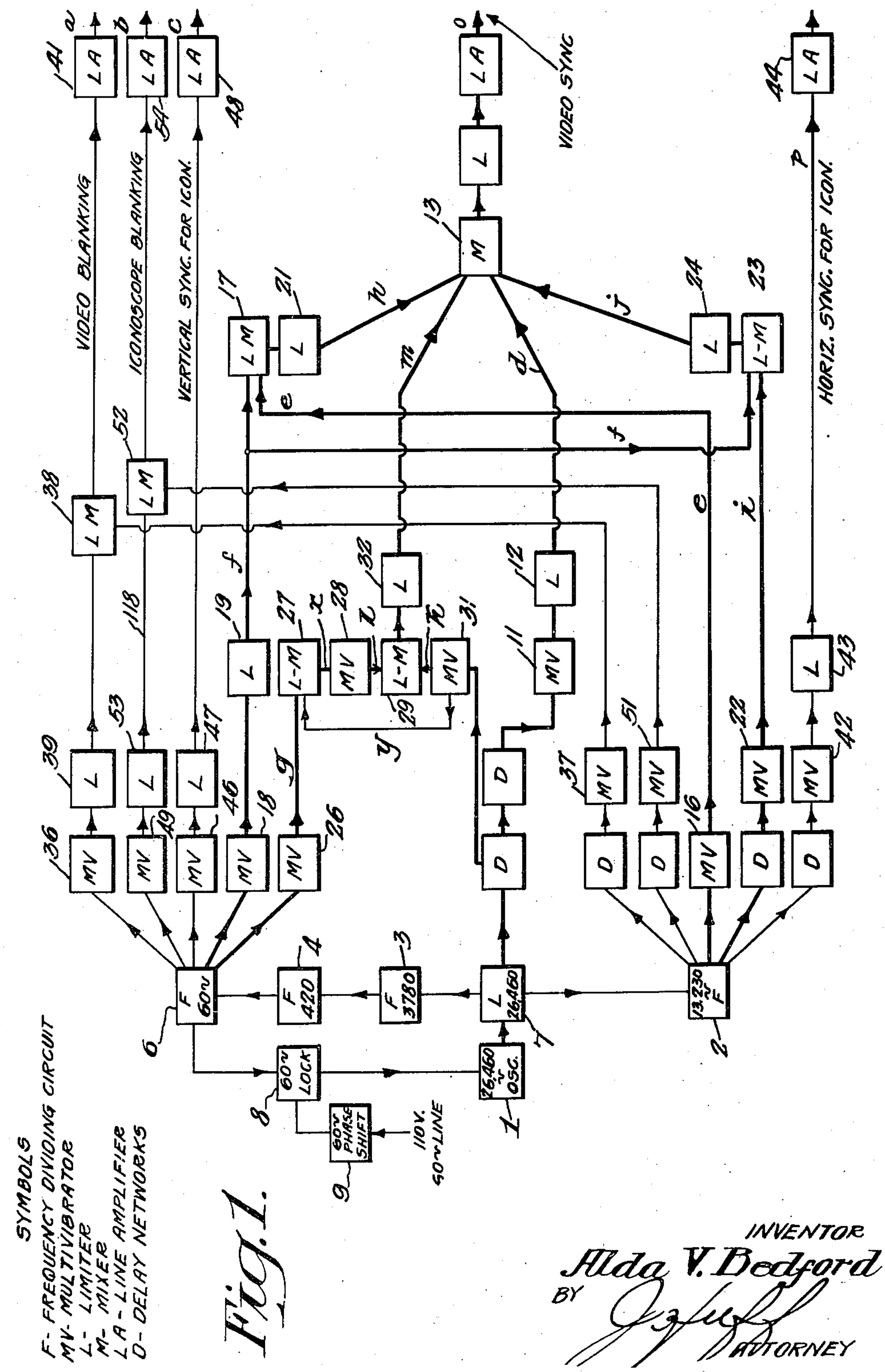
SYNCHRONIZING SIGNAL GENERATOR

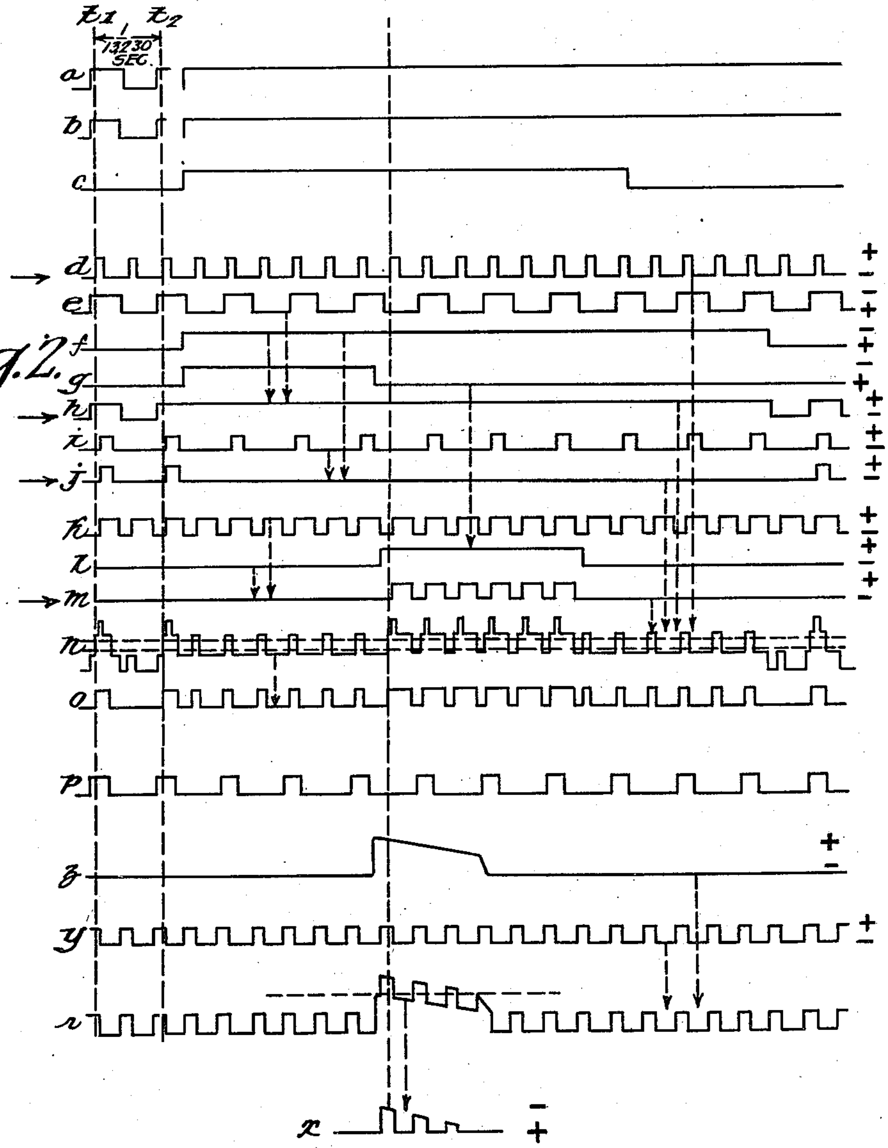
Filed Nov. 30, 1938 7 Sheets-Sheet 1



SYNCHRONIZING SIGNAL GENERATOR

Filed Nov. 30, 1938 7 Sheets-Sheet 2

Fig. 2.



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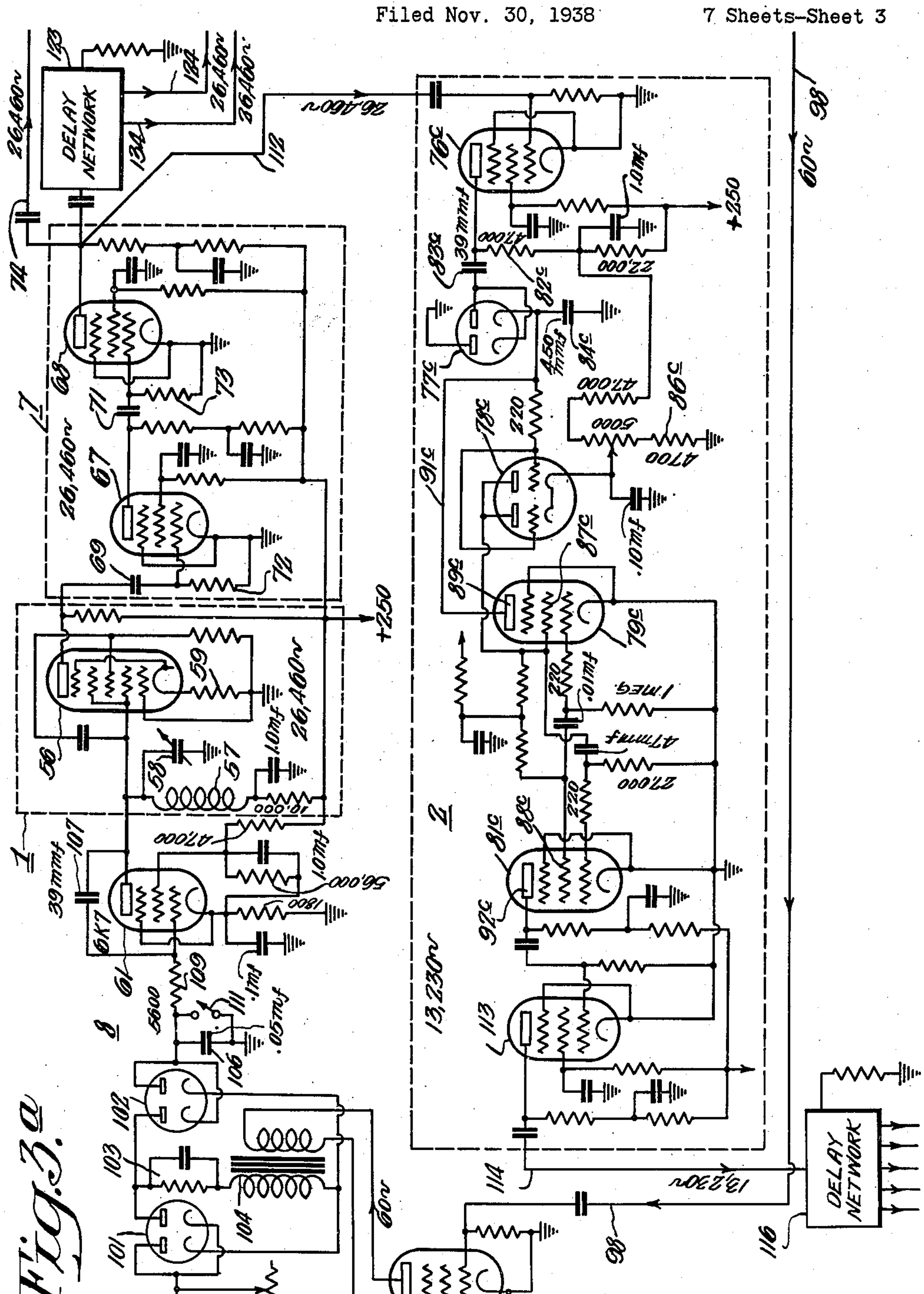
SYNCHRONIZING SIGNAL GENERATOR

Filed Nov. 30, 1938 7 Sheets-Sheet 3



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SYNCHRONIZING SIGNAL GENERATOR

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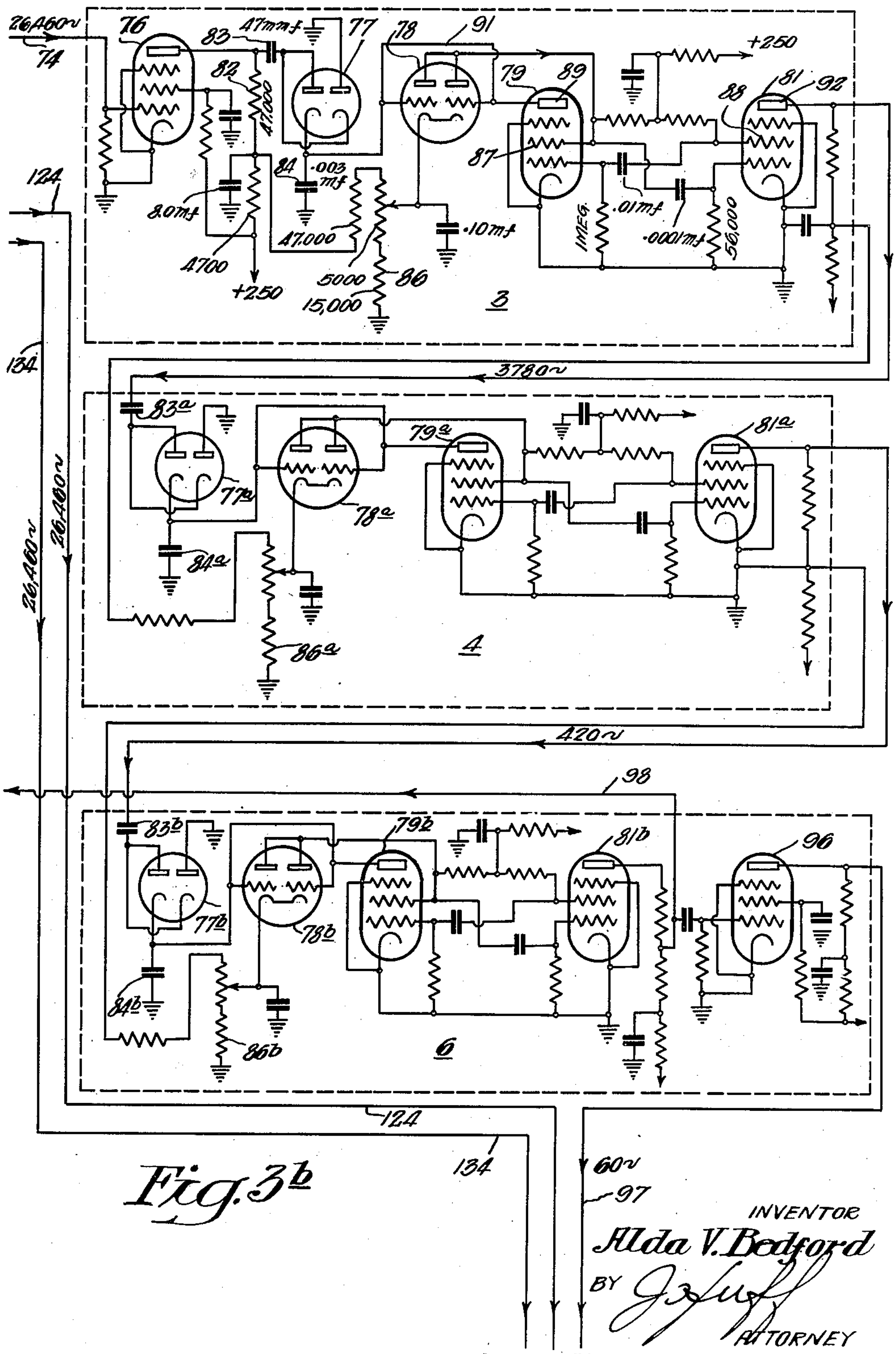

Fig. 3b

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SYNCHRONIZING SIGNAL GENERATOR

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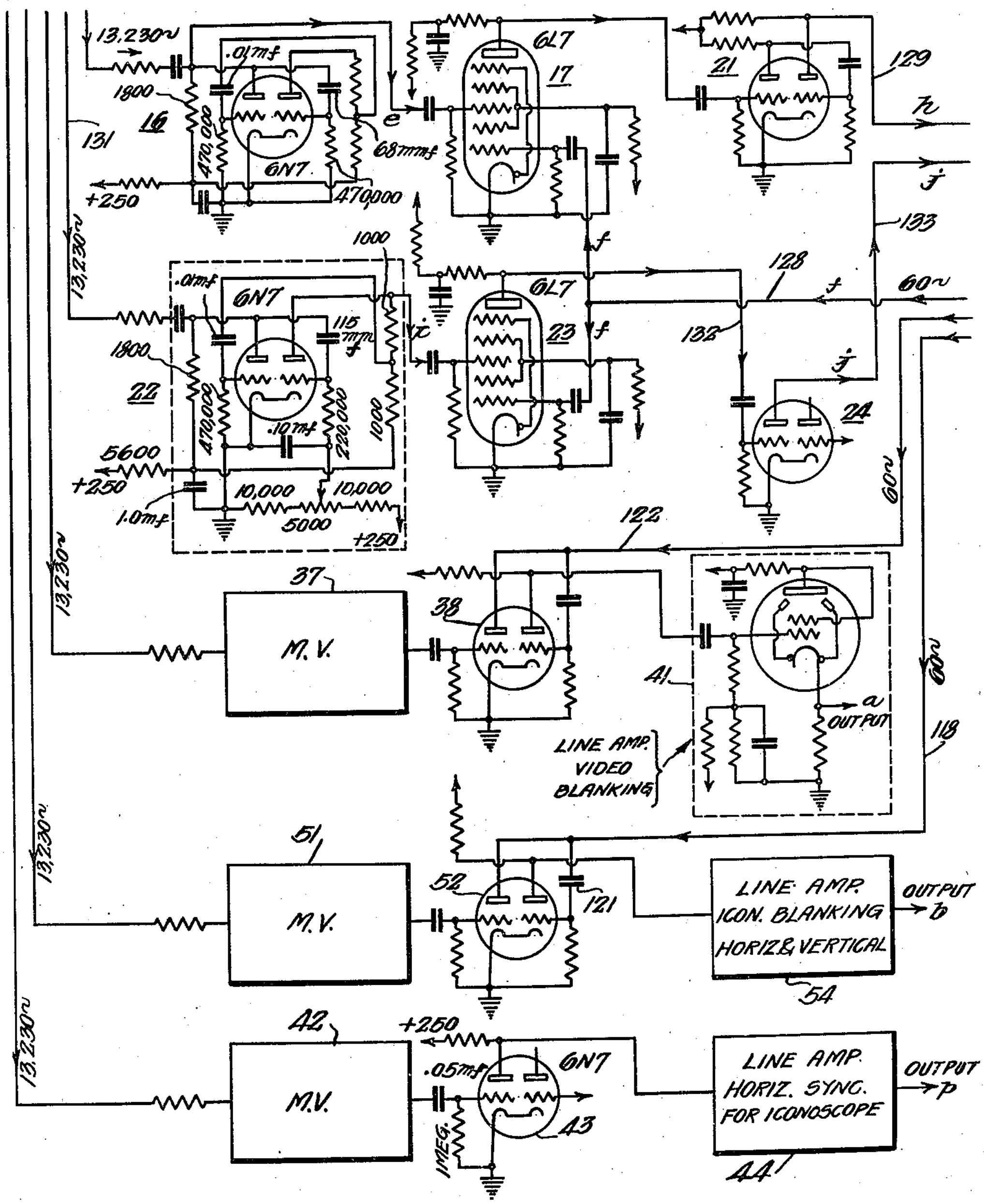

Fig. 3c

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SYNCHRONIZING SIGNAL GENERATOR

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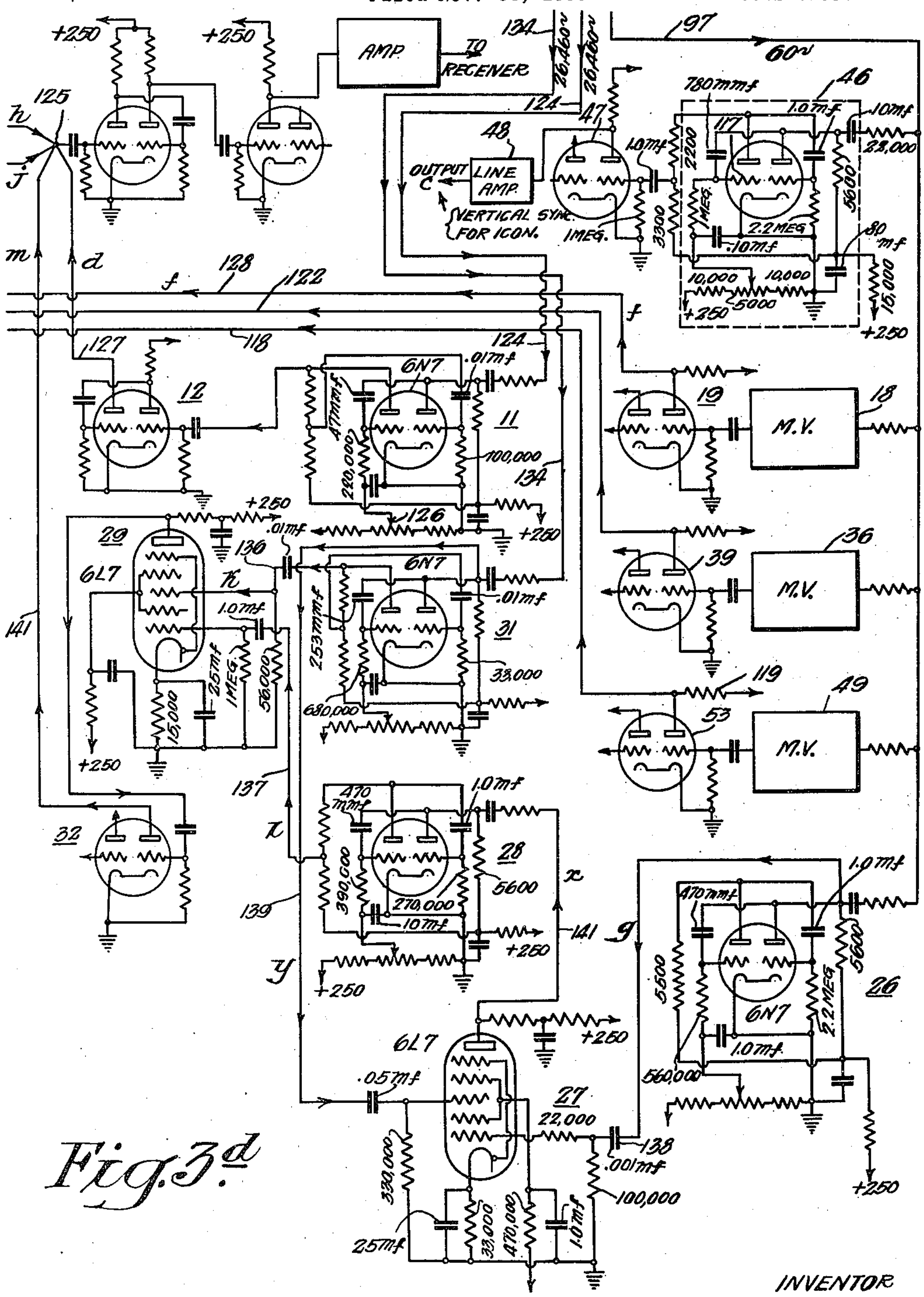

Fig. 3d

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SYNCHRONIZING SIGNAL GENERATOR

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Fig. 4.

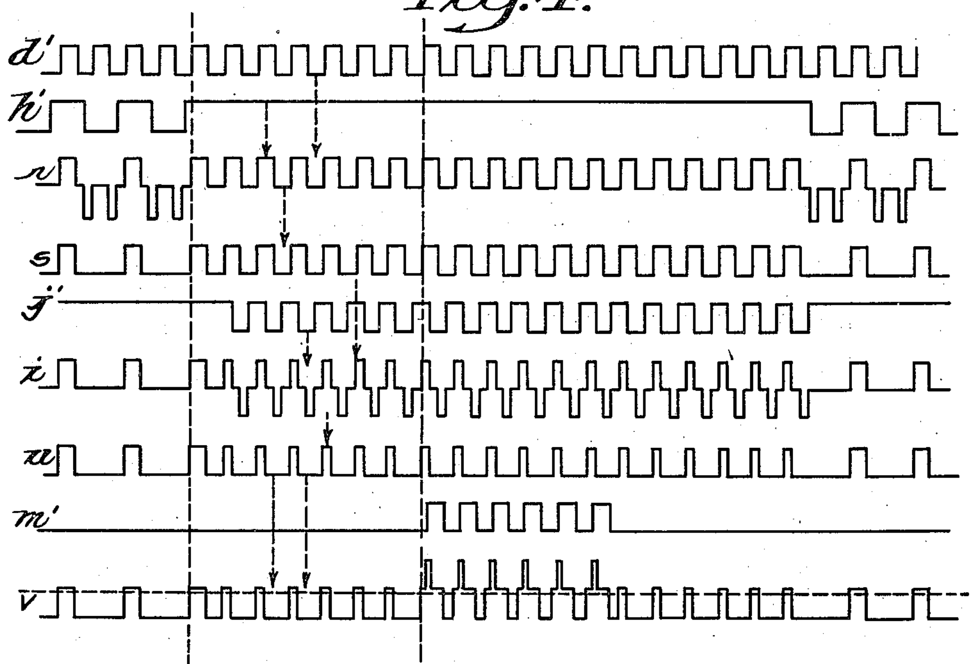
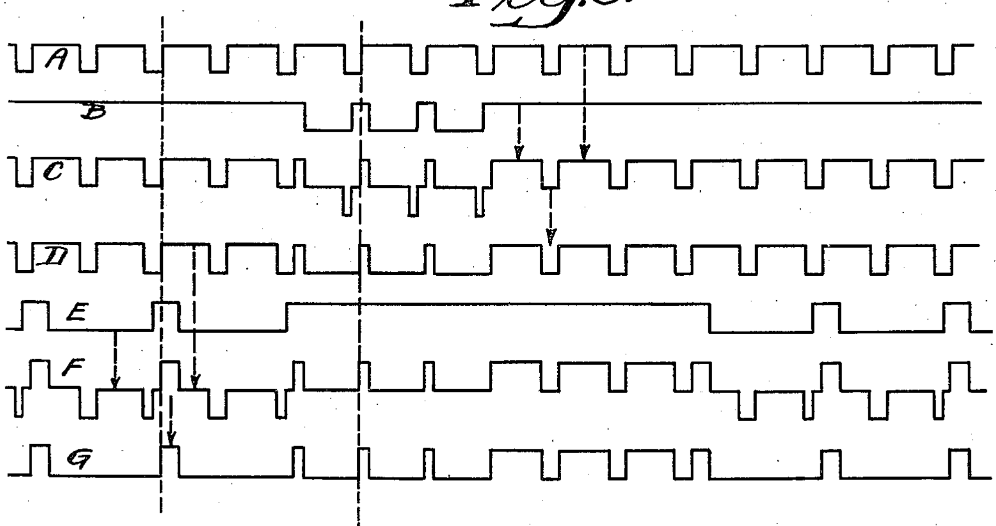


Fig. 5.



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Patented Oct. 14, 1941 2,258,943

UNITED STATES PATENT OFFICE

2,258,943

SYNCHRONIZING SIGNAL GENERATOR

Alda V. Bedford, Collingswood, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application November 30, 1938, Serial No. 243,238

19 Claims. (Cl. 178—69.5)

My invention relates to television transmitters and particularly to a method of and means for producing synchronizing signals or impulses. More specifically, my invention relates to a synchronizing signal generator of the general type described in Patent No. 2,132,655, issued October 11, 1938, to J. P. Smith and assigned to the Radio Corporation of America.

The aforesaid Smith patent proposes to produce at a television transmitter by electronic means or oscillators horizontal and vertical synchronizing impulses with the vertical synchronizing impulses preceded by preparatory or equalizing impulses occurring at a multiple frequency such as twice the frequency of the horizontal synchronizing impulses. It is also proposed that the vertical synchronizing impulses be slotted in order that the horizontal deflection will remain in synchronism during the vertical deflection period. While the Smith patent describes a signal wherein the double frequency impulses are "set into" these slots, it is preferred at the present time that the front edge of a slot be utilized for maintaining horizontal synchronization.

The specific synchronizing signal produced by the generator which is described by way of example in this application is the signal disclosed in my copending application Serial No. 222,081, filed July 30, 1938, entitled Television systems and assigned to the Radio Corporation of America. As described in this application, the preparatory double frequency impulses have one-half the width of the horizontal synchronizing impulses.

From the foregoing, it will be understood that the synchronizing signal consists of several groups of impulses, namely, horizontal synchronizing impulses, double frequency preparatory impulses and vertical synchronizing impulses. Since the front edges of these various impulses produce synchronizing voltage "kick" or sharp impulse that is applied to the horizontal deflecting circuit, it is essential that there be a fixed time interval between these front edges if there is to be a perfect synchronizing action.

This desired fixed time relation is somewhat difficult to obtain with the synchronizing signal generator described in the above-mentioned Smith patent because each group of impulses is produced by or derived from a separate oscillator and the several groups of impulses then combined in a common circuit. Any slight drift of these oscillators will cause a slight displacement of the different groups of impulses with a corresponding displacement of their front edges.

The principal object of the present invention is to provide a synchronizing signal generator of the electronic type, as distinguished from the rotating disc type, in which all edges of the signal which determine horizontal synchronization have a fixed time relation. In the preferred embodiment, these edges are the front edges.

States more broadly, an object of my invention is to provide an improved method of and means for producing a synchronizing signal.

My invention is based on the idea that impulses derived from a single oscillator may be utilized to provide the front edges for the impulses of all the above-mentioned groups of impulses.

Briefly, this may be accomplished, for example, by generating one-half width double frequency impulses, the front edges of which, in the final signal, are the front edges of all impulses. In the region of the synchronizing signal where the regular horizontal synchronizing impulses are desired, alternate double frequency impulses are removed by means of impulses occurring at the horizontal scanning or line frequency. The remaining one-half width impulses in this region are widened to full width by adding line frequency impulses to their back side.

In the region where the slotted vertical synchronizing impulse is to appear, comparatively wide double frequency impulses are added to the back sides of the one-half width impulses to produce the vertical synchronizing impulse.

Thus, four signals are added together to produce a synchronizing signal which will be the final signal after it has been "clipped off" at both top and bottom, these four signals being (1) the double frequency one-half width impulses, (2) line frequency impulses which occur outside the region of the preparatory impulses and which remove alternate double frequency impulses, (3) line frequency impulses which also occur outside the region of the preparatory impulses and which widen the one-half width impulses outside this region to produce the horizontal synchronizing impulses, and (4) wide double frequency impulses which produce the slotted vertical synchronizing impulse.

Also, the invention may be practiced in other ways as will be pointed out hereinafter.

The invention will be better understood from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a block diagram of a synchronizing signal generator embodying my invention,

Figure 2 is a group of curves which are referred to in explaining the invention, the dotted lines and arrows indicating the waves which are combined to produce a new wave,

Figures 3*a*, 3*b*, 3*c* and 3*d* together are a circuit diagram of the generator shown in Figure 1, and

Figures 4 and 5 are groups of curves illustrating different rays of practicing my invention.

General description

The invention will first be described very generally with reference to Figs. 1 and 2. The present synchronizing impulse generator, like that of the above-mentioned Smith application, in the specific design illustrated, is for use in an odd-line interlaced scanning system. The desired whole number plus ½ relation between the scanning line frequency and the frame frequency is obtained by utilizing a main or master oscillator 1 operating at double the line frequency, in this particular case at 26,460 cycles per second, by dividing this frequency by two by means of a frequency divider 2 to produce the horizontal deflecting or line scanning frequency of 13,230 per second and by dividing the double frequency by odd numbers by means of frequency dividers 3, 4 and 6 to produce the vertical deflecting or frame frequency of 60 per second. This method of obtaining the synchronizing impulses for interlaced scanning is described in my British Patent 434,469, issued September 2, 1935.

Since the oscillator 1 is a sine wave oscillator in the present design, its output is passed through a limiter or clipper circuit 7 for the purpose of producing rectangular impulses, these impulses being impressed upon the frequency dividers.

The main oscillator 1, from which the horizontal and vertical synchronizing impulses are derived, is locked in with the 60 cycle power line by means of a suitable lock-in circuit indicated at 8 to which is supplied 60 cycle impulses from frequency divider 6 and sine wave voltage from the 60 cycle power line, the sine wave voltage passing through a phase shifter 9 which determines the phase relation of the synchronizing impulses with respect to the power line supply.

The generator of Fig. 1 produces five signals as follows:

First, and of the most interest, the video synchronizing signal which is to be transmitted to the receiver,

Second, the video blanking signals which are to be transmitted to the receiver along with the picture signals and the synchronizing signals,

Third, the horizontal synchronizing or driving impulses for the transmitter iconoscope,

Fourth, the vertical synchronizing or driving impulses for the transmitter iconoscope, and

Fifth, the iconoscope blanking impulses.

The present invention relates primarily to the production of the first group of video impulses, i. e., the synchronizing signals which are transmitted to the receiver. The portion of the generator for producing these signals is drawn in heavy lines in Fig. 1. As previously stated, the video synchronizing signals are produced by combining four kinds of impulses which are shown in Fig. 2 by the curves *d*, *h*, *j* and *m*.

The one-half width double frequency impulses *d* are the impulses upon which the final signal is built. Specifically, the front edges of the impulses *d* are the front edges of all impulses comprising the final signal shown at *o* in Fig. 2.

The 26,460 cycle impulses *d* are obtained by taking impulses from the limiter circuit 7, delaying them a suitable amount by a delay network D to make the front edges of the impulses start at proper time, impressing them upon a multivibrator 11 which may be adjusted to make the impulses *d* of the proper width, passing the resulting impulses through a limiter or clipping circuit 12 which supplies the final impulses *d* to a mixing portion of the circuit indicated at 13 where the impulses *d*, *h*, *j* and *m* are to be mixed or added.

It may be noted that in the actual circuit, which is hereinafter described, there is no specific unit 13 since the addition of signals is accomplished by means of a common plate circuit for the limiter 12 and the limiters for the other three signals *h*, *j* and *m*.

The impulses *h*, which are for the purpose of removing alternate impulses *d* in the region where double frequency impulses are not desired, are obtained by taking impulses from a 13,230 cycle multivibrator 16 which feeds into a limiter-mixer circuit 17. To eliminate the impulses *h* for the period during which double frequency impulses are desired, 60 cycle impulses are also fed into the limiter-mixer 17, the 60 cycle impulses being taken from a multivibrator 18 through a limiter circuit 19. The two groups of impulses which are fed into circuit 17 are shown at *f* and *e* in Fig. 2.

The technique for removing an undesired group of impulses by means of the circuit 17 may be the same as that described in the above-mentioned Smith patent. For example, a group of 13,230 cycle impulses may be depressed below a certain voltage level by the 60 cycle impulse and then only the impulses above this level passed through a limiter or clipping circuit 21 following the mixer 17. Thus the final signal *h* may be produced. In the specific circuit 17 to be described later the signal *h* is produced by causing the 60 cycle impulses *f* to block a mixer tube periodically whereby the impulses *e* do not pass through the mixer tube during the blocking period.

The impulses *j*, which are for the purpose of doubling the width of impulses *d* in the region where alternate impulses *d* have been removed, are obtained by taking 13,230 cycle impulses from a multivibrator 22 which is driven by the frequency divider 2 through a delay circuit D, the delay circuit determining the time the front edges of the impulses start and the adjustment of multivibrator 22 determining the width of the impulses. The 13,230 cycle impulses from multivibrator 22 are fed into a limiter-mixer circuit 23 together with the 60 cycle impulses *f*. The desired signal *j* appears in the output of a limiter 24 following the mixer 23.

Finally, the impulses *m* which, when added to impulses *d*, produce the slotted vertical synchronizing impulse, are obtained from a mixture of 60 cycle impulses derived from a multivibrator 26 and 26,460 cycle impulses taken from the limiter 7.

A comparison of curve *m* with curve *f* in Fig. 2 will show that the slotted impulse *m* should start at a considerably later time than the impulse *f*. This rather large delay is conveniently obtained by adjusting multivibrator 26 to produce impulses g which have such width that the back edge occurs just before the slotted impulse m is to start. The impulses g are supplied to a limiter-mixer 27 together with 26,460 cycle impulses from a multivibrator 31 whereby a selected 26,460 cycle impulse is caused to trigger off a 60 cycle near the back edge of each impulse g. In the output circuit of multivibrator 28 there appear the delayed impulses l which are fed into a limiter-mixer 29.

There are also fed into the limiter-mixer 29 the 26,460 cycle impulses k shown in Fig. 2, these impulses having their width determined by the multivibrator 31 which is driven through delay circuits D and D from the limiter 7.

The final signal m appears in the output of a limiter 32 following the limiter-mixer 29.

The signals d, h, j and m add in the mixing circuit 13 to produce the signal n which, when clipped at the levels indicated by the dotted lines, produces the final signal shown by the curve o.

A comparison of the curves d, j and m will show that the front edges of impulses d are also the front edges of the horizontal synchronizing impulses as well as the front edges of the individual impulses comprising the slotted vertical synchronizing impulse. The impulses d themselves are the double frequency preparatory impulses.

Reference will now be made to the production of the above-mentioned second, third, fourth and fifth signals.

The second signal (the video blanking signal) is shown at a in Fig. 2. This signal is a mixture of 60 cycle impulses produced by a multivibrator 36 and 13,230 cycle impulses produced by a multivibrator 37. The two groups of impulses are supplied to a limiter mixer circuit 38, the 60 cycle impulses first passing through a limiter 39. The final signal a appears in the output circuit of a line amplifier 41.

The third and fourth signals, the horizontal and vertical synchronizing or driving impulses, are shown at p and c, respectively, in Fig. 2. The horizontal driving impulses p are obtained from a multivibrator 42 through a limiter or clipper tube 43, the final signal p appearing in the output circuit of a line amplifier 44.

The vertical driving impulses c are obtained from a 60 cycle multivibrator 46 through a limiter circuit 47, the final signal c appearing in the output circuit of a line amplifier 48.

The fifth signal, the iconoscope blanking impulses, is obtained from a 60 cycle multivibrator 49 and a 13,230 cycle multivibrator 51, the outputs of these multivibrators being supplied to a limiter-mixer circuit 52, the 60 cycle signal first passing through a limiter 53. The final signal b appears in the output circuit of a line amplifier 54.

Main oscillator and frequency dividers

My improved generator will now be more fully described in connection with the circuit diagram shown in Figs. 3a to 3d. The four sheets of drawings form a complete circuit diagram when they are placed next to each other with Fig. 3a in the upper left hand corner, Fig. 3b in the upper right hand corner, Fig. 3c in the lower left hand corner and Fig. 3d in the lower right hand corner. It may be noted that the sheet containing Fig. 3a should be placed on its side while the other three sheets should be placed in an upright position. In the block and circuit diagrams like parts are indicated by the same reference characters. On the circuit diagram the lower case letters indicate the points in the circuit where the signals have the wave shapes shown by the curves having corresponding letters in Fig. 2.

Referring to Fig. 3a, the main oscillator 1 may be a sine wave oscillator of the negative transconductance type having a tank circuit comprising an inductance coil 57 and a condenser 58. This particular oscillator is of the general type described in Patent 2,109,752 issued to Poch et al. and assigned to the Radio Corporation of America, one of the resistors in the Poch et al. circuit being replaced by a tank circuit.

The oscillator tube indicated at 56 is of the 6L7 type, the second grid acting as the plate and the third grid being biased negatively by a cathode resistor 59 as taught by the Poch et al. patent. Unlike the Poch et al. circuit, however, the resistor 59 is not by-passed with the result that stronger and more stable oscillations are produced as described and claimed in RCV docket 5851.

The sine wave output of the oscillator 1 is fed into the limiter circuit 7 by means of electron coupling, the plate of the oscillator tube 1 being used for this purpose.

The oscillator 1 is preceded by an automatic frequency control (A. F. C.) tube 61 which forms part of the lock-in circuit 8 for holding the oscillator 1 in a fixed frequency relation to the power line frequency, the power line being indicated at 66. The lock-in circuit 8 will be described hereinafter.

The limiter 7 is for the purpose of converting the sine waves of oscillator 1 into rectangular waves or impulses. It comprises two limiter or clipping tubes 67 and 68, each of which is adjusted to pass only the more positive portions of an impressed wave. This is accomplished by grid-leak biasing the two tubes to make them clip at the desired level as described in the above-identified Smith patent. It will be understood that the impulses drive the control grids of tubes 67 and 68 positive periodically whereby the grid condensers 69 and 71 are charged periodically to provide the biasing currents which flow through the grid resistors 72 and 73. The time constant of the grid condenser-grid resistor circuit of each tube is such that the grid condenser discharges only a very small amount between successive waves or impulses.

The means shown in Fig. 3b for deriving 60 cycle rectangular impulses from the 26,460 cycle rectangular impulses will now be described. The 26,460 cycle impulses are supplied from the limiter 7 over a conductor 74 to the frequency divider 3 which divides the frequency by 7 to produce 3,780 cycle impulses.

Frequency divider 3 consists of an amplifier tube 76, a "counter circuit" comprising tubes 77 and 78 and a multivibrator comprising tubes 79 and 81. The tubes 79 and 81 are of the 6F6 type in the example illustrated.

The amplifier tube 76 is operated at high efficiency and is made to limit or clip both positive and negative impulses by driving it alternately to plate current saturation and to cut-off.

The positive rectangular impulses appearing across the plate resistor 82 charge a condenser 83 and a condenser 84 which are in series with the left-hand section of the diode 77. The other diode section of tube 7 is connected across condenser 83 whereby it is discharged by each negative impulse. The tube 77 may conveniently be of the 6H6 type.

It will be seen that the condenser 84, however, is charged up in steps, the voltage across condenser 84 being a fixed value between successive positive impulses and rising sharply from this value at the start of each succeeding positive impulse. This voltage is impressed upon the tube 78 which is biased beyond cut-off and, therefore, will not pass a voltage impulse until the voltage across condenser 84 reaches a certain level.

The tube 78 may conveniently be a 6N7 type with the plates and grids connected in parallel as shown. It will be seen that tube 78 is biased beyond cut-off by connecting its cathodes to a positive point on the voltage divider 86.

From the foregoing description it will be apparent that after a predetermined number of positive impulses from the conductor 74 the condenser 84 is charged step by step to such a voltage level that the next positive impulse from line 74 drives the grids of tube 78 above the cut-off point whereby a negative impulse is applied to the screen grid 87 of tube 79. The screen grid 87 and the screen grid 88 of the tube 81 function as plate electrodes for the multivibrator.

The plate 89 of the tube 79 is connected through a conductor 91 to one side of the condenser 84 whereby the tube 79 may periodically discharge the condenser 84 to ground potential. Thus, each time the multivibrator 79—81 is triggered off by sufficient rise in the voltage across condenser 84, there is produced an impulse on the plate 92 of tube 81 and the condenser 84 is immediately discharged through the tube 79 since the control grip of tube 79 is driven positive at this instant. The counter circuit has now been returned to its original condition, and after another group of 26,460 cycle impulses has occurred the multi-vibrator will again be triggered off to produce another impulse on the plate 92 of the tube 81.

The multivibrator 79—81 is adjusted to have a free oscillation period which is very low compared with 26,460 cycles whereby it functions more nearly as a non-oscillatory driven circuit then as an oscillator which is merely pulled into synchronism. Also, it will be noted that the multivibrator is unsymmetrical, the two grid condensers and the two grid resistors differing greatly in value, whereby a very narrow impulse (of positive polarity) appears on the plate 92 of the tube 81. The plate 92 is used for electron coupling the multivibrator 79—81 to the next frequency divider in a well-known manner.

The adjustment of the frequency divider 3 is such that it divides by 7 to produce 3780 cycle impulses which are impressed upon the frequency divider 4. Divider 4 produces 420 cycle impulses which are impressed upon the frequency divider 6 to obtain narrow 60 cycle impulses. These 60 cycle impulses are fed through an amplifier 96 to a conductor 97 which supplies 60 cycle impulses to the several circuits shown in Fig. 3*d*.

The frequency dividers 4 and 6 are the same as the unit 3 except for the circuit constants. Parts in units 4 and 6 corresponding to like parts in the unit 4 are indicated by the same reference numerals with the reference letters *a* and *b*, respectively, affixed thereto.

The frequency divider 6 also supplies 60 cycle impulses over a conductor 98 through an amplifier tube 99 to the lock-in circuit 8 (Fig. 3*a*).

The lock-in circuit 8 is of the type covered broadly in my copending application Serial No. 237,052, filed October 26, 1938, entitled Frequency control circuits and assigned to the Radio Corporation of America. The specific circuit shown is described and claimed in application Serial No. 237,051, filed October 26, 1938, in the name of Karl R. Wendt, entitled Frequency control circuits and assigned to the Radio Corporation of America.

The circuit 8 comprises four diodes, two diodes in each of the tubes 101 and 102, which are connected in the form of a bridge. Across one diagonal of the bridge there is connected an RC network 103 in series with the secondary of a transformer 104. The primary of this transformer is connected to the output circuit of the amplifier 99.

Voltage from the 60 cycle power line is impressed across the other bridge diagonal through the phase shifter 9 which is of conventional design and through a condenser 106 across which the frequency control voltage appears.

The voltage across condenser 106, which is a measure of the phase difference between the 60 cycle wave and the 60 cycle impulses, is obtained as follows: The impulses supplied through transformer 104 drive the plates of the diodes positive periodically, an opposing voltage building up across the RC network 103. Each time the diode plates are driven positive, the 60 cycle line voltage is connected through the diodes across the condenser 106 and it receives an additional charge if the phase shift has been in one direction or is permitted to discharge slightly if the phase shift has been in the opposite direction.

The A. F. C. circuit comprising tube 61 is of the type which operates to vary the reactance of the tank circuit 57—58 of the main oscillator 1. A circuit of this type is described and claimed in application Serial No. 19,563, filed May 3, 1935, in the name of Charles Travis, and assigned to the Radio Corporation of America.

The A. F. C. circuit will be described with reference to specific circuit values and a particular type of tube but it should be understood that these are given merely by way of example. The plate of tube 61 is connected to the high potential end of the tank circuit 57—58 while the cathode is connected to ground, and thus to the other end of the tank circuit, through an 1800 ohm cathode resistor. The screen grid of tube 61 has a suitable potential applied thereto from a potentiometer or voltage divider connection comprising the 47,000 and 56,000 ohm resistors. A 1.0 mf. by-pass condenser is connected from the screen grid to the lower end of the 56,000 ohm resistor rather than directly to ground, as this has been found to give improved results.

Current from the tank circuit 57—58 feeds through a condenser 107, a resistor 109 and the condenser 106 to ground. Because of the comparatively large capacity of the condenser 106 the input electrodes of tube 61 are, in effect, connected directly across the resistor 109 through which there flows a current nearly 90 degrees out of phase with the current through the condenser 107. Thus, the tube 61 is caused to act as a reactance across the tank circuit, the amount of reactance depending upon the bias applied to the control grid of tube 61 by the condenser 106. Thus the frequency of oscillator 1 is controlled to hold it locked in with the power line frequency.

A switch 111 is provided to short circuit the condenser 106 during initial adjustments of the apparatus.

In order to obtain the 13,230 cycle impulses, i. e., the line frequency impulses, the double frequency impulses from the unit 7 are fed over a conductor 112 to the frequency divider 2. This divider is the same as the frequency divider 3 except for the circuit constants. Similar parts in frequency dividers 2 and 3 are indicated by the same reference numerals with the letter c affixed to the numerals in the unit 2.

The 13,230 cycle output of the multivibrator 79c—81c is supplied through an amplifier 113 and a conductor 114 to a delay circuit 116.

Production of blanking impulses and iconoscope driving impulses

Before describing the portion of the circuit which combines 26,460 cycle, 13,230 cycle and 60 cycle impulses to produce the video synchronizing signal, there will be described the comparatively simple part of the circuit for producing the iconoscope driving and blanking signals *p*, *c* and *b*, and the video blanking signal *a*.

Referring to Fig. 3*d*, there is shown the multivibrator 46 for producing the 60 cycle vertical driving or synchronizing impulses *c* for the iconoscope at the transmitter. This multivibrator is employed for controlling the width of the impulses *c* as follows: The 60 cycle impulses from conductor 97 have been made very narrow, considerably narrower than the desired width for the impulses *c*. The multivibrator 46 is given the proper circuit constants to produce impulses of the desired width when the positive bias on the grid 117 has been adjusted to the proper value. Also, these circuit constants are such that the natural or free period of the multivibrator is very low compared with 60 cycles, whereby it functions more as a positively driven circuit than as one merely pulled into synchronism. Thus, the narrow 60 cycle impulses from line 97 drive the unit 46 to produce the comparatively wide 60 cycle impulses *c*.

The impulses from unit 46 are clipped by the limiter tube 47 which is grid leak biased before they are supplied to the line amplifier 48. It may be noted that the narrow impulses from the line 97 are negative whereby the narrow impulses applied to the tube 47 are positive, the polarities of impulses on the two plates of the double triode tube (a 6N7) being opposite.

Considering next the generation of the horizontal driving or synchronizing impulses, reference is made to Fig. 3*c*. The 13,230 cycle impulses are taken from a suitable point on the delay circuit 116 so that they start at the correct time and are supplied to the multivibrator 42 which, like the multivibrator 46, is utilized to determine the width of the synchronizing impulses. The unit 42 also is utilized for the reason that the 13,230 cycle impulses from the delay circuit 116 are distorted and must be reshaped in some way.

The narrow impulses in the output circuit of unit 42 are positive and are clipped by the limiter 43, which is grid leak biased, to remove any irregularities at the base of the signal. The final signal *p* is amplified by a suitable line amplifier 44.

The horizontal and vertical blanking impulses for the iconoscope are obtained by mixing 60 cycle and 13,230 cycle impulses. As shown in Figs. 3*a* and 3*c*, 13,230 cycle impulses are taken from a point on delay network 116 which gives the proper timing for the beginning of each impulse. They are supplied to the multivibrator 51 which reshapes them into good rectangular impulses and which also determines their width. They are then fed into the limiter-mixer tube 52, the left-hand part of this tube being utilized for adding the 13,230 cycle impulses to the 60 cycle impulses which are supplied over a conductor 118 from the multivibrator 49 (Fig. 3*d*).

Multivibrator 49 is similar to the unit 46 and functions to determine the width of the vertical iconoscope blanking impulses. The positive narrow impulses appearing in the output circuit of 49 are clipped by the grid leak biased tube 53 to supply negative impulses free from irregularities to the conductor 118. The actual mixing of the 13,230 cycle impulses and 60 cycle impulses occurs in the plate resistor 119 of limiter tube 53, this resistor being common to tube 53 and the mixer half of tube 52.

The mixed blanking impulses are impressed through a coupling condenser 121 upon the other half of tube 52 which clips off the tops of the narrow impulses since they are negative at this point and drive the clipping section of the tube beyond cutoff. The resulting iconoscope blanking signal *b* is supplied to a suitable line amplifier 54. The signal *b* is shown in Fig. 2 with a break in it because of the fact that the signal is not drawn to scale, and it is desired to indicate both the width of a horizontal blanking impulse and the starting time of a vertical blanking impulse.

The video blanking signal is generated in substantially the same way as the iconoscope blanking signal by mixing 13,230 cycle impulses from the multivibrator 37 with 60 cycle impulses in the left hand portion of the mixer-limiter tube 38. The 13,230 cycle impulses are taken from the proper point on the delay network 116 to give them the desired starting time and supplied to the multivibrator 37 which is adjusted to give them the desired width. The resulting impulses are added to the 60 cycle impulses taken from the conductor 122, clipped in the other half of the tube 38 and supplied to the line amplifier 41 as the video blanking impulses *a*. The signal *a* is shown in Fig. 2 with a break for the reason given in connection with signal *b*.

The 60 cycle impulses which are fed over conductor 122 are obtained from the multivibrator 36 (Fig. 3*d*) and the limiter tube 39 which function the same as units 49 and 53, respectively, the multivibrator 36 being adjustable to give the 60 cycle impulses, the desired width.

The line amplifier 41, like the other line amplifiers in the system may be of the "cathode follower" type. In such amplifiers the output signal is taken off a resistor between the cathode and ground, the polarity of the output signal being the same as that of the input signal. The amplifier tube illustrated for amplifier 41 is of the so-called beam type.

Production of video synchronizing signals

In accordance with my invention, the front edge of each impulse in the final video synchronizing signal *o* (Fig. 2) is derived from the front edges of the double frequency impulses *d*. The manner in which this is accomplished will now be described.

The half width double frequency impulses *d* are produced by taking the 26,460 cycle impulses from a suitable point on a delay circuit 123 (Fig. 3*a*) and supplying them over a conductor 124 to the multivibrator 11 (Fig. 3*d*). The impulses supplied over the conductor 124 are narrow as compared with the width of the final impulses *d* whereby the multivibrator 11 may be utilized to determine the width of the impulses *d*. The point on the delay network 123 to which conductor 124 is connected, of course, determines the starting point of each impulse *d*.

As described in connection with the multivibrator 46, the width of the impulses *d* may be adjusted to exactly the desired value by adjusting a variable tap 126 to change the positive bias on a multivibrator control grid. It will be noted that the bias is varied on that grid which is connected to a multivibrator plate through the smaller of the two multivibrator plate-to-grid coupling condensers.

Since the narrow impulses supplied over conductor 124 are negative, the narrow impulses which are supplied to the grid of the first half of the limiter tube 12 are positive, the input and output being from opposite multivibrator plates. The impulses are clipped in the first half of the tube 12 by utilizing grid leak biasing, and they are again clipped in the second half of the tube due to the narrow impulses driving this section of the tube beyond cut-off. The final narrow impulses *d* appear with positive polarity in the output conductor 127 and are supplied to a junction point 125. These are the impulses which are to determine the front edges of all impulses in the complete video synchronizing signal.

Alternate double frequency impulses *d* are removed by the 13,230 cycle impulses *h* with the exception of the region within which the double frequency impulses are desired. The signal *h* is obtained by combining 13,230 cycle impulses *e* with a 60 cycle impulse *f* as follows.

Referring to Fig. 3*c*, 13,230 cycle impulses are taken from a point on the delay network 116 (Fig. 3*a*) where there is little or no delay and supplied to the multivibrator 16 which is adjusted to supply narrow negative impulses *e* to a grid of the limiter mixer tube 17. It will be noted that tube 17 reverses the polarity of impulses *e* as they appear in the signal *h*.

The 60 cycle impulses *f* are obtained from a multi-vibrator 18 (Fig. 3*d*) which is driven by the 60 cycle impulses fed over the conductor 97. The multi-vibrator 18 is the same as the multivibrator 46 except for a difference in certain circuit constants and is adjusted to produce an impulse *f* of the desired width. The narrow 60 cycle impulses *f* appearing in the output of unit 18 are clipped by means of the limiter tube 19, which is grid leak biased. Thus, the narrow impulses supplied over the conductor 128 and to the first grid of the tube 17 are of negative polarity. They are of sufficient amplitude to block the tube 17 whereby the impulses *e* will not appear in the plate circuit of the tube for the duration of the impulse *f*.

Between narrow impulses *f* the negative impulses *e* will periodically drive the tube 17 beyond cut-off whereby they appear in the plate circuit of tube 17 as narrow positive impulses with squared tops. They are next further squared up by clipping twice in the limiter tube 21, the first half of the tube being grid leak biased to provide the desired clipping and the second half of the tube being driven beyond by the negative narrow impulses impressed on the second grid to affect the second clipping. The final narrow impulse *h* of positive polarity (or wide impulse of negative polarity) is supplied over a conductor 129 to the junction point 125.

By comparing signals *d* and *h*, it will be seen that each negative impulse *h* (the wider impulse) occurs just before an impulse *d* and lasts longer than the impulse *d* whereby it may be utilized to remove this double frequency impulse.

Impulses *j*, which occur at the rate of 13,230 per second, are produced for the purpose of adding them with those half width impulses *d* which have not been removed by the impulses *h* to produce the full width horizontal synchronizing impulses. The impulses *j* which would normally appear in the region of the vertical synchronizing impulse are removed by the 60 cycle impulse *f* just as certain as the impulses *h* were removed. The circuit for accomplishing this is as follows:

Impulses occurring at the rate of 13,230 per second are obtained from a suitable point on the delay network 116 and supplied over a conductor 131 to the multi-vibrator 22, which has the proper circuit constants and grid bias adjustment to produce 13,230 cycle impulses *i* of the desired width. The impulses *i* are supplied with positive polarity to the second control grid of the mixer limiter tube 23 while the negative 60 cycle impulse *f* is supplied to the first control grid of the tube 23. As in the case of the mixer tube 17, the tube 23 is blocked for the duration of the negative impulse *f* whereby the impulses *i* do not appear in the plate circuit of the tube 23.

Between successive negative impulses *f*, the impulses *i* appear in the plate circuit of tube 23 as negative impulses, having been clipped a certain amount in the tube 23 by the use of grid leak biasing on the second control grid. The output of tube 23 is supplied over a conductor 132 to the grid leak biased limiter tube 24 which further clips the signal and reverses the polarity to produce the final signal *j*, the narrow impulses being of positive polarity. Signal *j* is fed over the conductor 133 to the junction point 125.

It will be seen from a comparison of the signal *j* and *d* that each impulse *j* has been made to start at a slightly later time than an impulse *d*, but substantially earlier than the back edge of an impulse *d*. Thus, when impulses *d* and *j* are added, they always overlap a sufficient amount to prevent any possibility of a gap in the signal due to a change or shift in the starting time of an impulse *j* or due to any other variation in the circuit. It will be apparent that in the combined signal the front edge of a horizontal synchronizing impulse is the front edge of an impulse *d*, while the back edge of this synchronizing impulse is the back edge of the impulse *j*.

The signals *d*, *h* and *j*, when combined, will produce a signal consisting of horizontal synchronizing impulses and the half-width double-frequency preparatory signals. The video synchronizing signal is completed by the generation and addition of the signal *m*, which provides the slotted vertical synchronizing impulse. The means for generating the signal *m* will now be described.

The slotted impulse *m* is obtained by combining the comparatively wide double frequency impulses *k* and the delayed 60 cycle impulses *l*. It will be noted that the wide impulses *k* occur at a slightly later time than the impulses *d*, whereby in the final signal the front edges of the impulses *d* will be the front edges of the impulses making up the slotted vertical synchronizing impulse.

To produce the impulses *k*, 26,460 cycle impulses are taken from a suitable point in the delay network 123 (Fig. 3*a*) and supplied over a conductor 134 to the multivibrator 31 (Fig. 3*d*). The impulses *k* appear in the output circuit of the multivibrator 31 with the wide impulses having a positive polarity and the desired width. The multi-vibrator 31, like the multi-vibrator 11 is adjusted to function as a driven oscillator, its free oscillation frequency being much lower than 26,460 cycles. The positive wide impulses k are supplied over a conductor 136 to the second control grid of the limiter mixer tube 29.

The delayed positive 60 cycle impulse l is fed through a conductor 137 to the first control grid of the tube 29. This signal is produced as follows: The multi-vibrator 26 is driven by the narrow 60 cycle impulses supplied over conductor 97 to produce the 60 cycle impulses g. The multivibrator 26 is adjusted to make the width of a narrow impulse g such that its back edge occurs slightly before the time that the slotted vertical synchronizing impulse is to start. Roughly speaking, it may be said that the back edge of the narrow impulse g triggers off the multi-vibrator 28 to produce the delayed impulse l, but, as will appear from the following description, this is not strictly true. Actually the multivibrator 28, in effect, is triggered off by the back edge of a wide impulse k for reasons which will appear hereinafter.

The narrow impulse g is taken from the proper plate of the multivibrator tube to make it of negative polarity whereby the wide impulse portion of the signal g is positive. The signal g is passed through a differentiating circuit comprising the small capacity condenser 138 whereby there is impressed upon the first grid of the tube 27 a signal having a comparatively narrow positive portion indicated at z in Fig. 2. It may be noted that the curve z shows only the useful positive portion of the differentiated signal. To the second control grid of the tube 27 there is supplied the signal y having positive narrow impulses, signal y being the same as signal k, but of opposite polarity. The positive narrow impulses y are taken from one plate of the multivibrator 31 and supplied over a conductor 139 to the limiter mixer tube 127.

The impulses z and y are added in the tube 27 to produce the signal r which is clipped by the tube 27 at the level indicated by the dotted line to supply over the conductor 141 and to the multivibrator 28 the signal x including at least one of the impulses y. It will be understood that the signals z and y add in the tube 27 since they are supplied to grids controlling a common electron stream. The clipping action is obtained by providing the tube 27 with a sufficient self bias to bias the tube close to cut-off whereby only the more positive portions of the signal appear in the plate circuit.

It may be noted that there is no reason why the impulse z could not be made considerably narrower whereby only one of the impulses y would appear in the output circuit of tube 27 except that, as a practical matter, an impulse this narrow cannot readily be obtained by the differentiating circuit.

A comparison of the impulses l and x will show that the multi-vibrator 28 is triggered off by the leading edge of the first impulse x to produce in its output circuit the impulse l.

The reason for employing the above-described method of triggering off or driving the multivibrator 28 is that the impulse g may shift slightly in its timing with respect to the impulses k. Thus if the impulse l were produced by using the back edge of impulse g directly to drive the multivibrator 28, the impulses l and k might add in such time relation as to make the first impulse of the signal m of less than full width. Obviously this cannot happen when the impulse l is produced, in effect, by the back edge of an impulse k.

The above-described circuit and method for driving the multivibrator 28 to produce impulses at the rate of 60 per second while making such impulses occur in a fixed time relation to the 26,460 cycle impulses are described and claimed in application Serial No. 76,108, filed April 24, 1936, in the name of Alan D. Blumlein and assigned to the Radio Corporation of America.

The impulses l and k are added and clipped in the limiter mixer tube 29 to produce a signal which, after further clipping in the limiter 32, appears as the signal m. The signal m is supplied over the conductor 141 to the junction point 125, where it is added to the signals h, j and d.

The tube 29 is self-biased close to cut-off and functions the same as the limiter mixer 27. Since the signals appearing in the plate circuit of the tube 29 are of negative polarity, the clipping by the tube 32 is accomplished by the negative impulses driving the tube beyond cut-off.

It may be noted that the addition of the signals h, j, m and d actually occurs in the plate resistor of the right hand section of tube 21 (Fig. 3c), this plate resistor being common to the vacuum tube plates to which the conductors 129, 133, 127, and 141 are connected.

The combined signal which appears at the junction point 125 is shown at n in Fig. 2. It will be seen that the impulses d have been added to the front edges of the impulses of the signal m with a certain amount of overlap, the overlap being provided to avoid the necessity of a critical adjustment of the circuit. As previously pointed out, the impulses d have been added in a similar manner to the front edges of the impulses j. In the region just preceding and just following the slotted vertical synchronizing impulse, the impulses d themselves act as the half-width double-frequency impulses.

The final video synchronizing signal which is to be mixed with the picture signal and transmitted to the receiver is shown at o. It will be seen that the final signal o is obtained by clipping the signal n at the levels indicated by the dotted lines, the signal o being the portion of the signal n which appears between these dotted lines.

On the drawings, merely by way of example, the types of various tubes have been indicated as well as the values of various resistors and condensers, these values being in ohms, megohms, microfarads, and micro-microfarads.

It may be noted that the circuits of multivibrator units 22, 37 and 51 are duplicates except as to slight differences in some circuit constants, and that the unit 42 is also a duplicate of unit 22 except as to certain circuit constants and except for the fact that the .10 mf. bypass condenser connected to the cathode in unit 22 is omitted. Likewise the multivibrators 46, 18, 36 and 49 are duplicates except as to some of the circuit constants.

With reference to the curves in Fig. 2, they are not drawn to scale although the relative timing of the various signals is shown exactly. Specifically, the ratio of the duration of an impulse to the time between successive impulses is much less in practice than indicated in Fig. 2, the horizontal video blanking impulses, for example, occupying about 15 percent of the time between the beginnings of two successive blanking impulses.

It should be understood that the various signals need not be produced and mixed in the specific manner described in the foregoing detailed description in order to practice my invention. For example, instead of adding waves *d, h, j* and *m* to produce the wave *n* before clipping, the adding the clipping may be done in several steps. For instance, the waves *d* and *h* may be added and then those alternate impulses from wave *d* which are depressed by the negative impulses of wave *h* can be immediately removed by clipping. Waves *j* and *m* may then be added to the wave so clipped. A final clipping operation will then produce the signal *o*.

It should also be understood that the invention may be practiced in various other ways. For example, the invention may be practiced in accordance with Fig. 4 which illustrates the use of full width "base" impulses, some of these being narrowed to half width during the process of producing the final signal. No circuit diagram is illustrated for producing the waves shown in Fig. 4 other than that previously described as it is apparent that the circuit shown in Figs. 3*a* to 3*d* may be employed for this purpose by making slight adjustments or modifications.

Referring to Fig. 4, double frequency "base" impulses *d'* are generated which have a width equal to the desired width of the horizontal synchronizing impulses. These are then combined with the signal *h'* (thus producing the signal *r*) for the purpose of removing alternate double frequency impulses *d'* except in the region where the double frequency preparatory impulses are desired.

Clipping or limiting the amplitude of signal *r* produces the signal *s* having double frequency, full width impulses. These are narrowed to half width by adding the signals *s* and *j'*, the negative impulses of the signal *j'* being delayed sufficiently to depress only the last half of double frequency, full width impulses as shown by the curve *t*. It will be noted that the negative impulses of the signal *j'* start during and last longer than the positive impulses of the signal *d'*.

After clipping the signal *t*, the signal *u* is produced which, when combined with the slotted vertical signal *m'*, gives the signal *v*. Clipping off the top of the signal *v* as indicated by the dotted line gives the final synchronizing signal. Just as in the example shown in Fig. 2, the front edges of the base signal *d'* form the front edges of all impulses in the final signal.

In Fig. 5 there is illustrated one way of producing a synchronizing signal by utilizing a base signal having wide impulses, a few of which are utilized to form the slotted framing impulses. In order to simplify the curves and explanation, the synchronizing signal assumed in Fig. 5 (curve G) has been simplified but it still has double frequency preparatory impulses of half width and a slotted vertical synchronizing impulse.

Referring to Fig. 5, double frequency wide impulses of positive polarity are produced, the front edges of the wide impulses being used to determine the starting time of impulses in the final signal G.

A signal B is produced by delaying signal A, reversing its polarity and combining with a 60 cycle impulse as taught in the foregoing description. The addition of signals A and B produces signal C in which the wide negative impulses of signal B have depressed the back portions of certain wide positive impulses of the signal A to produce the half width, double frequency preparatory signals.

Clipping the signal C to pass only the top part produces the signal D which contains the desired half width, double frequency preparatory impulses.

The signal E is made up of line frequency impulses which have been combined with a 60 cycle impulse to remove line frequency impulses in the region of the framing impulse. This signal may be considered to consist of negative wide impulses.

The addition of signals D and E causes the wide negative impulses of signal E to depress the back portions of the wide impulses of signal D and also to depress alternate wide impulses of signal D as shown by the resulting signal F. Clipping signal F to pass only the top portion gives the final desired signal G.

It will be noted that the front edges of the wide positive impulses of signal A determine the timing of the front edges of all impulses in the final signal G. It will also be noted that each of the wide negative impulses of signal B and of signal E occurs during and last longer than each of the wide positive impulses of the signal A.

From the foregoing it will be apparent that in a rectangular wave the impulse may be either the upward part or the downward part, not necessarily the part having the shorter duration. In the claims the wording "adding" is used in an algebraic sense.

I claim as my invention:

1. The method of producing a synchronizing signal comprising comparatively high frequency horizontal synchronizing impulses and comparatively low frequency vertical synchronizing impulses which comprises producing impulses occurring at said high frequency, producing impulses occurring at said low frequency, producing additional impulses occurring at a frequency at least as high as said high frequency and in harmonic relation thereto, and so combining all of said impulses that said additional impulses determine the timing of the front edges of said horizontal and vertical synchronizing impulses.

2. The method of producing a synchronizing signal comprising comparatively high frequency horizontal synchronizing impulses and comparatively low frequency vertical synchronizing impulses which comprises producing impulses occurring at said high frequency, producing impulses occurring at said low frequency, producing additional impulses occurring at a frequency at least as high as said high frequency and adding certain of said additional impulses to the front edges of said high frequency impulses and adding others of said additional impulses to the front edges of said low frequency impulses.

3. The method of producing a synchronizing signal which comprises producing high frequency impulses each beginning at a certain time for line synchronizing, producing low frequency signals each beginning at a certain time for framing, producing additional impulses occurring at a frequency at least as high as said high frequency impulses and each beginning at a time slightly before the time at which each of said line synchronizing impulses and each of said framing signals begin, and adding all of said signals and impulses whereby the front or first occurring edges of said additional impulses form the front edges of both said line synchronizing impulses and said framing signals.

4. The method of producing synchronizing signals which comprises producing impulses occurring at a high frequency for line synchroniz-

ing, producing signals occurring at a comparatively low frequency for framing, producing additional impulses occurring at a frequency which is a multiple of said high frequency with each of said additional impulses occurring just before the start of each line synchronizing impulse and just before the start of each framing signal and occurring in overlapping relation thereto, removing a group of said high frequency impulses which would normally occur in the region of the framing impulse, removing all of said additional impulses except those which occur in the region where said line synchronizing impulses have been removed, and adding said line synchronizing impulses, said framing signals and said additional impulses whereby the front edge of each impulse in the final synchronizing signal is the front edge of one of said additional impulses.

5. The method of producing a synchronizing signal comprising impulses of different duration or width, the impulses of one width beginning at time intervals equal to k units and the impulses of a different width beginning at time intervals equal to nk units where n is a small whole number, said method including the steps of producing a first wave of uniform impulses which occur at intervals of k units, producing a second wave of impulses each of which begins during and which last longer than certain impulses of said first wave, adding said first and second waves to produce a third wave, and so limiting the amplitude of said third wave that a fourth wave is produced having certain impulses which start at the times corresponding to one of the edges of the impulses of the first wave and lasting for a time determined by the impulses of the second wave.

6. A synchronizing signal generator for television or the like comprising means for producing impulses recurring at a certain frequency, means for producing other impulses recurring in a fixed time relation to said certain frequency, means for producing additional impulses occurring in a fixed time relation to said certain frequency and means for so combining all of said impulses that said additional impulses determine the timing of said first mentioned and second mentioned impulses.

7. A synchronizing signal generator for television or the like comprising means for producing horizontal synchronizing impulses occurring at a certain frequency, means for producing framing impulses, means for producing impulses occurring at a frequency which is a multiple of said certain frequency, means for producing additional impulses occurring at said multiple frequency, and means for so combining all of said impulses that said additional impulses determine the timing of the remaining impulses.

8. A synchronizing signal generator for television or the like comprising means for producing slotted framing impulses, means for producing impulses occurring at a frequency which is a multiple of the horizontal scanning frequency, means for so removing certain of said multiple frequency impulses except in the region of a framing impulse that there are impulses occurring at the horizontal scanning frequency outside said region, and means for so combining said remaining impulses that said multiple frequency impulses determine the timing of the slots in the framing impulses.

9. A synchronizing signal generator for television or the like comprising electronic oscillator means for producing a synchronizing signal comprising horizontal synchronizing impulses, framing impulses and multiple frequency impulses occurring immediately preceding each framing impulse, and means for causing the front edges of impulses occurring at said multiple frequency to form the front edges of all of said impulses.

10. The method of producing a synchronizing signal comprising horizontal synchronizing impulses, slotted framing impulses and multiple frequency preparatory impulses occurring in the region of each framing impulse which comprises producing impulses occurring at said multiple frequency and each having a front edge, removing certain of said multiple frequency impulses outside said region to make the remaining impulses occur at the frequency of the horizontal synchronizing impulses, and causing the front edges of the resulting signal to become the front edges of all of said impulses.

11. A synchronizing impulse generator comprising means for producing impulses occurring at intervals of k units, means for producing other impulses occurring at intervals of nk units where n is a small whole number which impulses start during and last longer than said first impulses, means for adding all of said impulses and clipping the resulting signal to produce impulses which start at a time determined by said first mentioned impulses and which end at a time determined by said other impulses.

12. A synchronizing impulse generator comprising means for producing impulses occurring at intervals of k units, means for producing other impulses occurring at intervals of nk units where n is a small whole number which impulses start during and last longer than said first impulses, means for adding all of said impulses and clipping the resulting signal to produce impulses which start at a time determined by said first mentioned impulses and which end at a time determined by said other impulses, and means for periodically removing $1/n$ of said first impulses to make them recur at intervals of nk for said period.

13. A synchronizing impulse generator comprising means for producing impulses occurring at intervals of k units, means for producing other impulses occurring at intervals of nk units where n is a small whole number, means for removing groups of said other impulses periodically, means for so combining said first impulses and the remaining second-mentioned impulses in such time relation that each of said remaining impulses starts during and last longer than each of said first impulses whereby impulses are produced which start at a time determined by the front edges of said first impulses and which end at a time determined by said other impulses.

14. The method of producing synchronizing signals for television or the like which comprises producing impulses occurring at a frequency which is a multiple of the horizontal scanning frequency, producing impulses occurring at said horizontal scanning frequency, removing a group of said last impulses periodically, so combining said first impulses and the remaining impulses of said last impulses as to remove certain of said first impulses to make them recur at said horizontal scanning frequency whereby the resulting signal consists of horizontal synchronizing impulses and multiple frequency impulses, so adding other impulses to the back portion of said multiple frequency impulses as to remove said back portion and produce narrow multiple fre-

quency impulses, and adding slotted framing impulses to the resulting signal.

15. The method of producing synchronizing impulses for television or the like which comprises producing wide impulses occurring at double the horizontal scanning frequency, periodically removing the back portions of certain of said impulses to produce double frequency narrow impulses, producing wide impulses starting during and lasting longer than said wide impulses and occurring at said horizontal scanning frequency and periodically removing groups thereof, and so combining all of said signals which have not been removed that said last wide impulses narrow alternate double frequency wide impulses and remove the remaining double frequency wide impulses whereby the resulting signal consists of horizontal synchronizing impulses, double frequency narrow impulses and slotted framing impulses.

16. The method of producing a synchronizing signal comprising impulses of different width or duration, the narrower impulses beginning at time intervals equal to k units and the wider impulses beginning at intervals equal to nk units where n is a small whole number, said method comprising producing a first wave of uniform impulses which occur at intervals of k units, producing a second wave of uniform impulses each of which occurs in overlapping relation to each of said first impulses, periodically removing a group of said second impulses, combining said two waves whereby said second wave changes the width of certain of said first impulses, and means for passing only the signal on the same amplitude level as said impulses of changed width.

17. The method of producing a synchronizing signal comprising pulses having leading edges recurring at precise intervals which comprises generating pulses recurring at a comparatively high frequency, generating pulses recurring at a comparatively low frequency, and adding said two groups of pulses in such time relation that certain of said high frequency pulses overlap the front edges of said low frequency pulses whereby the front edges of said high frequency pulses are the front edges of both high frequency pulses and low frequency pulses in said synchronizing signal.

18. The method of producing a synchronizing signal comprising pulses having leading edges recurring at precise intervals which comprises generating pulses recurring at the highest frequency at which pulses in said synchronizing signal are to occur, generating other pulses recurring at a lower frequency, and so combining said pulses that the leading edges of all pulses in the synchronizing signal are the original leading edges of said highest frequency pulses.

19. A synchronizing signal generator for producing pulses having leading edges recurring at precise intervals which comprises means for producing a group of pulses recurring at a frequency at least as high as the line frequency, means for producing a second group of pulses recurring at the comparatively low vertical deflection frequency, and means for so combining said groups of pulses that there is produced a synchronizing signal including pulses of different widths having front edges which are the original front edges of said first group of pulses.

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