

[54] CATHODE-RAY TUBE DRIVING SYSTEM

[75] Inventors: Teruhiro Tsukuda, Osaka; Noboru Yasumatsuya, Neyagawa; Takashi Tsutsumi, Takatsuki; Taiichi Saeki, Katano; Yasuyoshi Hirai, Hirakata, all of Japan

[73] Assignee: Matsushita Electric Industrial Co., Ltd., Osaka, Japan

[22] Filed: Dec. 21, 1972

[21] Appl. No.: 317,308

[30] Foreign Application Priority Data

Dec. 24, 1971	Japan	47-218
Dec. 24, 1971	Japan	47-219
Dec. 24, 1971	Japan	47-220
Dec. 23, 1971	Japan	47-504

[52] U.S. Cl. 315/408; 315/410

[51] Int. Cl. H01j 29/70

[58] Field of Search 315/27 R, 27 TD, 28, 29, 315/31

[56] References Cited

UNITED STATES PATENTS
2,591,918 4/1952 Cole et al. 315/19

3,417,285	12/1968	Sennik	315/31 R
3,519,741	7/1970	Knight	315/29
3,609,446	9/1971	Hursh	315/27 TD

Primary Examiner—T. H. Tubbesing
Assistant Examiner—J. M. Potenza
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] ABSTRACT

A system for driving a cathode-ray tube in a television receiver or the like comprising means for generating an output voltage variable depending on the variation of beam current, means for combining the output voltage of the generating means with a voltage obtained by reducing the high voltage applied to the cathode-ray tube, and means for applying the resultant voltage to the focusing electrode of the cathode-ray tube. Thus, with the increase in the beam current, the voltage applied to the focusing electrode is reduced at a greater rate than the rate of reduction of the high voltage applied to the anode of the cathode-ray tube so that the televised picture can be satisfactorily reproduced.

9 Claims, 17 Drawing Figures

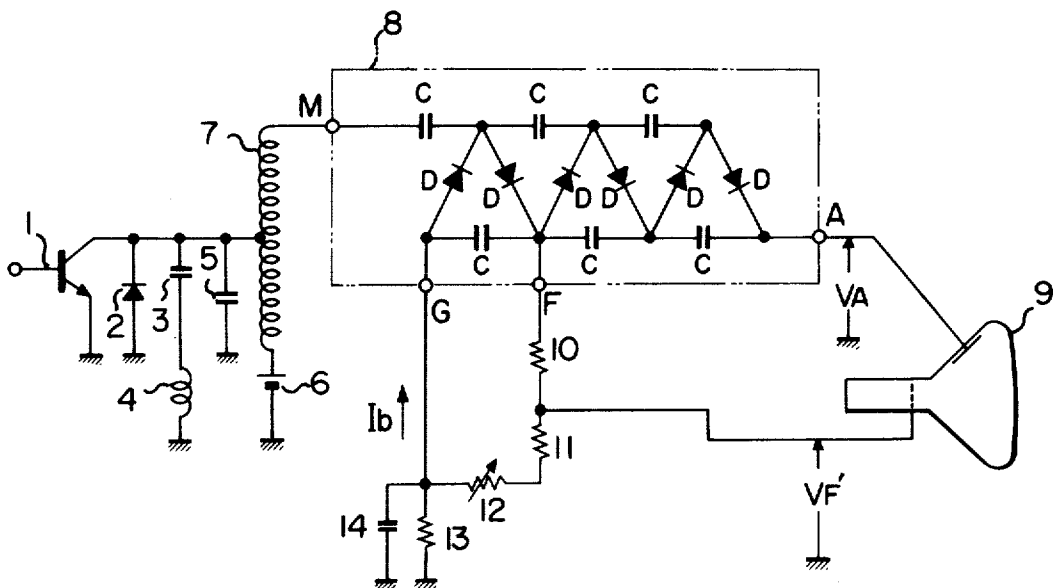


FIG. 1

PRIOR ART

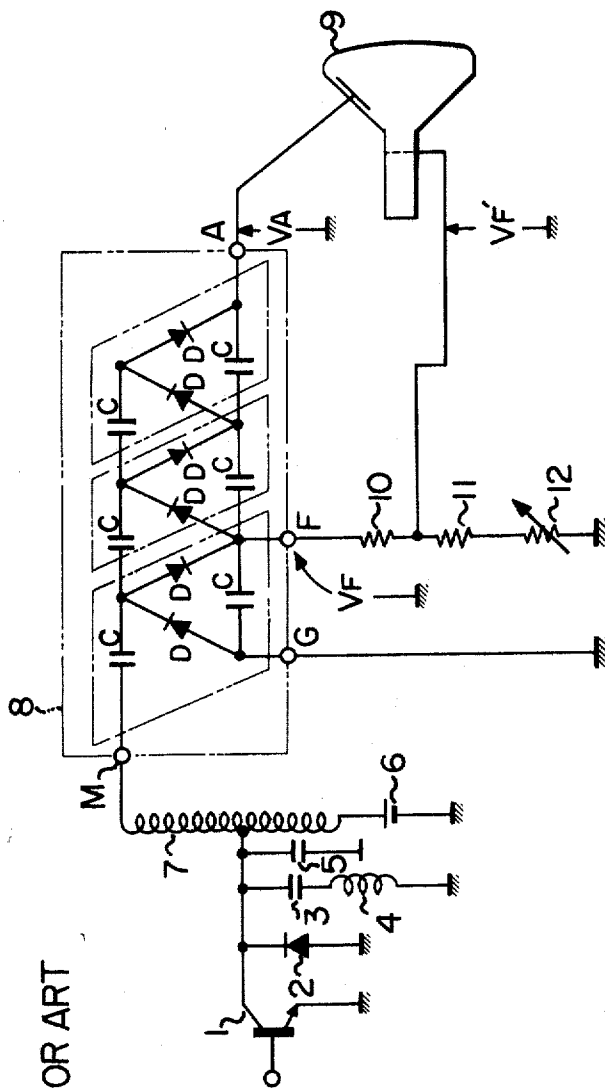


FIG. 2a PRIOR ART

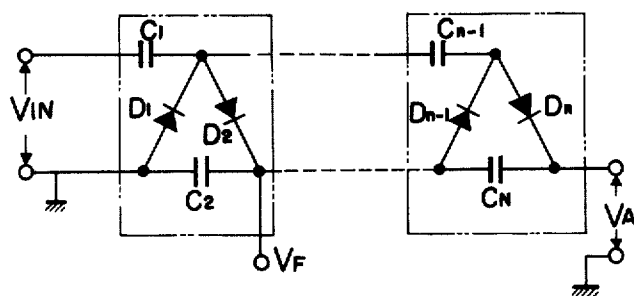


FIG. 2b PRIOR ART

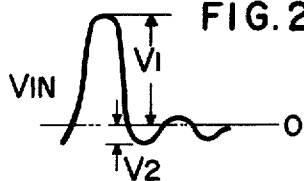


FIG. 3

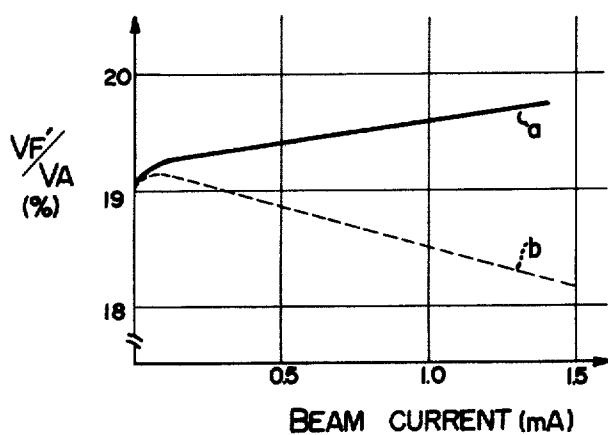


FIG. 4

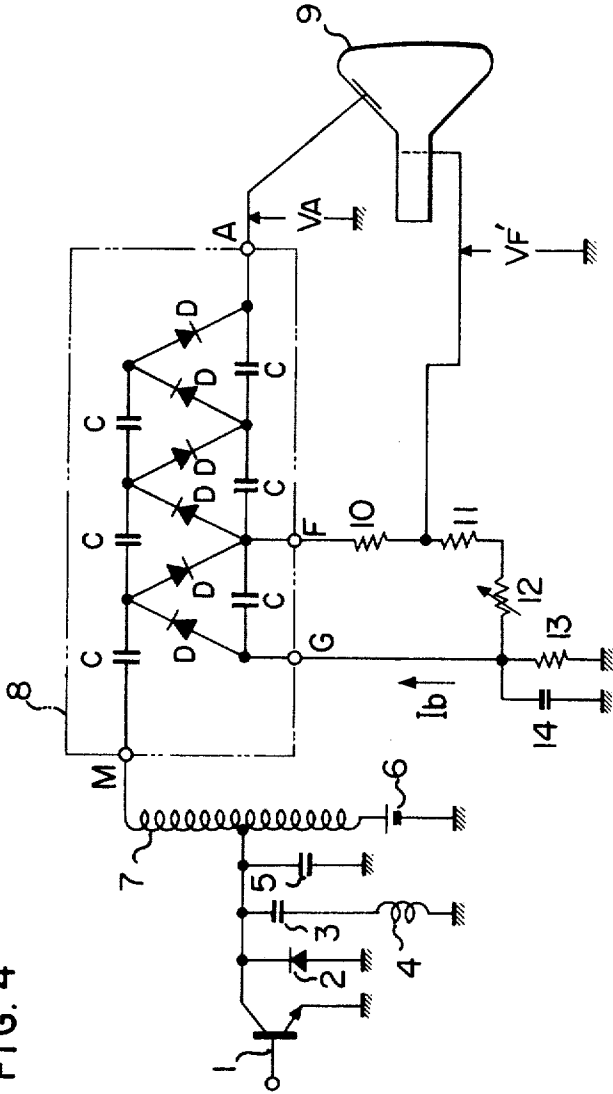


FIG. 5

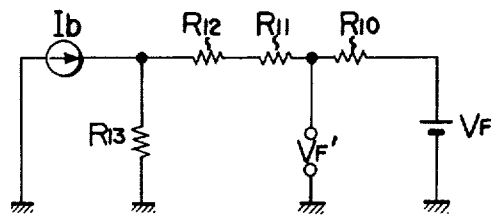


FIG. 6

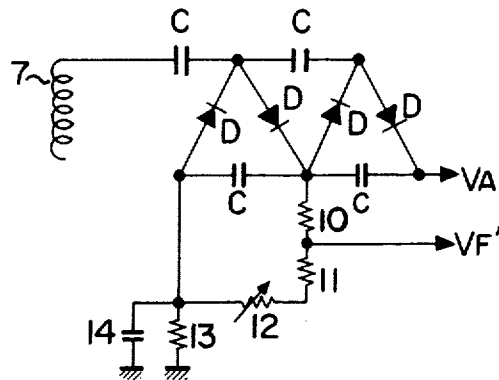


FIG. 7

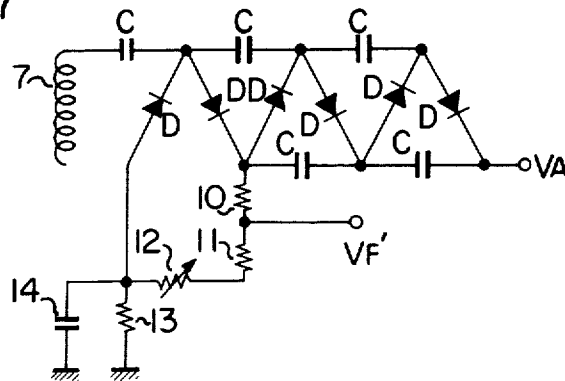


FIG. 8

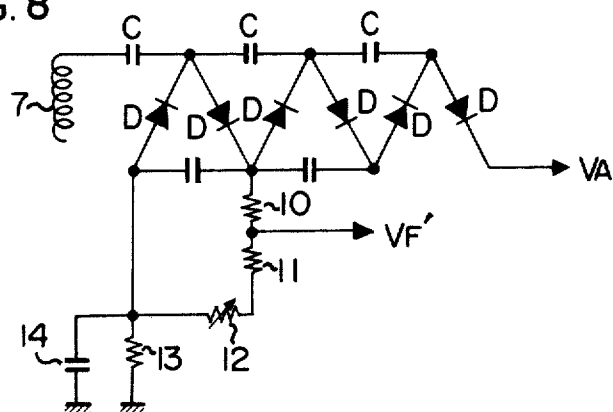


FIG. 9

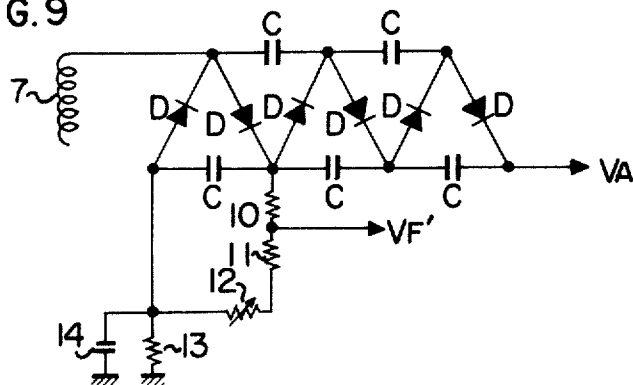


FIG. 10

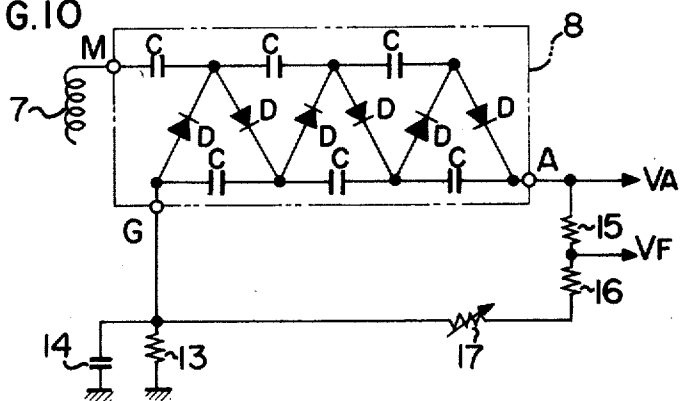


FIG. 11

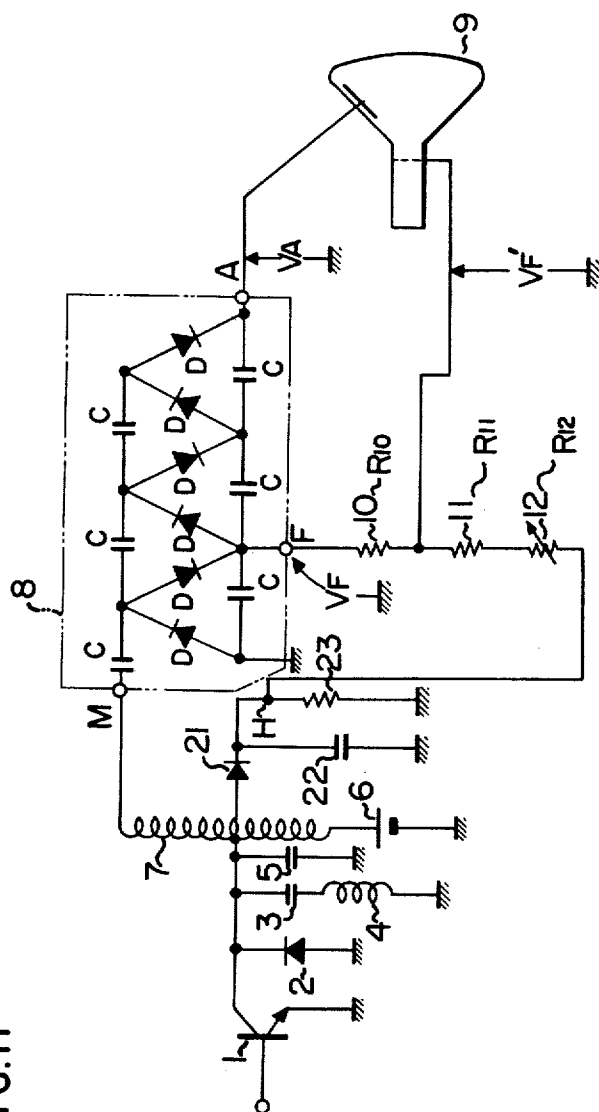


FIG. 12

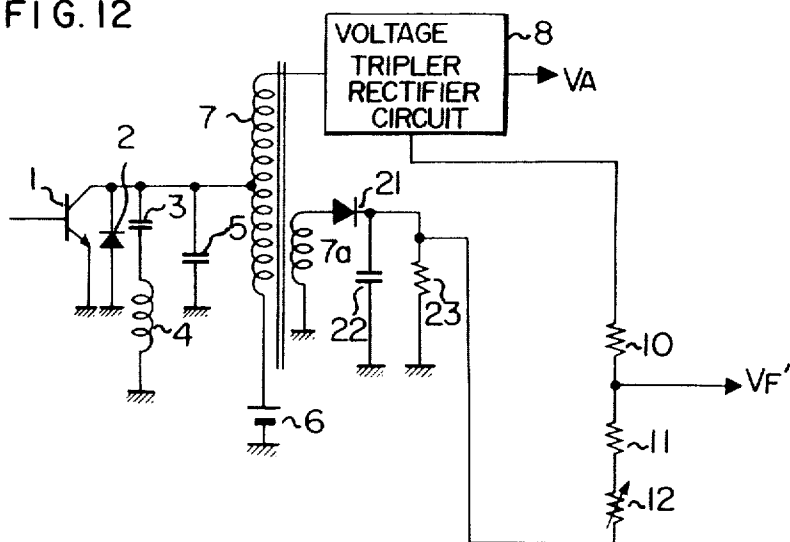


FIG. 13

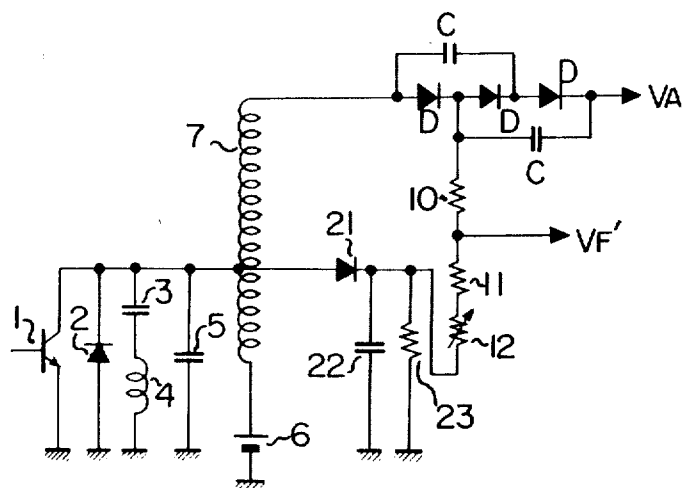


FIG. 14

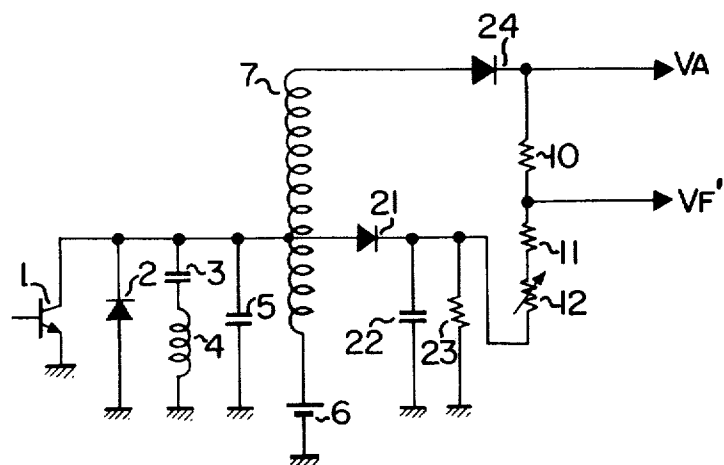


FIG. 15

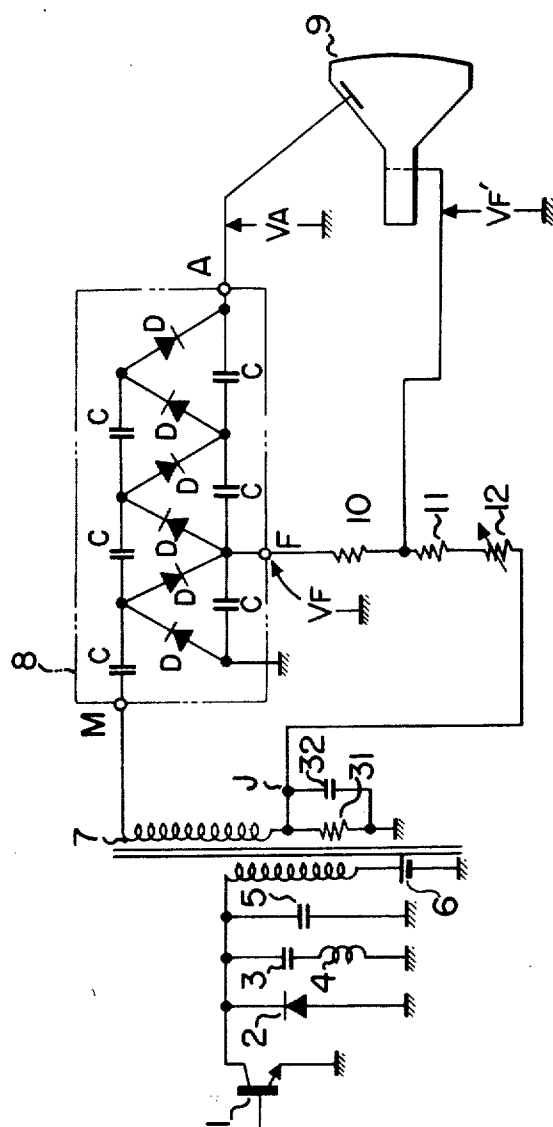
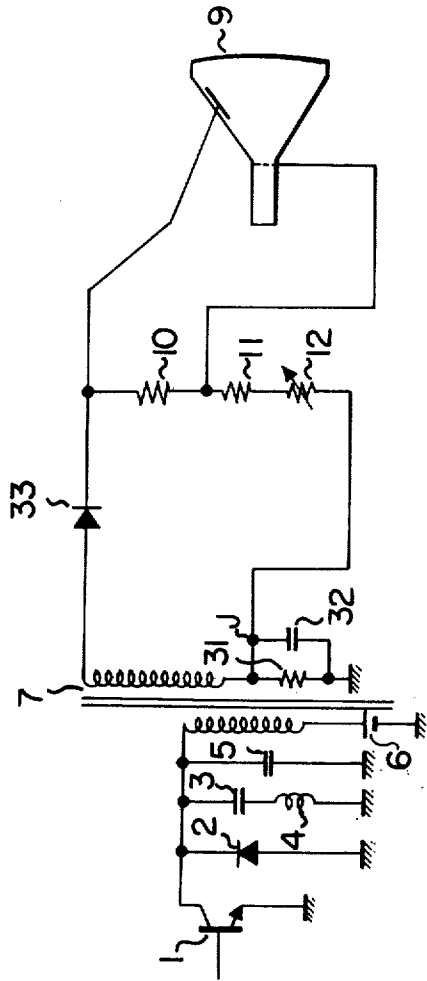


FIG. 16



CATHODE-RAY TUBE DRIVING SYSTEM

This invention relates to a system for driving a cathode-ray tube.

In a cathode-ray tube for use in a television receiver, the ratio between the anode voltage and the focusing voltage must be generally maintained substantially at a predetermined value in order to focus the electron beam most satisfactorily. This voltage ratio varies slightly depending on the beam current, and especially in a color, picture tube of the kind having bipotential type electron guns, the beam current exerts a great influence on this voltage ratio. Therefore, a strict relationship between the anode voltage and the focusing voltage is demanded.

In a conventional cathode-ray tube driving system in which the anode voltage is derived from, for example, a voltage multiplying and rectifying circuit consisting of a plurality of diodes and capacitors, it is common practice to derive the focusing voltage from a lower stage of the voltage multiplying and rectifying circuit. It has however, been difficult with such a system to continuously maintain the optimum ratio between the anode voltage and the focusing voltage over the entire varying range of beam current. According to another common practice, the focusing voltage is obtained by directly dividing the anode voltage by means of resistors. However, this arrangement has been liable to cause a trouble such as a fire due to the fact that the resistors have a large resistance value and generate a large amount of heat.

It is an object of the present invention to obviate such prior art defects and to provide means for suitably varying the ratio between the anode voltage and the focusing voltage applied to a cathode-ray tube so that this voltage ratio can be varied to follow variations of beam current.

Another object of the present invention is to provide a safe and reliable cathode-ray tube driving system which does not utilize any resistors for deriving the focusing voltage by directly dividing the anode voltage.

In accordance with the present invention, there is provided a cathode-ray tube driving system comprising high-voltage rectifying means for rectifying flyback pulses supplied from a flyback transformer, means for applying the rectified high-voltage output of said high-voltage rectifying means to the anode of a cathode ray tube, beam current variation detecting means for detecting any variation of the beam current and delivering an output which is variable depending on the variation of the beam current, means for combining the output of said detecting means with the rectified high-voltage output of said high-voltage rectifying means or the output of a voltage m -times multiplying and rectifying circuit included in a voltage n -times multiplying and rectifying circuit (where m and n are positive integers and $m \leq n$) when said high-voltage rectifying means is in the form of such a voltage n -times multiplying and rectifying circuit thereby obtaining a resultant d.c. voltage whose rate of reduction is smaller than or equal to the rate of reduction of the rectified high-voltage output due to the variation of the beam current, and means for applying the resultant d.c. voltage to the focusing electrode of said cathode-ray tube.

The above and other objects, features and advantages of the present invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a connection diagram of a prior art cathode-ray tube driving system;

FIG. 2a is a circuit diagram of a voltage n -times multiplying and rectifying circuit similar to that employed in the driving system shown in FIG. 1;

FIG. 2b shows a waveform of an input to the circuit shown in FIG. 2a;

FIG. 3 is a graph showing the operating characteristic of the system shown in FIG. 1;

FIG. 4 is a connection diagram of an embodiment of the present invention; and

FIGS. 5 to 16 show other embodiments of the present invention.

Before describing the present invention, a prior art cathode-ray tube driving system employing a voltage three-times multiplying and rectifying circuit will be described with reference to FIGS. 1 to 3. Referring to FIG. 1, a switching transistor 1 is connected at the collector thereof to the cathode of a damper diode 2 whose anode is grounded. An S-curve characteristic compensating capacitor 3, for rendering a deflection current to exhibit S-curve characteristic, is connected at one end thereof to the collector of the switching transistor 1 and at the other end thereof to one end of a horizontal deflection coil 4 which is grounded at the other end thereof. A flyback time determining capacitor 5 is connected at one end thereof to the collector of the switching transistor 1 and is grounded at the other end thereof. A flyback transformer 7 is connected at one end thereof to a power supply 6 and at the other end thereof to an input terminal M of a voltage three-times multiplying and rectifying circuit 8 consisting of a plurality of capacitors C and diodes D. A series circuit consisting of resistors 10 and 11 and a variable resistor 12 is connected to an output terminal F of the first section of the voltage multiplying and rectifying circuit 8 for obtaining the focusing voltage V_F' , and the variable resistor 12 is grounded at one end thereof.

In response to the application of a suitable driving signal to the base of the switching transistor 1, a saw-tooth current flows through the deflection coil 4 and a flyback pulse appears during the flyback time. This flyback pulse is applied to the flyback transformer 7 and the output of the flyback transformer 7 is applied to the input terminal M of the voltage three-times multiplying and rectifying circuit 8. The input voltage is multiplied and rectified by the voltage multiplying and rectifying circuit 8 and a high d.c. voltage about three times the input voltage appears at an output terminal A of the voltage multiplying and rectifying circuit 8. This high d.c. voltage V_A is applied to the anode of a cathode-ray tube 9.

On the other hand, the focusing voltage V_F' is derived from the junction point between the resistors 10 and 11 in the series circuit of the resistors 10, 11 and 12 connected between the output terminal F of the first section of the voltage multiplying and rectifying circuit 8 and ground. The voltage ratio V_F'/V_A between the focusing voltage V_F' and the anode voltage V_A is generally selected to lie within the range of 0.18 to 0.2. The focusing voltage V_F' can be regulated by suitably adjusting the variable resistor 12.

Referring to FIG. 2a, a plurality of sections each consisting of two diodes D and two capacitors C are connected in cascade to constitute a high-voltage rectifying circuit. The output voltage V_F of the first section in

this circuit and the output voltage V_A of the last section are given by

$$V_A = \frac{n}{2} (V_1 + V_2)$$

$$V_F = V_1 + V_2$$

where n is the number of the diodes or capacitors and V_1 and V_2 are the maximum positive value and maximum negative value respectively of a voltage waveform as shown in FIG. 2b. This voltage waveform corresponds to the output voltage waveform delivered from the flyback transformer 7 shown in FIG. 1, hence the input voltage waveform applied to the input terminal M in FIG. 1.

In the case of the voltage multiplying and rectifying circuit 8 shown in FIG. 1, $n = 6$ due to the fact that three sections are connected in cascade. Therefore, ideally, the voltage ratio V_F/V_A between the output voltage V_F of the first section and the output voltage V_A of the last section, or the voltage ratio V_F'/V_A between the focusing voltage V_F' and the anode voltage V_A is determined by the number n of the diodes or capacitors. Actually, however, the voltage ratio V_F'/V_A , hence V_F'/V_A varies depending on the beam current due to the internal resistance of the diodes, variations of the input waveform, etc. FIG. 3 shows the relation between the voltage ratio V_F'/V_A and the beam current. The solid curve a in FIG. 3 represents the operating characteristic of the prior art system shown in FIG. 1. It will be apparent from FIG. 3 that the voltage ratio V_F'/V_A increases by +0.6 percent at the beam current of 1 mA and +0.75 percent at the beam current of 1.5 mA compared with the ratio at zero beam current.

In order to attain the best focusing of the electron beam, it is generally desirable to maintain the voltage ratio V_F'/V_A substantially constant or to decrease the voltage ratio with the increase in the beam current preferably at a rate of about 0.5 percent relative to the variation of the beam current from zero to 1 mA. However, the prior art system is defective in that the voltage ratio V_F'/V_A increases with the increase in the beam current, and thus, the desired best beam focusing cannot be attained even when the variable resistor 12 is adjusted to give the best beam focusing at a certain value of the beam current.

An embodiment of the present invention which obviates such a defect is shown in FIG. 4. In FIG. 4, like reference numerals and characters are used to denote like parts appearing in FIG. 1 and any detailed description as to the operation of such parts is unnecessary. The cathode-ray tube driving system shown in FIG. 4 differs from the system shown in FIG. 1 in that a parallel circuit of a resistor 13 and a capacitor 14, which are grounded at one end thereof, is connected in series with a common grounded terminal G of a voltage three-times multiplying and rectifying circuit 8, and a series circuit of resistors 10, 11 and a variable resistor 12 is connected across the common grounded terminal G and the output terminal F of the voltage one-times multiplying rectifier for deriving the focusing voltage V_F' from the junction point between the resistors 10 and 11.

FIG. 5 shows an equivalent circuit of the circuit portion for deriving the focusing voltage V_F' . In FIG. 5, R_{10} , R_{11} , R_{12} and R_{13} correspond to the resistors 10, 11,

12 and 13 in FIG. 4 respectively. From FIG. 5, the focusing voltage V_F' is given by

$$V_F' = \frac{V_F(R_{11} + R_{12})}{R_{10} + R_{11} + R_{12}} - \frac{R_{10}R_{13}}{R_{10} + R_{11} + R_{12}} I_b$$

where $R_{13} \ll R_{10}$, R_{11} , R_{12} , and I_b is the mean value of current flowing through the common grounded terminal G and is proportional to the beam current in the cathode-ray tube. Therefore, when it is supposed that the output voltage V_F of the voltage one-times multiplying rectifying circuit is constant, it is apparent from the above equation that the focusing voltage V_F' is reduced with the increase in the beam current. The rate of reduction in the focusing voltage V_F' can be freely set by suitably selecting the resistance value of the resistor 13. More precisely, although the output voltage V_A and focusing voltage V_F' vary in normal operation with the increase in the beam current, the voltage ratio V_F'/V_A can be freely regulated by suitably selecting the resistance value of the resistance R_{13} , and thus, the best beam focusing can be attained over the entire varying range of the beam current. The dotted curve b in FIG. 3 represents the relation between the voltage ratio V_F'/V_A and the beam current observed with the system of the present invention shown in FIG. 4.

The constants of some of the elements in FIG. 4 are enumerated below by way of example:

$C = 1000 \text{ pF}$, $D: \text{H 435}$, $R_{10} = 20 \text{ M}\Omega$, $R_{11} = 28 \text{ M}\Omega$,
 $R_{12} = 10 \text{ M}\Omega$, $R_{13} = 220 \text{ k}\Omega$, $C_{14} = 0.01 \text{ }\mu\text{F}$

The above description has referred to an application of the present invention to a voltage three-times multiplying and rectifying circuit in which the number n of diodes or capacitors is 6. However, it is apparent to those skilled in the art that the present invention is also applicable to a voltage two-times multiplying and rectifying circuit in which $n = 4$, to a voltage four-times multiplying and rectifying circuit in which $n = 8$, and to any other voltage multiplying and rectifying circuits in which n is greater than 8.

FIG. 6 shows an application of the present invention to a voltage two-times multiplying and rectifying circuit. In FIG. 6, like reference numerals and characters are used to denote like parts appearing in FIG. 4. The operating principle of the circuit shown in FIG. 6 is similar to that of the circuit shown in FIG. 4 and any detailed description is unnecessary.

FIG. 7 shows a modification of the system shown in FIG. 4, and in this modification, one of the capacitors in the first section is eliminated. FIG. 8 shows another modification in which one of the capacitors in the third section is eliminated. The operation and technical merits of these modifications are similar to those of the embodiment shown in FIG. 4. The elimination of the capacitor can be applied to any other voltage multiplying and rectifying circuits in which $n = 4$ and n is greater than 6. In a further modification shown in FIG. 9, the capacitor connected directly to the flyback transformer 7 is eliminated. It is apparent that the operation and technical merits of this modification are similar to those of the embodiment shown in FIG. 4.

In another modification shown in FIG. 10, a series circuit of resistors 15, 16 and a variable resistor 17 is provided in lieu of the series circuit of the resistors 10, 11 and 12 for deriving the focusing voltage V_F' by dividing the output voltage, hence the anode voltage V_A applied from the voltage three-times multiplying and

rectifying circuit 8, the variable resistor 17 being connected at one end thereof to the common grounded terminal G, and the parallel circuit of the resistor 13 and capacitor 14 is connected between the common grounded terminal G and ground as in FIG. 4. This modification is effective in attaining better beam focusing over the entire varying range of the beam current. The voltage ratio V_F'/V_A is constant when the resistance value of the resistor 13 in the parallel circuit is zero. When the resistor 13 has a predetermined resistance value, the voltage ratio V_F'/V_A is decreased with the increase in the beam current and the desired best beam focusing can be attained.

FIG. 11 shows another embodiment of the present invention and like reference numerals and characters are used therein to denote like parts appearing in FIG. 1. The system shown in FIG. 11 differs from the system shown in FIG. 1 in that a diode 21 is connected at the anode thereof to an intermediate tap of a flyback transformer 7 and at the cathode thereof to ground through a parallel circuit of a capacitor 22 and a resistor 23. The terminal voltage of the resistor 23 is connected to the grounded side of a series circuit of resistors 10, 11 and a variable resistor 12.

In the system shown in FIG. 11, the horizontal output pulse is rectified by the diode 21 and is then smoothed by the capacitor 22 to appear as a d.c. voltage at one end of the resistor 23, that is, at a point H. An increase in the beam current results in a larger pulse width of the horizontal output pulse. Therefore, the pulse voltage is reduced and the voltage appearing at the point H is also reduced. At the same time, the focusing voltage V_F' is also reduced due to the lowering of the output voltage V_F of the first section of a voltage three-times multiplying and rectifying circuit 8. In this manner, the voltage ratio V_F'/V_A between the focusing voltage V_F' and the anode voltage V_A is reduced with the increase in the beam current, that is, with the increase in the load, so that the characteristic shown by the dotted curve *b* in FIG. 3 can be obtained. The anode voltage V_A is also reduced in the above situation, but the rate of reduction of the anode voltage V_A is small compared with the rate of reduction of the focusing voltage V_F' . Thus, the voltage ratio V_F'/V_A is reduced in the manner above described.

There must be the condition $R_{23} \ll R_{10}, R_{11}, R_{12}$ between the resistance values R_{10}, R_{11}, R_{12} and R_{23} of the respective resistors 10, 11, 12 and 23. This is because, if the resistance value R_{23} of the resistor 23 were larger than those of the resistors 10, 11 and 12, a correspondingly higher voltage appears at the point H and the smoothing capacitor 22 must have a larger capacity. Further, the above condition is required in that appearance of a higher voltage than the pulse voltage at the point H results in non-conduction of the diode 21.

Good results could be obtained when the resistances R_{10}, R_{11}, R_{12} and R_{23} of the resistors 10, 11, 12 and 23 and the capacitance C_{22} of the capacitor 22 were set at the following values:

$$R_{10} = 50 \text{ M}\Omega, R_{11} = 28 \text{ M}\Omega, R_{12} = 10 \text{ M}\Omega, R_{23} = 270 \text{ k}\Omega, C_{22} = 0.1 \text{ }\mu\text{F}$$

The d.c. voltage obtained by applying the horizontal output of the flyback transformer 7 to the diode 21 and capacitor 22 can be utilized as a screen voltage for common television receivers. Therefore, the system shown in FIG. 11 can be used not only for the control

of the focusing voltage but also as a means for obtaining the screen voltage.

FIG. 12 shows a partial modification of the system shown in FIG. 11. Referring to FIG. 12, the flyback transformer 7 includes a tertiary winding 7a so that the voltage induced in this tertiary winding 7a can be rectified to obtain the voltage for adjusting the focusing voltage. The provision of the tertiary winding 7a is convenient in that, even when the horizontal output pulse supplied from the flyback transformer 7 is of negative polarity, the polarity of the pulse can be inverted to positive polarity.

FIG. 13 shows another modification of the system shown in FIG. 11. In FIG. 13, a voltage two-times multiplying and rectifying circuit is employed in place of the voltage three-times multiplying and rectifying circuit 8 shown in FIG. 11, and the operation and technical merits of the system shown in FIG. 13 are similar to those of the system shown in FIG. 11. Referring to FIG. 14 showing a further modification of the system shown in FIG. 11, the voltage multiplying and rectifying circuit 8 is replaced by a single high-voltage rectifying diode 24, and the resistor 10 is connected to the output side, that is, the anode voltage delivering terminal of the diode 24.

FIG. 15 shows another embodiment of the present invention and like reference numerals and characters are used to denote like parts appearing in FIG. 1. Any detailed description of the operation of such parts is unnecessary.

Referring to FIG. 15, a parallel circuit of a resistor 31 and a capacitor 32 is connected in series with the secondary winding of a flyback transformer 7, and a series circuit of resistors 10, 11 and a variable resistor 12 for deriving the focusing voltage V_F is connected at one end of the variable resistor 12 to the junction point J between the secondary winding of the flyback transformer 7 and the said end of the parallel circuit. The parallel circuit of the resistor 31 and capacitor 32 is grounded at the other end thereof.

When the load current flows to a cathode-ray tube 9, a negative voltage appears at the point J through the high-voltage winding of the flyback transformer 7. This negative voltage increases with the increase in the load or beam current and the focusing voltage V_F' is reduced with the reduction in the output voltage V_F of the first section of a voltage three-times multiplying and rectifying circuit 8. The anode voltage V_A is also reduced in this case, but the rate of reduction of the anode voltage V_A is small compared with the rate of reduction of the focusing voltage V_F' . Therefore, the voltage ratio V_F'/V_A between the focusing voltage V_F' and the anode voltage V_A is reduced with the increase in the load and the relation between the voltage ratio V_F'/V_A and the beam current varies in a manner as shown by the dotted curve *b* in FIG. 3. There must be the condition $R_{31} \ll R_{10}, R_{11}, R_{12}$ between the resistance values R_{31}, R_{10}, R_{11} and R_{12} of the respective resistors 31, 10, 11 and 12. Good results could be obtained when these resistance values and the capacitance C_{32} of the capacitor 32 were set at the following values:

$$R_{10} = 50 \text{ M}\Omega, R_{11} = 28 \text{ M}\Omega, R_{12} = 10 \text{ M}\Omega, R_{31} = 270 \text{ k}\Omega, C_{32} = 0.1 \text{ }\mu\text{F}$$

Similar results can be obtained when the voltage three-times multiplying and rectifying circuit 8 shown in FIG. 15 is replaced by any other voltage multiplying

and rectifying circuit in which the factor is 2 or greater than 3 or by a direct rectifying circuit.

Referring to FIG. 16 showing a modification employing such a direct rectifying circuit, a high-voltage rectifying diode 33 is connected at the anode thereof to the secondary winding of the flyback transformer 7 and at the cathode thereof to the anode of the cathode-ray tube 9 and to one end of the resistor 10. The operation and technical merits of this modification are similar to those of the system shown in FIG. 15.

What we claim is:

1. In a cathode-ray tube driving circuit which includes a horizontal deflection circuit having a flyback transformer generating flyback pulses, the improvement comprising:

a high-voltage rectifying and n -times multiplying circuit having a first input coupled to an output of said flyback transformer to rectify and boost the voltage of said flyback pulses, the n th output of said rectifying and multiplying circuit being coupled to the anode of said cathode-ray tube;

a parallel circuit comprising a resistance element and a capacitance element having a first common terminal connected to ground and a second common terminal connected to a second input terminal of said high voltage rectifying and multiplying circuit; resistance means coupled between said second common parallel circuit terminal and a third terminal of said high voltage rectifying and multiplying circuit, the voltage at said third terminal being the flyback pulse input voltage multiplied and rectified m -times (where m and n are positive integers and $m \leq n$); and

means coupling an intermediate tap of said resistance means to a focusing electrode of said cathode ray tube for applying a voltage derived from said resistance means to said focusing electrode.

2. The apparatus according to claim 1, wherein said second input of said rectifying and multiplying circuit comprises a common ground terminal thereof.

3. The apparatus according to claim 2, wherein said resistance means includes a series circuit of fixed resistors and a variable resistor, and the resistance value of said variable resistor is adjusted to regulate the focusing voltage applied to said focusing electrode.

4. In a cathode-ray tube driving circuit which includes a horizontal deflection circuit having a flyback transformer generating flyback pulses, the improvement comprising:

a high-voltage rectifying and n -times multiplying circuit having a first input coupled to an output of said flyback transformer to rectify and boost the voltage of said flyback pulses, the n th output of said rectifying and multiplying circuit being coupled to the anode of said cathode-ray tube;

further rectifying means coupled to said flyback transformer for rectifying the flyback pulse signals generated by said transformer;

a parallel circuit comprising a resistance element and a capacitance element coupled to the output of

said further rectifying means for smoothing the output signal of said further rectifying means;

resistance means coupled between the junction of said parallel circuit and said further rectifying means and an output terminal of said high voltage rectifying and multiplying circuit, the voltage at said output terminal being the flyback pulse input voltage multiplied and rectified m -times (where m and n are positive integers and $m \leq n$); and

means applying a voltage derived from said resistance means to a focusing electrode of said cathode-ray tube.

5. The apparatus according to claim 4, wherein said flyback transformer comprises at least two output windings, said first input of said high voltage rectifying and multiplying circuit being coupled to a first one of said output windings and said further rectifying means being coupled to a second one of said output windings.

6. The apparatus according to claim 5, wherein said resistance means includes a series circuit of fixed resistors and a variable resistor, and the resistance value of said variable resistor is adjusted to regulate the focusing voltage applied to said focusing electrode.

7. The apparatus according to claim 5, wherein said parallel resistance-capacitance circuit is coupled between the output of said further rectifying means and ground.

8. In a cathode-ray tube driving circuit which includes a horizontal deflection circuit having a flyback transformer for generating flyback pulses, wherein said flyback transformer comprises at least one output winding, the improvement comprising:

a high voltage rectifying and n -times multiplying circuit having a first input coupled to one terminal of said at least one output winding to rectify and boost the voltage of said flyback pulses, the n th output of said rectifying and multiplying circuit being coupled to the anode of said cathode-ray tube;

a parallel circuit comprising a resistance and a capacitance element having a first common terminal connected to ground and a second common terminal connected to a second terminal of said output winding;

resistance means coupled between said second common parallel circuit terminal and a third terminal of said high voltage rectifying and multiplying circuit, the voltage at said third terminal being the flyback pulse input voltage multiplied and rectified m -times (where m and n are positive integers and $m \leq n$); and

means applying a voltage derived from said resistance means to a focusing electrode of said cathode-ray tube.

9. The apparatus according to claim 8, wherein said resistance means includes a series circuit of fixed resistors and a variable resistor, and the resistance value of said variable resistor is adjusted to regulate the focusing voltage applied to said focusing electrode.

* * * * *