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(54) Automatically corrected electronic timepiece.

(57) The present invention provides an electronic timepiece comprising time keeping means (13) for counting a current time, correction means (13, steps 21, 23) responsive to received time information signals for automatically correcting the current time, calculating means (13, steps 22, 24, 25) responsive to the received time information signals for calculating current time compensation values, and means (13, step 26) for periodically adjusting the current time counted by the time keeping means according to an output from the calculating means.

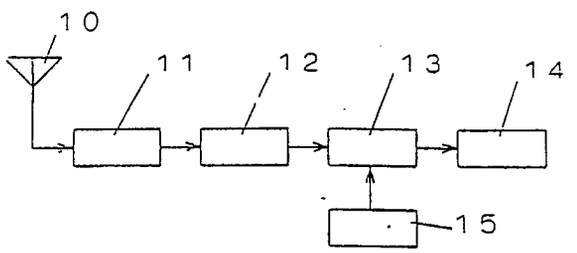

FIG 1

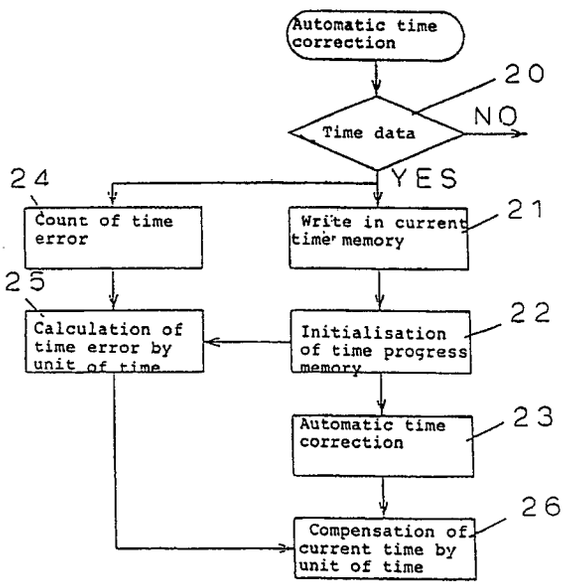

FIG 2

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AUTOMATICALLY CORRECTED ELECTRONIC TIMEPIECE

The invention relates to an automatically scorrected electronic timepiece suitable for use with a radio receiver and, in particular, to means for automatically correcting the electronic timepiece in accordance with an external signal.

Conventional electronic timepieces for use with radio receivers have never been provided with an automatic time correcting function performed in accordance with external signals, although electronic clocks exist in which the time is automatically corrected every hour on receiving time information from the radio. However, such electronic cjocks cannot be used for radio receivers. The time information received from the radio is limited to time units of a minute or second, being unable to provide correction by units of an hour or correction for the date. In addition, since the time in such a clock is corrected every hour, as kept by the clock's own standard time, an accumulated time error is corrected at single correction when the time information is received from the radio. Therefore, it has not been possible always to keep correct time using such time correcting technology, and especially such technology as not applicable to a stopwatch. In fact, a completely automatically corrected electronic timepiece, which receives all of the time information perfectly, has not yet been manufactured.

Currently, a multiplex broadcast system is being provided and the bus standard for home information is being unified. Contrary to this improving the environment for such external information, the dis advantage of the time error accumulating from one time correction to the next is not improved. Automatic time correction will thus continue to spoil a timepiece having high accuracy, or a time keeping apparatus for measurement etc., until the disadvantages of the electronic timepieces mentioned above are improved. Hence, even if it has been possible to transmit the external time information punctually, it has to date been impossible always to keep time correctly in automatically corrected electronic timepieces.

It is one object of the present invention to provide an electronic timepiece suitable for use with a radio receiver, in which the difference between the current time of the timepiece and a correct time received from an external source is made as small as possible and in which the need for correction in response to signals from the external source is reduced to a minimum.

In accordance with the present invention, there is provided an electronic time comprising time keeping means for counting a current time, correction means responsive to received time information signals for automatically correcting the current time, and characterised by calculating means responsive to the received time information signals for calculating current time compensation values, and means for periodically adjusting the corrected current time according to an output from the calculating means.

The invention also provides a radio receiver including such an electronic timepiece.

The invention is described further, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a block diagram showing the circuit structure of an electronic timepiece with an external time information receiving function according to one embodiment of the present invention;

Figure 2 is a flow chart representing a time scorrection process in the electronic tinepiece of Figure 1;

Figure 3 is a block diagram showing the circuit structure of an electronic timepiece with an external time information receiving function according to another embodiment of the present invention; and

Figure 4 is a block diagram showing the circuit structure of an electronic timepiece with an external time information receiving function according to a further embodiment of the present invention.

Referring initially to Figure 1, an external signal, which is input through an antenna 10, is converted into a digital signal by a radio receiver 11 and, then, it is decoded by a decoder circuit 12. If the decoder circuit 12 judges the external signal to contain time information, the decoded external signal is transmitted to an operating circuit 13. The reference numerals 14 and 15 designate a display and switching apparatus, respectively.

Referring to Figure 2, time information transmitted from the decoder circuit 12 is checked once again in the operating circuit 13 to perform a time information judgement 20. Time information is detected critically in order to avoid the considerable influence caused by wrong information. First, the decoder circuit examines whether a received signal represents time information or not. Then, that information is checked again in the operating circuit 13 to establish whether it really exists as data therein. For example, if a signal "15" is received as month data, the operating circuit 13 judges this signal to be a false one, even if it has already been checked and decoded in the decoder circuit 12. Decoded time information is then written in a time information recording portion of the operating cir-

cuit 13 or current time memory thereof (step 21). Thus, the current time in a time keeping circuit included in the operating circuit 13 of an electronic timepiece with an external sjgnal receiving function is automatically corrected (step 23).

At the same time, the time error between the received time information and the current time previously kept by the timepiece at that time is calculated as a correction value (step 24). In the operating circuit 13, the time information recording portion or a further time keeping circuit thereof, which counts the time interval from each time correction, is initialised (step 22) and then begins to count the time interval until the next time information is received. At the same time, the calculated correction value is divided by the previous final count in the further time keeping circuit of the operating circuit 13 (step 25). The result of this division is added to the current time when the electronic timepiece is fast, and is subtracted when it is slow, on the next occasion for incrementing the current time and at predetermined time intervals thereafter (step 26).

The accuracy of the automatic time correction is affected by the accuracy of the external time information. It is also affected by the electronic timepiece itself because the time correcting process within it requires a certain time. After the time correction, the accuracy of the current time keeping becomes the same as that of the corrected time. Therefore, when a crystal of 32768 Hz, of the type normally employed in electronic timepieces, is used in the present electronic timepiece, an error of twenty seconds per month is produced at a standard temperature. For example, if the automatic time correction takes place every hour, an error of 0.03 seconds at the maximum is produced every hour. Although the error can be reduced conventionally by providing short time intervals for the automatic time correction, this consumes more electrical current. Further, if the transmitted wave is in a bad condition, the error may accumulate whereupon the time could be corrected at the second time unit level on the next automatic time correcting occasion. However, the time keeping function would then become dis-continuous and such an electronic timepiece would not be desirable for use in apparatus for measurement or in a stopwatch, even if it had the automatic functions of receiving correct time information and correcting the current time. Moreover, without external time information, the accuracy of such a conventional electronic timepiece is no greater than the accuracy of an ordinary one.

By contrast, according to the present invention, the time error arising between the time information receiving occasions is divided by a certain time unit (the length of the time information receiving interval) and is fed back into the time keeping. For example, when the time in the electronic timepiece comes to be 0.1 seconds fast during a five hour time information receiving interval, the current time may be made 0.01 second slower every thirty minutes from the next time keeping occasion. In this way, it becomes possible to keep the time with much greater accuracy than by simply counting the current time for time keeping. Moreover, even if the current time is affected by ageing or by temperature changes during the four seasons, it is possible to correct the time automatically in such an electronic timepiece, which makes it possible to keep the time with high accuracy without punctual time correcting.

Turning to Figure 3, external time information accompanied by pre-determined address information is transmitted by way of an information bus, which is connected to an information receiving circuit 40. A first counter circuit 44 is provided for counting the magnitude of the correction made in the automatic time correction and a second counter circuit 45 is provided for counting the time interval of the automatic time correction. Both of the circuits 44, 45 can be included in an operating circuit 42.

The received signal is converted into a digital signal in the information receiving circuit 40 and is then decoded in a decoder circuit 41. On receiving the pre-determined address designation signal from the information receiving circuit 40, the decoder circuit 41 transmits the decoded time information to the operating circuit 42. The transmitted time information is written in a current time memory of a time keeping circuit in the operating circuit 42 and the time is automatically corrected in this way.

At the same time as this automatic time correction, the value of the correction is counted in the first counter circuit 44, with the time interval between the last time correction and this time correction being counted in the second counter circuit 45 every pre-determined time unit, for example every ten minutes. The correction value counted in the first counter circuit 44 is divided by the time interval counted in the second counter circuit 45, in the operating circuit 42, and the current time is compen sated in accordance with the result of this calculation at every time unit of the second counter circuit after the automatic time correction.

Even if the time cannot be compensated in accorsdance with the calculation because of non-correspondence between the result of the calculation and the clock frequency, it is possible in the present electronic timepiece to compensate the time by selecting an approximate compensation value or by increasing or reducing the number of compensations. On counting the correction value at the following automatic time correction, the time

compensation continues unchanged from the last compensation, if this value is within a certain range. Otherwise, the compensation value is re-calculated.

Another embodiment shown in Figure 4 includes an antenna 50, a radio receiving circuit 51 and a decoder circuit 52. An operating circuit 53, receiving external time information in the same way as the operating circuit in Figure 1, reads the information from the last time correction mezrioris-ed in a memory circuit 59 and counts the time interval from the last time correction. At the same time, the operating circuit 53 calculates the compensation value to be employed on this occasion, according to the difference between the time kept in a time keeping circuit 57 and the time received from the external time information. The compensation value per unit "A" is calculated by dividing the difference by the counted time interval and is memorised in the memory circuit 59.

The time keeping circuit 57 keeps the time by dividing a signal from an oscillating circuit 56. A time compensating circuit 58 constitutes the dividing circuit for the time keeping circuit 57, in which a 256 Hz frequency is divided into a 1 Hz frequency. without receiving a time compensation signal from the operating circuit 53, the dividing circuit counts the 256 Hz frequency 256 times and outputs the 1 Hz frequency. swhen the time compensation signal is received, the count may be reset. Thus, the time can be compensated per unit every 1/256 second when the time to be compensated per unit "A" is calculated. For example, the operating circuit 53 sets 256 per certain unit time in the time compensating circuit 58 if a 1/256 second retardation is required every time unit.

The present invention is not limited to the embodiments described above and can also be applied to other communication apparatus having various time keeping functions, for example apparatus for measurement, and stopwatches or timers of high resolution.

As described above, it is possible according to the present invention to reduce to a minimum the difference between the current or standard time kept in the time keeping circuit and the time received as external time information, and to keep the correct time continuously.

Claims

1. An electronic timepiece comprising time keeping means (13; 42; 56, 57) for counting a current time, correction means (13; 42; 53; 59) responsive to received time information signals for automatically correcting the current time, and characterised by calculating means (13; 42, 44, 45; 53, 58, 59) responsive to the received time information signals for calculating current time compensation values, and means (13; 42; 53, 58) for periodically adjusting the corrected current time according to an output from the calculating means.

2. An electronic timepiece according to claim 1 characterised by a receiver (11; 40; 51) for selectively receiving external signals, and checking means (12; 41; 52) for checking whether said external signals represent time information or not.

3. An electronic timepiece according to claim 1 or 2 characterised in that the calculating means comprise a first counter (13; 44; 53) for counting a correction value representing the difference between the current time before correction by the correction means and the current time corrected by the.. correction means, a second counter (13; 45; 53) for counting the time interval between successive corrections by the correction means, and dividing means (13; 42; 58) for dividing the correction value counted in the first counter by the time interval counted in the second counter for calculating the current time compensation value.

4. An electronic timepiece according to claim 3 characterised in that the adjusting means are arranged to add or subtract the current time compensation value calculated in the dividing means to the corrected current time at a time period synchronised with counting by the second counter.

5. An electronic timepiece according to claim 3 characterised in that the adjusting means are arranged to increase or decrease the frequency of counting by the time keeping means according to the current time compensation value calculated in the dividing means.

6. An electronic timepiece according to claim 3 characterised in that the adjusting means are arranged to add or subtract the current time compensation value to the corrected current time at a predetermined time interval.

7. An electronic timepiece according to claim 3 characterised in that the adjusting means are arranged to increase or decrease the frequency of the counting by the time keeping means at a predetermined time interval.

8. An electronic timepiece for a radio receiver for automatically correcting the time characterised by first time keeping means (13; 42; 56, 57) for counting a current time, receiver means (11; 40; 51) for selectively receiving external signals, checking means (12; 41; 52) for checking whether said received external signals represent time information or not, second time keeping means (13; 42, 44, 45; 53, 58, 59) for keeping time information selectively received from said external signals; setting means (13; 42; 53) for automatically setting time information selected from said external signals in said second time keeping means, and correction means (13; 42; 53, 58, 59) for automatically correcting the

current time in accordance with said time information selected from said external signals.

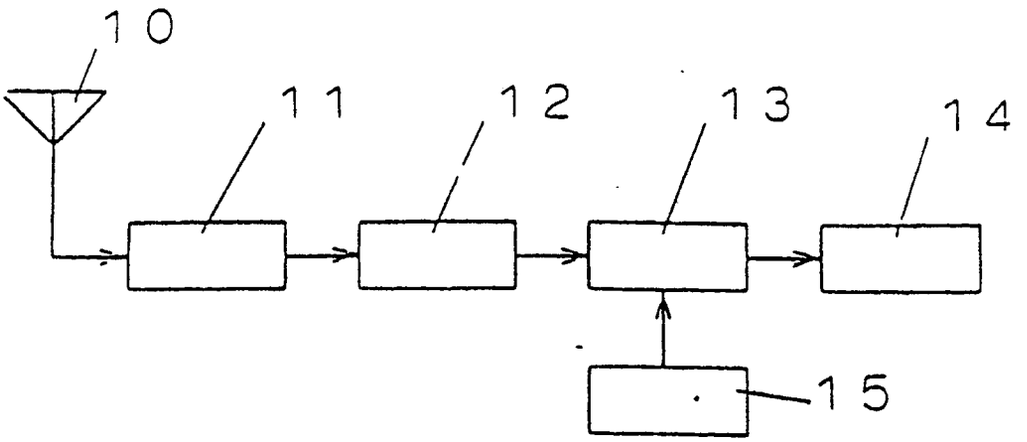
10
11
12
13
14
15

FIG 1

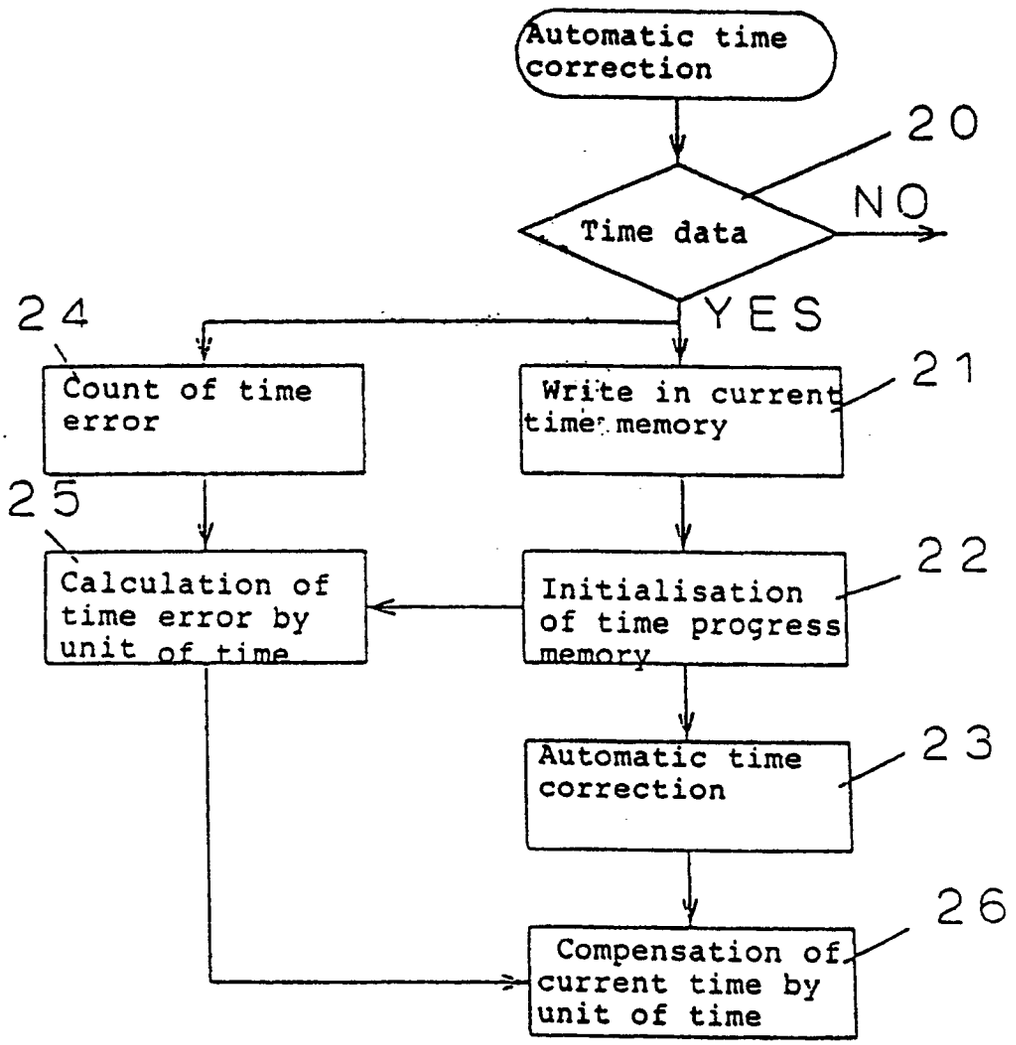
Automatic time correction
20
Time data
NO
YES
24
Count of time error
Write in current time memory
21
25
Calculation of time error by unit of time
Initialisation of time progress memory
22
Automatic time correction
23
26
Compensation of current time by unit of time

FIG 2

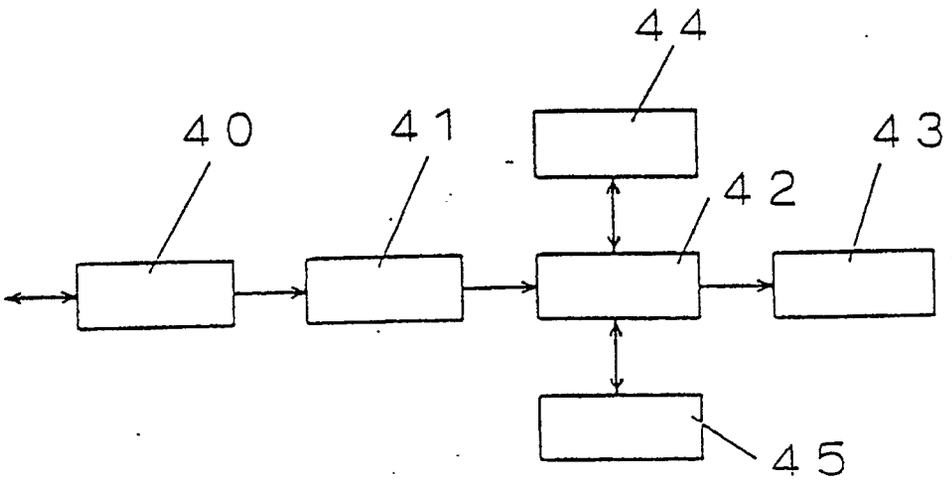

FIG 3

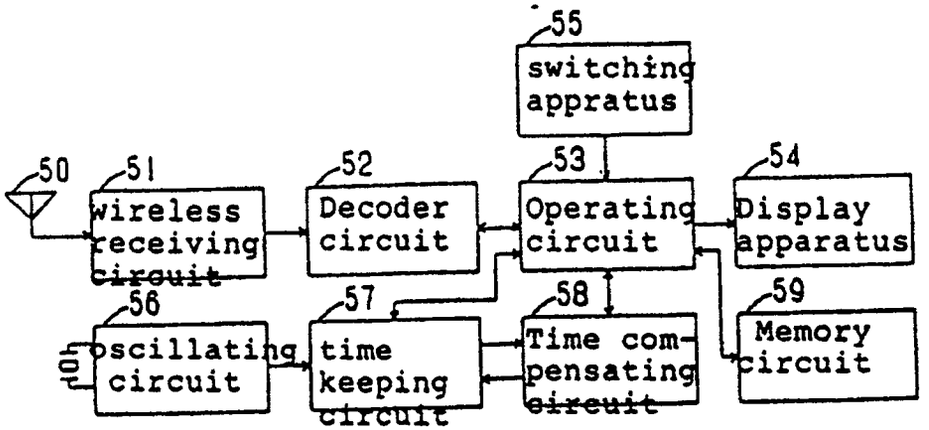
55
switching appratus
50
51
wireless receiving circuit
52
Decoder circuit
53
Operating circuit
54
Display apparatus
56
oscillating circuit
10h
57
time keeping circuit
58
Time compensating circuit
59
Memory circuit

FIG 4