

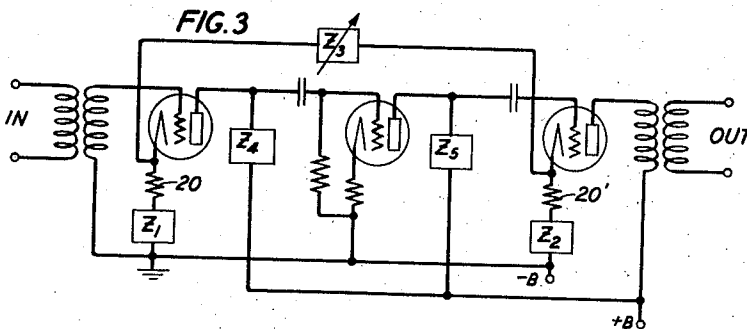
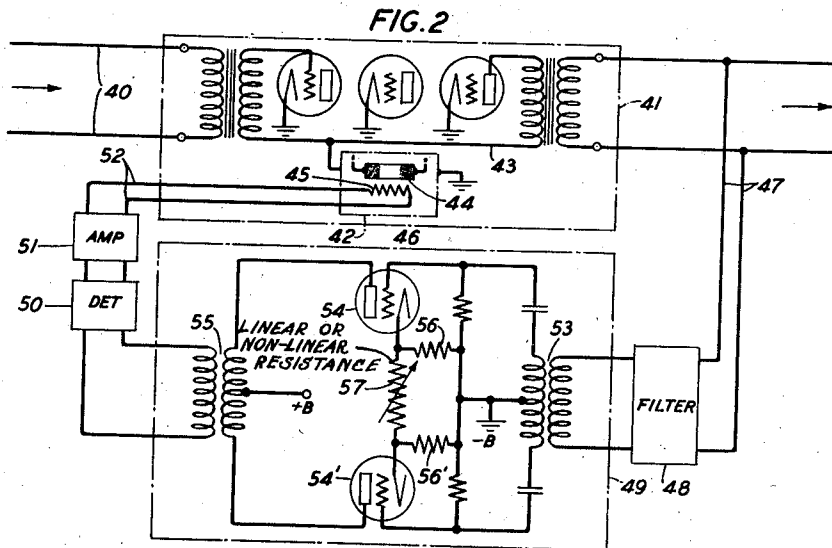
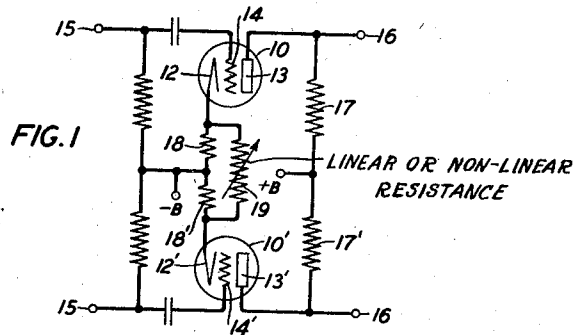
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ELECTRON DISCHARGE DEVICE CIRCUIT

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ELECTRON DISCHARGE DEVICE CIRCUIT

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This invention relates to electron discharge device circuits, and, more particularly, to circuits utilizing negative feedback.

It is known to use electron discharge devices or tubes connected in balanced or push-pull arrangement to obtain a circuit from whose output even order harmonics are substantially eliminated. If it is desired to control or vary the output of such an arrangement, it is necessary, if the even harmonic balance is to be maintained, that the gains of the tubes be equal to each other for all settings of the output control. If two ganged-potentiometers are used as an output control, the necessity of maintaining a balance places a very severe tracking requirement on the potentiometer. It would be preferable, therefore, for the output control to consist of a single variable impedance element which varies the gains of the tubes simultaneously.

An object of the invention is to vary the output of a balanced or push-pull circuit and yet maintain the harmonic balance of the output.

A feature of the invention comprises varying the output of a balanced or push-pull circuit by varying the amount of local degenerative feedback in said circuit.

Another feature of the invention comprises utilizing local degenerative feedback for each tube of a balanced or push-pull circuit and simultaneously varying the amount of degenerative feedback for each tube without affecting the balanced character of the output of the circuit.

A further feature comprises regulating the gain of an amplifier comprising an odd number of electron discharge devices in tandem, in which impedances are included in the common paths of the cathode-control grid and cathode-anode circuits of the initial and the final devices, by varying an impedance connected between the cathode ends of the cathode impedances.

In one embodiment in accordance with the invention, a pair of electron discharge devices or tubes are connected in balanced or push-pull arrangement, the control grid-cathode and cathode-anode circuits of each device having an impedance, preferably, a resistance, therein providing a predetermined biasing potential for the control grid and a preassigned degenerative feedback of signal. The output of the balanced circuit is controlled or regulated by simultaneously changing the gains of the tubes, the control being exercised through a variable impedance, preferably, a variable resistance, connected in shunt of the series-connected cathode resistances and located in the alternating current path only of

the output circuit of the balanced circuit. The variable resistance may be of the type in which a slide or contact is adjusted in position to vary the amount of resistance effectively connected or removed from the circuit with which it is associated; or, it may be of the type comprising a material having a non-linear current-resistance characteristic, whose resistance varies with the amount of current flowing therethrough, for example, silver sulphide.

In another embodiment, in accordance with the invention, a plurality of electron discharge devices or tubes are connected in tandem, the initial and the final device each having impedance means common to their control grid-cathode and cathode-anode circuits, and having additional impedance means connected between the cathode ends of the common impedances, the biases on the control grids of the tubes preferably being the same. Each impedance may be a resistance, with the impedance connecting the common impedances a variable resistance.

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

Fig. 1 shows a single-stage balanced or push-pull circuit embodying the invention;

Fig. 2 shows a circuit arrangement embodying the invention for regulating the gain of an amplifier in a transmission line; and

Fig. 3 shows a multistage amplifier having an odd number of stages embodying the gain control arrangement of the invention.

Fig. 1 shows a pair of electron discharge devices or tubes 10, 10' connected in balanced or push-pull arrangement in a wave translating circuit that may comprise a single stage of an amplifier, an oscillator or a detector. Each device comprises a cathode 12, 12', which may be of the indirectly heated type; an anode 13, 13'; and an input control grid 14, 14'. Each control grid is connected to a signal input terminal 15, and each anode is connected to an output terminal 16 and, through an output resistance 17, 17', to the positive terminal of a suitable anode power supply. A resistor 18, 18' is connected in the cathode-control grid and cathode-anode circuits of each tube. A variable resistor 19 is connected in shunt of the resistors 18, 18' connected in series. The resistor 19 may be of the type including a slide or a contact, adjustment of which varies the amount of resistance effectively in the circuit, or it may be of the type in which the resistance varies with the amount of current flowing therethrough, i. e.,

it may be one, or of a material, having a non-linear current-resistance characteristic.

The resistors 18, 18' provide a predetermined biasing potential for the control grids and, when signal is applied to the control grids, a local degenerative feedback from the output to the input of the tubes. The resistor 19 enables the gain of the push-pull circuit to be varied by variation in the amount of degenerative feedback, without affecting the even harmonic balance obtainable with a push-pull arrangement of a pair of electron discharge devices.

With the arrangement described, if feedback in the tubes is set equal at one value of output by selecting appropriate values of resistance for the resistors 18, 18', feedback in the tubes will track automatically at all other values as the resistance of the element 19 is varied. It will be noted that there is no direct current potential across the resistor 19. This reduces contact noise inasmuch as with zero signal on the grids, changes in the resistance of element 19 produce no output. The direct current operating potentials of the tubes are constant and are independent of the setting of the feedback control. Although the latter may be adjusted so that the feedback of the signal has been reduced to zero, there will be feedback to suppress any unbalance in even order harmonics which might be generated.

Inasmuch as alternating current only flows through resistor 19, it is possible to use a resistor of a material having a non-linear current-resistance characteristic that could not be used advantageously if direct current were to flow through it, for example, silver sulphide. With this material, the gain of the push-pull stage may be caused to vary automatically as the load thereon varies from a preassigned normal value.

The gain control arrangement described with reference to Fig. 1 may be applied to vary the gain in a negative feedback amplifier containing an odd number of stages, for example, the three-stage amplifier shown in schematic in Fig. 3. The impedances Z_4 and Z_5 represent interstage networks, and the impedances Z_1 , Z_2 and Z_3 comprise the beta circuit of a negative feedback amplifier of the type described in H. S. Black Patent 2,102,671, issued December 21, 1937. The networks Z_1 and Z_2 are designed to provide the desired phase shift and gain around the feedback loop, and Z_3 is a variable impedance, preferably a variable resistance, for changing the gain of the amplifier. Although separate biasing resistors 20 and 20' are shown, the networks Z_1 and Z_2 could be designed to include the necessary resistance to provide the desired bias on the grid of the respective stage. Assuming equal bias on the first and the final stages of the amplifier, there will be no direct current potential across Z_3 . Variation in Z_3 will vary the amount of feedback around the amplifier and vary its gain, without disturbing the direct current operating conditions.

Fig. 2 shows how the invention may be applied to a circuit arrangement for regulating the gain of an amplifier in a transmission line transmitting, for example, carrier frequency currents. The line 40 has therein an amplifier 41, shown schematically, which may have three stages and be of the negative feedback type disclosed in H. S. Black Patent 2,102,671, issued December 21, 1937. A shunt impedance pad 42 is shown

connected in the beta circuit 43 of the amplifier 41. One element of the impedance pad comprises a resistance element 44 having a high negative temperature coefficient of resistance. The resistance element is controlled by a heater element 45. An increase of current flow in the heater element decreases the resistance of element 44 for decreasing the amount of feedback through the beta circuit 43 to increase the gain of the amplifier. A decrease in the current flow through the heater element produces an opposite action whereby the gain of the amplifier is decreased.

A regulator circuit 46 is provided for controlling the heater element 45 to maintain the output from the amplifier substantially constant. The transmission line transmits not only the carrier currents but also a pilot current used for controlling the operation of the regulator circuit, the pilot current being affected in the same manner as the carrier frequency currents by changes in the amplifier output. The regulator circuit comprises a line 47 connected to the line 40 on the output side of the amplifier 41; a filter 48 for passing the pilot frequency only; a control circuit 49 embodying the gain control arrangement of Fig. 1; a detector circuit 50; an amplifier 51; and a line 52 for connecting the output of the amplifier 51 to the heater element 45.

The control circuit 49 comprises an input transformer 53 the ends of whose secondary winding are connected through condensers to the control grids of the electron discharge devices or tubes 54, 54' connected in push-pull arrangement. The anodes are connected to the ends of the primary winding of an output transformer 55. The grid-cathode and cathode-anode circuits of each tube contain a biasing and degenerative feedback resistor 56, 56', a variable resistance element 57 being connected in shunt of said cathode resistors connected in series. The element 57 is of a material having a non-linear current-resistance characteristic, and preferably of silver sulphide, a material having a high negative temperature coefficient of resistance.

For normal output of the line amplifier the control circuit is adjusted so that the current flow in the heater element is of a value such that the amplifier has the desired normal gain. Should the gain of the line amplifier vary for any reason, the change in its output will be reflected in the control circuit of the regulator through the variation in the pilot frequency input thereto. If it is assumed that the output of the line amplifier decreases, the pilot frequency input to the control circuit decreases, the output of the control circuit is less, the current flowing in the heater element is less, and the latter has a decreased effect on the resistance element in the pad in the beta circuit of the amplifier, causing the resistance element to increase in resistance and the amount of feedback to decrease whereby the gain of the amplifier is increased. If the output of the line amplifier increases, the increased output of the control circuit produces an increased current flow in the heater element, a reduced resistance of the resistance element in the beta circuit, and a decrease in the gain of the line amplifier.

What is claimed is:

1. In combination, electron discharge devices arranged in push-pull relation, each device com-

prising a control grid, a cathode and an anode, an anode circuit for each device, means comprising an individual unbypassed impedance in each anode circuit to control the potential difference between each grid and its associated cathode, and means comprising a variable impedance connected in shunt of said impedances, said shunt impedance being of a material having a non-linear current-resistance characteristic.

2. The combination as claimed in the preced-

ing claim in which said shunt impedance is of silver sulphide.

3. In combination, electron discharge devices in push-pull relation, a grid biasing and degenerative feedback resistor common to the cathode-control grid and cathode-anode circuits of each device, and a variable resistor shunted across said resistors, said variable resistance being of a material having a non-linear current-resistance characteristic.

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