

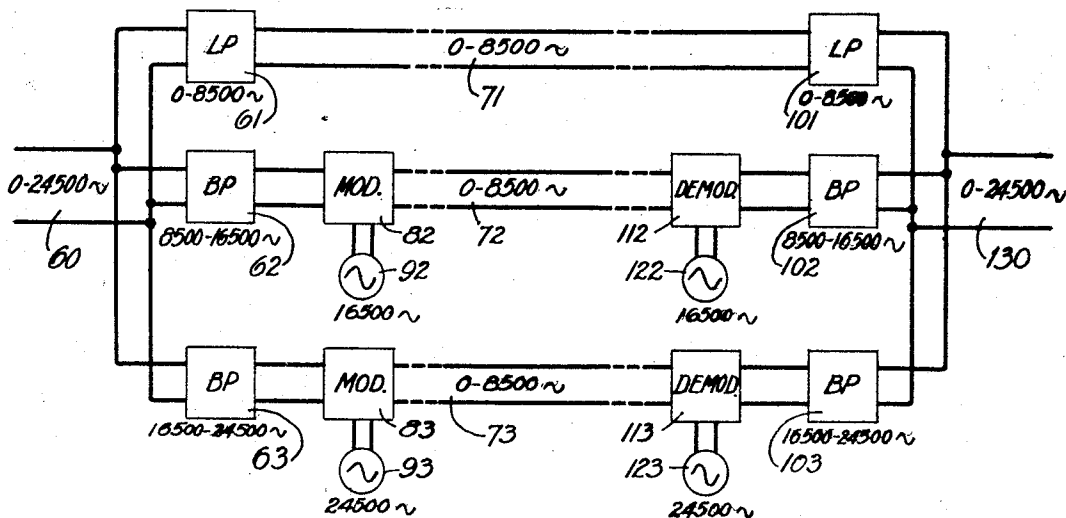
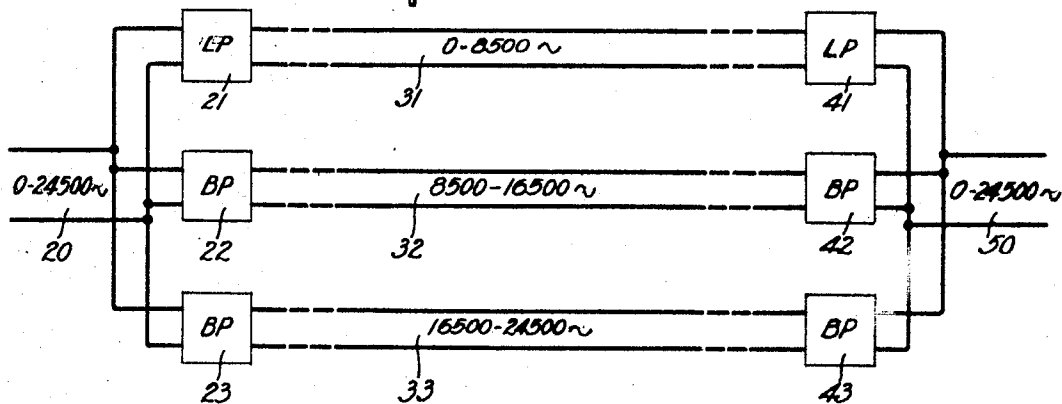
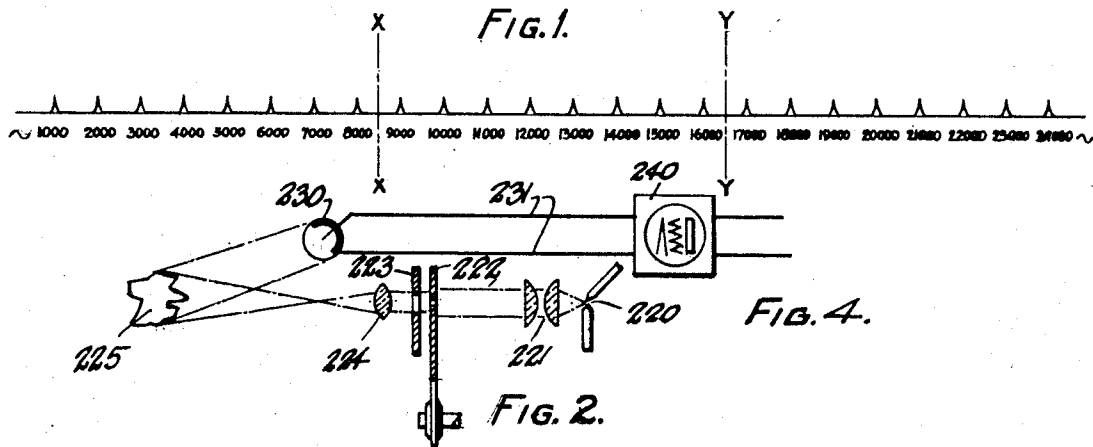
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ELECTROOPTICAL TRANSMISSION SYSTEM

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ELECTROOPTICAL TRANSMISSION SYSTEM

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

5 It was recently discovered 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 energy is large-
10 ly concentrated in a number of distinct bands of frequencies between which there is very little energy, and the position of the bands in the frequency spectrum is dependent upon the field scanning frequency and upon the
15 line scanning frequency. The energy concentrations resulting from scanning an ordinary field occur in the regions of the field scanning frequency and some of the lower harmonics thereof and in the regions of the
20 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. These energy
25 concentration bands may, for example, have 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 approximately
30 80% of the line scanning frequency.

This invention provides for splitting the total scanning frequency band of the photoelectric signal current into a number of narrower frequency bands or sections by means
35 of filters or the like so that the different sections may be segregated for any purpose, such as transmission over different circuits. The low energy gaps between the groups of frequency components permit the composite
40 current resulting from scanning to be so divided without interfering with essential frequencies. When the narrow or sub-groups are transmitted over separate channels or circuits respectively, each circuit may have
45 transmission characteristics suitable for the transmission of one of the sections of the photoelectric current, the splitting being made in the above mentioned gaps; or each segregated section or band of frequencies so
50 split may be transposed, by combination re-

spectively with suitable currents of different constant frequencies, to the same or different part of the frequency spectrum for transmission over different circuits having similar or suitable characteristics, thus permit-
55 ting the use of comparatively low grade circuits or circuits having a comparatively limited frequency range. The different sections after being transmitted may be restored to their original frequency position thereby pro-
60 ducing a signal current corresponding to the original photoelectric current.

The photoelectric current in television transmission involves a relatively wide frequency range. Even for a field of compar-
65 atively small size and with only a reasonable degree of resolution, the frequency range of the signal current is much greater than employed in telephony or other ordinary tele-
70 dynamic electric signaling operations. In the transmission of television signals efficiency from an energy standpoint is important, but this is less important than the faithful trans-
75 mission of the wave forms involved. The great width of the range of essential frequencies in television transmission extends beyond the distortionless frequency range of the usual circuits available. For certain cir-
80 cuits the distance to which transmission may be had is limited because of the difference in transmission of the various frequency com-
85 ponents involved. In attempting to improve the transmission of such circuits for the higher frequency components and to equalize the attenuation experienced by the different
90 frequency components, resort to various expedients has been made. Such expedients in general involve change in the characteristics of the transmission circuit itself or special terminal apparatus. Inductance loading, for
95 example, is feasible on circuits for limited distances for improving transmission, but it imposes an upper frequency limit upon the transmission range of the circuit lower than
100 that possessed by the unloaded circuit. In lieu of loading attenuation equalization may be resorted to to reduce each of the components after transmission to the same proportional or relative amplitude which they had before transmission. This requires extensive

terminal apparatus and high amplification, and any disturbance or interference is also highly magnified in the amplifying system. Under the foregoing arrangements the circuit and the terminal apparatus are designed to best meet the requirements of the signal to be transmitted. Another method of attacking the problem is to reduce the effective frequencies of the signal currents to be transmitted to within the substantially distortionless range of circuits of limited frequency range. This principle of frequency reduction may be applied alone or in conjunction with the expedients previously known in the art such as loading and attenuation equalization. It has been applied in telephone, where the highest essential frequency elements exceed the upper limit of the frequency transmission range of the circuit, by reducing the frequencies of the various components of a band of the higher frequency currents so as to make them vary within the transmission range of commercial transmission circuits. In the prior art the point of division of the signal current into two or more bands was arbitrarily selected and division at any particular point in the frequency band was considered about as favorable as any other. In accordance with the present invention, however, division of the television current into a number of narrow bands is made at certain definite and predetermined positions as heretofore stated, namely, at low energy gaps between energy concentrations thus avoiding cutting essential frequency components of the signal current.

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

Fig. 1 is a current-frequency diagram of the energy concentrations resulting from scanning an ordinary object in a series of parallel lines at a line scanning rate of approximately 1000 cycles per second.

Fig. 2 is a general schematic representation of the terminal apparatus for splitting the signal current in the region of the mid-point between energy concentration into a number of narrow bands and for transmitting the different portions of the divided signal current over different transmission channels having suitable frequency transmission characteristics.

Fig. 3 is a general schematic representation of the terminal apparatus for splitting the signal current in the region of the mid-point between energy concentrations into a number of narrow bands and for transposing the frequencies of such of the several sub-divided sections of the original signal current as may require transposing to substantially the same frequency spectrum range for transmission over different channels having similar and quite limited frequency characteristics.

Fig. 4 is a general schematic representation

of a scanning arrangement for successively scanning a field of view having different tone values and producing a photoelectric current having a plurality of groups of frequency components of large amplitude.

As already described, when an object or field of view having different tone values is periodically scanned in a series of parallel lines and the light tone values of elemental areas are translated into electric current variations the energy is largely concentrated in a number of distinct bands of frequencies between which there is very little energy. The arrangement shown in Fig. 4 diagrammatically shows a well known means for successively scanning a field of view and producing such a current having a plurality of groups of frequency components of large amplitude. The scanning apparatus includes a powerful light source 220, whose light is directed by means of lenses 221 upon the scanning area of a scanning disc 222. This disc contains a series of small apertures arranged in a spiral. A beam of light upon passing through an aperture in the scanning disc, which is passing through the scanning field, passes through the apertured screen 223 whose opening is so positioned that light can pass from only one aperture in the disc 222 at any instant, and is projected by a lens 224 to the object 225 whose image is to be transmitted. The scanning disc 222 may be rotated by any suitable means. As the scanning disc rotates it causes a small beam of intense light, passing successively through each one of its apertures, to scan in a series of parallel paths the object whose image is transmitted and reflected light from the successively illuminated elemental areas of the object is impressed upon a photo-electric cell or other suitable light sensitive device 230, thereby setting up current variations in accordance with the light tone values of the elemental areas of the object.

Arrangements for scanning in a series of parallel lines are shown in Patent No. 1,671,302, issued to R. C. Mathes, May 29, 1928, and also in Patent No. 1,769,918, issued to Frank Gray et al, July 8, 1930. The first of these patents discloses a spotlight illuminating arrangement and the second discloses a flood light arrangement for illuminating the object scanned.

The current-frequency diagram, Fig. 1, shows the relative positions of the energy concentrations resulting from scanning an ordinary object in a series of parallel lines at a line scanning rate of approximately 1000 cycles per second. Different scanning rates may be employed and this diagram is typical in illustrating the positioning of the low energy gaps and the high energy peaks but not their relative values. In a patent to Frank Gray et al., No. 1,769,918, issued July 8, 1930, copies of several current-frequency

curves showing the magnitude of response at different frequencies over a frequency band or spectrum ranging from approximately 100 to 5000 cycles per second of the photo-electric current generated in the scanning of ordinary objects such as geometric figures or human subjects are shown and the current-frequency diagram of Fig. 1 herein is based upon the generation of such current. This diagram shows the general distribution of the energy concentrations up to approximately 24000 cycles per second. The total frequency band may be divided into a number of sub-bands each containing several energy concentrations. The sub-divisions are made in accordance with this invention in low energy regions between the different energy concentrations as indicated by dash-dot lines $x-x$ and $y-y$ in Fig. 1, so as to avoid cutting essential frequency components of the signal current. Division of the total frequency band may be made by filters which are incapable of making a sharp division or a vertical line cutoff. The fact that it is impracticable to design filters having a vertical line cutoff and that filters cause a phase distortion of the current near their cutoff frequencies makes it impossible to sharply divide a signal current in the zones of essential frequency components. This invention prevents the introduction of appreciable distortion in the division of a composite electric current containing a plurality of spaced groups of frequency components of relatively large amplitude as it provides for the positioning of two adjacent filters which may or may not have overlapping frequency ranges so that their cutoffs occur in the region of the comparatively low energy gaps or valleys in the signal current and thus avoids the cutting of essential components or the causing of distortion by having essential frequencies occur near the cutoff frequencies of the filters.

As heretofore stated the signal current may be subdivided into a number of sections and each section without frequency change transmitted over separate circuits having frequency characteristics suitable for transmitting the section of the signal current impressed upon it. Fig. 2 shows an arrangement for transmitting a signal current having a frequency range up to 24,500 cycles over three circuits. The signal current transmitted over circuit 20 is divided into three sections by means of filter networks. Low pass filter 21 transmits current having a frequency range from zero to 8500 cycles to circuit 31, band pass filter 22 transmits current having a range within 8500 to 16,500 cycles to circuit 32, and the band pass filter 23 transmits current having a range from 16,500 to 24,500 cycles to circuit 33. At the other end of these three relatively narrow frequency channels are low pass filter 41, band pass filter 42, and band pass filter 43, corresponding to similar filters

21, 22 and 23, respectively, at the other end of these channels. The other side of filters 41, 42 and 43 is connected in multiple to the line 50 arranged for transmitting current having a frequency range from zero to 24,500 cycles. It is obvious that division of the total signal current into three equal sections by means of the above circuit arrangement causes a minimum interference with the essential frequency components when the sub-divisions are made at approximately the mid-point between energy concentrations occurring in the regions between 8000 and 9000 cycles and between the concentrations occurring in the region between 16,000 and 17,000 cycles. A different number of sub-divisions may be made by selecting other low energy regions for making the divisions. This arrangement permits dividing the total signal frequency band into sections suitable for transmission over available circuits having the necessary transmission characteristic, a part of the circuits being required to transmit current of relatively low frequency and a part being required to transmit higher frequencies all of a comparatively narrow frequency band width.

A further adaptation of this invention is shown in Fig. 3. In this arrangement all of the channels transmitting sub-divisions of the signal current are arranged to transmit frequency bands of comparatively low frequencies and of comparatively narrow width. After the signal current is sub-divided between energy concentrations to avoid cutting essential frequency components of the signal current, the sub-divisions having the higher frequency ranges are transposed to lower frequency ranges within the requirements of the transmission channels or circuits. The transmission circuits or channels, may for example, as here shown have a frequency range from zero to approximately 8500 cycles per second. The reduction in frequency of the signal current is brought about by combining the higher frequency sections with suitable carrier currents. The signal current having a frequency range up to 24,500 cycles from circuit 60 is sub-divided by suitable filters. Low pass filter 61 transmits all frequencies up to 8500 cycles, band pass filter 62 transmits all frequencies between 8500 and 16,500, and band pass filter 63 transmits all frequencies between 16,500 and 24,500. The lower frequency section transmitted by low pass filter 61 is directly impressed upon the transmission circuit 71. The current transmitted by band pass filter 62 is impressed upon modulator 82 where it modulates a carrier current of 16,500 cycles supplied by oscillator 92. The modulator circuit is preferably arranged so that only the lower side band is transmitted with the result that the transmitted current impressed upon the transmission circuit 72 has a frequency range between zero and 8500 cycles. A similar ar-

rangement is provided for transposing the portion of the signal current transmitted by the band pass filter 63 to a frequency between zero and 8500 cycles, which is transmitted by the circuit 73. The modulator 83 supplied with a carrier current of 24,500 cycles by the oscillator 93, reduces the frequency of the signal current to a range between zero and 8500 cycles for transmission. Preferably only one side band, the lower band, is transmitted in each case. Low pass filter 101, band pass filter 102, and band pass filter 103 are similar to filters 61, 62 and 63, respectively, and are all connected in multiple to circuit 130 arranged for transmitting current from zero to 24,500 cycles. The portion of the signal current transmitted by circuit 71 is transmitted without frequency change between circuits 60 and 130. The portions of the signal current transmitted by circuits 72 and 73 have had their frequencies transposed from that of the original signal and consequently the original frequency must be restored. This is accomplished by means of demodulators and the application of suitable carrier currents. The demodulator 112 supplied with 16,500-cycle carrier current generated by oscillator 122, transposed the frequency of the modulated current transmitted over circuit 72 to a frequency having a range between 8500 and 16,500 cycles. The demodulator 113 supplied with 24,500-cycle carrier current generated by oscillator 123, transposed the frequency of the modulated current transmitted over circuit 73 to a frequency having a range between 16,500 and 24,500 cycles. The various sections of the signal current transmitted through the filters 101, 102 and 103 comprises all of the frequency components of the original signal and these components are impressed upon the common circuit 130. Modulators 82 and 83, or demodulators 112 and 113 are provided with the necessary controls to adjust or equalize the amplitude of the current transmitted by the several channels, or separate amplifiers may be provided for each channel to accomplish this result. This circuit arrangement permits using a plurality of circuits or channels having a comparatively narrow frequency range for transmitting a signal current having a relatively wide frequency range. The sub-divisions of the signal current and the various frequencies above mentioned have been chosen to facilitate the description and obviously other combinations may be employed.

What is claimed is:

1. The method of signaling which comprises scanning a field of view of different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, and cutting said plurality of groups of frequency components between

adjacent groups to form a plurality of subgroups.

2. The method of signaling which comprises scanning a field of view of different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, cutting said plurality of groups of frequency components between adjacent groups to form a plurality of subgroups, and operating a receiving device under control of said subgroups.

3. The method of signaling which comprises successively scanning a field of view of different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, and cutting said plurality of groups of frequency components between adjacent groups to form a plurality of subgroups.

4. The method of signaling which comprises successively scanning a field of view of different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, cutting said plurality of groups of frequency components between adjacent groups to form a number of subgroups and transmitting said subgroups over different channels.

5. The method of signaling which comprises successively scanning a field of view having different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, and combining said groups with other currents of different frequencies to produce currents of other group frequencies.

6. The method of signaling which comprises successively scanning a field of view having different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, combining said groups with other currents of different frequencies to produce currents of other group frequencies and transmitting said last mentioned groups over different channels.

7. The method of signaling which comprises successively scanning a field of view having different tone values, producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, transmitting a number of groups of frequencies originally produced over one channel and another group produced by combination with another frequency over another channel.

8. An electro-optical system comprising means for successively scanning a field of view having different tone values, means for producing from said scanning a composite electric current containing a plurality of

groups of frequency components of large amplitude, and filtering means for separating said plurality of groups of frequency components into a number of subgroups, the cut-off regions of said filters being in regions between adjacent energy concentrations of said composite current.

9. An electro-optical system comprising means for successively scanning a field of view having different tone values, means for producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, filtering means for separating said plurality of groups of frequency components into a number of subgroups, the cut-off regions of said filters being in regions between adjacent energy concentrations of said composite current, and means for separately transmitting said subgroups.

10. An electro-optical system comprising means for successively scanning a field of view having different tone values, means for producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, filtering means for separating said plurality of groups of frequency components into a number of subgroups, the cutoff regions of said filters being in regions between adjacent energy concentrations of said composite current, means for separately transmitting said subgroups and a receiving device under control of all of said subgroups.

11. An electro-optical system suitable for the transmission and production of images comprising means for successively scanning line series of elemental areas of a field of view having different tone values, means for producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, means for combining said groups with other currents of different frequencies to produce current of other group frequencies, and means for transmitting the last mentioned groups over different transmission channels respectively.

12. An electro-optical system suitable for the production of images comprising means for successively scanning line series of elemental areas of a field of view having different tone values, means for producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, means for dividing the said plurality of groups of frequency components into a number of subgroups, said dividing being in the region of the mid-frequency point between adjacent energy concentrations, and transmitting said subgroups over different channels.

13. An electro-optical system comprising means for scanning a field of view, means for producing from said scanning a composite

electric current containing a plurality of groups of frequency components of large amplitude, a plurality of filtering means for dividing said plurality of groups into a smaller number of subgroups, a plurality of transmission channels over which said subgroups are respectively transmitted, and means for shifting the frequencies of the components of at least one of said subgroups whereby said subgroups better fit the frequency characteristics of said channels.

14. An electro-optical system comprising means for successively scanning a field of view of different tone values, means for producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, filtering means for selecting a band of said groups, a modulator upon which said band is impressed, a source of current of constant frequency associated with said modulator so that said modulator inverts the frequencies of said band, a demodulator, a second source of constant frequency current, means for impressing said inverted band and current from said second source upon said demodulator to reinvert the frequencies from said second band, and image producing apparatus controlled by said reinverted band.

15. An electro-optical system comprising means for successively scanning a field of view, means for producing from said scanning a composite electric current containing a plurality of groups of frequency components of large amplitude, a plurality of transmission lines, a filter in each transmission line for selecting from said current adjacent groups of frequencies, modulators in said lines upon which said groups are respectively impressed, means for impressing different constant frequencies upon said modulators such that the frequencies within each of said filter bands are inverted by said modulators, demodulators in said lines, and means for impressing upon said demodulators currents of constant frequency to reinvert said inverted frequencies, and an image producing apparatus under control of said reinverted frequencies.

In witness whereof, I hereunto subscribe by name this 24th day of May, 1929.

HERBERT E. IVES.