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COMPLETE SPECIFICATION

Improvements in Television Apparatus

We, ZENITH RADIO CORPORATION, a corporation organized and existing under the laws of the State of Illinois, United States of America, of 6001 West Dickens Avenue, City of Chicago, County of Cook, State of Illinois, United State of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in television apparatus which produces or uses a coded television signal. In a transmitter the television signal is coded by the actuation of a coding device included in the transmitter. In a receiver the received coded television signal is decoded by the actuation of a decoding device included in the receiver. Herein the term "television apparatus" implies either a transmitter or a receiver. For the sake of simplicity the term "coding device" is used herein as including either the coding device of the transmitter or the decoding device of the receiver.

The object of the invention is to provide a television apparatus which produces or uses a television signal which is coded with a high degree of complexity.

The invention consists in a television apparatus having a coding device which is actuable into at least two operating conditions, each of which establishes a different operating mode in said apparatus, characterized in that the actuation of said coding device from one operating condition to another is occasioned by a control signal produced by a control mechanism upon the completion of a sequence of operating steps, said control mechanism being responsive to the establishment of a predetermined operating condition within any such sequence for interrupting such sequence and initiating another sequence of operating steps.

The invention also consists in a television apparatus having a coding device which is actuable into at least two operating conditions, each of which establishes a different operating mode in said apparatus characterized in that actuation of the coding device is effected by a pulse counting mechanism upon the registration by said mechanism of a predetermined count of pulses applied thereto, while a reference count registration by said mechanism of the pulses applied thereto is established by a pulse responsive reset circuit to which a means applies reset pulses with a timing that varies in accordance with a coding schedule.

The invention further consists in a television apparatus which translates a television signal having a series of line-trace intervals arranged in successive groups such as image frames and which includes a coding device which is actuable into at least two operating conditions each of which establishes a different operating mode in said apparatus characterized in that said coding device is actuated by a control signal produced by a control mechanism upon the completion of a sequence of operating steps, where the number of such operating steps in the sequence is non-integrally related to the number of line-trace intervals per group.

Referring now to the accompanying drawings:—

Figure 1 is a schematic representation of a television transmitter in accordance with one embodiment of the invention.

Figures 2 and 3 show various curves used in explaining the operation of the transmitter of Figure 1, the curves in Figure 3 being shown on a reduced horizontal (time) scale as compared to the curves in Figure 2.

Figure 4 is a detailed representation of a pulse counting mechanism included in the transmitter of Figure 1,

Figure 5 shows a combined counter and pulse modifying unit included in the transmitter of Figure 1,

Figure 6 shows various curves employed in explaining the operation of the unit shown in Figure 5,

Figure 7 represents a television receiver for operation in conjunction with the transmitter of Figure 1,

Figure 8 represents a portion of a transmitter in accordance with another embodiment of the invention,

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Figure 9 shows a number of curves depicting certain operating characteristics of the transmitter of Figure 8.

Figure 10 is a circuit diagram of one of the components of the transmitter of Figure 8,

Figure 11 is a schematic diagram of a portion of a receiver for utilizing the signal emitted by a transmitter according to Figure 8,

Figure 12 is a schematic representation of a television transmitter constructed in accordance with a still further embodiment of the invention,

Figure 13 shows a number of curves used in explaining the operation of one feature of the transmitter of Figure 12, and

Figure 14 represents a television receiver for operating in conjunction with the transmitter of Figure 12.

The transmitter of Figure 1 includes a picture-converting device 10 which may be an iconoscope, image orthicon or any other known device for deriving a video signal representing an image to be televised. The output terminals of picture converting device 10 are connected to a video amplifier 11 which, in turn, is connected to a video-delay line and switch unit 12. Unit 12 comprises a beam deflection tube having at least two target elements to which video amplifier 11 may be selectively coupled in accordance with the deflected position of the beam. A time-delay network is connected in cascade with only one of the target elements so that when the beam is incident upon that target a delay is introduced into the video channel, otherwise it is not. A third target element with a time-delay network of different value may be included in the unit 12 to produce a third operating condition. A control signal applied to the deflection elements of the beam tube determines whether or not the delay network is functionally included in the video channel of the transmitter. The output terminals of unit 12 are connected to a mixer amplifier 13 having output terminals coupled through a direct-current inserter 14 to a carrier-wave generator and modulator unit 15, the output terminals of which are connected to a suitable antenna circuit 16, 17.

The transmitter further includes a synchronizing and pedestal signal generator 18 connected to mixer amplifier 13 to supply line- and field-synchronizing pulses and associated pedestal pulses thereto. Generator 18 also supplies line-drive pulses to a line-sweep unit 20 and field-drive pulses to a field-sweep unit 21 to synchronize the operation of these systems in well-known fashion. The output terminals of units 20 and 21 are connected to line-deflection elements 22 and field-deflection elements 23 associated with picture converting device 10.

Generator 18 additionally supplies line-drive pulses to a pulse counting mechanism 24 which, as shown within the dotted outline identified by that numeral, comprises a series of binary counters 25—28, and a feed back path 29 extending from counter 28 to counter 25. The output terminals of counter 28 are connected to a counter and pulse modifying units 30 which, in turn, is connected to the deflection elements of video-delay line and switch unit 12 by leads 31. As the dotted line marked with the numeral 24 indicates, the pulse counting mechanism includes the counters 25—28 and the counter within unit 30. Generator 18 supplies field-drive pulses to a random frequency divider 32, the output terminals of which are connected to a multivibrator 33 which, in turn, is connected to a key-signal generator 34. One pair of output terminals of the key-signal generator is connected to a line circuit 35 which extends to the various receivers, while another pair of output terminals is connected to unit 30 by leads 36.

Generator 18 further supplies line-drive pulses to a delay line 37 connected through a gate circuit 38 to the input circuit of the pulse counting mechanism 24 for reset purposes as will be explained hereinafter. Generator 18 also supplies field-drive pulses to two delay lines, viz:—delay 39 connected to gate circuit 38 through a differentiating circuit 40 and a delay line 41 connected to pulse counting unit 30 through a differentiator and clipper unit 42.

In the operation of the transmitter, picture-converting device 10 develops video-frequency components representing the image intelligence of a program to be televised. These components are amplified in video amplifier 11 and supplied to mixer amplifier 13 through video-delay line and switch unit 12. Unit 12 selectively delays the video components supplied to the mixer amplifier 13 under control of the control signal applied thereto over leads 31 from unit 30. The video components are combined in the mixer amplifier 13 with the synchronizing and pedestal components from generator 18. The resulting television signal is adjusted as to back-ground level in D—C inserter 14, modulated on a picture carrier in unit 15, and radiated to the receivers over antennas 16 and 17. The application of a control signal to unit 12 causes the radiated television signal to be effectively coded since the video components thereof do not have an invariable timing with respect to the synchronizing components. Rather, their time relation is varied in accordance with a coding schedule represented by the control signal applied to the deflection elements of unit 12 to deflect the beam thereof from one to the other of its target elements.

In a manner to be described in detail hereinafter, pulse counting mechanism 24 registers predetermined pulse counts in response to the recurring line-drive pulses from generator 18 and supplies to unit 30 a first control signal having characteristic variations determined by such pulse counts. Unit 30 utilizes the

first control signal to supply a second control signal to video-delay line and switch unit 12 over leads 31.

The operation of pulse counting mechanism 24 and its reset arrangement as well as unit 30 may best be understood by reference to the curves of Figures 2 and 3. In these curves the horizontal distance X corresponds to a field retrace interval and the horizontal distance Y to a field trace interval. In Figure 2, the field retrace interval is indicated by X and the field trace interval is indicated by Y. Line-drive pulses from generator 18, shown in curve 2A, are supplied with negative polarity to the input circuit of counter 25 which, in accordance with well-established principles of binary counters, effects a 2:1 frequency division and develops the signal shown in curve 2B, which signal, however includes occasional double pulses, as shown. The output signal from counter 25 is applied to counter 26 which is actuated by each negative excursion of the applied signal and thereby produces the signal of source 2C. In like manner, the output signal from counter 26 triggers counter 27 causing it to ~~generate~~ the signal of curve 2D. Counter 27, in turn, actuates counter 28 to generate the signal of curve 2E. Due to the fact that there are four counters in the illustrated arrangement, the normal count or frequency division is 16:1, that is, the signal of curve 2E normally has a negative excursion corresponding to every sixteenth line-drive pulse of curve 2A. However, due to the feed-back connection 29, the count of pulses applied to mechanism 24 is 15:1. The use of a feed-back connection to establish an odd count is a well known practice and a detailed description thereof is deemed to be unnecessary. Briefly, the feed-back connection 29 is so arranged that a positive excursion of the feed-back signal (curve 2E) affects counter 25 in the same manner as an applied line-drive pulse and advances the count register one unit. This gives rise to the aforementioed double-pulse portions of curve 2B. The resulting 15:1 count is preferably in view of the composition of present-day commercial television signals in the U.S.A. in which each complete frame comprises two interlaced fields individually constituted by 525 lines. When a 15:1 count is used, the counters are always in a selected condition at the beginning of each frame; whereas if a 16:1 count were used, the operating conditions of counter 25 would alternate between two conditions at the beginning of successive frames. For reasons to become apparent, it is preferable that the counters assume the same operating condition at the beginning of each frame so that a reset pulse supplied thereto at such times has no effect on the operating condition thereof unless any of the counters should become out of step due to noise or for any other reason. Therefore, the purpose of the reset pulses is to assume that under all conditions the counters will be in a reference condition at the beginning of each frame.

Line-drive pulses are concurrently applied to delay line 37 wherein they are delayed slightly and applied to gate circuit 38. In addition, the field-drive pulses after a slight delay in delay line 39 are also applied to gate circuit 38 through a differentiating circuit 40. The positive pulse component derived at the trailing edge of the field-drive pulse in differentiator 40 opens gate 38 for a short time interval to pass any line pulse received in that interval from line 37. The delays of lines 37 and 39 are so correlated that gate circuit 38 translates a line-drive pulse corresponding to, but delayed in respect of, the first line-drive pulse following the start of each frame interval. The function of delay line 37 is to introduce such a delay that this pulse from gate circuit 38 occurs after counter 25 has been actuated by the corresponding, but undelayed, line-drive pulse delivered thereto. Gate circuit 38 is also opened at the start of the second field of each frame, but due to the shift in timing between the field-drive and line-drive pulses during the second field for interlace, no line-drive pulse arrives at the gate while it is thus open. Consequently the gate circuit admits a reset pulse to counters 25—28 shortly after the start of the first field of every frame, but at no other times. This reset pulse is shown in the curve 2F.

The counters 25—28 are constructed so that when the reset pulse is received just after the output signal of any counter has undergone a negative excursion, the reset pulse has no effect thereon. An examination of curves 2B, 2C, 2D and 2E reveals that, in normal operation, each reset pulse occurs just after a negative excursion of the output signal of each counter and thus it has no effect. However, should any of the counters 25—28 be out of step due to the influence of noise or for any other reason, the reset pulse immediately restores it to its proper operating condition. When a 15:1 count is adhered to, the counters normally tend to assume such operating conditions at the start of each frame. Thus the reset pulse is merely a precaution to assume that even in the presence of noise the counters 25—28 are in a reference condition, registering a reference or zero count.

The output signal (curve 2E) of pulse counting mechanism 24, which is referred to as the first control signal, is operated on by unit 30 to derive a second control signal for application to video-delay line and switch unit 12. Unit 30, which is to be described more particularly hereinafter, functions in one aspect as a further counter imparting another count or division to the output signal from counter 28. In the absence of a key signal on leads 36, the unit 30 effects a simple 2:1 division of the signal from counter 28 and supplies the second

control signal to video-delay line and switch unit 12, as shown in curve 2G. This signal actuates unit 12 between its two operating conditions to establish different operating modes in the transmitter. One mode prevails when the signal has its maximum value and another mode is established when that signal has its minimum value. The change from one mode to another occurs at a faster-than-field rate, specifically, after each group of 15 lines. At the same time, the field-drive pulses from generator 18 are delayed in delay line 41 and are differentiated and clipped in unit 42 to supply positive reset pulses shown in curve 2J, to the unit 30. The reset pulses occur at the beginning of each field, just after the signal (curve 2E) from counter 28 has undergone a negative amplitude excursion. As long as there is no key signal on leads 36, the reset pulses of curve 2J maintain the shown phase relation between the signal (curve 2E) from the counter 28 and the output signal (curve 2G) of the unit 30. However, whenever, a burst of key signal is present on leads 36 and for a time corresponding to the duration of such burst, the reset pulses applied to the unit 30 effect a phase reversal of the output signal of that unit.

Therefore, the video-delay line and switch unit 12 is actuated every 15 lines of each field-trace interval to provide a mode change in the transmitter; and the phase of the control signal applied to unit 12 is inverted from time to time further to complicate the coding process, as determined by the key-signal generator 34. The times of the phase inversions are indicated to receivers by bursts of key signal distributed over line circuit 35.

Preferably key-signal generator 34 is energized at random intervals and in the following manner. Field-flanking pulses are supplied to random-frequency divider 32, the output of which triggers multivibrator 33 at random times determined by this division. The multivibrator develops a pulse-modulated signal which has pulse components initiated and terminated by successive randomly-divided pulses from the frequency divider 32 and supplies that signal to the key-signal generator 34. The key-signal generator is turned on for the duration of each pulse component of a chosen polarity (positive for example) and supplies a burst of key signal to line circuit 35 and unit 30 for the duration of each such component.

By way of recapitulation, the curves of Figure 3 repeat certain of those shown in Figure 2 but on a reduced time scale. Curve 3J shows the reset pulses applied to unit 30 at the begining of each field-trace interval, and curve 3K shows a key-signal burst applied thereto over leads 36 from the key-signal generator. The duration of this burst corresponds substantially to an integral multiple (one or more) of the field periods. Curve 3E shows the control signal from pulse counting mechanism 24. Prior to the initiation of the key-signal burst unit 30 develops the signal of curve 3G with the illustrated phase relation in respect of the signal of curve 3E obtained from the counter 28. However, the first reset pulse of curve 3J occurring after the key-signal burst has reached full amplitude, causes the output signal of curve 3G to be inverted in phase (as shown). This inversion is maintained until the occurrence of the reset pulse immediately following the termination of the key-signal burst, the latter reset pulse re-establishing the former phase relation.

The control signal derived from unit 30 exhibits, therefore, characteristic variations in time coincidence with corresponding variations in the control signal from counter 28 applied to the unit 30. However, the control signal derived from the unit 30 additionally exhibits a further variation (such as a phase reversal) from time to time in response to the key-signal bursts from generator 34. When counters 25—28 are constructed so that the control signal applied to unit 30 has negative amplitude excursions occurring every 15 lines of each field-trace, the control signal from the unit 30 has a positive or a negative excursion occurring every 15 lines in correspondence with the excursions of the control signal from counter 28. These excursions of the control signal from the unit 30 operate unit 12 every 15 lines of each field trace so that a corresponding mode change in the operation of the transmitter ocurs at such intervals. The counters 25—28, however, need only be reset or maintained in a desired condition at intervals corresponding to several fields, and in the intervening intervals proceeds to produce precisely timed mode changes in the transmitter at a faster-than-field rate.

Figure 4 shows details of the chain of binary counters 25—28. The chain has a pair of input terminals 50 connected to generator 18 to receive the line-drive pulses. One of the terminals is grounded; the other is coupled to the anodes of a pair of electron-discharge devices 51 and 52 through networks 53, 54 and 55, 56 respectively. The anodes of those electron discharge devices are cross-connected to the respective control electrodes through respective networks 57 and 58, and are further connected to the positive terminal of a source of unidirectional potential 59 through load resistors 60 and 61. The cathodes of these electron discharge devices are connected to ground through a common resistor 62.

The chain also includes further input terminals 63 connected to gate circuit 38 to derive the reset pulses therefrom. One of these terminals is grounded and the other is connected to the control electrode of electron discharge device 52 through a resistor 64, the control electrode of electron discharge device 51 being returned to ground through a resistor 65. The anode

of electron discharge device 52 is connected to one of the input terminals of counter 26 which, in turn, is similarly connected to counter 27. One of the output terminals of counter 27 is coupled to the anodes of the electron discharge devices of counter 28 in a manner similar to the input connections of counter 25, and the other output terminal is grounded. The feed-back connection 29 from counter 28 to counter 25 extends from the anode of electron discharge device 51 in counter 28 to the control electrode of electron discharge device 52 of counter 25 through an amplifier, differentiator and clipper 65. The anode of electron discharge device 52 in the counter 28 is connected to one of the output terminals 66 of the chain, the other output terminal being grounded. Output terminals 66 are connected to unit 30 as shown in Figure 1.

In considering the operation of the counter, it will be assumed initially that the mechanism is registering a zero or reference count in which condition electron discharge device 51 of each counter is cut-off and electron discharge device 52 thereof is highly conductive. The negative-polarity line-drive pulses (curve 2A) applied to input terminals 50 trigger counter 25, that is, sucessive pulses reverse the conductive state of its electron discharge devices 51 and 52 causing it to generate the wave form of curve 2B. The negative excursions of the output signal of counter 25 are similarly effective in triggering counter 26 so that a frequency division or count is achieved and counter 26 generates the wave of curve 2C. The output signal of counter 26 in like manner causes counter 27 to develope the wave of curve 2D which, in turn, causes counter 28 to generate the wave of curve 2E, utilized as the first control signal and supplied to output terminals 66 for application to unit 30. During normal operation of the counters 25—28, each counter is in its aforedescribed reference condition at the beginning of each frame period and thus during the occurrence of each reset pulse of curve 2F. These reset pulses are of positive polarity and are applied to control electrodes of the conductive electron discharge device of the counters and have no effect. If for any reason any counter becomes out of step so that its electron discharge device 52 is non-conductive when the reset pulse arrives, the reset pulse immediately triggers that counter back to its proper condition. Moreover, a negative pulse is applied to the control electrode of electron discharge device 52 in counter 25 from counter 28 by virtue of the feed-back circuit just after the sixteenth count so that, in well-known manner the counters 25—28 count 15 instead of 16 insofar as the line-drive pulses are concerned.

In this fashion, counters 25—28 respond to a predetermined operating condition established by the reset pulses of curve 2F for registering a reference count, and are effective upon the registration of predetermined pulse counts to effect actuation of video-delay line and switch unit 12 from one to another of its operating conditions. The actuation of unit 12 is at a faster-than-field rate, occurring in the illustrated embodiment every fifteen lines of each field, while the reset pulses occur every second field to establish and maintain a point of reference for the count. Obviously, any other count register may be adopted to change the operating mode of the transmitter.

Unit 30 is illustrated in Figure 5. It has a pair of input terminals 70 connected to key-signal generator 34 over leads 36 to receive bursts of key-signal. One of the terminals is grounded and the other is coupled to the control electrode 71 of an amplifier 72 through a coupling capacitor 73, the control electrode being connected to ground through a grid-leak resistor 74. The cathode 75 of electron-discharge device 72 is connected to ground through a resistor 76 and the anode 77 is connected to the positive terminal B+ of a source of unidirectional potential through the primary winding 78 of a transformer 79, the negative terminal of this source being connected to ground. One side of the secondary winding 80 of transformer 79 is connected to ground, and the other side of the secondary is connected to the control electrode 81 of an electron-discharge device 82 through a rectifier 83 and a series resistor 84. The junction of the rectifier and series resistor is connected to ground through a resistor 100 shunted by a capacitor 101. The cathode 85 of electron-discharge device 82 is connected to ground through a resistor 86 shunted by a capacitor 87 and is also connected to the positive terminal of a source of unidirectional potential 88 through a resistor 89. The anode 90 of electron-discharge device 82 is connected to the anode of an electron-discharge device 91 which in conjunction with an electron-discharge device 92 constitutes a binary counter. The anodes 91a, 92a of electron-discharge devices 91 and 92 are connected to the positive terminal of source 88 through resistors 93 and 94 respectively, and their cathodes 91b, 92b are connected to ground.

The unit 30 further includes another pair of input terminals 95 connected to counter 28, one of these terminals being grounded and the other being connected to the anodes of electron-discharge devices 91 and 92 through networks 113 and 114 respectively. The electron-discharge devices 91 and 92 are cross-connected and their control electrodes 91c, 92c are returned through respective grid resistors 91d, 92d to the negative terminals of a bias source C-, the positive terminals of this source being connected to ground. The anodes 91a, 92a of electron-discharge devices 91 and 92 are further connected to a pair of output terminals

137 extending to video-delay line and switch unit 12.

The ungrounded side of secondary winding 80 is also connected to the control electrode 96 of an electron-discharge device 97 through a rectifier 98 and a series resistor 99, the junction of the rectifier and series resistor being connected to ground through a resistor 102 shunted by a capacitor 103. The cathode 104 of electron-discharge device 97 is connected to ground through a resistor 105 which is shunted by a capacitor 106 and is also connected to the positive terminal of a source 107 through a resistor 108. The anode 109 of electron discharge device 97 is connected to the anode of electron-discharge device 92.

Unit 30 includes a further pair of input terminals 110 connected to differentiating circuit 42 to derive the reset pulses for the control system, one of these terminals being grounded and the other being coupled to control electrodes 81 and 96 through coupling capacitors 111 and 112 respectively.

The operation of the unit 30 may best be understood by reference to the curves of Figure 6. Whenever a burst of key-signal, as shown in the curve 6K, is impressed across terminals 70 it is amplified in amplifier 72, rectified in rectifier 83, and supplied with positive polarity to the control electrode 81 of electron-discharge device 82. The amplified burst is also rectified in rectifier 98 and applied to control electrode 96 of electron-discharge device 97 but with negative polarity. The reset pulses of curve 6J from differentiator and clipper 42 are impressed across terminals 110 and are supplied to the control electrodes 81 and 96 with positive polarity. In this manner, a composite signal comprising the positive rectified bursts of key-signal and positive reset pulses (shown in curve L and wherein the dashed line represents the cut-off level of electron-discharge device 82) is supplied to the control electrode 81 of electron-discharge device 82, whereas a composite signal comprising the negative rectified bursts of key-signal and positive reset pulses (shown in curve M and wherein the dashed line represents the cut-off level of electron-discharge device 97) is applied to the control electrode 96 of electron-discharge device 97. Due to the forced bias on the cathodes of these electron-discharge devices by sources 88 and 107, electron-discharge device 82 translates the reset pulses only during the intervals when they appear pedestalled on the positive rectified key-signal burst, whereas electron-discharge device 97 translates these pulses only during the intervals between each negative rectified key-signal burst. The reset pulses translated by electron-discharge device 82 appear across resistor 93 of electron-discharge device 91 and are shown in curve N, while the pulses translated by electron-discharge device 97 appear across resistor 94 of electron-discharge device 92 and are shown in curve P.

Electron-discharge devices 91 and 92 may be thought of as another binary counter with two stable operating conditions between which it is triggered with each negative excursion of the control signal (curve 6E) from counter 28. Therefore, if the conductive condition of the electron-discharge devices is altered intermediate two successive negative excursions of the control signal, a phase reversal of the output signal of the circuit of these electron-discharge devices is obtained. As explained previously herein, counters 25—28 receive reset pulses (curve 2F) which establish and maintain a particular phase relation of the control signal from the counter 28, as shown in curves 2E and 6E.

In the absence of key-signal bursts on leads 36, the pulses of curve P are translated by the electron-discharge device 97 and are applied to the control electrode of electron-discharge device 91. If at that instant, electron-discharge device 91 is not cut-off as it should be during normal operation for the assumed condition, the applied pulse (curve P) establishes that condition. As a consequence, the phase of the output signal from counter 91, 92 is indicated in curve 6G between the reference times t_1 and t_2.

Assume now that a burst of key-signal appears on leads 36 between the times t_1 and t_2, and that the first pulse of curve 6J to occur after the burst reaches maximum amplitude occurs immeditely after the time t_2. At this time electron-discharge device 92 is cut-off and electron-discharge device 92 is conductive due to the triggering action of the control signal (curve 6E) from counter 28. (This is the normal condition referred to immediately above). The reset pulse of curve 6J is now translated by electron-discharge device 82 to the control electrode of electron-discharge device 92 and reverses the conductive states of electron-discharge devices 91 and 92 is shown in curve 6G. This effects a phase reversal of the output signal from counter 91, 92 as compared with the phase preceding time t_2. The reversed phase condition continues until the time t_3 when the pulse of curve 6P succeeding the termination of the key-signal burst again introduces a phase change restoring the condition preceding the time t_2.

In this manner, the control signal (curve 6E) from counter 28 causes the unit 30 to supply a second control signal or actuating signal (curve 6G) to video-delay line and switch unit 12. The second control signal has a selected phase relative to the first control signal when no key-signal burst is impressed across terminals 70, but has an inverted phase in response to the reception of such a key-signal burst. The reversals of phase of the actuating signal applied to the video-delay line and switch unit 12 are determined by the first pulse of curve 6J following the initia-

tion and termination of each key-signal burst.

The receiver of Figure 7, which may utilize the telecast from the transmitter of Figure 1, includes a radio-frequency amplifier 115 having input terminals connected to an antenna circuit 116, 117 and output terminals connected to a first detector 118. The first detector is connected through an intermediate-frequency amplifier 119 to a second detector 120 which, in turn, is connected to a video amplifier 121. The video amplifier is coupled through a video-delay line and switch unit 122 to the input electrodes 123 of a cathode-ray image-reproducing device 124. Video-delay line and switch unit 122 may be similar in construction to unit 12 (Figure 1) utilized at the transmitter, but connected in a reverse manner so that when transmitter unit 12 is in a "delay" condition receiver unit 122 is in an "undelayed" condition and *vica versa*. Second detector 120 is also connected to a synchronizing-signal separator 125 which, in turn, is connected to a field-sweep unit 126 and line-sweep unit 127. The sweep units 126 and 127 are connected respectively to the field-deflection elements 128 and line-deflection elements 129 of electron-discharge device 124.

Field-sweep unit 126 is connected through a delay line 130 and a differentiator circuit 131 to a mixer 132, Line-sweep unit 127 is connected throrugh the mixer 132 to a pulse counting mechanism 133, and the output terminals of the counter are connected to a counter and pulse modifying unit 134 which may be generally similar to unit 30 of the transmitter. Field-sweep unit 126 is also connected through a delay line 135 to a differentiator and clipper unit 136 having output terminals connected to the unit 134.

The television signal from the transmitter of Figure 1 is intercepted by antenna circuit 116, 117, amplified in radio-frequency amplifier 115 and heterodyned to the selected intermediate frequency of the receiver in first detector 118. The resulting intermediate-frequency signal is amplified in intermediate-frequency amplifier 119 and detected in second detector 120 to produce a composite video signal. The video signal is amplified in amplifier 121 and supplied to the input electrodes 123 of reproducing device 124 through video delay-line and switch unit 122. The synchronizing components of the television signal are separated in separator 125 and supplied to sweep units 126 and 127 in order that the field- and line-scansions of reproducing device 124 may be controlled in synchronism with the incoming signal.

Line-synchronizing pulses are derived from line-sweep unit 127 and supplied to pulse counting mechanism 133 through mixer 132. The pulse counting mechanism 133 may comprise a simple multivibrator type frequency divider which in the illustrated embodiment has a 15:1 division rate in respect of the line pulses applied to the input terminals thereof. Pulse counting mechanism 133 supplies a first control signal to unit 134 similar to the signal of curve 2E supplied to unit 30 at the transmitter.

Field-blanking pulses derived from field-sweep unit 126 are delayed in delay line 130, differentiated in differentiating circuit 131 and supplied to mixer 132. The delay of line 130 is such that the positive-polarity components of the differentiated pulse from circuit 131 and supplied to mixer 132. The delay of line 130 is such that the positive-polarity components of the differentiated pulse from circuit 131 occur in time coincidence with the first line-synchronizing pulse of the first field of each frame of the received signal. As a result of this coincidence pulse counting mechanism 133 is returned to a reference or zero count no matter what condition it might be in at that time. In this manner pulse counting mechanism 133 is established at a reference count at the beginning of the first field of each frame with the like establishment of counters 25—28 at the transmitter. The technique of delay and differentiation prevents the first line-synchronizing pulse of the second or interlaced field of each frame from occurring in time coincidence with the differentiated field pulse.

Of course, a counting mechanism may be used for unit 133 that is identical in construction to counter 24 at the transmitter. Obvious circuit changes would have to be made to provide corresponding associated circuitry. Unit 122 is controlled to operate in a complementary fashion to unit 12. When coding device 12 imparts a delay to the video signal, decoder 122 transmits the video signal with no appreciable time delay. Similarly, when coder 12 is in the "no delay" operating condition, decoding device 122 introduces a delay in the video channel. This establishes the same constant and unvarying time delay between the video and line-synchronizing components effectively to unscramble or decode the picture.

The field-blanking pulses are similarly delayed in delay line 135, and differentiated and clipped in circuit 136 to supply a pulse to unit 134 at the beginning of each field, these pulses occurring in time coincidence with the reset pulses of curve 2J applied to the unit 30 at the transmitter. They key-signal bursts from the transmitter are received over line circuit 35 and are also applied to the unit 134. In like manner to that at the transmitter, unit 134 develops a second control signal (similar to that developed by the unit 30 at the transmitter) and under the control of the first control signal from pulse counting mechanism 133. During the absence of key-signal bursts, a selected phase relation is maintained between the second control signal from unit 134 and the first control signal from the pulse count-

ing mechanism 133 by the reset pulses from circuit 136 and, during the presence of a key signal burst, an inverted phase is maintained between these two signals by the reset pulses. Consequently, each time the video-delay line and switch unit 12 at the transmitter is actuated to change the timing between the video and synchronizing components of the television signal, video-delay line and switch unit 122 at the receiver is also actuated to compensate for such variations.

In the transmitter shown in Figure 8 additional coding is effected by varying the timing of the reset pulses applied to the pulse counting mechanism in accordance with a coding schedule, which schedule is disseminated to receivers in any appropriate manner. More specifically, synchronizing-signal generator 18 is connected to a multivibrator 150 which in turn is connected to a gate circuit 151 having input terminals coupled to D—C inserter 14 and output terminals connected to a selector 152. Multivibrator 150 is also coupled to a further multivibrator 153 which has output terminals connected to a gate circuit 154. The gate circuit 154 has input terminals connected to the D—C inserter 14 and output terminals connected to selector 152. The selector 152 has further input terminals connected to the junction of multivibrator 33 and key-signal generator 34, and output terminals connected through a delay circuit 155 and shaper 156 to a mixer 157. The mixer 157 is connected to generator 18 to receive line-drive pulses therefrom and has output terminals connected to a pulse counting mechanism 158. The pulse counting mechanism has further input terminals connected to generator 18 to receive field-drive pulses and has output terminals connected to video-delay line and switch unit 12 by leads 159. The transmitter also includes a pair of key-signal generators 160 and 161 having input terminals connected respectively to the output terminals of gate circuit 151 and gate circuit 154, and output terminals connected through a delay line 162 to D—C inserter 14.

The operation of this transmitter may best be understood by reference to the curves of Figure 9 wherein curve 9R represents a portion of the television signal translated by D—C inserter 14 including those components occurring during a field-retrace interval and the beginning of a succeeding field trace interval. These components comprise equalizer pulses 192, a serrated field-synchronizing component 193, further equalizer pulses 194 and line-synchronizing pulses 195, all pedestalled on a field-blanking pulse 196; and additional line-synchronizing pulses 197 pedestalled on individual line-blanking pulses.

The positive-polarity signal of curve 9S is derived from generator 18 during field retrace and is normally used in standard television transmitters to gate in the equalizing and serrated field-synchronizing components 192, 193 and 194. In accordance with the present invention, this signal is additionally applied to multivibrator 150 which is triggered by the trailing edge thereof to generate the pulse of curve 9T having a duration determined by the operating cycle of the multivibrator. The trailing edge of this pulse from multivibrator 105 triggers multivibrator 153 to generate the pulse of curve 9U having a duration determined by the operating cycle of multivibrator 153. The output pulse from multivibrator 150 is delivered to gate circuit 151 while the output pulse from multivibrator 153 is supplied to gate circuit 154. The operating cycles and actuation times of multivibrators 150 and 153 are so adjusted that gate circuit 151 is opened to pass the first line-synchronizing pulse of series 195 to selector 152, as shown in curve 9V, whereas gate circuit 154 selects the second line-synchronizing pulse from series 195 for application to selector 152 as shown in curve 9W. The pulses of curves 9V and 9W are also employed, respectively, to turn on key-signal generators 160 and 161 to generate bursts of key signal corresponding in time and duration to such pulses. The key-signal generators have different operating frequencies to facilitate separating the key-signal bursts which are delayed slightly by delay line 162 and supplied to D—C inserter 14. They are delayed so that when added to the television signal they are impressed on blanking pedestal 196 of curve 9R immediately following the corresponding line-synchronizing pulses and, in each instance, occur before the next succeeding line-synchronizing pulse. (This has not been illustrated in curve 9R because the curve is more readily understood in the absence of this additional information).

Selector 152 may conveniently comprise two electron-discharge devices feeding into a common output circuit but having individual input circuits respectively coupled to gate circuits 151, 154. Moreover, these electron-discharge devices are responsive in alternation according to the actuation of multivibrator 33. The output signal of that multivibrator is pulse-modulated in a random fashion by divider 32 and thus comprises positive and negative components of random duration occurring in alternation. During intervals of the positive components one electron-discharge device of the selector 152 functions to translate the pulses admitted by gate circuit 151; and during intervals of the negative components the other electron discharge device translates the pulses admitted by gate circuit 154. From the seletcor 152, the pulses are supplied to mixer 157 through delay circuit 155 and shaper 156. The selective actuation of the electron-discharge devices in the selector 152 by multivibrator 33 is indicated to receivers by bursts of key signal from generator 34 which is turned on for the duration of

each positive (or negative) pulse component of the output signal from the multivibrator.

Line-drive pulses from generator 18 are applied to pulse counting mechanism 158 through mixer 157 and are counted thereby so that video-delay line and switch unit 12 may be actuated at a rate determined by the preselected count of the pulse counting mechanism to be described in detail hereinafter. It is sufficient for present purposes to note that the pulse counting mechanism has the general form of a frequency-dividing multivibrator and is actuated from one to the other of two stable operating conditions upon the registration of a preselected count of the line-drive pulses. A reference or zero count is established in the pulse counting mechanism from time to time as determined by the pulses delivered by selector 152 and referred to as "reset pulses". These pulses are shown in curve 9X wherein the full-line representation denotes a timing corresponding to the first line-synchronizing pulse of series 195 of curve 9R, while the broken line representation denotes a timing corresponding to the second line-synchronizing pulse of that series. One or the other pulse is effective, depending upon the condition of selector 152. The pulses are delayed in circuit 155 as shown in curve 9Y and are then translated through shaper 156 which may be any known form of pulse regenerator employed to form a pedestal pulse as shown in curve 9Z. The delay of circuit 155 is such that the pedestal obtained from shaper 156 (curve 9Z) occurs in time coincidence with the next succeeding line-drive pulse obtained from generator 18 and supplied to mixer 157. Such line-drive pulse is superposed on the pedestal, as shown in curve 9AA, and exceeds the trigger level of pulse counting mechanism 158 and returns the pulse counting mechanism to a reference or zero count regardless of its particular operating condition at that time. Therefore, during each field-retrace interval the pulse counting mechanism is returned to a reference count at times corresponding to the second or third line-synchronizing pulse of series 195 (curve 9R) depending upon the condition of selector 152. The dashed line above curve 9AA indicates the trigger level. It is apparent that multivibrators 150, 153 can be controlled so that gate circuits 151, 154 select pulses from series 195 other than the second and third, and that any such selected pulses may be used for the above-described purposes.

In other words, pulse counting mechanism 158 is returned to a reference condition after each field-trace interval but at a time determined by the reset pulses from gate circuit 151 for one operating condition of selector 152, and at a time established by the reset pulses from gate circuit 154 during the other operating condition of the selector. The resetting of pulse counting mechanism 158 varies, therefore, each time the selector is actuated from one to the other of its operating conditions, and these variations are indicated to receivers by bursts of key signal on line circuit 35. Pulse counting mechanism 158, therefore, responds to the line-drive pulses to supply an actuating signal to video-delay line and switch unit 12 having amplitude excursions occurring, for example, every fifteenth line of each field trace. To complicate the coding, the pulse counting mechanism is returned to a reference condition after each field trace but at a selected time determined by the operation of selector 152.

The pulse counting mechanism 158, shown in Figure 10, comprises a pair of electron-discharge devices 167 and 172. The anode 168 of electron-discharge device 167 is connected to the positive terminal of a source of unidirectional potential 169 through a load resistor 170 and resistor 192 and is coupled to the control electrode 171 of electron-discharge device 172 through a coupling capacitor 173. The cathodes 174 and 175 of electron-discharge devices 167 and 172 are connected to ground through a common resistor 176 shunted by a capacitor 177, while the control electrodes of these electron-discharge devices are connected to the cathodes through resistors 178 and 179 respectively. The anode 180 of electron-discharge device 172 is connected to the positive terminal of source 169 through a load resistor 181 and resistor 192, and is coupled to control electrode 166 through a capacitor 182. Cathodes 174 and 175 are also connected to the positive terminal of source 169 through a resistor 183. Anode 180 is connected to one of the output terminals 184 of the circuit while the other output terminal is connected to ground. The circuit includes a pair of input terminals 165 connected to mixer 157 to derive the line-drive pulses, one of the terminals 165 being grounded and the other connected to the junction of resistors 170 and 192. The circuit also includes a further pair of input terminals 185 connected to generator 18 to derive field-drive pulses therefrom. One terminal 185 is grounded and the other is connected to the control electrode 186 of an electron-discharge device 187. The cathode 188 of electron-discharge device 187 is connected to ground through a cathode resistor 189 shunted by a capacitor 190 and is also connected to the positive terminal of source 169 through a resistor 193. The anode 191 is connected to control electrode 166 of electron-discharge device 167.

Electron-discharge devices 167 and 172 constitute a well-known frequency-dividing multivibrator differing from the usual type only in that the cathodes of the electron-discharge devices are established at a positive potential with respect to ground by virtue of the potentiometer connection of resistors 176 and 183 Assume initially that the multivibrator has been tripped rendering electron-

discharge device 167 non-conductive and electron-discharge device 172 conductive. At this time capacitor 182 is charged to establish control electrode 166 at a more negative potential relative to cathode 174, and this charge gradually leaks off through resistor 178. Positive-polarity line-drive pulses applied across terminals 165 are delivered to the control electrodes of both electron-discharge devices 167 and 172. These pulses have no effect on electron-discharge device 172 which is conductive and have no effect on electron-discharge device 167 until the charge on capacitor 182 has reduced to a point where a line-drive pulse on control electrode 166 exceeds the trigger level of the electron-discharge device and trips the circuit to its second operating condition in which electron-discharge device 167 is conductive and electron-discharge device 172 non-conductive. The circuit parameters are so chosen that this occurs, for example, at the fifteenth line-drive pulse following the first-mentioned trip of the multivibrator.

Capacitor 173 is now charged and biases control electrode 171 more negative with respect to cathode 175, and this charge leaks off through resistor 179 sufficiently that the suceedincg fifteenth line-drive pulse returns the circuit to its first described condition. In this manner, a control signal is supplied to output terminals 184 for application to video-delay line and switch unit 12. This signal has amplitude excursions occurring each fifteenth line of each field trace period to actuate unit 12 at these times and effect changes in the mode of operation of the transmitter in the manner explained in connection with Figure 1.

As previously mentioned, the multivibrator circuit is established at a reference condition during each field-retrace interval but at a selected time that may vary from one field-retrace interval to another in a random pattern. This is achieved as follows. During field-trace intervals, electron-discharge device 187 is non-conductive due to the forced bias applied to its cathode 188 by potentiometer 189, 193 and has no effect on the circuit of electron-discharge devices 167 and 172. However, at the start of each field-retrace interval a field-drive pulse impressed on terminals 185 renders electron-discharge device 187 conductive. For the duration of the field drive pulse the control electrode 166 of electron-discharge device 167 is driven negative with respect to its cathode 174, assuming a potential corresponding substantially to the potential of cathode 188. Resistors 193 and 189 are given such values with respect to resistors 183 and 176 that the potential of cathode 188 is much less than that of cathode 174. For example, cathode 174 may have a forced bias potential of approximately thirty volts, whereas cathode 188 has a forced bias potential of two or three volts. Consequently, the circuit of electron-discharge devices 167 and 172 is established in that operating condition wherein electron-discharge device 167 is non-conductive and electron-discharge device 172 is conductive. Capacitor 182 has acquired a high negative charge so that after the termination of the field-drive pulse the circuit of electron-discharge devices 167 and 172 remains in this condition and does not respond to the immediately subsequent line-drive pulses impressed across terminals 165. Finally, however, a line-drive pulse pedestalled upon the output pulse from a shaper 156 is received from mixer 157 with an amplitude level high enough to trigger the multivibrator to its alternate operating condition. In this manner, during each field-retrace interval, the circuit of electron-discharge devices 167 and 172 is initially established in a first operating condition and is triggered to its second operating condition by the line-drive pulse combined with a pedestal pulse in mixer 157. Therefore, a fixed phase is established in the trigger circuit during each field-retrace interval but under the time control exercised by selector 152 which determines the time of occurrence of the output pulse from shaper 156.

The receiver arrangement of Figure 11 is intended to operate in conjunction with the transmitter of Figure 8. It includes a selector 200 connected to video amplifier 121 through a pair of parallel arranged key-signal filter and rectifier units 201 and 202, respectively selective to the frequency of the key signal produced by generators 160 and 161 of Figure 8. The selector 200 is further connected to line circuit 35 extending to the transmitter and has output terminals coupled to a mixer 203 through a delay line 204 and a shaper circuit 205. Mixer 203 has input terminals connected to the line-sweep unit 127 to derive line-synchronizing pulses therefrom and has output terminals connected to a pulse counting mechanism 206. Pulse counting mechanism 206 is also connected to a field-sweep unit 126 to derive field-synchronizing pulses therefrom and has output terminals connected to delay line and switch unit 122 included in the video channel of the receiver.

The bursts of key signal selected and rectified by units 201 and 202 are impressed on selector 200 which is controlled by the key-signal bursts received over line circuit 35 to translate one or the other of the rectified key signals to delay line 204 in the same manner as and in time coincidence with the application of one or the other of the pulse outputs of selector 152 at the transmitter to its associated delay line 155. The selected and translated pulses, after a delay in line 204, are shaped in circuit 205 to provide for 203 pulses that correspond to the pulses of curve 9Z at the transmitter. Pulse counting mechanism 206, which may be similar in construction to

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pulse counting mechanism 158 at the transmitter, supplies a control signal to delay line and switch unit 122 to actuate that unit in synchronism, but in a compensating sense, with respect to the actuation of unit 12 at the transmitter. During each field-retrace interval, pulse counting mechanism 206 receives a field-synchronizing pulse from field-sweep unit 126 as well as line-synchronizing pulses from line-sweep unit 127 and a pedestal pulse from shaper 205 which conjointly phase the pulse counting mechanism as described in connection with Figure 10. In this manner, the receiver compensates for the timing variations in the television signal, which variations occur during field trace intervals at intervals corresponding, for example, to every 15 lines. Moreover, the pulse counting mechanism is established at a reference count during each field-retrace interval in time coincidence with the establishing of a reference count at the transmitter as determined by the key signal received over line 35 and supplied to selector 200 which accordingly translates output pulses from unit 201 or unit 202.

The transmitter shown in Figure 12 is similar to the transmitter of Figure 1 in including the following parts:—

Picture converting device	10
Video amplifier	11
Switch unit	12
Mixer amplifier	13
D—C inserter	14
Modulator unit	15
Antenna circuit	16
Synchronizing signal generator	18
Line-sweep unit	20
Field-sweep unit	21
Pulse counting mechanism	24
Counters 25, 26, 27,	28
Counter and pulse modifying unit	30
Divider	32
Multivibrator	33
Key-signal generator	34
Line circuit	35
Delay line	37
Gate circuit	38
Delay line	39
Differentiating circuit	40
Delay line	41
Clipper unit	42

A detailed description of these parts, their connections and manner of operation is therefore unnecessary. It must be noted however that there is no feed back connection 29 in the pulse counting mechanism 24 between counters 25 and 28. The division effected by counters 25—28 is therefore 16:1 and not 15:1 as in the case of the similar counters in the transmitter of Figure 1.

Further, it will be seen that reset pulses are not directly supplied to the counters 25—28 from gate circuit 38 but that the output terminals of that circuit are connected to a multivibrator 50, as is further explained later. Since the division effected by the counters 25—28 is 16:1 the switch unit 12 is actuated every 16 line trace to provide a mode change in the transmitter. The result is that the unit 12, which is the coding device of this transmitter, effects mode changes at a rate not integrally related to the image frame repetition rate so that the counters 25—28 do not return to the same operating condition at the beginning of each frame period.

As already indicated, mode changes, in the transmitter illustrated in Figure 12, occur every 16 line trace intervals and since 16 is not evenly divisible into 525, the number of such line-intervals per frame according to standard U.S. practice, the counting mechanism is established at its 13th step at the termination of a first or initial frame period, and thus three steps must carry over to the next succeeding frame period. Therefore, whereas in the initial frame period mode changes occur at the 16th, 32nd, 48th, 64th, etc., line trace, mode changes in the second or succeeding frame are effected at the 3rd, 19th, 35th, 51st, etc., line trace. Likewise, in the third frame period mode changes occur at the 6th, 22nd, 38th, 54th, etc., line trace in the frame. Since the mode changes occur three line traces later in each succeeding frame, the picture gives the appearance or illusion of "walking", "rolling" or "moving" toward the bottom of the picture tube at an unauthorized receiver, thus rendering the image reproduction completely unintelligible.

It is possible that the counters at some of the receivers may fall out of step with the counters at the transmitter, even when supplied with the appropriate key signal, due to noise or other extraneous signals. To remedy this condition, the reset circuit is operated occasionally during a telecast to translate a signal to the counters at the transmitter and to control the application of a corresponding signal to the counters at the various receivers for resetting or "locking in" of all the counters. Specifically, in the illustrated embodiment resetting is accomplished once every 60 field-trace intervals.

The operation of this reset arrangement may best be understood by reference to the curves of Figure 13. Line-drive pulses are applied to delay line 37 wherein they are delayed slightly and applied to normally-closed gate circuit 38. In addition, delayed field-drive pulses from delay line 39 are differentiated and applied to gate circuit 38. Moreover, once every 60 field intervals, a field-drive pulse is translated to circuit 38 from divider 54. The pulse component derived at the leading edge of a delayed field-drive pulse in differentiator circuit 40 operates in conjunction with a gating pulse from divider 54 to open gate 38 for a short time interval to pass a delayed line -drive pulse received in that interval from delay line 37. The delay-

times of lines 37 and 39 are so correlated that gate circuit 38 translates a pulse corresponding to but delayed in respect of the first line-drive pulse of the series occurring during the post-equalizing pulse period of the field-retrace intervals.

A pulse from gate circuit 38 is shown in curve 13A and is applied to mono-stable multivibrator 50 to develop the pulse shown in curve 13B. This pulse, after being delayed by delay line 51 to produce the gating pulse shown in curve 13C, is applied to normally-closed gate circuit 52 to open that circuit and permit translation of a line-drive pulse (curve 13D) to the various binary counters 25—28. Such a reset pulse actuates the counters so that they all assume a reference condition, in a well-known manner.

The parameters of multivibrator 50 and delay line 51 are so chosen that the pulse of curve 13C thereby produced, overlaps in point of time only the next succeeding line-drive pulse from generator 18. Thus, at reference times t_0 recurring every 60 fields or one every second, all of the counters at the transmitter are conditioned to an initial operating step.

To facilitate the communication of the timing of these reset pulses to the receivers, the signal of curve 13B is also applied to reset-frequency generator 53 to pulse-actuate that generator and produce a reset burst as shown in curve 13E. This reset-frequency burst is applied to mixer amplifier 13 wherein the composite television signal is downward modulated by the reset signal. The wave form of a portion of the composite television signal including those components normally occurring during a field-retrace interval plus the reset burst is illustrated in curve 13F. These components comprise equalizing pulses 92, a serrated-field synchronizing component 93, further equalizing pulses 94, and line-synchronizing pulses 95, all pedestalled on a field-blanking pulse 96, and additional line-synchronizing pulses 97 pedestalled on individual line-blanking pulses. By comparing curve 13F with the other curves of Figure 13, it may be seen that delay line 37 and multivibrator 50 cooperate to produce a pulse to operate generator 53 for an interval occurring between the first and second line-drive pulses superimposed on the field-blanking pulse. With this arrangement, resetting may thus be accomplished during field-retrace intervals, and the resetting information is transmitted to the receivers along with the video signal.

The television transmitter of Figure 12 may also be modified to code the television signal in such a way that the image at an unauthorized receiver appears to be "walking" or "moving" toward the top of the picture tube rather than toward the bottom. For example, if the count is established at, say, 13:1 by modifying the counting chain in well-known manner, the counters 25—28 are established at their 5th operating step at the termination of the first or initial frame and therefore mode changes are effected at the 8th, 21st, 34th, 47th, etc., line trace in the next succeeding frame rather than at the 13th, 26th, 39th, 52nd, etc., line trace as in the first frame. Similarly, the mode changes occur at the 3rd, 16th, 29th, 42nd, etc., line trace during the next or third frame period. It should be apparent that mode changes at this rate result in the appearance or illusion at an unauthorized receiver of an image "walking" up. Obviously, any suitable count may be utilized to cause this "walking" or "rolling" effect for either upward or downward motion, and such motion may be effected at varying traveling rates determined by the relation of the count selected to the number of scanning lines constituting an image frame.

It may be stated as a general proposition that when the numbers of line traces per frame period, namely 525, is divided by the count employed (e.g. M), the remainder is an indication of the rate or speed of the "walking" or "rolling" effect. That is, if the remainder of $\frac{S}{M}$ is a number of less than half of the count (less than $\frac{M}{2}$), the image gives the appearance of "walking" up, whereas if the remainder of $\frac{S}{M}$ is a number greater than half of the count (greater than $\frac{M}{2}$), the picture appears to be "walking" down. Moreover, if the remainder is equal to exactly half of the count the picture will "walk" up during alternate frames and "walk" up down during the intervening frame periods; that is, the picture will "move" down in one frame and "move" right back up to its original position during the succeeding frame. If the count used is evenly divisible into 525, as is the case in the transmitter of Figure 1, no vertical motion is effected. It should be noted, however, that the form of the invention shown in Fig. 12 is not necessarily limited to faster-than-field coding, since any suitable count not integrally related to the number of scanning lines in an image frame may be employed.

In many respects the receiver shown in Figure 14, which is adapted to utilize the telecast from the transmitter of Figure 12, is similar to the receiver shown in Figure 7, the following parts shown in Figure 14 being the same as those shown in Figure 7.

Radio-frequency amplifier	115
Antenna circuit	116—117
1st detector	118
Intermediate frequency amplifier	119
2nd detector	120
Video amplifier	121

Switch unit	122
Picture tube electrodes	123
Image reproducing device	124
Synchronizing-signal separator	125
Field-sweep unit	126
Line-sweep unit	127
Field deflection elements	128
Line deflection elements	129
Counter and pulse modifying unit	134
Delay line	135
Differentiating and clipping circuit	136

A detailed description of these parts, their connection, and manner of operation is therefore unnecessary.

Line-synchronizing pulses are derived from sweep unit 127 and supplied to pulse counting mechanism 133 and to gate circuit 132. Pulse counting mechanism 133 may be similar to the mechanism used at the transmitter of Figure 12 or may comprise a simple multivibrator type frequency divider. In either case it must have a 16:1 division rate in respect of the line pulses applied to its input terminals. Pulse counting mechanism 133 supplies a first control signal to unit 134 similar to the signal supplied to unit 30 at the transmitter.

The composite video signal of curve 13F is derived from second detector 120 and supplied to filter and rectifier 130. The reset-frequency burst is filtered and rectified in unit 130 to form a pulse corresponding substantially to the wave form of the pulse shown in curve 13B and is applied through delay line 131 to gate circuit 132 after being delayed by an amount similar to the delay impressed by means of delay line 51 at the transmitter. A pulse of the wave form corresponding to that of curve 13C thus conditions gate circuit 132 to pass the line-synchronizing pulse as shown in curve 13D to reset pulse counting mechanism 133 to a reference time t_0 in synchronism with the reset of pulse counting mechanism 24 at the transmitter.

The field-blanking pulses are delayed by delay line 135, and differentiated and clipped in circuit 136 to supply a pulse to unit 134 at the beginning of each field, these pulses occurring in time coincidence with the reset pulses applied to the unit 30 at the transmitter. Key signal bursts from the transmitter are received over line circuit 35 and are applied to the unit 134, which develops a second control signal similar to that developed by the unit 30 at the transmitter and under the control of the first control signal from pulse counting mechanism 133. In the absence of key-signal bursts, a selected phase relation is maintained between the second control signal from unit 134 and the first control signal from the pulse counting mechanism 133 and, in the presence of a key-signal burst, an inverted phase may or may not be maintained between these two signals depending upon the instantaneous phase of the control signal from pulse counting mechanism 133 at the beginning of each frame period during the occurrence of such a key-signal burst. Consequently, each time the video-delay line and switch unit 12 at the transmitter is actuated to change the timing between the video and synchronizing components of the television signal, video-delay line and switch unit 122 at the receiver is also actuated to compensate for such variations.

Six forms of television apparatus embodying the invention have been described, three being transmitters producing a coded television signal and three receivers using a coded television signal. The three transmitters are shown in Figures 1, 8 and 12, the three receivers in Figures 7, 11 and 14.

In each one of these six television apparatuses there is a unit designated " video delay line and switch unit ". This unit is the coding device or the decoding device for the transmitter or receiver in which it is shown. In the transmitter of Figures 1, 8 and 12 this unit is identified by the numeral 12, while in the receivers of Figures 7, 11 and 14 it is identified by the numeral 122. As already explained, the term " coding device " is used in the claims to designate either the coding device of a transmitter or the decoding device of a receiver.

The " video delay line and switch unit " in each instance is actuated by a control signal from a control mechanism. In the transmitter of Figure 1 and the cooperating receiver of Figure 7, this control mechanism produces the control signal upon the completion of a sequence of operating steps and is responsive to the establishment of a predetermined operating condition within any such sequence for interrupting such sequence and initiating another sequence of operating steps.

In Figures 1 and 7 the control mechanism includes a pulse counting mechanism 24 and 133 respectively to which synchronizing components, specifically line drive pulses, are applied. The pulse counting mechanism, upon registration of a predetermined count of such components as it executes its sequence of operating steps produces the control signal in accordance with a coding schedule. The control mechanism shown in Figure 1 is identified by the numeral 24 and includes the four counters 25—28 and also a fifth counter forming part of the unit 30. Because of the feedback connection 29, the four counters 25—28 produce a 15:1 division of the pulses applied to counter 25. A similar division is effected by the pulse counting mechanism 133 of Figure 7. The unit 30 of Figure 1 and the unit 134 of Figure 7 also include a pulse modifying unit which is part of the control mechanism. This pulse modifying unit, according to a second coding schedule, modified or codes the coded control signal produced by the pulse counting mechanism.

Specifically, the modification according to the second coding schedule is a phase variation of the coded control signal produced by the pulse counting mechanism 24, 133. In the case of the transmitter shown in Figure 1, the second coding schedule is determined by the production at randomly spaced intervals by the key signal generator 34 of a signal which is not only supplied to the unit 30 but also transmitted to distant receivers by the line circuit 35. This signal is received in the receiver of Figure 7 over the line circuit 35 and supplied to the unit 134.

In both Figures 1 and 7 the predetermined operating condition of the control mechanism within any sequence of operating steps of such mechanism is effected by a reset circuit containg, in the case of the transmitter in Figure 1, the delay line 41 and the differentiator and clipper unit 42, and in the receiver of Figure 7 the delay line 135 and the differentiator and clipper unit 136.

In the transmitter of Figure 8 the pulse counting mechanism 158 produces a control signal which actuates the coding device (video delay line and switch unit 12) upon the registration by said mechanism of a predetermined count of pulses applied thereto, while a reference count registration by said mechanism of the pulses applied thereto is established by a pulse responsive reset circuit (delay line 155, shaper 156, mixer 157) to which a means (selector 152) applies reset pulses with a timing that varies in accordance with a coding schedule. In the corresponding receiver shown in Figure 11, the decoding device is the video delay line and switch unit 122, the reset circuit comprises the delay line 204, shaper 205 and mixer 203, while the timing means which applies the reset pulses is the selector 200.

In the transmitter of Figure 12 and the cooperating receiver of Figure 14 the division effected by the counters 25—28 and by the counter 133 is 16:1 in relation to a television signal using 525 lines per image frame. Consequently the control signal is produced by the counters 25—28 or counter 133 upon the completion of a sequence of operating steps with the number of steps in the sequence (viz. 16) being non-integrally related to the number of line-trace intervals per group, i.e., per image frame.

What we claim is:—

1. A television apparatus having a coding device which is actuable into at least two operating conditions, each of which establishes a different operating mode in said apparatus characterized in that the actuation of said coding device from one operating condition to another is occasioned by an electrical control signal produced by a control mechanism upon the completion of a sequence of operating steps, said control mechanism being responsive to the establishment of a predetermined operating condition within any such sequence for interrupting such sequence and initiating another sequence of operating steps.

2. A television apparatus having a coding device which is actuable into at least two operating conditions, each of which establishes a different operating mode in said apparatus characterized in that actuation of the coding device is effected by a pulse counting mechanism upon the registration by said mechanism of a predetermined count of electric pulses applied thereto, while a reference count registration by said mechanism of the pulses applied thereto is established by a pulse responsive reset circuit to which a means applies reset pulses with a timing that varies in accordance with a coding schedule.

3. A television apparatus which translates a television signal having a series of line-trace intervals arranged in sucessive groups such as image frames and which includes a coding device which is actuable into at least two operating conditions each of which establishes a different operating mode in said apparatus characterized in that said coding device is actuated by a control signal produced by a control mechanism upon the completion of a sequence of operating steps, where the number of such steps in the sequence is non-integrally related to the number of line-trace intervals per group.

4. A television apparatus according to claim 1 characterized in that the control mechanism includes a pulse counting mechanism to which synchronizing components of the television signal produced by the television apparatus are applied, such pulse counting mechanism, upon registration of a predetermined count of such components as the sequence of operating steps of the control mechanism, producing the control signal in accordance with a coding schedule.

5. A television apparatus according to claim 4 characterized in that the control mechanism also includes a pulse modifying unit to which synchronizing components of the television signal are applied during predetermined field retrace intervals and which in response to such applied components modifies, according to a second coding schedule, the coded control signal produced by the pulse counting means.

6. A television apparatus according to claim 5 characterized in that the modifying, according to the second coding schedule, of the coded control signal produced by the pulse counting mechanism is a phase variation of said signal.

7. A television apparatus according to claim 5 or 6 characterized in that the second coding schedule is determined by the production at randomly spaced intervals of a signal which is applied to the pulse modifying unit and which, in the case of a transmitter, is also transmitted to distant receivers but, in the case of a

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Specifically, the modification according to the second coding schedule is a phase variation of the coded control signal produced by the pulse counting mechanism 24, 133. In the case of the transmitter shown in Figure 1, the second coding schedule is determined by the production at randomly spaced intervals by the key signal generator 34 of a signal which is not only supplied to the unit 30 but also transmitted to distant receivers by the line circuit 35. This signal is received in the receiver of Figure 7 over the line circuit 35 and supplied to the unit 134.

In both Figures 1 and 7 the predetermined operating condition of the control mechanism within any sequence of operating steps of such mechanism is effected by a reset circuit containg, in the case of the transmitter in Figure 1, the delay line 41 and the differentiator and clipper unit 42, and in the receiver of Figure 7 the delay line 135 and the differentiator and clipper unit 136.

In the transmitter of Figure 8 the pulse counting mechanism 158 produces a control signal which actuates the coding device (video delay line and switch unit 12) upon the registration by said mechanism of a predetermined count of pulses applied thereto, while a reference count registration by said mechanism of the pulses applied thereto is established by a pulse responsive reset circuit (delay line 155, shaper 156, mixer 157) to which a means (selector 152) applies reset pulses with a timing that varies in accordance with a coding schedule. In the corresponding receiver shown in Figure 11, the decoding device is the video delay line and switch unit 122, the reset circuit comprises the delay line 204, shaper 205 and mixer 203, while the timing means which applies the reset pulses is the selector 200.

In the transmitter of Figure 12 and the cooperating receiver of Figure 14 the division effected by the counters 25—28 and by the counter 133 is 16:1 in relation to a television signal using 525 lines per image frame. Consequently the control signal is produced by the counters 25—28 or counter 133 upon the completion of a sequence of operating steps with the number of steps in the sequence (viz. 16) being non-integrally related to the number of line-trace intervals per group, i.e., per image frame.

What we claim is:—

1. A television apparatus having a coding device which is actuable into at least two operating conditions, each of which establishes a different operating mode in said apparatus characterized in that the actuation of said coding device from one operating condition to another is occasioned by an electrical control signal produced by a control mechanism upon the completion of a sequence of operating steps, said control mechanism being responsive to the establishment of a predetermined operating condition within any such sequence for interrupting such sequence and initiating another sequence of operating steps.

2. A television apparatus having a coding device which is actuable into at least two operating conditions, each of which establishes a different operating mode in said apparatus characterized in that actuation of the coding device is effected by a pulse counting mechanism upon the registration by said mechanism of a predetermined count of electric pulses applied thereto, while a reference count registration by said mechanism of the pulses applied thereto is established by a pulse responsive reset circuit to which a means applies reset pulses with a timing that varies in accordance with a coding schedule.

3. A television apparatus which translates a television signal having a series of line-trace intervals arranged in sucessive groups such as image frames and which includes a coding device which is actuable into at least two operating conditions each of which establishes a different operating mode in said apparatus characterized in that said coding device is actuated by a control signal produced by a control mechanism upon the completion of a sequence of operating steps, where the number of such steps in the sequence is non-integrally related to the number of line-trace intervals per group.

4. A television apparatus according to claim 1 characterized in that the control mechanism includes a pulse counting mechanism to which synchronizing components of the television signal produced by the television apparatus are applied, such pulse counting mechanism, upon registration of a predetermined count of such components as the sequence of operating steps of the control mechanism, producing the control signal in accordance with a coding schedule.

5. A television apparatus according to claim 4 characterized in that the control mechanism also includes a pulse modifying unit to which synchronizing components of the television signal are applied during predetermined field retrace intervals and which in response to such applied components modifies, according to a second coding schedule, the coded control signal produced by the pulse counting means.

6. A television apparatus according to claim 5 characterized in that the modifying, according to the second coding schedule, of the coded control signal produced by the pulse counting mechanism is a phase variation of said signal.

7. A television apparatus according to claim 5 or 6 characterized in that the second coding schedule is determined by the production at randomly spaced intervals of a signal which is applied to the pulse modifying unit and which, in the case of a transmitter, is also transmitted to distant receivers but, in the case of a

receiver, is a signal received from a distant transmitter.

8. A television apparatus according to any of claims 1, 4, 5, 6 or 7 characterized in that the predetermined operating condition of the control mechanism within any sequence of operating steps of such mechanism is effected by a reset circuit.

9. A television apparatus according to claim 2 having means for selecting at predetermined intervals certain ones of the synchronizing components of the television signal while the means for applying reset pulses to the reset circuit with a timing that varies in accordance with a coding schedule is a circuit which utilizes such selected components.

10. A television apparatus according to claim 9 in which the selecting means selects the certain ones of the synchronizing components during predetermined field-retrace intervals.

11. A television apparatus according to claim 3 in which the number of steps in the sequence is not only non-integrally related to but is also less than the number of line-trace intervals per group.

12. A television apparatus according to claims 1 or 11 characterized in that the control mechanism includes a pulse counting mechanism to which is supplied a series of input pulses individually corresponding to one of the line-synchronizing components of the television signal and which produces the control signal in response to the application of such pulses in a predetermined number which forms the sequence of operating steps of the control mechanism.

13. A television apparatus for translating a television signal having video components included within a recurring series of field-trace intervals characterized by a coding arrangement comprising a coding device having at least two distinct operating conditions each of which establishes a different operating mode in said system effectively to code said television signal, a cycling mechanism having a plurality of operating steps in each cycle for producing an electrical control pulse upon the completion of each cycle of operating steps; means coupling said cycling mechanism to said coding device to actuate said device from one to another of its aforesaid operating conditions in response to each control pulse; and means for effecting actuation of said cycling mechanism at a rate that is faster than the recurrence rate of said field-trace intervals to effect corresponding faster-than-field rate operation of said coding device.

14. A television apparatus according to claim 13 characterized by an electric pulse-signal source for supplying to the cycling mechanism a series of actuating pulses recurring at a rate that is faster than the recurrence rate of the field-trace intervals and individually representing one line-synchronizing component of the television signal.

15. A television apparatus according to claim 13 or 14 characterized by means for resetting the cycling mechanism at times to a predetermined reference operating step in accordance with a prescribed reset schedule.

16. A television apparatus according to claim 14 or 15 characterized in that the pulse actuted cycling mechanism is responsive to the application of a predetermined number of pulses for executing a cycle of operations having at least two operating steps, which cycling mechanism from one operating step to the next in response to another predetermined number of pulses.

17. A television apparatus for translating a television signal characterized by a coding device having at least two operating conditions each of which establishes a predetermined operating mode in said system effectively to code said television signal, a control mechanism having a sequence of operating steps for producing a control signal exhibiting a charateristic which varies between at least two predetermined values upon the completion of each sequence, means for developing a series of reset components occurring according to a predetermined code schedule, means for applying each of said reset components to said control mechanism to effect actuation thereof to a predetermined reference condition thereby modifying said control signal, and means coupling said control mechanism to said coding device to effect actuation of said device in accordance with said modified control signal.

18. A television apparatus for translating a television signal characterized by a coding device having at least two distinct operating conditions each of which establishes a different operating mode in said apparatus; a control mechanism coupled to said coding device and responsive to an applied signal for effecting actuation of said coding device between said operating conditions to code said television signal in accordance with a predetermined code schedule; means for applying a periodic signal to said control mechanism to effect said actuation of said coding device in a predetermined periodic repeating sequence; and means coupled to said control mechanism for interrupting said periodic sequence at times and effecting actuation of said coding device to a predetermined one of said operating conditions thereby to modify said code schedule.

19. A transmitter substantially as herinbefore described with reference to and as illustrated in Figures 1, 8 or 12 in the accompanying drawings.

20. A receiver substantially as herinbefore described with reference to and as illustrated in Figures 7, 11 or 14 in the accompanying drawings.



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