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(54) OSCILLATING CIRCUIT

(71) We, KABUSHIKI KAISHA DAINI SEIKOSHA, a Japanese company of 31-1, 6-chome, Kameido, Koto-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 oscillating circuits and in particular although not so restricted to oscillating circuits, for time-pieces, e.g. clocks and watches.

In, for example, conventional clocks and watches having an oscillating circuit, the electronic components of the oscillating circuit are not necessarily formed as a unit. This makes assembly and servicing troublesome because the oscillating circuit has a relatively large number of connections between its electronic components. Furthermore, when such an oscillating circuit is incorporated into a watch, difficulties arise due to the small amount of space which is available.

Generally, the natural frequencies of vibration of mass produced quartz crystal vibrators are distributed around a predetermined resonant frequency. To obtain an output signal of a desired frequency from an oscillating circuit having such a quartz crystal vibrator, a passive element, such as for example a capacitor forming a part of the oscillating circuit has to be adjusted in value so that the output signal of the desired frequency is obtained.

According to the present invention there is provided an oscillating circuit comprising a quartz crystal vibrator which is mounted within a casing, a printed circuit board fixed to the exterior of the casing, a passive electronic element mounted on the printed circuit board and electrically connected to the vibrator, the value of the passive electronic element being chosen to compensate for the difference between an electrical parameter of the vibrator and the nominal value of the parameter so that the output signal of the circuit has a predetermined frequency, after compensation, for all

vibrators having the same nominal characteristics.

The passive electronic element may be a capacitor or may be a resistor whose parasitic capacitance at the predetermined frequency is negligible.

In the preferred embodiment the printed circuit board has a pair of prongs, one of the prongs, carrying the passive electronic element, being bent from the plane of the remainder of the printed circuit board.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 is a circuit diagram of conventional oscillating circuits;

Figure 2 shows graphically the relationship between the frequency of the output signal of the oscillating circuit of Figure 1 and the value of a capacitor of the oscillating circuit;

Figure 3, consisting of Figures 3(A) and 3(B) illustrates a practical embodiment of a vibrator unit of an oscillating circuit according to the present invention; and

Figure 4 is a plan view of a watch incorporating the vibrator unit shown in Figure 3.

Throughout the drawings like parts have been designated by the same reference numerals.

A conventional oscillating circuit as shown in Figure 1 consists of a quartz crystal vibrator 1, an inverter circuit 2 for causing the vibrator to vibrate, a variable capacitor C_v and a fixed value capacitor C_n .

Deviation of the frequency f of the output signal of the oscillator circuit from the desired frequency f_0 is caused by deviation of the natural frequency of the quartz crystal vibrator from a predetermined resonant frequency and by deviation of the values of other electronic components of the oscillating circuit from predetermined values, the effects of the first deviation being far larger than the latter. However, adjustment of the natural frequency of a vibrator itself is so difficult that the frequency f of the output signal of the oscillating cir-

cuit is carried out, in the main, by adjusting the value of the capacitors C_G and/or the capacitor C_D .

Figure 2 shows graphically the change in frequency f of the output signal of the oscillating circuit of Figure 1 when the capacitance value of the capacitor C_G or the capacitor C_D is varied.

When the capacitance value of the capacitor C_G is changed, but the capacitance value of the capacitor C_D is maintained fixed, the frequency of the output signal of the oscillating circuit is shifted along the line PQ. Alternatively, if the capacitance value of the capacitor C_D is changed and the capacitance value of the capacitor C_G is maintained fixed, the resulting change in frequency is shifted along the same line PQ. As mentioned above, the natural frequencies of mass produced quartz crystal vibrators are distributed about a predetermined resonant frequency. This distribution is shown on the line PQ.

For adjusting the frequency f of the output signal of an oscillating circuit having a vibrator with a given natural frequency, the capacitance value of one or both capacitors C_G or C_D has to be changed. Using fixed value capacitors only, if this is to be performed precisely for all vibrators having natural frequencies within a given distribution, many capacitors having different capacitance values have to be made available.

It will be seen from Figure 2 that if the frequency f of the output signal of the oscillating circuit is f_1 , which is +20 p.p.m. from the desired frequency f_0 , using a capacitor C_1 having a capacitance value of 10 pF will alter the frequency of the output signal to the desired frequency f_0 . Similarly, if the frequency of the output signal of the oscillating circuit is f_2 , which is -20 p.p.m. from the desired frequency f_0 , using a capacitor C_2 having a capacitance value of 70 pF will alter the frequency of the output signal to the desired frequency f_0 .

If, after measuring the actual frequency of vibration of a quartz crystal vibrator, a suitable capacitor is selected and fitted, the deviation between the frequency of the output signal of the oscillating circuit and the desired frequency f_0 will have been compensated. That is to say, it is possible to compensate for the difference between the actual value of an electrical parameter of the vibrator and the nominal value of the parameter so that the output signal of the oscillating circuit has the desired frequency f_0 , after compensation, for all vibrators having the same nominal frequency dependent parameters. The vibrator and a suitable condenser can then be connected to form a vibrator unit. A fixed value capa-

citor may, if desired, be used in place of the variable capacitor C_G . In the case where a variable capacitor C_G is used, this may be of relatively small physical size since the variable capacitor C_G only requires to be variable over a relatively narrow range, and this enables the oscillating circuit to be incorporated in a watch, for example, where space is at a premium.

Referring now to Figure 3 there is shown a vibrator unit for an oscillating circuit according to the present invention. A capacitor 7 has a capacitance value which is selected to compensate for deviations of the natural frequency of a quartz crystal vibrator of the oscillating circuit from the frequency which would cause the oscillating circuit to produce an output signal of the desired frequency f_0 . The capacitor 7 is fixed on a printed circuit board 4, this printed circuit board having prongs 4a, 4b and being fixed to a casing 3 housing the quartz crystal vibrator. The prong 4b of the printed circuit board carries the capacitor 7 and has a terminal 8, the prong being bent out of the plane of the remainder of the printed circuit board along the upper surface of the casing 3. The prong 4a of the printed circuit board has terminals 5, 6. These three terminals are provided to connect the vibrator unit to other electronic circuits (not shown). Thus a compact vibrator unit may be formed. The vibrator unit is mounted on a supporting board 9 having holes 10, 11 by means of which it is fixed on a watch movement (see Figure 4) by screws 12, 13.

The above described embodiment of the present invention enables the vibrator unit to be constructed in a relatively inexpensive manner. Thus adjustment of the frequency of the vibrator during assembly of the oscillating circuit is unnecessary and, furthermore, the vibrator unit may be replaced during servicing if this is found to be necessary.

WHAT WE CLAIM IS:—

1. An oscillating circuit comprising a quartz crystal vibrator which is mounted within a casing, a printed circuit board fixed to the exterior of the casing, a passive electronic element mounted on the printed circuit board and electrically connected to the vibrator, the value of the passive electronic element being chosen to compensate for the difference between an electrical parameter of the vibrator and the nominal value of the parameter so that the output signal of the circuit has a predetermined frequency, after compensation, for all vibrators having the same nominal characteristics.

2. An oscillating circuit as claimed in



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When the capacitance value of the capacitor C_G is changed, but the capacitance value of the capacitor C_D is maintained fixed, the frequency of the output signal of the oscillating circuit is shifted along the line PQ. Alternatively, if the capacitance value of the capacitor C_D is changed and the capacitance value of the capacitor C_G is maintained fixed, the resulting change in frequency is shifted along the same line PQ. As mentioned above, the natural frequencies of mass produced quartz crystal vibrators are distributed about a predetermined resonant frequency. This distribution is shown on the line PQ.

For adjusting the frequency f of the output signal of an oscillating circuit having a vibrator with a given natural frequency, the capacitance value of one or both capacitors C_G or C_D has to be changed. Using fixed value capacitors only, if this is to be performed precisely for all vibrators having natural frequencies within a given distribution, many capacitors having different capacitance values have to be made available.

It will be seen from Figure 2 that if the frequency f of the output signal of the oscillating circuit is f_1 , which is +20 p.p.m. from the desired frequency f_0 , using a capacitor C_1 having a capacitance value of 10 pF will alter the frequency of the output signal to the desired frequency f_0 . Similarly, if the frequency of the output signal of the oscillating circuit is f_2 , which is -20 p.p.m. from the desired frequency f_0 , using a capacitor C_2 having a capacitance value of 70 pF will alter the frequency of the output signal to the desired frequency f_0 .

If, after measuring the actual frequency of vibration of a quartz crystal vibrator, a suitable capacitor is selected and fitted, the deviation between the frequency of the output signal of the oscillating circuit and the desired frequency f_0 will have been compensated. That is to say, it is possible to compensate for the difference between the actual value of an electrical parameter of the vibrator and the nominal value of the parameter so that the output signal of the oscillating circuit has the desired frequency f_0 , after compensation, for all vibrators having the same nominal frequency dependent parameters. The vibrator and a suitable condenser can then be connected to form a vibrator unit. A fixed value capacitor

may, if desired, be used in place of the variable capacitor C_G . In the case where a variable capacitor C_G is used, this may be of relatively small physical size since the variable capacitor C_G only requires to be variable over a relatively narrow range, and this enables the oscillating circuit to be incorporated in a watch, for example, where space is at a premium.

Referring now to Figure 3 there is shown a vibrator unit for an oscillating circuit according to the present invention. A capacitor 7 has a capacitance value which is selected to compensate for deviations of the natural frequency of a quartz crystal vibrator of the oscillating circuit from the frequency which would cause the oscillating circuit to produce an output signal of the desired frequency f_0 . The capacitor 7 is fixed on a printed circuit board 4, this printed circuit board having prongs 4a, 4b and being fixed to a casing 3 housing the quartz crystal vibrator. The prong 4b of the printed circuit board carries the capacitor 7 and has a terminal 8, the prong being bent out of the plane of the remainder of the printed circuit board along the upper surface of the casing 3. The prong 4a of the printed circuit board has terminals 5, 6. These three terminals are provided to connect the vibrator unit to other electronic circuits (not shown). Thus a compact vibrator unit may be formed. The vibrator unit is mounted on a supporting board 9 having holes 10, 11 by means of which it is fixed on a watch movement (see Figure 4) by screws 12, 13.

The above described embodiment of the present invention enables the vibrator unit to be constructed in a relatively inexpensive manner. Thus adjustment of the frequency of the vibrator during assembly of the oscillating circuit is unnecessary and, furthermore, the vibrator unit may be replaced during servicing if this is found to be necessary.

WHAT WE CLAIM IS:—

1. An oscillating circuit comprising a quartz crystal vibrator which is mounted within a casing, a printed circuit board fixed to the exterior of the casing, a passive electronic element mounted on the printed circuit board and electrically connected to the vibrator, the value of the passive electronic element being chosen to compensate for the difference between an electrical parameter of the vibrator and the nominal value of the parameter so that the output signal of the circuit has a predetermined frequency, after compensation, for all vibrators having the same nominal characteristics.

2. An oscillating circuit as claimed in 130



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claim 1 in which the passive electronic element is a capacitor.

3. An oscillating circuit as claimed in claim 1 in which the passive electronic element is a resistor whose parasitic capacitance at the predetermined frequency is negligible.

4. An oscillating circuit as claimed in any preceding claim in which the printed circuit board has a pair of prongs, one of the prongs, carrying the passive electronic element, being bent from the plane of the

remainder of the printed circuit board.

5. An oscillating circuit substantially as herein described with reference to, and as shown in Figures 3 and 4 of the accompanying drawings.

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