through a repeating coil 92.

The arrangement of the elements of the receiving filter network 210 shown in Fig. 9 is disclosed in somewhat greater detail by two alternative arrangements shown in Fig. 12 and Fig. 13. The dot-dash lines X—X and Y—Y in each of these three figures indicate the points of connection of the input and output circuits. Fig. 12 is a simple network designed to directly pass all of the incoming photoelectric current signals in the most direct manner. The series arms of this filter network contain no impedance elements and connection with the circuit leading to the receiving lamp is made through the repeating coil 212. Three shunt arms are employed each comprising impedance elements. The shunt arm comprising impedance elements 213 and 214 has a small impedance in the region of 3300 to 3700 cycles in comparison with the impedances of the output side of the repeating coil 201 and the input side of the repeating coil 212. This shunt arm practically short-circuits any currents within this band and thus prevents the telegraph transmitting apparatus at this station interfering with the action of the television receiving lamp 270. The shunt arm comprising the impedance elements 215 and 216 are designed to pass the current having a frequency band of 2300 to 2700 cycles which is the frequency used for the incoming telegraph signals. The impedance of these elements in the region of 2300 to 2700 cycles is small in comparison with the impedance of the output side of the repeating coil 201 and the input side of the repeating coil 212. The telegraph receiving apparatus 230 is connected for incoming signals through these impedance elements. The third shunt arm comprising the impedance elements 217 and 218 is designed to pass a narrow frequency band in the region of 1500 cycles and is connected with the synchronous motor 243. The impedances of these elements in the region of 1500 cycles is small in comparison with the impedance of the output side of the repeating coil 201 and the input side of repeating coil 212. The alternative arrangement of the elements comprising the filter network 210 shown in Fig. 13 comprises a number of circuits in parallel each of which contains a filter passing certain frequency bands. The input side of all of the filter elements is connected to a common input circuit coupled with the transmission line 100 while the output side of these filter elements is connected to one of the three terminal circuits such as the television receiving circuit, the synchronizing circuit, and the telegraph receiving circuit. The television signals are transmitted by the low pass filter 313 having a cut-off frequency at about 1300 cycles, by the high pass filter 314

having a cut-off frequency at about 3700 cycles, by the band-pass filter 316 having cut-off frequencies at about 1700 and 2300 cycles and the band-pass filter 318 having cut-off frequencies at about 2700 cycles and 3300 cycles. These filter elements pass all significant frequencies for the transmission of the photoelectric current and do not pass the frequencies employed in synchronizing and telegraphing. The band-pass filter element 315 has cut-off frequencies at about 1300 and 1700 cycles and passes the synchronizing current to the synchronous motor 243. The band-pass filter 317 has cut-off frequencies at about 2300 and 2700 cycles and passes the incoming telegraph signals to the telegraph receiving apparatus 230. By means of this filter network all of the incoming signals are passed to the respective receiving apparatus elements and any telegraph signals originating at this station and transmitted by the telegraph transmitting apparatus 220 are prevented from reaching the local receiving apparatus. The filter networks for either the transmitting or the receiving station are typical arrangements and any other suitable arrangements known to the art may be employed.

The different frequencies used in describing this system are typical and are used primarily to facilitate the description. Obviously the television photoelectric current is not limited to a range of 20 to 20,000 cycles and different frequencies from those mentioned may be used for the synchronizing and the communication or other channels. An essential feature is that the auxiliary currents have a frequency or frequency band which may be fitted into the low energy bands or gaps in the television photoelectric current, thus making the energy concentrations of the different signal currents occur at mutually exclusive frequency positions.

The operation of each of the principal elements of the system has been described in more or less detail in the foregoing description of the apparatus. In the general operation of the system as a whole the light tone values of line series of elemental areas of the object are translated into photoelectric current, which as heretofore explained consists of energy concentration in narrow frequency bands at various predetermined separated frequency positions, by the scanning apparatus and this current after being amplified, with the exception of the direct current component and very low frequency components, is impressed upon a common transmission line together with the synchronizing current and the telegraph signals of suitable frequencies. The energy of these several signal currents is concentrated in different frequency bands which have mutually exclusive frequency positions so as to permit segregation of the different signals at the receiving station. A filter network at the

receiving station makes the necessary segregation as already pointed out and thus directs each of the several signed currents to their respective receiving elements so that each signal acts as if it had been kept separated throughout its transmission. The direct current and very low frequency components are restored by local means at the receiving station. The frequency positions of the energy concentration bands of the different signals up to 5000 cycles with the exception of the picture scanning frequency band as they are originated at the transmitting station are shown in the current-frequency curve, Fig. 7, and due to their generation in such non-interfering positions transmission of all over a single circuit and subsequent segregation and routing to the respective receiving apparatus units by suitable filtering networks for translation is possible. Obviously bands of both lower and higher frequencies than shown by this curve are comprised in the photoelectric current. The utilization of the low energy gaps in the photoelectric signal current makes possible the utilization of the transmission medium at a greater efficiency and also makes possible the direct transmission of all signal currents necessary for the operation of the system over a single transmission circuit.

What is claimed is:

1. The method of transmission which comprises generating and transmitting image current representing the tone values of elemental areas of a picture or object and extending over a wide band of frequencies and concurrently transmitting in part at least over the same medium, non-image current within said band.
2. A transmission system comprising means for generating image current corresponding to the tone values of elemental areas of a field of view, the essential frequency components of said current being distributed over a wide frequency band, means for impressing upon a transmitting medium said essential frequency components, and means for separately and concurrently impressing upon said transmitting medium current having components within said band and different from said essential frequencies.
3. A transmission receiving system comprising means for concurrently receiving image current representing the tone values of elemental areas of a picture or object and occupying a wide band of frequencies and non-image current having frequency components within said band, means for separating said image current from said non-image current, and means for separately utilizing said currents.
4. An electro-optical receiving system comprising means for concurrently receiving electro-optical image currents extending

over a wide band of frequencies and synchronizing current having a frequency within said band, means for separating said synchronizing current from said image currents, image producing means for utilizing said image currents in the production of an electro-optical image, and means for utilizing said synchronizing current to control said image producing apparatus.

5. A transmission receiving system comprising means for concurrently receiving image current representing the tone values of elemental areas of a picture or object and extending over a wide band of frequencies and non-image currents respectively occupying narrow widely spaced bands within said wide band, and means for selecting and directing each of said currents into a separate channel.

6. The combination with a scanning field of means for repeatedly scanning said field in substantially parallel lines, light sensitive means for receiving light from said field as it is scanned and a source of current for said light sensitive means whereby a current is generated having a plurality of frequency components, and filtering means for selecting non-contiguous bands of frequency components from within the range of frequencies thus generated.

7. The method of signaling which comprises scanning a field of view having different tone values, controlling by said scanning the generation of a composite electric current containing one or more groups of frequency components of large amplitude, generating a current having a frequency range outside those of said groups and between said scanning frequency and the uppermost of said groups, impressing said composite current upon a transmitting medium and separately impressing upon said transmitting medium said current having a frequency range outside those of said groups.

8. The method of transmission which comprises successively scanning a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components of large amplitude, transmitting said current, and utilizing a frequency range outside of said groups and between the scanning frequency and the uppermost of said groups for the transmission of separately generated currents.

9. The method of transmission which comprises successively scanning a field of view having different tone values, producing from said scanning a composite electric signaling current containing one or more groups of frequency components of large amplitude, generating synchronizing current of a frequency outside of said groups and between the scanning frequency and the uppermost of said groups, and simultaneously transmitting said

signaling current and said synchronizing current.

10. An electro-optical system comprising means for scanning successively elemental areas of an object and generating photoelectric signal current having concentrations of signal energy at a fundamental frequency and at multiple frequencies thereof, means for generating other signal currents having concentrations of signal energy at different frequencies from said photoelectric signal current and between said fundamental and the uppermost of said multiple frequencies, and means for transmitting all of said currents over the same transmission medium.

11. A transmission system comprising means for successively scanning a field of view having different tone values, means for controlling by said scanning the generation of a composite electric current containing groups of frequency components of large amplitude which are harmonics of the scanning frequency, means for transmitting said current, and means for transmitting a separately generate current having a frequency range outside those of said groups and between said scanning frequency and the uppermost of said groups.

12. A transmission system comprising means for successively scanning in substantially parallel lines a field of view having different tone values, means controlled by said scanning means for generating a composite electric current containing groups of frequency components of large amplitude which are harmonics of the field scanning frequency, said groups also containing harmonics of the line scanning frequency, means for transmitting said current and means for transmitting a separately generated current having a frequency range outside those of said groups and between said scanning frequency and the uppermost of said groups.

13. A signaling system comprising means for successively scanning a field of view having different tone values, said means comprising an apertured scanning disc, each aperture of which scans a line of said field, means controlled by said scanning means for generating a composite electric current containing groups of frequency components of large amplitude which are harmonics of the field scanning frequency, means for separately generating other currents having a frequency range outside those of said groups and between said field scanning frequency and the uppermost of said groups, and means for simultaneously impressing all of said current upon the same transmitting medium.

14. A signaling system comprising means for successively scanning a field of view having different tone values, means for controlling by said scanning means the generation of a composite electric current containing

groups of frequency components of large amplitude which are harmonics of the field scanning frequency, means for generating synchronizing current of a frequency outside of the frequency ranges of said groups and between the field scanning frequency and the uppermost of said groups, and means for simultaneously impressing all of said current upon the same transmitting medium.

15. A television system comprising means for successively scanning a field of view having different tone values, said means comprising a scanning element for successively scanning lines of said field, light sensitive means cooperating with said scanning element, means including said scanning means and said light sensitive means for generating a composite electric current containing groups of frequency components of large amplitude which are harmonics of the field scanning frequency, said groups also containing harmonics of the line scanning frequency, means for generating a television synchronizing current having a frequency range outside those of said groups and between said field scanning frequency and the uppermost of said groups, and means including filtering means for simultaneously impressing all of said currents upon the same transmitting medium.

16. The combination with a scanning field of means for repeatedly scanning said field in substantially parallel lines, light sensitive means for receiving light from said field as it is scanned and a source of current for said light sensitive means whereby a current is generated having a plurality of frequency components, and filtering means for selecting at least three bands of frequency components from within the range of frequencies thus generated.

17. The method of signaling which comprises repeatedly scanning a field of view having different tone values, controlling by said scanning the generation of a composite electric current containing one or more groups of frequency components of large amplitude, generating a current having a frequency range outside those of said groups and between said scanning frequency and the uppermost of said groups, impressing said composite current upon a transmitting medium and separately impressing upon said transmitting medium said current having a frequency range outside those of said groups.

18. An electro-optical system comprising means for scanning successively and repeatedly elemental areas of an object and generating photoelectric signal current having concentrations of signal energy at a fundamental frequency and at multiple frequencies thereof, means for generating other signal currents having concentrations of signal energy at different frequencies from said photoelectric signal current and between said fundamental and the uppermost of said multiple frequen-

cies, and means for transmitting all of said currents over the same transmission medium.

19. A transmission system comprising means for repeatedly and successively scanning the same field of view having different
5 tone values, means for controlling by said scanning the generation of a composite electric current containing groups of frequency components of large amplitude which are harmonics of the scanning frequency, means for
10 transmitting said current, and means for transmitting a separately generated current having a frequency range outside those of said groups and between said scanning frequency and the uppermost of said groups.

15 In witness whereof, we hereunto subscribe our names this 31st day of January, 1929.

FRANK GRAY.
JOHN R. HEFELE.

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