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(54) AN ELECTRONIC TIMEPIECE

(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 electronic timepieces.

Electronic wristwatches, especially quartz crystal electronic wristwatches, have become increasingly popular in recent years because of their high reliability and accuracy. However, in general, electronic wristwatches can stand no comparison with mechanical watches as far as design is concerned, since the movement of an electronic watch is bigger and larger than the movement of a mechanical watch. In the field of ladies' watches, where fashion is important, an extremely small size movement for a ladies' electronic watch has not been developed and so it is currently difficult for ladies' electronic wristwatches to supplant ladies' mechanical watches. In recent years, however, a demand has developed for a ladies' quartz crystal electronic wristwatch and so it has become highly desirable to make a movement for such a wristwatch which is of small size and thinner than conventional movements and to make an electronic wristwatch with relatively great flexibility of design.

According to the present invention there is provided an electronic timepiece comprising: an oscillator unit for producing a standard time signal; a frequency divider for frequency dividing the standard time signal to produce a driving signal; a stepper motor arranged to be driven by the driving signal and including a driving coil; a gear train mechanism for driving time indication means from a mechanical output of the stepper motor, the oscillator unit and coil being disposed around the periphery of the gear train and so that they do not overlap the gear train, the oscillator unit including a quartz crystal oscillator; a battery for driving the electronic timepiece; and a base plate, a region of the periphery of the battery being substantially at a centre point of the base plate.

Said coil may have a core disposed adjacent to the battery to locate the same.

The electronic timepiece may include a dial fixed to the base plate at positions beneath the coil and the battery.

The base plate may include a recess to accommodate the oscillator unit.

Preferably the electronic timepiece includes a setting lever engageable with a pinion of a gear wheel forming part of the gear train mechanism, during setting of the time indication means of the electronic timepiece.

A terminal of the battery may be connected to a shaft about which the setting lever pivots.

The base plate may be a truncated circle in plan.

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

Figure 1 is a plan view of an electronic timepiece according to the present invention;

Figures 2*a* and 2*b* are sectional views of the electronic timepiece of Figure 1;

Figure 3 is a plan view of a setting lever and a rest mechanism of the electronic timepiece of Figure 1;

Figure 4 is a sectional view of the setting lever and reset mechanism of Figure 3; and

Figure 5 is a plan view illustrating the relative positions of a front gear train and a back gear train of the electronic timepiece of Figure 1.

Referring first to Figures 1 and 2, there is illustrated an electronic timepiece, e.g. a

wristwatch, according to the present invention. The electronic timepiece has a timepiece movement including a base plate 1 and a cell or battery 2, a portion 2*b* of whose periphery is substantially at a centre-point of the base plate. At present, the smallest battery for practical use in a wristwatch is 7.9 millimetres in diameter. In the case of an electronic timepiece having three hands, the pinion or gear of a seconds hand shaft and the battery cannot overlap. Thus the conventional electronic timepiece has a diameter equal to the sum of the diameter of the battery, the diameter of the gear of the seconds hand shaft, the dimensions of other components, and the spaces between each such component. Accordingly, a conventional electronic timepiece has a minimum diameter of substantially 18 millimetres. To assist miniaturization, the electronic timepiec illustrated in Figure 1 has only two hands, i.e. a minutes hand and an hours hand.

As shown in Figure 1, the battery 2 overlaps a centre wheel and pinion arrangement 25. As a result, the timepiece movement has a maximum diameter of 16 millimetres and a minimum diameter of 13.6 millimetres. The electronic timepiece has a coil 3 and a quartz crystal vibrator unit 4. The vibrator unit 4 includes a quartz crystal vibrator (not shown) made by a photoetching technique and disposed in a casing. The casing of the quartz crystal vibrator is cylindrical and so its volume and planar surfaces are smaller than those of conventional box-shaped casings of quartz crystal vibrators. A quartz crystal vibrator of this type may be used to a great advantage in a sub-miniature and thin electronic timepiece. Furthermore, such a quartz crystal vibrator may be mass-produced relatively easily since it is made by a photoetching technique as mentioned above.

The electronic timepiece has a circuit block 5 fixed to the vibrator unit 4, a C-MOS integrated circuit 6 which has a relatively low consumption of power, a trimmer capacitor 7 which acts as a frequency regulating element, and other circuit elements, (not shown).

The circuit block 5 includes a frequency divider circuit for frequency dividing a standard time signal produced by the vibrator unit and the other components necessary to drive the electronic timepiece. Assembling and adjustment of the circuit block 5 in the electronic timepiece are thus relatively easy and may be performed efficiently. A third wheel bridge 8 locates a front gear train to be described in greater detail hereinafter. The front gear train drives the two hands, the third wheel bridge 8 including bearings for supporting the individual gears of the front gear train.

The external form of the base plate 1 is not circular as is conventional, but has a diameter in the direction of 3 o'clock — 9 o'clock which is greater than that in the direction of 12 o'clock — 6 o'clock. The form of the base plate 1 is that of a truncated circle in plan, that is to say of the so-called side-cut form. The base plate 1 is made by cutting opposite sides 1*a* of a circular shape by straight lines. Each arcuate part of the base plate 1 has the same radius, the arcuate parts joining the straight parts by further arcuate parts of different radii. Conventional side-cut base plates are larger than the base plate 1 which seems to provide scope for miniaturising an electronic timepiece. In actual fact, however, most of the surplus area of a conventional base plate is used as a contact surface for mounting the base plate in a casing, so that there is little space which can be used for parts of the timepiece movement. Therefore, the effect of the surplus area is insignificant. With a conventional side-cut base plate, the form of the case is substantially square since the base plate itself is substantially square. In the case of oval-shaped base plates, the conventional are larger in size than those which may be used in the present invention. The external form of the base plate 1 increases flexibility of design of a case for the electronic timepiece.

The vibrator unit 4, fixed to the back side of the circuit block 5, is set in the base plate 1. To this end, an aperture 1*b* is provided in the base plate 1 in order to accommodate the vibrator unit 4. However, as the electronic timepiece is made smaller and thinner, the thickness of the base plate 1 is reduced and so it is disadvantageous that the aperture 1*b* is of large size. A part of the vibrator unit 4 is positioned very close to the periphery of the base plate 1. If the aperture 1*b* is also provided close to the periphery of the base plate, the latter is unduly thin and likely to be deformed during manufacture of the base plate or assembly of the electronic timepiece. In order to prevent this, the strength of the base plate 1 is maintained by inclining a wall 1*c* to define the aperture 1*b* to the plane of the base plate.

The portion of the base plate 1 in which the battery 2 is housed has nearly the same diameter as the battery 2. The strength of the base plate 1 is again maintained by inclining the surfaces of an aperture 2*a* in the base plate to the plane of the latter. A positive terminal 9 electrically connects with the battery 2 and is fixed to the base plate 1 by pins 10, 34. Electrical connection with the circuit block 5 is provided by the pin 10. A negative terminal 12 of the battery 2 is electrically connected to the circuit block 5 by a terminal 11, electrically insulated from the base plate 1. The terminal 11 has a

notch 11*a* therein to prevent electrical contact of the terminal 11 with the centre wheel and pinion arrangement 25. Output terminals 13 of the circuit block 5 are resilient and are urged against electrodes 16*a* of a coil terminal plate 16 to which both ends of turns 15 of the coil 3 are soldered. An output driving signal of the circuit block 5 is transmitted to the coil 3 by way of the terminals 13. The external form of the terminal plate 16 projects beyond the core 14. In a conventional watch, electrodes are formed inside the external form of a terminal plate of a coil. However, as the electronic timepiec is miniaturized, the form of the core 14 becomes smaller and the area available for the terminal plate thereof inevitably becomes smaller. Accordingly, the area on which the electrodes can be provided also becomes smaller. The external form of the terminal plate 16, therefore, is adapted to the electrodes 16*a* in order to solve such problems. However, the electrodes 16*a* tend to bend during formation of the terminal plate 16 and there is the possibility of the electrodes 16*a* being short-circuited by the core 14. The external form of the terminal plate 16, therefore, extends beyond the core 14 to prevent the electrodes 16*a* from being short-circuited. A part of the core 14 is located near the battery 2 and its outline conforms to the shape of the battery. The battery 2 thus is guided and located by this part of the core during insertion and positioning in the electronic timepiece. The battery is fixed against the core 14 by virtue of the resiliency of the terminal 9. Both ends of the core 14 and a stator 17 of a stepper motor overlap. The coil 3 is fixed to the base plate 1 by fixing screws 19, 20. The stator 17 is positioned on the surface of the base plate 1 and a fixed gap is provided between polepieces 17*a*, 17*b* thereof.

A front gear train will be described in conjunction with Figure 1 and Figure 2*a*. A rotor 21 forms with the stator 17 part of the motor. The rotor 21 has a rotor magnet 21*a* fast therewith so that the rotor 21 has two magnetic poles. The motor converts the driving signal from the circuit block 5 which appears every 2.5 seconds, into rotary motion. The rotor pinion 21*b* drives a fifth wheel and pinion arrangement 22, a fourth wheel and pinion arrangement 23, a third wheel and pinion arangement 24, and a centre wheel and pinion arrangement 25 by means of which the hours and minutes hands are driven. The centre wheel and pinion arangement 25 form part of a back gear train. Upper and lower pivots of the fifth wheel and pinion arrangement 22 and the fourth wheel and pinion arrangement 23 are rotatable in bearings supported in the base plate 1 and the third wheel and pinion arrangement 24 is rotatably supported by a bearing in a plate 26 fixed to the back surface of the base plate 1. The centre wheel and pinion arrangement 25 is supported by loosely fitting an axle 27 in a hollowed portion thereof, the axle 27 being fixed to the back surface of the base plate 1. A third wheel pinion 24*a* of the third wheel gear and pinion arrangement 24 is engaged by a centre wheel 25*b* of the centre wheel and pinion arrangement 25 so that a gap between the third wheel 24*b* of the third wheel and pinion arrangement 24 and the battery 2 is extremely small. The stator 17 is provided with a hole 17*c* coaxial with the third wheel and pinion arrangement 24 and this hole prevents the third wheel and pinion arrangement from being misaligned during assembly of the electronic timepiece. In the present case, although the third wheel and pinion arrangement 24 can be disposed in the position occupied by a minutes wheel 28, the position of the minutes wheel 28 is determined in relation to a clutch wheel 30 and to a setting wheel 29. If the minutes wheel 28 is symmetrically positioned with respect to the axis of a stem 31, the minutes wheel and the battery 2 will overlap and therefore, it will be impossible for the minutes wheel 28 to be removed. Thus the position of the third wheel and pinion arrangement 24 where it is adjacent the coil 3 and the battery 2, as shown in Figure 1, is the most suitable having regard for the space distribution of the front gear train. A fourth wheel pinion 23*a* of the fourth wheel and pinion arangement 23 is engaged with the third wheel 24*b*. A clearance exists between the fourth wheel 23*b* and the fifth wheel 22*b* which is engaged with a rotor pinion 21*b*. The rotor is located where the third wheel 24*b* and the rotor magnet 21*a* overlap. Thus the wheels in the front gear train are mutually overlapped and the third wheel and pinion arrangement 24 is located so as not to overlap the minutes wheel 28. The front gear train and the back gear train do not, however, overlap to any appreciable extent which is advantageous in the manufacture of a relatively thin electronic timepiece. Futhermore, as the battery 2 and the gear train are adjacent, the area occupied is relatively small and makes good use of the space available. This disposition of the front and back gear trains is shown in Figure 5.

Figures 3 and 4 shown details of a setting lever and a reset mechanism of the electronic timepiece of figure 1. A setting lever 32 can be moved to a position 33 which is illustrated by a broken line.

In that case a portion 32*a* of the setting lever is moved to a position 33*a* and engages with the fifth wheel pinion 22*a*.

The axis of rotation of the setting lever 32 is positioned on the surface of the base plate and is shown in Figure 4 as being constituted by a pin 34 which is fixed to the base plate 1. The pin 34 as described previously, also serves to fix the terminal 9 in position. A tail portion of a spring section 32*b* of the setting lever 32 is engaged with a pin 35. A setting lever pin 36 is fixed to the setting lever 32 and is urged against the pointed end of stem 31 during normal running of the electronic timepiece *via* the spring section 32*b*. The pin 34 is provided with a collar adjustment where it is engaged with the setting lever 32. The position of the setting lever 32 is determined by the pin 34. A section 32*c* of the setting lever 32 is engaged with a groove 37*a* provided in a third bridge 37 either during normal running or during setting of the time indication. The position of a pointed end of the setting lever 32 is determined by the section 32*c*. The setting lever 32 is moved to the position 33 by disengaging a setting lever pin 36 from the stem 31 and the fifth wheel pinion 22*a* is thereby engaged. At the same time, the circuit is reset by electrical engagement of the setting lever 32 with a reset pin 38 which is fixed to the base plate 31. An insulating frame 39 for insulating the reset pin 38 from the base 1 is made of plastics material. The insulating frame 39 is easily deformed during manufacture and it would be possible for it to touch other parts. The play of the insulating frame 39 is prevented by overlapping portion 39*a* thereof with the third bridge 37. A portion of the insulating frame 39 is provided with an aperture 39*b* coaxial with the fourth wheel and pinion arrangement 23.

The inclination of the fourth wheel and pinion arangement 23 is controlled by the guiding of the lower pivot at the time of assembling the fourth wheel and pinion arrangement 23 and by engagement of the fourth wheel pinion 23*a* with the aperture 39*b*. As a result, it is easy to engage the upper pivot.

With respect to the fifth wheel and pinion arrangement 22, the same effect as with the fourth wheel and pinion arangement 23 is obtained by the stator 17 which is provided extremely near the fifth wheel and pinion arrangement 22 and a recess portion 39*c* which is provided in the insulating frame 39 and which is coaxial with the fifth wheel and pinion arrangement 22.

The method of fixing a dial 42 is shown in Figure 1 and Figure 2*b*. Dial feet 42*a*, 42*b*, which are fixed to the dial 42 are inserted into respective apertures 40, 41 provided on the base plate 1 and secured by screws 43, 44. The apertures 40, 41 are provided in locations where they overlap the coil 3 and the battery 2 respectively. The coil and the battery occupy a relatively large area, but there is space under the coil or under a curved portion of the battery and they are put to good use. The parts which are provided on the back surface of the base plate and which rotatably supports the third wheel and pinion arrangement 24 overlap with the coil 3. This fact contributes to a good usage of space.

In the electronic timepieces described above, each element is made of small size and thinner than conventionally. In the case of an electronic wristwatch limited space is put to good use by suitably designing and locating each element. The movement as a whole is shaped to maximise flexibility of design of the casing. The size of the movement is, in the main, determined by the battery, coil and quartz crystal vibrator unit. The gear trains, circuit block, trimmer capacitor etc., and adjusting mechanism have to be arranged between these elements.

WHAT WE CLAIM IS:

1. An electronic timepiece comprising: an oscillator unit for producing a standard time signal; a frequency divider for frequency dividing the standard time signal to produce a driving signal; a stepper motor arranged to be driven by the driving signal and including a driving coil; a gear train mechanism for driving time indication means from a mechanical output of the stepper motor, the oscillator unit and coil being disposed around the periphery of the gear train and so that they do not overlap the gear train, the oscillator unit including a quartz crystal oscillator; a battery for driving the electronic timepiece; and a base plate, a region of the periphery of the battery being substantially at a centre point of the base plate.

2. An electronic timepiece as claimed in claim 1 in which said coil has a core disposed adjacent to the battery to locate the same.

3. An electronic timepiece as claimed in claim 1 or 2 including a dial fixed to the base plate at positions beneath the coil and the battery.

4. An electronic timepiece as claimed in any preceding claim in which the base plate includes a recess to accommodate the oscillator unit.

5. An electronic timepiece as claimed in any preceding claim in which the base plate is a truncated circle in plan.

6. An electronic timepiece as claimed in any preceding claim including a setting lever engageable with a pinion of a gear wheel forming part of the gear train mechanism, during setting of the time indication means of the electronic timepiece.

7. An electronic timepiece as claimed in

The axis of rotation of the setting lever 32 is positioned on the surface of the base plate and is shown in Figure 4 as being constituted by a pin 34 which is fixed to the base plate 1. The pin 34 as described previously, also serves to fix the terminal 9 in position. A tail portion of a spring section 32*b* of the setting lever 32 is engaged with a pin 35. A setting lever pin 36 is fixed to the setting lever 32 and is urged against the pointed end of stem 31 during normal running of the electronic timepiece *via* the spring section 32*b*. The pin 34 is provided with a collar adjustment where it is engaged with the setting lever 32. The position of the setting lever 32 is determined by the pin 34. A section 32*c* of the setting lever 32 is engaged with a groove 37*a* provided in a third bridge 37 either during normal running or during setting of the time indication. The position of a pointed end of the setting lever 32 is determined by the section 32*c*. The setting lever 32 is moved to the position 33 by disengaging a setting lever pin 36 from the stem 31 and the fifth wheel pinion 22*a* is thereby engaged. At the same time, the circuit is reset by electrical engagement of the setting lever 32 with a reset pin 38 which is fixed to the base plate 31. An insulating frame 39 for insulating the reset pin 38 from the base 1 is made of plastics material. The insulating frame 39 is easily deformed during manufacture and it would be possible for it to touch other parts. The play of the insulating frame 39 is prevented by overlapping portion 39*a* thereof with the third bridge 37. A portion of the insulating frame 39 is provided with an aperture 39*b* coaxial with the fourth wheel and pinion arrangement 23.

The inclination of the fourth wheel and pinion arangement 23 is controlled by the guiding of the lower pivot at the time of assembling the fourth wheel and pinion arrangement 23 and by engagement of the fourth wheel pinion 23*a* with the aperture 39*b*. As a result, it is easy to engage the upper pivot.

With respect to the fifth wheel and pinion arrangement 22, the same effect as with the fourth wheel and pinion arangement 23 is obtained by the stator 17 which is provided extremely near the fifth wheel and pinion arrangement 22 and a recess portion 39*c* which is provided in the insulating frame 39 and which is coaxial with the fifth wheel and pinion arrangement 22.

The method of fixing a dial 42 is shown in Figure 1 and Figure 2*b*. Dial feet 42*a*, 42*b*, which are fixed to the dial 42 are inserted into respective apertures 40, 41 provided on the base plate 1 and secured by screws 43, 44. The apertures 40, 41 are provided in locations where they overlap the coil 3 and the battery 2 respectively. The coil and the battery occupy a relatively large area, but there is space under the coil or under a curved portion of the battery and they are put to good use. The parts which are provided on the back surface of the base plate and which rotatably supports the third wheel and pinion arrangement 24 overlap with the coil 3. This fact contributes to a good usage of space.

In the electronic timepieces described above, each element is made of small size and thinner than conventionally. In the case of an electronic wristwatch limited space is put to good use by suitably designing and locating each element. The movement as a whole is shaped to maximise flexibility of design of the casing. The size of the movement is, in the main, determined by the battery, coil and quartz crystal vibrator unit. The gear trains, circuit block, trimmer capacitor etc., and adjusting mechanism have to be arranged between these elements.

WHAT WE CLAIM IS:

1. An electronic timepiece comprising: an oscillator unit for producing a standard time signal; a frequency divider for frequency dividing the standard time signal to produce a driving signal; a stepper motor arranged to be driven by the driving signal and including a driving coil; a gear train mechanism for driving time indication means from a mechanical output of the stepper motor, the oscillator unit and coil being disposed around the periphery of the gear train and so that they do not overlap the gear train, the oscillator unit including a quartz crystal oscillator; a battery for driving the electronic timepiece; and a base plate, a region of the periphery of the battery being substantially at a centre point of the base plate.

2. An electronic timepiece as claimed in claim 1 in which said coil has a core disposed adjacent to the battery to locate the same.

3. An electronic timepiece as claimed in claim 1 or 2 including a dial fixed to the base plate at positions beneath the coil and the battery.

4. An electronic timepiece as claimed in any preceding claim in which the base plate includes a recess to accommodate the oscillator unit.

5. An electronic timepiece as claimed in any preceding claim in which the base plate is a truncated circle in plan.

6. An electronic timepiece as claimed in any preceding claim including a setting lever engageable with a pinion of a gear wheel forming part of the gear train mechanism, during setting of the time indication means of the electronic timepiece.

7. An electronic timepiece as claimed in

claim 6 in which a terminal of the battery is connected to a shaft about which the setting lever pivots.

8. An electronic timepiece substantially as herein described with reference to and as shown in the accompanying drawings.

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