

SPECIFICATION

Electronic timepiece

This invention relates to electronic timepieces.

According to the present invention there is

- 5 provided an electronic timepiece comprising: a power source; an oscillator circuit for frequency dividing the standard time signal; a wave shaping circuit for receiving a plurality of output signals from the frequency divider circuit and producing a
- 10 plurality of control signals; a control circuit connected to receive said control signals to produce an output signal; a driving circuit connected to receive said output signal and to provide a driving signal; and a stepping motor
- 15 arranged to be driven by said driving signal from the driving circuit, the arrangement being such that if the output voltage of the power source differs substantially from a predetermined voltage the driving signal consists of a pulsiform signal
- 20 each pulse of which comprises a plurality of pulse units, the pulse width of the pulse units of each pulse being determined by the output voltage of the power source.

- 25 The power source may be a lithium battery or may comprise a secondary battery and a charging device, for example, a solar battery, for charging the secondary battery.

- Said control circuit preferably includes a detecting circuit for detecting the output voltage
- 30 of the power source to determine the waveform of the driving signal in dependence upon the detected voltage.

- The control circuit may be such that the time between consecutive pulse units of the driving
- 35 signal is less than the time constant of the coil of the stepping motor. Thus the detecting circuit may be arranged to detect the output voltage of the power source when the voltage is applied to the

- 40 The electronic timepiece, in the preferred embodiment, is arranged so that, in operation, each pulse of the driving signal has a mark-to-space ratio between 0.1 and 1.0.

- The coil of the stepping motor is short-circuited
- 45 when no pulse or pulse unit is present.

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

- Figure 1 is a block diagram of a conventional
- 50 electronic timepiece;

Figure 2A is a perspective view of a stepping motor used in the conventional electronic timepiece of Figure 1 and in an electronic timepiece according to the present invention;

- 55 Figure 2B shows the waveform of current applied to the stepping motor of the conventional electronic timepiece of Figure 1;

Figure 3A shows graphically the discharge characteristics of a lithium battery;

- 60 Figure 3B shows graphically the charging/discharging characteristics of a secondary battery charged by a solar battery;

Figure 4 is a block diagram of one embodiment of an electronic timepiece according to the

- 65 present invention;

Figure 5A to 5D illustrate graphically the characteristics of a stepping motor versus voltage when driving pulse width is varied in a conventional electronic timepiece;

- 70 Figure 6A illustrates driving voltage waveforms produced by an electronic timepiece according to the present invention;

Figures 6B to 6F show graphically current waveforms in response to the driving voltage

- 75 waveforms of Figure 6A;

Figures 7A to 7D illustrate graphically the characteristics of a stepping motor versus voltage in response to the driving voltage waveforms of Figure 6A;

- 80 Figures 8A to 8C are circuit diagrams of voltage detecting circuits of the electronic timepiece of Figure 4;

Figure 9A is a circuit diagram of a wave shaping circuit of the electronic timepiece of

- 85 Figure 4;

Figure 9B is a timing chart illustrating the operation of the wave shaping circuit of Figure 9A;

Figure 10 is a circuit diagram of a control circuit and a driving circuit of the electronic timepiece of

- 90 Figure 4.

Figure 1 illustrates conventionally an electronic timepiece comprising a quartz crystal resonator 1 connected to an oscillator circuit 2 which

- 95 produces a time standard output signal with a frequency of 32768 Hz. The output signal from the oscillator circuit is fed to a frequency divider circuit 3 having 15 flip-flop stages. The output signal of the frequency divider circuit has a frequency of 1 Hz and is supplied to a wave
- 100 shaping circuit 4 which produces pulse driving signals which are fed to a driving circuit 5. The driving circuit 5 supplies current to drive a stepping motor 6 on receipt of pulses of the driving signals produced from the wave shaping circuit 4.

- 105 Figure 2A illustrates a stepping motor used in conventional electronic timepieces and electronic timepieces according to the present invention. The stepping motor has a stator 11, a rotor 12 and a coil 13.

- Figure 2B illustrates the voltage waveform of the current fed to the coil 13 from the driving circuit 5 of the conventional electronic timepiece illustrated in Figure 1. This waveform consists of pulses of alternate polarity the pulse width being 6.8 msec and the period being 1 second.

- All the circuits shown in Figure 1 are composed within an IC and power is supplied to the electronic timepiece by a power source 7. Since the power source 7 is usually a silver battery which produces a constant voltage of 1.5 volts up to nearly the end of its life, the operation of the circuits of the stepping motor of the conventional electronic timepiece are stable. Moreover, the
- 125 electronic timepiece may have a battery life display device which detects battery voltage at the end of the life of the battery i.e. when the battery voltage begins to fall. Therefore, it is not necessary to take account of voltage variation in the

design of the stepping motor in an electronic timepiece which uses a silver battery for power source.

On the other hand when the power source 7 is a silver peroxide battery whose output voltage is 1.8 volts just after it is manufactured, the operation of the stepping motor 6 is unstable. In order to eliminate this defect, the output voltage of the silver peroxide battery is artificially reduced to 1.5 volts by a silver treatment during manufacture. However, this means that best use is not made of the silver peroxide battery which has the advantage over other types of battery of a relatively large capacity per unit volume.

The power source 7 could also be a lithium battery which has a remarkably high reliability and high energy density but very disadvantageous discharge characteristics. Figure 3A shows the discharge characteristics of a lithium battery. A lithium battery has an initial output voltage of 3 volts which drops to 2.7 volts after a given time and remains at 2.7 volts for a while and thereafter falls gradually. These discharge characteristics make it exceedingly difficult to drive the stepping of the conventional electronic timepiece shown in Figure 1 stably. Further since current consumption and output torque of a stepping motor is influenced by the output voltage of the power source driving it, it is difficult to drive the stepping motor of the conventional electronic timepiece with a power source with a variable voltage. Further to drive the stepping motor of Figure 2A with a voltage of 3 volts makes it necessary to wind the coil 13 with thin wire in order to increase its resistance. However this results in increased manufacturing cost.

Figure 3B illustrates the variation of supply voltage of a silver battery or silver peroxide battery when used as a secondary battery and charged by a solar battery. In this case the supply voltage varies between 1.57 volts and 1.8 volts upon charging and discharging of the secondary battery.

Since the performance of a stepping motor is unstable when the output voltage of a power source varies significantly it is desirable to provide an electronic timepiece with means to ensure that the stepping motor has constant performance even when the output voltage of the power source varies. One embodiment of an electronic timepiece according to the present invention is shown in Figure 4. Like parts in Figure 1 and 4 have been designated by the same reference numerals. The electronic timepiece of Figure 4 includes a supply voltage detecting circuit 9 and a control circuit 8 which varies driving pulse width supplied to the stepping motor according to the voltage variation of the power source 7 in order to shorten the driving pulse width when the supply voltage is high.

The characteristics of the stepping motor of Figure 2A versus voltage in the case where the driving pulse width is varied in the conventional electronic timepiece of Figure 1 are illustrated in Figure 5A, 5B, 5C and 5D which respectively shows mean current, output torque at a centre

wheel and pinion driven by the stepping motor, efficiency and peak current, versus voltage.

However, even varying the driving pulse width of the stepping motor, there is a voltage range where the operation of the stepping motor is still unstable. As will be seen from Figures 5A and 5B in the voltage range from about 2.3 volts to 2.7 volts the desired output torque cannot be obtained. Moreover efficiency decreases with increase in voltage as shown in Figure 5C and peak current increases with voltage as shown in Figure 5B so that the design of a battery and the integrated circuitry is restricted.

Figure 6 shows driving voltage waveforms produced by an electronic timepiece according to the present invention and applied to a stepping motor such as that shown in Figure 2A. By repeating this waveform a driving signal with an overall driving pulse width of 6.8 msec. is achieved. Each driving pulse consists of a plurality of pulse units the pulse width of which is dependent upon the output voltage of the power source. If the driving pulse has some portions where the driving voltage is 0 volts on the basis of a unit of 0.12 msec. pulse width, the duty factor varies at 4/8, 5/8, 6/8, 7/8 and 8/8 for waveforms PD₁ to PD₅.

Figures 6B to 6F respectively show current waveforms when the stepping motor is driven by driving voltage waveforms PD₁ to PD₅ respectively when the supply voltage is 3.2 volts, 2.7 volts, 2.2 volts 1.8 volts and 1.6 volts. These figures show that the envelope of the current waveforms remain substantially constant in each case.

The current waveforms remain substantially constant for the following reasons. The current waveforms in Figure 6A to 6F show the current flowing from the power source so the current is zero when the driving voltage is 0 volts. However, current keeps flowing in the coil 13 of the stepping motor by virtue of the inductance of the coil through a closed loop including the driving circuit. In other words the coil is short-circuited when no pulse or pulse unit is present at its input terminal. The power applied to the rotor of the stepping motor is, as a result, average. Accordingly, if a part of a driving pulse is eliminated at an appropriate effective value when the supply voltage is high, the same driving power as the driving power when the stepping motor is driven by a non-eliminating driving pulse can be applied to the rotor using a large supply voltage.

In the case of Figures 6B to 6F since the conditions are chosen so that the value obtained by multiplying the supply voltage by the duty factor of the driving pulse is substantially constant, the movement of the rotor is almost the same in each case. Accordingly, the overall current waveforms are substantially constant.

The space between the driving pulse units is determined by the power available from the power source and the power required to driving the rotor of the stepping motor. The shorter the space between the driving pulse units the more the driving electric power and the driving power of the

rotor are averaged in comparison with the time constant determined by the inductance and resistance of the coil stepping motor.

- Figures 7A to 7D illustrate operation of the stepping motor versus voltage when the stepping motor is driven by the driving voltage waveforms PD₁ to PD₅. Figures 7A to 7D show respectively mean current, output torque at a centre wheel and pinion driven by the stepping motor, efficiency and peak current of the stepping motor versus voltage. It will be seen that the stepping motor operates stably over a wide range of supply voltages. If the driving voltage waveforms PD₁ to PD₅ are changed by an optimum voltage, power consumption, output torque and efficiency are kept substantially at a constant level while the peak current can be kept within substantially constant limits as shown in Figure 7D.

- Figure 8A illustrates the voltage detecting circuit 9 and the power source 7 of Figure 4 in greater detail. Reference numeral 33 denotes a battery comprising an ideal battery 49 which provides a battery voltage V_B and reference numeral 48 denotes the internal resistance of the battery having a value R_B. The battery has terminals V_D, V_S.

- The voltage detecting circuit consists of a comparator 30, a reference voltage generator 31 and a voltage divider 32. The comparator 30 compares the voltages at an input I⁺ and an input I⁻ and the output from the comparator 30 is level H when I⁺ > I⁻. An inverter 34 serves as a buffer of the comparator and at the same time inverts the output of the comparator. The output from the inverter is V_{comp}. Generally since the comparator consumes power when it operates, a NMOSFET 35 is ON only when a signal Z₀ is level H.

- The reference voltage generator 31 may be regarded as a battery producing a reference voltage V₀. Since current is also necessary for generating the reference voltage, a switch 37 is ON only when the signal Z₀ is level H. In other words, battery voltage is only detected when a voltage is applied to the coil of the stepping motor since this is under overall control of the signal Z₀.

- The reference voltage generator 31 in effect detects battery life by using the difference in threshold voltage between two NMOSFETs. Figure 8B shows the voltage detecting circuit in greater detail.

- A NMOSFET 91 has a threshold voltage V_{TN}. A NMOSFET 90 is formed by ion implantation and has a threshold voltage V'_{TN} and the reference voltage V₀ is given by:

$$V_0 = V_{TN} - V'_{TN}$$

- Although the absolute values of V_{TN} and V'_{TN} vary with density of the substrate on which the FETs 90, 91 are formed, temperature etc, the value V_{TN} - V'_{TN} can be controlled by the amount of ion implantation during the IC manufacturing process. The switch 37 is operated by the signal Z₀ applied to the gate of the FET 91.

Operation of the voltage divider 32 of the

- power source will now be described. If a terminal Z₁ is level H, a NMOSFET 44 is ON. When the resistance R_B = 0 and the On resistance of the NMOSFET 44 is 0, the voltage V_M applied to the input I⁻ of the comparator 30 is:

$$V_B \cdot R_1 / (R_0 + R_1)$$

- where R₀, R₁ are the resistances of resistors 39, 40 respectively. The comparator 30 compares the voltages V_M, V₀ and determines which is the higher.

- In the case where the driving voltage varies, resistance ratios between R₀, R₁, R₂, R₃, R₄, where R₂, R₃, R₄ are the resistances of resistors 41, 42, 43 respectively can be determined by the following equations when the voltages to be detected (detecting voltages) are 2.8V, 2.2V, 1.9V and 1.6V:

$$V_{D1} = 2.8 = (1 + R_0/R_1)V_0$$

$$V_{D2} = 2.2 = \{1 + R_0/(R_1 + R_2)\}/V_0$$

$$V_{D3} = 1.9 = \{1 + R_0/(R_1 + R_2 + R_3)\}/V_0$$

$$V_{D4} = 1.6 = \{1 + R_0/(R_1 + R_2 + R_3 + R_4)\}/V_0$$

- In the above equations, the reference voltage V₀ can be regarded as constant and the resistance ratios can be determined by length ratios of IC patterns. Therefore, the temperature characteristic of the detecting voltages V_{D1} to V_{D4} is excellent and the resistance ratios are not influenced by IC manufacturing techniques and, as a result, the detecting voltages can be set accurately.

- Figure 8C shows another embodiment of the voltage divider. The voltage divider of Figure 8C is similar to the voltage divider of Figure 8A in operation but different from it in its method of determining resistance ratios.

- Figure 9A illustrates the wave shaping circuit 4 of Figure 4 to produce a signal necessary for operating the control circuit 8 and the detecting circuit 9. Figure 9B is a timing chart illustrating the operation of the wave shaping circuit. An oscillator circuit 50 produces a reference signal of 32768 Hz using a quartz crystal resonator as an oscillating source. The reference signal is frequency divided by flip-flops 51 to 55. The divided signals are processed by gates 56 to 62 and signals Z_R, Z₁ to Z₄ and Z₀ are produced. A signal having period of 1 second and a pulse width of 6.8 msec is produced in another wave shaping circuit (not shown) is fed to an input terminal Z_D.

- The signals Z₁ to Z₄ are clock pulses, the signal Z₀ is an 8 KHz signal and the signal Z_R is an 8 KHz signal with a duty cycle of 1:3. All these signals are masked by the signal Z_D having a pulse width of 6.8 msec and a 1 second period.

- Figure 10 shows the control circuit 8 and the driving circuit 5 in greater detail. A SR flip-flop 72 latches the output V_{comp} of the detecting circuit 9. A T flip-flop 73 inverts the outputs alternately upon receipt of the signal Z_D each second and feeds driving voltage from an OR gate 74 to inverters 77, 78 via NAND gates 75, 76 alternately so as to excite a coil 79 of the

stepping motor.

Now the operation of the electronic timepiece of Figure 4 will be described. The driving voltage waveform is level H by the driving signal Z_0 at a time T_1 in Figure 9B and simultaneously voltage detection is performed by the signal Z_2 . The flip-flop 72 is previously reset by the signal Z_R . Since the signal V_{comp} is level H when the supply voltage is more than 2.2 volts, the flip-flop 72 is set. As a result the driving voltage waveform is level L with a supply voltage of more than 2.2 volts and level H with a supply voltage of less than 2.2 volts with time T_2 . Likewise the driving signal Z_0 is produced at times T_3 , T_5 , T_7 and supply voltage is detected in the same way. The driving voltage waveform at the next timing is level L when the supply voltages are more than 1.9 V, 2.8 V and 1.6 V and level H when less than 1.9 V, 2.8 V and 1.6 V. As a result the driving voltage waveforms at supply voltages over 2.8 V, 2.2 V, 1.9 V and 1.6 V and under 1.6 V are as shown by voltage waveforms PD_1 to PD_5 in Figure 6A in 0.98 msec. A 6.8 msec driving pulse is produced by repeating the above-mentioned operation seven times.

The present invention enables the stepping motor driven by a 1.5 V battery to operate with a constant output, a constant power consumption and a constant efficiency in an operable range several times higher than in conventional electronic timepieces. Although the effective rates of the driving voltages against the overall duty factor vary at 4/8, 5/8, 6/8, 7/8 and 8/8 by detecting the driving voltages at four levels in this embodiment, the stepping motor can be driven with higher voltages under constant conditions by varying the duty factor at 1/8, 2/8, 3/8. In other words, the duty factor of the pulse units can be between 0.1 and 1.0. On the other hand, although the conventional stepping motor driven by a 1.5 volt battery has been illustrated against a 3 volt battery such as a lithium battery, the detecting voltage levels and duty factor of the driving voltage waveforms may be reduced since the variation range of the battery voltage of a conventional silver oxide battery is 0.2 volts to 0.3 volts. Thus the present embodiment is advantageous in that the stepping motor is driven at a constant output and a constant efficiency automatically in accordance with variation in output voltage of a battery by optimum combination of the setting value of the voltage detecting levels and the duty factor of the driving pulses.

Moreover, the present invention is effective even when driving conditions vary due to increase in the internal resistance of the battery since the voltage levels are detected. This is because current flowing in the coil of the stepping motor causes the output voltage of the battery to drop by a factor equal to the product of the current value and internal resistance of the battery, and an increase in the voltage drop causes a large duty factor and a decrease in the voltage drop causes a smaller duty factor. Therefore the driving power of

the stepping motor will be constant regardless of the internal resistance of the battery. Accordingly, reduction of output torque of the stepping motor at low temperature, which is detrimental to accuracy of an electronic timepiece, is reduced and the electronic timepiece can be designed to reduce driving power. As a result, the output torque at room temperature is also reduced and the current is simultaneously reduced.

Since the motor can be driven at constant conditions even with variation of internal resistance of the battery an electronic timepiece capable of withstanding low temperatures and using a silver battery with an output voltage of 1.5 volts can be made.

According to the present invention, the voltage detecting operation is actuated at the same time as the driving control operation in a period of 0.98 msec. Seven cycles of the voltage detecting operation are actuated in the driving control operation in the driving pulse width of 6.8 msec.

Each pulse unit has a width of 0.12 msec and this is relatively short in comparison with the overall driving pulse width of 6.8 msec. The space between consecutive pulse units is also 0.12 msec and is determined by the time constant of the inductance and DC resistance of the coil. By arranging the space to be shorter than this time constant zero current flow in the coil is avoided.

Although the detecting voltage and the reference voltage are compared in the order of 2.2 V $\rightarrow$ 1.9 V $\rightarrow$ 2.8 V $\rightarrow$ 1.6 V in the embodiment of the the present invention described above it will be appreciated that this order can be changed at will. Moreover, though the stepping motor of the above embodiment of the present invention is a bipolar one-piece stator stepping motor usually used in an electronic wristwatch, an electronic timepiece according to the present invention may have any type of stepping motor such as a multipolar stepping motor, a single-face stepping motor, a two-piece stator stepping motor, a clock stepping motor etc.

CLAIMS

1. An electronic timepiece comprising: a power source; an oscillator circuit for producing a standard time signal; a frequency divider circuit for frequency dividing the standard time signal; a wave shaping circuit for receiving a plurality of output signals from the frequency divider circuit and producing a plurality of control signals; a control circuit connected to receive said control signals to produce an output signal; a driving circuit connected to receive said output signal and to provide a driving signal; and a stepping motor arranged to be driven by said driving signal from the driving circuit, the arrangement being such that if the output voltage of the power source differs substantially from a predetermined voltage the driving signal consists of a pulsiform signal each pulse of which comprises a plurality of pulse units, the pulse width of the pulse units of each pulse being determined by the output voltage of



stepping motor.

Now the operation of the electronic timepiece of Figure 4 will be described. The driving voltage waveform is level H by the driving signal Z_0 at a time T_1 in Figure 9B and simultaneously voltage detection is performed by the signal Z_2 . The flip-flop 72 is previously reset by the signal Z_R . Since the signal V_{comp} is level H when the supply voltage is more than 2.2 volts, the flip-flop 72 is set. As a result the driving voltage waveform is level L with a supply voltage of more than 2.2 volts and level H with a supply voltage of less than 2.2 volts with time T_2 . Likewise the driving signal Z_0 is produced at times T_3 , T_5 , T_7 and supply voltage is detected in the same way. The driving voltage waveform at the next timing is level L when the supply voltages are more than 1.9 V, 2.8 V and 1.6 V and level H when less than 1.9 V, 2.8 V and 1.6 V. As a result the driving voltage waveforms at supply voltages over 2.8 V, 2.2 V, 1.9 V and 1.6 V and under 1.6 V are as shown by voltage waveforms PD_1 to PD_5 in Figure 6A in 0.98 msec. A 6.8 msec driving pulse is produced by repeating the above-mentioned operation seven times.

The present invention enables the stepping motor driven by a 1.5 V battery to operate with a constant output, a constant power consumption and a constant efficiency in an operable range several times higher than in conventional electronic timepieces. Although the effective rates of the driving voltages against the overall duty factor vary at 4/8, 5/8, 6/8, 7/8 and 8/8 by detecting the driving voltages at four levels in this embodiment, the stepping motor can be driven with higher voltages under constant conditions by varying the duty factor at 1/8, 2/8, 3/8. In other words, the duty factor of the pulse units can be between 0.1 and 1.0. On the other hand, although the conventional stepping motor driven by a 1.5 volt battery has been illustrated against a 3 volt battery such as a lithium battery, the detecting voltage levels and duty factor of the driving voltage waveforms may be reduced since the variation range of the battery voltage of a conventional silver oxide battery is 0.2 volts to 0.3 volts. Thus the present embodiment is advantageous in that the stepping motor is driven at a constant output and a constant efficiency automatically in accordance with variation in output voltage of a battery by optimum combination of the setting value of the voltage detecting levels and the duty factor of the driving pulses.

Moreover, the present invention is effective even when driving conditions vary due to increase in the internal resistance of the battery since the voltage levels are detected. This is because current flowing in the coil of the stepping motor causes the output voltage of the battery to drop by a factor equal to the product of the current value and internal resistance of the battery, and an increase in the voltage drop causes a large duty factor and a decrease in the voltage drop causes a smaller duty factor. Therefore the driving power of

the stepping motor will be constant regardless of the internal resistance of the battery. Accordingly, reduction of output torque of the stepping motor at low temperature, which is detrimental to accuracy of an electronic timepiece, is reduced and the electronic timepiece can be designed to reduce driving power. As a result, the output torque at room temperature is also reduced and the current is simultaneously reduced.

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Although the detecting voltage and the reference voltage are compared in the order of 2.2 V $\rightarrow$ 1.9 V $\rightarrow$ 2.8 V $\rightarrow$ 1.6 V in the embodiment of the the present invention described above it will be appreciated that this order can be changed at will. Moreover, though the stepping motor of the above embodiment of the present invention is a bipolar one-piece stator stepping motor usually used in an electronic wristwatch, an electronic timepiece according to the present invention may have any type of stepping motor such as a multipolar stepping motor, a single-face stepping motor, a two-piece stator stepping motor, a clock stepping motor etc.

CLAIMS

1. An electronic timepiece comprising: a power source; an oscillator circuit for producing a standard time signal; a frequency divider circuit for frequency dividing the standard time signal; a wave shaping circuit for receiving a plurality of output signals from the frequency divider circuit and producing a plurality of control signals; a control circuit connected to receive said control signals to produce an output signal; a driving circuit connected to receive said output signal and to provide a driving signal; and a stepping motor arranged to be driven by said driving signal from the driving circuit, the arrangement being such that if the output voltage of the power source differs substantially from a predetermined voltage the driving signal consists of a pulsiform signal each pulse of which comprises a plurality of pulse units, the pulse width of the pulse units of each pulse being determined by the output voltage of



the power source.

2. An electronic timepiece as claimed in claim 1 in which the power source is a lithium battery.

5 3. An electronic timepiece as claimed in claim 1 in which the power source comprises a secondary battery and a charging device for charging the secondary battery.

4. An electronic timepiece as claimed in claim 3 in which the charging device is a solar battery.

10 5. An electronic timepiece as claimed in any preceding claim in which said control circuit includes a detecting circuit for detecting the output voltage of the power source to determine the waveform of the driving signal in dependence upon the detected voltage.

15 6. An electronic timepiece as claimed in any preceding claim in which the control circuit is such that the time between consecutive pulse units of

the driving signal is less than the time constant of the coil of the stepping motor.

20 7. An electronic timepiece as claimed in claim 5 or claim 6 when dependent thereon in which the detecting circuit is arranged to detect the output voltage of the power source when the voltage is applied to the stepping motor.

8. An electronic timepiece as claimed in any preceding claim arranged so that, in operation, each pulse of the driving signal has a duty factor between 0.1 and 1.0.

30 9. An electronic timepiece as claimed in any preceding claim in which the coil of the stepping motor is short-circuited when no pulse or pulse unit is present.

10. An electronic timepiece substantially as herein described with reference to and as shown in Figures 4 to 10 of the accompanying drawings.