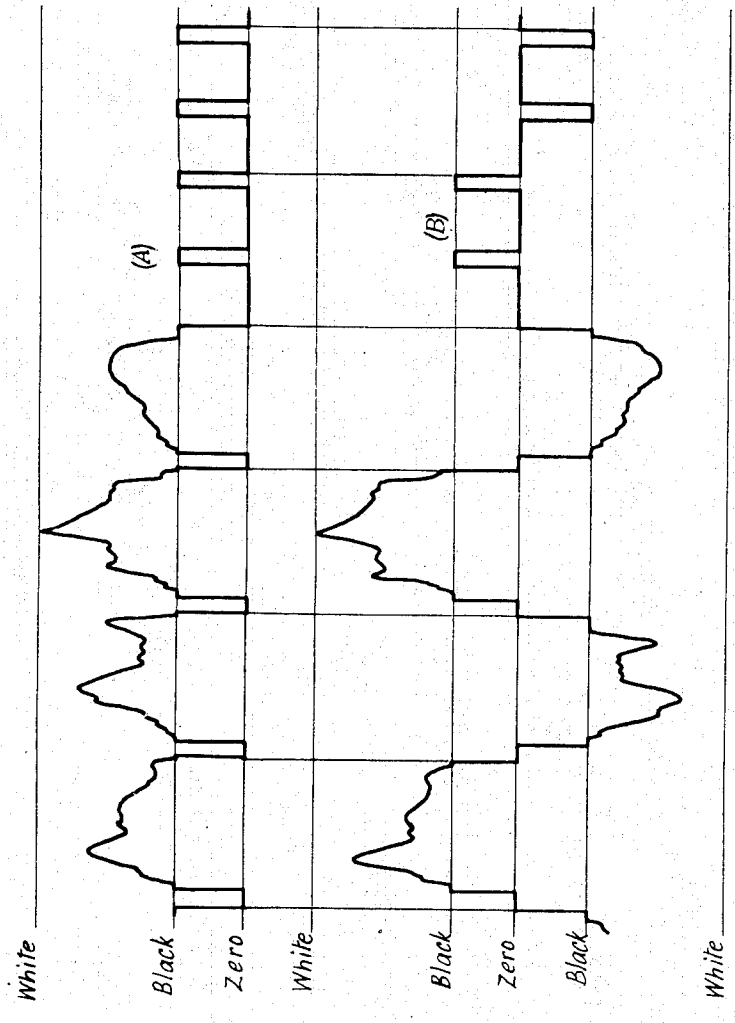
May 5, 1942. V. J. TERRY 2,281,891

PICTURE TRANSMISSION, TELEVISION, AND THE LIKE

Filed Sept. 8, 1938 2 Sheets-Sheet 1

Fig. 1.



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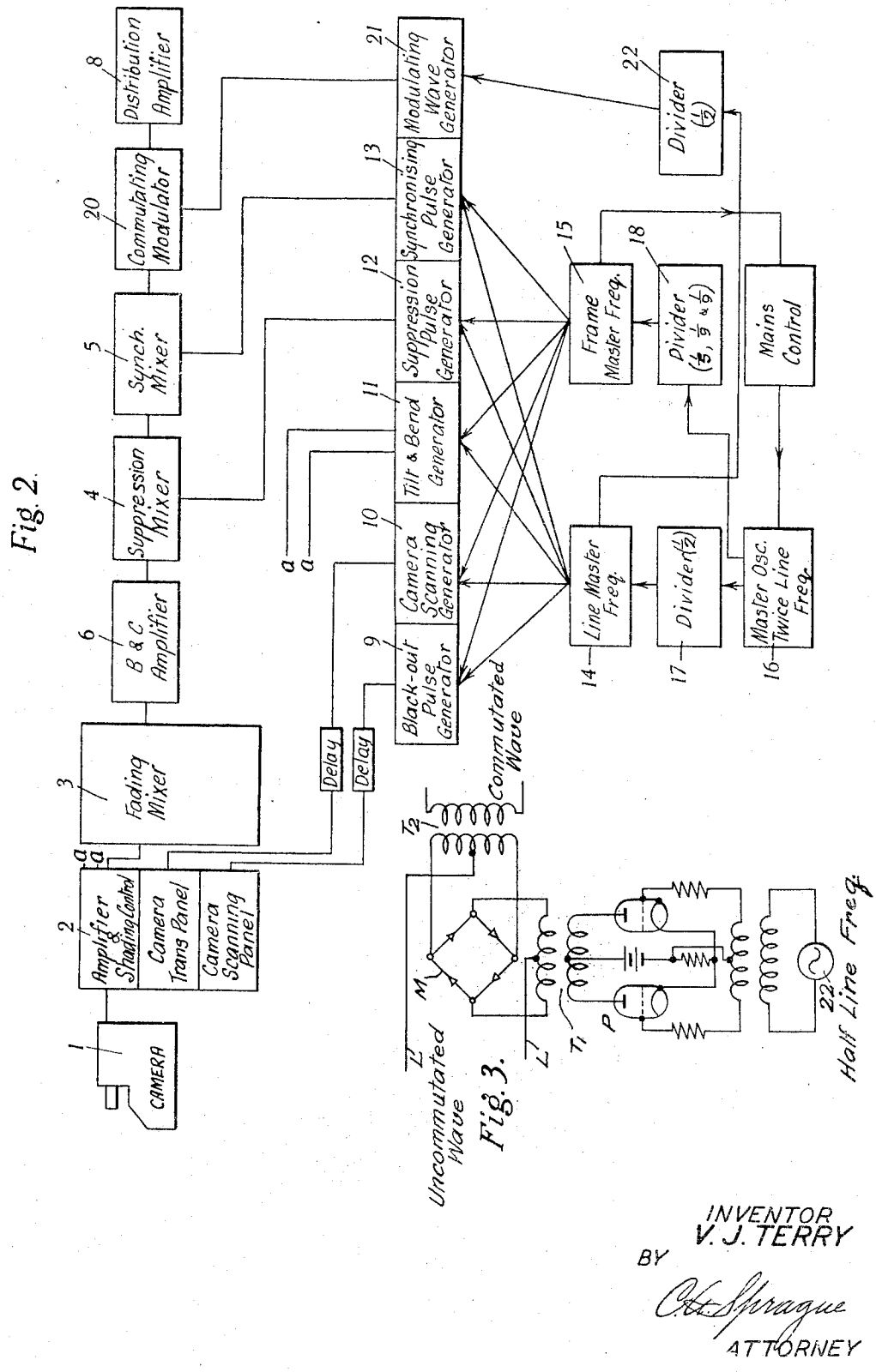


Fig. 3.

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UNITED STATES PATENT OFFICE

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PICTURE TRANSMISSION, TELEVISION, AND THE LIKE

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4 Claims. (Cl. 178—7.1)

This invention relates to image current transmission and more particularly to the production and utilization of a form of such current particularly useful for transmission over lines, and through amplifiers, modulators, networks, filters, etc.

An object of the invention is to provide a novel method and means for generating an image current in which the direct and very low frequency components resulting from the scanning operation are effectively eliminated as such and in which the values of these components are represented by other components, and a further object is to provide simple means for generating from said current another current in which said direct and low frequency components as such are present.

A further object is to provide a novel method of and means for producing synchronizing signals of very precise form as a part of a television or picture transmission current.

Other objects and advantages of the invention will be apparent from the following description:

The principle of the invention is to commutate the current whose frequency characteristic it is desired to modify, by switches or a modulating circuit at regularly recurrent intervals, so choosing the frequency and phase of the instants of commutation, that they occur at times when the value of the current is unimportant or is of a known value which may subsequently be reproduced.

In the case of a picture current, suitable moments for commutation usually occur between the end of every line and the beginning of the next, for here the current value is usually unimportant: in the case of certain well known systems of television suitable moments occur in the intervals between lines and between frames. In each of these intervals there is normally a period (or periods) when the current has a predetermined amplitude and another period or other periods when the current is zero. Any such period is equally suitable for commutation and any odd number of commutations may be effected during each of the available periods. It is not even essential that the same number of commutations should take place in each of the regularly recurrent suitable intervals.

The effect of the commutation process on the frequency range required for transmission depends on the rapidity of the commutation process.

Theoretically, when the commutation is accomplished absolutely instantaneously, it adds infinitely to the frequency content of the current, unless it takes place at an instant when the current is zero in which case it may either reduce or increase the range of the Fourier components.

When the commutation process takes a finite time, as when it is accomplished by modulation with a wave of "squarish" but not perfectly square wave form, it is desirable to arrange that the squarish wave is sufficiently rounded, or the commutation sufficiently slow, to ensure that the current changes it produces are not more rapid than other changes of amplitude inherent in the wave, and the tendency of the commutation process is then to move the frequency range bodily upward by about half of the line frequency, without appreciable alteration in the total range.

An indication of the nature of these frequency changes is obtained by considering the energy-frequency distribution of a typical television current. The composition of a typical television signal is shown in an article by Pierre Mertz and Frank Gray in Bell System Technical Journal 1934 at page 478.

It will be found to contain a strong zero frequency component (D. C.). There will also be strong components of the order of a fraction of a hertz but practically no energy above one hertz until the frame frequency (usually 25 hertz) is approached. Thereafter, there are ranges of practically zero energy, separated by regions of small (but appreciable energy corresponding to the lower harmonics of the frame frequency. These grow weaker and are almost negligible after about the twentieth leaving a gap of zero energy until the "line" frequency (usually about 10 k. c.) is nearly reached. The energy distribution, both above and below this frequency corresponds approximately to that in the first few hundred cycles above zero.

Around each harmonic of the line frequency is centred a similar energy frequency group.

Between each of the first few groups there is a wide range of almost zero energy, but the groups corresponding to the higher harmonics, though weaker in energy, are more diffuse in frequency distribution. Towards the upper end of the frequency range, the groups are no longer well defined and the energy distribution is almost uniform.

The effect of the modulation process is to replace every former component present by a series of components. Two in the series corresponding to a single component differ from the original by the fundamental of the modulation

frequency and two more differ by each odd harmonic thereof.

The fundamental of the modulation frequency for one commutation between each line is half of the "line" frequency so that the total effect of the modulation on the complex television current is to replace the group occurring at and immediately above zero frequency (up to the frame frequency and stronger harmonics thereof), and the groups centred around the line frequency, and harmonics thereof, by other groups centred around half the line frequency and odd harmonics thereof. Each of these new groups is a combination of one of original groups raised by half the line frequency and another reduced by half the line frequency plus smaller additions from other groups raised or lowered by odd multiples of half the line frequency.

Components of the modified wave which lie close to zero frequency can only be derived from components in the original wave which lay mid-way between zero and the fundamental "line" frequency or mid-way between adjacent harmonics of the "line" frequency. In all these regions the components are normally so weak that they may be eliminated without appreciable error.

Therefore for the transmission of the modified wave, it is not necessary to transmit the lowest frequencies.

When, owing to the size of the scanning spot or to the use of selective circuits, the frequency of the highest components in the unmodified signal is limited, the usual effect of the commutation is to extend the range upward by the modulating frequency and to add unimportant components extending several times the line frequency above the original limit. This is usually a negligible addition.

If, on the other hand, the components of the original wave are not limited in this way but extend above the efficient range of the transmission path, some of the components in the original wave which might have been transmitted are translated upward beyond the range of efficient transmission. Others on the other hand, which would have fallen beyond the transmission range are translated downwards into it and are thus rendered usable. The net result is therefore that for a given upper limit of frequency, the commutating process involves no loss of detail, if the frequency limitation is applied after the modification. The restoration of the original wave is very easily accomplished by full wave rectification.

If the commutations occurred at a moment of zero current, the restoration may be perfect, but if at instants when the current is finite, then the instants are marked by short periods during which the current falls to zero and rises again. These short period falls need not prove objectionable because they occur between the lines of the vision or picture.

In a system for transmission it is convenient to effect the commutation at the earliest possible moment and to retain the current in the modified form as long as possible.

Thus in a system employing for transmission a linear scanning device followed by an amplifier of the electron multiplier type (which amplifies all frequencies down to zero) a line amplifier (transmitting only alternating current), a transmission line, a further line amplifier (like the first), and a radio transmitter, the commutating device should preferably follow immediately after the electron multiplying amplifier. Rectification should be applied (if at all) immediately before the first modulator in the radio transmitter.

It is, however, preferable to omit the rectifier and to employ a modulator in the radio transmitter, which gives double side band transmission with the carrier suppressed.

The envelope of the carrier wave is then exactly the same as if the modified wave had been restored by rectification, but at each instant of commutation the phase of the carrier is reversed. This reversal does not affect the ordinary television receiver, but if signals having the phase reversed are detected with a synchronised local oscillator, the commutated wave is reproduced, which is convenient for amplification and for the control of the synchronising circuits.

To take full advantage of the convenience of the modified wave as a control for the synchronising circuits, it is desirable to eliminate entirely from the uncommutated wave the zero amplitude period, leaving a constant amplitude period between the actual "vision" periods.

If the commutation is carried out during the constant amplitude period at a rapid but not necessarily infinite speed, a very precise indication is obtained for synchronising, and the end of "frame" (which is normally marked by a succession of "line" periods during which the current value is varied in accordance with a predetermined code between zero and some value equal to or less than the lowest picture value), can be indicated by several "line" periods having a lower current value than any associated with the actual vision period, or by the insertion of additional commutations or both.

If additional commutations are inserted, the total during any "line" period should preferably be odd, in order to eliminate the direct current component as completely as possible.

When using the commutation principle it is desirable that the number of actual lines per frame, and the number of blank lines between frames should both be even, and it is preferable that the actual lines should both start and finish with a half line.

All these conditions are easily arranged in a plain scanning system, but in an interlaced system something must be sacrificed. The number of actual lines in each half frame may still be even, but the number of blank lines must then contain a fraction, and if half an actual line is used to start and finish one half frame, the other half frame cannot readily be made to do the same.

Departure from these conditions introduces a very small steady D. C. or frame frequency component which may normally be neglected. A steady D. C. component may, of course, be balanced out very easily.

When two side bands of the commutated wave have been transmitted, for example by radio, and, for the sake of precise synchronisation in special receivers, the normal synchornising intervals of zero current have been omitted, it is advantageous to make the rate of commutation moderate, for then the envelope of the transmitted side bands is for an appreciable time approximately of zero amplitude and the interval of approximately zero amplitude will be accepted by ordinary receivers as a substitute for the normal zero amplitude synchronising pulses.

The invention will be further described as embodied in a particular television transmitting sys-

tem, and with reference to the accompanying drawings. In the drawings:

Fig. 1A is a diagram showing the wave-form of a television signal produced in known manner for example by the apparatus described in an article hereinafter mentioned.

Fig. 1B is a diagram showing one way in which the wave form of Fig. 1A may be commutated in accordance with the invention.

Fig. 2 is a block circuit diagram incorporating features of the invention and capable of giving the wave form of Fig. 1B, and

Fig. 3 is a more detailed circuit diagram of a modulating circuit suitable for use in Fig. 2 in the case where the input line to the modulating circuit is balanced.

Referring first to Fig. 2, this figure shows how the invention may be applied to the television transmitting system described in a paper by Messrs. Blumlein, Browne, Davis and Green, read before the Institute of Electrical Engineers on April 21, 1938. The figure is based on Fig. 3 of that article. Here the scanning device or camera 1 produces the vision wave subject to several varieties of distortion called "shading" distortions which are corrected by means of a "shading" control in the first amplifier 2. Subsequent "mixers" 3, 4 and 5 suppress parts of the wave and add further impulses for synchronisation. In this case the commutation process of the invention should not be applied until the correction and "mixing" are complete, unless the phase reversals are to be used for both line and frame synchronising controls in which case the synchronising mixer 5 is omitted.

The picture channel of the transmitter includes additional amplifiers at 6 and a distribution amplifier 8.

The various generators 9 to 13 are controlled as described in the aforesaid article by a line master frequency source 14 and a frame master frequency source 15 which are controlled in turn over frequency dividers 17, 18 by a master oscillator 16 of twice line frequency. The divider 17 effects a division by two and the divider 18 provides various divisions as necessary for the frame source 15.

In order to adapt the system for the commutation of the picture wave in accordance with the invention a commutating modulator 20 is inserted in front of the distribution amplifier 8 and is controlled by a modulating wave generator 21 provided for that purpose. The frequency applied to the phase reversing commutator or commutating modulator 20 is assumed to be half the line frequency (giving one commutation per line). An additional frequency divider 22 is therefore provided which operates from the line master frequency source 14 and provides say an approximately sinusoidal output of half the line frequency. This sinusoidal output is converted in modulating wave generator 21 into a squarish wave of the same fundamental frequency and this squarish wave operates to commutate the picture wave passing through commutating modulator 20.

The usual wave form applied to the distribution amplifier 8 is shown in Fig. 1A. It includes line synchronising intervals of substantially zero amplitude and frame synchronising signals extending for the duration of several lines and having two pulses per line interval as shown.

The effect of commutation at line frequency and during the line synchronising intervals is to give the wave form shown in Fig. 1B, where the signals of alternate lines are negative. It has been assumed in Fig. 1B that the commutation is instantaneous but it will be clear that the commutation may take a finite time within the synchronising interval.

A simple circuit for the commutating process is shown in Fig. 3. It consists of the well known metal rectifier "ring" modulator M supplied over transformer T1 by a carrier wave at half the line frequency. The commutated or modulated wave is taken from transformer T2 and the unmodulated wave is applied over line L. For rapid and accurate commutation the carrier wave is given an approximately "square" outline by passage through an overloaded push-pull amplifier P to suppress the peaks, the positive and negative half cycles of the output being equal in duration and the amplitudes of the positive and negative half cycles being constant during the whole of the periods during which the amplitude of the picture or television wave corresponds to parts of the scene (about 85% of each half cycle). The amplifier P constitutes the modulating wave generator 21 of Fig. 2 and receives its input from the divider 22. The ring modulator M is illustrated as being the simplest type fulfilling the essential requirements that (*a*) the input transmission path must be capable of transmitting all frequencies down to zero, (*b*) there must be complete suppression in both input and output circuits of the commutating wave and (*c*) there must be complete suppression in the output circuit of the uncommutated input wave.

The ring modulator is not however, to be regarded as necessarily best for the purpose and other suitable forms of modulator will be readily appreciated.

What is claimed is:

1. Television transmitter comprising means for scanning elemental lines of a field of view in succession to produce an image current, and means including commutating means for reversing in sign with respect to the preceding group every group of signal waves corresponding to the light-tone values of successively scanned lines or pairs or groups of lines, thereby eliminating or weakening the direct current component and the lower frequency components of the signal wave and producing components indicative of said eliminated or weakened components.

2. Means for scanning elemental lines of an object or object field in succession with relatively short intervals between said line scannings, means including said scanning means for setting up a single unitary image current having variations corresponding to the light-tone values of said lines in the order in which they are scanned, said current being alternately oppositely directed with reversal of direction taking place only at times corresponding to said short intervals and such that each period of unidirectional flow represents the light-tone value of an integral number of said elemental lines, whereby said current over a period corresponding to the time of scanning a multiplicity of said lines in succession has no direct or very low frequency component of more than negligible amplitude, and means for impressing said current upon a transducing element which cannot correctly transmit a continuously direct image current representative of successively scanned lines because of its inability properly to transmit direct and very low frequency components.

3. Means for scanning elemental lines of an object or object field in succession and for set-

ting up a direct image current representative of the light-tone value of the successively scanned lines having large-amplitude components of line scanning frequency and integral multiples thereof, the frequency spectrum of said current having regions midway between adjacent ones of said components where there are no components of appreciable amplitude, said current also having large-amplitude direct or very low frequency components representative of the average light-tone value of a multiplicity of successively scanned lines, a transducing element incapable of properly handling said current because of the presence therein of the direct or low frequency components, and means for receiving said current and transmitting it to said transducing element comprising means for transforming said current into a second current similar in amplitude variations to said first current but having alternate portions of equal duration oppositely directed each consisting of direct current only and representing the light-tone values of an integral number of successively scanned lines, said second current having no components of appreciable value corresponding to said direct or very low frequency components of said first current.

4. The combination with means for scanning elemental lines of a field of view in succession to obtain an image current made up of succeeding portions respectively representative of the light-tone values of the successively scanned elemental lines, of means for causing alternate ones of said portions to be opposite in polarity from the intermediate ones of said portions, and means for producing in said current of reversed polarity as a part of each of said portions and at the end thereof a relatively short portion of constant amplitude, throughout said current, and of the same polarity as the portion which it terminates.

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