June 4, 1940. D. E. HARNETT 2,203,528

TELEVISION SCANNING SYSTEM

Filed Nov. 29, 1937 2 Sheets-Sheet 1

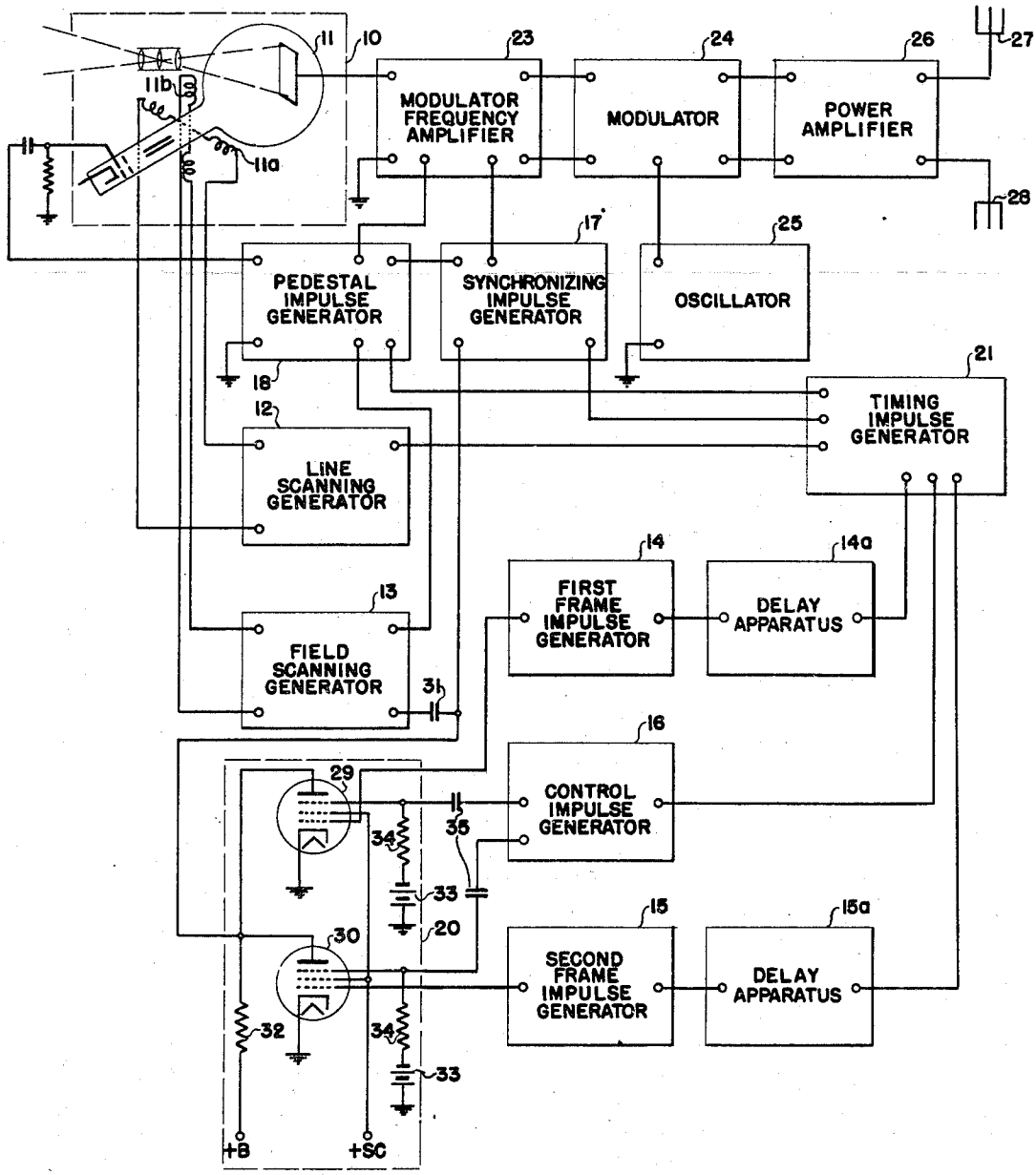


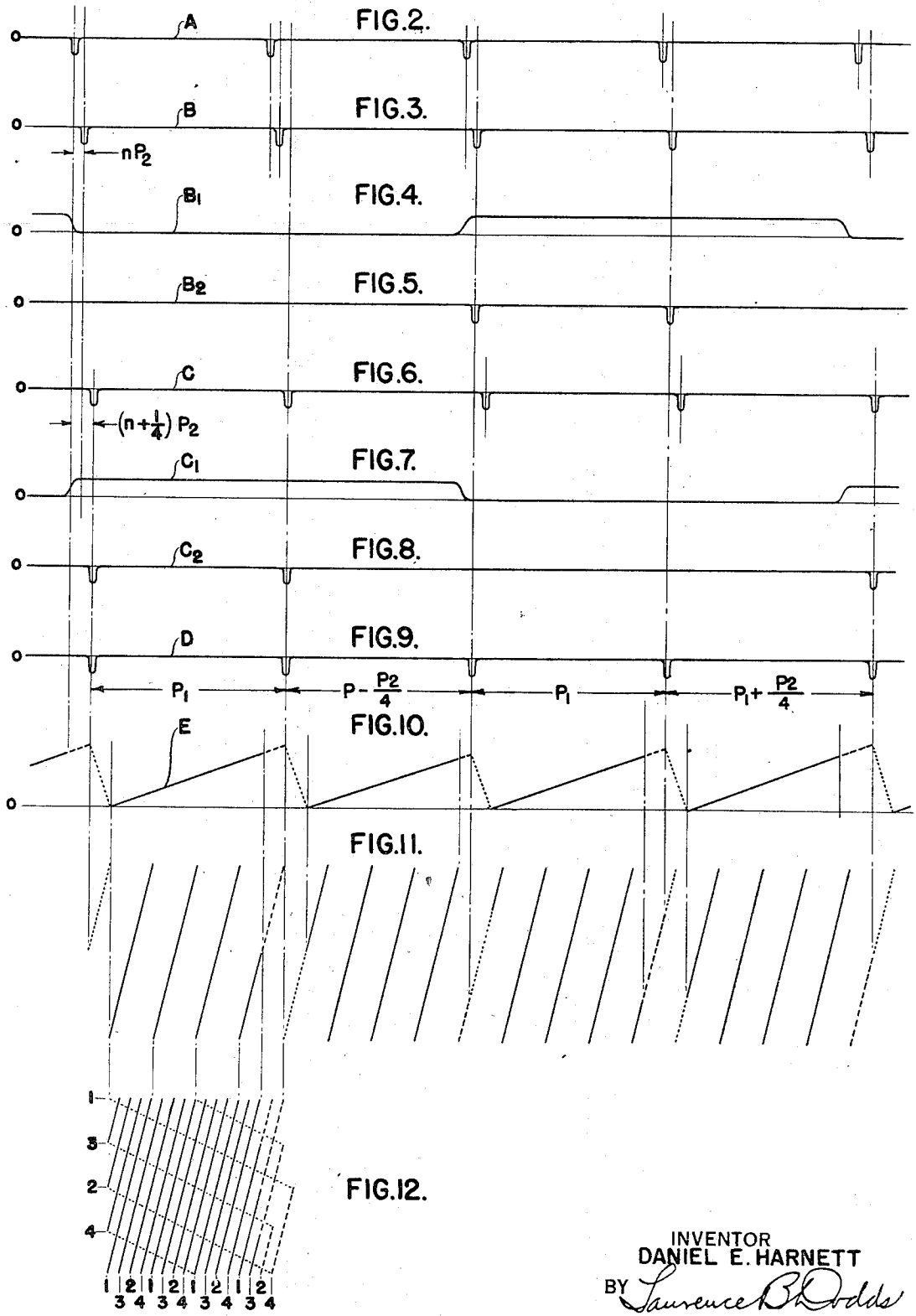
FIG. I.

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Filed Nov. 29, 1937 2 Sheets-Sheet 2



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2,203,528

TELEVISION SCANNING SYSTEM

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16 Claims. (Cl. 178—7.7)

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

Various types of scanning systems for television apparatus have heretofore been devised, systems of the interlaced type having proved especially advantageous. In such systems a beam, such as the cathode ray in apparatus of the cathode-ray tube type, 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 systems, the field-scanning frequency is a fractional multiple of the line-scanning frequency so that the lines of one field interlace or fall between lines of the preceding field, two successive fields constituting a single frame 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-scanning frequency were equal to the field-scanning 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. For optimum utilization of the available transmission frequency band, the resolution in the vertical direction should be substantially the same as that in the horizontal direction. 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; or if, with the same number of lines per second, the effect of a greater number of lines can be obtained, as by increasing the number of fields per frame, the picture resolution can be improved without increasing the video-frequency band.

In order to prevent undesirable hum effects due to the power supply frequency, which may, for the purpose of the present case, be considered as 60 cycles, the field frequency must be either equal to, or an integral sub-multiple of, the power supply frequency. In the single-field-per-frame type of scanning originally proposed, in order to avoid flicker and undesirable hum effects, 60 frames per second are required. As mentioned above, in interlaced scanning systems the frame-scanning frequency appears to be equal to the field-scannig frequency insofar as flicker is concerned, so that the number of fields per second may be the same as the number of frames per second required in the earlier systems and the number of frames per second may be reduced without increasing the flicker. Therefore, in such interlaced scanning systems in which the number of frames per second is reduced, while maintaining constant the number of fields per second, either the required video-frequency band may be reduced, for a given resolution, by reducing the number of lines per field and maintaining constant the apparent number of lines per frame; or improved vertical image resolution may be obtained by increasing the apparent number of lines per frame by maintaining constant the number of lines per field; or a compromise between these effects may be obtained.

The conventional two-field-per-frame type of interlaced scanning, as briefly described above, achieves to a certain degree the above-mentioned advantages over the single-field-per-frame type of scanning originally proposed. Various modified forms of interlaced scanning have also heretofore been proposed as improvements over 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 waves in the reproduced pictures which move toward the top or bottom of the picture when the lines of the several fields of each frame follow each other in regular sequence.

It is an object of the present invention to provide a novel and improved system of interlaced scanning whereby the successive fields are traced in interlaced relation but displaced in irregular sequence.

In accordance with the present invention, there is provided an interlaced scanning system for television apparatus which may be of the mechanical, cathode-ray tube, or equivalent type, wherein a beam constituting either a light ray, cathode ray, or equivalent medium is employed in a signal-generating or reproducing device. The apparatus comprises means for deflecting the beam to scan the target of the apparatus in a given direction, which includes means for developing a first periodic saw-tooth wave of a pre-

determined line-scanning frequency. Means are further provided for deflecting the ray to scan the target in a second direction normal to the given direction and including means for generating a second periodic saw-tooth wave of a predetermined field-scanning frequency related to the line-scanning frequency. Means are also provided for tracing m-interlaced fields of parallel lines on said target, where m is an integer greater than three, while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically varying the durations of the trace portions of successive cycles of the second wave by an amount equal to an integral multiple of $1/m$th the period of the first wave in a predetermined cycle having a period m times that of the second or field-scanning wave to displace the fields in the second direction in irregular sequence.

In a preferred form of the present invention, there are provided a generator for developing a saw-tooth wave of an average field-scanning frequency such that the line-scanning frequency is a fractional multiple thereof and synchronizing apparatus for varying the durations of successive cycles of the field-scanning saw-tooth wave. The durations of the trace portions of alternate waves are alternately decreased and increased by an amount equal to one-quarter of the time separation of adjacent lines, with the result that each frame includes four fields and the sequence of the vertical displacements or interlace is irregular, for example, one, three, two, four.

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 circuit diagram of a complete television transmitting system, partially schematic, including a scanning system embodying the present invention; Figs. 2–10, inclusive, are curves illustrating current or voltage wave forms developed at various points of the system of Fig. 1; and Figs. 11 and 12 are graphs illustrating the paths traced by the scanning beam on the target of the system, in accordance with the present invention, to aid in the understanding thereof.

Referring now more particularly to Fig. 1 of the drawing, there is illustrated a television transmitting system comprising a camera device of conventional design indicated generally at 10 and including a cathode-ray signal-generating tube 11 having the usual electron gun, photosensitive target, and line- and field-scanning elements 11*a* and 11*b*. In accordance with the present invention, as hereinafter described in detail, there are provided a line-scanning saw-tooth wave generator 12 and a field-scanning saw-tooth wave generator 13, having their output circuits connected directly to the line-scanning elements 11*a* and the frame-scanning elements 11*b*, respectively. For synchronizing the field-scanning generator 13 in accordance with the present invention, there are provided first and second frame-impulse generators 14 and 15, respectively, and a control-impulse generator 16. The impulse generators 14 and 15 are coupled to the field-scanning generator 13 by way of a combining amplifier 20, while the control impulse generator 16 is coupled to the amplifier 20 to control the operation thereof as will hereinafter be further described.

In order to provide pedestal impulses for blocking out or 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 18 having an output circuit coupled to the control grid of the signal-generating tube 11. A synchronizing-impulse generator 17 is provided for developing a synchronizing modulation wave for use in controlling the action of scanning apparatus at receivers in synchronism with the transmitter scanning apparatus. In order to synchronize the waves developed by the generators 12—18, inclusive, there is provided a timing-impulse generator 21 having a plurality of output circuits coupled to the generators 12—18, inclusive, as shown. Suitable delay apparatus 14*a* and 15*a* are interposed between the timing generator 21 and the frame-impulse generators 15—16, inclusive, as shown. Preferably, the pedestal generator 18 is also coupled to the synchronizing-impulse generator 17 and the field-scanning generator 13, as shown, to ensure synchronism of the operations of these generators.

A modulation-frequency amplifier 23 is coupled to the output circuits of the cathode-ray signal-generating tube 11, the pedestal generator 18 and the synchronizing-impulse generator 17. Connected, in cascade, to the output circuit of the amplifier 23, in the order named, are a modulator 24, provided with a local oscillator 25, a power amplifier 26, and an antenna system 27, 28, all according to conventional practice.

Neglecting for the moment the details of the structure and operation of the scanning apparatus, per se, the system just described comprises a television transmitting system of conventional design, those parts of the system illustrated schematically being of well-known suitable construction so that a detailed description of the system and its operation is unnecessary herein. Briefly, however, the image of the scene to be transmitted is focused upon the target of the tube 11 in which a cathode ray or beam is developed, accelerated, and focused upon the target. Scanning or deflection currents developed by the generators 12 and 13 are applied to the scanning elements or coils 11*a* and 11*b* and serve to deflect the ray to scan successive series or fields of parallel lines on the target. Pedestal impulses developed by the generator 18 are applied to the control electrode of the tube 11 to suppress or block-out the beam during certain portions, particularly the retrace portions, of the scanning cycles and are applied to the modulation-frequency amplifier 23 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 depending upon the varying values of light and shade at corresponding incremental areas of the images focused thereon, as the cathode ray scans 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 23. The synchronizing impulses developed by the generator 17 are applied to the amplifier 23 and to the pedestal generator 18 to lock the latter in synchronism. Suitable timing or synchronizing impulses are applied from the generator 21 to the

generators 12—18, inclusive, the coupling to the generators 14 and 15 being by way of the delay apparatus 14a and 15a, to maintain these generators in synchronism with either the master frequency, in the case of direct camera shots, or the moving picture camera, in the case such pictures are being transmitted. The various modulation-signal components applied to the amplifier 23 are properly combined and amplified therein, and, in turn, are supplied to the modulator 24, wherein they are impressed upon the carrier wave generated by the oscillator 25. The resultant modulated-carrier signal is supplied to the power amplifier 26 and is thereupon impressed upon the antenna system 27, 28 for radiation.

Coming now to that part of the system embodying the present invention, the scanning wave-generating apparatus comprises the scanning generators 12 and 13, which may be relaxation oscillators of conventional design adapted to develop saw-tooth current waves of the proper frequencies for exciting the scanning elements 11a and 11b, respectively, of the cathode-ray tube 11. Similarly, the generators 14, 15, and 16 may be conventionally designed relaxation oscillators which develop periodic waves of the required wave forms and of predetermined frequencies. The delay circuits 14a and 15a may comprise any suitable apparatus for delaying the phase of the timing impulses supplied to the generators 14 and 15, relative to the impulses supplied from the timing generator 21. Preferably, delay apparatus, such as that described in copending application, Serial No. 176,963, filed concurrently herewith, may be utilized.

For the purpose of combining the voltages developed by the generators 14 and 15, there is provided the combining amplifier 20 which comprises two pentode amplifier tubes 29 and 30. The output circuits of the generators 14 and 15 are coupled to the control grids of the tubes 29 and 30, respectively, while the anode circuits of these tubes are connected in parallel and coupled to the synchronizing input circuit of the field-scanning generator 13 by way of a suitable coupling condenser 31. Operating potentials are supplied to the anodes of the tubes, by way of a common load resistor 32, and to the screens from suitable sources indicated, respectively, at +B and +Sc. The suppressor grids of the tubes are normally biased sufficiently negatively to maintain these tubes nonconductive, as by means of suitable batteries 33 and isolating resistors 34. The suppressor grids of the tubes 29 and 30 are also coupled to output circuits of the generator 16, by way of suitable coupling condensers 35, to receive control signals therefrom which serve, during the positive half cycles of such signals, to unblock the tubes and permit the synchronizing-impulse waves to be repeated.

The operation and results obtained by the system just described may best be understood with reference to the curves of Figs. 2–12, inclusive. The curves of Figs. 2–10, inclusive, represent the wave forms of the voltages or currents developed at different points in the system shown in Fig. 1, the abscissae representing time and the ordinates amplitude, in each instance. Curve A shown in Fig. 2 represents the periodic voltage-impulse wave developed by the timing generator 21 for controlling the generators 14—16, inclusive, this wave being of the desired field-scanning frequency; for example, in the preferred embodiment, 60 cycles. Curves B and C, shown in Figs. 3 and 6, respectively, represent the periodic voltage-impulse waves developed in the output circuits of the generators 14 and 15, respectively. These two waves are both of the field-scanning frequency, but, due to the action of the delay apparatus, 14a and 15a, the impulses of these waves are delayed in phase with respect to corresponding impulses of wave A by predetermined amounts. The phase displacement is preferably such that the impulses of wave B are delayed with respect to those of wave A for a suitable short duration, as represented by n times the period of one line-scanning cycle; and the impulses of wave C are delayed with respect to those of wave A by $(n + \frac{1}{4})$ times the period of one line-scanning cycle, so that the time delay of C relative to B is one-quarter of the time separation of adjacent lines.

The waves developed in the output circuits of the control generator 16 are illustrated by the curves B_1 and C_1 of Figs. 4 and 7, respectively, and are of rectangular wave form and of a frequency which is a predetermined fraction of the field frequency; in the preferred embodiment, for example, one quarter of the field frequency or 15 cycles. The waves B_1 and C_1, however, are of opposite polarities or 180 degrees out of phase with respect to each other and, since they initiate concurrently with the impulses of the wave A, they are displaced in phase with respect to the impulses of waves B and C. Hence, when the positive half of a cycle of the wave B_1 is applied from the generator 16 to the suppressor grid of the tube 29 via condenser 35 to unblock the tube and permit the synchronizing impulses of wave B to be repeated, the corresponding negative half cycle of wave C_1 is applied to the suppressor grid of the tube 30 and, due to its initial fixed bias, this tube will remain blocked. Similarly, when a positive half-cycle of the wave C_1 is applied to the tube 30 to render it conductive, a negative half-cycle of wave B_1 is being applied to the tube 29, leaving the latter tube blocked. By virtue of this selective alternate control of the tubes 29 and 30 of the combining amplifier, alternate pairs of impulses of the waves B and C are suppressed, as indicated by the waves B_2 and C_2, which represent the waves B and C as they appear in the output circuits of the tubes 29 and 30, respectively. The combined synchronizing wave appearing across the resistor 32 of the amplifier 20 is, therefore, of the form illustrated by curve D of Fig. 9, in which pairs of impulses of the wave B alternate with pairs of impulses of wave C. In wave D, therefore, the time interval between successive impulses varies in regular sequence in a cycle comprising four field-scanning cycles. Thus, the synchronizing wave D comprises a periodic wave of frame-scanning frequency, only one cycle being shown which comprises four field-synchronizing impulses separated by intervals of: P_1; $P_1 - P_{2/4}$; P_1; and $P_1 + P_{2/4}$ where P_1 is the average period of the field-scanning wave and P_2 is the period of the line-scanning wave.

The generator 13, as mentioned above, is designed to develop a periodic saw-tooth scanning current wave of an average frequency equal to the average field frequency which, in the preferred embodiment of the invention, is 60 cycles. However, the synchronizing signal indicated at D is applied to the generator 13 from the combining amplifier 20 so that the retrace portions of the saw-tooth wave developed thereby are initiated and the trace portions thereof are ter-

minated upon the occurrence of the synchronizing impulses of the wave D and the saw-tooth scanning current wave developed by the generator 13 is of the form illustrated by curve E of Fig. 10. The durations of the trace portions of the cycles of this wave thus correspond to the periods of irregular timing of the synchronizing impulses of the wave D as described above. The saw-tooth wave E is returned to the same datum value after each retrace, due to the inherent operating characteristics of the relaxation generator B, thus ensuring accurate interlacing.

The magnetic deflecting field developed by the field-scanning coils 11b is of the same form as the saw-tooth current wave E, so that, with the line-scanning generator 12 and scanning elements 11a providing a saw-tooth deflecting field at the related line-scanning frequency and normal to the field-scanning field, successive fields of parallel lines are traced by the cathode ray or beam upon the target of the tube in interlaced relation and displaced in irregular sequence. In accordance with conventional practice, the beam is blocked out during the retrace periods of both the line-scanning and field-scanning waves and, in accordance with the present invention as presently explained, it is also blocked out during portions of the trace portions of the field-scanning cycles.

The patterns traced on the target are illustrated by the curves of Figs. 11 and 12. In these figures, as well as in Fig. 10, visible trace portions of the waves are indicated by full lines, blocked-out trace portions by broken lines, and retrace portions by dotted lines. For the purpose of clarity in illustration, in Figs. 11 and 12 an average of only five lines per field, including trace and retrace portions, have been shown, although, in an actual embodiment of the invention utilizing a 13,230 cycle line-scanning frequency and a 60 cycle average field frequency, there actually would be an average of 220½ lines per field or 882 lines per frame. Fig. 11 is so arranged with respect to Fig. 10 that the lines of each field are disposed adjacent their correspoding portions of the field-scaning wave E and the beginnings and terminations of the visible trace, block-out trace, and retrace portions of the waves of Figs. 10 and 11 occur at the same points with respect to time. Thus, the first field-scanning cycle illustrated includes 4½ lines; the second, 4¼ lines; the third, 4½ lines; and the fourth, 4¾ lines. The actual numbers of lines in the above embodiment would be 220½, 220¼, 220½, and 220¾. It will be noted that the visible parts of the trace portions of each field-scanning cycle are of the same durations. In other words, the block-out of the beam, which is effected by the pedestal-impulse generator 18, is initiated at points prior to the initiation points of the retrace portions of the cycles, the latter points corresponding to the impulses of the wave D. The block-out action, therefore, may be said to endure for periods corresponding to the invisible trace and retrace portions of each cycle, and to initiate at points which are either delayed with respect to the initiations of the trace portions of the cycles or advanced with respect to the initiations of the trace portions thereof. Suitable circuit constants may be chosen to effect this purpose in the pedestal-impulse generator 18, which is synchronized by its connection with the field-scanning generator 13 and timing generator 21, as stated above.

Fig. 12 represents the scanning pattern of one complete frame including four successive fields. The four successive trace portions of the curve of Fig. 11 are superimposed, thus indicating the entire scanning pattern which is traced on the target of the tube in the preferred irregular sequence. The particular fields of the frame to which the several lines belong are indicated at the ends of the lines in Fig. 12 and it will be seen that they are vertically displaced, due to the variation in the duration of the trace portions of successive field-scanning cycles, in the irregular sequence one, three, two, four, thus avoiding the crawling effects mentioned above. Since the beam is returned to the same vertical levels after each vertical scansion, the first line of each field, as shown in Fig. 12, initiates in the same horizontal line, and by virtue of the predetermined block-out control noted above the last line of each field terminates in the same horizontal line, thereby providing substantially smooth upper and lower edges for the scanning pattern.

Considered from another standpoint, it will be seen that the arrangement of Fig. 1 is one for tracing m-interlaced fields of parallel lines on the target of cathode-ray device 11, where m is an integer greater than three, specifically, four, while avoiding the appearance of moving waves in the reproduced television image, comprising means including generator 20 for periodically varying the durations of the trace portions of successive cycles of the field-scanning wave by an amount equal to an integral multiple of $1/m$th, specifically, one-fourth, the period of the line-scanning wave in a predetermined cycle having a period m times, specifically, four times, that of the field-scanning wave to displace the four interlaced fields on the target in irregular sequence.

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

Obviously, other relations between the line-scanning and field-scanning frequencies may be utilized. For example, frames of 450 lines at a line-scanning frequency of only 6,750 cycles 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 resolution as is obtained by ordinary two-field-per-frame interlaced scanning where approximately twice this line frequency is required to obtain 441 lines per frame. If desired, a compromise between these two improved results may be obtained by selecting other relationships between the line-scanning and field scanning frequencies.

While in the above-described system a particular circuit arrangement is disclosed for obtaining the interlacing in a particular irregular sequence, it will readily be appreciated by those skilled in the art that applicant's novel method of generating and utilizing irregular field-synchronizing signals to obtain multiple interlacing may be practiced by various other circuit arrangements and, further, that interlacing with other irregular sequences may be had. Moreover, applicant's improved apparatus may be employed in either its preferred or in a modified form for effecting irregular interlaced scanning in television systems of the mechanical or partly mechanical and partly electronic types and in sys-

tems where beams other than cathode rays, for example, light beams, are utilized with suitably modified beam-deflecting apparatus.

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. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic wave including cycles having trace and retrace portions and of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing m-interlaced fields of parallel lines on said target, where m is an integer greater than three, while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically varying the durations of the trace portions of successive cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period m times that of said field-scanning wave to displace said fields in said second direction in irregular sequence.

2. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing m-interlaced fields of parallel lines on said target, where m is an integer greater than three, while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically varying the durations of the trace portions of successive cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period m times that of said field-scanning wave to displace said fields in said second direction in irregular sequence.

3. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing m-interlaced fields of parallel lines on said target, where m is an integer greater than three, while avoiding the appearance of moving waves in the reproduced television image comprising means for alternately decreasing and increasing the durations of the trace portions of alternate cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period m times that of said field-scanning wave to displace said fields in said second direction in irregular sequence.

4. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined field-scanning frequency related to said line-scanning frequency, and means for alternately decreasing and increasing the durations of the trace portions of alternate cycles of said second wave by amounts corresponding to one-quarter of the time separation of adjacent lines for tracing four successive fields of parallel lines on said target in interlaced relation and displaced in said second direction in irregular sequence.

5. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions, and of an average predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing m-interlaced fields of parallel lines on said target, where m is an integer greater than three, while avoiding the appearance of moving waves in the reproduced television image comprising means for synchronizing the action of said last-mentioned generating means periodically to vary the durations of the trace portions of successive cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period m times that of said field-scanning wave for tracing a plurality of successive fields of parallel lines on said target in interlaced relation and displaced in said given direction in irregular sequence.

6. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined field-scanning frequency such that said line-scanning frequency is a fractional multiple of said field-scanning frequency, and means for tracing m-interlaced fields of parallel lines on said target, where m is an integer greater than three, while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically varying the durations of the trace portions of successive cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period m times that of said field-scanning wave

to displace said fields in said second direction in irregular sequence.

7. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and at a predetermined field-scanning frequency such that said line-scanning frequency is a fractional multiple of said field-scanning frequency, and means for alternately decreasing and increasing the durations of the trace portions of alternate cycles of said second wave by amounts corresponding to one-quarter of the time separation of adjacent lines for tracing four successive fields of parallel lines on said target in interlaced relation and displaced in said second direction in irregular sequence.

8. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising a means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined field-scanning frequency related to said line-scanning frequency, and means for tracing four interlaced fields of parallel lines on said target, while avoiding the appearance of moving waves in the reproduced television image comprising means for periodically varying the durations of the trace portions of successive cycles of said second wave by an amount equal to an integral multiple of one-fourth the period of said first wave in cycles having a period four times that of said field-scanning wave to displace said fields in said second direction in irregular sequence.

9. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined average field-scanning frequency related to said line-scanning frequency, means for generating a first synchronizing impulse wave of said average frequency, means for generating a second synchronizing impulse wave of said average frequency but having its impulses displaced in phase a predetermined amount with respect to the impulses of said first synchronizing wave, means for combining said synchronizing waves to provide a wave including alternate portions corresponding, respectively, to said first and second synchronizing waves, and means for utilizing said last-mentioned wave to so control said second periodic wave-generating means as to vary the duration of at least one portion of certain of the cycles of said second wave for tracing a plurality of successive fields of parallel lines on said target in interlaced relation and displaced in said given direction in irregular sequence.

10. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined average field-scanning frequency related to said line-scanning frequency, means for generating a first synchonizing impulse wave of said average frequency, means for generating a second synchronizing impulse wave of said average frequency but having its impulses displaced in phase a predetermined amount with respect to the impulses of said first synchronizing wave, a combining amplifier having input circuits coupled to said first and second synchonizing impulse-generating means, means for so controlling said amplifier as alternately and selectively to pass predetermined portions of said first and second synchronizing waves, and means coupling the output circuit of said amplifier to said second periodic wave-generating means to so synchronize the action thereof as to vary the duration of at least one portion of certain of the cycles of said second wave for tracing a plurality of successive fields of parallel lines on said target in interlaced relation and displaced in said given direction in irregular sequence.

11. In a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, a scanning wave generator comprising means for generating a first periodic wave of a predetermined line-scanning frequency, means for generating a second periodic saw-tooth wave including cycles having trace and retrace portions and of a predetermined average field-scanning frequency related to said line-scanning frequency, means for generating a first synchronizing impulse wave of said average frequency, means for generating a second synchronizing impulse wave of said average frequency but having its impulses displaced in phase a predetermined amount with respect to the impulses of said first synchronizing wave, a combining amplifier having input circuits coupled to said first and second synchronizing impulse-generating means, first and second generators for developing first and second control waves of rectangular wave form, of a predetermined frequency which is a fraction of said average frequency, and which are relatively displaced in phase 180 degrees, and means for applying said first and second control waves to said amplifier selectively to effect the passage thereby of said first and second synchronizing waves, respectively, only during the positive half cycles of said control waves, and means coupling the output circuit of said amplifier to said second periodic wave-generating means to so synchronize the action thereof as to vary the duration of at least one portion of certain of the cycles of said second wave for tracing a plurality of successive fields of parallel lines on said target in interlaced relation and displaced in said given direction in irregular sequence.

12. A method of developing scanning waves for a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, which comprises generating a first periodic wave of a predetermined line-scanning fre-

quency, generating a second periodic wave of a predetermined field-scanning frequency related to said line-scanning frequency and comprising cycles having trace and retrace portions, and tracing m-interlaced fields of parallel lines on the target, where m is an integer greater than three, while avoiding the appearance of moving waves on the reproduced television picture by periodically varying the durations of trace portions of successive cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period of m times that of said field-scanning wave to displace said fields in said second direction in irregular sequence.

13. A method of developing scanning waves for a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, which comprises generating a first periodic wave of a predetermined line-scanning frequency, generating a second periodic wave of a predetermined field-scanning frequency related to said line-scanning frequency and comprising cycles having trace and retrace portions, alternately decreasing and increasing the durations of the trace portions of alternate cycles of said second wave by amounts corresponding to one-quarter the time separation of adjacent lines for tracing four successive fields of parallel lines on said target in interlaced relation and displaced in said second direction in irregular sequence.

14. A method of developing scanning waves for a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, which comprises generating a first periodic wave of a predetermined line-scanning frequency, generating a second periodic ray-deflecting field of a predetermined field-scanning frequency such that said line-scanning frequency is a fractional multiple thereof and comprising cycles having trace and retrace portions for scanning the target of the tube in a second direction normal to said given direction, and tracing m-interlaced fields of parallel lines on the target, where m is an integer greater than three, while avoiding the appearance of moving waves on the reproduced television picture by periodically varying the durations of the trace portions of successive cycles of said second wave by an amount equal to an integral multiple of $1/m$th the period of said first wave in a predetermined cycle having a period of m times that of said field-scanning wave to displace said fields in said second direction in irregular sequence.

15. A method of developing scanning waves for a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, which comprises generating a first periodic wave of a predetermined line-scanning frequency, generating a second periodic ray-deflecting field of a predetermined field-scanning frequency such that said line-scanning frequency is a fractional multiple thereof and comprising cycles having trace and retrace portions for scanning the target of the tube in a second direction normal to said given direction, and alternately decreasing and increasing the durations of the trace portions of alternate cycles of said second wave by amounts corresponding to one-quarter the time separation of adjacent lines, for tracing four successive fields of parallel lines on said target in interlaced relation and displaced in said second direction in irregular sequence.

16. A method of developing scanning waves for a television interlaced scanning system including means for developing a scanning beam, a target, and means for deflecting the beam to scan the target in two directions normal to each other, which comprises generating a first periodic wave of a predetermined line-scanning frequency, generating a second periodic ray-deflecting field in cycles having trace and retrace periods and at a predetermined average field-scanning frequency related to said line-scanning frequency, generating a first synchronizing impulse wave of said average frequency, generating a second synchronizing wave of said average frequency but having its impulses displaced in phase a predetermined amount with respect to said first synchronizing wave, combining said synchronizing waves to provide a wave including alternate portions corresponding, respectively, to said first and second synchronizing waves, and controlling the generation of said second periodic wave in accordance with said synchronizing wave to vary the duration of at least one portion of certain of the cycles of said second wave, for tracing 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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