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VACUUM TUBE CIRCUIT

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Fig. 1

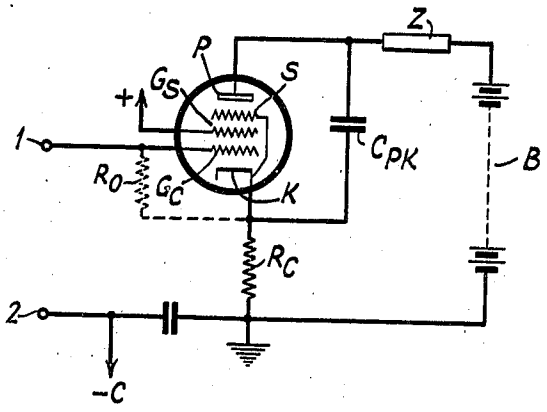
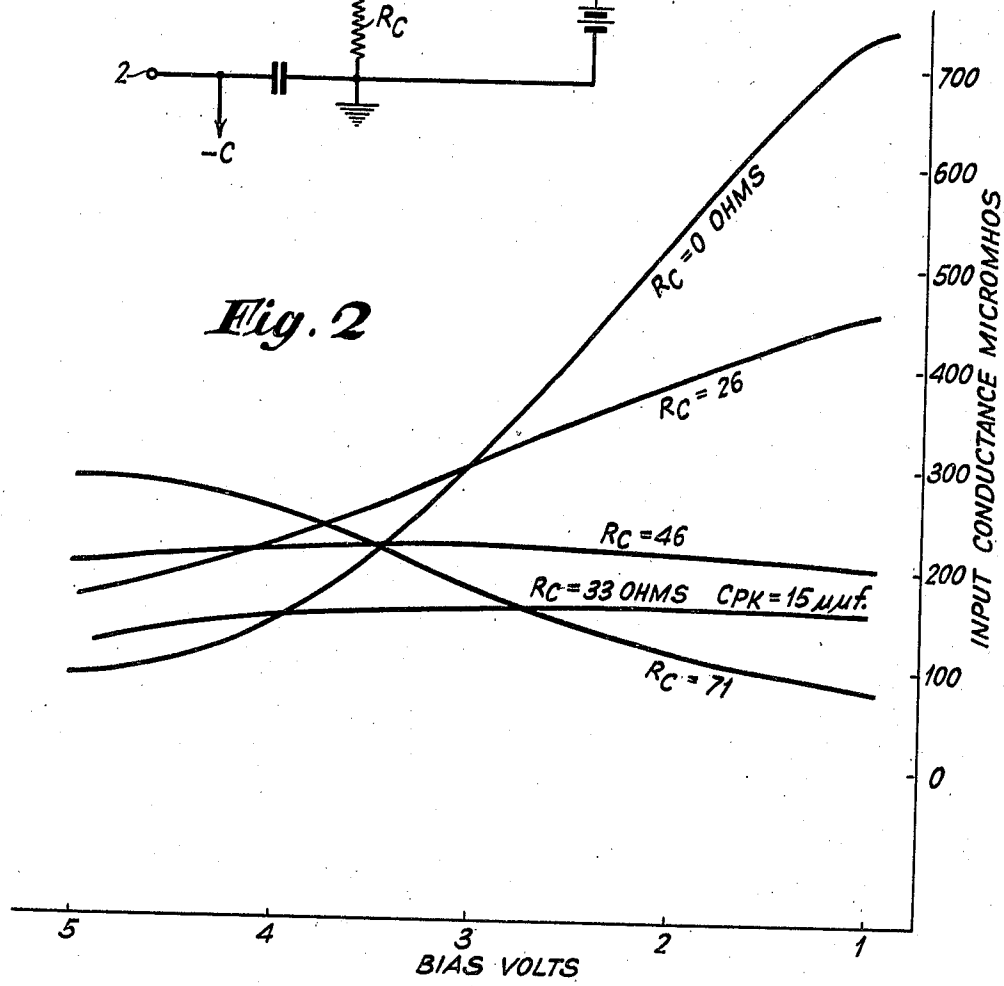



Fig. 2




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## VACUUM TUBE CIRCUIT

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5 Claims. (Cl. 179—171)

This invention relates to vacuum tube circuits adapted for operation at high frequencies, and more particularly to a circuit arrangement including elements which have the effect of reducing or lowering the tube input conductance and maintaining the same constant over a comparatively wide range of negative grid biasing voltages.

In vacuum tube circuits operated at high frequencies, such as are involved in the reception and transmission of television signals, there is a finite inherent input conductance between the input electrodes (signal grid and cathode) by virtue of the transit time effect. The input conductance has a loading effect on the circuit connected to the tube input terminals, and in the case of a tuned input circuit the result is a damping and a loss of selectivity thereof. It is desirable therefor not only to operate the tube so that it will have a substantially constant and uniform input conductance characteristic with change in bias, but also that the conductance be at as low a value as possible. It is known to employ an unbypassed cathode resistor or other impedance for making the input conductance constant with bias change.

The present invention contemplates the use of an additional circuit element whereby a constant but lower input conductance with bias change is obtained, and the unbypassed cathode resistor utilized for this purpose is of smaller magnitude than is required without the use of the above mentioned additional element.

The novel features characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and mode of operation together with additional objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawing in which

Fig. 1 illustrates a vacuum tube circuit incorporating the invention, and

Fig. 2 illustrates a number of curves which will serve to explain the invention, and which show the variation in input conductance of a known tube with change in grid bias for cathode resistors of different values.

Fig. 1 shows an amplifier stage for very high frequencies including an electron discharge tube T which may be of the screen grid or pentode type having the cathode K, the signal control grid $G_c$, the screen grid $G_s$, the plate or anode P and optionally the suppressor grid S. B is the source of plate voltage, Z, the plate load impedance, and —C represents a variable source of grid biasing voltage which may be supplied from an AVC path as well known. 1 and 2 are the input terminals connected respectively to the signal control grid $G_c$ and the cathode K and they are adapted to have connected thereto a source of signal energy which may consist of a tuned circuit, a band pass filter or other circuit network. A resistance $R_c$ is connected to the cathode and is common to both the input and output circuits of the amplifier. By suitable choice of the value of this resistance $R_c$ it is possible to make the input conductance, represented by $R_c$ in the figure, substantially constant over a comparatively wide range of variation in signal control grid bias.

In Fig. 2 I have shown several input conductan curves for a tube, known as "RCA type 1851." The tube was operated at 45 Mc with zero plate load, 300 volts on the plate or anode and 150 volts on the screen grid. In the absence of a cathode resistor, or a perfectly by-passed resistor, the input conductance is seen to vary from about 740 micromhos with —1 v. bias to approximately 90 micromhos at a grid bias of —5 volts. For the tube under consideration it is found that a cathode resistor of 46 ohms is suitable to make the input conductance substantially constant at about 200 micromhos over the range from —1 volt to —5 volts grid bias.

In order to still further reduce the input conductance and at the same time maintain it at a constant value I have discovered that an added capacity $C_{pk}$ between plate and cathode has beneficial effects in reducing the magnitude of the cathode resistance necessary. The reduction of this cathode resistance enables obtaining a higher value of input resistance, that is lower conductance, uniform with bias change. In other words, by adding the anode to cathode condenser $C_{pk}$ the value of $R_c$ which produces constant input conductance with variable bias is decreased and the value of input conductance resulting is likewise decreased over the constant value without $C_{pk}$. As seen from the lower curve in Fig. 2 a resistance having the value 33 ohms will result in obtaining a substantially constant input conductance curve of approximately 150 micromhos when the plate load has a low value.

Considering the curves of Fig. 2 in greater detail, it will be observed that in an amplifier stage having an unbypassed resistor, the input conductance varies with bias, depending upon the value of the cathode resistor, when there is no capacitance between plate and cathode, and when the impedance in the plate circuit is zero or has a low value, for example, 1000 ohms. As shown in that figure, there is a value of cathode resistance (in the case of the 1851 tube this value being 46 ohms or thereabouts) which gives substantially uniform input conductance with variation of bias. A lower value of cathode resistance causes the input conductance for low bias values to be higher than that for high bias values, whereas a higher value of cathode resistance as exemplified by the curve marked 71 ohms shows that the input conductance then decreases with decreasing values of

bias. If still more cathode resistance is included, the input conductance for low bias values will become negative, which means that the amplifier becomes regenerative. This regenerative tendency may be understood if the effects of stray capacitances from plate to cathode and from cathode to ground are taken into account. With those two capacitances considered, the configuration takes on some of the properties of a Colpitts oscillator.

Now what is desired is a value of input conductance which not only is invariable with bias, but also one which is as low as possible without being negative. A high value of cathode resistance decreases the input conductance for low bias values, and therefore makes the stray capacitance effect more pronounced. If a capacitance $C_{pk}$, as shown in Fig. 1, is added between plate and cathode, the regenerative effect will be enhanced and will take place with a lower value of cathode resistance.

As may be seen from Fig. 1, the current which will flow through capacitance $C_{pk}$, will depend not only on the cathode to ground capacitance and the magnitude of cathode resistance Rc, but also on the value of the plate load impedance Z. If the plate load impedance Z is high at the frequency of operation, the effect of $C_{pk}$ in producing regeneration will be greater than if Z is low. With capacitance $C_{pk}$ added to the circuit, the regenerative effect will occur with a lower value of cathode resistance, and therefore by proper choice of cathode resistance and plate-cathode capacitance, a value or series of values may be found which will give constant input conductance with bias variation.

For example, in the case of an 1851 tube with a cathode resistance of 33 ohms, it has been found that with a low value of plate load impedance that a plate to cathode capacitance of 15 $\mu\mu$fds. will produce a constant input impedance, with variable bias, of about 150 $\mu$mhos. With a high value of plate load impedance, for example 10,000 ohms or greater, and with a high mutual conductance such as the 1851, the regenerative tendencies become very great if a large value of plate cathode capacitance is used. For example, it has been found with a high plate load impedance, 5 $\mu\mu$fds. will produce satisfactory results with a value of unbypassed cathode resistance of the order of 10 ohms, the resultant input conductance then being of the order of 50 $\mu$mhos. Further increase of the plate-cathode capacitance when the plate load impedance is high, will result in unstable operation of an input conductance, which varies appreciably with bias.

It may be seen therefore that the input conductance depends not only on the cathode resistance, but also on the plate-cathode capacitance value and on the plate load impedance value. The additon of a plate-cathode capacitance permits the use of a low value of unbypassed cathode resistance for obtaining input conductance which is constant with bias variation, and by choice of plate-cathode capacitance and cathode resistance the input conductance can be stabilized at almost any desired value between zero and the value which obtains for zero plate cathode capacitance. It should be borne in mind, however, that input conductance values close to zero represent a potentially regenerative condition, and are therefore subject to more variation than are higher values of input conductance.

While I have shown and described a preferred embodiment 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.

What I claim is:

1. In a vacuum tube circuit adapted for operation at high frequencies, said circuit utilizing a tube having at least a cathode, a control grid and an anode, each of which is provided with an external terminal, and wherein an unbypassed cathode resistor is employed for obtaining a constant input conductance with change in grid bias, characterized in that a condenser is connected between the external terminal of the anode and that of the cathode whereby the constant input conductance is reduced to a lower value.

2. In a vacuum tube circuit adapted for operation at high frequencies, said circuit utilizing a tube having at least a cathode, a control grid and an anode, each of which is provided with an external terminal, and wherein an unbypassed cathode resistor of a predetermined value is employed for obtaining a constant input conductance with change in grid bias, characterized in that a condenser is connected between the external terminal of the anode and that of the cathode, the addition of said condenser having the effect of maintaining the input conductance constant at a lower level and permitting the use of a smaller cathode resistor.

3. A circuit for amplifying high frequencies comprising an electron discharge tube having at least a cathode, a control grid and an anode, each of said electrodes being provided with an external terminal, an unbypassed resistor connected to the cathode and common to the input and output circuits whereby the tube input conductance is maintained constant with change in grid bias, and means connected between the anode and cathode terminals whereby the value of the input conductance is reduced and still maintained at a constant value with change in grid bias.

4. A circuit for amplifying high frequencies comprising an electron discharge tube having at least a cathode, a control grid and an anode, each of said electrodes being provided with an external terminal, an unbypassed resistor of a predetermined value connected to the cathode terminal and common to the input and output circuits whereby the tube input conductance is maintained constant with change in grid bias, and a condenser connected between the anode and cathode terminals, the addition of said condenser having the effect of maintaining the input conductance constant at a lower level and permitting the use of a smaller cathode resistor.

5. A circuit for amplifying high frequencies comprising an electron discharge tube having at least a cathode, a control grid and an anode and external terminals therefor, said tube operating in a range of frequencies where the tube input conductance varies appreciably with change in control grid bias, an unbypassed resistor connected to the cathode terminal and common to the input and output circuits whereby the input conductance of the tube is made constant with change in bias, and a condenser connected between the anode and cathode terminals whereby the linearized input conductance is reduced to a lower value.

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