June 29, 1965 HANS-DIETER SCHNEIDER 3,192,433

CIRCUIT ARRANGEMENT FOR MODIFYING THE DEFLECTION CURRENT WAVEFORM OF TRANSFORMER-COUPLED SCAN GENERATORS

Filed Jan. 31, 1963 2 Sheets-Sheet 1

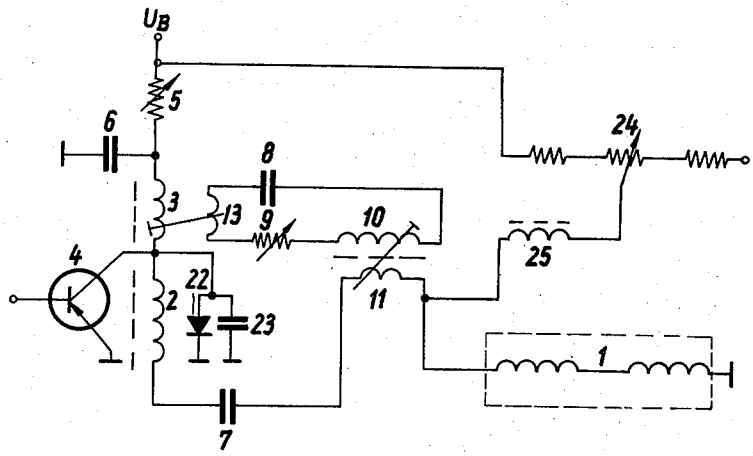


Fig.1

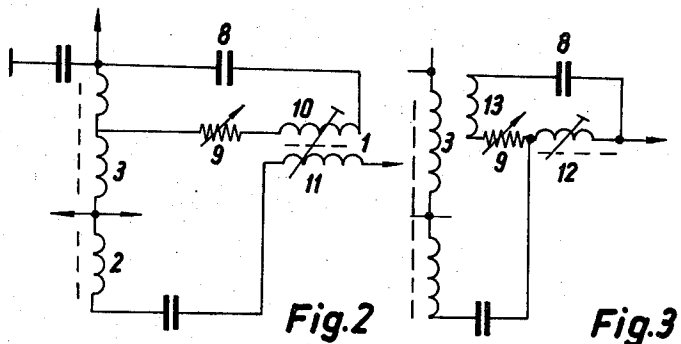


Fig.2

Fig.3

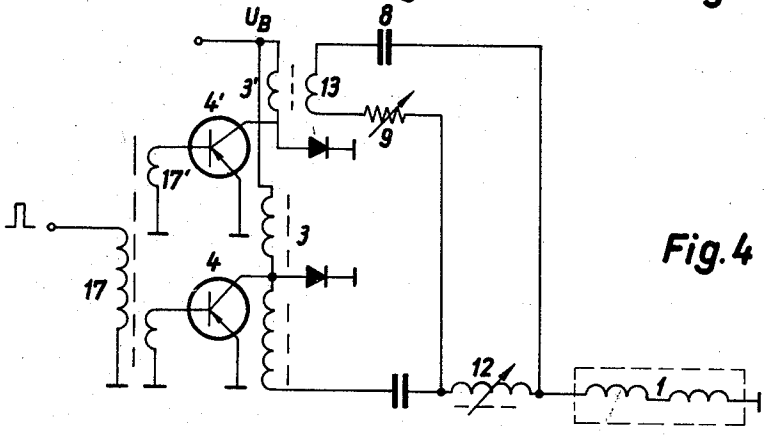


Fig.4

Inventor:
Hans-Dieter Schneider
by Michael S. Striker
Attorney

June 29, 1965 HANS-DIETER SCHNEIDER 3,192,433

CIRCUIT ARRANGEMENT FOR MODIFYING THE DEFLECTION CURRENT WAVEFORM OF TRANSFORMER-COUPLED SCAN GENERATORS

Filed Jan. 31, 1963 2 Sheets-Sheet 2

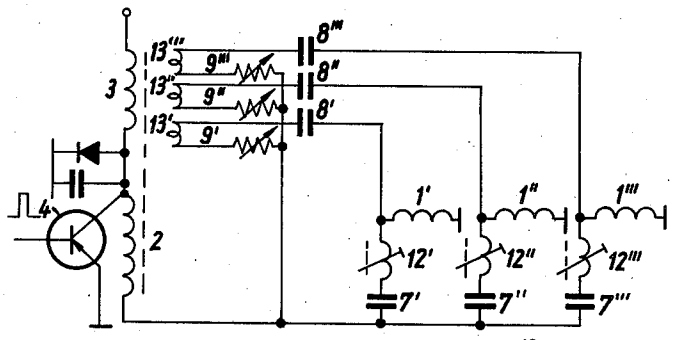


Fig. 5

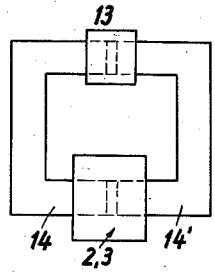


Fig. 6

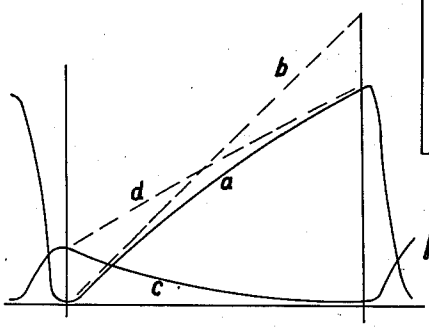


Fig. 7

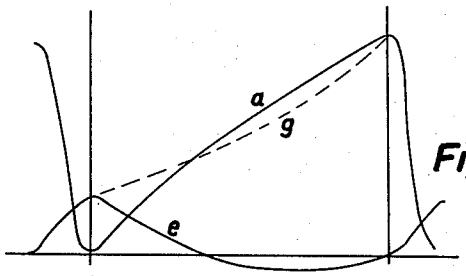


Fig. 8

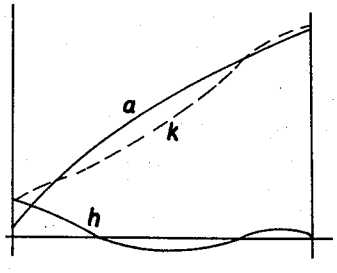


Fig. 9

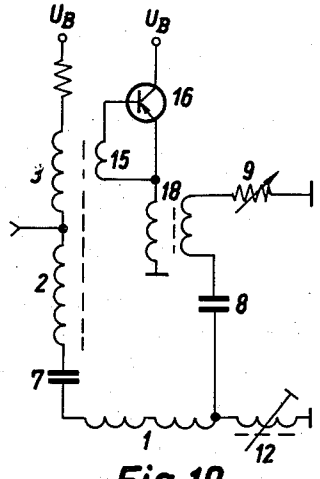


Fig. 10

Inventor:
Hans-Dieter Schneider
by Michael S. Striker
Attorney

United States Patent Office 3,192,433 Patented June 29, 1965

3,192,433

CIRCUIT ARRANGEMENT FOR MODIFYING THE DEFLECTION CURRENT WAVEFORM OF TRANSFORMER-COUPLED SCAN GENERATORS

Hans-Dieter Schneider, Gross-Gerau, Germany, assignor to Fernseh G.m.b.H., Darmstadt, Germany

Filed Jan. 31, 1963, Ser. No. 255,281
Claims priority, application Germany, Feb. 3, 1962, F 35,909
8 Claims. (Cl. 315—27)

To linearize the deflection waveform of valve scan generators there has often been employed a saturated choke, connected in series or in parallel with the deflector coils, which effects a deformation of the initial scan-generator current waveform such that the current through the deflector coils varies substantially linearly with time during the working stroke. There is a limit to the amount of linearization which can be effected in this manner, however, because the magnetization curve of the choke can be varied only over a limited range, so that it is not possible to meet very strict requirements as to deflection linearity and some geometric picture distortion must be expected. It is also a disadvantage of such an arrangement that the relatively high impedance of the choke produces an increase in the load impedance of the scan generator and thus an increase in the flyback voltage.

Another known method of increasing the linearity of valve scan generators is to influence the voltage applied to the transformer inductance, with the aid of a resonant circuit, so that a linearizing effect is obtained. In a particular case a series-resonant circuit is connected between the junction of the economy diode with its capacitor and a tapping on the scan transformer.

In scan generators using low-impedance switching devices, such as transistors, the use of an oscillatory circuit to linearize the deflection in a manner analogous to that employed with valves is not advantageous, since when a low-impedance switching device of this kind is employed the advantage is gained that the deflection current may be switched directly.

Therefore it is a principal object of the invention to arrange a deflection circuit of the low impedance switching type with a simply adjustable linearisation circuit.

Another object is an arrangement of a transistorized line deflection system with an economical and simply adjustable linearisation circuit.

A further object of the invention is an arrangement of a line deflection system with two or more degrees of freedom for controllably modifying the wave form of the current deflection coil system.

Another object is an arrangement of a line deflection system for color television apparatus with separate modifying or linearizing circuits for each of a plurality of cathode ray tubes.

According to the present invention there is provided a circuit arrangement for modifying the deflection current waveform of a scan generator, comprising an impedance connected in series with the deflection coils, said impedance also forming an element of a circuit of variable time-constant, to which energy is supplied from the scan generator by way of a phase inverting coupling.

A circuit arrangement according to the invention provides the advantage that there may be produced in the modifying circuit, and therefore in the deflector coil circuit, a current component of variable phase and amplitude. At least two degrees of freedom are available: the amplitude of the current flowing in the modifying circuit and its time-constant, both of which may be varied to produce a desired modification of the current in the deflector coils. It has been found by practical tests that a substantially higher degree of linearity can be produced

with this simple circuit arrangement than has hitherto been attained in scan generators of the type to which the present invention relates.

The coupling of the modifying circuit to the scan generator is preferably loose, so that the voltage waveform appearing on the scan transformer is not substantially affected by adjustment of the modifying circuit. This point is particularly important when the flyback conditions and the power losses in the scan generator are important, since these are disadvantageously influenced by close coupling of the modifying circuit to the scan generator.

The impedance connected in the deflector coil circuit and in the modifying circuit may be an inductor, the value of which should be large compared with that of the inductor which is coupled to the scan transformer to inject energy into the modifying circuit. At the same time this common impedance must be sufficiently large in comparison with the impedance of the deflector coils that a sufficient amplitude of modifying current is available to produce the desired modification of the deflector coil current. Preferably the modifying circuit contains in addition to the adjustable impedance a variable resistance with which the desired phase of the modifying current injected into the deflector coil circuit may be adjusted. The time-constant of the modifying circuit suitably amounts to a fraction of the periodic time of the scanning process.

A particularly advantageous application of the circuit arrangement according to the present invention occurs in color television apparatus employing two or more cathode ray tubes to scan or reproduce a single image. Because of the independence of the main scan generator from the modifying circuit is an arrangement according to the invention it is possible to use separate modifying circuits for each of a plurality of cathode ray tubes, the deflector coils of which are all fed from a common scan generator. By this means it is possible to adjust each cathode ray tube for the optimum linearity without thereby affecting the adjustments of the remaining tube or tubes.

The invention will now be further described with reference to the accompanying drawings, comprising FIGURES 1 to 10, of which:

FIGURE 1 is a circuit diagram illustrating one embodiment of a circuit arrangement according to the present invention,

FIGURES 2 and 3 are partial circuit diagrams showing alternative arrangements for coupling the modifying circuit to the scan generator,

FIGURE 4 shows an alternative embodiment of circuit arrangement according to the invention,

FIGURE 5 shows the circuit diagram of deflector circuits for one embodiment of color-television apparatus employing the present invention,

FIGURE 6 illustrates the construction of a transformer suitable for use in carrying out the present invention,

FIGURES 7, 8 and 9 are waveform diagrams illustrating the effects of different conditions of adjustment of the circuit arangement according to the invention, and

FIGURE 10 shows the circuit diagram of another embodiment of circuit arrangement according to the invention.

In the circuit arrangement shown in FIGURE 1, deflector coils **1**, which may be assumed to be the line deflector coils associated with a cathode ray tube, not shown, are fed with deflection current from the scan transformer **2**, **3** of a scan generator by way of a coupling capacitor **7**. A switching transistor **4**, the base of which is driven by rectangular voltage impulses, serves to generate the deflection currents. Current from a direct-

voltage source represented by a terminal U_B is fed to the auto-transformer 2, 3 by way of an adjustable resistor 5, the junction of which with the transformer winding 3 is taken to earth by way of a decoupling capacitor 6 to prevent feedback of deflection voltages into the power supply circuits. To the connection between the two winding portions 2, 3 of the auto-transformer there is also connected a diode 22 in parallel with a capacitor 23, which serve in known manner to dispose of the energy stored in the transformer when the switching transistor 4 ceases to conduct. Shift current may be passed through deflector coils 1 from a potentiometer 24 connected across the supply in series with limiting resistors, by way of a high-impedance choke 25.

In the circuit arrangement described above, distortion of the current through the deflector coils from the desired linear variation with time arises as a result of the internal impedance of the transformer and of the deflector coils, which results in the actual variation with time of the deflector current becoming an exponential function. During the working stroke the deflector current i_d then obeys a law of the form:

$$i_d = A.(1-e^{-t})$$

where A is a constant.

To obviate this distortion in accordance with the present invention there is now connected in series between the deflector coils and the scan transformer an impedance, in the present case a transformer 10, 11, with the help of which there is injected into the deflector coil circuit a component of current which modifies the deflector coil current so as to correct the distortion. This impedance is also connected in a modifying circuit, containing also a capacitor 8, a variable resistor 9 and a coupling winding 13, coupled to winding 3 of the scan transformer so that a small amount of energy is fed from the scan generator into the modifying circuit. The capacitor 8, the variable resistor 9 and the windings 10 and 13 are connected in series with each other.

According to the value chosen for capacitor 8 and the state of adjustment of the inductor 10 and the resistor 9, there will arise in this modifying circuit either a damped oscillation or an aperiodically varying current in antiphase with the deflector current from the scan generator. By adjusting the values of resistor 9 and of the inductance of the transformer 10, 11, the component of current injected by the modifying circuit into the deflector coil circuit may be altered so that a purely linear sawtooth current flows in the deflector coils 1. The appropriate relations are further discussed below in relation to the waveform diagrams contained in FIGURES 7, 8 and 9.

Waveform *a* in FIGURE 7 shows the variation with time of the current flowing through the deflector coil in the absence of the modifying circuit. It will be seen that the current follows an approximately exponential law, deviating markedly from the desired linear variation with time, shown by waveform *b*, towards the end of the working stroke. If the modifying circuit is now adjusted to give a suitable aperiodic response, and ignoring for the present the effect of capacitor 8, there will be injected into the deflector coil circuit a component of current of which the waveform is as illustrated by waveform *c*. This is combined with the original current of waveform *a* to yield a current varying linearly with time during the working stroke as illustrated by waveform *d*. The modifying current component i_m thus injected into the deflector coil circuit has a form which may be expressed by the equation: $i_m = B.e^{-t}T$ and is found to yield good linearization. A further improvement in linearity may be obtained by choosing the impedances in the modifying circuit such that residual curvature of the ideally rectilinear sawtooth deflection current is compensated by the superposition of a current varying with time in accordance with a cosine function. A component of current having this form may be produced by an appropriate choice of the value of capacitor 8.

The amplitude of deflection may be adjusted as desired by altering the setting of the variable resistor 5 without upsetting the operation of the modifying circuit once this has been adjusted, since because the modifying circuit is fed with current derived from the scan generator there always flows in it a current proportional to the distorted current in the deflector circuit.

It is possible to effect the coupling of the modifying circuit to the scan generator in different ways. In simple cases in which very great linearity is unnecessary and a certain loss of power can be tolerated, the coupling may be effected by connecting the modifying circuit across a few turns of the transformer winding 3, as is shown in FIGURE 2. Usually, however, it is more advantageous to provide a secondary winding for this purpose.

Instead of the transformer 10, 11 used as the current injecting impedance in the circuit described in relation to FIGURE 1, it may often be more convenient to employ an inductance common to the two circuits, as shown at 12 in FIGURE 3. This inductance is advantageously made adjustable by means of a movable core in order that the time-constant of the modifying circuit may readily be adjusted.

Where a very high linearity is required and freedom from reaction of the modifying circuit upon the scan generator is important, a circuit arrangement such as that shown in FIGURE 4 may be employed. Here there is provided to excite the modifying circuit in addition to the main scan-generating transistor 4 an auxiliary transistor 4′ connected in series with an inductance 3′ across the direct voltage source. Inductor 3′ is chosen such that the voltage waveform which arises across it is substantially the same as that which appears across inductor 3 in series with the main transistor 4. The base of auxiliary transistor 4′ is driven from an auxiliary secondary winding 17′ on the same transformer from the secondary winding 17 of which the main transformer is driven. The loading of the auxiliary transistor 4′ may be less than that of the main transistor, amounting for example, to only some 20 to 30% of that of the main transformer. A similar advantage can be obtained if the modifying circuit is coupled to the scan transformer by way of a buffer amplifier as described later in connection with FIGURE 10.

The independence of the scan generator from the adjustment of the modifying circuit enables a circuit arrangement according to the invention to be advantageously employed in color television apparatus using more than one cathode ray tube, in which the difficulty has previously existed that because of the substantial reaction of the deflection linearizing adjustment upon the scan generator it has been necessary to provide a separate scan generator for each cathode ray tube. Color television apparatus incorporating the present invention is illustrated by FIGURE 5, in which there are associated with deflector coils 1′, 1″, 1‴ for separate cathode ray tubes (not shown) individual modifying circuits 8′, 9′, 12′; 8″, 9″, 12″ and 8‴, 9‴, 12‴, each associated also with an individual coupling winding 13′, 13″ and 13‴ and coupling capacitor 7′, 7″ and 7‴ respectively. In a practical embodiment of such a circuit the inductors 12′, 12″, 12‴ may be pre-set components and fine adjustment may be carried out by means of variable resistors 9′, 9″, and 9‴.

A transformer constructed as illustrated by FIGURE 6 is advantageously employed to produce the desired loose coupling between the primary winding 3 and the coupling winding 13 of the circuit arrangements described above. In FIGURE 6, the two halves 14, 14′ of a ferrite core are separated by narrow gaps. Over one such gap there are disposed the main windings 2, 3 of the scan transformer and over the diametrically opposed air-gap there is placed the coupling winding 13 for the modifying circuit. The leakage of a transformer so constructed is

relatively large, since a substantial proportion of the lines of force from winding 2, 3 passes through the air. The desired loose coupling of winding 13 to winding 3 is thus obtained.

FIGURES 8 and 9 are waveform diagrams which relate to further applications of a circuit arrangement according to the invention in the production of deflection currents of which the variation with respect to time follows an S-shaped curve varying substantially from the original form of the deflection current.

In FIGURE 8, *a* is again the original waveform of the deflection current. The variation with the time of the current in the modifying circuit is shown by curve *e*, which corresponds approximately to an exponential function with a superimposed cosine function. The addition of this component to the original deflection current results in a final deflection current of the form illustrated by waveform *g*.

It is also possible, as illustrated by FIGURE 9, to produce a deflection current exhibiting an S-shaped waveform by superimposing on the original current *a* a current which consists of the combination of a somewhat different exponential function with a cosine function of rather higher frequency than that used in FIGURE 8. The current in the modifying circuit now has the form shown by waveform *h*, while the resultant deflection current is illustrated by waveform *k*. A deflection current of this waveform is required, for example, to compensate for the screen curvature in receiver tubes.

A circuit arrangement using a buffer amplifier to provide the desired loose coupling between the scan transformer and the modifying circuit is shown in the circuit diagram of FIGURE 10. In this circuit arrangement, as in FIGURE 2, a scan transformer 2, 3 has its primary winding 3 coupled very loosely to a coupling coil 15, from which energy is fed at high impedance into a buffer amplifier transistor 16, from the emitter circuit of which the energy is taken at low impedance by way of a transformer 18 and fed into a modifying circuit comprising a capacitor 8, a variable resistor 9 and a variable inductor 12, this latter component also being included in the deflector coil current circuit of deflector coils 1. The circuit arrangement here shown differs from those previously discussed in that the inductor 12 is connected between the deflector coils 1 and earth, instead of between the deflector coils and the coupling capacitor 7. This change does not, of course, affect the operation of the circuit arrangement.

From the examples described above it will be appreciated that there are many ways in which the invention can be carried into effect, although only two variables, namely the time-constant and the damping of the modifying circuit, require to be altered. It has been found in practice that a circuit arrangement according to the invention is capable of providing a deflection current of which the linearity is sufficient not only for domestic television receivers but also for studio pickup equipment, such as a television camera incorporating a 4½ inch image-orthicon camera tube, where enhanced linearity coupled with high deflection power is required.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a line deflection circuit for television apparatus including deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection current comprising damped resonant circuit means including inductive means and phase inverting coupling means coupled to the scan transformer winding means, and means connecting said inductive means between said deflection coils and said scan transformer winding means, said damped resonant circuit means having an adjustable time constant and frequency.

2. In a line deflection circuit for television apparatus including deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection current comprising damped resonant circuit means including inductive means and phase inverting coupling means coupled to the scan transformer winding means, said inductive means having one winding included in said damped resonant circuit means and another winding inductively coupled with said one winding, and means connecting the other winding of said inductive means between said deflection coils and said scan transformer winding means, said damped resonant circuit means having an adjustable time constant and frequency.

3. In a line deflection circuit for television apparatus including deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection current comprising damped resonant circuit means including inductive means and phase inverting coupling means coupled to the scan transformer winding means, said inductive means having two windings inductively coupled with each other, said damped resonant circuit means comprising a series circuit connection of one winding of said inductive means, said phase inverting coupling means, a capacitor and a variable resistor, and means connecting the other winding of said inductive means between said deflection coils and said scan transformer winding means.

4. In a line deflection circuit for television apparatus including deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection current comprising damped resonant circuit means including inductive means having two windings inductively coupled with each other, said damped resonant circuit means comprising a series circuit connection of one winding of said inductive means, a portion of said scan transformer winding means, a capacitor and a variable resistor, and means connecting the other winding of said inductive means between said deflection coils and said scan transformer winding means.

5. In a line deflection circuit for color television apparatus including a plurality of deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in each of said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to each of said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection currents comprising a plurality of damped resonant circuit means each including inductive means and phase inverting coupling means coupled to the scan transformer winding means, and means connecting the inductive means of each of said damped resonant circuit means between a corresponding one of said deflection coils and said scan transformer winding means, each of said damped resonant circuit means having an adjustable time constant and frequency.

6. In a line deflection circuit for color television apparatus including a plurality of deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in each of said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to each of said

deflection coils, a system for compensating for distortions in the substantially sawtooth deflection currents comprising a plurality of damped resonant circuit means each comprising a series circuit connection of a corresponding one of a plurality of inductive means each connected between a corresponding one of said deflection coils and said scan transformer winding means, a corresponding one of a plurality of phase inverting coupling means each of which is coupled to the scan transformer winding means, a corresponding one of a plurality of capacitors and a corresponding one of a plurality of variable resistors.

7. In a line deflection circuit for television apparatus including deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection current comprising damped resonant circuit means comprising a series circuit connection of inductive means connected to said deflection coils, coupling means, a capacitor and a variable resistor, and buffer amplifier means inductively coupled between said scan transformer winding means and the coupling means of said damped resonant circuit means.

8. In a line deflection circuit for television apparatus

including deflection coils and sawtooth scan generator means for providing a substantially sawtooth deflection current in said deflection coils, said sawtooth scan generator means including a scan transformer having winding means connected to said deflection coils, a system for compensating for distortions in the substantially sawtooth deflection current comprising damped resonant circuit means comprising a series circuit connection of inductive means connected to said deflection coils, coupling means, a capacitor and a variable resistor, and buffer amplifier means comprising a transistor amplifier having an input inductively coupled with said scan transformer winding means and an output inductively coupled with the coupling means of said damped resonant circuit means.

References Cited by the Examiner

UNITED STATES PATENTS

2,654,855 10/53 Denton ..... 315—27

FOREIGN PATENTS

736,005 8/55 Great Britain.

OTHER REFERENCES

IRE Dictionary of Electronics Terms and Symbols. Institute of Radio Engineers. New York, 1961, page 130.

DAVID G. REDINBAUGH, *Primary Examiner.*