April 11, 1939.

O. E. DOW

2,154,200

VOLTAGE REGULATOR DEVICE

Filed Nov. 12, 1934

2 Sheets-Sheet 1

Fig. 1

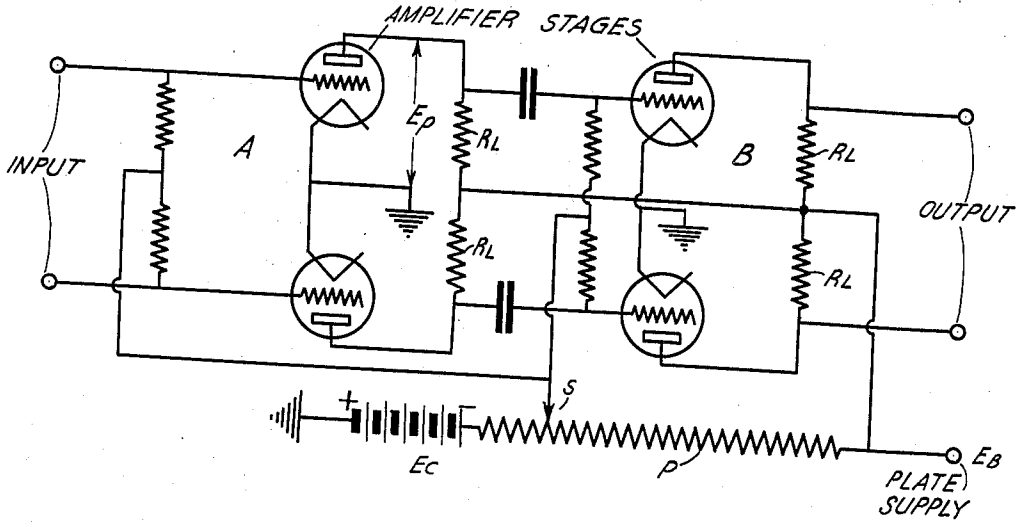
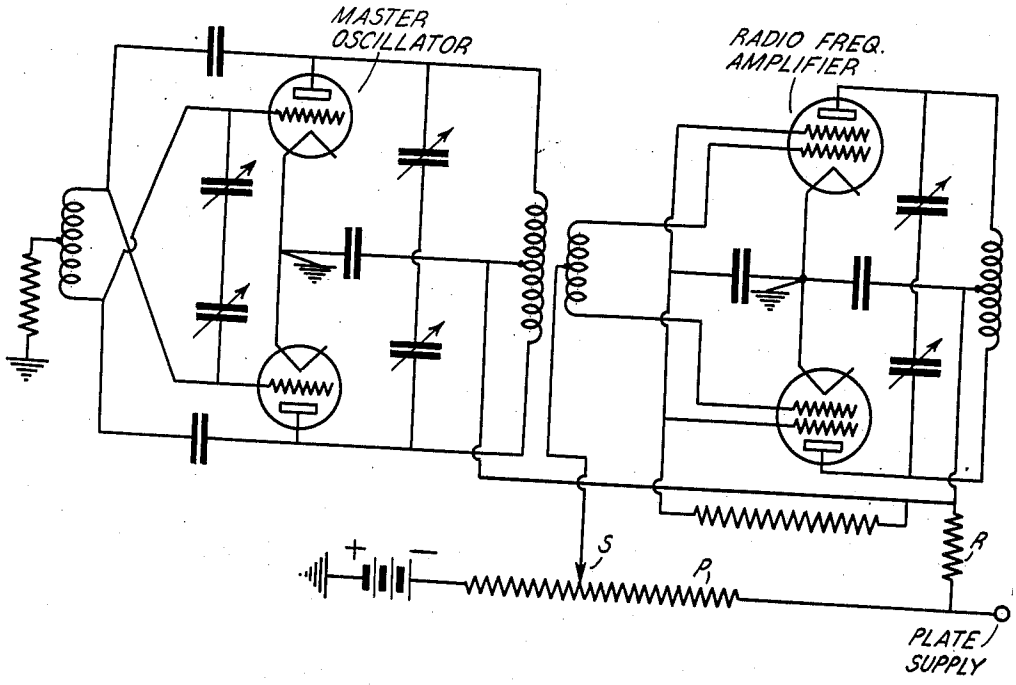


Fig. 2



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2 Sheets-Sheet 2

Fig. 3

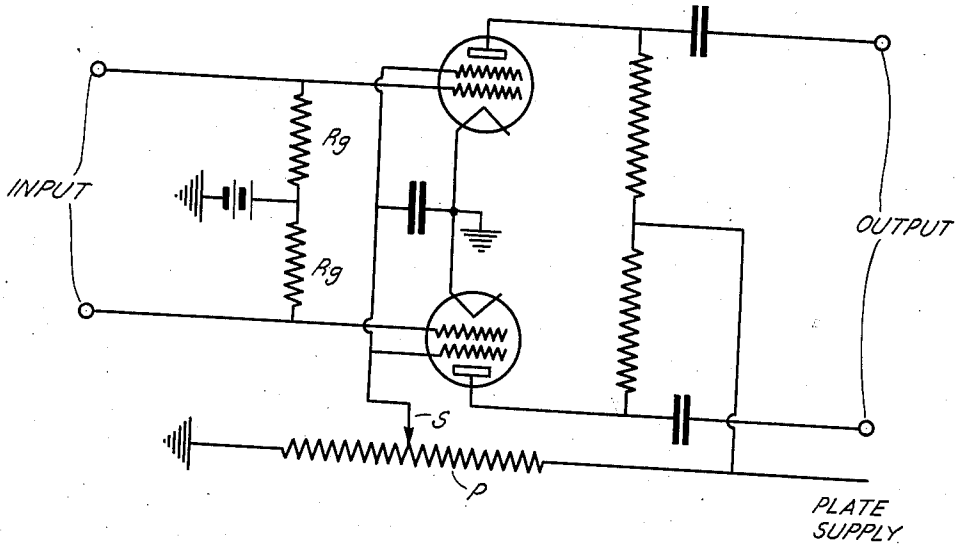
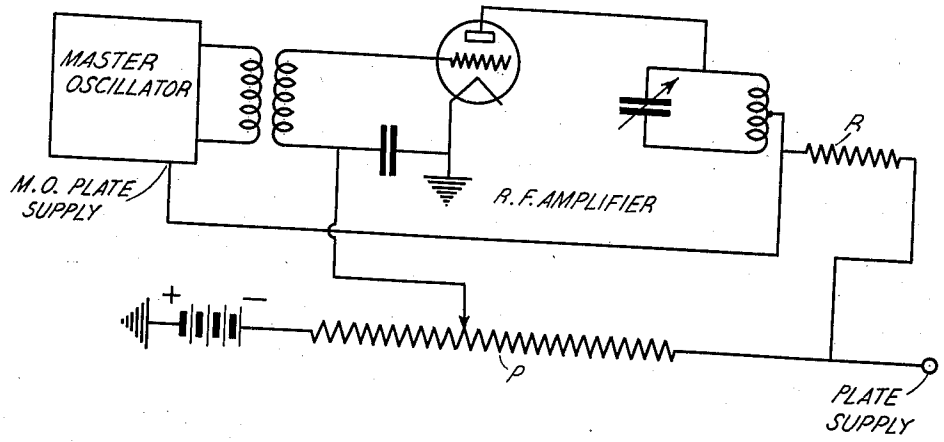


Fig. 4



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Patented Apr. 11, 1939

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UNITED STATES PATENT OFFICE

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VOLTAGE REGULATOR DEVICE

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Application November 12, 1934, Serial No. 752,653

4 Claims. (Cl. 179—171)

This invention relates to voltage regulator devices.

Hitherto in the use of electron discharge devices in high frequency circuits it has been the practice to employ a separate unit as a regulator, with a consequent increase in the initial cost and maintenance of the circuit.

The present invention obviates the foregoing disadvantages by providing a circuit wherein the vacuum tube circuits themselves act as voltage regulators. In a specific embodiment the thermionic tubes of a push-pull amplifier are made to operate in parallel relationship as voltage regulators. Thus, any variation of current or voltage which may result from the circuit acting as a voltage regulator is balanced out in the push-pull circuit and hence does not interfere with the operation of the amplifier. In another embodiment, a similar result is obtained by a single amplifier tube acting as a voltage regulator.

A better understanding of the invention may be had by referring to the following detailed description which is accompanied by drawings, wherein

Figure 1 shows two stages of push-pull amplification arranged in accordance with principles underlying the present invention,

Figure 2 shows a push-pull radio frequency amplifier acting as a voltage regulator both for itself and a master oscillator,

Figure 3 shows the invention used in connection with screen grid tubes, and

Figure 4 shows the invention as applied to a single tube circuit.

Referring to Figure 1, there are shown two stages of push-pull resistance coupled amplifiers A and B. For energizing the anodes of the tubes of each stage there is provided a common source of potential E_B which is an approximately constant anode voltage supply. The energizing voltage is fed to the anode of each tube through an individual load resistor R_L of suitable size. The mid-points of the grids of both stages are connected together and fastened to the sliding contact S of potentiometer P. A battery Ec supplies the grids of the tubes with the proper bias. Potentiometer P is connected between the anode source of supply E_B and ground.

Since the operation of the circuit as a push-pull amplifier is well known, it will not be described as such herein. The operation of the circuit as a voltage regulator, however, is as follows:

Assuming that the anode supply voltage E_B is raised to a value E'_B, then immediately, the bias on all the grids is made more positive by an amount $r(E'_B - E_B)$, where r is the ratio of the potentiometer P. This causes each tube to change its normal average anode current from Ip to $I'p$. This produces a voltage drop,

$$E = R_L(I'p - Ip)$$

across each load resistor, which will just equal the amount of increase in the anode supply voltage if the ratio, r, of the potentiometer is of the proper value. Thus, the anode voltage Ep is unaffected from the change in the anode supply voltage. Similarly the anode supply voltage may decrease without changing Ep. Care should be taken to prevent the change of grid bias in the performance of the voltage regulator function from moving the tube into a non-linear region for its push-pull operation. It is also necessary that the voltage $r(E'_B - E_B)$ impressed on the grids should vary in phase with the voltage $(E'_B - E_B)$ across the potentiometer.

Another useful application of this principle is illustrated in Figure 2. Here the push-pull radio frequency amplifier acts as a voltage regulator for itself and the master oscillator. The master oscillator is not used as a regulator, since the variation of the grid bias would tend to change the frequency although the anode voltage is constant.

The circuit may also be used on impedance and transformer coupled circuits. In the cases where the load impedance is mainly reactive it is necessary to use a regulating resistor, R, as shown in Figure 2. Figure 3 illustrates how this circuit may be used with screen grid tubes. Here the screen grids act in parallel to prevent any fluctuations in the anode supply from reaching the anodes of the tubes. The operation is similar to the three element vacuum tube. In instances where the capacity reactance of the control grid to ground at the frequency of the supply voltage variations is comparable to the grid resistof R_g it is advisable to use the circuit shown in Figure 3. Since on portions of the operation characteristic of a screen grid tube the mutual conductance is fairly independent of the screen grid voltage, the performance of the circuit as an amplifier will be unimpaired.

Figure 4 illustrates a circuit wherein a single tube functions as a voltage regulator for the master oscillator. The operation of the circuit is similar to that above described in connection with Figure 2 and will be clear from what has been said before.

What I claim is:

1. In combination, a pair of electron discharge devices, each having anode, cathode and control grid electrodes, said cathodes being connected together, an input circuit coupled to said control electrodes and an output coupled to said anodes whereby said pair of devices act in push-pull relationship with respect to one another, a master oscillator having an output circuit coupled to the input circuit of said pair of electron discharge devices, a common source of supply for the output electrodes of said master oscillator and pair of electron discharge devices, and a connection including a resistance in common to said master oscillator and pair of devices from said source to the electrical mid-point of said output circuit and the output circuit of said master oscillator, a potentiometer extending from said source to ground, and a connection from the electrical mid-point of said input circuit to a point on said potentiometer whereby said pair of electron discharge devices acts as a voltage regulator both for itself and said master oscillator.

2. In combination, two amplifier stages in cascade, each stage comprising a pair of electron discharge devices connected in push-pull relation, each device having an anode, a cathode and a control electrode, the cathodes of each stage being connected together, a connection comprising a pair of resistances between the anodes of each stage, another connection comprising a pair of resistances between the control electrodes of each stage, a source of anode potential, a potentiometer having one end connected to the positive terminal of said source, a connection from the other end of said potentiometer to ground, said connection including a source of grid bias potential, individual connections from the junction points of both said pairs of resistances across said control electrodes to a common point on said potentiometer intermediate its ends, and individual connections from the junction points of both said pairs of resistances across said anodes to the positive terminal of said source.

3. In combination, a pair of electron discharge devices arranged in push-pull relation, each having an anode, a cathode and a grid, a connection between said grids including at least one impedance, a connection between said anodes including at least one impedance, a source of anode potential, a potentiometer having one end connected to the positive terminal of said source, a connection from the other end of said potentiometer to a point of relatively fixed radio frequency potential, said connection including a source of grid potential, a connection from the electrical center of said first connection to a point on said potentiometer intermediate its ends, and a connection from the electrical center of said second connection to the positive terminal of said source, whereby a variation in voltage of said source of anode potential produces a cophasal variation in potential on said grids relative to the respective cathodes for producing an increase of current in the anode circuits.

4. In combination, a pair of electron discharge devices each having anode, cathode and control grid electrodes, said cathodes being connected together, a center tapped input circuit having its ends connected to said control electrodes and a center tapped output circuit having its ends connected to said anodes whereby said pair of devices act in a push-pull relationship with respect to one another, a master oscillator having an output circuit coupled to the input circuit of said pair of electron discharge devices, a common source of anode potential for said master oscillator and said pair of electron discharge devices, and a connection including a resistance in common to said master oscillator and said pair of electron discharge devices from said source to said master oscillator and the center tap of the electron discharge device output circuit, a potentiometer extending from said source to a common return and a connection from the center tap of said input circuit to a point on said potentiometer whereby said pair of electron discharge devices act as a voltage regulator both for themselves and said master oscillator.

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