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(54) IMPROVEMENTS RELATING TO MINIATURE VARIABLE CONDENSERS

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a miniature variable thin film condenser having an evaporated dielectric.

The present invention seeks to provide a miniature variable condenser taking up a minimum of space and whose capacity may be changed stepwise easily and which requires the minimum number of output terminals.

According to one aspect of the present invention, there is provided a miniature variable thin film condenser having an evaporated dielectric, a common electrode, at least two further electrodes which co-operate with the common electrode to form individual capacitors, and lead terminals with respective contacts for contacting the said further electrodes to permit variation of the total capacity of said condenser by step-by-step selection of, or combination of, said individual capacitors.

Preferably the said contacts are in the form of flexible plates movable by respective screws into and out of engagement with said further electrodes.

In one preferred embodiment, said common electrode is of aluminium while the said further electrodes are of chrome-gold with a silica dielectric therebetween.

According to another aspect of the present invention, there is provided an electric circuit including a miniature variable condenser as set forth above.

Optionally, said circuit is a temperature-compensated oscillator circuit including a quartz crystal vibrator to which said condenser is connected.

Said circuit may include a capacitor having a BaTiO_3 dielectric and connected in series and in parallel with respective said condensers

to form together a temperature-compensating device.

The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a somewhat diagrammatic sectional view of a miniature variable thin film condenser in accordance with the present invention,

Figure 2 is a schematic plan view of one of the electrodes of the condenser shown in Figure 1 divided into a plurality of individual plates,

Figures 3a and 3b are respective plan and cross-sectional views of the contact terminals for use with the condenser of Figure 1,

Figure 4 is a plan view of the condenser of Figure 1 in association with the contact terminals of Figures 3a and 3b as actually arranged in practice,

Figure 5 is a somewhat schematic cross-section view of a practical embodiment of a miniature variable condenser of the present invention, and

Figure 6 is a wiring diagram of a temperature-compensating circuit of a quartz-crystal oscillator, the circuit incorporating a condenser in accordance with this invention.

Referring to the drawings, in Figure 1 there is shown a thin film condenser including a glassy substrate 1, a lower electrode 2, a dielectric 3 and an upper electrode 4.

In order to provide a stepped variable condenser, the upper electrode 4 is a unitary structure, but the lower electrode 3 is subdivided into a plurality of individual plates, and in Figure 2 one preferred embodiment of such a lower electrode is shown, wherein individual plates 5 to 8 have areas in the ratio of (left to right) 1:2:4:8, it being clearly understood that these areas are proportional to the capacitances.

It will moreover be understood that by combining the four individual capacitor plates 5 to 8, fifteen capacitance values may be obtained in steps of one unit of capacitance.

[Price 25p]

Expressed more precisely, if n represents the number of divisions of the electrode 2, or in other words the number which is one less than the number of plates into which the lower electrode is subdivided, then the capacitor is divided into $(2^{n+1}-1)$ parts which require $(n+1)$ lead terminals. Accordingly, a stepped variable capacitor is realised in a very compact manner and with a relatively small number of output terminals.

The method for changing the total capacity of the condenser and the method for leading out by means of respective lead terminals with contacts will now be described with reference to Figures 3a, 3b, 4 and 5.

In Figures 3a and 3b a comb-shaped flexible metallic plate is provided with a plurality of contacts 9 to 12 each provided with respective screws 13 to 16, and as can be seen in Figure 3b, the contacts 9 to 12 are substantially of the shape of an inverted V in section. By tightening or loosening the respective screw, the respective contact may be moved towards and into contact with or away and out of contact from the opposing portion of the lower electrode 2. In fact, the individual plates 5 to 8 of Figure 2 are respectively located for co-operation with the contacts 9 to 12. Output terminals are provided for the upper electrode 4 and the comb-shaped metallic plate. This can be seen better in Figure 4 in which 17 is a region of the evaporated thin film capacitor and 18 is the region where the output terminals are located.

Figure 5 shows the internal structure of the stepped condenser according to this invention. 19 is a substrate made of glass or ceramic on which is deposited a chrome-gold electrode 21a. The other electrode 21 is preferably made of aluminium and 22a represents a silica dielectric film. A protective thin film 22b covers the electrode 21 and this protective film may also be made from silica. The lead terminal 23 and the adjusting screw 24 are shown in full and chain-dotted lines, with the lead terminal 23 "in contact" and "out of contact" with a fixed contact plate 20.

Turning now to Figure 6, there is shown a quartz crystal oscillating circuit which is temperature-compensated as described below. The temperature-compensating device for the circuit includes a capacitor C_{th} and a pair of variable condensers C_p and C_s which are miniature variable condensers in accordance with the present invention. The capacitor C_{th} is a temperature-compensating element having a high dielectric material such as $BaTiO_3$ which has its Curie point at substantially room temperatures, approximately 20°C . As the temperature increases over the Curie point the temperature coefficient of the dielectric constant of this element reverses from positive to negative. This characteristic is very convenient when applied to a quartz crystal oscillator having a cut angle of e.g.

5° X. However, it is difficult to compensate the temperature characteristics of the quartz crystal oscillator denoted by X on the circuit diagram by means of the capacitor C_{th} only and for this reason the miniature variable condensers C_p and C_s are provided to adjust the compensation rate and to regulate the frequency of the oscillator.

The condenser C_p is provided because the ratio of capacity change of the high dielectric material of the condenser C_{th} is too large and therefore by increasing the capacity of the condenser C_p the frequency characteristics of the quartz crystal oscillator may be regulated to be constant at all temperatures. By adjusting C_s the frequency of the quartz crystal oscillator is regulated to be suitable for a particular frequency band, e.g. for operating timepieces. By regulating the capacitor C_s over a given range, one can maintain the gradient of the temperature compensating curve, that is to say the curve can be shifted to a position which is parallel with the original curve.

In the circuit of Figure 6, $R_1, R_2, \dots, R_n$ are resistors, C_1 is a feedback capacitor and C_2 is a coupling capacitor connected to the emitter of a transistor.

Although in the present invention $n=3$ has been described, the value of n is purely optional and can be increased or decreased. Moreover, the dividing ratio is not limited to a geometrical progression as in the present case.

WHAT WE CLAIM IS:—

1. A miniature variable thin film condenser having an evaporated dielectric, a common electrode, at least two further electrodes which co-operate with the common electrode to form individual capacitors, and lead terminals with respective contacts for contacting the said further electrodes to permit variation of the total capacity of said condenser by step-by-step selection of, or combinations of, said individual capacitors.

2. A miniature variable condenser as claimed in claim 1 wherein the said contacts are in the form of flexible plates movable by respective screws into and out of engagement with said further electrodes.

3. A miniature variable condenser as claimed in claim 1 or claim 2 wherein said common electrode is of aluminium, while the said further electrodes are of chrome-gold with a silica dielectric therebetween.

4. An electric circuit including a miniature variable condenser as claimed in any preceding claim.

5. A circuit as claimed in claim 4 wherein said circuit is a temperature-compensated oscillator circuit including a quartz crystal vibrator to which said condenser is connected.

6. A circuit as claimed in claim 5 wherein



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3. A miniature variable condenser as claimed in claim 1 or claim 2 wherein said common electrode is of aluminium, while the said further electrodes are of chrome-gold with a silica dielectric therebetween.

4. An electric circuit including a miniature variable condenser as claimed in any preceding claim.

5. A circuit as claimed in claim 4 wherein said circuit is a temperature-compensated oscillator circuit including a quartz crystal vibrator to which said condenser is connected.

6. A circuit as claimed in claim 5 wherein

5 said circuit includes a capacitor having a TaTiO_3 dielectric and connected in series and in parallel with respective said condensers to form together a temperature-compensating device.

7. A miniature variable condenser substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

8. An electric circuit substantially as 10 hereinbefore described with reference to Figure 6 of the accompanying drawings.

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