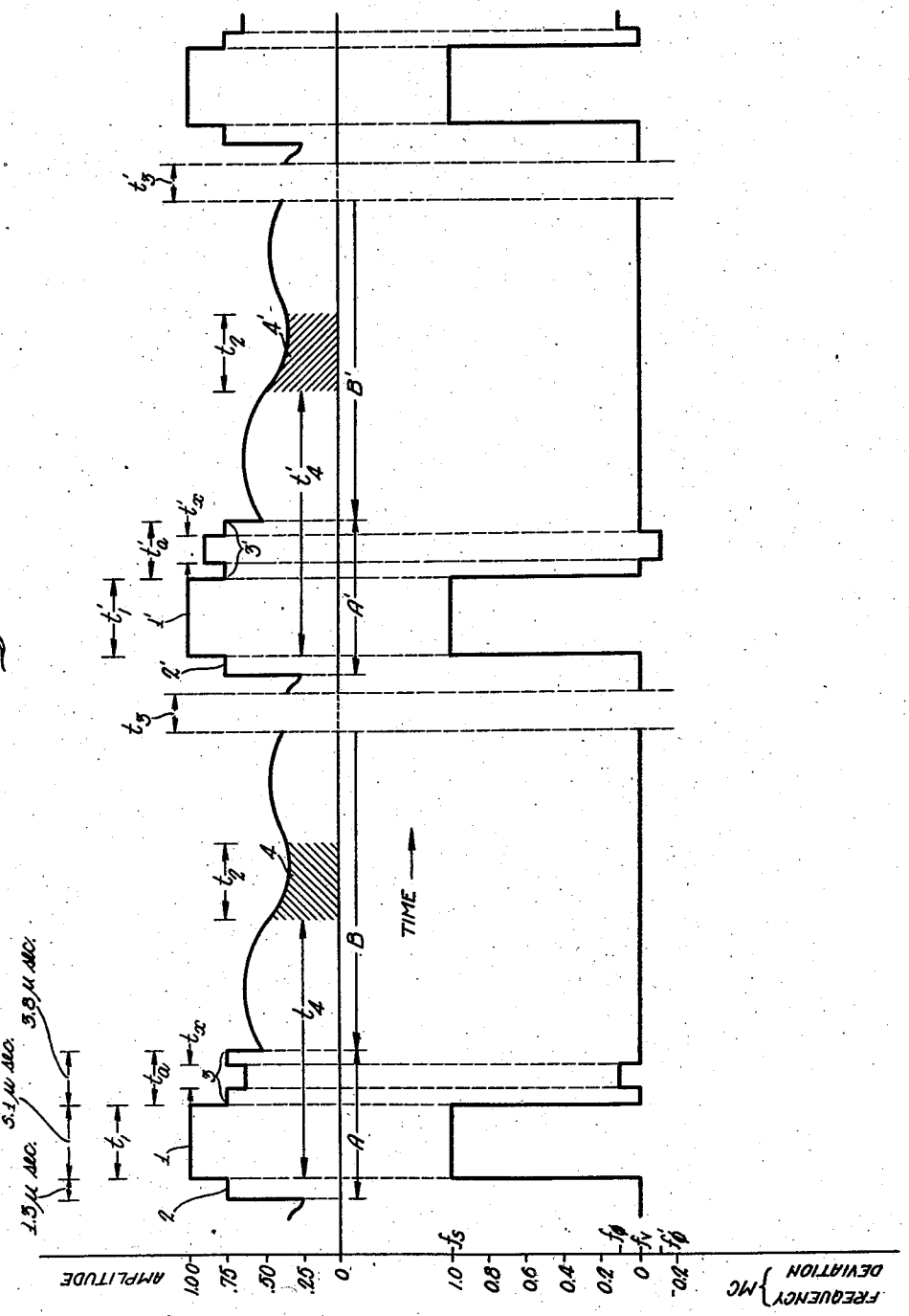
Feb. 13, 1945. D. B. SMITH 2,369,614

METHOD AND APPARATUS FOR REDUCING ECHO EFFECTS IN PICTURE TRANSMISSION SYSTEMS

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Fig. 1.



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METHOD AND APPARATUS FOR REDUCING ECHO EFFECTS IN PICTURE TRANSMISSION SYSTEMS

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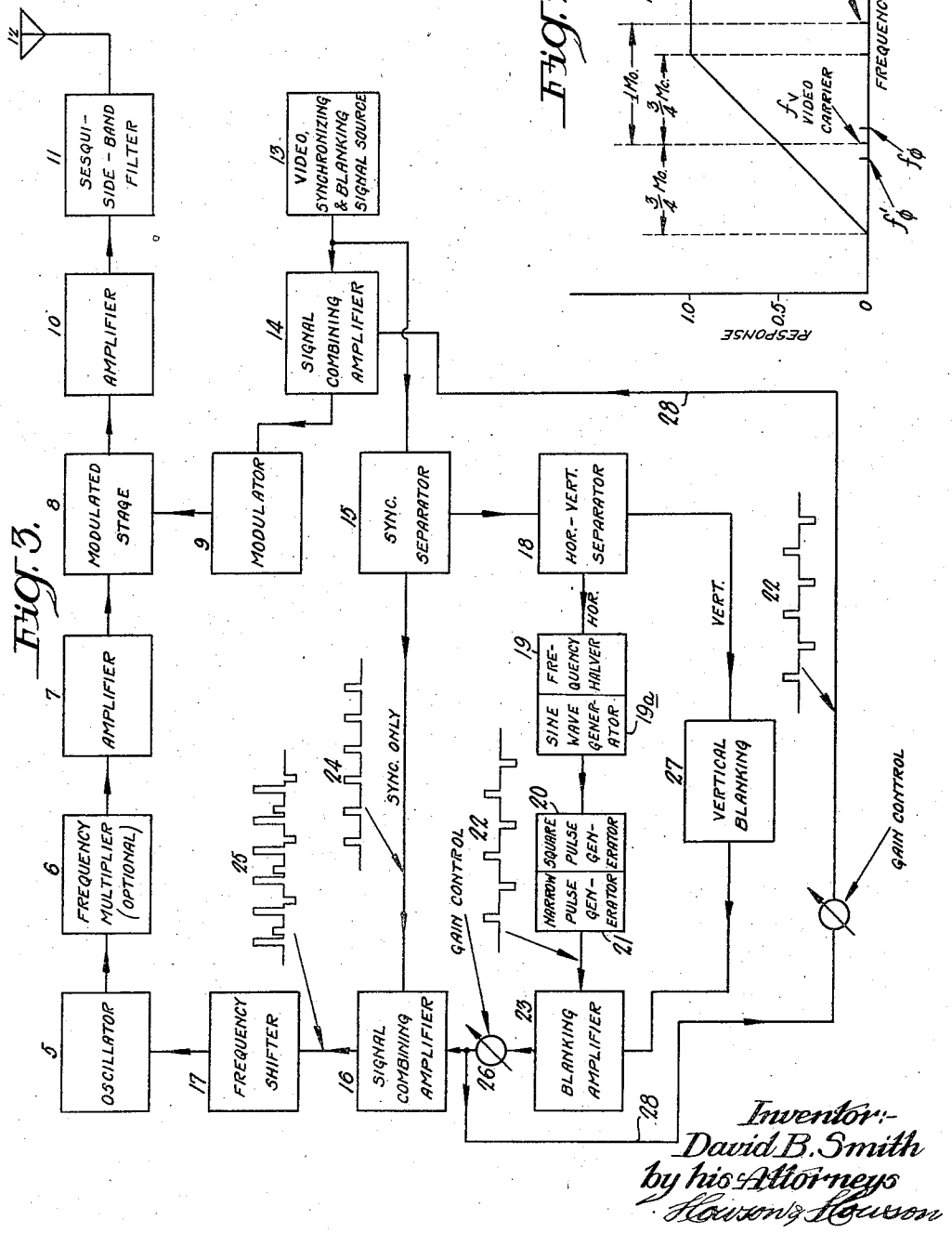


Fig. 3.

Fig. 2.

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METHOD AND APPARATUS FOR REDUCING ECHO EFFECTS IN PICTURE TRANSMISSION SYSTEMS

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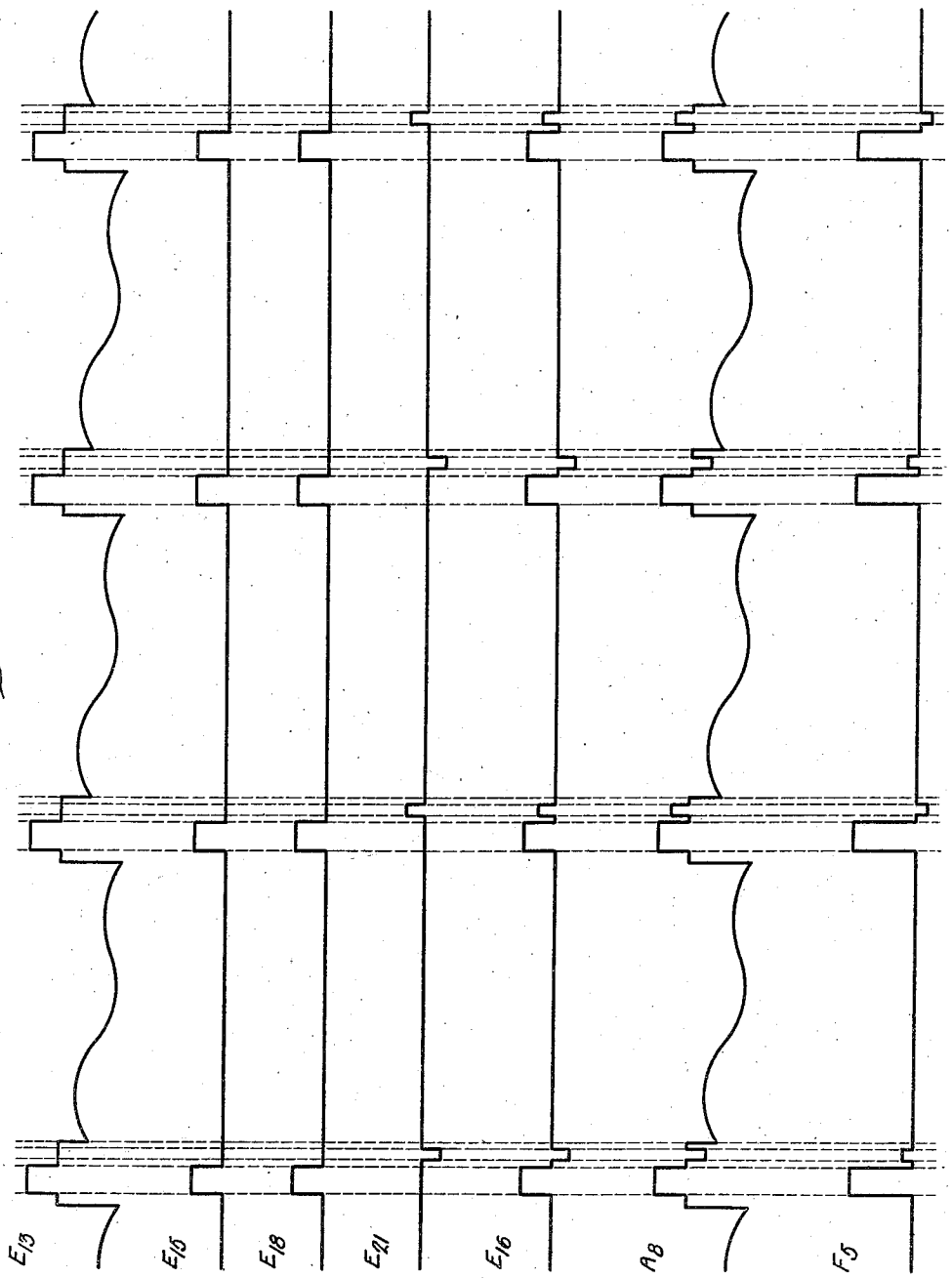


Fig. 4.

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Patented Feb. 13, 1945 2,369,614

UNITED STATES PATENT OFFICE

2,369,614

METHOD AND APPARATUS FOR REDUCING ECHO EFFECTS IN PICTURE TRANSMISSION SYSTEMS

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Application May 5, 1942, Serial No. 441,874

24 Claims. (Cl. 178—7.1)

This invention relates to picture transmission systems and the like, and to a method and means for substantially reducing or eliminating the effects of echo signals on the received or reconstituted picture. More particularly, the invention relates to television systems, and to an improved method and means for reducing or substantially eliminating certain undesirable effects resulting from the arrival, during the picture line periods, of echoes of the horizontal or line synchronizing signals.

One of the problems encountered in picture or television transmission, and one that obtains with any type of modulation, is that which results from the reception of long delayed echoes, corresponding to signal path differences of the order of a mile or several miles. Since the speed of propagation of a radio wave is approximately one thousand feet per micro-second, a path difference of say three or four miles, as between the direct and the reflected signal path, may produce echoes delayed by 15 or 20 micro-seconds. In magnitude, these echoes may be relatively faint due to the greater path length, to the fact that the echo-signal normally suffers considerable attenuation in reflection, and to the fact that the indirect path is usually closer to the earth than is the direct path. On the other hand, since the synchronizing signals are of greater amplitude than the line or picture portions of the signal, reflected synchronizing signals of considerable strength sometimes appear in the picture as a result of these long-delayed echoes.

In general, an echo may appear in a television picture by combining or beating with the picture carrier. Thus the echo may add to or subtract from the picture carrier depending upon the particular phase relation between the two signals at a given instant. This phase relation depends (except for changes effected at the transmitter itself) upon the difference in path length between the direct and reflected signals; and the only way in which this difference can be appreciably varied, assuming that the transmitting and receiving antennas are fixed, is by a variation in the placement of the reflector causing the echo. But since the reflector is usually a high building, bridge, gas tank, hill, or similar object, it too can be regarded as a substantially fixed structure, and hence in any given installation the echo signal, as it appears upon the viewing screen at the receiver, is subject only to such phase relations between the direct and reflected signals as may result from periodic phase changes effected within the transmitter itself.

F. J. Bingley and W. E. Bradley have found that the deleterious effects of these echo signals may be substantially reduced or eliminated by periodically changing the phase or polarity of the echoes so that they are opposite in successive frames. As is fully described in the copending joint application of F. J. Bingley and W. E. Bradley, Serial No. 433,660, filed March 6, 1942, and the copending application of F. J. Bingley, Serial No. 435,402, filed March 19, 1942, this can be accomplished most readily by periodically changing the phase of the echo carrier with respect to the picture carrier, these changes being so timed that the successive echoes balance each other out so far as their impression upon the observer is concerned. The phase changes referred to are effected at the transmitting station and require no additional equipment at the point of reception.

The present invention utilizes the broad principles disclosed in the above-named copending joint application, but an improved method is utilized to effect the changes in phase between the echo carrier and the picture carrier. In the method described by Bingley and Bradley, the carrier phase changes are effected suddenly—almost instantaneously—through the agency, for example, of an electronic phase-reversing switch. Now while the Bingley-Bradley method has proven satisfactory in practice, it is possible, under certain conditions, that such method may produce short-time amplitude transients which may be difficult to eliminate. According to the present invention, the phase of the carrier is advanced, retarded, or reversed, gradually by changing the carrier frequency a predetermined amount for a predetermined time interval until the carrier has lost or gained the desired number of electrical degrees (180 degrees in a phase reversal system). When the carrier phase is changed in this manner, the carrier amplitude may remain substantially constant and consequently no amplitude transients are produced.

It is a principal object of this invention to provide a method and means for substantially eliminating certain echo effects which may be encountered in picture transmission systems.

Another object of the invention is to provide an improved method and means for transmitting a television signal, or the like, which when received will produce a picture which is substantially free of echoes of the synchronizing signals.

Still another object of the invention is to provide a method and means by which the relative phase of echo signals may be periodically advanced or retarded without causing amplitude

transients to appear during the blanking or video intervals of the television signal.

A further object of the invention is to provide an improved television transmitter which is capable of generating my improved echo-cancelling carrier signal.

These and other objects and features of the invention will be apparent from the following description and the accompanying drawings in which:

Figs. 1 and 2 are explanatory diagrams in connection with which the method of the present invention will be explained;

Fig. 3 is a block diagram of a television transmitter, constructed in accordance with the invention, for generating the improved television signal; and

Fig. 4 is an explanatory diagram illustrating the operation of the television system of Fig. 3.

In Fig. 1 there is represented the amplitude and frequency characteristics of a television carrier wave modulated in accordance with the principles of the present invention. The portions shown comprise the blanking interval A and a part of the video interval B of a given picture line, and the blanking interval A' and part of the video interval B' for the same line in the succeeding frame. In a 525-line, 30-frame television system the signal A—B and the signal A'—B' are separated in time by a 525-line interval t_3 of substantially one-thirtieth of a second. The upper portion of Fig. 1, which is plotted against an amplitude scale, may be regarded as a representation of the positive half of the carrier wave envelope. Since the negative half of the envelope is identical in appearance, it has been omitted in this illustration. The blanking and synchronizing portion of the signal which occupies the interval A, comprises the synchronizing signal 1 of duration t_1, the "front-porch" portion 2 of the blanking signal, and the "back-porch" portion 3 of the blanking signal. In conventional television systems the amplitude level of the carrier wave is maintained substantially constant, generally at 75% of maximum carrier amplitude, throughout both the "front porch" and "back porch" intervals of the blanking signal. In accordance with the preferred embodiment of the present invention, this practice is departed from in a manner to be described hereinafter.

Although the present invention is applicable to common carrier as well as to alternate carrier television systems, the invention will be described with particular reference to the alternate carrier system of transmission which is described in detail in the copending application of F. J. Bingley, Serial No. 401,533, filed July 8, 1941, and in my copending application, Serial No. 401,494, filed July 8, 1941. The frequency characteristic of the carrier wave here under consideration is illustrated in the lower portion of Fig. 1 and is plotted against frequency deviation in megacycles, i. e., deviation from the normal blanking and video carrier frequency. This normal or "assigned" carried frequency may be of the order of 60 or 70 megacycles. In a conventional alternate carrier television system, the carrier frequency during the blanking intervals (excluding the synchronizing intervals t_1) and during the video intervals B is held constant at the assigned video frequency f_v where the deviation is, of course, zero. During the synchronizing intervals t_1, t_1', etc. the carrier frequency is established at a different value f_s which may differ from the normal carrier frequency by, say, one megacycle. This alternate carrier system of television transmission provides improved synchronizing performance at the receiving station for reasons which are fully described in the last-mentioned applications of Bingley and Smith.

In a 525-line television system the complete line interval has a duration of approximately 63.5 micro-seconds, and this period is divided approximately as follows: interval A—10.2 micro-seconds, front-porch 2—1.3 micro-seconds, synchronizing pulse 1—5.1 micro-seconds, back-porch 3—3.8 micro-seconds, and video interval B—53.3 micro-seconds. The signal representations of Fig. 1 are taken for identical lines in successive frames, and hence are separated in time by a 525-line interval t_3 of substantially one-thirtieth of a second. If now a wave reflecting structure is so situated with respect to the transmitting and receiving antennas that an echo of the carrier wave is received, say, 20 micro-seconds after the reception of the original signal which travels the direct path, it will be seen that an echo of the synchronizing signal 1 will arrive during the following video interval B and will beat with the carrier wave for a time equal to the duration of the synchronizing signal 1, which in the case under consideration is 5.1 micro-seconds. Consequently if a synchronizing signal 1 of duration t_1 is delayed for a time t_4, the synchronizing signal echo will beat with the video carrier during the portion t_2 of the interval B, where the interval t_1 is equal to the interval t_2. The portion 4 of the signal corresponding to the time interval t_2 has been cross-hatched to indicate diagrammatically that this part of the signal is interfered with by the delayed reception of the synchronizing signal 1. Similarly the echo of the next-illustrated synchronizing signal 1' will be delayed a like amount t_4', and will interfere with the video carrier during the interval t_2' as indicated by the cross-hatched area 4'.

As is disclosed on the above-named copending joint application of Bingley and Bradley, the echo images appearing on the screen of the television receiver may be eliminated, so far as the observer is concerned, by transmitting the television signal in a manner such that dark echoes in one frame are followed by corresponding light echoes in the immediately succeeding frame, and vice versa. This may be accomplished by periodically reversing the phase of the carrier wave, as between synchronizing and video intervals, in a sequence such that the phase or "polarity" of the resulting beat or echo signal is opposite in successive frames. The present invention provides an improved method of effecting the carrier phase reversals or changes. In the preferred embodiment of the present invention the carrier phase reversals (i. e. 180° phase changes) are not obtained directly, but rather through pairs of phase changes of 90° each, and these changes are obtained not by a substantially instantaneous phase change, but by a relatively gradual phase change effected through the agency of a small carrier frequency deviation held for a short time. For example, as will now be explained, a deviation of 125 kilocycles from an assigned frequency of 67.5 megacycles will, if held for two micro-seconds, produce a carrier phase change of 90°.

According to the invention, the phase of the carrier may be advanced 90° during the interval t_x (a portion of the back-porch interval 3), and retarded 90° during the interval t_x' (a portion of the back-porch interval 3'). Assume that the frequency of the undeviated carrier wave is equal

to 67.5 megacycles, and that we wish to utilize 2 micro-seconds of the 3.8 micro-second back-porch 3 for effecting the 90° carrier phase change by the frequency deviation method of the present invention. The desired phase change ϕ is given by the equation

$$\phi=\int_{t_1}^{t_2}(\omega_1-\omega_0)dt$$

where $\omega_1/2$ is the shifted frequency and $\omega_0/2$ is the original frequency. Now in two micro-seconds the 67.5-megacycle radio frequency carrier will go through 135 cycles. Hence to effect a 90° phase change requires a frequency shift of 90/135, or two-thirds of a degree per cycle. This corresponds to a frequency change of

$$67.5\cdot\frac{2/3}{360}=0.125 \text{ megacycle}$$

or 125 kilocycles. Thus the frequency may be shifted higher by 125 kilocycles and held for two micro-seconds to produce a phase advance of 90°, or reduced by 125 kilocycles to produce a phase retardation of 90° in the same interval. Stated simply, the method of the present invention is to speed up, or slow down, the frequency of oscillation until the desired phase shift has been gained or lost, and then to return the frequency of oscillation to normal.

The above-described frequency changes which produce the desired phase shifts during the back-porch intervals t_x and t_x' are plotted in the lower portion of Fig. 1 which illustrates the frequency excursions of the carrier in megacycles. Assume that we have established the normal, or video, carrier frequency f_v (where deviation is zero) at 67.5 megacycles. In accordance with the principles of alternate carrier television transmission the carrier may be shifted to 68.5 megacycles during the synchronizing intervals t_1, t_1'. This amounts to a deviation of one megacycle, and establishes the carrier at the frequency f_s during the said synchronizing intervals.

At the receiving station the carrier of the delayed synchronizing signal 1 will beat, or heterodyne, with the carrier of the directly-received video signal during the interval t_2, and an echo image will appear on the screen of the picture tube in a manner which is fully described in the above-mentioned joint application of Bingley and Bradley. The phase or polarity of the echo will be determined by the difference in path length between the directly-received and the reflected signals, which is fixed, and by the relative carrier phase of the video and synchronizing portions of the transmitted signal, which is controllable at the transmitter by means of the frequency deviation method of the invention. During the portion t_x of the back-porch interval t_a the carrier frequency may be increased 125 kilocycles to the upper phase-shifting level f_ϕ and held at that frequency until the desired 90° carrier phase advance has been produced, at which time the carrier may be returned to frequency f_v. During the portion t_x' of the back-porch interval t_a' the carrier frequency is decreased 125 kilocycles to the lower phase-shifting levels f_ϕ' and held at that frequency until the desired 90° phase retard has been effected, at which time the carrier may again be returned to frequency f_v. The effect of the described phase advance and phase retard is, of course, to reverse the character of the echo for identical lines in successive frames. When the reversed echoes are superimposed one on the other, as is done by the eye in viewing quickly the time successive identical lines, the echo 4' substantially balances out the echo 4.

In the foregoing, specific reference has been made only to the phase change as between identical lines in successive frames. In the preferred embodiment of the invention, for systems using an odd number of lines, the same alternating phase changes are effected in successive lines in time sequence (this is equivalent to alternate lines in space sequence in interlaced systems). It will be seen that in any odd-line system wherein the phase is alternately shifted forward and backward, one shift following each horizontal synchronizing interval, the frame relations described with reference to Fig. 1 will be preserved, and hence echo cancellation will obtain over the entire scanning pattern. It is not necessary that the phase shifting operation take place during the vertical synchronizing intervals, although the proper sequence must be preserved throughout.

In the preferred odd-line embodiment just described, the general appearance of the individual frames, when receiving a strong echo, is substantially as described with reference to Fig. 6 of the above-mentioned joint application of Bingley and Bradley.

The invention is, of course, not limited to the specific combination of frequency deviation and interval t_x calculated above. Moreover it is not necessary that a rectangular frequency shift characteristic (see Fig. 1) be utilized in the interval t_x, and if desired a triangular or parabolic characteristic may be adopted. Furthermore the invention is not limited to the specific 90-degree phase shift method (which provide carrier phase reversal in two steps). If desired the invention may be utilized to provide the 180-degree phase shifts directly, these being timed and utilized in a manner taught by the above-mentioned joint application of Bingley and Bradley. Likewise the present invention may be utilized to effect echo cancellation by the polyphase (e. g. three-phase) methods described in the said joint application. In a three-phase system echo cancellation may be secured by changing the phase of the carrier of time successive identical lines by an amount $a°$, $a°+120°$, and $a°-120°$, or in general

$$a°, a°+\frac{k}{360}, a°+\frac{2k}{360} \cdots a+\frac{(n-1)k}{360}$$

where $nk=360°$; a small integral value of n is, however, preferred. In its broadest aspect the present invention should be regarded as one which discloses a method and means for effecting a desired phase change by means of frequency deviations which are controlled both as to duration and magnitude.

Reference is now made to Fig. 2 which shows the frequency response characteristic of a typical television receiver adapted to receive the standard single-side-band transmissions. This response is characterized in that it varies from substantially zero three-fourths megacycle below the video carrier frequency, through approximately 50% at the video carrier (f_v of Fig. 1), to substantially 100% at and above $f_v+¾$ megacycle, and then falls to zero in the neighborhood of four megacycles above f_v (not shown). In the alternate carrier method of transmission, the shift of the carrier frequency from f_v to f_s during the synchronizing intervals t_1 produces a two-to-one increase in the overall output of the detector, and a five-to-one increase in the synchronizing signal output of the detector; this is fully explained in the above-mentioned copend-

ing application of Smith and copending application Serial No. 401,533 of Bingley. In a similar manner the lesser frequency shifts which occur during the phase-shifting intervals t_x, t_x', tend to change the amplitude of the signal developed in the receiver. Specifically, a frequency deviation or shift of 0.125 megacycle on either side of the video carrier frequency f_v will produce a change in developed signal amplitude of 0.125/1.5 or one-twelfth of the full amplitude. Taking into account the fact the normal black level (75% of maximum carrier amplitude) is attenuated 50% (at frequency f_v) it follows that the amplitude variation produced by the 125 kilocycle frequency shift can be substantially eliminated by a compensating carrier amplitude change of approximately

$$\frac{1}{12}\times\frac{1}{50\%}\times 75\% = 12.5\%$$

in terms of the peak carrier at the transmitter. Therefore at the same time that the carrier is shifted upward by 125 kilocycles its amplitude may be cut from the normal black (i. e., blanking) level of 75% to 62.5%, and when the carrier is shifted downward by 125 kilocycles its amplitude may be increased from 75% to 87.5%. This procedure maintains the black level at the television receiver substantially constant throughout the back-porch intervals t_a, t_a', etc. The compensating amplitude changes which are effected during the intervals t_x, t_x' are clearly apparent in the carrier amplitude characteristic which constitutes the upper portion of Fig. 1.

Reference is now made to Fig. 3 which is a block diagram of a television transmitter constructed and arranged to generate the television signal which has been described with reference to Figs. 1 and 2. The transmitter's primary source of carrier wave oscillations is an oscillator 5 of controllable frequency. Where the oscillator operates at a sub-multiple of the transmitter's assigned frequency it may be followed by a frequency multiplier stage 6. Following the multiplier stage there may be an amplifier 7, a modulated stage 8, a modulator 9, a linear amplifier 10, a sesqui-side-band filter 11, and an antenna 12, all of which may be of conventional design. Video, synchronizing, and blanking signals may be supplied from the source 13, through a device 14 whose function will be described in detail hereinafter, to the amplitude modulator 9. The combined video, synchronizing and blanking signal is also supplied to a synchronizing signal separator stage 15 whose function is to separate the synchronizing signals from the combined signal. Synchronizing signals from the separator stage 15 may then be supplied through a device 16, whose function will be described hereinafter, to a frequency shifter 17, the function of which is to shift or deviate the frequency of the oscillator 5 in accordance with the control signal supplied by the device 16. The application of the synchronizing signals to the frequency shifter 17 controls the frequency of oscillation of the oscillator 5 in accordance with the principles of alternate carrier transmission described in the above-mentioned copending application of Smith and copending application Serial No. 401,533 of Bingley. The frequency shifter 17 may be any suitable device which is adapted to shift the frequency of the oscillator in either direction in response to a control signal. For example, various embodiments of such a device are shown in U. S. Patent No. 2,240,428 to C. Travis.

The circuit of Fig. 3, as thus far described, is capable of generating the signal of Fig. 1 with the exception of the frequency and amplitude changes occurring during the intervals t_x and t_x' of the back-porch portions 3 of the blanking signals. A method and means for producing the frequency and amplitude variations of the present invention will now be described.

Synchronizing signal from the separator stage 15 is supplied to a device 18 whose function it is to separate the horizontal synchronizing signal from the vertical synchronizing signal, and vice versa. Such separating devices are well known in the art, and therefore the device 18 is not described in detail. Horizontal synchronizing signal from the device 18 is supplied to a frequency halver stage 19, which supplies a signal of half the horizontal synchronizing frequency to the sine wave generator 19a, which in turn produces a sine wave signal whose frequency is also half the horizontal synchronizing frequency. The device 19—19a may comprise, as will be understood by those skilled in the art, a blocking tube oscillator adjusted to fire at every second horizontal synchronizing pulse; this blocking tube oscillator may be followed by one or more resonant circuits tuned to the desired half-frequency to produce an output signal of approximately sine wave shape. This latter signal may then be supplied to the square wave generator 20 which produces a substantially square wave signal of half the horizontal synchronizing frequency. The square wave output of the unit 20 is supplied to the narrow pulse generator 21, which so utilizes the square wave as to produce a wave of the type shown at 22, which comprises spaced alternately positive and negative narrow pulses, each pulse having a duration of approximately two micro-seconds to correspond in duration and timing to the intervals t_x of Fig. 1. The signal 22, for reasons which will become apparent, may be referred to as the "echo-cancellation signal." A satisfactory method for generating such alternating pulses of predetermined width and timing is fully described in U. S. Patent No. 2,171,536 to F. J. Bingley (see especially Figs. 4 and 21). Devices suitable for use in the unit 19—19a are also described in the said Bingley patent.

The alternating narrow pulse 22, derived from the narrow pulse generator 21, is supplied through the blanking amplifier 23 to the signal combining amplifier 16 where it is combined with the synchronizing signal from the unit 15. The combined signal 25 is then applied to the frequency shifter stage 17 where it controls the frequency of the oscillator 5 in accordance with the frequency characteristic illustrated in the lower portion of Fig. 1. Preferably a gain control device 26 is inserted between the device 23 and the signal combining amplifier 16 so that the relative amplitude of the signals 22 and 24 may be controlled to provide the proper relation between f_s on the one hand, and f_ϕ and f_ϕ' on the other (see Fig. 1).

As is indicated in the above-mentioned copending joint application of Bingley and Bradley, it is preferred that the phase changing operations be suspended during the vertical synchronizing intervals. In the present invention this is accomplished by means of the vertical blanking stage 27 in combination with the blanking amplifier 23. Vertical synchronizing signals from the unit 18 are supplied to the device 27

which generates a blanking signal of such duration and magnitude that the gain of the said amplifier is periodically reduced substantially to zero, thereby to interrupt the supply of the signal 22 to the signal combining amplifier 16 during the vertical synchronizing intervals. Blanking amplifiers are, of course, well known to those skilled in the art and consequently a detailed description of this device is not deemed necessary. The transmitter as thus far described is capable of generating the signal of Fig. 1 with the sole exception of the amplitude changes, shown in the upper portion of Fig. 1, which occur during the intervals t_x, t_x', etc.

In order to effect the above-mentioned amplitude variations, which compensate for the amplitude variations introduced in the television receiver by the frequency variations which occur during the same intervals, the signal 22 is supplied, by way of the signal channel 28, to the signal combining amplifier 14 where it is combined with the video, synchronizing, and blanking signal and thence supplied to the modulator stage 9 which, in combination with the modulated stage 8 effects the amplitude modulation of the carrier wave in accordance with the principles already described with reference to Fig. 1. Preferably the signal channel 28 includes a gain control device 29 to enable the amplitude of the alternating narrow pulse signal 22 to be adjusted to a point where the presence of this signal just compensates for the effect of the frequency shifts which occur during the back-porch intervals t_a, t_a', etc.

The relative timing and general relation between the several signals referred to with reference to Fig. 3 are best understood in connection with the illustration of Fig. 4. In this illustration, no attempt has been made to maintain the identical scales used in the signal representations of Fig. 1 or 3. The first signal, E_{13}, represents the combined video, synchronizing and blanking signal output of the source 13. E_{15} represents the synchronizing signal output of the device 15. It includes horizontal and vertical synchronizing signal components, the latter not occurring in the interval chosen for illustration. The signal E_{18} represents the horizontal synchronizing signal which is derived from the separator stage 18 and supplied to the frequency halver 19. E_{21} is the alternating narrow pulse signal supplied by the narrow pulse generator 21, and corresponds to the signal 22 illustrated in Fig. 3. It will be noted that the narrow pulses occur within the back-porch intervals of the signal E_{13}, and they may be of substantially two micro-seconds duration. The generation of the alternating "echo cancellation signal" 22, even though its timing differs from that of the horizontal synchronizing signal E_{18}, presents no difficulties, since the narrow-pulse generator of the above-mentioned Bingley patent embodies means for controlling the time of occurrence of the narrow pulses.

The signals E_{15} and E_{21} are supplied to the signal combining amplifier 16 which combines the said signals to form the combined signal E_{16}, which corresponds to the signal 25 illustrated in Fig. 3. The amplitude characteristic A_8 of Fig. 4 represents the positive half of the envelope of the carrier wave output of the modulated stage 8. The frequency characteristic F_5 represents the frequency of the output signal of the oscillator 5.

In Fig. 3 the frequency multiplier 6 is shown as optional equipment. If the oscillator 5 is operated directly at the transmitter's assigned frequency, the multiplier is not employed. However it is usually desirable to operate the oscillator at a much lower frequency inasmuch as frequency control circuits are usually more conveniently applied at lower frequency levels. Where a multiplier is used, and the oscillator is operated at a sub-multiple of the transmitter's assigned frequency, the frequency shifts which are effected during the synchronizing intervals t_1, t_1', etc., and the shorter intervals t_x, t_x', etc., are reduced to $1/n$th of the deviations referred to with reference to Fig. 1, where n is the multiplying factor of the frequency multiplier 6.

In certain of the appended claims mention is made of the "phase-shift method" of echo cancellation; this reference is, of course, to the broad method of echo cancellation disclosed in the above-mentioned joint application of Bingley and Bradley.

Although the invention has been described with reference to a specific embodiment, it will be understood that it is capable of expression in other physical forms which will occur to those skilled in the art after reading the foregoing description, and that wide alterations and modifications may be made within the scope of this invention as defined in the appended claims.

I claim:

1. In an echo neutralizing system for television transmitters and the like, the method of effecting a predetermined phase change in a carrier wave of predetermined frequency, which comprises changing the frequency of said carrier wave, controlling said frequency change both as to magnitude and duration, and reestablishing said predetermined frequency when said predetermined phase change has been effected.

2. In an echo neutralizing system for television transmitters and the like, the method of alternately advancing and retarding the phase of a carrier wave of predetermined frequency, which comprises alternately increasing and decreasing the said carrier frequency to effect phase gains and phase losses respectively, controlling said frequency changes both as to magnitude and duration, and reestablishing said predetermined frequency when the desired phase changes have been effected.

3. In a television transmission system, the method which comprises periodically changing the frequency of the carrier wave to effect phase shifts in said carrier wave, controlling said frequency changes both as to magnitude and duration to produce phase shifts of predetermined magnitudes, and so establishing the periodicity and magnitudes of said phase shifts that echo cancellation is obtained in accordance with the phase-shift method.

4. The method according to claim 3, wherein said frequency changes are effected during blanking interval portions of the transmitted wave.

5. In a television transmission system, the method which comprises periodically advancing the phase of the carrier wave 90° by means of a carrier frequency deviation sustained for a short time, periodically retarding the phase of said wave 90° by means of a carrier frequency deviation sustained for a short time, and so fixing the periodicity of said phase changes that echo cancellation is effected in accordance with the phase-shift method.

6. The method according to claim 5, wherein the said carrier frequency deviations are of the

order of 125,000 cycles, and the deviation intervals are of the order of 2 micro-seconds.

7. The method according to claim 5, wherein the phase advances and phase retards follow in simple alternating sequence.

8. In a carrier wave television transmission system wherein the transmitted signal includes at least video intervals, synchronizing intervals, and back-porch blanking intervals, the method of transmission which comprises utilizing a portion of some of said back-porch intervals for periodically advancing the phase of the carrier wave 90° through the agency of a brief carrier frequency increase, utilizing a portion of other of said back-porch intervals for periodically retarding the phase of the carrier wave 90° through the agency of a brief carrier frequency decrease, and so fixing the sequence and periodicity of said changes that echo cancellation is effected in accordance with the phase-shift method.

9. In a television transmission system, the method which comprises periodically changing the frequency of the carrier wave to effect predetermined phase shifts therein, simultaneously changing the amplitude of said carrier wave to compensate, in television receivers having sloping frequency response characteristics, for the amplitude variations introduced by said frequency changes, controlling said frequency changes both as to magnitude and duration to produce phase shifts of predetermined magnitudes, and so establishing the periodicity and magnitudes of said phase shifts that echo cancellation is obtained in accordance with the phase-shift method.

10. The method according to claim 9, wherein said periodic frequency and amplitude changes are interrupted during the vertical synchronizing intervals of the transmitted carrier wave.

11. In a television transmitter, a source of carrier wave oscillations, means responsive to a control signal for controlling the frequency of said oscillations, means for generating a control signal which, when applied to said control means, will periodically change the frequency of said carrier wave to effect phase shifts in said wave, said frequency changes being of such magnitude and duration as to produce phase shifts of predetermined magnitude, and means for so establishing the periodicity and magnitude of said phase shifts that echo cancellation in accordance with the phase-shift method is obtained.

12. A television transmitter as claimed in claim 11, wherein the last-recited means is adapted to produce phase shifts of the order of $360/n$ degrees, where n is a small integer.

13. A television transmitter as claimed in claim 11, wherein the last-recited means is adapted to produce carrier phase shifts in the intervals which occur in the periods between the end of the synchronizing intervals and the beginning of the video intervals.

14. In an echo neutralizing circuit for television transmitters and the like, a source of carrier wave oscillations, means responsive to a control signal for controlling the frequency of said oscillations, means for generating a control signal for application to said control means for alternately increasing and decreasing said carrier frequency to effect phase gains and phase losses respectively, and means for so establishing the periodicity and magnitude of said phase shifts that echo cancellation in accordance with the phase-shift method is obtained.

15. A television transmitter as claimed in claim 14, wherein the last-recited means is adapted to produce phase changes each having a magnitude of substantially 90 degrees.

16. In a television transmitter or the like, a source of carrier wave oscillations, means including a frequency-deviating device for periodically shifting the phase of said carrier wave for the purpose of effecting echo signal cancellation in accordance with the phase-shift method, and means operative synchronously with said frequency-deviating device for amplitude-modulating said carrier wave to prevent amplitude transients when said wave is received by a receiving circuit having a sloping frequency-response characteristic.

17. A television transmitter as claimed in claim 16, wherein the recited means are adapted to effect said carrier frequency deviations and said synchronous carrier-amplitude-modulation during intervals other than the synchronizing and video intervals.

18. A television transmitter as claimed in claim 16, wherein the recited means are adapted to effect said carrier frequency deviations and said synchonous carrier-amplitude-modulation during the back-porch blanking intervals.

19. A television transmitter as claimed in claim 16, wherein the first recited means is adapted to advance the phase of said carrier 90° after alternate synchronizing intervals and to retard the carrier phase 90° after the other synchronizing intervals.

20. In a television transmitter, a source of carrier wave oscillations, means responsive to a control signal for controlling the frequency of said oscillations, a source of synchronizing impulses, means responsive to said impulses for generating a control signal adapted to change the frequency of said carrier wave periodically in a manner to effect echo cancellation phase shifts in said wave, and means for applying said control signal to said frequency-control means.

21. In a television transmitter, a source of carrier wave oscillations, means responsive to control impulses of opposite polarity for varying the frequency of said oscillations in either direction, a source of synchronizing impulses, means responsive to said impulses for generating a pulse signal in which consecutive pulses are of opposite polarity and the pulses are arranged to effect echo cancellation phase shifts of the carrier frequency, and means for applying said pulse signal to said frequency-control means.

22. In a television transmitter, a source of carrier wave oscillations, means responsive to a control signal for controlling the frequency of said oscillations, a source of horizontal and vertical synchronizing impulses, means for deriving horizontal synchronizing impulses from said source, means responsive to the said derived impulses for generating an echo-cancellation control signal, means for combining said signal with said synchronizing impulses, and means for applying the resultant signal to said frequency control means, thereby to effect frequency shifts of the carrier wave both to transmit synchronizing intelligence and to effect echo cancellation.

23. In a television transmitter, means for generating a carrier wave of predetermined normal frequency, a source of video, blanking and synchronizing signals, means for amplitude-modulating said carrier wave with said signals, means for deriving synchronizing signals only from said source, means for further deriving horizontal synchronizing impulses only, means operable by

said last-named impulses to generate an echo cancellation signal, means for combining said derived synchronizing signals with said echo cancellation signal, and a frequency shifter operable by said combined signals to shift the frequency of the carrier wave.

24. In a television transmitter, a source of carrier wave oscillations, means responsive to a control signal for controlling the frequency of said oscillations, means for generating a control signal adapted to change the frequency of said carrier wave periodically in a manner to effect echo cancellation phase shifts in said wave, and means for applying said control signal to said frequency-control means.

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