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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO ELECTRONIC TIMEPIECES WITH DIGITAL DISPLAY

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to electronic timepieces with digital display (more shortly digital electronic timepieces) and more specifically to such timepieces of the kind which can display not only time but can give a calendar display also. The object of the invention is to provide improved timepieces of the kind referred to which will themselves determine automatically from the year count whether it is a leap year or not and which, once set correctly, will keep the calendar display automatically correct (despite that months do not all have the same number of days and whether the year is a leap year or not) until or unless the timepiece stops through getting out of order or through the user having to change an exhausted battery.

The year contains thirty-one day months, thirty day months and the month of February which is a twenty-nine day month in a leap year and a twenty-eight day month in other years. As will be seen later, the present invention provides a digital electronic timepiece having a digital display which is fully automated and which automatically takes into account, from the year count itself, the change of February to a twenty-nine day month when a leap year occurs.

According to this invention there is provided a digital electronic timepiece able to provide a time display and a calendar display and including day counting means, month counting and year counting means, and means, jointly controlled in dependence upon the month counts and the year counts, for automatically correcting the calendar display to be correct irrespective to the number of days in the month and whether the year is a leap year or not, the last mentioned means including means for detecting the count of the year counting means to determine whether it is a leap year or not and utilising the result of such determination to control said day counting means.

Said jointly controlled means may include gates individually responsive to day counts of 29, 30, 31 and 32; a gate responsive to day counts of 30, 31 or 32; a gate responsive to month counts of 4 or 6; gates individually responsive to month counts of 2, 9 and 11; and a gate responsive to a month count of 13. In one such embodiment the outputs of the gates individually responsive to the 29, 30 and 31 day counts are fed as inputs to an OR gate; the output of the gate responsive to day counts of 30, 31 or 32 supplies its output to a control input terminal of each of the gates responsive individually to 30, 31 and 32 day counts; and the outputs of the gates individually responsive to month counts of 9 and 11 and of the gate responsive to month counts of 4 or 6 are fed as inputs to another OR gate.

Preferably either the time display or the calendar display can be selectively displayed, at will, by the same display device by operation of a mode selection control, and preferably also both displays include a day of the week display.

There may be a two-position control switch in one position of which the display, whether of time or of calendar, can be manually corrected and, in a preferred arrangement of this nature, correction can be effected of any selected item in the display (hours, minutes or seconds, or day of the month, month or year depending upon whether a time display or a calendar display is being given) by means of a display correcting control which corrects the selected item, selection of the item being effected successively by successive operations of the mode selection control when the two position switch is in said one

position, means being provided for causing the display of the item selected for correction to flicker.

The invention is illustrated in and further explained in connection with the accompanying drawings, in which:

Figure 1 is a simplified block diagram of one embodiment of the invention;

Figure 2 is a diagram explanatory of the displays available from the embodiment of Figure 1 and which is referred to in describing how the controls for the displays are used; and

Figure 3 is a circuit diagram showing the circuit means whereby the required full automation of the calendar display is obtained.

Referring to Figure 1, block 1 represents a time standard relatively high frequency oscillator, such as a quartz crystal controlled oscillator, the output of which is fed to a multistage divider 2 producing therefrom a lower frequency signal, e.g. a 1 Hz signal. This signal is fed to a counter system 3 counting seconds, minutes and hours. The final output, i.e. the hour count output of the counting system 3, is fed to a second counting system 4 counting days, months and years and also to a counter circuit 5 counting the days of the week. Count output signals from the counting circuits 3 and 4 are passed to a display switching circuit 17. The switching circuit 17 effects selective switching so as to transmit signals from either the seconds, minutes and hours counting system 3 or from the days, months and years counting system 4 to a decoder 18. The said display switching circuit 17 is controlled by a display switching signal 14 fed to it over a line so referenced from a switching control circuit 9. The decoder 18 transforms the signals switched in to it and also signals from the day of the week counting circuit 5 (signals from which are also fed to the decoder 18) into signals suitable for display by a digital display device 20 of the alpha-numeric type, e.g. a liquid crystal display device. The signals from the decoder 18 are passed to the display device 20 *via* a display flickering circuit 19 the function of which will be understood later.

Figure 2 is a diagram explanatory of the display. In this diagram the timepiece case is represented by a circle and has three control switch knobs or stems referenced 6, 7 and 8. On the face of the timepiece is the display which (by the aid of abbreviations of their names) can display day of the week together with time in hours, minutes and seconds and (in the case of a timepiece displaying time in accordance with the 12-hour clock) AM or PM; or it can display day of the week together with the date (day of the month, month and year). The diagram of Figure 2 is divided horizontally into two rows each with two representations in it, and vertically into two columns each with two representations in it. The rows are referenced (on the left in the Figure) "Time" and "Correction" and the columns are headed "A" and "B". The representations in the A column illustrate the display given when the timepiece is showing day of the week and time while those in the B column illustrate the display given when the timepiece is showing day of the week and date. Thus, in column A, the timepiece is displaying Thursday, AM, 12h 59m 34s and, in column B, it is displaying Thursday, 30th May 1974. (In this particular example the American convention of putting the month first is adopted for the date). The timepiece is assumed to be, and is represented as, a wrist watch and when in normal use a "lock" switch 6 (see Figure 1: the same reference is used for its operating knob in Figure 2) prevents the displayed time from being corrected. In this condition operation of a mode selection switch, which is the switch 7, will change over the display from day and time to day and date (i.e. from a column A display to a column B display) or vice versa and operation of a set switch—the switch 8—switches in a lamp throwing light on the liquid crystal display. It also has another function, as will be seen later. Each successive pressing of the mode selection switch knob 7 changes the display from what was displayed before such pressing. The displays in the A column (day and time) show seconds by steady figures when the timepiece is in normal use ("Time" row) and by flickering figures when displayed time is to be corrected ("Correction" row). This is indicated in Figure 2 by the broken representation of the figures 34. The flickering is regular, i.e. the seconds display is repeatedly switched out at closely spaced regular intervals. To correct the time, the lock switch 6 is moved to the unlocked position by pulling out its operating knob 6 from its normal position (see Figure 2A column "Correction" row). This causes a flicker signal 15 from the switch controlling circuit 9 to be fed to the flickering circuit 19 and hence to the display device 20 where it causes flickering of the display given by only the seconds display elements. When the knob 6 is pulled out, every time the set switch 8 is pressed it causes a seconds reset signal 10 to be transmitted from circuit 9 over lead 10 to reset the divider 2 and the seconds counter incorporated in the counting system 3. Thus, after operation of the switch 8, seconds counting starts from an initial count of 00. If now the mode selection switch 7 is operated the display flicker

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controlling signal 15 operates only on the minutes display elements, and only the minute display flickers. In this condition, the display of minutes will be increased by 1 every time the set switch 8 is pushed. If now the mode selection switch 7 is pushed again, the display flicker controlling signal 15 operates only on the hours display elements and, after this, the display of hours will be increased by 1 every time the set switch knob 8 is pushed. If now the mode selection switch knob 7 is again pushed, the display flicker controlling signal 15 operates only on the day of the week display indication, and, after this, every time the switch 8 is pushed only the day of the week indicated will change, advancing by one day every time said set switch 8 is pushed. If the selection switch knob 7 is again pushed, only the seconds display will flicker and subsequent operations of the switch 8 will cause the seconds display to increase by 1 at each such operation.

Recapitulating, after the lock switch knob 6 is pulled out for time correction, successive operations of the switch knob 7 will cause the flickering of the displays in the order minutes-hours-day of the week-seconds-minutes... and so on, and, by operating the switch knob 8, whatever display (other than the seconds display) is flickering will be advanced by 1 every time said set switch knob 8 is pushed.

If the lock switch 6 is pulled out when a B column display is being given, the display flicker controlling signal 15 operates only on the display elements displaying the year and only the year display flickers (see the broken figures 74 in B column "Correction" row). After this, each time the set switch knob 8 is pushed, 1 will be added to the year displayed. Next, if the selection switch 7 is pushed, only the display of the day in the month will flicker and successive operations of the set switch knob 8 will advance the data by one day. If now the selection switch knob 7 is pressed again, only the digits displaying the month will flicker and subsequent operations of knob 8 will advance the display of the month by one month. If now the selection switch knob is pressed once more only the indication of the day of the week will flicker and subsequent operations of knob 8 will advance this indication by one day.

Recapitulating, if the lock switch knob 6 is pulled out when a B-column display is being given the year digits flicker and, thereafter, successive operations of the selection switch will cause flickering, successively, of the day of the month-month-day of the week-year-day of the month... and so on, and, in each case, every time the set switch knob 8 is pushed, 1 will be added to whichever display is flickering at the time.

Referring again to Figure 1, the signals 11, 12 and 13, appearing on the lines 11, 12 and 13 respectively, and fed in respectively to the counter system 3, the counter system 4 and the day of the week counter 5, are digit assignment correction signals for securing correction of the counts in these parts of the apparatus. The arrow 21 represents a driving signal input to the display device 20.

As will now be seen, operation of the mode selection switch 7 will produce either an A column display (day of the week and time) or a B column display (day of the week and date) at will. Both displays are given by the same display device so that there is economical and efficient use of available space—a very important matter in a wrist watch. Where correction of a display is required this can be done, as described above, simply and easily, as regards any item (hours, minutes, seconds, day of the week, day of the month, month or year) after selection of the item the display of which is to be corrected. The user is never in doubt as to which item is being corrected, for only that item the display of which is flickering at the time, will be corrected. Not only is there the advantage of using the same display device for both column A and column B displays, but there is also the advantage of having only a minimum of terminals on the display device, having regard to the extensive nature of what it is used to display. Even in the case of a relatively large timepiece, such as a table clock, where economical utilisation of available space is not so important as it is in a wrist watch, these advantages still apply and there is the practical advantage that the items in each of the selectable displays which can be given, appear in a convenient order, i.e. hours, minutes and seconds; month, day of the month and year; day of the week being given in the same way in both cases.

In view of the description given above it is thought that the legends and leading lines in Figure 2 will be found self explanatory.

Figure 3 shows the circuitry which functions in such manner as to avoid need for adjustment or correction at the end of a month whether it is a leap year or not and despite that the months do not all contain the same number of days. In Figure 3 blocks 22 to 27 represent display elements and each of these blocks is assumed to include a decoder-driver. 22 gives a display of the unit figure of the day of the month; 23 displays the tens figure of the day of the month; 24 displays the unit figure of the month; 25 displays the tens figure of the month; 26 displays the unit figure of the

year; and 27 displays the tens figure of the year. 28 is a 1/10 counter, 29 is a 1/4 counter, 30 is a 1/10 counter, 31 is a 1/2 counter, 32 is a 1/10 counter and 33 is a 1/4 counter. Each of these counters memorises the digits counts and each has a reset terminal. When a reset signal 34 on line 34 is fed into the counter 28, this counter is set to 1 and the same signal resets counter 29. The counter 30 is set to 1 when a reset signal 35 on line 35 is fed into it as also is counter 31. As regards the years display, when a reset signal on line 36 is fed into counters 32 and 33, they are reset so that 70 is displayed by the elements in blocks 27 and 26. The year display is a display showing the last two figures of the year, changing year by year and covering 40 years from (19)70 through (20)00 to (20)10. The counter outputs indicated by binary related figures are BCD outputs. 37 to 40 are AND gates. Of these 37 is responsive to a count of the thirty-second day of the month; 38 is responsive to a count of the thirty-first day; 39 is responsive to a count of the thirtieth day; and 40 is responsive to a count of the twenty-ninth day. 70 is an AND gate which is responsive to counts of the thirtieth, thirty-first and thirty-second days. 41 to 44 are AND gates and of these 41 is responsive to counts of the months of April and June (i.e. counts of 4 and 6); 42 is responsive to a count of the month of September (9); 43 is responsive to a count of the month of November (11); and 44 is responsive to a count of the month of February (2). An AND gate 45 responds to a count of the thirteenth month and, when it responds, sends a signal to a reset/set (RS) flip-flop 52 to cause it to generate the reset signal 35 which changes over a display of December to a display of January. The leap years in the year of (19)70~(20)00~(20)09 are 1972, '76, '80, '84, '88, '92, '96, '00, '04, and '08. When the tens digits of a leap year is an even number, and unit digit is 0, 4 or 8. When the tens digit of a leap year is an odd number, the unit digit is 2 or 6. An AND gate 53 responds to leap years whose tens digit is even. An AND gate 54 responds to leap years whose tens digit is odd. 55 is an OR gate with inputs fed from the AND gates 53 and 54 and because gates 53 and 54 also receive appropriate inputs from counter 32, when either of these gates responds, OR gate 55 transmits a leap year signal to the AND gate 40. 47 is an OR gate with inputs fed from the gates 41, 42 and 43 and, when it responds transmits what is, in effect, a 30-day months signal to the AND gate 38. An OR gate 46 provides an output signal which effects correction except for a 32-day count to one input of an AND gate 49.

One second after 11h 59m PM on Sunday December 31st 1969, the hour signal which is transmitted from the hour counter in the system 3 (Figure 1) to the system 4, is also applied at 63 to the counter 28 through an AND gate 57 and an OR gate 58, and 1 is added to the count in the counter 28 and a HIGH signal from the OR gate 50 is transmitted to the set terminal S thus setting the RS flip-flop 51 the Q output of which becomes HIGH for a short time until a HIGH signal is applied to its reset terminal R. This Q output is applied as the reset signal 34 to the counters 28 and 29 and is also applied through the AND gate 59 and the OR gate 60 to cause 1 to be added to the count in the counter 30.

When 1 is added to the count in the counter 30, AND gate 45 responds and a HIGH signal is transmitted to the set terminal S of the RS flip-flop 52 setting this flip-flop. The Q output of 52 becomes HIGH for a short time until a HIGH signal is applied to its reset terminal R, and provides the signal 35 which resets the counters 30 and 31. The Q output from 52 is also fed through the AND gate 61 and the OR gate 62 and adds 1 to the count in the counter 32.

When this 1 is added to the count in counter 32, a HIGH signal is applied to the set terminal S of the RS flip-flop 56 and the Q output of this flip-flop becomes HIGH for a short time until a HIGH signal is applied to its reset terminal R. This Q output from 56 constitutes the reset signal 36 which resets the counters 32 and 33. The performance of the above actions causes 12h 00m 00s AM and the day and date MON, 1 January, '70 to be displayed.

The counters 28 and 29 are reset by a HIGH signal which is applied to the set terminal S of the RS flip-flop 51 through AND gate 37 and OR gate 50 in case of a thirty-one day month; from the AND gate 38 in case of a thirty day month; from the AND gate 40 in the case of the month of February in a year which is not a leap year; and from the AND gate 39 in the case of the month of February in a leap year.

For time correction, the reset terminal R of the RS flip-flop 48 is changed from HIGH to LOW when the lock switch knob 6 is pulled out. Then, if the set switch knob 8 is pressed, a HIGH signal is applied to the set terminal S of the RS flip-flop 48 the $\overline{Q}$ output of which thus becomes LOW, thus blocking the signal from the OR gate 46 so that the day of the month can be displayed up to the thirty-first day, and the counters 28 and 29 are reset by the AND gate 49. Because the day of the month can be displayed up to the thirty-first day during correction a non-existent date may often be displayed, for instance, February 30, April 31, and so on, during the step of correction.

This, however, does not matter for when the timepiece is returned into the "locked" condition (knob 6 is pushed in again) a HIGH signal is applied to the reset terminal R of the RS flip-flop 48, and its $\overline{Q}$ output becomes HIGH again and, as some of AND gates 38 to 40 are operated, the HIGH signal is applied to the set terminal S of the RS flip-flop 51 through the OR gate 46, the AND gate 49 and the OR gate 50, the counters 28 and 29 are reset and the required date correction (February 30 to March 1, April 31 to May 1, for example) is automatically performed.

At leads 67, 68 and 69 are applied the signals for the correction of the display by operation of the set switch knob 8. At 64, 65 and 66 are applied signals for preventing digits being carried forward when correction is being performed. Carrying forward by the time keeping circuits of the timepiece is not prevented. For convenience of drawing, the counters 28 to 33 are shown in Figure 3 as supplying their BCD outputs directly to the following circuits but, in practice, these outputs are transmitted through a display switching circuit 17 as in the block diagram of Figure 1.

In the timepiece described and illustrated the year display covers forty years, i.e. 1970 to 2009. The reason for this is to make correction easy if the year display has been corrected by mistake. The adoption of this "40 year" feature is, however, obviously not essential and a year display giving up to the year 2099 can easily be arranged with comparatively little and obvious changes from the circuitry illustrated. The same results as are obtained from the illustrated circuitry can still be obtained if the year counting circuit is replaced by a divide-by-4 counter.

As will now be seen, the timepiece illustrated and which includes the circuitry of Figure 3 will continue to show the correct date automatically, despite the months do not all have the same number of days, and whether it is a leap year or not, so long as it is correctly adjusted whenever a new battery is put in.

It will also be seen that, with this invention, because the day counter is controlled by detecting whether or not the year is a leap year from the condition of the year counter, the user has merely to set the correct year to be displayed to ensure that the calendar will operate correctly.

Attention is directed to our Patent No. 1,404,514 the claims of which cover related subject-matter.

WHAT WE CLAIM IS:—

1. A digital electronic timepiece able to provide a time display and a calendar display and including day counting means, month counting and year counting means, and means, jointly controlled in dependence upon the month counts and the year counts, for automatically correcting the calendar display to be correct irrespective of the number of days in the month and whether the year is a leap year or not, the last-mentioned means including means for detecting the count of the year counting means to determine whether it is a leap year or not and utilising the result of such determination to control said day counting means.

2. A timepiece as claimed in Claim 1 wherein the jointly controlled means include gates individually responsive to day counts of 29, 30, 31 and 32; a gate responsive to day counts of 30, 31 or 32; a gate responsive to month counts of 4 or 6; and gates individually responsive to month counts ot 2, 9 and 11.

3. A timepiece as claimed in Claim 1 wherein the means for detecting a leap year comprise means for detecting the unit year digit of 0, 4 or 8, in the year count if the tens digit thereof is an even number and detecting a unit year digit of 2 or 6 if said tens digit is an odd number.

4. A timepiece as claimed in Claim 2 wherein the outputs of the gates individually responsive to the 29, 30 and 31 day counts are fed as inputs to an OR gate; the output of the gate responsive to day counts of 30, 31 or 32 supplies its output to a control input terminal of each of the gates responsive individually to 30, 31 and 32 day counts; and the outputs of the gates individually responsive to month counts of 9 and 11 and of the gate responsive to month counts of 4 or 6 are fed as inputs to another OR gate.

5. A timepiece as claimed in any of the preceding Claims wherein either the time display or the calendar display can be selectively displayed, at will, by the same display device by operation of a mode selection control.

6. A timepiece as claimed in any of the preceding Claims wherein both displays include a day of the week display.

7. A timepiece as claimed in any of the preceding Claims and having a two-position control switch in one position of which the display, whether of time or of calendar, can be manually corrected.

8. A timepiece as claimed in Claims 5 and 7 wherein correction can be effected of any selected item in the display (hours, minutes or seconds, or day of the month, month or year depending upon whether a time display or a calendar display is being given) by means of a display correcting control which corrects the selected item, selection of the time being effected successively by

This, however, does not matter for when the timepiece is returned into the "locked" condition (knob 6 is pushed in again) a HIGH signal is applied to the reset terminal R of the RS flip-flop 48, and its $\overline{Q}$ output becomes HIGH again and, as some of AND gates 38 to 40 are operated, the HIGH signal is applied to the set terminal S of the RS flip-flop 51 through the OR gate 46, the AND gate 49 and the OR gate 50, the counters 28 and 29 are reset and the required date correction (February 30 to March 1, April 31 to May 1, for example) is automatically performed.

At leads 67, 68 and 69 are applied the signals for the correction of the display by operation of the set switch knob 8. At 64, 65 and 66 are applied signals for preventing digits being carried forward when correction is being performed. Carrying forward by the time keeping circuits of the timepiece is not prevented. For convenience of drawing, the counters 28 to 33 are shown in Figure 3 as supplying their BCD outputs directly to the following circuits but, in practice, these outputs are transmitted through a display switching circuit 17 as in the block diagram of Figure 1.

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As will now be seen, the timepiece illustrated and which includes the circuitry of Figure 3 will continue to show the correct date automatically, despite the months do not all have the same number of days, and whether it is a leap year or not, so long as it is correctly adjusted whenever a new battery is put in.

It will also be seen that, with this invention, because the day counter is controlled by detecting whether or not the year is a leap year from the condition of the year counter, the user has merely to set the correct year to be displayed to ensure that the calendar will operate correctly.

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2. A timepiece as claimed in Claim 1 wherein the jointly controlled means include gates individually responsive to day counts of 29, 30, 31 and 32; a gate responsive to day counts of 30, 31 or 32; a gate responsive to month counts of 4 or 6; and gates individually responsive to month counts ot 2, 9 and 11.

3. A timepiece as claimed in Claim 1 wherein the means for detecting a leap year comprise means for detecting the unit year digit of 0, 4 or 8, in the year count if the tens digit thereof is an even number and detecting a unit year digit of 2 or 6 if said tens digit is an odd number.

4. A timepiece as claimed in Claim 2 wherein the outputs of the gates individually responsive to the 29, 30 and 31 day counts are fed as inputs to an OR gate; the output of the gate responsive to day counts of 30, 31 or 32 supplies its output to a control input terminal of each of the gates responsive individually to 30, 31 and 32 day counts; and the outputs of the gates individually responsive to month counts of 9 and 11 and of the gate responsive to month counts of 4 or 6 are fed as inputs to another OR gate.

5. A timepiece as claimed in any of the preceding Claims wherein either the time display or the calendar display can be selectively displayed, at will, by the same display device by operation of a mode selection control.

6. A timepiece as claimed in any of the preceding Claims wherein both displays include a day of the week display.

7. A timepiece as claimed in any of the preceding Claims and having a two-position control switch in one position of which the display, whether of time or of calendar, can be manually corrected.

8. A timepiece as claimed in Claims 5 and 7 wherein correction can be effected of any selected item in the display (hours, minutes or seconds, or day of the month, month or year depending upon whether a time display or a calendar display is being given) by means of a display correcting control which corrects the selected item, selection of the time being effected successively by

successive operations of the mode selection control when the two position switch is in said one position, means being provided for causing the display of the item selected for correction to flicker.

9. Digital electronic timepieces substantially as herein described with reference to the accompanying drawings.

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