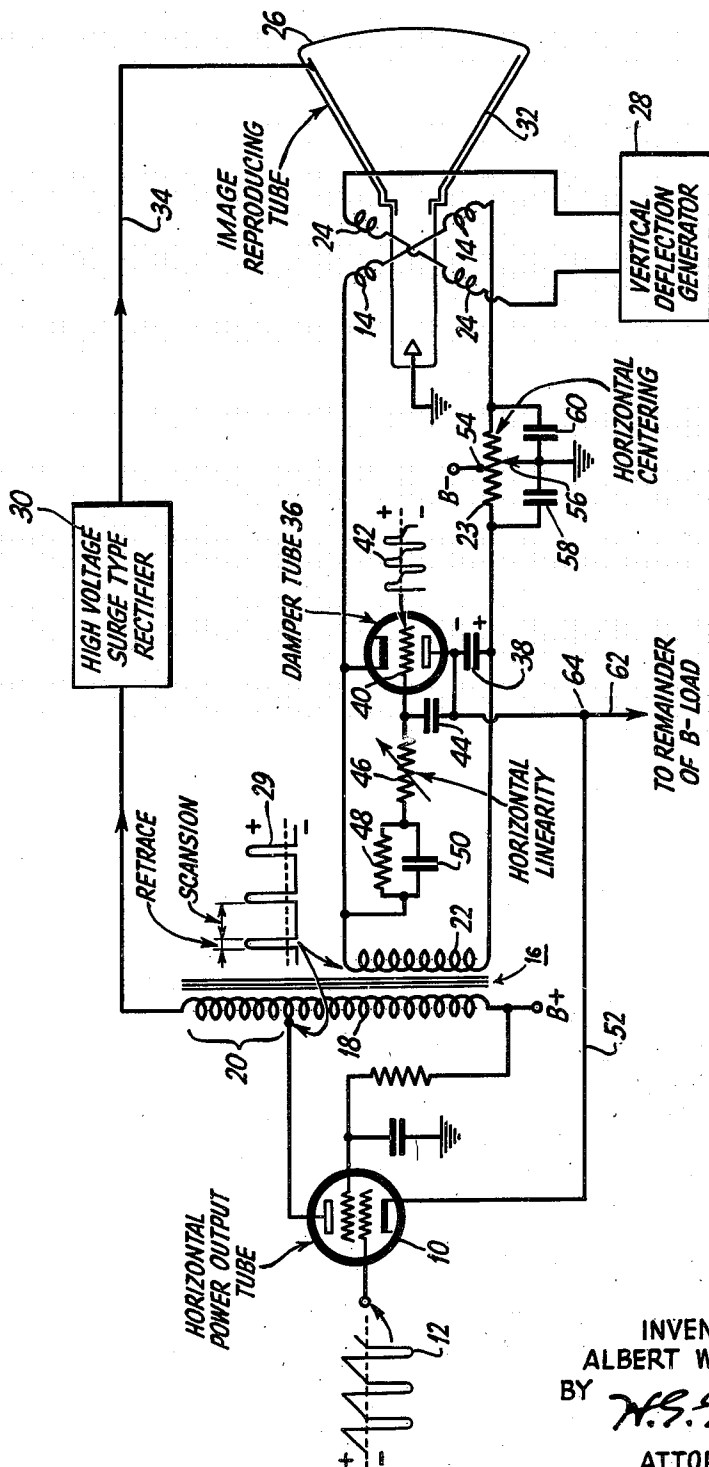


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POWER RECOVERY CIRCUIT FOR CATHODE-RAY
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POWER RECOVERY CIRCUIT FOR CATHODE-RAY APPARATUS DEFLECTION SYSTEMS

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1

The present invention relates to power recovery systems, and in a preferred form relates to means whereby normally unused power may be recovered from the horizontal, or line, cathode ray beam deflection circuit of a television receiver or other unit utilizing a cathode ray device to scan a target area or to reproduce an image or raster of any sort on such an area.

It is known in the art to connect a so-called damper tube across the cathode ray beam deflection coils, or across one winding of the transformer which may couple these coils to the power output tube in the horizontal deflection circuit of a television receiver. One purpose of this damper tube is to aid in suppressing the high-frequency oscillations which would otherwise occur, due to the inductive nature of the deflection circuit, following the retrace, or snap-back, of the cathode ray scanning beam at the end of each line-scanning operation. Such a system is exemplified by way of example by Blumlein United States Reissue Patent No. 21,400, dated March 19, 1940.

It is also known to employ a grid-controlled damper tube for the above purpose, and to control the conduction of this tube by applying to its grid a voltage variation having a particular waveform, so that the flow of current through the damper tube will combine with the current output of the power tube to result in a substantially linear summation current through the cathode ray beam deflection coils. A system of the latter type is disclosed, for example, in Tolson United States Patent No. 2,280,733, granted April 21, 1942.

Damper tubes, such as set forth above, are frequently employed in combination with an energy-storage device on which a substantially constant D.-C. (direct current) potential is developed during operation of the system. This developed energy is normally dissipated in a resistance, or other non-useful load. However, in a copending United States patent application of Otto H. Schade, Serial No. 593,161, filed May 11, 1945, there is disclosed a method and means for reclaiming a portion of the energy which is thus developed in the damper tube circuit, and for applying this reclaimed energy so as to either (1) increase the amount of power available for application to the load circuit, or (2) maintain the same power output to the load circuit while reducing the amount of input, or source, energy required. In other words, the reclaimed D.-C. power may be used to reduce the required supply voltage while maintaining the same deflection

2

amplitude, or it may be added to "boost" the original supply voltage to result in greater scanning power.

A preferred type of circuit set forth in the above-mentioned Schade application makes use of a triode damper, or suppressor, tube in combination with a condenser. The D.-C. voltage developed on the condenser during operation of the circuit is fed back with proper polarity to the plate of the power output tube in series with the tube supply voltage, so that the latter is, in effect, increased or "boosted." One condition for such operation is that the average plate currents of the power tube and of the damper tube be substantially equal. This may be accomplished by a proper selection of deflection coil impedance and/or transformer step-down ratio.

One of the characteristics of a system such as set forth in the above-mentioned Schade application is that the damper, or suppressor, tube is not "inverted" with respect to the power output tube, as is the case, for example, in the mentioned Blumlein reissue patent. Instead, the deflection secondary winding of the coupling transformer is wound in an opposite direction to the primary winding, so that when a voltage of one polarity appears across the primary winding, the voltage induced across the secondary winding is of opposite polarity. As a result, the positive voltage surges developed across the transformer primary winding during the retrace, or snap-back, periods of the cathode ray scanning beam appear as negative voltage surges on the anode of the damper tube, thus blocking the latter during these periods and effectively assisting the grid voltage in controlling the flow of damper tube current in such a manner as to bring about linearity of beam deflection.

As above set forth, the substantially smooth D.-C. potential which is developed during operation of the system on the "boost" condenser (or other energy-storage device connected in series with the damper tube) is fed back to the plate of the power output tube in such a manner that this condenser potential is additively in series with the positive supply voltage. To accomplish this, however, it is necessary that the portion of the circuit including the transformer secondary winding and the deflection coils, as well as the damper tube and its associated elements, be maintained at a D.-C. potential which is approximately equal in value to the positive supply voltage of the power output tube. This increases insulation problems and circuit design considerations with respect to damper tube ar-

rangements in which energy from the secondary circuit is not reclaimed, since, in the latter case, it is possible to maintain the circuit components at or near D.-C. ground potential.

According to a feature of the present invention, therefore, a cathode ray beam deflection circuit is provided utilizing a grid-controlled damper, or suppressor, tube which is so associated with an energy-storage element that the D.-C. potential developed on this energy-storage element during operation of the system is fed back to the cathode of the power output tube with such polarity as to be additively in series with the negative supply voltage. As a means of bringing this about, the secondary winding of the coupling transformer is wound in the same direction as the primary winding, so that positive voltage surges appear across each winding during retrace. In order that these positive voltage surges may serve to block the damper tube, the latter is actually "inverted"—that is, its cathode is connected to that end of the secondary winding of the coupling transformer on which the positive voltage surges appear, and its anode is connected to that terminal of the "boost" condenser on which the negative D.-C. potential is developed. By maintaining the deflection coils themselves at substantially ground, or B—, potential, therefore, the negative voltage on this "boost" condenser may be combined with the negative supply voltage for application to the cathode of the power output tube, thus resulting in greater current flow through such tube, greater applied voltage across the load circuit, and hence increased scanning power.

A further advantage of the presently disclosed invention, in cases where the deflection coils are connected directly across all or a portion of the transformer secondary winding, is that horizontal or line centering of the cathode ray beam may be made at substantially ground potential, instead of at, or near, the positive supply voltage, as in the above-mentioned Schade application, for example. This permits the use of less expensive components, and, as above brought out, reduces circuit design complications.

One object of the present invention, therefore, is to provide an improved system for recovering a portion of the reclaimable energy normally lost in cyclic reactive load circuits.

A further object of the invention is to provide a power recovery system particularly adapted for the horizontal deflection circuit of a television receiver, and possessing the advantages enumerated in part above.

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 a preferred form of the present invention.

Referring now to the drawing, there is shown a television deflection and high-voltage rectifier circuit which includes a horizontal, or line frequency, power output tube 10. Power tube 10 is adapted to supply, when voltage variations which may have a waveform such as indicated by the reference numeral 12 are applied to the control electrode thereof, cyclically varying current to a pair of horizontal, or line, cathode ray beam deflection coils 14 through a coupling transformer 16.

Transformer 16 is provided with a primary winding 18, a step-up winding 20 forming, in effect, an extension of the primary winding 18, and a secondary winding 22. This secondary winding

22 is connected across the horizontal or line cathode ray beam deflection coils 14 in series with a centering resistor 23, the function of which will be later described. The horizontal cathode ray beam deflection coils 14, together with a pair of vertical, or field, deflection coils 24, preferably form part of a yoke assembly encircling the neck of a cathode ray image-reproducing tube, or kinescope, 26. The vertical cathode ray beam deflection coils 24 are energized by sawtooth current of field-scanning frequency from a deflection generator 28, which may be of any suitable and well-known design already described profusely in the literature. It will not, therefore, be set forth in detail.

During operation of the illustrated circuit, as will be subsequently brought out, positive voltage surges are produced during the retrace, or snap-back, periods of the cathode ray scanning beam of tube 26 across the primary winding 18 of transformer 16 and also across the secondary winding 22. These voltage surges, which may have a waveform such as indicated by the reference numeral 29, are stepped up by the winding 20 and applied to a surge-type rectifier 30 which may, for example, be of the type disclosed in a copending United States patent application of Otto H. Schade, Serial No. 573,678, filed February 19, 1945, and issued April 6, 1948 as Patent No. 2,439,223, or in a copending United States patent application of Albert W. Friend, Serial No. 631,732, filed November 29, 1945 and issued October 19, 1948 as Patent No. 2,452,013. The output of rectifier 30 (which is diagrammatically represented in view of the disclosure in the last-mentioned Schade application, for instance) is a substantially smooth D.-C. potential. This potential is applied to the second anode 32 of the kinescope, or cathode ray image-reproducing tube, 26 over the conductor 34.

The voltage variations 12 applied to the control electrode of power tube 10, together with its bias potential (applied in any suitable manner but not shown for simplicity of illustration) produce a rising current in tube 10 during scanion. This current is cut off at the beginning of retrace time. The current in the deflection coils 14 and transformer 16 does not disappear at the instant of cut-off of tube 10, however, due to the inherent distributed capacity of the circuit. This distributed capacity, at the instant of the beginning of retrace, is charged to a relatively low voltage.

The inductance of the deflection coils 14 and transformer 16, together with the above-mentioned distributed capacity, forms a tuned circuit in which high-frequency oscillations would normally be produced, these oscillations beginning with the start of retrace time. After one-half cycle of the natural period of oscillation of the circuit, the current in the deflection coils 14 is reversed, and the oscillation is stopped at the negative current peak. The means for producing such a result include a triode, or other grid-controlled damper tube 36, connected across the secondary winding 22 of transformer 16 in series with a condenser, or other energy-storage device, 38.

During retrace—that is, during the half-cycle of the natural period of oscillation of the circuit, the current in each of tubes 10 and 36 is completely blocked, the voltage across the deflection coils 14 and transformer 16 reaching a high value at approximately one-fourth cycle when the current passes through zero. In order that linear deflection of the cathode ray beam be produced,

it is necessary that the rate of change of the current in the deflection coils 14 be maintained constant during the scanning portion of the deflection cycle, and as long as this rate of change of current is constant, the voltage across the deflection coils 14 will remain substantially steady at a predetermined level.

The polarity of the voltage applied to the cathode of the damper tube 36 immediately following retrace, is such as to cause this damper tube 36 to conduct. When the current through the damper tube 36 is properly matched with the current through the power output tube 10, the summation of these currents will have a linear characteristic which represents the current actually flowing through the deflection coils 14 during scanion.

In order to match the damper tube current to the power tube current so as to produce deflection linearity, means are provided for applying a voltage having a particular waveform to the control electrode 40 of the damper tube 36. This voltage variation must be such that the damper tube 36 begins to conduct immediately following retrace time and operates to produce a decreasing plate current. Accordingly, the voltage variation may have a waveform such as indicated in the drawing by the reference numeral 42.

The voltage variation 42 applied to the control electrode 40 of the damper tube 36 and the nominal bias on the electrode 40 are so adjusted as to give the desired waveform to the anode current permitted to flow through the damper tube 36. The most positive part of the waveform 42 occurs immediately following retrace, with negative peaking impulses occurring during retrace time.

After the initiation of current flow in the damper tube 36, the waveform 42 of the potential on the control electrode 40 is changed exponentially in a negative direction. This reduces, at a predetermined rate, the current flow through the damper tube 36, thereby resulting in a combined current flow through the power tube 10 and damper tube 36 that is linear, and that will produce linear deflection of the cathode ray beam of the image-reproducing tube, or kinescope, 26.

The means for obtaining a voltage variation having a waveform such as represented by the curve 42 includes a differentiating network comprising a condenser 44 and a resistor 46, the upper plate (in the drawing) of condenser 44 being connected to the control electrode 40 of damper tube 36, and the lower plate of condenser 44 being connected directly to the anode of tube 36 and also to that plate of condenser 38 on which a negative voltage is developed as a result of the current flow through tube 36. Bias for the control electrode 40 of tube 36 is obtained from the grid current flow through a resistor 48 in parallel with a by-pass condenser 50, one end of resistor 48 being connected to the cathode of damper tube 36. The resistor 46 is made adjustable, and acts as a linearity control by changing the differentiating constant of the R.-C. combination 44, 46. The voltage output of the differentiating network, as developed across resistor 46, is applied to the control electrode 40 of tube 36.

The voltage appearing on the control electrode 40, as represented by the waveform 42, has two exponential sections. When the control electrode 40 is positive, current flows through

the grid-cathode impedance of tube 36. This impedance shunts the differentiating resistor 46 so as to change the differentiating constant of the network 44, 46. The result is a fast-decaying transient during the initial portion of the scanning period, and this transient produces a heavy initial plate current output from the damper tube 36 which is effective in damping out the first strong oscillations in the circuit. The second section of waveform 42 is a slow-decaying transient caused by the resistor 46 when the control electrode 40 is negative and no grid current flows.

The anode of power tube 10 is supplied with a positive operating potential from a source indicated in the drawing as B+ through the primary winding 18. The cathode of power tube 10, on the other hand, is joined by means of the conductor 52 to the anode of damper tube 36 and also to the upper plate (in the drawing) of the "boost" condenser 38, the latter being the plate on which a negative voltage is developed during operation of the system by means of the current flow through the damper tube 36.

The lower plate of condenser 38 is connected to the low-potential end of the secondary winding 22 of transformer 16, and also to the deflection coils 14 through the centering resistor 23. A center tap 54 on the resistor 23 is connected to the negative terminal of the supply voltage source for power output tube 10, this negative terminal being indicated in the drawing as B-. A further adjustable tap 56 on resistor 23 is connected to ground, while two by-pass condensers 58 and 60 are respectively connected between ground and the opposite ends of the resistor 23, thereby providing a low-impedance path around such resistor for the cyclically varying beam deflection current flowing through the deflection coils 14. By varying the position of the adjustable tap 56, the direction and magnitude of the steady direct current flowing through the deflection coils 14 may be selected so as to effect a proper centering of the cathode ray beam of the image-reproducing tube 26. As before stated, however, the resistor 23 does not impede the flow of deflection current, since the condensers 58 and 60 together provide a low-impedance A.-C. path around the resistor 23.

The "boost" condenser 38, on which a voltage is developed having the polarity indicated in the drawing, is connected between the cathode of power tube 10 and the negative terminal B- of the source of operating potential for tube 10. Furthermore, the polarity of the voltage developed on condenser 38 is such as to additively combine with the supply voltage source to result in a higher negative voltage on the cathode of power tube 10. This may be caused to increase the current flow through tube 10, in addition to increasing the voltage which may be applied across the tube and the plate load circuit, and hence the deflection amplitude. It will be appreciated, however, that, if desired, the strength of the current flowing through the horizontal deflection coils 14 may be maintained constant. The value of the supply voltage source may be reduced by an amount equal to the voltage developed on condenser 38, or by any desired fraction thereof. It will be noted, however, that the recovered energy may be used to increase the deflection and high-voltage output capabilities of the system without requiring additional power input, or to maintain the same system operation with reduced energy input requirements, or to

compromise these two results in any desired proportion.

In accordance with the present invention, it is possible to supply other load circuits in the television receiver (of which the deflection and high-voltage circuit of the drawing may form a part) from the negative plate of condenser 38 over a conductor 62. In fact, such an additional load circuit or circuits in parallel with the power output tube 10 may, in some cases, be necessary or desirable, due to the presence of fixed values of inductance for the deflection coils 14 and also by limitations on the peak values of the voltages developed across other of the circuit components. In such an event, the load across condenser 38 provided by the driver or power output tube 10 may be insufficient. However, instead of connecting the anode of damper tube 35 to additional load circuits by means of the conductor 62, as indicated in the drawing, a variable resistor (not shown) may be employed between the connection point 64 and ground. In certain cases this may be advantageous, since adjustment of such a resistor may act as an additional linearity control by regulating the flow of both power and damper tube currents.

I claim:

1. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, a control electrode, and a source of operating potential is adapted to deliver cyclically varying current to a cathode ray beam deflection coil unit through a coupling transformer when a cyclically varying voltage is applied to the said control electrode, a portion of each cycle of which varies in a substantially linear manner with respect to time and in which at least a portion of the primary winding of said transformer is connected in the anode-cathode circuit of said power tube and at least a portion of the secondary winding of said transformer is connected across said cathode ray beam deflection coil unit, the combination of a damper tube having at least an anode and a cathode, a connection from the cathode of said damper tube to a point on the secondary winding of said transformer on which a voltage of negative polarity appears during the said linearly varying portion of each cycle of the said cyclically varying voltage; an energy-storage device; a connection from the anode of said damper tube through said energy-storage device to a further point on the secondary winding of said transformer which is relatively positive with respect to the point to which the cathode of said damper tube is connected; means for connecting said energy-storage device in the anode-cathode circuit of said power tube additively in series with said source of operating potential, so that the energy stored in said device during operation of said circuit will effectively increase the normal value of the negative potential applied to the cathode of said power output tube from the said operating potential source, said damper tube is additionally provided with a control electrode, and further including means for applying a control voltage to the control electrode of said damper tube so as to vary the internal impedance of said damper tube during each cycle of the voltage variations applied to the control electrode of said power output tube.

2. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, a control electrode, and a source of operating potential is adapted to

deliver cyclically varying current to a cathode ray beam deflection coil unit through a coupling transformer when a cyclically varying voltage is applied to the said control electrode, a portion of each cycle of which varies in a substantially linear manner with respect to time and in which at least a portion of the primary winding of said transformer is connected in the anode-cathode circuit of said power tube and at least a portion of the secondary winding of said transformer is connected across said cathode ray beam deflection coil unit, the combination of a damper tube having at least an anode and a cathode, a connection from the cathode of said damper tube to a point on the secondary winding of said transformer on which a voltage of negative polarity appears during the said linearly varying portion of each cycle of the said cyclically varying voltage; an energy storage device; a connection from the anode of said damper tube through said energy-storage device to a further point on the secondary winding of said transformer which is relatively positive with respect to the point to which the cathode of said damper tube is connected; means for connecting said energy-storage device in the anode-cathode circuit of said power tube additively in series with said source of operating potential, so that the energy stored in said device during operation of said circuit will effectively increase the normal value of the negative potential applied to the cathode of said power output tube from the said operating potential source, said damper tube is additionally provided with a control electrode, and further including means for differentiating the voltage developed across at least a portion of the secondary winding of said transformer, and means for applying the output of said differentiating means to the control electrode of said damper tube.

3. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, a control electrode, and a source of operating potential is adapted to deliver cyclically varying current to a cathode ray beam deflection coil unit through a coupling transformer when a cyclically varying voltage is applied to the said control electrode, a portion of each cycle of which varies in a substantially linear manner with respect to time and in which at least a portion of the primary winding of said transformer is connected in the anode-cathode circuit of said power tube and at least a portion of the secondary winding of said transformer is connected across said cathode ray beam deflection coil unit, the combination of a damper tube having at least an anode and a cathode, a connection from the cathode of said damper tube to a point on the secondary winding of said transformer on which a voltage of negative polarity appears during the said linearly varying portion of each cycle of the said cyclically varying voltage; an energy-storage device; a connection from the anode of said damper tube through said energy-storage device to a further point on the secondary winding of said transformer which is relatively positive with respect to the point to which the cathode of said damper tube is connected; means for connecting said energy-storage device in the anode-cathode circuit of said power tube additively in series with said source of operating potential, so that the energy stored in said device during operation of said circuit will effectively increase the normal value of the negative potential applied to the cathode of

said power output tube from the said operating potential source, a source of steady centering current of relatively low value, means for connecting said source of centering current in series with both the secondary winding of said transformer and also with said cathode ray beam deflection coil unit, and means for maintaining said source of centering current at substantially the same D.-C. voltage as that of the negative terminal of said power output tube operating potential source.

4. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, a control electrode, and a source of operating potential is adapted to deliver cyclically varying current to a cathode ray beam deflection coil unit through a coupling transformer when a cyclically varying voltage is applied to the said control electrode, a portion of each cycle of which varies in a substantially linear manner with respect to time and in which at least a portion of the primary winding of said transformer is connected in the anode-cathode circuit of said power tube and at least a portion of the secondary winding of said transformer is connected across said cathode ray beam deflection coil unit, the combination of a damper tube having at least an anode and a cathode, a connection from the cathode of said damper tube to a point on the secondary winding of said transformer on which a voltage of negative polarity appears during the said linearly varying portion of each cycle of the said cyclically varying voltage; an energy-storage device; a connection from the anode of said damper tube through said energy-storage device to a further point on the secondary winding of said transformer which is relatively positive with respect to the point to which the cathode of said damper tube is connected; means for connecting said energy-storage device in the anode-cathode circuit of said power tube additively in series with said source of operating potential, so that the energy stored in said device during operation of said circuit will effectively increase the normal value of the negative potential applied to the cathode of said power output tube from the said operating potential source, a centertapped adjustable resistor, one end of said resistor being connected to that end of the said cathode ray beam deflection coil unit on which a relatively low potential is developed during operation of said circuit, the other end of said resistor being connected both to one terminal of said energy-storage device and also to a point on the secondary winding of said transformer, the center tap of said resistor being connected to the negative terminal of said source of power output tube operating potential, and the adjustable element of said resistor being grounded.

5. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, and a source of operating potential is adapted to deliver cyclically varying current to at least one cathode ray beam deflection coil through a coupling transformer, the positive terminal of said source of operating potential being connected to the anode of said power output tube through at least a portion of said transformer, the combination of a damper tube and a condenser connected in series across said cathode ray beam deflection coil so that a relatively constant voltage is developed on said condenser during operation of said circuit, means for connecting the negative plate of said con-

denser to the cathode of said power output tube, means for connecting the positive plate of said condenser to the negative terminal of said source of power output tube operating potential, a source of direct current of relatively low value, means for connecting said direct current source between a point on said coupling transformer and the low-potential end of said cathode ray beam deflection coil, said source of direct current includes a center-tapped potentiometer the adjustable element of which is grounded and the center tap of which is connected to the negative terminal of said power output tube operating potential source, and whereby said potentiometer is maintained substantially at ground potential during operation of said circuit.

6. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, a control electrode, and a source of operating potential is adapted to deliver cyclically varying current to a cathode ray beam deflection coil unit through a coupling transformer when a cyclically varying voltage is applied to the said control electrode, a portion of each cycle of which varies in a substantially linear manner with respect to time and in which at least a portion of the primary winding of said transformer is connected in the anode-cathode circuit of said power tube and at least a portion of the secondary winding of said transformer is connected across said cathode ray beam deflection coil unit, the combination of a damper tube having at least an anode and a cathode, a connection from the cathode of said damper tube to a point on the secondary winding of said transformer; an energy-storage device; a connection from the anode of said damper tube through said energy-storage device to a further point on the secondary winding of said transformer; means for connecting said energy-storage device in the cathode circuit of said power tube additively in series with said source of operating potential, so that the energy stored in said device during operation of said circuit will effectively increase the normal value of the negative potential applied to the cathode of said power output tube from the said operating potential source, a source of steady centering current of relatively low value, means for connecting said source of centering current in series with both the secondary winding of said transformer and also with said cathode ray beam deflection coil unit, and means for maintaining said source of centering current at substantially the same D.-C. voltage as that of the negative terminal of said power output tube operating potential source.

7. In a cathode ray beam deflection circuit of the type in which a power output tube having at least an anode, a cathode, a control electrode, and a source of operating potential is adapted to deliver cyclically varying current to a cathode ray beam deflection coil unit through a coupling transformer when a cyclically varying voltage is applied to the said control electrode, a portion of each cycle of which varies in a substantially linear manner with respect to time and in which at least a portion of the primary winding of said transformer is connected in the anode-cathode circuit of said power tube and at least a portion of the secondary winding of said transformer is connected across said cathode ray beam deflection coil unit, the combination of a damper tube having at least an anode and a cathode, a connection from the cathode of said damper tube to

11

a point on the secondary winding of said transformer; an energy-storage device; a connection from the anode of said damper tube through said energy-storage device to a further point on the secondary winding of said transformer; means for connecting said energy-storage device in the cathode circuit of said power tube additively in series with said source of operating potential, so that the energy stored in said device during operation of said circuit will effectively increase the normal value of the negative potential applied to the cathode of said power output tube from the said operating potential source, a center-tapped adjustable resistor, one end of said resistor being connected to that end of the said cathode ray beam deflection coil unit on which a relatively low potential is developed during operation of said circuit, the other end of said resistor being connected both to one terminal of

12

said energy-storage device and also to a point on the secondary winding of said transformer, the center tap of said resistor being connected to the negative terminal of said source of power output operating potential, and the adjustable element of said resistor being grounded.

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