

PATENT SPECIFICATION

DRAWINGS ATTACHED

1.059.305



Date of Application and filing Complete Specification: Jan. 29, 1965.

No. 4163/65.

Application made in United States of America (No. 343539) on Feb. 10, 1964.

Complete Specification Published: Feb. 15, 1967.

© Crown Copyright 1967.

Index at acceptance: —H3 P(1M4, 1M5A2, 1M5S, 2A, 2L, 2R, 2T, 2U, 3E, 4T2, 5B)

Int. Cl.: —H 03 k 3/62

COMPLETE SPECIFICATION

Linearity Correction Circuits for Television Apparatus

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to linearity correction circuit arrangements for use in electromagnetic deflection circuits of television apparatus.

In accordance with the present invention, there is provided an electromagnetic deflection circuit comprising: a deflection output transformer having a winding formed of a plurality of turns; an electron beam deflection winding, positioned relatively to a cathode ray tube and adapted to deflect an electron beam of the tube when a sawtooth current is caused to flow in the deflection winding; means coupled to said transformer winding and adapted for exciting said transformer at a frequency f_h and causing a sawtooth current to flow in said deflection winding; a linearity correction network including a capacitor and an inductor coupled across a segment of said transformer winding and forming a circuit loop with the segment, said capacitor and inductor being adapted to provide resonance of said loop at a frequency f_r having a value substantially equal to the frequency f_h ; and means coupling said deflection winding between said correction network and said transformer winding.

The circuit loop may include a branch having an impedance adapted for reducing the Q of the loop circuit. The reduced Q of the circuit reduces the effect of deviations in the electrical characteristics of the different impedances in the loop on the amplitude and phase of a current circulating in the loop and thus eliminates the need for relatively close tolerance components.

[Price 4s. 6d.]

Means may be provided for adjusting the phase and amplitude of the circulating loop current with respect to the sawtooth current. For example, an adjustable reactive impedance may be coupled in a branch of the circuit loop. This arrangement provides a means for initially establishing a phase relation and amplitude to effect desired linearity correction and serves to adjustably re-establish these relations when variations in the electrical characteristics of circuit components occur.

The invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a diagram, partly in block and partly in schematic form, illustrating an embodiment of the present invention;

FIGURE 2 is an equivalent circuit diagram of the transformer output circuit illustrating the various currents flowing therein; and

FIGURE 3 is a diagram illustrating the various electrical current waveforms existing in the transformer output circuit.

FIGURE 4 is a diagram, partly in block and partly in schematic form, illustrating another embodiment of the present invention;

FIGURE 5 is a diagram illustrating the variation in the current circulating in the resonant circuit loop for different values of circuit Q;

FIGURE 6 is a diagram illustrating the variation in phase of circulating loop current for different values of circuit Q; and

FIGURE 7 is a partial schematic diagram of another embodiment of the linearity correction circuit of FIGURE 4.

Referring now to FIGURE 1, a horizontal deflection stage for a television apparatus is shown and is indicated generally as 10. The deflection stage is illustrated for use in a television receiver. Various other conventional stages of the television receiver which provide a driving signal for the deflection stage 10 are indicated as 12 and 14. The block 12

includes radio frequency, intermediate frequency amplifier, video detector, video amplifier, sync separator and automatic frequency control stages. The block 14 represents a conventional deflection waveform generator, such as a multivibrator or blocking oscillator. A direct current control voltage is coupled from the automatic frequency control stage of 12 to the waveform generator 14 for controlling the frequency of operation. A deflection waveform 16 is provided at an output terminal of the waveform generator 14 and is R—C coupled to a driver amplifier in the deflection stage 10.

The deflection stage is adapted to generate an electromagnetic field for deflecting an electron beam in a cathode ray tube 17. The deflection stage 10 includes, generally, a horizontal deflection winding 18, a horizontal output transformer 19, and a driver amplifier 20. The driver amplifier periodically excites the transformer and causes a sawtooth current to flow in the winding 18.

The driver amplifier 20 is conventional and comprises a pentode electron discharge device 21. An anode electrode 28 of the amplifying device 21 is coupled to a terminal 30 of a winding 31 of the horizontal output transformer 19. For the purposes of this specification and the accompanying claims, the expression "terminal" when utilized with respect to the transformer 19 refers to means for providing a direct current connection to the winding 31. The transformer includes a high voltage output terminal 36, an efficiency diode terminal 38, a secondary circuit output terminal 40, an intermediate terminal 42, and a secondary output terminal 44. A conventional power recovery circuit is provided and includes an efficiency diode 46 and a B+ boost capacitor 48. Direct current operating potential is coupled from a source 50 to a junction of an anode electrode of the efficiency diode 46 and boost capacitor 48. In a known manner, a boost voltage B++ is provided at the capacitor 48 during operation of the circuit. This voltage constitutes an anode operating potential for the pentode 21 and is applied thereto via a portion of the winding 31. A conventional adjustable width control inductor 52 is coupled between transformer terminals 42 and 44 for adjusting the amplitude of horizontal deflection.

The horizontal deflection winding 18 comprises a pair of windings 55 and 56 which are symmetrically disposed about the neck of a cathode ray tube 17. A capacitor 57 shunts the winding section 55 for tuning the deflection winding for minimum ringing. When a sawtooth current flows in the winding, an electromagnetic field is established at the cathode ray tube 17 for horizontally deflecting an electron beam, indicated by the dashed line 53, across a face of the picture tube 17. The winding 18 is coupled to the transformer

19 for establishing this sawtooth current in the deflection winding. A first terminal 58 of the winding 18 is coupled to the transformer secondary terminal 40 while a second terminal 59 is coupled to an L—C linearity correction network. An L—C network comprising a serially coupled inductor 60 and a capacitor 62 is coupled in parallel with a segment of the transformer winding extending between terminals 42 and 44. The expression "terminal" when referring to the deflection winding 18 refers to means providing a direct current connection to the winding 18.

A conventional high voltage rectifier 66 is coupled to a tertiary winding of the transformer which comprises those turns extending between terminals 30 and 36. The rectifier provides a direct current accelerating potential which is filtered by an R—C combination comprising capacitor 68 and resistor 70.

In operation, the voltage waveform 16 recurs periodically at a frequency f_h which, in a conventional television receiver, is 15.750 kilocycles per second. This waveform drives the pentode 21 into conduction during a latter portion of a trace segment 72 of the waveform 16. Driver tube current conduction contributes to the formation of a latter portion of a trace segment 73 of a sawtooth current waveform 74 flowing between terminals 58 and 59 of the winding 18. At the termination of the trace segment 72 of the voltage waveform 16, the pentode 21 is cut-off and a retrace segment 75 of the sawtooth current waveform is thereby generated. During retrace, various transient voltages exist in the output circuit of the transformer 19 including a flyback pulse 76 at a tertiary winding for establishing a high beam accelerating voltage. In addition, a voltage is developed across the winding of the transformer which causes current to flow in a reverse direction through the deflection winding 18 and in the diode 46. As is well known, this current contributes to the formation of the sawtooth current flowing in the winding 18 during the initial or early portions of the trace segment 73 of the sawtooth current waveform 74. In addition, a pulse voltage 77 is developed between terminals 42 and 44 during retrace. As is indicated herein-after, the energy of this pulse excites the aforementioned L—C network.

The inductor 60 and capacitor 62 form a circuit loop with the segment of the transformer winding extending between terminals 42 and 44. The circuit loop is adapted to be series resonant at a frequency f_r which is substantially equal to the horizontal deflection frequency f_h . The pulse 77 occurring between terminals 42 and 44 excites this resonant circuit and causes the circuit to oscillate. A sinusoidal current flows in this circuit loop and thereby provides a means for altering the form of the deflection wave.

For a detailed explanation of the manner

in which the sinusoidal current modifies the trace segment, reference is now made to FIGURES 2 and 3. FIGURE 2a is an equivalent AC circuit of a part of the deflection output circuit, while FIGURE 2b is an equivalent AC circuit of the deflection output circuit, but which does not include the capacitor 62 of the correction network for purposes of the explanation. In the arrangement of FIGURE 2b, it can be seen that the linearity inductor 60 is in series with the deflection winding 18 and thus comprises an inductive load in addition to the yoke winding 18. An uncorrected sawtooth current, i_{uo} , flows serially in these windings. A trace segment of this current has an exponential rise in amplitude as indicated in FIGURE 3A, and a non-linear segment 79 near the termination of the trace segment causes compression of the raster near an edge. Nonlinearity is illustrated by comparison of a linear dotted line 80 with the curves A, C and D of FIGURE 3. As indicated previously, it is desirable to reduce this compression.

In FIGURE 2a, the capacitor 62 provides a closed circuit loop I with the inductor 60 and the segment of the transformer windings between terminals 42 and 44, and a sinusoidal current is caused to flow in the loop as the loop is periodically excited by the pulse 77. A sinusoidal current i_s flows in the capacitor 62. This current is illustrated in FIGURE 3B. Part of this sinusoidal current, i_{s60} , flows in the inductor 60. Another part of this sinusoidal current, i_{s18} , flows in the deflection winding 18. These sinusoidal components add to provide the current i_s and combine with the uncorrected sawtooth current, i_{uo} , of FIGURE 3A to provide a resultant sawtooth currents i_{s60} and i_s in the inductor 60 and deflection winding 18 respectively. The waveform of the current i_{s60} is illustrated in FIGURE 3C. It can be seen that the non-linearity of this current is increased substantially over the uncorrected current of FIGURE 3A. Whereas the current i_{s60} combines with the current i_{uo} according to the relation $i_{s60} = i_{uo} + i_{s60}$, the current i_{s18} combines with the current i_{uo} according to the relation $i_s = i_{uo} - i_{s18}$. That is, the currents i_{s18} and i_{s60} are phase opposed with respect to i_{uo} . FIGURE 3D illustrates the resultant S-shaping of the trace segment of deflection current i_o .

In order to provide the desired S-shaping, the frequency f_s of the current i_{s18} should be substantially equal to the deflection frequency f_h . The frequency of the current i_{s18} may be regulated by regulating the resonant frequency of the circuit loop I. The amount of "S" shaping necessary to effect desired linearity correction may be provided by suitably adjusting the phase and amplitude of i_{s18} with respect to i_{uo} .

Thus, a relatively simple arrangement has been described for improving deflection line-

arity, yet which operates independently of the power recovery circuit and has little affect on the electrical characteristics of the yoke winding.

Referring now to FIGURE 4, the deflection system comprises a source 112 of deflection signal of desired waveform 113, a drive amplifier 114, an output transformer 116, and a deflection winding 118. The waveform generator 112 comprises a conventional relaxation oscillator having an output wave-shaping network.

The winding 118 is coupled between an output terminal 150 of the transformer winding and a linearity correction network 151, which includes a capacitor 152 and an inductor 154. The capacitor 152, which is coupled to a terminal 156 of the transformer winding, and the inductor 154, which is coupled to the terminal 136, form with that segment of the transformer winding 126 between terminals 136 and 156 a series circuit loop I. The electrical characteristics of the capacitor 152 and the inductor 154 are selected to provide that this circuit loop I is series resonant at the frequency f_s , where f_s is substantially equal to the frequency f_h . In order to maintain the established frequency of resonance, it has been proposed to use a capacitor 152 and an inductor 154 having close requirements on the tolerances of their electrical characteristics. These requirements add to the cost of the deflection system.

Circuit means comprising an impedance are coupled in a branch of the loop I for reducing the adverse effects resulting from deviations from the resonant frequency. In FIGURE 4, a resistance 164 is coupled in a branch of the loop I between the terminal 156 and the inductor 154. The resistance 164 has an ohmic value which substantially reduces the Q of the circuit loop from a value of Q_1 , provided by the inductor 154, the winding of the transformer, and the capacitor 152, to a lower value Q_2 , and consequently reduces or minimizes the effect of the aforementioned circuit variations.

In further explanation of the circuit operation, reference is made to FIGURES 5 and 6. In FIGURE 5, which is a plot of the amplitude of circulating loop current "i" flowing in the aforementioned branch vs. frequency, a curve 166 represents the selectivity of the circuit loop I when the capacitor 152, the inductor 154, and impedance of the segment of the winding are considered. These elements provide a Q characteristic referred to as Q_1 .

FIGURE 6 is a diagram illustrating the variation in the phase of circulating loop current as frequency of excitation varies. When FIGURE 6 is viewed in the analogous manner of FIGURE 5, it can be seen that a detuning of the resonant loop by a frequency deviation Δf_1 for the curve 168 causes a phase shift $\Delta\theta_1$. Linearity correction is dependent upon

both the amplitude and phase of the circulating current. Hence, these changes in current Δi_1 and phase shift $\Delta \theta_1$ substantially vary the waveform of a sawtooth deflection current and causes raster distortion. When the Q of the circuit is reduced, as indicated by the curves 170 in FIGURE 5 and 172 in FIGURE 6, it can be seen that corresponding variations in loop current Δi_2 and phase $\Delta \theta_2$ are substantially reduced for an equivalent shift in frequency Δf_1 . The reduced Q of the loop circuit, referred to as Q_2 , is provided by coupling an impedance, such as the resistor 164 in the circuit loop. Although a loss in power efficiency of the loop circuit accompanies this lower Q, a relatively stable and low-cost linearity correction circuit is provided.

In cathode ray tubes of the type having relatively large electron beam deflection angles, as for example the type 19AYP4 having a deflection angle of 114° , a relatively high energy level is required for scanning the electron beam. Because a corresponding high amplitude current circulates in the linearity correction circuit loop to provide the high current level with reasonable power input to the loop, a low loss circuit is desirable. Because of a relatively high Q attending the low loss circuit, a small deviation in the resonant frequency of the correction circuit loop may result in raster distortion.

Adjustable means for varying the amplitude of the circulating current and the resonant frequency of the circuit loop may be provided. By virtue of this adjustable means, deviations from the resonant frequency can be corrected. FIGURE 7, which is a diagram of the deflection circuit loop, illustrates another embodiment of the invention which is particularly useful with cathode ray tubes having a relatively large deflection angle. The similar components of FIGURES 4 and 7 are referenced by similar numerals. The circuit includes an adjustable inductance 174 coupled in a branch of the circuit loop. Adjustment of the inductance varies the frequency of resonance of the loop and operates to re-establish the desired resonant frequency when deviations occur. In addition, the adjustment of the inductor functions to vary the amplitude of circulating current. Energy is coupled into the loop during the occurrence of pulses 178. These pulses, which charge capacitor 152, have a duration approximately equal to the flyback time. By varying the inductance 174, the time constant of the circuit and thus the energy coupled into the circuit during occurrence of the pulses can be adjusted. When the resistance of inductor 174 is larger than desired, a resistor 176 is shunted across the inductor 174 to lower the effective dissipative impedance of the circuit.

Although the resistor 164 of FIGURE 4 is illustrated as coupled in series with the cap-

acitor 152 and in parallel with the inductor 174 in FIGURE 7, other arrangements of the resistor may work equally well. For example, it may, at times, be more desirable to couple the resistor in parallel with the capacitor or in series with the inductor 174 for adjusting the Q of the circuit.

WHAT WE CLAIM IS:—

1. An electromagnetic deflection circuit comprising: a deflection output transformer having a winding formed of a plurality of turns; an electron beam deflection winding positioned relative to a cathode ray tube and adapted to deflect an electron beam of the tube when a sawtooth current is caused to flow in the deflection winding; means coupled to said transformer winding and adapted for exciting said transformer at a frequency f_1 and causing a sawtooth current to flow in said deflection winding; a linearity correction network including a capacitor and an inductor coupled across a segment of said transformer winding and forming a circuit loop with the segment, said capacitor and inductor being adapted to provide resonance of said loop at a frequency f_2 having a value substantially equal to the frequency f_1 ; and means coupling said deflection winding between said correction network and said transformer winding.

2. An electromagnetic deflection circuit according to Claim 1, wherein said transformer winding has first, second, and third terminals, said second terminal being positioned along the length of said winding at a point electrically intermediate said first and third terminals; said capacitor and inductor are serially connected between said first and second terminals and have a junction point at a connection of said capacitor and inductor; said capacitor and inductor are adapted to form a series resonant circuit loop with a segment of the transformer extending between said first and second terminals; said deflection winding has first and second terminals; and means connecting the first terminal of said deflection winding to the junction point of said capacitor and inductor and said second deflection winding terminal to said third transformer terminal.

3. An electromagnetic deflection circuit according to Claim 2, wherein said inductor is connected to said first terminal and said capacitor is connected to said second terminal.

4. An electromagnetic deflection circuit according to Claim 1, wherein said capacitor, inductor and winding segment provide a characteristic circuit Q for the loop; and said network includes a resistor for decreasing the Q of the circuit loop.

5. An electromagnetic deflection circuit according to Claim 4, wherein a variable inductor shunts said resistor.

6. An electromagnetic deflection circuit according to Claim 1, wherein said circuit loop has a first branch including a capacitor and

both the amplitude and phase of the circulating current. Hence, these changes in current Δi_1 and phase shift $\Delta \theta_1$ substantially vary the waveform of a sawtooth deflection current and causes raster distortion. When the Q of the circuit is reduced, as indicated by the curves 170 in FIGURE 5 and 172 in FIGURE 6, it can be seen that corresponding variations in loop current Δi_2 and phase $\Delta \theta_2$ are substantially reduced for an equivalent shift in frequency Δf_1 . The reduced Q of the loop circuit, referred to as Q_2 , is provided by coupling an impedance, such as the resistor 164 in the circuit loop. Although a loss in power efficiency of the loop circuit accompanies this lower Q, a relatively stable and low-cost linearity correction circuit is provided.

In cathode ray tubes of the type having relatively large electron beam deflection angles, as for example the type 19AYP4 having a deflection angle of 114° , a relatively high energy level is required for scanning the electron beam. Because a corresponding high amplitude current circulates in the linearity correction circuit loop to provide the high current level with reasonable power input to the loop, a low loss circuit is desirable. Because of a relatively high Q attending the low loss circuit, a small deviation in the resonant frequency of the correction circuit loop may result in raster distortion.

Adjustable means for varying the amplitude of the circulating current and the resonant frequency of the circuit loop may be provided. By virtue of this adjustable means, deviations from the resonant frequency can be corrected. FIGURE 7, which is a diagram of the deflection circuit loop, illustrates another embodiment of the invention which is particularly useful with cathode ray tubes having a relatively large deflection angle. The similar components of FIGURES 4 and 7 are referenced by similar numerals. The circuit includes an adjustable inductance 174 coupled in a branch of the circuit loop. Adjustment of the inductance varies the frequency of resonance of the loop and operates to re-establish the desired resonant frequency when deviations occur. In addition, the adjustment of the inductor functions to vary the amplitude of circulating current. Energy is coupled into the loop during the occurrence of pulses 178. These pulses, which charge capacitor 152, have a duration approximately equal to the flyback time. By varying the inductance 174, the time constant of the circuit and thus the energy coupled into the circuit during occurrence of the pulses can be adjusted. When the resistance of inductor 174 is larger than desired, a resistor 176 is shunted across the inductor 174 to lower the effective dissipative impedance of the circuit.

Although the resistor 164 of FIGURE 4 is illustrated as coupled in series with the capacitor 152 and in parallel with the inductor 174 in FIGURE 7, other arrangements of the resistor may work equally well. For example, it may, at times, be more desirable to couple the resistor in parallel with the capacitor or in series with the inductor 174 for adjusting the Q of the circuit.

WHAT WE CLAIM IS:—

1. An electromagnetic deflection circuit comprising: a deflection output transformer having a winding formed of a plurality of turns; an electron beam deflection winding positioned relative to a cathode ray tube and adapted to deflect an electron beam of the tube when a sawtooth current is caused to flow in the deflection winding; means coupled to said transformer winding and adapted for exciting said transformer at a frequency f_h and causing a sawtooth current to flow in said deflection winding; a linearity correction network including a capacitor and an inductor coupled across a segment of said transformer winding and forming a circuit loop with the segment, said capacitor and inductor being adapted to provide resonance of said loop at a frequency f_r having a value substantially equal to the frequency f_h ; and means coupling said deflection winding between said correction network and said transformer winding.

2. An electromagnetic deflection circuit according to Claim 1, wherein said transformer winding has first, second, and third terminals, said second terminal being positioned along the length of said winding at a point electrically intermediate said first and third terminals; said capacitor and inductor are serially connected between said first and second terminals and have a junction point at a connection of said capacitor and inductor; said capacitor and inductor are adapted to form a series resonant circuit loop with a segment of the transformer extending between said first and second terminals; said deflection winding has first and second terminals; and means connecting the first terminal of said deflection winding to the junction point of said capacitor and inductor and said second deflection winding terminal to said third transformer terminal.

3. An electromagnetic deflection circuit according to Claim 2, wherein said inductor is connected to said first terminal and said capacitor is connected to said second terminal.

4. An electromagnetic deflection circuit according to Claim 1, wherein said capacitor, inductor and winding segment provide a characteristic circuit Q for the loop; and said network includes a resistor for decreasing the Q of the circuit loop.

5. An electromagnetic deflection circuit according to Claim 4, wherein a variable inductor shunts said resistor.

6. An electromagnetic deflection circuit according to Claim 1, wherein said circuit loop has a first branch including a capacitor and



* C L M S *

an adjustable inductor and a second branch
having an inductor.

A. M. & WM. CLARK,
Chartered Patent Agents,
5 Stone Buildings,
Lincoln's Inn,
London, W.C.2.

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1967.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained. *YR*

