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(54) WEEKDAY DETERMINING CIRCUIT FOR AN ELECTRONIC TIMEPIECE

(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 weekday determining circuits for electronic timepieces, e.g. electronic watches.

Conventional weekday determining circuits for so-called permanent calendar electronic watches that produce minutes, hours, days, months, years, and weekdays indications, the weekdays indication is set independently of the years, months, and days indications. Properly speaking, however, the weekdays indication is univocal if the years, months and days indications are known.

According to one aspect of the present invention there is provided a weekday determining circuit for an electronic timepiece comprising an electronic circuitry for receiving data representative of a time indication consisting of day, month, and year and for dividing said data by seven, the remainder resulting from the calculation being an univocal indication of the day of the week corresponding to the said time indication.

In the preferred embodiment, the circuit includes an input selector for receiving binary data representative of the time indication, adder means for receiving outputs of the selector, and latch means connected in a feedback loop between outputs and inputs of the adder means.

The circuit may include means connected to an input of the input selector for feeding data corresponding to −7 thereto to produce said data.

According to a further aspect of the present invention there is provided an electronic timepiece, for example an electronic watch having a weekday determining circuit as recited above.

The electronic timepiece preferably includes a years counter, a months counter and a days counter for producing the said data representative of a time indication. Moreover, the electronic timepiece may include a liquid crystal display device for displaying the time indication.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 is a block diagram of one embodiment of a weekday determining circuit according to the present invention; and

Figure 2 is a timing chart illustrating the operation of the weekday determining circuit of Figure 1.

An embodiment of a weekday determining circuit according to the present invention is illustrated in Figure 1. Each output of a 5-bit years counter 11, a 4-bit months counter 12 and a 5-bit days counter 13 is fed to a data decoder selector 14, having a 3-bit output temporarily and then forms the input to an input selector 16. A "−7" decoder 15 produces outputs which are also fed to the input selector 16 and are selectively and temporarily fed thereby to one input of a 4-bit adder 17. To one input of the adder 17 is fed an output from a latch 19. An output of the adder 17 is fed to a latch 18, and the latch 19. The output of a weekday decoder 20 is fed to a display device (not shown) to drive display elements thereof. The display device may be a liquid crystal display device.

The logic of the operation of the weekday determining circuit is as follows. As each output bit is a pure binary digit, they will be designated for the sake of con-

venience by the subscripts α, β, γ, δ, ϵ. Thus, the contents (W_γ, W_β, W_α) of the latch 18 is shown in Table 1, from which it will be appreciated that 0 represents Sunday, 1 represents Monday, 2 represents Tuesday, 3 represents Wednesday, 4 represents Thursday, 5 represents Friday and 6 represents Saturday. It will be appreciated that the remainder left after dividing the days, indication i.e. the number of days by 7 is indicative of the weekday.

Number	W_γ	W_β	W_α	Day
0	0	0	0	Sun.
1	0	0	1	Mon.
2	0	1	0	Tues.
3	0	1	1	Wed.
4	1	0	0	Thur.
5	1	0	1	Fri.
6	1	1	0	Sat.

TABLE 1

The contents (D_ϵ, D_δ, D_γ, D_β, D_α) of the days counter is shown in Table 2, where "0-day" represents the last day of the previous month. A reminder is obtained by dividing the content of the days counter by 7. The calculation of this remainder is performed simply by electronic circuitry by calculating a first remainder D_1, and a second remainder D_2 where D_1 ($D_{1\gamma}$, $D_{1\beta}$, $D_{1\alpha}$) and D_2 ($D_{2\gamma}$, $D_{2\beta}$, $D_{2\alpha}$) and where $D_1=0$, $D_{1\beta}=\epsilon$, $D_{1\alpha}=D_\delta$, $D_{2\gamma}=D_\gamma$, $D_{2\beta}=D_\beta$, and $D_{2\alpha}$ is D_α. The required remainder is given by D_1+D_2. However, in the case where the remainder is (1,1,1) or greater, the remainder is divided by 7 again. For example, the 29th day is denoted by D_1 is 3, D_2 is 5, then D_1+D_2 is 8 and the remainder is 1.

The contents (M_δ, M_γ, M_β, M_α) of the months counter are shown in Table 3, which indicates the remainder M_1 left after dividing by 7, taking March or November as a standard, and the adjustment M_2 in case of a leap year. To arrive at the remainders M_1 shown in Table 3, March is taken as a standard. Since March has 31 days the remainder M_1 for April is 3 after having divided 31 by 7. April has 30 days which gives a remainder 2 after division by 7, so that the remainder M_1 for May is 5 (2+3). June has 31 days giving a remainder of 3 after division by 7, so that the remainder M_1 is theoretically 8 (5+3) but this theoretical remainder is divided by 7 giving a value of 1 for the remainder M_1 for June. The remainder M_1 for the other months is determined in a similar manner. The calculation of the remainders M_1, M_2 are calculated electronically as follows:

Putting M_1 ($M_{1\gamma}$, $M_{1\beta}$, $M_{1\alpha}$) and M_2 ($M_{2\gamma}$, $M_{2\beta}$, $M_{2\alpha}$) we get

$$M_{1\gamma}=\overline{M}_\delta \cdot \overline{M}_\beta \cdot M_\alpha + M_\gamma \cdot \overline{M}_\alpha,$$

$$M_{1\beta}=\overline{M}_\beta \cdot (\overline{M}_\alpha + M_\delta) + M_\gamma \cdot M_\beta \cdot M_\alpha$$

$$M_{1\alpha}=M_\gamma$$

$$M_{2\gamma}=M_{2\beta}=1 \cdot \overline{M}_\delta \cdot \overline{M}_\gamma \cdot (\overline{M}_\beta \cdot M_\alpha + M_\beta \cdot \overline{M}_\alpha)$$

$$M_2=0,$$

where is a datam which 1 in a leap year and 0 in a non-leap year.

The contents Y (Y_ϵ, Y_γ, Y_β, Y_α) of the years counter is shown in Table 4. The remainder of dividing the 365 days of an ordinary year by 7 is 1, and the remainder of dividing the 366 days of a leap year by 7 is 2. Table 4 shows the deviation for each year taking March (or November) of 1976 as a standard. By putting Y_1 (Y_γ, Y_β, Y_α), Y_2 ($Y_{2\gamma}$, $Y_{2\beta}$, $Y_{2\alpha}$) and Y_3 ($Y_{3\gamma}$, $Y_{3\beta}$, $Y_{3\alpha}$), the deviation is equal to ($Y_1+Y_2+Y_3$).

Electronically, Y_1, Y_2, Y_3 are calculated by putting $Y_1=Y_\epsilon$, $Y_{1\beta}=Y_\delta$, $Y_{1\gamma}=Y_\gamma$, $Y_{2\gamma}=0$, $Y_{2\beta}=Y_\epsilon$, $Y_{2\alpha}=Y_{2\delta}$, $Y_{3\gamma}=Y_\gamma$, $Y_{3\beta}=Y_\gamma$, $Y_{3\alpha}=Y_\alpha$. For example, in the year 2001, $Y_1+Y_2+Y_3=6+3+1=10$ and the remainder after dividing by 7 is 3 which is the deviation.

Date	D_ϵ	D_δ	D_γ	D_β	D_α	remainder	D_1	D_2
0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	1	0	1
2	0	0	0	1	0	2	0	2
3	0	0	0	1	1	3	0	3
4	0	0	1	0	0	4	0	4
5	0	0	1	0	1	5	0	5
6	0	0	1	1	0	6	0	6
7	0	0	1	1	1	0	0	7
8	0	1	0	0	0	1	1	0
9	0	1	0	0	1	2	1	1
10	0	1	0	1	0	3	1	2
11	0	1	0	1	1	4	1	3
12	0	1	1	0	0	5	1	4
13	0	1	1	0	1	6	1	5
14	0	1	1	1	0	0	1	6
15	0	1	1	1	1	1	1	7

Date	D_ϵ	D_δ	D_γ	D_β	D_α	remainder	D_1	D_2
16	1	0	0	0	0	2	2	0
17	1	0	0	0	1	3	2	1
18	1	0	0	1	0	4	2	2
19	1	0	0	1	1	5	2	3
20	1	0	1	0	0	6	2	4
21	1	0	1	0	1	0	2	5
22	1	0	1	1	0	1	2	6
23	1	0	1	1	1	2	2	7
24	1	1	0	0	0	3	3	0
25	1	1	0	0	1	4	3	1
26	1	1	0	1	0	5	3	2
27	1	1	0	1	1	6	3	3
28	1	1	1	0	0	0	3	4
29	1	1	1	0	1	1	3	5
30	1	1	1	1	0	2	3	6
31	1	1	1	1	1	3	3	7

TABLE 2

Month	M_δ	M_γ	M_β	M_α	M_1	$M_{1\gamma}$	$M_{1\beta}$	$M_{1\alpha}$	M_2
1	0	0	0	1	4	1	0	0	6
2	0	0	1	0	0	0	0	0	6
3	0	0	1	1	0	0	0	0	0
4	0	1	0	0	3	0	1	1	0
5	0	1	0	1	5	1	0	1	0
6	0	1	1	0	1	0	0	1	0
7	0	1	1	1	3	0	1	1	0
8	1	0	0	0	6	1	1	0	0
9	1	0	0	1	2	0	1	0	0
10	1	0	1	0	4	1	0	0	0
11	1	0	1	1	0	0	0	0	0
12	0	0	0	0	2	0	1	0	0

TABLE 3

The "0-day" of March (or November) of 1976, that is, the last day of February (or October) was a Sunday, and if this day is taken as a standard, the remainder after dividing $(D_1+D_2+M_1+M_2+Y_1+Y_2+Y_3)$ by 7 is representative of the week-day. Data is fed to the adder 17 from the years counter 11, months counter 12 and days counter 13 in succession, and if the sum is more than 7 then an input of -7 is fed to the adder from the "-7" decoder 15 the result being indicative of the day of the week. Since the binary code of -7 is (1001) by representing the output of the latch A19 as (A_δ, A_γ, A_β, A_α) and the output of the "-7" decoder 15 as (C_δ, C_γ, C_β, C_α), then $C_\delta=C_\alpha=A_\delta+A_\gamma A_\beta A_\alpha$ and $C_\gamma=C_\beta=0$.

Year	Y	deviation	Y_1	Y_2	Y_3	Year	Y	deviation	Y_1	Y_2	Y_3
76	0	0	0	0	0	92	16	6	4	2	0
77	1	1	0	0	1	93	17	0	4	2	1
78	2	2	0	0	2	94	18	1	4	2	2
79	3	3	0	0	3	95	19	2	4	2	3
80	4	5	1	0	4	96	20	4	5	2	4
81	5	6	1	0	5	97	21	5	5	2	5
82	6	0	1	0	6	98	22	6	5	2	6
83	7	1	1	0	7	99	23	0	5	2	7
84	8	3	2	1	0	2000	24	2	6	3	0
85	9	4	2	1	1	01	25	3	6	3	1
86	10	5	2	1	2	02	26	4	6	3	2
87	11	6	2	1	3	03	27	5	6	3	3
88	12	1	3	1	4	04	28	0	7	3	4
89	13	2	3	1	5	05	29	1	7	3	5
90	14	3	3	1	6	06	30	2	7	3	6
91	15	4	3	1	7	07	31	3	7	3	7

TABLE 4

Figure 2 is a timing diagram illustrating the operation of the weekday determining circuit of Figure 1. A calculation performing timing pulse 30 becomes logic 1 for a predetermined period of time at a given hour, and during this period the weekday is determined. In reality, it is sufficient for the period to be 1/32 second. Selection timing 31 for data is represented by eight time periods t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8, where t_1 is an hours reset, t_2 is Y_1, t_3 is Y_2, t_4 is Y_3, t_5 is M_1, t_6 is M_2, t_7 is D_1 and t_8 is the timing for selecting each datum. Actually, the selection of data is effected by using three kinds of signal frequency and a switch circuit, and the result of the calculation is the output of the data decoder selector 14. An input selector timing pulse 32 actuates the input selector 16, and selects the data in the data decoder selector 14 when a logic 1 signal appears, outputting data represents −7 from the "−7" decoder 15 when a logic 0 signal appears to the input of the 4-bit adder 17. A latch S writing-in pulse 33 writes in the sum output (S_δ, S_γ, S_β, S_α) of the 4-bit adder 17 when a logic 1 signal appears. Because the hours of the pulse 33 and the pulse 34 are out-of-phase, it is possible to feed the sum output of the 4-bit adder 17 to the A-input at the succeeding hour.

In this way, is achieved an effective electronic circuit wherein the calculation of weekday is comparatively easily performed. In practice the calculation is completed in 1/32 sec.

A circuit other than described above in relation to Figure 1, is conceivable. But the operation of adding data representative of the years, months, days indication and dividing the result by 7 is indispensable.

Since the weekdays indication can be automatically determined, it is possible to predict a weekday in the past as well as in the future, resulting in an electronic timepiece, for example, a permanent calendar watch which has commercial value.

WHAT WE CLAIM IS:—

1. A weekday determining circuit for an electronic timepiece comprising an electronic circuitry for receiving data representative of a time indication consisting of day, month, and year and for dividing said data by seven, the remainder resulting from the calculation being an univocal indication of the day of the week corresponding to the said time indication.

2. A circuit as claimed in claim 1 in which the circuit includes an input selector for receiving binary data representative of the time indication, adder means for receiving outputs of the selector, and latch means connected in a feedback loop between outputs and inputs of the adder means.

3. A circuit as claimed in claim 2 including means connected to an input of the input selector for feeding data corresponding to −7 thereto to produce said remainder.

4. A weekday determining circuit substantially as herein described with reference to and as shown in the accompanying drawings.

5. An electronic timepiece, for example, an electronic watch, having a weekday determining circuit as claimed in any preceding claim.

6. An electronic timepiece as claimed in claim 5 including a year counter, a months counter and a days counter for producing the said data representative of a time indication.

7. An electronic timepiece as claimed in claim 5 or 6 including a liquid crystal display device for displaying the time indication.

J. MILLER & CO.,
Chartered Patent Agents,
Agent for the Applicants,
Lincoln House,
296/302 High Holborn,
London WC1V 7JH.

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