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Oct. 2, 1945. F. J. BINGLEY ET AL 2,386,087

METHOD AND APPARATUS FOR REDUCING ECHO EFFECTS IN PICTURE TRANSMISSION SYSTEMS

Filed March 6, 1942 6 Sheets-Sheet 1

Fig. 1.

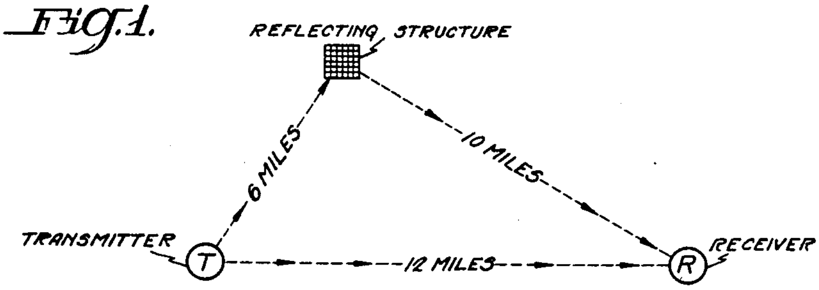

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Fig. 2.

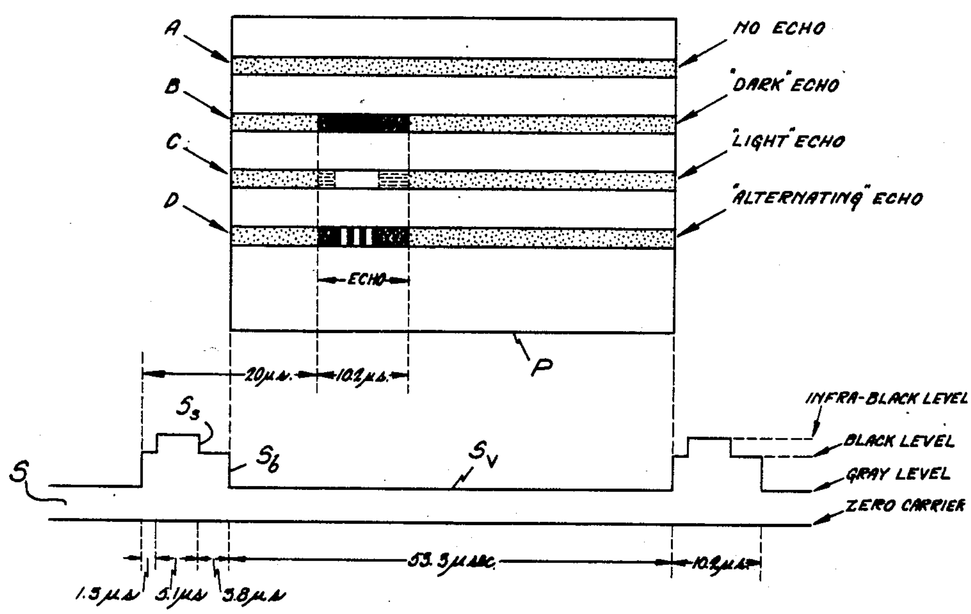

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Fig. 3.

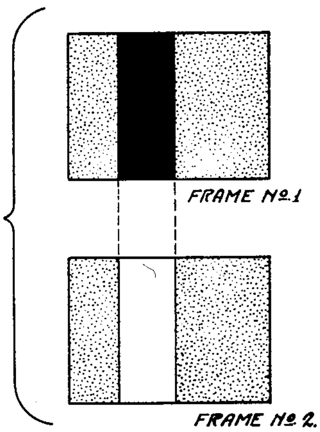

Fig. 4.

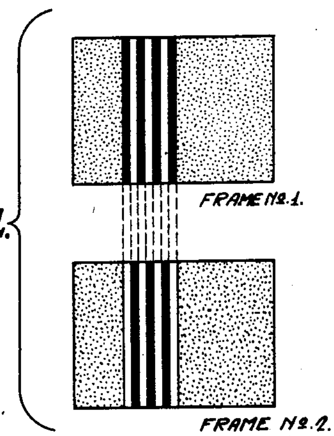

Fig. 5.

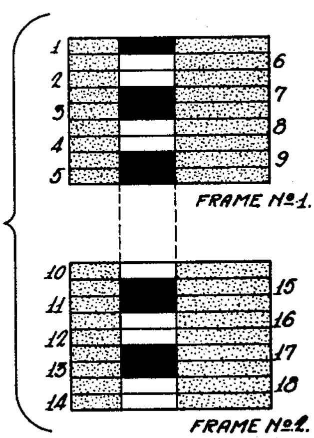

Fig. 6.

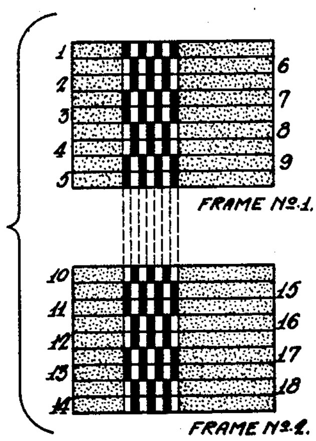

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Fig. 7.

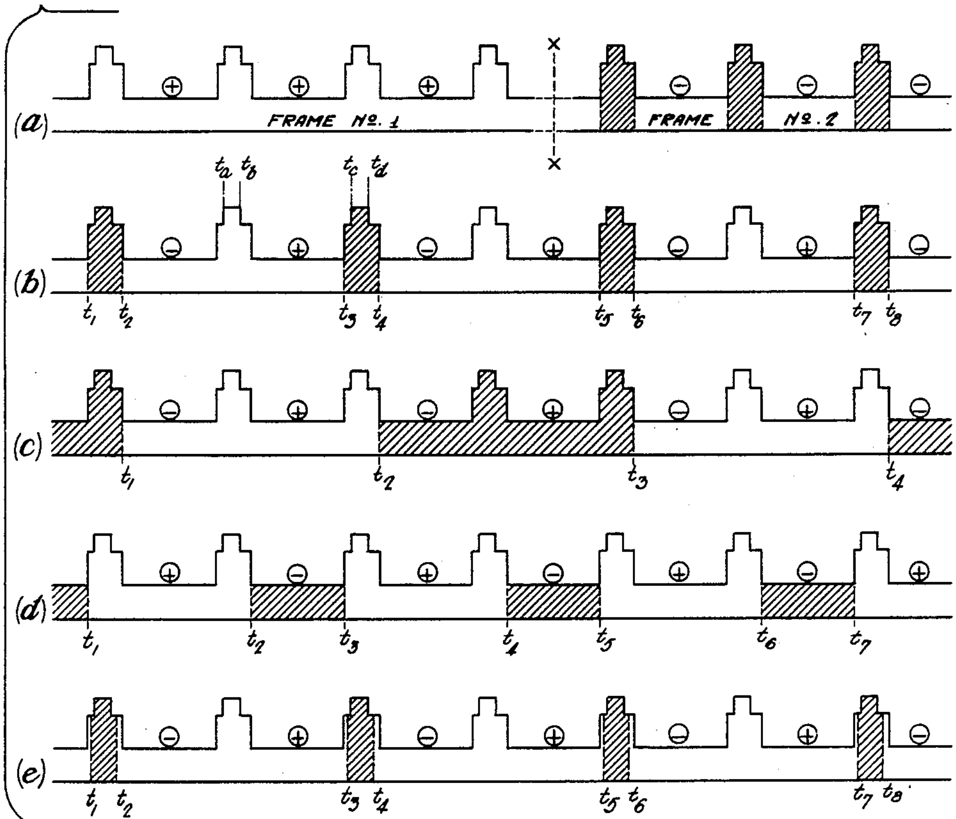
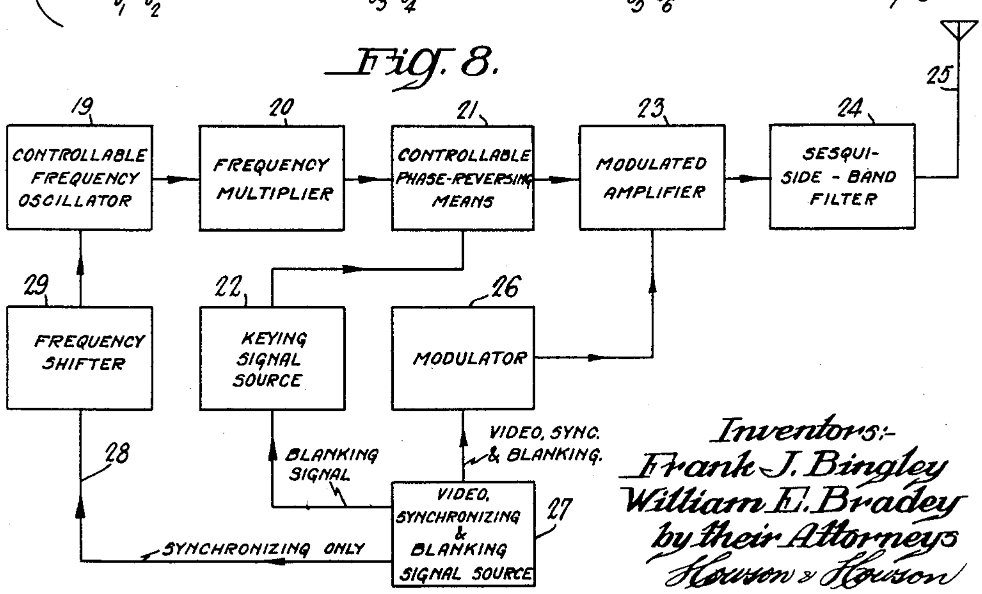


Fig. 8.



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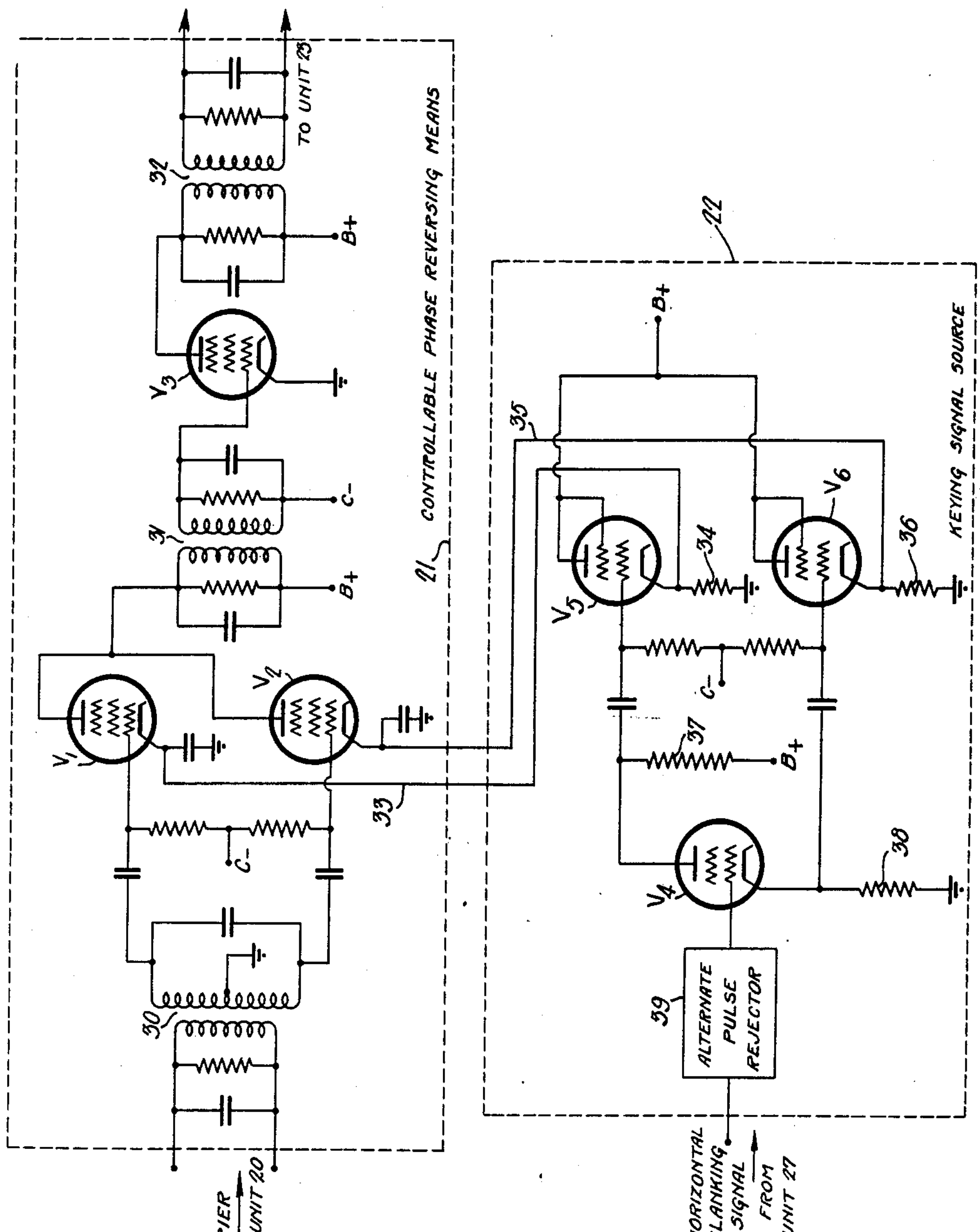

Fig. 9.

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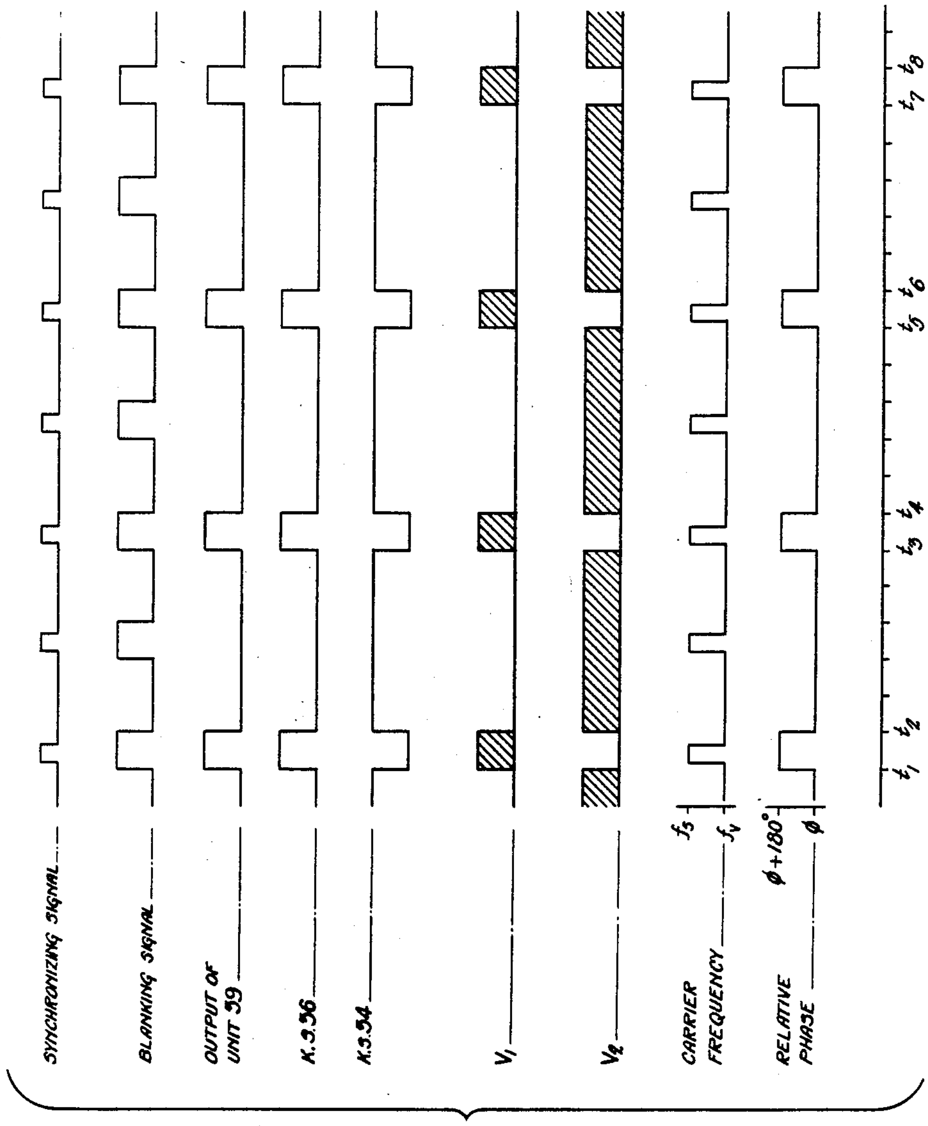

FIG. 10.

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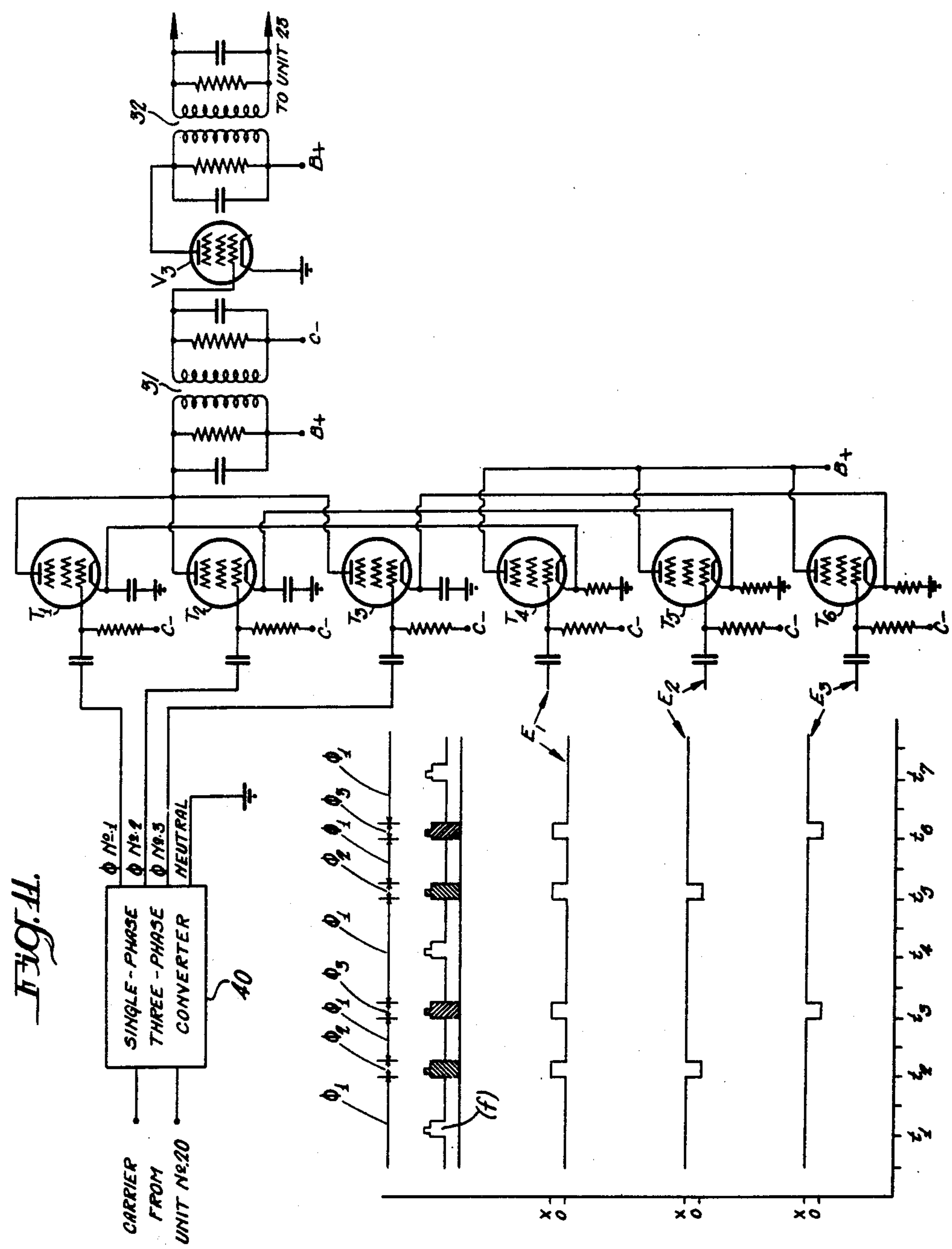

Fig. 11.

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178. TELEGRAPHY,

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UNITED STATES PATENT OFFICE

2,386,087

METHOD AND APPARATUS FOR REDUCING ECHO EFFECTS IN PICTURE TRANSMISSION SYSTEMS

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Application March 6, 1942, Serial No. 433,660

35 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 a 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 the radio wave is approximately 1000 feet per microsecond, a path difference of say three or four miles, as between the direct and the reflected signal path, may produce echoes delayed by fifteen or twenty microseconds. 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 blanking, and particularly the synchronizing signals are of greater amplitude than the line or picture portion of the signal, reflected blanking and 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.

We have found that the deleterious effects of these echo signals may be substantially reduced or eliminated by periodically changing the polarity of the echoes seen at the receiver, so that they are opposite in successive frames. 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.

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 a 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 means for eliminating certain of the spurious images produced when television signals are received by way of two or more transmission paths.

A further object of the invention is to provide a method and means by which the relative phase of echo signals may be periodically advanced, retarded, or otherwise changed, the individual changes themselves being of such a magnitude that, if continued in a given sense, a small integral number of the said changes would produce an effective echo phase rotation of substantially 360 degrees.

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

Fig. 1 shows a typical disposition of transmitter, receiver, and reflecting structure, which may give rise to objectionable echo signals;

Fig. 2 is an explanatory diagram illustrating certain characteristics of typical echo patterns;

Figs. 3, 4, 5 and 6 are illustrative of some of the methods employed to effect cancellation of various echo patterns;

Fig. 7 is a diagrammatic representation of television signals which may be employed to attain the desired objects of this invention;

Fig. 8 is a block diagram of a transmitting system, constructed in accordance with the invention, for generating a television signal which, when received, will be substantially free of deleterious echo effects;

Fig. 9 is a schematic diagram illustrating certain of the details of the system of Fig. 8;

Fig. 10 is an explanatory diagram illustrating the operation of the system of Fig. 8; and

Fig. 11 is a schematic diagram illustrating a three-phase phase-changing circuit arrangement.

The present invention may best be understood by considering first the causes of echo signals, and their appearance when viewed on the screen of the picture tube. A typical condition which may give rise to objectionable echoes is illustrated in Fig. 1. In this figure, a television receiver R is represented as being 12 miles distant from a transmitting station T. At distances of 6 and 10 miles from the transmitter and receiver, respectively, is a wave reflecting structure such as a tall building, a water tower, a steel bridge, or the like. Taking the speed of a radio wave as about one-fifth mile per microsecond, it will be apparent that the time required for the signal to traverse the direct 12-mile path between the transmitter and receiver will be about 60 microseconds, while the time required for the reflected signal to traverse the indirect 16-mile path will be about 80 microseconds. Consequently, the reflected wave, i. e., the echo, will arrive at the receiver about 20 microseconds behind the direct wave. This may be regarded as illustrative of a simple echo, as differentiated from multiple echoes which arise when a plurality of reflecting structures provide a plurality of indirect signal paths of different length.

Fig. 2 is an explanatory diagram in which the time and amplitude characteristics of a typical television signal S are related to the screen P of a conventional television picture tube. The television signal, in accordance with the present practice, may comprise synchronizing pulses S_s of approximately 5.1 microseconds duration, blanking pulses S_b of approximately 10.2 microseconds, and a line or video period S_v of approximately 53.3 microseconds. These are substantially the specifications employed in a conventional 525-line interlaced television system, with 30 frames (60 fields) per second. Since the line period corresponds to the time required for the electron beam in the picture tube to trace one line across the picture tube screen, the width of the screen P has, for convenience, been made equal in length to the line portion of the television signal S. As is conventional, the amplitude of the blanking pulses S_b may be regarded as corresponding to a "black" signal level, zero carrier as corresponding to a very bright signal level, while the synchronizing pulses may be regarded as corresponding to a blacker-than-black or "infra-black" signal level. The video signal existing during the 53.3 second line period has, for the purpose of this description, been established at a level midway between zero carrier and the black level, and will correspond approximately, therefore, to a gray level.

When a signal of these characteristics is received without an attendant echo, there will be reproduced, upon the screen of the picture tube, a line similar to that shown (with exaggerated width) at A in Fig. 2, and having a uniform grayish appearance, the latter being indicated in the drawing by the closely spaced dots. This uniform appearance will be destroyed, however, if one or more echo signals is received along with the desired direct signal. Strictly speaking, under these conditions, the appearance of the entire line will be affected, but in general echoes of the video portion of the signal can, by reason of their lesser amplitude, be ignored, and, consequently, for most practical purposes only those echoes produced by the higher amplitude blanking and synchronizing pulses need be considered. Of these pulses, the latter are, of course, the more important by reason of their greater amplitude.

Line B in Fig. 2 is illustrative of the normal appearance of a picture line when receiving a strong echo signal. The echo illustrated resembles those which are produced by the delayed reception of the blanking and synchronizing signal, and is displaced from the left-hand edge of the screen P by a distance which is proportional to the time interval between the arrival of the signal traveling the direct path and the arrival of the signal traveling the indirect or reflected path. If the difference in length between these paths is small, the echo will be reproduced at or near the left-hand edge of the screen, whereas greater path differences cause the echo to appear further to the right. Of course, where the path difference is very great, the attenuation suffered by the reflected signal is usually so considerable that the echo is too weak to be noticeable.

As is indicated in the drawings, the echo shown in line B is produced by the arrival of blanking and synchronizing pulses during the line or video period S_v. Specifically, this echo is produced by the arrival of the pulses S_s, S_b, by way of an indirect path, approximately 20 microseconds after the reception of these pulses by way of the direct path. The echo signal produces on the screen P an echo pattern whose width is equal to the width of the line, and whose length is equal to the distance traveled by the scanning beam in 10.2 microseconds, the duration of the combined blanking and synchronizing signal. The 20-second delay chosen for this illustration, it will be recalled, is approximately the delay produced as a result of a reflected signal traveling an additional 4 miles as illustrated in Fig. 1.

Whether the echo, as it appears upon the picture tube screen, will be a "dark" echo or a "light" echo, depends upon the phase relation between the video carrier and the echo carrier at the point of detection. If these carriers arrive more or less in phase, the resultant R. F. signal supplied to the detector will be greater than the amplitude of the video carrier alone, and, consequently, the combined signal will tend toward the black level and a "dark" echo will be produced as shown in line B. The darkest part of the echo will be that central portion which corresponds to the synchronizing pulse S_s, while the outer portions corresponding to the blanking signal 4 will be somewhat less dark, but darker than that part of the line which is not distorted by echo. On the other hand, if the video and echo carriers arrive in generally opposite phase, the reverse will be true, and a "light" echo such as that shown in line C will result.

Still a different type of echo results when television transmission is carried out in accordance with the system described by A. V. Loughren (Electronics, February 1940, pp. 27–30), or with the system described in the copending application of Frank J. Bingley, Serial No. 401,533, filed July 8, 1941. In the alternate carrier system disclosed by Bingley, the synchronizing pulse is transmitted not only as a variation in carrier amplitude (as in Fig. 2), but also as a variation or shift in carrier frequency. In this system, the synchronizing signal carrier may be of the order of 1 megacycle or more higher than the video signal carrier, and, consequently, when a reflected (and, hence, delayed) synchronizing signal is received with the video carrier, there will result a beat signal whose frequency is equal to the frequency difference between these signals, e. g., 1 megacycle. Since this frequency lies within the video frequency band, the synchronizing signal portion of the echo signal will be reproduced on the picture tube screen as an "alternating" echo, i. e., one which alternates from dark to light to dark, etc., as shown in line D of Fig. 2. The number of these light and dark bars depends upon the number of beat cycles contained within the duration of the synchronizing pulse. The change in shading from a dark bar to a light bar, and vice versa, is gradual, of course, and not abrupt, as shown in the illustration.

In general, where strong echo signals are received, the echo images reproduced upon the screen of the picture tube are apt to be more objectionable in an alternate carrier system than in the single carrier systems heretofore employed. This is because in the former system the synchronizing signal is transmitted at a frequency for which the receiver's sensitivity is approximately double that in the latter system, and, consequently, the reproduced echo is that much more pronounced. Thus, while the present invention is adapted for use in any type of television system, its use is especially desirable in alternate carrier systems, or more generally in systems wherein the synchronizing signal is transmitted in such a manner as to produce unusually strong synchronizing impulses in the receiver circuits.

Attention is now directed to Figs. 3, 4, 5 and 6, which illustrate certain of the methods which may be employed, in accordance with the present invention, to effect substantial cancellation of echo patterns. No attempt has been made in these figures to maintain the identical scale employed in Fig. 2. Moreover, for simplicity, only the echo caused by the delayed arrival of the synchronizing signal is illustrated, the lesser echo produced by the blanking signal being omitted. Of the numerous echo cancellation schemes that we have developed, with the present invention as a basis, perhaps one of the simplest is illustrated in Fig. 3. The assumption in Fig. 3 is that transmission is carried out in accordance with the single-carrier system, i. e., where video and synchronizing signals are transmitted on a common carrier frequency. Assume that a dark echo, such as is shown in frame No. 1 of Fig. 3, is obtained. This echo extends from top to bottom of the picture as shown, for each individual line of the frame includes an echo of the type shown in detail in line B of Fig. 2, and the echo in each of the lines will be, of course, in substantially identical positions relative to the edge of the picture. If transmission were carried out in the conventional manner, frame No. 2, and all succeeding frames, would present the same appearance, so far as echo is concerned, as frame No. 1. According to the present invention, however, transmission is carried out in such a manner that a periodic reversal of phase relation takes place between the "echo carrier" and the video carrier, causing each frame having a dark echo to be followed by a frame having a light echo, such as that shown in frame No. 2 of Fig. 3. This may be accomplished at the transmitting station by changing carrier phases or polarities at predetermined times. For example, all odd-numbered frames might be transmitted in the conventional manner with no carrier phase changes, while all even-numbered frames might be so transmitted that the carrier phase obtaining during the synchronizing (or blanking and synchronizing) intervals is reversed with respect to the carrier phase obtaining during the video intervals.

This may best be understood in connection with the composite signal representation of Fig. 7 (a) which is intended to illustrate, in reduced scale, a television signal of the type shown in the lower portion of Fig. 2. The signals to the left of the dashed line x—x may be considered as those producing the scan shown as frame No. 1 in Fig. 3, while the signals to the right of the dashed line are those producing the scan denoted frame No. 2 in Fig. 3. In each frame the echo is produced, as hereinbefore described, by the delayed arrival of echoes of the synchronizing and blanking signals. In Fig. 7 (a) the absence of cross-hatching in the signals to the left of the dashed line x—x is intended to indicate that no phase shift is produced in the carrier as between the video and the synchronizing and blanking intervals, whereas in the signals shown to the right of x—x, the cross-hatched blanking and synchronizing signals are intended to indicate that the phase of the carrier wave, during the blanking and synchronizing intervals, is reversed with respect to the phase of the carrier during the video intervals. Consequently, if the delayed synchronizing signal echoes arrive in such phase, during frame No. 1, as to produce a dark echo, it follows that during frame No. 2 (with relatively reversed phase relationships) light echoes will be produced. The characteristic of the echo (whether dark or light) during the video intervals of frame No. 1 is indicated arbitrarily in Fig. 7 (a) by the circled plus signs; whereas, during frame No. 2, circled minus signs are employed to indicate that the echo would have a different characteristic as a result of the reversal in phase relations. An electrical system adapted to produce the desired phase changes will be described in detail hereinafter.

From the standpoint of the observer, the optical effect produced by the rapid alternation of dark and light echoes upon the screen of the picture tube is substantially that which would obtain if no echoes were being reproduced at all. In a conventional television system based on 30 complete frames per second, there will be fifteen complete "echo alternations" per second, each alternation consisting of one frame having a dark echo followed by a frame with a light echo. Apparently the rapid substitution of light echoes for dark echoes, and vice versa, causes the eye to average the echo effects and to substantially ignore the individual echo images themselves.

Where an alternate carrier television system is employed, i. e., one in which the video and synchronizing signals are transmitted at different carrier frequencies, the echoed synchronizing signal beats with the directly received video signal to produce an "alternating echo," as has already been explained with reference to line D of Fig. 2. When this occurs, the screen of the picture tube (which may be made up of 525 lines) may present the appearance of either one of the frames illustrated in Fig. 4 (depending upon the initial phase relation between the echo and the direct signal). Here the echoes are seen to consist of a series of narrow vertical alternating dark and light bars. An echo of the nature of that shown in frame No. 1 of Fig. 4 may be substantially cancelled by alternating with it an echo of the nature of that shown in frame 2, the latter echo being the reverse or the conjugate of the other.

The same general form of signal which was used to produce the alternating echo effect described with reference to Fig. 3, i. e., the signal represented in Fig. 7 (*a*) can also be employed to give the alternating sequence illustrated in Fig. 4. However, since the system described with reference to Fig. 4 is an alternate carrier system, it will be understood that for the duration of each of the synchronizing pulses shown in Fig. 7 (*a*), the carrier frequency will be shifted in accordance with the practice in alternate carrier systems. Means for accomplishing these operations will be described in greater detail hereinafter.

We have found that cancellation of echoes can be made even more effective if, in each frame, the echo is broken up into a series of alternate light and dark areas as illustrated in Figs. 5 and 6. These figures show patterns that may advantageously be employed in conventional and in alternate carrier systems respectively. Patterns of this character may be obtained by using signals in which carrier phase reversal is effected at the transmitter at approximately the beginning and the end of each of the cross-hatched intervals shown in the signal representations (*b*) to (*e*) of Fig. 7. With signals of this type, the character of the echo (i. e. whether dark or light) changes for successive lines in time sequence. In a conventional interlaced scanning system, the effect produced will be similar to that illustrated in Fig. 5 in which the lines are numbered from **1** to **18** in time sequence for two complete frames, i. e., four complete fields. In line **1**, it is assumed that the phase relation between the synchronizing signal echo and the video carrier is such that a dark echo results. In line **2** (which in an interlaced system is spaced from line **1** by the width of one line), this phase relation is reversed to produce a light echo, reversed again in line **3** to produce a dark echo, and so on for five lines to produce the first field. The second field, comprising lines **6** to **9**, is transmitted without change in sequence so that the scanning pattern, or raster as it is called, consists of a plurality of pairs of lines with alternately dark and light echoes, as illustrated in Fig. 5, frame No. 1. In frame No. 2, this process is continued without change in sequence, the first field of frame 2 comprising lines **10** to **14**, while the second field comprises lines **15** to **18**. It will be seen, however, that because each frame includes an odd number of lines, the dark echoes in frame No. 2 occupy those parts of the raster which in frame No. 1 were occupied by the light echoes, and conversely. Since these frames are effectively superimposed at short intervals in transmission, the echoes tend to cancel as far as the observer is concerned. The system illustrated in Fig. 5 has the advantage over that in Fig. 3 that it breaks up the echo signal so completely as to substantially eliminate all trace of flickering in even those locations where echo signals are very strong. Effectively, the system of Fig. 5 interlaces the echoes in both time and space relation.

Where the last-described system of echo interlacing is employed in an alternate carrier system, the echoes are further broken up in the manner illustrated in Fig. 6, which may be regarded as the result of a combination of the methods employed in obtaining the rasters shown in Figs. 4 and 5. Of the several systems illustrated in Figs. 3 to 6, the system of Fig. 6 may be regarded as the preferred one. When the simpler system of Fig. 3 is employed, and where very strong echo signals are encountered, it may be found that a trace of flicker may be visible as a result of the 15 cycle alternation between relatively large unbroken areas of light and dark echoes. (The flicker has a frequency of 15 cycles per second, because there are 30 frames per second, 15 of which have a dark echo and 15 of which have a light echo.) If this flicker is deemed objectionable, it may be eliminated or greatly reduced by employing the system of Fig. 6 in which the general or overall illumination of the echo area remains substantially constant from frame to frame, as well as from field to field.

It has already been explained, in general, how echo cancellation may be obtained by successively reversing the phase of the echo with respect to the picture carrier in time relation. Specific examples showing just when these phase reversals may be made, to secure echo cancellation of the types described with reference to Figs. 5 and 6, are illustrated in Fig. 7 (*b*) to (*e*) inclusive. In these illustrations, the cross-hatched portions of the signals may be regarded as representing one arbitrary phase relation, the open portions of the signals representing a substantially opposite phase relation.

In Fig. 7 (*b*), at time t_1, the carrier phase is reversed and is maintained in that relative phase until time t_2, at which time the carrier phase is again reversed to bring it back to its original relative phase. The following video interval, blanking and synchronizing interval, and second video interval are transmitted without change in relative carrier phase, but at time t_3 the carrier phase is again reversed, and is returned to its original relative phase at the end of the blanking signal at time t_4. This cycle of events may be continued without interruption from frame to frame, although it is preferred to suspend these phase changes during a portion of each vertical blanking and synchronizing interval so as to avoid any possibility of impairment of interlacing. Preferably, the phase changes are suspended for the nine lines following the beginning of the vertical blanking period.

It is not necessary that the desired phase changes be effected precisely at the beginning and end of the selected blanking pulses as shown in Fig. 7 (*b*). If desired, these changes may be made to occur at the beginning and end of the synchronizing pulses, or at some time within the blanking signal intervals preceding and succeeding the synchronizing signals themselves. The latter system of timing is illustrated in Fig. 7 (*e*). Where phase changes are effected to coincide in time with the synchronizing signals, rather than with blanking signals, it follows that echo cancellation will be secured only for the synchronizing signal echoes, but since echoes of the synchronizing signals are by far the most important, particularly in an alternate carrier system, the choice between the various timing sequences may be found to be largely one of convenience.

Referring generally to the signals represented in Fig. 7 at (*b*) and (*e*), it will be seen that every other blanking and synchronizing signal is transmitted with its carrier phase reversed relative to the phase of the carrier during the rest of the television signal. Consequently, if the synchronizing pulse transmitted in the interval t_1—t_2 is received as an echo during the immediately following video line interval, an echo image will appear on the television screen for that particular line. If this echo be a light one, indicated by the circled minus sign, the echo in the following line (in time sequence) will be a dark one, as is indicated by the circled plus sign. That the "sign" of the echo will be different in the two cases will be seen from the fact that in one case an echo of one phase will beat with a video line of opposite phase, whereas in the other case, the echo and video line are of like phase. Thus, the echo image alternates from dark to light to dark, and so on, from line to line in time sequence, this being indicated in Fig. 7 (*b*) by the alternating plus and minus signs.

In the foregoing, cases have been described where the echo arrives alternately in-phase and out-of-phase with the video signal. Obviously, of course, there will be instances wherein the echo will arrive alternately, leading and lagging the video signal, for example, by 90 degrees. Where this occurs, the echo is of little importance, since the resultant of a strong signal (the direct signal) and a weak signal (the echo) differing 90° in phase is not substantially different in magnitude from the strong signal.

Another phase changing sequence capable of producing an echo image which alternates from line to line in time sequence, is illustrated in Fig. 7 (*c*). Here the phase of the carrier is reversed after alternate synchronizing or blanking pulses, i. e., after every second pulse. Thus, at t_1, the end of the first blanking interval, the carrier phase is reversed, but no further reversal in relative phase occurs until time t_2, which corresponds to the end of the third blanking interval, and again at t_3, the end of the fifth blanking interval, and so on. Here again the echo image will alternate from light to dark, etc., as indicated by the circled plus and minus signs.

In Fig. 7 (*d*) the carrier phase is reversed for alternate video (line) periods, the phase reversals taking place at times t_1, t_2, t_3, etc., as indicated. It will be seen that this procedure will also produce an alternating echo similar to those produced by the signals of Fig. 7 (*b*) to (*e*) inclusive. In all of these variations, it should be understood that the phase changes are not necessarily made precisely at the beginning and/or end of the blanking periods, but may be effected within the blanking periods, as illustrated in Fig. 7 (*e*), or may coincide with the beginning and/or end of the synchronizing pulses themselves. Similarly, it should be understood that the invention is not limited to the specific methods of echo cancellation illustrated in Fig. 7, since other suitable sequences of phase reversal may be utilized by those skilled in the art without departing from the methods and teachings of this invention.

From the illustrations of Fig. 7, it will be seen that the carrier phase is preferably reversed at least

$$\frac{LF}{2}$$

times per second, where L is the number of picture lines per frame and F is the number of complete frames transmitted per second.

Our invention may be put into effect by means of the transmitting system shown diagrammatically in Fig. 8. For purposes of explanation, an alternate carrier type of television system has been selected, but it will be understood that the present invention is likewise adapted for use with the more conventional fixed-frequency systems. An oscillator **19** of controllable frequency serves as the primary source of carrier signal. If desired, this source may operate at a submultiple of the desired carrier frequency, the desired carrier frequency being obtained by passing the wave from the source **19** through a suitable frequency multiplier circuit **20**. The carrier derived from the unit **20** may then be supplied to a suitable phase-reversing means **21** whose reversing operation is controlled in response to a keying signal from a source **22**. The operation and construction of the units **21** and **22** will be described in detail hereinafter. The carrier signal output of the unit **21** may then be passed through a suitable modulated amplifier stage **23**, thence through the sesqui-side-band filter **24**, and finally to a suitable antenna or radiating system **25**.

Amplitude modulation of the carrier wave may be accomplished by means of a conventional modulator stage **26** supplied with video, synchronizing, and blanking signals from the source **27**. During the synchronizing signal intervals the frequency of the carrier wave may be shifted to provide alternate carrier transmission of the kind described in the above-mentioned copending application of Frank J. Bingley. This may be accomplished by applying synchronizing signals from the source **27**, by way of the path **28**, to the frequency shifting device **29**, which is connected to the oscillator stage **19** in such a manner as to control the frequency thereof. The frequency shifting device **29** may be of the reactance tube variety, and the circuits employed may be of the type disclosed in the copending application of David B. Smith, Serial No. 401,494, filed July 8, 1941. In the operation of a typical alternate carrier system (disregarding for the moment the functions of the units **21** and **22**), the normal carrier frequency, which is held constant during the video and blanking portions of the signal, may be established at 67.25 megacycles (to take a typical example). During the synchronizing signal intervals, this carrier frequency may be shifted to another predetermined frequency, for example, to 68.25 megacycles, and since the television receiver is designed to respond both to the frequency and to the amplitude of the carrier during the synchronizing interval, a synchronizing pulse is produced in the television receiver which is of substantially greater amplitude than that produced in a fixed frequency system under similar circumstances.

The phase reversals contemplated in the present invention may be produced in the transmitting system of Fig. 8 by means of the phase-reversing device **21** which is capable of producing a pair of waves of carrier frequency, but whose relative phases differ by substantially 180 degrees. The device **21** is further characterized by the provision of means for selecting either of these waves to the exclusion of the other, in response to a control or keying signal. This keying signal may be derived from the unit **22** which comprises the circuit means necessary for generating the proper keying signal in response to signals derived from the source **27**. Where it is desired to employ the phase reversal sequence illustrated in Fig. 7 (*b*), only the blanking signals need be supplied to the keying signal source **22** from the source **27**. The unit **22** may then be constructed and arranged to supply a keying signal comprising impulses whose duration and timing correspond to the duration and timing of every second blanking signal, i. e., to the cross-hatched signals of Fig. 7 (*b*).

The operation of the system of Fig. 8 may be most readily described with reference to the signal representation of Fig. 7 (*b*). Commencing at time t_2 transmission is carried on at the normal carrier frequency (e. g. 67.25 mc.) until the beginning of the synchronizing interval at time t_a. At time t_a, in accordance with the principles of alternate carrier transmission, the frequency of the carrier is shifted a substantial amount (e. g. to 68.25 mc.), returning to the normal carrier frequency at time t_b, the end of the synchronizing interval. At time t_3, the beginning of the third blanking interval in the illustration, the phase-reversing device **21** of Fig. 8, in response to a keying signal from unit **22**, causes a sudden reversal in the phase of the carrier. At time t_c the carrier frequency is again shifted (to 68.25 mc.), returning to normal (67.25) at time t_d. At time t_4 the carrier phase is reversed through the agency of the device **21** of Fig. 8. The cycle of events occurring during the period t_2—t_4 is repeated during the period t_4—t_6, and so on, being interrupted only during the vertical blanking period, which period is not illustrated in the signal representations of Fig. 7. It will be understood that while this periodic interruption of the phase-reversing operation is preferred, it is not necessary to the operation of the present invention.

Reference is now made to Fig. 9 in which there is shown a schematic diagram of a circuit adapted for use in the controllable phase-reversing means **21** and the keying signal source **22** of Fig. 8.

The controllable phase-reversing means **21** illustrated in Fig. 9 comprises a pair of vacuum tube amplifiers V_1 and V_2 having their input grids connected in push-pull relation to the balanced secondary winding of the carrier input transformer **30**, and their anodes connected in parallel to the interstage transformer **31**. In the operation of this circuit the tubes V_1 and V_2 are differentially biased in such a manner (to be explained in detail hereinafter) that only a selected one of the tubes is operative at any given time. If the tube V_1 is operative, the signal supplied to the transformer **18** will be in relatively reversed phase to the signal supplied in the event that tube V_2 is operative and V_1 inoperative. This follows from the fact that the grids of V_1 and V_2 are connected to opposite ends of the split secondary of transformer **30**, whereas the anodes of V_1 and V_2 are connected together and to the upper or high potential end of the primary winding of transformer **31**. Since the circuit included in the unit **21** must transfer not only the normal carrier frequency but also the shifted or synchronizing carrier frequency, it is preferred that each of the transformers **30** and **31**, as well as the output transformer **32**, be capable of transferring either carrier frequency with equal facility. Accordingly, these transformers may be suitably damped and overcoupled to provide the desired band-pass characteristic.

The keying signal unit **22** is a device for controlling the bias of tubes V_1 and V_2 of unit **21** in such a manner that a selected one of the said tubes is rendered operative while the other is rendered inoperative, or vice versa. The bias of the tubes V_1 and V_2 are controlled by the tubes V_5 and V_6 respectively, the cathode of V_1 being connected by way of the lead **33** to the cathode load **34** of the tube V_5. Similarly, the cathode of V_2 is connected by way of the lead **35** to the cathode load **36** of the tube V_6. Neither of the tubes V_5 and V_6 is here provided with a plate circuit load, their screens and anodes being connected directly to the positive high potential supply terminal B+.

The control grids of tubes V_5 and V_6 are condenser-coupled to the anode and cathode loads **37** and **38**, respectively, of the signal inverting driver tube V_4. Preferably, the anode and cathode loads **37** and **38** are substantially equal in magnitude so that the signals applied to the control grids of V_5 and V_6 will be not only opposite in phase, but equal in magnitude as well. The operation of tube V_4 may be controlled by a suitable source of control pulses represented by the rectangle **39**. To carry on the preceding description of a system for supplying a signal of the type described with reference to Fig. 7 (*b*), the device **39** may comprise a circuit adapted to be energized by the blanking signal and capable of supplying to the control grid of V_4 a signal similar to the blanking signal, but having only half the number of pulses per second. In Fig. 9 the rectangle **39** has, accordingly, been referred to as an "Alternate pulse rejector." Circuits capable of performing such a function are known to those skilled in the art, and, consequently, it is deemed unnecessary to provide herein a detailed description of this device. By way of example, however, it may be said that satisfactory devices and methods for selecting or rejecting predetermined pulses are disclosed in the F. J. Bingley Patent No. 2,171,536 (e. g., see Fig. 5), and the copending application of F. J. Bingley, Serial No. 357,179 (e. g., see Fig. 4).

Assume that the tube V_4 is normally biased substantially to plate-current cut-off (i. e. during the longer intervals t_2—t_3, t_4—t_5, etc. of Fig. 7 (*b*), but is driven substantially to plate-current saturation during the shorter intervals t_1—t_2, t_3—t_4, etc., by the pulses received from the device **39**. Under these conditions there will be established across the cathode load **36** a signal having the wave shape and polarity (phase) of the signal applied to the grid of V_4, while across the cathode load **34** there will appear a signal having like wave shape, but opposite polarity. These signals (i. e. the signals appearing at the cathodes of V_5 and V_6) may then be employed as "keying signals" to differentially render operative and inoperative tubes V_1 and V_2 in the phase reversing unit **21**, for the purpose hereinbefore described.

It has already been stated that the carrier phase reversals are preferably suspended during a portion of the vertical synchronizing intervals. This is readily accomplished through the agency of one of the signals supplied by conventional generators of standard RMA synchronizing signals. This signal is a substantially rectangular signal occurring at the rate of sixty per second, and having a duration of approximately nine line periods. The signal in question starts in synchronism with the vertical blanking pulse, but has a duration of only nine line periods, and, hence, extends about three lines beyond the end of the vertical synchronizing pulse. Its interval corresponds to the interval occupied by the equalizing pulse train of the standard RMA signal. Accordingly, this 9-line signal (which can be derived from unit **27** of Fig. 8) may be supplied to the keying signal source **22** along with the modified blanking signal supplied by the "alternate pulse rejector" **39** of Fig. 9. The signals may be added together by means of a conventional signal combining circuit, of which many varieties are well known in the art.

The relation between the blanking, synchronizing, and keying signals, the operation of tubes V_1 and V_2, and the frequency and phase changes involved in the operation of the specific embodiment illustrated and described with reference to Figs. 7 (*b*), 8, and 9, may best be understood by referring to the explanatory drawings of Fig. 10. The various functions here illustrated are all drawn against a common time axis which employs the notations t_1, t_2, etc. already used in Fig. 7 (*b*).

The first signal illustrated in Fig. 10 is the synchronizing signal which, in Fig. 8, is transferred from the source **27** to the frequency shifter **29** to produce the necessary frequency shift in the oscillator **19** to provide the desired alternate-carrier operation of the transmitter. This signal is also supplied (together with the video and blanking signals) to the modulator stage **26** to amplitude-modulate the carrier wave in the usual manner. The second signal illustrated is the blanking signal which is transferred from the source **27** to the alternate pulse rejector **39** of Fig. 9. The output of unit **39** is the third signal illustrated in Fig. 10. The keying signal derived from cathode load **36** of V_6 is denoted K. S. **36** in Fig. 10. The keying signal K. S. **34**, derived from cathode load **34** of V_5, is seen to be of similar wave form, but of opposite polarity. Signal K. S. **34**, which is applied to the cathode of V_1, renders tube V_1 inoperative during the periods t_2—t_3, t_4—t_5, etc. but operative during the periods t_1—t_2, t_3—t_4, etc., as is indicated by the cross-hatched areas in line V_1 of Fig. 10. On the other hand, signal K. S. **36** which is applied to the cathode of V_2, renders the tube V_2 inoperative during the periods t_1—t_2, t_3—t_4, etc., but operative during the periods t_2—t_3, t_4—t_5, etc., as represented by the cross-hatched areas in line V_2 of Fig. 10.

The phase and frequency changes undergone by the carrier wave are illustrated in the diagrams designated "Relative phase" and "Carrier frequency," respectively. During the video (line) intervals, as well as during those portions of the blanking intervals which immediately precede and succeed the synchronizing signals, the carrier frequency is represented as being fixed at frequency f_v (e. g. 67.25 mc.). During the synchronizing signal intervals, the carrier frequency is represented as being shifted to a substantailly different frequency f_s (e. g. 68.25 mc.). This periodic carrier frequency shift is in accordance with the alternate carrier system of transmission already referred to.

During the longer intervals t_2—t_3, t_4—t_5, etc., the relative phase of the carrier may be regarded as substantiallly fixed at some arbitrary value ϕ. The phase is periodically reversed, however, and, accordingly, during the shorter intervals t_1—t_2, t_3—t_4, etc., the relative phase of the carrier is advanced to a value $\phi+180°$. Of course, it might just as well be retarded to a value $\phi-180°$. These phase shifts are effected during alternate blanking signal impulses in accordance with the echo cancellation method described with reference to Fig. 7 (*b*).

Strictly speaking, the "phase" of an alternating wave varies continuously at the rate of 360 degrees per cycle. In the present invention, however, we are not concerned with this kind of phase variation, but rather with the "phase difference" between a directly received carrier signal and an indirectly received carrier (echo) signal. It should be recognized, however, that even this "phase difference" or "differential phase" may be variable. Thus in an alternate carrier system the phase relation between the video carrier and the synchronizing signal carrier is constantly changing, and it is this continuous phase change which produces the "echo beats" and hence the "alternating echoes" described with reference to Figs. 2, 4, and 6. Consequently, in the foregoing description, and in the claims, the term "phase" or "relative phase" is employed as a measure of the kind of phase that concerns us most in the description of our invention. Thus, in the function designated "Relative phase" in Fig. 10, the regular phase progression from cycle to cycle of the R. F. carrier is ignored, as are also the less regular phase changes which may occur as a result of carrier frequency drift or variation, and only the phase reversals produced by the phase reversing means **21** of Figs. 8 and 9 are represented.

While the operation of the apparatus of Figs. 8 and 9 has been described in detail only with respect to the echo cancellation method of Fig. 7 (*b*), the foregoing example will enable one skilled in the art to put into practice other echo cancellation methods, such, for example, as those described with reference to Fig. 7 (*a*), (*c*), (*d*) and (*e*). Since methods for generating the necessary keying signals in response to the blanking and/or synchronizing signals are well known, it is not deemed necessary to refer to the details of this process. U. S. Patent No. 2,171,536, issued to F. J. Bingley, discloses certain specific methods and means for forming various types of recurrent pulses which may be adapted for use in the present invention.

The echo cancellation systems so far described may be referred to as two-phase echo cancellation systems, inasmuch as they rely for their operation upon a system of phase reversals, i. e., of successive phase changes of 180 degrees. As has already been inferred in one of the stated objects of this invention, other phase changes are likewise adapted for use in putting our invention into practice. Thus, it is readily possible to employ three- and four-phase systems of phase changing if desired. In a two-phase system, the carrier phase may be caused to change according to the order of 0°, 180°, 0°, 180°, etc. in some predetermined time sequence, as described with reference to the drawings of Fig. 7. In a three-phase system, the changes may take the order of 0°, 120°, 240°, 0°, etc. For example, in frame No. 1, the video and synchronizing signals might be transmitted without change in carrier phase relations. In frame No. 2 the carrier phase during the synchronizing intervals would be advanced (or retarded) 120° with respect to carrier phase during the video intervals. And during frame No. 3 the carrier phase during the synchronizing intervals would be advanced (or retarded) 240° with respect to carrier phase during the video intervals. This corresponds, for the three-phase case, to the two-phase case illustrated in Fig. 3. In the three-phase system of echo cancellation, three frames are required for each echo cancellation cycle, as compared to two frames for the two-phase system. In the three-phase system, it is, therefore, particularly advantageous to interlace the echo in both time and space relation, as in Figs. 5 and 6, to eliminate the occurrence of an objectionable 10 cycle echo flicker.

Reference is now made to Fig. 11 in which a three-phase circuit is shown which is capable of interlacing an echo in both time and space relation. As will be apparent the circuit of Fig. 11 represents the circuit of Fig. 9 adapted to three-phase operation. It will be understood that in converting the system of Fig. 8 from a two-phase to a three-phase system the circuits of Fig. 11 would be substituted for the rectangles denoted 21 and 22.

In Fig. 9, it will be recalled, a pair of carrier waves of opposite phase are derived from opposite ends of the center-tapped transformer 30. In the circuit of Fig. 11 the equivalent function is performed by the single-phase-three-phase converter 40. This device supplies in its output a three-phase carrier whose phases are preferably balanced to ground. Single-phase-three-phase converters which are suitable for the purposes of this invention are fully described and illustrated in Hund, "Phenomena in high-frequency systems," first edition, 1936, pages 144–146. Carrier signals of phases #1, #2 and #3 are applied respectively to the input circuits of carrier transfer tubes T_1, T_2 and T_3, whose anodes are connected to a common output circuit 31. As in Fig. 9, the operation of each of the tubes T_1, T_2, T_3, is controlled by means of corresponding control tubes T_4, T_5 and T_6. Preferably this control is of such a nature that at any one time only one of the tubes T_1, T_2 and T_3 is operative to transfer a carrier of selected phase to the common output circuit 31. The sequence of operation of the control tubes T_4, T_5 and T_6 is determined by control signals E_1, E_2 and E_3 which are applied to the input circuits of the said control tubes. Thus if a particular control signal, let us say E_1, is at the level designated "0" the corresponding carrier transfer tube T_1 will be operative, and will transfer phase #1 carrier to the output circuit 31. On the other hand when the control signal E_1 is at the level designated "X" the carrier transfer tube T_1 is rendered inoperative, and the carrier is transferred through tube T_2 or T_3, depending upon which of the latter tubes are operative. The same mode of operation holds with respect to signals E_2 and E_3, and carrier transfer tubes T_2 and T_3.

In Fig. 11 the signal "*f*" represents, for the three-phase condition of operation, what the signal *b* of Fig. 7 represents for two-phase operation. With respect to the signal *f* and to the time scale shown therewith, it will be seen that phase #1 is maintained for video and blanking alike until time t_2, at which time the phase is advanced (or retarded) by 120 electrical degrees. At the end of the blanking interval the phase is again returned to the original phase, phase #1. At time t_3 the phase is again changed, this time by 240 degrees and this condition is maintained until the end of the blanking interval, at which time the phase is again returned to the original condition, i. e. to phase #1. This cycle of events is repeated as is indicated in the diagram which appears above the signal *f*.

The above-described phase changes may be accomplished by the application of the control signals E_1, E_2 and E_3 to the control tubes T_4, T_5 and T_6 respectively. While the signal E_1 is at the operative level "O" (and the signals E_2 and E_3 at the inoperative levels x), phase #1 carrier is transferred to the output circuit 31 by way of the carrier transfer tube T_1. At time t_2, and for a time equal to the duration of the blanking signal, the tube T_1 is rendered inoperative while the tube T_2 is rendered operative through the agency of the signal E_2 and the control tube T_5. Immediately thereafter tube T_1 again becomes operative, but at time t_3 is rendered inoperative, while the tube T_3 is caused to become operative through the agency of the signal E_3 and the control tube T_6. At the end of the third illustrated blanking signal the tube T_3 is rendered inoperative, while the tube T_1 is again rendered operative. In a thirty-frame-per-second television system this cycle of events may be repeated each one-tenth of a second.

The control signals E_1, E_2 and E_3 are readily generated by means of devices which are well known in the art. The signal E_2, for example, may be provided by means of a device which, when provided with blanking signals from the transmitter's blanking signal source, will select every third one of the said blanking signals. Thus signal E_2 may be regarded as representing blanking signals Nos. 2, 5, 8, and so on, while control signal E_3 may be regarded as comprising blanking signals Nos. 3, 6, 9, and so forth. Circuits and means for producing such control signals are fully described in the aforementioned F. J. Bingley copending application and issued patent. Control signal E_1 represents the sum of control signals E_2 and E_3 (added together in a suitable combining circuit), inverted to produce the proper sequence of operation of control tube T_4.

In conventional television transmission systems it is customary to employ a raster having an odd number of lines, for example 525 lines. In the three-phase system just described it is desirable that, in order to proceed with an uninterrupted phase-changing sequence, the total number of lines per frame be not divisible by the numeral 3. Thus a 605-line raster would be acceptable in a three-phase echo-cancellation system, since 605 is an odd number not divisible by 3. The present invention however is not to be limited, for the three-phase case, to a raster having an odd number of lines not divisible by 3, inasmuch as it is always possible to control the "phase" of the echo image by advancing (or retarding), by one line and blanking period, the sequence of operation of the control tubes T_4, T_5 and T_6 at the beginning of each frame. This would be done so that a given "black" echo would occupy the same position, on a given line, only once during a period of three frames.

Thus far our invention has been described with particular reference to television transmission systems in which the video signal is transmitted by amplitude modulating the carrier. The invention is also adapted for use, however, in systems wherein the video signal is transmitted by frequency modulating the carrier. In fact, because of the particularly obnoxious appearance of the echo images in FM television transmission systems, some means for eliminating or cancelling echoes is especially to be desired.

In FM systems the widths of the echo bars are not fixed as they are in an alternate carrier AM system (e. g. see Figs. 4 and 6). Instead they vary in width from time to time in accordance with the changing illumination of the picture in the screen area affected by the echo. This is because in an FM television system the instantaneous carrier frequency is a function of illumination, and, consequently, the number of beats (which produce the echo bars) between the delayed synchronizing signal (i. e. the echo) and the received picture signal varies with picture illumination. Thus, as the illumination of the picture varies in a given area—e. g. as caused by the movement of actors or vehicles, or by movement of the television camera—the echo will present an ever-varying and moving image, which because of its motion is much more objectionable to the observer than the motionless or fixed echoes encountered in AM systems of television. The present invention can greatly reduce the effect of these echoes in spite of their movement, because in general this movement (of the echo over the screen) takes place slowly enough so that between identical lines in successive frames there is sufficient similarity as to echo image position to enable an alternating dark-and-light echo in one frame to be replaced by a substantially correspondingly-placed alternating light-and-dark echo in the immediately following frame. Thus, it will be seen that our invention is adapted not only to systems wherein the echo produces a substantially fixed pattern upon the picture tube screen, but also to systems in which the echo pattern, while varying substantially from minute to minute, or second to second, changes only slightly, or to a negligible degree, from frame to frame.

Although our invention has been described and illustrated with reference to certain preferred embodiments, it should be understood that wide alterations and modifications may be made within the scope of this invention as defined in the appended claims.

We claim:

1. In a carrier wave television transmission system, the method of reducing the deleterious effects of echo signals on the desired signal, which comprises periodically altering the relative carrier phase of selected carrier intervals to produce echo images of contrasting characteristics in successive frames.

2. In a carrier wave television transmission system, the method of substantially diminishing the deleterious effects of synchronizing signal echoes on the desired picture signals, which comprises periodically changing the phase of the synchronizing signal carrier relative to the phase of the video signal carrier to produce echo images of periodically changing characteristics.

3. In a carrier wave television transmission system wherein video signals are transmitted at one carrier frequency and synchronizing signals are transmitted either at the same carrier frequency or at a different carrier frequency, the method of reducing the deleterious effects of beats between the desired video signals and echoes of the synchronizing signals, which comprises periodically changing the phase of the synchronizing signal carrier relative to the phase of the video signal carrier.

4. In an alternate carrier television transmission system wherein video signals are transmitted at one carrier frequency and synchronizing signals are transmitted at a different carrier frequency, the method of reducing the deleterious effects of carrier frequency beats between the desired video signals and echoes of the synchronizing signals, which comprises reversing the phase of said beats in successive frames of the transmitted picture.

5. In a carrier wave television transmission system, the method of reducing the deleterious effects of echo signals on the desired signal, which comprises reversing the carrier phase at least

$$\frac{LF}{2}$$

times per second in predetermined sequence prior to transmission, thereby to cause echo images of complementary characteristics to appear upon a receiver's picture viewing screen in alternating sequence, where L is the number of picture lines per frame, and F is the number of complete frames transmitted per second.

6. In a television system, the method of generating a television signal which will ensure substantially echo-free reception, which comprises generating a carrier wave, periodically altering the relative phase of said wave in a predetermined time sequence, and modulating said wave in accordance with the intelligence to be transmitted.

7. In a television system, the method of generating a television signal which will ensure substantially echo-free reception, which comprises generating a first carrier wave, generating a second carrier wave of like frequency but of substantially opposite phase, alternately selecting one and then the other of said waves in a predetermined repetitive time sequence, and modulating the selected wave in accordance with the intelligence to be transmitted.

8. In a television system, the method of generating a television signal which will ensure substantially echo-free reception, which comprises generating a first carrier wave, generating a second carrier wave of like frequency but of opposite phase, selecting the first of said waves during even frame periods, selecting both of said waves in alternating sequence during odd frame intervals, and modulating the selected wave in accordance with the intelligence to be transmitted.

9. In a television system, the method of generating a television signal which will ensure substantially echo-free reception, which comprises generating a first carrier wave, generating a second carrier wave of like frequency but of opposite phase, selecting the first of said waves during video intervals and during even synchronizing intervals, selecting the second of said waves during odd synchronizing intervals, and modulating the selected wave in accordance with the intelligence to be transmitted.

10. In a carrier wave television transmission system, the method of reducing the deleterious effects of synchronizing signal echoes on the video signal, which comprises reversing the phase of the transmitted carrier wave before and after every second line-synchronizing pulse in the picture interval.

11. In a carrier wave television transmission system, the method of reducing the deleterious effects of synchronizing signal echoes on the video signal, which comprises reversing the phase of the transmitted carrier wave after every second line-synchronizing pulse in the picture interval.

12. In a carrier wave television transmission system, the method of reducing the deleterious effects of synchronizing signal echoes on the video signal, which comprises reversing the phase of the transmitted carrier wave before and after every second video line period in the picture interval.

13. In a carrier wave television transmission system, the method of substantially diminishing the deleterious effects of synchronizing signal echoes on picture signals, which comprises changing, in a predetermined time sequence, the differential carrier phase between horizontal synchronizing signals and the succeeding line signals.

14. In a carrier wave television transmission system, the method of substantially diminishing the deleterious effects of synchronizing signal echoes on picture signals, which comprises re-

versing, in a predetermined time sequence, the differential carrier phase between horizontal synchronizing signals and the succeeding line signals.

15. In a carrier wave television transmission system, the method of substantially diminishing the deleterious effects of synchronizing signal echoes on picture signals, which comprises changing, in a predetermined time sequence, the differential carrier phase between horizontal synchronizing signals and the succeeding line signals, said differential carrier phase changes being of such magnitude that a small integral number of them produce a phase rotation of substantially 360 degrees.

16. In a carrier wave television transmission system, the method of substantially diminishing the deleterious effects of synchronizing signal echoes on picture signals, which comprises periodically changing the differential carrier phase between the line synchronizing signals and the succeeding line signals, and interrupting said periodic differential carrier phase changes during vertical synchronizing signal periods.

17. In a carrier wave television transmission system wherein the transmitted signal includes video line periods, horizontal synchronizing signal periods, and horizontal blanking signal periods immediately preceding and succeeding said synchronizing signal periods, the method of substantially diminishing the deleterious effects of synchronizing signal echoes on picture signals, which comprises changing, in a predetermined time sequence, the differential carrier phase between selected horizontal synchronizing signals and the succeeding line signals, said changes being effected during selected horizontal blanking signal periods.

18. In a carrier wave television transmission system in which synchronizing and picture signals are transmitted at dissimilar carrier frequencies, the method of effectively eliminating the echo images produced by the beating of the picture signal with echoes of the preceding synchronizing signal, which comprises periodically reversing the differential carrier phase between preselected synchronizing signals and picture signals, the periodicity selected being such that pairs of complementary echo images are produced upon the viewing screen at the receiver within time intervals substantially equal to that of the persistence of vision.

19. In a 30-frame-per-second television transmission system, the method claimed in claim 18, wherein pairs of complementary echo images are produced each fifteenth of a second.

20. In a television transmitting system including a source of carrier wave oscillations, apparatus for reducing the deleterious effects of echo signals on the desired signal, comprising controllable means for periodically shifting the relative phase of said oscillations in response to a control signal, the magnitude of each phase shift being substantially $360/n$ electrical degrees, where n is a small integer other than 1, and a source of control signals connected to said phase shifting means to control the periodicity of said phase shifts.

21. A television transmitting system as claimed in claim 20, wherein the integer n is the number 2.

22. In a television transmitting system including a source of carrier wave oscillations, apparatus for reducing the deleterious effects of echo signals on the desired signal, comprising controllable means for reversing the relative phase of said oscillations in response to a control signal, means for modulating the oscillations derived from said phase reversing means in accordance with an intelligence signal, a source of synchronizing and blanking signals, a control signal source connected to and deriving signals from said second-named source, and a connection between said control signal source and said phase reversing means for effecting carrier phase reversals in accordance with a predetermined function of signals derived from said second-named source.

23. In a television transmitting system, apparatus for reducing the deleterious effects of echo signals on the desired signal, comprising means for producing carrier wave oscillations of predetermined frequency and phase, means for producing other carrier wave oscillations of like frequency but of substantially different phase, controllable means connected to both of said first two means for alternately selecting one and then the other of said oscillations in response to a control signal, a source of timing signals, means for generating a control signal synchronized with said timing signals, connections for applying said control signals to said controllable means to control the operation thereof, and a transfer channel for transferring the selected oscillations to subsequent elements of the transmitting system.

24. A television transmitting system as claimed in claim 23, wherein the phase difference between the carrier wave oscillations is substantially $360/n$ degrees, where n is a small integer other than 1.

25. In a television transmitting system including a source of carrier wave oscillations, apparatus for reducing the deleterious effects of echo signals on the desired signal, comprising means connected to said source for deriving therefrom a first carrier wave of controlled frequency and a second carrier wave of like frequency but substantially opposite phase, wave selector means responsive to a control signal for periodically selecting and transferring one and then the other of said carrier waves to a latter stage of said transmitting system, and a source of periodic control signals for timing the selective operation of said wave selector means.

26. A television transmission system as claimed in claim 25, characterized in that the signals from said control signal source are synchronized with the system's synchronizing signals.

27. A television transmission system as claimed in claim 25, characterized in that said control signals are timed to reverse, in a predetermined time sequence, the differential carrier phase between horizontal synchronizing pulses and succeeding line signals.

28. In a television transmitting system, a source of carrier wave oscillations, means for modulating said oscillations with an intelligence signal, and auxiliary means operative upon said oscillations for producing upon the viewing screen at a television receiving station an echo image of one characteristic during odd frame intervals and an echo image of a substantially complementary characteristic during even frame intervals.

29. A television transmitting system as claimed in claim 28, characterized in the provision of additional means operative upon said oscillations to produce echo images of alternating characteristics during each frame, whereby the echo is

effectively interlaced in both time and space relation.

30. In a television system, the method of transmission which comprises transmitting video signals at one predetermined carrier frequency, transmitting synchronizing signals at a substantially different carrier frequency, and reversing, in a predetermined time sequence, the differential carrier phase between selected horizontal synchronizing signals and the succeeding video signals, thereby substantially to diminish the deleterious effects of echoes of the synchronizing signals on the video signals.

31. In a television transmitting system, a source of carrier wave oscillations, frequency control means connected to said source for controlling the frequency of said oscillations in response to a control signal, means for generating a control signal and for applying said control signal to said frequency control means to establish the frequency of said oscillations at one predetermined value during video intervals and at a substantially different value during synchronizing intervals, phase control means connected to said source for controlling, in response to a timing signal, the phase of the oscillations derived from said source, a source of periodic timing signals operatively connected to said phase control means, a source of video signals, and means operative during said video intervals for amplitude-modulating said derived oscillations in accordance with the signals from said last-named source.

32. A television transmitting system as claimed in claim 31, characterized in that said periodic timing signals are synchronized with the transmitter's synchronizing signals, and are of such periodicity as to change the phase of said derived oscillations during predetermined synchronizing intervals with respect to the phase of said derived oscillations during predetermined video intervals.

33. A television transmitting system as claimed in claim 31, characterized in that said periodic timing signals are synchronized with the transmitter's synchronizing signals, and are of such periodicity as to change the phase of said derived oscillations during predetermined synchronizing intervals with respect to the phase of said derived oscillations during other predetermined synchronizing intervals.

34. In a television transmitting system including a source of carrier wave oscillations, apparatus for reducing the deleterious effects of echo signals on the desired signal, comprising phase control means connected to said source for controlling, in response to a timing signal, the phase of the oscillations derived from said source, said phase control means being constructed and arranged to produce relatively instantaneous phase shifts of substantially $360/n$ electrical degrees, where n is a small integer other than 1, and a source of periodic timing signals connected to said phase control means to control the operation thereof.

35. A television transmitting system as claimed in claim 34, wherein the integer n is the number 3.

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