

DESCRIPTION

This invention relates to an analogue electronic watch having two motors, one for driving the time display, the other for driving means for numerically displaying the day of the month, and is more particularly concerned with a watch comprising, in addition, a perpetual-calendar circuit. This circuit includes day, month and year counters and issues a date indicating signal to a control circuit which activates the second motor by causing it to move forward by a number of steps whereby the numerical display of the day of the month may correspond to the contents of the day counter, and thus agree with the date shown by a perpetual calendar.

Such watches are known and a form of embodiment thereof is described in US Patent Specification 4 300 222. The watch described in this specification comprises a perpetual calendar displaying the day of the month and, possibly, the day of the week. Although the calendar is reliable when the watch operates normally, a change of cell causes the counters to be in states that are in no way related to the date since the calendar circuit is no longer able to generate correct signals.

After a change of cell, the counters, the day of the month display and the time display of the watch, need to be corrected. Correcting the day of the month display is done in the usual way. However, correcting the counters is hardly possible for the user or for a watch-repairer not having the required equipment. Indeed, to diminish the time spent, each counter must be corrected separately and this involves complex manipulations. Moreover, for such correction to be possible, the contents of the counters must be known. Now this information is not displayed by the watch.

A change of cell can therefore only be performed in the factory or in an after-sales service centre and this places an undesirable constraint in the use of an otherwise most practical watch.

An object of the invention is to overcome this drawback by providing a watch having a perpetual calendar that only involves, after

a change of cell, an easy correction of the day of the month display by the bearer of the watch.

To this end the watch provided by the invention comprises :

- an electrical energy source;
- a time-keeping device; and
- a day of the month indicator device,

wherein the time-keeping device includes :

- a time-keeping circuit able to generate a time base signal;
- a first motor responsive to said time base signal;
- a control mechanism including a first gear-train arranged to be driven by said first motor and a corrector member;

- an analogue time-display means arranged to be driven by said gear-train, the indications given by said time-display means being alterable by said corrector member; and

- means able to generate a daily signal, and wherein the day of the month indicator device includes :

- a second motor;
- a second gear-train arranged to be driven by said second motor;

- analogue day of the month display means arranged to be driven by said second gear-train;

- a perpetual calendar circuit including a date counter circuit arranged to be supplied by the daily signal and being arranged to generate a calendar signal, representative of the state of the calendar, and a monthly signal able to identify the end of each month; and

- a control circuit arranged to receive said daily signal and said monthly signal for issuing a control signal to said second motor, said control signal serving to alter the day of the month display by one day at the end of each day, and by the required number of days at the end of each month in order that the day of the month display means comes on the number 1,

characterized in that the day of the month indicator device further comprises :

- a reprogrammable non-volatile memory, a first transmission circuit for ensuring the transmission of said calendar signal into said non-volatile memory in order to safeguard the informations contained in said counter in case of an interruption of the supply by the energy source; and
- a control device comprising a detector and a second transmission circuit, said detector arranged to receive a signal representative of the voltage issued by the energy source and to issue, in response to the detection of a rising edge of the voltage, an activation signal of said second transmission circuit for transferring unconditionally the contents of said non-volatile memory into the date counter, when after an interruption of the supply of circuits by the energy source, said supply is restored.

One advantage of the invention is that, after a change of cell, the permanent calendar circuit may be made to perform again correctly by merely correcting the numerical indication of the day of the month that is shown, a simple operation that can be done by the user in the same way as with ordinary calendar watches.

Other characteristics and advantages of the watch according to the invention will appear from the following description given in connection with the accompanying drawings of a non-limiting embodiment of such a watch. In the drawings where the same references designates analog parts Figures 1A and 1B together show, in block diagram form, a preferred form of embodiment of the watch provided by the invention.

The illustrated watch comprises a time-keeping circuit 1 which supplies a clock signal S1 to a first motor 2 which, via a control mechanism 3, drives a time display 4 having hour, minute and second hands.

Time-keeping circuit 1 includes an oscillator 10 whose frequency is stabilized by a quartz resonator 11, generating a signal of e.g. 32768 Hz, a two-input AND gate 12 having one input connected to the

output of the oscillator, a frequency divider 13 having a first input connected to the output of AND gate 12, and a drive circuit 14 which receives from a first output of the frequency divider a 1 Hz signal and issues signal S1 on its own output. Frequency divider 13 further has a second output which issues a retrieval signal S13 having a frequency of about 10Hz, and a reset input R connected to the output of an inverter 15 whose input is connected to the second input of AND gate 12.

First motor 2 may for instance be a stepping motor that rotates in one direction only. It drives, in control mechanism 3, a first gear-train, not shown, which causes the hands of display 4 to move forward. This gear-train also actuates a first, daily contact X, causing it to close it when the watch moves on to the next day, i.e. at midnight, in order to generate a daily logic signal Sx. It will be assumed that signal Sx is low when contact X is open and high when closed. The same applies to signals generated by other contacts described later.

Control mechanism 3 further comprises correction means, not shown, for resetting the watch by means of a correction member, e.g. a time-setting crown 16 shown in an inner, neutral position. This crown may be moved to an outer, correction position 16' in which it is mechanically coupled with the hands, enabling the indications of display 4 to be corrected in a conventional manner.

Crown 16 further acts, irrespective of its angular position, on a second, position contact Y that generates a logic signal Sy which is applied to the second input of AND gate 12. Contact Y is closed when crown 16 is in the neutral position, and open when the crown is in the correction position.

The components described so far are those of a conventional analogue watch that operates as follows. When crown 16 is in its inner,

neutral position, with signal Sy high, AND gate 12 lets the signal from oscillator 10 through to frequency divider 13. The reset input R of the divider 13 being low, the circuit issues the 1 Hz signal to the

input of drive circuit 14 which in turn issues clock signal S1 to first motor 2. This motor drives, via the first gear-train, the hands of time display 4 and actuates contact X by means of this gear-train. The dialy signal Sx generated by this contact switches at midnight from low to high and returns shortly afterwards to low where it remains until the beginning of the following day.

In the outer, correction position 16' of crown 16, signal Sy is low, thus closing AND gate 12 and resetting frequency divider 13 which, in these conditions, receives no signal. The same applies to motor 2, which remains idle. The hands of display 4 can then only be moved by the crown which, in this position, is connected to the gear-train to enable accurate time-setting of the watch. When the hands, driven by the crown, go through the midnight point, contact X is of course actuated as if the hands were driven by the first motor.

The watch further comprises a perpetual day of the month indicator giving the number of each day of a month. This information is provided by a day of the month display 20 embodied in the usual way by a disc bearing numbers 1 to 31. In Figure 1A, display 20 is separate from display 4, but in practice the day of the month will appear in an aperture 21 of the time display 4.

Display 20 further activates a contact Z on the first day of each month, as by means of a cog 22 provided on the disc opposite number 1. This contact, which constitutes an object of the invention, generates a first day of the month signal Sz which goes high at the start of the first day of each month and which reverts to low one day later so to remain till the beginning of the next month.

Disc 20 is driven forward at the start of each new day by a second unidirectional motor 23 which drives disc 20 via a second gear-train 24, and motor 23 is activated by a control signal S25 generated by a control circuit 25.

Circuit 25 comprises a three-input AND gate 26, a two-input OR gate 27 having one input connected to the output of AND gate 26, and a drive circuit 28 connected to the output of gate 27 and which issues on its output control signal S25. One input of AND gate 26 receives retrieval signal S13, a second receives first day of the month signal Sz, and a third receives a monthly signal Sm, described later. The second input of OR gate 27 receives daily signal Sx.

The watch further comprises a perpetual calendar circuit 30 having a five-bit day counter 31 which counts in thirty-ones, a four-bit counter 32 which counts in twelves, and a two-bit year counter 33 which counts in fours. These counters, constitute a date counter circuit, are connected in series. Counter 31 receives on its input daily signal Sx and issues on one output, at the beginning of each month, monthly signal Sm to counter 32 which, in turn, issues at the beginning of each year an annual signal Sa to counter 33. Each counter further issues, on another output, a signal indicative of its contents, i.e. S31 for counter 31, S32 for counter 32 and S33 for counter 33. Additionally, counter 32 issues a signal Smc indicative of a short month and counter 33 issues a signal Sab indicative of a leap year in a four-year cycle.

Circuit 30 further has a correction circuit 34 which receives signals Smc and Sab. This circuit generates, from signals Smc and Sab, a correction signal S34 for counter 31 to set its contents to 1 when the calendar switches from a short month to the following month. In this way, the contents of counter 31 will always agree with what is shown by a perpetual day of the month indicator.

The switch to 1 of the contents of counter 31 generates signal Sm. It will be assumed that this signal is normally low and goes high

at midnight, when the calendar circuit moves from one month to the next, and reverts to low at the latest the following day.

Signals S31, S32 and S33 together make up an eleven bit calendar signal S30 representative of the date in counters 31, 32 and 33. Each of these counters further has an input E for setting them, by means of a logic signal, to a given day, month and year respectively. This date setting can however only be done at the factory.

Circuit 30 will not be described in detail since such circuits are known and a form of embodiment is described in the US patent specification referred to earlier.

Monthly signal Sm is applied to the third input of AND gate 26 in control circuit 25, which operates as follows. Assuming disc 20 and calendar circuit 30 have been set to the correct date, daily signal Sx, which reaches at midnight the input of drive circuit 28 via OR gate 27, causes disc 20 to move forward by one day. This same signal also increments by one unit day counter 31. If disc 20 and day counter 31 show a day other than the last day of a month, signals Sz and Sm will respectively be high and low. Retrieval signal S13 will in this case be blocked by AND gate 26 through signal Sm. Disc 20, having rotated through one step, will thus remain in this position until contact X is closed again. But if disc 20 shows the 30th day of a thirty-day month, signal Sx at midnight will cause disc 20 to rotate to 31 and the contents of the day counter to switch to 1. Signal Sm then goes high, which is the same logic level as signal Sz since contact Z is closed for this position of the disc. It is assumed that retrieval signal S13 is made up of pulses and has a frequency of say 8 Hz. This signal can, under these conditions, transit through AND gate 26 and OR gate 27 to reach circuit 28. In response to each pulse of signal S13, circuit 28 causes disc 20 to move forward by one day. In the present case, with disc 20 indicating 31, a simple pulse of signal S13 is sufficient to move the disc to 1 and to bring it into agreement with the contents of counter 31. In this new position of the disc, contact Z is open and signal Sz is low. This causes signal S13 to be blocked by AND gate 26. The disc will therefore remain in this position

until the next daily signal S_x , which will cause disc 20 and the contents of counter 31 to go to 2. In these states of disc 20 and of counter 31, signal S_z is high, contact Z being closed, and signal S_m is low. Signal S_m thus causes signal S_{13} to be blocked by AND gate 26 until the contents of counter 31 again are 1.

The same thought process would show that at the end of a twenty-nine day month of February in a leap year, AND gate 26 of control circuit 25 would allow two consecutive pulses of retrieval signal S_{13} to go through, causing disc 20 to rotate rapidly from 30 to 1. And at the end of a twenty-eight day month of February, three pulses of the retrieval signal S_{13} would cause disc 20 to rotate from 29 to 1.

Besides the above described function of contact Z, the latter further enables, in the event of a malfunction of disc 20, to synchronize the latter with the contents of day counter 31 on the first day of each month. This is due to the fact that, whatever indication is provided by disc 20 when the contents of day counter 31 are 1 and monthly signal S_m is high, AND gate 26 will allow the required number of pulses of retrieval signal S_{13} to transit through it in order to rotate disc 20 to the first day of the month.

Drive circuit 28 issues on its output control signal S_{25} whenever a signal issues on the output of OR gate 27. The duration of this latter signal therefore does not affect the control signal. Thus, if a pulse of retrieval signal S_{13} is interrupted and shortened through contact Z being opened, the disc will still rotate normally.

To move disc 20 by one day, control signal S_{25} may contain only one pulse causing motor 23 to rotate one step. However, to reduce the torque that needs to be supplied by the motor and lower its consumption, it is preferred for the disc to be rotated by the driving motor. through N steps in response to a control signal S_{25} made up of a series of N consecutive pulses. The triggering of one pulse of a series automatically generates the other pulses in the series, such that the disc can only move through whole days.

Control circuit 25 can also be designed to generate the control

signal S25, that causes the disc to advance by the required number of days at the end of a short month, on the basis of the information supplied by signals Smc and Sab, instead of that supplied by signal Sz. An embodiment of such a circuit is described, for example, in the US patent specification mentioned earlier. Contact Z then serves no purpose. This arrangement however has the drawback of not enabling disc 20 in the case of a malfunction of the latter to be synchronized with the contents of counter 31 on the first day of each month.

The circuits of the described watch are supplied with energy by a cell not shown. After initially time and date setting the watch the latter will carry on showing the correct time so long as the voltage of the cell remains above a critical threshold.

After a while, as the cell runs out, its voltage will drop below the critical threshold and the watch will stop. This stoppage entails the loss, and this is important, of the date contained in counters 31, 32 and 33 of calendar circuit 30 since these counters form a memory which is cleared when it no longer receives sufficient energy. Replacement of the used cell by a new cell does not, of course, enable this date to be recovered since the counters are then in random states, or in a state in no way related with the date on which the watch stopped, such date continuing however to appear on disc 20.

When the cell is replaced, the counters thus need to be re-programmed. This is a complex operation requiring the watch to be sent back to the factory, a major inconvenience.

To avoid this drawback, the watch further comprises a first transmission circuit 40, a reprogrammable non-volatile memory 41 also referred to as EEPROM, a second transmission circuit 42 and a voltage detection circuit 43.

The transmission circuits can, for instance, be made up of transmission gates which are known electronic components, while the non-volatile memory, with its interface circuits that enable items of information to be entered and read, can with advantage be of the FAMOS type, also known. The use of such a memory in the watchmaking art

is known as for instance in Swiss patent specification 534913 which describes a frequency correction logic circuit wherein the contents of the non-volatile memory governs the operation of a watch.

First transmission circuit 40 enables the contents of the counters of calendar circuit 30 to be transferred to non-volatile memory 41 in response to a transfer signal. To this end, circuit 40 comprises a first series 44 of five transmission gates. These gates are connected, firstly, to the output of counter 31 so as to receive the five-bit signal S31 and, secondly, to the input of a first, five-bit section 47 of memory 41. These gates are controlled by the transfer signal which in this case is daily signal Sx.

Thus, every day at midnight when the content of counter 31, representative of the day of the month, changes, the new date is transferred from counter 31 to section 47 of memory 41, in which it remains memorized irrespective of the voltage of the cell.

Second transmission circuit 42 has the same structure as circuit 40. It thus also has a first series 50 of five transmission gates. These gates are connected, firstly, to the output of section 47 of memory 41 so as not to receive signal S31 and, secondly, to the input E of counter 31.

When changing the cell, circuit 43, which is a monostable flip-flop of a known type, generates a detection signal S43 that indicates that the voltage across the terminals of the circuits is again at least equal to the critical threshold. This signal is used as the transfer signal for second transmission circuit 42. Thus, at that instant, when the state of counter 31 is random, counter 42 receives on its input E the signal S31 that existed at the time the watch stopped.

Circuit 40 further comprises a series 45 of four transmission gates for transferring each month, in response to signal Sm, signal S32 to a section 48 of memory 41. Finally, a series 46 of two transmission gates enables signal S33 to be transferred to a section 49 of memory 41.

Like circuit 40, transmission circuit 42 further comprises a series 51 of four transmission gates, connected here to the output of section 48 and to input E of counter 32, and a series 52 of two transmission gates connected to the output of section 49 of the memory and to input E of counter 33, signal S43 acting as transfer signal for all these gates.

As a result, when changing the cell, calendar circuit 30 receives, from non-volatile memory 41, the signal S30 that existed at the instant the watch stopped, thus setting the counters of this circuit in a state corresponding to the date when the watch stopped.

Once the cell has been changed, all that needs to be done is to set the date and time displayed by the watch by rotating the hour hand as many times 24 hours as days have elapsed since the watch stopped. As this operation may be lengthy, a much faster way of date setting will be described later.

The watch described above can usefully further comprise a known time-zoning device involving magnetic positioning. Crown 16 must then be able to move into a second correction position, not shown, in which it can act on part of the first gear-train to move, by an integral number of hours, only the hour hand and to activate contact X. Each time the hour hand moves past midnight, disc 20 moves forward by one whole day and counter 31 is incremented by one unit. In the second correction position of the crown contact Y remains closed to enable the watch to carry on working normally.

If the watch is provided with the time-zoning device mentioned above, second motor 23 should be able to rotate in both directions, i.e. be bidirectional. Control mechanism 3 must then have means, e.g. contacts, for ascertaining, by means of a discrimination circuit not shown but known, the direction of rotation of crown 16 when it is in a correction position. The discrimination circuit generates a logic signal which is applied to an input not shown of circuit 28, and to an input not shown of counters 31, 32 and 33. One logic level of this signal will correspond to forward rotation of the motor, causing the disc to advance,

and to incrementation of the counters, whereas the other logic level will correspond to backward rotation of the motor and decrementation of the counters. The day of the month displayed by disc 20 will, under the above conditions, always agree with the contents of counter 31, whatever the direction of rotation of the hour hand at the time contact X is activated, in response to rotation of crown 16 while in a correction position.

The time-zoning device, besides the function for which it is designed, further enables, in conjunction with bidirectional motor 23, the day of the month displayed by disc 20 to be easily and rapidly modified after a change of cell.

The watch could also be time set electronically by signals generated by a time setting circuit, not shown but known, that activates first motor 2 in response to a rotation of crown 16.

To facilitate this operation, motor 2 should also be bidirectional.

Of course, the watch that has been described may be modified in various other ways obvious to the man skilled in the art without departing of the scope of the invention.



CLAIMS

1. An electronic watch which comprises :
 - an electrical energy source;
 - a time-keeping device; and
 - a day of the month indicator device,wherein the time-keeping device includes :
 - a time-keeping circuit (1) able to generate a time base signal (S1);
 - a first motor (2) responsive to said time base signal;
 - a control mechanism (3) including a first gear-train arranged to be driven by said first motor and a corrector member (16);
 - an analogue time-display means (4) arranged to be driven by said gear-train, the indications given by said time-display means being alterable by said corrector member; and
 - means (X) able to generate a daily signal (Sx),and wherein the day of the month indicator device includes :
 - a second motor (23);
 - a second gear-train (24) arranged to be driven by said second motor;
 - analogue day of the month display means (20) arranged to be driven by said second gear-train;
 - a perpetual calendar circuit (30) including a date counter circuit (31, 32, 33) arranged to be supplied by the daily signal (Sx) and being arranged to generate a calendar signal (S30), representative of the state of the calendar, and a monthly signal (Sm) able to identify the end of each month; and
 - a control circuit (25) arranged to receive said daily signal (Sx) and said monthly signal (Sm) for issuing a control signal (S25) to said second motor, said control signal serving to alter the day of the month display by one day at the end of each day, and by the required number of



days at the end of each month in order that the day of the month display means comes on the number 1, characterized in that the day of the month indicator device further comprises :

- a reprogrammable non-volatile memory (41), a first transmission circuit (40) for ensuring the transmission of said calendar signal (S30) into said non-volatile memory in order to safeguard the informations contained in said counter in case of an interruption of the supply by the energy source; and

- a control device comprising a detector (43) and a second transmission circuit (42), said detector arranged to receive a signal representative of the voltage issued by the energy source and to issue, in response to the detection of a rising edge of the voltage, an activation signal of said second transmission circuit for transferring unconditionally the contents of said non-volatile memory into the date counter, when after an interruption of the supply of circuits by the energy source, said supply is restored.

2. A watch according to claim 1, characterized in that said means able to generate a daily signal (Sx) comprise a contact (X) activated by said first gear-train as one day moves to the next.

3. A watch according to claims 1 or 2, characterized in that said calendar circuit (30) comprises day (31), month (32) and years (33) counters connected in series and constituting said date counter, and a correction circuit (34) connected to the month and year counters, for setting to 1 the contents of the day counter at the end of each month comprising less than 31 days, taking into account, by virtue of the correction circuit, the number of days in each month of the year and leap years.



4. A watch according to one of the preceding claims, characterized in that said control circuit (25) further receives a retrieval signal (S13) having pulses with a period substantially shorter than 8 hours, and comprises means (26, 27, 28) for elaborating said control signal (S25) so that at the end of each month comprising less than 31 days said signal comprises, in addition to the daily signal (Sx), 1, 2 or 3 pulses of said retrieval signal, the number of pulses depending on the month and the year, so that the day of the month display means comes on the number 1.

5. A watch according to one of the preceding claims, characterized in that it further comprises a day of the month contact (Z) activated by said day of the month display means (20) when the latter passes to 1 issuing a day of the month signal (Sz) to said control circuit (25) for putting, at the end of each month, the day of the month displayed in agreement with the contents of the day counter (31).

6. A watch according to claims 4 and 5, characterized in that said means of the control circuit (25) comprise :

- a three input AND-gate (26), having a first input for receiving the monthly signal (Sm), a second input for receiving the retrieval signal (S13) and a third input for receiving the day of the month signal (Sz);

- a two input OR-gate (27), having a first input for receiving the output signal of said AND-gate and a second input for receiving the daily signal (Sx); and

- a drive circuit (28) receiving the output signal of said OR-gate and issuing said control signal (S25) to said second motor (23).