May 29, 1956 J. J. P. VALETON ET AL 2,748,336

ELECTRIC CIRCUIT-ARRANGEMENT

Filed March 8, 1950 2 Sheets-Sheet 1

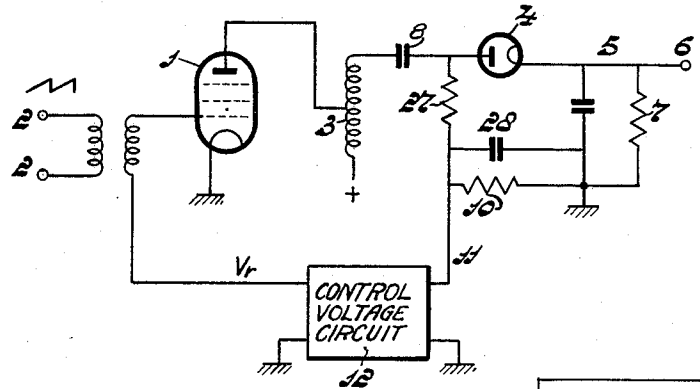


Fig. 1

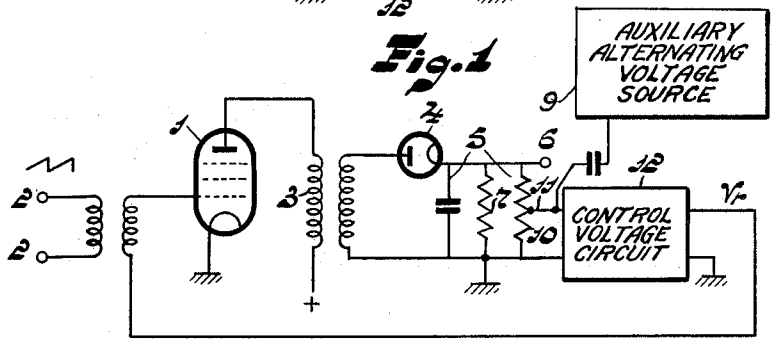


Fig. 2

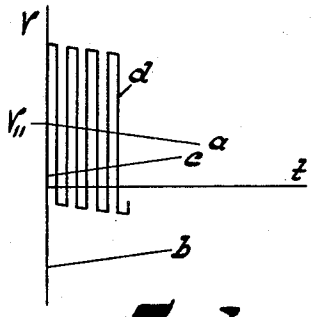


Fig. 4

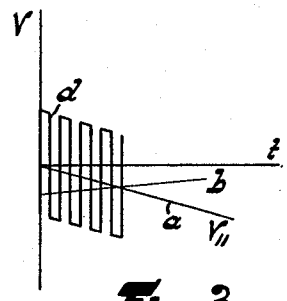


Fig. 3

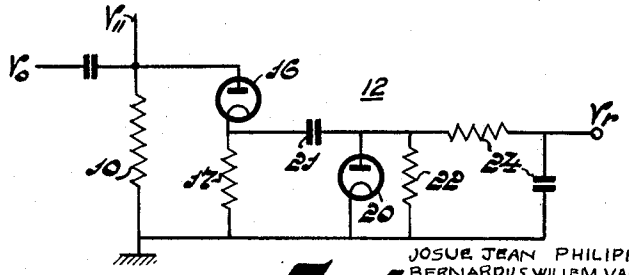


Fig. 5

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ELECTRIC CIRCUIT-ARRANGEMENT

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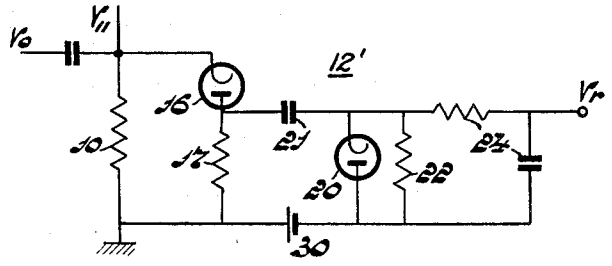


Fig. 6

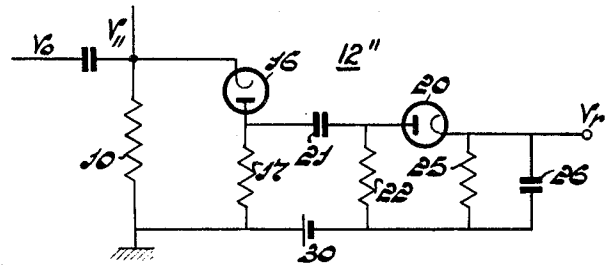


Fig. 7

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ELECTRIC CIRCUIT-ARRANGEMENT

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4 Claims. (Cl. 321—2)

This invention relates to circuit-arrangements for converting a variable voltage into a voltage varying in the opposite sense; that is, a negative-going voltage is converted into a positive-going voltage, and vice versa.

Such an arrangement is used, for example, in devices for stabilising a high voltage generator. In this case the variation in the high voltage generated provides a control voltage controlling the high voltage generator so as to counteract the said variations. However, in most cases the variations in the required control voltage must be opposed in polarity to the variations in the high voltage generated.

The present invention provides a circuit arrangement through means of which such a control voltage may be derived.

In order that the invention may readily be carried into effect, a number of examples will be described in detail with reference to the accompanying drawings of which:

Fig. 1 is a schematic circuit diagram of a high voltage generator in which a control voltage is derived which varies in accordance with variations in the output current of the generator,

Fig. 2 shows a modified form of high voltage generating circuit in which a control voltage is derived which varies in accordance with variations in the output voltage of the generator,

Fig. 3 is a voltage diagram by which the operation of the circuit of Fig. 1 is explained,

Fig. 4 is a voltage diagram correspondingly relating to Fig. 2,

Figs. 5, 6 and 7 represent schematically alternative circuit arrangements according to the invention represented in block form and by the reference 12 in Figures 1 and 2 and, in particular

Figs. 5 and 6 show circuit-arrangements in which the amplitude detector comprises a series condenser, a parallel rectifier, a parallel resistance and a smoothing filter.

Fig. 7 shows an arrangement in which the amplitude detector comprises a series condenser, a parallel resistance, a series rectifier, a parallel resistance and a parallel condenser.

In Figures 1 and 2 the reference numeral 1 indicates an electric discharge tube having an input circuit 2 to which a sawtooth oscillation is supplied, the output circuit including an inductance 3 at which a pulsatory oscillation corresponding to the said sawtooth oscillation is set up. This pulsatory oscillation is rectified by a rectifier 4 having an output filter 5 so that a positive high potential with respect to ground is produced at an output terminal 6 and produced across a load impedance 7. The current-responsive circuit of Fig. 1 includes a coupling capacitor 8, and the voltage-responsive circuit of Fig. 2 includes a source 9 of auxiliary alternating voltage.

When the current traversing the load impedance 7 increases, the high voltage generated will decrease because of the fairly high internal resistance of the generator so that a variable high voltage would appear across the load 7. This is undesirable as a rule. For example, if

the said load is the cathode-ray tube of a televison receiver, the variable high voltage would lead to lack of definition and variation in image size.

In order to stabilise the high voltage, the discharge tube 1 may be controlled so as to counteract variation. In the example described, this requires a control voltage which drives tube 1 to a higher anode current when the high voltage decreases; that is, the control voltage fed to the grid of tube 1 must increase in a positive sense when the output voltage decreases in a negative sense, so as to increase the power output of tube 1, thereby maintaining the output voltage at a stabilized value.

In the stabilized current circuit-arrangement shown in Fig. 1, a voltage corresponding to the variations in the current traversing the load 7 is derived from a resistance 10 connected in the circuit between electrical ground and the coupling capacitor 8. However, the control voltage across this resistance varies, in response to variations in the output current in the load 7, in a sense opposite to that required for the control of tube 1. This is shown in Fig. 3; curve *a* of this figure shows the control voltage V_{11} at the point 11 with respect to ground as a function of the output current in load 7 increasing with time (shown in exaggerated form), whereas the control voltage required for tube 1 would have to vary, in response to the aforesaid increase in load current, as shown in curve *b* of Fig. 3. The aforesaid decrease in the variable voltage V_{11} (curve *a* in Fig. 3) across the resistor 10 of Fig. 1, in response to an increase in load current, occurs in the following manner. During the positive-polarity portion of the signal in the circuit 3, the rectifier 4 conducts a current pulse, through the capacitor 8, to the load 7. This leaves a voltage charge on capacitor 8, whereby the right-hand terminal of capacitor 8 is of negative polarity as compared to the left-hand terminal thereof. A current immediately flows, from electrical ground and through resistors 10 and 27, to the capacitor 8 in order to neutralize the aforesaid charge, and this current is a direct current which flows substantially constantly due to the repeated positive-polarity current pulses which flow from the circuit 3 to the load 7. This neutralizing current causes a direct voltage at the point 11 which has negative polarity with respect to ground. This is the control voltage V_{11}, shown as curve *a* in Fig. 3, which decreases when the load current increases, due to the fact that an increase in load current causes a larger charge to attempt to occur on capacitor 8, which in turn causes a larger neutralizing current to flow in resistor 10, thereby making the point 11 become more negative. As pointed out hereinbefore, this decrease in voltage, which is in a negative-going direction, is in the wrong sense to be applied to the grid of tube 1 in order to increase the output voltage (which has decreased due to the increase in output current) to its desired value thereby to stabilize the system. Therefore, the circuit 12 is necessary in order to convert the negative-going variable voltage V_{11} into a positive-going control voltage, and vice versa in the case of a positive-going variable voltage V_{11}.

In the stabilized voltage circuit-arrangement shown in Fig. 2, the variable voltage V_{11}, which varies directly in accordance with the variable high voltage is derived from the potential divider comprising the parts of the resistance 10. In this case the control voltage V_{11}, shown by curve *a* in Fig. 4, also varies in the opposite sense to that required, the required control voltage being shown by the curve *b*. The auxiliary alternating voltage V_0 is fed from the source 9 to the resistor 10.

A control signal circuit 12, shown in block form in Figs. 1 and 2, serves to convert the variable voltage V_{11} (curves *a*) into the required control voltage V_r (curves *b*).

In the circuit arrangement for the device 12 shown in Fig. 5, the variable voltage V_{11}, which may have the shape

of curve *a* in Fig. 3 or 4, is increased by superimposing thereon an auxiliary alternating voltage V_0, whose amplitude exceeds that of the voltage V_{11}. The auxiliary alternating voltage V_0 is produced, in the circuit of Fig. 1, by the signal voltage from the inductance **3**, which signal voltage appears, in reduced magnitude, across the resistor **10**, and in the circuit of Fig. 2 this auxiliary alternating voltage V_0 is produced by the source **9**. The voltage thus set up across resistance **10** has the shape of curve *d* in Fig. 3 or 4. This voltage operates as an electromotive force in a closed, series connected circuit which comprises, in addition to the resistance **10** a rectifier **16** and an ohmic resistance **17**, across which is developed a voltage corresponding to the part of curve *d* projecting above the zero axis. That is, the threshold point of rectifier **16** is represented by the zero axis in Figs. 3 and 4, and the rectifier **16** thus passes that part of the signal *d* which is above the zero axis and rejects that part of the signal *d* which is below the zero axis. The amplitude of this voltage at resistor **17** thus varies in accordance with the instantaneous value of the variable voltage V_{11}. This voltage is susbequently supplied to an amplitude detector comprising a series condenser **21**, a parallel rectifier **20**, a parallel resistance **22** and a filter network **24** the output of which yields a voltage which varies in accordance with curve *b* of Fig. 3 or 4 and hence may be used as the control voltage V_r. The amplitude detector functions as follows. The rectifier **20** substantially shorts out the positive-polarity portion of the incoming signal, and the negative-polarity portion thus passes on to the filter **24** where it is smoothed out to provide a negative-polarity control voltage V_r. It will be evident that, when the voltage V_{11} decreases, as shown by the curves *a* in Figs. 3 and 4, in response to an increase in load current (in the circuit of Fig. 1) or to a decrease in load voltage (in the circuit of Fig. 2), then the magnitude of the control voltage V_r will be reduced. This reduction in magnitude of the negative control voltage constitutes the desired positive-going change in control voltage in response to a negative-going change in the voltage V_{11}. Therefore, the confrol voltage V_r changes in the proper manner so that, when fed to the control grid of tube **1** in Figs. 1 and 2, the high voltage generating circuits will be stabilized.

The arrangement of the control voltage circuit **12'** shown in Fig. 6 is distinguished from that shown in Fig. 5 in that the two rectifiers **16** and **20** are connected to conduct in opposite senses. The operation of Fig. 6 is as follows:

Assuming that the variable voltage V_{11} varies as shown by the curve *a* in Fig. 4, the voltage set up across the resistance **17** will have the shape of the part of curve *d* of this figure projecting below the zero axis, because the rectifier **16** is polarized to pass only negative-polarity voltages. After rectification by the amplitude detector **20**, **21**, **22**, a control voltage V_r will thus be generated as shown by curve *c*, due to the rectifier **20** substantially shorting out the negative-polarity portion of the incoming signal and passing the positive-polarity portion on to the filter **24**. It will be noted that the control voltage V_r, represented by the curve *c* in Fig. 4 and produced by the circuit of Fig. 6, is positive in polarity, whereas the control voltage V_r represented by the curve *b* in Fig. 4 and produced by the circuit of Fig. 5 (in which the rectifier polarities are reversed with respect to their polarities in Fig. 6) is negative in polarity. However, the curves *b* and *c* both vary in the proper sense, i. e., in a positive-going direction when the variable voltage V_{11} (represented by curve *a*) varies in a negative-going direction. Whether it is desired for the control voltage V_r to be of positive polarity as shown by curve *c* of Fig. 4 and produced by the circuit of Fig. 6, or of negative polarity as shown by curve *b* of Fig. 4 and produced by the circuit of Fig. 5, will depend on the bias voltage requirements of the controlled tube **1**, and will further depend on whether any additional sources of bias voltage are connected to electrodes of the tube **1**. Although the operation of the circuit of Fig. 6 has been described with particular reference to Fig. 4, the operation will be similar with reference to Fig. 3.

In the control voltage circuit arrangement **12''** shown in Fig. 7, of which the portion up to and including the rectifier **16** and the resistance **17** is identical with the arrangement shown in Fig. 6, the amplitude detector comprises a series condenser **21**, a parallel resistance **22**, a series rectifier **20**, a parallel resistance **25** and a parallel condenser **26**. The operation of the arrangement is otherwise identical with that shown in Fig. 6, and the output control voltage V_r will have a positive polarity as shown by the curve *c* in Fig. 4.

The arrangements shown in Figs. 5–7 will operate in the same manner, if the rectifier **16** and the impedance **17** are interchanged. If point **11** has a low capacity with respect to ground and if the alternating voltage is supplied without the use of condensers, the resistance **17** may even be left out completely.

In a high voltage generator with voltage-stabilising means, according to the invention, the auxiliary voltage may be derived from the pulsatory voltage across the inductance **3** (Fig. 1), for example by voltage division of these pulses over a resistance **27** and a resistance-capacity combination **10—28**. In this case a separate source of auxiliary alternating voltage is not required.

An important advantage of the arrangements according to the invention is furthermore that the direct voltage level of the generated voltage V_r, which is characterized, for example, by the intersection of curve *b* and of the V-axis, may be varied by variation of the amplitude of the auxiliary alternating voltage V_0. This may be effected, for example, by adjusting the condenser **28** of Fig. 1 to a different value.

Furthermore, the direct-voltage level is adjustable to a different value with the use of fixed or variable biassing potentials. For example, in the arrangement shown in Fig. 6 or 7, the lower end of resistance **10** may be connected to a voltage which is negative with respect to ground. As an alternative, the conductor connected to ground may include a suitable source of voltage, for example the source of voltage **30** shown in Figs. 6 and 7, so that a control voltage V_r having the form of curve *b* will be generated instead of a voltage having the form of curve *c*. If the voltage across the resistance **10** were always higher than the amplitude of the alternating voltage V_0, through the use of such sources of voltage the value of the voltage supplied to the series combination of rectifier **16** and impedance **17** will be held smaller than the amplitude of the alternating voltage V_0.

The shape of the alternating voltage V_0 furthermore affects the functional relation between the control voltage V_r generated and the variable voltage V_{11}. The examples shown in Figs. 3 and 4 illustrate an auxiliary alternating voltage V_0 of block-shaped character. In this case there is a linear relation between the control voltage V_r and the voltage V_{11} to be converted. If, however, the alternating voltage V_0 is a linear saw-tooth wave, the functional relation between the average value of the voltage across the resistance **17** and hence the functional relation between the control voltage V_r generated and the variable voltage V_{11} appears to require a quadratic term. As a rule, the function giving the relation between the control voltage V_r generated and the variable voltage V_{11} is one degree higher than the degree of the function giving the instantaneous value of the auxiliary alternating voltage V_0 in the vicinity of the apical value. This non-linear relation of function allows the degree of counteraction of a decrease in high voltage to be raised as this decrease becomes non linear.

What we claim is:

1. Apparatus for deriving from an incoming variable voltage a control voltage which varies in the opposite

sense, said apparatus comprising a closed series circuit constituted by a rectifying element in connection with an impedance element, means to supply said incoming voltage and an auxiliary alternating voltage whose amplitude is substantially constant and exceeds that of said incoming voltage to said closed series circuit to produce across each of said elements an alternating output voltage whose amplitude is dependent upon the instantaneous value of said incoming voltage, and means including an amplitude detector and coupled to one of said elements to derive said control voltage from said output voltage.

2. Apparatus as set forth in claim 1 wherein said amplitude detector is constituted by a capacitance, a rectifier coupled to said capacitance, a resistance shunting said rectifier, and a filter network coupled to said resistor.

3. Apparatus for deriving from an incoming variable voltage yielded by the output of a high voltage generator having a variable load, a control voltage which varies in the opposite sense and which is supplied to said generator to stabilize the output thereof, said apparatus comprising a closed series circuit constituted by a rectifying element in connection with an impedance element, means to supply said incoming voltage and an auxiliary alternating voltage whose amplitude is substantially constant and exceeds that of said incoming voltage to said closed series circuit to produce across each of said elements an alternating output voltage whose amplitude is dependent upon the instantaneous value of said incoming voltage, and means including an amplitude detector and coupled to one of said elements to derive said control voltage from said output voltage.

4. Apparatus for deriving from an incoming variable voltage yielded by the output of a high voltage generator having a variable load, a control voltage which varies in the opposite sense and which is supplied to said generator to stabilize the output thereof, said apparatus comprising a closed series circuit constituted by a rectifying element in connection with an impedance element, means to develop an auxiliary alternating voltage having an amplitude which is substantially constant and which exceeds that of said incoming voltage from said generator, means to supply said incoming voltage and said auxiliary alternating voltage to said closed series circuit to produce across each of said elements an alternating output voltage whose amplitude is dependent upon the instantaneous value of said incoming voltage, and means including an amplitude detector and coupled to one of said elements to derive said control voltage from said output voltage.

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