LINE DEFLECTION CIRCUIT HAVING TRANSFORMER WITH TERTIARY WINDING TO COMPENSATE FOR HIGH VOLTAGE LOAD VARIATIONS
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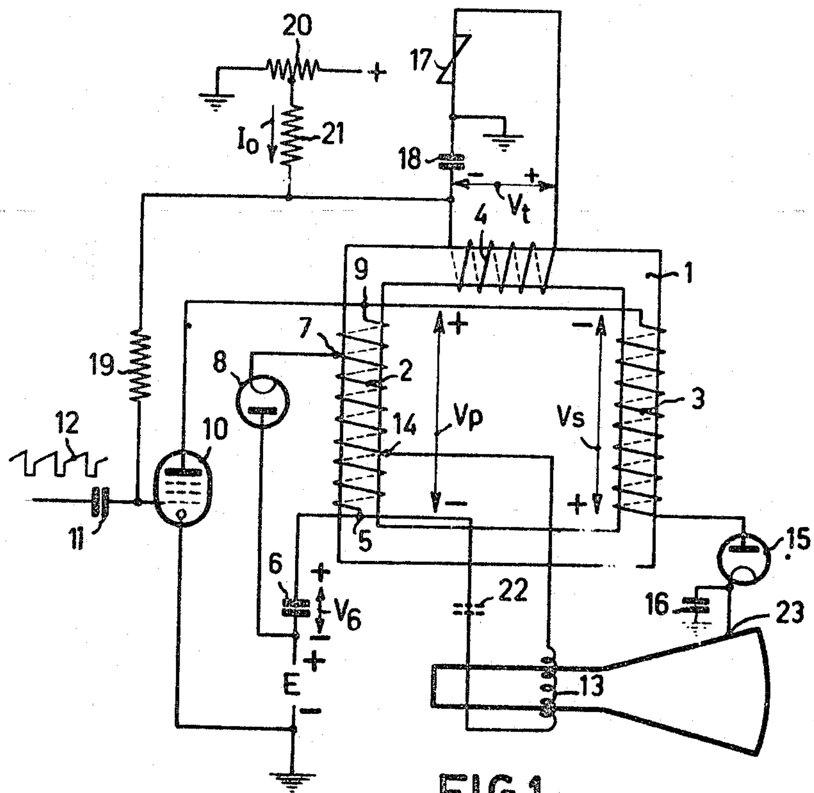

FIG.1

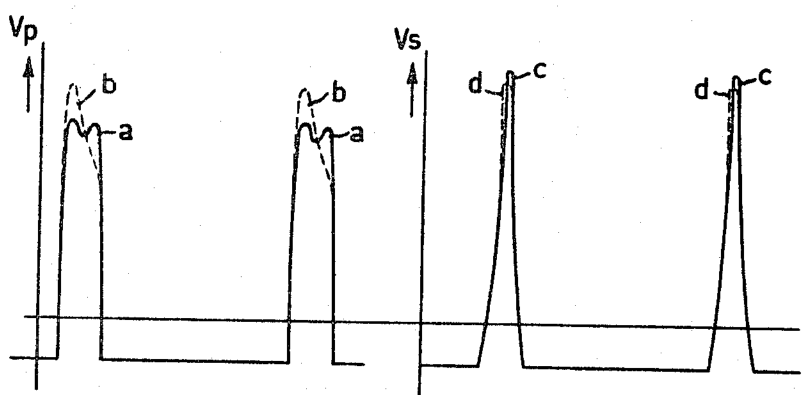

FIG.2

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LINE DEFLECTION CIRCUIT HAVING TRANSFORMER WITH TERTIARY WINDING TO COMPENSATE FOR HIGH VOLTAGE LOAD VARIATIONS

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The invention relates to a line deflection circuit for use in a television receiver, and more particularly to a deflection circuit including means for compensating for the high voltage load variations of the system. The circuit comprises a transformer connected in the output circuit of an amplifying element. The transformer primary winding is coupled to one or more deflection coils and the secondary winding is connected to a rectifier for producing an acceleration voltage for the final anode of the display tube. The transformer also includes a tertiary winding which supplies a voltage to a control-circuit by means of which a direct control-voltage is produced. The control voltage is in turn supplied to a control-electrode of the amplifying element to compensate for high voltage load variations.

The control-circuit contained in the arrangement of the kind set forth serves two purposes. In the first place variations of the slope of the sawtooth current passing through the deflection coils and of the high voltage produced are thus counteracted, which variations may be due to supply voltage fluctuations. In the second place the control-circuit serves to reduce variations of the slope of the sawtooth current due to variations of the mean brightness of the scene to be reproduced. To the secondary winding is connected the display tube via the rectifier, said tube constituting a load varying with the mean brightness of the scene to be reproduced. With an increasing brightness the high voltage produced and the slope of the sawtooth current are reduced. The control-circuit has for its object to keep the slope of the sawtooth current substantially constant for a varying high voltage load, whereby at the same time a certain degree of stabilisation of the high voltage is achieved.

In order to obtain a satisfactory control, it is desirable to supply to the control-circuit a voltage which depends not only upon the supply voltage but also upon the high-voltage load and which has, in addition, an adequate amplitude. These requirements are in general fulfilled only by the fly-back pulses occurring in the transformer.

In the known arrangements of the kind set forth the transformer is provided with a tertiary winding which is coupled magnetically and fixedly with the primary winding or which forms part of said primary winding. The primary fly-back pulses appearing across this tertiary winding are fed to the control-circuit.

A non-linear element is included in the control-circuit and conveys current only, or substantially only, during that part of the fly-back time in which the fly-back pulses supplied to the element are at a maximum. The arrangement adjusts itself for the operation of the control-circuit so that the maximum value of these pulses is kept constant. This provides a satisfactory stabilisation of the slope of the sawtooth current and of the high voltage in the event of supply voltage fluctuations.

It is found, however, not to be possible to obviate also the variations in the slope of the sawtooth current due to variations in the high-voltage load. This is due to the fact that with the variable high-voltage load there is not an unambiguous relationship between the slope of the

sawtooth current and the peak value of the primary fly-back pulses which is kept constant by the control-circuit. In spite of the constance of this peak value, the slope of the sawtooth current will vary with variations in the high-voltage load.

This phenomenon is principally due to the stray inductance always prevailing between the primary winding and the secondary winding of the transformer. This stray inductance is, moreover, chosen to be fairly high in order to avoid dying-out phenomena during the forward stroke (so-called third-harmonic tuning).

In order to obviate the aforesaid drawback, the control-circuit in known line deflection arrangements of the kind set forth receives apart from the primary fly-back pulses a voltage which depends, with a varying high-voltage load, unambiguously upon the slope of the sawtooth current. A first disadvantage of this method is, however, that optimum stabilisation cannot be attained. A second disadvantage consists in that the voltages available in the arrangement which depend unambiguously upon the slope of the sawtooth current are, in general, too low for the said purpose, so that it is necessary to include in the control-circuit a rectifying element with a control-electrode, to which said voltage is fed. For economical reasons the use of a rectifying element without a control-electrode in the control-circuit is preferred, for example, a voltage-dependent resistor.

The invention provides a line deflection arrangement in which a single voltage-dependent resistor as a rectifying element in the control-circuit is sufficient, whilst nevertheless a satisfactory control is obtained. Furthermore, it is possible to maintain a strict control over the slope of the sawtooth current or to allow this slope to vary slightly with the varying high-voltage, which may be desirable under certain conditions.

The line deflection arrangement according to the invention is characterized in that the tertiary winding is magnetically coupled both with the primary winding and with the secondary winding, so that the ratio between the part of the tertiary voltage which corresponds to the secondary voltage and the part of the tertiary voltage which corresponds to the primary voltage lies between 0.2 and 5, whilst the polarities of the two said parts of the tertiary voltage are the same.

The invention is based on the recognition of the fact that by adding secondary fly-back pulses to the primary fly-back pulses to be fed to the control-circuit the instant at which the rectifying element of the control-circuit is mainly conducting is displaced towards the middle of the fly-back time, where a substantially unambiguous relationship exists between the primary fly-back voltage and the slope of the sawtooth current, whilst, moreover, by the choice of the magnitude of the secondary fly-back pulses to be added the influence of the finite control-gain can be compensated wholly or partly.

It should be noted that it is already known to derive a voltage from a tertiary winding coupled with the primary winding and with the secondary winding, said voltage being fed to a phase detector in the television receiver. The measure according to the invention, however, serves a different purpose and the principle of the known measure deviates completely from the fundamental idea of the invention.

The invention will be described more fully with reference to the accompanying drawing, in which

FIG. 1 shows an embodiment of a line deflection circuit arrangement according to the invention.

FIG. 2 serves for explaining the measure according to the invention.

Referring to FIG. 1, reference numeral 1 designates an output transformer comprising a closed circuit of ferromagnetic material, on which are arranged a primary winding 2, a secondary winding 3 and a tertiary winding 4. The primary winding is connected at one end 5 via a large booster capacitor 6 to the positive terminal of a supply voltage source E, whilst a tapping 7 of the primary winding is connected through an efficiency diode 8 to the said positive terminal. The end 9 of the primary winding is connected to the anode of a pentode 10, the cathode of which is connected to earth (the negative terminal of the supply voltage source) and to the control-grid of which is fed via a capacitor 11 a signal 12, which blocks the pentode periodically. The connections of the further electrodes of the pentode are not indicated since they may be made in any known manner.

One or more horizontal deflection coils 13, arranged on the display tube and producing the horizontal deflection of the electron beam in the display tube, are connected between the end 5 of the primary winding of the transformer and a tapping 14 of the same. For the whole duration of the forward stroke the pentode 10 is made conductive by the control-signal 12 to an extent such that the diode 8 is conducting. Between the connections 5 and 7 of the transformer there prevails, consequently, the constant booster voltage V_6 of the capacitor 6 for the whole duration of the forward stroke. The transformed constant voltage V_6 appears also throughout the primary winding and across the deflection coils 13. This voltage produces in the deflection coils a sawtooth current, which may, if desired, be given a substantially S-shaped waveform by including in series with the deflection coils a capacitor 22 of suitably chosen capacitance.

During the fly-back time, the pentode 10 is blocked by the control-signal 12, so that the diode 8 is also blocked. The energy available in the transformer and in the deflection coils then produces an electric oscillation across the parasitic capacities of the transformer and of the deflection coils, so that a large positive voltage pulse (the primary fly-back pulse) is produced across the primary winding. This positive voltage pulse is stepped up in the secondary winding 3 and rectified by means of a rectifier 15. The positive direct voltage thus obtained is smoothed by a capacitor 16 and fed to the final anode 23 of the display tube.

The display tube thus constitutes a high-voltage load varying with the mean brightness of the scene to be reproduced and connected to the rectifier 15. Owing to an increasing high-voltage load the voltage of the booster capacitor 6 drops for a number of periods and hence the slope of the sawtooth current in the deflection coils 13 decreases. A decrease in high-voltage load involves an increase in booster voltage and hence an increase of the slope of the sawtooth current.

For counteracting these variations of the booster voltage the arrangement of FIG. 1 includes a control-circuit comprising a tertiary winding 4 on the transformer and the series combination of a voltage-dependent resistor 17 and a capacitor 18, to which the fly-back pulses appearing across the tertiary winding 4 are fed. The junction of the voltage-dependent resistor 17 and the capacitor 18 is connected to earth and the direct voltage occurring across the capacitor 18 due to the rectifying effect of the element 17 is supplied via a resistor 19 to the control-electrode of the pentode 10. When due to a drop in high-voltage load the booster voltage and hence the fly-back pulses of the transformer increase, also the tertiary fly-back pulses fed to the series combination 17, 18 increase. Owing to the rectifying effect of the element 17 an increasing negative direct voltage is produced across this element and hence across the capacitor 18, which voltage is fed via the resistor 19 as a control-voltage to the control-grid of the pentode. Thus the anode current of the pentode decreases, so that the booster voltage is reduced. In a similar manner the effect of an increase in high-voltage load is compensated by the control-circuit. Moreover, the undesirable influence of variations in the supply voltage from the source E is neutralised by the control-circuit.

In the embodiment shown in FIG. 1 the control-circuit is provided with a high-ohmic direct-current source formed by a potentiometer 20, connected to the direct voltage and a large resistor 21. This direct current source supplies via the tertiary winding 4 to the voltage-dependent resistor an adjustable direct current I_0. It is known that this measure provides a considerable increase in control-gain, whilst by the adjustment of said direct current the values of the voltages of the transformer and hence the width of the image reproduced by the display tube can be adjusted.

In known deflection arrangements of the kind set forth the tertiary winding is magnetically and fixedly coupled with the primary winding or the tertiary winding is formed as part of the primary winding. It has been found, however, that in this case correct stabilisation of the booster voltage can not be obtained with a varying high-voltage load. The cause thereof will be explained with reference to FIG. 2.

FIG. 2 illustrates the voltage (V_p) across the primary winding of the transformer for a low high-voltage load (curve *a*) and for a great high-voltage load (curve *b*) with such a control that the voltage occurring during the forward stroke and hence the booster voltage V_6, which is proportional to the primary forward-stroke voltage remain constant. Curves *a* and *b* of FIG. 2 illustrates the primary voltage in dependence upon the high-voltage load with an ideal control aimed at for maintaining a constant slope of the sawtooth current across the deflection coils 13.

From this figure it is apparent that such an ideal control cannot be achieved by means of a control-circuit receiving only the primary fly-back pulses. Since the rectifying element of the control-circuit (the voltage-dependent resistor) is conducting only or substantially only during the peak value of the pulses fed thereto, the arrangement will adjust itself always so that this peak value is kept substantially constant. Since, as will be seen from curves *a* and *b* of FIG. 2 the peak value of the primary fly-back pulses strongly depends, with an ideal control, upon the high-voltage load, a control deviating considerably from the ideal control is obtained, when this peak value is kept strictly constant. With such a control the booster voltage V_6 and hence the slope of the deflection current will exhibit a drop with an increase in high-voltage load; this drop is, indeed, considerably smaller than in the absence of a control, but the control is far from being satisfactory.

It should be noted that the waveform of the fly-back pulses deviating materially from the sine-wave form and depending strongly upon the high-voltage load is due to the effect of the diode 15 varying with the high-voltage load and to the stray inductance occurring between the primary winding 2 of the transformer and the secondary winding 3 thereof. This stray inductance is often chosen so high that during the forward stroke no dying-out phenomena occur (so-called third-harmonic tuning).

For obviating this disadvantage use is made, in accordance with the invention, of the fact that, as will be seen from curves *a* and *b* of FIG. 2 the primary fly-back voltage is substantially independent of the high-voltage load during the middle of the fly-back period in the case of an ideal control. It must therefore be ensured that the rectifying element of the control-circuit is conducting only or substantially only during the middle of the fly-back period and in accordance with the invention this is achieved by adding adequate secondary fly-back pulses to the primary fly-back pulses to be fed to the control-circuit. The secondary fly-back pulses, as will be seen from curves *c* and *d* of FIG. 2, exhibit narrow peaks very suitable to this end during the middle of the fly-back period. By adding sufficiently high secondary fly-back pulses to the primary fly-back pulses to be fed to the control-circuit the maximum value of the teritary voltage and hence the instant when the element 17 is mainly conducting are shifted from the first part of the fly-back period towards the centre thereof. The measure according to the invention provides an additional advantage in that sufficiently high secondary fly-back pulses are available in the arrangement, so that a control-circuit including only a voltage-dependent resistor will suffice.

A further advantage of the measure according to the invention is that the peaks of the secondary fly-back pulses exhibit flattening, since the diode **15** is conducting during these peaks, which flattened part increases with an increase in high-voltage load. Curves *c* and *d* of FIG. 2 illustrate the waveform of the secondary fly-back pulses for a low and a high high-voltage load with a constant forward-stroke voltage. The larger flattening with an increase in high-voltage load results in that, when the control-circuit would receive only secondary fly-back pulses an overcompensation control would be obtained, which would mean that the booster voltage V_6 would increase with an increase in high-voltage load.

By adding in the correct ratio the secondary fly-back pulses to the primary fly-back pulses to be fed to the control-circuit it can be ensured that the influence of the finite steepness of the control-circuit, resulting in an insufficient compensation of the influence of the varying high-voltage load, is neutralised by the overcompensation of the secondary fly-back pulses fed to the control-circuit.

FIG. 1 illustrates how the measure according to the invention can be carried out in practice. In this embodiment the output transformer comprises a ferro-magnetic circuit composed of four limbs arranged in a square and connected with each other. The primary winding **2** and the secondary winding **3** are arranged on two opposite limbs and the tertiary winding is disposed on one of the intermediate limbs of the transformer, so that the tertiary winding is coupled partially with the primary winding and partially with the secondary winding.

By displacing the tertiary winding along the intermediate limb, the extent of the control can be adjusted at will. From the foregoing it will be obvious that a shift of the tertiary winding into an excessively near proximity of the primary winding results in a control in which the influence of the varying high-voltage load on the deflection currents is not completely compensated, whereas a shift of the tertiary winding to an excessively near proximity of the secondary winding results in overcompensation. It should be noted here that it will not always be the intention to obtain a strict stabilisation of the deflection currents. In accordance with the aspect ratio of the display tube, and with the degree of dependence of the high voltage fed to the final anode of said tube upon the high-voltage load, it may be preferred to have a booster voltage varying slightly with the high-voltage load. For this purpose the invention provides a simple method in which the tertiary winding can be arranged at such a place of the intermediate limb that a control is obtained which corresponds to the optimum to the preference of the designer.

In accordance with the invention the control-circuit receives a tertiary voltage which is composed of a part corresponding to the secondary voltage and a part corresponding to the primary voltage, whilst the ratio (ϵ) between the part corresponding to the secondary voltage and the part corresponding to the primary voltage lies between 0.2 and 5.

From a calculation it will be seen that it applies to this ratio ϵ that:

$$\epsilon=\frac{\dfrac{k_{23}}{k_{13}}-k_{12}}{\dfrac{1}{k_{12}}-\dfrac{k_{23}}{k_{13}}} \qquad \text{(I)}$$

wherein

k_{12} is the coefficient of coupling between the primary winding and the secondary winding,

k_{13} is the coupling coefficient between the primary winding and the tertiary winding and

k_{23} is the coupling coefficient between the secondary winding and the tertiary winding.

The ratio ϵ may be measured in a simple manner on a transformer.

If α_{12} and α_{13} designate the ratios between the secondary voltage and the tertiary voltage, respectively, to the primary voltage when the supply voltage is fed to the primary winding and when the secondary winding and the tertiary winding are not loaded, and

α_{21} and α_{23} designate the ratios between the primary voltage and the tertiary voltage, respectively, to the secondary voltage when the supply voltage is fed to the secondary winding and the primary winding and the tertiary winding are not loaded, it applies to ϵ that:

$$\epsilon=\frac{\dfrac{\alpha_{23}}{\alpha_{13}}-\alpha_{21}}{\dfrac{1}{\alpha_{12}}-\dfrac{\alpha_{23}}{\alpha_{13}}} \qquad \text{(II)}$$

It should be noted that in accordance with the invention the series combination of for example two windings, one of which is magnetically and fixedly coupled with the primary winding or forms part of the latter, whereas the other is coupled magnetically and fixedly with the secondary winding or forms part thereof, may be considered to be a tertiary winding. The ratio ϵ can then be calculated in the manner described above.

What is claimed is:

1. A deflection circuit for a display tube comprising, amplifier means for generating a deflection signal and including a control electrode, a transformer comprising a primary winding, a secondary winding, and a tertiary winding inductively coupled with both the primary winding and the secondary winding so as to have induced therein a tertiary flyback voltage composed of first and second voltage components corresponding to the primary and secondary winding flyback pulses, respectively, said transformer windings being arranged so that the polarity of said first and second components are the same and the ratio of said second voltage component to said first voltage component lies in the range between 0.2 and 5, means for applying said deflection signal to said primary winding, a deflection coil coupled to said primary winding, a rectifier connected to said secondary winding to produce the high voltage for the acceleration anode of said display tube, a control circuit coupled to said tertiary winding and including a non-linear element for developing a direct current control voltage determined by said tertiary voltage, and means for supplying said direct current voltage to said control electrode thereby to compensate for variations in the high voltage load.

2. A circuit as described in claim **1** wherein said non-linear element comprises a voltage-dependent resistor, a capacitor, said control circuit comprising the series combination of said capacitor and said voltage-dependent resistor and means for supplying said tertiary voltage to said series combination.

3. A circuit as described in claim **1** wherein said transformer further comprises a ferromagnetic core comprising four interconnected limbs arranged in the shape of a rectangle, said primary and secondary windings being arranged on two opposed limbs of the rectangle and said tertiary winding being arranged on one of the remaining limbs thereof.

4. A circuit as described in claim **3** wherein the position of said tertiary winding on said one limb is adjustable so as to vary the coefficient of coupling between said tertiary winding and said primary and secondary windings.

5. A circuit as described in claim **1** further comprising a capacitor connected in series with said non-linear element and across said tertiary winding, means for connecting the common junction between one terminal of said capacitor and the non-linear element to a fixed potential, and direct current connecting means for coupling the other terminal of said capacitor directly to said control electrode.

6. A circuit as described in claim **1** wherein said non-linear element comprises a resistance element having a non-linear symmetrical current-voltage characteristic, said control circuit further comprising a capacitor connected in series circuit with said resistance element and said tertiary winding, and means providing a direct voltage bias to said resistance element.

7. A deflection circuit for a television receiver comprising, an amplifier device having a control electrode and an output electrode, a transformer comprising a primary winding, a secondary winding, and a tertiary winding inductively coupled with both the primary winding and the secondary winding, a source of direct voltage, means connecting said primary winding and said output electrode in series with said voltage source, means coupled to said control electrode for interrupting the current flow in said amplifier device so as to cause a deflection current to flow in said primary winding, said tertiary winding having induced therein a flyback voltage pulse composed of first and second components of voltage in a predetermined ratio and of the same polarity and corresponding to the primary and secondary winding flyback pulses, respectively, a rectifier interconnecting said secondary winding and the acceleration anode of the receiver display tube, a control circuit for stabilizing the current in said amplifier device upon variation of said direct voltage comprising a non-linear element coupled to said tertiary winding for developing a direct current control voltage proportional to said tertiary flyback pulse, and means for supplying said direct current voltage to said control electrode in a sense to counteract said variation of the direct voltage.

8. A circuit as described in claim **7** wherein the ratio ϵ of said second component of voltage to said first component of voltage is given by the expression:

$$\epsilon=\frac{\frac{k_{23}}{k_{13}}-k_{12}}{\frac{1}{k_{12}}-\frac{k_{23}}{k_{13}}}$$

wherein k_{12} is the coefficient of coupling between primary and secondary windings, k_{13} is the coefficient of coupling between primary and tertiary windings, and k_{23} is the coefficient of coupling between secondary and tertiary windings.

9. A circuit as described in claim **8** wherein said primary, secondary and tertiary windings are arranged on a common magnetic core so that the value of ϵ lies in the range between 0.2 and 5.

10. A circuit as described in claim **7** wherein said control circuit further comprises a capacitor connected in series with said non-linear element and said tertiary winding for developing said direct current control voltage, said means for supplying comprising a direct current connection for applying the voltage across said capacitor to said control electrode.

References Cited by the Examiner

UNITED STATES PATENTS

2,907,825 10/1959 Janssen .... 315—27 X

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