

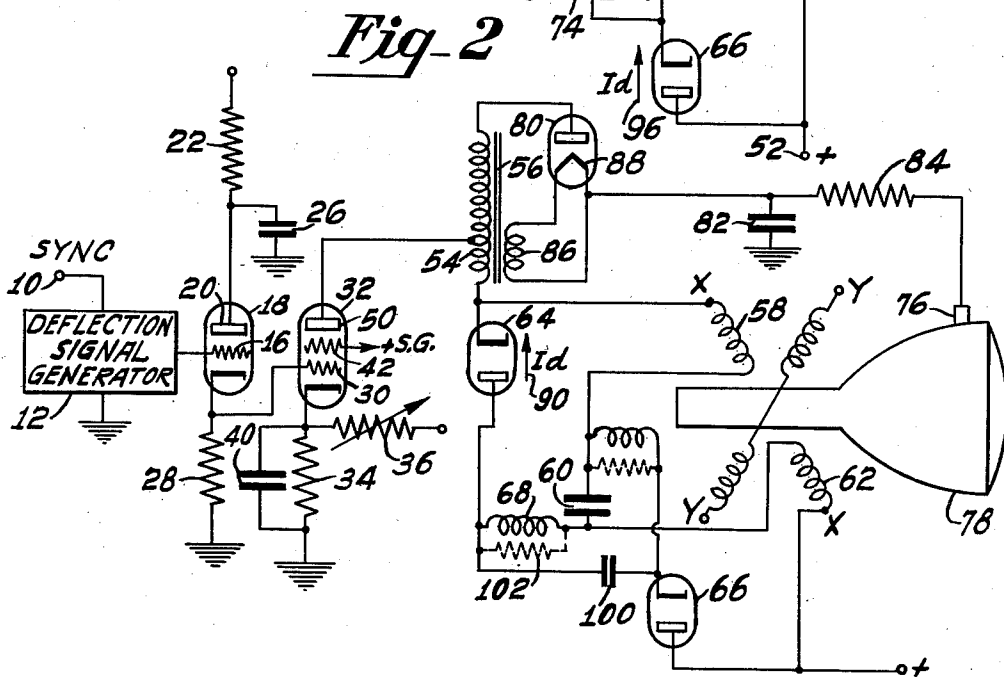
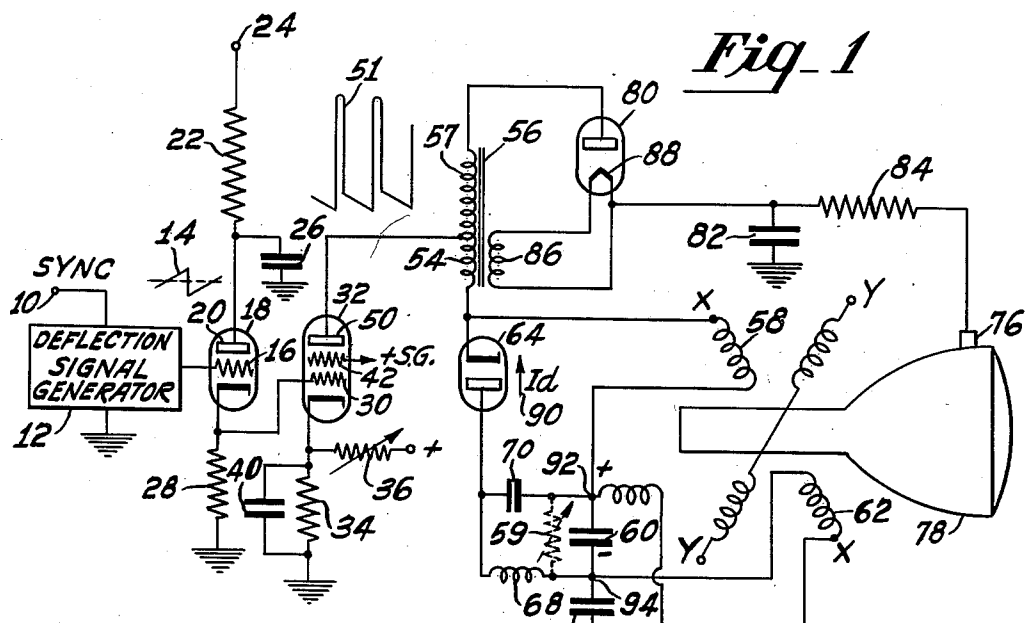
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TELEVISION DEFLECTION POWER RECOVERY CIRCUIT

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The present invention relates to electrical damping systems of the reaction scanning power recovery type and more particularly to electromagnetic cathode ray beam deflection circuits of the type employed in television 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 overall efficiency of operation is considerably lowered because of the energy dissipated in the damping circuits, this energy not being gainfully utilized. In early television practice, cathode ray electromagnetic beam deflection systems suffered substantial losses in this respect, which in turn stimulated the development of power recovery deflection 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 the B supply voltage applied to the vacuum tube driving the deflection system. Such power recovery or power feedback systems have 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 deflection coupling 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, until recently, a direct drive reaction scanning connection of this type has not been regarded as readily lending itself to high efficiency B boost power recovery operation. In my co-pending U. S. patent application, Serial No. 62,844 filed December 1, 1948, entitled "Power Recovery Damping System," there is, however, disclosed a direct drive circuit which provides a relatively high degree of B boost power recovery action. The major problem with this particular form of direct drive system, as well as other prior art arrangements, is that of obtaining sufficient linearity of sweep during that

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portion of the deflection cycle supplied by the reaction scanning operation in addition to correcting for the non-linearity of sweep distribution due to flatness of the cathode ray tube screen.

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 step-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, entitled "High Voltage Power Supply," this latter difficulty has been overcome in part through the use of an autotransformer having its primary connected in series with the deflection yoke circuit. The high voltage pulses appearing in the secondary winding are then rectified to produce the appropriate high unidirectional beam accelerating potential. The inclusion of this autotransformer primary in the yoke circuit does, however, reduce to a considerable extent the operating voltage actually supplied 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 the initial "B" potential represents considerable additional cost in the design of the television receiver low voltage power supply.

The present invention aims to provide a high efficiency low cost reaction scanning system of the direct drive B boost type which overcomes some of the disadvantages hereinabove set forth.

It is therefore a purpose of the present invention to provide an improved form of reaction scanning power recovery damping system for direct drive electromagnetic beam deflection systems which exhibits an efficient B boost action with an attendant high degree of deflection linearity.

Another object of the present invention rests in the provision of a novel and simple B boost circuit for direct coupled electromagnetic cathode ray beam deflection yokes in which energy from an associated reaction scanning damping circuit is recovered for B boost action and in which such a B boost recovery action is compensated in the reaction scanning cycle to provide substantially linear deflection operation.

It is another purpose of the present invention

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to provide an improved form of deflection circuit for television systems wherein a portion of the cyclically damped 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.

A still further object of the present invention is to provide certain improvements in the waveform of the deflection signal developed by the power recovery apparatus shown in my co-pending application, Serial No. 62,844, filed December 1, 1948.

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 by circuit diagram one form of the present invention as applied to a typical direct driven television deflection system;

Figure 2 shows by circuit diagram another form of the present invention as applied to a direct driven deflection system similar to that shown in Figure 1.

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 conventional deflection sawtooth waveform illustrated at 14. The signal 14 is then applied to grid 16 of a 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 resistor 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 connected 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. A cathode by-pass condenser, such as 40, may be provided to reduce signal degeneration in the cathode circuit of the output tube. Screen grid 42 is conveniently supplied with a positive polarizing potential indicated as S. G.

The anode 50 of the output vacuum tube 32 is then connected to a source of positive polarizing

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potential having a terminal at 52 through the series circuit comprising the primary winding 54 of autotransformer 56, the first section 58 of the deflection coil X—X, a storage capacitor 60, and the second section 62 of the deflection coil X—X. In accordance with my co-pending application, Serial No. 62,844, supra, damper diodes such as 64 and 66 are respectively connected through the storage capacitor 60 for damping the respective sections of the deflection coil 58 and 62.

According to the present invention, a low-pass filter circuit is connected between each of the damping diodes 64 and 66 and the storage capacitor 60. In the arrangement shown in Figure 1, the filter circuit shown associated with diode 64 comprises the inductance 68 and the capacitor 70 while the inductance 72 and associated capacitor 74 form the low-pass filter for the diode 66. It is noted in the case of Figure 1 that the inductive elements 68 and 72 provide a direct current conductive path from the respective diodes to opposite terminals of the capacitor 60.

As is shown, a novel form of high voltage power recovery supply for the accelerating anode 76 of the kinescope 78 is provided through the use of the autotransformer 56. This form of high voltage power supply for use in connection with deflection systems having deflection yoke directly connected in the anode-cathode circuit of the driven vacuum tube it is disclosed in the above-cited co-pending application by Simeon I. Tourshou et al., Serial No. 56,562. As more fully described in the Tourshou et al. specification, the output tube deflection current for the yoke winding X—X passes through the primary winding 54 of the autotransformer 56 and thereby induces in the autotransformer secondary 57 high voltage positive pulses corresponding in time to the kickback pulses 51 occurring at the plate 50 of the output tube 32. These high voltage pulses are then rectified by the diode 80 to develop a high unidirectional potential across the storage capacitor 82. The voltage appearing thereacross is further filtered through the resistor 84 acting in combination with stray circuit capacitance and applied to accelerating terminal 76 of the cathode ray tube 78. An auxiliary winding 86 of the transformer 56 may be arranged to supply heater power for the filament 88 of the high voltage rectifier 80.

As described in my co-pending application, Serial No. 62,844 filed December 1, 1948, the damping diodes 64 and 66 operate in accordance with basic reaction scanning deflection system operation in relationship to the individual sections of the deflection windings 58 and 62. Accordingly, the first part of the deflection cycle, which will be here considered as resulting from the reaction scanning effect of the individual diode damping, is provided by energy stored in the respective inductances 58 and 62 at the end of the retrace phase of the deflection cycle. It is well known to those skilled in the television art that 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 64 and 66 will become conductive to establish a reversed current flow through the respective winding sections, the current energy of which represents the stored magnetic energy in these coil sections. For instance, in the case of the diode 64, immediately following retrace, the diode 64 will become conductive to pass a damping current

id in the direction of the arrow 90. This passage of current in the direction indicated in effect adds energy to the capacitor 60 thereby making the terminal 92 thereof more positive than its corresponding terminals 94. In similar fashion the damping current of diode 66 connected to damp the second portion 62 of the yoke winding X—X is in the direction of the arrow 96, and can be seen to also add energy to the capacitor 60 and thereby cause the terminal 92 to charge positively with respect to the terminal 94. It is clear that the damping currents through the respective diodes 64 and 66 occur simultaneously so that as far as the yoke X—X is concerned a proper overall damping arrangement has been provided, the respective damping currents through the diode in practice being substantially equal.

Investigation of the circuit arrangement shows that the capacitor 60 is in fact placed in series between the positive B supply terminal at 52 and the anode 50 of the vacuum tube 32 so that any voltage developed across capacitor 60 is additively combined with the positive B supply. Thus, damped reactive energy is stored by capacitor 60 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 appreciated that if the storage capacitor 60 is made sufficiently large that its terminal voltage during the conduction period of the driver tube 32 will remain substantially constant allowing the production of a substantially linear sawtooth of current through the deflection coil X—X. As is well known to those skilled in the art, it is, however, not always desirable to produce a perfect sawtooth of current in order to achieve linear scanning distribution of the beam on the face of the kinescope. Such factors as the flatness of the cathode ray tube screen surface and the non-linear flux distribution of average deflection yoke coils make it often desirable to generate through the deflection coil itself a sawtooth of current having considerable deliberate distortion of a variety tending to compensate for these factors.

According to the embodiment of the present invention, as illustrated in Figure 1, in order to achieve proper shaping of the sawtooth current through the yoke, there is placed in the damping circuit of each diode a linearity control inductance, such as 68 and 72. Corresponding capacitors, such as 70 and 74, are then connected from the diode sides of the linearity control inductances to the opposite terminal of the storage capacitor 60.

With such an arrangement, the voltage variation of substantially sawtooth waveform appearing across the storage capacitor 60 during conduction of vacuum tube 32, will be shaped by the low-pass filters formed by the linearity control inductances 68 and 72 with their respective shunt capacitances 70 and 74. The resulting voltage will be somewhat parabolic in form and will in effect be placed in series with the anode-cathode circuit of the damper diodes. This parabolically varying voltage in the damping circuit will then act as a variable bias for the diodes 64 and 66 and act to control their degree of conduction during circuit operation. It is found that this control bias on the damper diodes so alters the resulting current flow through the yoke windings 58 and 62 to produce a linear deflection distribution of the beam on the cathode ray tube face and hence produce a high degree of overall deflection circuit linearity. The inductances 68

and 72, as well as the capacitors 70 and 74, forming the shaping network, may be made variable so that the linearity and size of the resulting deflection signal may be easily controlled. Furthermore, a variable resistor, such as 59 (shown in dotted lines), may be placed in shunt with the capacitor 64 in order to provide a further control over the waveform and size of the resulting deflection current. This resistance 59, although not necessarily employed, may assume values of from 5,000 to 10,000 ohms.

Another form of the present invention is shown in Figure 2, here the deflection signal output tube 32 is operated as in Figure 1 with a similar form of high voltage autotransformer 56 connected in its plate circuit to provide accelerating potential for the kinescope 78. As in Figure 1, the deflection yoke winding X—X is split into two sections 58 and 62 and connected by the "B boost" storage capacitor 60. Damping diodes 64 and 66 are again connected in shunt with the deflection coil sections 58 and 62 respectively and have in their respective damping circuits, the linearity control inductances 68 and 72. Here, however, the individual low-pass filter condensers 70 and 74 (in Figure 1) are omitted and replaced by a single capacitor 100 connected between the two linearity control inductances 68 and 72 at their damping diode terminations. This arrangement also provides shaping of the sawtooth of current normally appearing across the capacitor 60 and serially imposes an A. C. bias of parabolic waveform in series with each of the damping diodes thereby correcting the current sawtooth through the deflection yoke to achieve proper and linear distribution of the beam deflection on the kinescope screen. In practice, the arrangement in Figure 2 is found to yield results substantially equivalent to the arrangement of Figure 1 with the additional advantage of decreased circuit complexity and cost. Again, the individual linearity inductances 68 and 72 may be made variable as well as the capacitor 100 to act as a linearity and/or size control in the circuit. Moreover, a variable resistor such as 59 in Figure 1 may be placed in shunt with the capacitor 60 if further control over the size and linearity of the deflection action is desired.

In the practice of the present invention, it may be found that unavoidable stray circuit capacitances acting in combination with the linearity control inductances 68 and 72, as well as the effective inductive reactance of the primary 54 of the autotransformer 56 and the reactance of the deflection yoke itself will be responsible for the occurrence of spurious transients in the generated deflection signal current. It has been found that such transients may be notably reduced by employing linearity inductances having a sufficiently low Q. For a given linearity inductance Q, however, it is evident that the transients could also be reduced by applying damping resistors of a suitable value, such as 102 and 104 (shown in dotted lines in Figure 2) in shunt with the linearity control inductances. Furthermore, although a particular type of low-pass filter has been shown in Figures 1 and 2, it is manifest that more complex and different types of low-pass filters could be employed without departing from the spirit and scope of the present invention.

From the foregoing it can be seen that the applicant has provided an improved form of direct drive deflection circuit which provides reaction scanning and B boost power recovery with

an inexpensive and novel arrangement for control of the deflection signal waveform so as to correct the developed sawtooth current waveform for deflection distortion influences common to ordinary television apparatus.

What is claimed is:

1. In an electromagnetic cathode ray deflection system of the direct drive type which employs a winding of a deflection yoke connected in series with the anode-cathode circuit of an electronic output amplifier, a capacitor connected in series with the deflection yoke winding in the output amplifier anode-cathode circuit, a low-pass filter connected in shunt with a portion of the amplifier anode-cathode circuit which includes said capacitor a portion of said low-pass filter being conductive to direct current, and an electrical damper connected in shunt with a portion of said output amplifier anode-cathode circuit through at least the direct current conducting portion of said low-pass filter.

2. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection yoke coil connected in series with the anode-cathode circuit of an electronic output amplifier, a capacitor connected in series with the deflection yoke coil in the output amplifier anode-cathode circuit, a low-pass filter connected in shunt with a portion of the amplifier anode-cathode circuit which includes said capacitor, a portion of said low-pass filter being conductive to direct current, and an electrical damper connected in shunt through the direct current conducting portion of said low-pass filter with a portion of said anode-cathode circuit which embraces the series connection of said capacitor and deflection yoke.

3. In a cathode ray beam deflection and accelerating potential generating system of the type employing an electron discharge tube having directly connected in its anode-cathode circuit the series combination of a pulse step-up transformer primary winding and a cathode ray beam deflection yoke winding, such that undesirably excessive unidirectional voltage drop is produced across the pulse step-up transformer primary winding thereby tending to evasively reduce the active anode-cathode biasing potential of the electron discharge tube, a power recovery unidirectional potential boosting arrangement comprising in combination: a storage capacitor connected in series with the electron discharge tube anode-cathode circuit between the pulse step-up transformer primary winding and said deflection yoke winding, a low-pass filter circuit connected in shunt with said storage capacitor, said low-pass filter having a portion thereof conductive to direct current, a unilaterally conductive damping device connected in shunt through the direct current conductive portion of said low-pass filter with the series connection of the storage capacitor and at least a portion of said deflection yoke such that the voltage developed across said storage capacitor tends to compensate for the undesirable excessive voltage drop across said pulse step-up transformer primary winding.

4. In a cathode ray beam deflection and accelerating potential generating system of the type employing an electron discharge tube having directly connected in its anode-cathode circuit the series combination of a pulse step-up transformer primary winding and a cathode ray beam deflection yoke winding such that an undesirably excessive unidirectional voltage drop is pro-

duced across the pulse-step-up transformer primary winding thereby tending to reduce the average anode-cathode biasing potential of the electron discharge tube, a power recovery unidirectional potential boosting arrangement comprising in combination: a storage capacitor serially connecting the primary of said pulse step-up transformer with one terminal of said deflection yoke winding, an inductance and a capacitance connected in series with one another to form a wave-shaping network, connections placing said wave-shaping network in shunt with said storage capacitor, a unilaterally conductive damping device having an anode and a cathode, a connection from said damping device cathode through said inductance to the step-up transformer primary winding side of said storage capacitor, and a connection from said damping device anode to another terminal on said deflection yoke.

5. Apparatus according to claim 4 wherein said inductance connected in series with said capacitance to form said wave-shaping network is restricted in Q in accordance with undesirable circuit transients so as to minimize the appearance of these transients in the waveform of current through said deflection yoke winding.

6. In a cathode ray beam deflection and accelerating potential generating system of the type employing an electron discharge tube having directly connected in its anode-cathode circuit the series combination of a pulse step-up transformer primary winding and a cathode ray beam deflection yoke winding, such that an undesirably excessive unidirectional voltage drop is produced across the pulse step-up transformer primary winding thereby tending to reduce the active anode-cathode biasing potential of the electron discharge tube, a power recovery unidirectional potential boosting arrangement comprising in combination: a storage capacitor connected to one terminal of said deflection yoke winding, an inductance and a capacitance connected in series to form a wave-shaping network, connections placing said wave-shaping network in shunt with said storage capacitor, a unilaterally conductive damping device having an anode and a cathode, a connection from said damping device anode through said inductance to one side of said storage capacitor, and a connection from said damping device cathode to another terminal on said deflection yoke.

7. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection coil directly connected in the anode-cathode circuit of an output amplifier, the combination of, a first capacitor connected in series with said deflection coil in the output amplifier anode-cathode circuit, an inductance and second capacitor connected in series with one another to form a combination, said serially connected inductance and capacitor combination being placed in shunt with a portion of the amplifier anode-cathode circuit including said first capacitor, and an electrical damper connected in shunt with a portion of said output amplifier anode-cathode circuit through at least a portion of said inductance.

8. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection coil directly connected in the anode-cathode circuit of an output amplifier, the combination of, a first capacitor connected in series with said deflection coil in the output amplifier anode cathode circuit, an inductance and

second capacitor connected in series with one another to form a combination, said serially connected inductance and capacitor combination being placed in shunt with a portion of the amplifier anode-cathode circuit including said first capacitor, and an electrical damper connected in shunt with a portion of said output amplifier anode-cathode circuit including said first capacitor and deflection yoke through at least a portion of said inductance.

9. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection coil directly connected in the anode-cathode circuit of an output amplifier, the deflection coil comprising a first and second winding section, each having an inner and outer extremity, the combination of: a storage capacitor connected in series with the anode-cathode circuit of said amplifier between the inner extremities of the first and second deflection yoke winding sections, a low-pass filter having a first and second input terminals and corresponding first and second output terminals, a connection between the first deflection winding inner extremity and said filter first input terminal, connections between said second winding inner extremity and said second filter input terminal, a first unilaterally conductive damping device connected between the outer extremity of said first deflection winding section and said filter second output terminal, a second unilaterally conductive damping device connected between the outer extremity of said second deflection yoke winding section and said filter first output terminal.

10. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection coil directly connected in the anode-cathode circuit of an output amplifier, the deflection coil comprising a first and second winding section, each having an inner and outer extremity, the combination of: a first capacitor connected in series with the anode-cathode circuit of the output amplifier between the inner extremities of the deflection yoke first and second winding sections, a first network comprising the series connection of an inductance and capacitance, said first network being placed in shunt with said first capacitor, a first and second unilaterally conductive damping devices, each having an anode and a cathode, a connection between the outer extremity of the first yoke winding section and the first damping device cathode, a connection between the outer extremity of the second yoke winding section and the second damping device anode, an inductance connected between the inner extremity of the first yoke winding section and the cathode of the second damping device, an inductance connected between the inner extremity of the second yoke winding section and the anode of the first damping device, a capacitance connected between the inner extremity of the first yoke winding section and the anode of the first damping device, and a capacitance connected between the inner extremity of the second yoke winding section and the cathode of the second damping device.

11. Apparatus according to claim 10 wherein said inductance connected between the inner extremity of the first yoke winding section and the cathode of the second damping device and said inductance connected between the inner extremity of the second yoke winding section and the anode of the first damping device are each restricted in Q such to minimize spurious deflection

system response resulting from undesirable resonant conditions therein.

12. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection coil directly connected in the anode-cathode circuit of an output amplifier, the deflection coil comprising a first and second winding section, each having an inner and outer extremity, comprising the combination of: a first capacitor connected in series with the anode-cathode circuit of the output amplifier between the inner extremities of the deflection yoke first and second winding sections, a first network comprising the series connection of an inductance and capacitance, said first network being placed in shunt with said first capacitor, a first and second unilaterally conductive damping devices, each having an anode and a cathode, a connection between the outer extremity of the first yoke winding section and the first damping device cathode, a connection between the outer extremity of the second yoke winding section and the second damping device anode, an inductance connected between the inner extremity of the first yoke winding section and the cathode of the second damping device, an inductance connected between the inner extremity of the second yoke winding section and the anode of the first damping device, a capacitance connected between the inner extremity of the first yoke winding section and the anode of the first damping device, and a capacitor connected between the anode of the first damping device and the cathode of the second damping device.

13. In an electromagnetic cathode ray beam deflection system employing a deflection coil comprising at least a first and second separate winding sections, 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 storage 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 and second unilaterally conductive damping devices each having an anode and a cathode, an inductance connected between the first damping device anode and the first terminal of the second coil winding section, an inductance connected between the cathode of the second damping device and the first terminal of the first coil winding section, a connection between the first damping device cathode and the anode terminal of the first coil winding section, a connection between the second damping device anode and the second terminal of the second coil winding section; a capacitor connected between the anode of the first damping device and the cathode of the second damping device, and connections applying the terminal voltage developed across said storage capacitor as the result of the combined separate damping sections of said first and second damping devices in series with said source of polarizing potential and said vacuum tube anode-cathode circuit.

14. In an electromagnetic cathode ray deflection system of the direct drive type which employs a deflection coil directly connected in the anode-cathode circuit of an output amplifier in

combination: a first capacitor connected in series with said deflection yoke in said amplifier anode-cathode circuit; an inductance and second capacitor connected in series with one another; said serially connected inductance and capacitor being placed in shunt with a portion of the amplifier anode-cathode circuit including said first capacitor; a damping element having an anode and a cathode, a connection from said anode to the amplifier cathode side of said deflection yoke, and a connection from said damping element cathode to said inductance.

15 In an electromagnetic cathode ray beam deflection system employing a deflection coil comprising at least a first and second separate winding sections, 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 storage 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 and second unilaterally conductive damping devices each having an anode and a cathode, an inductance connected between the first damping device anode and the first terminal of the second coil winding section,

an inductance connected between the cathode of the second damping device and the first terminal of the first coil winding section, a connection between the first damping device cathode and the second terminal of the first coil winding section, a connection between the second damping device anode and the second terminal of the second coil winding section; a first capacitor connected between the first terminal of the first coil winding section and the anode of the first damping device, a second capacitor connected between the first terminal of the second coil winding section and the cathode of the second damping device, and connections applying the terminal voltage developed across said storage capacitor as the result of the combined separate damping sections of said first and second damping devices in series with said source of polarizing potential and said vacuum tube anode-cathode circuit.

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