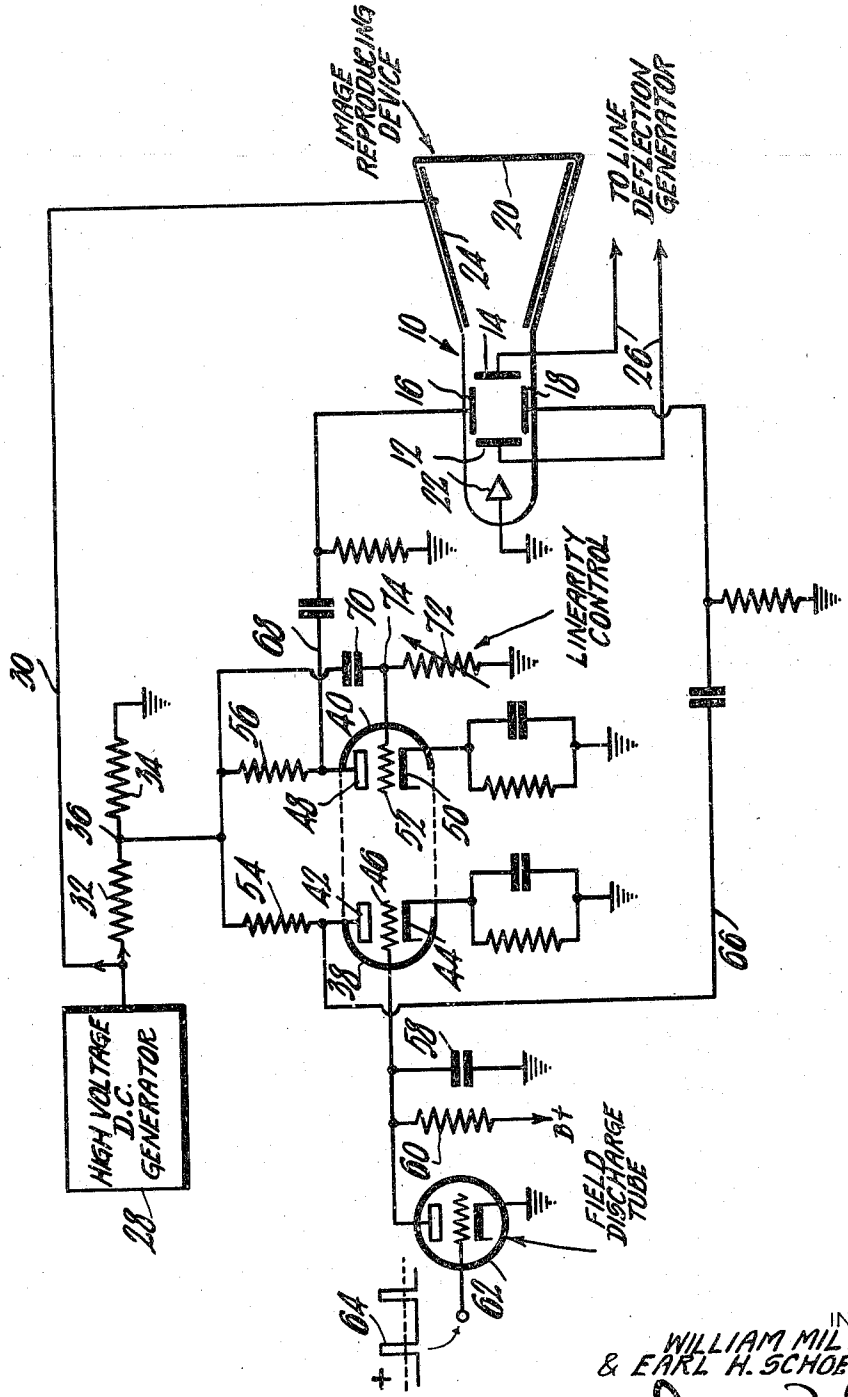
Nov. 8, 1949 E. H. SCHOENFELD ET AL 2,487,602

CATHODE-RAY BEAM DEFLECTION SYSTEM

Filed May 28, 1947



INVENTORS
WILLIAM MILWITT
& EARL H. SCHOENFELD
BY Samuel B. Smith
ATTORNEY

Patented Nov. 8, 1949 2,487,602

UNITED STATES PATENT OFFICE

2,487,602

CATHODE-RAY BEAM DEFLECTION SYSTEM

Earl H. Schoenfeld, Mamaroneck, N. Y., and William Milwitt, Perth Amboy, N. J., assignors to Radio Corporation of America, a corporation of Delaware

Application May 28, 1947, Serial No. 750,984

8 Claims. (Cl. 315—26)

1

The present invention relates to cathode ray beam deflection systems, and more particularly relates to systems of this nature in which at least one direction of deflection of the cathode ray beam is carried out through the action therein of an electrostatic field.

In certain cathode ray tube applications, such, for example, as in television and oscillographic apparatus, it is desirable to supply balanced, or "push-pull," voltages to the deflecting plates of an image-reproducing tube, or kinescope. This enhances the ease of obtaining good focus over the entire image raster area on the face of the cathode ray tube. These balanced voltages are frequently obtained by generating a sawtooth voltage wave of relatively low amplitude, passing this sawtooth voltage wave through one or more amplifier stages, and then employing a tube, whose unique function is phase inversion, so as to obtain two output potentials which are substantially of opposite phase. While a system of the above nature is generally satisfactory insofar as linearity of cathode ray beam deflection is concerned, it is relatively complex and costly from a manufacturing standpoint.

Another known expedient, especially suitable for electrostatically deflected cathode ray tubes, includes an electron discharge device having a resistance-capacitance, or time-constant, network in the anode circuit of the tube, and a similar resistance-capacitance, or time-constant, network in the tube cathode circuit. When the time constants of these two networks are made equal, a selective energization of the tube will produce voltages on the anode and cathode thereof which are substantially opposite in phase. In such a system, however, these output voltages are generally not of sufficient amplitude for application directly to the deflection plates of the cathode ray tube, and suitable amplifying devices are necessary.

In television receivers employing electrostatic deflection of a cathode ray scanning beam, it is important from the standpoints of reliability and economy to employ as low a value of operating potential as possible. It has been found in some receiving systems that "B" supply voltages as low as two to three hundred volts (for a kinescope having a screen diameter of seven inches, for example) are adequate for all circuit requirements except that of beam deflection. For this particular purpose, considerably higher voltages are normally necessary in order to obtain sufficient deflection amplitude. With respect to the horizontal, or line, deflection of the beam, it has

2

been found that adequate deflection voltages may be obtained by utilizing a choke or auto-transformer in the output circuit of the horizontal power tube. Due to the relatively high line-scanning frequency, the reactance of such an inductive element is sufficiently high so that voltages of considerable magnitude are developed thereacross. However, a similar method of obtaining voltages for vertical deflection is not practical, due in part to the lower field frequency and the consequent expense involved in constructing a choke or autotransformer for use at this lower frequency.

Accordingly, systems have been devised for obtaining vertical deflection voltages of higher amplitude than those obtainable directly from the "B" supply source. One of these systems utilizes a portion of the bleeder current from the second anode accelerating potential supply. However, an arrangement of this type requires the use of relatively large plate load resistors in the anode circuits of the vertical deflection amplifier, as otherwise the current drained through the bleeder resistor would be high enough to affect the stability of second anode voltage. Such relatively high plate load resistors may be used with the vertical, or field, deflection power tubes without objectionable distortion in the output voltage waveform, since the frequency of field deflection is sufficiently low to make the effects of stray capacitances to ground relatively negligible.

As a development of the above, a number of circuits have been devised for utilizing part of the voltage output of a separate radio-frequency power supply for vertical deflection, and which, in addition, include a so-called push-pull output stage. A phase-splitting tube and associated network is employed in some cases to provide excitation for the two grids of the push-pull amplifier. Such an arrangement, however, has the objectionable feature of additional cost. Furthermore, the employment of a phase-splitting network (usually a tube) introduces a certain degree of non-linearity into the waveforms of the output voltages.

Another known system utilizes a pair of output tubes together with means for applying a sawtooth wave of voltage to one of the grids. The grid of the other tube is connected to a tap on the plate resistor of the first tube. This results in considerable waveform distortion for the reason that, since the "B" voltage for each tube is obtained from a point on the R. F. supply bleeder, the resistance from this point to ground may be of a value comparable to or greater than

the value of each output tube plate resistor. Although this could be partially circumvented by employing a condenser of relatively large capacity connected between the bleeder tap and ground, nevertheless such an addition not only increases equipment costs but furthermore constitutes a relatively serious shock hazard.

One other approach to the above problem resides in the use of a cathode-coupled power output tube. However, when commercially available values of the other circuit components were used, it was found in practice that the nonlinearity of the output voltage of such an arrangement were generally beyond the limit of acceptability.

In accordance with one embodiment of the present invention, a system is provided for supplying balanced (or "push-pull") deflection voltages to the two vertical, or field, deflection plates of an electrostatically deflected image-reproducing cathode ray tube. This embodiment follows that principle set forth above, whereby a relatively high deflection voltage amplitude is obtained by utilizing a portion of the direct voltage developed across a so-called bleeder resistor forming part of a separate radio-frequency second anode power supply.

According to one feature of the invention, a pair of grid-controlled power output tubes are employed. The anodes of these tubes are connected through suitable plate resistors to a tap on the R. F. power supply bleeder resistor. A cyclically varying voltage of substantially sawtooth waveform, which may be developed in the usual discharge tube circuit, is applied to the grid of one of the power output tubes so as to develop on the plate of this tube an output voltage which possesses a sufficiently high degree of linearity for application directly to one of the vertical deflection plates of the cathode ray tube.

Since the other vertical deflection plate of the cathode ray tube must be supplied with a cyclically varying voltage which is substantially 180° out-of-phase with the voltage applied to the first-mentioned deflection plate, the former is connected directly to the anode of the remaining power output tube. This last-mentioned tube is arranged to operate in a substantially out-of-phase condition with respect to the first power output tube by applying to its grid a control voltage which is substantially in phase opposition to the control voltage applied to the grid of the first-mentioned power output tube from the discharge circuit. The means for obtaining this out-of-phase control voltage comprises a series condenser and a shunt resistor arranged to act in effect as both a coupling and a differentiating network. This network is connected to the tap on the R. F. supply bleeder resistor which is also connected to the anode of each of the power output tubes through its respective plate load resistor. This arrangement provides for a high degree of deflection linearity in addition to possessing the advantages of economy of construction. For example, by employing a condenser of relatively small capacity as part of the coupling and differentiating network, it is possible to eliminate the high-voltage, high-capacitance, low-leakage condenser which would otherwise be necessary in a practical system employing a non-differentiating network. The use of the present invention additionally provides a higher degree of deflection linearity than is possible with previously known arrangements and, in addition, permits a control over this linearity through a variation in the value of resistance included in the differentiating network.

One object of the present invention, therefore, is to provide an improved type of vertical, or field, deflection system for use with electrostatically deflected image-reproducing cathode ray tubes.

Another object of the invention is to provide an improved cathode ray beam deflection system of the electrostatic type in which the normal deflection amplitude is increased through the use of a power tube whose operating voltage is obtained from the output of a separate radio-frequency power supply unit.

A still further object of the invention is to provide a system of balanced, or push-pull, electrostatic deflection for cathode ray tubes in which the operating potential for each of the push-pull output tubes is obtained from a tap on the bleeder resistor in the output of a separate R. F. power supply unit, and furthermore to excite the grid of one of these push-pull output tubes from this bleeder resistor tap through a suitable coupling and differentiating network.

Other objects and advantages will be apparent from the following description of a preferred form of the invention and from the drawing, the single figure of which is a schematic representation of one form of cathode ray tube deflection system in accordance with the present invention.

Referring now to the drawing, there is shown an image-reproducing cathode ray tube generally indicated by the reference numeral 10. Tube 10 may be an electrostatically-deflected cathode ray tube of any suitable type which includes a pair of horizontal, or line, deflection plates, 12, 14, and a pair of vertical, or field, deflection plates 16, 18. Tube 10 is also provided with a luminescent target or screen element 20. A beam of electrons is developed and directed toward the screen 20 by an electron gun 22. A second anode 24 (which may be in part a conductive coating on a portion of the inner surface of tube 10) accelerates the electrons emitted from the electron gun 22 toward the luminescent screen 20 in the usual manner.

The horizontal, or line, deflection plates 12, 14 are provided with deflecting potentials, preferably of sawtooth waveform, from a line deflection generator of any suitable type (not shown) over the conductors 26. The second anode portion 24 of tube 10 is provided with relatively high D.-C. potential from a high-voltage D.-C. generator 28 over the conductor 30. The D.-C. generator 28 may be of any construction which is capable of supplying a substantially smooth D.-C. potential of sufficient magnitude to accelerate with adequate velocity toward the screen 20 the electrons emitted by the electron gun 22. It may, for example, comprise a radio-frequency power supply of the nature set forth in Patent No. 2,374,781 granted May 1, 1945 to Otto H. Schade.

The output of the high-voltage D.-C. generator 28 is developed across a bleeder resistor which includes at least two sections 32, 34, although it is obvious that any additional number of bleeder resistor sections may be employed, if necessary or desirable. A tap 36 between the resistor sections 32 and 34 permits a connection to be made to the bleeder resistor at this point.

A pair of vertical, or field, power output tubes, illustrated as two triodes 38 and 40, may actually comprise separate tubes or they may constitute the two sections of a twin triode (such as a 6SL7) having a common envelope. Tube 38 is provided with an anode 42, a cathode 44 and a

grid 46. Tube 40 is similarly provided with an anode 48, a cathode 50 and a grid 52. Anode 42 of tube 38 is connected to the tap 36 on the bleeder resistor 32, 34 through a plate load resistor 54. Anode 48 of tube 40 is similarly connected to the bleeder tap 36 through a plate load resistor 56. The load resistors 54 and 56 are preferably chosen to have substantially identical values, for reasons which will later become apparent. Each of the cathodes 44 and 50 of tubes 38 and 40 is connected to ground or a point of constant potential through a bias resistor shunted by a by-pass condenser as shown.

The means for supplying a voltage variation of substantially sawtooth waveform to the grid 46 of tube 38 includes a condenser 58 which is charged through a resistor 60 from a source of positive potential designated in the drawing as B+. A discharge tube 62 is connected in parallel relation with the condenser 58, so that when pulses 64 of positive polarity are applied to the grid of tube 62, the latter will be rendered conductive to discharge the condenser 58 to ground. This type of sawtooth wave-generating circuit 58, 60, 62 is well known in the art, and a further description thereof will not be given in the present application.

When voltage variations of sawtooth waveform are generated in the above manner and applied to the grid 46 of tube 38, this tube, which is designed to act as a substantially linear, or class A, amplifier, produces on the plate 42 thereof a voltage variation which will also be of substantially sawtooth waveform. This voltage variation is applied to the vertical deflection plate 18 of the cathode ray tube 10 over a conductor 66. It will be noted that, neglecting for the moment the presence of tube 40, the D. C. anode circuit of tube 38 comprises its plate load resistor 54 in series with the bleeder resistor portion 32. Hence, the voltage at point 36 during operation of tube 38 alone would be proportional to the voltage on the tube anode 42.

Assume now that tube 40 is conducting in push-pull relation to tube 38 so as to provide on the anode 48 of tube 40 a sawtooth voltage variation for application to the vertical deflection plate 16 of tube 10 over a conductor 68. The D. C. anode circuit of tube 40 comprises the plate load resistor 56 in series with the bleeder resistor portion 32. (The voltage drop on the cathode resistors is relatively very small and will be neglected for the purpose of this description.) Since the tubes 38 and 40 are arranged to operate in a push-pull, or, in other words, substantially 180° out-of-phase, it will be appreciated that the anode currents at point 36 will tend to cancel one another. Accordingly, the voltage variations at point 36 resulting from the operation of the tubes 38 and 40 will be only sufficient to keep tube 40 in operation. In this respect the circuit is self regulating because, if tube 40 draws more current, there will be a greater degree of cancellation of the current of tube 38 and therefore less voltage at point 36 to drive tube 40. Conversely, if tube 40 draws less current there will be more voltage at point 36 to drive it.

When equilibrium conditions have become established, small voltage variations appear at point 36. These variations representing the difference in the anode currents of the tubes 38 and 40 flow through the bleeder resistor portion 32 in common to both tubes. The A. C. component thereof appears across resistor portion 34 in parallel with the series combination of portion 32 and the internal impedance of generator 28. Hence the anode-cathode (output) circuits of tubes 38 and 40 contain such parallel impedances in common, and in series therewith the individual resistances 54 and 56 respectively. The voltage variations appearing at point 36 during operation of the illustrated circuit are utilized to provide for linearity of deflection of the cathode ray beam of tube 10 by applying such variations to the grid 52 of tube 40 through a coupling and differentiating network consisting of the series capacitor 70 and the adjustable shunt resistor 72. These elements 70 and 72 act to differentiate the voltage appearing at point 36 and thus provide with the common impedance 34, 32, 28 (as above mentioned), a voltage of substantially sawtooth waveform at point 74 which is applied directly to the grid 52 of tube 40 to control the conduction of this tube in such a manner that its phase relation will be opposed to that of tube 38. Hence, the sawtooth voltage waves applied to the deflection plates 16, 18 over the conductors 68, 66, respectively, will be of opposite polarity and substantially balanced to ground. Adjustment of resistor 72 provides a control over the effect of the differentiating network 70, 72 and hence over the linearity of beam deflection. To explain such effect, it is first noted that tubes having high voltage amplification (such as the 6SL7 above mentioned) do not have straight characteristic curves, especially when they are operated for maximum amplitude as is desirable for electrostatic deflection. The characteristic curve of tube 38 will bend away from a straight line and, for convenience, may be called convex. Tube 40 would have a similar convex characteristic if it were supplied with the same grid voltage as tube 38. However, the characteristic curve of the differentiating network 70, 72 bends in the opposite, or concave, direction. By varying resistance 72 the curvature of grid voltage on tube 40 is changed so that its characteristic curve can be made less convex, substantially straight, or concave, as desired. Hence, proper adjustment of resistance 72 can over-compensate the curvature of tube 40, so that the total potential difference (provided by tubes 38 and 40) appearing across the deflecting electrodes 16, 18 varies linearly in sawtooth fashion.

It has been found in practice that when the plate load resistors 54 and 56 are each chosen to have a value of approximately four megohms, then the illustrated circuit may be caused to provide deflection linearity by choosing the condenser 70 to be in the order of 1000 mmf. and adjustable resistor 72 to have a maximum value of 5 megohms. A value of 150,000 ohms has been found suitable for the cathode bias resistor of tube 38, and a value of 22,000 ohms has similarly been found suitable for the cathode bias resistor of tube 40. Tube 38 requires a larger bias resistor because its grid 46 receives a positive potential from condenser 58 to which it is directly coupled. However, it should be clearly understood that the above values are being given merely as examples, and that other values may be substituted therefor as may prove necessary or desirable.

Hoving now described the invention what is claimed is:

1. A cathode ray deflection circuit of the electrostatic type adapted to be energized from a high voltage direct current generator, comprising in combination, a bleeder resistor across

the output of said generator, two voltage amplifiers each having anode, cathode, and control electrodes, individual resistors connecting said anodes to a common tap on said bleeder resistor, a source of sawtooth voltage in the control-cathode circuit of one amplifier, a differentiating network connecting said bleeder tap to the control-cathode circuit of the other amplifier, and a pair of deflecting plates connected respectively to said anodes.

2. A cathode ray deflection circuit according to claim 1, in which said differentiating network comprises a capacitor connected between said bleeder tap and the control electrode of said other amplifier, a shunt resistor connected between the control electrode and cathode of said other amplifier, and means for varying the value of said shunt resistor to thereby alter the wave shape of said network.

3. In a system of the class described having a source of D.-C. potential, the combination of an electrostatically deflected cathode ray tube, a pair of grid-controlled electron discharge tubes connected in "push-pull" relation and adapted to deliver voltages of opposite polarity to two field deflection plates of said cathode ray tube, an impedance connected across said D.-C. potential source, a pair of resistors of substantially equal value, means for connecting one of said pair of resistors and at least a portion of said impedance in the anode-cathode circuit of one of said electron discharge tubes, means for connecting the other of said pair of resistors and said impedance portion in the anode-cathode circuit of the other of said electron discharge tubes, means for applying a cyclically varying voltage to the grid of one of said electron discharge tubes, a circuit for differentiating the varying voltage developed across said impedance portion during the push-pull operation of said electron discharge tubes, and means for applying said differentiated voltage to the grid of the other of said electron discharge tubes.

4. The combination of claim 3, in which said means for applying a cyclically varying voltage to the grid of one of said electron discharge tubes includes a circuit for generating a control voltage of substantially sawtooth waveform.

5. A circuit for producing sawtooth voltages

of opposite phase, comprising a pair of electron discharge devices each having at least an anode, a cathode and a control electrode, an impedance, means for connecting said impedance in the anode-cathode circuit of both of said electron discharge devices so as to form a common portion of the load on each such device, a circuit for generating a control voltage variation of substantially sawtooth waveform, means for applying the output of said voltage-generating circuit to the control electrode of one of said electron discharge devices, a wave-shaping network, and means for connecting the control electrode of the other of said electron discharge devices through said wave-shaping network to one end of said impedance.

6. The combination of claim 5, in which said wave-shaping network comprises a series capacitor and a shunt resistor arranged to form a time-constant circuit.

7. The combination of claim 6, in which said shunt resistor is adjustable to vary the time constant of said wave-shaping network.

8. In an electrostatic cathode ray deflection circuit of field frequency, the combination of two amplifiers for supplying sawtooth deflecting potentials of opposite polarity, each said amplifier having an input circuit and an output circuit, a resistance individual to each output circuit, an impedance common to both output circuits, said resistances and impedance being connected together at a common point, a differentiating network in the input circuit of one of said amplifiers and connected to said common point, and means for applying a substantially sawtooth potential to the other input circuit.

EARL H. SCHOENFELD.
WILLIAM MILWITT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,246,168	Donie	June 17, 1941
2,300,452	Lewis	Nov. 3, 1942
2,386,728	Theisen	Oct. 9, 1945