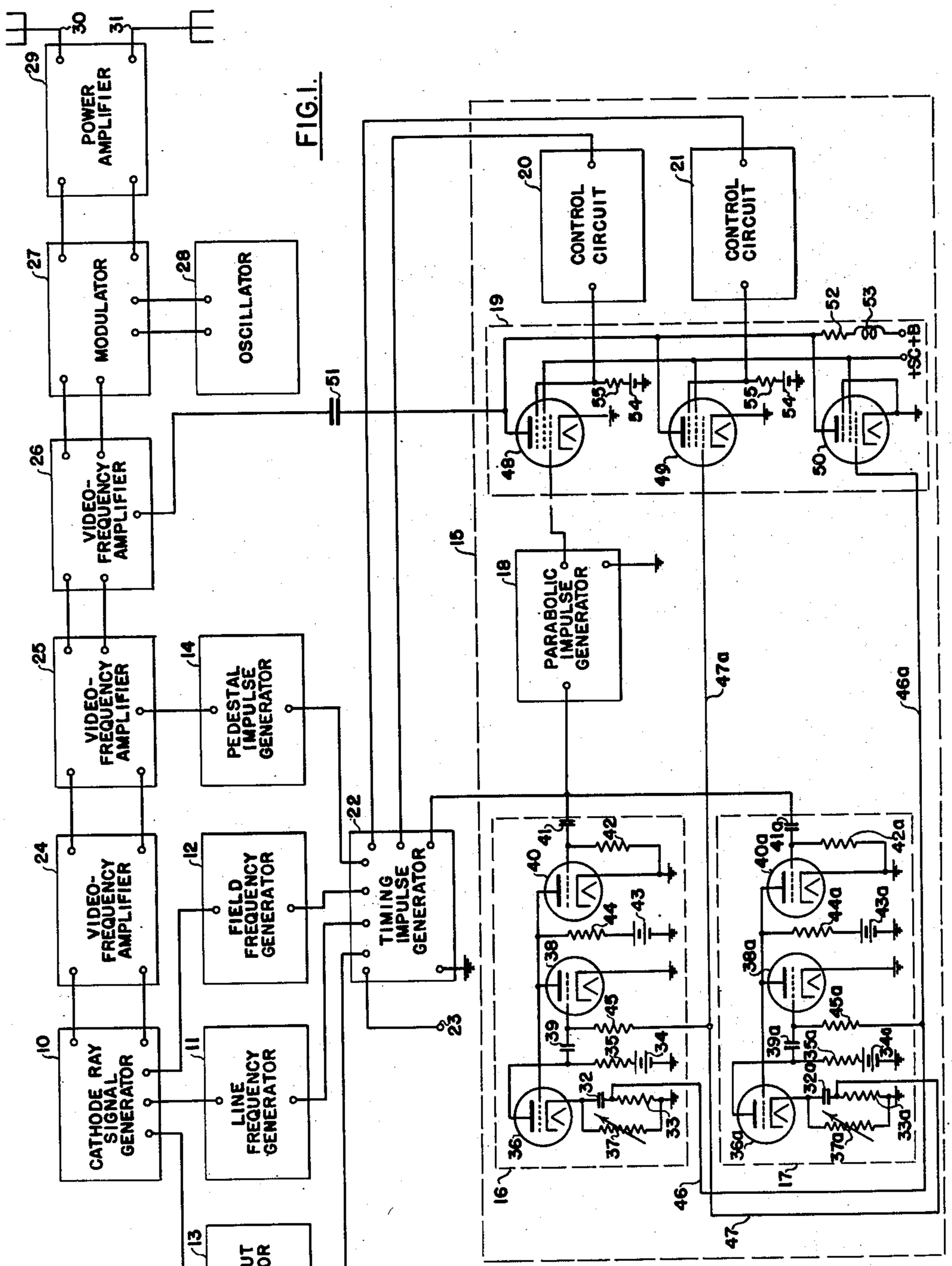
Dec. 19, 1939. H. M. LEWIS 2,183,966

PERIODIC WAVE-GENERATING SYSTEM

Filed Dec. 22, 1937 2 Sheets-Sheet 1

FIG. 1.



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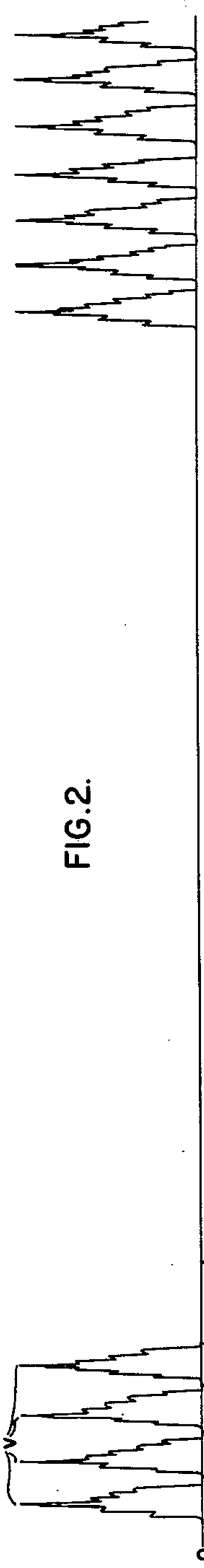

FIG.2.

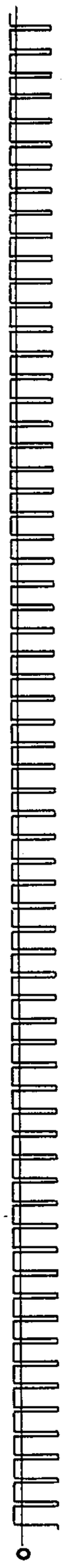

FIG.3.

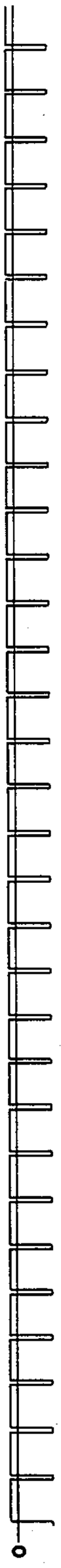

FIG.4.

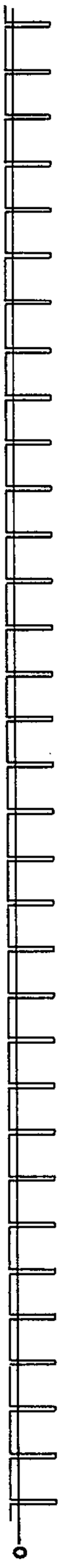

FIG.5.

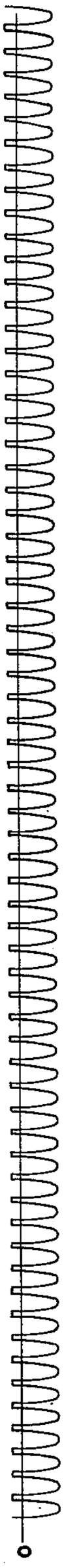

FIG.6.

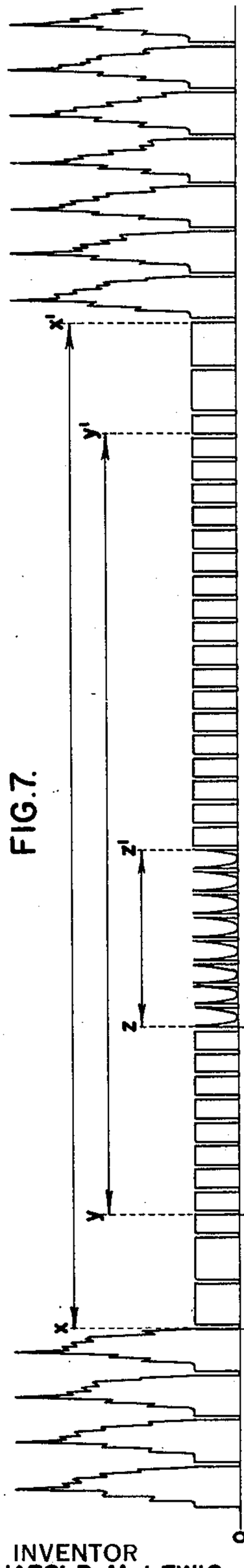

FIG.7.

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PERIODIC WAVE-GENERATING SYSTEM

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Application December 22, 1937, Serial No. 181,129

9 Claims. (Cl. 250—36)

This invention relates to periodic wave-generating systems. The invention is especially concerned with the provision of a wave-generating system for developing a scanning-synchronizing signal for use in a television system.

In accordance with present television practice, there is developed and transmitted a signal which comprises a carrier wave, modulated during recurring intervals or trace periods by video-frequency components representative of light and shade values of an image being transmitted. During the retrace intervals, between the trace periods, the carrier wave is modulated by a composite synchronizing signal which comprises impulses or components corresponding to the initiations of successive lines and fields in the scanning of the image. At the receiver a beam is so deflected as to scan and illuminate a target in a series of successive fields of parallel lines, the video-frequency components of the signal being utilized to control the intensity of the beam. The line-synchronizing and field-synchronizing components are separated from the video-frequency components and from each other and utilized to synchronize the operation of the receiver line-scanning and field-scanning apparatus with the corresponding apparatus utilized at the transmitter in developing the signal. The transmitted image is thereby reproduced on the target of the receiver.

In scanning of the interlaced type, line and field frequencies are so related that successive fields are staggered, the lines of one field falling between or interlacing those of a preceding field and, due to persistence of vision, an optical effect is produced as though each field comprised a multiple of the actual number of lines scanned per field.

Various types of synchronizing signals and apparatus for developing them have heretofore been proposed, the type of signal required ordinarily being dependent upon the type of scanning utilized. Where interlaced scanning is employed, certain of the field-synchronizing impulses must occur between line-synchronizing impulses and, in order that the line-synchronizing and frame-synchronizing impulses of the composite synchronizing signal may be successfully separated from each other and utilized, a special type of synchronizing signal is required. One such type of signal which has been proposed comprises line-synchronizing and frame-synchronizing impulses of the same amplitude, but with the latter of substantially longer duration than the former and serrated to permit uninterrupted recurrence of the former. Such a signal may be developed by generating a line-synchronizing impulse wave of the desired frequency and, in addition, generating a similar alternate-impulse wave and a parabolic-impulse wave, the alternate wave being of the line-scanning frequency but having its impulses so displaced in phase as to occur between the line-synchronizing impulses, and the parabolic wave being of double the line-scanning frequency with its impulses in such phase as to occur intermediate the line-synchronizing and alternate impulses. These three waves may then be periodically combined at field-scanning frequency intervals and for predetermined durations, thereby to produce the desired serrated field-synchronizing impulses. Certain difficulties, however, are presented in the development of the several waves in the precise synchronism required to procure the necessary phase relationships, this being particularly true with regard to the line-synchronizing and alternate-impulse waves.

It is an object of the present invention, therefore, to provide an improved periodic composite impulse wave-generating system.

More particularly, it is an object of the invention to provide a system of the character described which is especially adapted in developing a composite synchronizing signal for use in a television system.

In accordance with the present invention there is provided a periodic wave-generating system which comprises means for generating a first periodic-impulse wave of a predetermined frequency, for example, a desired line-scanning frequency, together with separate means for generating a second similar periodic-impulse wave of the same frequency. Preferably, a synchronizing circuit, adapted for the reception of a synchronizing-impulse wave of double the predetermined frequency, is coupled directly to each of the two generating means for synchronizing their respective operations. Means are provided for ensuring the selective synchronization of the two generators by successive cycles of said first and second waves. This later means may comprise a direct connection between the two generating means for controlling the operation of one in accordance with the operation of the other.

Each of the generating means may comprise energy-storage means with charging and discharging circuits therefor and suitable control means, such as a vacuum tube, for controlling these circuits to effect periodic charging and discharging of the storage means. The control connection between the two generating means pref-

erably serves to disable one circuit of one of the generating means during operation of the corresponding circuit of the other of the generating means. An arrangement for generating wave forms of the general type of those utilized in the present invention and which, per se, forms no part of the present invention is disclosed and broadly claimed in a copending application of Madison Cawein, Serial No. 176,963, filed November 29, 1937, and assigned to the same assignee as the present application.

For a better understanding of the 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, partially schematic, of a complete television transmitting apparatus embodying the invention; while Figs. 2-7, inclusive, are curves illustrating the wave forms of periodic waves developed at various points of the system of Fig. 1 to aid in the understanding of the invention.

Referring now more particularly to Fig. 1 of the drawings, there is illustrated a television transmitting system comprising a cathode-ray signal generator 10, which may be of a conventional design and include the usual signal-generating tube, camera, and scanning elements. For the purpose of developing scanning voltages or currents for the generator 10, there are provided a line-frequency saw-tooth wave generator 11 and a field-frequency saw-tooth wave generator 12, the output circuits of these generators being connected to the scanning elements of the signal generator 10 in the usual manner. In order to block out the cathode ray of the generator 10 during the retrace scanning periods, there is provided a block-out wave generator 13 having its output circuit suitably connected to the signal generator 10. For providing pedestal impulses to suppress undesirable signal impulses during retrace scanning periods and to ensure the proper form of the modulation signal to be developed, there is provided a pedestal-impulse generator 14 and, in order to develop a composite scanning-synchronizing signal in accordance with the present invention, there is provided a synchronizing signal generator 15. The generator 15 comprises a line-synchronizing impulse-wave generator 16, an alternate-impulse wave generator 17, a parabolic-impulse wave generator 18, and a signal-combining network 19. Suitable control circuits 20 and 21 are provided in connection with the combining network. For the purpose of synchronizing the generators 11—14, inclusive, and 16—18, inclusive, and the control circuits 20 and 21, there is provided for the system a timing-impulse generator 22 to which are coupled the input circuits of the last-mentioned generators and control circuits. Preferably, the generators 16—18, inclusive, are all connected to a single output circuit of the generator 22, across which is developed a periodic synchronizing-impulse wave of double the desired line-scanning frequency, for example, 26,460 cycles for 441 line interlaced scanning with a field frequency of 60 cycles.

In accordance with the present invention as hereinafter described, the generators 16 and 17 are arranged to be individually synchronized by successive impulses of the double-frequency wave, while the parabolic-impulse wave generator 18 develops a wave of the double frequency and is synchronized by all of the impulses of the timing wave from generator 22. The generator 22 is preferably stabilized by means of a connection 23 to a suitable source of periodic voltage, for example, the power supply circuit or the synchronizing source of motion picture mechanism, where such is employed.

Connected in cascade to the output circuit of the cathode-ray signal generator 10, in the order named, are video-frequency amplifiers 24, 25, and 26, a modulator 27 and associated coupled oscillator 28, a power amplifier 29, and an antenna system 30, 31, all according to conventional practice. The output circuit of the pedestal generator 14 is coupled to the video-frequency amplifier 25, while the output circuit of the combining network 19 is coupled to the video-frequency amplifier 26.

Neglecting for the moment the details of the synchronizing signal-generating apparatus which embodies the present invention, the system just described comprises a television transmitting system of conventional design and the various parts thereof, illustrated schematically, being of well-known construction, a detailed description of the general system and its operation is unnecessary. Briefly, however, the image of a scene to be transmitted is focused on the target of the cathode-ray tube of the signal generator 10, in which tube a cathode ray is developed, focused, and accelerated toward the target in the usual manner. Scanning or deflecting currents or voltages developed by the generators 11 and 12 are applied to the scanning elements of the generator 10 to provide electric fields which serve to deflect the cathode ray horizontally and vertically, thereby to scan successive series of parallel lines or fields upon the target. The deflecting currents or voltages and, hence, the scanning fields are of well-known saw-tooth form providing a relatively slow linear trace and rapid retrace. The number of lines per field are determined by the relative field-scanning and line-scanning frequencies and these frequencies are preferably such, for example, 26,460 kilocycles and 60 cycles, respectively, that the successive fields are staggered or interlaced in the well-known manner. Block-out impulses developed by the generator 13 are applied to a control electrode of the cathode-ray tube to suppress or block-out the beam during retrace portions of the scanning cycles, while pedestal impulses developed by the generator 14 are applied to the amplifier 25 to suppress surges developed during the retrace period and to modify the resultant video-frequency wave developed, thereby to aid in the separation of line-synchronizing and frame-synchronizing impulses at the receiver.

The synchronizing impulses developed by the generators 16—18, inclusive, are combined in the network 19 and applied therefrom as a composite synchronizing signal to the modulation amplifier 26. Timing impulses developed by the generator 22 are applied to the generators 11—14, inclusive, and 16—18, inclusive, and to the control circuits 20, 21 to lock these generators in synchronism.

The photosensitive elements of the target in the cathode-ray tube generator 10 being electrically affected to an extent depending upon the varying values of light and shade at incremental areas of the images focused thereon as the cathode-ray scans the target, a video-frequency voltage of correspondingly varying amplitude is developed in the output circuit of the generator 10 and applied to the video-frequency amplifier 24, wherein this voltage is amplified and from which

it is translated to the amplifier 25. Here the video-frequency voltages are further amplified and mixed with the pedestal impulses supplied from the generator 14. The mixed amplified voltages in the output circuit of the amplifier 25 are thereupon applied to the amplifier 26, wherein they are further amplified and mixed with the composite synchronizing signal supplied from the combining network 19. The composite modulation signal is then supplied to the modulator 27, wherein it is impressed upon the carrier wave generated by the oscillator 28, and the resultant modulated-carrier signal is delivered to the power amplifier 29 for amplification and is thereafter impressed upon the antenna system 30, 31 to be broadcast.

Referring now more particularly to the apparatus embodying the present invention and the circuits associated therewith, the composite synchronizing signal-generating apparatus 15 includes, as stated above, the line-synchronizing impulse wave generator 16, the alternate-impulse wave generator 17, and the parabolic-impulse wave generator 18. The generator 16 includes energy-storage means, such as a condenser 32, having a resistor 33 in series therewith, the latter having an impedance which is relatively very small compared to that of the condenser 32 at the oscillation frequency. A charging circuit is provided for the condenser 32 which includes a source of direct current, for example, a battery 34, preferably grounded at its negative terminal, a resistor 35 and the space current path of a vacuum tube 36. A discharging circuit comprising an adjustable resistor 37 is connected across the condenser 32. The tube 36 serves as means for controlling the charging and discharging circuits to effect periodic charging and discharging of the condenser 32. There is also provided regenerating tube 38 having its cathode grounded and its anode connected to the control electrode of the tube 36, while the control grid of the regenerating tube is connected by way of a suitable coupling condenser 39 to the anode of the tube 36. A buffer amplifier tube 40 is preferably interposed between the generator, per se, and the timing-impulse generator 22 to which it is coupled by way of a suitable condenser 41 to receive synchronizing or control impulses of twice the line-scanning frequency. A suitable grid-leak resistor 42 is connected between the control grid and cathode of the tube 40, while operating potentials may be supplied to the anodes of the tubes 38 and 40 from a battery 43 by way of a common load resistor 44. A leak resistor 45 is connected to the grid of the regenerating tube 38 and is utilized in accordance with the present invention, as will be presently explained. The alternate-impulse wave generator 17 is of the same construction and operation as the generator 16, similar elements being designated by the same reference numerals with the suffix *"a"*.

For the purpose of controlling the operation of each of the generators 16, 17 in accordance with the operation of the other, or more particularly to disable one of the charging or discharging circuits of one of these generators during the operation of the corresponding circuit of the other generator, there is provided a direct connection 46, including resistor 45*a*, between the control grid of the regenerating tube 38*a* of the generator 17 and the high potential terminal of the resistor 33 of the generator 16. If desired, a similar additional connection 47, including resistor 45, may be provided between the control grid of the regenerating tube 38 of generator 16 and the high potential terminal of the resistor 33*a* of generator 17.

The combining network 19 preferably comprises three high impedance pentode amplifier tubes 48, 49, and 50. The output circuits, including the leads 46*a* and 47*a*, of the generators 16 and 17 are connected to the control grids of the tubes 50 and 49, respectively, while the output circuit of the parabolic-impulse generator 18 is connected to the control grid of the tube 48. The anode circuits of these tubes are connected in parallel and coupled to the amplifier 26 by way of a coupling condenser 51. Operating potentials are supplied to the anodes of the tubes by way of load resistor 52 and choke 53 and to the screens from suitable sources indicated generally at +B and +Sc. The suppressor grids of the tubes 48 and 49 are normally biased sufficiently negatively to maintain these tubes nonconductive, as by means of batteries 54 and leak resistors 55. The suppressor grids of the tubes 48 and 49, however, are also coupled to the control circuits 20 and 21, respectively, each of which comprises suitable apparatus for generating a periodic voltage wave of rectangular impulse wave form at the desired field-scanning frequency and of predetermined duration, these waves being applied positively to the suppressor grids of the respective tubes 48 and 49 to bias them above cutoff in the presence of the control impulses. The control circuits are connected, as stated above, to the timing-impulse generator 22 for synchronization at the field frequency.

In the operation of the synchronizing signal-generating apparatus 15, the generators 16 and 17 operate as conventional regenerative relaxation oscillators, such as described in United States Letters Patent No. 2,052,184, granted August 25, 1936, upon the application of Harold M. Lewis, generating periodic-impulse waves of line-scanning frequency in a manner well understood in the art, so that a detailed explanation thereof is unnecessary. Briefly, however, in generator 16, the condenesr 32 is rapidly charged from the source 34 by way of the tube 36 and is discharged at a relatively slow rate through the resistor 37. The discharging action continues until the potential difference developed across the tube 36 is sufficient, upon the application of a synchronizing impulse to its control grid from the generator 22, to break down the tube 36 and initiate another charging action. The initial surge of charging current results in a voltage impulse across the resistor 35 which is impressed negatively by way of condenser 39 upon the control grid of the regenerating tube 38, reducing its conductivity. A positive impulse peak is thereby developed across the load resistor 44 and applied to the control grid of the tube 36 to accelerate or regenerate its charging action. The synchronizing or timing impulses from the generator 22 are applied to the control grid of the tube 36 by way of the condenser 41 and the buffer amplifier 40 and serve to synchronize the operation of the generator at the line-scanning frequency.

The periodic charging and discharging of the condenser 32 causes a voltage to be developed thereacross which has a saw-tooth wave form and, hence, a current flows through the condenser 32 and resistor 33 which has a periodic rectangular-impulse wave form, that is, a wave form which is the first derivative of the saw-tooth voltage wave form. This voltage is impressed upon tube 50 of the combining network

19 by way of the leads 46 and 46*a*. Similarly, the generator 17 develops a voltage across the resistor 33*a* which is applied by way of the leads 47 and 47*a* to tube 49 of the combining network. The natural frequencies of the generators 16 and 17, that is, the frequency at which they would operate without synchronizing control, are slightly lower than the desired line-synchronizing frequency to ensure operation at half the applied synchronizing frequency, the latter being double the line frequency.

Assuming a point in the cycle when the tube 36 is passing current to charge its condenser 32, the current is then flowing through the resistor 35 in its anode circuit biasing the control grid of the reversing tube 38 negatively, which is the proper direction to effect the regenerative action, while the current is flowing through resistor 33 in series with the condenser 32 in such direction as to develop thereacross a positive voltage which is applied to the control grid of the reversing tube 38*a*. This positive voltage is in the proper sense to cause the reversing tube 38*a* to block the tube 36*a*, that is, it is opposite to that required for regeneration of generator 17 so that the initiation of the next cycle of this generator is prevented. Similarly, the voltage developed across the resistor 33*a* during charging of condenser 32*a* of the generator 17 is applied to the control grid of the regenerating tube 38 of the generator 16 to prevent the initiation of the next cycle of this generator during charging of generator 17. That is, the charging circuit of each generator is disabled during the charging operation of the other generator. Obviously, therefore, the two generators, while having a synchronizing-impulse wave from generator 22 applied thereto which is of double the frequencies developed thereby, are selectively synchronized by successive impulses of this wave. In other words, the predetermined phase displacement between the impulses of the waves developed by the two generators is maintained.

The general operation of the system may be explained with reference to the curves of Figs. 2–7, inclusive, which show the wave forms of the voltages or currents developed at various points in the system. Fig. 2 represents the signal appearing at the output circuit of the video-frequency amplifier 25, video-frequency impulses indicated at V having been supplied from the cathode-ray signal generator 10 and line-frequency and frame-frequency pedestals p_l and p_f having been determined or formed by voltage from generator 14 mixed with the video-frequency signal in the amplifier 25. The curve of Fig. 3 represents the double line-frequency synchronizing-impulse wave developed in one of the output circuits of the timing generator 22 and applied to the input circuits of the generators 16, 17, and 18. The curve of Fig. 4 represents the line-synchronizing impulse wave developed by the generator 16 and applied to the input circuit of the tube 50, while the curves of Figs. 5 and 6 represent the alternate line-frequency impulse wave and parabolic-impulse wave, the latter being at the double-line frequency developed by the generators 17 and 18 and applied to the input circuits of the tubes 49 and 48, respectively. As explained above, alternate-line impulses occur intermediate the line-scanning impulses, while the parabolic impulses occur between the succeeding impulses of the combined line-synchronizing impulse and alternate-impulse waves.

The final desired modulation signal developed by the system is of the wave form shown in Fig. 7, including the video-frequency voltages as well as the composite synchronizing signal. To develop such a wave, the line-synchronizing impulses are repeated continuously by the tube 50, its operating voltages being such as to effect this operation, while the alternate impulses are added during a part of the retrace portion of each field-frequency cycle, this portion corresponding to the duration of the field-frequency pedestal. During a part of the line-doubling period, the parabolic impulses are added or inserted between the line-synchronizing and alternate impulses to provide, in effect, relatively long serrated field-synchronizing impulses for each field cycle without interruption of the line-synchronizing impulses. The combined synchronizing signal is then combined with the video signal, as stated above, in the amplifier 26.

The line-doubling and inserting operations are effected at the proper times and for the proper durations by virtue of the actions of tubes 48 and 49, controlled by their respective control circuits 20 and 21. More particularly, since these two tubes are normally biased beyond cutoff by the suppressor bias batteries 54, they are normally nonconductive and the alternate and parabolic waves do not appear in the common output circuit of the network 19. The positive control impulses which are supplied by the circuits 20 and 21, however, serve to unblock these tubes for predetermined periods at the field-scanning frequency, thereby to effect the combining actions, as described above.

In Figs. 2 and 7 the points x and x' correspond to the beginning and termination, respectively, of the frame-pedestal impulses, such as are supplied by the generator 14. The line doubling, or addition of alternate impulses, takes place during the time interval between the points indicated at y and y' in Fig. 7, the initiation of this action being preferably delayed for the period represented at d_1. The addition or insertion of the parabolic impulses takes place between the points z and z', the initiation of this action being delayed for a period represented as d_2. The control circuits 20 and 21 include suitable apparatus for effecting the required delays and durations of the control impulses.

The output circuits of the tubes 48, 49, and 50 being connected in parallel, when these tubes are conductive the signals impressed on their input circuits are combined in their common output circuit, the tube 50 continuously repeating the line-synchronizing impulses (Fig. 4) received from the generator 16 and the tubes 48 and 49 operating intermittently, as described above. The combined synchronizing signal is thus developed in the output circuit of the combining network 19, supplied to the amplifier 26, and therein mixed with the video-frequency signal, the resultant modulation signal of the desired wave form shown in Fig. 7 being thus obtained.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious 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. A periodic wave-generating system, comprising a generator for generating a first periodic

wave of a predetermined frequency, a separate generator for independently generating a second periodic wave of said predetermined frequency, a synchronizing circuit adapted for the reception of a synchronizing wave of double said predetermined frequency and coupled directly to each of said generators for synchronizing their respective operations, and means for ensuring selective synchronization of said two generators by successive cycles of said synchronizing wave comprising a direct connection between said generators for controlling the operation of one in accordance with the operation of the other.

2. A periodic wave-generating system, comprising a generator for generating a first periodic wave of a predetermined frequency, a separate generator for independently generating a second periodic wave of said predetermined frequency, each of said generators comprising energy-storage means, charging and discharging circuits for said storage means, and a control circuit for controlling said charging and discharging circuits to effect periodic charging and discharging of said storage means, and means for coupling the control circuit of one of said generators to one of the charging and discharging circuits of the other of said generators for disabling the corresponding circuit of said one of said generators during operation of said corresponding circuit of the other of said generators.

3. A periodic wave-generating system, comprising means for generating a first periodic wave of a predetermined frequency, means for generating a second periodic wave of said predetermined frequency, each of said generating means comprising energy-storage means, charg- and discharging circuits for said storage means and means for controlling said circuits to effect periodic charging and discharging of said storage means, and means coupling said generating means to prevent charging of the storage means of one of said generating means during charging of the storage means of the other of said generating means.

4. A periodic wave-generating system, comprising means for generating a first periodic wave of a predetermined frequency, means for generating a second periodic wave of said predetermined frequency, a synchronizing circuit adapted for the reception of a synchronizing wave of double said predetermined frequency and coupled to said generating means for synchronizing their respective operations, each of said generating means comprising energy-storage means, charging and discharging circuits for said storage means, and means for controlling said circuits to effect a periodic charge and discharge of said capacitance means, and means for ensuring selective synchronization of said two generating means by successive cycles of said synchronizing wave comprising means coupling said generating means to prevent charging of the storage means of one of said generating means during charging of the storage means of the other of said generating means.

5. A periodic wave-generating system, comprising means for generating a first periodic wave of a predetermined frequency, means for generating a second periodic wave of said predetermined frequency, each of said generating means comprising energy-storage means, charging and discharging circuits for said storage means, means for controlling said circuits to effect a periodic charge and discharge of said storage means and means for regenerating the action of said control means, and means coupling the charging circuit of one of said generating means to the regenerating means of the other of said generating means to prevent charging of the storage means of said other generating means during charging of the storage means of said one of said generating means.

6. A periodic voltage-generating system, comprising means for generating a first periodic wave of a predetermined frequency, means for generating a second periodic wave of said predetermined frequency, each of said generating means comprising energy-storage means, charging and discharging circuits for said storage means, and a vacuum tube included in said charging circuit for effecting periodic charging and discharging of said storage means, an impedance element in series with said tube in the charging circuit of one of said generating means, and means connecting a control element of the other of said generating means across said impedance element for preventing charging of the storage means of said other generating means during charging of the storage means of said one generating means.

7. A periodic voltage-generating system, comprising means for generating a first periodic-impulse wave of a predetermined frequency, means for generating a second periodic-impulse wave of said predetermined frequency, each of said generating means comprising energy-storage means, charging and discharging circuits for said storage means, and a vacuum tube included in said charging circuit for effecting periodic charging and discharging of said storage means, a synchronizing circuit adapted for the reception of a synchronizing-impulse wave of double said predetermined frequency and coupled to said generating means for synchronizing the respective operations, and means for ensuring selective synchronization of said two generating means by successive impulses of said synchronizing wave, comprising an impedance element in series with the tube in the charging circuit of one of said generating means, and means connecting a control element of the other of said generating means across said impedance element for preventing charging of the storage means of said other generating means during charging of the storage means of said one generating means.

8. A periodic voltage-generating system, comprising means for generating a first periodic wave of a predetermined frequency, means for generating a second periodic wave of said predetermined frequency, each of said generating means comprising energy-storage means, charging and discharging circuits for said storage means, and a vacuum tube included in said charging circuit for effecting periodic charging and discharging of said storage means, means coupled to said tube for regenerating the action thereof, and means coupling the charging circuit of one of said generating means to the regenerating means of the other of said generating means for preventing charging of the storage means of said other generating means during charging of the storage means of said one generating means.

9. A periodic voltage-generating system, comprising means for generating a first periodic-impulse wave of a predetermined frequency, means for generating a second periodic-impulse wave of said predetermined frequency, each of said generating means comprising capacitance means, charging and discharging circuits for said capacitance means, and a vacuum tube included in

said charging circuit for periodically effecting charging and discharging of said capacitance means, means coupled to said tube for regenerating the action thereof, a synchronizing circuit adapted for the reception of a synchronizing-impulse wave of double said predetermined frequency and coupled to said generating means for selectively synchronizing the respective operation thereof by successive synchronizing impulses, and means coupling the charging circuit of one of said generating means to the regenerating means of the other of said generating means for preventing charging of the capacitance means of said other generating means during charging of the capacitance means of said one generating means.

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