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CONTROL CIRCUIT

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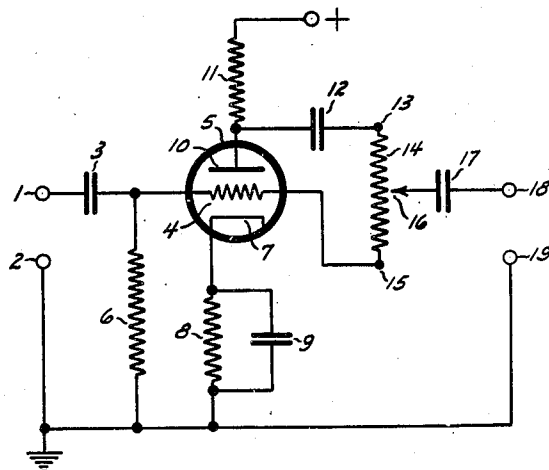


Fig. 1

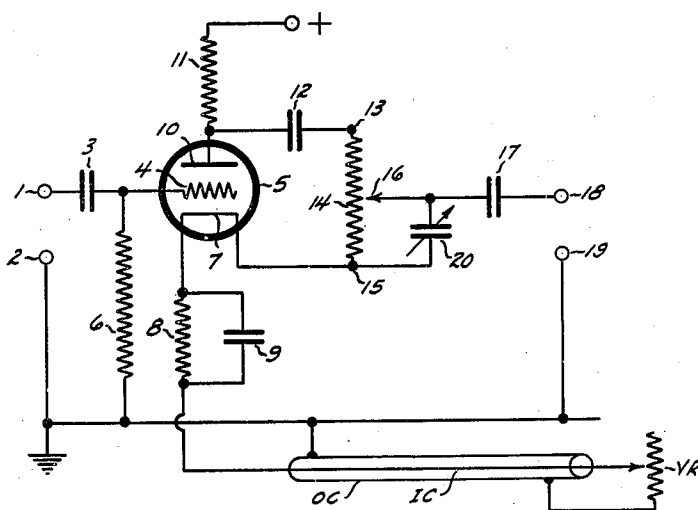


Fig. 2

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CONTROL CIRCUIT

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This invention relates to remote control systems for volume or gain control of electron discharge device amplifiers and more particularly to remotely controllable volume control systems for the low frequency amplifiers of radio receivers, for gramophone amplifiers and for similar apparatus.

It is often required to provide for remote volume control of low frequency amplifiers—for example, for remote volume control of remotely tunable radio receivers—but it has hitherto been found very difficult to provide for such control satisfactorily except by the use of somewhat complex and expensive apparatus. For example, it has been proposed to effect remote volume control of the audio reproduction of a radio receiver by means of an attenuator in the speech coil circuit of the usual moving coil loudspeaker. Even, however, when the receiver embodies anti-fading automatic volume control acting on a carrier amplifier (A. V. C.)—the usual case—the audio output valve will tend to be overloaded when receiving strong signals from local stations (which usually provide best quality of reception) and under-loaded when receiving weak stations, thus causing loss of sensitivity the reason for this defect being that the A. V. C. system is never perfect. Moreover, with volume control by means of an attenuator in the speech coil circuit, mismatching of the output valve and the loudspeaker will be occasioned unless a constant impedance attenuator—a device which is difficult to design to be really of constant impedance and which, moreover, is apt to be expensive—is employed. Those known systems in which remote control is effected electro-mechanically by means of a tele-motor or similar system controlled at the control point and operating to move the handle of a volume control impedance positioned at the receiver itself do not, of course, present the above type of defect, but they are complex and are lacking in reliability.

According to this invention the output circuit of the electron discharge device which is to be subjected to remote volume control is connected between a point on a potentiometer resistance included between the anode and cathode of the said device and "earth" or "frame" or other fixed potential point, and the cathode of said device is connected to said fixed potential point through a cable which is in series with a remotely situated variable impedance which accordingly acts as a variable negative feedback impedance, the point on the potentiometer resistance being so chosen that when said variable impedance is adjusted to

its maximum value said point on said potentiometer is at or near earth potential as respects the signals. Volume control by a variable negative feedback impedance in a cathode leg is, of course, well known per se.

The invention is illustrated in and further explained in connection with the accompanying drawing, in which Figure 1 is a theoretical circuit illustrating the principle of the invention, and Figure 2 is a practical embodiment.

In order that the invention may be the better understood there will first be described with reference to Fig. 1 a theoretical circuit which will assist in an understanding of the modus operandi of the invention. In the theoretical circuit of Fig. 1 the terminal 1 of two signal input terminals 1, 2 is connected through an input condenser 3 to the grid 4 of a triode 5 and the other terminal 2 is earthed. The grid 4 is connected to earth through a grid resistance 6 and the cathode 7 of the triode is connected to earth through a resistance 8 shunted by a by-pass capacity 9. The anode 10 of the triode receives anode potential from a source (not shown) through an anode resistance 11 and is connected through a coupling condenser 12 to one end 13 of a potentiometer resistance 14 the other end 15 of which is connected to the grid 4. A tap 16 on the potentiometer 14 is connected through a condenser 17 to one output terminal 18 and the other output terminal 19 is earthed. Now, in this circuit, it is possible to adjust the tap 16 to a point which will be at or near zero potential as respects the working frequency (actually stray capacity will usually prevent an absolute zero potential point being found) this point being such as to divide the potentiometer resistance into two parts a and b , (the part a being between 15 and 16 and the part b being between 13 and 16) such that $b=ma$ where m is the magnification factor of the stage. As will be seen later, this theoretical circuit, so adjusted, is practically electrically equivalent to the embodiment of this invention now to be described with reference to Fig. 2, when adjusted to minimum volume.

In the embodiment shown in Fig. 2 the terminal 1 of two signal input terminals 1, 2 of an amplifier valve 5 to be subjected to remote volume control is connected to the control grid 4 of said valve through a condenser 3 and the other input terminal 2 is earthed. The grid 4 is connected to earth through a grid resistance 6. The cathode 7 of the valve is connected through a cathode leg resistance 8 shunted by a capacity 9 to one end of the inner conductor IC of a con-

centric cable (or to one wire of any other suitable cable) the outer conductor OC of which is earthed. The cable extends to the control point where a variable resistance VR is connected between its two conductors. The anode 19 of the valve receives anode potential through a resistance 11 and is connected through a condenser 12 to one end 13 of a potentiometer resistance 14 the other end 15 of which is connected to the cathode. One output terminal 18 is connected through a condenser 17 to an adjustable tap 16 on the potentiometer and the other 19 is earthed. A condenser 20, which may be adjustable, is preferably connected between the tap and the cathode.

With this arrangement the resistance VR at the control point—this resistance is the volume control device—applies negative feedback. When this resistance is short circuited the stage acts almost as a normal resistance-coupled amplifier, there being only a slight loss of gain due to the potentiometer and a slight loss in higher frequency response (this can be compensated for, if desired, in a preceding or succeeding stage) due to the condenser 20 which is in shunt with a portion of the potentiometer. When the volume control resistance VR is adjusted to maximum value, however, most of the signal input voltage is developed across it, the grid and cathode potentials become nearly equal (as respects signals) and, if the tap 16 is suitably adjusted, a well defined position of minimum or approximately zero output is obtained just as in the theoretical circuit of Fig. 1. In initially adjusting the circuit the volume control resistance VR is set at its maximum resistance value and the tap 16 and the condenser 20 are then alternately adjusted until as nearly as possible zero output results. This adjustment once made, smooth gain control from approximately zero up to approximately the maximum gain of the valve can be obtained with very little distortion by adjusting the volume control resistance.

The main purpose of the condenser 20 is to compensate for the cable capacity which is in shunt with the volume control resistance VR but it also allows the effects of valve and other stray capacities to be compensated.

The above described embodiment has been experimentally tested with satisfactory results when using a volume control resistance having a maximum value as high as 50,000 ohms the cable being about 200 feet long with a capacity of about 17 micro-micro-farads per foot.

For the sake of simplicity it has been assumed that the valve 5 is a simple triode. It may, however, be any other suitable form of valve. If—as may be the case in some radio receivers—the valve 5 to be controlled is of the double-diode-triode type or some similar type of multiple section valve minor difficulties may arise due to internal valve capacities. In the normal double-diode-triode valve both the diode and triode sections have a common cathode and appreciable capacities exist between the diode anodes and the triode electrodes, particularly the cathode. The fact that there is a common cathode will introduce no difficulties provided that the load resistance of each diode is returned directly to the cathode. If, however, one diode load is returned to earth, for example in a radio receiver in which one diode is used for A. V. C. purposes and its load is returned to earth in order to give a delayed A. V. C. action, it should be borne in mind that the delay voltage will be

to some extent affected by the operation of the volume control. The effect of the inter-electrode capacities is to prevent a really good balance point and, therefore, a really good "minimum volume" adjustment being obtained. Nevertheless, even in this case a good range of volume control is obtainable.

I claim:

1. In an arrangement for controlling the output of an electronic tube, means including a variable impedance device for providing negative feedback between the output circuit and the input circuit of said tube, said variable impedance device being adapted to control the amount of negative feedback, additional coupling for signal energy between said output circuit and the input circuit, said additional coupling being adjusted so that with the variable impedance adjusted to provide maximum feedback the output of the amplifier is substantially zero.

2. In combination with an electron discharge device provided with an anode, a cathode and a grid electrode, a pair of input terminals one thereof being connected with said grid electrode and the other thereof being connected to a point of fixed potential, a pair of output terminals, a potentiometer resistance included in a circuit between the anode and cathode of said device, a connection between a tap on said resistance and one of said output terminals, the other of said output terminals being common with the input terminals which is connected to said point of fixed potential, a cable having one conductor connected to said point of fixed potential and another conductor connected to said cathode through a cathode impedance device, and means including a variable resistance for connecting said two cable conductors together.

3. In an arrangement as described in the next preceding claim, capacity connected across that portion of the potentiometer resistance which is between the tap thereon and the cathode of the electron discharge device.

4. In combination with an electron discharge device provided with an anode, a cathode and a grid electrode, a pair of input terminals one of which is connected with said grid electrode and the other thereof to a point of fixed potential, a pair of output terminals, a potentiometer resistance included in a circuit between the anode and cathode of said device, a connection between an intermediate point of said resistance and one of said output terminals, the other of said output terminals being connected to said point of fixed potential, a cable provided with a pair of conductors, means including a cathode resistor for connecting one end of one of said conductors to the cathode, means for connecting the corresponding end of the other of said conductors to said point of fixed potential, and variable resistance means connecting the other ends of said two conductors.

5. An arrangement as described in the next preceding claim wherein one end of said potentiometer resistance is connected to the anode through a coupling condenser and the other end is connected directly to the cathode and a variable condenser connected between the tap on said potentiometer and the cathode end thereof.

6. In an arrangement for controlling the volume output of a signal energy amplifier including at least one electronic tube, negative feedback means between the output circuit and input circuit of said amplifier, said negative feedback means including a variable impedance

device for controlling the amount of negative feedback, additional means for feeding back signal energy from said output circuit to said input circuit, said additional means being adjusted so that with said variable impedance adjusted to provide maximum feedback, the output of the amplifier is substantially zero.

5 7. The arrangement described in claim 4 characterized by that the point of said potentiometer resistance to which the first named output terminal is connected adjusts the amplifier for substantially zero output with the variable resistor adjusted for maximum feedback.

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