

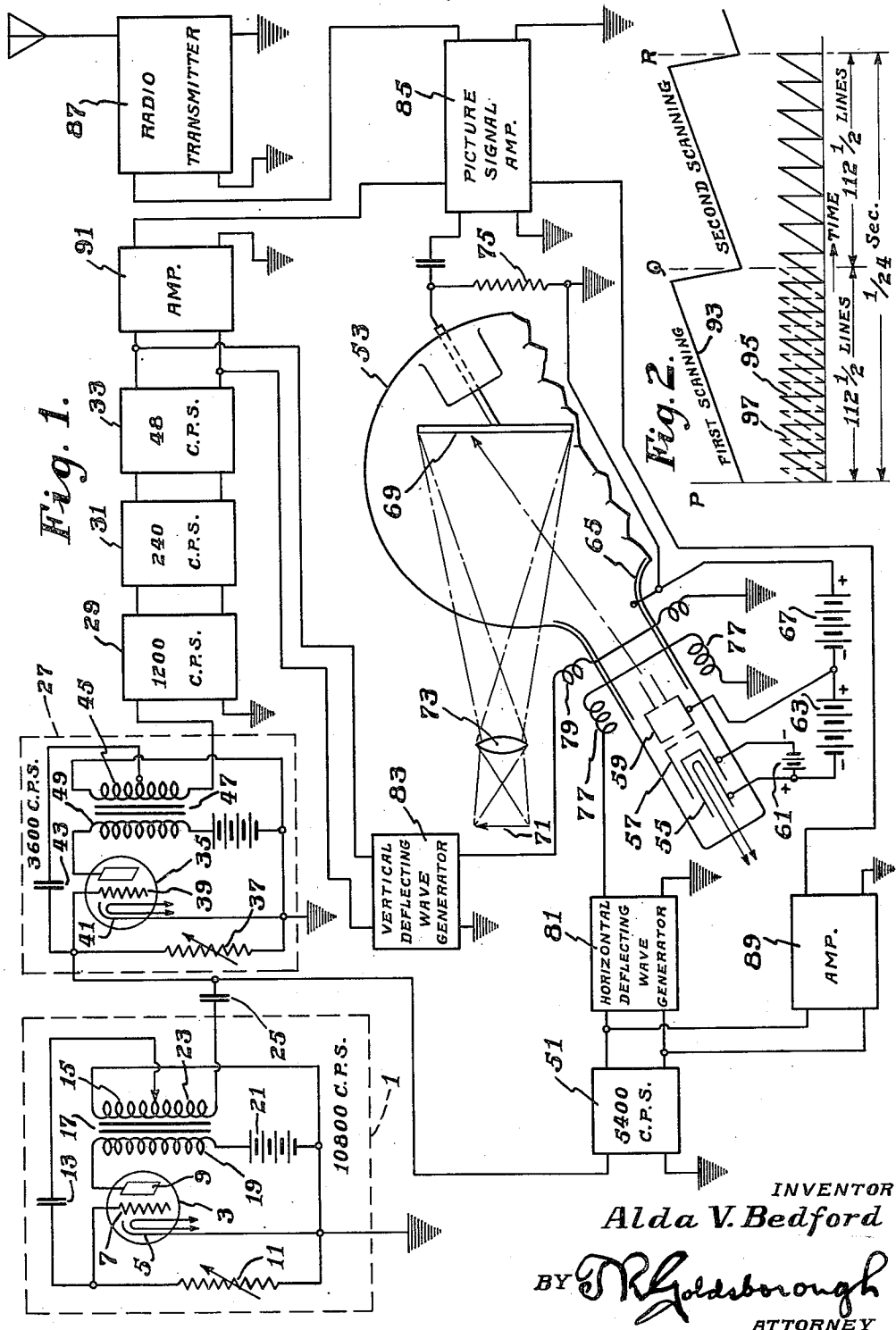
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**A. V. BEDFORD**

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TELEVISION SYSTEM

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## UNITED STATES PATENT OFFICE

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## TELEVISION SYSTEM

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

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My invention relates to television systems and particularly to television systems which employ interlaced scanning.

As explained in application Serial No. 623,325 filed July 19, 1932, now Patent No. 2,152,234, granted March 28, 1939, in the name of R. C. Ballard and assigned to the same assignee as this application, it has been found advantageous to employ what is known as interlaced scanning. In a preferred form of interlaced scanning, the scanning lines of one picture-frame fall half-way between the scanning lines of the preceding frame. The result is that the picture appears to have twice the number of lines that it actually has and the quality of the picture, accordingly, is improved. In systems employing interlaced scanning, it is preferred to follow that usual practice of synchronizing the scanning at the receiver with that at the transmitter by transmitting a horizontal synchronizing impulse at the end of each scanning line and a vertical synchronizing or framing impulse at the end of each picture frame.

In the above-mentioned Ballard application, a television system is described in which a scanning disc is employed at the transmitter both for scanning the object to be transmitted and for generating the synchronizing impulses. In a preferred system, a cathode-ray transmitter tube is employed in which the scanning is done by deflecting an electron beam whereby no rotating parts are required at the transmitter for scanning. A transmitter tube of this character was described in an article by Dr. V. K. Zworykin which appeared in the Journal of the Franklin Institute for January, 1934.

While it is possible to generate electrical impulses for deflecting the electron beam of the transmitter tube and for synchronizing the scanning at the transmitter and receiver by utilizing a rotating disc, this is undesirable for various reasons.

It is accordingly an object of my invention to provide a generator of deflecting and/or synchronizing impulses for a television system employing interlaced scanning which has no moving mechanical parts.

More specifically, an object of my invention is to provide an electric discharge tube generator of deflecting and/or synchronizing impulses for obtaining interlaced scanning.

In one embodiment of my invention in which the apparent number of lines per picture is twice the actual number of lines per picture, I provide an oscillator, such as a blocking oscillator,

which produces twice the number of electrical impulses per second that are required for the horizontal scanning. The output of this oscillator is impressed upon a frequency divider in which the frequency is divided by two and half-frequency is then impressed upon the horizontal deflecting circuit.

In order to obtain the vertical deflecting or frame frequency, the output of the oscillator is impressed upon a chain of frequency dividers which divide the frequency of the oscillator output in small odd-numbered steps until the desired frame frequency is reached. The impulses at the frame frequency are then impressed upon the vertical deflecting circuit. By this procedure, the number of actual scanning lines per picture is made equal to a whole number plus one-half to provide interlaced scanning in the manner described in the above Ballard application.

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

Figure 1 is a view of a television transmitter system embodying my invention, and

Figure 2 is a group of curves which are referred to in explaining the invention.

Referring to Fig. 1, I have shown a system for producing a picture in which the apparent number of lines per picture is twice the actual number of lines per picture. This is accomplished by causing the scanning lines of one picture to fall half-way between the scanning lines of the preceding picture, as described in the Ballard application. In the specific embodiment shown, the vertical scanning or frame frequency is 48 cycles per second while the horizontal scanning frequency is 5400 cycles per second. The actual number of lines per picture, therefore, is  $112\frac{1}{2}$  or the number of times that 48 goes into 5400.

The apparatus for generating the horizontal synchronizing and framing impulses comprises a blocking oscillator 1 which consists of an electric discharge tube 3 having a cathode 5, a control grid 7 and an anode 9. The control grid 7 is connected through a variable grid leak resistor 11 to the cathode 5 which may be grounded. The grid circuit of the oscillator 1 also includes a grid condenser 13 and a section 15 of the secondary winding of a transformer 17, the condenser 13 and the secondary section 15 being connected in series between the control grid 7 and the cathode 5.

The anode 9 is connected through the primary winding 19 of the transformer 17 to a suitable

source of positive potential, such as a battery 21. The coupling thus provided between the plate and grid circuits of the tube 3 is such that, as the plate current through the primary winding increases, the control grid 7 is made more positive. The resulting positive voltage of the control grid 7 causes a flow of grid current which charges the grid condenser 13 in a direction such that it tends to make the control grid 7 negative. The plate current reaches a maximum value and then decreases, at the same time reversing the direction of the induced voltage in the grid circuit whereby the control grid 7 is made so negative that the tube is biased beyond cut-off. The above-described action charges the grid condenser 13 sufficiently to bias the tube 3 beyond the cut-off point. Therefore, no current will flow again in the plate circuit until the charge has leaked off the condenser 13 through the grid leak resistor 11 to lower the negative bias on the control grid 7 a sufficient amount. By properly adjusting the values of the various elements in the oscillator circuit, and, in particular, by properly adjusting the damping therein and values of the grid condenser 13 and the grid leak resistor 11, the oscillator may be made to oscillate at a desired frequency such as the frequency of 10,800 cycles per second, as indicated in the drawing.

The electric impulses generated by the oscillator 1 are supplied to the frequency dividing circuits through a second section 23 of the secondary winding and through a coupling condenser 25. It should be understood that the blocking oscillator may be coupled to the frequency dividers in any other suitable manner, and that instead of a blocking oscillator any other suitable source of electrical impulses such as a dynatron or relaxation oscillator may be employed.

In the circuit illustrated, the frequency of the oscillator 1 is divided in two steps of three and two steps of five by the frequency dividers 27, 29, 31 and 33 to obtain the frame frequency. Each frequency divider may be a blocking oscillator adjusted to oscillate at approximately the desired sub-multiple frequency so that it will lock in with and be controlled by the next preceding frequency divider. The circuit for only the first frequency divider 27 is shown. It will be seen that it is the same as the circuit of the main oscillator 1 and includes an electric discharge tube 35 having a variable grid leak resistor 37 connected between the control grid 39 and the cathode 41 and having a grid condenser 43 and a portion 45 of the secondary winding of the transformer 47 connected in series and between said grid and cathode. As in the main oscillator 1 the primary winding 49 of the transformer 47 is included in the plate circuit of the tube to drive the grid 39 positive as the plate current increases.

Instead of using blocking oscillators as frequency dividers, any other suitable frequency divider, such as a dynatron oscillator, may be utilized.

The electrical impulses of the main oscillator 1 are also impressed upon a frequency divider 51 which divides the 10,800 cycle frequency by two in order to provide the desired horizontal synchronizing frequency. The frequency divider 51, like the others, may be a blocking oscillator, a dynatron oscillator, or a frequency divider of any other well known type.

Attention is here called to the fact that in the circuit for double interlaced scanning, which is illustrated, the horizontal scanning frequency is

obtained by dividing the frequency of the main oscillator 1 by an even number while the framing frequency is obtained by dividing the frequency of the main oscillator 1 by odd numbers.

The transmitter tube 53 is of the type described in the above-mentioned publication. It consists of an evacuated envelope having an electron gun therein comprising a cathode 55, a control electrode 57 and a first anode 59. The control electrode 57 is maintained at a suitable negative potential as by means of a battery 61 while the first anode 59 is maintained at a suitable positive potential as by means of a battery 63. A second anode 65, which serves both to accelerate and to aid in the focusing of the electrons, is maintained at a comparatively high positive potential by suitable means such as a battery 67 connected in series with the battery 63.

A mosaic 69 of light-sensitive elements is mounted in the envelope in such position that it may be scanned by the electron beam from the gun. It is also so positioned that an optical image of an object 71 to be transmitted may be formed thereon by means of a suitable lens system 73. The back side or signal plate of the mosaic 69 is connected through an output resistor 75 to the second anode 65 which functions also as a common anode for the light sensitive elements of the mosaic. The second anode 65 is preferably connected to ground.

The transmitter tube 53 is provided with a suitable deflecting means such as deflecting coils 77 for deflecting the electron beam horizontally and deflecting coils 79 for deflecting the beam vertically.

The output circuit of the 5400 cycle voltage divider 51 is connected to the input circuit of a saw-tooth wave generator 81. The output circuit of the generator 81 is connected across the horizontal deflecting coils 77 for supplying them with current having a saw-tooth wave shape.

The output circuit of the 48 cycle voltage divider 33 is connected to the input circuit of a saw-tooth wave generator 83, the output circuit of which is connected across the vertical deflecting coils 79 for supplying a saw-tooth wave of current therethrough.

It will be seen that the above described system deflects the electron beam horizontally 5400 times per second while it is deflected vertically 48 times per second. Each time the electron beam strikes a light sensitive element of the mosaic 69 it causes a flow of picture current through the output resistor 75. This picture current is impressed upon the input circuit of a picture signal amplifier 85 where it is amplified and then supplied to the input circuit of a radio transmitter 87 or, if preferred, to a transmission line (not shown).

Since the transmitter tube per se forms no part of my present invention, no necessity is seen for explaining in detail the manner in which it operates nor is it necessary to expatiate upon the underlying theory thereof.

In order to synchronize the scanning at the receiver with the scanning at the transmitter, the horizontal synchronizing impulses and the framing impulses are impressed upon the picture signal amplifier 85 for amplification and transmission to the radio transmitter 87. The horizontal synchronizing impulses are supplied from the output of the frequency divider 51 through an amplifier 89 to the picture signal amplifier 85 while the framing impulses are supplied from the output of the frequency divider 33 through another amplifier 91 to the picture signal amplifier 85. Each

of the amplifiers 89 and 91 preferably includes amplifier tubes which are operated beyond their cut-off point to obtain a flat-topped synchronizing impulse and to eliminate transients following the main impulse.

To facilitate separation of the synchronizing and framing impulses from the picture signals at the receiver, these impulses are impressed upon an amplifier stage in the picture signal amplifier 85 such that the transmitted synchronizing and framing impulses will have a polarity opposite to that of the picture signals representing white. It will be understood that the said impulses are transmitted during intervals when no picture signal is being transmitted.

The television receiver may be the same as that disclosed in the above-identified Ballard application, it being understood, of course, that the saw-tooth wave generators at the receiver are adjusted to supply deflecting currents having frequencies substantially corresponding to the frequencies of the deflecting currents at the transmitter.

Referring now, more specifically, to the manner in which interlaced scanning is obtained by means of my vacuum tube generator, the curves 93 and 95 shown in Fig. 2 indicate the relation between the saw-tooth waves for vertical deflection and the saw-tooth waves for horizontal deflection. In order to simplify the drawing, a comparatively small number of horizontal deflection saw-tooth waves for each vertical deflection saw-tooth wave have been shown, the actual number of lines being indicated by the legend. By comparing the two solid line curves 93 and 95, it will be noted that there are an odd number of horizontal saw-tooth waves for each pair of vertical saw-tooth waves. In other words, there are an odd number of horizontal lines (225 in the example illustrated) for each pair of vertical scanings, or, for each vertical scanning, the number of horizontal lines is equal to a whole number plus one-half.

In the drawing, a condition is assumed where the vertical scanning and the horizontal scanning circuits are just beginning saw-tooth cycles in step at the time P. At the time Q, the beginning of the second vertical scanning, the horizontal scanning circuit is in the middle of a scanning cycle due to there being a whole number plus one-half of horizontal lines per vertical scanning. Since each vertical scanning saw-tooth wave is exactly like the preceding vertical scanning saw-tooth wave, the horizontal lines of the second vertical scanning occupy the same space vertically on the mosaic of the transmitter tube and on the fluorescent screen of the receiver tube as the horizontal lines of the preceding vertical scanning. Therefore, we may superimpose the horizontal saw-tooth waves between Q and R upon those between P and G as shown by the dotted line curve 97. Since the dotted line saw-tooth waves fall half way between the solid line saw-tooth waves, it follows that the horizontal lines of the second scanning fall half way between the horizontal lines of the preceding scanning to produce what may be called a double-interlaced picture. As the end of the second scanning, the above described operation is repeated.

The actual path taken by the cathode ray on the mosaic of the transmitter tube and on the fluorescent screen of the receiver tube is exemplified and described in the above-mentioned Ballard application.

While I have described my invention as ap-

plied to double-interlaced scanning, it should be understood that it may be applied to systems in which the picture is interlaced any desired number of times. For example it may be applied to what may be termed triple-interlaced scanning in which the horizontal lines of three successive picture frames fall evenly spaced apart upon different parts of the mosaic or fluorescent screen. It should also be understood that interlaced scanning may be obtained with my vacuum tube generator for a variety of framing and horizontal scanning frequencies. For example, in the case of double-interlaced scanning  $94\frac{1}{2}$  actual lines per picture may be obtained with a framing frequency of 48 cycles per second by employing a main oscillator having an output frequency of 9072 cycles per second. In this case the frequency of the main oscillator is divided by two to provide a horizontal scanning frequency of 4536 and it is divided in three steps of three and one step of seven to provide the 48 cycle framing frequency.

As another example of my invention  $121\frac{1}{2}$  actual lines per picture may be obtained with a framing frequency of 48 cycles per second by employing a main oscillator having an output frequency of 11,664 cycles per second. The main oscillator frequency is divided by two to obtain a horizontal scanning frequency of 5832 while it is divided in five steps of three to obtain a 48 cycle framing frequency.

In designing my improved generator, the following procedure may be followed:

Let L equal the actual number of lines per picture (L being  $121\frac{1}{2}$  in the system illustrated), let N equal the number of interlacings (N being equal to two in the system illustrated) and let F equal the output frequency of the main oscillator:

1. Multiply several small numbers not whole number multiples of N (odd numbers for double interlacing) to give a number NL, NL being the desired "apparent" number of lines per picture.

2. Multiply NL by the desired frame frequency to obtain the frequency F.

Having determined the frequency F, the generator may be constructed in accordance with the previously described design, the frequency F being divided by N in order to obtain the horizontal scanning frequency. The frame frequency is derived from the current of frequency F by dividing the frequency F in a number of steps, each step dividing the frequency by one of the small numbers mentioned in the above step #1.

The reason for step #1 in the procedure outlined above is that the frequency division should be made in fairly small steps in order to make each frequency divider lock in with the next preceding frequency divider and stay locked in. Step #1 insures that the frequency F is one which may be divided in the desired small steps.

The necessary values for the horizontal scanning frequency  $f_h$  and the vertical synchronizing or framing frequency  $f_v$  may be stated in terms of the main oscillator frequency F and the number of interlacings N as follows:

The general requirement for an interlaced picture is expressed by the equation

$$\frac{f_h}{f_v} = C + \frac{A}{N}$$

where C is equal to any whole number and A is equal to any whole number less than N. For my vacuum tube generator it is also required that

$$f_h = \frac{F}{N}$$

Since from the above general expression for interlaced scanning we find that

$$f_h = f_s \left( C + \frac{A}{N} \right)$$

it follows that

$$f_s \left( C + \frac{A}{N} \right) = \frac{F}{N}$$

or

$$f_s = \frac{F}{N \left( C + \frac{A}{N} \right)} = \frac{F}{NC + A}$$

From the foregoing description it will be apparent that various other modifications may be made in my invention, and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and set forth in the appended claims.

I claim as my invention:

1. In combination, a source of alternating current having a certain frequency, means coupled to said source for dividing said frequency by at least one even number to produce current having a desired frequency, and means coupled to said source for dividing said certain frequency by at least one odd number to produce current having a definite frequency relation to said desired frequency, said two means being in separate frequency dividing channels.

2. In a television system, an electrical impulse generator comprising means for generating a current having a certain frequency, means for dividing said frequency by an even number to produce a current from which horizontal scanning impulses may be derived, and means for dividing said frequency by an odd number to produce a current from which framing impulses may be derived, said two means being in separate frequency dividing channels.

3. In a television system, means for generating electrical impulses for interlaced scanning, said means comprising means for generating current having a certain frequency, means for dividing said frequency by small odd numbers to obtain a vertical scanning frequency, and means for dividing said certain frequency by an even number to obtain a horizontal scanning frequency, said two means being in separate frequency dividing channels.

4. In a television system in which two groups of electrical impulses having a certain frequency relation to each other are required for interlaced scanning, means for producing current having a certain frequency, means for producing one group of said impulses having a frequency exactly equal to said certain frequency divided by at least one even number, and means for producing another group of said impulses having a frequency exactly equal to said certain frequency divided by at least one odd number, said last two means being in separate frequency dividing channels.

5. In a television system in which two groups of electrical impulses having a certain definite frequency relation to each other are desired, a source of current having a certain frequency, means for producing one group of said impulses having a frequency equal to said certain frequency divided by an even number and having a definite phase relation thereto, and means for producing another group of said impulses having a frequency equal to said certain frequency divided by an odd number and having a definite phase relation thereto, said two means being in separate frequency dividing channels.

6. In a television system employing interlaced scanning, there being N interlacings, an electric discharge tube oscillator, means for deriving both horizontal and vertical synchronizing impulses from the output of said oscillator, said horizontal synchronizing impulses having a frequency equal to the frequency of the vertical synchronizing impulses times the quantity

$$C + \frac{A}{N}$$

where C is any whole number and A is any whole number less than N.

7. In a television system, a cathode-ray tube including means for producing an electron beam, a mosaic of light-sensitive elements positioned in the path of said beam, deflecting means for deflecting said beam horizontally and vertically simultaneously to scan said mosaic, said horizontal deflection to take place at a constant horizontal scanning frequency, said vertical deflection to take place at a constant vertical scanning frequency, said first frequency being equal to said second frequency times a whole number plus  $\frac{1}{2}$ , means for producing a current having a frequency higher than either of said scanning frequencies, means for deriving from said higher frequency current two groups of electrical impulses, one group having said horizontal scanning frequency, the other group having said vertical scanning frequency, and means for impressing said electrical impulses upon said deflecting means.

8. In a television system in which a mosaic of light-sensitive elements is to be so scanned that the horizontal lines interlace with N interlacings, means for producing horizontal synchronizing and deflecting impulses having the frequency  $f_h$ , means for producing vertical synchronizing and deflecting impulses having the frequency  $f_v$ , means for producing a current having the frequency F, and means for maintaining

$$Nf_h = (NC + A)f_v = F$$

where C is any whole number and A is any whole number less than N.

9. In a television system in which successive picture frames are scanned by lines falling on picture areas not scanned during the preceding frame to give the effect of a number of lines per picture equal to N times the actual number of lines per picture and in which

$$\frac{f_h}{f_v} = C + \frac{A}{N}$$

where  $f_h$  is the horizontal scanning frequency,  $f_v$  the frame frequency, C any whole number, and A any whole number less than N, means for supplying current having a frequency F where

$$F = Nf_h = (NC + A)f_v,$$

and means for maintaining  $f_h$  exactly equal to

$$\frac{F}{N}$$

and  $f_v$  exactly equal to

$$\frac{F}{NC + A}$$

10. In a television system, a vertical deflecting impulse channel having output terminals and a horizontal deflecting impulse channel having output terminals, said channels having a common input circuit and including in the order named from the output terminals of the first channel through said input circuit to the output terminals

of the second channel means for producing impulses occurring at the vertical deflecting frequency, means for producing impulses occurring at a frequency equal to an odd number times said vertical deflecting frequency, said odd number being greater than one, and equal to an even number times the desired horizontal deflecting frequency, means for producing impulses occurring at said horizontal deflecting frequency, and means for maintaining all of said impulses in a predetermined time relation with respect to each other.

11. The invention according to claim 10 characterized in that said second means includes a plurality of units each of which supplies impulses occurring at a frequency equal to an odd number times said vertical deflecting frequency and each

of which supplies impulses occurring at a different frequency than the other units.

12. The method of scanning a picture field with a cathode ray beam which comprises developing a predetermined frequency, developing from the predetermined frequency a high frequency saw-tooth wave for horizontally deflecting the beam, and developing from the predetermined frequency a low frequency saw-tooth wave which is interlocked with said high frequency saw-tooth wave and which has such a characteristic that the course of said beam is cyclically shifted relative to said picture field between successive low frequency deflections to produce interlaced scanning.

ALDA V. BEDFORD.