

**SEIKO**

**QUARTZ WATCH**

**ANALOGUE TYPE**

**TECHNICAL MANUAL**

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## I. SEIKO QUARTZ WATCHES

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The SEIKO QUARTZ WATCH is a high-precision quartz crystal oscillator type watch developed by making the most of SEIKO's high-precision machining technology and micro-electronics of which SEIKO can boast in the field of horology. It is a reliable quartz crystal oscillator type watch manufactured by the integrated operation from all necessary parts to products based on SEIKO's more than ten years' experiences in the development of quartz watches. To offer a time standard, large scaled quartz clock systems are used at observatories and broadcasting stations in various parts of the world. SEIKO has been making efforts to miniaturize these systems into a high-precision low-energy wrist watch. In 1962, SEIKO succeeded in putting on the market a desk-top quartz clock. Following this, SEIKO announced quartz pocket watches and quartz wrist watches in rapid succession and won a series prize in Les Concours des Chronomètres d'Observatoire à Neuchâtel. In 1969, SEIKO brought to market Cal. 35 series, the first quartz wrist watch in the world. And SEIKO has been trying to apply these achievements to the manufacture and diversification of its models. Now SEIKO offers a great variety of timepieces from ultra-high-precision TWIN QUARTZ, popular QUARTZ WATCHES to fashionable ultrathin quartz watches to give the customers a wide range of selection.

### FEATURES OF SEIKO Quartz Watches

- **High reliability**

Every part of SEIKO QUARTZ WATCHES is a SEIKO's original into which its efforts and experiences of many years are incorporated. All the components are manufactured through a continuous production system for integration of high precision and high reliability of SEIKO QUARTZ WATCHES.

- **Highly stable quartz crystal oscillator**

The quartz crystal oscillator, the heart of SEIKO QUARTZ WATCHES, is a high-efficiency tuning fork type of SEIKO's own. It can be tuned in with ease and is very sturdy against external shocks.

- **High accuracy**

The SEIKO QUARTZ uses a high-precision quartz crystal oscillator to be adjusted best. Its timing accuracy is amazingly high.

- **Precise ticking by step motor**

SEIKO's microminiaturized motor (step motor) moves the hands exactly once every second as it can convert an electric signal from the electronic circuit into mechanical motion without being influenced by external disturbances and shocks.

- **High serviceability**

In the SEIKO QUARTZ WATCHES, the quartz crystal oscillator, electronic circuit, coil and movement are built into interchangeable blocks for ease of maintenance.

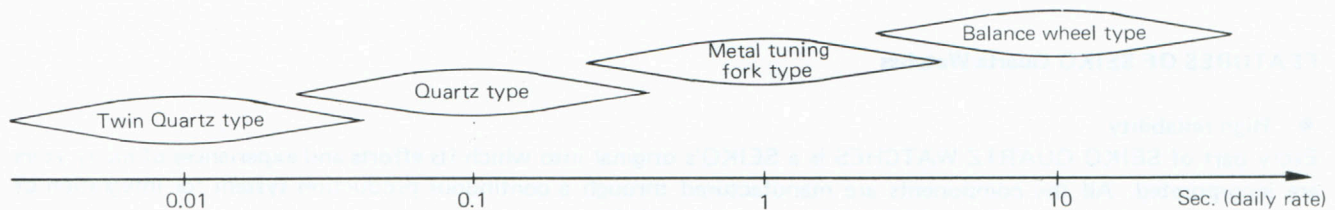


## II. QUARTZ CRYSTAL OSCILLATOR TYPE WATCHES

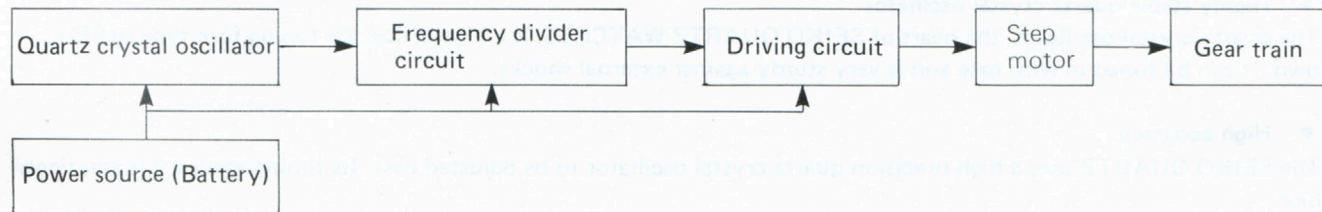
The quartz crystal oscillator type watch uses a quartz oscillator instead of a balance wheel. The following shows isochronal sources and types of watches.

Isochronal source	Energy source	Type of watch
Balance wheel	Mainspring	Mechanical watch
	Battery	Electromechanical balance watch
Metal tuning fork	Battery	Metal tuning fork watch
Quartz crystal oscillator	Battery	Quartz watch

The oscillation of the quartz crystal oscillator is extremely stable, and can offer far and away higher timing accuracy than the timed annular balance type and metal tuning fork type.



The construction of the quartz crystal oscillator type watch is as follows.



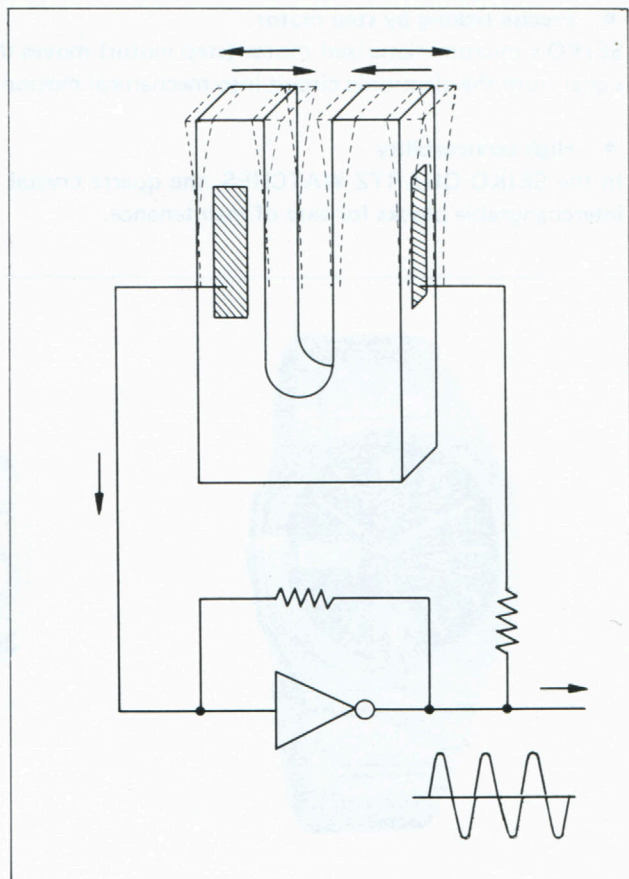
### • Quartz crystal oscillator

The quartz oscillator is composed of a quartz tuning fork and an oscillator circuit to drive it and serves as an isochronal source.

Quartz is a transparent, hexagonal crystal of a compound of silicon and oxygen. It is cut into a tiny piece of a specific shape and applied the metal films as electrodes to its surface. This piece serves as an oscillating element as shown on the right. When a voltage is applied to the electrodes, the arms of the quartz crystal oscillator deflect.

On the other hand, the deflection of the arms is accompanied by generation of voltage across the electrodes.

The quartz crystal oscillator keeps on oscillating by boosting this voltage generated in it by the oscillator circuit and feeding it back to the quartz crystal oscillator to keep it exciting.



**\* Piezoelectric effect**

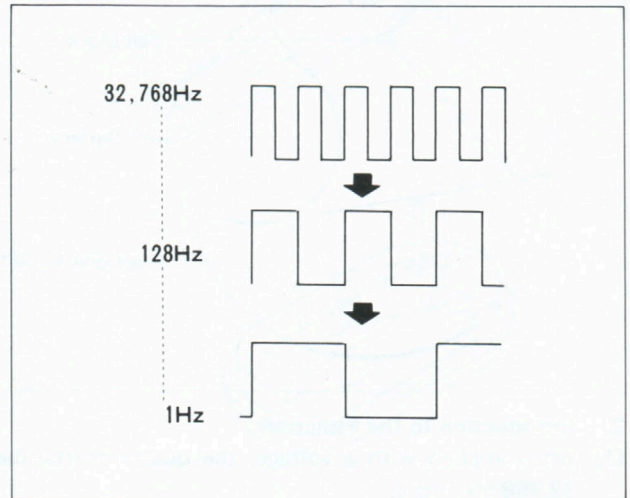
Some substances are deformed when applied with a voltage. On the other hand, when they are strained, they develop a voltage. This electromechanical reciprocity known as "piezoelectric effect" was discovered by Pierre Curie in 1880. The quartz crystal oscillator working on this effect shows an amazingly high physical stability and can offer a highly accurate isochronal source.

**● Frequency divider circuit**

The frequency divider circuit converts a high-frequency signal of the quartz crystal oscillator to a low-frequency signal suitable for driving the step motor.

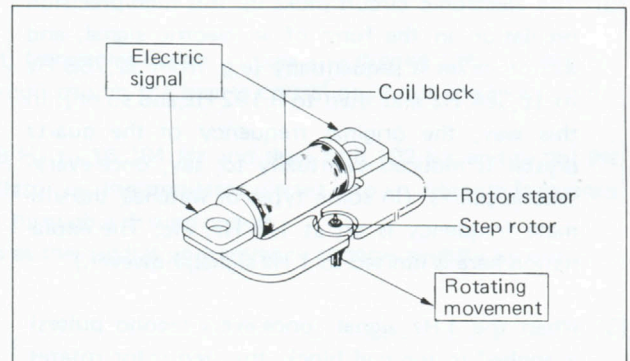
**● Driving circuit**

The driving circuit supplies electric energy to the step motor according to the output signal from the frequency divider circuit. In the quartz watches, the MOS-IC functions as the oscillator circuit, frequency divider circuit and driving circuit.



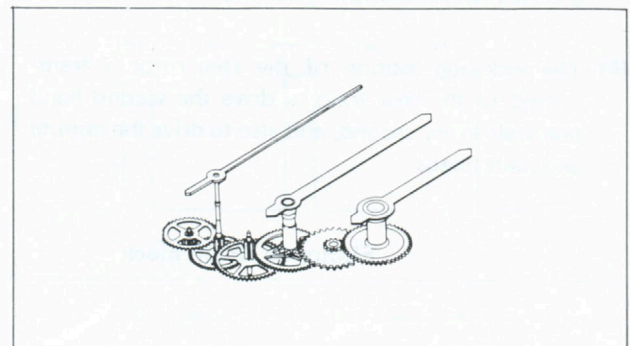
**● Step motor**

The step motor converts electric energy from the driving circuit into mechanical rotational motion.



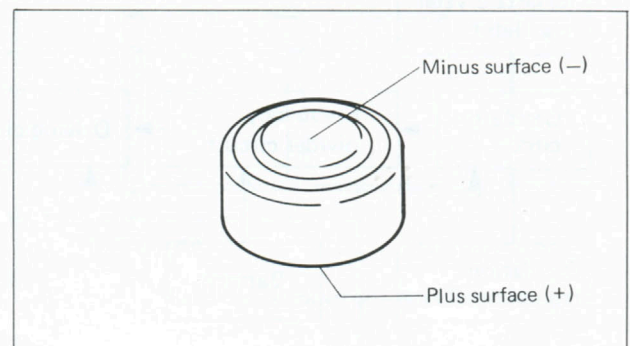
**● Gear train**

The gear train transmits the rotations of the step motor to the indicating mechanism precisely.



**● Power source**

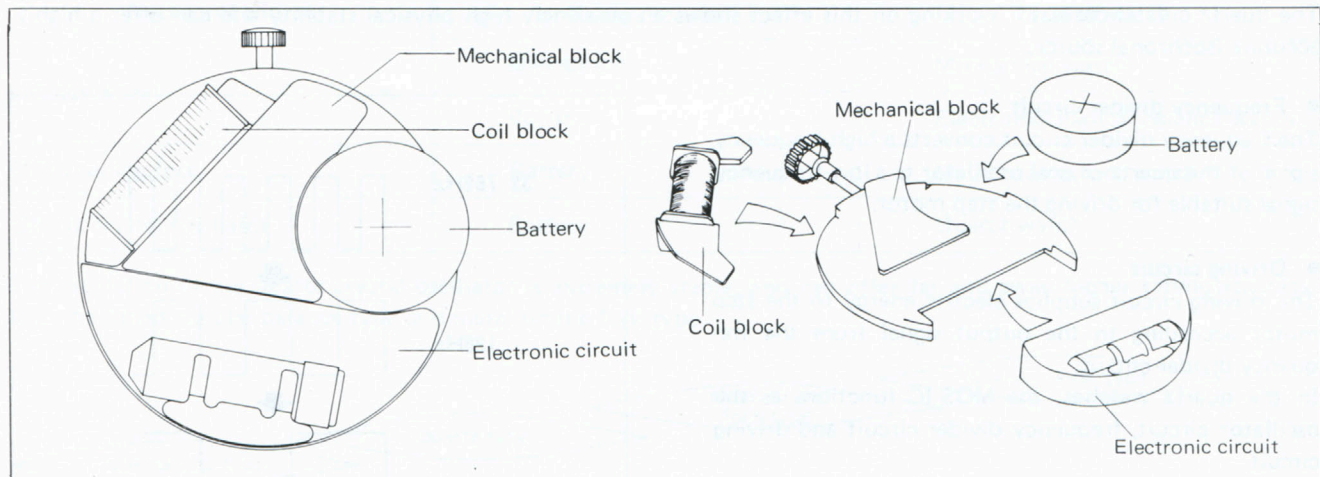
The power source supplies all the energy necessary for keeping the watch moving. A miniature battery serves as a power source.



### III. OPERATING PRINCIPLE

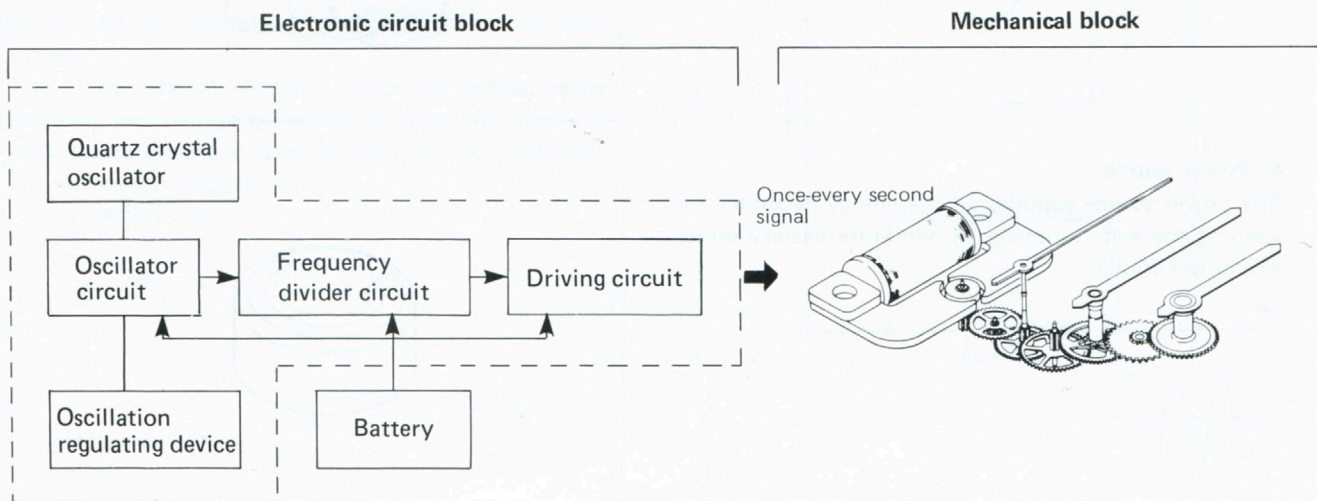
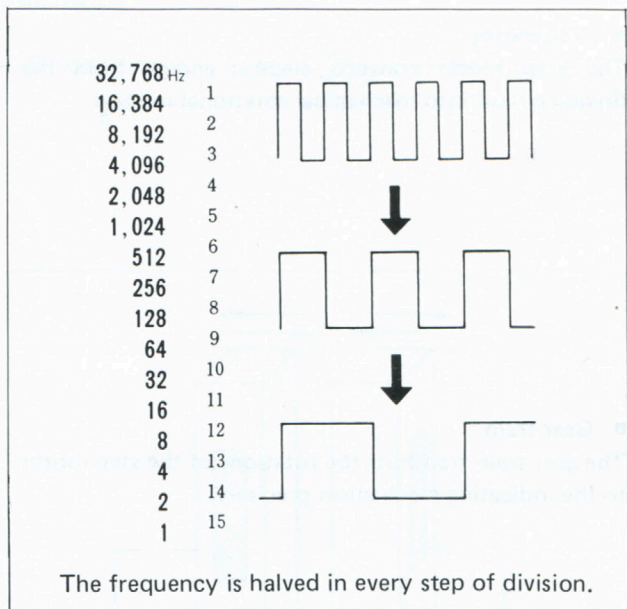
#### 1. Movement Arrangement

The SEIKO QUARTZ WATCH is composed of an electronic circuit, coil block, battery and a mechanical block made up of a gear train, step motor and indicating mechanism.



#### 2. Introduction to the Function

- (1) When applied with a voltage, the quartz crystal oscillates at an amazingly high-precision frequency (16,384 Hz, 32,768 Hz., etc.).
- (2) The electronic circuit picks up this high-precision oscillation in the form of an electric signal, and dichotomizes it sequentially (e.g. from 32,768 Hz to 16,384 Hz and then to 8,192 Hz, and so on). In this way, the original frequency of the quartz crystal is reduced eventually to, say, once-every-second pulses. (In some types of watches, the ultimate frequency is set at 1/5 Hz, etc. The explanation here is limited to 1 Hz signal, however.)
- (3) When the 1 Hz signal (once-every-second pulses) is applied to the coil block, the step rotor rotates a certain angle once every second.
- (4) The indexing motion of the step rotor is transmitted to the gear train to drive the second hand one scale every second, and also to drive the minute and hour hands.

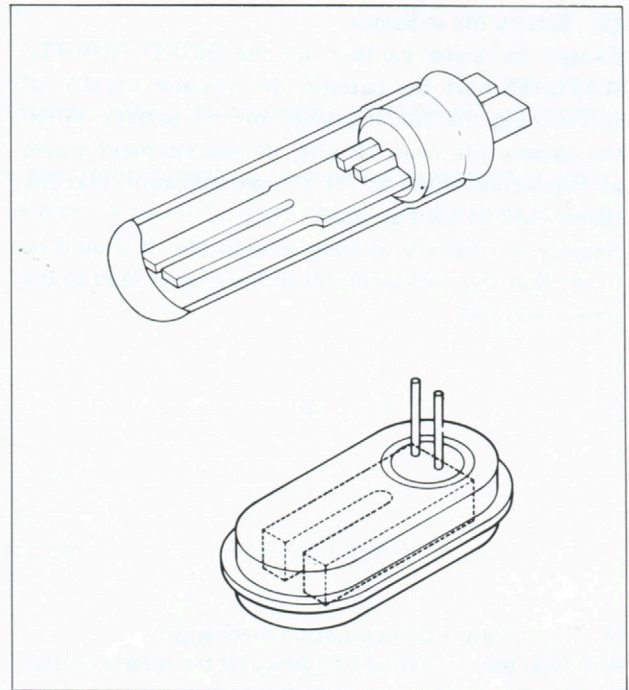


### 3. Electronic Circuit

#### (1) Quartz crystal oscillator

The quartz crystal oscillator is one of the most important parts of SEIKO QUARTZ WATCHES and is sealed up in the ultrahigh vacuum case for its stabilized performance and protection. This must not be opened. For microminiaturization, the quartz crystal oscillator is shaped into a special tuning fork and connected to the electronic circuit. When applied with a voltage, it oscillates precisely at its specific frequency (16,384 Hz, 32,768 Hz, etc.).

This high stability of quartz crystal oscillation is the source of the high timing accuracy SEIKO QUARTZ WATCHES offer.



#### (2) Electronic circuit

The electronic circuit system consists of an oscillator circuit, frequency divider circuit and driving circuit. They are interconnected electrically with one another. The oscillator circuit excites the quartz crystal oscillator and picks up the oscillation in the form of an electric signal.

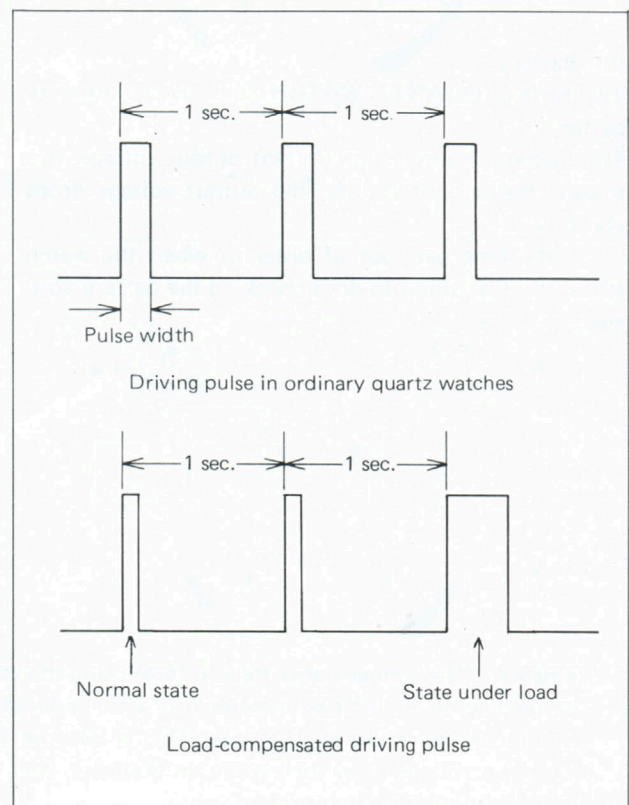
The frequency divider circuit dichotomizes (e.g., from 32,768 Hz to 16,384 Hz and then to 8,192 Hz, and so on) the original electric signal picked up from the quartz crystal oscillator by the oscillator circuit into an ultimate frequency of 1 Hz. This ultimate frequency is supplied to the step motor through a driving circuit.

In the oscillator circuit, the regulation adjustment is performed as the oscillating frequency changes slightly by changing the capacity of the trimmer condenser generally.

#### • Load-compensated driving pulse system

In the ordinary quartz watches, the frequency divider circuit delivers pulses (electric signals) of a fixed width to the step motor.

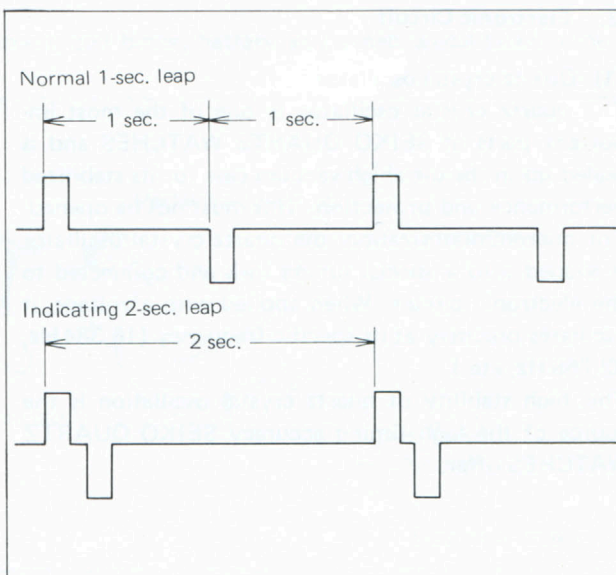
In the watch using a load-compensated driving pulse system, the width of each pulse is varied to meet the load which it must overcome. Under normal conditions, the pulse width to drive the hands alone is necessary. When the load increases as when driving the calendar or at the time of low temperatures, the pulse width is widened enough to overcome the load increase.



### (3) Battery life indicator

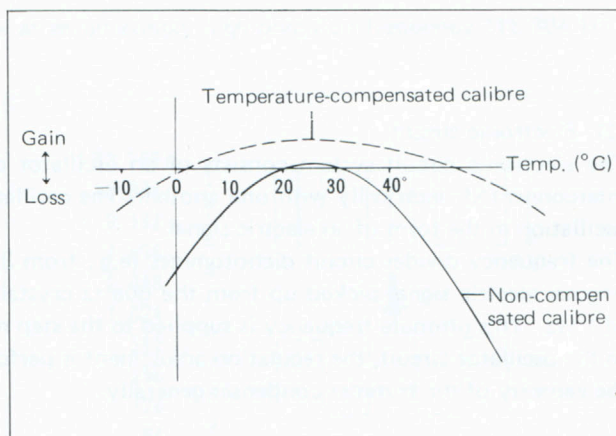
Except for some calibres, all the SEIKO QUARTZ WATCHES have the battery life indicator capable of forewarning the running-down of the battery. When the battery life nears its end, the second hand moves at two-second intervals. This is an indication that the battery will be used up soon.

Replace the battery as soon as possible. It should be noted that this two-second leap does never lead to the time inaccuracy.



### (4) Temperature-compensation mechanism

Although the oscillating frequency of the quartz crystal oscillator is highly stable, it changes slightly with the change of temperature. In order to offset this frequency change, there is used a temperature-compensation condenser whose capacity changes with the change of temperature. The calibres with this temperature-compensation mechanism are higher in accuracy than those without.

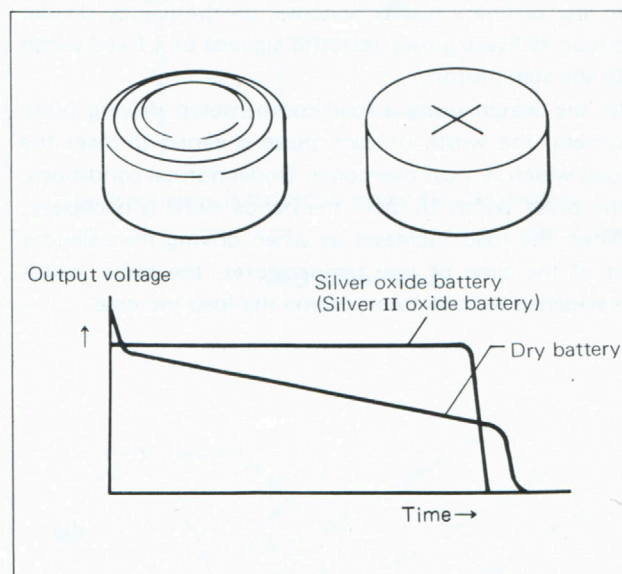


### (5) Battery

The SEIKO QUARTZ WATCH runs by a miniature battery.

This battery maintains a constant output voltage. But toward the end of its life, the output voltage drops abruptly.

When the time gets out of order or when the watch stops, the first thing to do is checking the battery voltage.



#### \* Remarks: Measurement of battery voltage using the volt-ohm-meter

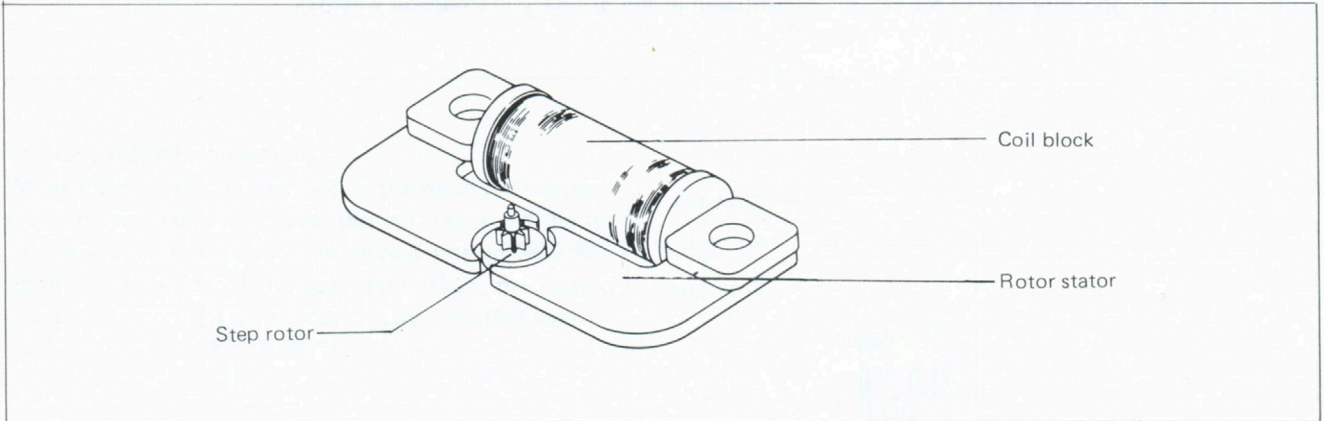
The reading on the volt-ohm-meter just after application of its probes to the battery may be less than 1.55 V depending on the types of batteries. This is because the battery applied with the probes of the volt-ohm-meter develops a voltage drop for a while. In that case, wait twenty to thirty seconds with the probes on the battery, and the reading will indicate a correct value.

#### 4. Mechanical Block

##### (1) Step motor

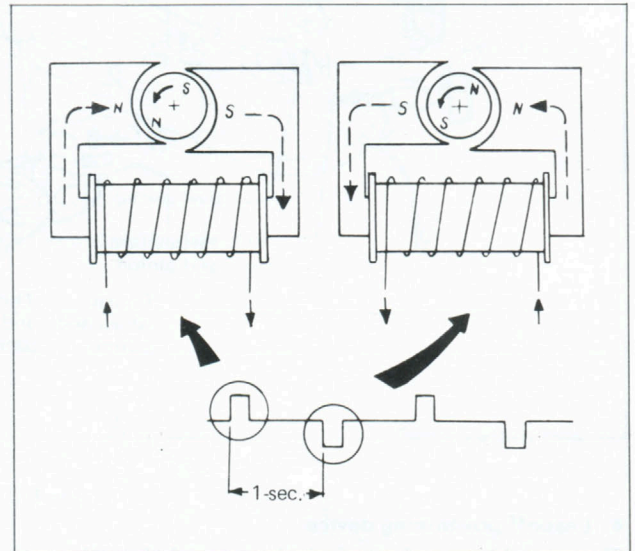
The step motor which converts the oscillation of the quartz crystal oscillator into a precise rotational motion is composed of a coil block, rotor stator and step rotor.

The rotor stator is made of a material with a high permeance. The step rotor is made of a cylindrical permanent magnet. This magnet is available in two types; one in which three S and three N poles (6 poles) are provided alternately and the other having one S pole and one N pole (2 poles).



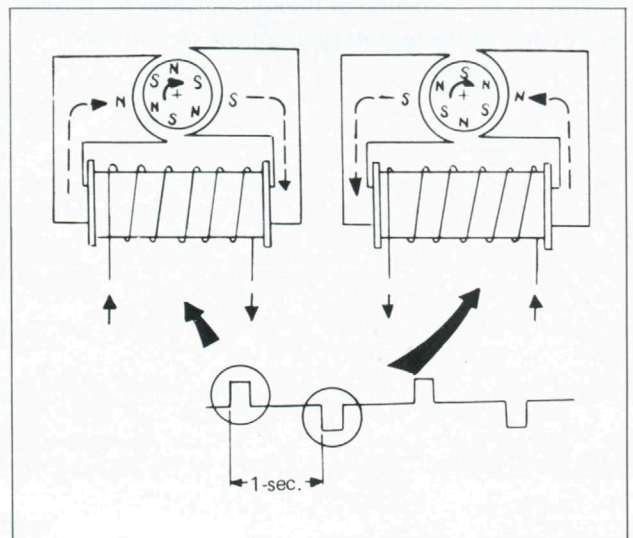
##### • Step motor (2 poles)

- 1 A current runs through the coil block. A polarized current (a pulse current whose polarity changes positive and negative alternately) is supplied from the driving circuit to the coil block.
- 2 The rotor stator is magnetized. When the coil block carries a current, the arms of the rotor stator are polarized.
- 3 The step rotor turns. The S and N poles of the rotor stator and the step rotor repel and attract each other and the step rotor turns  $180^\circ$  in a specified direction for an instant by the repulsive and attractive forces generated between the poles of the rotor stator and step rotor.
- 4 The gear train runs. The turning of the step rotor is transmitted to the train wheel by way of the pinion on the step rotor, driving the entire gear train.



##### • Step motor (6 poles)

The step rotor turns at an interval of  $60^\circ$  for an instant every time the step rotor carries a current.

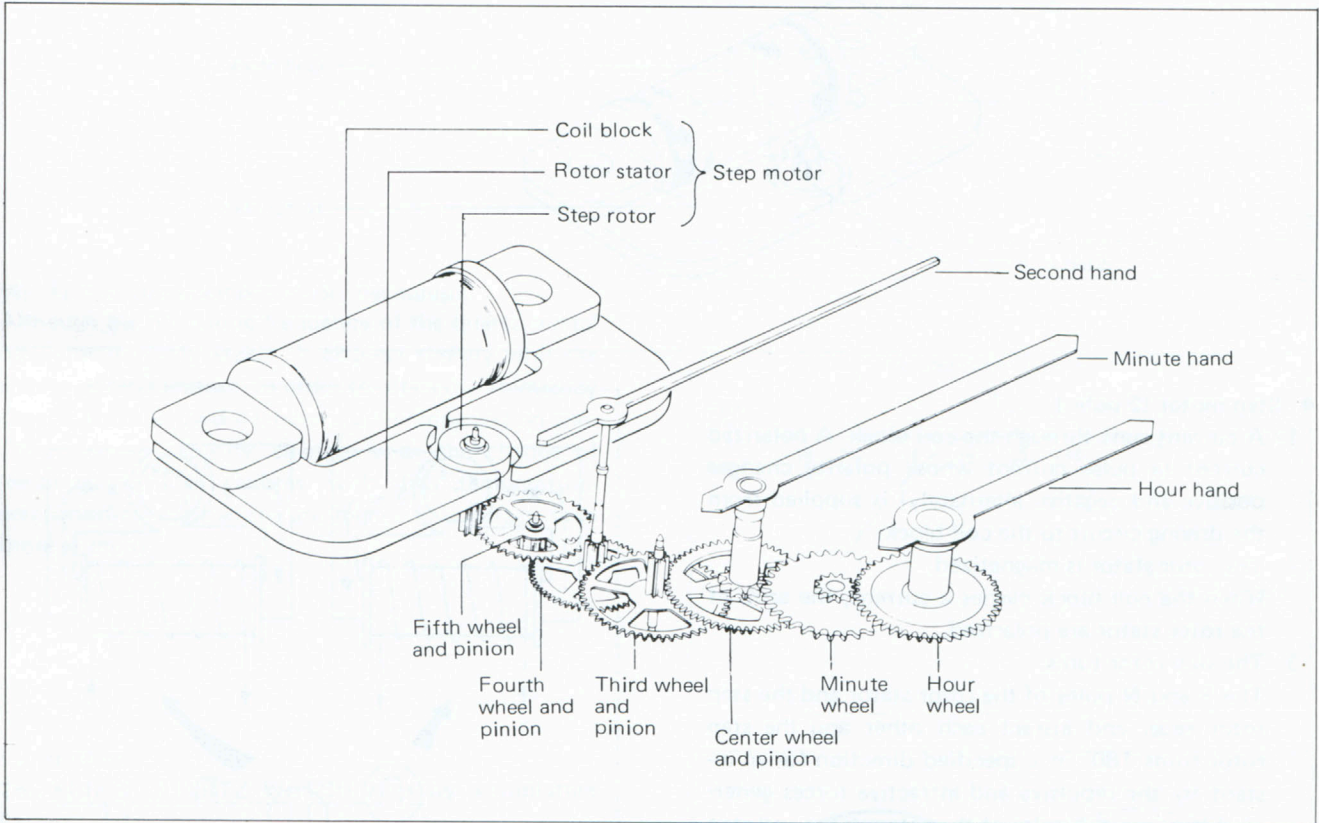


**(2) Gear train**

The gear train in the SEIKO QUARTZ WATCHES is a simple, handy mechanism and transmits the rotation of the step motor precisely to the indicating mechanism. In some calibres, the gear train is provided with a special device for determining a leapoff point.

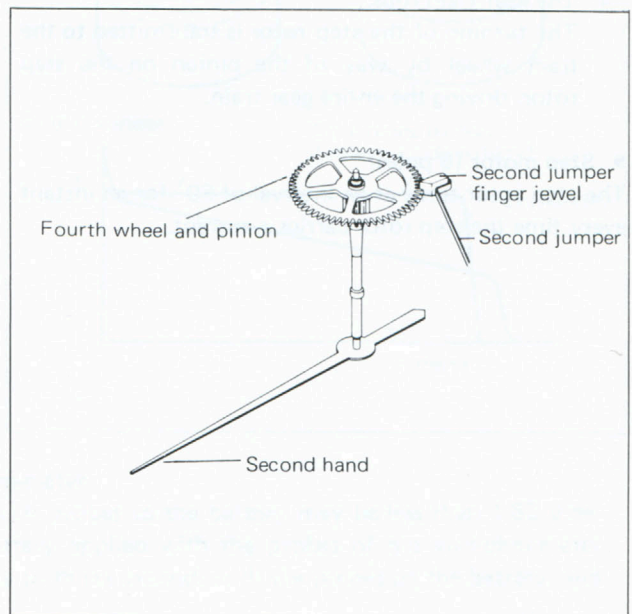
● **Power transmission**

The driving force of the step rotor of the step motor is transmitted to the fifth wheel and pinion, the fourth wheel and pinion, the third wheel and pinion, and then to the center wheel and pinion, minute wheel and finally to the hour wheel, just in the opposite way to the power transmission in the ordinary mechanical watches.



● **Leapoff positioning device**

The second jumper finger jewel at the end of the second jumper locks the pinion of the fourth wheel for precise positioning of the leapoff point of the second hand.



### (3) Second setting and reset switch

The SEIKO QUARTZ WATCH is provided with a unique second setting device and a reset switch, and the second hand can be adjusted to the time signal.

#### ● Second setting device

The following three types are available by calibre. In any type, the second hand starts running a second after the crown is pushed in.

##### 1) One-second-step setting

When the crown is pulled out to the hand setting position, the second setting lever pin will come off the tip of the winding stem and the second setting lever will control the pinion of the gear train. Thus, the second hand will stop right on a second mark, whether even or odd.

##### 2) Even-second-step setting

When the crown is pulled out to the hand setting position, the second setting lever pin will come off the tip of the winding stem and the second setting lever will control the step rotor cam to bring the second hand onto an even second mark.

##### 3) Ten-second-step setting

When the crown is pulled out to the hand setting position, the second setting lever will control the second setting cam, and the second hand will leap to a second mark which stands for a multiple of ten seconds and which is just ahead of the second hand.

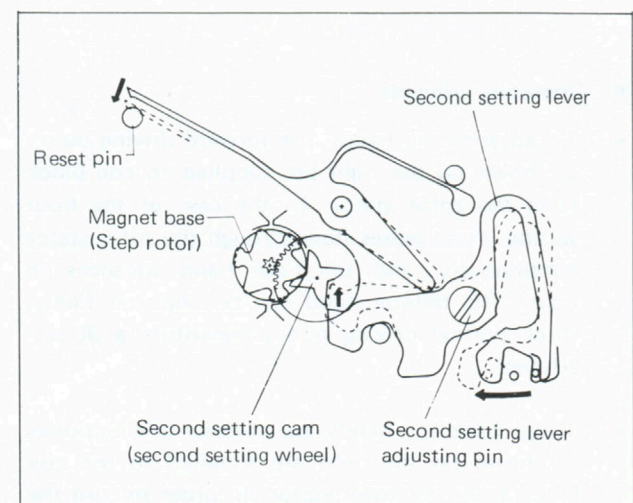
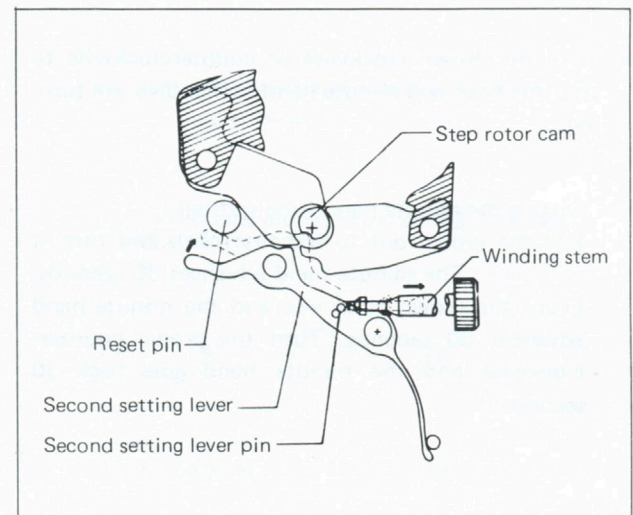
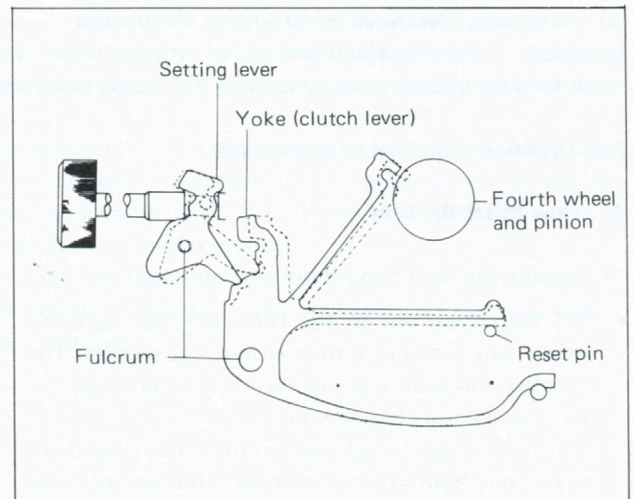
#### ● Reset switch

When the crown is pulled out, the second setting lever works to stop the second hand. At the same time the reset switch will make the electronic circuit reset to zero so that when the crown is pushed in the second hand will restart just after a second.

Pull out the crown fully, and the hands will stop. At the same time, the second setting lever contacts the second setting lever pin to actuate the reset switch.

Although the hands are stopped, part of the electronic circuit is kept powered from the battery to keep the quartz crystal oscillator oscillating.

Namely, the quartz crystal oscillator is ready for restart at any time.



#### (4) Automatic Electronic-Hand-Setting Mechanism

Automatic Electronic-Hand-Setting is different from the existing hand setting mechanism. It electrically turns the hands forward or backward by turning the crown clockwise or counterclockwise.

Cal. 1320A is explained as an example.

##### • How to set the time

##### 1 Setting the hour hand (hour setting/rough setting)

- Pull the crown out to the first click and turn the crown two clicks at a time within 1/2 second. The minute hand turns just one turn and accordingly the hour hand advances one hour.  
(Turn the crown clockwise and the hour hand advances one hour. Turn the crown counterclockwise and the hour hand goes back one hour.)

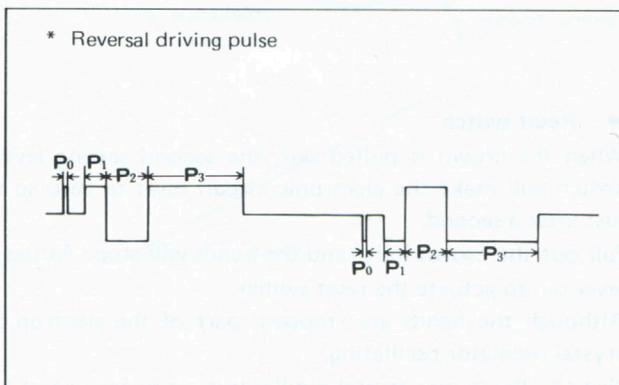
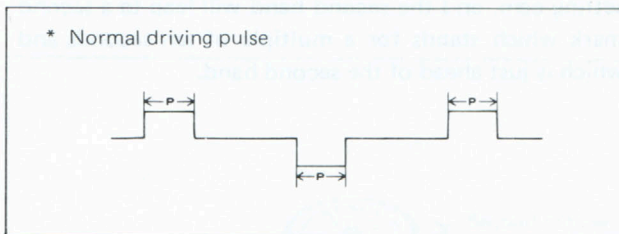
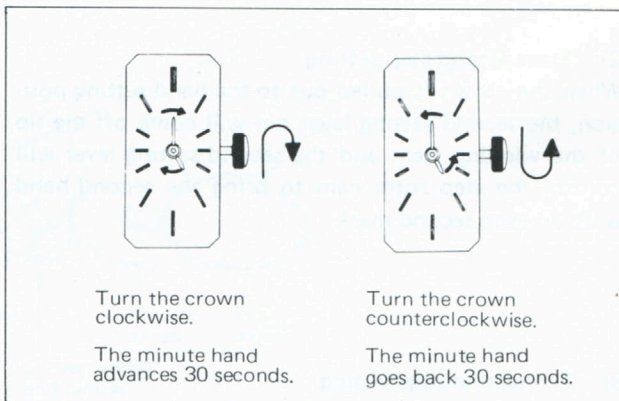
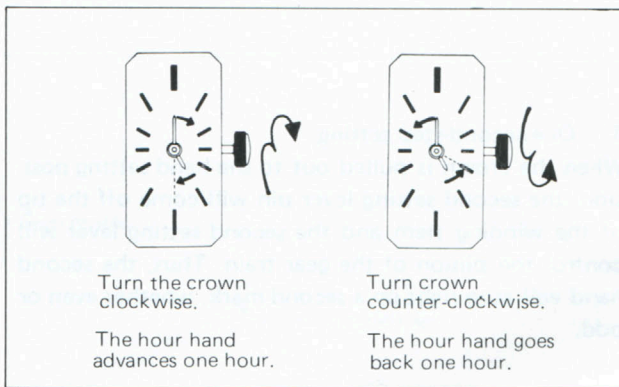
- Turn the crown clockwise or counterclockwise to stop the hour and minute hands while they are turning.

##### 2 Setting the minute hand (fine setting)

- Pull the crown out to the first click and turn it one click. The minute hand advances 30 seconds.  
(Turn the crown clockwise and the minute hand advances 30 seconds. Turn the crown counterclockwise and the minute hand goes back 30 seconds.)

##### • Operating principle

- To advance the hands, the forward driving pulses as shown on the right are supplied to coil block from the rotor stator. In the case of the hour setting, these pulses flow through the rotor stator continuously, and the hour hand advances an hour. The minute hand can be adjusted finely; three normal driving pulses constitute a 30-sec. advance.
- To go back the hands, the reversal driving pulses as shown on the right are supplied to the coil block from the rotor stator. In order to turn the step rotor backward, pulse P1 is given to turn the step rotor a little forward. Then another pulse P2 is applied to kick it backward by taking the advantage of its momentum. This is followed by still another pulse P3 to run the step rotor on in the counterclockwise direction. Thus in the hour setting, the hour hand is turned back by an hour and in the minute hand fine adjustment, the minute hand is turned back 30 seconds.



## IV. ACCURACY OF TWIN QUARTZ WATCHES

### ● TWIN QUARTZ WATCHES

The high timing accuracy of the SEIKO QUARTZ WATCHES is ensured by the highly stabilized oscillation of the quartz crystal oscillator. But the frequency of the quartz crystal oscillator shows a delicate change with the change of temperature, causing a slight loss or gain.

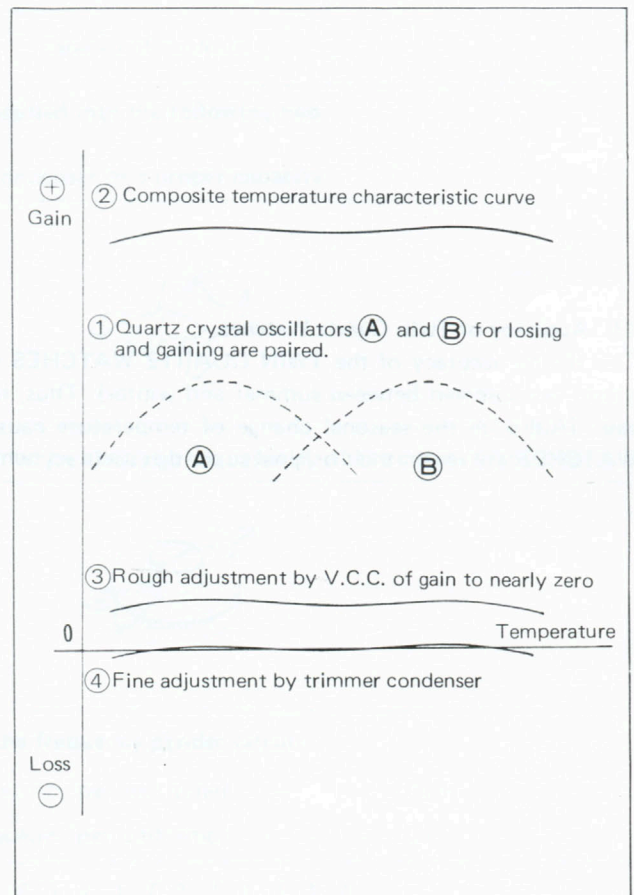
In order to minimize this temperature effect a temperature-compensation mechanism using a condenser has been used. In the TWIN QUARTZ WATCHES, however, a revolutionary new temperature-compensation mechanism is incorporated in which a pair of quartz crystal oscillators are combined; when we speak of the TWIN QUARTZ WATCHES, we must discuss their accuracy in terms of some seconds or so a year, instead of seconds a month.

\* As its name suggests, the TWIN QUARTZ WATCH uses a couple of quartz crystal oscillators, and its temperature compensation is accomplished in either of the following two methods.

#### (1) Twin Quartz Watches Cal. 97 Series

A pair of quartz crystal oscillators having different temperature characteristics are used as a quartz unit. The composite temperature characteristics of the two quartz crystal oscillators are roughly adjusted by the variable counter circuit system (V.C.C.) to reduce the rate to nearly zero. (The V.C.C. is the system that performs adjusting the submultiple of an input frequency.)

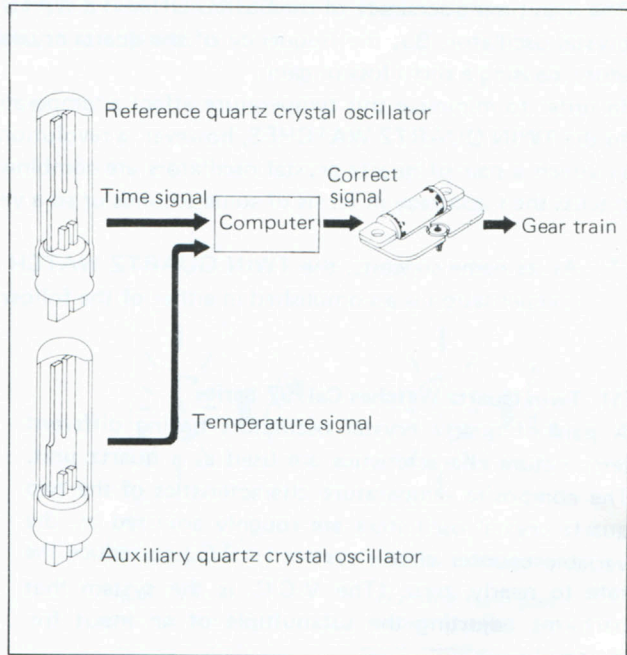
The fine adjusting is carried out using the trimmer condenser. As the V.C.C. and the trimmer condenser are used in combination this way, the composite temperature characteristics are highly stabilized over a wide range of temperature changes.



### (2) Twin Quartz Watches Cal. 99 Series

Two quartz crystal oscillators — one as a reference crystal oscillator for determining the timing accuracy and the other as an auxiliary quartz crystal oscillator for detecting the temperature — and a built-in computer are combined for temperature compensation.

The temperature change vs. timing accuracy relationship is calculated by the computer in the electronic circuit. This computer reads from the auxiliary quartz crystal oscillator the error of the reference crystal oscillator due to temperature changes and functions to offset the error automatically.



### (3) Accuracy of Twin Quartz Watches

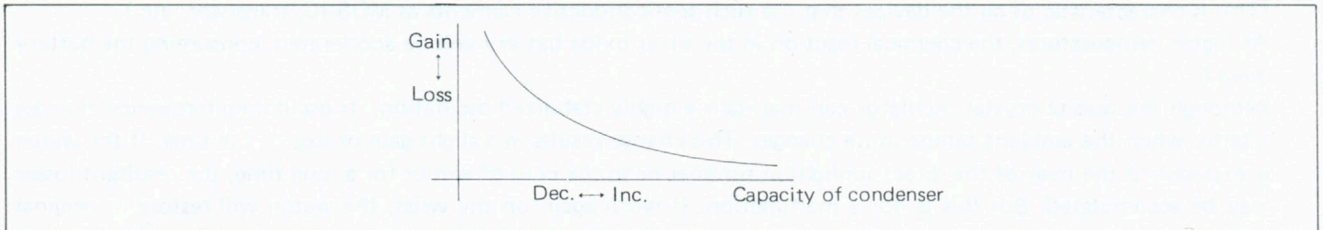
The timing accuracy of the TWIN QUARTZ WATCHES may change slightly with major changes of ambient temperatures (as observed between summer and winter). Thus, its monthly rate may not assume a duodecimal of its annual rate. (Although the seasonal change of temperature causes a slight change in timing accuracy, the TWIN QUARTZ WATCHES will regain their original superhigh accuracy when the temperature becomes normal.)

## V. METHODS OF TIME ACCURACY ADJUSTMENT

The loss or gain of the SEIKO QUARTZ WATCHES is adjusted in two ways; one in which the frequency of the oscillator circuit is changed by changing the capacity of the condenser, and the other in which the rotary step switch is used to change the ultimate frequency of the frequency divider circuit.

### (1) Time accuracy adjustment by changing the capacity of the condenser

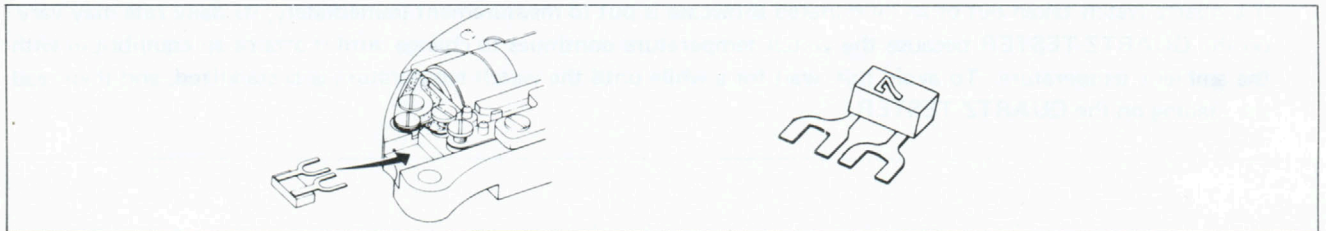
Decrease in capacity → Increase in frequency of quartz crystal oscillator → Gain  
 Increase in capacity → Decrease in quartz crystal oscillator → Loss



• The method to change the capacity of the condenser is classified into the following two.

#### 1) Condenser for oscillation regulation

Time accuracy adjustment is performed by replacing the condenser of a proper capacity.

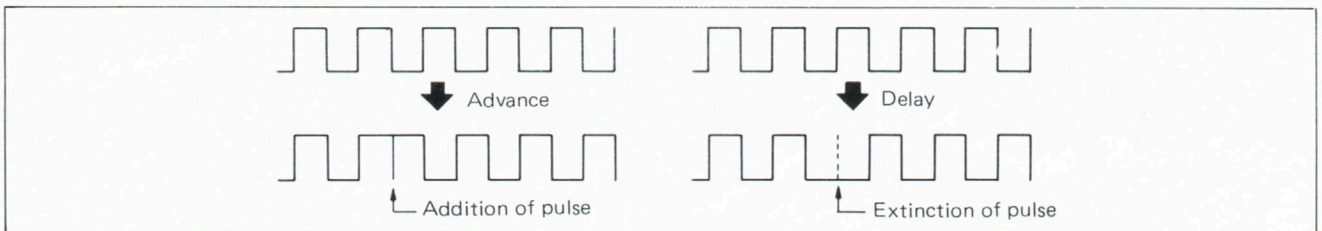


#### 2) Trimmer condenser: Time accuracy adjustment is performed by changing the capacity of the condenser steplessly.

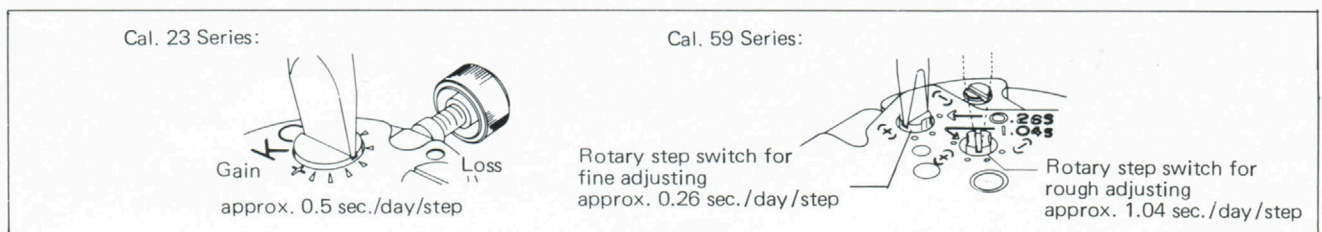


### (2) Time accuracy adjustment by changing the oscillation of the frequency divider circuit

Increased ultimate divided frequency (increased pulse frequency per unit time) → Gain  
 Decrease ultimate divided frequency (decreased pulse frequency per unit time) → Loss



• **Rotary step switch:** The ultimate divided frequency (pulse frequency) is changed step by step for loss or gain control.



## VI. HANDLING OF SEIKO QUARTZ WATCHES

In order to maintain the integrity of the high-precision performance of SEIKO QUARTZ WATCHES, observe the following conditions.

- (1) The watch can operate in a temperature range of  $-10^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ . But it is designed to exhibit its best at normal temperatures.

When the watch is worn on the wrist, the body temperature offers a thermostatic effect and the watch can operate at a high accuracy. If the ambient temperature is below  $-10^{\circ}\text{C}$  or above  $+60^{\circ}\text{C}$ , the electronic circuit may fail. But, when the normal working temperature is restored, the watch will resume its high-accuracy performance.

(This is characteristic of all the devices that use such semiconductive elements as MOS-IC, transistor, etc.)

At higher temperatures, the chemical reaction in the silver oxide battery will be accelerated, consuming the battery quickly.

Although the quartz crystal oscillator can maintain a highly stabilized oscillation, its oscillating frequency changes slightly when the ambient temperature changes. This change results in a slight gain or loss of the time. If the watch is exposed to the heat of the direct sunlight in summer or to the cold of winter for a long time, the resultant losses may be accumulated. But this is not a malfunction. If worn again on the wrist, the watch will restore its original high timing accuracy.

- (2) Measurement of timing accuracy

If a quartz watch taken out of an illuminated showcase is put to measurement immediately, its daily rate may vary on the QUARTZ-TESTER because the watch temperature continues to change until it attains an equilibrium with the ambient temperature. To avoid this, wait for a while until the watch temperature gets stabilized, and then read the reading on the QUARTZ-TESTER.

