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2,478,744

POWER RECOVERY SYSTEM

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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 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 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 amplitude, or it may be added to "boost" the

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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 necessary 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.

The amount of power which may be reclaimed in the above manner is an inverse function of the internal resistance of the damper tube. Since the internal resistance of a triode is relatively great, the degree of power recovery is limited. It has, therefore, been found that an increase in the amount of power which is available for recirculation may be brought about by utilizing a damper tube having a lower internal resistance, such, for example, as a diode. A system of this nature is disclosed in a copending United States patent application of Charles E. Torsch, Serial No. 610,368, filed August 11, 1945.

When a diode damper tube is employed, however, it is difficult to obtain linearity of deflection, as ordinarily the flow of damper tube current is not subject to control due to the fact that the tube resistance is a fixed quantity. In a United States Patent of Simeon I. Tourshou, No. 2,440,418, granted April 27, 1948, this difficulty is partially overcome by applying to one of the electrodes of the diode damper tube a voltage having a predetermined phase displacement with respect to the voltage appearing across the primary winding of the coupling transformer. In this manner, a cathode ray tube deflection which is sufficiently linear for most purposes is conveniently obtained, especially in the case of relatively inexpensive television apparatus. The degree of linearity in such a system, however, does not approach that of the grid-controlled suppressor tube circuit, in which the waveform of the voltage variation applied to the grid of the damper tube may be chosen so as to compensate for circuit conditions which would otherwise tend to produce a relatively high degree of distortion.

According to one feature of the present invention, therefore, a cathode ray beam deflection

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circuit is provided utilizing a pair of damper, or suppressor, tubes. One of these tubes is utilized for the purpose of obtaining linearity of deflection of the cathode ray scanning beam, and hence is preferably a triode, or other grid-controlled tube, to the control electrode of which a voltage variation is applied having a waveform which is chosen to produce linearity of scan under the prevailing circuit conditions. The other damper tube is preferably of the diode type, and is connected in series with a condenser, or other energy-storage element. Since the internal resistance of the diode is relatively low, a maximum voltage is developed on its associated condenser, and this condenser voltage is preferably fed back to the power tube with proper polarity and in series with the supply voltage source so as to result in increased scanning output. Furthermore, since two damper tubes are utilized, the suppression of high-frequency oscillations following retrace is more complete, resulting in less image distortion.

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 cathode ray beam deflection coils 14 in series with all or a portion of 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 design. It will not, therefore, be set forth in detail.

During operation of the illustrated circuit, as will be subsequently brought out, voltage surges are produced across the primary winding 18 of transformer 16. These voltage surges 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 United States patent of Otto H. Schade, No. 2,439,223, granted April 6, 1948, or in a United States patent of Albert W. Friend, No. 2,452,013, issued on October 19, 1948. The output of rectifier 30, which is a substantially

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smooth D.-C. potential and which is diagrammatically represented in view of the disclosure in the mentioned Schade application, for instance, 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, 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, and also the series combination of a diode damper tube 40 and a condenser 42 connected across the secondary winding 22 of transformer 16 through all or a portion of the centering resistor 23.

During retrace—that is, during the half-cycle of the natural period of oscillation of the circuit, the current in each of tubes 10, 36 and 40 is completely blocked, the voltage across the deflection coils 14 and transformer 16 reaching a high value at one-quarter 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 steady at a predetermined level.

The polarity of the voltage applied to the anode of each of the damper tubes 36 and 40 immediately following retrace is such as to cause these damper tubes 36 and 40 to conduct. When the combined currents of the damper tubes 36 and 40 are properly matched with the power tube current, the summation of these currents will have a linear characteristic which represents the current actually flowing through the deflection coils 14 during scanion.

In accordance with the present invention, the overall, or combined, value of the currents flowing through the damper tubes 36 and 40 is adjusted for linearity of deflection coil current by adjusting the waveform of the voltage variation applied to the control electrode 44 of the triode damper tube 36. This voltage variation must be such that the damper tube 36 begins to conduct immediately following the 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 46.

The voltage variation 46 applied to the control electrode 44 of the damper tube 36, and the normal bias on the electrode 44 must, therefore, be 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 46 accordingly occurs immediately following the retrace time, with negative peaking impulses occurring concurrently with the retrace time.

After the initiation of current flow in the damper tube 36, the waveform 46 of the potential on the control electrode 44 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, damper tube 36 and damper tube 40 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 46 includes a differentiating network comprising a condenser 48 and resistors 50 and 52, the upper plate of condenser 48 being connected through the relatively small resistor 54 to the upper end of the secondary winding 22 of transformer 16 and also to the high-impedance end of the horizontal deflection coils 14. Bias for the control electrode 44 of damper tube 36 is obtained from the grid current flow through a resistor 56 in parallel with a by-pass condenser 58, one end of resistor 56 being connected to the cathode of damper tube 36. The resistor 52 is made adjustable and acts as a linearity control by changing the differentiating constant of the elements 48, 50 and 52. The voltage output of the differentiating network, as developed on resistors 50 and 52, is applied to the control electrode 44 of tube 36 through a shaping resistor 60.

The voltage appearing on the control electrode 44, as represented by the waveform 46, has two exponential sections. When the control electrode 44 is positive, current flows through the resistor 60 and the grid-cathode impedance of tube 36. This impedance shunts the differentiating resistor 50 so as to change the differentiating constant of the network 48, 50 and 52. 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 parasitic oscillations in the circuit.

The second section of waveform 46 is a slow-decaying transient caused by the resistor 50 when the control electrode 44 is negative and no current flows through resistor 60. Resistor 60, therefore, acts in effect as a current limiter to vary the impedance of the control electrode 44 of tube 36.

The series combination of diode damper tube 40 and condenser 42, as above brought out, is connected, in parallel with the triode damper tube 36, across both the secondary winding 22 of transformer 16 and also across the horizontal deflection coils 14. As such, the conduction of the diode damper tube 40 occurs substantially simultaneously with the conduction of the triode damper tube 36. This results in a substantially smooth D.-C. potential being developed on condenser 42. However, the magnitude of this voltage on condenser 42 is dependent upon the internal resistance of tube 40, since the greater the voltage drop across the tube, the less will be the voltage developed on the condenser. The internal resistance of the diode 40, however, is normally considerably less than the internal resist-

ance of the triode 36, or of any other grid-controlled damper tube. Accordingly, the D.-C. potential developed on the condenser 42 will be greater than if the diode 40 were replaced with a tube having one or more additional electrodes.

The anode of power tube 10 is supplied with operating potential from a source indicated in the drawing as +B. The condenser 42, on which a relatively smooth potential is developed in the manner above described, is connected between this source of operating potential +B and the anode of power tube 10 in series with the primary winding 18 of transformer 16. Furthermore, the polarity of the voltage developed on condenser 42 is such as to additively combine with the supply source voltage to result in increased anode voltage for the power tube 10, and hence increased scanning power. It will be appreciated, however, that, if desired, the amplitude of the current flowing through the horizontal deflection coils 14 may be maintained constant, and the value of the supply voltage source +B reduced by an amount equal to the voltage developed on condenser 42.

The remaining elements of the television system of which the deflection and high-voltage circuit above described forms a part may be supplied with energy from the +B source illustrated in the drawing through the centering resistor 23. This resistor, which is adjustable as shown, permits a selected steady current of relatively low value to flow through the deflection coils 14, and hence provides for horizontal centering of the cathode ray beam of the kinescope 26. The portion of the centering resistor 23 included in the secondary circuit of transformer 16 is bypassed by a capacitor 52 which provides a low-impedance path for the beam deflection current, thus effectively removing resistor 23 for the A.-C. deflection components. A centering arrangement of this general nature is illustrated and described in the above-mentioned Tourshou application.

An adjustable reactance element such as an inductor 64 may, if desired, be connected across all or a portion of the secondary winding 22 of transformer 16 so as to provide a size, or width, control of the image raster produced on the face of the image reproducing tube 26. Such an arrangement is set forth in a United States patent of Antony Wright, No. 2,449,969, issued September 28, 1948.

It will thus be seen that, by means of the disclosure herein set forth, a maximum amount of power may be reclaimed from the energy normally lost in the horizontal deflection circuit of a television system without a sacrifice of scanning linearity. In other words, the present disclosure incorporates in a preferred embodiment the linearity-producing advantages of a triode damper tube with the increased "boost" voltage available in damping circuit utilizing a diode.

I claim:

1. In a cathode ray beam deflection circuit, the combination of a grid-controlled power output tube and a source of operating voltage therefor, means for applying a voltage variation to the grid of said power output tube so as to produce a cyclically varying current output therefrom, a transformer, a pair of cathode ray beam deflection coils connected to receive the cyclically varying current output of said power tube through said transformer, a first grid-controlled damper tube connected across one winding of said transformer, means for applying a voltage variation to the grid of said first damper tube to control the conduction thereof, an energy-storage device, a sec-

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ond two-electrode damper tube connected in series with said energy-storage device, the series combination of said energy-storage device and said second damper tube being connected across one winding of said transformer in parallel with said first damper tube, and means connecting said energy-storage device to said power output tube additively in series with said source of power output tube operating voltage.

2. In a power recovery system of the type in which at least one power output tube is connected to deliver cyclically varying current to an inductive load member, the combination of damping means for reducing undesired oscillations in said system during a portion of each current cycle due in part to the inductive nature of said load member, said means including a triode damper tube, a diode damper tube, and a condenser, said diode damper tube and said condenser being connected in series, with the resulting series combination being connected in parallel relation with said triode damper tube so that a substantially constant D.-C. voltage is developed on said condenser during operation of said system, and means for applying the said substantially constant D.-C. voltage thus developed on said condenser to increase the normal current output of said power output tube.

3. A power recovery system according to claim 2, further comprising means for selectively controlling the conduction of said triode damper tube.

4. A power recovery system according to claim 2, further comprising means for differentiating the voltage developed across said inductive load member during operation of said system, and means for applying said differentiated voltage to control the conduction of said triode damper tube.

5. A power recovery system according to claim 2, in which the said inductive load member comprises a pair of cathode ray beam deflection coils.

6. In a cathode ray beam deflection circuit of the type in which at least one power output tube is connected to deliver cyclically varying current to a pair of cathode ray beam deflection coils through an inductive coupling member, the combination of a grid-controlled electron discharge device in parallel with at least a portion of said inductive coupling member, an energy-storage element, a two-electrode electron discharge device connected in series with said energy-storage element, means for connecting the series combination of said energy-storage element and said two-electrode electron discharge device effectively in parallel with said grid-controlled electron discharge device, and means for applying the energy

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stored in said energy-storage element during operation of said circuit to increase the current output of said power output tube.

7. A cathode ray beam deflection circuit according to claim 6, in which said energy-storage element is a condenser of high capacity having low surge impedance relative to the internal resistance of said two-electrode device.

8. A cathode ray beam deflection circuit according to claim 6 in which said inductive coupling member is a transformer, said grid-controlled electron discharge device being connected across at least a portion of one winding of said transformer.

9. In a cathode ray beam deflection circuit of the type in which at least one power output tube is connected to deliver cyclically varying current to a pair of cathode ray beam deflection coils through an inductive coupling member, the combination of a grid-controlled damper tube connected in parallel with at least a portion of said inductive coupling member, a condenser, a diode damper tube connected in series with said condenser, the series combination of said condenser and said diode damper tube also being connected in parallel with at least a portion of said inductive coupling member, and means connecting said condenser to said power output tube through at least a portion of said inductive coupling member so that the energy stored in said condenser during operation of said circuit will be effective to increase the normal current output of said power output tube.

10. A cathode ray deflection circuit comprising, a deflection coil, means for supplying deflecting current to said coil, two damping circuits for said coil connected in parallel, one said damping circuit comprising a grid-controlled damper tube, the other damping circuit comprising a diode damper tube and a storage condenser connected in series, the internal resistance of said diode being low compared to the impedance of said grid-controlled tube whereby a portion of the reactive energy developed in said deflection coil is stored in said condenser, and means connecting said condenser effectively in series with said means for supplying deflecting current.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,382,822	Schade	Aug. 14, 1945