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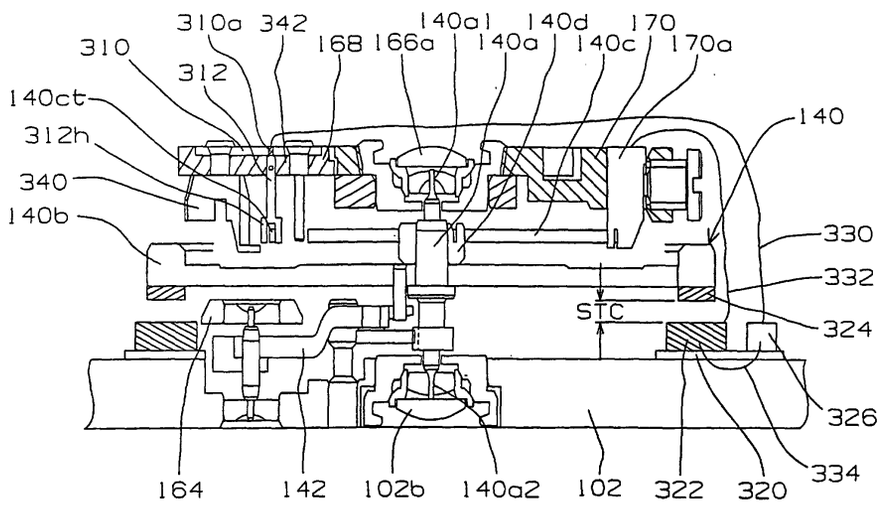
(54) MECHANICAL TIMEPIECE WITH TIMED ANNULAR BALANCE ROTATING ANGLE CONTROL MECHANISM

(57) In a mechanical time piece according to the invention, a movement 300 includes a barrel complete 120, a center wheel & pinion 124, a third wheel & pinion 126, a fourth wheel & pinion 128, a balance with hairspring 140, an escape wheel & pinion 130 and a pallet fork 142. The mechanical time piece of the invention is provided with a balance rotational angle control mechanism constituted to generate static electricity when a rotational angle of the balance with hairspring 140 becomes equal to or larger than a predetermined threshold and not to generate the static electricity when the rotational angle of the balance with hairspring 140 does not exceed the predetermined threshold. The balance rotational angle control mechanism includes a balance insulating plate 324 provided to the balance with hairspring 140, a main plate insulating plate 322 arranged to a main plate 102, a switch lever 168 rotatably provided to a balance bridge 166, a hairspring switch member 312 attached rotatably to the switch lever 168 and provided to operate by being brought into contact with a hairspring and degree contact members 340, 342 for determining a position of the hairspring switch member 312.

By rotating the hairspring switch member 312, generation of the static electricity between the balance insulating plate 324 and the main plate insulating plate 322 can be controlled.

FIG. 4



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Description

Technical Field

[0001] The present invention relates to a mechanical time piece having a balance rotational angle control mechanism constituted to exert a force for restraining rotation of a balance with hairspring.

Background of the Invention

[0002] According to a conventional mechanical time piece, as shown in Fig. 12 and Fig. 13, a movement (machine body) 1100 of a mechanical time piece 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 plate 1104 (shown in Fig. 13 by an imaginary line) is attached to the movement 1100.

[0003] 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 thereof 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".

[0004] A position in the axis line direction of the winding stem 1110 is determined by a switch apparatus including a setting lever 1190, a yoke 1192, a yoke spring 1194 and a setting lever jumper 1196. A winding pinion 1112 is provided rotatably at a guide shaft portion of the winding stem 1110. When the winding stem 1110 is rotated in the state in which the winding stem 1110 is disposed at a first winding stem position (0-stage) on a side most proximate to the inner side of the movement along the 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 & 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.

[0005] An escapement & speed control apparatus for controlling rotation of the front train wheel includes a balance with hairspring 1140, the escape wheel & pinion 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, a cannon pinion 1150 is simultaneously rotated. A minute hand 1152 attached to the cannon pinion 1150 displays "minute". The cannon pinion 1150 is provided with a slip mechanism relative to the center pinion & wheel 1124. Based on rotation of the cannon pinion 1150, via rotation of a minute wheel, an hour wheel 1154 is rotated. An hour hand 1156 attached to the hour wheel 1154 displays "hour".

[0006] The barrel complete 1120 is supported rotatably by the main plate 1102 and a barrel bridge 1160. The center wheel & pinion 1124, the third wheel & pinion 1126, the fourth wheel & pinion 1128 and the escape wheel & pinion 1130 are supported rotatably by the main plate 1102 and a train wheel bridge 1162. The pallet fork 1142 is supported rotatably by the main plate 1102 and a pallet bridge 1164. The balance with hairspring 1140 is supported rotatably by the main plate 1102 and a balance bridge 1166.

[0007] The hairspring 1140c is a leaf spring in a helical (spiral) shape 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 via a hairspring stud 1170a attached to a stud support 1170 fixed to the balance bridge 1166 by fastening screws.

[0008] A regulator 1168 is attached rotatably to the balance bridge 1166. A hairspring bridge 1340 and a hairspring rod 1342 are attached to the regulator 1168. A portion of the hairspring 1140c proximate to the outer end portion is disposed between the hairspring bridge 1340 and the hairspring rod 1342.

[0009] Generally, according to a conventional representative mechanical timepiece, as shown by Fig. 8, with elapse of a duration time period of rewinding the mainspring from a state in which the mainspring has completely been wound up (fully wound state), mainspring torque is reduced. For example, in the case of Fig. 8, the mainspring torque is about 27 gcm in the fully wound state, becomes about 23 gcm after elapse of 20 hours from the fully wound state and becomes about 18 gcm after elapse of 40 hours from the fully wound state.

[0010] Generally, according to a conventional representative mechanical time piece, as shown by Fig. 9, when the mainspring torque is reduced, the swing angle of the balance with hairspring is also reduced. For example, in the case of Fig. 9, when the mainspring torque is 25-28 gcm, the swing angle of the balance with hairspring is about 240-270 degree and when the mainspring torque is 20-25 gcm, the swing angle of the balance with hairspring is about 180-240 degree.

[0011] In reference to Fig. 10, there is shown a transitional change of instantaneous rate with regard to swing angle of a balance with hairspring according to a conventional representative mechanical time piece (numerical value indicating accuracy of time piece). In this case, the "instantaneous rate" is defined as "a value indicating gain or loss of a mechanical time piece after elapse of one day after the mechanical time piece is assumed to be left for one day while maintaining state or environment of swing angle of a balance with hairspring

or the like when the rate is measured". In the case of Fig. 10, when a swing angle of a balance with hairspring is equal to or larger than 240 degree or is equal to or smaller than 200 degree, the instantaneous rate is retarded.

[0012] For example, according to a conventional representative time piece, as shown by Fig. 10, when the swing angle of the balance with hairspring falls in a range of about 200 through 240 degree, the instantaneous rate is about 0 through 5 seconds / day (gain of 0 through 5 seconds per day), however, when the swing angle of the balance with hairspring is about 170 degree, the instantaneous rate becomes about -20 seconds / day (loss of about 20 seconds per day).

[0013] In reference to Fig. 11, there is shown a transitional change of elapse time and instantaneous rate when a mainspring is rewound from a fully wound state in a conventional representative mechanical time piece. In this case, in the conventional mechanical time piece, "rate" indicating gain of the timepiece or loss of the time piece per day, is provided by integrating instantaneous rate with regard to elapse time of rewinding the balance with hairspring from a fully wound state, which is indicated in Fig. 11 by an extremely slender line, over 24 hours.

[0014] Generally, according to the conventional mechanical timepiece, with elapse of duration time period of rewinding the mainspring from the fully wound state, the mainspring torque is reduced, the swing angle of the balance with hairspring is also reduced and accordingly, the instantaneous rate is retarded. Therefore, according to the conventional mechanical timepiece, by estimating loss of the time piece after elapse of the duration time period of 24 hours, instantaneous rate when the mainspring is brought into the fully wound state, is previously gained and previously adjusted such that the "rate" indicating gain of the time piece or loss of the time piece per day becomes positive.

[0015] For example, according to the conventional representative time piece, as shown by the extremely slender line in Fig. 11, although in the fully wound state, the instantaneous rate is about 3 seconds / day (gain of about 3 seconds per day), after elapse of 20 hours from the fully wound state, the instantaneous rate becomes about -3 seconds / day (loss of about 3 seconds per day), after elapse of 24 hours from the fully wound state, the instantaneous rate becomes about -8 seconds per day (loss of about 8 seconds per day) and after elapse of 30 hours from the fully wound state, the instantaneous rate becomes about -16 seconds / day (loss of about 16 seconds per day).

[0016] Further, as a conventional apparatus of adjusting a swing angle of a balance with hairspring, there is disclosed in Japanese Utility Model Laid-Open No. 41675/1979, a constitution having a swing angle adjusting plate exerting braking force to a balance with hairspring by generating eddy current at each time of pivotal approach of a magnet of the balance with hairspring.

[0017] It is an object of the present invention to provide a mechanical time piece having a balance rotational angle control mechanism capable of controlling a swing angle of a balance with hairspring to fall in a constant range.

[0018] Further, it is an object of the present invention to provide a mechanical time piece having excellent accuracy in which a change in a rate is inconsiderable even after elapse of an elapse time period from a fully wound state.

Disclosure of the Invention

[0019] An aspect of the invention is characterized in that in a mechanical time piece having a mainspring constituting a power source of the mechanical time piece, a front train wheel rotated by a rotational force when the mainspring is rewound and an escapement and speed control apparatus for controlling rotation of the front train wheel in which the escapement and speed control apparatus is constituted to include a balance with hairspring repeating right rotation and left rotation, an escape wheel & pinion rotated based on the rotation of the front train wheel and a pallet fork controlling rotation of the escape wheel & pinion based on operation of the balance with hairspring, the mechanical time piece comprising a balance rotational angle control mechanism constituted to generate static electricity when a rotational angle of the balance with hairspring becomes equal to or larger than a predetermined threshold and not to generate the static electricity when the rotational angle of the balance with hairspring does not exceed the threshold.

[0020] According to another aspect of the mechanical time piece of the invention, the balance rotational angle control mechanism includes a balance insulating plate provided at the balance with hairspring and a main plate insulating plate arranged to a main plate and a clearance is provided between the balance insulating plate and the main plate insulating plate.

[0021] Further, according to another aspect of the invention, it is preferable that the balance rotational angle control mechanism including a switch lever rotatably attached to a balance bridge, a hairspring switch member attached rotatably to the switch lever and provided to operate by being brought into contact with a hairspring, and degree contact members for determining a position of the hairspring switch member, wherein generation of the static electricity between the balance insulating plate and the main plate insulating plate can be controlled by rotating the hairspring switch member.

[0022] By using the balance rotational angle control mechanism constituted in this way, the rotational angle of the balance with hairspring of the mechanical time piece can effectively be controlled, thereby, accuracy of the mechanical time piece can be promoted.

Brief Description of the Drawings

[0023] Fig. 1 is a plane view showing an outline shape of a front side of a movement of a mechanical time piece according to the invention (in Fig. 1, portions of parts are omitted and bridge members are indicated by imaginary lines).

[0024] Fig. 2 is an outline sectional view of portions of the movement of the mechanical time piece according to the invention (in Fig. 2, portions of parts are omitted).

[0025] Fig. 3 is a plane view of an enlarged portion showing an outline shape of a portion of a balance with hairspring of the mechanical time piece according to the invention in a state in which a circuit is closed.

[0026] Fig. 4 is a sectional view of an enlarged portion showing an outline shape of the portion of the balance with hairspring of the mechanical time piece according to the invention in the state in which the circuit is closed.

[0027] Fig. 5 is a plane view of the enlarged portion showing the outline shape of the portion of the balance with hairspring of the mechanical time piece according to the invention in a state in which the circuit is opened.

[0028] Fig. 6 is a sectional view of the enlarged portion showing the outline shape of the portion of the balance with hairspring of the mechanical time piece according to the invention in the state in which the circuit is opened.

[0029] Fig. 7 is a block diagram showing operation when the circuit is opened and operation when the circuit is closed in the mechanical time piece according to the invention.

[0030] Fig. 8 is a graph showing an outline relationship between an elapse time period in which a mainspring is rewound from a fully wound state and mainspring torque in a mechanical time piece.

[0031] Fig. 9 is a graph showing an outline relationship of a swing angle of a balance with hairspring and mainspring torque according to a mechanical time piece.

[0032] Fig. 10 is a graph showing an outline relationship of a swing angle of a balance with hairspring and instantaneous rate in a mechanical time piece.

[0033] Fig. 11 is a graph showing an outline relationship between an elapse time period in which a mainspring is rewound from a fully wound state and instantaneous rate in a mechanical time piece according to the invention and a conventional mechanical time piece.

[0034] Fig. 12 is a plane view showing an outline shape of a front side of a movement of a conventional mechanical time piece (in Fig. 12, portions of parts are omitted and bridge members are indicated by imaginary lines).

[0035] Fig. 13 is an outline sectional view showing a portion of a movement in the conventional mechanical time piece (in Fig. 13, portions of parts are omitted).

Best Mode for Carrying Out the Invention

[0036] An explanation will be given of embodiments of a mechanical time piece according to the invention in reference to the drawings as follows.

[0037] In reference to Fig. 1 and Fig. 2, according to an embodiment of a mechanical time piece of the invention, a movement (machine body) 300 of the mechanical time piece is provided with 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 (refer to Fig. 2) is attached to the movement 300.

[0038] 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 a 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 300. The tooth B is provided at an end portion of the clutch wheel proximate to an outer side of the movement 300.

[0039] The movement 300 is provided with a switch apparatus for determining a position of the winding stem 110 in the axial line direction. The switch apparatus includes a setting lever 190, a yoke 192, a yoke spring 194 and a setting lever jumper 196. Based on rotation of the setting lever 190, the position in the rotational axis line of the winding stem 110 is determined. Based on rotation of the yoke 192, a position in the rotational axis line direction of the clutch wheel is determined. Based on rotation of the setting lever 190, the yoke 192 is positioned to two positions in the rotational direction.

[0040] A winding pinion 112 is provided rotatably at 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-stage) most proximate to the inner side of the movement 300 along the rotational axis line, the winding pinion 112 is constituted to rotate via rotation of the clutch wheel. A crown wheel 114 is constituted to rotate by rotation of the winding pinion 112. A ratchet wheel 116 is constituted to rotate by rotation of the crown wheel 114.

[0041] The movement 300 is provided with a mainspring 122 contained in a barrel complete 120 as its power source. The mainspring 122 is made of an elastic material having spring performance such as iron. By rotating the ratchet wheel 116, the mainspring 122 is constituted to be capable of being wound up.

[0042] A center wheel & pinion 124 is constituted to rotate by rotation of the barrel complete 120. A third wheel & pinion 126 is constituted to rotate based on rotation of the center wheel & pinion 124. A fourth wheel & pinion 128 is constituted to rotate based on rotation of the third wheel & pinion 126. An escape wheel & pin-

ion 130 is constituted 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.

[0043] The movement 300 is provided 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 right rotation and left rotation at a constant period, the escape wheel & pinion 130 rotating based on rotation of the front train wheel and a pallet fork 142 for controlling rotation of the escape wheel & pinion 130 based on operation of the balance with hairspring 140.

[0044] The balance with hairspring 140 includes a balance stem 140a, a balance wheel 140b and a hairspring 140c. The hairspring 140c is made of an elastic material having spring performance such as "elinbar". That is, the hairspring 140c is made of an electrically conducting material of metal.

[0045] Based on rotation of the center wheel & pinion 124, a cannon pinion 150 is simultaneously rotated. A minute hand 152 attached to the cannon pinion 150 is constituted to display "minute". The cannon pinion 150 is provided with a slip mechanism having a predetermined slip torque relative to the center wheel & pinion 124.

[0046] Based on rotation of the cannon pinion 150, a minute wheel (not illustrated) is rotated. Based on rotation of the minute wheel, an hour wheel 154 is rotated. An hour hand 156 attached to the hour wheel 154 is constituted to display "hour".

[0047] The barrel complete 120 is supported rotatably by the main plate 102 and a barrel bridge 160. The center wheel & pinion 124, the third wheel & pinion 126, the fourth wheel & pinion 128 and the escape wheel & pinion 130 are supported rotatably by the main plate 102 and a train wheel bridge 162. The pallet fork 142 is supported rotatably by the main plate 102 and a pallet bridge 164.

[0048] The balance with hairspring 140 is supported rotatably by the main plate 102 and a balance bridge 166. That is, an upper mortise 140a1 of the balance stem 140a is supported rotatably by a balance upper bearing 166a fixed to the balance bridge 166. The balance upper bearing 166a includes a balance upper hole jewel and a balance upper cap jewel. The balance upper hole jewel and the balance upper cap jewel are made of an insulating material such as ruby.

[0049] A lower mortise 140a2 of the balance stem 140a is supported rotatably by a balance lower bearing 102b fixed to the main plate 102. The balance lower bearing 102b includes a balance lower hole jewel and a balance lower cap jewel. The balance lower hole jewel and the balance lower cap jewel are made of an insulating material such as ruby.

[0050] The hairspring 140c is a leaf spring in a helical (spiral) shape having a plural turn number. An inner end portion of the hairspring 140c is fixed to a hairspring holder 140d fixed to the balance stem 140a and an outer end portion of the hairspring 140c is fixed by screws via a hairspring holder 170a attached to a hairspring holder cap 170 rotatably fixed to the balance bridge 166. The balance bridge 166 is made of an electrically conductive material of metal such as brass. The hairspring holder cap 170 is made of an eclectically conductive material of metal such as iron.

[0051] Next, an explanation will be given of a balance rotational angle control mechanism of a mechanical time piece according to the invention.

[0052] In reference to Fig. 1 through Fig. 4, a switch lever 168 is rotatably attached to the balance bridge 166. The switch lever 168 is attached with a first degree contact member 340 and a second degree contact member 342. The switch lever 168 is attached to the balance bridge 166 and is rotatably attached thereto centering on the rotational center of the balance with hairspring 140. The switch lever 168 is formed by an insulating material of plastic such as polycarbonate. A switch lead substrate 310 is arranged to the switch lever 168. The switch lead substrate 310 is provided with a switch pattern 310a. The switch lead substrate 310 is, for example, constituted by two faces substrate having copper foil patterns on the two faces and the switch patterns 310a are formed to conduct the copper foil patterns provided on the two faces by through-hole plating. As a modified example, in place of the switch pattern 310a, a switch pin fabricated by a conductive material of brass or the like may be provided.

[0053] The first degree contact member 340 and the second degree contact member 342 are fixed to the switch lever 168 by penetrating the switch lead substrate 310. It is preferable that the first degree contact member 340 and the second degree contact member 342 are fabricated by a metal such as brass. The first degree contact member 340 and the second degree contact member 342 may be fabricated by plastic.

[0054] A hairspring switch member 312 is attached to the switch lever 168. The hairspring switch member 312 is fabricated by a conductive material and is preferably fabricated by, for example, a metal such as brass. The hairspring switch member 312 is rotatably attached to the switch lever 168 to be able to produce two states of a state of being conducted to the switch pattern 310a of the switch lead substrate 310 and a state of not being conducted to the switch pattern 310a of the switch lead substrate 310. That is, in a state in which the hairspring switch member 312 is rotated and is brought into contact with the first degree contact member 340 or the second degree contact member 342, the hairspring switch member 312 is constituted not to be conducted to the switch pattern 310a of the switch lead substrate 310.

[0055] The hairspring switch member 312 is provided with a hairspring receive portion 312h formed in a groove-like shape for receiving a portion 140ct proximate to an outer end portion of the hairspring 140c. The portion 140ct proximate to the outer end portion of the

hairspring 140c is disposed in the groove of the hairspring receive portion 312h. The portion 140ct proximate to the outer end portion of the hairspring 140c is brought into contact with the hairspring switch member 312.

[0056] Amain plate insulating base plate 320 is fixed by adhering or the like to a face of the main plate 102 on the surface side such that a portion thereof is opposed to a face of the balance wheel 140b on the main plate side. The main plate insulating base plate 320 is fabricated by an insulating material such as polyimide. Amain plate insulating base plate 322 is attached by adhering or the like to a face of the main plate insulating base plate 320 on the surface side such that a portion thereof is opposed to the face of the balance wheel 140b on the main plate side. The main plate insulating plate 322 is provided with a plane shape in a ring-like shape and is fabricated by an insulating member such as polyimide, polycarbonate, polyethersulfon or the like. Further, the main plate insulating plate 322 is formed in a shape of escaping from the escape wheel & pinion 130 and the pallet fork 142.

[0057] A balance insulating plate 324 is attached to a face of the balance wheel 140b on the main plate side to be opposed to a face of the main plate insulating plate 322 on the surface side. The balance insulating plate 324 is provided with a plane shape in a ring-like shape and is fabricated by an insulating material such as polyimide, polycarbonate, polyethersulfon or the like. The plane shape of the balance insulating plate 324 is formed to be substantially equal to the plane shape of the main plate insulating plate 322 or smaller than the plane shape of the main plate insulating plate 322. The balance insulating plate 324 is fixed by adhering or the like to the face of the balance wheel 140b on the main plate side in a state in which one face thereof is brought into contact with a ring-like rim portion of the balance wheel 140b and other face thereof is opposed to the face of the main plate insulating plate 322 on the surface side.

[0058] A clearance is provided between the base plate insulating plate 322 and the balance insulating plate 324. The clearance between the main plate insulating plate 322 and the balance insulating plate 324 is determined such that static electricity is generated between the main plate insulating plate 322 and the balance insulating plate 324 by rotation of the balance wheel 140b.

[0059] A resistor 326 is attached by adhering or the like to the face of the main plate insulating base plate 320 on the surface side. The resistor 326 is of, for example, 100 ohm through 1 kiloohm. When a value of the resistor is excessively small, spark is induced and when the value of the resistor is excessively large, brake is excessively effected and accordingly, the value of the resistor can specifically be calculated by a calculation from electrostatic force and necessary brake force.

[0060] A first lead wire 330 is provided to connect one terminal of the resistor 326 and the switch pattern 310a of the switch lead substrate 310. The switch pattern 310a is conducted to the hairspring switch member 312 when rotational angle of the balance with hairspring 140 is smaller than a predetermined angle. A second lead wire 332 is provided to connect the main plate insulating plate 322 and the hairspring holder 170a. A third lead wire 334 is provided to connect the main plate insulating plate 322 and other terminal of the resistor 326.

[0061] Further, although in Fig. 2, Fig. 4 and Fig. 6, a thickness of the hairspring 140c (thickness in a radius direction of the balance with hairspring) is illustrated to exaggerate, the thickness is, for example, 0.021 millimeter. According to the balance insulating plate 324, for example, an outer diameter thereof is about 9 millimeters, an inner diameter thereof is about 7 millimeters and a thickness thereof is about 1 millimeter. According to the main plate insulating plate 322, for example, an outer diameter thereof is about 10 millimeters, an inner diameter thereof is about 6 millimeters and a thickness thereof is about 1 millimeter. The clearance STC between the main plate insulating plate 322 and the balance insulating plate 324 is, for example, about 0.4 millimeter.

[0062] Next, an explanation will be given of the balance with hairspring 140 when a circuit is closed in reference to Fig. 3, Fig. 4 and Fig. 7.

[0063] The hairspring 140c is expanded or contracted in the radius direction of the hairspring 140c in accordance with the rotational angle for rotating the balance with hairspring 140. For example, in a state shown by Fig. 3, when the balance with hairspring 140 is rotated in the clockwise direction, the hairspring 140c is contracted in a direction toward the center of the balance with hairspring 140, in contrast thereto, when the balance with hairspring 140 is rotated in the counterclockwise direction, the hairspring 140c is expanded in a direction remote from the center of the balance with hairspring 140.

[0064] Therefore, in Fig. 4, when the balance with hairspring 140 is rotated in the counterclockwise direction, the portion 140ct proximate to the outer end portion of the hairspring 140c is operated to be brought into contact with the outer side of the groove of the hairspring receive portion 312h of the hairspring switch member 312. Further, when the balance with hairspring 140 is rotated in the clockwise direction, the portion 140ct proximate to the outer end portion of the hairspring 140c is operated to be brought into contact with the inner side of the groove of the hairspring receive portion 312h of the hairspring switch member 312.

[0065] When the rotational angle (swing angle) of the balance with hairspring 140 is less than a constant threshold, for example, 180 degree, an amount of expanding and contracting the hairspring 140c in the radius direction is small and therefore, the hairspring 140c is brought into contact with the groove of the hairspring receive portion 312h of the hairspring switch member

312 and the hairspring switch member 312 stays to be conducted to the switch pattern 310a of the switch lead substrate 310.

[0066] Therefore, in a state in which the swing angle of the balance with hairspring 140 falls in a range of exceeding 0 degree and less than 180 degree, the outer side portion of the hairspring receive portion 312h of the hairspring switch member 312 is not brought into contact with the first degree contact member 340 and is not brought into contact with the second degree contact member 342.

[0067] Under the state, the base plate insulating member 322 is conducted to the hairspring 140c and the hairspring holder 170a via the resistor 326. As aresult, the main plate insulating plate 322 is brought into a shortcircuited state and therefore, even when the balance with hairspring 140 is rotated, static electricity is not generated between the base plate insulating plate 322 and the balance insulating plate 324.

[0068] Next, an explanation will be given of operation of the balance with hairspring 140 when the circuit is opened in reference to Fig. 5, Fig. 6 and Fig. 7. That is, Fig. 5 and Fig. 6 show a case in which the swing angle of the balance with hairspring 140 is equal to or larger than 180 degree.

[0069] Further, in Fig. 6, the thickness of the hairspring 140c (thickness of the balance with hairspring in the radius direction) is illustrated to exaggerate.

[0070] When the rotational angle (swing angle) of the balance with hairspring 140 is equal to or larger than a constant threshold, for example, 180 degree, the amount of expanding and contracting the hairspring 140c in the radius direction is sufficiently large and accordingly, the hairspring 140c pushes the groove of the hairspring receive portion 312h of the hairspring switch member 312 in an outward or an inward direction, the hairspring switch member 312 is rotated and is not conducted to the switch pattern 310a of the switch lead substrate 310. Further, the outer side portion of the hairspring receive portion 312h of the hairspring switch member 312 is brought into contact with and positioned by the first degree contact member 340 and the second degree contact member 342.

[0071] Under the state, the main plate insulating plate 322 is not shortcircuited and therefore, static electricity is generated between the base plate insulating plate 322 and the balance insulating plate 324. By the static electricity, a force of restraining rotational motion of the balance with hairspring 140 is exerted to the balance with hairspring 140. Further, by the operation, balance brake force of restraining rotation of the balance with hairspring 140 is exerted and the swing angle of the balance with hairspring 140 is reduced.

[0072] Further, when the swing angle of the balance with hairspring 140 is reduced to arrange of exceeding 0 degree and less than 180 degree, the rotational angle of the hairspring switch member 312 is reduced and the hairspring switch member 312 is conducted to the switch pattern 310a of the switch lead substrate 310. Then, as shown by Fig. 3 and Fig. 4, the main plate insulating plate 322 is brought into the shortcircuited state and therefore, even when the balance with hairspring 140 is rotated, static electricity is not generated between the main plate insulating plate 322 and the balance insulating plate 324.

[0073] According to the mechanical time piece of the invention constituted in this way, the rotational angle of the balance with hairspring 140 can efficiently be controlled.

[0074] As has been explained above, the invention is constructed by the constitution having the balance rotational angle control mechanism in the mechanical time piece constituted such that the escapement & speed control apparatus includes the balance with hairspring repeating right rotation and left 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 & train based on an operation of the balance with hairspring and accordingly, the accuracy of the mechanical time piece can be promoted without reducing the duration time period of the mechanical time piece.

[0075] That is, according to the invention, attention is paid to the correlation between the instantaneous rate and the swing angle, by maintaining constant the swing angle, the change in the instantaneous rate is restrained and the time piece is adjusted such that gain or loss of the time piece per day is reduced.

[0076] In contrast thereto, according to the conventional mechanical time piece, the swing angle is changed with elapse of time by the relationship between the duration time period and the swing angle. Further, by the relationship between the swing angle and the instantaneous rate, the instantaneous rate is changedwith elapse of time. Therefore, it has been difficult to prolong the duration time period of the time piece capable of maintaining constant accuracy.

[0077] Next, an explanation will be given of a result of a simulation with respect to the mechanical time piece of the invention which is developed to resolve the problem of the conventional mechanical time piece.

[0078] In reference to Fig. 11, the mechanical time piece according to the invention is initially adjusted to a state of gaining the instantaneous rate of the time piece as shown by plots of x marks and a slender line in Fig. 11. According to the mechanical time piece of the invention, when the balance with hairspring 140 is rotated by a certain angle or more, the outer side portion of the hairspring receive portion 312h of the hairspring switch member 312 is brought into contact with and positioned by the first degree contact member 340 and the second degree contact member 342, the effective length of the hairspring 140c is shortened and accordingly, the instantaneous rate is further gained.

[0079] According to the mechanical time piece of the invention, in a state in which the outer side portion of

the hairspring receive portion 312h of the hairspring switch member 312 is separated from the first degree contact member 340 and the second degree contact member 342, as shown by plots of x marks and the slender line in Fig. 11, the rate is about 18 seconds / day in a state in which the mainspring is completely wound up (gain of about 18 seconds per day), when 20 hours has elapsed from the fully wound state, the instantaneous rate becomes about 13 seconds / day (gain of about 13 seconds per day) and when 30 hours has elapsed from the fully wound state, the instantaneous rate becomes about -2 seconds / day (loss of about 2 seconds per day).

[0080] Further, in the mechanical time piece of the invention, when the balance rotational angle control mechanism is assumed not to operate, as shown by plots in a triangular shape and a bold line in Fig. 11, in the state in which the outer side portion of the hairspring receive portion 312h of the hairspring switch member 312 is brought into contact with and positioned by the first degree contact member 340 and the second degree contact member 342, the rate is about 25 seconds / day in the state in which the mainspring is completely wound up (gain of about 25 seconds per day), when 20 hours has elapsed from the fully wound state, the instantaneous rate becomes about 20 seconds / day (gain of about 20 seconds per day) and when 30 hours has elapsed from the fully wound state, the instantaneous rate becomes about 5 seconds / day (gain of about 5 seconds per day).

[0081] In contrast thereto, according to the mechanical time piece of the invention, when the balance rotational angle control mechanism is operated, as shown by plots of black circles and an extremely bold line in Fig. 11, the instantaneous rate can be maintained at about 5 seconds / day until 27 hours has elapsed from a state of operating the balance rotational angle control mechanism, that is, the state in which the mainspring is completely wound up (state of gaining about 5 seconds per day is maintained) and when 30 hours has elapsed from the fully wound state, the instantaneous rate becomes about -2 seconds / day (loss of about 2 seconds per day).

[0082] According to the mechanical time piece having the balance rotational angle control mechanism of the invention, by controlling the swing angle of the balance with hairspring, the change in the instantaneous rate of the time piece is restrained and therefore, when compared with the conventional mechanical time piece shown by square plots and an imaginary line in Fig. 11, the elapse time period from the fully wound state in which the instantaneous rate is about 0 through 5 seconds / day can be prolonged.

[0083] That is, according to the mechanical time piece of the invention, the duration time period in which the instantaneous rate falls within plus and minus 5 seconds / day is about 32 hours. The value of the duration time period is about 1.45 times as large as the duration time period in which the conventional mechanical time piece falls within about plus and minus 5 seconds / day in the conventional mechanical time piece, or about 22 hours.

[0084] Therefore, according to the mechanical time piece of the invention, there is provided the result of the simulation in which the accuracy is very excellent in comparison with that of the conventional mechanical time piece.

Industrial Applicability

[0085] The mechanical time piece according to the invention is provided with the simple structure and is suitable for realizing a mechanical time piece having very excellent accuracy.

Claims

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

   a balance rotational angle control mechanism (322, 324, 326) constituted to generate static electricity when a rotational angle of the balance with hairspring (140) becomes equal to or larger than a predetermined threshold and not to generate the static electricity when the rotational angle of the balance with hairspring (140) does not exceed the threshold.

2. The mechanical time piece according to Claim 1, characterized in that the balance rotational angle control mechanism (322, 324, 326) includes a balance insulating plate (324) provided at the balance with hairspring (140) and a main plate insulating plate (322) arranged to a main plate (102) and a clearance is provided between the balance insulating plate (322) and the main plate insulating plate (322).

3. The mechanical time piece according to Claim 2, characterized in that the balance rotational angle control mechanism (322, 324, 326) including:

   a switch lever (168) rotatably attached to a bal-

ance bridge (166);
a hairspring switch member (312) attached rotatably to the switch lever (168) and provided to operate by being brought into contact with a hairspring; and
degree contact members (340, 342) for determining a position of the hairspring switch member (312);
wherein generation of the static electricity between the balance insulating plate (324) and the main plate insulating plate (322) can be controlled by rotating the hairspring switch member (312).

4. The mechanical time piece according to Claim 3, characterized in that the balance rotational angle control mechanism (322, 324, 326) includes a resistor (326) provided to shortcircuit the main plate insulating plate (322) and conducted to the main plate insulating plate (322) and the hairspring switch member (312).

FIG. 1

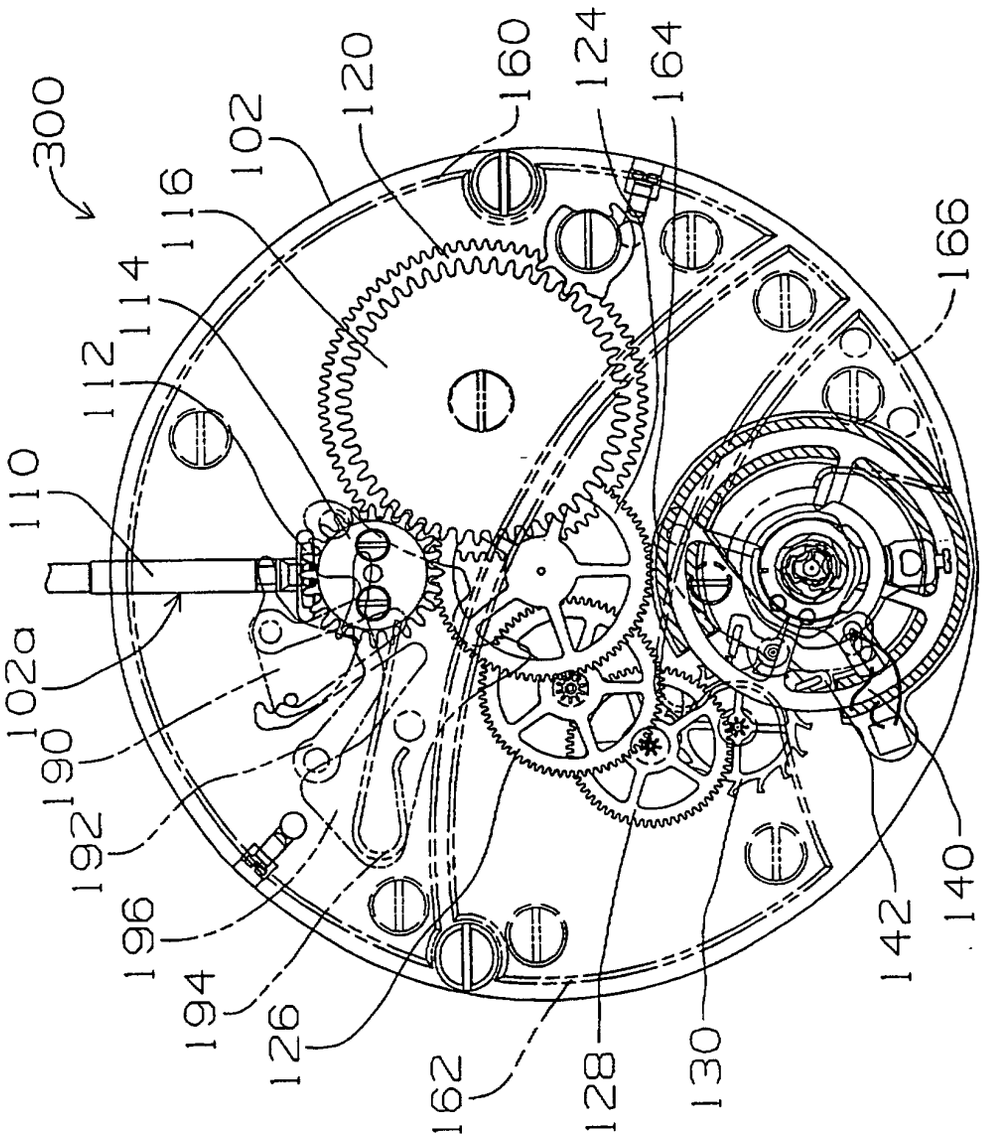

300
102
120
160
124
164
116
114
112
110
166
102a
190
192
196
194
126
162
128
130
142
140

FIG. 2

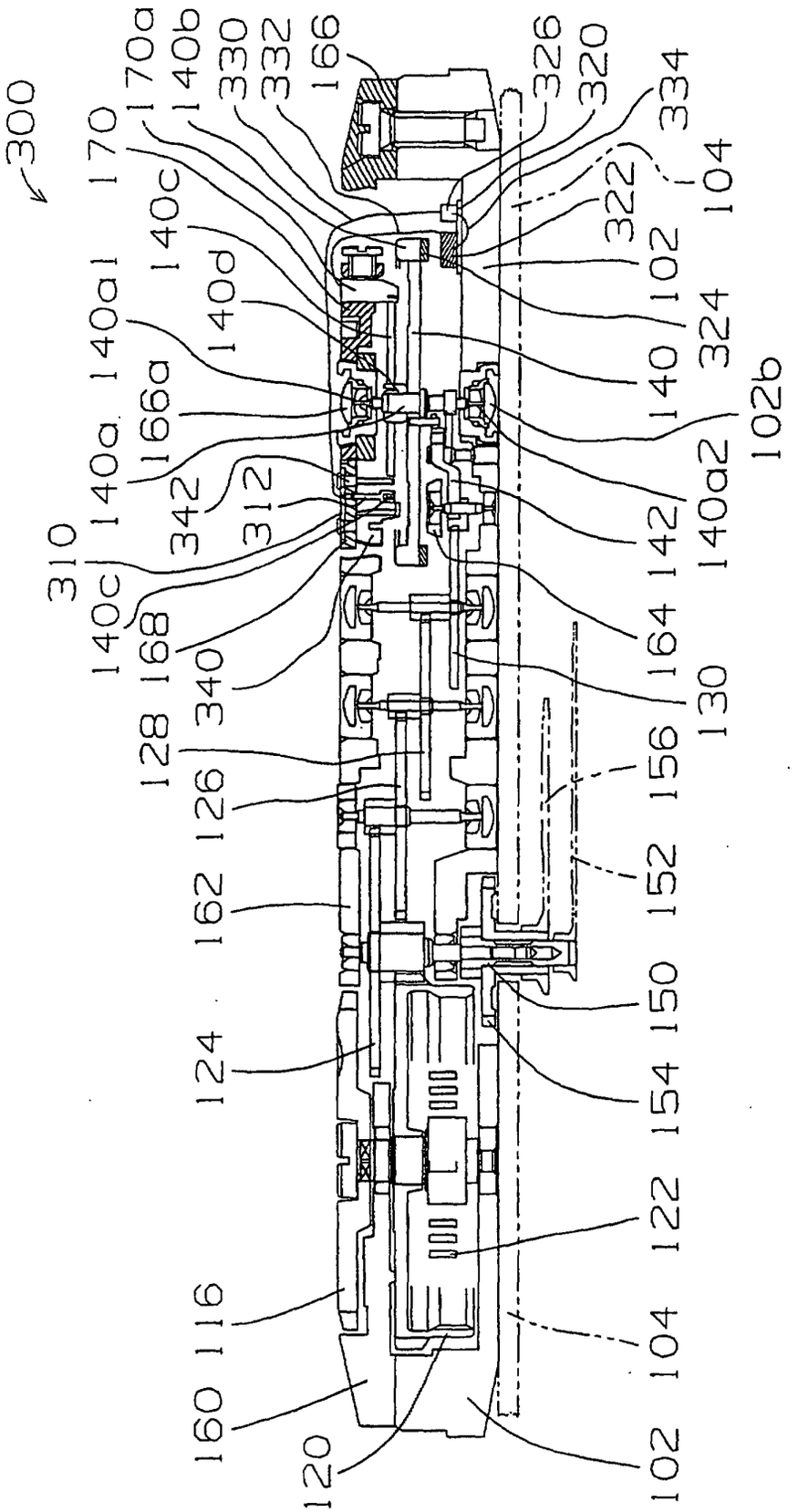

300
170
170a
140b
330
332
166
326
320
334
104
322
102
140c
140d
140
324
102b
140a1
140a
166a
342
312
310
140c
168
340
128
126
162
124
160
116
120
140a2
142
164
130
156
152
150
154
122
104
102

FIG. 3

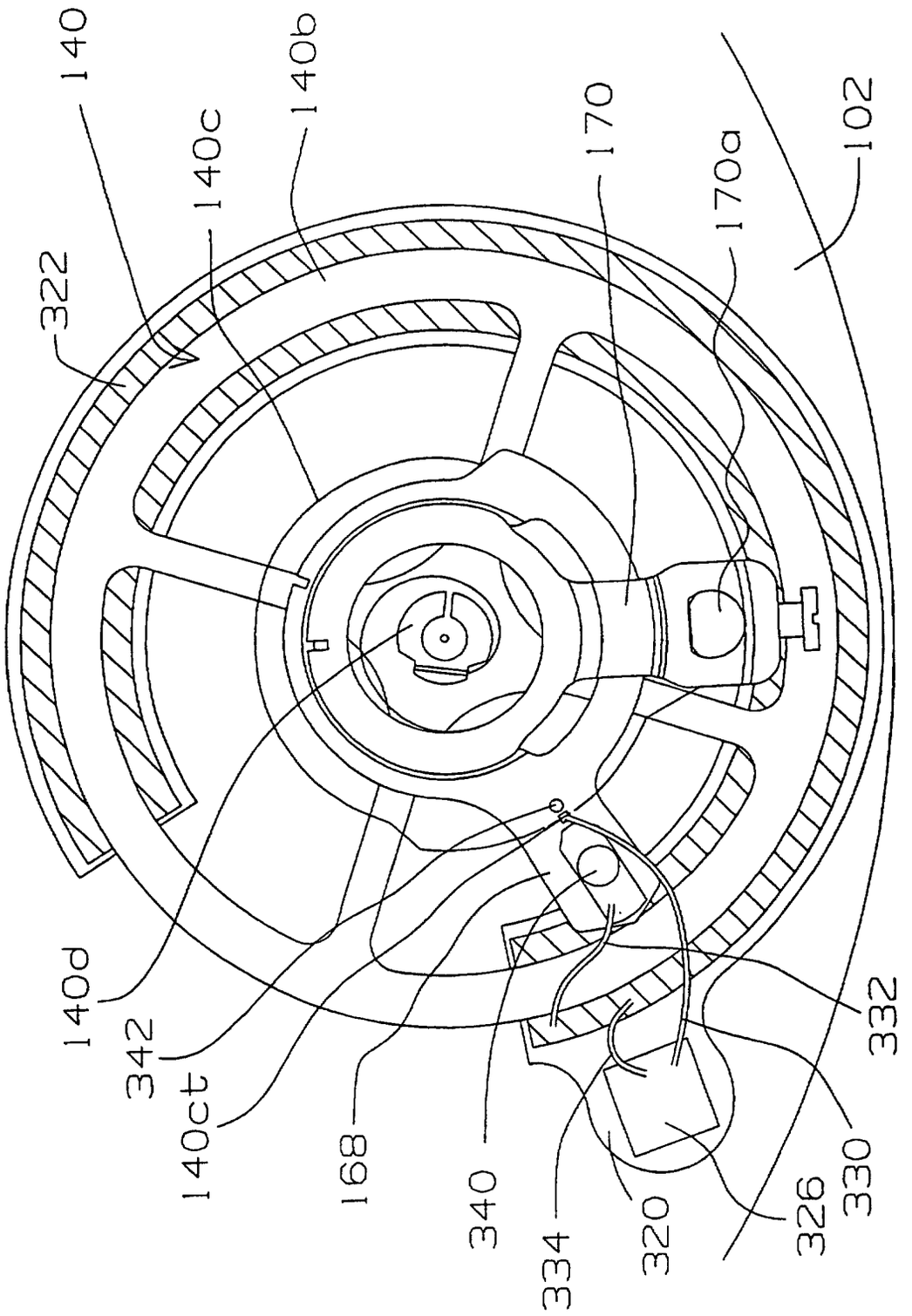

140
140c
140b
170
170a
102
322
140d
342
140ct
168
340
334
320
326
330
332

FIG. 4

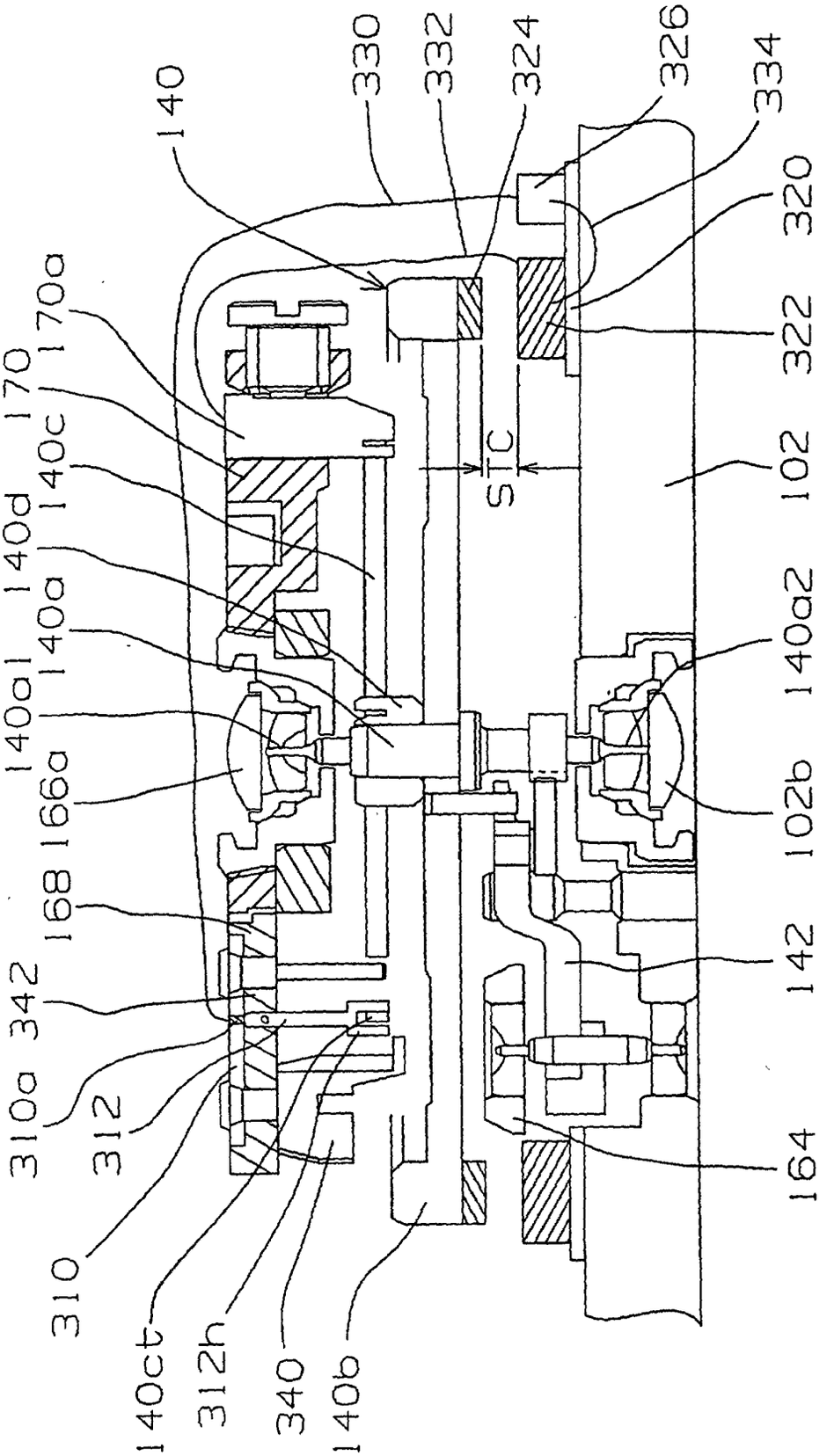

140
330
332
324
326
334
320
322
170a
170
140c
140d
140a
140a1
166a
168
342
310a
312
310
140ct
312h
340
140b
STC
102
140a2
102b
142
164

FIG. 5

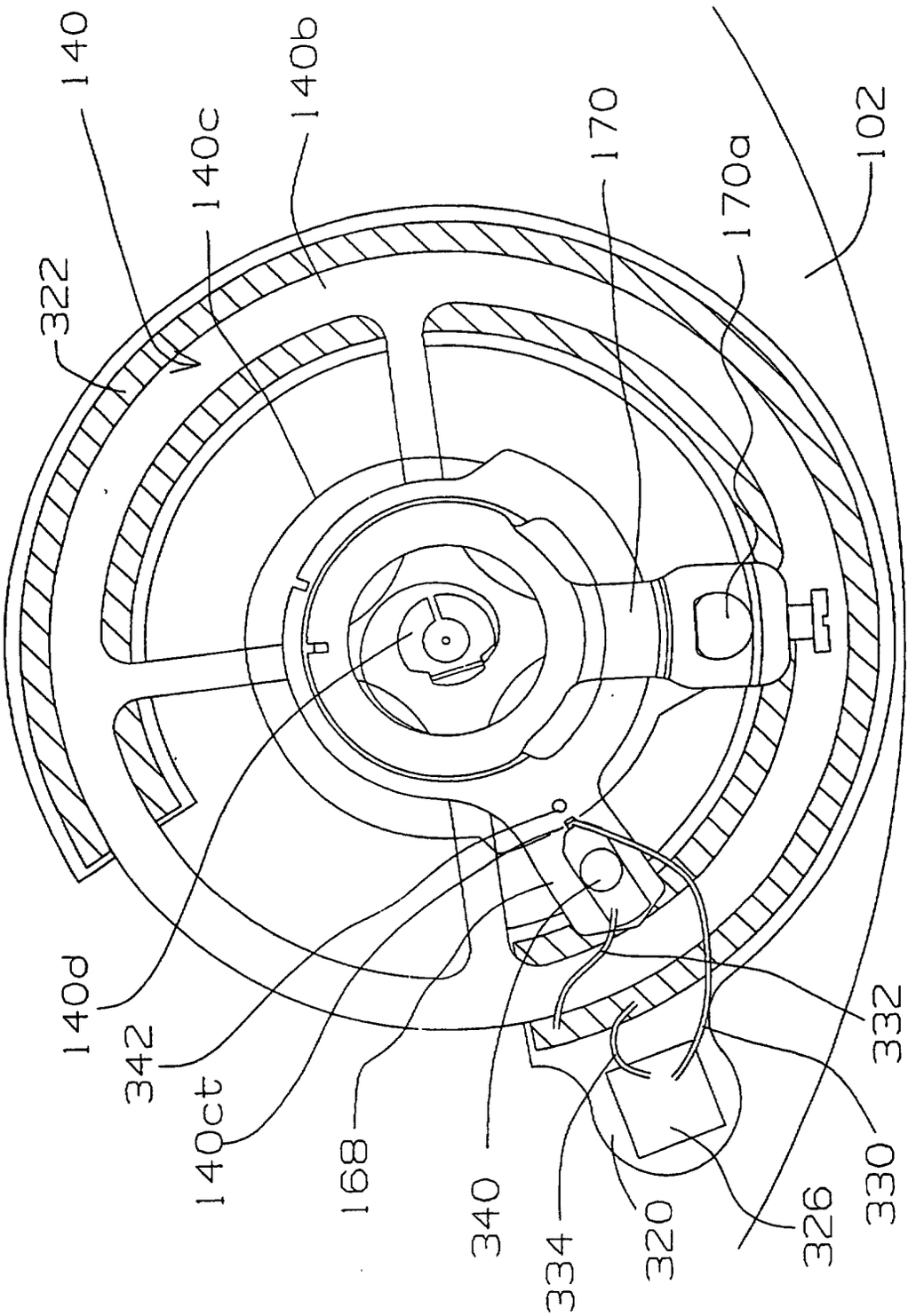

140
140c
140b
170
170a
102
322
140d
342
140ct
168
340
334
320
326
330
332

FIG. 6

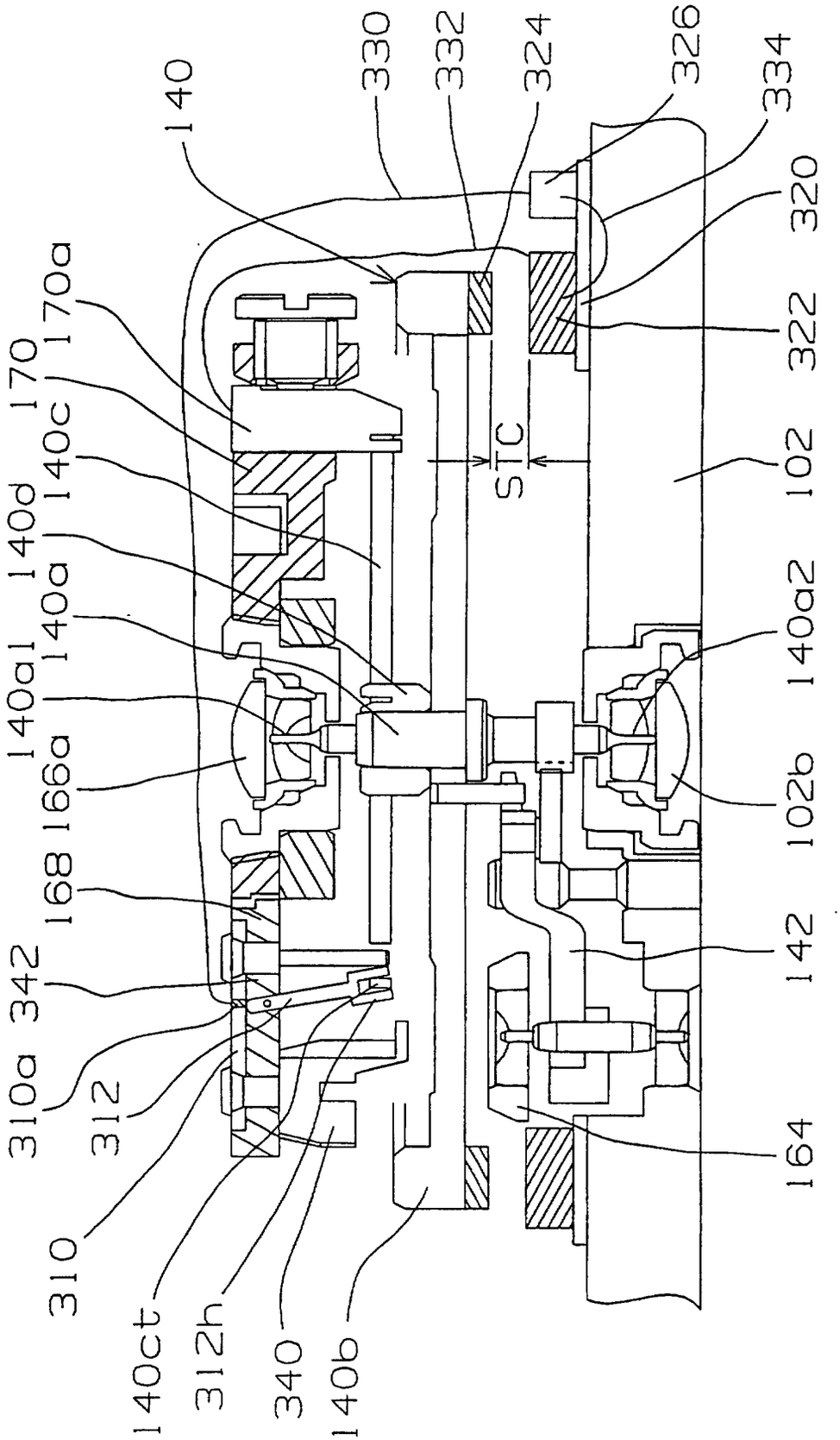

140
330
332
324
326
334
320
322
170a
170
140c
140d
140a
140a1
166a
168
342
310a
312
310
140ct
312h
340
140b
STC
102
140a2
102b
142
164

FIG.7

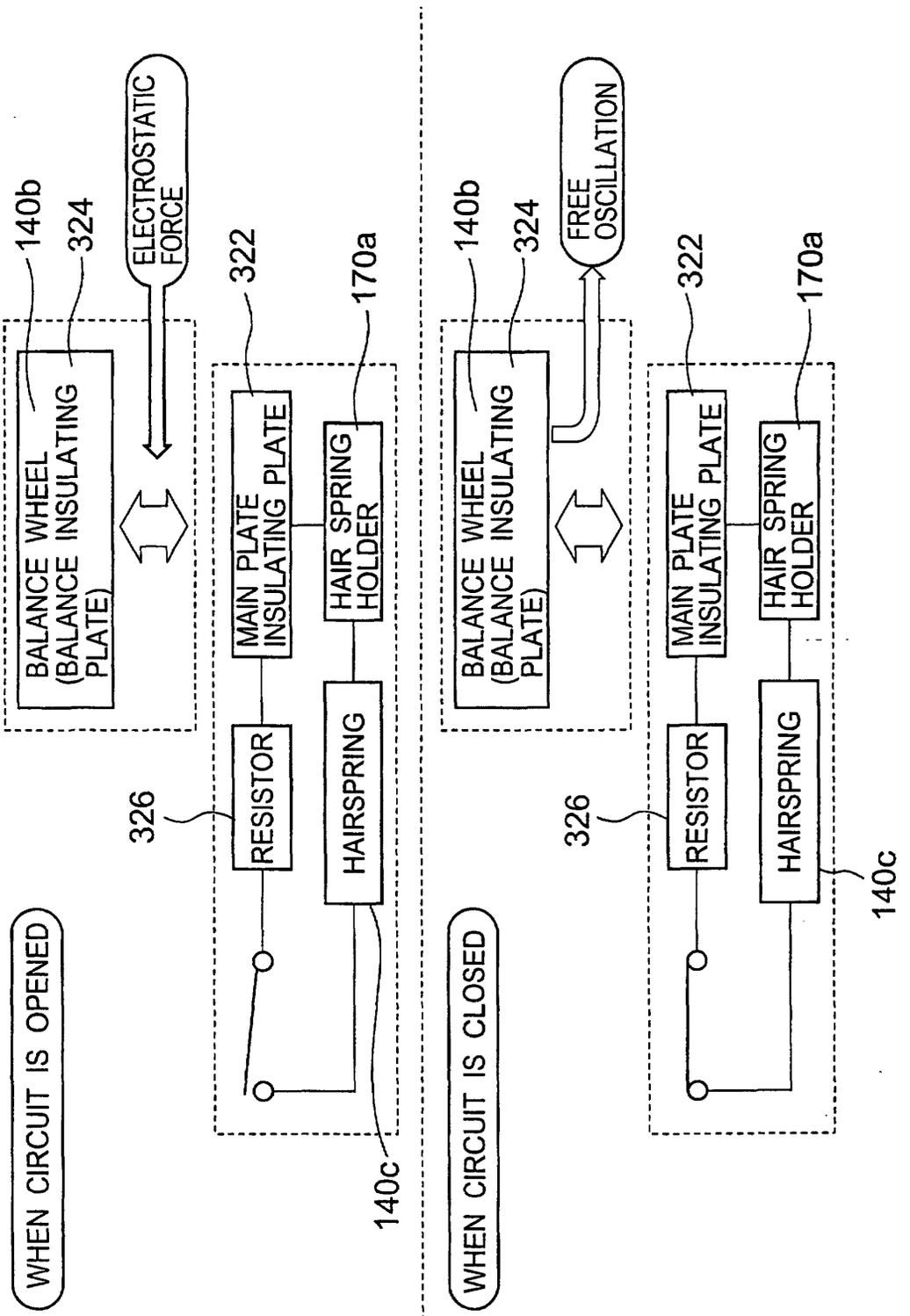

WHEN CIRCUIT IS OPENED
BALANCE WHEEL (BALANCE INSULATING PLATE)
140b
324
ELECTROSTATIC FORCE
322
MAIN PLATE INSULATING PLATE
HAIR SPRING HOLDER
170a
326
RESISTOR
HAIRSPRING
140c
WHEN CIRCUIT IS CLOSED
BALANCE WHEEL (BALANCE INSULATING PLATE)
140b
324
FREE OSCILLATION
322
MAIN PLATE INSULATING PLATE
HAIR SPRING HOLDER
170a
326
RESISTOR
HAIRSPRING
140c

FIG.8

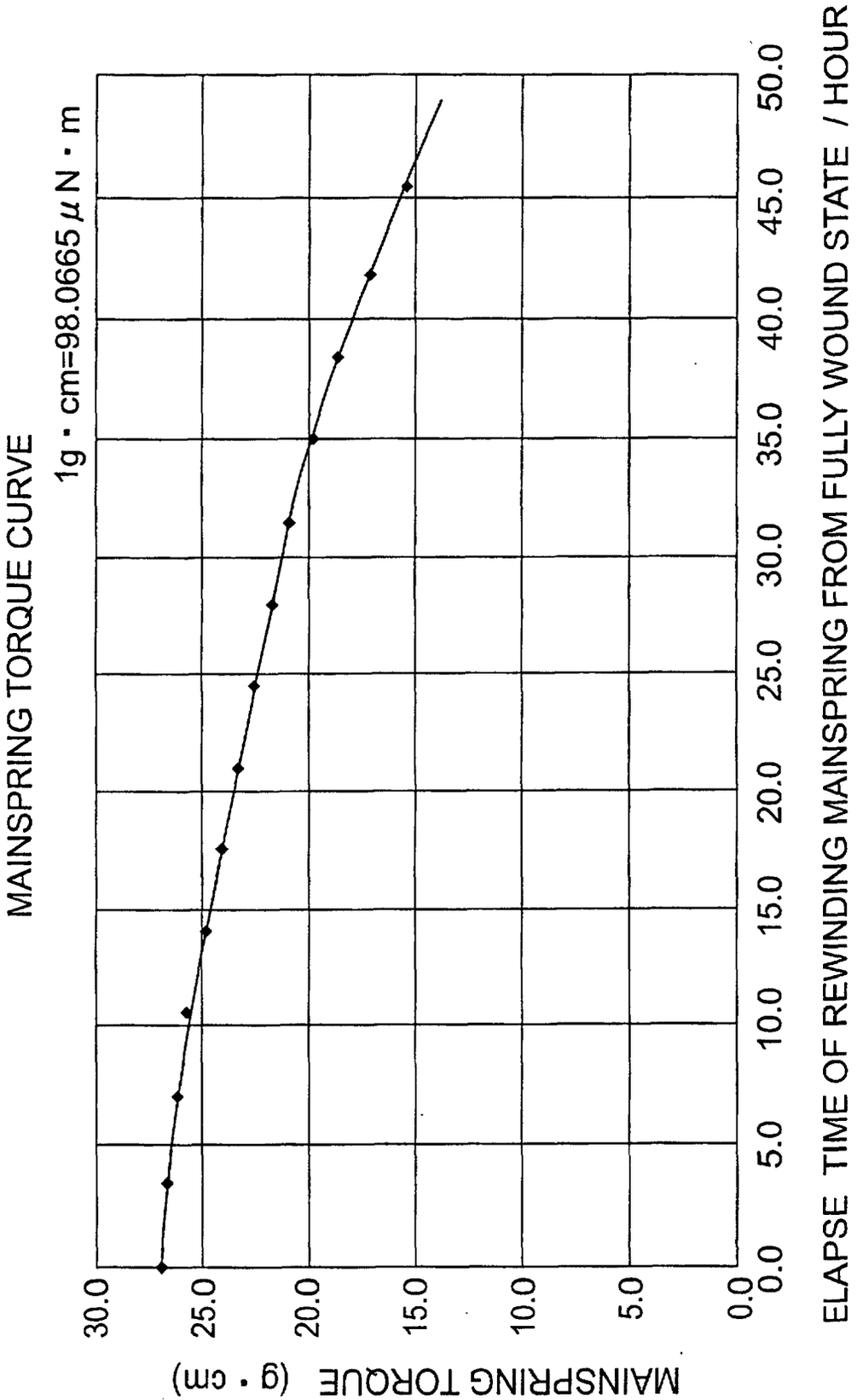

MAINSPRING TORQUE CURVE
1g • cm=98.0665 μ N • m
MAINSPRING TORQUE (g • cm)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
ELAPSE TIME OF REWINDING MAINSPRING FROM FULLY WOUND STATE / HOUR

FIG.9

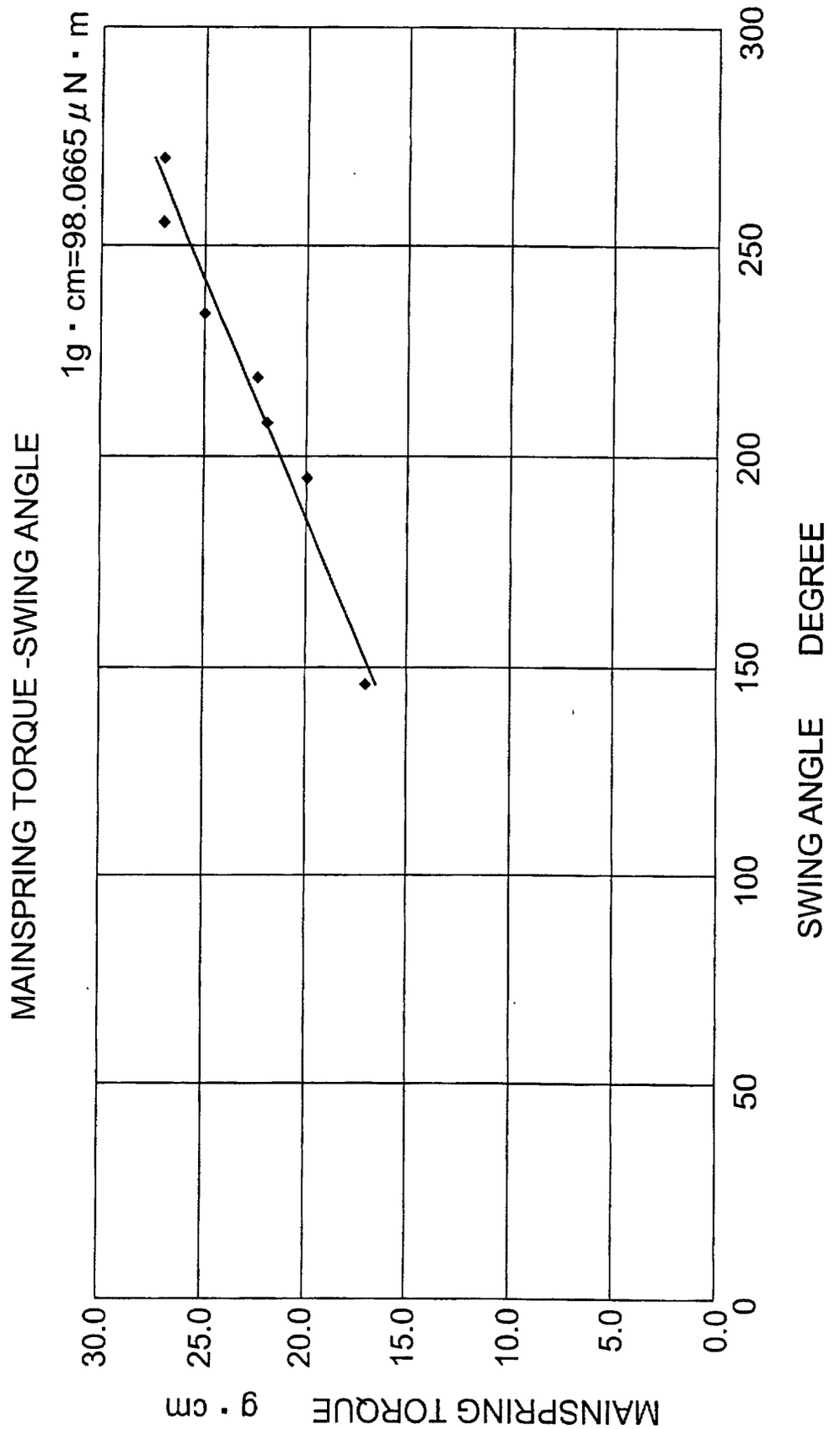

MAINSPRING TORQUE -SWING ANGLE
1g・cm=98.0665μN・m
MAINSPRING TORQUE g・cm
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
250
300
SWING ANGLE DEGREE

FIG.10

TRANSITIONAL CHANGE OF INSTANTANEOUS RATE BY SWING ANGLE

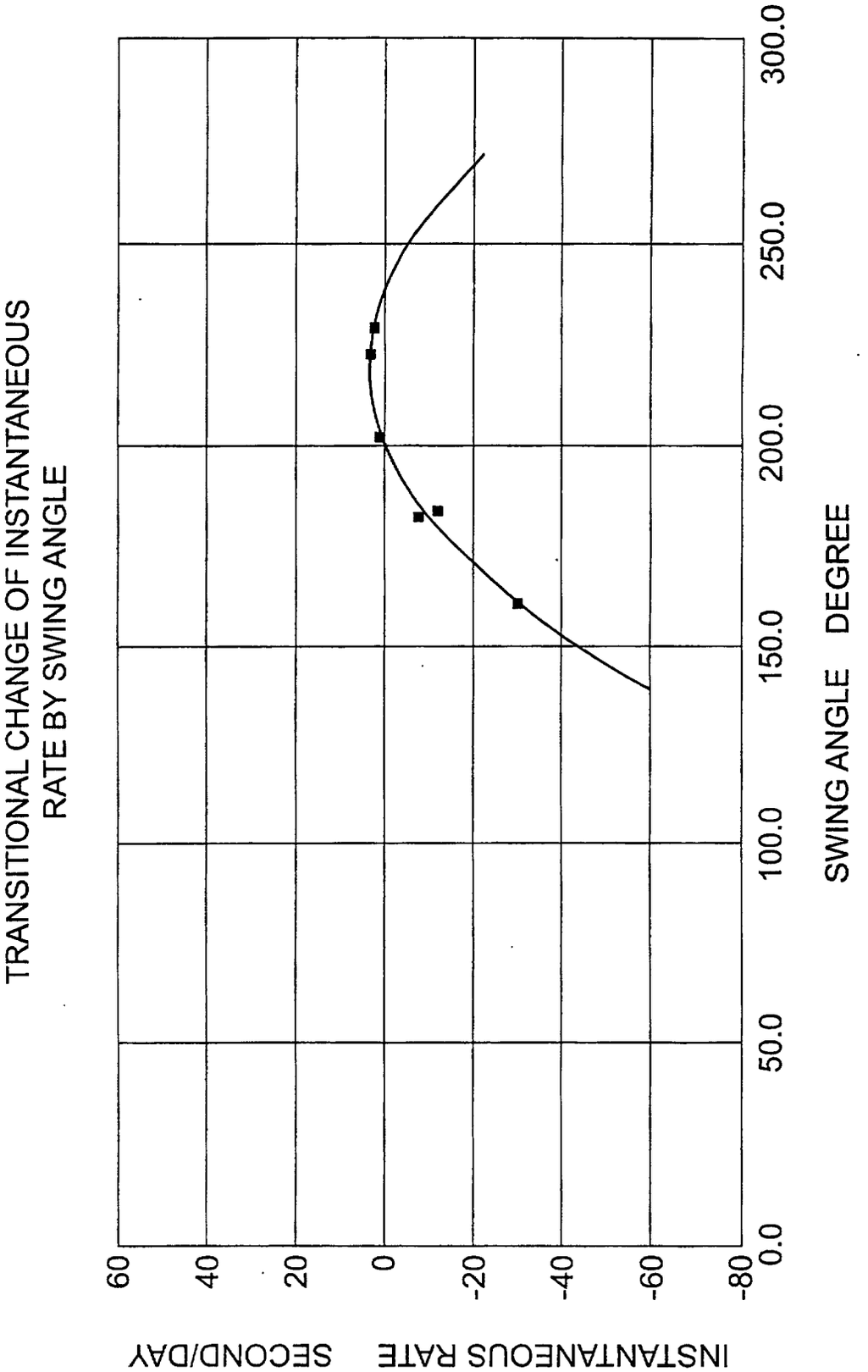


FIG.11

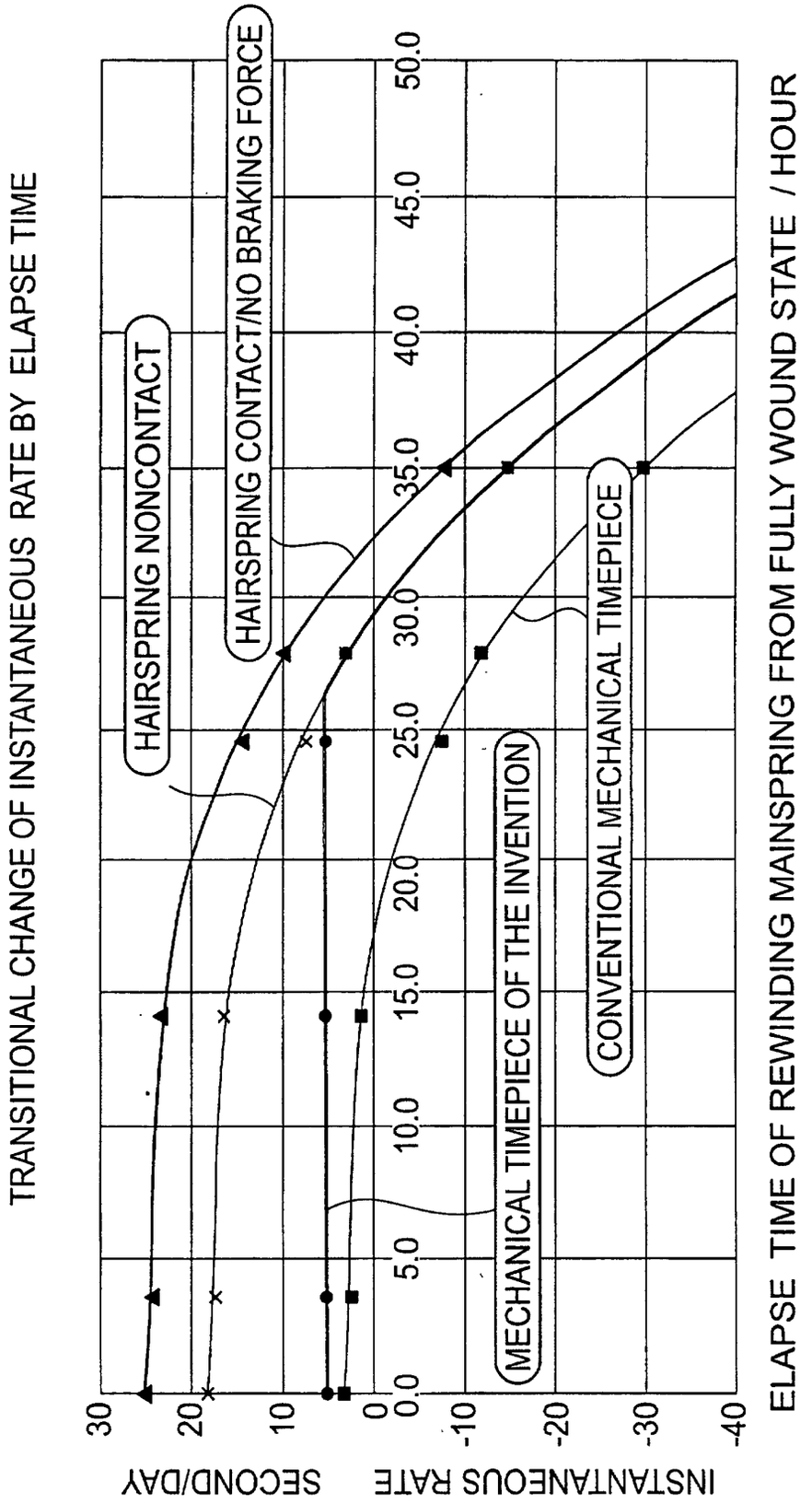

TRANSITIONAL CHANGE OF INSTANTANEOUS RATE BY ELAPSE TIME
HAIRSPRING NONCONTACT
HAIRSPRING CONTACT/NO BRAKING FORCE
MECHANICAL TIMEPIECE OF THE INVENTION
CONVENTIONAL MECHANICAL TIMEPIECE
INSTANTANEOUS RATE SECOND/DAY
30
20
10
0
-10
-20
-30
-40
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
ELAPSE TIME OF REWINDING MAINSPRING FROM FULLY WOUND STATE / HOUR

FIG. 12

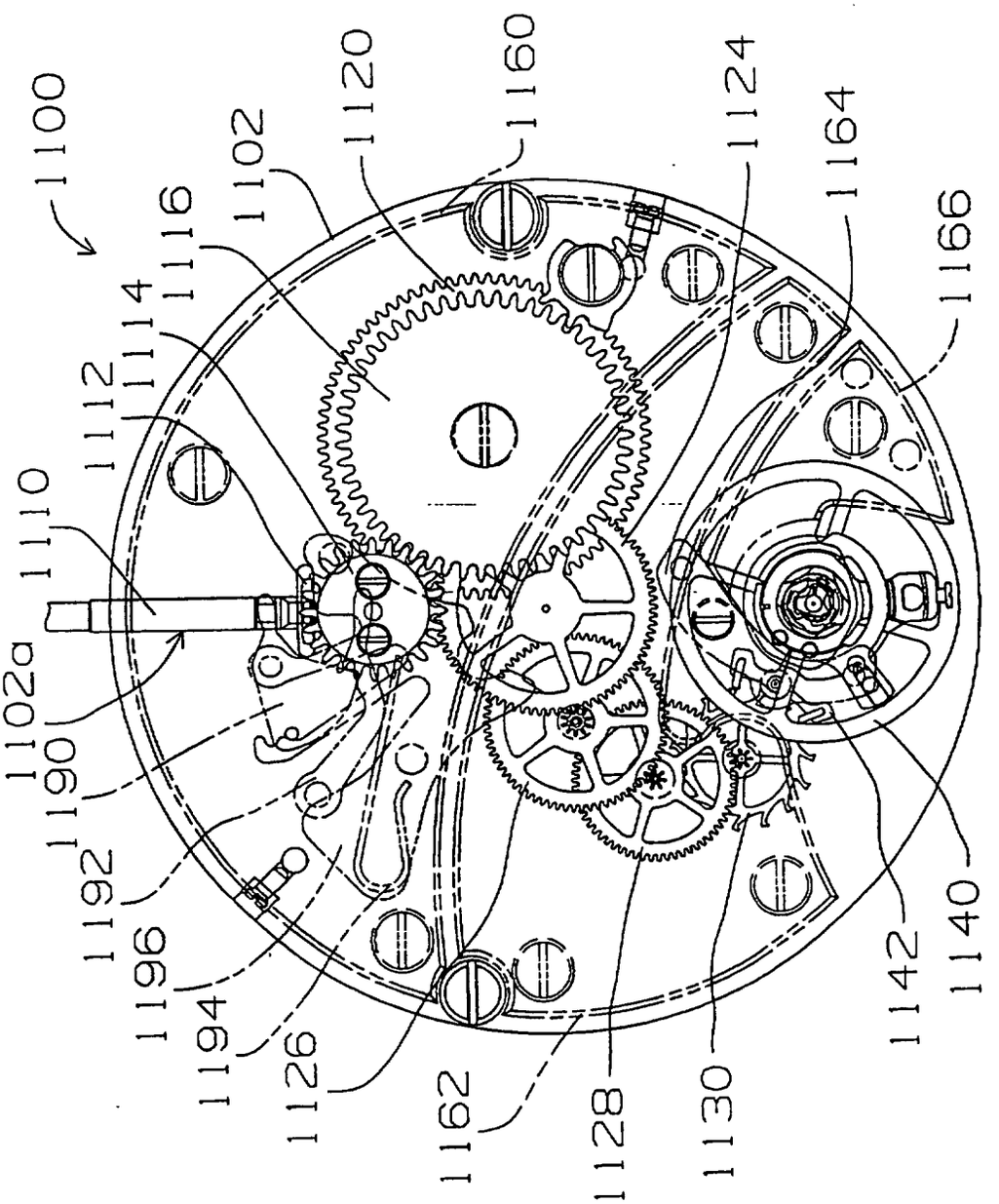
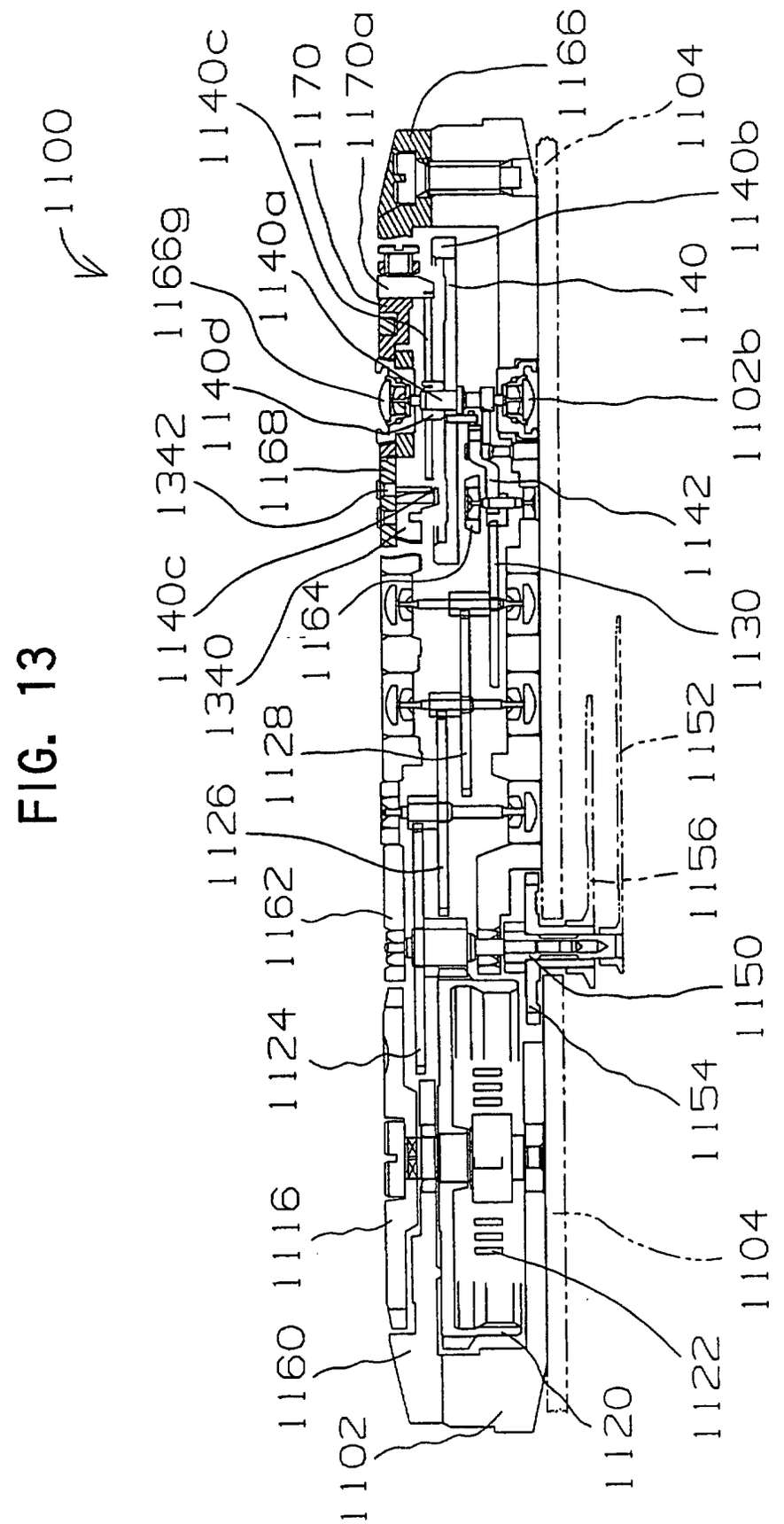

1100
1102
1120
1160
1124
1164
1166
1116
1114
1112
1110
1102a
1190
1192
1196
1194
1126
1162
1128
1130
1142
1140

FIG. 13


1100
1140c
1170
1170a
1166
1104
1140b
1669
1140a
1140
1140d
1102b
1342
1168
1142
1140c
1164
1130
1340
1128
1152
1126
1156
1162
1150
1124
1154
1116
1104
1160
1122
1102
1120

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/03488

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] G04B17/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] G04B17/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-1999
Kokai Jitsuyo Shinan Koho 1971-1999 Jitsuyo Shinan Toroku Koho 1996-1999

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 48-43369, A (Bernard Golay S.A.), 22 June, 1973 (22. 06. 73), Full text ; all drawings & US, 3735586, A & DE, 2245548, A & FR, 2154666, A & GB, 1370172, A & IT, 985551, A	1-4
A	JP, 48-85278, A (Citizen Watch Co., Ltd.), 12 November, 1973 (12. 11. 73), Full text ; all drawings (Family: none)	1-4
A	JP, 57-1799, B (Rhythm Watch Co.Ltd.), 12 January, 1982 (12. 01. 82), Full text ; all drawings (Family: none)	1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 August, 1999 (23. 08. 99)	7 September, 1999 (07. 09. 99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)