

June 4, 1940.

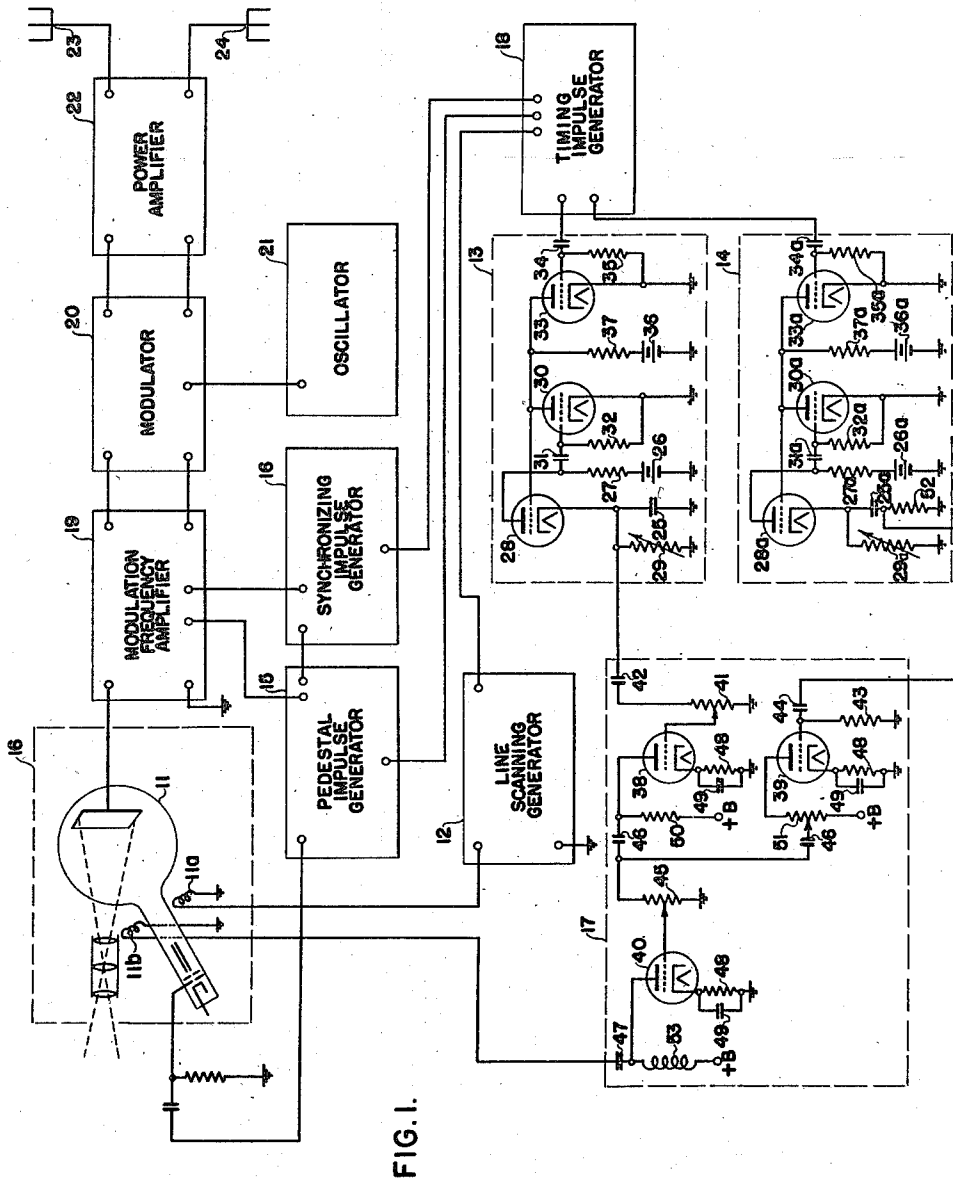
M. CAWEIN

2,203,520

TELEVISION SYSTEM

Filed Oct. 29, 1937

2 Sheets-Sheet 1



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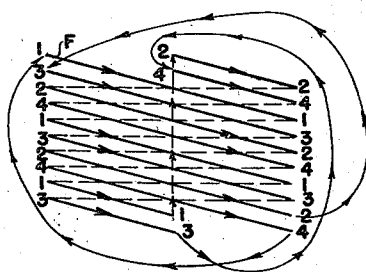
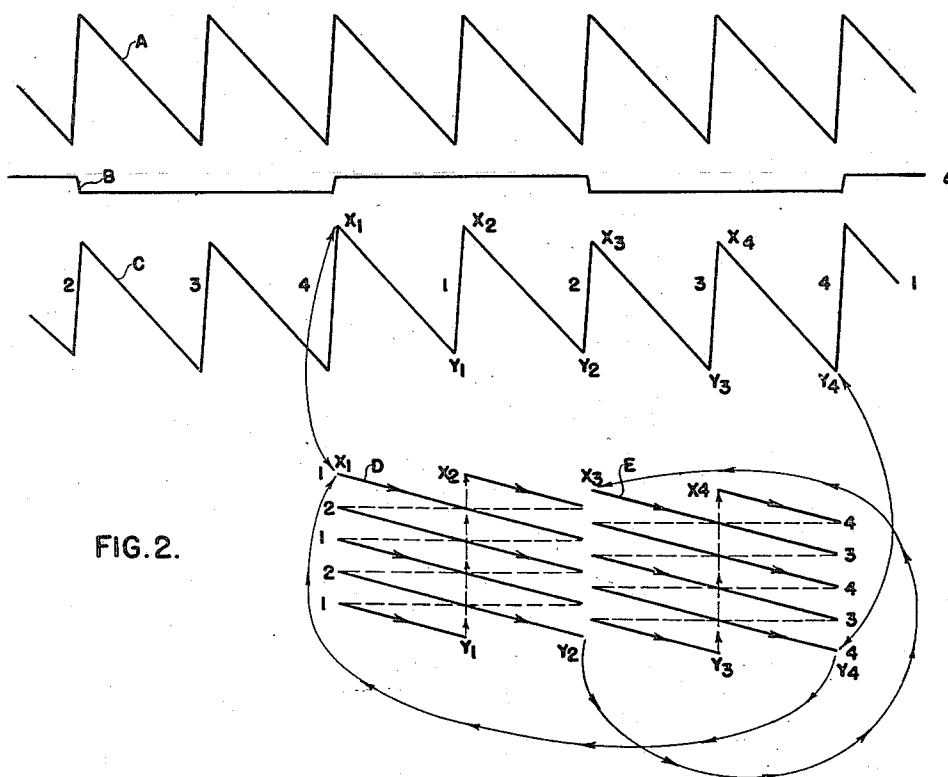
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2 Sheets-Sheet 2



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2,203,520

TELEVISION SYSTEM

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Application October 29, 1937, Serial No. 171,697

14 Claims. (Cl. 178—7.7)

This invention relates to television systems and, more particularly, to the provision of an improved method of, and means for, effecting scanning of the interlaced type.

5 Various types of scanning systems for television and similar apparatus have heretofore been designed, systems of the interlaced type having proved especially advantageous. In such systems, the beam, as, for example, the cathode ray
10 where television cathode-ray tubes are employed, is deflected in two directions normal to each other, so as to trace upon the target of the apparatus series of parallel lines, usually horizontal, forming successive fields. In conventional interlaced scanning, the field frequency is a fractional multiple of the line frequency so that the lines of one field interlace or fall between the lines of a preceding field, a plurality of successive fields thus constituting a single frame and representing a single complete image. Due to persistence of vision, the optical effect produced is as though each frame were traversed but once and comprised a multiple of the number of lines of a single field and as though the frame frequency
20 were equal to the field frequency.

The number of lines in each frame determines the resolution obtainable in a vertical direction, that is, the number of picture elements or variations in light intensity from top to bottom of the image, which may be transmitted or reproduced. Preferably, the resolution in the vertical direction should be substantially the same as in the horizontal. Since the width of the video-frequency band required for transmitting the image is determined by the number of separate picture elements scanned per second, one determining factor of this band width is the number of lines transmitted per second. Hence, the greater the number of lines per second, other factors remaining the same, the wider the video-frequency band required. Therefore, if the number of lines per second can be reduced, as by reducing the number of frames per second, the required video-frequency band can correspondingly be reduced without impairing the picture definition, or if with the same number of lines per second, the effect of a greater number can be obtained, as by increasing the number of fields per frame, the picture definition can be improved without increasing the required video-frequency band. In the single field per frame type of scanning originally proposed, a minimum of 40 fields per second is required in order to avoid flicker, 60 fields per second being preferable; as mentioned above, in interlaced scanning several fields

appear as a single frame, so that the number of fields required per second is the same as the number of frames per second originally required. Hence, either the required video-frequency band for a given picture definition may be reduced, or the picture definition may be improved without increasing the video-frequency band by reducing the number of frames per second and increasing the number of fields per frame.

The conventional type of double interlaced scanning, as briefly described above, achieves these desirable results to a certain degree over the single field per frame type of scanning originally employed. Various modified forms of multiple interlaced scanning systems have also heretofore been proposed to increase the degree of improvement over the single field scanning. However, certain difficulties are presented when it is attempted to interlace more than two fields per frame, among which are included the phenomenon known as "crawling," that is, the appearance of moving waves in the reproduced pictures toward the top or bottom of the picture when the lines of the several fields of each frame follow each other in consecutive order.

It is an object of the present invention, therefore, to provide a novel and improved type of interlaced scanning for television systems.

It is a further object of the invention to provide a scanning system of the character described, whereby there may be utilized a reduced video-frequency band without impairment of definition, or an improved definition may be procured for a given video-frequency band, or both, without crawling or flicker.

In accordance with the present invention, there is provided an interlaced scanning system for television or similar apparatus which may comprise either cathode-ray tubes, or mechanical signal-generating or receiving devices employing either cathode rays, light beams, or other equivalent means in connection therewith. The apparatus comprises means for deflecting the ray to scan the target in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency. The system also comprises means for deflecting the ray to scan the target in a second direction normal to the given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to the line-scanning frequency. Means are further provided for tracing a plurality of fields of parallel lines on the target while avoiding the appearance of moving waves in the reproduced tele-

vision image comprising means for periodically modifying the action of the field-deflecting means in cycles having a period at least four times as long as the period of, that is, at a frequency not greater than one-fourth that of, the field-scanning frequency to displace the field in the second direction in irregular sequence. In other words, the lines of one field are traced between corresponding lines of preceding fields and the field order is in irregular sequence, such as 1, 3, 2, 4 or 1, 4, 2, 3 as distinguished from the conventional regular sequence of 1, 2, 3, 4 which has heretofore been proposed. By virtue of this irregular interlacing sequence, undesirable crawling effects are avoided while the interlacing produces the well-known optical effect of each frame including the total lines of all of the fields and of the flicker occurring at the field frequency. Hence, either the number of lines per second, and, therefore, the required video-frequency band, may be substantially reduced without impairing the definition, or the same number of lines per second may be used with no increase in the video-frequency band, to provide substantially improved definition, or a combination of both of these two desirable results may be obtained. Flicker and similar defects may be overcome by closely spacing or overlapping the lines of the fields of each frame and this may be done in the present system without reducing the picture height since a substantially increased number of lines per frame may be used without increasing the video-frequency band width.

In accordance with one embodiment of the present invention, the frame-frequency deflecting means is arranged to deflect the ray with two deflection components at predetermined different amplitudes and frequencies. One component, the field frequency, may, for example, be of the usual saw-tooth form at quadruple the desired frame frequency, while the other component is of rectangular wave form having an amplitude corresponding to one-half of the line separation of each field and of a frequency equal to one-quarter that of the saw-tooth component, that is, equal to the frame frequency. The frequency of the line-frequency deflecting means is preferably a fractional multiple or aliquant of the field frequency so that, with this arrangement, each frame includes four fields and the sequence of their vertical displacement or interlace is 1, 3, 2, 4.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

In the accompanying drawings, Fig. 1 is a diagram of a complete cathode-ray tube television-transmitting system, partially schematic, including a scanning system embodying the present invention, while Figs. 2 and 3 are groups of curves illustrating the current or voltage wave forms developed at various parts of the system of Fig. 1 and the scanning paths traced by the beam on the cathode-ray tube target in accordance with the system of the present invention, to aid in the understanding thereof.

Referring now more particularly to Fig. 1 of the drawings, the television system there illustrated comprises a cathode-ray signal-generating tube and camera device of conventional design indicated generally at 10, including a signal-generating tube 11 having the usual electron

gun, photosensitive target, and line- and field-scanning elements 11a and 11b, respectively, as indicated. For developing scanning currents for the signal-generating tube in accordance with the present invention as hereinafter described in detail, there are provided a saw-tooth line-scanning wave generator 12, a saw-tooth field-scanning wave generator 13, and a rectangular impulse frame-scanning wave generator 14. The output circuit of the line-scanning generator 12 is connected directly to the line-scanning elements 11a of the cathode-ray tube 11, while the output circuits of the field-scanning generator 13 and rectangular wave generator 14 are coupled to the frame-scanning elements 11b, by way of suitable signal-combining apparatus 17.

In order to provide pedestal impulses for blocking-out or suppressing the cathode ray during retrace portions of the scanning cycles, and for suppressing undesirable impulses in, and ensuring the proper wave form of, the modulation signal developed by the generator 10, there is provided a pedestal impulse generator 15 having an output circuit coupled to the control grid of the signal-generating tube 11. A synchronizing-impulse generator 16 is provided for developing a synchronizing-modulation wave for use in controlling the action of scanning apparatus at receivers corresponding to the transmitter-scanning apparatus. In order to synchronize the frequencies developed by the generators 12-16, inclusive, there is provided a timing-impulse generator 18, the output circuits of which are connected to the generators 12-16, inclusive, as shown. Preferably, the pedestal- and synchronizing-impulse generators are also suitably coupled, as shown, to ensure synchronism of the operations.

A modulation-frequency amplifier 19 is coupled to the output circuits of the cathode-ray signal-generator tube 10, the pedestal generator 15, and the synchronizing-impulse generator 16. Connected in cascade to the output circuit of the amplifier 19, in the order named, are a modulator 20 provided with a local oscillator 21, as shown, a power amplifier 22, and an antenna system 23, 24, all according to conventional practice.

Neglecting for the moment the details of the structure and operation of the scanning apparatus 12-16, inclusive, per se, the system just described constitutes a television-transmitting system of conventional design, those parts of the system illustrated schematically being of any well-known suitable construction so that a detailed description of the system and its operation is unnecessary herein. Briefly, however, the image of a scene to be transmitted is focused on the target of the tube 11, in which a cathode ray or beam is developed accelerated, and focused upon the target. Scanning or deflecting currents developed by the generators 12, 13, and 14 are applied to the scanning coils of the signal-generating tube to provide magnetic fields which serve to deflect the ray so as to scan successive series of parallel lines on the target. Pedestal impulses developed by the generator 15 are applied to the control electrode of the tube 11 to suppress or block-out the beam during the retrace portions of the scanning cycles and are applied to the modulation-frequency amplifier 19 to suppress undesirable impulses developed in the system and to aid in attaining the required wave form of the modulation signal. The photosensitive elements of the target being electrically

affected to an extent dependent upon the varying values of light and shade at corresponding incremental areas of images focused thereon as the cathode ray passes over the target a voltage of correspondingly varying amplitude is developed in the output circuit of the signal-generating tube 11 and applied to the amplifier 19. Synchronizing impulses developed by the generator 16 are applied to the amplifier 19 and to the pedestal generator 15 to lock the latter in synchronism. The proper timing or synchronizing impulses developed by the timer 18 are applied to the generators 12-15 inclusive to maintain these generators in synchronism with either a master frequency in the case of direct camera shots, or the moving-picture camera in the case where such pictures are being transmitted. The various modulation-signal components applied to the amplifier 19 are properly combined and amplified therein and, in turn, are supplied to the modulator 20, wherein they are impressed upon the carrier wave generated by the oscillator 21. The resultant modulated-carrier signal is delivered to the power amplifier 22 for amplification and is thereupon impressed upon the antenna system 23, 24 for radiation.

Coming now to that part of the system embodying the present invention, the scanning wave-generating apparatus comprises the line-scanning generator 12 which, as stated above, may be of conventional design and adapted to develop a saw-tooth current wave of line-scanning frequency which is applied to the line-scanning elements 11a of the cathode-ray tube 11.

The field-scanning generator 13 may include a conventional relaxation oscillator which comprises a condenser 25 having a charging circuit including a source of direct current, such as a battery 26 preferably grounded at its negative terminal, a resistor 27, and the space current path of a vacuum tube 28. A discharge circuit comprising an adjustable resistor 29 is connected across the condenser for discharging the same at a predetermined rate. A regenerating tube 30 is preferably provided in connection with the tube 28, having its cathode grounded and its anode connected to the control electrode of the tube 28. The control grid of the regenerating tube 30 is connected by way of a suitable coupling condenser 31 and leak resistor 32 to the anode of the charging tube 28. A buffer amplifier tube 33 is preferably interposed between the relaxation oscillator and the impulse generator 13, its control grid being coupled to the latter by way of a suitable coupling condenser 34 and leak resistor 35. Operating potential is applied to the anodes of the tubes 30 and 33 from a suitable source, such as a battery 36, by way of a common load resistor 37.

The generator 14 may be of substantially the same design as the generator 13 and a detailed description thereof is, therefore, unnecessary. In the drawings, the elements of the generator 14 are designated by the same reference numerals as applied to corresponding elements of the generator 13, with the added appendix "a." In the generator 14, a resistor 52 is included in series with the main condenser 25a for developing an output voltage of the desired wave form.

For the purpose of combining the voltages developed by the generator 13 and 14, there is provided the signal-combining apparatus, indicated generally at 17, comprising input tubes 38 and 39 and an output tube 40. The control grid of the tube 38 is coupled across the condenser

25 of the generator 13 by way of a voltage divider resistor 41 and coupling condenser 42, while the control grid of the tube 39 is coupled by way of a suitable leak resistor 43 and condenser 44 across the output resistor 52 of the generator 15. The control grid of the tube 40 is coupled to the anodes of the tubes 38 and 39 by way of a voltage divider resistor 45 and coupling condensers 46, while the anode of this tube is coupled to the field-scanning elements 11b by way of a suitable coupling condenser 47. Bias resistors 48 and bypass condensers 49 are included in the cathode circuits of the tubes 38, 39, and 40. Anode potential is supplied to the tubes 38 and 39 by way of suitable load resistors 50 and 51, the latter being an adjustable voltage divider resistor, as shown. Anode potential for the tube 40 may be supplied from a suitable source, also indicated as +B, by way of a choke 53.

In the operation of the generator 13, the condenser 25 is rapidly charged from the source 26, by way of the resistor 27 and tube 28, and is discharged at a relatively slow rate through the resistor 29. This discharging action continues until the potential difference developed across the tube 28 is sufficient, upon the application of a synchronizing impulse to its control grid from the impulse generator 18, to break down the tube 28 and initiate a charging action. This initial surge of charging current develops a voltage impulse across the resistor 27 which is impressed negatively by way of the condenser 31 upon the control grid of the regenerating tube 30, reducing the conductivity of this tube. A positive peak is thereby developed across the load resistor 37 and applied to the control grid of the tube 28 to accelerate the charging action. The synchronizing or timing impulses supplied from the generator 18 through the buffer amplifier 33 serve to synchronize the operation of the generator. The periodic charging and discharging of the condenser 25 develops thereacross a periodic voltage wave of saw-tooth form having a cycle including relatively slow trace and rapid retrace portions, this voltage being applied to the grid of the tube 38 by way of the coupling condenser 42 and voltage divider resistor 41.

The operation of the generator 14 is substantially the same as that of the generator 13 so that a detailed explanation thereof is unnecessary. The voltage across the condenser 25a is of equal slope saw-tooth wave form and the current through this condenser is the first derivative thereof, or of rectangular wave form. Therefore, in this case an output voltage of rectangular wave form is developed across the resistor 52 and applied to the control grid of the tube 39 by way of the coupling condenser 44 and resistor 43.

The output saw-tooth and rectangular voltages are amplified by the tubes 38 and 39 and applied by way of the resistors 50 and 51, respectively, condensers 46 and resistor 45 to the control grid of the tube 40. The tube 39 is preferably so biased as to operate beyond cutoff, thereby to ensure flat-topped rectangular voltage waves in its output circuit. The combined amplified current wave developed in the anode circuit of tube 40 is applied by way of the coupling condenser 47 to the scanning elements or windings 11b of the cathode-ray tube 11.

The relative amplitudes of the voltages supplied from the generators 13 and 14 may be readily adjusted by adjustment of the voltage divider resistors 41 and 51, while the amplitude of the combined frame-scanning current in the anode

circuit of the tube 40 may be determined by adjustment of the voltage divider resistor 45.

The general operation of, and results obtained by, the system just described may best be understood with reference to the curves of Figs. 2 and 3. In these figures, curves A, B, and C represent the wave forms of the signals developed in the output circuit of the generators 13, 14 and the combining apparatus 17, respectively, the abscissae representing time and the ordinates amplitude. The saw-tooth voltage wave A is of the desired field frequency which may, for example, be 60 cycles per second, while the auxiliary or rectangular wave B is of one-quarter this frequency, or 15 cycles per second. While the relative amplitudes of these two waves have been shown in the drawings as not greatly different, the rectangular wave C, in fact, has an amplitude equal to only half the distance of the spacing between two lines of a field, while the amplitude of curve A corresponds to the height of a complete field, or the product of the line spacing by the number of lines per field. The periodic current wave C, as shown, includes both the saw-tooth and rectangular components at their respective frequencies, this representing the current applied to the frame-scanning coils and, hence, the shape of the electromagnetic deflecting field developed thereby. In other words, means are provided for modifying the deviation of the trace portions and the velocity of the retrace portions of the cycles of the saw-tooth wave developed by the generator 13 in a predetermined sequence and at a predetermined frequency, or in cycles having a period longer than the field-scanning frequency. In a preferred embodiment of the invention, the line scanning may be accomplished by the application of a saw-tooth current wave to the line-scanning elements 11a in conventional manner, at a frequency which is a fractional multiple or aliquant of the field frequency, for example, 13,230 cycles per second or $220\frac{1}{2}$ times the field frequency of 60, so that an odd number of half lines occurs during each field cycle.

The patterns traced by the beam on the target of the cathode-ray tube, as the result of its deflection by scanning elements 11a and 11b in the directions normal to each other, are illustrated by the curves D and E of Fig. 2 and the curve F of Fig. 3, retrace portions of the cycle being indicated by the broken-line portions of the curves. Only two complete lines of each frame are illustrated for the purpose of clarity, although actually a much larger number will, of course, be traced. Curves D and E are positioned immediately below the portions of the combined wave of curve C which correspond thereto in point of time. Curve D represents lines of the first and second fields of a frame cycle, the lines being numbered 1 and 2, respectively, the first lines of these two fields starting at the points X_1 and X_2 , respectively, and the last lines thereof terminating at the points Y_1 and Y_2 , respectively, corresponding points being similarly indicated on curve C. Due to the fact that the line-scanning frequency is the proper fractional multiple of the field frequency, the first field terminates in the middle of its last line, as indicated, while the second field starts in the middle of its first line, the lines of the second frame falling between or interlacing the lines of the first, as shown.

In ordinary interlaced scanning, at the termination of the second field the frame cycle would be completed and the scanning of the next succeeding frame cycle would start, being a repetition of the first.

In the present system, however, due to the rectangular wave component in the wave C, the third and fourth fields, as represented by curve E, are vertically displaced so that lines of the third field fall between the lines of the first and second fields and the lines of the fourth field fall between those of the second and first. As shown in the drawings, the third and fourth fields initiate at the points X_3 and X_4 and terminate at the points Y_3 and Y_4 , corresponding points being indicated on curve C. Curve F of Fig. 3 represents a complete frame including four successive fields, that is, curve D and curve E superimposed, thus indicating the entire actual scanning pattern which is traced on the target of the tube in one frame. The particular fields to which the different lines belong are indicated at the ends of the lines and it will be clear therefrom that the vertical displacements of the fields of the frame are in irregular sequence, thus avoiding crawling effects noted above.

Thus the interlaced scanning system described comprises means for deflecting the ray to scan the target of the tube 11 in a given direction including the line-scanning element 11a and the line-scanning generator 12 for generating a periodic saw-tooth wave of a predetermined line-scanning frequency. The system also includes means for deflecting the ray to scan the target in a second direction normal to the given direction and including a field-scanning element 11b and a field-scanning generator 13 for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to the line-scanning frequency. The cathode ray of tube 11, deflected as thus described, is caused to trace a plurality of fields of parallel lines on the target, while avoiding the appearance of moving waves in the reproduced television image, by the frame-scanning generator 14 and signal-combining amplifier 17, which comprises means effective periodically to modify the action of the last-named deflecting means in cycles having a period at least four times as long as that of the field-scanning frequency to displace the fields in the second section in irregular sequence. Specifically, the frame-scanning generator 14 develops a rectangular wave of a frequency preferably equal to one-quarter the field-scanning frequency and of an amplitude preferably equal to one-half the field line displacement, periodically to modify the amplitude of the wave generated thereby and the velocity of retrace portions of successive field-scanning cycles, in cycles having a period four times as long as, or a frequency one-fourth that of, the field-scanning wave, to displace the fields in the second scanning direction in irregular sequence. This is facilitated by making the field-scanning frequency such that the ratio of the line-scanning frequency to the field-scanning frequency is an integer and a proper fraction.

While in the particular arrangement described an irregular sequence of 1, 3, 2, 4 is obtained, it will be apparent that, by simply adjusting the rectangular wave-generating circuits so as to effect a 180-degree shift in the phase of the rectangular wave supplied to the combining apparatus, a sequence of 1, 4, 3, 2 may be obtained.

It will be apparent that, in the particular arrangement and with the frequencies noted, frames of 882 lines may be obtained at a line frequency of 13,230 cycles, the same frequency by which, in ordinary two field per frame interlaced scanning, frames of only 441 lines are obtainable. Such a large number of lines per

frame may be overlapped, by proper adjustment of the amplitude of the field-scanning wave without undesirably altering the picture height and with avoidance of flicker, while, as stated, the interlacing in irregular sequence avoids crawling effects. Obviously other relations between the line and field frequencies may be utilized. For example, frames of 450 lines at a line frequency of only 6,750 per second may be had, thereby substantially reducing the required video-frequency band width, as explained above, while obtaining a picture of substantially the same definition as is obtained by ordinary interlaced scanning where twice this line frequency is required to obtain 441 lines per frame. If desired, a combination of these two improved results may, of course, be obtained by properly relating the line and field frequencies.

While in the above-described system a particular circuit arrangement in a cathode-ray tube television system is disclosed for obtaining the interlacing in a particular irregular sequence, it will be readily appreciated by those skilled in the art that applicant's novel method of irregular interlacing may be practised by various other circuit arrangements in various other types of systems, including mechanical arrangements where a light ray or beam is utilized instead of cathode rays, and, also, that interlacing with other irregular sequences may be had. Moreover, the combined saw-tooth rectangular wave field scanning with the odd multiple relationship may also be utilized to obtain interlacing of the regular sequence type.

Thus, while there has been described what is at present considered to be the preferred embodiment of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically modifying the action of said last-named deflecting means in cycles having a period at least four times as long as that of said field-scanning frequency to displace said fields in said second direction in irregular sequence.

2. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency

each cycle of which comprises trace and retrace portions, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically modifying the amplitude of one portion of successive field-scanning cycles in a predetermined sequence and at a predetermined frequency not greater than one-fourth of said field-scanning frequency to displace said fields in said second direction in irregular sequence.

3. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency each cycle of which comprises trace and retrace portions, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically modifying the velocity of the retrace portion of successive field-scanning cycles in a predetermined sequence and at a predetermined frequency not greater than one-fourth of said field-scanning frequency to displace said fields in said second direction in irregular sequence.

4. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for generating and combining with said field-scanning wave an auxiliary periodic wave having a frequency not greater than one-fourth said field-scanning frequency, the amplitude and frequencies of said field-scanning wave and said auxiliary wave being proportioned to displace said fields in said second direction in irregular sequence.

5. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency such that the ratio of said line-scanning frequency to said field-scanning frequency is an integer and a proper fraction, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically modifying the action of said last-named deflecting means in cycles having periods at least four times those of said field-scanning frequency so that groups of at least four suc-

cessive fields are displaced in said second direction in irregular sequence.

6. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency such that the ratio of said line-scanning frequency to said field-scanning frequency is an integer and a proper fraction, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically so modifying the action of said last-named deflecting means in cycles having periods at least four-times those of said field-scanning frequency so that at least four successive fields are displaced in said second direction in irregular sequence.

7. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency such that the ratio of said line-scanning frequency to said field-scanning frequency is an integer and a proper fraction, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for generating and combining with said field-scanning wave an auxiliary periodic wave having a frequency not greater than one-fourth said field-scanning frequency, the amplitudes and frequencies of said field-scanning wave and said auxiliary wave being related to displace said fields in said second direction in irregular sequence.

8. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for generating and combining with said field-scanning wave an auxiliary periodic wave, the amplitude of said auxiliary wave being a predetermined fraction of that of said field-scanning saw-tooth wave and the frequency of said auxiliary wave being a predetermined fraction not greater than one-fourth said field-scanning frequency so that successive fields are displaced in said second direction in irregular sequence.

9. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given

direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency such that the ratio of said line-scanning frequency to said field-scanning frequency is an integer and a proper fraction, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for generating and combining with said field-scanning wave an auxiliary periodic wave having a frequency not greater than one-fourth said field-scanning frequency, the amplitude and frequency of said auxiliary wave being predetermined fractions of those of said field-scanning saw-tooth wave so that a plurality of successive fields are displaced in said second direction in irregular sequence.

10. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for generating and combining with said field-scanning wave an auxiliary periodic wave of rectangular wave form, the amplitudes of said field-scanning wave and said auxiliary wave being so related and the frequency of said auxiliary wave being a predetermined fraction not greater than one-fourth said field-scanning frequency so that a plurality of successive fields are displaced in said second direction in irregular sequence.

11. An interlaced scanning system for television apparatus comprising means for deflecting the ray to scan the target of the apparatus in a given direction including means for generating a periodic saw-tooth wave of a predetermined line-scanning frequency, means for deflecting the ray to scan the target in a second direction normal to said given direction including means for generating a periodic saw-tooth wave of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing a plurality of fields of parallel lines on said target while avoiding the appearance of moving waves in the reproduced television image comprising means for generating and combining with said field-scanning wave an auxiliary periodic wave of rectangular form of a frequency equal to one-quarter said field-scanning frequency and of an amplitude corresponding to one-half of the field line displacement to displace said fields in said second direction in irregular sequence.

12. A method of interlaced scanning for television apparatus while avoiding the appearance of undesirable moving waves in the reproduced picture which comprises scanning a first field of parallel lines on the target of the apparatus, scanning a second field of parallel lines on said target so displaced in a direction normal to said

lines that lines of said second field are traced between lines of said first field, scanning a third field of parallel lines on said target so displaced in said direction that the lines thereof are traced between lines of said first and second fields, and scanning a fourth field of parallel lines on said target so displaced in said direction that lines thereof are traced between lines of said second and first fields in the sequence 1, 3, 2, 4.

- 10 13. A method of interlaced scanning for cathode-ray tube apparatus while avoiding the appearance of undesirable moving waves in the reproduced picture which comprises generating a periodic ray-deflecting field of saw-tooth wave form and of line-scanning frequency for scanning the target of the tube in a given direction, generating a periodic ray-deflecting field of saw-tooth wave form and of a predetermined field-scanning frequency related to said line-scanning frequency and comprising trace and retrace portions for scanning the target of the tube in a second direction normal to said given direction and periodically modifying the amplitude of one portion of successive field-scanning cycles in a predetermined sequence and at a predetermined frequency not greater than one-fourth said

field-scanning frequency, thereby to trace a plurality of successive fields of parallel lines on said target in interlaced relation and displaced in said second direction in irregular sequence.

14. A method of interlaced scanning for cathode-ray tube apparatus while avoiding the appearance of undesirable moving waves in the reproduced picture which comprises generating a periodic ray-deflecting field of saw-tooth wave form and of line-scanning frequency, for scanning the target of the tube in a given direction, generating a periodic ray-deflecting field of saw-tooth wave form and of a predetermined field-scanning frequency related to said line-scanning frequency and comprising trace and retrace portions for scanning the target of the tube in a second direction normal to said given direction and periodically modifying the velocity of the retrace portion of successive field-scanning cycles in a predetermined sequence and at a predetermined frequency not greater than one-fourth said field-scanning frequency, thereby to trace a plurality of successive fields of parallel lines on said target in interlaced relation and displaced in said second direction in irregular sequence.

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