

DESCRIPTION

MECHANICAL TYPE TIMEPIECE HAVING TRAIN WHEEL OPERATION CONTROL UNIT

[Technical Field]

The present invention relates to a mechanical type timepiece capable of displaying time with high accuracy.

Particularly, the invention relates to a mechanical type timepiece having a time counting unit for counting time with an accuracy higher than an accuracy of an escapement & speed control apparatus of a mechanical type timepiece, a train wheel operation detecting unit for detecting a rotational operation state of a train wheel and a train wheel operation control unit for controlling operation of the train wheel based on a count result counted by the time counting unit and the rotational operation state of the train wheel detected by the train wheel operation detecting unit.

[Background of the Invention]

In a conventional mechanical type timepiece, as shown in Fig. 15 and Fig. 16, a movement (machine body) 1100 of a mechanical type timepiece is provided with a main plate 1102 constituting a base plate of the movement. A winding stem 1110 is rotatably integrated to a winding stem guide hole 1102a of the main plate 1102. A dial 1104 (shown by imaginary lines

in Fig. 16) is attached to the movement 1100.

Generally, in both sides of the main plate, a side thereof having the dial is referred to as "back side" of the movement and a side opposed to the side having the dial is referred to as "front side" of the movement. A train wheel integrated to the "front side" of the movement is referred to as "front train wheel" and a train wheel integrated to the "back side" of the movement is referred to as "back train wheel".

By a switch apparatus including a setting lever 1190, a yoke 1192, a yoke spring 1194 and a setting lever jumper 1196, a position of the winding stem 1110 in an axis line direction thereof is determined. A winding pinion 1112 is rotatably provided to a guide shaft portion of the winding stem 1110. When the winding stem 1110 is rotated in a state in which the winding stem 1110 is disposed at a first winding stem position (0-th stage) mostly proximate to an inner side of the movement along a rotational axis line, the winding pinion 1112 is rotated via rotation of a clutch wheel. A crown wheel 1114 is rotated by rotation of the winding pinion 1112. A ratchet wheel 1116 is rotated by rotation of the crown wheel 1114. By rotating the ratchet wheel 1116, a mainspring 1122 contained in a barrel complete 1120 is wound up. A center wheel & pinion 1124 is rotated by rotation of the barrel complete 1120. An escape wheel & pinion 1130 is rotated via rotation of a fourth wheel & pinion 1128, a third wheel & pinion 1126 and the center wheel

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& pinion 1124. The barrel complete 1120, the center wheel & pinion 1124, the third wheel & pinion 1126 and the fourth wheel & pinion 1128 constitute a front train wheel.

An escapement & speed control apparatus for controlling rotation of the front train wheel includes a balance with hairspring 1140, the escape wheel & train 1130 and a pallet fork 1142. The balance with hairspring 1140 includes a balance stem 1140a, a balance wheel 1140b and a hairspring 1140c. Based on rotation of the center wheel & pinion 1124, an hour pinion 1150 is simultaneously rotated. A minute hand 1152 attached to the hour pinion 1150 displays "minute". The hour pinion 1150 is provided with a slip mechanism relative to the center wheel & pinion 1124. Based on rotation of the hour pinion 1150, an hour wheel 1154 is rotated via rotation of a minute wheel. An hour hand 1156 attached to the hour wheel 1154 displays "hour".

The barrel complete 1120 is supported by the main plate 1102 and a barrel bridge 1160 rotatably thereto. The center wheel & pinion 1124, the third wheel & pinion 1126, the fourth wheel & pinion 1128 and the escape wheel & pinion 1130 are supported by the main plate 1102 and a train wheel bridge 1162 rotatably thereto. The pallet fork 1142 is supported by the main plate 1102 and a pallet bridge 1164 rotatably thereto. The balance with hairspring 1140 is supported by the main plate 1102 and a balance with hairspring bridge 1166 rotatably

thereto.

The hairspring 1140c is a thin plate spring in a helical (spiral) mode having a plural turn number. An inner end portion of the hairspring 1140c is fixed to a hairspring holder 1140d fixed to the balance stem 1140a and an outer end portion of the hairspring 1140c is fixed by screw fastening via a hairspring support 1170a attached to a stud support 1170 fixed to the balance with hairspring bridge 1166.

A regulator 1168 is rotatably attached to the balance bridge 1166. A hairspring bridge 1168a and a hairspring rod 1168b are attached to the regulator 1168. A portion of the hairspring 1140c proximate to the outer end portion is disposed between the hairspring bridge 1168a and the hairspring rod 1168b.

Generally, as shown by Fig. 17 according to a conventional representative timepiece, mainspring torque is reduced as a duration time period elapses by rewinding the mainspring from a state in which the mainspring is completely wound up (fully wound state). For example, in the case of Fig. 17 the mainspring torque is about 27 g•cm in the fully wound state, becomes about 23 g•cm after 20 hours has elapsed from the fully wound state and becomes about 18 g•cm after 40 hours has elapsed from the fully wound state.

Generally, as shown by Fig. 18 according to a conventional representative mechanical type timepiece, when

mainspring torque is reduced, a swing angle of the balance with hairspring is also reduced. For example, in the case of Fig. 18 when the mainspring torque falls in a range of 25 through 28 g•cm, the swing angle of the balance with hairspring is about 240 through 270 degrees and when the mainspring torque falls in a range of 20 through 25 g•cm, the swing angle of the balance with hairspring is about 180 through 240 degrees.

In reference to Fig. 19, there is shown a transitional change of instantaneous rate (numerical value indicating accuracy of timepiece) with regard to swing angle of a balance with hairspring in a conventional representative mechanical type timepiece. Here, "instantaneous rate" or "rate" is referred to as "value indicating gaining or losing of a mechanical type timepiece when 1 day has elapsed when assuming that the mechanical type timepiece is left for 1 day while maintaining state or environment of the swing angle of the balance with hairspring or the like when the rate is measured". In the case of Fig. 19, the instantaneous rate is retarded when the swing angle of the balance with hairspring is equal to or larger than 240 degrees and equal to or smaller than 200 degrees.

For example, although in a conventional representative mechanical type timepiece, as shown by Fig. 19 when a swing angle of a balance with hairspring falls in a range of about 200 through 240 degrees, the instantaneous rate is about 0

through 5 seconds/day (gaining of about 0 through 5 seconds per day), when the swing angle of the balance with hairspring is about 170 degrees, the instantaneous rate becomes about -20 seconds/day (losing of about 20 seconds per day).

In reference to Fig. 20, there is shown a transitional change of an elapse time period and an instantaneous rate when a mainspring is rewound from a fully wound state in a conventional representative mechanical type timepiece. According to the conventional mechanical type timepiece, "rate" indicating gaining of the timepiece or losing of the timepiece per day, is provided by integrating a curve of the instantaneous rate with regard to the elapse time period of rewinding the mainspring from the fully wound state over 24 hours shown by Fig. 20.

Generally, according to the conventional mechanical type timepiece, with elapse of a duration time period by rewinding the mainspring from the fully wound state, mainspring torque is reduced, the swing angle of the balance with hairspring is also reduced and therefore, the instantaneous rate is retarded. Therefore, the conventional mechanical type timepiece is previously adjusted such that there is estimated retardation of the timepiece after duration time period has elapsed for 24 hours, the instantaneous rate in the case in which the mainspring is brought into the fully wound state, is previously gained and the "rate" indicating

gaining of the timepiece or losing of the timepiece per day becomes positive.

For example, according to the conventional representative mechanical type timepiece, as shown in Fig. 20, although the instantaneous rate is about 3 seconds / day in the fully wound state (gaining of about 3 seconds per day), when 20 hours has elapsed from the fully wound state, the instantaneous rate becomes about -3 seconds / day (losing of about 3 seconds per day), when 24 hours has elapsed from the fully wound state, the instantaneous rate becomes about -8 seconds / day (losing of about 8 seconds per day) and when 30 hours has elapsed from the fully wound state, the instantaneous rate becomes about -16 seconds / day (losing of about 16 seconds per day).

According to the conventional mechanical type timepiece, the accuracy of the timepiece is determined by an accuracy of operating the escapement & speed control apparatus including the balance with hairspring alternately repeating right-hand rotation and left-hand rotation, the escape wheel & pinion rotated based on rotation of the front train wheel and the pallet fork for controlling rotation of the escape wheel & pinion based on operation of the balance with hairspring.

Therefore, in order to promote the accuracy of the timepiece, the oscillation period of operation of the balance with hairspring is obliged to increase and it has been difficult

to fabricate the escapement & speed control apparatus including such a balance with hairspring.

Further, according to the conventional mechanical type timepiece, a range of capable of increasing the oscillation period of the operation of the balance with hairspring is limited and accordingly, there poses a problem in which a range of capable of improving accuracy of the timepiece is limited.

Therefore, accuracy of the conventional mechanical type timepiece has been worse than accuracy of a crystal type timepiece. Therefore, the user of the conventional mechanical type timepiece has been obliged to correct time indicated by the mechanical type timepiece at respective constant time period.

Hence, it is an object of the invention to provide a mechanical type timepiece having extremely excellent accuracy.

Further, it is a further object of the invention to provide a mechanical type timepiece having high accuracy capable of being used over a long period of time.

[Disclosure of the Invention]

A mechanical type timepiece according to the invention comprises a movement having a mainspring constituting a power source of the mechanical type timepiece, a front train wheel rotated by a rotational force when the mainspring is rewound

and an escapement & speed control apparatus for controlling rotation of the front train wheel, the escapement & speed control apparatus including a balance with hairspring alternately repeating right-hand rotation and left-hand rotation, an escape wheel & pinion rotated based on rotation of the front train wheel and a pallet fork for controlling rotation of the escape wheel & pinion based on operation of the balance with hairspring and the balance with hairspring including a hairspring, a balance stem and a balance wheel.

The mechanical type timepiece of the invention further comprises a time counting unit having a crystal oscillator constituting an oscillation source, IC including a dividing unit for inputting an output signal outputted by oscillation of the crystal oscillator, dividing the signal and outputting a signal with regard to time and a power source for operating IC for counting time, a train wheel operation detecting unit for detecting a rotational operation state of the train wheel of the mechanical type timepiece, and a train wheel operation controlling unit for controlling operation of the train wheel based on a count signal counted by the time counting unit and an operational control signal indicating the rotational operation state of the train wheel detected by the train wheel operation detecting unit.

The power source is a primary battery of, for example, a silver battery, a lithium battery or the like. The power

source may be a solar cell, may be a chargeable secondary battery or may be a chargeable condenser. Further, the mechanical type timepiece according to the invention may be provided with an automatically wound power generating unit.

It is preferable that the train wheel operational control unit of the mechanical type timepiece according to the invention controls the operation of the train wheel at a period between once per hour and once per day.

Further, it is preferable that the train wheel operation detecting unit of the mechanical type timepiece of the invention includes a mechanical type contact point provided to the front train wheel and a transmitting member for transmitting a detection signal from the mechanical type contact point to the IC.

Further, the train wheel operation detecting unit of the mechanical type timepiece of the invention may be a mechanical type contact point provided to a center wheel & pinion included in the front train wheel. According to the constitution, a detection signal can be outputted once per hour by bringing the transmitting member into contact with the mechanical type contact at every rotation of the center wheel & pinion. As a modified example, the mechanical type contact point may be provided to a member included in the train wheel other than the center wheel & pinion. According to the constitution, the detection signal can be outputted in correspondence with a

period of rotating the member.

Further, it is preferable that the train wheel operation detecting unit of the mechanical type timepiece of the invention includes a detecting piezoelectric element provided at a pin for detecting operation of the pallet fork and a counting unit for counting a detection signal outputted from the detecting piezoelectric element.

Further, it is preferable that the train wheel operation control unit of the mechanical type timepiece of the invention includes a train wheel operation controlling piezoelectric element for stopping the escape wheel & pinion at a position at which the escape wheel & pinion has finished impact and is dropping toward a first stop point. According to the mechanical type timepiece of the invention constituted in this way, rotation of the escape wheel & pinion can be stopped by previously making the rate of the mechanical type timepiece gain by moving a regulator and using a bimorph piezoelectric element. In this way, the time for stopping rotation of the escape wheel & pinion can be set based on the count signal counted by the counting unit.

Further, it is preferable that the train wheel operation control unit of the mechanical type timepiece of the invention is provided to be brought into contact with a portion of the hairspring on a side proximate to an outer end portion thereof and includes a hairspring controlling piezoelectric element

for moving in and out the hairspring in a length direction and a hairspring holding spring provided for holding a portion of the hairspring on the side proximate to the outer end portion.

According to the mechanical type timepiece of the invention constituted in this way, a hairspring holder of the mechanical type timepiece is constituted by the hairspring controlling piezoelectric element and the hairspring holding spring. Further, the hairspring is moved in and out in the length direction by the hair spring controlling piezoelectric element at a frequency equal to or larger than a value of the natural frequency of the hairspring holding spring in conformity with rotation of the balance with hairspring. Thereby, the rate of the mechanical type timepiece can be adjusted by changing the oscillation frequency of the balance with hairspring.

In a normal analog type quartz timepiece, there are used battery, quartz, IC, motor, train wheel, hands and so on. According to such an analog time quartz timepiece, energy provided by a battery is used for measuring time by operating quartz or IC and displaying time by rotating a motor. A ratio of energy used for measuring time by operating quartz or IC to energy used for displaying time by rotating a motor is about 3:7. Therefore, in an analog time quartz timepiece, when only a function of measuring time is used, the battery life is extended by a multiplication factor of 3 even when the same

battery is used. In the case of a normal analog type quartz timepiece, the battery life is about 2 years and therefore, according to the mechanical type time piece of the invention, even when a battery having a configuration the same as that of a normal analog type quartz timepiece, is used, the battery can be used for 6 years or more.

Further, the normal mechanical type timepiece can be used for about 5 years without repairing the timepiece at all and when the timepiece is overhauled after 5 years from start of use, the timepiece can be used further for about 5 years. Therefore, a normal mechanical type timepiece can be used for about 10 years when the timepiece is overhauled once.

Therefore, according to the mechanical type timepiece of the invention, even when a battery, a quartz and IC similar to those in a normal analog type quartz timepiece are used, it is not necessary to interchange the battery until overhaul is needed. Further, according to the mechanical type timepiece of the invention, when the capacity of the battery is increased and power consumption of IC is reduced, there can be provided a timepiece which does not need to interchange the battery until life of a portion of a mechanical structure thereof is exhausted.

Further, according to the mechanical type timepiece of the invention, the timepiece is operated by the mechanical structure and therefore, even when the life of the battery is

exhausted, there is no concern of stopping the timepiece and only the accuracy of time display is deteriorated before exhausting the life of the battery.

When a power generating mechanism and a chargeable power source are mounted, there is no concern of exhausting the life of the battery.

[Brief Description of the Drawings]

Fig. 1 is a plane view showing an outline shape of a front side of a movement according to a first embodiment of a mechanical type timepiece of the invention (In Fig. 1, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 2 is an outline partial plane view showing operation of an escapement apparatus (portions of escape wheel & pinion, pallet fork and swing jewel) according to a second embodiment of a mechanical type timepiece of the invention.

Fig. 3 is a block diagram showing an outline of operation of the escapement apparatus (portions of escape wheel & pinion, pallet fork, swing jewel) according to the second embodiment of the mechanical type timepiece of the invention.

Fig. 4 is a block diagram showing an outline of operation of controlling operation of a train wheel according to the first embodiment of the mechanical type timepiece of the invention.

Fig. 5 is an outline partial plane view showing a

constitution of a portion of detecting operation of the train wheel according to the first embodiment of the mechanical type timepiece of the invention.

Fig. 6 illustrates time charts showing the principle of controlling operation of the train wheel according to the first embodiment of the mechanical type time piece of the invention.

Fig. 7 is an outline partial plane view showing a constitution of a portion of controlling operation of the train wheel according to the first embodiment of the mechanical type timepiece of the invention.

Fig. 8 is a plane view showing an outline view of a front side of a movement according to the second embodiment of the mechanical type timepiece of the invention (in Fig. 2, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 9 is a block diagram showing an outline of operation of controlling operation of a train wheel according to the second embodiment of the mechanical type time piece of the invention.

Fig. 10 is a block diagram showing an outline of operation of controlling the operation of the train wheel according to the second embodiment of the mechanical type timepiece of the invention.

Fig. 11 is an outline partial plane view showing a constitution of a portion of controlling the operation of the

train wheel according to the second embodiment of the mechanical type timepiece of the invention.

Fig. 12 illustrates time charts showing the principle of controlling the operation of the train wheel according to the second embodiment of the mechanical type timepiece of the invention.

Fig. 13 is an outline partial plane view showing a constitution of a portion of controlling the operation of the train wheel according to the second embodiment of the mechanical type timepiece of the invention.

Fig. 14 is an outline partial sectional view showing a constitution of the portion for controlling the operation of the train wheel according to the second embodiment of the mechanical type timepiece of the invention.

Fig. 15 is a plane view showing an outline shape of a front side of a movement of a conventional mechanical type timepiece (in Fig. 15, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 16 is an outline partial sectional view of the movement of the conventional mechanical type timepiece (in Fig. 16, portions of parts are omitted).

Fig. 17 is a graph showing an outline relationship between an elapse time period from a fully wound state to a rewound state and mainspring torque.

Fig. 18 is a graph showing an outline relationship

between a swing angle of a balance with hairspring and mainspring torque in a mechanical type timepiece.

Fig. 19 is a graph showing an outline relationship between a swing angle of a balance with hairspring and an instantaneous rate in a mechanical type timepiece.

Fig. 20 is a graph showing an outline relationship between an elapse time period from a fully wound state to a rewound state and an instantaneous rate in a mechanical type timepiece.

[Best Mode for Carrying Out the Invention]

An explanation will be given as follows of a mode of carrying out a rate adjusting method of a mechanical type timepiece according to the invention in reference to the drawings.

(1) First embodiment

In reference to Fig. 1 through Fig. 3, according to a first embodiment of a rate adjusting method of a mechanical type timepiece according to the invention, a movement 200 of the mechanical type timepiece includes a main plate 102 constituting a base plate of the movement. A winding stem 110 is rotatably integrated to a winding stem guide hole 102a of the main plate 102.

A dial 104 (not illustrated) is attached to the movement 100 after adjusting a rate by using the rate adjusting method

of the mechanical type timepiece according to the invention. The dial 104 is provided with, for example, 12 o'clock indicator, 3 o'clock indicator, 6 o'clock indicator and 9 o'clock indicator.

The winding stem 110 is provided with a square portion and a guide shaft portion. A clutch wheel (not illustrated) is integrated to the square portion of the winding stem 110. The clutch wheel is provided with a rotational axis line the same as the rotational axis line of the winding stem 110. That is, the clutch wheel is provided with a square hole and is provided to rotate based on rotation of the winding stem 110 by fitting the square hole to the square portion of the winding stem 110. The clutch wheel is provided with tooth A and tooth B. The tooth A is provided at an end portion of the clutch wheel proximate to the center of the movement. Tooth B is provided to an end portion of the clutch wheel proximate to an outer side of the movement.

The movement 200 is integrated with a switch apparatus for determining a position of the winding stem 110 in the axis line direction. The switch apparatus includes a setting lever 132, a yoke 134, a yoke spring 136 and a setting lever jumper 136. The position of the winding stem 110 in the rotational axis line is determined based on rotation of the setting lever 132. A position of the clutch wheel in the rotational axis line is determined based on rotation of the yoke 134. Based

on rotation of the setting lever 132, the yoke 134 is positioned at two positions in a rotational direction.

A winding pinion 112 is rotatably integrated to the guide shaft portion of the winding stem 110. When the winding stem 110 is rotated in a state in which the winding stem 110 is disposed at a first winding stem position (0-th stage) mostly proximate to the inner side of the movement 100 along the rotational axis line direction, the winding pinion 112 is constituted to rotate via rotation of the clutch wheel. A crown wheel 114 is integrated to rotate by rotation of the winding pinion 112. A ratchet wheel 116 is integrated to rotate by rotation of the crown wheel 114.

The movement 200 is provided with a main spring (not illustrated) contained in a barrel complete 120 as a power source. The mainspring is fabricated by an elastic material having spring performance such as iron. It is constituted that the mainspring can be wound up by rotating the ratchet wheel 116.

A center wheel & pinion 124 is integrated to rotate by rotation of the barrel complete 120. A third wheel & pinion 126 is integrated to rotate based on rotation of the second wheel & pinion 124. A fourth wheel & pinion 128 is integrated to rotate based on rotation of the third wheel & pinion 126. An escape wheel & pinion 130 is integrated to rotate based on rotation of the fourth wheel & pinion 128. The barrel complete

120, the center wheel & pinion 124, the third wheel & pinion 126 and the fourth wheel & pinion 128 constitute a front train wheel.

The movement 100 is integrated with an escapement & speed control apparatus for controlling rotation of the front train wheel. The escapement & speed control apparatus includes a balance with hairspring 140 repeating to rotate in the right-hand direction and rotate in the left-hand direction at a constant period, the escape wheel & pinion 130 rotated based on rotation of the front train wheel and a pallet fork 142 for controlling rotation of the escape wheel & pinion 130 based on rotation of the balance with hairspring 240.

The basic operation principle of the escape wheel & pinion 130, the pallet fork 142 and the balance with hairspring 240 is the same as that of the movement of the conventional mechanical type timepiece.

In reference to Fig. 2 and Fig. 3, the pallet fork 142 is provided with an in-finger jewel 142a provided to be capable of being brought into contact with the escape wheel & pinion 130, an out-finger jewel 142b provided to be capable of being brought into contact with the escape wheel & pinion 130, a pallet fork sword tip 142c provided such that a swing jewel 240f of the balance with hairspring 240 can move therein and thereout and a pallet fork rod portion 142d.

When the balance with hairspring 240 and the swing jewel

240f are rotated left-handedly (in the counterclockwise direction), the swing jewel 240f moves into the pallet fork sword tip 140c. Then, the swing jewel 240f rotates the pallet fork 142 right-handedly (in the clockwise direction) and the pallet fork 142 is released of stopping on the side of the in-finger jewel 142a. Then, a rocking corner of the escape wheel & pinion 130 is shifted to an impact face of the in-finger jewel 140a. By force of the escape wheel & pinion 130, the impact face of the in-finger jewel 140a is pushed up and the pallet fork 142 is rotated right-handedly (in the clockwise direction). Then, the pallet sword tip 140c pushes the swing jewel 240f and the swing jewel 240f is rotated left-handedly (counterclockwise direction).

When the impact has been finished, a tooth of the escape wheel & pinion 130 leaves the in-finger jewel 142a, the escape wheel & pinion 130 rotates idly, and the escape wheel & pinion 130 drops. Fig. 7 shows such a state of dropping the escape wheel & pinion 130. When the escape wheel & pinion 130 finishes dropping, other tooth of the escape wheel & pinion 130 is brought into contact with a stop face of the out-finger jewel 142b to thereby bring about a first stop state.

When the first stop state has been finished and the swing jewel 240f leaves the pallet for sword tip 142c, by the force of the escape wheel & pinion 130, the pallet fork 142 rotates the swing jewel 240f left-handedly (in the counterclockwise

direction). Further, the pallet fork rod portion 142d is brought into contact with a first bank pin 102d and rotation of the pallet fork 142 is stopped to thereby bring about a second stop state.

Further, the balance with hairspring 240 is rotated left-handedly (in the counterclockwise direction) and carries out free oscillation.

Next, when the balance with hairspring 240 reaches a position of a maximum swing angle, the balance with hairspring 240 is rotated right-handedly (in the clockwise direction) and the swing jewel 240f is rotated also right-handedly (in the clockwise direction). Then, the swing jewel 240f is brought into contact with the pallet fork sword tip 142c and the pallet fork 142 is rotated left-handedly (in the counterclockwise direction). Then, stopping is released on the side of the out-finger jewel 142b and operation similar to that of the out-finger jewel 142b is repeated on the side of the in-finger jewel 142a.

In reference to Fig. 1, the balance with hairspring 240 includes a balance stem 240a, a balance wheel 240b and a hairspring 240c.

The hairspring 240c is fabricated by an elastic material having spring performance such as "elinvar" or the like. That is, the hairspring 240c is fabricated by an elastically conductive metal material.

Based on rotation of the center wheel & pinion 124, an hour pinion (not illustrated) is simultaneously rotated. A minute hand (not illustrated) attached to the hour pinion is constituted to display "minute". The hour pinion is provided with a slip mechanism having a predetermined slip torque relative to the center wheel & pinion 124.

A minute wheel (not illustrated) is rotated based on rotation of the hour pinion. An hour wheel (not illustrated) is rotated based on rotation of the minute wheel. An hour hand (not illustrated) attached to the hour wheel is constituted to display "hour".

The barrel complete 120 is supported by the main plate 102 and a barrel bridge 160 rotatably thereto. The center wheel & pinion 124, the third wheel & pinion 126, the fourth wheel & pinion 128 and the escape wheel & pinion 130 are supported by the main plate 102 and a train wheel bridge 162 rotatably thereto. The pallet fork 142 is supported by the main plate 102 and a pallet bridge 164 rotatably thereto.

The balance with hairspring 240 is supported by the main plate 102 and a balance with hairspring bridge 166 rotatably thereto. That is, an upper mortise of the balance stem 240a is supported by a balance upper bearing fixed to the balance with hairspring bridge 166 rotatably thereto. The balance upper bearing 160a includes a balance upper hole jewel and a balance upper bridge jewel. The balance upper hole jewel and

the balance upper bridge jewel are fabricated by an insulating material such as ruby or the like.

A lower mortise of the balance stem 240a is rotatably supported by a balance lower bearing fixed to the main plate 102. The balance lower bearing 102b includes a balance lower hole jewel and a balance lower bridge jewel. The balance lower hole jewel and the balance lower bridge jewel are fabricated by an insulating material of ruby or the like.

The hairspring 240c is a thin plate spring in a helical (spiral) mode having a plural turn number. An inner end portion of the hairspring 240c is fixed to a hairspring holder fixed to the balance stem 240a and an outer end portion of the hairspring 240c is fixed by a screw via a hairspring support attached to a stud support 166a rotatably fixed to the balance bridge 166. The balance with hairspring 166 is fabricated by a metallic electricity conductive material of brass or the like. The stud support 166a is fabricated by a metallic electricity conductive material of iron or the like.

A regulator 166c is rotatably attached to the balance with hairspring bridge 166.

The hairspring 240c is elongated and contracted in the radius direction of the hairspring 240c in accordance with a rotational angle rotated by the balance with hairspring 240. For example, in a state shown by Fig. 1, when the balance with spring 240 is rotated in the clockwise direction, the

hairspring 240c is contracted in a direction directed to the center of the balance with hairspring 240 and in contrast thereto, when the balance with hairspring 240 is rotated in the counterclockwise direction, the hairspring 240c is expanded in a direction remote from the center of the balance with hairspring 240.

Next, an explanation will be given of a time counting unit, a train wheel operation detecting unit and a train wheel operation control unit of a mechanical type timepiece according to the invention.

In reference to Fig. 1 and Fig. 4, a crystal oscillator 210 constitutes an oscillation source of a circuit for counting time. IC 212 includes a dividing circuit 214 for inputting an output signal outputted by oscillation of the crystal oscillator 210, dividing the signal and outputting a signal with regard to time, a correction pulse comparing circuit 216 for comparing with a correction pulse and a piezoelectric element drive circuit 218 for outputting a pulse for driving a piezoelectric element of a bimorph type. A battery 220 constitutes a power source for operating IC 212. The crystal oscillator 210, the dividing circuit 214 in IC 212 and the battery 220 constitute the time counting unit for counting time.

An explanation will be given of structure of the train wheel operation detecting unit for detecting a rotational

operation state of a train wheel of the mechanical type timepiece in reference to Fig. 1 and Fig. 4.

A train wheel 224 is rotated with a main spring 222 as a power source. The timepiece is constituted such that by rotation of the train wheel 224, a minute hand 226 displays "minute" and an hour hand 228 displays "hour". The minute hand 226 is fixed to the center wheel & pinion 124. The center wheel & pinion 124 is constituted to rotate once per hour. By rotating the train wheel 224, the escape wheel & pinion 130 is rotated. The pallet fork 142 controls rotation of the escape wheel & pinion 130 based on operation of the balance with hairspring 240.

A center wheel & pinion detecting pin 124p is fixed to the center wheel & pinion 124. A center wheel & pinion detecting spring 232 is fixed to the main plate 102. The center wheel & pinion selecting pin 232 is formed by an electricity conductive material such as a metal or the like. The second wheel & pinion detecting spring 232 is fixed to the main plate 102 via an insulating member 236.

The center wheel & pinion detecting spring 232 and the center wheel & pinion detecting pin 124p constitute a time detecting unit 230 for detecting the rotational operation state of the train wheel. Further, the timepiece is constituted such that when the center wheel & pinion detecting spring 232 is brought into contact with the center wheel &

pinion detecting pin 124p, a detection signal is inputted to IC 212. The center wheel & pinion 124 rotates once per hour and accordingly, the time detecting unit 130 is made ON once per hour.

Here, in reference to Fig. 6, the correction pulse comparing circuit 216 is constituted to compare a period of 1 hour measured by the escapement & speed control apparatus and a period of 1 hour measured by IC 212.

According to the time detecting unit 230, by bringing the second wheel & pinion detecting spring 232 into contact with the second wheel & pinion detecting pin 124p, the escape wheel & pinion 130 and the pallet fork 142 output a detection signal of a period of 1 hour measured by the escapement & speed control apparatus including the balance with hairspring 240 to IC 212 (refer to (1) of Fig. 6).

That is, the train wheel operation detecting unit includes a mechanical contact point provided to the train wheel 224 (front train wheel), that is, the center wheel & pinion detecting pin 124p and a transmitting member for transmitting the detection signal from the mechanical contact point to IC 212, that is, the center wheel & pinion detecting spring 232.

Further, the dividing circuit 214 divides an output signal of 32768 Hertz outputted by oscillation of the crystal oscillator 210 and outputs a divided signal of a period of 1 hour to the correction pulse comparing circuit 216 (refer to

(2) of Fig. 6).

The correction pulse comparing circuit 216 compares the detection signal of the period of 1 hour measured by the escapement & speed control apparatus with the divided signal of the period of 1 hour and counts a difference therebetween (refer to (3) of Fig. 6). The difference is a time period to be corrected in the mechanical type timepiece of the invention.

In reference to Fig. 1, Fig. 4 and Fig. 7, a time correcting unit 250 includes a correction spring 252 operated by the piezoelectric element of the bimorph type and a stopping member 254 fixed to the correction spring for stopping rotation of the escape wheel & pinion 130. The stopping member 254 is constituted by, for example, a jewel such as ruby. The correction spring 252 is constituted to stop rotation of the escape wheel & pinion 130 between a first stop point and a second stop point of the escape wheel & pinion 130 by applying voltage on the piezoelectric element of the bimorph type. That is, the stopping member 254 of the train wheel operation control unit is provided at a position of being brought into contact with the tooth of the escape wheel & pinion 130 in order to stop rotation of the escape wheel & pinion 130 at a position at which the escape wheel & pinion 130 has finished the impact and is dropping toward the first stop point. Further, time of bringing the stopping member 254 into contact with the tooth of the escape wheel & pinion 130 by applying voltage to the

piezoelectric element of the bimorph type, is time in correspondence with the difference shown by (3) of Fig. 6.

The piezoelectric element drive circuit 218 is constituted to apply voltage on the piezoelectric element of the bimorph type based on a signal in correspondence with the difference outputted by the correction pulse comparing circuit 216. When needed, a transistor may be provided between the piezoelectric element of the bimorph type and the piezoelectric element drive circuit 218.

Therefore, the correction pulse comparing circuit 126, the piezoelectric element drive circuit 218, the correction spring 252 and the stopping member 254 constitute the train wheel operation control unit for controlling operation of the train wheel 224. Further, the train wheel operation control unit is constituted to control operation of the train wheel 224 at a period between once per hour and once per day.

By constituting in this way, operation of the mechanical type timepiece can be stopped by applying voltage to the piezoelectric element of the bimorph type by the time in correspondence with the difference shown by (3) of Fig. 6. When applying the voltage to the piezoelectric element of the bimorph type is stopped, the stopping member 254 leaves the escape wheel & pinion 130 and accordingly, the mechanical type timepiece can be operated again.

By constituting in this way, the rate of the mechanical

type timepiece can be adjusted with high accuracy.

Further, according to the first embodiment of the mechanical type timepiece of the invention, the train wheel operation control unit is constituted such that the operation of the mechanical type timepiece cannot be gained and the operation of the mechanical type timepiece can only be stopped. Therefore, it is necessary to previously adjust the mechanical type timepiece such that the rate of the mechanical type timepiece is gained.

(2) Second embodiment

An explanation will be given as follows of a second embodiment of a mechanical type timepiece according to the invention. In the following explanation, a description will mainly be given of a point by which the second embodiment of the mechanical type timepiece according to the invention differs from the first embodiment of the mechanical type timepiece according to the invention.

In reference to Fig. 8 and Fig. 9, and explanation will be given of a time counting unit, a train wheel operation detecting unit and a train wheel operation control unit with regard to the second embodiment of the mechanical type timepiece according to the invention.

The crystal oscillator 210 constitutes an oscillation source of a circuit for counting time. IC 312 includes a

dividing circuit 314 for inputting the output signal outputted by oscillation of the crystal oscillator 210, dividing the signal and outputting a signal with respect to time, a correction pulse comparing circuit 316 for comparing with a correction pulse, a piezoelectric element drive circuit 318 for outputting a pulse for driving the piezoelectric element, a waveform correcting circuit 332 for correcting the waveform of a detection signal and a detection signal dividing circuit 334 for dividing the detection signal. The battery 220 constitutes the power source for operating IC 312. The crystal oscillator 210, the dividing circuit 314 in IC 312 and the battery 220 constitute the time counting unit for counting time.

Next, an explanation will be given of structure of the train wheel operation detecting unit for detecting the rotational operation state of the train wheel of the mechanical type timepiece in reference to Fig. 1, Fig. 9 and Fig. 11.

The train wheel 224 is rotated with the mainspring 222 as the power source. The timepiece is constituted such that by rotation of the train wheel 224, the minute hand 226 displays "minute" and the hour hand 228 displays "hour". The minute hand 226 is fixed to the center wheel & pinion 124. The center wheel & pinion 124 is constituted to rotate once per hour. By rotating the train wheel 224, the escape wheel & pinion 130 is rotated. The pallet fork 142 controls rotation of the

escape wheel & pinion 130 based on operation of a balance with hairspring 340.

A pallet fork detecting piezoelectric element 336 is fixed to the first bank pin 102d of the main plate. Therefore, the pallet fork rod portion 142d is constituted to be brought into contact with the pallet fork detecting piezoelectric element 336. At instance at which the pallet fork rod portion 142d is brought into contact with the pallet fork detecting piezoelectric element 336, the pallet fork detecting piezoelectric element 336 generates voltage (refer to (4) of Fig. 12).

The pallet fork detecting piezoelectric element 336 constitutes a time detecting unit 330 for detecting the rotational operation state of the train wheel. Further, the timepiece is constituted such that when the pallet fork rod portion 142d is brought into contact with the pallet fork detecting piezoelectric element 336, a detection signal is inputted to IC 312. The balance with hairspring 340 is oscillated at 3 Hertz and therefore, the time detecting unit 230 outputs the detection signal at 3 Hertz.

The waveform correcting circuit 332 is constituted to input the detection signal outputted from the pallet fork detecting piezoelectric element 336, shape the waveform and output a correction signal to the detection signal dividing circuit 334. The detection signal dividing circuit 334 is

constituted to divide the correction signal and output a correction divided signal to the correction pulse comparing circuit 316.

In reference to Fig. 9, the correction pulse comparing circuit 316 is constituted to compare a period of 1 hour measured by the escapement & speed control apparatus with a period of 1 hour measured by IC 312.

According to the time detecting unit 330, by bringing the pallet fork rod portion 142d in contact with the pallet fork detecting piezoelectric element 336, the escape wheel & pinion 130 and the pallet fork 142 output to IC 312, a detection signal of a period of 1 hour measured by the escapement & speed control apparatus including the balance with hairspring 340.

That is, the train wheel operation detecting unit includes the pallet fork rod portion 142d and the pallet fork detecting piezoelectric element 336.

Further, the dividing circuit 314 is constituted to divide the output signal of 32768 Hertz outputted by oscillation of the crystal oscillator 210 and outputting a divided signal of a period of 1 hour to the correction pulse comparing circuit 316.

The correction pulse comparing circuit 316 is constituted to compare the detection signal of the period of 1 hour measured by the escapement & speed control apparatus with the divided signal of the period of 1 hour and count a

difference therebetween (refer to (3) of Fig. 6). The difference is the time period to be corrected in the mechanical type timepiece of the invention.

In reference to Fig. 8, Fig. 13 and Fig. 14, a time correcting unit 350 is constituted to control operation of a hairspring 340c of the balance with hairspring 340. A hairspring holder bridge 370 is fixed to the balance with hairspring bridge 166. A hairspring holder 356 is fixed to the hairspring holder bridge 370. A hairspring controlling piezoelectric element 354 is fixed to the hair spring holder 356. The hairspring controlling piezoelectric element 354 is provided to be brought into contact with a portion of the hairspring 340c on a side proximate to an outer end portion thereof and is provided to make the hairspring 340c move in and out in the length direction.

A hairspring holding spring 352 is provided to hold the portion of the hairspring 340c on the side proximate to the outer end portion. Therefore, the portion of the hairspring 340c on the side proximate to the outer end portion is arranged between the hairspring controlling piezoelectric element 354 and the hairspring holding spring 352. The hairspring holding spring 352 is formed by an elastic material such as a metal or the like.

In reference to Fig. 10, a detection signal is inputted to IC 312 by the train wheel operation detecting unit, that

is, by bringing the pallet fork rod portion 142d into contact with the pallet fork detecting piezoelectric element 336. The train wheel operation detecting unit includes a pallet fork detection signal counting unit. The pallet fork detection signal counting unit is constituted to count the detection signal outputted from the pallet fork detecting piezoelectric element 336.

The waveform correcting circuit 332 inputs the detection signal counted by the pallet fork detection signal counting unit, shapes the waveform and outputs a correction signal shown by (5) of Fig. 12 to the detection signal dividing circuit 334. The detection signal dividing circuit 334 divides the correction signal outputted from the waveform correcting circuit 332 by 10800 times and outputs the correction divided signal shown by (2) of Fig. 6 to the correction pulse comparing circuit 316.

Next, the correction pulse comparing circuit 316 compares the correction divided signal outputted from the correction pulse comparing circuit 316 with a divided signal of a period of 1 hour outputted from the dividing circuit 314 and counts a difference therebetween.

When the correction pulse comparing circuit 316 determines that the rate of the mechanical type timepiece gains, at T2 of (5) of Fig. 2, the piezoelectric element drive circuit 318 outputs a pulse of driving the piezoelectric element to

the hairspring controlling piezoelectric element 354 based on a piezoelectric electric element drive control signal outputted from the correction pulse comparing circuit 316. In this case, the timing of applying voltage to the hairspring controlling piezoelectric element 354 is T2 shown by (5) of Fig. 12 and time of applying voltage to the hairspring controlling piezoelectric element 354 is time in correspondence with the difference shown by (3) of Fig. 6. In this case, the timing T2 can previously be provided by experiment by using a sample of the mechanical type timepiece.

When the correction pulse comparing circuit 316 determines that the rate of the mechanical type timepiece does not gain (lose), at T1 of (5) of Fig. 12, the piezoelectric element drive circuit 318 outputs the pulse of driving the piezoelectric element to the hairspring controlling piezoelectric element 354 based on the piezoelectric element drive control signal outputted from the correction pulse comparing circuit 316. In this case, the timing of applying voltage to the hairspring controlling piezoelectric element 354 is T1 shown by (5) of Fig. 12 and time of applying voltage to the hairspring controlling piezoelectric element 354 is time in correspondence with the difference shown by (3) of Fig. 6. In this case, the timing T1 corresponds to a point of rise of the pulse shown by (5) of Fig. 12. Further, a detailed specification of the timing T1 can also be provided previously

by experiment by using a sample of the mechanical type timepiece.

That is, the piezoelectric element drive circuit 318 operates the hairspring controlling piezoelectric element 354 by applying voltage to the hairspring controlling piezoelectric element 354 based on the signal in correspondence with the difference outputted from the correction pulse comparing circuit 316.

Therefore, the correction pulse comparing circuit 316, the piezoelectric drive circuit 318 and the hairspring controlling piezoelectric element 354 constitute the train wheel operation control unit for controlling operation of the train wheel 224. Further, the train wheel operation control unit is constituted to control operation of the train wheel 224 at a period of between once per hour and once per day.

According to the mechanical type timepiece of the invention, a value of frequency of oscillation of the hairspring controlling piezoelectric element 354 is constituted to be larger than a value of the natural frequency of the hairspring holding spring 352. In this case, oscillation of the hairspring controlling piezoelectric element 354 is adjusted in conformity with operation of the hairspring 340c of the balance with hair spring 340.

That is, in reference to Fig. 13, in the case in which the hairspring controlling piezoelectric element 354 is

oscillated when the balance with hairspring 340 is rotated in the right-hand (clockwise) direction, the hairspring 340c moves from a position in contact with the hairspring controlling piezoelectric element 354 and the hairspring holding spring 352 in the right-hand (clockwise) direction and comes out from the hairspring controlling piezoelectric element 354 and the hairspring holding spring 352. In contrast thereto, in the case in which the hairspring controlling piezoelectric 354 is oscillated when the balance with hairspring 340 is rotated in the left-hand (counterclockwise) direction, the hairspring 340c is moved from the position in contact with the hairspring controlling piezoelectric element 354 and the hairspring holding spring 352 in the left-hand (counterclockwise) direction and enters the side of the hairspring controlling piezoelectric element 354 and the hairspring holding spring 352.

According to the mechanical type timepiece, generally, when an effective length of oscillating the hairspring 340c is prolonged, the rate loses and when the effective length of oscillating the hairspring 340c is shortened, the rate gains. Therefore, in the case in which the correction pulse comparing circuit 316 determines that the rate of the mechanical type timepiece gains, in order to oscillate the hairspring controlling piezoelectric element 354 when the balance with hairspring 340 is rotated in the right-hand (clockwise)

direction, at T2 of (5) of Fig. 12, the piezoelectric element drive circuit 318 outputs a pulse of driving the piezoelectric element to the hairspring controlling piezoelectric element 354 based on the piezoelectric drive control signal outputted from the correction pulse comparing circuit 316.

In the case in which the correction pulse comparing circuit 316 determines that the rate of the mechanical type timepiece does not gain (lose), in order to oscillate the hairspring controlling piezoelectric element 354 when the balance with hairspring 340 is rotated in the left-hand (counterclockwise) direction, at T1 of (5) of Fig. 12, the piezoelectric drive circuit 318 outputs a pulse of driving the piezoelectric element to the hairspring controlling piezoelectric element 354 based on the piezoelectric element drive control signal outputted from the correction pulse comparing circuit 316.

In this case, by inputting the signal of (5) of Fig. 12 by the piezoelectric element drive circuit 318, the timing at which the pallet fork rod portion 142d is brought into contact with the pallet fork detecting piezoelectric element 336 is known and accordingly, the timing of stopping the pallet fork 142 is known. Therefore, the rotational direction of rotating the balance with hairspring 340 can be detected from such a timing of stopping the pallet fork 142.

By constituting in this way, the rate of the mechanical

type timepiece can be adjusted with high accuracy.

Further, according to the second embodiment of the mechanical type timepiece of the invention, the train wheel operation control unit can make the rate of the mechanical type timepiece gain and can make the rate of the mechanical type timepiece lose. Therefore, it is not necessary to previously adjust the rate of the mechanical type timepiece.

By constituting in this way, the rate of the mechanical type timepiece can be adjusted by a simple adjusting step.

Other characteristics of the second embodiment of the mechanical type timepiece of the invention is similar to characteristics of the first embodiment of the mechanical type timepiece of the invention, described above. Therefore, with respect to the other characteristics of the second embodiment of the mechanical type timepiece according to the invention, a duplicated description thereof will be avoided by applying here the description with regard to the first embodiment of the mechanical type timepiece according to the invention.

Further, in any of the embodiments of the mechanical type timepiece of the invention, circuits for carrying out various functions may be constituted in IC and IC may be PLA-IC incorporating programs of carrying out various operation. Further, in any of the embodiments of the mechanical type timepiece according to the invention, as necessary, external elements of resistor, condenser, coil, diode, transistor and

the like can be used along with IC.

The train wheel operation control unit in the first embodiment of the mechanical type timepiece of the invention can also be applied to the second embodiment of the mechanical type timepiece of the invention. However, in this case, it is necessary to previously adjust to make the rate of the mechanical type timepiece gain.

[Industrial Applicability]

The mechanical type timepiece of the invention is suitable for fabricating a mechanical type timepiece having high accuracy.

Claim(s)



1. A mechanical type timepiece characterized in that in a mechanical type timepiece comprising a movement having a mainspring constituting a power source of the mechanical type timepiece, a front train wheel rotated by a rotational force when the mainspring is rewound and an escapement & speed control apparatus for controlling rotation of the front train wheel, said escapement & speed control apparatus including a balance with hairspring alternately repeating right-hand rotation and left-hand rotation, an escape wheel & pinion rotated based on rotation of the front train wheel and a pallet fork for controlling rotation of the escape wheel & pinion based on operation of the balance with hairspring and said balance with hairspring including a hairspring, a balance stem and a balance wheel, said mechanical type timepiece comprising:

a time counting unit having a crystal oscillator (210) constituting an oscillation source, IC (212) including a dividing unit (214) for inputting an output signal outputted by oscillation of the crystal oscillator (210), dividing the signal and outputting a signal with regard to time and a power source (220) for operating IC (212) for counting time;

a train wheel operation detecting unit (124p, 232) for detecting a rotational operation state of the train wheel of the mechanical type timepiece; and



a train wheel operation controlling unit (252, 254) for controlling operation of the train wheel based on a count signal counted by the time counting unit and an operational control signal indicating the rotational operation state of the train wheel detected by the train wheel operation detecting unit.

2. The mechanical type timepiece according to Claim 1, characterized in that the train wheel operational control unit (252, 254) controls the operation of the train wheel at a period between once per hour and once per day.

3. The mechanical type timepiece according to Claim 1 or Claim 2, characterized in that the train wheel operation detecting unit includes a mechanical type contact point (124p) provided to the front train wheel and a transmitting member (232) for transmitting a detection signal from the mechanical type contact point to the IC.

4. The mechanical type timepiece according to Claim 1 or Claim 2, characterized in that the train wheel operation detecting unit (124p, 232) includes a pallet fork detecting piezoelectric element (336) provided at a pin (102d) for detecting operation of the pallet fork (142) and a pallet fork detection signal counting unit for counting a pallet fork detection signal outputted from the pallet fork detecting piezoelectric element (336).

5. The mechanical type timepiece according to any one of Claim 1 through Claim 4, characterized in that the train



wheel operation control unit (252, 254) includes a train wheel operation controlling piezoelectric element for stopping the escape wheel & pinion (130) at a position at which the escape wheel & pinion (130) has finished impact and is dropping toward a first stop point.

6. The mechanical type timepiece according to any one of Claim 1 through Claim 4, characterized in that the train wheel operation control unit (252, 254) is provided to be brought into contact with a portion of the hairspring (340c) on a side proximate to an outer end portion thereof and includes a hairspring controlling piezoelectric element (354) for moving in and out the hairspring (340c) in a length direction and a hairspring holding spring (352) provided for holding a portion of the hairspring (340c) on the side proximate to the outer end portion.