Aug. 18, 1942. R. D. KELL ET AL 2,293,147

TELEVISION SYSTEM

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Fig. 1.

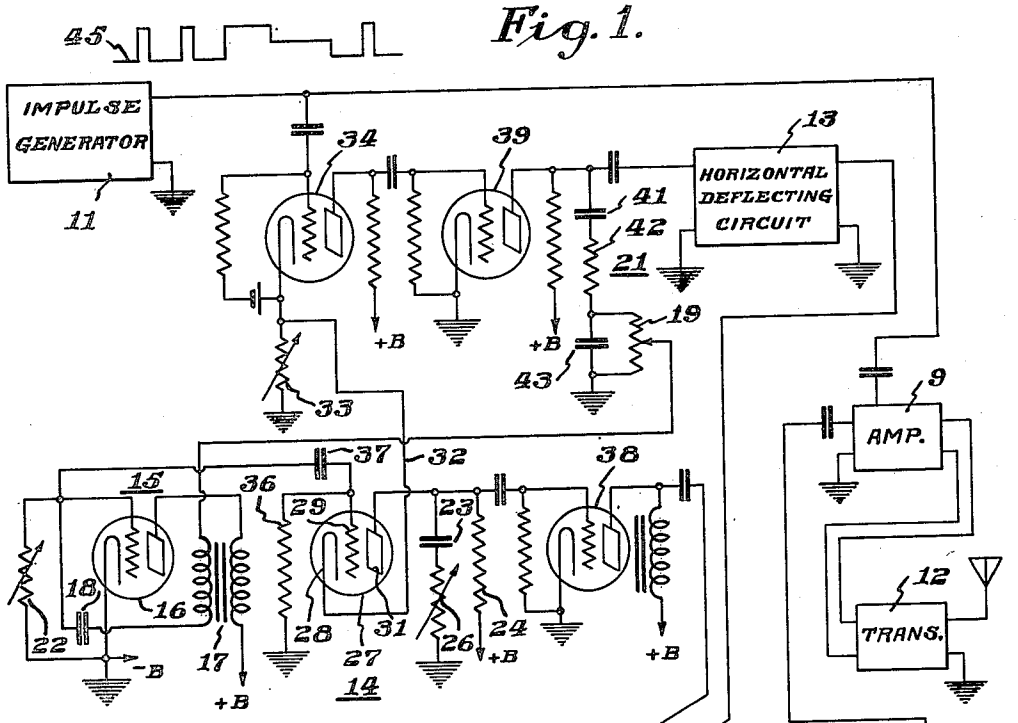
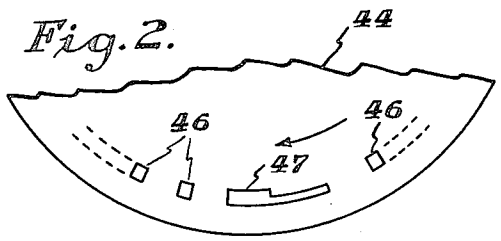


Fig. 2.



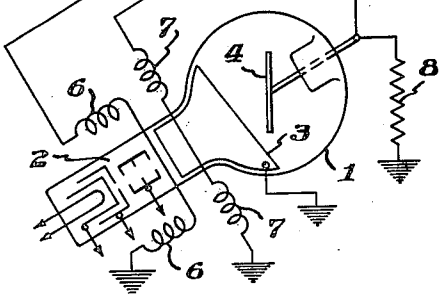


Fig. 3.

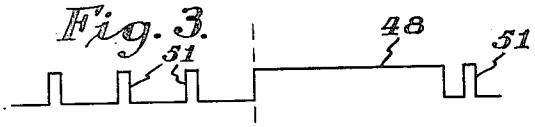


Fig. 4.

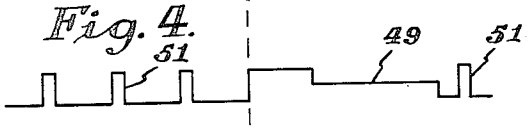


Fig. 5.

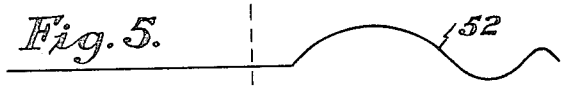


Fig. 6a.

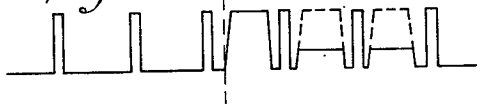
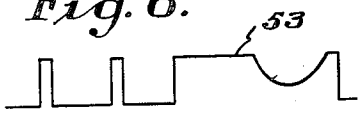


Fig. 6.



INVENTORS
Ray D. Kell
Alda V. Bedford
BY R. Goldsborough
ATTORNEY

Aug. 18, 1942. R. D. KELL ET AL 2,293,147

TELEVISION SYSTEM

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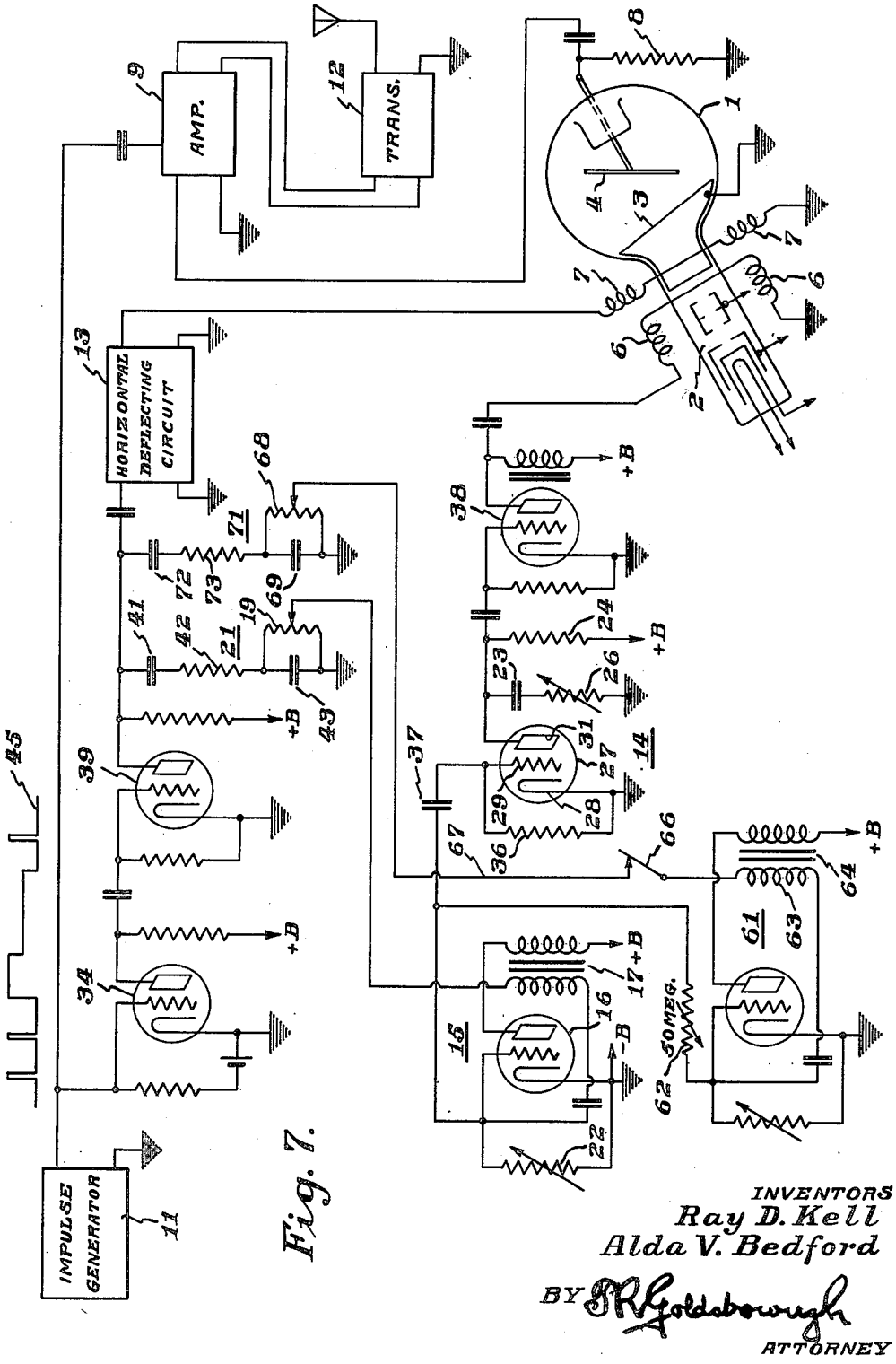


Fig. 7.

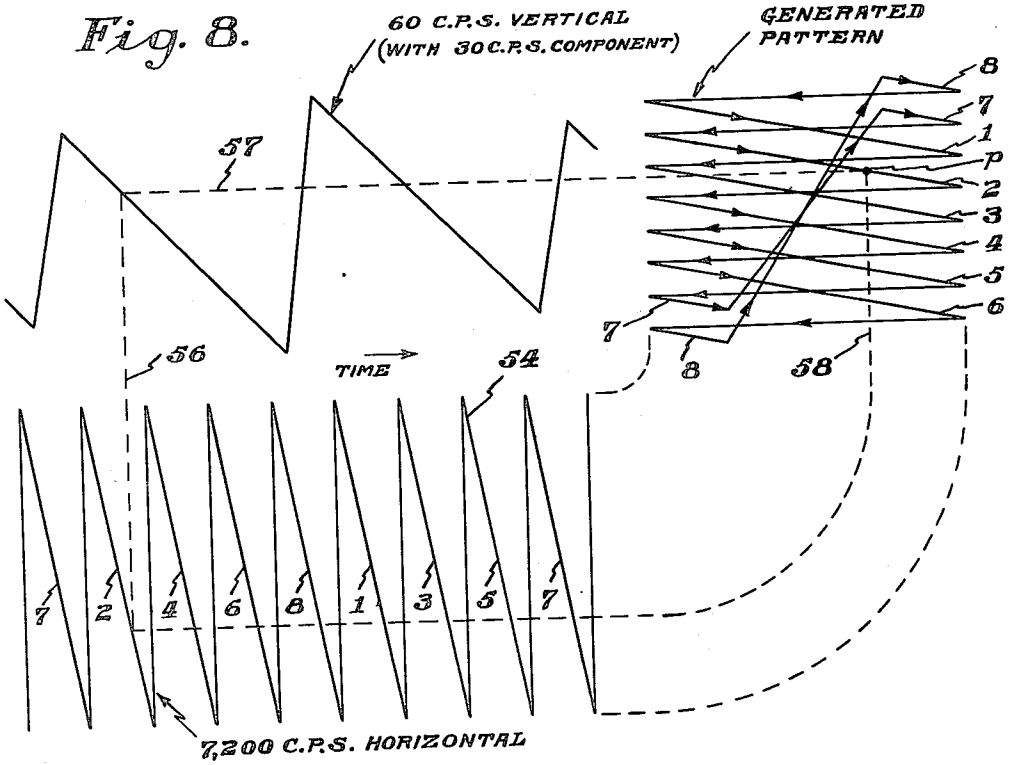
INVENTORS
Ray D. Kell
Alda V. Bedford
BY R. R. Goldsborough
ATTORNEY

Aug. 18, 1942. R. D. KELL ET AL 2,293,147

TELEVISION SYSTEM

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Fig. 8.



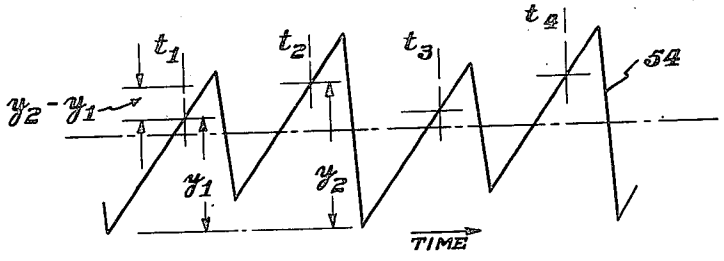


Fig. 9.

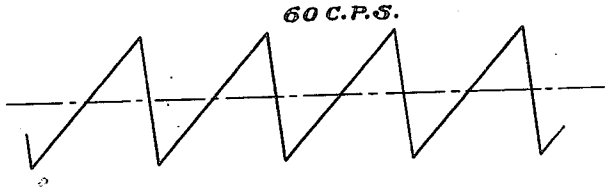


Fig. 10.

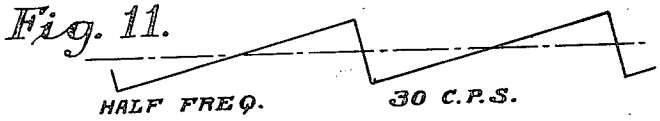


Fig. 11.

INVENTORS
Ray D. Kell
Alda V. Bedford
BY J R Goldsborough
ATTORNEY

Patented Aug. 18, 1942 2,293,147

UNITED STATES PATENT OFFICE

2,293,147

TELEVISION SYSTEM

Ray D. Kell, Haddonfield, and Alda V. Bedford, Collingswood, N. J., assignors to Radio Corporation of America, a corporation of Delaware

Application March 26, 1935, Serial No. 13,022

6 Claims. (Cl. 178—6.8)

Our invention relates to television systems and particularly to systems employing interlaced scanning.

Various methods and systems have been proposed for causing the scanning lines of one picture frame to fall between the scanning lines of a preceding picture frame to produce what is referred to as interlaced scanning and thereby to improve the quality of the received picture. In one of these systems the interlacing is obtained by so selecting the frequency of the vertical deflecting impulses and the frequency of the horizontal scanning impulses that the first frequency goes into the second frequency an even number of times plus one-half. This method of interlacing, which is referred to as the "odd line" method, is fairly satisfactory, but it has certain disadvantages.

In other systems for interlaced scanning, the vertical deflecting frequency goes into the horizontal deflecting frequency a whole number of times, this being referred to as the "even line" method of interlacing.

An object of our invention is to provide an improved method of and means for producing interlaced scanning in a television system.

A further object of our invention is to provide an improved method of and means for producing interlaced scanning by the so-called "even line" method.

A further object of our invention is to provide a television system in which interlacing is obtained by the "even line" method with the minimum number of mechanical moving parts.

A still further object of our invention is to produce, without the use of any mechanical switching, vertical deflecting impulses characterized in that each impulse differs slightly from the preceding impulse, alternate impulses being identical, whereby the scanning lines of alternate picture frames interlace.

In one of the preferred embodiments of our invention the television transmitter includes a cathode ray transmitter tube having deflecting devices for deflecting the cathode ray vertically at a comparatively low frequency and horizontally at a comparatively high frequency for scanning a light sensitive surface. The deflecting devices are supplied with electric impulses having a saw-tooth wave form, the horizontal deflecting impulses being produced by apparatus well known in the art, and the vertical deflecting impulses being produced by a circuit embodying our invention.

The latter circuit, which will be referred to as the vertical deflecting circuit, preferably includes a condenser which is slowly charged through a resistor and then suddenly discharged through an electric discharge tube for the purpose of producing a saw-tooth wave. The periodic discharge of the condenser may be caused by impulses supplied from an oscillator which is driven in synchronism with impulses from an impulse generator supplying synchronizing impulses both to the transmitter and to the receiver.

The impulse generator supplies both horizontal synchronizing impulses and vertical synchronizing impulses, the first impulses occurring at the comparatively high horizontal deflecting frequency and the other occurring at the comparatively low vertical deflecting frequency. In accordance with one embodiment of my invention, successive vertical synchronizing impulses are unlike in wave form. The vertical synchronizing impulses are utilized not only for the purpose of holding the oscillator in synchronism but they are also utilized for the purpose of controlling the impedance of the discharge tube during the period that the condenser is discharging. By giving alternate vertical synchronizing impulses different wave forms, the impedance of the discharge tube is caused to vary for alternate picture frames whereby the scanning lines of one picture frame are displaced with respect to the scanning lines of the preceding picture frame to produce interlaced scanning.

The impulses produced by the impulse generator are transmitted to the receiver together with the picture signals, as described in British Patent 407,409, and the vertical and horizontal synchronizing impulses separated from each other by means of filter circuits. The deflecting circuits at the receiver preferably are the same as those at the transmitter whereby interlaced scanning is produced on the fluorescent screen of a cathode ray receiver tube, this scanning corresponding to that at the transmitter.

Other objects, features and advantages of our invention will appear from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a circuit diagram of a television transmitter embodying our invention;

Fig. 2 is a fragmentary view of a disc which may be employed in the impulse generator shown in Fig. 1;

Figs. 3, 4, 5, 6 and 6*a* are curves which are referred to in explaining our invention;

Fig. 7 is a circuit diagram of another embodiment of our invention; and

Figs. 8 to 11 are curves which are referred to in explaining our invention.

Referring to Fig. 1, the television transmitter includes a cathode ray transmitter tube 1 of a well known type which comprises an electron gun 2, a second anode 3 and a mosaic 4 of light sensitive elements upon which is formed an image of the picture to be transmitted. Vertical deflecting coils 6 and horizontal deflecting coils 7 are provided for the purpose of causing the cathode ray to scan the mosaic 4 whereby picture signals are caused to flow through an output resistor 8. These picture signals are impressed upon an amplifier 9, where they are amplified and mixed with synchronizing impulses supplied from the impulse generator 11, and the combined picture and synchronizing signals are then supplied to a radio transmitter 12 for transmission to the receiver.

Saw-tooth current impulses are supplied to the deflecting coils 7 and 6 from a horizontal deflecting circuit 13 and a vertical deflecting circuit 14, respectively. In a preferred embodiment, the vertical deflecting circuit includes a blocking oscillator 15 such as described in British Patent 402,629 which comprises an electric discharge tube 16 having a plate circuit which is coupled to the grid circuit through a transformer 17. The grid circuit of the tube 16 includes a grid condenser 18 connected in series with the secondary of the transformer 17 and a resistor 19 in a filter circuit 21 which will be referred to hereinafter. The grid circuit also includes a grid resistor 22 through which the grid condenser 18 discharges periodically.

As described in the above mentioned British patent, a blocking oscillator such as oscillator 15 oscillates freely at a frequency determined largely by the values of the grid condenser 18 and grid resistor 22. The oscillations consist of a flow of plate current which charges the grid condenser 18 through the transformer 17 to a value such as to block the tube 16, after which the condenser 18 discharges through the resistor 22 to unblock the tube and permit the action to be repeated. Oscillators of other types, such as a dynatron, may be substituted for the blocking oscillator, if desired.

Saw-tooth waves are produced in a circuit which includes a condenser 23 and a resistor 24 having high impedance through which the condenser 23 is charged by means of a "B" battery or other suitable source of voltage. In order to add an impulse component to the saw-tooth wave a resistor 26 is connected in series with the condenser 23.

An electric discharge tube 27, which may be of the three element type, is connected with its plate circuit in shunt to the condenser 23 and peaking resistor 26 whereby the condenser 23 may be discharged therethrough by lowering the plate impedance of the tube 27. The tube 27 includes a cathode 28, a control grid 29 and a plate 31, the plate 31 being connected to the junction point of the condenser 23 and the resistor 24, and the cathode 28 being connected to ground through a conductor 32 and a resistor 33 which is included in the cathode lead of a tube 34 to be described later. The control grid 29 is connected to ground through a grid resistor 36 and is maintained normally at a high negative potential by means of the flow of grid current produced when the positive impulses from the oscillat 15 are impressed thereon.

The control grid 29 is also connected throug a coupling condenser 37 to the grid circuit of th blocking oscillator 15 whereby a positive impul is impressed upon the grid periodically to caus a discharge of the condenser 23.

The voltage appearing across the condense 23 and peaking resistor 26 is supplied to the in put circuit of an output tube 38 which supplie saw-tooth current impulses to the vertical de flecting coils 6.

The horizontal deflecting circuit indicated b the block 13 may be of the general type describe above comprising a blocking oscillator, a con denser which is charged through a high imped ance resistor and discharged through an electri discharge tube, and an output tube.

In order to produce scanning at the transmit ter which is synchronous with the scanning a the receiver, the oscillators in the deflecting cir cuits 13 and 14 are so adjusted that if they ar permitted to oscillate freely, they oscillate at slightly lower frequency than the frequency of the synchronizing impulses which are im pressed thereon from the impulse generato 11. The synchronizing impulses are supplied to the deflecting circuits 13 and 14 through amplifier tubes 34 and 39. The first amplifier tube 34 has the resistor 33 connected between its cathode and ground. The second amplifier tube 39 includes in its output circuit the filter circuit 21 comprising a blocking condenser 41, a resistor 42 and a second condenser 43 shunted by the resistor 19. Vertical synchronizing impulses appear across the resistor 19 substantially to the exclusion of the horizontal synchronizing impulses. Thus, because of the connection of the blocking oscillator 15 to the filter resistor 19, it is driven in synchronism with the vertical synchronized impulses. Likewise, the horizontal deflecting circuit is operated in synchronism with the horizontal synchronizing impulses.

Referring now to the means by which we obtain interlacing, it will be apparent that the plate impedance of the discharge tube 27 depends, to a certain extent, upon the voltage drop across the cathode lead resistor 33. It will also be apparent that, since the plate current of the amplifier tube 34 is flowing through the resistor 33, the voltage drop across it depends upon the magnitude and, therefore, the wave shape of voltage impulses impressed upon the control grid of the tube 34. In other words, the plate impedance of the discharge tube 27 for the duration of a vertical synchronizing impulse depends upon the wave shape or instantaneous value of said impulse.

The operation of the circuit will be better understood by referring to Figs. 2, 3, 4 and 5. The synchronizing impulse generator 11 may comprise a disc 44 having openings 46 and 47 therein for the production of electrical impulses having the desired wave shape as described in British Patent 407,409.

Fig. 3 shows the character of a vertical synchronizing impulse 48 for one picture frame and Fig. 4 and the curve 45 in Fig. 1 show the character of the next vertical synchronizing impulse 49 which controls the position of the horizontal scanning lines for the next picture frame. The vertical synchronizing impulse 49 is produced by means of the opening 47 in the disc 44 having the shape shown. Alternate vertical synchronizing impulses are of this shape. The remaining

vertical synchronizing impulses are of the shape shown in Fig. 3 and are produced by an opening of the proper shape in the disc 44 which is diametrically opposite the opening 47. It will be seen that in the arrangement described, there are two picture frames for each rotation of the generator disc 44. The impulses 51 shown in Figs. 3 and 4 are the horizontal synchronizing impulses produced by the openings 46 in the generator disc.

The curve 52 in Fig. 5 shows the wave shape of the voltage impulse supplied to the grid 29 of the discharge tube 27 by the blocking oscillator 15. This curve is drawn mainly to show the duration of the blocking oscillator impulse and it will be understood that the amplitude of the positive portion of the impulse is much greater than that of the synchronizing impulses, one hundred times as great, for example.

The voltage appearing across the cathode resistor 33 as the result of a vertical synchronizing impulse being impressed upon the grid of the tube 34 has the same wave shape as that impulse. Therefore, the curves in Figs. 3 and 4 also represent the voltages which appear across the resistor.

By comparing Figs. 3, 4 and 5, it will be seen that the occurrence of a vertical synchronizing impulse causes the blocking oscillator to produce a positive impulse an instant later. For the duration of this positive impulse, a synchronizing impulse such as the impulse 48 in Fig. 3, is being applied to the cathode 28 of the electric discharge tube 27. Assuming that this synchronizing impulse has a polarity such as to make the grid 29 more negative with respect to the cathode 28, it will be seen that the plate impedance of the tube 27 is higher during the period the condenser 23 is discharging than it would be if the synchronizing impulse 48 were not impressed upon the cathode 28.

The next vertical synchronizing impulse which occurs has the wave shape indicated at 49 in Fig. 4. Preferably, this impulse has the same amplitude at the beginning as the preceding impulse 48 in order to insure proper synchronizing of the blocking oscillator 15. Shortly after the beginning of the impulse 49, however, its amplitude becomes less and, since the polarity of the impulse 49 is the same as that of the impulse 48, it will be seen that the plate impedance of the discharge tube 27 is lower during the time the condenser 23 is discharging than it was during the preceding discharge period.

The reason that the positive impulse indicated in Fig. 5 begins an instant later than the beginning of impulses 48 and 49 is that in the filter circuit 21 it takes an appreciable time for sufficient voltage to build up across the condenser 43 to trigger off the oscillator in response to a vertical synchronizing impulse being impressed upon the filter circuit.

It is not essential that the vertical synchronizing impulses be of the particular wave shapes illustrated, these being given only by way of example. For instance, one vertical impulse might have the wave shape shown in Fig. 3 and the next vertical impulse might have the wave shape indicated at 53 in Fig. 6. Or, the vertical synchronizing impulses may be slotted, with horizontal synchronizing impulses inserted in the slots as shown in Fig. 6a. A system generating impulses of this character is described and claimed in Patent No. 2,192,121, issued February 27, 1940, in the name of A. B. Bedford, and assigned to the same assignee as this application. Alternate vertical impulses have the shape shown by the solid line curve while the remaining vertical impulses have three vertical impulse components of equal amplitude as indicated by the dotted line curve.

The voltage wave which appears across the condenser 23 as a result of the above described control of the discharge tube impedance is shown in Fig. 9. The first saw-tooth starts from a certain level, the condenser 23 being charged up to a certain point and then discharged. The amount the condenser 23 is discharged is controlled in part by the vertical synchronizing impulse 48 shown in Fig. 3. It will be seen that because of the higher impedance of the discharge tube 27 the condenser is not discharged to the voltage level at which the saw-tooth started. Therefore, the second saw-tooth begins at this higher level and the condenser 23 receives an additional charge, this charge being equal to the one which produced the first saw-tooth whereby the second saw-tooth is raised to a higher level than the first saw-tooth. This time the condenser 23 is discharged while the impedance of the discharge tube 27 is under the control of the vertical synchronizing impulse 49 shown in Fig. 4. Therefore, the plate impedance of the discharge tube 27 is lower than during the preceding condenser discharge and the condenser is discharged a greater amount than formerly to bring its voltage to the original level. It will be seen that the amount the condenser 23 is charged is the same for each saw-tooth but that the amount the condenser is discharged is different for successive saw-teeth and the same for alternate saw-teeth.

From an inspection of Fig. 9 it will be apparent that corresponding horizontal scanning lines for two adjacent picture frames will not fall upon one another, and that if successive saw-teeth are chosen having the proper relative amplitudes, the horizontal scanning lines of one picture frame will fall between the horizontal scanning lines of preceding picture frame to produce an interlaced picture. For example, if t_1, t_2, t_3, etc., represent the period of the vertical deflecting impulses, at the times t_1 and t_2 the amplitudes of the first two impulses are y_1 and y_2 respectively. The difference between these two amplitudes represents the difference in position of two corresponding horizontal scanning lines in successive picture frames.

It may be noted at this point that if the saw-tooth impulses shown in Fig. 9 occur at the rate of 60 per second, on analysis they are found to consist of the impulses shown in Fig. 10 occurring at the rate of 60 cycles per second and the impulse shown in Fig. 11 occurring at half this frequency or 30 cycles per second. This fact is of particular interest in connection with an embodiment of the invention to be described later.

It should be understood that the difference in amplitude of successive saw-tooth waves has been greatly exaggerated in Fig. 9. Actually, the amplitude of the smaller saw-tooth may be of the order of 99.8% of the amplitude of the larger saw-tooth.

The curves in Fig. 8 are of assistance in understanding how our system produces an interlaced picture. For obvious reasons the curve 54 which represents the horizontal deflecting impulses has been drawn to show only a few horizontal deflecting impulses for each vertical deflecting impulse. As indicated on the drawing,

in a preferred embodiment of the invention the vertical deflecting impulses occurred at the rate of 60 per second while the horizontal deflecting impulses occurred at the rate of 7,200 per second. For convenience in laying out the generated pattern shown at the right in Fig. 8, the saw-teeth have been shown as sloping in the opposite direction to the slope of the saw-teeth in Fig. 9. In this way, the generated pattern when laid out from the curves corresponds to the scanning produced at a receiver in actual practice in that the scanning is from top to bottom and from left to right.

The generated pattern represents the traces made by the cathode ray on the fluorescent screen in a receiver tube. The manner in which the generated pattern is laid out from the curves is apparent from an inspection of the drawings. For instance, it will be seen that the point P on the trace 2 of the generated pattern is located by drawing the dotted line 56 from a point on the saw-tooth 2 to the first vertical deflecting saw-tooth and then by extending the dotted horizontal line 57 until it intersects a vertical line 58, the distance of the line 58 from the right-hand edge of the pattern being determined by the distance of the above-mentioned point on saw-tooth 2 from the bottom of the saw-tooth. The horizontal deflecting saw-tooth impulse 1 produces the trace 1 on the generated pattern. Other corresponding deflecting saw-tooth impulses and corresponding traces in the generated pattern are similarly identified by corresponding reference numerals. It is apparent that the horizontal scanning lines or traces of one picture frame fall half way between the corresponding lines of the preceding picture frame.

The generated pattern on the mosaic 4 of the transmitter tube 1, of course, corresponds to the pattern shown in Fig. 8. It may be noted that it is the usual practice to project an inverted image on the mosaic 4 and scan it from bottom to top instead of from top to bottom as at the receiver.

Referring to the embodiment of our invention shown in Fig. 7, the differences in amplitude of successive vertical saw-tooth deflecting impulses is produced by means of an additional oscillator 61 which is caused to oscillate at a sub-multiple frequency of the main oscillator frequency. In Figs. 1 and 7 like parts are indicated by the same reference numerals.

In the circuit shown in Fig. 7 the cathode 28 of the discharge tube 27 is connected directly to ground whereby the shape of a synchronizing impulse has no direct control over the discharge tube impedance, as in Fig. 1. Instead, during one discharge period of the condenser 23 the plate impedance of the tube 27 is controlled solely by the impulse supplied by the main oscillator 15 and during the next discharge period the plate impedance of the tube 27 is controlled by the combined outputs of the two oscillators 15 and 61.

The sub-multiple frequency oscillator 61, which in the embodiment being described is adjusted to oscillate under the control of synchronizing impulses at one-half the frequency of the main oscillator 15, may be of any suitable type, but in the drawing is shown as a blocking oscillator similar to the main oscillator. The grid circuit of the oscillator 61 is coupled through a resistor 62 and the coupling condenser 37 to the grid 29 of the discharge tube 27. The resistor 62 is given a high resistance value such as 50 megohms in order that the voltage impulse supplied to the discharge tube 27 by the sub-multiple frequency oscillator 61 will have a magnitude which is small compared to that of the voltage impulse supplied by the main oscillator 15. Obviously, this is desirable since only a small difference in the magnitude of successive saw-tooth impulses is required to produce interlacing. The amplitude of the sub-multiple frequency impulses may be of the order of ¼% of that of the main saw-tooth impulses at the grid 29.

In order to make the oscillator 61 lock in with alternate vertical synchronizing impulses, the secondary winding 63 of the transformer 64 is connected through a switch 66 and a conductor 67 to a resistor 68 which is in shunt to the condenser 69 of a filter circuit 71 similar to the other filter circuit 21. The filter circuit 71 includes a blocking condenser 72, a resistor 73 of comparatively high resistance, and the condenser 69 connected in series between the plate of the amplifier tube 39 and ground.

The oscillator 61 is caused to lock in with alternate vertical synchronizing impulses by so adjusting it that when oscillating freely it will oscillate at a frequency somewhat lower than one-half the frequency at which the vertical synchronizing impulses occur. If the impulse generator 11 is designed to supply successive vertical synchronizing impulses which are identical in wave shape and amplitude, the sub-multiple frequency oscillator 61 may lock in on the wrong vertical synchronizing impulse so that at the instant a saw-tooth of the larger amplitude is produced at the transmitter a saw-tooth of the smaller amplitude will be produced at the receiver. In that event it would be necessary to open the switch 66 and reclose it, this operation being repeated until the oscillator locked in on the correct synchronizing impulse to give proper interlacing. Of course, the same results are obtained by performing a similar operation at the receiver instead of at the transmitter, and ordinarily it would be done at the receiver.

From the foregoing description it will be seen that successive saw-tooth impulses of different amplitude are produced by the circuit shown in Fig. 7 in much the same manner that they are produced by the circuit shown in Fig. 1. The operation of the circuit shown in Fig. 7 may be looked upon in a slightly different way, however, by taking note of the fact that the saw-tooth impulses appearing across the condenser 23 are made up of the saw-tooth components shown in Figs. 10 and 11. It may be considered that the main oscillator 15 together with the condenser 23, its charging circuit and discharging circuit produce the saw-tooth wave shown in Fig. 10, while the sub-multiple frequency oscillator 61 together with the condenser 23 and its charging and discharging circuits produce the half frequency saw-tooth wave shown in Fig. 11, and that these two waves are added to produce the wave shown in Fig. 9.

It will be evident that a separate condenser with its charging circuit and discharging circuit could be provided for the sub-multiple frequency oscillator 61 and then the saw-tooth waves appearing across this separate condenser and the condenser 23 added to provide a wave of the character shown in Fig. 9. As such duplication of apparatus is unnecessary, it is preferred to employ the circuit illustrated.

In order to ensure that the sub-multiple frequency oscillator 61 locks in with the proper ver-

tical synchronizing impulse, it is desirable that successive vertical synchronizing impulses be given different characteristics, as described in connection with Fig. 1. In this case, assuming filter circuits 21 and 71 are otherwise identical, the filter condenser 43 should have a considerably smaller capacity than the other filter condenser 69, one-third of the capacity of condenser 69 for example, and the sub-multiple frequency oscillator 61 is adjusted to oscillate freely at such a low frequency that only strong synchronizing impulses will cause it to lock in. The main oscillator 15, on the other hand, is so adjusted that it oscillates freely close to the desired frequency, whereby it locks in on both weak and strong synchronizing impulses.

Since the filter condenser 43 has been given a comparatively small capacity, the voltage built up across it by an impulse indicated at 49 (Fig. 4) containing a comparatively small amount of energy has a magnitude sufficient to trigger off the main oscillator 15. However, the voltage built up across the other filter condenser 69 by the same synchronizing impulse is less, and, especially since the oscillator 61 is adjusted to lock in on strong impulses only, it is insufficient to trigger off the sub-multiple frequency oscillator. Therefore, the oscillator 61 always locks in with the vertical synchronizing impulse containing the most energy (impulse 48 in Fig. 3) and the tracings of the cathode rays at the transmitter and receiver are properly interlaced.

It will be apparent from the above description that various modifications may be made in our invention without departing from the spirit and scope thereof, and we desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and set forth in the appended claims.

We claim as our invention:

1. In a television system, a cathode ray tube, means for deflecting the cathode ray horizontally at a certain frequency, and means for deflecting the cathode ray vertically at a comparatively low frequency, said second means comprising a condenser, a charging circuit for said condenser, a discharging circuit for said condenser, and means for making the impedance of said discharging circuit different for successive condenser discharges.

2. In a television system, a cathode ray tube, means for deflecting the cathode ray horizontally at a certain frequency, and means for deflecting the cathode ray vertically at a comparatively low frequency, said second means comprising a condenser, a charging circuit for said condenser, a discharging circuit for said condenser, and means for making the impedance of said discharging circuit different for successive condenser discharges and the same for alternate condenser discharges.

3. In a television system, a cathode ray tube, means for deflecting the cathode ray horizontally at a certain frequency, means for simultaneously deflecting the cathode ray vertically at a comparatively low frequency, means for generating horizontal synchronizing impulses and for controlling said horizontal deflections in accordance therewith, means for generating vertical synchronizing impulses characterized in that successive impulses have unlike characteristics and for so controlling said vertical deflections in accordance therewith that the horizontal deflections of the cathode ray for one vertical deflection interlace with the horizontal deflections for the preceding vertical deflection.

4. Television apparatus comprising a cathode ray tube, means for deflecting the cathode ray horizontally at a certain frequency, means for deflecting the cathode ray vertically at a comparatively low frequency, said second means including an oscillator and also including a condenser having a highly resistive charging circuit and having a discharging circuit which ineludes an electric discharge tube, means for producing horizontal synchronizing impulses and vertical synchronizing impulses, successive vertical synchronizing impulses having unlike characteristics, means for controlling said horizontal deflections in accordance with said horizontal synchronizing impulses, means for controlling said oscillator in accordance with said vertical synchronizing impulses, and means for controlling the impedance of said electric discharge tube in accordance with said unlike characteristics.

5. In television apparatus including a cathode ray tube and means for deflecting the cathode ray horizontally at a certain frequency, means for deflecting the cathode ray vertically at a comparatively low frequency, said second means comprising a condenser having a highly resistive charging circuit and a discharging circuit which includes an electric discharge tube, an oscillator adjusted to oscillate freely at approximately said low frequency, a second oscillator adjusted to oscillate freely at approximately a sub-multiple frequency of said low frequency, means for controlling the plate impedance of said discharge tube in accordance with the oscillations of said oscillators, means for producing synchronizing impulses characterized in that successive synchronizing impulses are unlike, alternate impulses being similar, and means for driving said oscillators in step with said synchronizing impulses, said sub-multiple frequency oscillator being adjusted to lock in only with predetermined alternate impulses.

6. An electro-optical system comprising a cathode ray discharge device having means for producing a cathode beam, means for controlling said beam, a fluorescent screen, and means for deflecting said beam to trace a pattern on said screen, a source supplying current of selected frequency, and means controlled by said source for causing the production of successive displaced patterns, comprising means for cyclically varying the deflecting field.

RAY D. KELL.
ALDA V. BEDFORD.