May 23, 1939. A. SENAUKE 2,159,453

DUAL ACTION VOLUME CONTROL

Filed June 13, 1929

FIG. 1

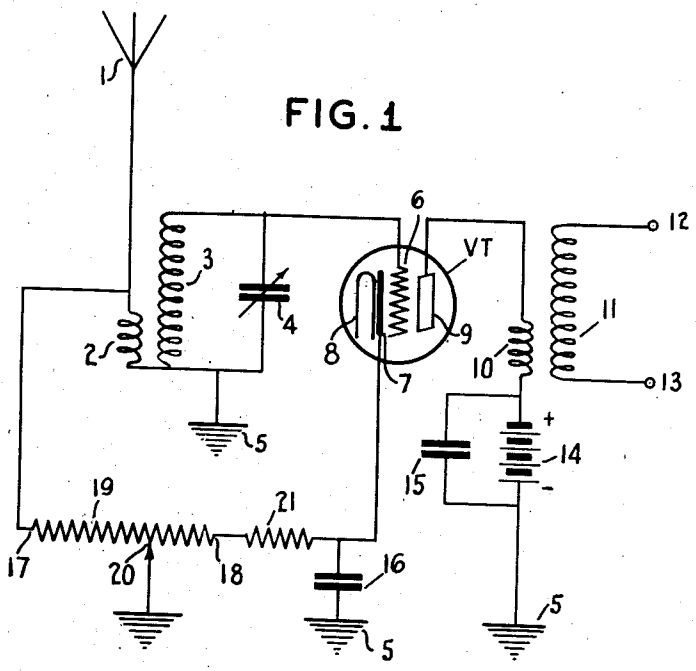
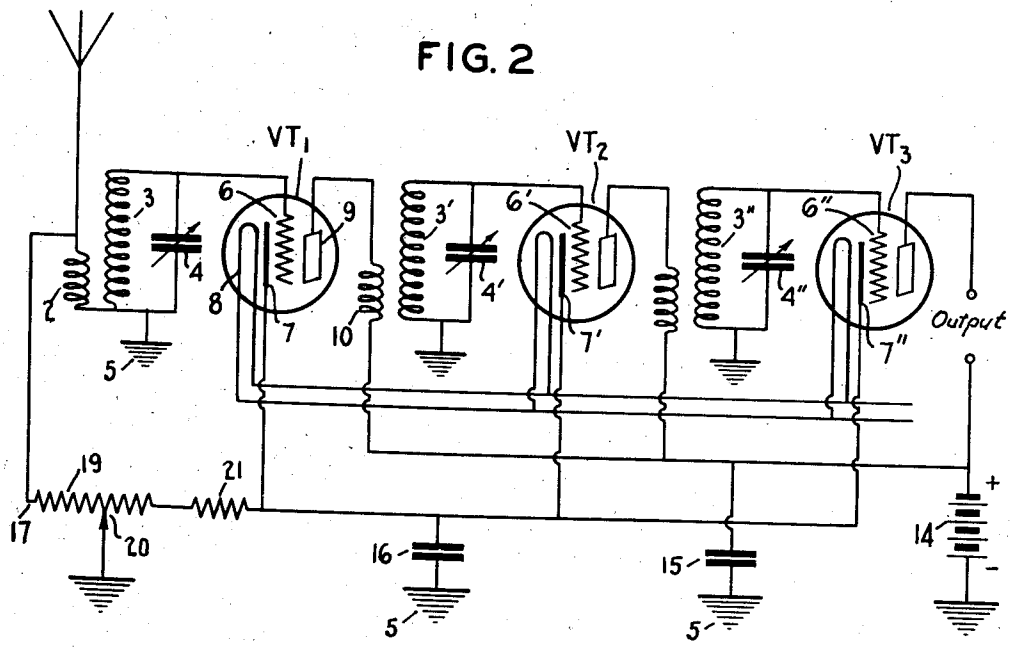


FIG. 2



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Patented May 23, 1939 2,159,453

UNITED STATES PATENT OFFICE

2,159,453

DUAL ACTION VOLUME CONTROL

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Application June 13, 1929, Serial No. 370,545

10 Claims. (Cl. 250—20)

My invention relates to amplifier systems utilizing thermionic vacuum tubes in which the amplification may be controlled by altering the bias potential applied to the control member or grid.

In amplifiers whose tubes have filaments heated with alternating current, it is not in general practicable to control volume by reducing the amount of filament current. Heretofore the method most widely used has been to shunt the input circuit with a variable resistance. This method is open to two serious objections. First, the output volume increases very fast when the control resistance is increased slightly from its zero value, making it impracticable to use a uniform wire wound resistance. Secondly, when such method of control is used in connection with a high gain multi-stage amplifier, it is difficult to cut the output volume down sufficiently, due to the fact that a strong signal may be picked up on the apparatus and wiring associated with the various stages.

One purpose of my invention is to provide means for simultaneously controlling the amount of the amplification and the amount of energy supplied to the input of the amplifier.

A further purpose is to provide a method of controlling the output energy of a radio receiving set from maximum to zero in such a way as to make the change in output volume approximately linear when a uniform volume control resistance is employed.

An additional purpose is to accomplish complete control of volume without increasing the negative bias on the amplifier grids to a point where troublesome distortion occurs.

Still other objects and advantages of my invention will be apparent from the specification.

The features of novelty which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its fundamental principles and as to its particular embodiments, will best be understood by reference to the specification and accompanying drawing, in which:

Figure 1 is a circuit diagram of a preferred form of my invention applied to a single stage amplifier using the heater type of three element vacuum tube, and

Figure 2 is a circuit diagram showing how my invention may be applied to a multi-stage amplifier such as is commonly used in radio receiving sets.

Referring now more particularly to Fig. 1, reference character 2 indicates a coil which receives energy from the antenna 1 and which is coupled to coil 3. Coil 3 and condenser 4 form a resonant circuit, grounded at 5, and connected at its upper end to the grid 6 of a control electrode or vacuum tube VT whose cathode 7 is heated by current from a source not shown and passing through heater 8. The plate or anode 9 is connected to the positive terminal of the source of B potential 14 through the coil 10. Coil 11 is inductively coupled to coil 10, and the output of the amplifier is delivered between the terminals 12 and 13. The source of B potential 14 has its positive terminal connected to anode 9 and its negative to ground 5 and is shunted by the by-pass condenser 15. A second by-pass condenser 16 connects the cathode 7 with ground 5. Resistance 21 and resistance 19 are connected in series between the antenna 1 and the cathode 7. The movable contact 20, associated with resistance 19, is connected to ground 5.

As will be readily understood, the electron stream which flows from cathode 7 to anode 9 when the amplifier is in operation causes a current to flow through resistance 21, and through that portion of the resistance 19, which is between the end 18 and the movable contact 20. The effect of this current is to cause the cathode 7 to assume a plus potential with respect to the ground 5. The grid 6 being at ground potential, so far as direct current is concerned, will therefore be held at a potential negative with respect to the cathode 7. When the movable contact 20 is brought over to the end 18 of the resistance 19, resistance 21 alone will be in circuit between the cathode and ground. This is the position for maximum amplification, and the value of resistance 21 is chosen to provide a proper negative bias for the grid 6 under such conditions. As the movable contact 20 is moved towards the end 17, an increasing amount of the resistance 19 will be included in the circuit between cathode and ground, resulting in an increased negative bias on the grid 6, and a consequent decrease in amplification.

While the method just described may in some cases serve as an adequate volume control, the preferred form of my invention combines with it the shunting effect of a resistance around the antenna coil 2. It will be noted that I connect the end 17 of the resistance 19 to the high potential end of the antenna coil 2. When the movable contact 20 is at the end 18, the antenna coil 2 will be shunted by the total resistance of 19, which is made high in comparison with the effective impedance of coil 2, whereby substantially all the antenna current flows through coil 2.

It will be recalled that this is also the position of the movable contact 20 which provides normal operating bias to the grid 6 and affords maximum amplification. If now the contact 20 is shifted towards 17, the amount of resistance shunting the antenna coil will be decreased, with a corresponding decrease in the amount of signal which reaches the grid 6 and with a simultaneous increase in bias potential and corresponding reduction in amplification. Should the contact 20 reach the end 17, the antenna coil will be shorted out of circuit and there will be approximately no current flowing in it to produce a voltage on the grid 6. At the same time, as pointed out above, the bias potential on grid 6 will have been increased to such an extent as to destroy the amplifying property of the tube.

It will thus be seen that by moving the contact 20 I simultaneously vary the amount of signal reaching the grid 6 and modify the amplifying property of the tube by altering the D. C. bias potential applied to the grid, thereby varying the mutual conductance of the tube.

Referring now to Fig. 2, it will be noted that the application of my invention to a cascade amplifier is accomplished by connecting together the leads from the cathodes 7, 7' and 7'' of vacuum tubes VT_1, VT_2 and VT_3 in the first, second and third stages respectively. It will be noted that in this instance resonant circuits comprising coil 3 and condenser 4, coil 3' and condenser 4' and coil 3'' and condenser 4'' are provided in the input of each tube according to common practice, and are each grounded. It will be understood that additional or fewer stages may be utilized if desired and that one or more of the tuning circuits may be omitted if desired. In this instance the heaters of the various tubes are shown as energized in parallel for purposes of simplicity, but other arrangements may be used if desired. The operation is the same as in the case of the single stage amplifier, except that in this case the common bias potential on grids 6, 6' and 6'' is controlled by the position of movable contact 20, so that as this contact is moved the input signal strength, as well as the amplification in each stage, is varied.

I have found that in applying my invention to a radio receiver it is practicable to make resistance 19 in the form of a uniform wire wound resistance. This I believe to be due to the fact that there is a considerable reduction in amplification due to increased grid bias, which becomes effective while the resistance shunting the antenna coil is still relatively high.

It is not necessary to physically separate the two resistances 19 and 21, as the same result may be secured by using a single resistance of greater value, provided with a stop so that the contact 20 may not be moved beyond a point which will provide the grids with normal operating bias potential.

I have found, when my invention is used to control the output of a multi-stage amplifier of the tuned radio frequency type, that the loss in selectivity due to shunting the antenna coil with a low resistance when contact 20 is moved toward end 17 tends to be compensated by the decrease in mutual conductance of the tubes, resulting from increased grid bias, which tends to sharpen the tuning of succeeding circuits.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the spirit and scope of my invention, as will be understood by those skilled in the art.

I claim:

1. In an amplifier system, in combination, a vacuum tube amplifier, an input circuit associated therewith, a variable resistance in shunt therewith, a second variable resistance traversed by the space current of said tube, means for applying the voltage drop developed therein as a bias potential to the grid of said tube and a single means for varying both said resistances simultaneously and in an opposite sense.

2. In an amplifier system, in combination, a vacuum tube amplifier, an input circuit associated therewith, a variable resistance in shunt therewith, a second variable resistance traversed by the space current of said tube, means for applying the voltage drop developed therein as a bias potential to the grid of said tube, and means for varying both said resistances simultaneously.

3. In an amplifier system, in combination, a vacuum tube amplifier, an input circuit associated therewith, a variable resistance in shunt therewith, a second variable resistance traversed by the space current of said tube, means for applying the voltage drop developed therein as a bias potential to the grid of said tube, and means for simultaneously increasing one of said resistances and decreasing the other.

4. In an amplifier system, in combination, a vacuum tube amplifier, an input circuit associated therewith, a resistance having one portion thereof traversed by the space current of said tube to provide a bias potential for the grid and having another portion in shunt with said input circuit, and a connection to said resistance shiftable to vary the value of said portions inversely.

5. In an amplifier system, comprising a thermionic vacuum tube, an input circuit, a variable resistance in shunt therewith, a fixed resistance and a variable resistance in series connected in the path of space current of said tube, means for applying the voltage drop through said last-named resistances as a bias potential to the grid of said tube, and means for simultaneously varying both said variable resistances.

6. A volume control for an amplifier using thermionic tubes having an anode, a cathode and a grounded grid, which grid is coupled to a pick-up device, comprising the combination of a resistor connected between the cathode and ground, a resistor connected between the pick-up device and the cathode, and a rider connected to ground and engaging said latter resistor.

7. The combination with a radio set having an antenna coupled to the grid of a thermionic tube which has a cathode, of a volume control comprising a shunt resistance connected between said antenna and said cathode, a resistor connecting said cathode to ground, and means for varying the effective value of said shunt resistance.

8. The combination in radio receiving apparatus of a thermionic tube having a cathode element and a grid element, an aerial connection, an earth connection, a resistor divided into two parts, one part of said resistor being connected between the aerial connection and the earth connection, and the other part between the cathode element and the grid element, and means comprising a single manually operable device for varying the relative resistance of the two parts of the resistor.

9. The combination in radio receiving apparatus of a thermionic tube, a cathode and a grid located in said tube, a resistor, a connection be-

tween said resistor unit and the said grid, a connection between the resistor and said cathode, an aerial connection, a connection between the aerial connection and the resistor, an earth connection and an adjustable connection between said earth connection and the resistor, said adjustable connection being adapted to vary the resistance in the connections between the aerial and earth connections on the one hand and between the cathode and grid of the tube on the other hand.

10. In a radio set, the combination with an antenna coil connected between an antenna and ground, a grid coil connected between the grid of a tube and ground and iductively coupled to said antenna coil, and a cathode in said tube, of a resistor connecting said cathode to ground, a resistor connecting said antenna to said resistor, and a rider connected to ground and engaging said second resistor and movable thereover to regulate the voltage induced in said grid coil and the potential of said grid with respect to said cathode.

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