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POWER RECOVERY DAMPING SYSTEM

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Fig. 1

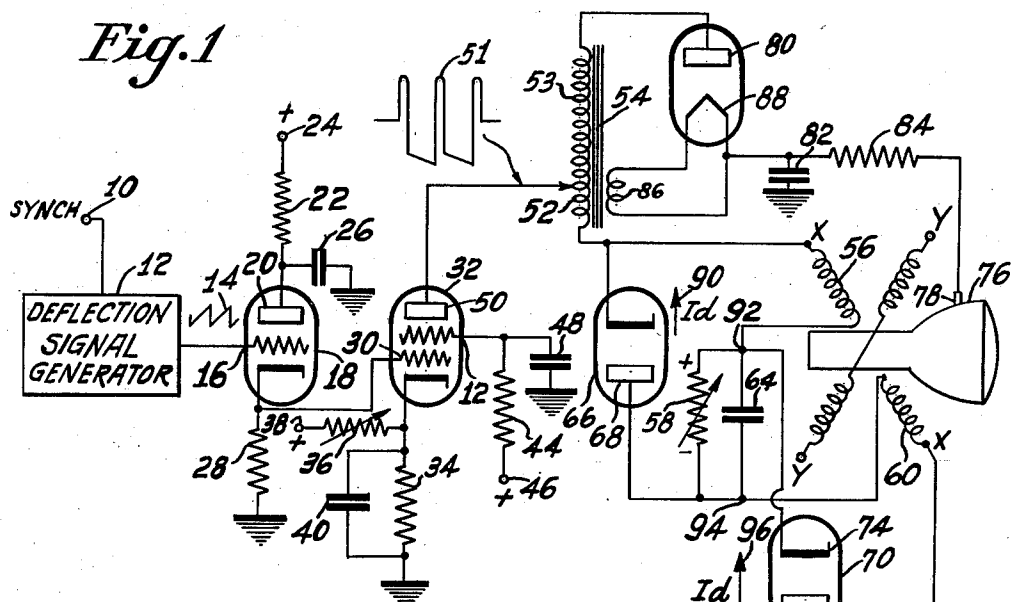
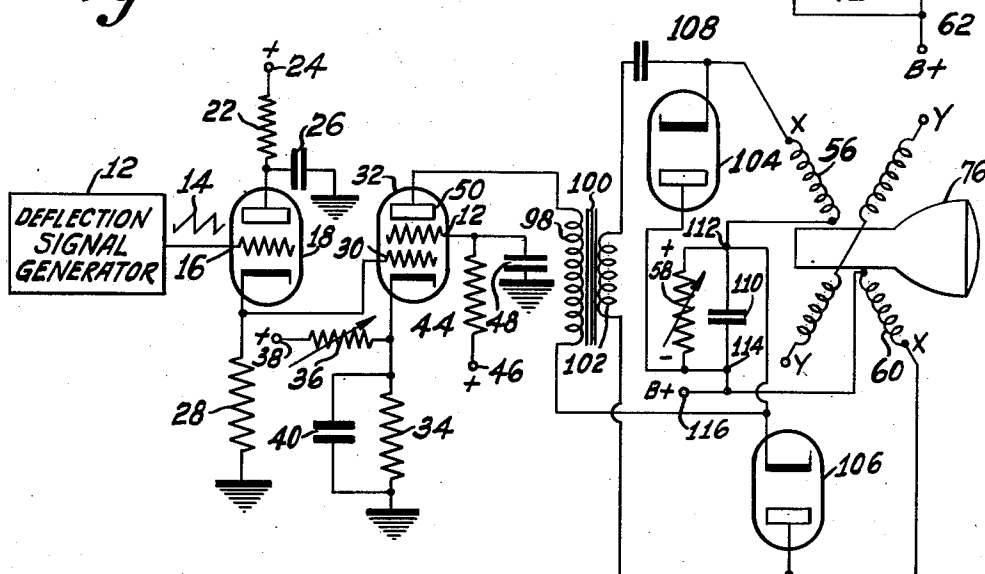


Fig. 2



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POWER RECOVERY DAMPING SYSTEM

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16 Claims. (Cl. 315-27)

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The present invention relates to electrical damping systems of the power recovery type and more particularly, although not necessarily limited thereto, to electromagnetic cathode ray beam deflection circuits of the type employed in television transmitting and receiving systems wherein a portion of the damped reactive energy in the deflection system is fed back for utilization by the deflection circuit to thereby improve the overall operating efficiency of the system.

Generally speaking in electrical circuits wherein some form of damping action is required, the efficiency of operation is usually lowered considerably due to the energy dissipated in the damping circuits, this energy not being gainfully utilized. In early television practice the electromagnetic deflection systems suffered considerable losses in this respect, which in turn stimulated subsequent development of power recovery systems in which some of the stored electromagnetic reactive energy normally dissipated in the damping system is capacitively stored and employed to effect a boost in B supply voltage applied to the vacuum tube driving the deflection system. Such power recovery or power feedback system has greatly improved the operating efficiencies obtainable in deflection systems as a whole. However, most prior art systems of this kind require the utilization of a step-down transformer in order to realize reactive damping currents of proper magnitude to readily permit power feedback into the B supply circuit of the driving vacuum tube. The use of a transformer in this connection of course represents certain additional costs in circuit construction as well as introducing inherent losses in the system due to leakage reactance and magnetic hysteresis. The losses incurred through use of a transformer for coupling energy from the plate circuit of the deflection driving tube to the damped deflection yoke of course may be obviated by direct inclusion of the yoke in the anode circuit of the vacuum tube. However, such a direct connection has not been regarded as one readily lending itself to power recovery operation.

Furthermore in television receiver applications, the direct drive arrangement for the deflection yoke has in the past displayed another awkward feature, that being the difficulty of obtaining from the deflection system an economical form of pulse set-up power supply for development of an accelerating potential for the associated cathode ray reproducing device. In a co-pending application by Simeon I. Tourshou and William E. Scull, Jr., Serial No. 56,562 filed October 26, 1948

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entitled "High Voltage Power Supply" this latter difficulty has been overcome in part through the application of an autotransformer having its primary connected in series with the deflection yoke circuit and subsequently rectifying the high voltage positive pulses so obtained to produce the appropriate high unidirectional accelerating potential. The inclusion of this autotransformer primary in the yoke circuit does, however, reduce to a considerable extent the unidirectional voltage actually applied to the anode of the output tube and consequently a somewhat higher B+ power supply potential is normally required to correct for this voltage drop. This provision of such an increase in potential represents considerable additional cost in the design of the television receiver power supply.

The present invention contemplates the realization of a power recovery system associated with an electromagnetic deflection system wherein the deflection yoke is directly included in the plate circuit of the driving vacuum tube. By capacitively coupling separate sections of the deflection coil and applying separate damping to each of said sections, there is then developed across the capacitance involved a B-boost voltage which results from recovery of the reactive energy cyclically stored in the deflection yoke sections.

It is therefore a purpose of the present invention to provide an improved form of power recovery damping system for electrical circuits.

It is another purpose of the present invention to provide an improved form of deflection circuit for television systems wherein a portion of the damped cyclically reactive energy in the yoke circuit is applied for effectively boosting the available polarizing potential of the driving vacuum tube.

Still another object of the present invention resides in the provision of a novel form of power recovery system particularly applicable to directly driven electromagnetic deflection coils in television systems wherein the deflection coils are included in the series with the anode-cathode circuit of the deflection system driving vacuum tube.

It is another purpose of the present invention to provide a simple and novel electrical damping arrangement which provides power feedback operation of a plurality of capacitively coupled inductance elements connected in series across a signal voltage.

The present invention has numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in

the following description of specific apparatus embodying and utilizing the invention's novel method. It is therefore to be understood that the present invention is not limited in any way to the apparatus shown in the specific embodiments as other advantageous applications in accord with the present invention, as set forth in the appended claims, will occur to those skilled in the art after having benefited from the teachings of the following description especially when considered in connection with the accompanying drawings in which:

Figure 1 shows one form of the present invention as applied to a typical direct-driven television deflection system.

Figure 2 shows another embodiment of the present invention as applied to a transformer coupled television deflection system.

Referring now to Figure 1, there is shown a portion of a typical television deflection system. Here synchronizing pulses are applied at terminal 10 to synchronize the operation of deflection signal generator 12 which in turn produces a typical deflection sawtooth waveform, such as 14. The signal 14 is then applied to grid 16 of cathode follower vacuum tube 18. The anode 20 of vacuum tube 18 accordingly is connected through a dropping resistor 22 to a source 24 of anode polarizing potential. The condenser 26 establishes the anode 20 at substantially A. C. ground potential. A suitable cathode follower resistance 28 is connected in the cathode to ground circuit of the vacuum tube 18 so as to provide a low impedance driving source for the grid 30 of output vacuum tube 32. A suitable negative operating bias is achieved for the grid 30 by inclusion of resistor 34 in the cathode ground circuit of vacuum tube 32. Rheostat 36, connected from a source of positive potential 38 to the top of resistor 34, allows the voltage drop across resistor 34 to be sufficiently in excess of the D. C. voltage drop across cathode follower resistor 28 to establish proper negative grid biasing of the tube 32. The cathode by-pass condenser 40 may be provided to reduce signal degeneration in the cathode circuit of the output tube. The screen grid 32 is conveniently supplied with a positive polarizing potential through resistor 44 connected with terminal 46 of a positive source of potential. The screen 42 is in turn held in substantially A. C. ground potential by means of by-pass capacitor 48.

The anode 50 of the output vacuum tube 32 is then connected through the primary winding 52 of autotransformer 54, through the first section 56 of the deflection coil X—X, through resistor 58 and then through the second section 60 of the deflection coil X—X to a source of positive polarizing potential having a terminal at 62. In shunt with resistor 58 is a storage capacitor 64 across which is to be developed (as hereinafter described) the B-boost or recovery voltage for the system. Damping diode 66 with its anode 68 connected with one terminal of capacitor 64 in effect provides damping for the first section 56 of the deflection coil X—X. Correspondingly, damping diode 70 with its anode 72 connected with the source of positive polarizing potential 62 and its cathode 74 connected with the other terminal of capacitor 64, effectively provides damping for the second section 60 of the deflection coil X—X. In practice deflection coil X—X may correspond to the usual 2-section horizontal or vertical deflection winding of a television deflection yoke designed for direct drive by inclusion in

the anode circuit of the deflection signal output tube.

As is shown, a novel form of high voltage power supply for the accelerating anode 78 of the kinescope 76 is provided through the use of autotransformer 54. This form of high voltage power supply for use in connection with deflection systems having the deflection yoke directly connected in the anode-cathode circuit of the driven vacuum tube is disclosed in a co-pending application by Simeon I. Tourshou et al., supra. As more fully described in the related specification, the deflection current for the yoke winding X—X passes through the primary 52 of the autotransformer 54 and therefore induces in the secondary 53 high voltage positive pulses corresponding in time to the kickback pulses 51 occurring on the plate 50 of vacuum tube 32. These high voltage pulses are then rectified by the diode 80 to develop a high unidirectional potential across capacitor 82. The voltage appearing thereacross is then filtered through filter resistor 84 and applied to accelerating terminal 78 of cathode ray tube 76. An auxiliary winding 86 on the transformer 54 supplies heater power for the filament 88 of the high voltage rectifier 80.

In the operation of the recovery circuit of Figure 1, the damping diodes 66 and 70 operate in accordance with conventional reaction scanning type of deflection system operation as related to the individual sections of the deflection winding with which they are respectively associated. Accordingly, the first part of deflection scanning cycle (which will be here considered as due to the reaction scanning action of the individual damping systems) is provided by energy stored in the respective inductances 56 and 60 at the end of retrace phase of the deflection cycle. As is well known to those skilled in the television art, immediately following the retrace or return phase of the deflection cycle, at which time there is zero current through the vacuum tube 32, the diodes 66 and 70 will become conductive to establish a reversed current flow through the respective winding sections as the result of the stored magnetic energy in these coil sections. For instance, in the case of the diode 66, immediately following retrace, the diode 66 will become conductive to pass a damping current I_d in the direction of the arrow 90. This passage of current in the direction indicated, in effect adds energy to the capacitance 64 thereby making the terminal 92 thereof more positive than its corresponding terminal 94. Correspondingly, the damping current through diode 70, associated with the second portion 62 of the yoke winding X—X, is in the direction of the arrow 96 and can be seen to further add energy to the capacitor 64 during its flow in such a direction to cause the terminal 92 to become positive with respect to the terminal 94. It is clear that the damping currents through the respective diodes 66 and 70 occur simultaneously so that as far as the yoke X—X is concerned, a conventional reaction scanning damping arrangement has been provided, the respective damping currents through the diodes in practice being substantially equal.

Investigation of the circuit arrangement will show, however, that the capacitor 64 is in fact in series between the positive B supply terminal at 62 and the anode 50 of vacuum tube 32, so that any voltage developed across capacitor 64 is additionally combined with the positive B supply. Thus, damped reactive energy is stored by capacitor 64 during the reaction scanning cycle and made

ready for use by the tube 32 during the ensuing driven phase of the deflection cycle.

It will be found in practice that the sum of the two equal damping currents through the diodes 66 and 70 will, to a close approximation, be equal to the average plate current required during the driven phase of the deflection cycle. Hence, the capacitor 64 will maintain an approximately steady unidirectional potential which represents a boost voltage for the system.

The value of the capacitor 64 should be large enough so that during the driven phase of the deflection cycle in which the vacuum tube 32 is rendered conductive, the plate current energy requirements of the vacuum tube will not be sufficient to appreciably alter the potential across the capacitor 64. This, of course, would produce distortion in the latter portion of the driven phase of the deflection cycle. Variable resistor 58 is shown in shunt with the capacitor 64 in order to provide a convenient control of the waveform of resulting deflection signal through the coil sections 56 and 60. This resistance 58, although not necessarily employed, may assume values of from five to ten thousand ohms and functions as a variable size and linearity control over the resulting television function.

As explained in connection with Figure 1, the deflection yoke winding X—X is in effect directly connected or direct-coupled to the output vacuum tube 32 by inclusion of the winding sections 56 and 60 in the anode-cathode circuit of the output tube. Advantages of the present invention, however, although finding particularly useful application in such direct-coupled systems, also may be enjoyed in combination with transformer coupled systems. Such an arrangement is shown in Figure 2 of the drawings. Here the anode-cathode circuit of the vacuum tube 32 includes the primary winding 98 of coupled transformer 100, such that deflection signal energy is made available across the transformer secondary 102 for activation of the damped deflection system embracing yoke winding sections 56 and 60 of the deflection winding X—X. Inspection of the damping arrangement of the deflection coil winding sections 56 and 60 by damping tubes 104 and 106 will show that the circuit configuration is substantially the same as that shown in Figure 1. The only difference in the transformer coupled arrangement being that the deflection coil X—X is not directly included in the anode-cathode circuit of the driving tube and hence does not pass anode current for the tube 32, but receives its alternating current deflection signal through the coupling medium of capacitor 108.

In the operation of Figure 2, again the damped reactive energy communicated by the diodes 104 and 106 supplies the first portion of the deflection cycle and in so doing stores energy on capacitor 110 thereby causing the terminal 112 to become positive with respect to the terminal 114. This action is identical with that described in connection with Figure 1 and follows from the influence of the sum of the damping currents through diodes 104 and 106 upon the capacitor 110, common to the load circuits of both damping diodes during the reaction scanning portion of the deflection cycle. Consequently, during the interval in which tube 32 is driven into plate current conduction, the effective anode polarizing potential will be the sum of the potential available at B+ terminal 116 and the terminal voltage of condenser 110 resulting from the storage of reactive energy. In this way a portion of the

energy extracted during the reaction scanning cycle of the deflection circuit is made available for operation of the vacuum tube 32 during the driven portion of the deflection cycle and in so doing produces the well-known B-boosting effect.

It will be appreciated that the coupling capacitor 108 serving to communicate deflection signal energy from the secondary of the output transformer 100 also serves as a D. C. blocking capacitor so that this B-boost voltage developed across capacitor 110 will not be in effect short-circuited by the low D. C. resistance of the secondary winding 102.

From the operation of Figure 1, it will be discerned that the configuration of the present invention in effect allows a virtual transformer step-down action without the actual utilization of a step-down transformer. This phase of the invention appears most vividly when considering the operation of Figure 1 on an average current basis. For example, after the circuit of Figure 1 has reached an equilibrium operating condition, it is apparent that the average current through capacitor 64 during the drive portion of the deflection cycle (that portion supplied by plate conduction of vacuum tube 32) is to all intents and purposes approximately twice that of the average current passed by each of the damping diodes 66 and 70 during the second portion or reaction scanning phase of the deflection cycle. This unique action in itself forms an important novel and useful part of the present invention. Such action has here, of course, been used in connection with a television deflection damping system. It clearly follows, however, that by connecting a plurality of inductance elements in series with one another with the interpositioning of a capacitance between adjacent inductances and appropriately applying a plurality of damping instrumentalities across suitable portions of the series combination, an impedance step-down action of practically any desired value can be obtained. In the most basic form of series damping arrangement in accordance with the present invention, the energy recovery will manifest itself in the unidirectional potential developed across the terminals of the inductance capacitance series, the potential being, of course, the sum of all the individual storage capacitors interposed between adjacent inductances. It is then only a matter of choice as to how this potential representing recovered energy is fed back into the overall system for improving the operating efficiency thereof. Figures 1 and 2, in this respect, are merely exemplary of two possible ways of advantageously using this recovered energy in the specific application of the invention to television deflection systems.

What is claimed is:

1. A damped electrical system comprising in combination, a plurality of inductance elements connected in series, at least one capacitance element connected in series between adjacent inductance elements, a plurality of damping instrumentalities connected with said series of capacitively connected inductances such that each damping instrumentality embraces a different inductance element but the same capacitance element, and means for exciting said series of capacitively connected inductances with alternating voltage.

2. A damped electrical system comprising in combination, a plurality of inductance elements connected in series, a capacitance element connected between adjacent inductance elements,

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a plurality of damping instrumentalities connected with said series of capacitively connected inductances such that at least two of said damping instrumentalities embrace a different inductance element but the same capacitance element, and means for exciting said series of capacitively connected inductances with alternating voltage.

3. A damped electrical system comprising in combination, a plurality of inductance elements connected in series to form a combination, at least one capacitance element connected between adjacent inductance elements, a plurality of damping instrumentalities connected with said series of capacitively connected inductances such that each damping instrumentality embraces only one inductance element and one only capacitance element, and means for applying alternating voltage across the extremities of said inductance combination.

4. A damped electrical system comprising in combination, two inductance elements connected in series, a capacitance element connected between said inductance elements, two damping instrumentalities connected with said series of capacitively connected inductances such that each damping instrumentality embraces a separate inductance element and said capacitance element, and means for exciting said series of capacitively connected inductances with alternating voltage.

5. An electrical damping system comprising in combination, a source of alternating voltage, a first and second electrical utilization means connected in series across said alternating voltage source, an impedance element, a first and second unidirectional current conducting damping means respectively connected across said first and said second utilization means, connections placing said impedance element in series with said first damping means such that unidirectional current flows in a given direction through said impedance element during action of said first damping means, connections placing said second damping means in series with said impedance element such that action of said second damping means causes unidirectional current flow through said impedance device in the same given direction of current flow produced by said first damping means whereby the potential appearing across said impedance element is a function of the additively combined damping currents conducted by said first and second damping means.

6. In an electrical damping system in combination, a source of alternating voltage, a first and second electrical utilization means connected in series across said alternating voltage source, a capacitor, a first and second unilaterally conductive damping devices respectively connected across said first and said second utilization means, connections placing said capacitor in series with said first damping means, connections placing said capacitance element also in series with said second damping device such that action of said second damping means causes said capacitor to receive charging energy in the same direction as that produced by said first damping device whereby the potential appearing across said capacitor is a function of the additively combined damping energy handled by said first and second damping device.

7. In an electrical damping system in combination, a first and second inductance device each having at least two utilization terminals, an impedance element connected with one terminal of each inductance device, connections applying

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the other terminals of the series inductance devices across a source of signal voltage, a first and second unilaterally conductive damping instrumentality, connections applying said first damping instrumentality across the series combination formed by said first inductance device and said impedance element, connections applying said second damping instrumentality across the series combination formed by said second inductance device and said impedance element, said damping instrumentalities being so polarized that the damping current flow through said impedance element due to said first damping instrumentality is in the same direction as the damping current flow through said impedance element produced by said second damping instrumentality whereby the potential developed across said impedance element is a function of the additively combined damping current of said first and second damping instrumentalities.

8. In an electrical system in combination, a first and second inductance devices, each having at least two utilization terminals, an impedance element connection with one terminal of each inductance device, a signal voltage generator connection with a source of operating energy, connections applying the output of said signal generator to the other terminals of said inductance devices, a first and second unilateral conductive damping instrumentalities, connections applying said first damping instrumentality across the series combination formed by said first inductance device and said impedance element, connections applying said second instrumentality across the series combination formed by said first inductance device and said impedance element, said damping instrumentalities being so polarized that the damping current flow through said impedance element due to said first damping instrumentality is in the same direction as the damping current flow through said impedance device produced by said second damping instrumentality, and connections placing said impedance element in series with said signal generator and its associated source of operating energy.

9. Apparatus according to claim 8 wherein said impedance element is a capacitor of sufficient size such that a substantially constant unidirectional potential is developed across its terminals due to energy communicated by said first and second damping instrumentalities.

10. In an electromagnetic cathode ray deflection system employing a deflection coil comprising at least two separate winding sections, said coil being adapted for excitation from a vacuum tube which in turn derives its operating energy from a source of unidirectional polarizing potential, a power recovery deflection coil damping arrangement comprising in combination, a first and second means for separately damping each coil winding section during one phase of the deflection cycle, an energy storage device, connections applying said energy storage device in series with each of said damping means and also in series with the connection of the vacuum tube with its associated unidirectional polarizing potential such that energy is stored in said storage means by said separate damping means during one portion of the deflection cycle and made available for utilization by said vacuum tube during another portion of the deflection cycle.

11. In an electromagnetic cathode ray deflection system employing a deflection coil comprising at least two separate winding sections, said coil being adapted for excitation from a vacuum

tube which in turn derives its operating energy from a source of unidirectional polarizing potential, a power recovery deflection coil damping arrangement comprising in combination, a first and second unilaterally conductive damping devices each separately connected for the respective damping of one of said deflection coil winding sections during one phase of the deflection cycle, a capacitance, and connections including said capacitor in series with each of said damping devices and also in series with the connection of the vacuum tube and its associated unidirectional polarizing potential such that energy is stored in said capacitor by said separate damping devices during said one portion of the deflection cycle is made available for utilization by said vacuum tube during another portion of the deflection cycle.

12. Apparatus according to claim 11, wherein a resistor is connected across the terminals of said capacitor for the purpose of correcting the waveform of the deflection signal current developed through said deflection coil winding sections.

13. In an electromagnetic cathode ray beam deflection system employing a deflection coil comprising at least a first and second separate winding section, each section having a first and second utilization terminals, a power recovery damping arrangement comprising in combination, a vacuum tube having at least an anode and a cathode, said vacuum tube being connected for excitation from a source of deflection signal, a source of polarizing potential for said vacuum tube anode-cathode circuit, a capacitor connected from the first terminal of the first deflection coil winding section to the first terminal of the second deflection coil winding section, means coupling deflection energy from said vacuum tube anode-cathode circuit to said deflection coil winding sections, a first unilaterally conductive damping device connected between said first coil winding section second terminal and said second coil winding section first terminal, a second unilaterally conductive damping device connected between said first coil winding section first terminal and said second coil winding section second terminal, and connections applying the terminal voltage developed across said capacitor as the result of the combined separate damping actions of said first and second damping devices in series with said source of polarizing potential and said vacuum tube anode-cathode circuit.

14. Apparatus according to claim 13, wherein said deflection energy coupling means comprises a step-down transformer having a primary connected in series with said vacuum tube anode-

cathode circuit and a secondary capacitively coupled to the second terminals of said first and second coil winding sections.

15. In an electromagnetic cathode ray system employing a deflection coil comprising at least a first and second separate winding section, each section having a first and second utilization terminals, a power recovery damping arrangement comprising in combination, a vacuum tube having at least an anode and a cathode said vacuum tube being connected for excitation from a source of deflection signal, a source of polarizing potential for said vacuum tube anode-cathode circuit, a capacitor connected from the first terminal of the first deflection coil winding section to the first terminal of the second deflection coil winding section, connections placing said first coil winding section second terminal and said second coil winding section second terminal in series with the anode-cathode circuit, a first unilaterally conductive damping device connected between said first coil winding section second terminal and said second coil winding section first terminal, a second unilaterally conductive damping device connected between said first coil winding section first terminal and said coil winding section second terminal whereby the effective polarizing potential for said vacuum tube anode-cathode circuit is increased by the magnitude of the terminal voltage developed across said capacitor as a result of the action of said first and second damping devices.

16. Apparatus according to claim 15, wherein the input terminals of an autotransformer pulse step-up type power supply is also connected with said anode-cathode circuit of said vacuum tube for the transformation of some deflection signal energy to a suitable high unidirectional potential for application to the accelerating electrode of a cathode ray electron tube.

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