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[11] **3,800,523**

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[54] **QUARTZ CRYSTAL WRIST WATCH**

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[52] **U.S. Cl.** ..... **58/23 R,** 58/55, 58/88 R
[51] **Int. Cl.** **G04c 3/00,** G04b 37/00
[58] **Field of Search**. 58/23 R, 23 A, 23 AO, 23 TF, 58/23 V, 53, 55, 88; 331/177, 179

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[57] **ABSTRACT**

A quartz crystal wrist watch wherein means are provided for removably mounting along the periphery of the watch the battery power source, the oscillator and associated circuitry and an electro-mechanical converter. The electro-mechanical converter is provided with a rotor coupled to the gear train of the watch positioned in the central portion thereof. The oscillator and associated circuitry are removably mounted in said watch by means of a resin case adapted to carry said oscillator and associated circuitry.

14 Claims, 5 Drawing Figures

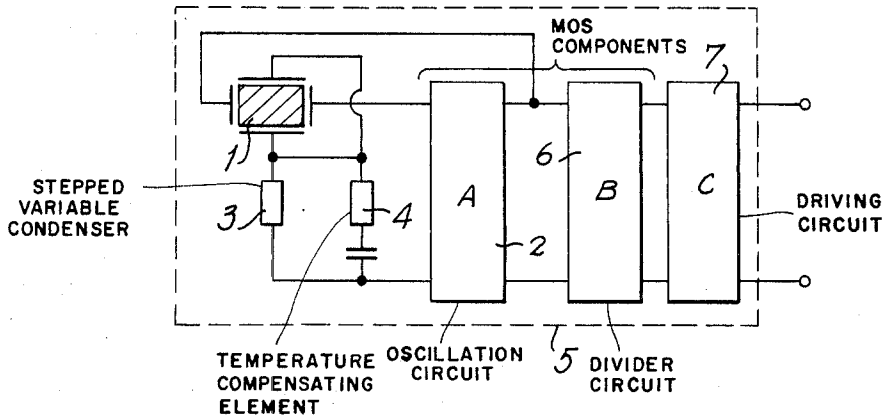
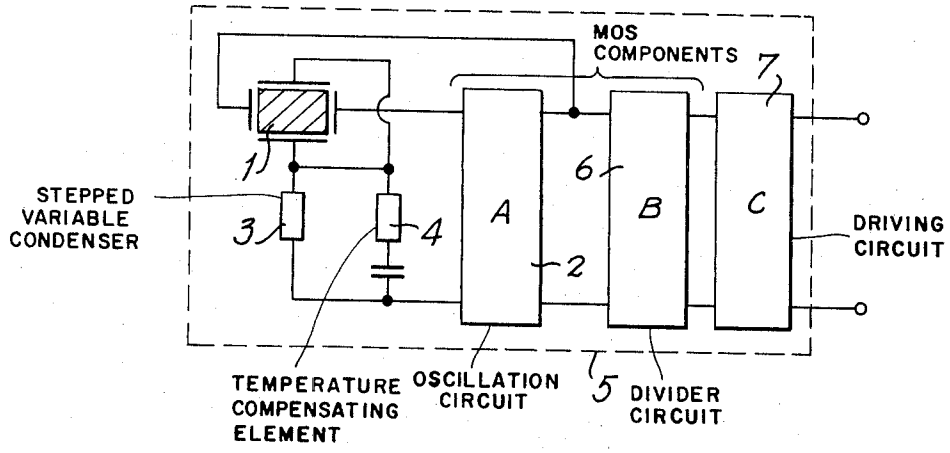


FIG. 1



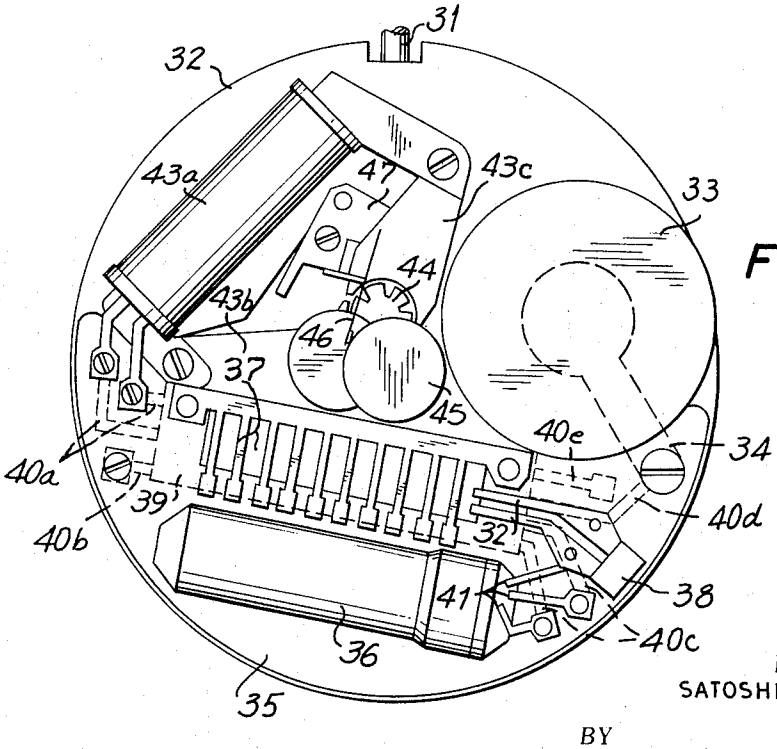


FIG. 5

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FIG. 2

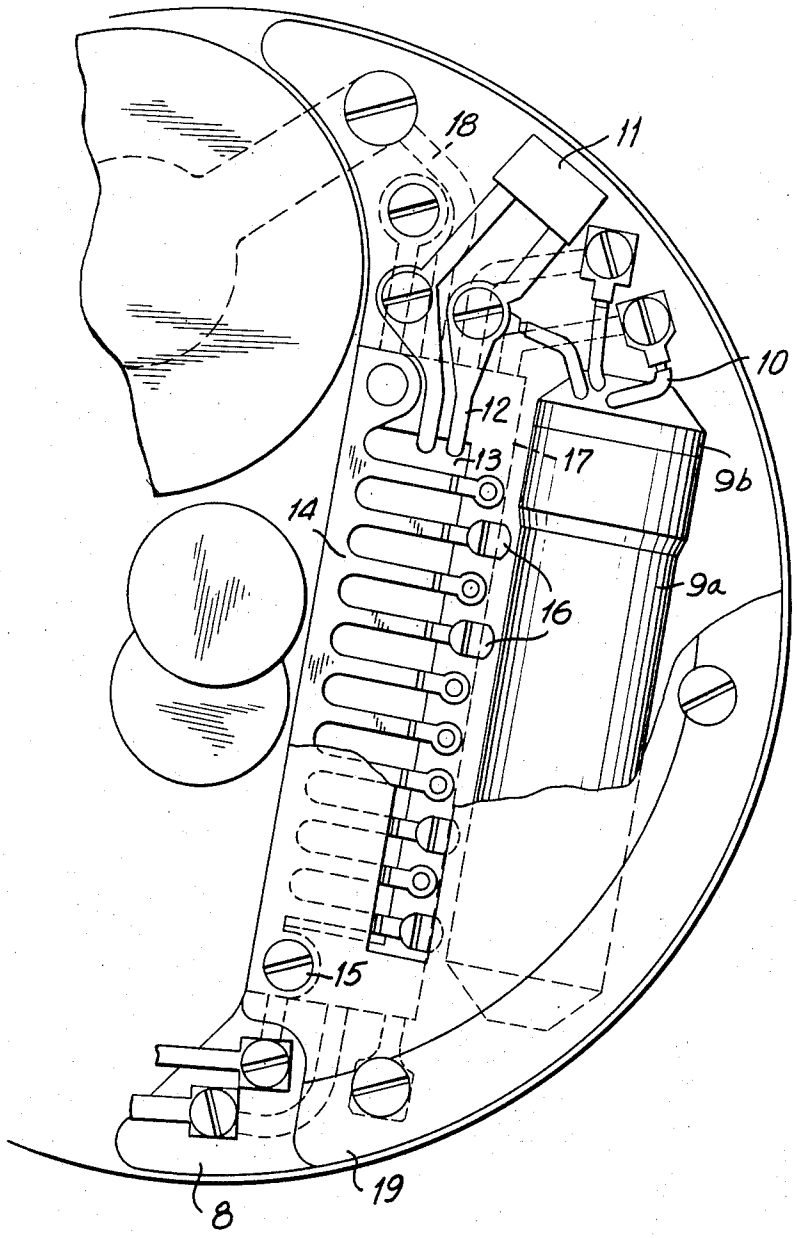

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FIG. 3

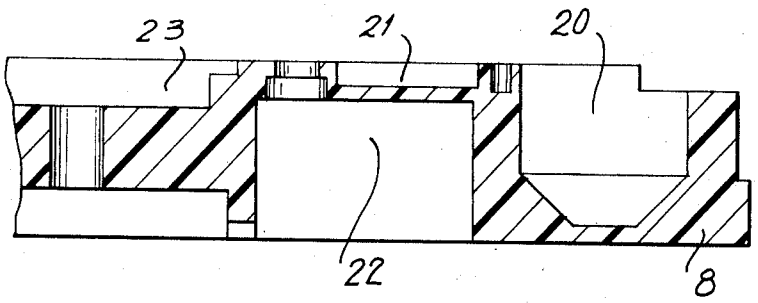
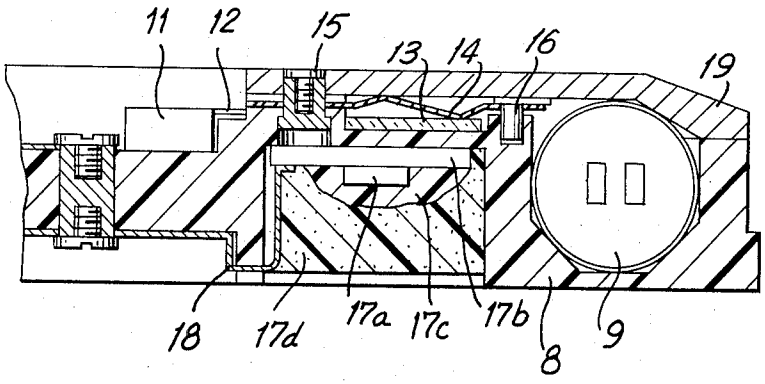


FIG. 4



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QUARTZ CRYSTAL WRIST WATCH

BACKGROUND OF THE INVENTION

This invention relates to quartz crystal wrist watches and to the physical structure thereof. Quartz crystal wrist watches are generally provided with a battery power source, a crystal oscillator which serves as a time standard and associated circuitry for converting the output of the oscillator to the desired driving signal, an electro-mechanical converter responsive to said driving signal such as a pulse motor and indexing mechanism, and the drive train of the watch.

These components must be mounted in a watch so as to provide a compact thin structure. Further, while it be most convenient to mount these components in a square watch, there is a larger demand for round wrist watches, thereby complicating the mounting of these structures into a watch case. Thus, the battery power source requires a substantial portion of the space of the wrist watch, and being generally round in shape, occupies a greater space than its volume would otherwise indicate. Further, if other components are mounted above or below the battery, the thickness of the watch would be substantially increased.

The oscillator and associated circuitry includes the crystal oscillator generally mounted in a vacuum in a hermetic sealed case provided with a shield cap and external lead terminal, an oscillation circuit, a fine adjusted mechanism for adjusting the frequency of the oscillator, a temperature compensating element, a divider circuit for dividing the frequency of the output of the crystal oscillator, and a driving circuit for the electromechanical converter. If these components are separately mounted, assembly and repair of the watch becomes difficult and expensive. Further, the method of mounting these components must avoid frequency change caused by stray capacitance and by external shock.

By the compact assembly approach of the invention, the foregoing difficulties are solved.

SUMMARY OF THE INVENTION

Generally speaking, in accordance with the invention, the components of a quartz crystal wrist watch are mounted so that the battery power source, the oscillator and associated circuitry and the electro-mechanical converter are mounted on the periphery of the watch, with the rotor of said electro-mechanical converter being positioned centrally of said watch for cooperative engagement with the drive train of said watch, also located in the central portion thereof. The oscillator and associated circuitry are removably mounted on said watch by means of a resin case provided with grooves therein for receiving the various components.

Accordingly, the object of the invention is to provide a compact electronic crystal wrist watch having a round configuration.

Another object of the invention is to provide an electronic quartz crystal wrist watch incorporating a tuning fork crystal oscillator as the time standard having a frequency of more than 16 kHz, oscillation and divider circuits including MOS transistors, a driving circuit including integrated circuits, and a pulse motor serving as an electro-mechanical converter.

A further object of the invention is to provide a quartz crystal wrist watch wherein the various components thereof are readily connected together for ease in after-sale service and assembly, and wherein the crystal oscillator and the associated circuitry thereof are removably mounted as a unit.

Still another object of the invention is to provide a quartz crystal wrist watch having a time standard oscillator not affected by the environment, such as external disturbances due to shock or ambient stray capacitance.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings, in which:

FIG. **1** is a circuit diagram of a quartz crystal wrist watch according to the invention;

FIG. **2** is a fragmentary plan view of the quartz crystal wrist watch according to the invention showing in particular the crystal oscillator and circuitry associated therewith according to the invention;

FIG. **3** is a cross-sectional view of a resin case for receiving said time standard oscillator and association circuitry;

FIG. **4** is a cross-sectional view of the resin case of FIG. **3** having said time standard oscillator and associated circuitry mounted therein; and

FIG. **5** is a full plan view of the quartz crystal wrist watch according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. **1**, wherein an equivalent circuit diagram of the time standard oscillator and associated circuitry of the watch according to the invention is depicted, crystal oscillator **1** is shown coupled to an oscillation circuit **2**, in part through a stepped variable condenser **3** for adjusting the frequency of the oscillator and a temperature compensating element **4**. A resin case for receiving the oscillator and its associated circuitry is shown schematically by dashed line **5**, said associated circuitry including a divider circuit **6** for reducing the frequency of the output signal of the oscillator and a driving circuit **7** for driving the motor or other electro-mechanical converter.

Referring now to FIG. **2**, the time standard oscillator and associated circuitry is shown mounted on a resin case **8** which may be formed, for example, from an elastic resin having thermo-setting properties, which resin case is in turn mounted in the quartz crystal wrist watch according to the invention. The time standard crystal oscillator is mounted within a cylindrical crystal oscillator casing **9***a*. The crystal oscillator is mounted within said casing on a stem, and is provided with three external lead terminals **10**. Casing **9***a* is evacuated, and is sealed hermetically.

The Crystal oscillator utilized as time standard may be a tuning fork crystal oscillator having a frequency of

more than 16 kHz. An alternate type of oscillator is a leaf spring oscillator, which is advantageous for mass production, but requires 23 mm in length where a frequency of 16 kHz is required, and where resistance to outside shocks is required. A leaf spring oscillator of less than 23 mm in length is substantially affected by the suspension wire and may not be used as a time standard source in a wrist watch. The length of the leaf spring oscillator is even further increased to about 28 mm when it is suspended within a hermetically sealed case by a shock resistant mounting. For the foregoing reaons, the left spring oscillator is not particularly adapted for use in compact and round wrist watch movements, and accordingly, the turning fork oscillator is preferred. Said tuning fork oscillator may be only 13 mm in length, and may be specially mounted and sealed hermetically within a cylindrical metal case of only 16 mm in length. A tuning fork crystal oscillator takes the general shape of a tuning fork, as illustrated in U.S. Pat. Nos. 2,081,405 and 3,131,320.

The crystal oscillator casing **9***a* is provided with a cap **9***b* on the external lead terminal portion thereof in order to minimize the effect of stray capacitance between said external lead terminals and other portions of the circuitry. The lead wires pass through windows in portions of said cap, but the crystal oscillator is shielded. The temperature compensating element **11** is formed of $BaTiO_3$ and is wired to other lead elements by a terminal plate **12.**

Also mounted on resin case **8** is a stepped variable condenser for fine adjustment of frequency of said oscillator. Said condenser consists of a group of condensers formed on a glass substrate **13** by vacuum evaporation. A contact spring **14** is mounted on said resin plate by means of a screw **15** above said glass substrate. The separate condensers deposited on substrate **13** can be selectively added to or removed from the circuit to determine the total capacitance thereof by means of a group of pins **16** which selectively engage one of the fingers of contact spring **14** to bring said finger into engagement with the corresponding capacitor on the substrate. In other words, the fingers of contact spring **14** may be selectively brought into and out of engagement with the capacitors on substrate **13** by inserting or removing pin **16.**

The oscillation circuit, divider circuit and driving circuit, formed from MOS components and integrated circuits, are mounted on the opposed side of resin case **8** opposite substrate **13.** Said components are retained within the resin case by means of an epoxy resin which protects said components from outside influences such as moisture. Said electronic circuits include a **15**-stage flip-flop divider circuit for dividing the frequency of the output of the oscillator circuit and a reset circuit. Both the oscillation and divider circuits may be formed of hybrid integrated circuits, but if MOS circuits are utilized, both the oscillation and divider circuits can be incorporated in about a **2** mm square space. Even with the use of epoxy resins, by using MOS circuits, the space required for the oscillation and divider circuitry can be reduced by from 1/2 to 1/3, as compared with the space required by conventional type of circuits using only integrated circuits. The lead terminals of the electric circuits mounted below the resin case **8** are electrically connected to the components above said resin case by means of screws and pin connectors, as well as a group of lead terminals **18** preferably formed as thin plates. The top surface of the resin case may be enclosed by a metal holder **19** which serves as a shield plate for the capacitors on substrate **13,** and as a retention device for contact spring **15,** pin **16** and crystal oscillator **9***a*.

Referring now to FIGS. **3** and **4,** we see that the top surface of resin case **8** is formed with a channel **20** for receiving the crystal oscillator **9,** a channel **21** for receiving the stepped variable condenser substrate **13,** and a channel **23** for receiving the temperature compensating element **11.** The back of resin case **8** is provided with a channel **22** for receiving the oscillation and divider circuits **17***a*, the driving circuit **17***b* which is coupled to an electro-mechanical converter, silicon **17***c* for protecting the circuits, and an epoxy resin **17***d* for retaining said components together. The channel **21** for receiving the stepped variable condenser substrate and channel **22** for receiving the electric circuits are positioned in overlapping relation on opposed sides of the resin case.

Accordingly, it is seen that the components of the crystal oscillator and its associated circuitry are all mounted on resin case **8** for removal from and mounting in the quartz crystal watch case according to the invention as a unit. The structure is extremely compact, occupying from about 1/3 to about 1/5 of the volume of the available space in the watch. The foregoing arrangement greatly enhances both the initial manufacture and the aftersaid maintenance of the watch, since the entire time standard oscillator assembly can be replaced as a unit, and can be worked on outside of the watch. The structure is particularly shielded to prevent the adverse affect of stray capacitance on the oscillator. Further, the crystal oscillator is firmly mounted within the resin case which is elastic, and therefore assists in shock resistance.

Referring now to FIG. **5,** the quartz crystal watch depicted therein is provided with a stem **31** disposed at the position of three o'clock, on a round plate **32.** A battery **33** is mounted on said plate at about twelve o'clock. As noted above, the battery is round but is positioned at the periphery of the watch. A negative pulse terminal plate **34** connects the battery **33** to the oscillator circuitry which is mounted on resin case **35.** Said resin case is similar to the resin case **8** described above, in that it supports all of the components of the oscillator and associated circuitry for removable mounting on plate **32.** The crystal oscillator casing **36** containing the crystal oscillator is disposed in a channel on the top surface of resin case **35.** Fine adjustment of the frequency of the oscillator is provided by stepped condenser **37** similar in structure to the condenser **13, 14, 15** and **16** of FIGS. **2** and **4.** Also mounted on the resin case is the temperature compensating device **38.** The electronic circuitry **39** is fixed on the opposed side of resin case **35** opposite the stepped condenser. The input and output terminals of said electronic circuitry include electrical signal terminal **40***a* for applying the driving signal to the pulse motor which serves as the electro-mechanical converter. These terminals all extend from one of the electronic circuitry, namely the side on which said pulse motor is positioned. The remaining terminals all extend from the opposed side of the electronic circuitry. Specifically, terminals **40***c* are connected to the crystal oscillator, terminal **40***d* is connected to the negative pulse terminal **34** of the battery, and terminal **40***e* is a reset terminal. The latter termi-

nals are all positioned on the side of the electronic circuitry adjacent the battery. The output and input terminals of the tuning fork crystal oscillator **41** are also disposed on the battery side of the oscillator case **36**, in order to simplify the terminal connection with the circuitry. Leads **42** are provided for connecting the stepped condenser and temperature compensating device. Coupled to the electrical circuitry **39** by leads **40***a* is the electro-mechanical converter **43***a* which converts the electrical output signal from said circuit into rotary movement of the gear train of the watch. Said electro-mechanical converter includes a coil **13***a* formed from copper wire having 2.5/100 ϕmm, which wire is wound in about 15,000 turns on a coil core formed of magnetic material. Coil **43***a* defines the driving coil of the pulse motor and is substantially cylindrical in shape. The output signal from said circuit consists of an alternating pulse train, one pulse of which is applied to said driving coil each second. The magnetomotive force generated in the coil is applied to stators **43***b* and **43***c* to rotate a rotor **44** in predetermined angular increments. The rotor **44** may be made of Pt CO material and is provided with six poles formed alternately as north and south poles.

The above described pulse motor is utilized in place of the conventional pallet-fork escapement as an electro-mechanical converter, since said pallet-fork escapement occupies too large an area, and would preclude the provision of a round compact wrist watch. Thus, the pallet-fork escapement has an outer diameter of about 5~7ϕmm, while the outside diameter of the pulse motor is only about 3ϕmm. However, the cylindrical shape of the driving coil **43***a* precludes the mouting of any components above or below said coil, where a thin wrist watch is desired. Accordingly, said driving coil is positioned on the periphery of the watch according to the invention.

Rotor **44** is rotated by the magnetomotive force and its rotating energy is transmitted to a fourth wheel **45** of the watch gear train, which in turn in operatively coupled to the gear train third wheel and center wheel for driving same. A second hand jumper **46** is coupled to fourth wheel **45** for indexing the position of the second hand. A regulating lever **17** for the operation of said second hand is also positioned in the central region of the watch, one end of said regulating lever being engaged with stem **31**, the other end of said regulating lever being engaged with the end of jumper **46** for manipulating said jumper. Not shown in FIG. **5** is a reset mechanism disposed near the stem which is provided with a switch mechanism cooperatively operated with the crown and regulating lever. Said reset switch cuts off a portion of the divider circuit so that the output signal of the divider is cut off.

The quartz crystal wrist watch according to the invention consists of a plurality of components arranged on a round plate in such manner that the stem is favorably disposed near the 3 o'clock position, the battery is disposed near the 12 o'clock position, the time standard oscillator and associated circuitry are formed as a unit and positioned adjacent the battery, and the driving coil of the pulse motor is disposed between the time standard oscillator and the stem. Said battery, time standard oscillator and associated circuitry and pulse motor driving coil are all positioned along the periphery of said round plate. The regulating and reset mechanism, along with the drive train of the watch are positioned in the central region of the watch, whereby overlapping relation between the larger components is avoided.

The foregoing arrangement provides for simplified terminal connections and for a round, particularly flat watch movement. Further, three major components of the watch, specifically the battery power source, the oscillator and associated circuitry, and the mechanical components of the watch, may be readily separated, with the function of each block being separately adjustable. This feature, which permits the removal of components by merely removing selected screws, is particularly advantageous to after-sales service. Further, this arrangement is also particularly adapted for mass production.

It will thus be seen that the objects set forth above, and those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. In a quartz crystal wrist watch, the improvement which comprises time standard crystal oscillator means; circuit means for producing a driving signal for said wrist watch in conjunction with said time standard oscillator means, said circuit means including fine adjustment means for adjusting the frequency of said oscillator means, a temperature compensating element, an electrical oscillation circuit means, an electrical divider circuit means coupled to the output of oscillation circuit for reducing the output frequency of said oscillation circuit and an electrical driving circuit means for producing said driving signal; and case means for receiving and carrying said time standard oscillator means and said circuit means and adapted for removable mounting in said watch, said case means being formed with a first channel in one side thereof dimensioned for receipt of said time standard oscillator means, a second channel in said one side thereof for receiving said fine adjustment means and a third channel in the opposed side of said case means for receiving said oscillation circuit means, said divider circuit means and said driving circuit means.

2. A quartz crystal wrist watch as recited in claim **1**, including a fourth channel in said one side of said case means for receiving said temperature compensating element.

3. A quartz crystal wrist watch as recited in claim **1**, wherein said second and third channels are in essentially overlapping relation on opposed sides of said case means.

4. A quartz crystal wrist watch as recited in claim **1**, wherein said time standard oscillator means is mounted in a substantially cylindrical housing means, said first channel being dimensioned to receive said housing means.

5. In a quartz crystal watch, the improvment which comprises time standard oscillator means of the tuning fork type of crystal oscillator having a frequency of

more than 16 kHz; and circuit means for producing a driving signal for said wrist watch in conjunction with said time standard oscillator means, said circuit means including an electrical oscillation circuit means coupled to said time standard oscillator means for maintaining the frequency of said oscillator, an electrical divider circuit means for receiving the high frequency signal produced by said time standard oscillator means and electrical oscillation circuit means for producing an output signal of reduced frequency, and an electrical driving circuit means for producing said driving signal in response to said output signal, said electrical oscillation circuit means and said divider circuit means including MOS component means, said driving circuit means including integrated circuits and case means for receiving and carrying said time standard oscillator means and said circuit means and adapted for removable mounting in said watch case.

6. A quartz crystal wrist watch as recited in claim **5,** including battery power source means adapted for removable mounting in said watch and for releasable electrical connection to said circuit means for energizing said circuit means; electro-mechanical converter means releasably electrically connected to said circuit means for receiving said driving signal therefrom; drive train means mechanically coupled to said electro-mechanical converter means for being driven thereby, said drive train means, electro-mechanical converter means, battery power source means, and said case means carrying said time standard oscillator means and circuit means being positioned in side-by-side relation in said watch.

7. A quartz crystal wrist watch as recited in claim **1,** wherein said case means is formed from an elastic resin.

8. A quartz crystal wrist watch as recited in claim **4,** wherein said case means includes a holder means removably mounted to said first-mentioned side of said case means for retaining said housing means and said fine adjustment means in said case means.

9. A quartz crystal wrist watch as recited in claim **8,** wherein at least a portion of said holder means is formed of a metal for providing capacitive shielding.

10. A quartz crystal wrist watch as recited in claim **2,** including screw-operated terminal means cooperating with said case means for providing releasable interconnection between said time standard oscillator means, said fine adjustment means, said temperature compensating element, and the combination of said electrical oscillation circuit means, said electrical divider circuit means, and said electrical driving circuit means.

11. A quartz crystal wrist watch as recited in claim **10,** wherein said combination of said electrical oscillation circuit means, electrical divider circuit means, and electrical driving circuit means is provided with output and input leads, positioned adjacent opposed ends of said case means and formed to permit releasable electrical connection therewith.

12. A quartz crystal wrist watch as recited in claim **6,** including a substantially round plate, said electromechanical converter being a step motor having a driving coil and a rotor; said step motor driving coil, said battery power source, and said case means incorporating said time standard oscillator means and said circuit means being positioned on the peripheral region of said plate, said step motor rotor and said drive train means being positioned in the central portion of said plate.

13. A quartz crystal wrist watch as recited in claim **12,** including a stem operatively coupled to said drive train and positioned at the 3 o'clock position on said plate, said battery power source means being positioned at the 12 o'clock position on said plate; said case means carrying said time standard oscillator means and said circuit means being positioned adjacent said battery power source means; and said step motor driving coil being positioned intermediate said stem and said case means.

14. A quartz crystal wrist watch as recited in claim **6,** wherein said circuit means includes input and output terminal means positioned respectively on opposed ends of said case means, said input terminal means being adjacent said battery power source means, and including screw-operated terminal means for releasably connecting said battery means to said circuit means input terminal means and said step motor driving coil to said circuit means output terminal means.

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