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COMPENSATED HUMIDITY-MEASURING CIRCUIT

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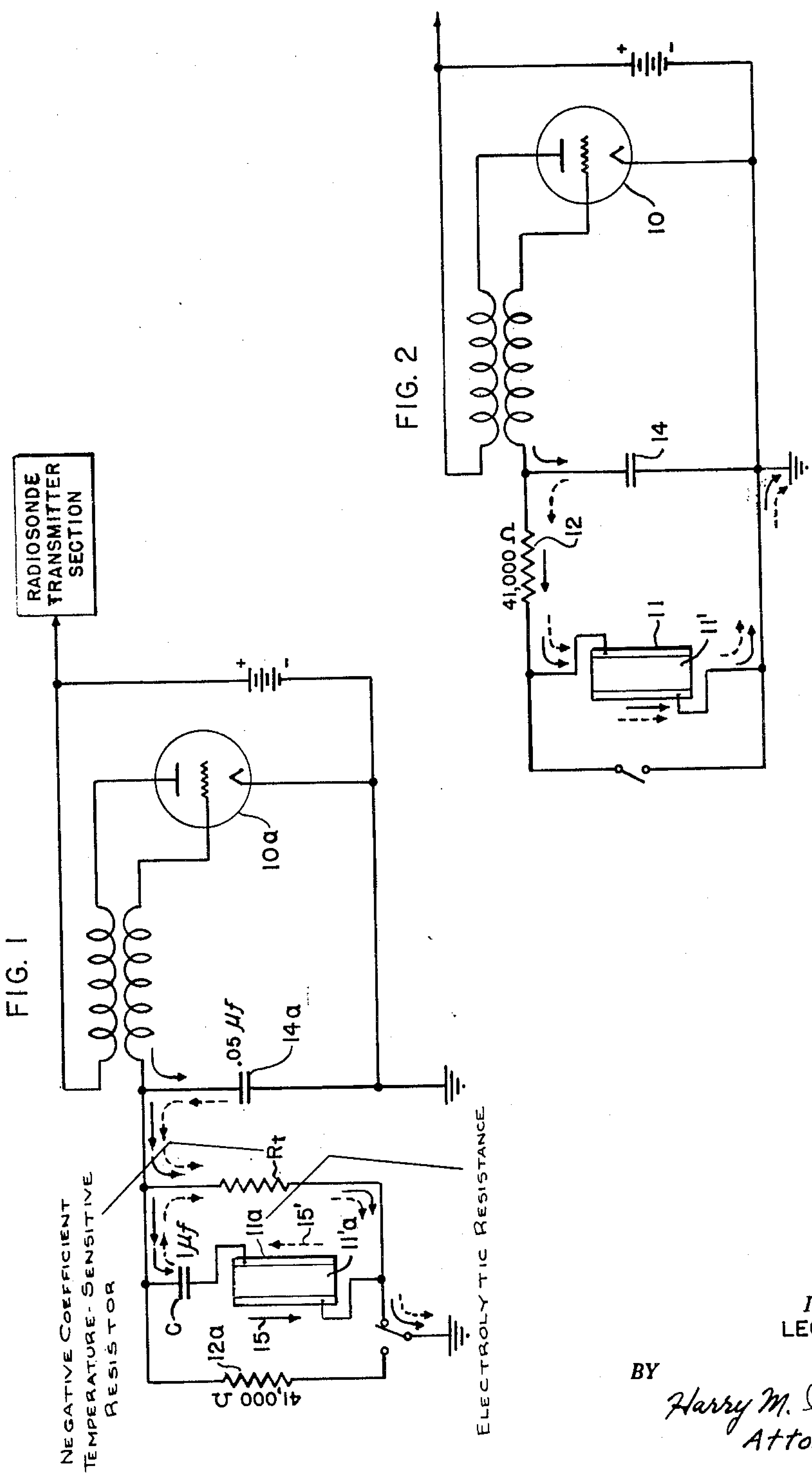

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COMPENSATED HUMIDITY-MEASURING CIRCUIT

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9 Claims. (Cl. 250—36)

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The invention described in the following specification and claims may be manufactured and used by or for the Government for governmental purposes, without the payment of any royalty thereon.

This invention relates to improvements in compensated humidity-measuring circuits, and more particularly to those designed for use in balloon-borne radiosondes.

In the use of a conventional radiosonde transmitter wherein the reference audi-frequency of a relaxation oscillator or audio section is determined by or is dependent upon the value of a fixed resistor connected across a condenser; the latter, after building up a charge sufficient to impart a cut-off bias to the grid of the oscillator tube, discharges through the fixed resistor and a conventional humidity element in the form of an electrolytic-type resistor connected in series with the fixed resistor. Since the hygroscopic-responsive structure of the humidity element varies with the ambient relative humidity, and since this variation effects a corresponding change in the audio-frequency of the relaxation-oscillator tube, a means is available for quickly and accurately determining the relative humidity. These electrolytic-type resistors or elements are quite reliable in their indications when used in circuits where an alternating-current power supply is available, but when used in a balloon-borne radiosonde where recourse must be had to circuits employing direct-current energy, polarization takes place. To this can be attributed the fact that relatively large errors have been introduced in the data recorded at the meteorological receiving station.

Polarization of the conventional electrolytic-type humidity element is generally believed to arise from the fact that the conduction phenomena occurring in the passage of an electric current through a layer of hygroscopic material are essentially electrolytic in nature, and are accompanied by changes at the electrode interface where the current enters the hygroscopic medium, thereby developing a varying counter-electromotive force as well as diminishing the effective interface area. The effect is cumulative and hence, while a number of hygroscopic-responsive resistors may possess identical characteristics at the moment of impression of an electric voltage thereon, yet, due to variation in their respective polarization characteristics as time passes, the divergent characteristics become increasingly obvious. Polarization effects are very difficult to render uniform, require correction by a factor controlled by the time of application of current to the resistor, and vary quite widely with temperature.

It has been proposed to prevent, or at least to retard the observed deterioration or polorization of the layer of hygroscopic material in conventional humidity elements, by periodically reversing the current therethrough. A system or arrangement for this purpose is disclosed in Patent No. 2,444,111 issued June 29, 1948, to Charles B. Pears, Jr. In this system mechanical means are employed for switching the poles of the humidity element, thereby to reverse the direction of current-flow through the layer of hygroscopic material. However, in this proposed system, the switching rate is at the very low frequency of approximately two times per minute, and while polarization is retarded, it inevitably takes place.

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With the foregoing in mind, it is one of the objects of this invention to provide an improved humidity-measuring circuit of the character referred to wherein provision is made to eliminate errors which otherwise would occur due to polarization effects attributable to the use of direct-current energy in the measuring circuit.

Another object resides in the provision of an improved humidity-measuring circuit of the character referred to which has advantages over those used heretofore in the way of increased sensitivity at low temperatures.

Still another object resides in the provision of an improved humidity-measuring circuit of the character referred to wherein there occurs reversal of current through the humidity element by electrical means having no mechanical moving parts, and wherein the rate of reversal is approximately one hundred times per second to eliminate any deterioration or polarization whatsoever.

Other objects and advantages will hereinafter appear.

For the purpose of illustrating the invention, an embodiment thereof is shown in the drawing, wherein

Figure 1 is a simplified, diagrammatic view of the audio section in a compensated humidity-measuring circuit constructed and having operating characteristics in accordance with the invention; and

Figure 2 is a view similar to Figure 1, showing a conventional form of audio section in which there can occur the disadvantageous operating effects which the improved circuit in Figure 1 eliminates.

With reference first to Figure 2, the numeral **10** designates the relaxation-oscillator tube in a conventional audio section of a radiosonde transmitter. In operation, the audio-frequency of tube **10** at any instant is determined by the resistance value at that instant of a humidity element **11** which, for the purposes of illustration, can be considered to be of the same construction and to have the same intrinsic and operating characteristics as the humidity-responsive resistor shown and described in Patent No. 2,481,728 issued September 13, 1949, to Alexis B.

Dember. In series with electrolytic resistor element 11 is the usual, fixed, reference resistance 12. These two series-connected resistances 11 and 12 are connected, as shown, across a condenser 14. Oscillation of the circuit causes condenser 14 to build up a charge rapidly, and to a point whereat the oscillation of the tube is cut off. During this condenser-charging phase of the operating cycle, the direction of current-flow through the various connections and parts is as indicated by the solid arrows. Oscillation of tube 10 being cut off, condenser 14 then discharges to ground through the fixed resistance 12 and thence through the interface surface 11' of resistance element 11, until the tube can once again begin oscillation. During this condenser-discharging phase of the operating cycle, the direction of current-flow through the various connections and parts is as indicated by the broken arrows.

From the foregoing, it will be apparent that in operation of the conventional circuit shown in Figure 2, all flow of current through the hygroscopic material or interface surface 11' is in the same direction, as indicated by the arrows. As explained in the Dember patent aforesaid, such unidirectional flow of current results, in time, in appreciable changes and corresponding polarization of the surface 11'. To this phenomenon is attributed directly the fact that in a conventional circuit such as is shown in Figure 2, the characteristic of the humidity element 11 varied in the course of time. There is, also, a decrease in sensitivity of this element at low temperatures. Any slight, undesirable variation in the characteristic of resistance element 11 causes a corresponding and undesirable change in the audio-frequency of tube 10, and such variation or change becomes apparent in relatively large errors introduced in the data recorded at the meteorological receiving station.

Examples of radiosonde apparatus or systems in which the present improved humidity-measuring circuit might be embodied, are illustrated and described in Department of the Army Technical Manual identified as TM 11-2430 and printed by the United States Government Printing Office, October 1947.

In the embodiment of subject invention disclosed in Figure 1, the various parts therein which correspond to or are the equivalent of those in Figure 2, have been designated by the same respective reference numerals, but those in Figure 1 have been given the suffix *a*. In series with the humidity element 11*a* is an additional or auxiliary condenser C, with a discharge resistance-path through a negative coefficient temperature-sensitive resistor R*t*. If desired, R*t* may be composed of one or more resistors.

At any given temperature, the resistance of humidity element 11*a* is much smaller at high humidities than at low humidities. At low humidity, the interface surface 11'*a* of electrolytic resistance 11*a* has a resistance value sufficiently high to constitute practically an open circuit. Under such conditions, the frequency is therefore determined by condenser 14*a* and resistor R*t*, the value of the latter being chosen to give a high frequency which, at the receiving station, would be located about one hundred divisions to the right on the chart paper. At high humidity, the interface surface 11'*a* of element 11*a* has a resistance value sufficiently low to constitute practically a connection placing condensers 14*a* and C in parallel. With the capacity of condenser C chosen to be ten to twenty times that of condenser 14*a*, it will then take the two parallel-connected condensers a much longer time to charge, and then to discharge through resistor R*t*, resulting in a low frequency. In other words, low resistance of element 11*a* results in low frequency, and high resistance of the same results in high frequency.

In operation of the improved circuit in Figure 1, the auxiliary or supplementary condenser C accumulates a charge as condenser 14*a* simultaneously builds up a charge to a point whereat the oscillation of tube 10*a* is cut off, as in Figure 2. During this condenser-charging period of the operating cycle in Figure 1, the direction of current-flow through the various connections and parts is as indicated by the solid arrows. Oscillation of tube 10*a* being cut off, the condensers C and 14*a* then discharge to ground through the resistor R*t*, until tube 10*a* can once again begin oscillation, similarly to the operating action in Figure 2. During this condenser-discharging period of the operating cycle in Figure 1, the direction of current-flow through the various connections and parts is as indicated by the broken arrows, condenser C discharging through resistor R*t*, and condenser 14*a* discharging through resistor R*t* and humidity element 11*a*. From this it will be seen that during the charging of condensers 14*a* and C, the flow of current through element 11*a* is in but one direction as indicated by the associated, solid arrow 15. During the discharge period of condensers 14*a* and C, the current-flow through element 11*a* is also unidirectional as indicated by the associated, broken arrow 15', but is flowing in a direction which is opposite to what it was during the charging period. The effect thus obtained is the same as though an alternating-current power supply were being used, and accordingly, polarization or deterioration of the hygroscopic material 11'*a* is entirely eliminated.

By choosing for condenser C a value at least ten times that of condenser 14*a*, there is obtained the desired range in recorder divisions, for change in the humidity element 11*a* from 100% to 15%.

By choosing for the reference resistor 12*a* a value of approximately 41,000 ohms, there results an audio-frequency of 190 cycles which is set on the recording apparatus at 95 divisions (1 division=2 cycles).

An important operating feature in the improved circuit as shown in Figure 1, resides in improvement of sensitivity at the low-temperature end of the operating range in actual use of a radiosonde. This is accomplished by appropriate variations in the resistor R*t*. For example, an increase in the resistance of humidity element 11*a* results in increased frequency, whereas an increase in the resistance (discharge resistance) of resistor R*t* results in decreased frequency. If, therefore, an increase in 11*a*, due to decrease in temperature at constant humidity, is compensated for by an appropriate increase in resistor R*t*, the circuit in Figure 1 will be temperature-compensated. To this end, it is proposed to use for R*t* a commercially-available resistor made of semi-conductor material, and having the characteristic desired. These resistors or thermal elements are referred to in the trade as negative temperature coefficient resistors, and are available in a variety of resistance values and coefficients.

The values of resistance and capacity given in the drawing are representative, and are given as approximations to obtain the desired results. These values are not critical in any strict sense of the word, and may vary over a substantial range, better to suit particular requirements.

Various modifications of the disclosed embodiment of the invention are possible without departing from the spirit thereof or the scope of the claims.

What is claimed is:

1. The combination with a compensated humidity-measuring circuit of the character described and comprising a relaxation-oscillator tube having a grid, a resistor and a condenser connected to said grid to determine the frequency of operation of said tube, said resistor serving as a discharge path for said condenser; of a second condenser connected to said grid to charge and discharge simultaneously with said first-named condenser, and a humidity element connected in series with said second condenser.

2. The combination with a compensated humidity-measuring circuit of the character described and comprising a relaxation-oscillator tube having a grid, a resistor and a condenser connected to said grid to determine the frequency of operation of said tube, said resistor serving as a discharge path for said condenser; of a second condenser connected to said grid to charge and discharge simultaneously with said first-named condenser, and a humidity element connected in series with said second condenser, the capacity of said second condenser being at least several times that of said first-named condenser.

3. In a compensated humidity-measuring circuit of the character described, a relaxation-oscillator tube having a grid, a resistor and a condenser connected to said grid to determine the frequency of operation of said tube, said resistor serving as a discharge path for said condenser, a second condenser connected to said grid to charge and discharge simultaneously with said first-named condenser, and a humidity element connected in said circuit and including hygroscopic-responsive structure in series with said second condenser.

4. The combination with a compensated humidity-measuring circuit of the character described and comprising a relaxation-oscillator tube having a grid, a resistor and a condenser connected to said grid to determine the frequency of operation of said tube, said resistor serving as a discharge path for said condenser; of a second condenser connected to said grid to charge and discharge simultaneously with said first-named condenser, and a humidity element connected in series with said second condenser, the capacity of said second condenser being at least ten times that of said first-named condenser.

5. In a compensated humidity-measuring circuit of the character described, a relaxation-oscillator tube having a grid, a resistor and a condenser connected to said grid to determine the frequency of operation of said tube, said resistor serving as a discharge path for said condenser, a second condenser connected to said grid to charge and discharge simultaneously with said first-named condenser, and a humidity element connected in said circuit and including hygroscopic-responsive structure in series with said second condenser, said resistor being characterized by the fact that the temperature coefficient thereof is negative to effect a temperature-compensating action at the low-temperature end of the operating range of said circuit.

6. The combination with an oscillatory circuit embodying a relaxation-oscillator tube having a grid, a humidity element and a condenser connected in parallel relation and to said grid to cause charging of said condenser during one interval of each oscillation of said tube and otherwise to cause discharge of said condenser through said element during another interval of each oscillation of said tube; of a second condenser series-connected with said element and in said circuit to charge simultaneously with said first-named condenser and to discharge simultaneously with the latter thereby to block current-flow through said element from said first-named condenser during said discharge of the latter.

7. The combination with an oscillatory circuit embodying a relaxation-oscillator tube having a grid, a humidity element and a condenser connected in parallel relation and to said grid to cause charging of said condenser during one interval of each oscillation of said tube and otherwise to cause discharge of said condenser through said element during another interval of each oscillation of said tube; of a second condenser series-connected with said element and in said circuit to charge simultaneously with said first-named condenser, and a resistor connected in said circuit to provide a common discharge path for both of said condensers, said second condenser being disposed between said element and the high-potential side of said first-named condenser to block current-flow through said element from said first-named condenser during said discharge of the latter.

8. The combination with an oscillatory circuit embodying a relaxation-oscillator tube having a grid, a humidity element and a condenser connected in parallel relation and to said grid to cause charging of said condenser during one interval of each oscillation of said tube and otherwise to cause discharge of said condenser through said element during another interval of each oscillation of said tube; of a second condenser in series with said element to prevent polarization of said element by balancing current-flow through said element during said intervals.

9. The combination with an oscillatory circuit embodying a relaxation-oscillator tube having a grid, a humidity element and a condenser connected in parallel relation and to said grid to cause charging of said condenser during one interval of each oscillation of said tube and otherwise to cause discharge of said condenser through said element during another interval of each oscillation of said tube; of a second condenser in series with said element to prevent polarization of said element by balancing current-flow through said element during said intervals, and a resistor connected in said circuit to provide a common discharge path for both of said condensers.

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REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
2,444,111	Pears	June 29, 1948
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2,558,342	Cosby	June 26, 1951