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TEMPERATURE AND VOLTAGE CONTROL CAPACITORS

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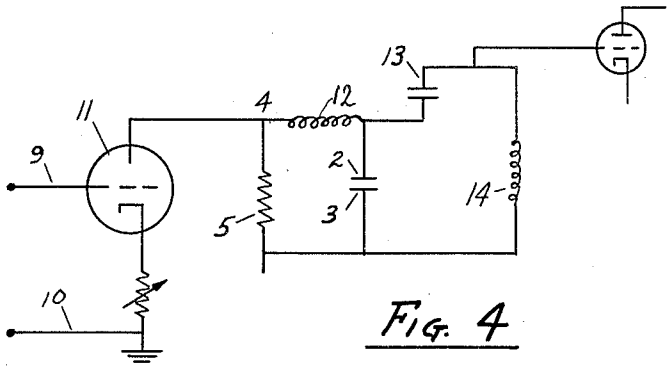


FIG. 4

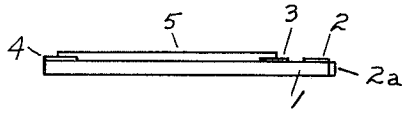


FIG. 2

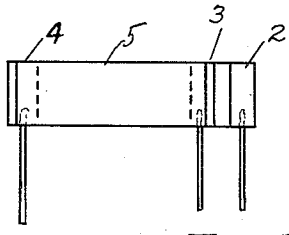


FIG. 1

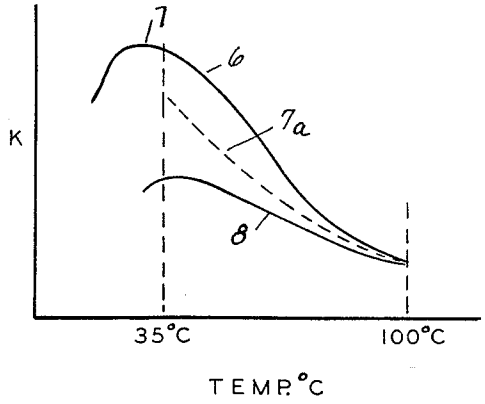


FIG. 3

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TEMPERATURE AND VOLTAGE CONTROL CAPACITORS

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3 Claims. (Cl. 323—74)

In radio circuits and the like, it is desirable to have a capacitor where the capacity varies with a control voltage. One such circuit is automatic frequency control. This invention is intended to provide such a capacitor. Use is made of dielectric whose Curie point is in the region of the normal ambient temperature. The dielectric carries the capacitor electrodes and the greater part of the area of the dielectric also carries the resistor coating. Connections are provided for applying the control voltage across both the resistor and the capacitor electrodes. The resultant change in capacity is due both to the drop in capacity with increased voltage and to the additional drop in capacity with increased temperature resulting from the heating of the resistance material. The resultant unit has a greater variation in capacity than would be obtainable from either temperature or voltage alone and is relatively unaffected by changes in the ambient temperatures.

In the accompanying drawing, Fig. 1 is a plan view of the resistance capacitor unit, Fig. 2 is an edge view, Fig. 3 is a diagram illustrating the control range of the capacitor unit, and Fig. 4 is a circuit diagram illustrating the use of the unit.

The unit comprises a thin, flat dielectric body 1 which can be conveniently made from a mixture of barium and strontium titanate having a maximum dielectric constant at its Curie point of the order of 7,000 but can vary over a wide range depending upon the composition and method of manufacture e. g. 1,200 to 10,000. With such a mixture, the Curie point will be in the region of 30–35° C. or in the region of the normal ambient temperature. On one face of the dielectric are metallized coatings 2, 3 and 4, the coatings 2 and 3 being the electrodes of a capacitor and the coating 4 being a terminal for a resistance 5 which preferably takes the form of a coating applied between the metallized coatings 3 and 4. The coatings 2 and 3 which comprise the condenser electrode are of small area and are quite widely spaced in order to obtain a small capacity with the high dielectric constant of the dielectric body 1. The coatings 2 and 3 are shown side by side on one face of the dielectric body, but it would be feasible to have one of the coatings, for example, the coating 2 on the edge of the dielectric body as indicated at 2*a* in Fig. 2. The coatings 3 and 4 between which the resistance coating 5 is arranged are spaced apart a substantial distance so that by far the greater part of the surface of the dielectric body 1 is coated with the resistance material. It would be possible to have the resistance material extend over to the opposite face of the dielectric body 1 thereby still further increasing the surface of the dielectric in contact with the resistance material. The resistance coating 5 is so related to the thermal mass of the dielectric body 1 that the dielectric body assumes the temperature of the resistance within a relatively short time, for example, twenty seconds or less. From another aspect, the dielectric body has a very small thermal capacity and the resistance coating 5 which is in intimate contact with the dielectric body throughout the greater portion of its surface can bring the dielectric body up to its temperature quickly or at least quick enough to follow the relatively slow drifts of frequency for which the heating action of the control capacitor is more useful in controlling.

The characteristics of the capacity between the electrodes 2 and 3 are illustrated in the curve Fig. 3. Curve 6 represents the change in capacity with temperature, the capacity being a maximum at the Curie point 7 and approaching a minimum at a temperature of the order of 100° C. Above 100° C., the drop in capacity with increasing temperature is small. Curve 8 represents the maximum change in capacity for a polarizing voltage. That is, for any particular temperature, the difference between the ordinates of curves 6 and 8 represent the change in capacity for a polarizing voltage applied across the electrodes 2 and 3. However, whenever a polarizing voltage is applied across the electrodes 2 and 3, if the same polarizing voltage is applied across the resistance coating 5, the dielectric body 1 will be heated and there will be a further drop in capacity due to the increased temperature. The result is that under the influence of the combined effect of a polarizing voltage across the electrodes 2 and 3 and also across the resistance coating 5, the capacity between the electrodes 2 and 3 will follow the dotted line curve 7*a* which closely represents the steady state capacity curve for the combination of temperature and voltage change of the capacity. It will be noted that instead of working on the difference between the ordinates of the curves 6 and 8, the capacitor works along the curve 7*a* and thereby produces a greater change in capacity than would be possible by just the polarizing voltage alone. If the capacitor responded only to the polarizing voltage, the response would be instantaneous but ambient temperature changes would change the capacity so as to take it out of the control range and thereby cause it to stop being useful. On the other hand, if the capacitor responded only to heating, it would have a limited control range and the further defect of not being instantly responsive to the error signal due to the thermal lag. However, if both the polarizing voltage and heating effects are combined, as disclosed here, there is not only the wider range of control as above stated but at any point in this wider range there is the further advantage of an instantaneous response to changes in the error signal voltage. For example, if the capacity change required to correct for all errors in an oscillator (ambient temperature, tube heating, mechanical creepage, etc.) is, say, 2 mmf. at the time it is turned on, and the combined control device range is 2.5 mmf. using both the polarizing voltage and the heating effects, the equipment will bring itself into tuned condition in two steps—instantly by perhaps 1 mmf. due to polarizing change, and within perhaps 10 seconds by the remaining 1 mmf. due to heating. Now having reached the tuned condition, all other corrections from that time on will be instantaneous providing the summation of such changes within a ten second interval does not exceed the polarizing range for the temperature of the device at that time. This means that for most applications, even though the required control range is greater than that provided by polarizing alone, all errors will be instantly corrected at any time after a short warm-up time after turning on the equipment.

This results in a control device with a wider control range through the combination of the two effects, but one which provides a range of instantaneous control within this wide range.

The circuit in Fig. 4 illustrates a typical use of the capacitor unit. The control input is applied across terminals 9 and 10 from an error signal generator not shown which for example may be a discriminator. The control input is applied to a D. C. amplifier 11 having the resistance

coating 5 in its output circuit. The resistance coating is connected across the condenser electrodes 2 and 3 through a choke 12. The tank circuit comprises the capacity between electrodes 2 and 3 in series with a capacitor 13 and an inductance 14.

By using both temperature and voltage to control the capacity and by operating at temperatures above the Curie point, the total change in capacity is materially increased. The nature of the change in capacity is adapted to control frequency drift. The voltage effect takes place almost immediately and supplies correction for fast changes. The temperature effect is slower e. g. 10–30 seconds and while too slow for effective use alone is an advantageous supplement. The temperature effect is, however, of magnitude comparable to the voltage effect, and, because the temperature is above the Curie point, the temperature effect adds to and supplements the voltage effect. This would not be possible if the dielectric had a large thermal mass or if the resistor were designed to carry the currents with small heating. The large thermal mass of the dielectric or the low temperature rise of the resistor would prevent any useful increase in the dielectric temperature and would confine the control predominantly to the voltage effect on the dielectric.

What is claimed as new is:

1. A capacitor unit for frequency control and the like comprising a dielectric body having both a voltage and temperature coefficient of capacity and having a Curie point in the region of the normal ambient temperature, a resistor material on the dielectric, a pair of capacitor electrodes on the dielectric, a source of control voltage variable in accordance with a quantity to be controlled, and connections for impressing the control voltage across the resistor and across the capacitor electrodes, said resistor being related to the thermal capacity of the dielectric such that the dielectric quickly assumes a temperature corresponding to the control voltage and the temperature rise of the dielectric supplements the change in capacity due to the control voltage.

2. A capacitor unit for frequency control and the like comprising a dielectric body having both a voltage and temperature coefficient of capacity and having a Curie point in the region of the normal ambient temperature, a resistor material covering the greater part of the dielectric, a pair of capacitor electrodes on the dielectric, a source of control voltage variable in accordance with a quantity to be controlled, and connections for impressing the control voltage across the resistor and across the capacitor electrodes, said resistor being related to the thermal capacity of the dielectric such that the dielectric quickly assumes a temperature corresponding to the control voltage and the temperature rise of the dielectric supplements the change in capacity due to the control voltage.

3. A capacitor unit for frequency control and the like comprising a titanate body having a Curie point in the region of the normal ambient temperature, a resistor material covering the greater part of the dielectric, a pair of capacitor electrodes on the dielectric, a source of control voltage variable in accordance with a quantity to be controlled, and connections for impressing the control voltage across the resistor and across the capacitor electrodes, said resistor being related to the thermal capacity of the dielectric such that the dielectric quickly assumes a temperature corresponding to the control voltage and the temperature rise of the dielectric supplements the change in capacity due to the control voltage.

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