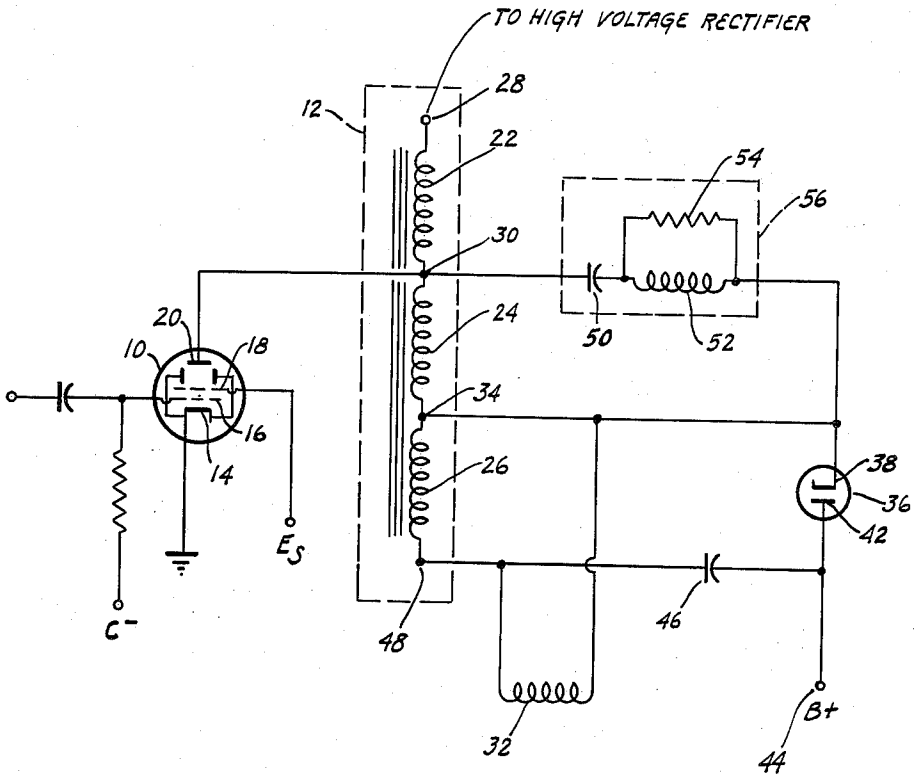
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ELECTRICAL SYSTEM

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ELECTRICAL SYSTEM

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This invention relates to electrical systems and more particularly, to improved electromagnetic systems of the type commonly used for deflecting the beam of a cathode-ray tube adapted to produce a television image.

In their usual form, electromagnetic deflection systems for the beam of a cathode-ray tube comprise a scanning yoke inductor which surrounds a portion of the tube in cooperative relationship with the cathode-ray beam, a source of a deflection signal for energizing the yoke, and a coupling system by which the source is coupled to the yoke in proper impedance matching relationship.

The energy source for the electromagnetic deflection system generally comprises a multigrid electron discharge tube of the beam tetrode or pentode type, such tubes being used because of their large power sensitivity. Tubes of these types are characterized by relatively high plate resistance values, whereas, in its usual form, the scanning yoke has an impedance which is relatively small. In order to achieve a satisfactory impedance match, the coupling element between source and yoke is thus necessarily a step-down coupling element. The coupling element generally takes the form of a transformer the input and output windings of which are appropriately related as to their numbers of turns, to produce the desired impedance ratio. In one form, the transformer may be an autotransformer having a single winding with appropriate taps, to which taps the source and the yoke are connected.

Most efficient energy transfer occurs when the coupling between the source and yoke is unity. However, in view of the different numbers of turns of the input and output windings, unity coupling cannot be fully achieved. The departure from unity coupling manifests itself as a leakage inductance effect, the magnitude of which is primarily determined by the geometry of the windings.

In the normal scanning cycle of the cathode-ray beam, the beam, starting from a given position, is advanced in one direction at a fairly uniform predetermined velocity and, at the end of the scanning cycle, is returned to its initial position. These movements of the beam may be produced by applying a signal of suitable waveform to the source, e. g., a sawtooth signal which, at the end of the scanning period, cuts off the source for at least a part of the flyback period and causes a collapse of the magnetic field in the coupling transformer and the deflection yoke. The energy which has been stored in the transformer and

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yoke during the scanning cycle may be dissipated to a greater or lesser extent by means of a suitably poled damping tube. Preferably, this energy is recovered, for example, by means of a so-called "boost" circuit which converts the magnetic field energy into additional supply energy for the source. Such a boost circuit may take the form of a capacitor coupled in series with a rectifier which usually is the damper tube above referred to. This series combination is connected in shunt with the yoke insofar as yoke currents are concerned, and in series with the anode supply of the source tube insofar as direct voltages are concerned.

Because of the leakage inductance referred to above, the boost circuit is unable to recover all of the energy stored in the deflection system at the end of the deflection cycle. This unrecovered energy has been found to produce spurious oscillations or ringing currents in the transformer windings. These spurious oscillations are undesirable from two standpoints. First, they may be radiated from the circuits in which they appear, causing interference in the nearby radio and television equipment. Secondly, these ringing currents are coupled to the anode of the tube constituting the source, and vary the anode potential during the flyback period. In practice, these spurious oscillations may have sufficient amplitude to cause the anode to assume periodically a considerably negative potential with respect to the screen grid of the tube, and may even cause the anode to assume a negative potential with respect to the cathode of the tube.

It has been found that when the potential of the anode of a beam tetrode or pentode undergoes variations of the above type, the negative voltage gradient between the screen grid and the anode may bring about further spurious oscillations of the type known as transit-time oscillations, and more especially, as Barkhausen-Kurz or Gill-Morrell oscillations. These oscillations, whose frequency is a function of the geometry of the tube, the tube electrode potentials and the external circuitry associated with the tube, may occur over a wide range of frequencies—of the order of fifty to thousands of mc./sec. Such high frequency currents have associated with them electromagnetic waves which are readily radiated by the tube and its associated circuits to surrounding circuits of the cathode-ray tube, e. g., to the video circuits of the receiver. Unless special precautions are taken, these radiations may overload the video-signal system of the receiver, and degrade the image seen upon the screen of

the cathode-ray tube. In some instances, the presence of these oscillations are manifested by irregular black lines on the screen of the cathode-ray tube, which lines are substantially perpendicular to the direction of scanning, and points of which lines usually occur near the start of the scanning lines.

It has been proposed to eliminate these transit-time oscillations by modifying the structure of the tube serving as the scanning signal source. Such a procedure, however, considerably increases the cost of the tube and has been found to be not effective for all circuit arrangements.

Another proposal has been to shield carefully the circuits in which the transit-time oscillations are likely to arise. While shielding may reduce image degradation by attenuating the radiated waves, it is an expensive expedient, particularly in assembly line production. Furthermore, since shielding does nothing to eliminate the transit-time oscillations themselves, the loss of energy represented thereby reduces the efficiency of the scanning circuit.

It has also been proposed to prevent these oscillations by reducing the screen grid voltage of the source tube during the flyback period. However, this method requires auxiliary equipment, the operation of which must be carefully synchronized in order that the screen grid potential is reduced to the proper value at the proper time.

It is an object of the invention to provide an improved magnetic deflection scanning circuit for a cathode-ray tube.

Another object of the invention is to provide an improved magnetic deflection scanning circuit in which spurious signals are reduced to a tolerable value or eliminated.

A further object of the invention is to provide an improved magnetic deflection scanning circuit in which radiation of spurious signals is reduced to a tolerable value or eliminated.

A specific object of the invention is to provide an improved magnetic deflection scanning circuit which is substantially free from transit-time oscillations.

A still further object of the invention is to provide an improved magnetic deflection scanning circuit characterized by simplicity of circuitry and low cost.

According to the invention, the foregoing objects are achieved, in an electromagnetic deflection system of the above-described type, by providing a low impedance path for the ringing currents, from the anode of the tube serving as a deflection energy source to the damping or boost component of the deflection circuit. By means of the low impedance path so provided, variations of the anode potential, which normally occur at the frequency or frequencies of the ringing currents generated because of the shock-excitation of the leakage inductance in the coupling transformer, are diminished. The anode is thus prevented from assuming a potential sufficiently negative with respect to the screen grid, particularly at or after the time at which the source tube begins to conduct, to produce the transit-time oscillations above referred to. In the preferred arrangement of the invention, this low impedance path between the anode of the source and the damping or boost circuit is a passive electrical network which comprises a series capacitor-inductor circuit, the components of which have values so selected that the circuit has a low impedance at the frequency of the ringing currents and has a high impedance at the scanning frequency.

The invention will be described in greater detail with reference to the appended drawing forming part of the specification, the single figure of which is a schematic diagram of a magnetic deflection system embodying the invention.

Referring to the drawing, the deflection system there shown comprises a source tube **10**, an autotransformer **12**, and a yoke **32**. Tube **10** comprises a cathode **14**, a control grid **16**, a screen grid **18** and an anode **20**. (Although tube **10** is specifically shown as a beam tetrode, it is apparent that the source tube may be a pentode or other multi-element tube.) The control grid **16** is energized by a suitable source of scanning potential (not shown), said source providing a scanning signal of generally sawtooth waveform in accordance with well-known practice. Approximate operating potentials are applied to the control grid **16** and the screen grid **18** from a source (not shown).

The autotransformer **12** comprises three winding sections, **22**, **24** and **26**, connected in series. The anode **20** of vacuum tube **10** is connected to the junction **30** of sections **22** and **24**, whereby the winding sections **24** and **26** together serve as an output coupling impedance for the tube **10**, whereas the yoke **32** is connected to the junction **34** of sections **24** and **26**, whereby the yoke is coupled to the winding **26**. In accordance with well-known practice, the turns ratio of the winding sections **24** and **26** is so selected that a desired impedance match between the tube **10** and the yoke **32** is effected.

Winding section **22** is the usual high voltage winding having a terminal **28** which may be connected to a suitable rectifier system (not shown) for supplying an accelerating potential for the beam of the cathode-ray tube.

The anode **20** of tube **10** is supplied from a suitable D. C. source (not shown), introduced at B^+ terminal **44**, and connected through a voltage boost circuit comprising a diode **36** and a boost capacitor **46**. Diode **36** has its cathode **38** connected to the junction **34** and its anode **42** connected to the B^+ terminal **44**. Capacitor **46** interconnects the anode **42** of tube **36** and the terminal **48** of the winding **26**.

In the normal operation of the scanning circuit, energy is stored during the scanning period of the beam in the transformer **12** and the yoke **32**. At the end of the scanning period the amplitude of the sawtooth voltage applied to grid **16** undergoes a sudden change, with the result that the anode current of source-tube **10** is suddenly cut off. This current cut-off causes the magnetic field of transformer **12** to collapse. The collapsing magnetic field induces a voltage across the winding sections of the transformer, of such polarity as to place terminal **28** of winding section **22** at a high positive potential with respect to ground. As already discussed, terminal **28** may be connected to a suitable rectifier system (not shown), so that part of the transformer energy is used to provide an accelerating voltage for the beam of the cathode-ray tube.

A second voltage pulse is further induced across section **26** by the changing magnetic field, of such polarity that the diode **36** conducts through the series path constituted by the diode, the capacitor **46** and the parallel combination of the winding section **26** and the yoke **32**. An additional part of the energy existing in the transformer **12** and the yoke **32** at the end of the

scanning period is accordingly supplied to the capacitor 46. This energy charges the capacitor 46 in a direction such that the voltage thereacross is in additive series relationship to the voltage at B+, so that the anode 20 of tube 10 is thereby energized at a total voltage equal to the sum of the B+ voltage and the voltage across capacitor 46.

Because of the leakage inductance of the transformer winding sections, all of the stored energy is not recovered by the high voltage system coupled to winding section 22, and by the boost circuit. The remaining part of the energy causes ringing currents to be set up in the resonant system constituted by the aforementioned leakage inductance and the distributed capacitance associated with the transformer windings, which ringing currents flow in winding 24. It has been found that these ringing currents are normally of sufficient magnitude to cause the anode 20 of tube 10 to be periodically driven to a potential considerably negative with respect to screen grid 18. The ringing currents are of sufficiently long duration so that the periodic lowering of the potential of the anode of tube 10 continues until conduction in the tube 10 is again initiated by the sawtooth wave applied to the control grid 16. Under these conditions, wherein a conduction path is provided through the tube 10, and the anode thereof is at a large negative potential with respect to the screen grid thereof, the criteria for generating transit-time oscillations in the tube 10 are fulfilled.

In accordance with the invention, these transit-time oscillations are substantially suppressed by insuring that the anode 20 does not assume an excessively negative potential with respect to screen grid 18 during the conduction period of tube 10. This result is accomplished in accordance with the invention by means of an auxiliary path coupled between the winding sections of the transformer 12 and the damping diode 36. This auxiliary path is so constituted that it provides a low impedance to the ringing currents, shunting them to alternating current ground potential through the diode 36, while nevertheless providing a high impedance path for the scanning currents in the transformer. As shown in the drawing, this path is an electrical network 56 which comprises a capacitor 50 and an inductor 52 connected in series, and which is connected between the junction 30 of the transformer and diode cathode 38. Preferably this path is series resonant at the frequency of the ringing currents so as to provide a desirably low impedance at the ringing frequency, and a desirably high impedance at the scanning frequency. In a typical arrangement, in which the ringing currents in winding section 24 have a frequency of the order of 220 kc./s., the capacitor 50 may have a value of 56 micromicrofarads and the inductor 52 may have a value of 9.5 millihenries.

In some instances, the inductor 52 may store sufficient energy to produce ringing currents of its own and thereby partially nullify the suppressive action of the path shunting the winding section 24. In accordance with a further feature of the invention, these ringing currents in the inductor 52 are attenuated by means of a damping resistor 54, which, as shown, is connected in shunt with inductor 52, but which, as is well known to those skilled in the art, may be connected in series with capacitor 50 and inductor 52.

The value of the damping resistor is determined by the amount of energy stored in the inductor and is selected so that the impedance of the network 56 remains sufficiently low to prevent the ringing currents induced in the transformer windings from continuing for a time beyond which the tube 10 begins to conduct. Typical values for resistor 54 in a network 56 which embodies an inductor and capacitor of the values given above, range from ten thousand to thirty thousand ohms.

The above-noted values for capacitor 50, inductor 52 and resistor 54 are given in connection with a transformer system having a self-resonant frequency of the order of 220 kc./s. as above specifically described. When ringing currents of frequency other than that specifically described are induced, the values of the capacitor 50, inductor 52 and resistor 54 are modified appropriately, as will be readily apparent to those skilled in the art.

The preceding discussion has assumed the existence of spurious ringing currents at only one frequency. In some instances, the transformer 12 may exhibit a plurality of such ringing currents, each occurring at a different frequency, in which case additional series-resonant circuits (not shown) conforming to the characteristics of network 56, may be connected between junctions 30 and 34, each such series-resonant circuit being tuned to the frequency of one of the said ringing currents.

While the network 56 has been shown to be connected across the whole of the winding 24, in some instances it has been found that satisfactory suppression of the ringing currents in the winding section 24 may be effected by connecting the network 56 between the junction 30, or the junction 34, and a tap on winding section 24 intermediate to the junctions 30 and 34, or between a tap on winding section 22 and a tap on winding section 24.

While we have described our invention by means of specific examples and in specific embodiments, we do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What we claim is:

1. A magnetic deflection system comprising a pulse signal source operating at a given repetition rate, a transformer comprising a plurality of winding elements connected in series and susceptible to ringing currents at a frequency different from said repetition rate, means to couple said winding elements to said source as a load therefor, a deflection element coupled to one of said winding elements, means to damp oscillations in said one winding element, and means to suppress ringing currents in another of said winding elements, said last-named means comprising a network shunting a portion of said other winding element, said network having a low impedance at the said frequency of said ringing currents and a high impedance at a frequency corresponding to said repetition rate.

2. A magnetic deflection system as claimed in claim 1, in which said means to damp oscillations in said one winding section comprises a unidirectional electrical conductor, and in which said means to suppress ringing currents in another of said winding sections comprises an electrical network, one terminal of which is connected to the source and a second terminal of which is

connected to an electrode of the said unidirectional electrical conductor.

3. A magnetic deflection system as claimed in claim 1, in which said network having a low impedance at said frequency of said ringing currents and a high impedance at a frequency corresponding to said repetition rate comprises a capacitive element and an inductive element connected in series relationship, said series circuit having a resonant frequency substantially equal to the frequency of said ringing currents.

4. A magnetic deflection system comprising a pulse signal source operating at a given repetition rate, said signal source being susceptible to transit-time oscillations, an autotransformer comprising first and second winding elements connected in series and susceptible to ringing currents at a frequency different from said repetition rate, means to couple said winding elements to said source as a load therefor, a deflection element comprising a deflection inductor coupled to said first winding element, means comprising a unidirectional electron discharge tube coupled to said first winding element and adapted to damp oscillations in said element, and means to suppress ringing currents in said second winding element and thereby to suppress said transit-time oscillations of said source, said latter means comprising an electrical network shunting a portion of said second winding element and having a low impedance at said frequency of said ringing currents and a high impedance at a frequency corresponding to said repetition rate.

5. A magnetic deflection system as claimed in claim 4, in which said electrical network interconnects said source and an electrode of said electron discharge tube, and in which said electrical network comprises a capacitive element and an inductive element connected in series relationship, said series circuit having a resonant frequency substantially equal to said frequency of said ringing currents.

6. A magnetic deflection system as claimed in claim 5, in which said electrical network further comprises a resistor for damping self oscillations in said electrical network.

7. A magnetic deflection system as claimed in claim 4 wherein said source is rendered periodically non-conductive at said given repetition rate and for a given time interval and wherein said electrical network substantially suppresses said ringing currents in a time interval less than said given time interval.

8. A magnetic deflection system comprising a pulse signal source operating at a given repetition rate, said signal source comprising a multi-element electron discharge tube having a cathode, a control electrode and an anode, said discharge tube being susceptible to transit-time oscillations, means to apply a signal to said control electrode, said signal having a frequency equal to said repetition rate and being adapted to interrupt conduction through said tube at said rate, an autotransformer comprising a winding having a tap defining first and second winding elements connected in series and being susceptible to ringing currents at a frequency different from said repetition rate, means for connecting the said anode to one end of said winding, a deflection yoke connected between said tap and the other end of said winding, a discharge tube having a cathode connected to said tap and having an anode, a capacitor interconnecting said anode and the said other end of said winding, means to apply a positive potential to said last-named anode, means to suppress ringing currents in said winding and thereby to suppress said transit-time oscillations within said multi-element electron discharge tube, said latter means comprising a capacitor and an inductor connected in series relationship between said last-named anode and said last-named cathode and having a resonant frequency substantially equal to said frequency of said ringing currents, and means comprising a resistor for damping self-oscillations in said circuit.

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