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(71) Applicants:
- **Seiko Instruments Inc.**
Chiba-shi, Chiba (JP)
- **Seiko Instruments R&D Center Inc.**
Chiba-shi, Chiba (JP)

(72) Inventor: **Kanesaka, Toshiya**
Mihama-ku, Chiba-shi, Chiba (JP)

(74) Representative: **Sturt, Clifford Mark et al**
Miller Sturt Kenyon
9 John Street
London WC1N 2ES (GB)

(54) Radio-controlled watch

(57) When a voltage generated by an electrical generator means becomes below a certain value, a detection signal from a voltage detection means opens a switching means. The supply of electrical power from an electrical storage means to a radio-controlled timepiece circuit is stopped. When the voltage generated by the generator means regains the given value, the detection signal from the voltage detection means closes the switching means, supplying electric power to a radio-controlled timepiece circuit. At the same time, a control signal from the voltage detection means activates a radio receiver circuit. Thus, a timepiece body circuit is synchronized by radio control technology. Precise time is displayed by a display means .

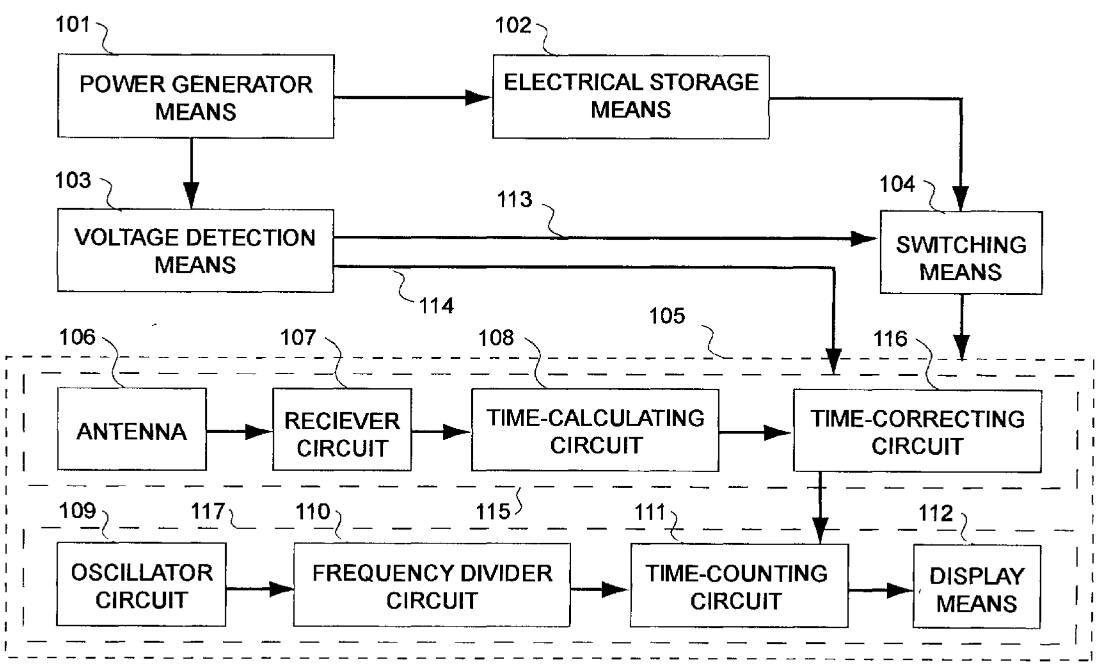

Fig.1

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Description

[0001] The present invention relates to a radio-controlled watch that receives time information transmitted in the form of radio waves and corrects the time.

Description of the prior Art:

[0002] Standard radio waves on which time information is superimposed have been heretofore transmitted under the jurisdiction of the Ministry of Posts and Telecommunications. Long-wave standard radio waves are transmitted with carrier of 40 kHz. Radio-controlled watches that receive these radio waves and correct the time have been put into practical use (see Japanese Unexamined Patent Publication No. Hei. 6-27266).

[0003] Fig. 5 is a diagram showing the time codes of long-wave standard waves (JG2AS). These codes are represented in binary codes. 0.8-second mark 501 indicates "0". 0.5-second mark indicates "1". 0.2-second mark indicates a position or reference marker. In Fig. 5, the date is days accumulated from January 1 and is 34 days. The time is 10:8. DUT1 = -0.3.

[0004] A radio-controlled watch has a function of receiving radio waves and a function of correcting the time, as well as a time-measuring function and a time-displaying function. The watch receives the aforementioned long-wave standard radio waves, corrects the time, and can provide a display of the correct time.

[0005] There is a demand for an electronic watch that does not need replacement of the battery. Electronic watches having an electrical power generator and a battery for storing the generated electrical power have been developed. Those, which use a thermoelectric generator that can be made smaller in size and weight as the power generator described above, have been developed.

[0006] An electronic wristwatch fitted with a thermoelectric generator is worn on an arm such that suction of heat by the thermoelectric generator is conducted from the arm. Heat is dissipated to the outside air. In this way, electric power is generated by making use of a temperature difference. Accordingly, when the electronic wristwatch is detached from the arm, no temperature difference is produced and so power generation may be stopped. If power generation is stopped for a long time, electric power stored in a storage device might be exhausted. Furthermore, when the outside air temperature and the body temperature on the arm become equal, power generation comes to a stop. If this condition lasts for a long time, there arises the problem that the electric power stored in the storage device is used up.

[0007] Since a thermoelectric generator produces only a small amount of electric power, if the storage device is exhausted, it is difficult to store a sufficient amount of electric power in the storage device in a short time after attaching the watch to an arm. For example, where a thermoelectric device has a temperature difference of about 2 °C, the electric power that can be generated is about 13.3 μW, provided that the generated voltage is 0.4 VOLT, the internal resistance is about 1500 Ω, and the input impedance of a step-up means for stepping up the generated voltage is 1500 Ω and that the loss of the step-up means is neglected. The electric power consumed by the electronic wristwatch is approximately 1 to 2 μW. Where a lithium-ion secondary battery that has a diameter of 6 mm and taking the form of a button battery is used as a power storage device, energy of about 6.5 J can be stored. Accordingly, if the device is worn on an arm and should be fully charged, it takes a time of 135.8 hours even if consumption and loss in the load circuit are neglected.

[0008] Accordingly, if power generation of the thermoelectric generator is stopped for a long time as mentioned previously, the storage voltage of the storage device drops or the storage device is exhausted. As a result, the watch malfunctions, whereby the time is made inaccurate or the watch comes to a stop.

[0009] Solar generators have similar problems if placed in environments where they do not receive light for a long time, because power generation is stopped. In this way, where other power generators are used, similar problems take place.

[0010] One proposed method for solving this problem is to reduce the frequency at which the second hand of a timepiece is reduced if the storage voltage drops, thus decreasing the electric power consumed (Japanese Unexamined Patent Publication No. Hei. 7-287080). Even with this method, however, electric motors or the like for driving the hour, minute, and second hands consume large amounts of electric power, though the electric power consumed can be decreased. If the generation of electric power by the generator is stopped for a long time, the stored electric power is consumed and so problems similar to the foregoing occur.

[0011] Therefore, where a power generator and an electric storage device are simply mounted in a radio-controlled watch, if an environment where the generator cannot produce electricity lasts for a long time, the stored electric power is exhausted, so that the watch malfunctions or the operation stops. The radio waves may not be normally received. The time may not be corrected normally if reception is done.

[0012] The present invention is intended to provide a radio-controlled watch that suppresses decreases in electric power stored in its electrical storage device and enables display of precise time.

[0013] A radio-controlled watch in accordance with the present invention comprises: a radio-controlled timepiece circuit having a timepiece body circuit for measuring and displaying time and a radio receiver circuit for receiving time information in the form of radio waves and correcting the time of said timepiece body circuit; an electrical power generator means; an electrical storage means for storing electrical power generated by said electrical power generator means; a switching means for feeding at least one circuit of circuitry forming said radio-controlled timepiece circuit from said electrical storage means; and a voltage detection circuit for detecting an output voltage from said electrical power generator means or electrical storage means and closing said switching means when said output voltage is in excess of a first voltage, said voltage detection circuit producing a detection output signal to open said switching means when the voltage is less than a second voltage that is equal to or different from said first voltage, said voltage detection circuit producing a control signal to operate said radio receiver circuit.

[0014] When the output voltage from the power generator means or the electrical storage means is in excess of the first voltage, the voltage detection means closes the switching means. This sets the radio-controlled timepiece circuit into operation. The time measured by the timepiece body circuit is displayed. Where the radio receiver circuit is set into operation and time information is received in the form of radio waves, the time of the timepiece body circuit is corrected. In this way, the timepiece body circuit displays the correct time. If the output voltage from the electrical generator means or the electric storage means is less than the second voltage, the voltage detection means produces a detection signal to open the switching means. This stops the functions of the radio-controlled circuit. In consequence, consumption of the electric power of the electrical storage means is suppressed. When the output voltage from the electrical generator means or the electric storage means becomes greater than the first voltage again, the voltage detection means produces a detection output to close the switching means. This sets the radio-controlled timepiece circuit into operation. At the same time, the voltage detection means produces a control signal to start the radio receiver circuit. The radio receiver circuit receives time information in the form of radio waves, corrects the time of the timepiece body circuit, and causes the timepiece body circuit to display the correct time. The second voltage may be identical with or different from the first voltage.

[0015] The oscillator circuit of the timepiece body circuit is always fed from the electrical storage means. Other circuits may be fed via the switching means. The oscillator circuit and the frequency division circuit in the timepiece body circuit may be always fed from the electrical storage means. Other circuits may be fed via the switching means. Preferably, the electrical power generator means has a power generator producing a voltage that varies with time. The power generator means may be composed of a thermoelectric generator and a step-up means for stepping up the voltage generated by the thermoelectric generator. The step-up means may be controlled by the output signal from the frequency divider circuit.

[0016] A part or all of the timepiece body circuit is always electrically fed. The output from the switching means operates and stops the timepiece body circuit. In consequence, consumption of electric power of the storage means is suppressed. When the output voltage from the power generator means or the electrical storage means is more than the first voltage, the voltage detection means closes the switching means. This sets the radio-controlled timepiece circuit into operation. The timepiece body circuit displays the measured time. When the radio receiver circuit is started and receives time information in the form of radio waves, the time of the timepiece body circuit is corrected. As a result, precise time is displayed by the timepiece body circuit. When the output voltage from the power generator means or the electrical storage means becomes less than the second voltage, the voltage detection means produces a detection signal to open the switching means. This stops the functions of the radio-controlled circuit, whereby the consumption of electric power of the storage means is suppressed.

[0017] A preferred form of the present invention is illustrated in the accompanying drawings in which:

Fig. 1 is a block diagram of an electronic wristwatch forming a first embodiment of the present invention;
Fig. 2 is a block diagram of an electronic wristwatch forming a second embodiment of the present invention;
Fig. 3 is a block diagram of an electronic wristwatch forming a third embodiment of the present invention;
Fig. 4 is a plan view showing the structure of an electronic wristwatch equipped with power generators in accordance with an embodiment of the invention; and
Fig. 5 is a diagram showing time codes of long-wave standard waves (JG2AS).

[0018] Fig. 1 is a block diagram of a radio-controlled wristwatch forming a first embodiment of the present invention. In Fig. 1, a power generator means 101 has an output portion connected with the input portion of an electrical storage means 102 and with the input portion of a voltage detection means 103. The power generator means 101 is preferably a power generator that can be made smaller in size and weight such as a thermoelectric generator and a solar generator. A thermal converter comprises two base plates and P- and N-type thermoelements sandwiched between the base plates. The P- and N-type thermoelements form a PN junction via a metal or other electrically conductive substance. Several P-and N-type thermoelements are connected in series, such as P, N, P, N, P, N, and so on. When a temperature difference is induced across the base plates, an electromotive force of a voltage according to the temperature difference is produced. An electromotive force of a higher voltage can be obtained by increasing the number of PN junctions. The time difference for the power generation is obtained by the difference between the body temperature and the outside temperature when the watch is worn on an arm.

[0019] Where the thermal converter is used, it is desired to incorporate a step-up circuit that steps up the voltage generated by the thermoelectric converter to a voltage sufficient to operate the radio-controlled timepiece circuit 105. One suitable example of the step-up circuit is a switched capacitor configuration consisting of a plurality of capacitors connected in parallel. These capacitors are charged in this condition. These capacitors are switched to a series connection by a switching device to produce a stepped up voltage. In this way, the operation for generating a stepped up voltage is repeated. In another suitable example, the current flowing through a coil is turned on and off by a switching device. The voltage is stepped up by making use of a self-induction current induced in the coil. This is adapted for miniaturization. Where the thermal converter is used, if a voltage sufficient to operate the radio-controlled timepiece circuit 105 can be obtained, then no step-up circuit is necessary.

[0020] The storage means 102 can be a lithium secondary battery, electric double-layer capacitors, or the like. The voltage detection circuit 103 can be a comparator circuit whose one input portion is connected with a reference voltage generator (not shown), while the other input portion is connected with the input portion of the power generator means 101.

[0021] The electrical storage means 102 has an output portion connected with the input portion of the switching means 104. The output portion of the switching means 104 is connected with power-supply terminals of the radio-controlled timepiece circuit 105. Thus, electrical power is supplied from the storage means 102 to the various circuits forming the radio-controlled timepiece circuit 105 via the switching means 104. The first output portion of the voltage detection circuit 103 is connected with the control input terminal of the switching means 104. The second output portion is connected with the control input terminal of a radio receiver circuit 115.

[0022] An antenna 106 is connected with the input portion of a time-correcting circuit 116 via a receiver circuit 107 and a time-calculating circuit 108. The antenna 106, the receiver circuit 107, the time-calculating circuit 108, and the time-correcting circuit 116 together form the radio receiver circuit 115. The output portion of the oscillator circuit 109 is connected with one input portion of a time-counting circuit 111 via the frequency divider circuit 110. The other input portion of the time-correcting circuit 111 is connected with the output portion of the time-correcting circuit 116. The output portion of the time-counting circuit 111 is connected with a display means 112.

[0023] The oscillator circuit 109, the frequency divider circuit 110, the time-counting circuit 111, and the display means 112 together constitute a timepiece body circuit 117. The radio receiver circuit 115 and the timepiece body circuit 117 form a radio-controlled timepiece circuit 105.

[0024] The operation of the present embodiment constructed as described thus far is described below. In normal state (i.e., the watch is worn on an arm), the electrical power generator means 101 produces electricity owing to a temperature difference between the body temperature on the arm and the outside temperature. The electrical storage means 102 is charged. Under this condition, the voltage generated by the electrical power generator means 101 is the first voltage, i.e., in excess of a given voltage (for example, more than 1.5 VOLT that is the operating voltage for a normal analog watch), the voltage detection means 103 detects it and produces a first detection signal 113. The switching means 104 is closed in response to the first detection signal 113.

[0025] Thus, the radio-controlled timepiece circuit 105 is fed from the electrical storage means 102 via the switching means 104 and is in operation. That is, the frequency divider circuit 110 divides down the output from the oscillator circuit 109 into a signal of 1 second and produces it to the time-counting circuit 111. The time-counting circuit 111 counts the signal from the frequency divider circuit 110 and produces it to the display means 112. In this way, time is displayed by the display means 112.

[0026] Under this condition, if the radio receiver circuit 115 is operated by manual operation or arrival of preset time, the time is adjusted by radio correction technology. That is, long-wave standard waves received by the antenna 106 are demodulated by the receiver circuit 107. Time codes are calculated by the time-calculating circuit 108. A signal indicating the present time is produced to the time-correcting circuit 116. This time-correcting circuit 116 produces a signal indicating the present time, corrects the data about the time in the time-counting circuit 111, and produces an output to the display means 112. In this way, precise present time corresponding to the aforementioned time codes is displayed by the display means 112.

[0027] Then, the watch is detached from the arm, and if the voltage generated by the power generator means 101 becomes lower than the given voltage, or the second voltage (for example, less than 1.5 VOLT that is the operating voltage for a normal analog watch), the voltage detection means 103 detects it and produces a second detection signal 113.

[0028] The switching means 104 is opened in response to the second detection signal 113. The supply of electrical power from the storage means 102 to the radio-controlled timepiece circuit 105 is stopped. The timepiece functions of the radio-controlled timepiece circuit 105 stop, and the consumption of electric power of the storage means 102 is suppressed.

[0029] Under this condition, if the watch is worn on an arm, the power generator means 101 restarts generation of electric power. If the voltage detection means 103 senses that the voltage generated becomes greater than the first voltage, the detection means produces the first detection signal 113. In response to the first detection signal 113, the switching means 104 is closed. The radio-controlled timepiece circuit 105 is fed from the storage means 102. The timepiece circuit 105 starts to operate.

[0030] At the same time, the voltage detection means 103 produces a control signal 114 to the radio receiver circuit 115. The radio receiver circuit 115 starts to operate. Information about the present time corresponding to the time codes of the long-wave standard waves is sent to the time-counting circuit 111 from the time-correcting circuit 116. The present time corresponding to the time codes is displayed by the display means 112.

[0031] As described thus far, in the present embodiment, when the voltage generated by the power generator means 101 is less than the second voltage, the supply of electrical power to the radio-controlled timepiece circuit 105 is stopped. Therefore, the consumption of electric power of the storage means 102 is suppressed. When the power generator means 101 begins to generate a voltage exceeding the first voltage as encountered when the watch is worn on an arm, the timepiece body circuit 117 and the radio receiver circuit 115 start to operate. Consequently, accurate present time can be displayed. When the watch is detached from the arm, the supply of electric power is stopped. When the watch is worn on an arm, power generation is started. The supply of electric power is started. Also, synchronization can be performed. The consumption of electric power can be suppressed. In addition, the serviceability is enhanced in use.

[0032] Fig. 2 is a block diagram of a radio-controlled wristwatch forming a second embodiment of the present invention. In Fig. 1, the input portion of the voltage detection means 103 is connected with the output portion of the power generator means 101. On the other hand, in Fig. 2, the input portion of a voltage detection means 203 is connected with the output portion of an electrical storage means 202. Fig. 2 is similar to Fig. 1 in other respects. The operation of the second embodiment constructed as described thus far is described below.

[0033] In normal use (i.e., the watch is worn on an arm), the power generator means 201 produces electricity owing to a temperature difference between the body temperature on the arm and the outside temperature. The storage means 202 is charged. Under this condition, the voltage stored in the storage means 202 is more than a given value that is the first voltage (e.g., more than 1 VOLT at which the motor in an analog watch does not rotate but might produce a malfunction). The voltage detection means 203 detects it and produces a first detection signal 213. The switching means 204 is closed in response to the first detection signal 213.

[0034] Thus, the radio-controlled timepiece circuit 205 is fed from the storage means 202 via the switching means 204 and is in operation. That is, a frequency divider circuit 210 divides the frequency of the output from an oscillator circuit 209 into a signal of 1 second and produces it to a time-counting circuit 211. The time-counting circuit 211 counts the signal from the frequency divider circuit 210 and produces an output to the display means 212. In this way, the time is displayed by the display means 212.

[0035] Under this condition, if the radio receiver circuit 215 operates in response to a manual operation or arrival of given time, the time is synchronized by radio control technology. That is, long-wave standard waves received by the antenna 206 are demodulated by the receiver circuit 207. Time codes are calculated by the time-calculating circuit 208. A signal indicating the present time is produced to the time-correcting circuit 216. This time-correcting circuit 216 produces a signal indicating the present time, corrects the data about the time in the time-counting circuit 211, and produces an output to the display means 212. In this way, precise present time corresponding to the aforementioned time codes is displayed by the display means 212.

[0036] Then, if the watch is detached from the arm and the generation of power by the electrical power generator means 201 stops, and if the voltage stored in the storage means 202 becomes higher than the second given value (e.g., more than 1 VOLT at which the motor of an analog watch does not rotate but might cause a malfunction), the voltage detection means 203 detects it and produces a second detection signal 213. The switching means 204 is opened in response to the second detection signal 213. The supply of electric power to the radio-controlled timepiece circuit 205 is stopped. The consumption of electric power from the storage means 202 is suppressed.

[0037] Under this condition, if the watch is again worn on an arm, the power generator means 201 starts to generate electricity, and if the voltage stored in the storage means 202 becomes higher than 1 VOLT, then the voltage detection means 203 detects it and produces a first detection signal 213. The switching means 204 is closed in response to the first detection signal 213. The radio-controlled timepiece circuit 205 is fed from the storage means 202. The timepiece body circuit 217 begins to operate. At the same time, the voltage detection means 203 produces a control signal 214 to the radio receiver circuit 215. The radio receiver circuit 215 starts to operate in response to the control signal 214.

[0038] In this way, the aforementioned radio-controlled correction is made. In particular, a signal corresponding to time codes of long-wave standard waves is produced to the time-correcting circuit 216, which produces a signal indicating the present time to correct the data about the time in the time-counting circuit 211. The data is delivered to the display means 212, which displays precise time corresponding to the time codes.

[0039] As described thus far, in the present embodiment, when the voltage stored in the storage means 202 is less than the second voltage, the supply of electrical power to the radio-controlled timepiece circuit 105 is stopped and so the consumption of electric power of the storage means 202 is suppressed. When the power generator means 101 starts to generate electricity and the storage voltage becomes higher than the first voltage as encountered when the watch is worn on an arm, the timepiece body circuit 217 and the radio-controlled circuit 215 start to operate. Therefore, the precise present time can be displayed. When the watch is detached from the arm, the supply of electrical power is stopped. When the watch is worn on an arm, generation of power is started, the supply of electrical power is started, and synchronization can be performed. Therefore, the consumption of electrical power is suppressed. In addition, the serviceability is enhanced in use.

[0040] Fig. 3 is a block diagram of a radio-controlled wristwatch forming a third embodiment of the present invention. This is similar to Fig. 2 in that the voltage stored in a storage means 302 is detected and the supply of electrical power to a radio-controlled timepiece circuit 305 is controlled. One difference is that a frequency divider circuit is divided into a first frequency divider circuit 310 and a second frequency divider circuit 311. Another difference is that an oscillator circuit 309 and the first frequency divider circuit 310 are always fed. The operation of the third embodiment constructed in this way is described below.

[0041] In normal use (i.e., the watch is worn on an arm), the power generator means 301 produces electricity owing to a temperature difference between the body temperature on the arm and the outside temperature. The storage means 302 is charged. Under this condition, the voltage stored in the storage means 302 is more than a given value that is the first voltage and so the voltage detection means 303 detects it and produces the first detection signal 314. The switching means 304 is closed in response to the first detection signal 314.

[0042] Thus, the radio-controlled timepiece circuit 305 is fed from the storage means 302 via the switching means 304 and is in operation. Specifically, the first frequency divider circuit 310 and the second frequency divider circuit 311 forming the timepiece body circuit 318 divides down the frequency of the output from the oscillator circuit 309 into a signal of 1 second and produces it to the time-counting circuit 312. The time-counting circuit 312 counts the signal from the second frequency divider circuit 311 and produces a signal to the display means 313. In this way, the time is displayed by the display means 313.

[0043] Under this condition, if the radio receiver circuit 316 operates in response to a manual operation or arrival of given time, the time is synchronized by radio control technology. That is, long-wave standard waves received by the antenna 306 are demodulated by the receiver circuit 307. Time codes are calculated by the time-calculating circuit 308. A signal indicating the present time is produced to the time-correcting circuit 317. This time-correcting circuit 317 produces a signal indicating the present time, corrects the data about the time in the time-counting circuit 312, and produces an output to the display means 313. In this way, precise present time corresponding to the aforementioned time codes is displayed by the display means 313.

[0044] If the generation of power by the power generator means 301 stops as encountered when the watch is detached from the arm, and if the voltage stored in the storage means 302 becomes less than a given value, or the second voltage, the voltage detection means 303 detects it and produces a second detection signal 314. The switching means 304 is opened in response to the second detection signal 314. The supply of electrical power to the radio-controlled timepiece circuit 305 is stopped. In consequence, the consumption of electric power of the storage means 302 is suppressed. At this time, the oscillator circuit 309 and the first frequency divider circuit 310 are kept fed.

[0045] Under this condition, if the watch is again worn on the arm, the power generator means 301 starts to generate electricity, and the voltage stored in the storage means 302 becomes higher than the first voltage, then the voltage detection means 303 detects it and produces a first detection signal 314. The switching means 304 is closed in response to the first detection signal 314. The radio-controlled timepiece circuit 305 is fed from the storage means 302 and begins to operate. At the same time, the voltage detection means 303 produces a control signal 315 to the radio receiver circuit 316. In response to this, the radio receiver circuit 316 starts to operate.

[0046] In this way, the aforementioned radio-controlled correction is made. In particular, a signal corresponding to time codes of long-wave standard waves is produced to the time-correcting circuit 317, which produces a signal indicating the present time to correct the data about the time in the time-counting circuit 312. The data is delivered to the display means 313, which displays precise time corresponding to the time codes.

[0047] The supply of electrical power to the circuitry excluding the oscillator circuit 309 and the frequency divider circuit 310 is stopped in this way. The consumption of electrical power is reduced. No time loss exists until the oscillator circuit 309 starts to oscillate. Therefore, the device can be smoothly set into operation. The output signal from the first frequency divider circuit 310 can be used as a clock signal for controlling the step-up means and so on. If this clock signal is not necessary, the first frequency divider circuit is not required to be fed at all times. The voltage detection means 303 may detect the voltage generated by the power generator means 301.

[0048] Fig. 4 is a cross-sectional view showing the structure of a radio-controlled wristwatch forming an embodiment of the present invention. In Fig. 4, a timepiece movement 401 including a radio-controlled timepiece circuit, motors, and hands is disposed in the center of the top of a heat-dissipating case 406 of the watch. The top is covered by a windshield glass 402. A thermoelectric generator 403 is disposed in the center of the lower portion of the watch. One end portion of the thermoelectric generator is in contact with the heat-dissipating case 406, while the other end portion is in contact with a transparent rear cover 405.

[0049] The peripheral portion of the lower portion of the electronic wristwatch is made of a heat-insulating member such as plastics and is formed by a heat-insulating material 404 that blocks heat transfer on the side of the rear cover 405 and on the side of the heat-dissipating case 406. Thus, the two opposite end portions of the thermoelectric generator 403 are thermally isolated from each other. An antenna unit 408 having a ferrite bar antenna 407 is mounted at an outer end of the watch. The antenna unit 408 is made of a heat-insulating member such as plastics to block thermal transfer on the side of the rear cover 405 and on the side of the heat-dissipating case 406.

[0050] Where the watch constructed as described thus far is worn on an arm, the body temperature on the arm is transmitted to the other end portion of the thermoelectric generator 403 via the rear cover 405. Meanwhile, one end portion of the thermoelectric generator 403 is held at the outside temperature by the heat-dissipating case 406. The thermoelectric generator 403 produces electricity owing to a temperature difference between the body temperature and the outside temperature. When the watch is detached from the arm, the aforementioned temperature difference no longer exists. Therefore, the thermoelectric generator 403 stops from generating electricity.

[0051] Meanwhile, the long-wave standard waves are received by the ferrite bar antenna 407. The time is corrected by the radio-controlled timepiece circuit as mentioned above. The precise time is displayed.

[0052] As described thus far, in the embodiments described above, the voltage detection means 103, 203, and 303 produce a first detection signal to switching means 104, 204, and 304 to close the switching means 104, 204, and 304, respectively, when the output signal from the power generators means 101, 201, 301 or the electrical storage means 102, 202, 302 is greater than a first voltage. When it is less than the second voltage, the voltage detection means produces a second detection signal to open the switching means. When the output voltage exceeds the first voltage, the voltage detection means produces a control signal to operate the radio receiver circuits 115, 215, and 316. Therefore, consumption of electric power can be suppressed. In addition, precise time can be displayed.

[0053] The oscillator circuit 309 or the combination of the oscillator circuit 309 and the frequency divider circuit 310 of the timepiece body circuit 318 is always fed. Therefore, no time loss occurs until the oscillator circuits 109, 209, and 309 start to oscillate. Consequently, as soon as supply of electrical power is started, time can be displayed quickly. Where the power generator means 101, 201, and 301 have step-up means, it can be driven with the output from the frequency divider circuit. Quick charging is possible without the need of additional circuit. Where power generators producing voltages that vary with time are used as the power generator means, especially great advantages can be obtained.

[0054] In the embodiments described above, the first and second voltages that are a threshold value in switching the switching means 104, 204, and 304 from closed state to open state or vice versa are identical. Hysteresis characteristics may also be given. They may also be made different. For example, when the storage voltage is less than 1.0 VOLT that is the second voltage, the switching means may be opened to stop the supply of electric power to the radio-controlled timepiece circuit. When the voltage regains more than 1.1 VOLT that is the first voltage, the switching means is again closed. The radio-controlled timepiece circuit is operated. Also, radio-controlled correction is made.

[0055] In determining the threshold voltage described above, the switching means 104, 204, and 304 may be opened and closed when the electric power more than the electric power described above is generated or stored, taking account of the electric power consumed by the watch.

[0056] Furthermore, a mechanical switch may be mounted instead of detecting the voltage generated by the electrical storage means and opening and closing the switching means. The switch is manually operated to start the supply of electrical power. Precise time can be displayed even by manual operation.

[0057] The radio-controlled timepiece circuits 105 and 205 may always be fed from the electrical storage means 102 and 202. The radio-controlled timepiece circuits 105 and 205 are operated and stopped by opening and closing the switching means 104 and 204. The consumption of energy can be suppressed by controlling the operation and stoppage of the radio-controlled timepiece circuits 105 and 205.

[0058] In the present invention, decreases in the electric power stored in an electrical storage device can be suppressed. In addition, precise time can be displayed. The invention is more adapted for cases in which the electrical storage means have an electrical generator producing a voltage that varies with time.

[0059] The oscillator circuit of the timepiece body circuit is always fed. Time loss from the start of the supply of electrical power to the start of oscillation is eliminated, compared with cases in which the supply of electrical power to the oscillator circuit is stopped. Quick display of time is possible. If electric power is always supplied to the oscillator circuit and the frequency divider circuit of the timepiece body circuit, the time loss from the start of the supply of electrical power to the start of oscillation is eliminated. Quick display of time is enabled. Furthermore, requisite circuits can be controlled using the output signal from the frequency divider circuit.

[0060] Moreover, quick charging operation by a thermoelectric generator can be performed without providing any extra circuit for driving the step-up means by constructing the thermoelectric generator means from the thermoelectric generator and the step-up means for stepping up the voltages generated by the thermoelectric generator.

[0061] In addition, the above-described power generator means may be constructed from a thermoelectric generator and a step-up means for stepping up the voltage generated by the thermoelectric generator. The step-up means may be controlled by the output signal from the frequency divider circuit.

Claims

1. A radio-controlled watch comprising:

a radio-controlled timepiece circuit having a timepiece body circuit for measuring and displaying time and a radio receiver circuit for receiving time information in the form of radio waves and correcting the time of said timepiece body circuit;
an electrical power generator means;
an electrical storage means for storing electrical power generated by said electrical power generator means;
a switching means for feeding at least one circuit of circuitry forming said radio-controlled timepiece circuit from said electrical storage means; and
a voltage detection circuit for detecting an output voltage from said electrical power generator means or electrical storage means and closing said switching means when said output voltage is in excess of a first voltage, said voltage detection circuit producing a detection output signal to open said switching means when the voltage is a second voltage that is equal to or different from said first voltage, said voltage detection circuit producing a control signal to operate said radio receiver circuit when said output voltage is in excess of said first voltage.

2. The radio-controlled watch of claim 1, wherein said timepiece body circuit has an oscillator circuit always fed from said electrical storage means, and wherein other circuits are fed via said switching means.

3. The radio-controlled watch of claim 1, wherein said timepiece body circuit has an oscillator circuit and a frequency divider circuit always fed from said electrical storage means, and wherein other circuits are fed via said switching means.

4. The radio-controlled watch of claim 1, 2, or 3, wherein said electrical power generator means has a power generator producing a voltage that varies with time.

5. The radio-controlled watch of claim 4, wherein said electrical power generator means is composed of a thermoelectric generator and a step-up means for stepping up a voltage generated by said thermoelectric generator, and wherein said step-up means is controlled by an output signal from said frequency divider circuit.

6. A radio-controlled watch comprising:

a radio-controlled timepiece circuit having a timepiece body circuit for measuring and displaying time and a radio receiver circuit for receiving time information in the form of radio waves and correcting the time of said timepiece body circuit;
an electrical power generator means;
an electrical storage means for storing electrical power generated by said electrical power generator means;
said radio-controlled timepiece circuit being partially or wholly fed from said electrical storage means at all times;
a switching means for producing a control signal to control operation and stop of a part or all of said radio-controlled timepiece circuit; and a voltage detection circuit for detecting an output voltage from said electrical power generator means or electrical storage means and operating a part or all of said radio-controlled timepiece circuit via said switching means when said output voltage is in excess of a first voltage, said voltage detection circuit producing a detection output signal to open said switching means via said switching means so as to stop the part or all of said radio-controlled watch when the voltage is a second voltage that is equal to or different from said first voltage.

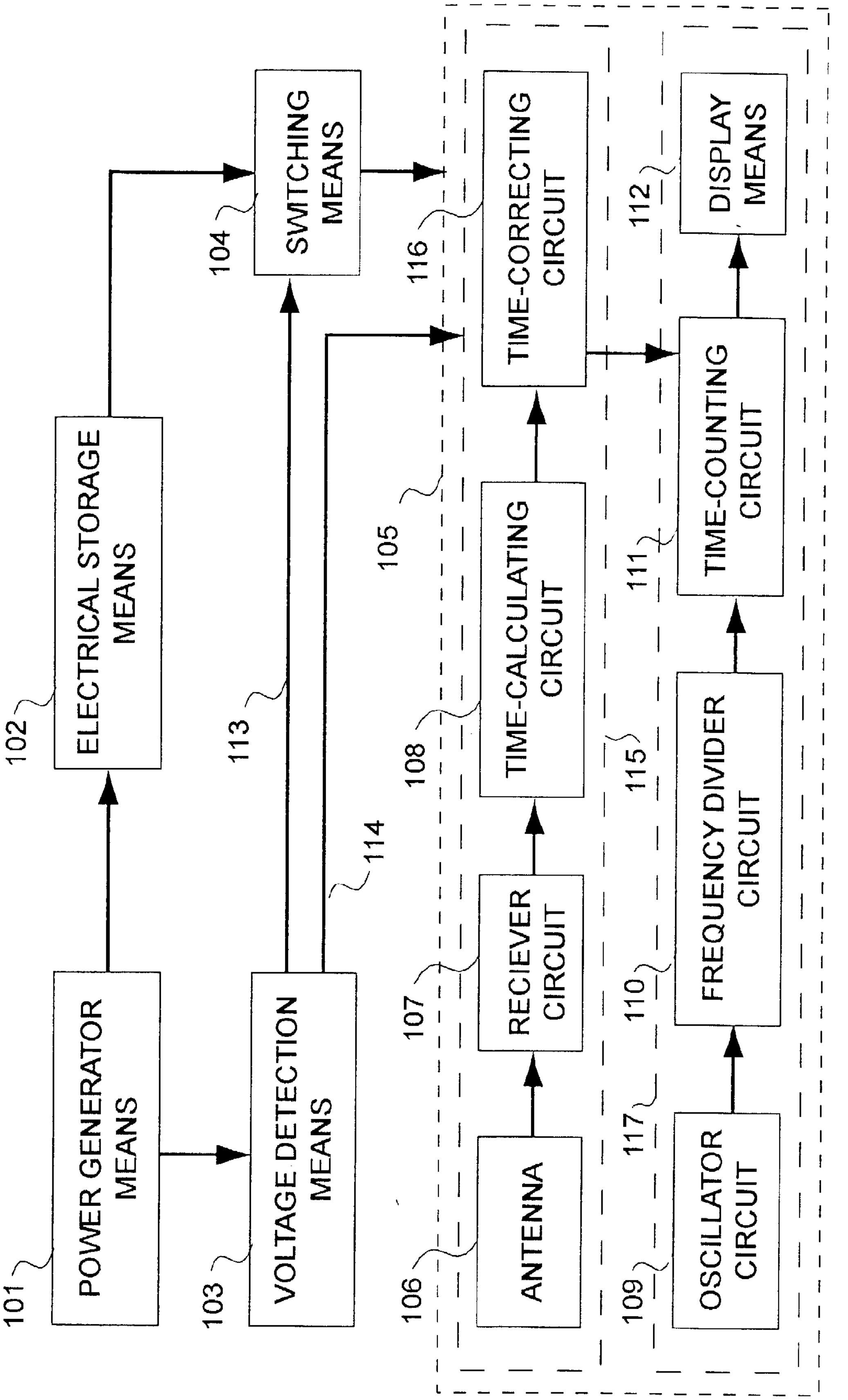

101
POWER GENERATOR MEANS
102
ELECTRICAL STORAGE MEANS
103
VOLTAGE DETECTION MEANS
104
SWITCHING MEANS
113
114
105
106
ANTENNA
107
RECIEVER CIRCUIT
108
TIME-CALCULATING CIRCUIT
116
TIME-CORRECTING CIRCUIT
115
109
OSCILLATOR CIRCUIT
117
110
FREQUENCY DIVIDER CIRCUIT
111
TIME-COUNTING CIRCUIT
112
DISPLAY MEANS

Fig.1

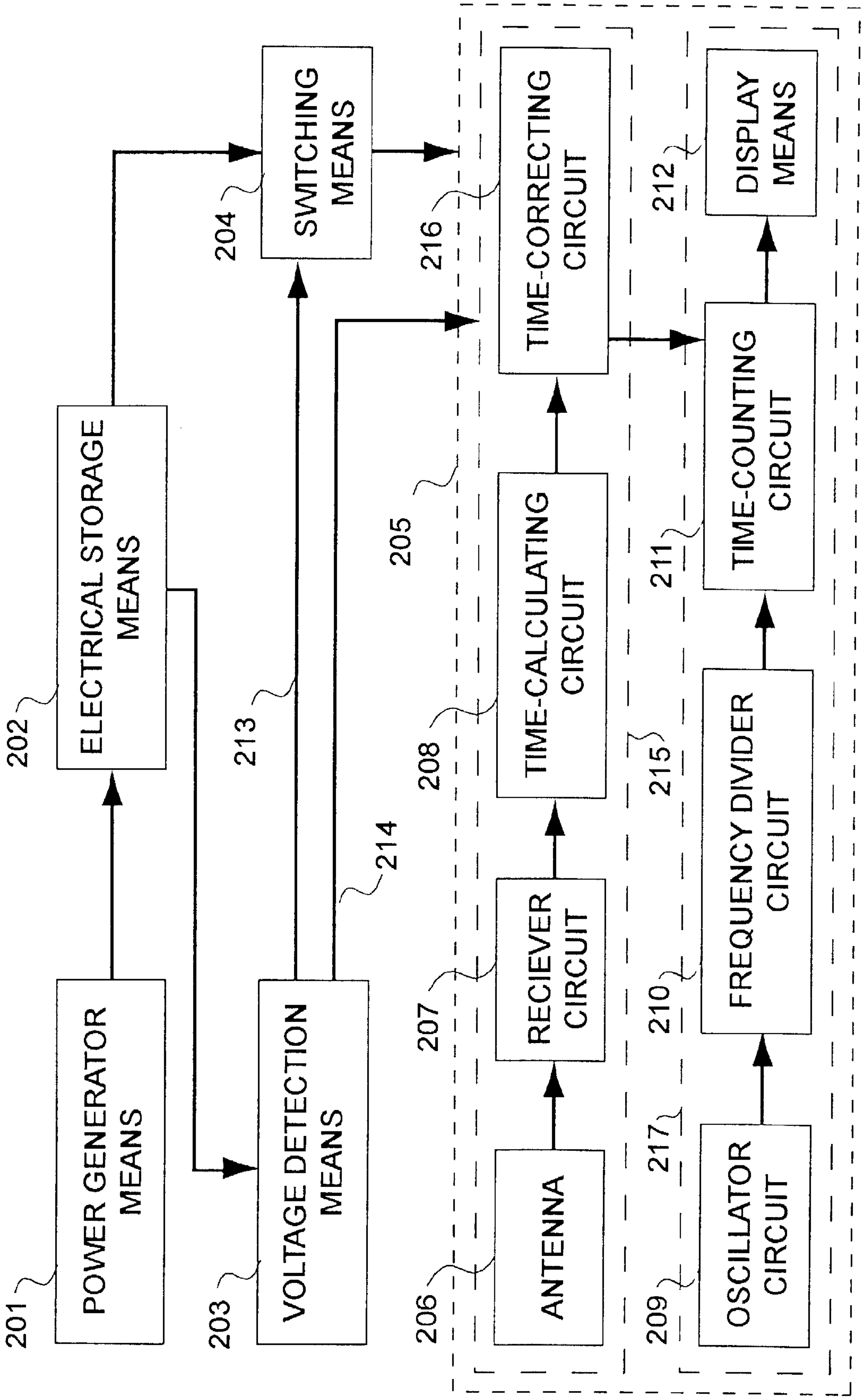
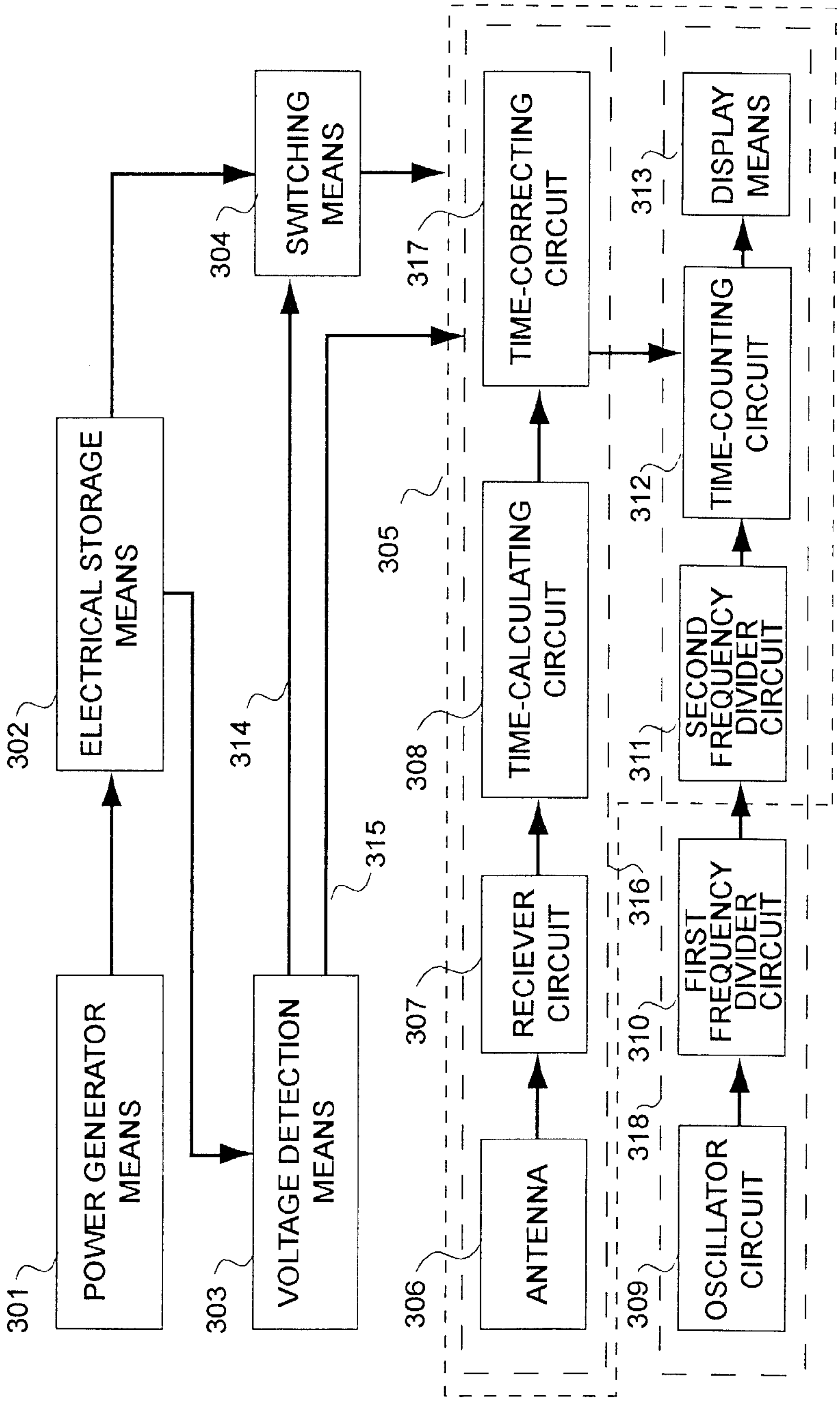

201
POWER GENERATOR MEANS
202
ELECTRICAL STORAGE MEANS
203
VOLTAGE DETECTION MEANS
204
SWITCHING MEANS
213
214
205
206
ANTENNA
207
RECIEVER CIRCUIT
208
TIME-CALCULATING CIRCUIT
216
TIME-CORRECTING CIRCUIT
215
209
OSCILLATOR CIRCUIT
217
210
FREQUENCY DIVIDER CIRCUIT
211
TIME-COUNTING CIRCUIT
212
DISPLAY MEANS

Fig.2



301
POWER GENERATOR MEANS
302
ELECTRICAL STORAGE MEANS
303
VOLTAGE DETECTION MEANS
304
SWITCHING MEANS
305
306
ANTENNA
307
RECIEVER CIRCUIT
308
TIME-CALCULATING CIRCUIT
309
OSCILLATOR CIRCUIT
310
FIRST FREQUENCY DIVIDER CIRCUIT
311
SECOND FREQUENCY DIVIDER CIRCUIT
312
TIME-COUNTING CIRCUIT
313
DISPLAY MEANS
314
315
316
317
TIME-CORRECTING CIRCUIT
318

Fig.3

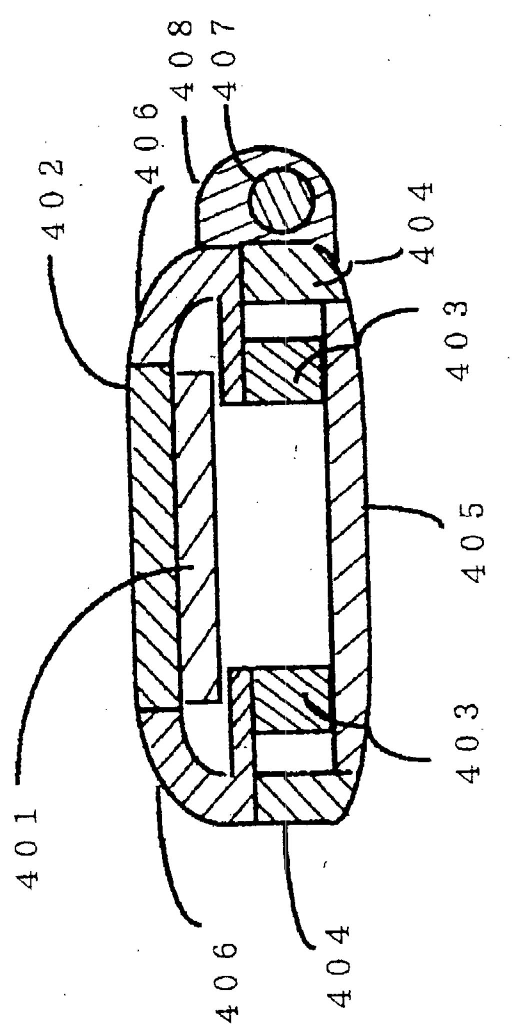


Fig.4

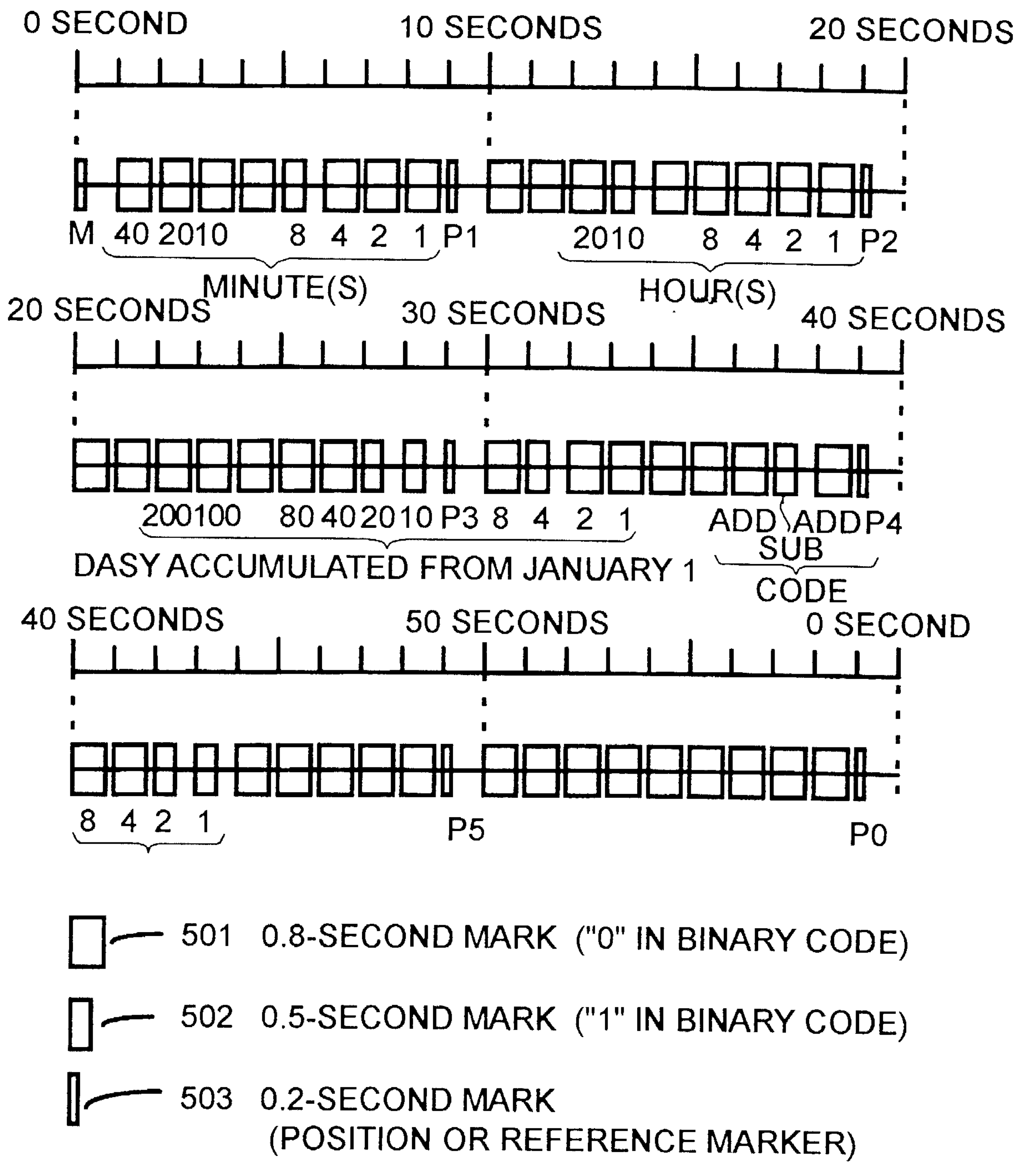

0 SECOND
10 SECONDS
20 SECONDS
M 40 20 10 8 4 2 1 P1
20 10 8 4 2 1 P2
MINUTE(S)
HOUR(S)
20 SECONDS
30 SECONDS
40 SECONDS
200 100 80 40 20 10 P3 8 4 2 1
ADD ADD P4
SUB
CODE
DASY ACCUMULATED FROM JANUARY 1
40 SECONDS
50 SECONDS
0 SECOND
8 4 2 1
P5
P0
501 0.8-SECOND MARK ("0" IN BINARY CODE)
502 0.5-SECOND MARK ("1" IN BINARY CODE)
503 0.2-SECOND MARK
(POSITION OR REFERENCE MARKER)

Fig.5