

PATENT SPECIFICATION

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(54) ELECTRONIC TIMEPIECE

(71) We, CITIZEN WATCH COMPANY LIMITED, a Japanese Corporation, of 9—18, 1-chome, Nishishinjuku, Shinjuku, 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 generally to drive arrangements for electronic timepieces.

There are known several kinds of drive systems employed in electronic timepieces, especially watches, for drive of sonic frequency mechanical vibrators contained therein. More specifically, they mainly utilise the electromagnetic drive and the piezoelectric drive.

Use of piezoelectric drive is rather advantageous and superior to other kinds of vibra-

tor drives in that the vibrators can be made in relatively small sizes with equal operational performance and even at a substantially reduced rate of power consumption, accompanied with ease of manufacture thereof.

It has been found that there is, in compensation of the aforementioned various advantages, a substantial drawback encountered, when driving energy is directly derived from the mechanical vibrator for the drive of the time-keeping and display gear train, which resides in a rather large force factor appearing at the operating field of the piezoelectric elements and thus results in a correspondingly reduced stability in the operational frequency. With unavoidable fluctuations of the mechanical load imposed by the gear train, the stability of the vibrator frequency will be correspondingly reduced.

The force factor is given by the following equation:—

$$\text{Force factor (B)} = \frac{\text{force generated at the end of the oscillator (F)}}{\text{drive voltage (V)}} \\ = \text{ampere seconds per metre.}$$

An object of the present invention is to provide an electronic timepiece operating with the piezoelectric drive principle in which at least one of the stated problems is alleviated.

According to this invention there is provided a drive arrangement for an electronic timepiece comprising a first electromechanical vibrator which, in operation functions as a time base and to which piezoelectric sensing and drive means are attached; an electronic circuit for maintaining vibratory movement of said first vibrator and for producing an output at the time base frequency; a signal converter connected to receive the signal output of said electronic circuit and for producing a signal output therefrom; a second electromechanical vibrator which carries piezoelectric drive means connected to receive the output of said converter; and a mechanical motion-converter for converting the

vibratory movement of said second mechanical vibrator into rotary motion.

It may be arranged that frequency of the first electromechanical vibrator can be adjusted in a highly precise manner.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic and explanatory sketch of a first electronic timepiece having a drive arrangement according to the invention for illustration of the basic principles of the invention.

Figure 2 is a schematic and substantially perspective view of a first piezoelectric and mechanical vibrator acting as a time base, and a second piezoelectric and mechanical vibrator acting as a timepiece movement drive employed in the first embodiment.

[Price 25p]

Figure 3 is a circuit diagram of an electronic amplitude-keeping circuit provided with a phase-shifting means and employed in the embodiment of Figure 1.

5 Figure 4 is a similar view to Figure 3, showing a modified phase shifting means.

Figure 5 is a circuit diagram illustrative of a phase shifting means adapted for use as a frequency regulator.

10 Figure 6 is a similar view of Figure 5, illustrative of a modified form of the phase shifter.

Figure 7 is a graph showing a frequency characteristic curve which can be derived by use of the circuit shown in Figure 3, in combination with the phase shifter shown in Figure 5.

Figure 8 is a graph 7, showing the frequency characteristic obtained by use of the circuit shown in Figure 4 in combination with the modified phase shifter shown in Figure 6.

Figure 9 is a similar view to Figure 1, illustrative of a second electronic timepiece having a drive arrangement according to the invention, wherein two sets of triple arm mechanical vibrators are employed.

Figure 10 is a perspective view of the second mechanical vibrator employed in the second embodiment of the invention.

Figure 11 is a schematic plan view of essential parts of a third embodiment of the invention, using a still further type of mechanical vibrator.

Figure 12 is a perspective view of two mechanical vibrators which are employed in the timepiece shown in Figure 11.

Figure 13 is a plan view of a fourth electronic timepiece having a drive arrangement according to this invention.

Figure 14 is a top plan view of a mounting piece adapted for receiving a mechanical vibrator formed into a tuning fork.

Figure 15 is a bottom view of the mounting piece shown in Figure 14.

Figure 16 is a sectional view taken substantially along a section line XVI—XVI' shown in Figure 14.

Figure 17 is an enlarged sectional view substantially taken along a section line XVII—XVII' shown in Figure 13.

Referring now to Figures 1 and 2 of the accompanying drawings, numeral 1 indicates generally a first mechanical vibrator constructed as a triple arm one and adapted for acting as the time base of the electronic timepiece as will become more apparent as the description proceeds. This vibrator 1 is made of a known permanent-elastic material such as that sold under the name "Elinvar" (Registered Trade Mark) which has substantially constant elasticity irrespective of temperature fluctuations within a practical range. Material of this nature will be used in all the 65 embodiments to be set forth. Numeral 2; 2'

and 3 indicate respective piezoelectric elements rigidly stuck onto respective parallel arms 1a; 1b and 1c of the vibrator 1. As will become more apparent hereinafter, the elements 2 and 2' serve as vibration sensing elements, while that shown at 3 serves as a drive element for the first vibrator 1.

A second mechanical vibrator 4 is composed of a tuning fork as shown more specifically in Fig. 2, having a pair of vibratory arms 4a and 4b on which respective piezoelectric elements 5a and 5b are fixedly stuck. As shown in Figure 1, the vibrator 1 is arranged partly between the timer of the tuning fork.

A pawl 6 is pivotably mounted at its root end 6a on the first vibrator arm 4a, a pallet stone 6b being fixedly mounted on the tip end of said arm 4a and adapted for cooperating with a ratchet wheel 7 operatively connected with a conventional time-keeping and time-indicating gear train 8, to be described, of the timepiece movement.

Numeral 9 indicates a battery unit fixedly mounted on the timepiece movement.

Numeral 10 indicates an electronic amplitude-keeper (i.e. a circuit which maintains the vibrations of the vibrator 1) and 11 denotes a signal converter.

The aforementioned parts 2; 2'; 3; 4; 5a; 5b; 9; 10 and 11 are electrically connected with each other, as specifically shown in Figs. 1 and 2.

The signal converter 11 receives sensed signals from the amplitude-keeper 10 and transmits them, with or without frequency division to the piezoelectric elements 5a and 5b, for oscillatingly driving the second vibrator 4 of the tuning fork type. The purpose of the provision of the first vibrator acting as time base resides only in the generation of time standard frequency signals and when it is constructed as the triple arm type vibrator having a high Q-value as employed in the first embodiment, the power consumption thereof can be minimal, as an example, less than 1 μ w or so. The piezoelectric elements 2; 2' and 3 may each have only a relatively small operational area and the first vibrator 1 can have a highly stabilized and reliable frequency characteristic.

As an example, the first vibrator is a triple arm type operating at 1,600 Hz. The arm length "l"=16.25 mm; width "b" of central arm 1b=1.6 mm; thickness "h" of arm=0.6 mm; length "l_e" of piezoelectric element=2 mm; width "b_e" of the element=0.3 mm; thickness "h_e" of the element=0.05 mm; each of these elements was glued at a position having a distance of 7 mm measured from the root of oscillatory arm; resonance sharpness "Q" of first vibrator of triple arm type is nearly 8100; input output ratio η_{ta} =0.7; then, the fore factor "B" will be 1.1×10^{-5} [As/m] (i.e. ampere seconds per metre). In

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the case of the numerical example set forth above, the first mechanical vibrator shown in Figs. 1 and 2, can oscillate satisfactorily with a small force factor, as was ascertained by practical experiments. The frequency stability of the first mechanical vibrator is, theoretically 10^{-6} — 10^{-7} and this was also determined by our practical experiments.

The electronic amplitude keeper 10 amplifies the oscillation-responsive voltages sensed at piezoelectric elements 2 and 2' and is provided with a first output terminal 10a for applying the amplified voltages to piezoelectric drive element 3 for maintaining the oscillation of the first mechanical vibrator 1, and with a second terminal 10b for transmitting the electrical signals to converter 11.

The amplitude keeper 10 may take the specific form shown either in Fig. 3 or 4.

In the arrangement shown in Fig. 3, the amplitude keeper 10 comprises a phase shifter 30 and an amplifier 31. The phase shifter 30 comprises a resistor 21 connected between an input terminal P connected to piezoelectric elements 2 and 2' and an input terminal 29 of the amplifier 31. A variable condenser 22 is connected between said input terminal 29 and earth, so as to provide the L-shaped phase shifter 30. The phase shift may be varied by modifying the capacitance of the condenser 22 and by this means the frequency can be adjusted substantially linearly within a certain limited range. The phase shifter 30 has relatively simple circuitry and, in addition, a frequency adjustment has no appreciable effect on the gain and power consumption of the amplifier 31. It will be seen that minor frequency fluctuations caused by unavoidable aging of the second vibrator 4 may be easily and accurately compensated for by manual modification of the capacitance of condenser 22.

Now denoting the resistance of resistor 21 by R and the capacitance of condenser 22 by C; then, the phase shift between the voltage at terminals P and 29 will be:

$$\Delta\phi = \tan^{-1} (2\pi f \cdot C \cdot R)$$

In the graph shown in Fig. 7, the frequency change $\Delta f/f$ has been plotted under the following conditions against the capacitance C:

R=2 MΩ;
resonance frequency=1,118 Hz;
Q=about 4,000; the vibrator is of the triple arm type.

In this case, it was found that there were no appreciable variation in the power consumption at amplifier 31 and no appreciable amplitude fluctuation at the first mechanical vibrator 1.

In the arrangement shown in Fig. 4, a resistor 21 is connected between terminal P

and the base electrode (connected to terminal 29) of input transistor 32 of amplifier 31, as in Fig. 3, and further, a series-combination of condenser 24 and variable resistor 25 is connected between said base electrode and earth as shown. In this modified arrangement, phase shift adjustment can also be carried out as in the case of the first arrangement shown in Fig. 3 in this case by manual adjustment of the variable resistance 25.

In the graph shown in Fig. 8, the frequency change $\Delta f/f$ has been plotted against variation of the resistance 25.

As seen from the foregoing by adjustment of the variable condenser or resistor connected between the base electrode of the transistor 32 and earth, the oscillating frequency of the triple arm type mechanical vibrator can be adjusted without varying the amplitude of oscillation.

The circuit diagram shown in Fig. 6 shows the phase shift circuit shown in Fig. 4. It is now assumed that the resistance of resistor 21 is R and the capacitance 24 is C, while the resistance of resistor 25 is R_0 . In this case, the phase shift between sensor terminal P and amplifier input terminal 29 will be:

$$\Delta\phi = \tan^{-1} \frac{R/2\pi f \cdot C}{R_0(R_0+R) + (1/2\pi f \cdot C)^2}$$

when $R_0 \rightarrow 0$, then

$$\Delta\phi = \tan^{-1} (2\pi f \cdot C \cdot R)$$

when $R_0 \rightarrow \infty$, then

$$\Delta\phi = 0$$

By intentional alteration of R_0 from $\infty \rightarrow 0$ an effect similar to that obtained by adjustment of capacitance C in the case of Fig. 5 can be easily attained.

Signal converter 11 receives electrical signals through the terminal 10b (Fig. 2) and converts them into the necessary drive voltages to the piezoelectric elements 5a and 5b for maintaining the vibrations of the vibrator 4 which drives the pawl 6.

As an example, an input electrical signal of 1,600 Hz to the converter 11 is subjected therein to a frequency division down to 400 Hz and is then applied to the second mechanical vibrator in the form of a.c. voltages of about 3 volts derived from 1.5 volt power source 9 shown in Figs. 3 and 4.

The resonant vibrator comprising tuning fork 4, drive piezoelectric elements 5a and 5b and pawl 6 will oscillate at its natural frequency which is substantially equal to that of the voltage supplied from the converter 11 for driving the gear train 8, thus providing a prime mover for the necessary time-keeping and time-indicating function of the timepiece

movement. For this purpose, in the case of an electronic watch, there is required power of the order of several μ w. This drive power is transmitted through drive piezoelectric elements 5a and 5b to the second mechanical vibrator 4. In this case, for obtaining the necessary power, the following relation must be satisfied:

$$Z_m = \frac{z}{B^2}$$

10 where,

B is the force factor for the piezoelectric conversion; z is the mechanical resistance; and

15 Z_m is the motion impedance as seen from the electronic circuit side.

In order to minimize the motion impedance Z_m as much as possible, the force factor at the second or driving mechanical vibrator 4 must be substantially smaller than that at the first mechanical vibrator 1 acting as the time base. To satisfy this requirement, the piezoelectric elements 5a and 5b attached to the second vibrator should have each a substantially large operating surface than that of each of those 2, 2' and 3 attached to the first mechanical vibrator 1. Further, these piezoelectric elements 5a and 5b must be glued at such positions where oscillation stresses or elastic deformations are liable to appear predominantly.

As an example, the second or driving mechanical vibrator 4 formed into a tuning fork having an operating frequency: 400 Hz, may have the following main dimensions.

35 length of oscillatory arm $l=19$ mm;
width of arm $b=2$ mm;
thickness of arm $h=0.3$ mm;

40 When the vibrator is driven with an a.c. voltage of 3 volts, the amplitude of the oscillation as measured at the tip end of each oscillatory arm is preferably 150μ metres of the pawl 6 is to satisfactorily drive the ratchet. In this case, the dimensions of each of the piezoelectric elements 5a and 5b are preferably as follows:

45 length of element $l_t=8$ mm;
width of element $b_t=1$ mm;
thickness of element $h_t=0.05$ mm;

50 These elements 5a and 5b should be attached to the respective oscillatory arms at positions preferably in proximity to the arm root ends. In this specific embodiment, the resonance sharpness Q is preferably 600 and the force factor may advantageously be 5×10^{-5} (As/m), "As" being an abbreviation of "ampere seconds".

For the reasons set forth above, the resonance oscillator comprising tuning fork 4 and piezoelectric elements 5 and 6 has a substantially reduced resonance sharpness, such as 100 at an oscillating frequency of 400 Hz. It will be, therefore, seen that the stability of natural oscillation frequency of the tuning fork 4 can be thus correspondingly lowered. With a reduction of the Q-factor, the width of frequency band will become broadened correspondingly. However, since the tuning fork 4 is driven by the converter 11, the stability of the amplitude of oscillation is not affected.

The time accuracy of the tuning fork 4 depends entirely upon the electric time base signal delivered from the first mechanical vibrator, said accuracy being thus independent of the stability of natural oscillation frequency of the tuning fork.

It should be mentioned that the conversion efficiency of the piezoelectrically operated electromechanical converter or vibrator has a substantial superiority over the nowadays widely used electromagnetically operated converters, the said efficiency amounting to nearly 100%. Heretofore the utilization of piezoelectric converters in electronic timepieces has been substantially prevented. The reason may be that to drive directly a ratchet wheel or magnetic escapement wheel through a feed pawl attached to the resonator for the purpose of driving the time-keeping a gear train of the movement will result in the employment of relatively large piezoelectric elements which must, in addition, be glued to the resonator in specifically selected zones thereof where substantial oscillatory stresses and elastic deformations are rather liable to appear.

This design and positioning of the piezoelectric elements have caused a substantially inferior stability in the oscillation frequency of the mechanical vibrator to such a degree that the electronic timepieces can not be fitted with these efficient resonators.

Thanks to the separate provision of the first or time base mechanical vibrator and the second or electromechanical converter or vibrator electrically connected to each other as described above and the described design and positioning of the piezoelectric elements attached to the respective mechanical vibrators, an accurate electronic timepiece, especially a watch, having a good efficiency, a low power consumption rate, and a rather small size in comparison with electronic timepieces employing electromagnetically driven balances or vibrators can be provided at a relatively low cost.

The essential working parts of a further embodiment are shown in Figs. 9 and 10. In this embodiment, numeral 41 indicates a first or time base mechanical vibrator and 42 a second or electromechanical converter

mechanical vibrator, both vibrators being designed as a triple arm vibrator. In this embodiment, the vibrators 41 and 42 are arranged in a physical parallel relationship with each other and on a common stationary mounting member 100 fixedly positioned as conventionally on the timepiece movement. In this embodiment, numerals 2, 2', 3, 5a, 5b, 6, 6b, 7, 8, 9, 10 and 11 denote the same or similar parts as before, having the same respective functions, irrespective of occasional configurational differences. The mode of operation is substantially the same as that of the first embodiment.

In a further embodiment shown in Figs. 11 and 12, the first or time base mechanical vibrator is shown at 51 and is a tuning fork having a pair of parallel oscillation arms 51a and 51b and a short mounting projection 51e. The tuning fork 51 is rigidly attached by said mounting projection 51e and a pair of fixing screws 101 and 102 onto the timepiece movement as shown. The oscillatory arms 51a and 51b carry fixedly respective balancers 51c and 51d for compensation of occasionally introduced position errors, said balancers extending parallel to respective carrier arms 51a and 51b. In Fig. 12, the balancer 51d has been shown only partially for the benefit of a clear view of the inner parts of the vibrator 51.

The balancers 51c and 51d oscillate in opposite phases to each other and in an imaginary plane parallel to the drawing paper when seen in Fig. 11.

The second mechanical vibrator is shown generally at 52 and, in the present embodiment, is a canti-lever type vibrator.

The second vibrator 52 comprises an elongated bar-shaped oscillatory mass 52a which is fixedly connected at its intermediate point 52c to a U-shaped spring member 52b comprising a pair of arms 52d and 52e, the respective tip ends of which are rigidly connected at 103 and 104 within an elongated supporting bar 105. This bar 105 is mounted at its end on the timepiece movement, although the mounting means have been omitted from the drawing only for simplicity.

Piezoelectric elements 53 and 53' are fixedly attached to the respective outer surfaces of the vibratory arms 51a and 51b. In the similar way, piezoelectric elements 55 and 55' are fixedly attached to the respective surfaces of vibratory arms 52d and 52e of the U-shaped spring member 52b, the surfaces bearing these piezoelectric elements being positioned on a common imaginary plane. Thus, when the member 52b is activated piezoelectrically, the arms 52d and 52e oscillate in phase with each other. In Figs. 11 and 12, numerals 6, 6a, 6b, 7, 8, 9, 10 and 11 indicate similar corresponding parts as before, which are adapted for performing respective similar functions as before, irrespec-

tive of occasional minor configurational differences. The mass oscillates in a plane parallel to the afore-mentioned one in which the balancers 51c and 51d oscillate when piezoelectrically driven by cooperation with the elements 53 and 53'.

As is the case of the first embodiment, the time accuracy of the present embodiment depends substantially exclusively upon the operating characteristics of the first or time base mechanical vibrator 51; it is not influenced upon disadvantageously by possible fluctuations in the loaded condition of the conventional time-keeping gear train represented at 8 in Fig. 11.

In all the embodiments, signal converter 11 may not have a frequency divider characteristic. In this case, the signal frequency fed from amplitude keeper 10 will be transmitted by signal converter 11 without the step of frequency division. The signal converter 11 may be, in this case, a wave-shaping circuit and amplifying buffer.

Referring further to Figs. 13—17, the final embodiment of the invention will be described in detail.

In Fig. 13, numeral 61 indicates a conventional lower plate of an electronic timepiece movement, said plate 61 having a recess 61a for receiving a battery 62 which is similar to that shown at 9 in the foregoing. A pressure strip 63 is held in position by means of a pair of set screws 63a and 63b, and exerts a resilient pressure onto the upper surface of the battery 62 when in position as shown. Numeral 64 indicates an electronic circuit including amplitude keeper 10 and signal converter 11 shown and described in the foregoing, although not shown. Conductor leads 65 and 66 extend from within the interior of circuit block 64 to a block 77 for the triple arm type first mechanical vibrator 1 which will be more specifically described hereinafter. Further leads 71 and 72 extend again from within the interior of the block 64, so as to connect the latter electrically with a support member 68 for a tuning fork type second mechanical vibrator 4. Support member 68 and insulator support 67 are rigidly connected by means of set screws 80 and 81, so as to provide a unified tuning fork support block fixedly mounted on the plate 61 by means of a further pair of set screws 73 and 74. Details of the configuration and the structure of the insulator support 67 is specifically shown in Figs. 14—16 in combination.

As shown, the insulator support 67 comprises a mounting part 91 formed with a pair of tapped holes 92 and 93 for the attachment of the tuning fork 4.

Insulator support 67 is formed with a further tapped hole 94 serving for positioning electrical leads 75 and 76, as well as to fix plug end 70a of a lead 71 extending from

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the circuit block 64. Tapped hole 95 serves for attaching the plug end of said lead 72, and for establishing, by inserting a metallic set screw 70b therein, an electrical connection between a printed conductor 98 applied onto the insulator support 67, on the one hand, and said plug end of lead 72, on the other hand. Printed conductor 98 is so designed and arranged to establish, upon assembled in position shown in Fig. 13, an electrical connection between the mounting part 68b of the support 68 for the tuning fork 4, and the plug end 70b. Tapped holes 96 and 97 serve for threaded reception of screw members 74 and 73, respectively.

Insulator support 67 is fixedly attached to the plate 61 by means of set screws 73 and 74, as shown in Fig. 17 in an enlarged sectional view.

In assembly the tuning fork 4 is fixed to the insulator support 67 and leads 75 and 76 extending respectively from piezoelectric elements 5a and 5b are fixedly attached to terminal 70a by soldering or the like conventional methods. These leads do not cause difficulty during fixing of the second mechanical vibrator 4 to the plate 61.

In order to take out a relatively large power output from the second vibrator 4, utilization of the double voltage drive system is highly recommended. In this case, the battery 9 and the tuning fork 4 must be electrically insulated from each other. By adopting the vibrator-supporting mechanism so far shown and described in connection with the present embodiment, the above requirement of electrical insulation between the plate 61 and the tuning fork 4 can be positively assured.

The first or time base mechanical vibrator 1 has a tuning fork of the triple arm type as in the case of the first embodiment and has been fabricated from a metal sheet stock by punching. The root end of this vibrator 1 is attached through a mounting piece 77a on the tip end of a resilient part 77b of the mounting member 77, the main portion of which is fixedly attached to the plate 61 by means of set screws 114 and 115. By the provision of said resilient part 77b for mounting the time base vibrator 1, an efficient shock-proof structure of the time base unit including first vibrator can be provided in a simplified way. The operation of the piezoelectric elements such as 2, 2' and 3 is similar to that which has been described hereinbefore in connection with the foregoing first embodiment of the invention.

In the present embodiment, the triple arm vibrator 1 has been positioned within the idle space substantially defined by and between the fork arms 4a and 4b.

Set screw 114 serves as a combined securing device and connector for a lead 116 extending to the circuit block 64, with a further

lead 66 extending from the circuit block 64. In a similar way, set screw 116 serves as a combined securing device and connector for further leads 66 and 117 so as to connect them directly with each other. Numeral 120 indicates the time-keeping gear train. Ratchet wheel 7 constitutes a member of the gear train, and cooperates with the pawl 6 pivotably mounted on the oscillatory arm 4a of the tuning fork 4, and a stop pawl 105 pivotably mounted on the plate 61. With steady oscillation of the driving tuning fork, the ratchet wheel 7 performs an intermittent rotational movement.

It will be seen from the foregoing that in the case of the electronic timepiece according to this invention, the main drive constituent parts are of simple design for easy manufacture and can be grouped into several units or blocks adapted for easy assembly thereof, as described by reference to the final embodiment.

WHAT WE CLAIM IS:—

1. A drive arrangement for an electronic timepiece comprising a first electro-mechanical vibrator which, in operation, functions as a time base and to which piezoelectric sensing and drive means are attached; an electronic circuit for maintaining vibratory movement of said first vibrator and for producing an output at the time base frequency; a signal converter connected to receive the signal output of said electronic circuit and for producing a signal output therefrom; a second electro-mechanical vibrator which carries piezoelectric drive means connected to receive the output of said converter; and a mechanical motion-converter for converting the vibratory movement of said second mechanical vibrator into rotary motion.

2. A drive arrangement as claimed in claim 1, wherein the piezoelectric means attached to said electro-mechanical vibrators are so chosen that the force factor of the first electro-mechanical vibrator is smaller than that of the second electro-mechanical vibrator.

3. A drive arrangement as claimed in claim 1 or claim 2 wherein the electronic circuit comprises an L-type phase shifter connected between an electrode terminal of a sensing piezoelectric element of the first mentioned electro-mechanical vibrator and an input terminal of an amplifier of the electronic circuit, the phase shifter comprising a resistor in its series arm and a variable condenser in its parallel arm.

4. A drive arrangement as claimed in any preceding claim wherein the second electro-mechanical vibrator is a tuning fork and the first electro-mechanical vibrator is positioned at least partially between the tines of the tuning fork.

5. A drive arrangement for an electronic timepiece substantially as hereinbefore des-

cribed with reference to the accompanying drawings.

- 5 6. An electronic timepiece incorporating a drive arrangement as claimed in any preceding claim.

7. An electronic timepiece as claimed in claim 6 wherein the second electro-mechanical vibrator is secured to a plate through an insulator member.

- 10 8. An electronic timepiece as claimed in

claim 6 wherein the first electro-mechanical oscillator is attached to a plate through a mounting member having a resilient part.

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FIG. 1

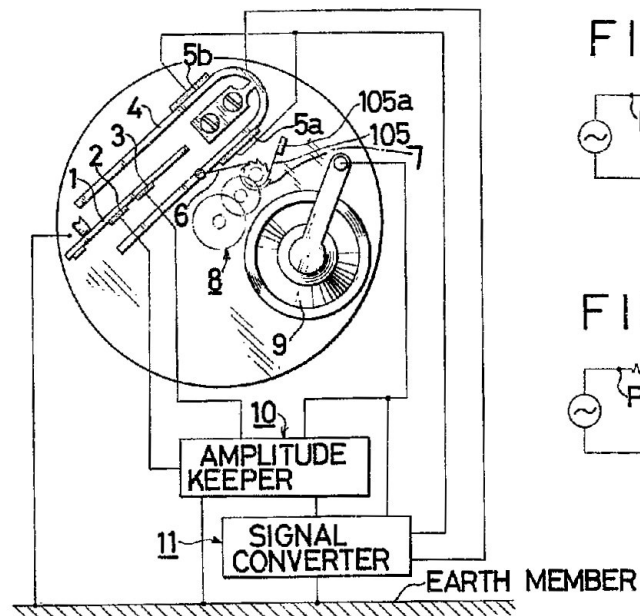


FIG. 5

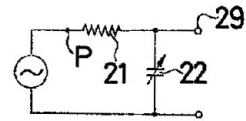


FIG. 6

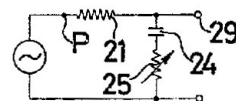
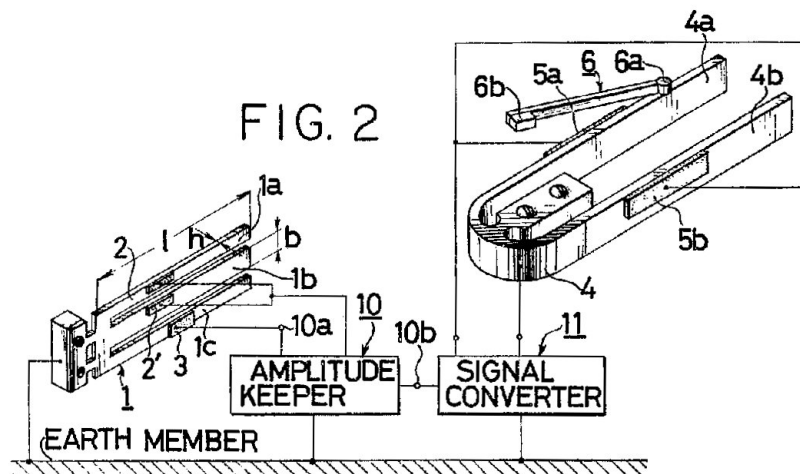


FIG. 2



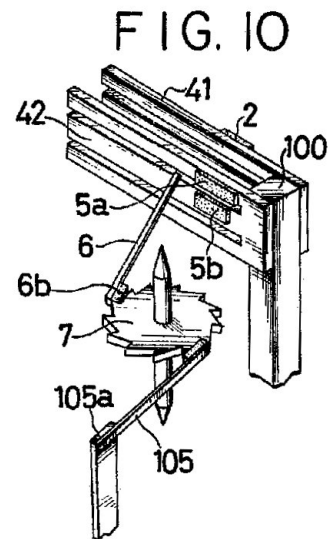
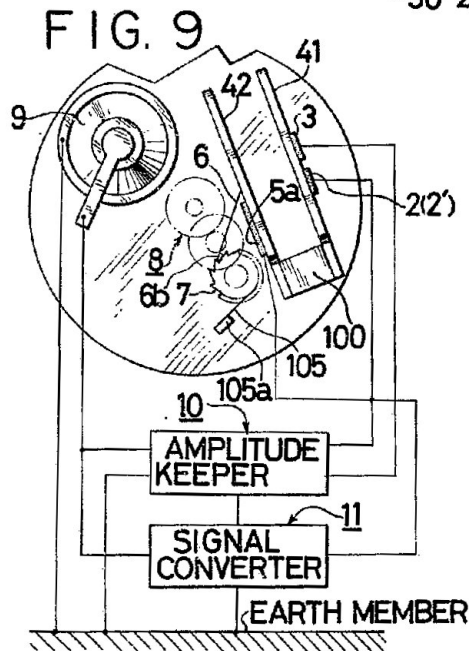
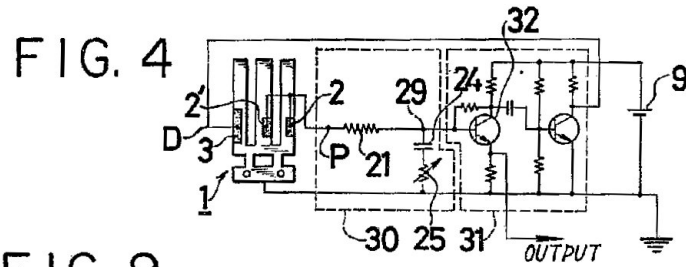
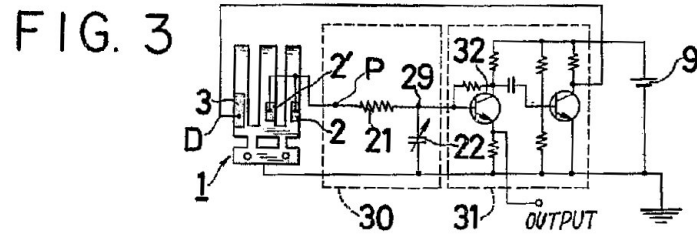


FIG. 8

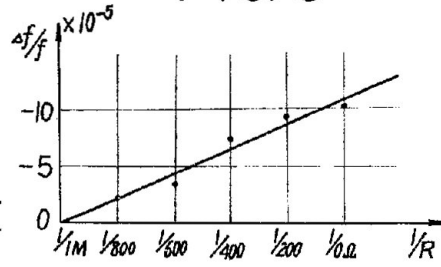


FIG. 7

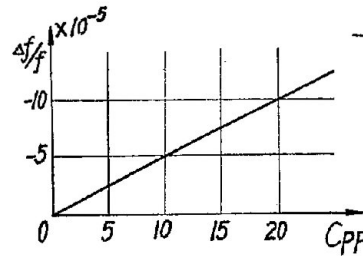


FIG. 13

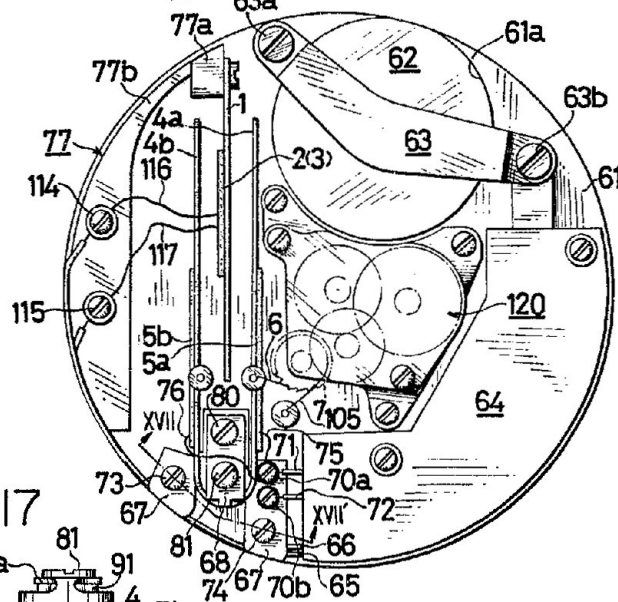


FIG. 17

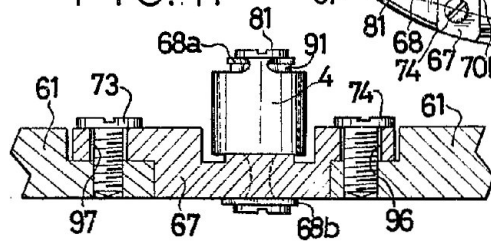


FIG. 11

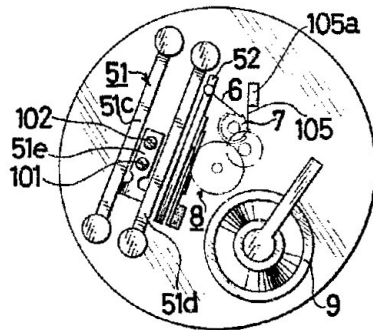


FIG. 14

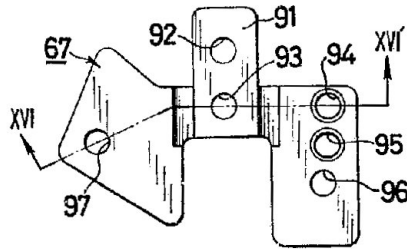


FIG. 15

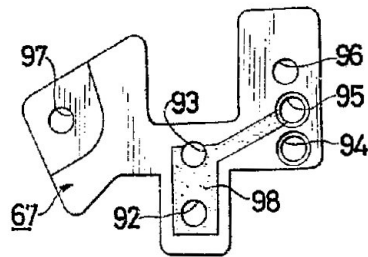


FIG. 16

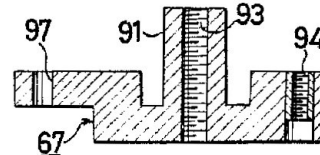


FIG. 12

