Aug. 26, 1947. P. K. CHATTERJEA ET AL 2,426,179

ELECTRICAL RELAXATION OSCILLATORS

Filed June 10, 1943

FIG. 1.

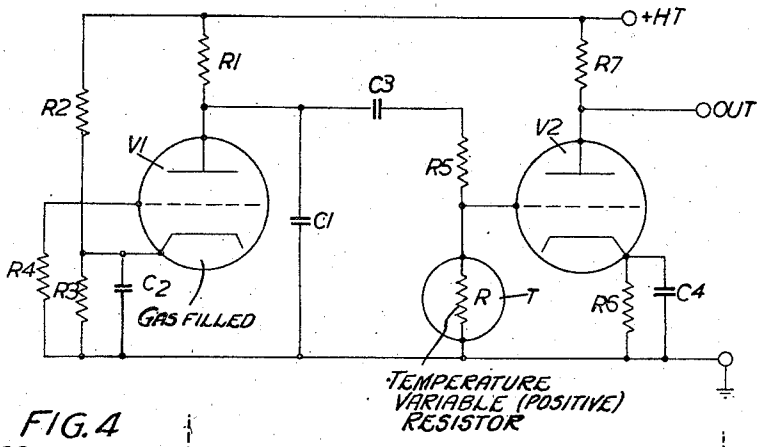


FIG. 4

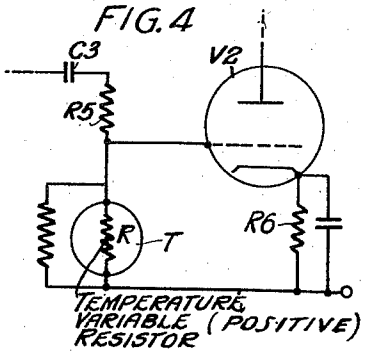


FIG. 3.

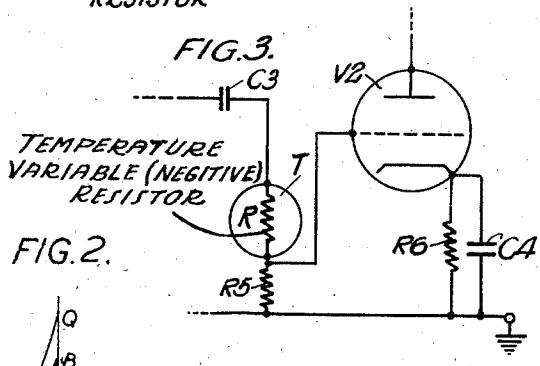
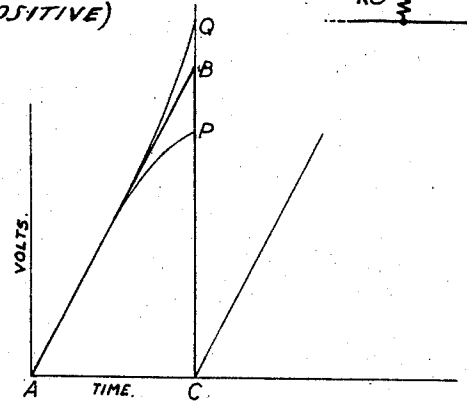


FIG. 2.



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Patented Aug. 26, 1947 2,426,179

UNITED STATES PATENT OFFICE

2,426,179

ELECTRICAL RELAXATION OSCILLATOR

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Application June 10, 1943, Serial No. 490,284
In Great Britain June 19, 1942

7 Claims. (Cl. 250—36)

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The present invention relates to electrical relaxation oscillators, and is directed towards eliminating the distortion of the waves generated by the use of thermally sensitive resistance devices known as thermistors.

Thermistors have been in use for some years and are characterised by a temperature co-efficient of resistance which may be either positive or negative and which is moreover many times the corresponding co-efficient 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 co-efficient 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 effected 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, December 1940, page 106.

In saw-tooth relaxation oscillators, which are used, for example, for generating scanning waves in television systems, the rate of increase of the voltage of the waves during the scanning strokes

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is not constant because the rate of charging of the condenser from which the oscillations are commonly obtained decreases as the charge increases. In order to avoid distortion, the scanning rate should be constant at each stroke, and by employing a directly heated thermistor in the circuit, as will be presently explained, the above described type of distortion can be compensated.

Saw-tooth oscillators are, of course, used for many other purposes besides television and the invention is not limited to use in television systems: it will, however, be convenient to refer in this specification to the sloping portion of the wave as the "scanning portion" or the "scanning stroke," and to the vertical portion as the "fly-back" stroke.

According to the invention, there is provided a relaxation oscillator for generating waves of saw-tooth form comprising means for correcting the curvature of the scanning portions of the waves, the said means comprising a resistance potentiometer including a directly heated thermistor for coupling the generating stage or stages to an amplifying stage, the thermistor being adapted to change its resistance progressively in the same direction during each scanning stroke.

The invention will be more clearly understood from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 shows a schematic circuit diagram of an embodiment of the invention;

Fig. 2 shows an explanatory diagram; and

Figs. 3 and 4 are respective modifications of Fig. 1.

Fig. 1 shows a gas-filled triode valve V_1 which serves as the relaxation oscillator. C_1 is the condenser charged through the resistance R_1 and periodically discharged by the triode V_1 in the well-known way. R_2 and R_3 form a potentiometer for biassing the cathode of V_1, C_2 being the corresponding by-pass condenser. R_4 is the usual grid resistance.

The potential across the condenser C_1 is applied to the amplifying valve V_2 through a blocking condenser C_3 and a potentiometer comprising a resistance R_5 and a directly heated thermistor T of which the resistance element is R. The junction point of the resistances R_5 and R is connected to the control grid of V_2. A resistance R_6 with a by-pass condenser C_4 is provided for biassing the cathode of this valve, and R_7 is the usual plate circuit load resistance.

The circuit associated with the valve V_1 for producing the saw-tooth oscillations is one of

the well known types, and the arrangements of the amplifying valve V_2 are typical and might be provided in other ways. The invention lies in the coupling arrangement between the two valves.

As already explained, the rate of variation of potential across the condenser is not uniform, and decreases as the charge increases.

In Fig. 2, ABC represents the ideal form of a single saw-tooth oscillation. The abscissae represent time and the ordinates represent, for example, the voltage applied to the grid of valve V_2 in Fig. 1. AB is the scanning stroke and is shown as a straight line. BC is the fly-back stroke, and is substantially a straight line at right angles to the time axis.

Assuming for the moment that the thermistor is replaced by a constant resistance, the form of the oscillation actually obtained will be like APC, on account of the decrease in the charging rate of the condenser C_1 as it becomes charged. Suppose, now that the thermistor is again connected in the circuit as shown in Fig. 1 and an undistorted saw-tooth wave is applied to the blocking condenser C_3 instead of the distorted wave derived from the condenser C_1, but having the same initial slope. Then the thermistor temperature will be higher at the end of the scanning stroke, near B, than at the beginning because the current is greater. If, therefore, it has a positive temperature co-efficient of resistance, its resistance will be higher at the end of the stroke than at the beginning, and the voltage applied to the grid of valve V_2 will be greater. A wave like AQC will now be obtained, the point Q being higher than the point B. Thus, if the resistances R_5 and R are chosen so that BQ=BP, then substantially the curve ABC will be obtained when the distorted waves from the condenser C_1 are applied to the blocking condenser C_3; in other words the thermistor has corrected the distortion of the saw-tooth waves by suitably changing the output to input voltage ration of the potentiometer.

It will be evident that if it is desired to use a thermistor with a negative temperature co-efficient of resistance, similar correction will be obtained by interchanging the thermistor and the resistance R_5 as illustrated in Fig. 3.

If desired, a second constant resistance can be connected in parallel with the resistance R of the thermistor as illustrated in Fig. 4.

Fig. 1 shows only one of the known arrangements as an example of the application of the invention. It will be evident that the same principles may be applied to other forms of relaxation oscillators which do not employ a gas discharge valve, for example.

What is claimed is:

1. Signal wave source comprising means for generating a saw tooth wave, means for translating said wave having input terminals and means for changing the shape of said saw tooth wave comprising a resistor and a temperature variable resistor, said resistor being in series with said generating means, means for coupling said temperature variable resistor to said generating means and means for coupling said input terminals to said temperature variable resistor, said temperature variable resistor having a variable resistance which changes progressively in the same direction during each voltage rise of said voltage wave.

2. Oscillator means comprising means for charging a condenser and means for discharging said condenser to produce a saw tooth wave, means for amplifying said saw tooth wave having input and output terminals, means for correcting undesired curvature in said saw tooth wave comprising a linear resistor and a temperature variable resistor connected in series to form a potentiometer, means for connecting said potentiometer across said capacity and means for coupling said input terminals across an intermediate point and a second point on said potentiometer, said temperature variable resistor having a non-linear resistance which changes its resistance progressively in the same direction during each voltage rise of said saw tooth wave.

3. A device in accordance with claim 2 in which said intermediate point is the junction point of said linear resistor and said temperature variable resistor.

4. A device according to claim 2 in which said temperature variable resistor is connected across said input terminals, and said linear resistor is connected in series with said temperature variable resistor between said capacity and said temperature variable resistor, the temperature coefficient of resistance of said temperature variable resistor being positive.

5. A device according to claim 2 in which said linear resistor is connected across said input terminals and said temperature variable resistor is connected in series with said linear resistor between said capacity and said input terminals, the temperature coefficient of resistance of the temperature variable resistor being negative.

6. A device according to claim 2 further comprising a second linear resistor connected in parallel with the temperature variable resistor.

7. A device according to claim 2 in which the characteristics of the said temperature variable resistor are so chosen that the total change of resistance of said temperature variable resistor during a voltage rise of said saw tooth wave produces a total increase in the output to input voltage ratio of said potentiometer substantially sufficient to compensate for curvature of predetermined portions of the saw tooth wave produced by said oscillator means.

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