CITIZEN
TECHNICAL MANUAL

BASIC
COURSE

PREFACE

This technical manual <Basic Knowledge Course> is written as a practical handbook for those needing to acquire a basic knowledge of the Citizen Quartz Watch in all its aspects.

We hope this manual will be helpful in offering after-sales service, such as repair service, and in promoting sales as well.

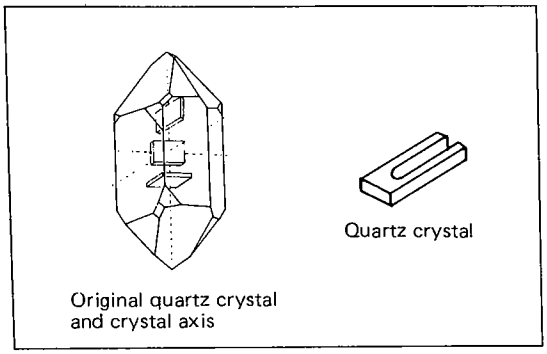
CONTENTS

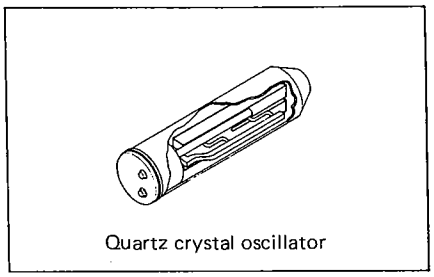
1. WHAT IS A QUARTZ WATCH

It's a watch which maintains a time standard by means of a quartz crystal oscillator, (the heart of the watch), an dthen creates an electrical signal for displaying the time in the IC (electronic circuit), using a power cell as the power source.

Quartz crystal oscillator

A quartz crystal oscillator is structured so that a gold electrode is attached to a chip of quartz crystal, which is obtained from a quartz crystal by accurately cutting against the axis at a specific angle. It is vacuum sealed in a special capsule so that it has a constant rate of oscillation.

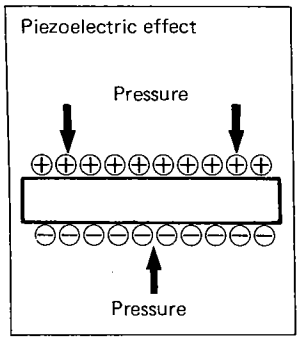


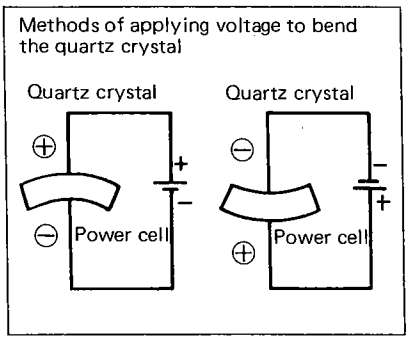


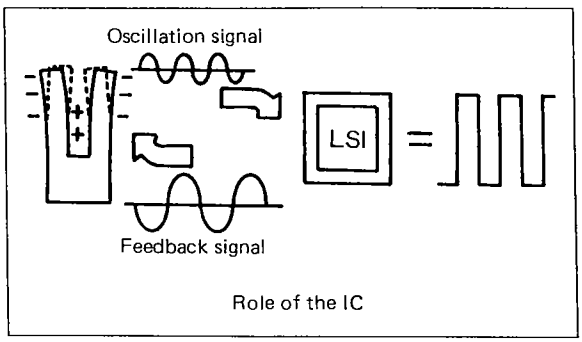
Piezoelectric effect of a quartz crystal

If pressure is applied to a quartz crystal which is cut into a specific form, it will generate voltage in a specific direction. This phenomenon is called the piezoelectric effect. On the contrary, if an electrode is attached to a chip of quartz crystal., to which voltage is applied, the chip will become distorted (reverse piezoelectric effect). At this time, if voltage is applied in the reverse direction, the chip will also be distorted in the reverse direction.

As described above, if + and - voltages are alternately applied, the chip will continuously show oscillation of its own peculiar frequency equivalent to its size. It is possible to produce a quartz crystal oscillator, which has the above-stated characteristics, which will continue to vibrate, by controlling the electrical signal from the IC.







IC (Integrated circuit)

The IC functions as the brain of the quartz watch, controlling the oscillation of the quartz crystal oscillator. In addition, the IC allows a variety of functions to be performed, and thus it can be called an ultra-compact electronic circuit.

The IC is structured so that many circuit elements (resistors, condensers, transistors, diodes, etc.) are inseparably mounted on the same substrate.

The IC cannot be used unsealed. Therefore, it must be mounted and formed in a circuit block, like the unit of an electronic circuit.

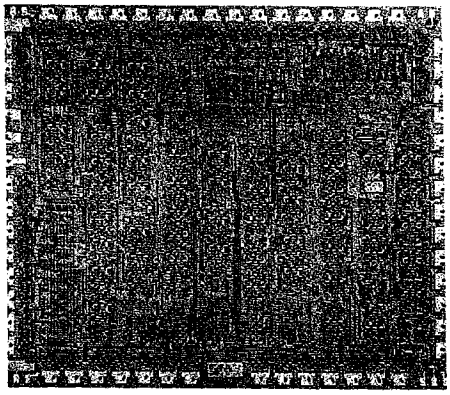
In addition, the IC is provided with a molded case for protection of the IC chip and to prevent external influences from affecting the chip. A small-sized, highly reliable circuit entity is thus produced.

An IC which is incorporated in a quartz watch is circuit with a high degree of integration, called an LSI (Large Scale Integrated Circuit).

- **Features of the IC**

One reason the IC is used in a quartz watch is because of its compactness. Another, and even more important reason is that the voltage and current consumption is low. Generally speaking, the IC has the following three features;

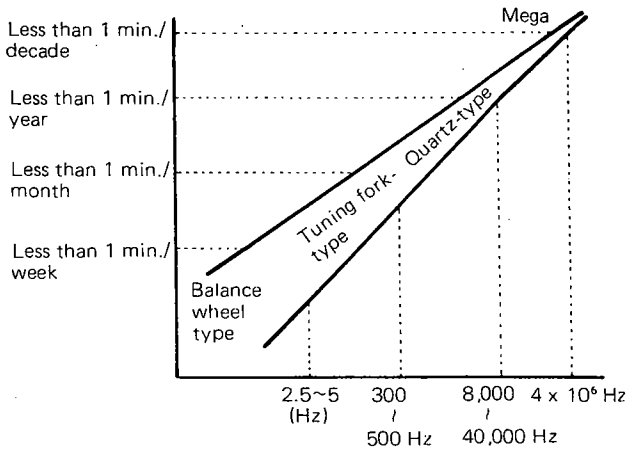
○ Ultra-compact ○ Highly reliable ○ Economical



LSI Circuitry

Features of the quartz watch

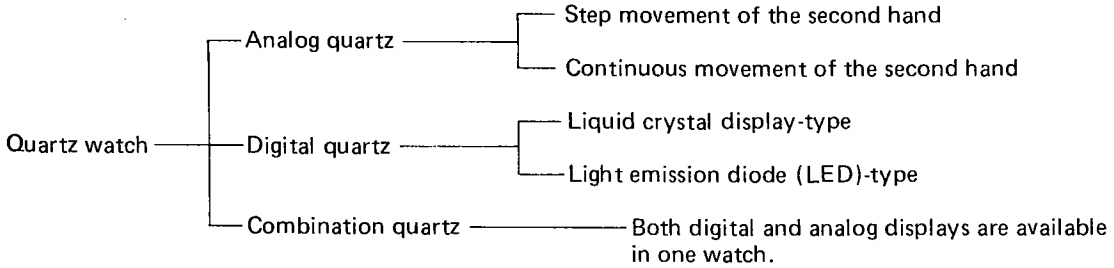
- **High accuracy**
  Because of the high frequency of the quartz crystal oscillator – 32,768 Hz per second, the quartz watch is highly accurate.
- **High reliability**
  The major portion of the quartz watch is made up of circuits which are almost completely integrated into the IC, which ensures the watch's high reliability.



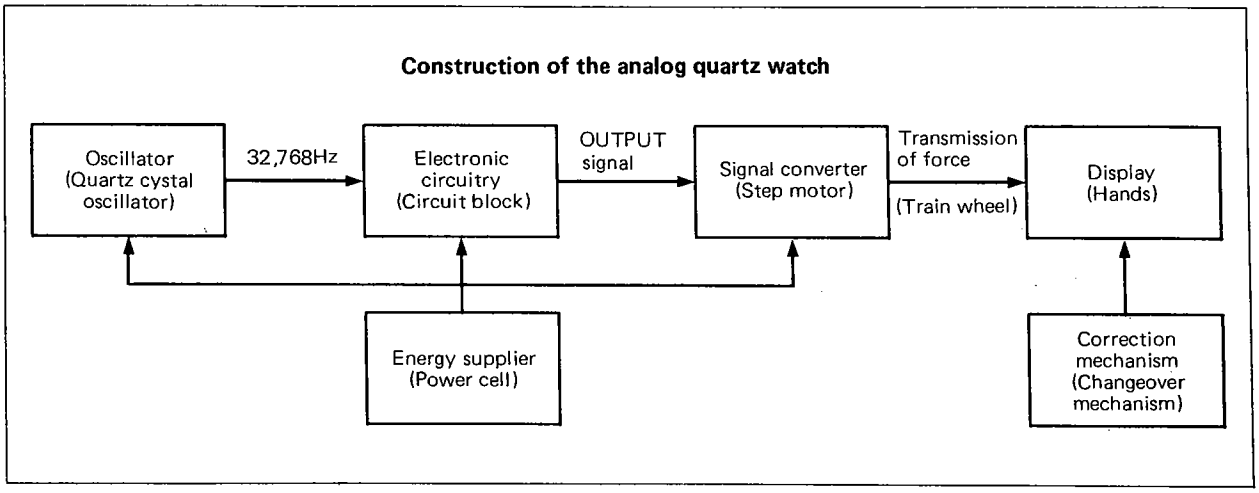
- **Long power cell life**
  In the quartz watch, a power cell is used as the power source. Most approximately power cells on the market today have a service life of approximately two years.
- **Good temperature characteristics**
  The temperature characteristics of the quartz crystal oscillator are so good that individual and environmental differences are becoming increasingly smaller. Accordingly, the margin of time discrepancy in quartz watch products is becoming smaller and the accuracy of the products is increasing.

Classification of the quartz watch

The quartz watch is roughly classified as follows, depending on the display method.



2. CONFIGURATION OF THE ANALOG QUARTZ WATCH

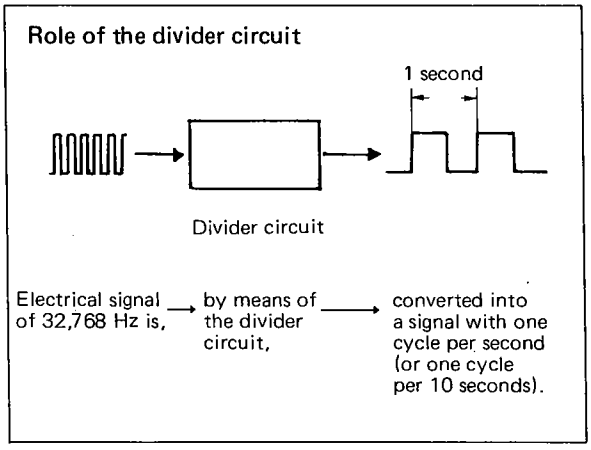


Oscillator circuit

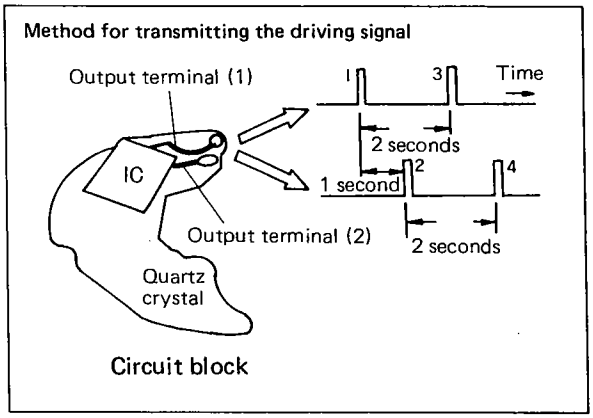
The oscillator circuit consists of a quartz crystal oscillator, a circuit in the IC, and a condenser to adjust time gain or loss. A quartz crystal oscillator with a frequency of 32,768 Hz is widely used. The condenser used to adjust the time rate in this oscillator is called a trimmer condenser.
Included among these condensers is a fixed condenser which does not adjust the time rate.

Divider circuit

In the analog quartz watch, a second hand movement is popular. Also available are models in which the hand moves every 5, 10, or 20 seconds.
The divider circuit is composed of many circuits, called flip flop (F.F.) circuits which are constructed in a succession of tiers.
One flip flop circuit reduces the frequency by half.
To convert a signal having a frequency of 32,768 Hz into a signal of 1 Hz (a signal with one cycel per second is needed to move the second hand every second.), flip flop circuits in tiers of 15 are used.
In short, the divider plays the role of converting a signal of 32,768 Hz into a signal to move the hand (decreasing frequency). Also, some models use the D.F.C. (Digital Frequency Control), which uses the divider cirucit to adjust the time rate.



For instance, to move the hand every second, the driving signal is transmitted from the output terminal (1) in one second, from (2) in two seconds, from (1) in three seconds, from (2) in four seconds and so on.



Step motor

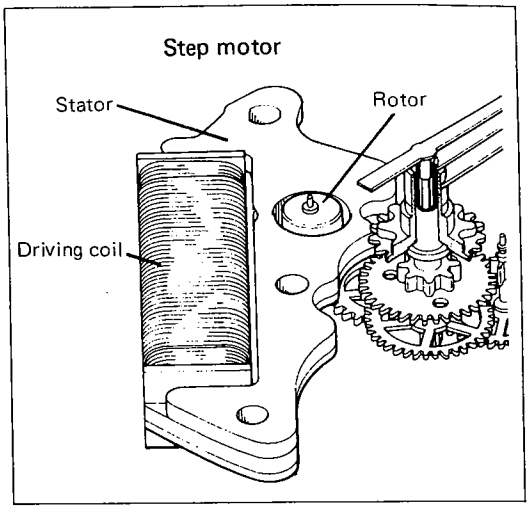
- **Construction of the step motor**

  The step motor consists of a driving coil, a stator and a rotor.

  The stator is made of easily magnitized material. The rotor is a disc-shaped permanent magnet, of which tow poles (or six poles) have become magnetized (with alternating N pole and S pole).

  The step motor plays a very important role in converting a signal obtained from the electric circuit. It converts the electrical energy into mechanical energy to move the hands.

  Citizen's own special step motor converts electrical energy into mechnical energy with a high degree of efficiency.



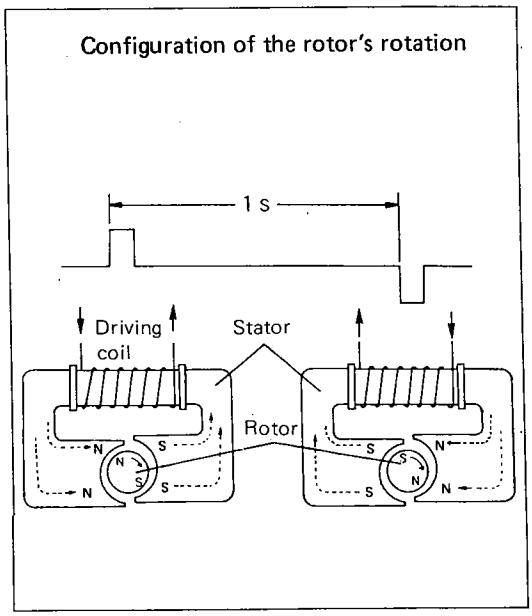
- **Operation of the step motor**

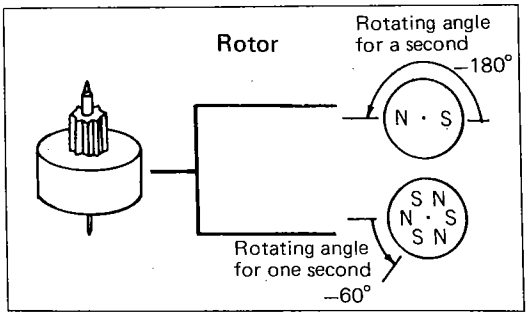
  * **An electric current flows through the driving coil.**
    The signal obtained from the divider circuit is increased by the driving circuit, and concurrently is converted into a signal which changes direction every second. This signal runs through the driving coil.

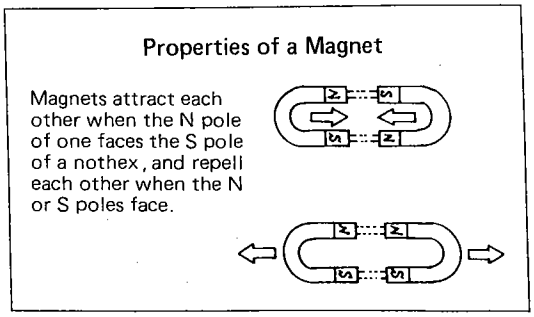
  * **The stator is magnetized.**
    When the current flows through the driving coil, the stator is magnetized by means of the driving coil. At this time, N and S poles are alternately generated on the pointed ends of the stator depending on the time and direction in which the current flows.

  * **The rotor rotates.**
    In accordance with the properties of a magnet, the N and S poles on the pointed ends of the stator and the rotor's counterparts, which have already become magnitized, repel each other when the poles are similax. On the contrary, if the poles different, they attract each other, thus causing the rotor to instantaneously rotate once every second by 180° (bipolar step motor) or by 60° (hexapolar step motor) in a certain direction.

  * **The second hand rotates.**
    When the rotor rotates, the fourth wheel and pinion, which engages with the pinion provided on the rotor, causes a stepping movement of the hand on a 1-second basis, thus moving the second hadn. (In the case of the bipolar step motor, the fifth wheel and pinion plays the same role the fourth wheel and pinion does in the above statement.)

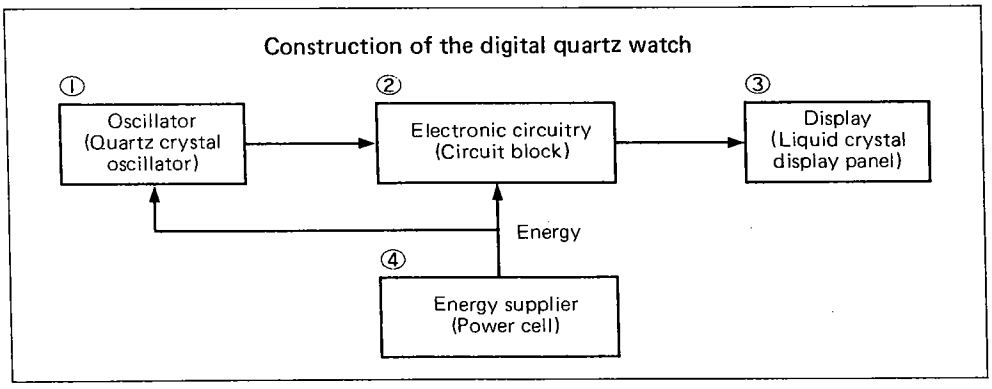






3. CONFIGURATION OF THE DIGITAL QUARTZ WATCH

The digital quartz watch is available in two display types; a liquid crystal display and an LED display. Most of the recent digital quartz watches presently on the market, employ the liquid crystal display. Therefore a digital quartz watch with a liquid crystal display will be explained below.

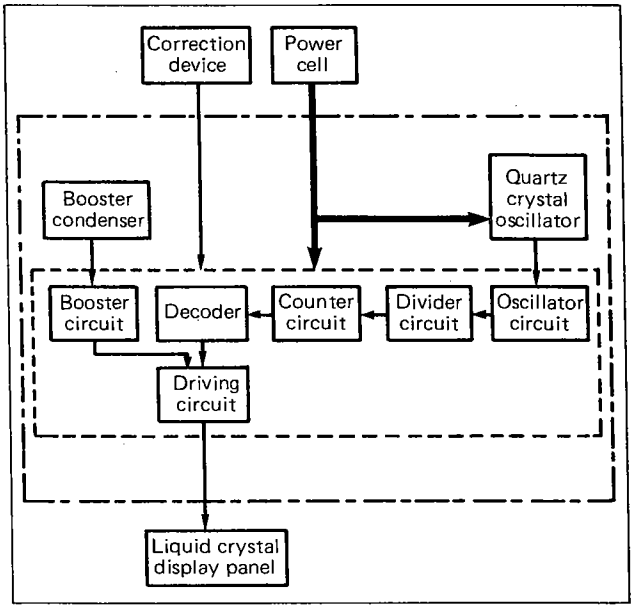


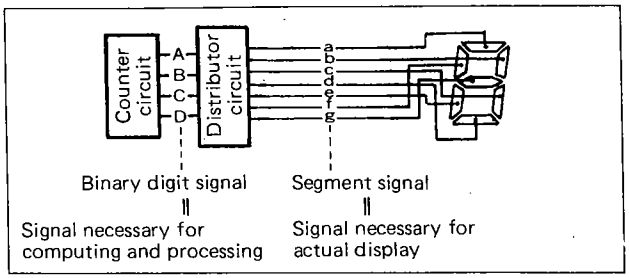
Electronic circuitry

- **Oscillator circuit, divider circuit**
  The digital quartz watch is identical with the basic analog quartz watch in terms of it's oscillator and divider circuits.

- **Counter circuit**
  A signal with a frequency of one cycle per second, which is generated by the divider circuit, is transmitted to the counter and a figure of "1-seconds" is counted there. When the "1-second" is counted ten times a figure for "10-seconds" takes up one place.
  When a signal for "10-seconds" is counted six times, a figure for "one minute" takes up one place.
  As described above, the signal is counted from a "second", through "a minute", to "an hour" by the counter. Thus, the counter manipulates each figure and then sends it to the decoder.

- **Decoder circuit**
  Decoding means that an encoded signal is transformed into, for example, a 7-segment display.
  An electrical signal within the electronic circuit is shown in binary notation (0 and 1). However, the electrical signal cannot be expressed in the segment display in binary notation form. Therefore, by using the decoder, the electrical signal is changed from binary notation to allow segment display. For example, for a 7-segment display, the decoder displays ON in place of a, b and c, and OFF in place of d, e, f and g, depending on how the 0 and 1 signals are transmitted. Thus, display conversion is carried out by the decoder.

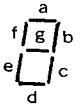




When the direct driving method is used.

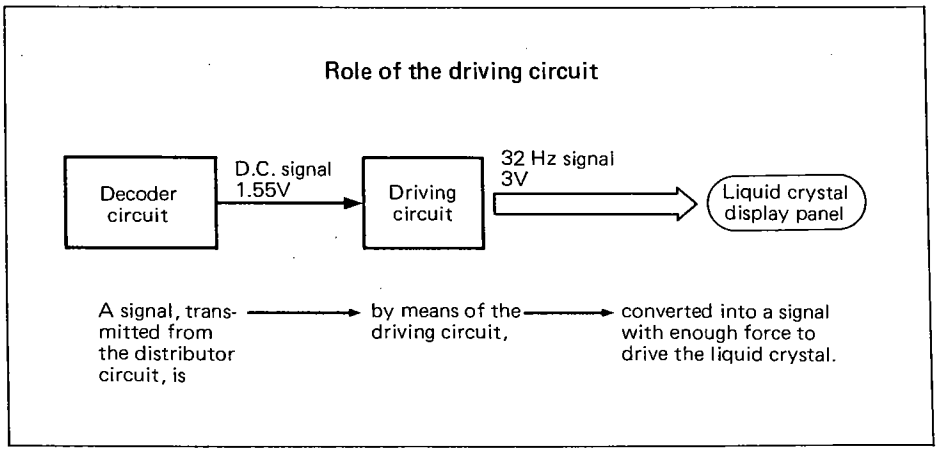
	Binary digit signal				Segment signal						
	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1

1 : ON
0 : OFF



- **Driving circuit**
  The decoder transmits signals which correspond to their respective segments. However, these signals cannot be expressed in the liquid crystal display in their present form, due to voltage, frequency, etc. To convert the signals into a form which can drive the liquid crystal, the driving circuit is used.
  The driving circuit changes the signal transmitted from the decoder as follows;
  Voltage: 1.55V ⟶ 3V
  Frequency: D.C. ⟶ AC 32 Hz

- **Booster circuit**
  Almost all the electronic circuits operate at a voltage of 1.55V. However, the liquid crystal display more efficiently at 3V, rather than at 1.55V. The maximum power cell voltage is 1.55V.
  By using the booster circuit, voltage is increased from 1.55V to 3V. The increased voltage is used to drive the liquid crystal.



Liquid crystal

- **What is a liquid crystal?**

Liquid crystal is a specific substance which is neither soild nor liquid when it is within a certain temperature range. With regularly arranged molecules, liquid crystal, like a normal crystal, is a substance having different optical properties in different directions.
Liquid crystal molecules are composed of carbon, hydrogen, oxygen and nitrogen atoms, shaped in a cylindrical, flat, or long and narrow forms.
If the arrangement of molecules is electrically disordered, the liquid crystal will change to optically. This is the principle of the liquid crystal display.
The liquid crystal used in the Citizen Quartz Chrystron LC is an FE-type (Field-effect-type), which offers a clear display, requires low operating voltage, and low current consumption. The FE-type is therefore, suitable for use in a wrist watch.

- **Construction and functioning of the liquid crystal display panel**

The liquid crystal display panel consists of a deflecting plate, the liquid crystal and a reflecting plate. The liquid crystal display panel is structured so that liquid crystal is placed between the two glass plates, provided with a clear electrode, and then so sealed. The "display panel" is a container into which a liquid crystal is placed.
The functions of the component parts of the liquid crystal display panel will be explained below.

* **Function of the deflecting plate**

Light waves have a wide range of angles. In this section, transverse and longitudinal light waves will be described. Transverse and longitudinal light waves vibrate in phase with each other, as they pass through the "deflecting plate". The deflecting plate passes light running in the same direction as the deflecting direction of the plate (either the transverse wave or the longitudinal wave), and absorbs light which is perpendicular to the deflecting direction, as shown in Fig-a.
Let's make a visual study of "deflection". As shown in Fig-b, light in which transverse waves and longitudinal waves cross at right angles, can be substituted for, using two sheets of paper which form a cross. The deflecting plate can be substituted by a block having a slit. (The slit has to be created in the same direction as the deflecting direction of the deflecting plate.) As shown by Fig-b, Paper A, placed in the same direction as the slit passes through the block, whereas Paper B which crosses the slit at right angles is stopped by the block, being unable to pass through it. The deflecting plate functions in the same manner.

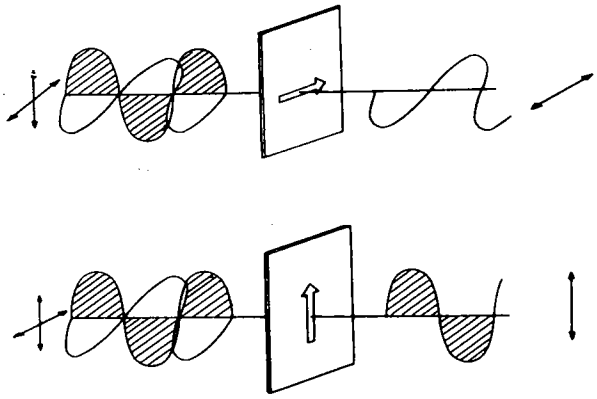


Fig. a

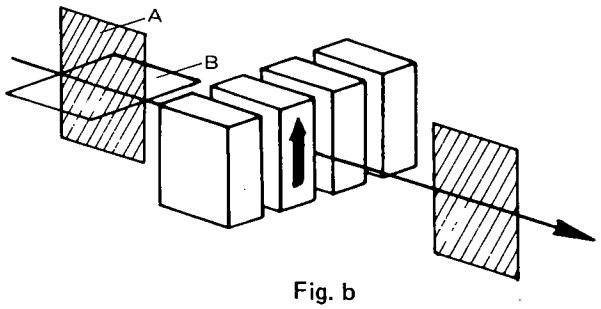


Fig. b

* **Function of the liquid crystal**

Before explaining the function of the liquid crystal, it is necessary to describe the arrangement of molecules and their optical properties.

The upper and lower glass require an orientation treatment so that the molecules of the liquid crystal can be twisted by 90 degrees between the two glass plates. When the liquid crystal is injected between the two glass plates, the molecules are slightly twisted in each layer.

Let's assume that there are N layers, in which when the molecules contained in each layer lie in different directions. When light is supplied to the upper glass from above, the light is reflected when it passes through the first layer and enters the second layer, as shown in Fig-d, causing the vibrating surface of the light to rotate slightly. When the light enters the third layer, the vibrating surface of the light is again rotated slightly. The rotation, at a slight angle, is repeated until the light reaches the Nth layer. With the aid of the arranged molecules, the light is rotated 90 degrees when it passes through the lower glass.

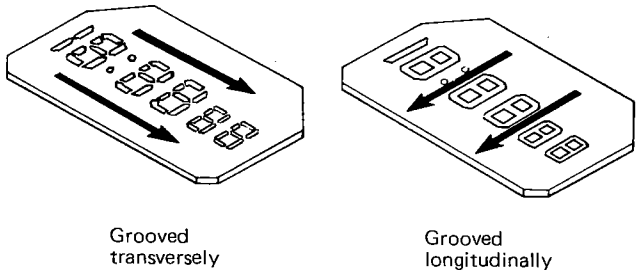


Fig. c Orientation treatment is made on each glass

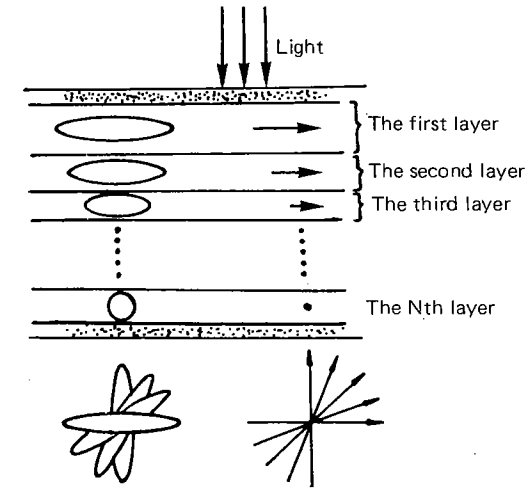


Fig. d The function of liquid crystals

Thus, the liquid crystal used in the Citizen Quartz — LC is called a Twisted Nematic-Type (TN-Type). The word "Twisted" refers to the fact that the liquid crystal molecules are rotated by 90 degrees. These twisted molecules have an interesting effect on light.

- **The principle of the liquid crystal display panel**

In the liquid crystal display, why does the portion to which voltage is applied appear dark? Why does the rest of the display appear bright? An explaination has offered to describe the role and function of the deflecting plate and liquid crystal. Let's now look at the principle of the liquid crystal display in combination with these two other elements.

We place two deflecting plates so that their respective deflecting directions cross at right angles. When liquid crystals are inserted between these two deflecting plates, incident light on the upper deflecting plate enters the liquid crystal layer, as shown in Fig-e, in the normal condition (when voltage is not applied), as long as the light (transverse wave) is in the same direction as the deflection of the upper deflecting plate.

The light which has entered the liquid crystal later is reflected by the molecules of the liquid crystal, causing its vibrating surface to rotate by 90 degrees. As a result, the vibrating surface of the light comes to have the same direction (longitudinal) as the deflection of the lower deflecting plate. Accordingly, the light passes through the lower deflecting place and reaches the reflecting plate. The light is reflected by the reflecting plate, returning to the upper deflecting plate at the same angle, only reversed. Therefore, under normal conditions, light is visible over the whole display area, which makes the entire display appear bright.

Next, when voltage is applied to the electrode of the display panel which is in the normal condition, only the molecules located in the area where voltage is applied are made perpendicular between the upper glass and the lower glass. In this molecular arrangement, the light deflected by the upper deflecting plate is not refracted by the molecules, and its vibrating surface does not rotate by 90 degrees.

Consequently, the light and the deflecting direction of the lower deflecting plate cross at right angles. The light is absorbed by the lower deflecting plate and thus it cannot reach the reflecting plate.
As explained above, for an electrode to which voltage is applied light does not reach the reflecting plate and no light is reflected. Therefore it appears dark.

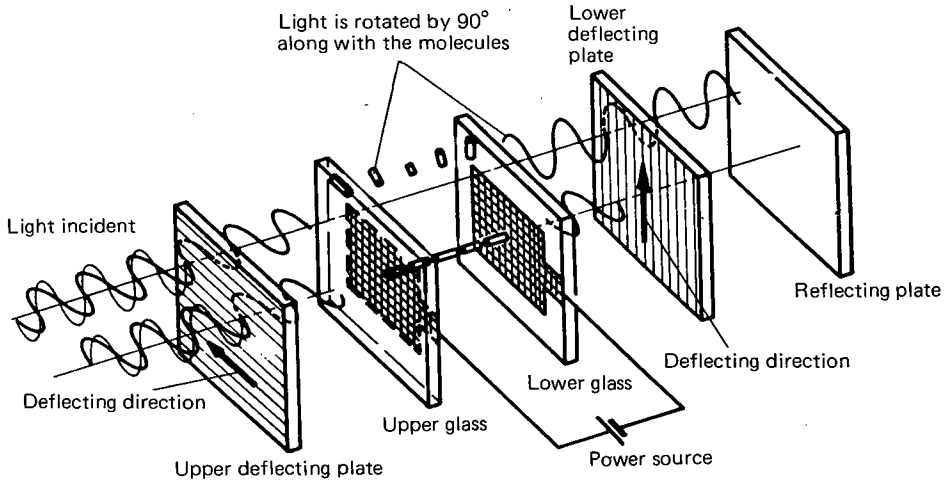


Fig. e Construction of the liquid crystal display panel

* **Display method of the liquid crystal display panel**

Numerals used by the liquid crystal display panel consist of seven portions, each of which is called a "segment". These seven segments are assigned letters from a to g as their respective names. The seven segments form a "digit".

The liquid crystal display panel is composed of two glass plates, each of which has a clear electrode pattern. On each glass is is printed the segment pattern or the common electrode pattern. When these two patterns are placed face to face, and a selective voltage is applied between these patterns, the desired numerals can be displayed.

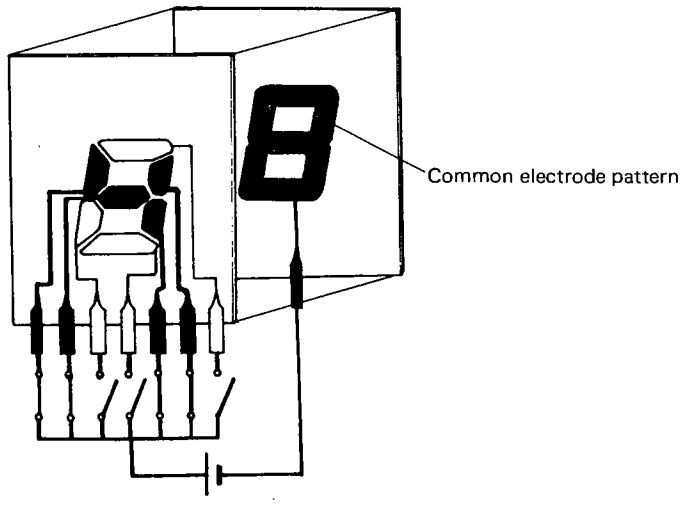


Fig. f Display method of the liquid crystal display panel

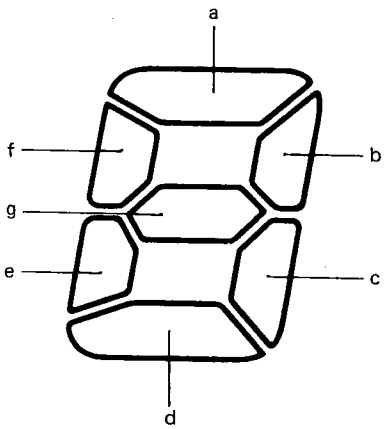
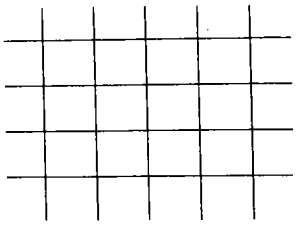


Fig. g 7-segment

Matrix

- **What is a matrix?**
  Matrix is a mathematical term which means "rows and columns", and is a concept widely used in electrical, electronic and acoustic systems, "Matrix" means "to cross" or to "intersect". A "Matrix" can be thought of in terms of the meshes of a net.



Matrix

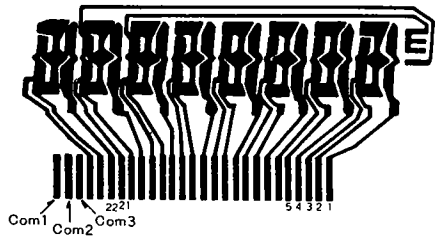
- **Method for driving the liquid crystal display panel**
  This method is roughly classified into Static Drive (S.D.) and Dynamic Drive (D. D).

  A. Static Drive (S. D)
  The conventional method for driving a liquid crystal display panel is typical of the State Drive. By inputting a pulse, whose phase is reversed (in terms of the common electrode), in the segments provided for each common electrode (Common), in other words, by supplying a potential difference to the segments, each segment can be displayed. Whether each segment is displayed or not is determined by the electrode which is capable of selecting either. A set pulse value is continuously applied to the Common. The ability to select the segment display is given to the electrode alone, as explained above. Therefore, the segment is divided into 7 parts (7-segments), each of which operates independently. The necessary number of electrodes is equal to those of the segments, and thus a relatively high number of electrodes are required.

  B. Dynamic Drive (D. D)
  The D. D, in general, has a few common electrodes (Common). A pulse whose phase has shifted is applied to the Common, electrodes one after another. When the pulse from the electrode and the pulse in a particular Common synchronize with each other, exceeding the operation voltage (threshold voltage value) of the liquid crystal, the display is produced. When the threshold value is not reached, the display will not be produced because the liquid crystal will not function. The display is produced only when the pulse from the Common coincides with the pulse from the electrode produced, exceeding the threshold voltage value. On the contrary, when both fail to coincide in time and do not exceed the threshold voltage, the display is not produced. In this sense, it can be seen that whether the display is produced or not is determined by both the Common and the electrode.

- **Operational principle of the matrix drive**
  The operational principle of the matrix drive, which is a type of Dynamic Drive, will be shown below, in comparison with the conventional liquid crystal display method (phase difference drive).

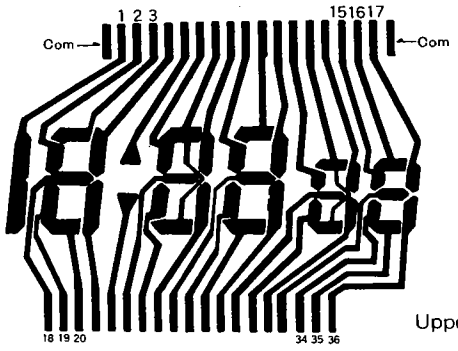
Segment of the matrix drive



Upper glass

Lower glass

Conventional segment (7-segment)



Upper glass

Lower glass

* **Segment**

Upper glass

Divide the number ⊟ vertically (|⊟|) and draw out 3 electrodes in one digit (|⊞|). (24 electrodes in 8 digits)

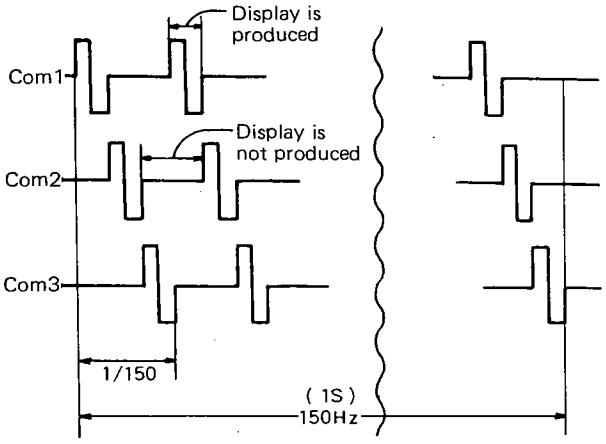
Lower glass

Divide the number ⊟ horizontally (⊟) and draw out 3 common electrodes (⊟⊟⊟).

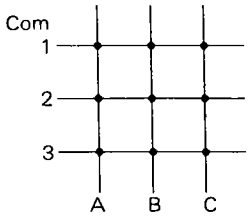
* **The principle of display**

Apply a pulse to the common electrodes (Com) numbers 1, 2 and 3, respectively. The pulses of the three common electrodes differ in terms of their phase shift. (Lower glass)

When a pulse is applied to a particular electrode, the display portion decision is dependent on which Com, (1, 2 and 3) the pulse is synchronized with.



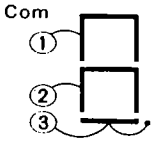
The above diagram shows a momentary movement of the Com pulse which is operating at 150 Hz.



Because the phase is shifted among the Coms, a particular Com and electrode have to be selected, depending on which portion is to be displayed. In other words, a matrix using Coms 1, 2 and 3 as the axes of the abscissas, and the electrodes as the ordinate axies is formed. Selection of an abscissa axis and an ordinate axis makes it possible to designate a particular position.

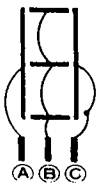
To display the number 2;

Apply a pulse synchronizing with Com ① to Electrodes Ⓑ and Ⓒ .
Apply a pulse synchronizing with Com ② to Electrodes Ⓐ and Ⓑ .
Apply a pulse synchronizing with Com ③ to Electrode Ⓑ .



To display the number 4;

Apply a pulse synchronizing with Com ① to Electrodes Ⓐ and Ⓒ .
Apply a pulse synchronizing with Com ② to Electrodes Ⓑ and Ⓒ .



Upper glass

Further divide the number ⊟ into seven parts (|⊟| 7-segment) and draw out seven electrodes. (36 electrodes in 5.5 digits)

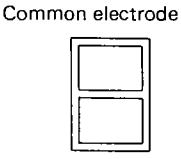
Lower glass

Use the number ⊟ as it is and draw out a common electrode.

If the pulse is in put to the common electrode (Com), it will pass through the lower glass.

If reverse pulse to that in the common electrode (Com) is in put to each electrode of each segment which is to be displayed, there will be a potential difference between a particular segment on the upper and lower glass, thus causing the display to appear.

Maintain a certain pulse value passing through the common electrode.

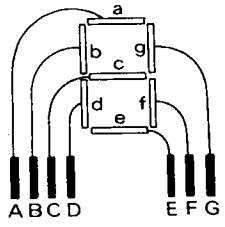


To display the number 2;

Apply a pulse, which is the reverse of that in the common electrode, (inverted pulse) to Electrodes A, G, C, D and E.

To display the number 4;

Apply a pulse, which is the reverse of that in the common electrode, (inverted pulse) to Electrodes B, C, G and F.



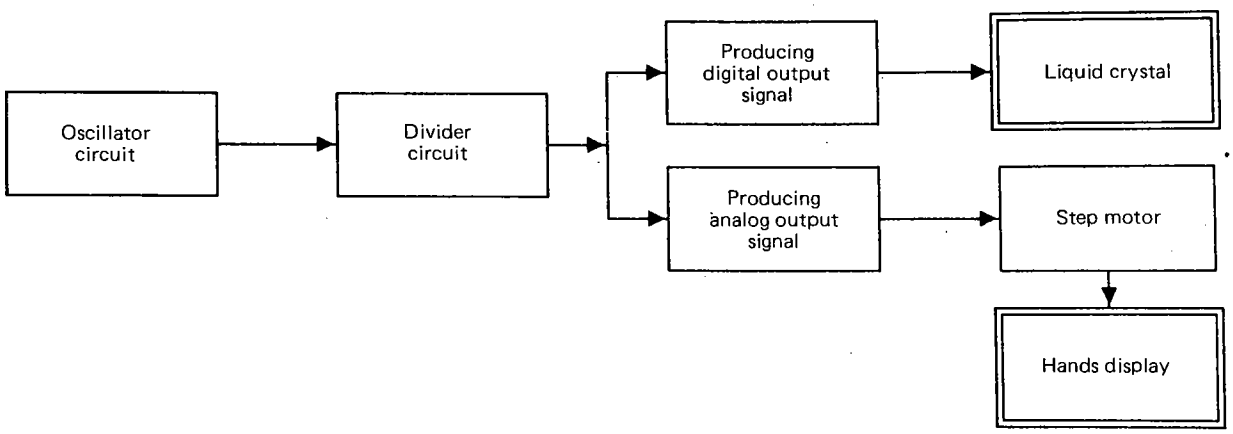
4. CONFIGURATION OF THE COMBINATION QUARTZ WATCH

A watch having both analog and digital displays is called a Combination quartz watch.

Combination quartz watch
- Analog section ..... Hands
- Digital section ..... Liquid crystal

* Some combination quartz watch products employ liquid crystal for their analog and digital displays.

In this Combo (Combination quartz watch is hereinafter referred to as the Combo), the analog and digital sections use the same time standard. Accordingly, both have the same time rate, thus causing both displays to gain or lose time in the same manner. However, the displayed time of the two displays can be changed by adjusting the time rate.



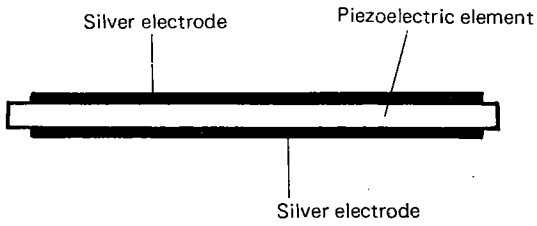
5. KNOWLEDGE RELAING TO THE MODULE

Alarm

The sound producer of the alarm used for a watch is available in two types, a piezoelectric-type and a dynamic type.

- **Peizoelectric-Type**

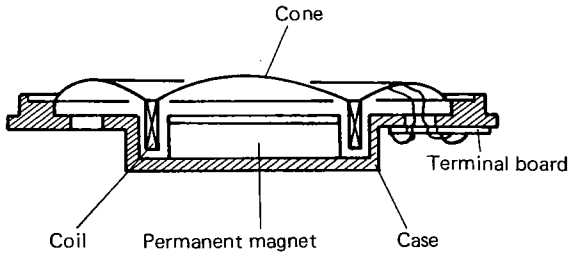
  Even in the piezoelectric-type, direct drive is not possible using the alarm signal from the IC therefore a high voltage is produced by the driving circuit by use of a booster coil, and the voltage is then applied to the sound producer.
  The piezoelectric-type is structured so that a silver electrode is attached to both surfaces of a piezoelectric element in layers.
  The piezoelectric element is attached to a stainless steel plate, and is then adhered to the case back.
  The piezoelectric element, like the quartz crystal, has the property of creating mechanical distortion if voltage is applied to it. To make use of this property, applied voltage transmitted from the driving circuit is to the piezoelectric element which causes the element to distort and begin vibrating. The alarm sounds when this vibration is conveyed to the case back.



To create a pleasant alarm sound, a wide frequency band is required.

- **Dynamic-type**

  To reproduce a voice or soft sound, a sound producer with the lowest resonance frequency is required.
  The dynamic loudspeaker is structured so that a cone made of thin plastic film is adhered to a light-weight coil which is inserted into a magnetic circuit composed of a permanent magnet and a case.
  Voice signals or alarm signals transmitted by the voice composite IC or watch IC are converted into a signal with a large flow of current by the amplifier circuit. When this signal passes through the coil, the coil starts to operate, causing the cone to vibrate, creating a sound.



Power cell life indicator (BLD)

When the life of a power cell nears its end in an analog watch, the second hand starts to make a step movement at intervals of two seconds. This does not affect the time accuracy because the second hand makes two steps every two seconds. (The second hand generally makes one step every second.)
A digital watch signals that the power cell is nearing its end, by flicking the indicator on and off at 1 Hz or 2 Hz.
When the life of a power cell is nearing its end, the voltage, which has been very stable, drops little by little, and finally the watch stops running. The BLD detects the voltage as it begins to drop and signals the user.
The BLD remains operating for a period of a few days to a week. The watch keeps time correctly while the BLD is in operation.
If the power cell is left in the watch the BLD starts to operate, the power cell may swell up or liquid may leak, possibly damaging the watch parts. When the BLD starts to operate, replace the power cell with a new one as soon as possible.

Auto return

The watch automatically returns to the normal time display one to two minutes after the time is reset. This function is called Auto Return.

The normal time display can also be restored by pressing any button while the time is being reset. This is called Instant Manual return.

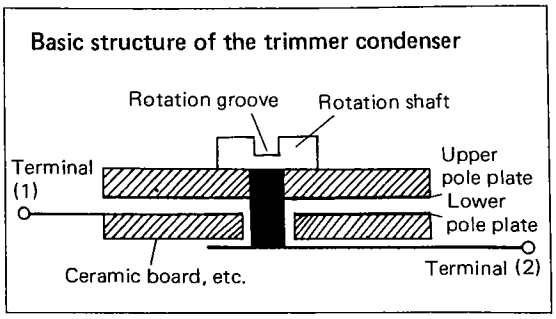
Adjustment of time rate

* Trimmer condenser method
* D.F.C. (Digital Frequency Control) method

- **Trimmer Condenser**

  The trimmer condenser consists of two pole plates, one on top of the other.

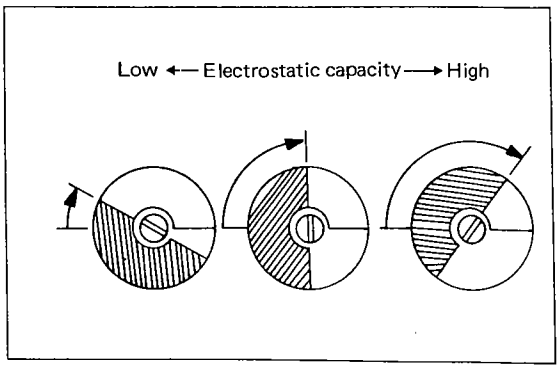
  The upper pole plate is mounted so that it can rotate. If the area where the upper pole plate faces the lower pole plate is changed, the electrostatic capacity of the condenser will also change, thus causing the oscillation period of the oscillator circuit to change. Therefore, the time rate can be adjusted.



- **D.F.C. (Digital Frequency Control)**

  The D.F.C., unlike the trimmer condenser which changes the oscillation period of the oscillator circuit, does not after the oscillation, but adjusts the time rate by logically increasing or decreasing the frequency of the divider tiers in the divider circuit. Thus, the D.F.C. is also known as the Logical Fast and Slow Method.

  Consequently, the D.F.C. makes a discontinuous adjustment, and as a result, the D.F.C. is capable of making only a limited degree of adjustment. Correction of the time rate is made in intervals of 2 or 10 seconds.



- $16{,}384\ \text{Hz} \times 1/2 \times \frac{86{,}400}{10} = 0.26$ sec./day (Approx. 8 sec./month)
- $8{,}192\ \text{Hz} \times 1/2 \times \frac{86{,}400}{10} = 0.52$ sec./day (Approx. 15 sec./month)
- $4{,}096\ \text{Hz} \times 1/2 \times \frac{86{,}400}{10} = 1.04$ sec./day (Approx. 30 sec./month)

To increase the time rate, increase the correction pulse to the divider circuit.
To decrease the time rate, reduce the pulse in to divider circuit.

There are two types of D.F.C.; for factory use and market use. Distinguish between the two types by referring to the technical manual of each Cal. No.

Electromagnetic correction of analog watches

This correction is made as follows; If the crown is turned it will generate an electric signal, thus driving the step motor. The step motor the moves the train and hands, making the correction.

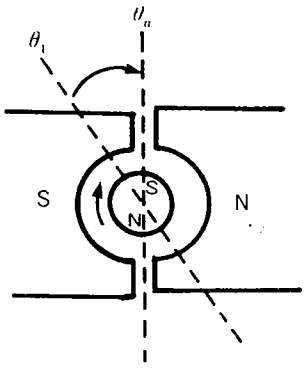
The electromagnetic correction allows elimination of the back gear train (The gear train is used for time correction) which results in a smaller and thinner watch.

Free correction and fixed incremental correction (every 20 seconds in the 20-second movement of the hand) can be made depending on the condition in which the crown is turned (depending on the way the correction signal is input).

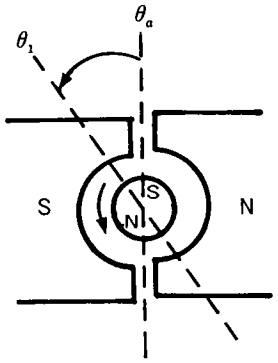
*** Operational principle**

In general, the rotor used in the analog quartz watch, rotates only in a forward direction (forward rotation). However, in this mechanism, the rotor rotates in the reverse direction (backward rotation) also, thus allowing the watch to be set forward or backward.

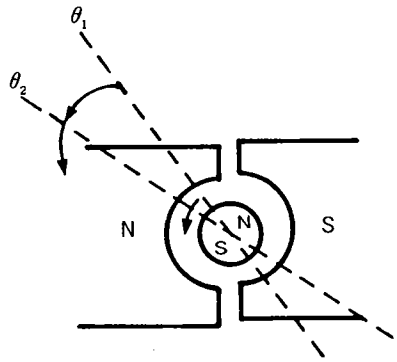
The principle of reverse driving of the step motor



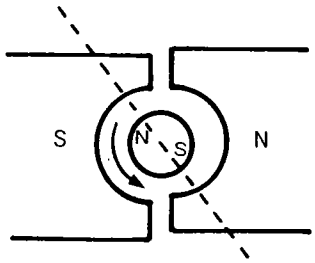
① Supply the driving pulse (pulse width = time) in the forward rotation direction.
② The rotor turns from the statically stable position (θ_1) to θ_a.



③ When the rotor starts making a reverse turn, supply the reverse turn toward θ_1.
④ When the rotor starts making a reverse turn, give the driving pulse so that the rotor may be absorbed and accelerated in the reverse direction.



⑤ The absorbed and accelerated rotor passes the electromagnetically stable position (θ_2) in accordance with the law of inertia. (This is called overshoot.)



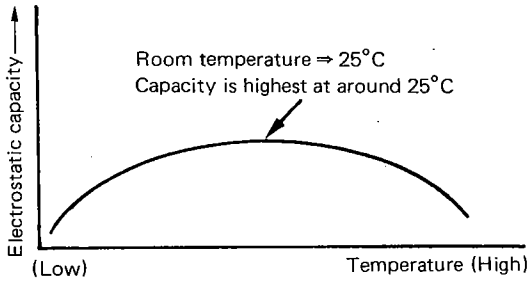
⑥ If the direction of the driving signal at the time when the overshoot is made is changed, the rotor continues to make a reverse rotation, up to 180 degrees, by the force of repulsion.

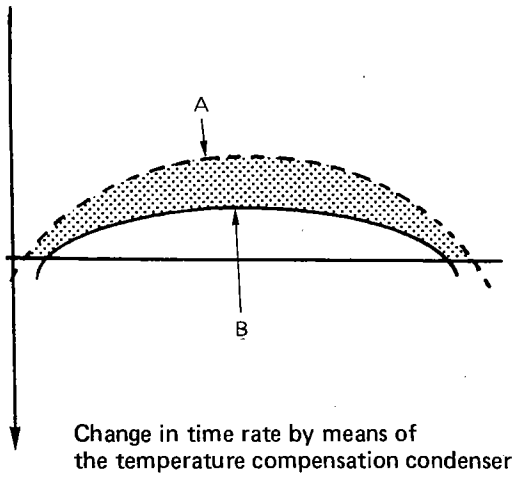
Temperature compensation function

The time rate of the watch changes when the temperature changes.
This is because a characteristic of the quartz crystal oscillator is that oscillation frequency changes due to a change in temperature.
To minimize changes in the time rate, a temperature compensation function is provided.
Temperature compensation is carried out in two ways. One is by means of the temperature compensation condenser, and the other, by the temperature sensor.

- Using the Temperature Compensation Condenser

  The larger the electrostatic capacity of the condenser in the oscillator circuit, the more the watch loses time.
  When the temperature compensation condenser is used for a watch having a temperature characteristic A , it carries out maximum compensation at around 25°C. At low and high temperatures it carries out a lower degree of compensation.
  Thus, the temperature characteristic A can be changed to B , which has a relatively moderate change due to temperature.





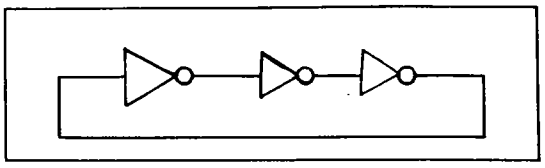
Change in time rate by means of the temperature compensation condenser

- Using the temperature compensation sensor

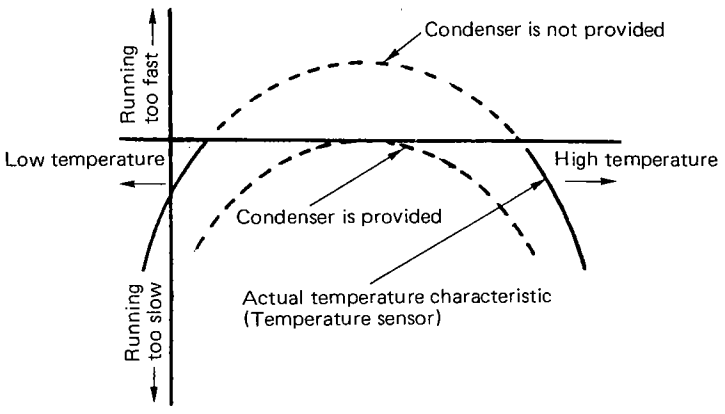
  The IC processes temperature information obtained by the thermal sensor (temperature sensor) in the IC by means of logical computation, and transmits a compensation signal which corresponds to the circumambient temperature. The frequency can be easily changed by intermittingly connecting the condenser mounted in the oscillator circuit at intervals over a certain period of time.

  The temperature sensor produces the compensation signal for each of about 500 small increments in a range of -5°C to +50°C. Its sensitivity is as follows; 50/5,000 = 0.1°C. This means that the temperature sensor transmits the compensation signal when there is 0.1°C of temperature change. In other words, a watch with compensating temperature function in its IC detects 0.1°C of temperature change, and constantly reduces the time difference. Thus, accuracy is maintained.

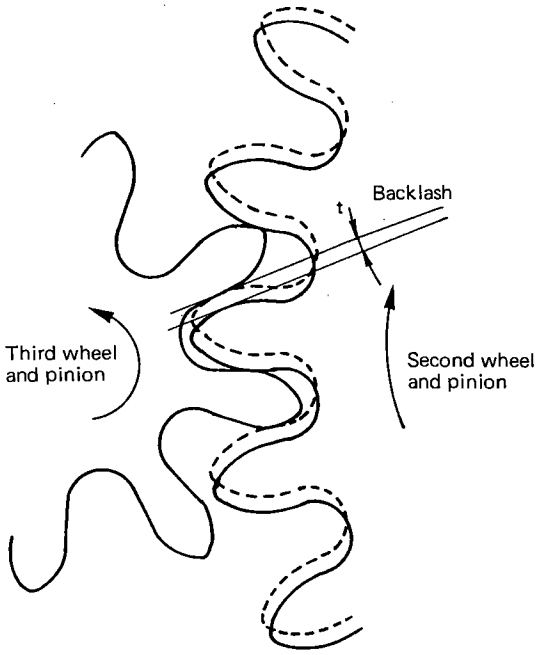
- Temperature sensor (Thermal oscillator)



Ring with C-R transmitter
(The condenser and resistor are connected to each other.)



What is backlash?
When gears rotate while engaging with each other, play, or lost motion is generated.



This is called backlash, which is shown in Figs. A and B to the left.
Looking at the second wheel and pinion and the third wheel and pinion, the normal transmission of force is made from the third wheel and pinion to the second wheel and pinion (Fig. A).
When correcting the time, transmission of force is made from the second wheel and pinion to the third wheel and pinion (Fig. B).
After correction is made, the third wheel and pinion starts rotating. However, the second wheel and pinion does not receive the force transmitted by the third wheel and pinion immediately because of backlash (t). Therefore, it is necessary to time an amount equivalent to backlash (t).

To set the correct time in consideration of backlash, it is necessary to advance the watch a few minutes and then turn back to the correct time.
In electromagnetic correction, this procedure is carried out with 3 pulses of the correction pulse.

6. KNOWLEDGE OF THE POWER CELL

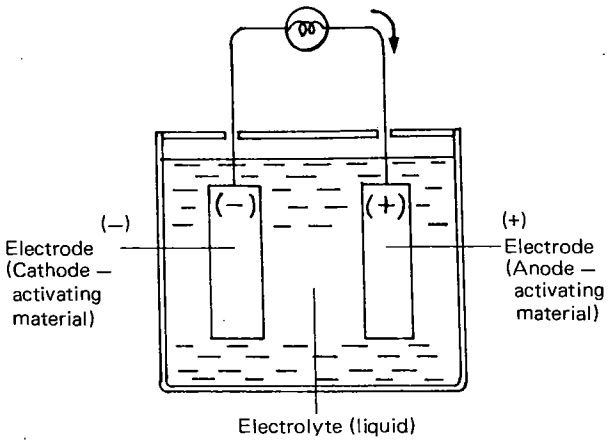
What is a power cell?

By making use of the chemical and physical changes caused by light or heat, the power cell generates electricity and produces electric current.
A chemical cell, which makes use of the chemical changes, is widely used.

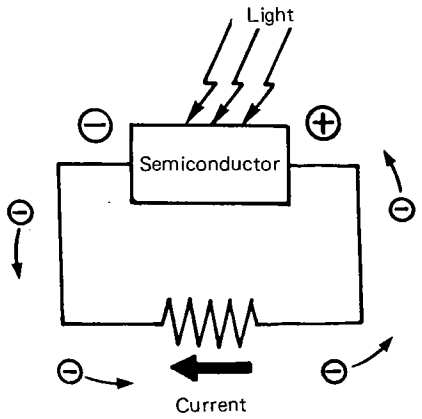
Types of Power Cells.

Classification		Characteristic	Type	Main application
Chemical cell	Primary cell	Cannot be charged	Manganese dry cell	Radio, cassette recorder, toy
			Alkaline manganese cell	Electric calculator, stroboscope, electric razor
			Silver oxide cell	Wrist watch, camera
			Lithium cell	Wrist watch, electric calculator
	Secondary battery	Can be charged	Lead storage battery	Auto, boat, airplane
			Nickel cadmium cell	Electric razor, illumination lamp
Physical cell		Turns light or radiation into electric energy	Solar cell	Wrist watch, electric calculator, space development
			Atomic battery	Space development, ocean development

- **Chemical cell**
  A chemical cell is a power cell which produces a potential difference between the cathode (material capable of giving off electrons) and the anode (material capable of receiving electrons) by making use of chemical changes.
  The biggest difference between the chemical cell and the physical cell is that the chemical cell can store energy.
  When the anode and cathode is placed in an electrolytic solution and connected to an external circuit, a chemical reaction will begin, and electrical energy is supplied to the external circuit.



- **Physical cell**
  A physical cell is a power cell which produces electrical potential between the electrodes by making use of physical change.
  Solar batteries which convert light energy into electrical energy through the use of a semiconductor element, and atomic batteries which convert radiation into electrical energy, have been put into practical use.



The basic construction of the power cell used for a watch

Basically, the power cell used for a watch consists of two electrodes, an anode-activating material and cathode-activating material, and an electrolytic solution.

- **Electrode**

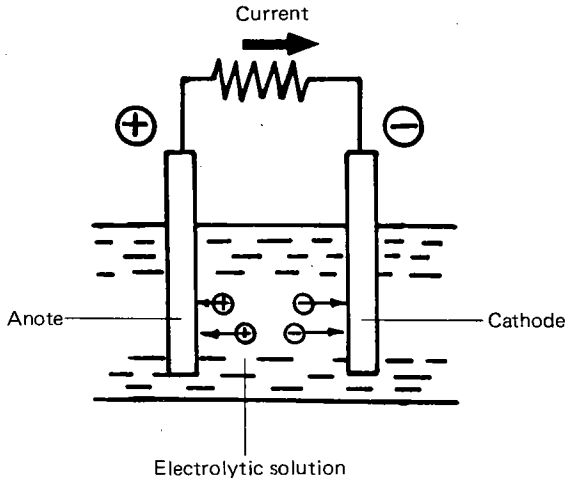
  A metallic oxide is generally used as an anode-activating material.
  For the cathode-activating material, Zinc (Zn), Cadmium (Cd) or lithium (Li) are used.
  When the anode and cathode are connected to the external circuit, electrons flow from the cathode and enter the anode by way of the external circuit, and are carried by ions (OH^-) to the cathode. Thus, a chemical reaction occurs.
  An electric current flows from the anode having a high electric potential, through the external circuit, to the cathode having a low electric potential.
  This phenomenon is called discharge. As described above, the electrodes play the role of generating electricity, in a power cell.

- **Electrolytic solution**

  Water or organic solvents in which certain materials are dissolved, is called an electrolytic solution, and the material is called an electrolyte.
  The electrolytic solution, in which the anode and cathode are immersed, ions necessary for the electrode reaction to move between both poles and causes the passage of current.
  For example, sodium hydroxide (NaOH) is separated into Na ions having a positive charge and OH^- ions having a negative charge, causing a chemical reaction which generates a current.

- **Power cell capacity**

  The total amount of electrical energy removed from a power cell is called the power cell capacity.
  The capacity is the time-integral value of current which is discharged until all the electrical energy is removed.
  The power cell for a watch uses mAH as a unit of capacity.

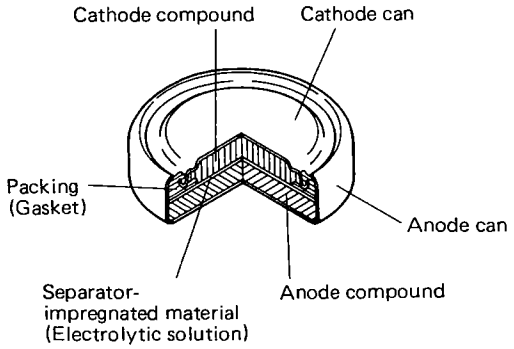


Power cell used for a quartz watch

- **Types of power cells**
  - * Silver oxide cell
  - * Silver peroxide cell
  - ——Silver oxide cell
  - * Lithium cell
  - * Solar cell

① Silver oxide cells

The silver oxide cell uses silver oxide (Ag_2O or AgO) as an anode material, sodium hydroxide (NaOH) or potassium hydroxide (KOH) as an electrolytic solution, and zinc (Zn) as a cathode material.



The silver oxide cells are classified as follows, depending on the reaction materials inside the power cell:
Two kinds of materials are used for the anode, and also for the electrolytic solution. By combining the two types of elements, respectively, four types of power cells are available.

Anode	Electrolytic solution		Power cell
Ag_2O (Monovalent silver oxide)	NaOH		Silver oxide cell
Ag_2O (↑)	KOH	=	Silver oxide cell
AgO (Dyadic silver oxide)	NaOH		Silver peroxide cell
AgO (↑)	KOH		Silver peroxide cell

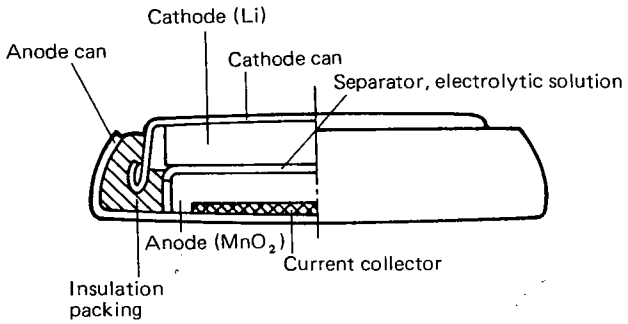
In monovalent silver oxide (Ag_2O), silver possesses only a single bond capable of reacting chemically, while the silver in dyadic silver oxide (AgO) possesses two bonds.
Accordingly, dyadic silver oxide is twice as active as monovalent silver oxide.
As a result, the capacity of a silver peroxide cell is 20% to 30% greater than that of a silver oxide cell.

The differences between sodium hydroxide (NaOH) and potassium hydroxide (KOH), both of which are used as electrolytic solutions, are as follows;

- * Sodium hydroxide (NaOH) . . . . . For use in light-load
  Analog quartz watches which require a small flow of current
- * Potassium hydroxide (KOH) . . . . . For use in heavy-load
  Watches with lamps and alarms necessitating a large flow of current

② Lithium cells

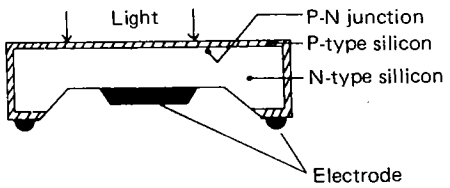
Lithium cells are classified into two types; the carbon fluoride lithium cell which uses carbon fluoride [(CF)n] as an anode material, and the manganese dioxide lithium cell which uses manganese dioxide as an anode material.
These two types of lithium cells should be used according to the specifications of the watch.
The electrolytic solution must be an organic electrolytic solution.
Lithium is used for the cathode.
The energy density of the lithium cell is two or three times higher than that of the conventional manganese cell in the same size range.



③ Solar cell

- **What is a solar cell?**

With the remarkable development in semiconductor materials, diode elements were developed to convert the light energy of the sun into electric energy. This diode element, the so called solar cell, is used as a power source in satellites, unattended lighthouses, and in radio relay stations.

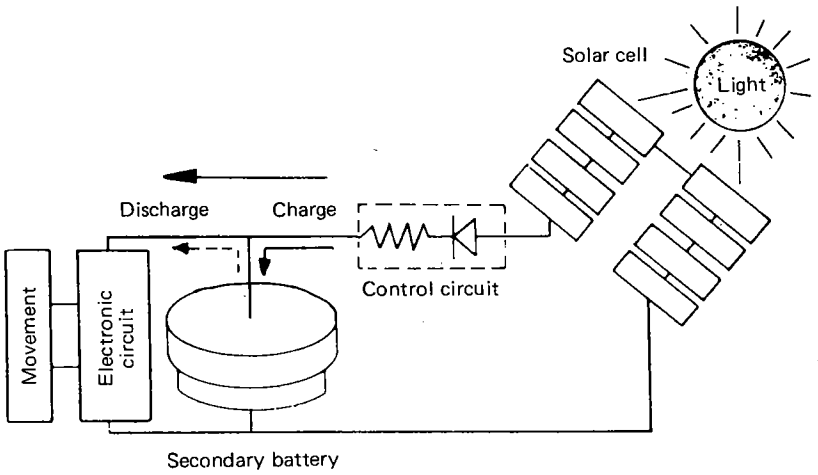


The principle of the solar cell is shown in the diagram to the right. When light is irradiated onto the surface of a PN junction, where P-type, semiconductor and N type semiconductors are joined together, a positive charge (positive hole) is collected at the P-type semiconductor and a negative charge, at the N-type semiconductor. As a result, it appears that the P-type semiconductor is positively electrified and the N-type semiconductor is negatively electrified. Mounting of the electrodes enables an electric current to be removed. Light energy is thus directly converted into electrical energy. Silicon, cadmium sulfide, or gallenium arsenide are used for the material of a solar battery. Among the three, silicon is most widely used as it is the most efficient in terms of photoelectric conversion.

- **Construction and functioning of the solar cell watch**

The composition of a solar cell watch is shown in the diagram below. Light energy from the sun is converted into electrical energy by means of the solar cell mounted on the dial. [A single solar cell cannot generate enough electromotive force. Therefore, several solar cells are normally connected in series. (8 solar batteries are connected in series in the Cal. no. 8629.)] The electrical energy passes through the control circuit, and is then charged in the secondary cell. A constant supply (discharge) of electrical energy is made available by the secondary battery to the movement, thus powering the watch.

The control circuit is used to prevent a reverse flow of electrical energy from the secondary battery to the solar cell, which can occur when the sun is not shining. It is also used to prevent a large flow of current, caused by strong light, from damaging the secondary battery.



Requirements of the power cell used for a watch

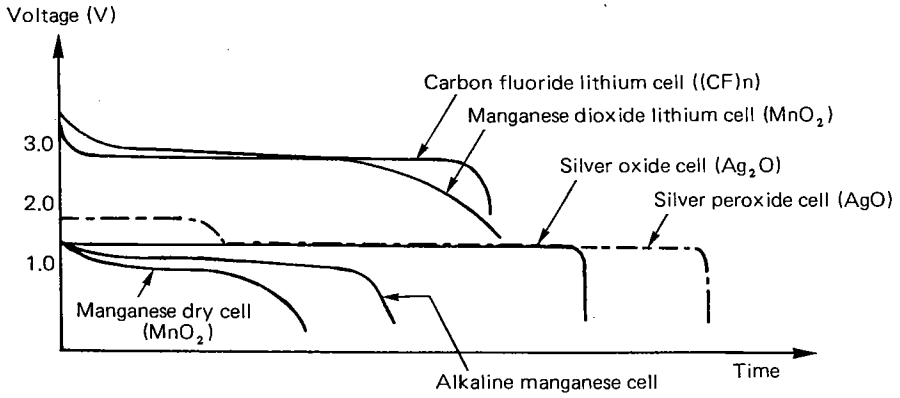
A watch is required to maintain constant accuracy in a variety of environments or conditions over a long period of time. Therefore, the power cell used in a watch must meet the requirements listed below;

1. Compact and thin, with high energy density.
2. Good temperature characteristics
   A watch is subjected to a wide range of temperature change, because it is used in various environments.
   Therefore, the power cell for a quartz watch is generally required to show stable characteristics in a range of −10°C to +60°C.
3. No leakage of the electrolytic solution.
   The power cell must be resistant to leakage which may damage the watch parts.
4. Maintain quality while being stored.
   A power cell which is not being used or is stored, decreases slowly in capacity over a period of time. This phenomenon is called self discharge. The self discharge rate varies depending on conditions (temperature, humidity) in which the watch is used.
   The discharge rate will double with every 10°C rise in temperature.
   The power cell should be stored in a place where the temperature is low, since the higher the temperature, the higher the self discharge rate.

Apart from the above, the following features are required, depending on the quartz watch type.

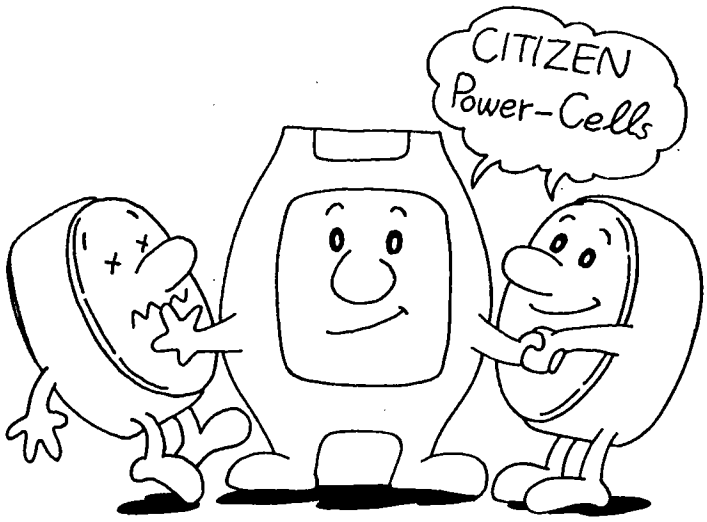
* Constant discharge voltage over a long period of time
* Excellent in terms of temporary discharge during a period of heavy load (when the alarm or illumination lamp is used)

* The graph below shows the discharge characteristics of various types of power cells (All power cells in the graph are the same size.)



Notes on the handling of the power cell

1. Do not store the power cell for long periods of time. Use the cell as soon as possible.
   It should be especially noted that the power cell has a shorter service life than normal if it is stored at high temperatures.
   One example of a good storage method is shown below; Place the power cell in a container together with silicagel. After sealing the container, store it in a refrigerator.
2. Do not leave the power cell in the watch after its service life comes to an end.
   If it is left unremoved, it may swell up or leakage may occur, thus damaging the watch parts.
   Replace the cell with a new one as soon as possible.
3. Use only power cells designated by Citizen. Do not use other power cells even though they are equivalent to those designated by Citizen in terms of size and type.
   By using two different electrolytic solutions, the silver oxide cell is available in two types; one is for a light loads (NaOH ... with a small current flow is mainly used in analog quartz watches). The other type is for heavy loads (KOH ... with a large current flow is mainly used in digital quartz watches.) Use of a light-load power cell in place of a heavy-load power cell does not affect the normal operation of the watch. However, it should be avoided, because when the illumination lamp or alarm is used, a large flow of current occurs and the voltage drops, possibly causing the watch to gain or lose time substantially, or the display to vanish.
   Power cells on the market vary in quality even though they are of the same type or have the same manufacturer code (Example: SR626SW). Citizen only accepts power cell products from power cell manufacturers which have passed Citizen's strict quality tests. Accordingly, only quality power cells are distributed.
   When replacing the power cell with a new one, make sure which power cell is required by referring to the "Watch Catalog", "list of Power Cells for Watches" and "Catalog of Movement Parts". Be sure to use the power cells designated by Citizen.



4. When placing a power cell removed from a blister pack or a watch on a conductive object, such as metal, be sure place it with the minus (cathode) surface facing upward. Recent power cells are becoming so thin that there is little or no projection on their minus (cathode) surface. If the power cell is placed with the minus (cathode) surface facing downward, it may be shorted.
5. Before mounting the power cell, wipe it with a dry cloth.
   If there is dust or dirt on the cell, conductivity may be impaired, causing the watch to run slow.
6. The power cell will rust easily. If it gets wet, wipe it with a dry cloth immediately.

Citizen power cells

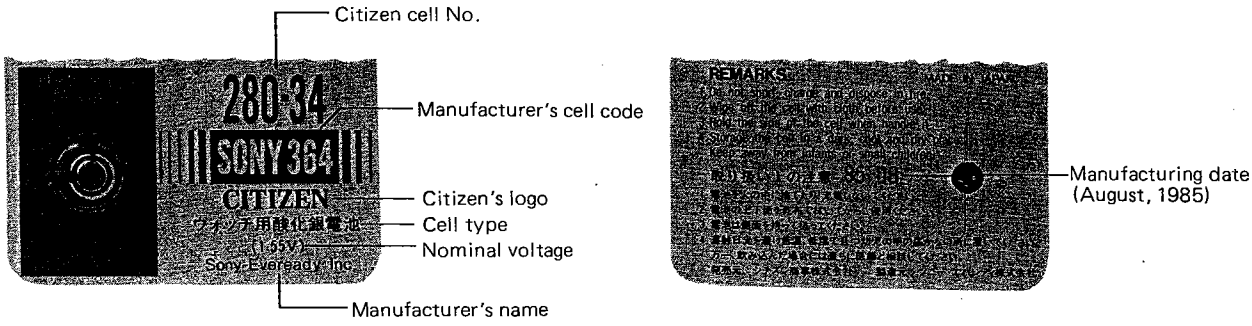
Types of power cells and blister packs

At present, there are some 10 types of Citizen replacement power cells.
They are roughly classified into, silver oxide cells, silver peroxide cells and lithium cells. These power cells are used depending on the watch type (Cal. No.) Replace the power cell only with a proper power cell.
If you have a clear understanding of the code printed on the blister pack of a power cell, you can properly replace or store the cell.

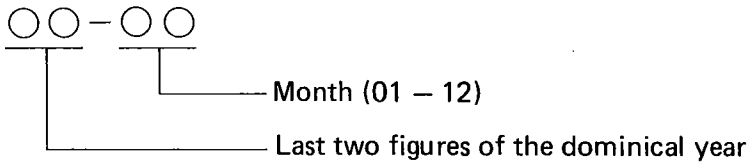
≪Reading the Blister Pack Code≫

- **Basic colors:** roughly classified into three depending on power cell type
  Silver oxide cell ——— Blue
  Silver peroxide cell —— Green
  Lithium cell (3V) ——— Red

- **Nomenclature**



- **Manufacturing date**
  The manufacturing date is shown in simplified form on the back of the blister pack.



There are cases where the manufacturing date shown on the power cell is different from that shown on the blister pack.
This is because the power cell is packed after passing strict quality tests in lots.

Power cell No.

Cell No.
- a. (Repair parts) cell No. . . . . Example 280–39
- b. (Manufacturer) cell code . . . . . Example SR626SW

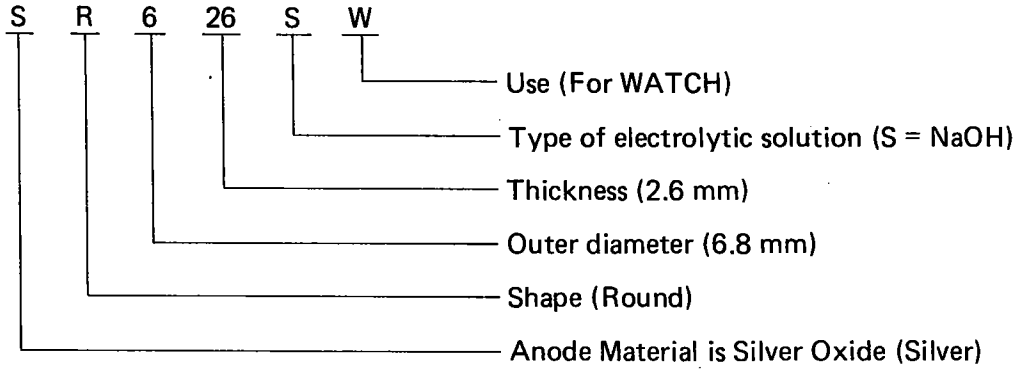
- **What does the cell No. represent?**

  280 – X X . . . . . Silver oxide cell
  280 – 1 X X . . . . . Silver peroxide cell
  2 X X . . . . . Lithium cell (3V)

- **What does the cell code represent?**

  The cell code, which the Japan Battery Manufacturers Association is promoting, is shown in the center of the blister pack. By noting the cell code, the specifications of the power can be determined.

< Example >



① Type of anode material
Type of power cell is determined by the anode material

Silver oxide cell ——— S (Silver oxide = Ag_2O)
Silver peroxide cell ——— T (Silver peroxide = AgO)
Lithium cell ——— BR or Cr (BR: Carbon fluoride = $(CF)n$ / CR: Manganese dioxide = MnO_2)
Mercury cell ——— M (Mercury oxide = HgO)

② Shape . . . . . R for round
③ Outer diameter . . . unit: mm
④ Thickness . . . . . unit: 1/10 mm
⑤ Type of electrolytic solution
S = Sodium hydroxide — For light loads (for a small flow of current)
Code is not given = Potassium hydroxide — For heavy loads (for a large flow of current)
⑥ Use . . . . . W for watch, for the exclusive use of watches.

Note: In the power cells identified by cell Nos., 280-01, 02, 18, 19, 41 and 47. Nos. 3 and 4 use different codes (numbers) which designate the power cell size.

Electrolyte	An insulator existing between anode and cathode. It prevents both electrodes from contacting with each other thus causing electron conductivity. [This is called a Short circuit.] At the same time, it moves ions or reaction-contributing materials, which are necessary for the electrode reaction, between the anode and the cathode.
Active material	Reactant contained in the anode and the cathode.
Energy density	Energy holdings for spacific amount of weight or capacity. The unit of energy density is Wh/ℓ.

7. NOTES ON HANDLING OF THE QUARTZ WATCH

Concerning magnetism

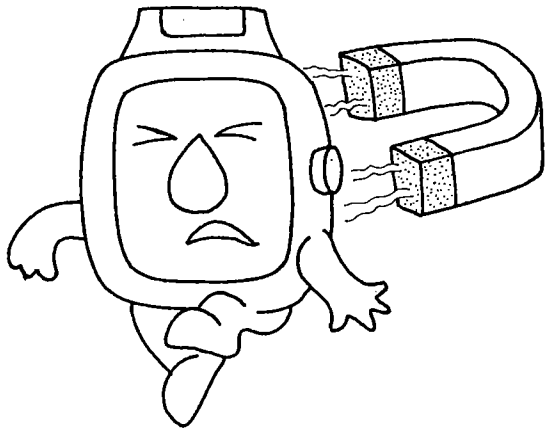
The analog quartz watch uses the rotor of the permanent magnet as its step motor.

If the analog quartz watch is brought near an instrument generating an intense magnetic field, such as a health care instrument with a magnet, a magnetic necklace, electric welder or electric mahjong table, the watch may run down, or it may gain or lose time.

This is because the intense magnetism has an influence on the rotor, and can cause erattic rotation. The intensity of a magnetic field increases in inverse proportion to the square of the distance. Therefore, if the distance triples, the magnetic field intensity is reduced to one-ninth. The watch resumes regular operation after it is moved away from an intense magnetic field.

Accordingly, the best way to use the analog quartz watch is not to bring it near a magnetic field.

However, general household electric applianaces won't cause a problem.



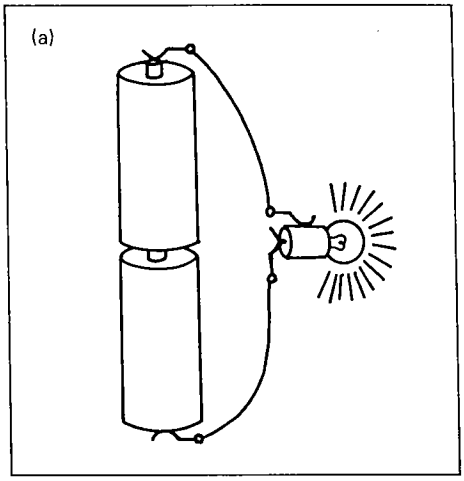
Explanation of the terminology

- **Current**

  Why does an electric lamp light? Why does a variety of electrical equipment operate? The answer to these questions is that on electric force flows through the electric lamp and the equipment. This electric force is called a current. Current intensity is measured in amperes (abbreviation: A)

  To cause a current to flow, a motive power is required. The source of this motive power is generally called the power source.

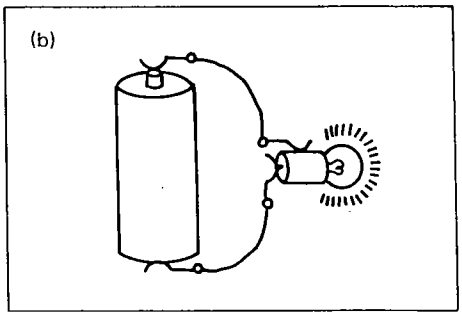
  Electrical equipment starts to operate when it is connected to a power source, thus allowing the current to flow.



- **Voltage**

  When a miniature electric lamp is connected to a power cell, current flows and the lamp lights. Let's compare the brightness (a) of a lamp employing two power cells and the brightness (b) of a lamp employing one power cell which have exactly the same standards as the two used above. The result is that (b) is darker than (a). This is because one power cell has less power to cause the current to flow than two power cells. The current generated in (b) is weaker than that in (a).

  As known from the above, the power cell or power source in general has the power to allow current to flow. This power is called voltage, which varys in strength. The volt (abbreviation: V) is used to show the strength of this power. The button-type power cell used in watches comes in two types; 1.5V and 3.0V.

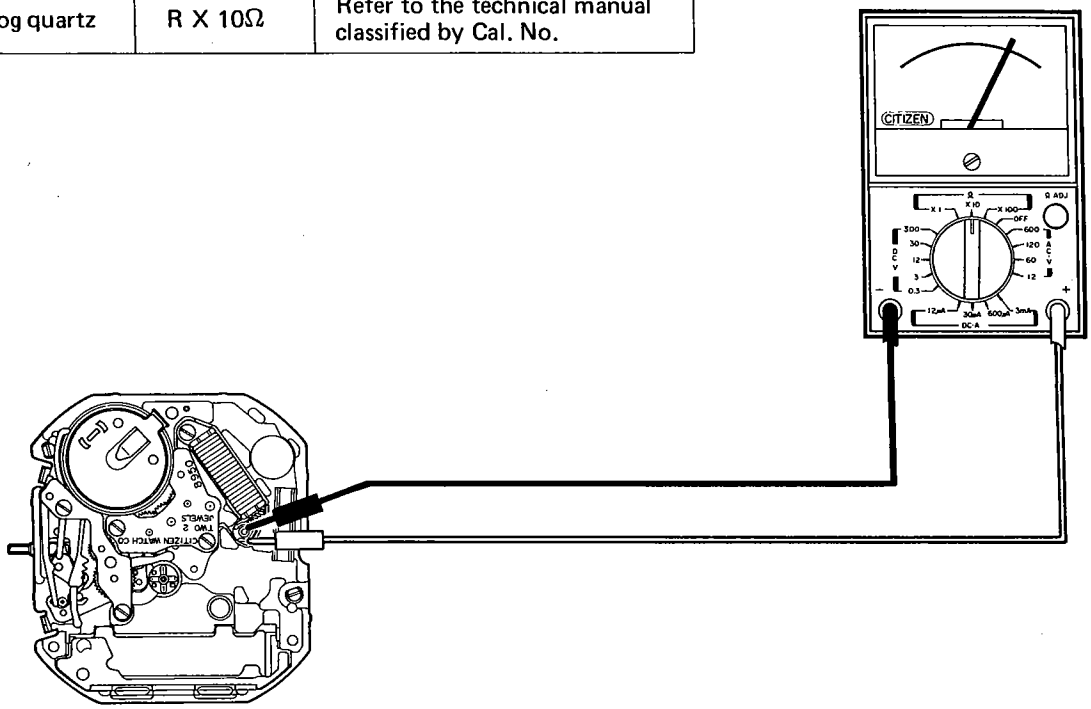


- **Chemical cell terminology**

Primary cell	Throwaway power cell. Cannot be charged.
Secondary battery	Can be repeatedly recharged. Also known as a storage battery.
Nominal voltage	Voltage value which is expected to remain during discharge in normal conditions.
Discharge	Delivery of current from the power cell to the external circuit.
Capacity	Time integral value of the current which is discharged until the final rated voltage, (Ah is used as the unit).
Charge	Electrical energy stored in chemical form in a secondary cell. Chemical energy is converted from electric energy by applying a current to the secondary battery, which has finished discharging, in the reverse direction.
Self discharge	When storing the power cell, or when it is left unused without being connected to a load, the power cell naturally loses discharge capacity. This phenomenon is called Self discharge. Self discharge expressed on a time basis is the self discharge rate.
Electrode	Consists of a current collector and an active material. The generation of electrical energy takes place in the electrodes. These are two types of electrodes; the anode and cathode.

Measuring coil resistance;
Apply the ⊕ and ⊖ lead pins of the tester to the terminal patterns of the coil, respectively, with the unit of the electronic circuit and the power cell removed from the watch. There is no polarity at this time.

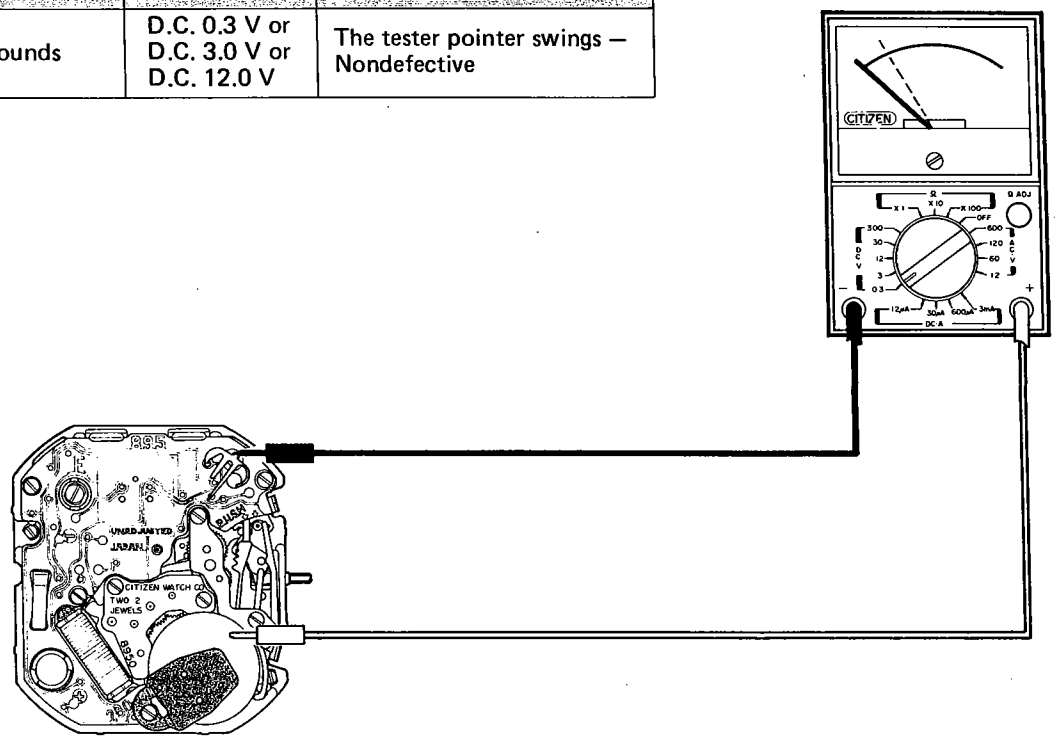
Watch type	Tester range	Standard for judgment
Analog quartz	R X 10Ω	Refer to the technical manual classified by Cal. No.



(Example: Cal. 8950-02)

Confirming the output signal of the alarm;
Apply the ⊕ lead pin of the tester to the upper surface of the power cell, and the ⊖ lead pin, to the buzzer contact spring, with the alarm switched ON.

Module	Tester range	Standard for judgment
Alarm sounds	D.C. 0.3 V or D.C. 3.0 V or D.C. 12.0 V	The tester pointer swings — Nondefective

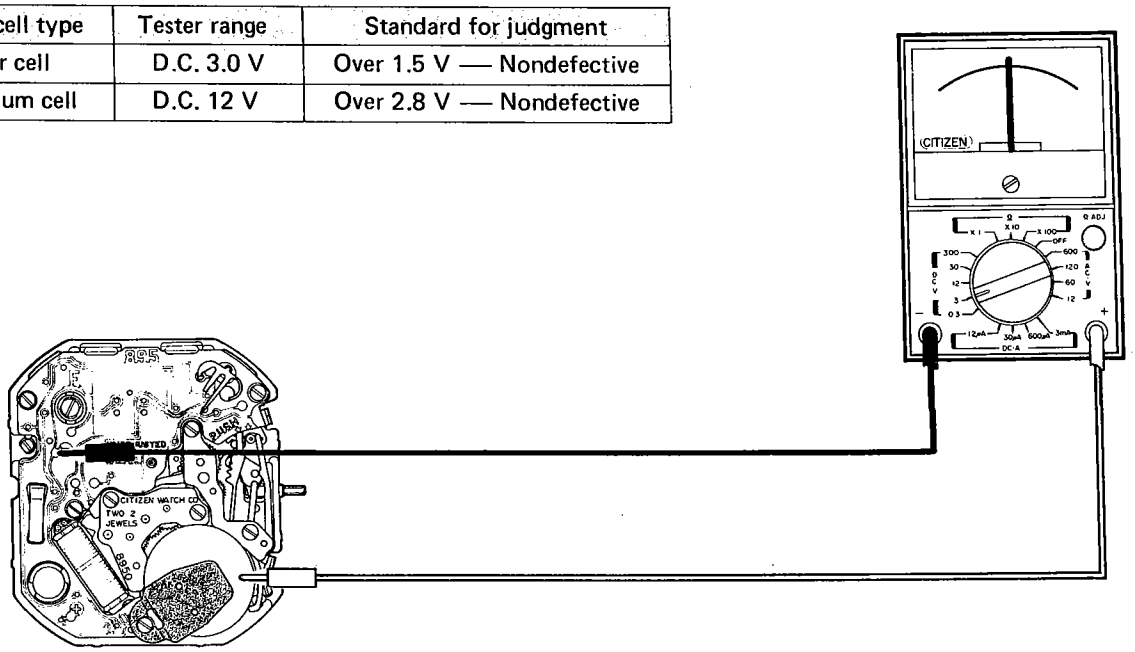


(Example: Cal. 8950-02)

1. TROUBLESHOOTING METHODS BY THE TESTER

Measuring power cell voltage;
Place the ⊕ lead pin of the tester on the upper surface of the power cell and the ⊖ lead pin on the - pattern of the circuit.

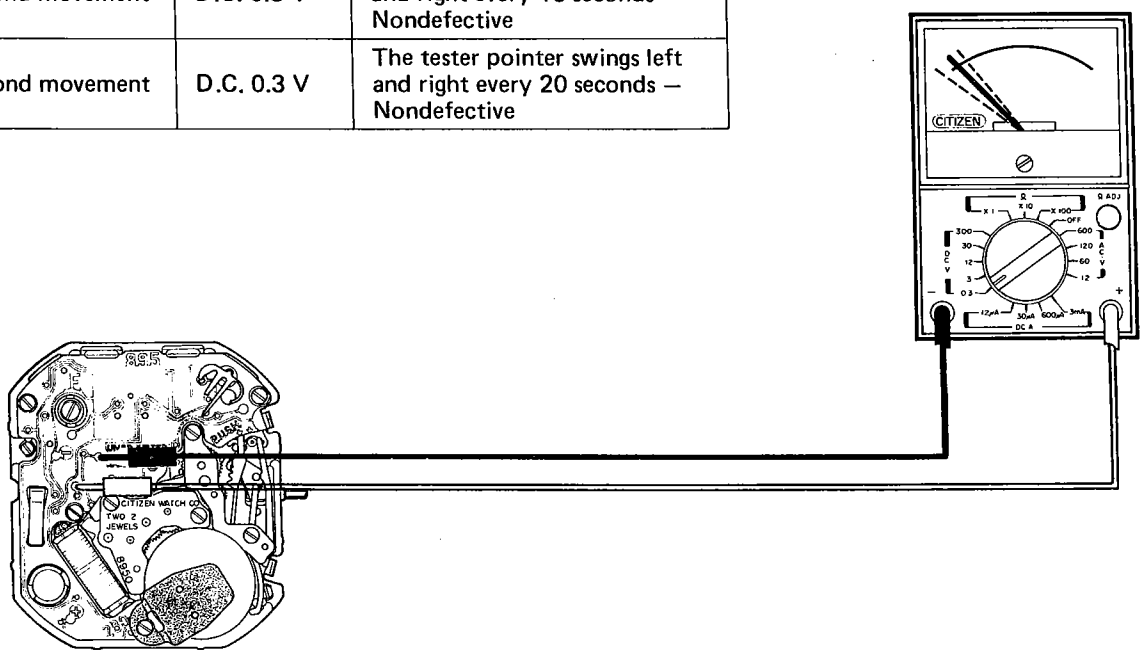
Power cell type	Tester range	Standard for judgment
Silver cell	D.C. 3.0 V	Over 1.5 V — Nondefective
Lithium cell	D.C. 12 V	Over 2.8 V — Nondefective



(Example: Cal. 8950-02)

Confirming output signal;
Confirm the final output signal of the analog quartz. Apply the ⊕ and ⊖ lead pins of the tester to the terminal patterns of the coil, respectively. There is no polarity at this time.

Hand movement mode	Tester range	Standard for judgment
1-second movement	D.C. 0.3 V	The tester pointer swings left and right every second — Nondefective
10-second movement	D.C. 0.3 V	The tester pointer swings left and right every 10 seconds — Nondefective
20-second movement	D.C. 0.3 V	The tester pointer swings left and right every 20 seconds — Nondefective



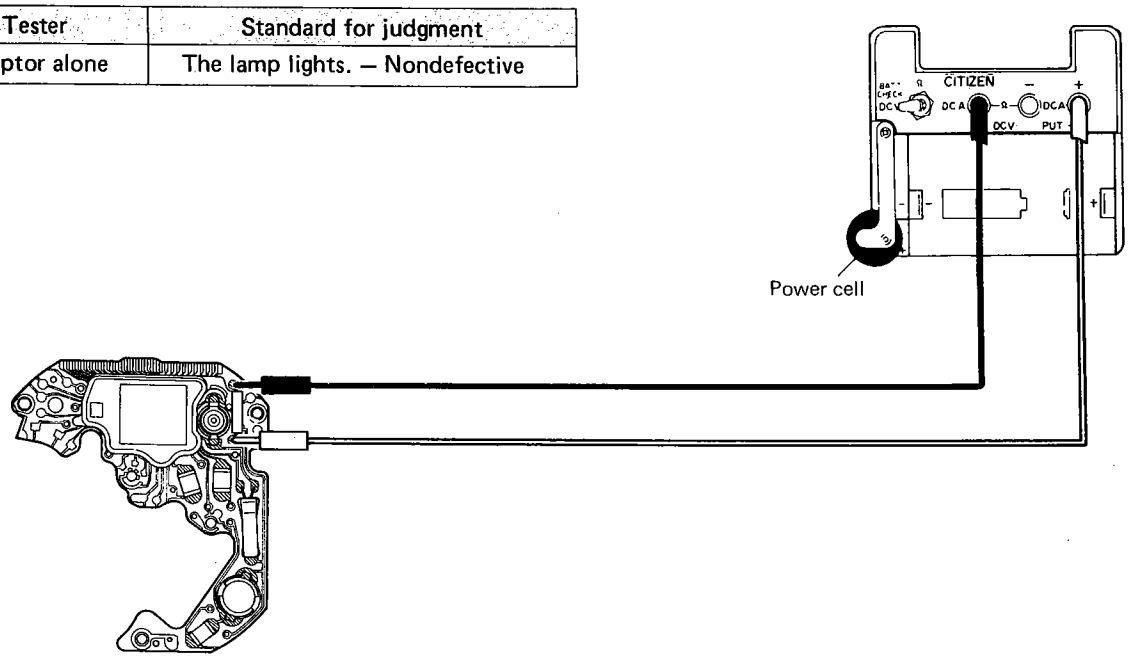
(Example: Cal. 8950-02)

2. GENERAL (COMMON) CHECK POINTS

Check point	How to check	Results & treatment
a. Checking connection parts	○ Analog section	
	1) Confirm that there is nothing wrong with the conductivity of the power cell. Check for dust or dirt.	1) Dust, dirt → Remove it
	2) Confirm that screws for mounting electronic parts (electronic circuit, power cell, etc.) are adequately tightened.	2) Screws have become loose → Tighten them
	3) Confirm that there is no dust or dirt on the coil and the connection pattern of the electronic circuit unit.	3) Dust, dirt → Remove it * No defect is found → Replace the electronic circuit unit
	○ Digital section Check the connection of the LC display panel.	
	1) Confirm that the LC display panel, LC display panel connection rubber, and the plate complete (or unit of electronic circuit) have been properly mounted.	1) Bad mounting → Mount again
	2) Check that there is no dust, dirt, cuts, or scratches around the conductive parts (circuit pattern — LC display panel connection rubber, LC display panel connection rubber — LC display panel)	2) Dust, dirt → Remove Cuts, scratches → Replace the parts
	3) Confirm that the screws attaching the LC display panel holder are not loose.	3) The screws have become loose → Tighten them
b. Checking train wheel	1) Check that the transmission operates smoothly, and that each gear has the appropriate clearance.	1) Improper clearance → Adjust it
	2) Check that the gears are properly lubricated. * Oversupply of lubricant may cause the watch to run down.	2) Improper lubrication → Lubricate again
	3) Check that there is no dust or dirt. Pay special attention to the rotor.	3) Dust, dirt → Remove it
c. (Calendar side) Checking dial side mechanism	1) Confirm that the hands rotate smoothly.	
	* If the date and day display functions are provided, confirm that quick correction can be made properly.	
	If a wrong is found → check the following points; a gears of the back train wheels, such as the minute wheel and pinion, hour, etc. have not been deformed; the parts of the indicating mechanism (calendar side parts) have not been deformed.	
	2) Check that lubrication is adequate.	2) Improper lubrication → Lubricate again

Checking the illumination lamp;
Apply the ⊕ and ⊖ lead pins of the tester to both ends of the lamp, respectively. There is no polarity at this time.

Tester	Standard for judgment
Adaptor alone	The lamp lights. – Nondefective



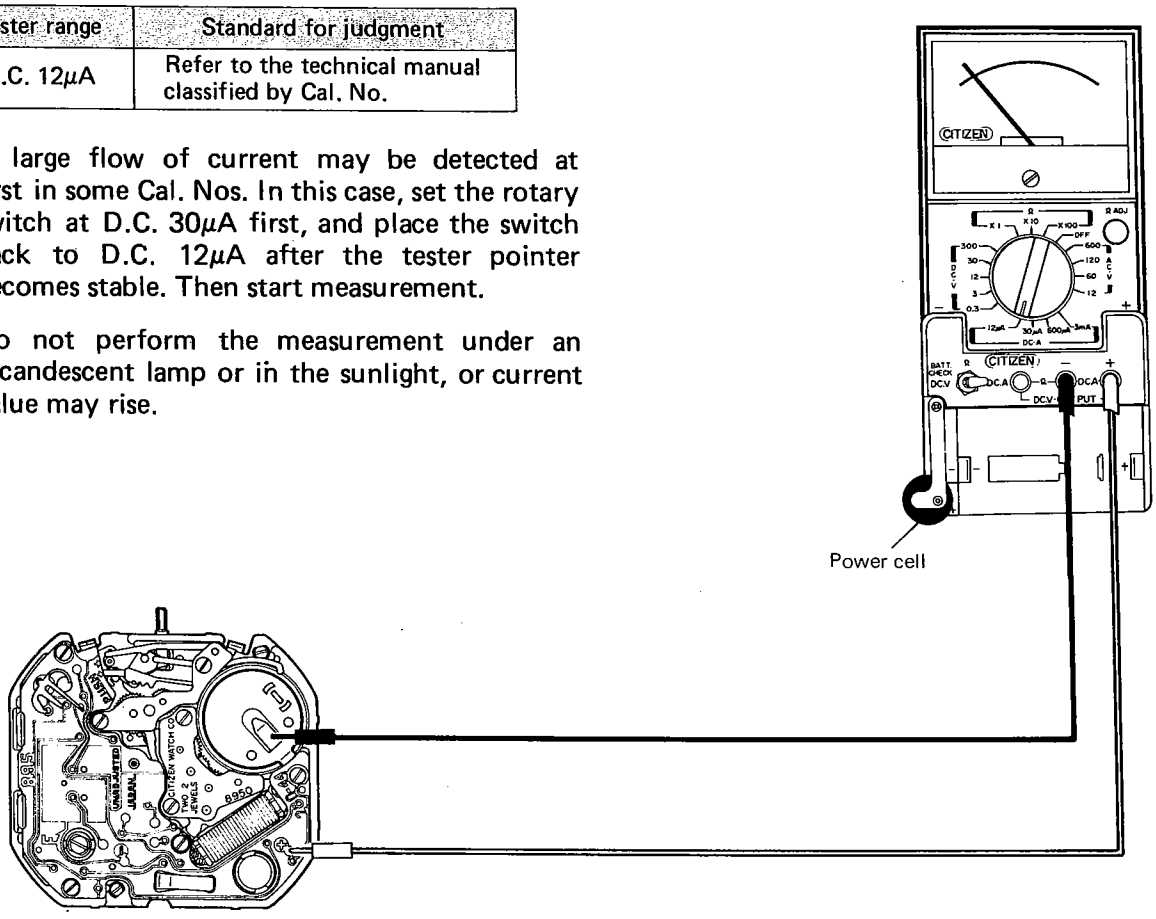
(Example: Cal. 8950-02)

Measuring current consumption;
Apply the ⊕ lead pin of the tester to the upper surface of the module (power cell strap, etc.), and the ⊖ lead pin, to the power cell connector spring.

Tester range	Standard for judgment
D.C. 12μA	Refer to the technical manual classified by Cal. No.

* A large flow of current may be detected at first in some Cal. Nos. In this case, set the rotary switch at D.C. 30μA first, and place the switch back to D.C. 12μA after the tester pointer becomes stable. Then start measurement.

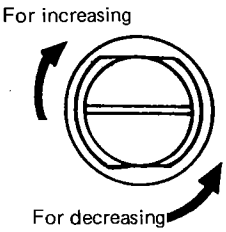
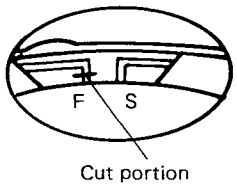
* Do not perform the measurement under an incandescent lamp or in the sunlight, or current value may rise.



(Example: Cal. 8950-02)

2. GENERAL (COMMON) CHECK POINTS

Check point	How to check	Results & treatment
a. Checking connection parts	○ Analog section	
	1) Confirm that there is nothing wrong with the conductivity of the power cell. Check for dust or dirt.	1) Dust, dirt → Remove it
	2) Confirm that screws for mounting electronic parts (electronic circuit, power cell, etc.) are adequately tightened.	2) Screws have become loose → Tighten them
	3) Confirm that there is no dust or dirt on the coil and the connection pattern of the electronic circuit unit.	3) Dust, dirt → Remove it * No defect is found → Replace the electronic circuit unit
	○ Digital section Check the connection of the LC display panel.	
	1) Confirm that the LC display panel, LC display panel connection rubber, and the plate complete (or unit of electronic circuit) have been properly mounted.	1) Bad mounting → Mount again
	2) Check that there is no dust, dirt, cuts, or scratches around the conductive parts (circuit pattern — LC display panel connection rubber, LC display panel connection rubber — LC display panel)	2) Dust, dirt → Remove Cuts, scratches → Replace the parts
	3) Confirm that the screws attaching the LC display panel holder are not loose.	3) The screws have become loose → Tighten them
b. Checking train wheel	1) Check that the transmission operates smoothly, and that each gear has the appropriate clearance.	1) Improper clearance → Adjust it
	2) Check that the gears are properly lubricated. * Oversupply of lubricant may cause the watch to run down.	2) Improper lubrication → Lubricate again
	3) Check that there is no dust or dirt. Pay special attention to the rotor.	3) Dust, dirt → Remove it
c. (Calendar side) Checking dial side mechanism	1) Confirm that the hands rotate smoothly. * If the date and day display functions are provided, confirm that quick correction can be made properly. If a wrong is found → check the following points; a gears of the back train wheels, such as the minute wheel and pinion, hour, etc. have not been deformed; the parts of the indicating mechanism (calendar side parts) have not been deformed.	
	2) Check that lubrication is adequate.	2) Improper lubrication → Lubricate again

Check point	How to check	Results & treatment
d. Measuring and adjusting time rate	Confirm which adjusting method is suitable for the watch being repaired. ○ Trimmer adjustment ——— Adjustment is made using the trimmer condenser ○ D.F.C. adjustment ——— No adjustment terminal for customers' use is provided ——— Adjustment terminal for customers' use is provided When the watch gains or loses time, adjust the time rate according to the following procedures: ○ Trimmer adjustment Adjustment is made by turning the trimmer condenser clockwise or counterclockwise using the screwdriver fitting in the groove of the trimmer. ●To increase the time rate, turn the trimmer condenser clockwise. ●To decrease the time rate, turn the trimmer condenser counterclockwise.   ○ For the D.F.C. with the adjustment terminal for customers' use, the pattern shown in the figure to the right has been mounted on the module. Depending on which portion of this pattern is cut (with a knife, etc.), three different adjustments as described below, are possible. ●Cutting portion F ——— +15 sec./month ●Cutting portion S ——— -15 sec./month ●Cutting portions F and S ——— -30 sec./month ○ For the D.F.C. without the adjustment terminal for customers' use, replace the electronic circuit unit when the watch gains or loses time. * Do not measure the time rate in direct sunlight or under an incandescent lamp, since correct measurement may not be obtained due to a shift in the time rate.	●Adjustment is possible → Nondefective ●The watch still gains or loses time substantially even after adjusting the time rate → Replace the electronic circuit unit
e. Confirming using conditions	Confirm how the customers' used their watches by checking the following points; 1. Whether they exposed it to temperatures beyond the effective temperature range; 2. Whether it was brought near an intensive magnetic field (health care product, electric mahjong table, etc.) — If it is an analog watch. 3. When was the power cell last replaced? 4. When was time setting last made? 5. Was the watch mishandled or not?	
f. Checking appearance and functions	Check the following points; ○ Whether there is anything wrong with the appearance; ○ Whether the crown functions properly; (This check is usually made for analog watches.) ○ Whether each of the buttons function properly; (This check is usually made for digital watches.) ○ Whether the alarm and lamp operate properly; (if they have been provided with the watch.)	

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