

"CIRCUIT ASSEMBLY, E.G. FOR AN ELECTRONIC TIMEPIECE"

The present invention relates to a circuit assembly, e.g. for an electronic timepiece, the circuit assembly comprising a semiconductor sensor, e.g. a semiconductor sensor for measuring temperature, pressure and the like.

5 In Japanese Patent Publication (Kokoku) No. 61-52955, there is disclosed a circuit substrate for the mounting of an integrated circuit (IC) chip. The circuit substrate is mounted on a base frame, such as a plate, except at mounting portions of electronic parts such as the IC chip or a quartz
10 oscillator. The circuit substrate is fixed by screws to parts such as a circuit supporting plate or the like, with the result that almost the entire circuit substrate is rigidly held in position.

In Japanese Patent Publication No. 61-52955, the portion
15 of the circuit substrate which provides a mounting for the IC chip is shown as planar, for reasons of convenience. Actually, the said portion is inevitably bent to some degree due to variations in the height of the said plate and in the thickness both of the circuit substrate and of the circuit
20 supporting plate, together with variations caused by warping and the degree of tightness of each part. The IC chip is also slightly bent through its connection to the circuit substrate

by a bonding portion and a moulded portion. When the IC chip is provided with a built-in semiconductor sensor, the bending of the IC chip causes changes in the channel length or in the channel width of the transistor which forms the sensor and thus produces a change in the properties of the sensor, even if the amount of bending is very small. In the above described construction, even if means permitting an off-set adjustment or an inclination adjustment of the sensor are provided for when the circuit substrate is assembled, since the portion of the circuit substrate around the IC chip contacts other parts, the degree of bending of the circuit substrate around the IC chip is changed greatly when the clamping force of a screw is changed due to a temperature change, vibrations or the like. As a result, there is the severe problem that the properties of the sensor can be substantially changed from those which it had initially.

According to the present invention, there is provided a circuit assembly comprising a circuit substrate; an integrated circuit (IC) chip which is secured to the circuit substrate so as to be carried thereby and which is provided with a semiconductor sensor; an oscillator whose frequency-temperature characteristic is controlled by the semiconductor sensor; and support structure to which the circuit substrate and oscillator are fixed by fixing means, the fixing means being spaced from the IC chip so that the IC chip and its semiconductor sensor are spaced from any other part of the circuit assembly except for their connection to the circuit substrate.

Preferably, the circuit substrate is fixed to the support structure only at end portions of the circuit substrate.

Thus, even if the fixing conditions around the circuit substrate are changed, the amount of bending of the circuit substrate around the IC chip is changed comparatively little due to the spacing between the fixing means and the IC chip. Consequently, a change in the shape of the semiconductor sensor, and thus a change in its properties, is avoided.

The semiconductor sensor preferably controls the said frequency-temperature characteristic so that a timepiece provided with the circuit assembly has an annual timekeeping error not exceeding 20 seconds.

The circuit substrate may be provided with a slit or recess which extends around the portion of the circuit substrate which carries the IC chip. There may be at least one lead which is connected to the IC chip and which passes across said slit or recess and which has a portion which extends substantially parallel to an adjacent portion of the slit

or recess so as to allow for relative movement between the IC chip and a part to which the lead is connected.

The circuit substrate may be provided with lead patterns which have outwardly projecting portions engageable by a probe.

5 The circuit substrate may be a flexible circuit substrate in which case it is preferable that the portion of the flexible circuit substrate on which the IC chip is mounted is selectively reinforced.

10 The invention also comprises an electronic timepiece provided with a circuit assembly as set forth above.

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

15 Figure 1 is a plan view of a first embodiment of a circuit assembly for an electronic timepiece according to the present invention,

Figures 2 and 3 are cross sectional views taken on the lines II-II and III-III of Figure 1;

Figure 4 is a detailed plan view of a circuit substrate forming part of the structure shown in Figures 1-3,

20 Figure 5 is a cross-sectional view showing a pin probe in contact with a portion of the structure shown in Figure 4,

25 Figure 6 is a cross sectional view similar to Figure 5 but showing an alternative arrangement which has been suggested previously,

Figures 7 and 8 are views similar to those of Figures 2 and 3 respectively, but showing a second embodiment of the present invention, and

Figure 9 is a detailed plan view of a circuit substrate forming part of the structure shown in Figures 7 and 8.

In Figures 1 to 3 there is shown a first embodiment of an analogue electronic timepiece provided with a circuit assembly according to the present invention. The circuit assembly comprises a CMOS-IC chip 1 which compensates for a secondary temperature characteristic of a quartz oscillator 2 on the basis of information provided by a built in semi-conductor temperature sensor 1a. A tuning-fork type quartz oscillator 2 oscillates at about 32768 Hz and has a secondary temperature characteristic. A flexible circuit substrate 3 has the IC chip 1 mounted therefrom by "face down" bonding. The quartz oscillator 2 is also supported by the circuit substrate 3 by a soldering. A plate 4, which forms a base of the timepiece and thus constitutes support structure, is moulded in a synthetic resin and is provided with dowels for adjusting the position of each part and with notches for receiving or releasing each part. Metallic screw pins are driven into the plate 4. A circuit supporting plate 5, which has a fixing portion 5a for fixing to the oscillator 2 and bending portions 5b, 5c, fixes parts such as the quartz oscillator 2, the circuit substrate 3

a coil 6, and a stator 9 by means of screws 14, 15, 16
17 and 18 to the plate 4. Reference numeral 7 indicates
a magnetic core of the coil 6; reference numeral 8 indicates
a coil lead substrate; reference numeral 9 indicates a
5 stator; reference numeral 10 indicates a silver oxide cell;
reference numeral 11 indicates a stem for adjusting the time
indication etc; reference numeral 12 indicates a setting lever;
reference numeral 13 indicates a gear train support, reference
numeral 19 indicates a negative terminal of the cell 10 and
10 reference numerals 20, 21 respectively indicate an insulating
plate for the cell 10 and a moulded portion of the circuit
substrate 3 for mounting the IC chip 1 onto the circuit
substrate 3 securely.

In the embodiment of Figures 1-3, the circuit substrate
15 3 is fixed in position only around the screws 14, 15 so that
the latter fix the circuit substrate 3 to the plate 4 only at
end portions of the circuit substrate 3, the screws 14, 15
being well spaced from the IC chip 1. The height of a notch
4a in the plate 4 and that of the bent portions 5b, 5c of the
20 circuit supporting plate 5 is such that the whole of the
portion of the circuit substrate 3 around the IC chip 1 is
spaced from other parts. In these circumstances, even
if the screws 14 or 15 become loose due to a temperature

change or to vibrations and the height of the fixed portions of the circuit substrate 3 is therefore changed, the amount of bending of the circuit substrate 3 around the IC chip 1 is changed very little due to the long distance between the mounting portions of the circuit substrate 3 at which it is mounted and the IC chip 1. Further, as the circuit substrate 3 is flexible and the rigidity of the circuit substrate 3 around the IC chip 1 is comparatively high because of the provision of the moulded portion 21, there is comparatively little change in the amount of bending of the circuit substrate 3 around the IC chip 1. Accordingly, the change in the amount of bending in the IC chip 1 is also small, and thus there is no substantial change in shape of a transistor forming the semiconductor sensor 1a of the IC chip 1, so that there is no substantial change in the characteristic of the sensor 1a.

In addition, as shown in Figure 4, the circuit substrate 3 of this embodiment is provided with a slit or recess 3a along the IC chip 1 between the portion of the circuit substrate 3 on which the IC chip 1 is mounted and that on which the oscillator 2 is mounted, whereby there is little transmission of any displacement produced at a quartz oscillator mounting portion 3b of the circuit

substrate 3 due to a change in the way in which the quartz oscillator 2 is fixed thereto. Moreover, any such transmission is also reduced by virtue of the fact that copper foil lead patterns 3c and 3d, which extend
5 between the IC chip 1 and the quartz oscillator 2 and which overhang the slit 3a, are lengthened by extending parallel to an adjacent portion of the slit 3a or by being disposed at an angle thereto so as to allow for relative movement between the oscillator 2 and the IC chip 1.

10 In the circuit substrate 3 of this embodiment, lead patterns or copper foils 3e, 3f, 3g, 3h, 3i, 3j and 3k, which have outwardly projecting portions, are provided for connection to check terminals for measuring the temperature characteristic of the quartz oscillator 2 or
15 for the temperature sensor, and for connection to check terminals for transferring or writing in data relating to the so-called "offset adjustment value" or the so-called "inclination (or slope) adjustment value" of the temperature characteristic of the quartz oscillator or of the temperature
20 sensor. In this connection it may be pointed out that a method for maintaining a constant output frequency from an oscillator circuit regardless of the temperature is described, for instance, in U.S. Patent No. 4,453,834. In this method, a compensation signal for compensating the temperature-frequency
20 characteristics of the quartz crystal oscillator is outputted,

the compensation signal being based on an output signal from the temperature sensor. However, as the output signal from the sensor varies by reason of manufacturing errors, it is required to adjust both the absolute value of the output of the sensor and the inclination or slope of the amount changed in order to obtain the ideal compensation signal. This adjustment is carried out by a digital control. The "off-set adjustment" thus controls the absolute value while the "inclination (or slope) adjustment" controls the inclination of the amount changed.

Therefore, for instance, when a pin probe 22 contacts the circuit substrate 3 to adjust the amount of offset and inclination of the sensor output signal so that the sensor is adjusted to the temperature characteristic of the quartz oscillator 2, only the copper foils are displaced as shown in Figure 5, and the circuit substrate 3 itself is not bent. On the other hand, if the lead patterns for the check terminals do not have projecting portions, the circuit substrate 3 is bent as shown in Figure 6, when the pin probe 22 contacts them, which causes a change in the characteristic of the sensor.

In addition, the change in the characteristic of the semiconductor sensor 1a can be reduced by making the circuit substrate 3 flexible and by reinforcing it selectively around the IC chip mounting portion.

5 Reference is next made to Figures 7-9 which illustrate a second embodiment of the present invention which is generally similar to that of Figures 1-4 and which for this reason will not be described in detail, like reference numerals indicating like parts. In the said second embodiment, 10 the IC chip mounting portion of the circuit substrate 3 is reinforced by attaching a 70 μ m thick copper foil 23 to the reverse side of the mounting portion. The copper foil 23 is etched so as to remain only around the IC chip mounting portion and the soldering portion of the lead patterns 15 for the quartz oscillator 2. The copper foil 23a around the IC chip mounting portion improves the rigidity of the circuit substrate 3 around the IC chip mounting portion. Further, the copper foil 23b attached to the reverse side of the soldering portion of the quartz oscillator 2 contacts the circuit supporting plate 5 around the screw 15 so as to be 20 brought to a positive potential, whereby a change in the capacity of the quartz oscillation circuit is avoided even when the movement which has been assembled in the watch case is brought to a positive potential.

In the embodiments described above, since the characteristic of the semiconductor temperature sensor la is not changed as a result of a change in the disposition of the circuit substrate 3 or as a result of contact by a pin probe, electronic timepieces of high-accuracy and reliability in which the characteristic of the sensor does not change with time due to mechanical factors can be produced with a high yield rate, i.e. a high proportion of acceptable products.

Further, even if a single circuit substrate is provided and the latter is fixed into a timepiece body, a change in the characteristic of the semiconductor temperature sensor la is not caused when the circuit substrate 3 is built into a timepiece body. Hence, the temperature characteristic of the quartz oscillator and the sensor can be measured and adjusted when a single circuit substrate is provided, which enables a compact and simple apparatus to be provided for measuring and adjusting. In particular, measuring and adjusting can be effected by a line system utilizing a tape (film) carrier method with a flexible circuit substrate 3, and hence automation of such measuring and adjusting and simplification of such apparatus can be achieved.

Furthermore, since an high-accuracy electronic timepiece can be provided with a satisfactory temperature characteristic merely by using a single circuit substrate, after-sale service merely involves an exchange of the circuit substrate. Thus, repair charges are reduced and the time for effecting a repair is reduced.

As indicated above, the circuit substrate may be fixed at at least two edge portions which are well separated from the IC chip mounting portion so that the substrate around the IC chip is not in contact with other parts. Hence, even if the height of the circuit substrate is changed as a result of a change in the fixing conditions due to a temperature change or vibrations, the amount of bending of the circuit substrate around the IC chip mounting portion can be reduced. Further, not only can an electronic timepiece of high-reliability be provided without a change in the shape of the transistor which forms a semiconductor sensor, and thus a change in the characteristic of the sensor, but automation can be facilitated by adjustment of the semiconductor when a single circuit substrate is provided. As a result, the repair cost and the length of time for effecting a repair can be reduced.

In addition, the circuit assembly of the present invention is usable not only in an electronic timepiece but also in a compact electronic apparatus having a

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1. A circuit assembly comprising a circuit substrate;
an integrated circuit (IC) chip which is secured to the circuit
substrate so as to be carried thereby and which is provided
with a semiconductor sensor; an oscillator whose frequency-
5 temperature characteristic is controlled by the semiconductor
sensor; and support structure to which the circuit substrate
and oscillator are fixed by fixing means, the fixing means
being spaced from the IC chip so that the IC chip and its
semiconductor sensor are spaced from any other part of the
10 circuit assembly except for their connection to the circuit
substrate.
2. A circuit assembly as claimed in claim 1 in which
the circuit substrate is fixed to the support structure
only at end portions of the circuit substrate.
- 15 3. A circuit assembly as claimed in claim 1 or 2
in which the semiconductor sensor controls the said
frequency-temperature characteristic so that a timepiece
provided with the circuit assembly has an annual timekeeping
error not exceeding 20 seconds.
- 20 4. A circuit assembly as claimed in any preceding claim
in which the circuit substrate is provided with a slit or
recess which extends around the portion of the circuit substrate
which carries the IC chip.
5. A circuit assembly as claimed in claim 5 in which at
25 least one lead which is connected to the IC chip and which
passes across said slit or recess has a portion which extends
substantially parallel to an adjacent portion of the slit or
recess so as to allow for relative movement between the IC
chip and a part to which the lead is connected.



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6. A circuit assembly as claimed in any preceding claim in which the circuit substrate is provided with lead patterns which have outwardly projecting portions engageable by a probe.
- 5 7. A circuit assembly as claimed in any preceding claim in which the circuit substrate is a flexible circuit substrate.
8. A circuit assembly as claimed in claim 7 in which the portion of the flexible circuit substrate on which the IC chip is mounted is selectively reinforced.
- 10 9. A circuit assembly substantially as hereinbefore described with reference to Figures 1-5 or Figures 7-9 of the accompanying drawings.
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