Dec. 6, 1938.

H. E. IVES

2,139,233

MULTICHANNEL TELEVISION SYSTEM

Original Filed June 30, 1934

FIG. 1

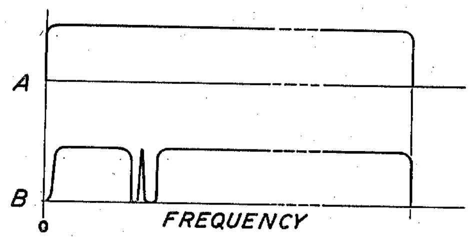


FIG. 2

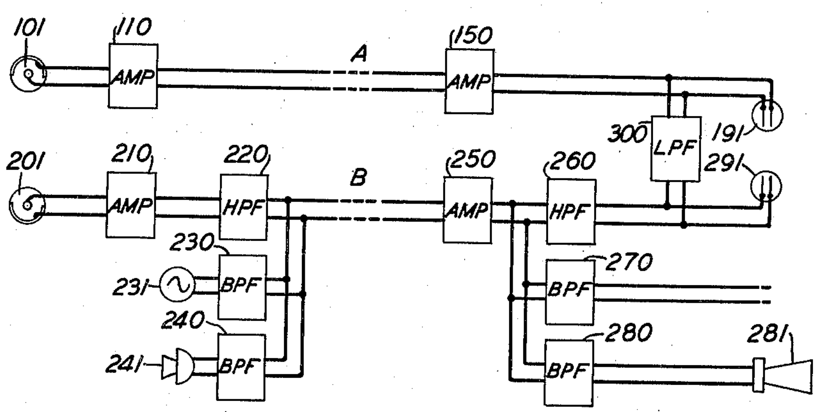


FIG. 3

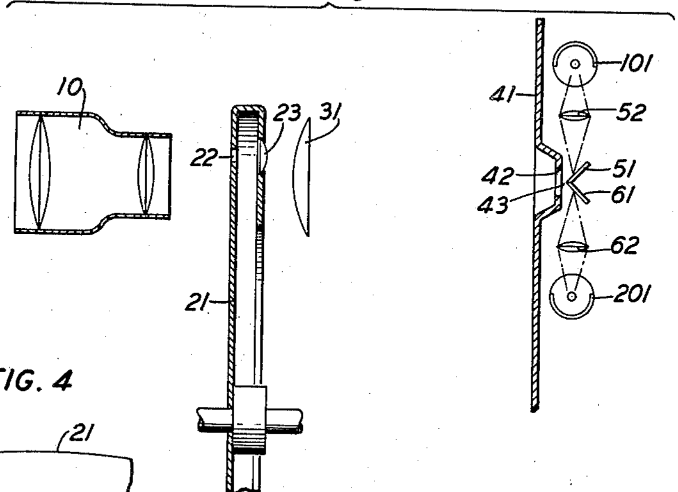


FIG. 4

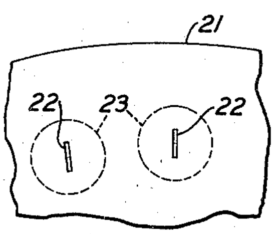
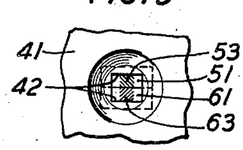


FIG. 5



INVENTOR
H. E. IVES
BY
C. G. Sprague
ATTORNEY

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MULTICHANNEL TELEVISION SYSTEM

Herbert E. Ives, Montclair, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Refiled for abandoned application Serial No. 733,163, June 30, 1934. This application April 11, 1935, Serial No. 15,918

4 Claims. (Cl. 178—6)

This application is a refile for abandoned application Ser. No. 733,163, filed June 30, 1904.

This invention relates to multiple channel signaling operation, and more particularly to a method of and apparatus for reducing the lined appearance of images produced by television or other electro-optical methods when the image currents are transmitted simultaneously over a plurality of channels, which lined appearance is due to physical differences in the several channels.

In the most usual type of television scanning the field of view is scanned in parallel elemental strips, the whole field being scanned within the period of the persistence of vision. The speed at which the scanning is carried out is very great and the resulting signaling current contains frequency components extending over a wide range compared with that encountered in ordinary signaling systems. Most transmission circuits are so designed that this wide band of frequencies can not be transmitted over them without undue distortion. To overcome this difficulty, it has been repeatedly proposed to utilize a plurality of channels and to assign to each channel a definite portion of the field of view. This amounts to a reduction in the size of the field to be scanned for transmission over a single channel and permits a corresponding reduction in the speed of scanning, thus materially reducing the width of the signal frequency band resulting from each scanning. At the receiving station the image is built up in portions corresponding to those assigned to the different channels at the transmitting station.

It has been found very difficult in practice to exactly match the impedance characteristics of the various channels and slight differences in physical characteristics result in differences in current levels sufficient to introduce a lined appearance in the produced image. For example, it is very difficult to obtain amplifier tubes whose characteristics are exactly the same. This effect may be considerably reduced by assigning adjacent elemental strips to different channels. Such a method is disclosed in the application of H. E. Ives, Serial No. 291,744 filed July 11, 1928. It is found that even when this precaution is taken the problem of matching up the several circuits with sufficient accuracy to reduce the lined appearance to an unobjectionably small value becomes serious. It is found that when several channels are matched for some particular character of scene so that the lined appearance of the image is no longer noticeable, the lining of the image again appears when the general character of the scene changes, showing that the circuits while in balance for a particular part of the tone range are unbalanced for another part.

An object of this invention is to provide a simple and improved method of and means for automatically controlling the channel levels in a manner to reduce line structure in the image and also to permit the transmission of other signals over some of the channels such as synchronizing and speech currents.

This invention is based upon the discovery that for many types of field of view the energy level of the lower frequency components can be equalized for the several channels without materially affecting the quality of the image, such equalization substantially eliminating the line structure resulting from variations in the transmission characteristics of the several channels, that variations in the energy level for the higher frequency components of the different channels are of minor importance so far as concerns the introduction of line structure when the transmission characteristics of the different channels vary and that by confining the equalization of energy to the lower frequency components the higher frequency components may be left free to vary in level as the scanning proceeds and therefore to be effective in producing the details of the image.

In accordance with the invention in its preferred form, means are provided which act selectively upon the signaling currents at the transmitter to separate the higher frequency components from the lower in all but one channel and then transmit the entire signal of the one channel and the higher frequency components of all of the other channels; and which at the receiver employ the higher frequency components of each of the channels in their respective channels and the lower frequency components of one of the channels in all of the channels, thus impressing identical lower frequency components and distinctive higher frequency components upon the light translating devices of each channel, respectively.

A characteristic of the invention is that when, for example, the elemental strip scanned for one channel is of decidedly different tone value than that for a different channel, an incorrect tone value will be produced at the receiver in one or more of the channels as the lower frequency components, common to all channels, are there the same. Such a decided difference will occur only occasionally, especially if adjacent strips are assigned to different channels throughout the scanning. It is therefore preferable to utilize the invention in connection with scanning arrangements which assign adjacent lines to the different channels, and an improved arrangement for doing this is shown herein.

An embodiment of the invention herein chosen for the purpose of illustration, and later described in detail with reference to the accompanying drawing, is briefly described in the following.

In this system the several channels must be operated in phase with each other in the generation of the several signal currents, unless other phasing means are employed. This may be accomplished by arranging the scanning apertures of the scanning disc for the respective channels so that those which simultaneously lie in the field of view are all on the same radius of the disc. As an alternative arrangement, the apertures may pass in succession if delay networks are used to bring the several simultaneous signals into phase. While it would be theoretically possible to have the several scanning apertures corresponding to the different channels in line with each other by making the scanning apertures rectangular and placing minute prisms over the rectangle, these minute prisms being closely juxtaposition with each other, this would not be practical. The proposed arrangement for scanning at the transmitter consists in means for forming an image of the object on the face of a scanning disc within the field of view, a lens being placed behind the disc and arranged to form an enlarged image of each aperture of the disc at a given point at which is placed mirrors or prisms which divide the image of the aperture in any desired manner and divert the light to a plurality of photoelectric cells, one for each channel. The disc apertures are in the form of several juxtapositioned or overlapping holes, or more simply, rectangular slots. The angular width of the slot apertures is substantially that of an elemental area of the image being scanned while its radial length is at least equal to the combined width of the plurality of juxtapositioned lines being simultaneously scanned. Their actual length may be even greater and their effective length then is limited by a stationary apertured plate positioned at the focus of a large stationary lens forming an image of the successive scanning disc slots. Behind each aperture of the disc and rotating with it is a short focus lens which in turn directs the scanning light to a stationary lens forming an enlarged image of the apertures in succession. Each slot aperture and associated lens scans a plurality of lines thus proportionately reducing the number of apertures in the scanning member and increasing the efficiency of scanning by making possible the use of larger lenses for the apertures. This scanning arrangement may be used for reception in which case an inverted system of the same sort may be used, an observer's eye taking the place of the objective image-forming lens, or other types of receivers may be used for forming an image.

The circuit arrangement for utilizing this multi-channel system designed to reduce the lined appearance in the formed image so operates that the whole spectrum of frequencies generated is transmitted over one of the transmission channels and in the other channel the direct current and lower frequency components are suppressed by means of high pass filters. At the receiving end the lower frequency signal components transmitted by the channel transmitting the whole spectrum of frequencies generated in one of the photoelectric cells is impressed upon each of the other channels by means of low-pass filters connecting each of the other channels with the one channel transmitting the whole spectrum of frequencies. The resulting signal currents as impressed upon each of the receiving lamps for the respective channels then contains distinctive high frequency components for each of the different channels and similar lower frequency components. The lower frequency range of one or more of the channels transmitting only the higher frequency components of the photoelectric signals may be used for the transmission of speech and synchronizing signals and these signals are blocked from the image receiving lamps by high pass filters and passed to their appropriate receiving devices by band-pass filters.

While this invention is particularly applicable to television systems, it is obvious that it is not limited in use to such systems, but may be applied wherever multi-channel signaling operation causes objectionable differences in level resulting from the differences in transmission characteristics of the several channels and where the resulting distortion results principally from a change of level in a certain portion of the transmission frequency range.

A more detailed description of the embodiment of the invention illustrated in the accompanying drawing follows:

Fig. 1 of the drawing diagrammatically shows the relative positioning of the frequency bands of the signals transmitted over two different channels;

Fig. 2 diagrammatically shows a possible circuit arrangement of two channels for the utilization of this invention in a two channel system;

Fig. 3 diagrammatically shows an optical arrangement for realizing this invention in direct scanning;

Fig. 4 shows a fragment of the scanning disc showing the scanning apertures as slots in association with respective lenses carried by the disc; and

Fig. 5 is a schematic representation of the image limited to the elemental areas being simultaneously scanned.

Fig. 1 diagrammatically shows the relative position of the frequency bands of the signals transmitted over two different channels A and B. The entire frequency spectrum of a photoelectric signal is transmitted over one of the channels, channel A, and only the higher frequencies of another photoelectric signal are transmitted over the second channel B. The lower frequency range of the second channel, which is not occupied by the photoelectric signal, is employed for the transmission of a synchronizing current for maintaining the transmitting and receiving apparatus in synchronism and in phase, and also for transmitting speech or any other desired signal. The speech frequency might occupy the range between zero to about 3300 cycles, the synchronizing current 3600 cycles, and the electro-optical transmission above about 4000 cycles per second, as diagrammatically indicated for channel B.

Fig. 2 diagrammatically shows a possible circuit arrangement of a two channel system arranged for the efficient utilization of this invention. The whole frequency spectrum of one photoelectric signal current is transmitted over one channel and the higher frequency components of a second photoelectric signal current and synchronizing and speech bands are transmitted over the second channel. The essential elements in the first channel, or channel A, are the photoelectric cell 101, amplifying apparatus 110 and necessary auxiliary equipment at the transmitting station. At the receiving station the essential apparatus is the amplifying apparatus 150, the receiving light translating device 191 and the necessary auxiliary apparatus. The general arrangement of the second channel, or channel B, over which the higher frequency components of a second photoelectric signal current are transmitted, and also the auxiliary signals such as synchronizing and speech, comprises a number of filters for separating the various signals both at the transmitting and at the receiving stations. The photoelectric signal current which is generated in the photoelectric cell 201 and amplified in the amplifying apparatus 210 has its lower frequencies, say up to about 4000 cycles per second, suppressed by the high pass filter 220 so that only the higher frequencies of this photoelectric signal are impressed upon the transmission line. This circuit is the same as for the other channel with the exception of the high pass filter 220 which prevents transmission of the lower frequencies of the signal current. The auxiliary signals, the synchronizing current and the speech current are within the frequency range suppressed by the high pass filter 220. An oscillator 231 generates a synchronizing current, say of 3600 cycles per second, which is passed to the transmission line through the band pass filter 230 designed to transmit a narrow band of frequencies. The speech currents generated by the transmitter 241 are passed to the transmission line through the band pass filter 240 which transmits a band of frequencies suitable for voice transmission and outside of the range of those employed for the photoelectric signal and the synchronizing current, say up to 3300 cycles per second and down to a few cycles per second. In fact, this filter 240 need not be a band pass filter but simply a low pass filter having a cut-off frequency of the order of 3300 cycles per second. At the receiving station all of the signals transmitted over this second channel are amplified by the amplifying apparatus 250 and the photoelectric signal current having frequency components above 4000 cycles are transmitted through the high pass filter 260 to the receiving light translating device 291. The two circuits or channels A and B at the receiving station are connected in multiple through low pass filter 300. This connection permits the lower frequency components of the signal current up to approximately 4000 cycles, transmitted over the first channel, to be impressed also upon the receiving light translating device 291 of the second channel. This circuit arrangement results in impressing upon the translating device 191 the whole spectrum of photoelectric current frequencies generated at the transmitting end of the first channel and in impressing upon the translating device 291 of the second channel the lower frequencies of the first channel and the higher frequencies of the second channel. Thus, both translating devices receive a complete spectrum of photoelectric signal frequency components, the lower frequencies being the same for both and the higher frequencies being distinctive for each. The synchronizing current is passed by the band pass filter 270 to the driving motor of the television receiver, and the speech or other signal is passed by the band pass filter 280 to the loud-speaker or other suitable receiving device 281. This filter 280 may be simply a low pass filter having a cut-off of approximately 3300 cycles per second. The different frequencies and band widths of the several signals here mentioned may obviously be different in different installations of this system. Suitable scanning apparatus, not shown in this figure, is provided at the transmitting and the receiving stations and maintained in synchronism and in phase by means of the synchronizing current.

As heretofore stated, it is necessary that the several channels be operated in phase with each other in the generation of the several photoelectric signal currents unless other phasing means are employed. This may be accomplished by arranging the scanning apertures that simultanously lie in the fields of view so that all lie on the same radius of the scanning disc. One theoretical method of making the several scanning apertures corresponding to the different channels in line with each other would be to make the scanning apertures rectangular and place minute prisms in close juxtaposition with each other over each aperture. However, the prisms would have to be very small and delicately adjusted which would be difficult to achieve. The arrangement here suggested avoids this difficulty by separating the various parts of the rectangular aperture at the point of formation of a suitably enlarged image of the scanning aperture according to the several elemental areas simultaneously scanned. An optical arrangement for accomplishing this by direct scanning is shown in Fig. 3. An image of the object being scanned is projected by the objective lens system 10 upon the surface of the scanning disc 21. The aperture in the disc are narrow elongated radial slots, arranged in a spiral, which limit the size of the elemental areas in the direction of scanning only. The size of these areas in the transverse direction is determined by an aperture in the stationary plate 41. Each aperture of the scanning disc is equipped with a lens 23 of short focal length. In order to simplify the drawing, only one of these lenses is shown. At the rear of the scanning disc and in line with the field of view is a large stationary lens system 31 of relatively long focal length. With this optical system an enlarged image of the aperture 22 is formed at some point 43 at which point are placed mirrors 51 and 61 which could, if desired, be in the form of prisms, which divide the image of the aperture and divert the light to photoelectric cells 101 and 201, respectively. The scanning apertures 22 and the point 43 are conjugate for this optical system. In order that the beams of light directed to the photoelectric cells shall be stationary, it is preferable to image the face of the mirrors by additional lens 52 and 62 into the photoelectric cells 101 and 201, respectively.

While, as above stated, the scanning apertures 22 might be made of several juxtapositioned or overlapping holes, it is preferable to make each aperture a slot as shown more clearly in Fig. 4 showing a fragment of the face of the scanning disc 21 and to limit the effective portion of its image by an aperture 42 in the opaque screen 41 positioned in the image field.

Fig. 5 is a schematic representation of the stationary plate 41 in the region of the aperture 42, showing a cross-section of the light beam which passes through this aperture. This beam, upon reaching the mirrors 51 and 61, is divided into two portions. The portions **53** and **63** of the beam respectively reach the mirrors **51** and **61**.

For the reception of the multichannel signals produced by the above described scanning arrangement, an inverted system of the same sort may be used, an observer's eye taking the place of the objective lens system **10**; or a multiple grid or mirror helix arrangement for multichannel reception may be used. Light sensitive cells **101** and **201** are replaced by light sources upon which the incoming signals are impressed. More than two channels may be used.

What is claimed is:

1. An electro-optical image producing system comprising a plurality of transmission channels, means for scanning simultaneously two different series of elemental areas of the same field of view, means for generating two sets of image currents representative of the light tone values of the elemental areas of said two series of elemental areas respectively, means to eliminate the direct current and low frequency components from one of said sets of image currents, means to transmit the resulting sets of image currents to a receiver each over one of said channels individual thereto, means for combining at the receiver with the set of image currents from which the direct current and lower frequency components have been eliminated direct current and lower frequency components derived from the other set of image currents, and means utilizing both sets of image currents to produce two different series of elemental areas in an image field corresponding respectively to the two different series of elemental areas at the transmitter for forming an image of the object being scanned at the transmitter.

2. A multiple channel television system, comprising two transmission channels, means for generating two distinct photoelectric signal currents of substantially the same frequency range, said currents being distinctly different in certain corresponding portions of their higher frequency range and similar in their other corresponding portions of lower frequency range, means for impressing upon one of said channels the entire spectrum of frequencies of one of said signal currents, means for impressing upon the other of said channels a portion of the spectrum of frequencies of the other of said signal while excluding therefrom said lower frequency portion which is similar to the corresponding portion of the other of said currents, means at the receiving terminal for adding the lower frequency components derived from said one channel to the frequency components received from said other channel to produce a resultant current of full frequency range, and means for producing corresponding distinctive portions of an image by means of the respective signal currents.

3. The method of multichannel television transmission which comprises, generating two distinct photoelectric signal currents representative of the light tone values at each instant of two different elemental areas of a field of view, transmitting substantially all of the frequency components of one of said currents, transmitting the higher frequency components only of the other of said currents, subsequently adding lower frequency components of the said one current to said other current to produce a resultant current of full frequency range, and producing an image by the combined action of two signal currents comprising the said one current and the said resultant current each representative of the light tone values at each instant of two different elemental areas of the produced image.

4. A method of image production which comprises simultaneously scanning different series of elemental areas of an image field, producing two sets of image currents by said scanning both sets including the direct current and low frequency components representative of the average tone value of the field as well as the higher frequency components, eliminating the direct current and lower frequency components from one set of image currents only, transmitting the remaining components of each set over transmission channels individual thereto, selecting a portion of the energy of said transmitted direct current and low frequency components at a receiving station from the set of transmitted image currents containing the direct current and lower frequency components and combining them with the higher frequency components of the other set, and producing scanning spots at the receiver corresponding to the simultaneously scanned different elemental areas at the transmitter to produce an image of the object being scanned.

HERBERT E. IVES.