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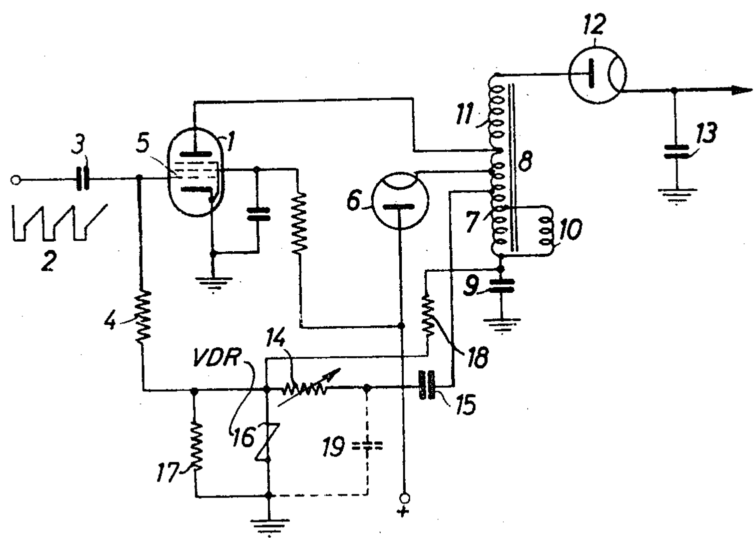

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DEFLECTION CIRCUIT WITH VDR FEEDBACK MEANS

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This invention relates to circuit arrangements for producing a sawtooth current in a coil by means of a discharge tube having a control grid to which is applied a voltage which periodically renders the tube conductive, the output circuit of the tube comprising a transformer to which the coil is coupled and a linearizing diode circuit. The pulses occurring at the transformer during the flyback of the sawtooth current are applied through a coupling capacitor to a resistor having a non-linear symmetrical voltage vs. current characteristic curve, across which a direct voltage occurs which is fed to the control circuit, for example, the grid of the tube.

When applying the available pulse voltage occurring at the transformer to said non-linear resistor, one cannot be certain that without the use of additional means the correct value of the direct control-voltage can be obtained which is necessary for the desired adjustment of the working-point of the tube. Consequently, a voltage-divider circuit is generally to be included, for example, a capacitor circuit dividing the amplitude of said pulse voltage. It may be required for this voltage divider to be made adjustable, in particular with a view to compensation of the tolerances of the associated structural elements, especially when using a voltage dependent resistor as the non-linear resistor, since VDR's are subject to wide tolerances in their properties.

In British patent specification 890,805, in which a positive bias voltage is applied to the non-linear resistor, a potentiometer circuit is connected to a stabilized voltage source, more particularly the booster voltage, and a connection exists from a tapping point on said potentiometer circuit through an ohmic resistor to the non-linear resistor. By varying the bias voltage, variations in the non-linear resistor within its tolerances could also be compensated, but only to a certain proportion, since only a limited variation of the potentiometer circuit was possible in view of the loading effect on the direct-voltage source and the reliability in operation of the direct-voltage potentiometer. The shift of the working point of the non-linear resistor due to the variable bias voltage otherwise also resulted in an undesirable variation of the control characteristic curve because with unchanged amplitude of the pulsed voltage applied, a variation in the bias results in an unwanted variation of the grid-bias derived for the tube.

In order to obviate these disadvantages, it has previously been suggested to leave the connection between the non-linear resistor and the pulse voltage source unchanged and to obtain the required adjustment by connecting a voltage divider, preferably adjustable, in parallel with the non-linear resistor. The tapping of the voltage divider is then connected to the control grid of the tube. This tapping may also be connected to another part of the circuit controlling the tube, whereby the required increase of energy supply in the output circuit of the tube may be controlled. The said circuit previously suggested may also be used if, besides the pulsed voltage, a direct voltage for the adjustment of the working-point is applied to the non-linear resistor, which results in an improvement in the control sensitivity.

Suitable non-linear resistors preferably have non-linear

symmetrical characteristic curves, which can be described by the equation $U=K\times I^{\beta}$, in which U is the voltage applied to, and I the current through the non-linear resistor, whereas K is a proportionally constant and β an exponent. It should be noted that the voltage U and the current I always have the same polarity and that only the absolute values of U and I should be inserted in the above given equation. The exponent β has values of, for example, 0.15 to 0.25. Such resistors may consist of silicon-carbide grains which are mixed with a bonding agent to form a ceramic-like mass and then sintered. The voltage dependency is based on the variable contact resistance between the individual carbide crystals. Such resistors are commercially available under the name of "VDR-resistors." With a tolerance of $\pm 10\%$ in the voltage applied to said resistor there occur deviations in the control voltage obtained due to the action of the exponent β in a ratio of 1:7 in the tolerance range. Consequently, the voltage divider which, according to the previous suggestion, was connected in parallel with the non-linear resistor, must be variable substantially throughout its ohmic value and, more particularly, a potentiometer so arranged is exposed to the full voltage, i.e. the alternating pulsed voltage, and must be rated to withstand this voltage. This involves considerable difficulties in practice.

In a circuit arrangement of the kind mentioned in the preamble, these disadvantages are avoided and with the use of a smaller number of structural elements which are subjected only to a slight load. A wide compensation range and a reliable and more accurate control are obtained if, according to the invention, the internal resistance of the pulse voltage source is varied.

This is possible by suitably influencing the circuit or by choosing the coupling capacitor through which the pulsed voltage is transmitted of the variable type.

Preferably, in accordance with the invention, a variable resistor is connected in series with the coupling capacitor. When voltage dividers are employed, for example, at the direct-current side or at the pulse supply side, resistors of comparatively low values must be used which constitute an undesirable load on the circuit arrangement. However, when using a series-resistor, the circuit may be proportioned so that the load is a minimum at one limit of the tolerance range at which a comparatively low direct voltage only is produced, whereas at the other limit of the tolerance range, the series-resistor is made active and hence the load impedance is increased. Since the non-linear resistor absorbs a particularly high current at high voltages and just the peak value is a measure of the control voltage obtained, the use of a series-resistor is particularly effective and this resistor may be of a comparatively low value.

In order that the invention may be readily carried into effect, it will now be described more fully, by way of example, with reference to the accompanying diagrammatic drawing.

The figure shows the output stage of a circuit arrangement for the horizontal deflection of the electron beam of the picture tube in a television receiver. A control voltage 2 is applied through a coupling capacitor 3 to the control grid 5 of an amplifier tube 1, for example, a pentode. The anode current of tube 1 flows through the primary winding 7 of a transformer 8 and produces, together with a series-booster diode 6 having a well known linearising effect, a sawtooth current through a deflection coil 10 which is connected to a tap on the winding 7. One end of the winding 7 is connected to ground through a capacitor 9 associated with the series-booster diode circuit. The cathode of diode 6 is connected to a further tap on the winding 7 and its anode is connected to the positive terminal (+) of a supply voltage source of, for example, 220 volts. Moreover, a diode **12** is connected to the high-voltage secondary winding **11** of transformer **8**. The diode **12** supplies a direct voltage for the output anode of a display tube (not shown) to a capacitor **13**.

A voltage which exhibits positive going pulses having an amplitude of, for example, 1,250 volts during the fly-back of the sawtooth current, is applied from a suitable tap on the primary **7** through a capacitor **15** and a variable resistor **14**, included in accordance with the invention, to a non-linear or VDR-resistor **16**, the other end of which is connected to ground. This resistor has the above-mentioned voltage-current characteristic curve $U=K\times I^{\beta}$, wherein K may have a value of 2,600 and β a value of 0.175. The coupling capacitor **15** may have a value of, for example, 270 pf. and the resistor **14** may have a linear characteristic curve and a value of 250,000 ohms. The VDR-resistor **16** is connected through a resistor **18** of, for example, 13.6 megohms to the capacitor **9** across which a direct current boost voltage of approximately 800 volts occurs.

A pulsed voltage is set up at the VDR-resistor **16** having a peak value which amounts to, for example, from 1,100 to 1,400 volts. The working-point of resistor **16** is shifted onto the positive branch by the direct voltage from resistor **18**. A mean direct voltage of, for example, −60 volts with respect to ground, is finally set up across resistor **16**, which mean voltage results from the combined action of the rectification of the pulses applied to resistor **16** and a shift due to the positive bias voltage applied to it. If resistor **14** is not included in the circuit, said direct voltage may assume values between 60 and 240 volts as a result of the wide tolerances in the properties of VDR 16. These great deviations may be satisfactorily compensated by the specified value of resistor 14, which is preferably active during the peaks of the pulses and exerts a current-limiting effect.

In order to balance the circuit, an ohmic resistor **17** of the order of a few hundred thousands of ohms may be connected in parallel with the non-linear resistor **16**.

The pulsed voltage may alternatively be matched to the requirements of the control circuit by connecting a capacitor **19** of about 20 to 50 pf. relative to earth between the junction of coupling capacitor **15** and variable resistor **14**. However, said circuit element may generally be omitted.

With the series-resistor **18** connected as illustrated, it has applied to it approximately half the pulsed voltage. In the arrangement shown, however, a corresponding direct-current potential is also applied to the tap to which the coupling capacitor **15** is connected. Consequently, an alternating-voltage load on resistor **18** may be avoided if the free end of resistor **18** is connected to the same tap as said capacitor. It will be evident that the other end of resistor **18** may also be connected to that end of resistor **14** which is connected to coupling capacitor **15**. In this case, the series-resistor **18** and the capacitor **15** are connected in parallel so that the resistor **18** is for all practical purposes uncoupled for alternating voltages, and thus loaded only minimally.

In principle, the direct voltage supplied through resistor **18** could be derived from an arbitrary voltage source of suitable value. If, for example, the supply source is used, it appears that fluctuations of the supply source are introduced into the control circuit and may produce interference therein. Such deviations need not be feared, if the voltage is derived from the series-booster diode circuit, since the stabilizing circuit also keeps the voltage across capacitor **9** substantially constant. The fluctuations of the capacitor voltage may thus give rise only to a certain decrease in control sensitivity, but external interferences can not influence the control action.

The supply source can then exercise a deterimental effect only as far as it constitutes a fixed part of the voltage across capacitor **9**. It is therefore advantageous to derive the direct voltage from a point of the circuit ar-

rangement which belongs substantially to the linearizing diode circuit only, and not from the supply voltage.

By the use of a direct bias voltage (across resistor **18**), a substantial increase in control sensitivity, that is to say of the variation in direct voltage (across resistor **16**) is obtained for a given percentage variation in the amplitude of the pulses. This control sensitivity varies only to an inappreciable extent if resistor **14** is adjusted for compensation of the tolerances to the same direct basic voltage (bias voltage for the grid of tube **1**). Consequently the operation of the circuit arrangement is independent of the tolerance.

It will be evident that the idea of the invention is also applicable to a circuit arrangement in which amplifier elements of a different kind, for example, transistors, are used.

What is claimed is:

1. A circuit for producing in a coil a sawtooth current having a linearly varying portion and a flyback portion, comprising an amplifier device having a control electrode and an output electrode, a transformer having winding means, means connecting said transformer winding to said output electrode and to a source of voltage, means for applying an electric signal to said control electrode for periodically rendering said amplifier device conductive whereby said sawtooth current is established in said winding means, means coupling said coil to said winding means, a control circuit comprising an output terminal coupled to said amplifier control electrode and a resistor having a symmetrical non-linear voltage-current characteristic curve for developing a direct current voltage at said output terminal, a capacitor connected between said winding means and said control circuit for coupling flyback pulses from said winding means to said control circuit, said non-linear resistor producing a direct current voltage which varies with the amplitude of said flyback pulses, and means for adjusting the amplitude of the flyback pulse applied to said non-linear resistor comprising a variable resistor connected in series with said capacitor.

2. Apparatus as described in claim **1** further comprising means for supplying a direct current voltage to said non-linear resistor of the same polarity as said flyback pulses.

3. Apparatus as described in claim **2** wherein the amplitude of said direct current voltage is of the same order of magnitude as the amplitude of said flyback voltage pulses.

4. Apparatus as described in claim **2** wherein said non-linear resistor is composed of a material which exhibits a variation in resistance with a variation in the voltage applied thereto, said apparatus further comprising an ohmic resistance element connected in parallel with said non-linear voltage dependent resistor.

5. A circuit for producing a sawtooth current in a coil, comprising an amplifier device having a control electrode and an output electrode, a capacitor, a transformer winding connected in series between said output electrode and said capacitor, means for applying an electric signal to said control electrode for periodically rendering said amplifier device conductive whereby a linearly varying current and a flyback voltage pulse are developed in said winding, said capacitor being charged by said flyback pulses to produce a direct current boost voltage therein, means coupling said coil to said transformer winding, a control circuit comprising a device having a symmetrical non-linear voltage-current characteristic curve, a coupling capacitor connected between said transformer winding and said non-linear device whereby said flybck pulses are coupled to said non-linear device, said non-linear device producing a direct current voltage which varies with the amplitude of said flyback pulses, a variable resistor connected in series with said coupling capacitor and said non-linear device, direct current coupling means for applying said capacitor direct current boost voltage to the series combination of said variable resistor and said non-linear

resistor, and means for supplying said direct current voltage produced by said non-linear device to said control electrode so as to oppose a variation in the amplitude of said sawtooth current.

6. Apparatus as described in claim 5 further comprising a damping diode coupled to said transformer winding and to a source of direct current voltage for improving the linearity of said sawtooth current flowing in said transformer winding, said direct current coupling means being connected to supply a direct current voltage which is derived only from the damping diode circuit.

7. A circuit for producing a sawtooth current in a coil, comprising an amplifier device having a control electrode and an output electrode, a capacitor, a transformer winding connected in series between said output electrode and said capacitor, means for applying an electric signal to said control electrode for periodically rendering said amplifier device conductive whereby a sawtooth current and a flyback voltage pulse are developed in said winding, said flyback pulse producing a direct current voltage on said capacitor, means coupling said coil to said transformer winding, a control circuit comprising a voltage dependent resistor having a symmetrical non-linear voltage-current characteristic and an adjustable resistor connected in series, a coupling capacitor for coupling said flyback pulse to said control circuit, means connecting said coupling capacitor in series with said voltage dependent resistor and said adjustable resistor and to a tap on said transformer winding at which said flyback voltage pulse and said direct current voltage appear, said voltage-dependent resistor producing a direct current negative feedback voltage which varies with the amplitude of the flyback pulses applied thereto, and means for supplying said direct current voltage produced by said voltage dependent resistor to said control electrode thereby to stabilize the amplitude of said sawtooth current.

8. Apparatus as described in claim 7 further comprising a resistor connected in parallel with said coupling capacitor, the resistance of said latter resistor being substantially greater than the maximum resistance value of said adjustable resistor.

9. A circuit for producing a sawtooth current in a coil, comprising an amplifier device having a control electrode and an output electrode, a capacitor, a transformer having a primary winding and a secondary winding, means connecting said primary winding in series between said output electrode and said capacitor, means for applying an electric signal to said control electrode for periodically rendering said amplifier device conductive whereby a sawtooth current and a flyback voltage pulse are developed in said primary winding, means coupling said coil to a tap on said primary winding, a voltage dependent resistor having a symmetrical non-linear voltage-current characteristic curve, a variable resistor, a coupling capacitor, means for connecting said voltage dependent resistor, said variable resistor and said coupling capacitor in series between a point of reference potential and a tap on said primary winding in the order recited, a resistor connected between said first named capacitor and the common junction of said voltage dependent resistor and said variable resistor to supply a positive direct current bias voltage to said voltage dependent resistor, said voltage dependent resistor producing a negative direct current voltage at said common junction which varies with the amplitude of said flyback pulses, a resistor connected between said common junction and said control electrode, an rectifier means connected to said secondary winding for producing a direct voltage.

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