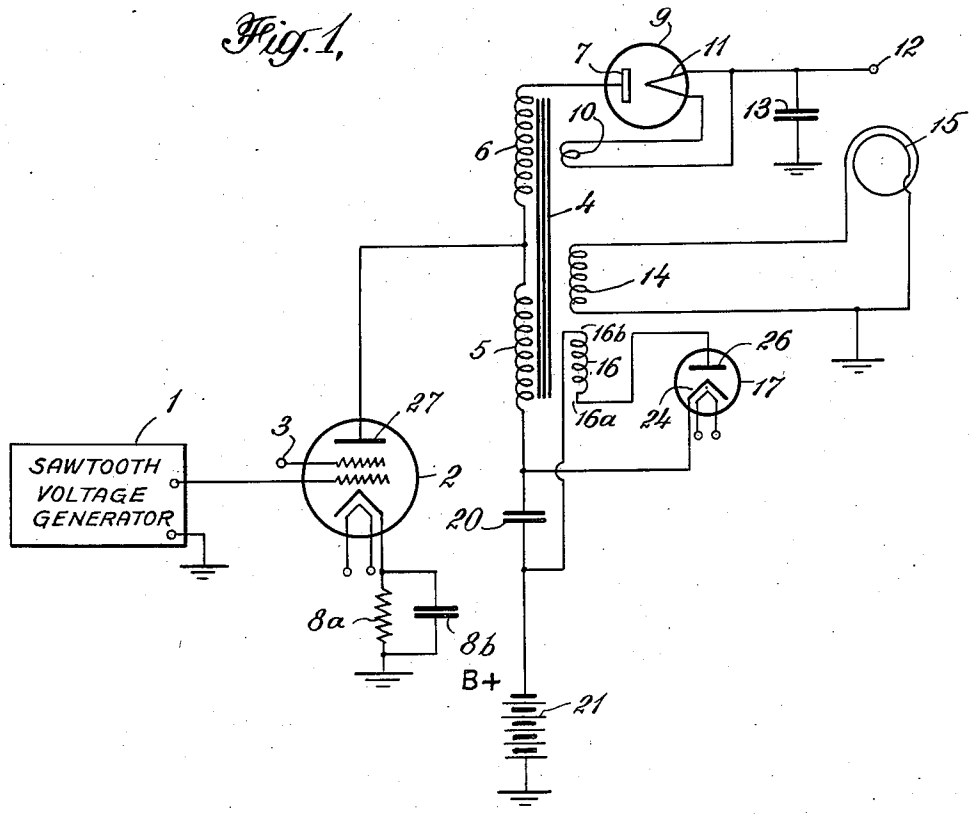
Jan. 11, 1949. K. SCHLESINGER 2,458,532

CATHODE-RAY TUBE CIRCUIT

Filed Aug. 7, 1946 2 Sheets-Sheet 1

Fig. 1.



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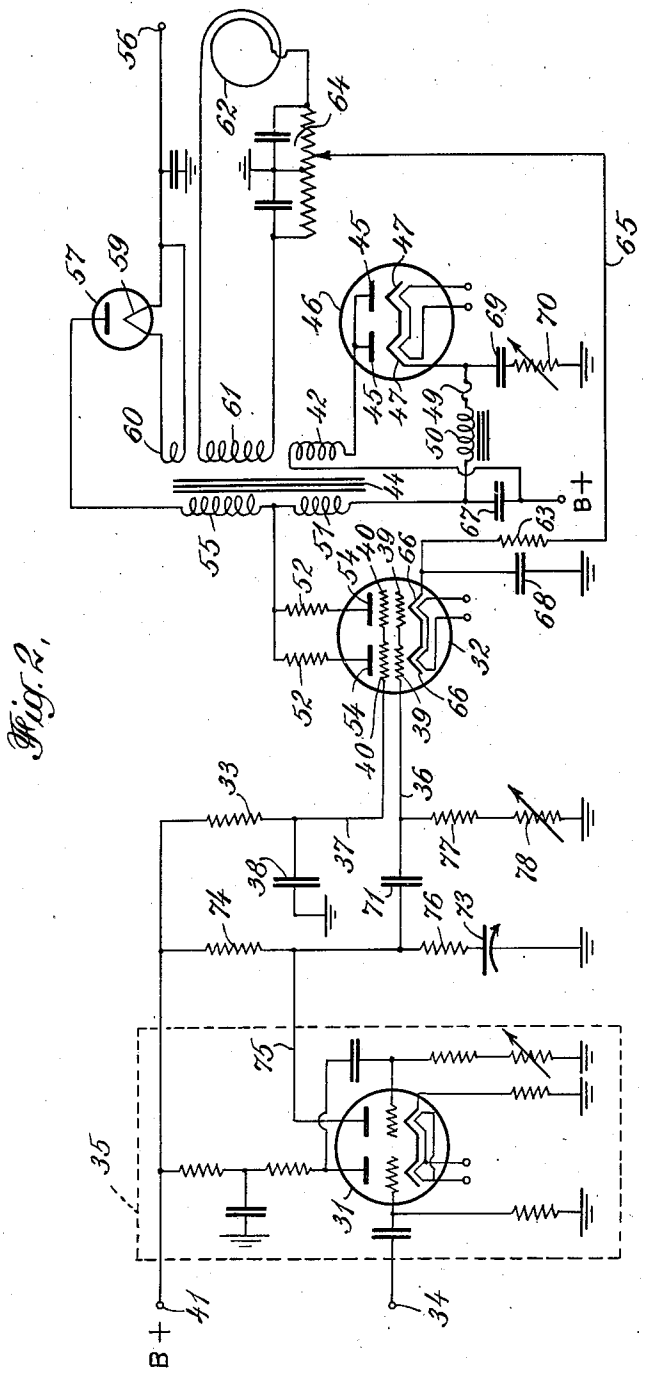


Fig. 2.

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2,458,532

CATHODE-RAY TUBE CIRCUIT

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Application August 7, 1946, Serial No. 688,895

11 Claims. (Cl. 315—27)

1

This invention relates to deflection circuits for cathode-ray tubes and particularly to means for utilizing energy stored in the circuit during the sweep periods to produce a high efficiency circuit. While especially designed and adapted for use in television, it is applicable to other fields as well.

A substantial amount of power is required to produce the electromagnetic fields required for sweep deflection in cathode-ray tubes of the electromagnetically deflected type. In television receivers particularly, present day requirements of increased line-scanning frequencies, the use of higher voltage tubes and hence stiffer beams, and the general introduction of tubes having substantially wider angles of deflection, have placed a great burden on the deflecting system. The problem is especially severe in color television, where line scanning frequencies are higher than in black-and-white television.

The power necessary for deflection purposes has become a major fraction of the total drawn by the set. Then, at the conclusion of each line sweep it is necessary to provide an outlet for the energy remaining in the deflecting circuit, and economically desirable to make use of it elsewhere.

Commonly the beam retrace or "flyback" takes place during an interval which is relatively short compared to the sweep interval. It will, therefore, be appreciated that the extremely rapid drop in current through the deflecting coils during the beam retrace period will tend to produce high transient voltages opposite in sense to those producing the sweep deflecting currents. Also, since the sweep circuit inevitably contains some capacitance as well as inductance, the rapid drop in current during retrace tends to set up transient oscillations which persist until the energy in the circuit is dissipated. These transient oscillations would interfere with the desired linear characteristic of the sweep deflecting current and hence the accurate reproduction on the cathode-ray screen of the material being televised, and so must be eliminated.

Absorption of the energy remaining in the magnetic field at the end of a given sweep has been accomplished by the use of various types of power absorbing circuits. Some difficulties arise in absorbing sufficient power in high-frequency high-power deflection circuits, but in any event systems of this type have the disadvantage that the energy is completely wasted. A further disadvantage arises in circuits where power is absorbed during the retrace intervals. This loads the sweep circuit and hence reduces the speed of retrace.

2

Such reduction is serious in high-frequency sweep circuits.

Systems have been developed for recovering a portion of the energy as useful power, but the proportion so recovered has been so small as to present no material economy in the over-all power consumption of the set. Any substantial saving of power is particularly important in the development of television receiving sets for home use. Furthermore, the systems proposed have recovered power during the retrace intervals, so that recovery of a greater portion of the field energy would slow down the retrace.

The present invention provides means for recovering a substantial portion of the energy stored in the magnetic field during the sweeps, without undesirably reducing the speed of retrace. To this end, briefly, a rectifier circuit is coupled to the sweep circuit and becomes conductive during sweep intervals to allow current flow, but becomes substantially nonconductive during retrace intervals. The rectified current, or at least a portion of it, is supplied to a storage circuit to develop a voltage which is then utilized as a source of power. In this manner, energy in the magnetic field is removed from the sweep circuit after the retrace and made available for further use, and in the preferred embodiment is removed immediately after the retrace so as to damp out oscillations without slowing down the retrace.

In accordance with a further aspect of the invention, the voltage developed from the magnetic field energy is utilized in the generation of the sweep currents. In the embodiments shown the developed voltage is used to supplement the anode power supply voltage for the output tube (or tubes) of the deflection generator. This not only makes effective use of the recovered power and reduces the required input power, but also permits a reduction in the power supply voltage from what would otherwise be required. In many cases such a voltage reduction permits considerable savings in the cost of power supply components.

The invention will be more fully understood by reference to the specific embodiments hereinafter described in conjunction with the drawings, in which:

Fig. 1 is a circuit diagram illustrating one embodiment of the invention; and

Fig. 2 is a circuit diagram showing a presently preferred embodiment of the invention.

Referring now to the drawings for more detailed discussion of the invention, I have shown circuits used in connection with the supply of horizontal high-frequency line deflecting cur-

rents and the accelerating potentials to a cathode-ray tube in a television receiver. Only those circuit elements relating directly to these functions have been illustrated, and it will be understood that they may be used with such additional circuit means as are desirable in the television art. It will also be understood that the invention is applicable to other uses of cathode-ray oscilloscopes in which it is desired to achieve a saving in power consumed or to obtain an increase in the potentials which are available for use.

In Fig. 1 the invention is shown in a simple form. A source of sawtooth deflecting potentials 1, shown as a block, is arranged to drive a sweep circuit including an electronic output tube 2, here shown as a beam power amplifier tube with screen grid potential conventionally provided through through lead 3. Suitable bias is provided by the cathode resistor 8*a* and shunting capacitor 8*b*.

A sweep transformer, indicated generally as 4, is connected in the output circuit of tube 2 to provide the horizontal deflecting currents and the high accelerating potential required by the cathode-ray tube. Transformer primary 5, connected in the anode circuit of tube 2, has a conventional high voltage winding 6 connected in series therewith leading to the anode 7 of a diode rectifier 9. A filament winding 10 on the transformer 4 may be used to furnish current for heater-cathode 11 of the diode 9, which delivers at terminal lead 12 a high positive potential built up across a capacitance 13 to ground. Lead 12 may be connected in the usual fashion to the accelerating anode of the cathode-ray tube, not shown in the figure.

A secondary winding 14 is connected to feed the horizontal deflecting coil 15 of the cathode-ray tube. Another winding 16 is provided on the transformer, and will be termed an "efficiency" winding. It is desirable that windings 14 and 16 be closely coupled, and it has been found advantageous in practice to wind them bifilarly.

Eficiency winding 16 is connected in series with a rectifier 17, which is advantageously a low impedance diode as shown. These elements are then introduced into the anode circuit of output tube 2 across a capacitor 20 interposed between the transformer primary 5 and the B+ or anode power supply 21. Winding 16 is connected so that as the current in winding 14 increases during a sweep interval, the voltage induced in winding 16 makes end 16*a* positive to end 16*b*. This positive potential adds to the B+ supply voltage and the sum is impressed on the anode 26 of diode 17. During the retrace the current in winding 14 decreases with a much greater rate of change than during the sweep, so that the induced voltage in winding 16 is reversed and greatly increased in magnitude. Thus the induced voltage in 16 opposes the B+ voltage and the potential applied to the anode 26 of diode 17 is reduced.

It may be seen from the circuit shown in Fig. 1 that when diode 17 is conductive, a D.C. path is provided from the anode of tube 2 through transformer primary 5, diode 17, and efficiency winding 16, to the B+ supply 21.

In operation, during a given sweep the sawtooth voltage generator 1 impresses a substantially linearly increasing voltage on the grid of output tube 2 and causes a substantially linearly increasing current to flow in the transformer primary 5 in the output circuit. This causes a similarly increasing current to flow in the secondary 14 and deflecting coil 15 to deflect the beam of

the associated cathode-ray tube. Neglecting for the moment the potential on capacitor 20, anode 26 of diode 17 is driven positive to cathode 24 by the induced voltage in the efficiency coil 16 and hence the diode is conductive. The voltage drop in primary 5 of the transformer opposes the B+ voltage and hence reduces the anode voltage of tube 2. In present day line-frequency deflecting circuits in television, the "bucking" voltage may reach several hundred volts.

At the end of the sweep, generator 1 reduces the voltage on the grid of the output tube toward or, advantageously, beyond cutoff. Thus anode current in tube 2 is reduced or cut off. The current in the circuit comprising the secondary 14 and deflecting coil 15 reverses for the retrace and decays rapidly, thereby inducing a relatively high negative voltage in the efficiency winding 16 which renders diode 17 nonconductive. At the same time a high positive voltage is induced in primary 5 and also in auxiliary winding 6, and these two highly positive voltages are impressed in series on diode 9 to render it conductive. Thus a high voltage, of the order of a number of thousands of volts, is built up across capacitor 13 and supplied to the accelerating anode of the cathode-ray tube through connection 12.

In addition to the inductances described, the sweep circuit of Fig. 1 necessarily contains distributed capacitances, the output capacitance of tube 2, etc., so that a resonant circuit exists for flow of current. The impedance of tube 2 is relatively high and the load imposed by diode 9 and associated circuit components is relatively small so that little damping is present and the retrace can take place quickly, as is desirable in high-frequency deflection circuits. The lack of damping, however, means that a considerable portion of the energy in the magnetic fields of the deflecting coil circuit remains after the retrace, and hence there is a tendency to set up transient oscillations until the energy is dissipated.

However, as soon as the current in the deflecting coil circuit again reverses and flows once more in the sweep direction, the induced voltage in efficiency winding 16 becomes positive and diode 17 becomes conductive. This provides a low impedance path to capacitor 20 which quickly absorbs the energy remaining in the deflecting coil circuit and damps out further oscillations. At least a portion of the rectified current flows into storage capacitor 20 to charge it and thereby develop a voltage across it. The polarity is such that the capacitor plate connected to diode 17 becomes positive, which is in the direction to aid the B+ voltage. Thus the voltage developed on capacitor 20 supplements the B+ supply and the resultant anode voltage for tube 2 is increased.

As subsequent cycles proceed, it will be understood that diode 17 is rendered substantially nonconductive during retrace intervals. Immediately following each retrace, diode 17 becomes conductive to absorb energy from the deflecting coil circuit to charge capacitor 20. The size of capacitor 20 may be made large so that the variation in voltage there-across from cycle to cycle is minimized. However, a smaller capacitor which provides substantial storage during a sweep interval, yet allows some decay from sweep to sweep, has been found satisfactory and offers certain advantages in linearity of sweep and low impedance for quickly absorbing energy following the retrace.

It will be appreciated that by this means energy

stored in the magnetic deflecting circuit, which would otherwise produce current flow in secondary 14 and coil 15 until dissipated as heat, is accumulated in the capacitance until returned to the circuit as useful power.

Another preferred embodiment of the invention is illustrated in Fig. 2. In this figure the sawtooth voltage generator is shown as a multivibrator circuit, indicated generally by the dotted enclosure 35, which controls the charge and discharge of the sawtooth voltage generating capacitor 73. The twin triode 31 is disposed in a conventional multivibrator circuit, employing cathode coupling, which is triggered by line synchronizing pulses applied to terminal 34. Capacitor 73 is charged from the B+ supply through resistor 74 and is periodically discharged by the multivibrator circuit through lead 75 to form a sawtooth voltage wave. Resistor 76 is a small resistor, sometimes called a "peaking" resistor, which improves the cutoff of the output tube 32, as is known in the art.

The sawtooth voltage wave is supplied to a linearity control circuit composed of capacitor 71, fixed resistor 77 and variable resistor 78. The time constant of this circuit is selected to introduce a certain amount of predistortion, which is desirable to correct for distortions in the following circuits. In effect, the sweep portions of the sawtooth voltage wave are made somewhat convex. The amount of predistortion is controllable by varying resistor 78.

The sawtooth wave is then applied through lead 36 to the control grids 39 of the sweep circuit output tube 32, which may be of the beam power type with heater cathodes. Screen grid voltage is obtained from the B+ supply through resistor 33 and shunting capacitor 38 by way of lead 37. In the circuit as shown in Fig. 2, the two sections of tube 32 are connected in parallel, so that the tube may function as a beam power tube of higher capacity than the embodiment of Fig. 1. For example, a type 815 tube has been used with success. Anode potential for tube 32 is obtained from the B+ power supply in series with the voltage across storage capacitor 67, through primary 51 of the sweep transformer 44 and the small plate resistors 52. The latter serve to prevent any parasitic oscillations in the two tube sections.

Secondary 61 supplies the sweep currents to the deflecting coil 62 of the cathode-ray tube (not shown). A conventional aligning circuit 64 for centering the beam is provided, with a return 65 through resistor 63 to the cathodes 66 of the output tube 32. The cathode resistance is shunted by capacitor 68 to provide cathode bias.

As in Fig. 1, a high voltage auxiliary winding 55 in series with primary 51 applies a high positive voltage to the anode of rectifier 57 during the retrace to provide accelerating voltage for the cathode-ray tube through lead 56.

The B+ power supply voltage is also applied through efficiency winding 42 of transformer 44 to the anodes 45 of a double diode rectifier tube 46. As in Fig. 1, the voltage induced in winding 42 is positive for currents flowing in the sweep direction in the secondary 61, and aids the B+ supply in impressing a positive voltage on anodes 45. Likewise, the efficiency winding 42 is closely coupled with secondary 61, and preferably wound bifilarly therewith. The two sections of diode 46 are in parallel and the tube is advantageously selected to provide a high conductance and low voltage drop thereacross.

Storage capacitor 69 and a small variable resistor 70 are in series with diode 46 to receive rectified current therefrom, and capacitor 67 is connected in shunt through inductance 50. Fuse 49 may be inserted for protection.

As explained before, during the sweep portion of the sawtooth deflection wave secondary 61 delivers energy to the magnetic field set up about coils 62. At the end of a sweep the current reverses and the magnetic field rapidly collapses. During this retrace interval a relatively high negative voltage is induced in efficiency winding 42 and diode 46 is rendered substantially nonconductive, thereby isolating the rectifier load from the sweep circuit and facilitating a rapid retrace. At the end of the retrace the current in secondary 61 again reverses and begins to flow in the sweep direction, thus inducing a positive voltage in efficiency winding 42 and rendering diode 46 conductive. This provides a relatively low impedance path to the storage circuit and the energy remaining in the sweep circuit is rapidly dissipated and transients avoided.

Furthermore, rectified current flowing into capacitor 69, and through inductance 50 into capacitor 67, builds up voltages across the capacitors due to charges stored therein. With the connections as shown, the voltage built up across capacitor 67 will be positive in a direction to aid the B+ power supply in supplying anode voltage for output tube 32. Thus at least a portion of the energy stored in the magnetic deflecting circuit at the end of a sweep will be fed back into the output tube circuit, with resultant economy.

Resistor 70 is usually small, of the order of a few ohms, and may be adjusted to give optimum results. If too high, it is found that transients may result. These are believed due to an impedance mismatch between the rectifier circuit and the remainder of the circuit. Generally a reasonable match is desirable to quickly absorb sufficient energy to damp out transients. In practice, it is often found possible to dispense with the resistor entirely. By using the two storage capacitors 67 and 69, connected in shunt by inductance 50, rather than the single capacitor of Fig. 1, a smoothing effect is obtained, and also a delay in the voltage wave across capacitor 67 which has been found helpful in obtaining good linearity of the sweep.

Large values may be employed for capacitors 67 and 69, with resultant small ripple across capacitor 67. However, in such case it may be found that an S type distortion exists in the sweep circuit in some cases. This S distortion results in crowding the picture near the middle of the horizontal sweep. Such a type of distortion is difficult to correct by conventional predistortion circuits. However, by employing smaller values of capacitors, and allowing considerable ripple across capacitor 67, this type of distortion may be avoided. The employment of inductance 50 is also helpful in avoiding undesired types of distortion. Preferably the inductance should have low distributed capacitance and low resistance.

Also, by making capacitor 69 relatively small, its charge will be substantially reduced toward the end of each sweep, and the diode 46 will then find a high instantaneous admittance at the beginning of each sweep which will help in dissipating flyback energy and eliminating transients. Connecting resistor 70 to the B+ supply

rather than to ground has been found possible, although present indications are that the connection to ground, as shown, has some advantages.

In common with many other deflecting circuits, the sweep circuit of Fig. 2, that is, output tube 32 and its associated circuits, may have an over-all distortion. This is corrected in Fig. 2 by linearity control resistor 78 which introduces a controllable amount of predistortion in the sawtooth voltage control wave. If desired, other types of linearity control circuits may be employed.

As a concrete example of an apparatus which has been successfully operated, the following circuit constants and results are given. It will be understood that the values given are in no way limiting, but may be widely departed from to suit the requirements of a given application. Using 350 volts B+ supply, 430 volts were found available at capacitor 67 for the anode supply of the amplifier tube 32, which was the commercially known type 815 tube. The deflecting coils 62 had about 800 microhenries inductance. Capacitors 67 and 69 were 0.02 mfd. and inductance 50 was about 30 millihenries. In the operation of a 10-inch cathode ray tube with circuit constants as specified, it was found possible to obtain wide angle (50°) beam deflection at a sweep frequency of 31.5 kc., using only 70 watts input. The D. C. power fed back across capacitance 67 by the economizer circuit amounted to about 18 watts in such case, raising the over-all efficiency of this type of scanning supply from 45% to about 65%. The maxima of the ripple voltage across capacitor 67 occurred near the middle of the sweeps, and linearity of sweep with proper adjustment of resistor 78 was excellent. Measurement of the current through diode 46 showed zero current during the retrace, a sharp peak immediately following the retrace, then a tapering off of the current to a relatively constant value for the remainder of the sweep interval.

As described in connection with the preferred embodiments, the invention particularly contemplates feeding back the voltage developed by the rectifier circuit in series with the anode power supply of the output tube. However, if desired, the developed voltage may be used for other purposes. In one such modification which has been employed with success, the terminal of the efficiency winding remote from the diode has been grounded instead of connected to the B+ power supply, or connected in series with the secondary winding and then to ground. The voltage developed across the storage capacitor is then fed through a filter circuit to supply direct current to the focusing coil of a magnetically focussed receiver tube. In this modification, as in the preferred embodiments, the efficiency winding is connected to render the diode conductive during the sweep intervals and nonconductive during the retrace intervals so as to damp out transient oscillations which would otherwise result from the energy stored in the deflection circuit at the end of each sweep. This energy is absorbed by the rectifier circuit and supplied in the form of D. C. energy to the focussing coil, with resulting economy. The storage capacitor and resistor in the cathode circuit of the rectifier are advantageously adjusted to provide a reasonable impedance match, which is found helpful in the elimination of transient oscillations in the sweep currents.

While the invention has been described particularly in connection with sawtooth deflecting currents, since these are of primary importance in television and for other purposes, the application to other forms of deflecting currents will be apparent to those in the art. It will further be understood that the embodiments described, while representing a preferred form of my invention, are susceptible of considerable variation within the scope of the appended claims and without departing from the spirit of the invention.

I claim:

1. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep circuit including an electronic tube and associated anode circuit for supplying periodic sweep currents to said deflecting coil during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, an anode power supply for said tube, a rectifier circuit coupled to said sweep circuit and connected to allow current flow during at least portions of said sweep intervals and to become substantially nonconductive during said retrace intervals, a first capacitor in said rectifier circuit connected to receive rectified current and develop a corresponding direct voltage, a second capacitor connected in shunt with said first capacitor through an inductance, said second capacitor being connected in said anode circuit in series with the anode power supply to supplement the voltage thereof.

2. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep circuit including an electronic tube and associated anode circuit for supplying period sweep currents to said deflecting coil during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, an anode power supply for said tube, a rectifier circuit coupled to said sweep circuit and connected to become conductive immediately following said retrace intervals to absorb energy from said electromagnetic field and to become substantially nonconductive during said retrace intervals, a first storage capacitor in said rectifier circuit connected to receive rectified current and develop a corresponding direct voltage, a second storage capacitor connected in shunt with said first capacitor through an inductance, said second capacitor being connected in said anode circuit in series with the anode power supply to supplement the voltage thereof, the size of said capacitors being selected to provide substantial voltage throughout sweep intervals but allowing substantial variation in voltage thereacross.

3. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep circuit including an electronic tube and associated anode circuit for supplying periodic sweep currents to said deflecting coil during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, an anode power supply for said tube, a rectifier circuit coupled to said sweep circuit and connected to become conductive immediately following said retrace intervals to absorb energy from said electromagnetic field and to become substantially

nonconductive during said retrace intervals, a first storage capacitor in said rectifier circuit connected to receive rectified current and develop a corresponding direct voltage of substantial magnitude throughout sweep intervals, the size of said first capacitor being selected to allow substantial decay from maximum voltage at the ends of said retrace intervals, circuit connections to supply said direct voltage to said anode circuit to supplement the anode power supply, and means in said circuit connections to improve the linearity of the sweep currents including a second capacitor connected in shunt with the first capacitor through an inductance.

4. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises means including an electronic tube having an output circuit for supplying periodic sweep currents during sweep inter va's, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, a transformer having a primary connected in said output circuit and a secondary connected to said deflecting coil, an economizer winding closely coupled with said secondary, rectifying means in series with said economizer winding and connected to pass current during at least portions of said sweep intervals and to become substantially nonconductive during said retrace intervals, storage capacitor means connected to receive at least a portion of the rectified current and develop a corresponding direct voltage, and means for applying said direct voltage to said electronic tube.

5. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep generator including an electronic tube having an anode output circuit for supplying periodic sweep currents during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, a transformer having a primary connected in said output circuit and a secondary connected to said deflecting coil, an anode power supply for said e'ectronic tube connected in series with said primary, an efficiency winding closely coupled with said secondary, a rectifier connected in series with said efficiency winding with the polarity selected to pass current during at least portions of said sweep intervals and to become substantially nonconductive during retrace intervals, first storage capacitor means connected to receive at least a portion of the rectified current and develop a corresponding direct vo!tage, and second storage capacitor means connected in shunt with said first storage capacitor means through an inductance, said second storage capacitor means being connected in series between said anode power supply and said primary to increase the anode voltage of said tube.

6. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep generator including an electronic tube having an anode output circuit for supplying periodic sweep currents during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, a transformer having a primary connected in said output circuit and a secondary connected to said deflecting coil, an anode power supply for said electronic tube connected in series with said primary, an efficiency winding closely coupled with said secondary, a rectifier having anode and cathode, said efficiency winding being connected between said anode power supply and the anode of the rectifier with polarity selected to render the rectifier conductive during sweep intervals and substantially nonconductive during retrace intervals, a storage capacitor supplied from the cathode of said rectifier to store at least a portion of the rectified current and develop a corresponding direct voltage, and connections for supp'ying said direct voltage to said anode output circuit in series with said anode power supply.

7. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep generator including an electronic tube having an anode output circuit for supplying periodic sweep currents during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, a transformer having a primary connected in said output circuit and a secondary connected to said deflecting coil, an anode power supply connected to supp'y anode voltage to said tube through the primary winding, a capacitor connected between said primary and said anode power supply, an efficiency winding closely coupled with said secondary, a rectifier having anode and cathode, said efficiency winding being connected between said anode power supply and the anode of the rectifier with polarity selected to render the rectifier conductive during sweep intervals and substantially nonconductive during retrace intervals, and a circuit connecting the cathode of said rectifier and said capacitor to periodically charge said capacitor and develop a direct voltage thereacross to supplement the anode power supply to said tube.

8. A high-efficiency deflection circuit for a cathode-ray tube having an associated deflecting coil for producing an electromagnetic deflecting field which comprises a sweep generator including an electronic tube having an anode output circuit for supplying periodic sweep currents during sweep intervals, said periodic sweep currents alternating with retrace currents during relatively shorter retrace intervals, a transformer having a primary connected in said output circuit and a secondary connected to said deflecting coil, an anode power supply connected to supply anode voltage to said tube through the primary winding, an efficiency winding closely coupled with said secondary, a rectifier having anode and cathode, said efficiency winding being connected between said anode power supply and the anode of the rectifier with polarity selected to render the rectifier conductive during sweep intervals and substantially nonconductive during retrace intervals, a first storage capacitor connected in the cathode circuit of said rectifier to receive rectified current and develop a corresponding direct voltage, and a second storage capacitor connected in shunt wtih said first capacitor through an inductance, said second storage capacitor being connected in said anode circuit in series with the anode power supply to supplement the voltage thereof.

9. In a television system employing a cathode-ray tube having an electromagnetic deflecting coil for high-frequency line deflection, a high-efficiency deflection circuit which comprises a sweep generator including an electronic tube

having an anode output circuit for supplying substantially sawtooth current waves at line-scanning frequency, said sawtooth waves having retrace intervals substantially shorter than the sweep intervals thereof, a transformer having a primary in said output circuit and a secondary connected to supply sweep currents to said deflecting coil, an anode power supply connected to supply anode voltage to said tube through said primary, an efficiency winding closely coupled with said secondary, a rectifier connected in series with said efficiency winding with the polarity selected to pass current during at least portions of said sweep intervals and to become substantially nonconductive during retrace intervals, storage capacitor means connected to receive at least a portion of the rectified current and develop a corresponding direct voltage, and circuit connections for supplying said direct voltage to said anode circuit to supplement said anode power supply.

10. In a television system employing a cathode-ray tube having an electromagnetic deflecting coil for high-frequency line deflection, a high-efficiency deflection circuit which comprises a sweep generator including an electronic tube having an anode output circuit for supplying substantially sawtooth current waves at line-scanning frequency, said sawtooth waves having retrace intervals substantially shorter than the sweep intervals thereof, a transformer having a primary in said output circuit and a secondary connected to supply sweep currents to said deflecting coil, an anode power supply connected to supply anode voltage to said tube through said primary, an efficiency winding closely coupled with said secondary, a rectifier having anode and cathode, said efficiency winding being connected between said anode power supply and the anode of the rectifier with polarity selected to render the rectifier conductive during sweep intervals and substantially nonconductive during retrace intervals, a storage capacitor supplied from the cathode of said rectifier to store at least a portion of the rectified current and develop a corresponding direct voltage, and circuit connections for supplying said direct voltage to said anode circuit to supplement said anode power supply.

11. In a television system employing a cathode-ray tube having low-frequency field deflecting means and an electromagnetic deflecting coil for high-frequency line deflection, a high-efficiency deflection circuit for said line deflection which comprises a sweep generator including an electronic tube having an anode output circuit for supplying substantially sawtooth current waves at line-scanning frequency, said sawtooth waves having retrace intervals substantially shorter than the sweep intervals thereof, a transformer having a primary in said output circuit and a secondary connected to supply sweep currents to said deflecting coil, an anode power supply connected to supply anode voltage to said tube through said primary, an economizer winding closely coupled with said secondary, a rectifier having anode and cathode, said economizer winding being connected between said anode power supply and the anode of the rectifier with polarity selected to render the rectifier conductive during sweep intervals and substantially nonconductive during retrace intervals, a first storage capacitor in said rectifier circuit connected to receive rectified current and develop a corresponding direct voltage, and a second storage capacitor connected in shunt with said first capacitor through an inductance, said second capacitor being connected in said anode circuit in series with the anode power supply to supplement the voltage thereof.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,074,495	Vance	Mar. 23, 1937
2,212,217	White et al.	Aug. 20, 1940

Disclaimer

2,458,532.—*Kurt Schlesinger*, New York, N. Y. CATHODE-RAY TUBE CIRCUIT. Patent dated Jan. 11, 1949. Disclaimer filed Nov. 3, 1951, by the assignee, *Columbia Broadcasting System, Inc.*

Hereby enters this disclaimer to claims 4, 6, 7, 9, and 10 of said patent. [*Official Gazette December 11, 1951.*]

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