Feb. 17, 1942. S. T. BREWER 2,273,432

ELECTRON DISCHARGE DEVICE CIRCUITS

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FIG. 1

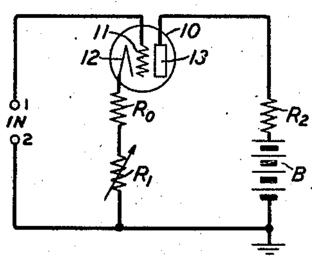

FIG. 2

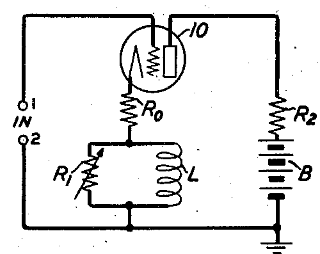

FIG. 3

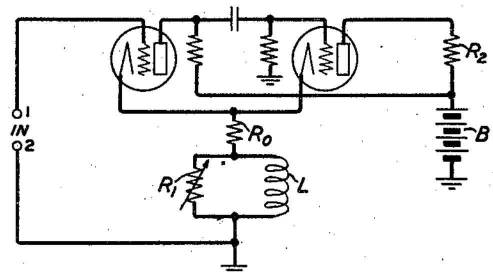

FIG. 4

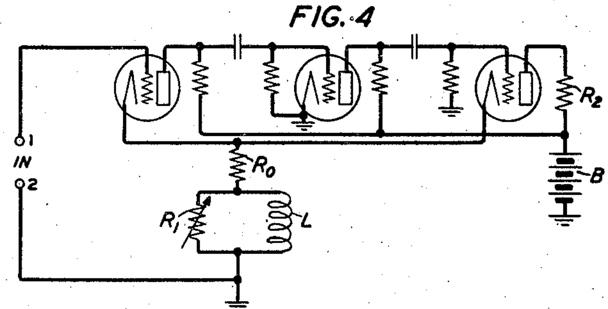

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FIG. 5

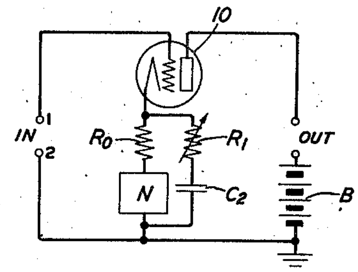


FIG. 6

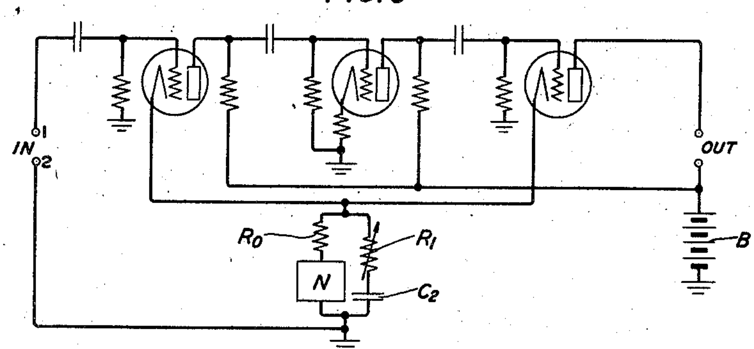
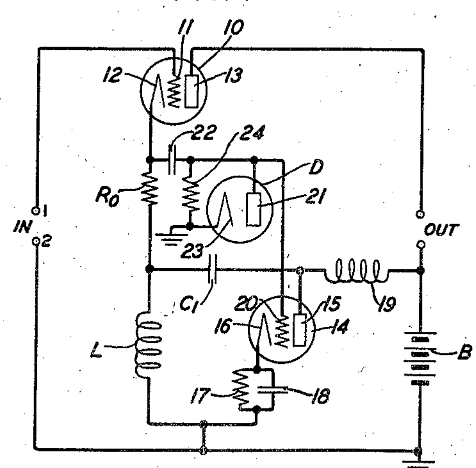


FIG. 7



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE CIRCUITS

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2 Claims. (Cl. 179—171)

This invention relates to electron discharge device circuits, and, more particularly, to circuits for expanding or compressing the volume range of a signal applied thereto.

An object of this invention is to cause the expansion or compression of the volume range of a signal applied to an electron discharge device, in a simple manner and with a minimum of circuit elements.

A feature of the invention comprises associating an element of high temperature coefficient of resistance with a portion of the electron discharge device common to its input and output circuits.

Another feature comprises varying the temperature, and, consequently, the impedance, of such an element by passage of substantially only alternating current therethrough.

A further feature comprises utilizing an element of either positive or negative temperature coefficient of resistance.

In accordance with the invention, a temperature controlled, variable resistance element having, for example, a high positive or negative temperature coefficient of resistance, is connected in the cathode lead of the circuit of an electron discharge device such that it is common to the input and output circuits of said device. The gain of the device used as an amplifier will be a function of the temperature and of the current through the element. Since this current comprises the space current and the amplified signal current, the gain will be a function of the applied signal voltage; the amplifier is suitable for expansion or compression purposes. If it is desired to have the expansion or compression responsive only to changes in the applied signal, the resistance element may be provided with a shunt for direct current or be included in series with direct current blocking means. In accordance with the invention, also, the circuit may comprise two or more electron discharge devices in tandem, the circuit constituting an expander or a compressor of the volume range, dependent on the number of stages and on whether a positive or negative temperature coefficient element is utilized. Preferably, the element of negative or positive temperature coefficient is of the type that evidences non-linear change in resistance with change in temperature, and that changes in temperature, and, therefore, in resistance, with change in the value of the current flow therethrough; silver sulphide resistance elements having such a characteristic may be utilized.

A more complete understanding of the invention will be obtained from the detailed description which follows, taken in conjunction with the appended drawings, wherein:

Fig. 1 shows an amplifying electron discharge device circuit embodying this invention;

Fig. 2 shows another circuit embodiment of the invention in which a direct current by-pass is associated with the feedback variable resistance element;

Figs. 3 and 4 show two-stage and three-stage electron discharge device circuits including the cathode lead arrangement of Fig. 2;

Fig. 5 shows a modification of the circuit arrangement of Fig. 1;

Fig. 6 shows a multistage circuit similar to that of Fig. 4 except that it includes the cathode lead arrangement of Fig. 5; and

Fig. 7 shows a modification of the circuit of Fig. 2 in which an electronic resistance is employed as the cathode lead variable resistance element.

Fig. 1 discloses the basic aspect of the invention in a single electron discharge device amplifying circuit. The signal input terminals 1, 2 are connected to the input control grid 11 and the low potential terminal of the cathode 12 of the device or tube 10, a grid biasing resistance R_0 and a feedback element R_1 being connected in series in the cathode lead. The element R_1, in accordance with the invention, is preferably of a substance or is a device having a high positive or negative temperature coefficient of resistance, and evidencing non-linear change in resistance with temperature change. Potential for the anode or plate 13 is provided by source B, for example, a battery, through the load R_2.

An input voltage is applied to terminals 1, 2 and a voltage across R_2 is developed which is greater than the applied voltage by the gain of the circuit, determined by the transconductance of the tube and the values of R_0 and R_1. The gain of the amplifier is, therefore, a function of the temperature and, consequently, of the current flowing through R_1. The current flowing through R_1, however, is composed of the cathode-anode direct or space current and the amplified signal current. Hence, the gain of the amplifier becomes a function of the applied signal voltage, and the amplifying circuit is suitable for volume expansion and compression purposes. The resistance R_1 merely provides the desired minimum bias on the control grid.

With the arrangement of Fig. 1, the grid bias and the local feedback are both functions of the applied signal. If it is desired to have only the feedback responsive to the changes in the signal, the arrangement of Fig. 2 may be used. An inductance L is connected in parallel with the element R_1, and is proportioned so that it offers a high impedance to signal currents thereby causing them to flow through R_1, while it offers a low impedance to the direct or space current thereby directing the direct flow through it rather than through the element R_1. Such an arrangement greatly increases the sensitiveness of the element R_1 to changes in signal current through it. Although a single inductance L is shown, a complex network could be used to accomplish the same purpose.

The application of the cathode lead arrangement of Fig. 2 to a two-stage and a three-stage resistance-capacity coupled amplifier is shown in Figs. 3 and 4.

Whether the amplifier expands or compresses the volume range of an applied signal depends upon whether the element R_1 has a positive or a negative temperature coefficient of resistance, and whether the amplifier has an odd or an even number of stages. If the element R_1 is of a material or is a device having a negative temperature coefficient of resistance, it will produce volume expansion when used in an amplifier having an odd number of stages, for example, that of Figs. 1, 2 and 4, and volume compression when used in an amplifying circuit having an even number of stages, for example, Fig. 3. If, on the other hand, the element R_1 is of a material or is a device having a positive temperature coefficient of resistance, it will produce volume compression in an amplifying circuit with an odd number of stages, for example, Figs. 1, 2 and 4, and volume expansion when the number of stages is even, for example, as in Fig. 3.

Although a directly or self-heated temperature-controlled resistance element has been described, other types of variable impedance might be used. For example, R_1 could be the plate resistance of a vacuum tube whose grid potential is varied in accordance with the signal to produce the desired expansion or compression. The use of an electronic resistance for R_1 possesses the advantage of making the time constant of the circuit more flexible. Thus the circuit could be arranged to accomplish the expansion or compression with any desired time lag. With zero time lag, R_1 would respond to the instantaneous value of the impressed voltage. Thus the amplifier might be made more nearly linear, or, if desired, non-linear.

Fig. 7 shows a circuit embodying an electronic resistance for range expansion. The vacuum tube 14 is connected in the grid-cathode and cathode-anode circuits with its anode or plate 15 connected through condenser C_1 to the junction of the biasing resistance R_0 and inductance L_1 and its cathode 16 connected through a biasing resistor 17 and by-pass condenser 18 to the junction of inductance L and the low potential terminal of the source B. Potential for anode 15 is obtained from the high potential terminal of source B through a coil 19. A diode D is connected between the cathode end of biasing resistor R_0 and the control grid 20 of tube 14. The anode 21 of the diode is connected to the cathode 12 of tube 10 through a condenser 22, to the diode cathode 23 through a resistance 24, and to the control grid of tube 14. The junction of cathode 23 and resistance 24 is connected to the low potential terminal of the source B.

Upon an increase in the magnitude of the signal impressed on termials 1, 2, the increased current flow through tube 10 increases the diode current, drives the control grid of tube 14 more positive, and reduces the plate resistance of tube 14. The amount of degenerative feedback of signal to the control grid of tube 10 is decreased, and the output of the circuit is increased, but in ratio greater than the relative change in the magnitude of the signal impressed at the terminals 1, 2.

In the circuit of Fig. 5, a biasing resistor R_0 is connected in series with a network N, having high impedance to the frequency of the signal current to be transmitted between the input and output terminals, the resistor and network being connected between the cathode and the low potential terminal of source B of anode potential. Series-connected condenser C_2 and temperature-controlled variable resistance element R_1 are connected in parallel with resistance R_0 and network N. The element R_1 may be of a material or a device having a negative or a positive temperature coefficient of resistance, and preferably, of the type that evidences non-linear changes in resistance with temperature change.

If element R_1 is of the negative temperature coefficient type, the circuit of Fig. 5 may be used to accomplish volume expansion. Volume expansion may be accomplished in a multistage amplifier having an odd number of stages, for example, such as is shown in Fig. 6; volume compression is obtainable with a multistage circuit having an even number of stages. With an element R_1 having a positive temperature coefficient, expansion is obtainable with a circuit having an even number of stages, and compression with an odd number of stages. If the element R_1 is of silver sulphide, condenser C_2 insures that direct current, which would render it unstable, cannot flow through the element R_1.

Although this invention has been disclosed with reference to certain specific embodiments, it is to be understood that it is not limited in scope thereto, but by the appended claims only.

What is claimed is:

1. A circuit comprising a plurality of electron discharge devices connected in tandem, each of said devices comprising a cathode, an anode and a control grid, and a single feedback means common to the cathode-grid and cathode-anode circuits of each of said devices for causing a change in the signal volume output of said circuit nonproportionate to a change in signal impressed on the input of said circuit, said means including a thermosensitive resistance element to be heated by current flow in said cathode-anode circuit and being of a substance having a non-linear temperature-resistance characteristic, and means in shunt with said resistance element and of high impedance to the signal current.

2. A circuit comprising a plurality of electric discharge devices, each device comprising a cathode, an anode and a control grid, the cathodes of said devices being connected directly together, input and output circuits for each of said devices, and impedance means common to said circuits and including a thermosensitive variable impedance to be heated by current flow in said output circuits and having one terminal common to said cathodes, said impedance being of a substance having a high temperature coefficient of resistance.

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