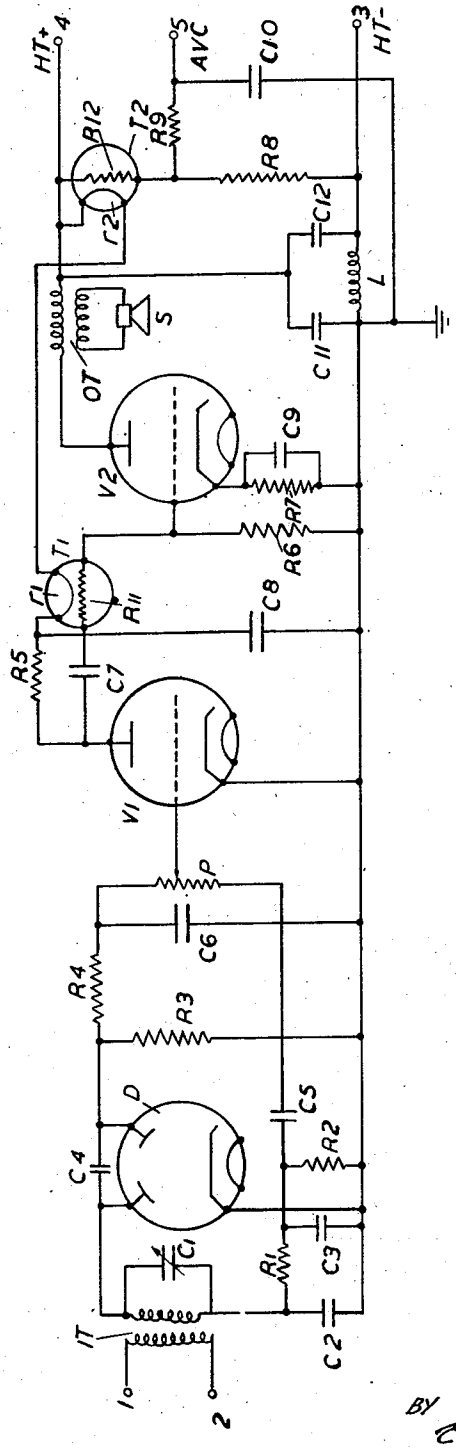
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THERMIONIC VALVE CIRCUIT

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THERMIONIC VALVE CIRCUITS

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The present invention relates to automatic volume control arrangements for radio receivers and in particular makes use of thermally sensitive resistance elements known as thermistors for amplifying the control voltage.

Thermistors have been in use for some years and are characterised by a temperature coefficient of resistance which may be either positive or negative and which is moreover many times the corresponding coefficient for a pure metal such as copper. This property renders thermistors particularly suitable for a variety of special applications in electric circuits.

Various different materials are available for the resistance element of a thermistor, these various materials having different properties in other respects; as one example, a resistance material having a high negative temperature coefficient of resistance comprises a mixture of manganese oxide and nickel oxide, with or without the addition of certain other metallic oxides, the mixture being suitably heat treated.

Thermistors have been employed in two different forms: (*a*) known as a directly heated thermistor and comprising a resistance element of the thermally sensitive resistance material provided with suitable lead-out conductors or terminals, and (*b*) known as an indirectly heated thermistor comprising the element (*a*) provided in addition with a heating coil electrically insulated from the element. A directly heated thermistor is primarily intended to be controlled by the current which flows through it and which varies the temperature and also the resistance accordingly. Such a thermistor will also be affected by the temperature of its surroundings and may therefore be used for thermostatic control and like purposes with or without direct heating by the current flowing through it. An indirectly heated thermistor is chiefly designed to be heated by a controlling current which flows through the heating coil and which will usually, but not necessarily, be different from the current which flows through the resistance element. but this type of thermistor may also be subjected to either or both of the types of control applicable to a directly heated thermistor.

More detailed information on the properties of thermistors will be found in an article by G. L. Pearson in the Bell Laboratories' Record, Dec. 1940, page 106.

In radio receivers provided with automatic volume control it is generally desirable to provide means for amplifying the control voltage derived from the incoming signals in order to obtain a better adjustment of the output level. It is, however, inconvenient and expensive to provide additional valves for this purpose, but it has been found that the necessary amplification can be very easily and cheaply obtained by the use of indirectly heated thermistors.

According to the invention, therefore, there is provided an automatic volume control arrangement for a radio receiver, comprising a first indirectly heated thermistor having its resistance element connected in series with a first constant resistance to a direct current source, the heating coil of the thermistor being connected in series between the positive terminal of the source and the plate of a first amplifying valve, the plate current of which is adapted to be varied in accordance with the level of the incoming signals, the volume control voltage being obtained from the junction point of the said resistance element and the said constant resistance.

The invention will be more clearly understood from the following detailed description of an embodiment with reference to the accompanying drawing which shows a schematic circuit diagram thereof. This diagram shows part of the circuit of a typical radio receiver to which the invention is applied. It shows a rectifying diode D from which the audio frequency signals are obtained, a first amplifying valve V_1 which is also used for obtaining the volume control voltage, and a final amplifying valve V_2 which supplies the signals to a loud-speaker S through an output transformer OT. The signals arrive at terminals 1 and 2 from other parts of the radio receiver circuit, which are not shown, and are applied to the left-hand plate circuit of the diode D through an input transformer IT, the secondary winding of which is tuned by an adjustable condenser C_1. The rectified signals are obtained across the load resistance R_2, a smoothing circuit R_1, C_2, C_3 being provided to remove the high frequency from the resistance R_2. The rectified audio frequency signals are applied to the control grid of valve V_1 through the blocking condenser C_5 and resistance chain comprising a potentiometer P and two resistances R_3 and R_4. By adjusting the potentiometer P the proportion of the rectified signal voltage applied to the grid may be varied.

The incoming signals are also applied to the right-hand plate of the diode through the condenser C_4 and produce a voltage drop across the resistance R_3 in a negative sense which depends on the level of the signals, so that the control grid of the valve V_1 is given a negative

bias which increases as the signal level increases. The valve V_1 is coupled to the valve V_2 through a blocking condenser C_7 and potentiometer comprising the resistance element R_{11} of an indirectly heated thermistor T_1 and a constant resistance R_6, the junction point of R_{11} and R_6 being connected to the control grid of V_2. The heating coil r_1 of the thermistor T_1 is connected in series with the plate circuit of the valve V_1, which circuit also includes a resistance R_5, a bypass condenser C_8 being provided. The cathode of the valve V_2 is biassed by means of a resistance R_7 with the usual bypass condenser C_9.

A high tension supply for the valves has its positive terminal connected to terminal **4** and its negative terminal to terminal **3**. The plate circuit of valve V_1 is supplied from terminal **4** through the heating coil r_2 of a second thermistor T_2 and also through r_1 and R_5 as previously explained. The plate of the valve V_2 is supplied from terminal **4** in series with the primary winding of the output transformer OT. The negative terminal **3** is connected to ground through the field coil L of the loud-speaker S. This provides the necessary excitation, and the inductance of the coil, together with the condensers C_{11} and C_{12} provides a smoothing filter. Owing to the resistance of the coil L the terminal **3** will be at a negative potential with respect to ground which might be as much as 100 volts.

Connected across the terminals **3** and **4** is a potentiometer comprising resistance R_8 and the resistance element R_{12} of the thermistor T_2. The junction point of R_8 and R_{12} is connected through a resistance R_9 to a terminal **5** where the automatic volume control voltage is obtained, and is supplied to the appropriate point or points in that portion of the radio receiver circuit which is not shown. The condenser C_{10} acts as a bypass condenser for smoothing this voltage.

It is, of course, not essential to provide the excitation current for the coil L in this manner, and it can if desired, be provided from a separate source of supply. It is, however, desirable that terminal **3** should have a negative potential with respect to ground and, accordingly, if the coil L is separately supplied a suitable resistance should be included instead between terminal **3** and ground.

When there are no signals arriving in the receiving circuit the grid bias voltage of the valve V_1 obtained from the resistance R_3 will be small or zero and the plate current of this valve will be a maximum. Accordingly both the thermistors T_1 and T_2 will be hot. These thermistors should have a negative temperature coefficient of resistance and their resistance will accordingly be low. When signals at a high level are received a large negative bias voltage will be applied to the valve V_1 and its plate current will fall, so that both the thermistors will cool and their resistance will increase. It will be evident that the potential of the terminal **5** will depend upon the resistance of the thermistor T_2 and, therefore, also upon the level of the incoming signals. It will be preferable to choose the value of the resistance R_8 and the value of R_{12} when the thermistor is hot, so that the potential of the therminal **5** with respect to ground is just sufficiently negative to provide the normal bias for the valve or valves which are being controlled. When the signal level increases the terminal **5** will become more negative and will accordingly increase the negative bias supplied to these valves and will reduce the gain of the circuit accordingly.

The action of the thermistor T_1 is different from that of T_2 since it operates to vary the coupling between the valves V_1 and V_2 instead of to provide a control voltage. This thermistor should also have a negative temperature coefficient of resistance. When there are no incoming signals it will be hot and its resistance R_{11} will be small, and accordingly the proportion of the signal voltage applied to the control grid of valve V_2 will be large. When signals at a high level are received the thermistor T_1 will cool and its resistance will increase and the proportion of the signal voltage applied to the valve V_2 will be reduced.

It will be evident that the thermistors T_1 and T_2 are quite independent in their operation and T_1 can be omitted if desired, the element R_{11} being replaced by a suitable constant resistance.

By a simple rearrangement of the circuit, thermistors having a positive temperature coefficient of resistance can be used if desired. To enable this to be done it is only necessary to interchange R_8 and R_{12}, and R_6 and R_{11} and the effect will be substantially the same. In the condition when no signals are being received both thermistors will be hot as before, their resistance will be high instead of low so that substantially the same voltage variations at terminal **5** or at the control grid of V_2 will be obtained when the signal level varies.

Although the valves V_1 and V_2 have been shown for simplicity as triodes, it is obvious that other types of valve could be used if desired and in many cases it will be preferable to use pentodes. In such cases the heating coils of the thermistors could, if desired be connected in series with the screen grid of the valve V_1, so that they would be heated by the screen grid current, which would also vary with the signal level in a manner similar to the plate current.

It will be understood that the circuit of the accompanying figure which has been described is only one particular case where the invention can be applied and various modifications of the details are clearly possible.

It will be seen that a valve V_1 can be regarded as acting both as an amplifier for the audio frequency signals and also as an amplifier for the continuous voltage which is developed across the resistance R_3 and which signifies the level of the incoming signals. It will be clear that if desired, a separate valve could be used for amplifying this continuous voltage, in which case the thermistor heating coils would be connected in series with the plate circuit of this separate valve.

What is claimed is:

1. An automatic volume control device for a radio receiver including a first amplifying valve and an indirectly heated thermistor having a heating coil and having a resistance element, a first constant resistance connected in series with said resistance element, a direct current source feeding both resistance in series, means connecting the heating coil of the thermistor in series between the positive terminal of said source and the plate of said first amplifying valve, the plate current of which valve is adapted to be varied in accordance with the level of the incoming signals, and means for obtaining the volume control voltage directly from the junction point of said resistance element and said constant resistance.

2. Device according to claim 1 further including a second amplifying valve and a second indirectly heated thermistor having a resistance

element and a heating coil, a second constant resistance, said second thermistor resistance being connected in series with said second constant resistance between said plate of said first amplifying valve and ground, said heating coil of the second thermistor being connected in series with said heating coil of the first thermistor and the control grid of said second valve being connected to the common point of said second resistance element and said second constant resistance.

3. Device according to claim 1, and also including a third resistance connected between the negative terminal of said direct current source and ground, the resistance element of said first thermistor, said first constant resistance, and the value of said third resistance being so chosen that the volume control voltage is slightly negative when no signals are being received and becomes increasingly negative as the level of incoming signals increases.

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