Sept. 19, 1939. W. A. TOLSON 2,173,239

CATHODE-RAY TUBE DEFLECTING CIRCUIT

Filed July 27, 1934 2 Sheets-Sheet 1

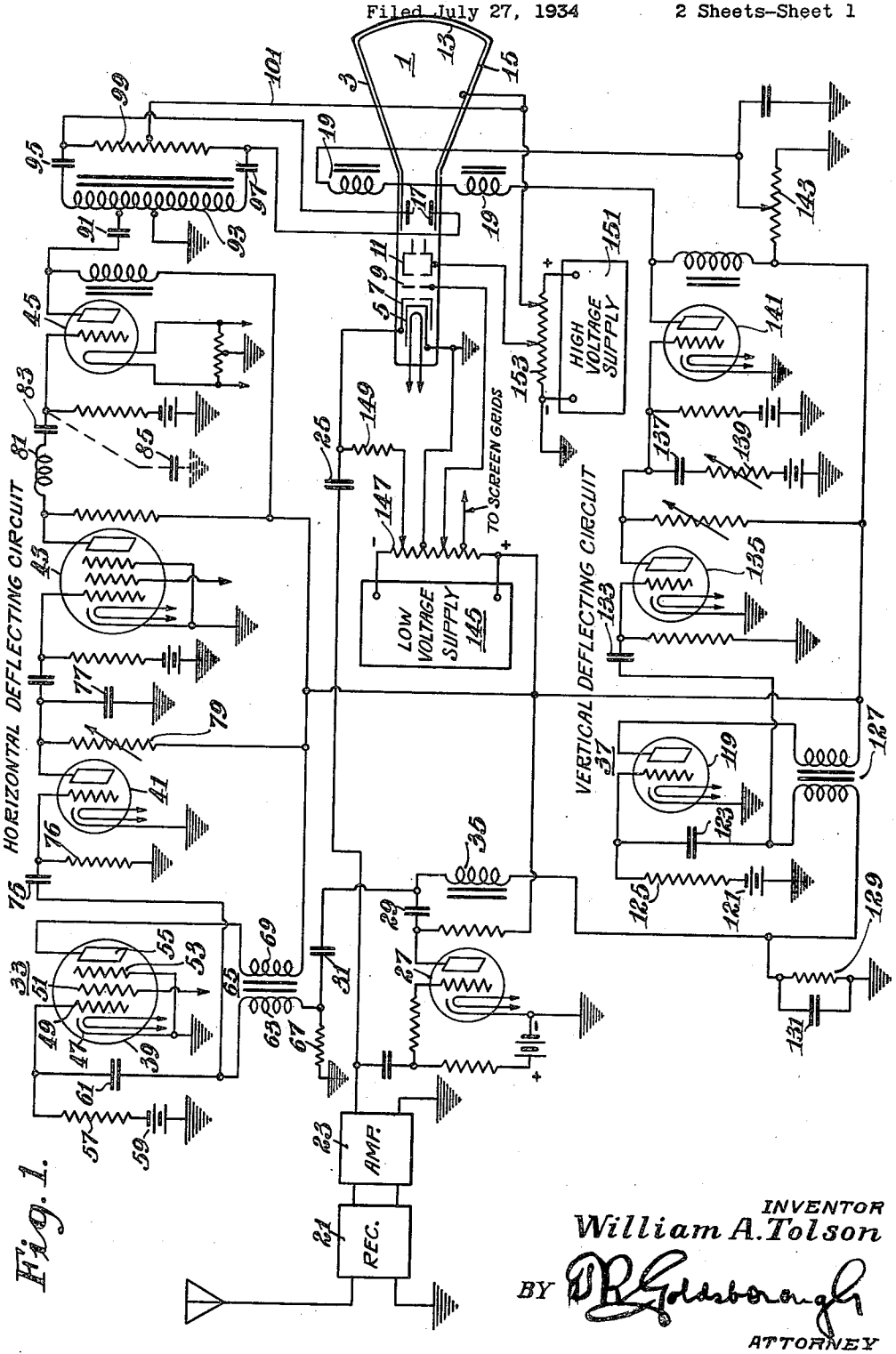


Fig. 1.

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Fig. 2.

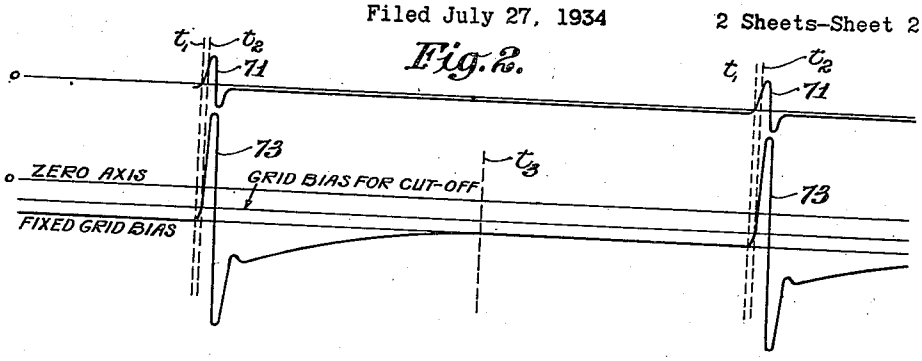


Fig. 3.

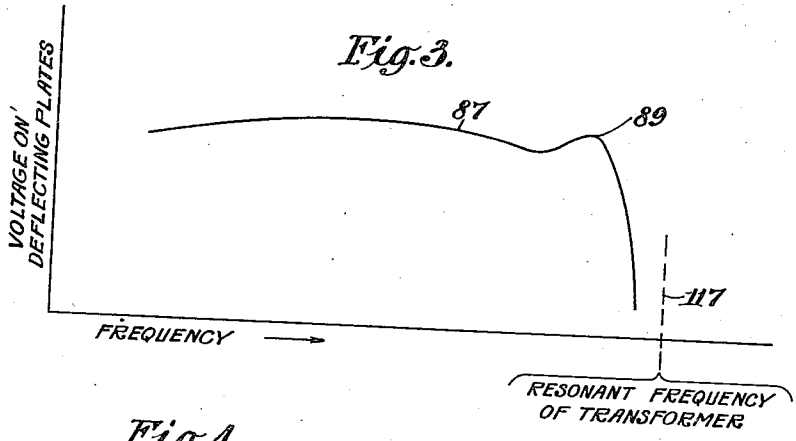


Fig. 4.

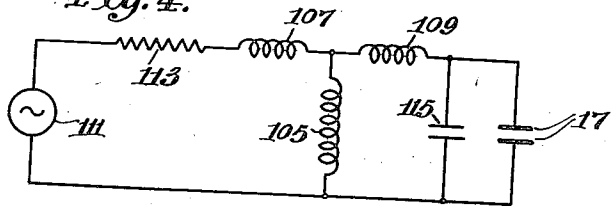


Fig. 5.

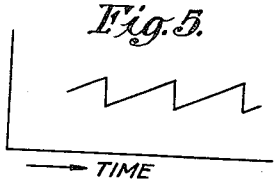
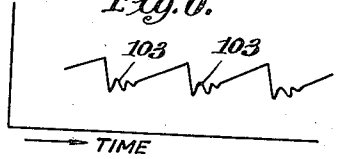


Fig. 6.



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CATHODE-RAY TUBE DEFLECTING CIRCUIT

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Application July 27, 1934, Serial No. 737,163

11 Claims. (Cl. 178—7.7)

The present invention relates to cathode-ray tube deflecting circuits and particularly to circuits for applying a deflecting voltage to electrostatic deflecting plates in a television receiver tube.

In cathode-ray tubes in which the electron beam is to be deflected at a high frequency and, especially, in which the electron beam must be deflected at a uniform speed across a fluorescent screen as in the case of a television receiver tube, it is highly desirable to obtain the deflection by means of electrostatic deflecting plates. In order to obtain a beam deflection of the desired magnitude without impressing an unduly high voltage upon the deflecting plates, the deflecting plates should be located inside the evacuated envelope of the cathode-ray tube. Even with this construction, the deflecting voltage must be rather high.

With the deflecting plates inside a cathode-ray tube of the type utilizing electrostatic focusing, it was found that if conventional deflecting circuits were employed the electron beam could not be focused to the small spot necessary for television, this difficulty apparently being a result of the deflecting plates distorting the electrostatic focusing field. It was also found that, while it is desirable to obtain the necessary high voltage for the electron beam deflection by means of a transformer, it is impossible to design a transformer which does not have a resonant point. Consequently, the transformer introduced transient voltages into the deflecting circuit which caused the electron beam to sweep across the fluorescent screen at a non-uniform speed.

It is, accordingly, an object of my invention to provide an improved electrostatic deflecting circuit for a cathode-ray tube.

More specifically, it is an object of my invention to provide an electrostatic deflecting circuit for a cathode-ray tube of the type utilizing electrostatic focusing which does not involve the above-mentioned disadvantages.

In a preferred embodiment of my invention, my improved deflecting circuit is utilized for impressing a voltage having a saw-tooth wave shape upon the deflecting plates in a cathode-ray tube of the above-mentioned type. An auto-transformer is employed for increasing the saw-tooth voltage to the desired value, the auto-transformer being so designed that it does not resonate at any frequency which is a necessary component of the saw-tooth voltage wave. Transient voltages are prevented from appearing on the deflecting plates by means of a filter preceding the auto-transformer which attenuates all frequency components having a frequency as high as the resonant point of the transformer.

In order to prevent defocusing of the electron beam, the voltage across the transformer is applied to the deflecting plates through a special potentiometer circuit.

Other objects, features, and advantages of my 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 receiver embodying my invention;

Figure 2 is a group of curves which are referred to in explaining the operation of a portion of the circuit shown in Figure 1;

Figure 3 is a curve showing the frequency response characteristic of an amplifier in the horizontal deflecting circuit shown in Figure 1;

Figure 4 is a diagram which is referred to in explaining the action of the auto-transformer shown in Figure 1; and

Figures 5 and 6 are diagrams which are referred to in explaining the operation of the horizontal deflecting circuit.

Referring to Figure 1, my invention is shown applied to a television receiver which includes a cathode-ray tube 1 comprising an evacuated envelope 3 having an electron gun therein. The electron gun consists of an indirectly heated cathode 5, a control grid 7, a screen grid 9, and a first anode 11. The electron beam is focused the desired amount by the electron gun and by a second anode 15 to obtain the desired small spot on the fluorescent screen 13 at the end of the envelope 3. The anode 15 may be in the form of a metallic coating on the inner surface of the envelope. It will be seen that the second anode 15 functions as an electrostatic focusing electrode as well as means for accelerating the electrons to the necessary velocity for obtaining a bright spot on the fluorescent screen 13.

Electrostatic deflecting plates 17 are located inside the envelope 3 for deflecting the electron beam in a horizontal direction. The vertical deflection of the beam is preferably obtained by means of deflecting coils 19. The cathode-ray tube described above is of the type described more in detail in the article by Taylor, Headrick, and Orth appearing in Electronics for December, 1933. In that article the manner in which the electron beam is focused is described. It may be noted that in some instances it is preferred to omit the screen or accelerating grid 9.

The receiving apparatus for applying picture

signals and deflecting impulses to the cathode-ray tube 1 includes a radio receiver 21 in which a received carrier wave is demodulated to obtain picture signals and horizontal and vertical synchronizing impulses. As stated in my co-pending application Serial No. 732,415, filed June 26, 1934, the transmitter which is used in combination with the television receiver illustrated preferably is of the type which transmits the picture signals and the synchronizing impulses on the same carrier wave, a horizontal synchronizing impulse being transmitted at the end of each scanning line and a vertical synchronizing impulse being transmitted at the end of each picture frame. The picture signals and the synchronizing impulses are amplified in an amplifier 23 and impressed through a coupling condenser 25 upon the control grid 7 of the cathode ray tube 1.

The signal output of the amplifier 23 is also impressed upon the input circuit of a vacuum tube 27 which serves to separate the synchronizing impulses from the picture signals. The synchronizing impulses are separated from the picture signals because of the fact that when applied to the control grid of the vacuum tube 27 they are more negative than the picture signals. In the output circuit of the vacuum tube, the horizontal synchronizing impulses are supplied through a condenser 29 and through a coupling condenser 31 to a blocking oscillator 33 in the horizontal deflecting circuit. The vertical synchronizing impulses are supplied through the condenser 29 and through an inductance coil 35 to a blocking oscillator 37 in the vertical deflecting circuit. This separating circuit is described and claimed in my copending application Serial No. 717,715 filed March 28, 1934, and assigned to the same assignee as this application.

In the particular receiver illustrated, the horizontal deflecting circuit includes a blocking oscillator or driver tube 39, an impulse tube 41, an amplifier tube 43, and a power output tube 45. The blocking oscillator tube 39 may be of the screen grid type including a cathode 47, a control grid 49, a screen grid 51, a suppressor grid 53 and an anode 55. The control grid 49 is connected through a grid leak resistor 57 and through a bias battery 59 to ground and through ground to the cathode 47. The grid circuit of the oscillator 33 also includes a grid condenser 61, the secondary 63 of a transformer 65 and a coupling resistor 67; the grid condenser, the secondary and the resistor being connected in series.

The anode 55 is connected through the primary 69 of the transformer 65 to a suitable source of positive potential. The screen grid 51 is supplied with positive potential in accordance with ordinary practice while the suppressor grid 53 is connected to the cathode 47.

The bias voltage applied to the control grid 49 by the biasing battery 59 is such that the oscillator will not oscillate unless a voltage impulse is applied to the circuit from an external source and, when such an impulse is applied to the circuit, it will oscillate through only one cycle and then stop. In the usual sense, therefore, the device is not an oscillator since it will not oscillate continuously of its own accord.

The operation of the blocking oscillator tube 39 as a driver tube will be understood by referring to Fig. 2, which indicates wave shape and phase relation but not relative magnitude. In this figure, the horizontal synchronizing impulse which appears across the coupling resistor 67 is represented by the curve 71, while the resulting voltage appearing in the grid circuit of the blocking oscillator 33 is represented by the curve 73.

Referring to the curves, it will be seen that at the time t_1 the voltage on the control grid of the driver tube is that supplied by the fixed bias battery and is below the cut-off point of the driver tube. At the time t_2, the grid potential of the driver tube has been raised by the incoming synchronizing impulse to the cut-off point, at which point current begins to flow and the cycle of operation is begun as shown. This cycle of operation is a typical blocking oscillator cycle such as described above, except that at the time t_3, when the charge has leaked off the grid condenser, the cycle does not repeat but instead the circuit is maintained in a negative or static condition because of the fixed bias on the control grid. The time from t_2 to t_3 may be referred to as the "active period" of the oscillator. The cycle of operation is not repeated again until the next horizontal synchronizing impulse occurs.

From the above description it will be understood that a positive voltage impulse appears in the driver tube's grid circuit as an amplified horizontal synchronizing impulse each time a horizontal synchronizing impulse is received. If no synchronizing signals are being received, the entire deflecting circuit, including the oscillator 33, is in an inactive or static condition.

The above-mentioned positive impulses are impressed upon the impulse tube 41 through a coupling condenser 75 for producing a saw-tooth voltage wave. The circuit for producing such a voltage wave includes a condenser 77 in the plate circuit of the impulse tube so connected that it is charged through a variable plate resistor 79 by energy supplied by the direct current supply. Each time a positive impulse is impressed upon the grid of the impulse tube 41, the condenser 77 is discharged through the plate circuit of the tube. The resulting saw-tooth voltage wave is amplified by the amplifier tube 43 and impressed upon the input circuit of the power tube 45 through a coupling circuit which includes an inductance coil 81 and a blocking condenser 83.

The inductance coil 81 is of such value that it resonates with the grid-cathode capacity of the power tube 45 at the high frequency end of the band of frequencies to be amplified. In some cases, additional capacity should be connected between the grid of the tube 45 and ground, as indicated at 85, in order to obtain a resonant point at the desired frequency. The tuned coupling circuit performs two functions, one being to increase the response of the amplifier 43—45 at the higher frequencies and the other being to cut off the highest frequency components of the same tooth wave for a purpose which will be described later.

The effect of the inductance coil 81 resonating with the capacity of the input circuit of the tube 45 is shown by the curve 87 in Fig. 3. It will be seen that at the high frequency end of the curve 87 the gain of the amplifier is maintained at a high level and that beyond the point of resonance of the coil 81 and the tube capacity (indicated at 89) the gain drops off very rapidly.

After being amplified in the power tube 45, the saw-tooth voltage wave is impressed through a coupling condenser 91 upon the primary of an auto-transformer 93. In order to prevent defocusing of the electron beam in the cathode-ray tube 1 during deflection, as explained hereinafter, the midpoint of the transformer winding 93 should be connected to ground as shown, this

midpoint being one end of the primary section of the auto-transformer.

The saw-tooth voltage wave appears at a much higher voltage across the terminals of the transformer secondary and is impressed upon the deflecting plates 17 through blocking condensers 95 and 97.

It has been found that de-focusing of the cathode beam during deflection is prevented if the voltage on the deflecting plates 17 is varied about the second anode potential. In order to obtain this result, a high resistance potentiometer 99 is connected across the deflecting plates 17 and the second anode 15 is connected through a conductor 101 to the midpoint of the potentiometer 99. It will be noted that the potentiometer 99 is also connected across the transformer secondary through the blocking condensers 95 and 97. By means of this circuit, upon the application of a deflecting voltage to the electrostatic deflecting plates 17, when one plate is made positive a certain amount, the other plate is made negative an equal amount and the potential at a point half way between the deflecting plates 17 remains unchanged. It is believed that because of this fact the electrostatic focusing field is not distorted, with the result that there is no de-focusing during deflection of the electron beam.

In employing a transformer for obtaining the desired high voltage on the deflecting plates, difficulty was encountered because of the leakage inductance of the transformer resonating with its distributed capacity at a certain high frequency, with the result that the resonance of the transformer introduced undesirable transients into the deflecting circuit. The effect of these transients is shown in Figure 6. It will be noted that at the beginning of each saw-tooth wave there are transients or irregularities in the wave shape indicated at 103 whereas a voltage having the wave shape shown in Figure 5 is desired.

The reason for the occurrence of the transients on the deflecting plates will be better understood by referring to Figure 4 where the equivalent diagram for the auto-transformer 93 is shown. The mutual inductance of the transformer is indicated at 105 while the primary and secondary leakage inductances are indicated at 107 and 109, respectively. The output circuit of the power tube 45 is represented by the alternating current generator 111 and resistor 113. The distributed capacity of the transformer winding is represented by the condenser 115 while the deflecting plates 17 of the cathode ray tube are shown connected across the output terminals of the transformer. It will be seen that the distributed capacity 115 is in series with the two leakage inductances 107 and 109 whereby a series resonance circuit is formed which is resonant at a high frequency.

In accordance with one of the features of my invention, the transients 103 are eliminated by reducing the leakage inductance of the transformer 93 to a minimum whereby the resonant frequency is made higher than any frequency component which must be transmitted to obtain a satisfactory saw-tooth voltage wave and, since the resonant frequency is still within the range of frequencies included in the saw-tooth wave being generated, shock excitation of the transformer resonant circuit is prevented by cutting off the high frequency components of the saw-tooth deflecting wave at a frequency below the resonant point of the transformer. This is accomplished, as shown in Figure 3, by means of the above-described tuned coupling circuit 81—83. In Figure 3, the leakage resonant point of the transformer 93 is indicated by the dotted line 117. It will be seen that by resonating the inductance coil 81 with the tube capacity, the amplifier is in effect given a sharp cut-off at a frequency below the resonant point of the transformer 93.

It has been found that, in order to obtain satisfactory results, the transformer 93 must not be resonant at any point within the range of frequencies which are impressed thereon. For this reason the transformer must be so designed that at the low end of the range of frequencies to be transmitted, the mutual inductance 105 of the transformer will not resonate with the distributed capacity 115 at too high a frequency. Therefore the transformer is so designed that its resonant point at the low frequency end is considerably below the fundamental frequency of the horizontal saw-tooth waves. For example, if the horizontal deflecting frequency is 10,000 cycles per second the transformer may be so designed that its low frequency resonant point is at 7,000 cycles per second.

Vertical deflection of the electron beam preferably is obtained by means of the deflecting coils 19 in view of the comparatively low frequency at which the vertical deflection occurs. The vertical deflecting circuit may include the blocking oscillator 37 comprising a vacuum tube 119 which is biased by means of a biasing battery 121 beyond the cut-off point the same as the oscillator tube 39 in the horizontal deflecting circuit. The oscillator includes grid condenser 123, a grid leak resistor 125, and a feed-back transformer 127, all of which performed the functions described in connection with the horizontal blocking oscillator.

The vertical synchronizing impulses are impressed upon the grid circuit of the tube 119 through a coupling resistor 129 which is included in the circuit in series with the secondary of the transformer 127. Preferably, a condenser 131 is provided for by-passing any horizontal synchronizing impulse component which may not be filtered out by the inductance coil 35.

The positive voltage impulses which appear in the grid circuit of the driver tube 119 in response to the reception of a vertical synchronizing impulse are impressed through a coupling condenser 133 upon an impulse tube 135. The output circuit of the impulse tube 135 includes a condenser 137 having a variable resistor 139 connected in series therewith for supplying a voltage impulse wave containing a saw-tooth component. This voltage wave appears across the input circuit of a power tube 141 and is impressed across the deflecting coils 19 to produce a saw-tooth wave of current therethrough. The resistor 143, to which one terminal of the deflecting coils 19 is connected, is provided for the purpose of adjusting the direct current component through the deflecting coils to center the electron beam on the fluorescent screen 13.

Referring now to the voltage supplies for the deflecting circuits and for the cathode-ray tube 1, all the voltages for the vacuum tubes are supplied from a low voltage supply 145 across which a voltage divider 147 is connected. All the plates of the vacuum tubes are connected to the positive terminal of the voltage divider 147. The screen grids of the screen grid tubes are connected to a point of lower potential on the voltage divider

147 as indicated. The screen grid 9 of the cathode-ray tube 1 is connected to a point of still lower potential on the voltage divider 147.

The cathode 5 of the cathode-ray tube 1 is connected to ground and to a point on the voltage divider 147 near its negative end, while the control electrode 7 of the cathode-ray tube is connected to the negative end of the voltage divider 147 through a resistor 149 for maintaining it at the proper negative potential with respect to the cathode 5.

The higher voltages for the anodes 11 and 15 of the cathode-ray tube are provided by a higher voltage supply 151 having a voltage divider 153 connected thereacross. The negative end of the voltage divider 153 is connected through ground to the cathode 5 of the cathode-ray tube. The second anode 15 is connected to the positive end of the voltage divider, while the first anode 11 is connected to a point of lower potential on the said voltage divider.

In either embodiment of my invention, the impulse tubes 41 and 135 are preferably biased close to or beyond cut-off. They may be biased beyond cut-off by inserting a biasing battery (not shown) in the grid circuit. In the particular circuit illustrated, which is the preferred one, the tubes 41 and 135 are biased close to cut-off by means of the flow of grid current in the coupling condenser-grid resistor combination.

Referring to the tube 41 as an example, a positive voltage impulse from the blocking oscillator 33 causes a flow of grid current to charge the condenser 75. Between positive voltage impulses, the condenser discharges through the grid resistor 76 to maintain the grid of the tube 41 negatively biased. If the blocking oscillator is replaced by an amplifier (two resistance coupled vacuum tubes, for example) the biasing circuit shown is especially desirable as the bias on the impulse tube 41 increases with increase in signal strength whereby an automatic volume action is obtained.

The features of using a blocking oscillator 33 as a driver tube and of driving a deflecting circuit directly and re-shaping a synchronizing impulse into a saw-tooth voltage or current wave are described and claimed in my above-mentioned co-pending application Serial No. 732,415, which is assigned to the same assignee as this application.

It will be seen from the foregoing description that I have provided a deflecting circuit in which a comparatively small power or amplifier tube supplies sufficient voltage to the electrostatic deflecting plates of a cathode ray tube to deflect the electron beam the desired amount without introducing transients during deflection. It will also be seen that I have provided a means for applying a deflecting voltage to internal deflecting plates in a cathode-ray tube without causing the electron beam to be de-focused.

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

I claim as my invention:

1. In combination, a cathode-ray tube comprising an evacuated envelope having means therein for producing a beam of electrons, a pair of deflecting plates therein for deflecting said beam, a transformer having a primary and a secondary, said transformer having leakage inductance and distributed capacity which resonate at a high resonant frequency to produce undesired effects, means for coupling said secondary across said deflecting plates, an amplifier having an output circuit and designed to pass a wide band of frequencies, said output circuit being connected to said primary, and means for preventing energy having a frequency as high as said resonant frequency from being impressed upon said primary.

2. Apparatus according to claim 1 characterized in that said amplifier includes an electric discharge tube comprising input electrodes having capacity effectively in shunt thereto, and further characterized in that said last means includes an inductance coil which is connected in series with said capacity and which has a value such that it resonates with said capacity at a frequency below the said resonant frequency of said transformer.

3. In a picture receiver, a cathode-ray tube comprising an evacuated envelope having means therein for producing a beam of electrons, a pair of deflecting plates therein for deflecting said beam, means for generating electrical deflecting impulses having a saw-tooth wave shape, means including a transformer for impressing said deflecting impulses upon said deflecting plates, said transformer being resonant at a certain high frequency, and means for preventing components of said impulses having a frequency as high as said certain frequency from being impressed upon said transformer.

4. In combination, a cathode-ray tube comprising an evacuated envelope having means therein for producing a beam of electrons, electrostatic means for focusing said beam, said electrostatic means including a second anode, a pair of deflecting plates in said envelope for deflecting said beam, a source of deflecting voltage for said plates, a transformer having a primary and a secondary, said primary being connected to said source, and an impedance unit having one end connected to one end of said secondary through a condenser and having its other end connected to the other end of said secondary through another condenser, said deflecting plates being connected across said impedance unit, and said second anode being connected to a point on said impedance unit which is a mid-point with respect to the points thereon to which said deflecting plates are connected.

5. In combination, a cathode-ray tube comprising an evacuated envelope having means therein for producing a beam of electrons, an electrode positioned to focus said beam electrostatically, a pair of electrostatic deflecting plates in said envelope for deflecting said beam, a source of deflecting voltage for said plates, a transformer having a primary and a secondary, said primary being connected to said source, and a resistor connected across said secondary through blocking condensers, said deflecting plates being connected across said resistor, and said focusing electrode being connected to a point on said resistor which is the mid-point with respect to the points thereon to which said deflecting plates are connected.

6. In combination, a cathode-ray tube comprising an evacuated envelope having an electron gun therein for producing a beam of electrons, said gun including a cathode, an electrostatic focusing electrode positioned to focus said beam, a pair of electrostatic deflecting plates in said envelope for deflecting said beam, a source of deflecting voltage for said plates, a transformer having a primary and a secondary, said primary being connected to said source and said second-

ary having its mid-point connected to said cathode, a resistor connected across said secondary through blocking condensers, said deflecting plates being connected across said resistor, said focusing electrode being connected to the mid-point of said resistor, and means for maintaining said focusing electrode at a positive potential with respect to said cathode.

7. In combination, a cathode-ray tube comprising an evacuated envelope having an electron gun therein for producing a beam of electrons, said gun including a cathode, said envelope also having therein an electrostatic focusing electrode positioned to focus said beam, a pair of electrostatic deflecting plates for deflecting said beam, a source of deflecting voltage for said plates, a single winding transformer, the mid-point of said winding being connected to one terminal of said source and to said cathode whereby it is maintained at the same alternating current potential as said cathode and another point on said winding being connected to the other terminal of said source, a resistor connected across said winding through blocking condensers, said deflecting plates being connected across said resistor, said focusing electrode being connected to the mid-point of said resistor, and means for maintaining said focusing electrode at a positive potential with respect to said cathode.

8. In combination, a cathode ray tube comprising an evacuated envelope having means therein for producing a beam of electrons, a pair of deflecting plates therein for deflecting said beam, a transformer having a primary and a secondary, said transformer having a low frequency resonant point and a high frequency resonant point and having no resonant point therebetween, means for coupling said deflecting plates across said secondary, means for producing a saw-tooth wave having frequency components all of which lie between said low frequency resonant point and said high frequency resonant point, and means for impressing said saw-tooth wave across said primary.

9. A cathode ray device comprising means for producing a moving beam of electrons, an anode for accelerating said beam, means for producing deflection of said beam comprising a pair of electrostatic deflecting plates, a high resistance connected between the plates, means for connecting substantially the midpoint of said resistance to said anode, means for generating saw-toothed sweep voltages, and transformer means for connecting said generating means to said deflecting plates.

10. A cathode ray device comprising means for producing a moving beam of electrons, an anode for accelerating said beam, means for producing deflection of said beam comprising a pair of electrostatic deflecting plates, a high impedance unit connected between said plates, means for connecting substantially the midpoint of said high impedance unit to said anode, means for generating deflecting voltages, and transformer means for connecting said generating means to said deflecting plates.

11. In a sweep circuit, a condenser, means comprising a source of potential for charging said condenser substantially linearly with respect to time, means comprising an electron discharge device for periodically discharging said condenser, means for amplifying the wave produced by the charging and discharging of said condenser, and a transformer the primary winding of which is connected in the output circuit of said amplifying means and the secondary of which is connected to a divided output circuit of balanced resistances and capacities.

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