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[54] **BATTERY-DRIVEN WATCH WITH BATTERY CONSUMPTION DISPLAY ALARM**

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[73] Assignee: **Citizen Watch Company, Limited,** Tokyo, Japan

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Nov. 20, 1972 Japan 47-116312

[52] **U.S. Cl.** ..... **58/23 BA;** 58/50 R; 58/152 H; 340/248 B

[51] **Int. Cl.²** **G04C 3/00;** G04B 19/30; G08B 21/00

[58] **Field of Search** ...58/23 R, 23 BA, 50 R, 152 H, 58/249; 340/248 B

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Primary Examiner—Edith Simmons Jackmon

Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

The invention provides an advance alarm means incorporated with an electronic watch driven by a battery and fitted with a digital time display means.

There is provided a detector sensing an abrupt voltage drop at the source battery. A selector represents its two states corresponding to the normal operating condition of the battery and to the voltage dropped condition thereof, respectively. This selector controls the feed of two different signal series to at least one electrically illuminatable elements of the digital time display means, depending upon the state of the selector and for providing an advance alarm before occurrence of an unacceptable voltage drop in the source battery.

6 Claims, 9 Drawing Figures

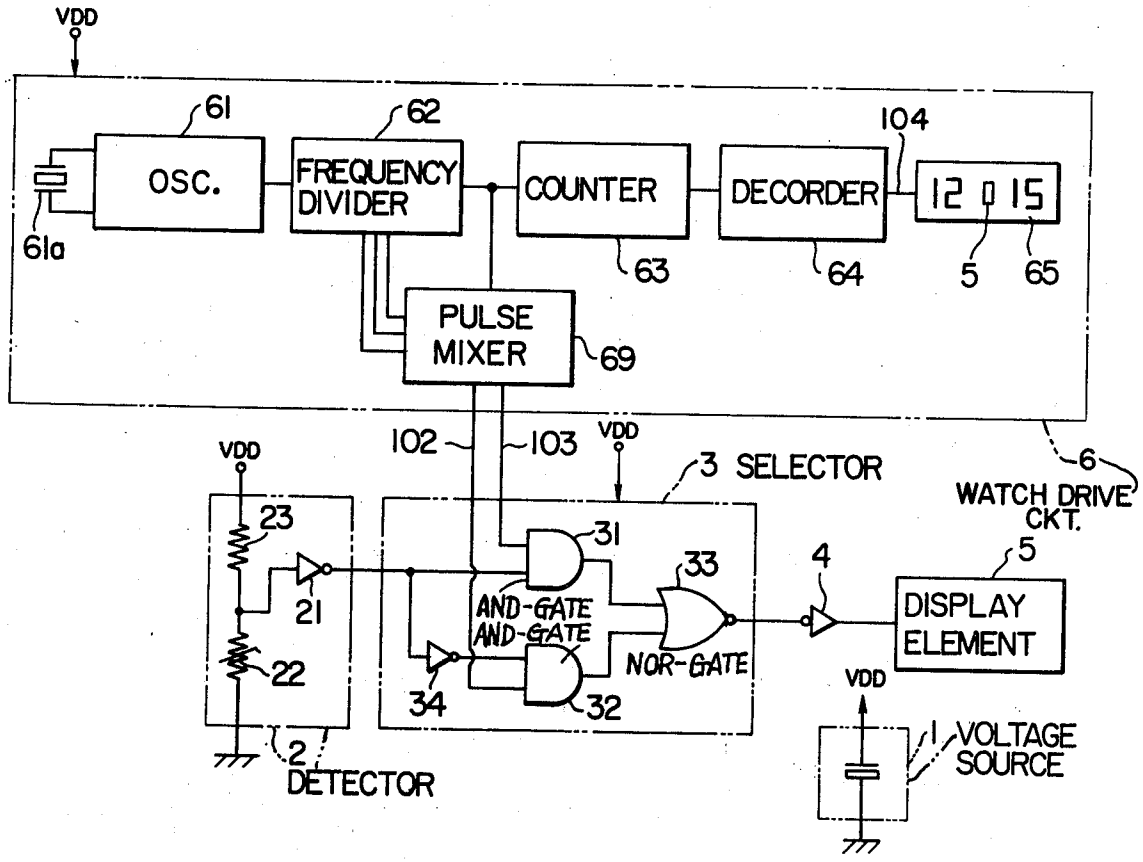
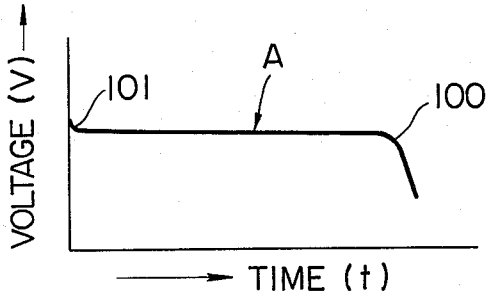


FIG. 1



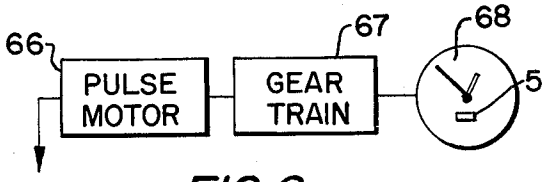


FIG. 2

FIG. 2a

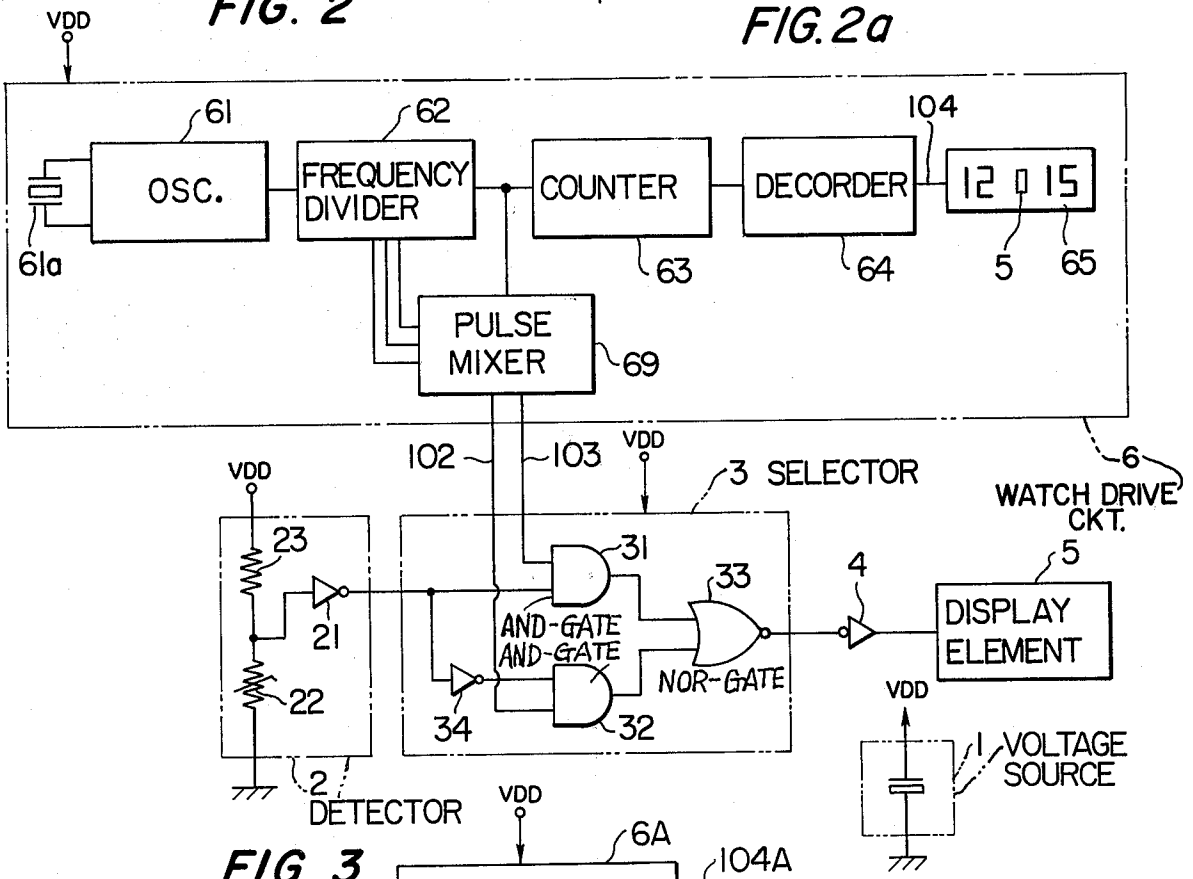


FIG. 3

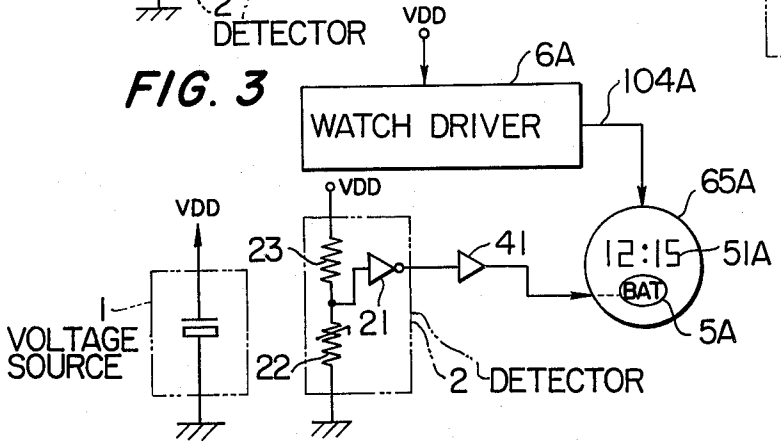


FIG. 4

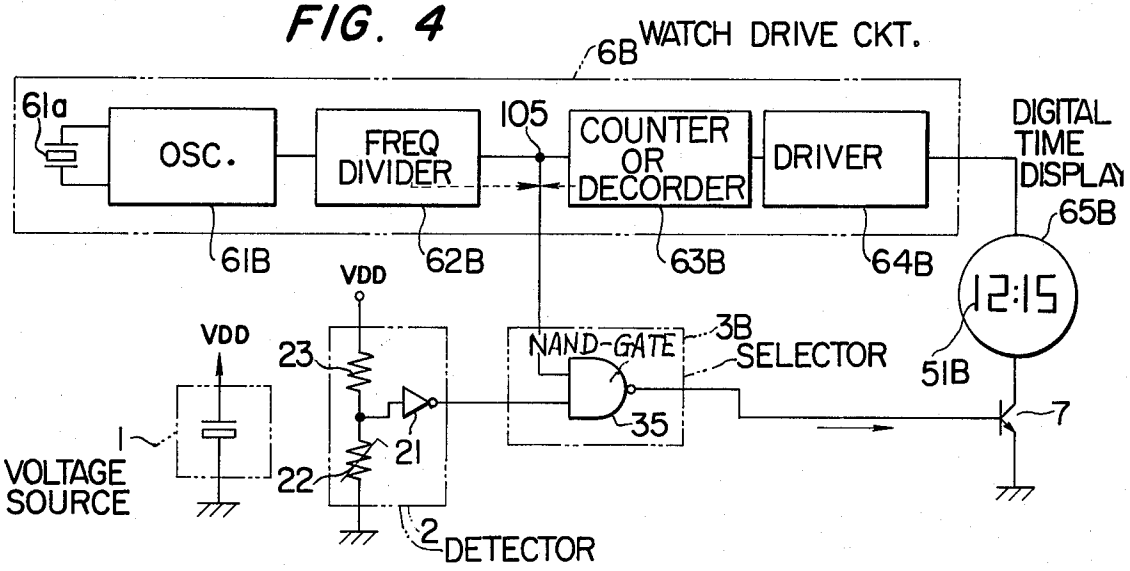


FIG. 5

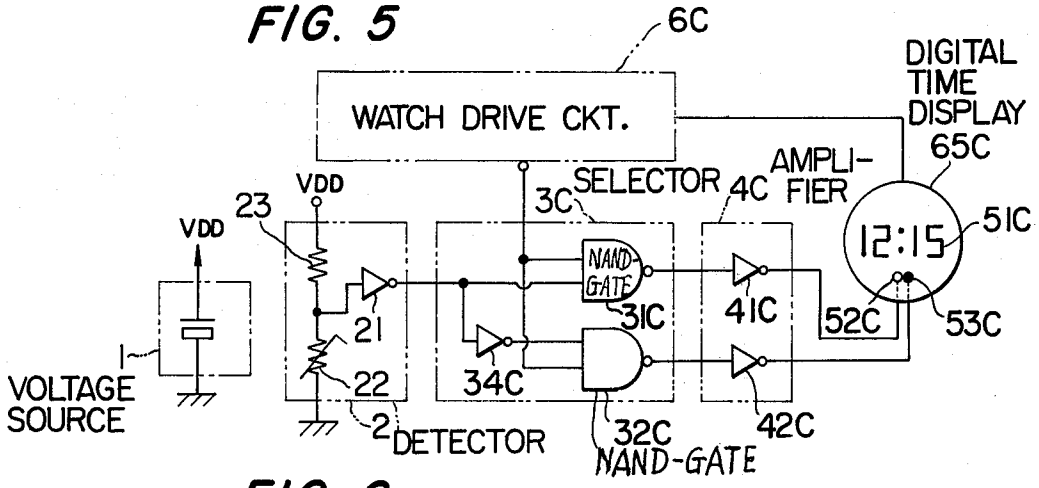


FIG. 6

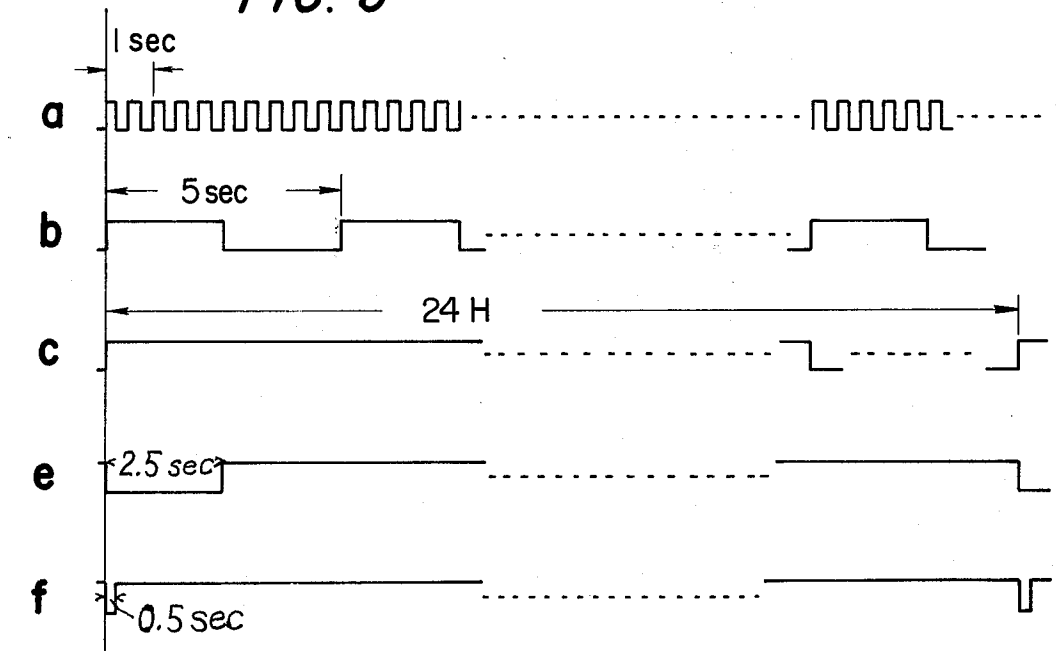


FIG. 7

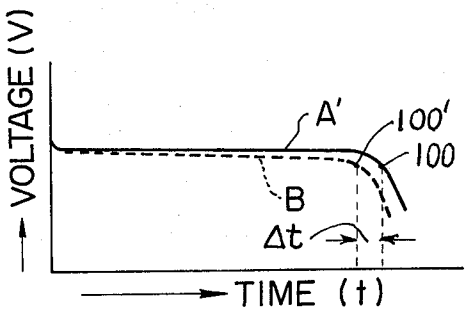
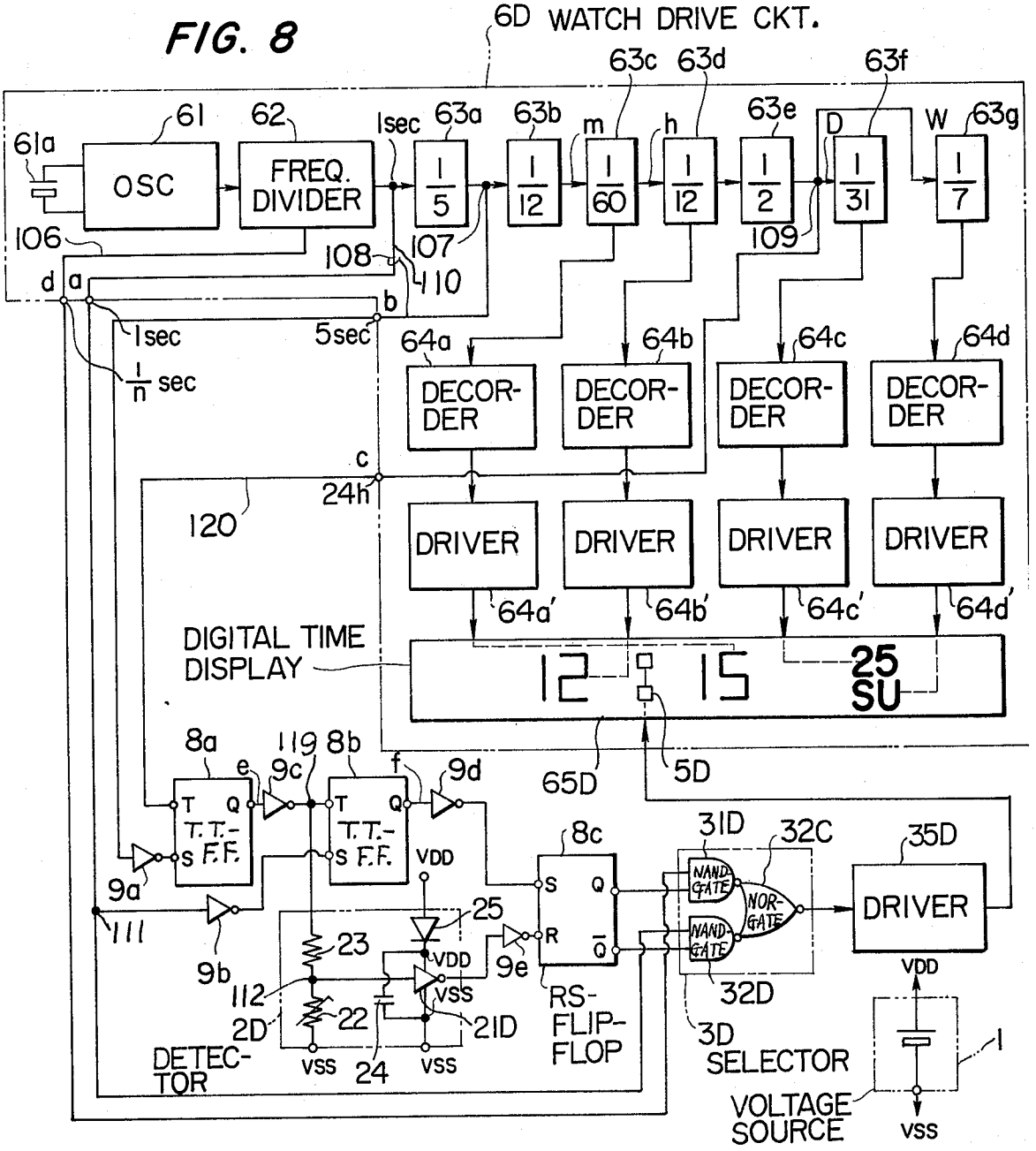

VOLTAGE (V)
A'
100'
100
B
Δt
TIME (t)

FIG. 8


6D WATCH DRIVE CKT.
61
62
1sec
63a
63b
63c
63d
63e
63f
63g
m
h
D
W
61a
OSC
FREQ. DIVIDER
1/5
1/12
1/60
1/12
1/2
1/31
1/7
106
107
108
109
110
d
a
b
1sec
5sec
1/n sec
64a
64b
64c
64d
DECOR-DER
c
24h
120
DRIVER
64a'
64b'
64c'
64d'
DIGITAL TIME DISPLAY
12 15 25 SU
65D
5D
8a
8b
119
9c
9d
e
f
T Q
T.T.-S F.F.
9a
9b
111
VDD
8c
S Q
R Q̄
RS-FLIP-FLOP
31D
32C
35D
NAND GATE
NOR-GATE
32D
3D SELECTOR
23
25
9e
112
2D
22
21D
24
VSS
DETEC-TOR
VOLTAGE SOURCE
1

BATTERY-DRIVEN WATCH WITH BATTERY CONSUMPTION DISPLAY ALARM

BACKGROUND OF THE INVENTION

This invention relates to a battery-driven watch fitted with a built-in alarm mechanism for alarming beforehand the consumed condition of the battery.

A predominant drawback of the battery-driven watch is such that the battery could be consumed up without alarming beforehand the consuming-up condition of the battery to the watch-carrying person. Conventionally, the watch owner will become aware of the consumed battery only upon it has been consumed up and the watch fallen into its inoperating state.

If there is substantially no battery change facility in such a case that the watch owner should make a trip to far from the town, as an example, he can not utilize the time-indicating service of the watch.

SUMMARY OF THE INVENTION

It is, therefore, a main object of the present invention to provide a battery-driven watch fitted with a built-in alarm device capable of warning a possible consumed-up condition of the watch beforehand, and say, at least a week before the perfect stoppage of the operation of the timepiece.

This and further objects, features and advantages of the invention will become more apparent when read the following detailed description of the invention by reference to the accompanying drawings illustrative by way of several preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a representative characteristic curve of a battery wherein the voltage is plotted against the battery operating time.

FIGS. **2** – **2***a* and **3** – **5** are connection diagrams of first to fourth embodiments of the invention, respectively.

FIG. **6** is a chart showing several wave forms appearing at several parts of a fifth embodiment shown in FIG. **8.**

FIG. **7** is a chart plotted in the similar manner to FIG. **1,** in a better form adapted for the illustration of operation of the fifth embodiment.

FIG. **8** is a similar view to FIG. **2,** illustrating the fifth embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the accompanying drawings, several preferred embodiments of the invention will be described in detail hereinbelow.

In FIG. **1,** a typical characteristic curve of a mercury- or silver battery is shown wherein the voltage is plotted against time as appearing when the battery is connected to a load.

According to the present standard practice, the voltage drop point as at **100** in FIG. **1** is set as appearing upon lapse of time longer than one year.

The setting will be influenced naturally by the occasionally encountered variation in the consumed current, the capacity of the battery and the loaded conditions.

As shown at **101** in FIG. **1,** the characteristic curve "A" represents an initial voltage drop and then a generally flat curve providing a substantially constant voltage

level over a rather long operating period until a sharp and abrupt voltage drop as at **100** will appear, as was referred to hereinabove. At the arrival of this voltage drop point **100,** the dry battery must be discarded as consumed up.

In FIG. **2,** a voltage drop detector **2** and a selector **3** are shown schematically as coupled to a regular electronic watch movement drive circuit **6.** In this embodiment, **1** represents a drive battery adapted for energization of all the circuit components to be described. The detector circuit **2** comprises a fixed resistor **23,** a variable resistor **22** and an inverter **21** electrically connected one after another as shown; said inverter **21** may preferably be a MOS-semiconductors.

The selector circuit **3** comprises AND-gates **31** and **32,** a NOR-gate **33** and an inverter **34;** these circuit elements are electrically connected with each other and with the circuits **2** and **6** as shown. The output of NOR-gate **33** is electrically connected through an amplifier **4** to a display element **5** which may be of the liquid crystal, illuminating diode or the like type.

The AND-gates **31** and **32** are controlled by output signals from the detector **2** for allowing selective passage of the pulses delivered from the drive circuit **6** and for periodical on-off operation of the display element **5,** as will be more fully described hereinbelow.

The watch movement drive circuit **6** of the conventional type comprises an oscillator **61** and a frequency divider **62** which combination is designed and arranged, so as to deliver an electric voltage pulse per second, as an example. When the timepiece is of the digital type, the circuit **6** further comprises a counter **63,** a decoder **64** and a digital display device **65** which are connected as shown. Or alternatively and as shown in FIG. **2***a*, when the watch is of the analog type, the circuit **6** comprises a pulse motor **66,** a regular time-indicating gear train **67** and a time display mechanism **68,** in place of and as direct substitutes for the aforementioned digital constituents **63** – **65,** although these elements **63** – **68** have been shown only schematically by virtue of their very popularity among those skilled in the art.

The drive circuit **6** comprises further a pulse mixer **69,** only schematically shown, adapted for delivery of seconds pulse series and half second pulse series having properly selected pulse width, in the preferred embodiment so far shown and described. The former pulse series is delivered through first output lead **102** and the latter pulse series is delivered through second output lead **103** which extend from the respective outputs of the mixer **69** to the inlets of AND-gates **32** and **31,** respectively.

The operation of the first embodiment is as follows:

By manipulating the variable resistor **22,** the input voltage to inverter **21** is adjusted to such level as slightly higher than the threshold voltage of an input transistor, not shown, contained in the inverter, upon applying the regular source voltage from the drive battery **1** to input terminal VDD of the detector **2.** The resultant resistance of the series-connected resistors **22** and **23** is selected to be a higher level as possible from the view point of power consumption efficiency, so far as allowable without giving rise to instability of the detector operation.

By the establishment of the aforementioned operational conditions, the output from first inverter **21** will become binary 0, so far as the drive battery **1** delivers

its regular voltage, while the output from second inverter **34** will become binary 1, thus, the AND-gate **32** being kept in its conducting state. Therefore, the display element **5** will periodically ignite with seconds-series pulses fed from the drive circuit **6** through first lead **102.**

On the other hand, if the source voltage should drop abruptly as at **100** in FIG. **1,** the output from first inverter **21** will become binary 1 and first AND-gate **31** is brought into its conducting state. Thus, the display element **5** will periodically ignite at a quicker frequency with the half-second pulse series conveyed from the drive circuit **6** through second lead **103.** In this respect, it should be noted that the element **5** is shown in triplicate in FIG. **2.**

It will be seen from the foregoing that the display element **5** performs a periodic flashing operation with seconds pulse series when the battery keeps its normal operating voltage and with half second pulse series when and after the battery voltage has dropped abruptly from the normal operating voltage.

By slight modification of the circuit arrangement although not shown on account of easy occurrence to any person skilled in the art, the half second pulse series to be delivered in the latter case may be modified to either slower or quicker mode than that above specified, so far as it can be discriminated from the regular seconds pulse series. As an example, the alarm signal pulse series may have a period of several seconds or of a second divided by an integer larger than **2,** as the case may be.

On the other hand, the regular seconds pulse series may be modified so as to have a different period than a second and as occasion may desire.

From the data raised in this Table 1, it will be seen that if the detector has been designed to detect a 50 mV-voltage drop and the electronic watch drive circuit can operate with 1.4 volts at the lowest, an alarm period longer than a week may be provided until the watch movement ceases its operation.

A more specific example of several consumption characteristic data of an electronic watch drive battery is shown in the following Table 1:

Table 1

battery capacity:	150 mA · h;
normal effective life:	longer than 360 days;
normal working voltage:	1.56 volts;
remaining working period:	15 days between voltages 1.56 and 1.50;
"	7 days between voltages 1.50 and 1.40;
"	3 days between voltages 1.40 and 1.30;

Next, referring to FIG. **3,** the second embodiment of the invention will be described in detail.

In this Figure, numeral **1A** represents again the drive battery having the output terminal VDD acting as an input to the detector circuit **2** which comprises fixed resistor **23,** variable resistor **22** and inverter **21** arranged in the similar manner as before.

Numeral **6A** represents the electronic watch movement drive circuit designed and arranged as at **6** in the foregoing first embodiment, yet being devoid of pulse mixer **69.** The output of the drive circuit **6A** is electrically connected through lead means **104A** to conventional digital display device **65A** which is similar in its design and function as those of the device which was shown at **65** in the foregoing. The device **65** or **65A** comprises a number of electro-optical display elements which are energizable by impressed voltages as commonly known supplied from the outputs of the drive circuit **6** or **6A** and now shows a specific time point of **12** hours **15** minutes, as an example.

The output of inverter **21** is connected through an amplifier **41** to an illuminatable alarm **5A** which is provided on the display device **5A.**

The operation of the second embodiment is as follows:

When the battery **1** keeps its normal operating voltage, the output from inverter **21** will become binary 0 and thus, the illuminatable alarm **5A** does not ignite.

On the other hand, when the battery voltage shows an abrupt drop as at **100** in FIG. **1,** the output from inverter **21** will represent binary 1 and thus the alarm **5A** will ignite for providing a visual alarm signal to the bearer of the watch.

In FIG. **4,** the third embodiment of the invention is illustrated.

In this Figure, numerals **1, 2, 21, 22** and **23** represent respective similar constituents as before. This is applied to FIG. **5** showing the fourth embodiment. In the similar way, numerals **6B, 61B, 62B, 63B, 64B** and **65B** represent respective similar constituents denoted **6, 61,** 62, 63, 64 and **65** as before.

The conventional digital display device comprises illuminatable time display elements **51B** which are energized by output voltages from the watch movement drive circuit **6B.**

Numeral **3B** represents a selector circuit which comprises a NAND-gate **35** having two inputs. One of these inputs is connected with a junction point **105** positioned between two blocks **62B** and **62C,** while the other input is connected with the output of inverter **21.**

7 represents a switching transistor which is so connected although not specifically shown as to earth the common negative terminal to the illuminatable time display elements **51B,** or to interrupt the earth connection, depending upon the implied input from NAND-gate **35.**

With the said arrangement, the output from inverter **21** will become binary 0 and the output from NAND-gate **35** will become binary 1 when the working voltage of battery **1** is at the normal level so that the illuminatable display elements **51B** perform their regular minutely and digitally stepping-up time display job by receiving signal output from the decoder **64B,** as known per se.

On the contrary, when the working voltage at the battery **1** shows an abrupt drop as at **100** in FIG. **1,** binary outputs 0 and 1 will alternatively appear at the output of NAND-gate **35,** depending upon the inputs from the drive circuit **6B.**

If occasion may desire, the time display mode can be reversed by slight modifying the design of the constituent circuit elements in such a way that with the regular working voltage kept at the battery **1,** the display elements **51B** will flicker, while, when the battery voltage should drop abruptly, they illuminate continuously when neglecting the minutes display changes, as may easily occur to those skilled in the art.

In the fourth embodiment shown in FIG. **5,** selector circuit **3C** comprises NAND-gates **31C** and **32C** and an inverter **34C** connected with each other and with the

watch movement drive circuit 6C, as shown, which may have similar structure and arrangement as those of the foregoing drive circuit 6B.

Amplifier circuit 4C comprises two separate amplifiers 41C and 42C, the outputs of which are connected to illuminatable or seconds flashing elements 52C and 53C, respectively, mounted on digital display device 65C as before. Outputs of NAND-gates 31C and 32C are connected to inputs of these amplifiers 41C and 42C, respectively. These flashing elements may preferably be green and red light dissipatable photo-diodes of their equivalent means.

With such arrangement of the present embodiment, green light flashing can be performed when the battery voltage is at its regular level, while red light flashing can be executed after the battery voltage has dropped beyond a predetermined critical level.

Before describing the fifth embodiment shown in FIG. 8, the principle thereof is briefly illustrated in FIG. 7 which is similar battery characteristics shown in FIG. 1. In FIG. 7, the full line curve A′ is similar to that denoted A in FIG. 1, denoting that a lightly loaded condition of a small mercury, silver or the like battery as most frequently used one for electronic watches. The dotted line B is that appearing under heavy loaded condition.

As seen from FIG. 7, when the battery is loaded nearly at the end of its durable life, a more predominant voltage drop will be encountered by application of a heavier load than the case of a lighter load application. There would be thus such a possibility that a daily, weekly or monthly application of a heavier load in a sampling manner to a battery normally operating with a lighter load, reliance may be placed upon the aforementioned rather more predominantly appearing voltage drop for detecting a nearly consumed condition of the battery. The next following embodiment utilizes such load sampling principle for the desired purpose.

In FIG. 8, 6D represents schematically an electronic watch drive circuit comprising an oscillator circuit 61 having a known quartz oscillator. The use of this kind of the high precision timebase can equally be applied to any of the foregoing embodiments. The circuit 6D further constituents 62; 63*a*; 63*b*; 63*c*; 63*d*; 63*e*; 63*f*; 63*g*; 64*a*; 64*b*; 64*c*; 64*d*; 64*a*′; 64*b*′; 64*c*′; 64*d*′ and 65D connected with each other as shown.

Numeral 62 represents the frequency divider as before, which is of a multistage type, processing the outputs from the oscillator circuit 61 into seconds pulse series, as commonly known per se. From an intermediate stage of the multistage frequency divider, a lead 106 extends so as to deliver therefrom a more frequent 1/*n*-second period pulse series when assuming that *n* is a positive integer.

The output from frequency divider 62 is supplied successively to conventional time computers 63*a*; 63*b*; 63*c*; 63*d*; 63*e*, thence simultaneously to time computers 63*g* and 63*f*, all the said computers being preferably respective conventional ring counters. In this respect, numerical representations: "1/5"; "1/12"; "1/60"; "1/12"; "1/2"; "1/31" and "1/7" represent respective frequency-divided ratios. From junction point 107 positioned between both blocks 63*a* and 63*b*, an output lead 108 extends for delivery of 5-seconds period pulse series. It will be seen from the foregoing that from the block 63*b*, 1 minute period pulses series is delivered to next following block 63*c* from which 1 hour period pulse series is delivered. In the similar manner, 24-hour period pulse series is delivered from junction point 109 positioned between the blocks 63*e* and 63*f* and through an output lead 120.

The ratio "1/31" corresponds naturally to the odd month. For even month, the ratio is modified accordingly and manually by supply of a shift pulse by conventional means coupled with the time-setting stem of the watch, although not specifically shown on account of its very popularly.

Binary contents of the ring counters 63*c*; 63*d*; 63*f* and 63*g* are conveyed to conventional decorders 64*a*; 64*b*; 64*c* and 64*d*, respectively, the outputs therefrom are conveyed through respective drivers of the conventional structure to digital illuminatable display elements on the digital time display device 65D, as conventionally. As seen from FIG. 8, the device 65D displays, as an example, "SUNDAY", 25th day of a month, and 12 hours 15 minutes.

The aforesaid 1-second period pulse series, shown at *a* in FIG. 6, will be conveyed from junction point 109 through output lead 110 extending therefrom via a terminal *a* and further junction 111 to inverter 9*b* and simultaneously to one input of NAND-gate 32D included in the selector 3D.

The aforesaid 5-second period pulse series, shown at *b* in FIG. 6, will be conveyed from junction point 107 through lead 108 including terminal *b* to inverter 9*a*, the output thereof being connected to a S-input terminal of a toggle type flip-flop 8*a*.

The aforementioned 24-hour period pulse series, shown at *c* in FIG. 6, will be transmitted from junction 109 through output lead 120, including terminal *c*, to another T-input terminal of the same flip-flop 8*a*.

The aforementioned 1/*n*-second period pulse series, including terminal *d*, *n* being 2 as an example, will be conveyed through lead 106 to an input of NAND-gate 31D included in the selector 3D. Q-output terminal of flip-flop 8*a*, the output signal being shown at *e* in FIG. 6, is connected through inverter 9*c* and a junction point 119 to T-input terminal of a further flip-flop 8*b*. The output of inverter 9*b* is connected to S-input terminal of the same flip-flop 8*b*. Q-output terminal of the latter, the output signal being illustrated at *f* in FIG. 6, is connected through a further inverter 9*d* to S-input terminal of RS-flip-flop 8*c*.

Detector 2D comprises, as before, fixed resistor 23 and variable resistor 22, the input side of the latter being connected with said junction 119. The input side of inverter 21D is connected to a point positioned between the resistors 22 and 23 as before. The output of the inverter 21D is connected through a further inverter 9*e* to R-input terminal of the flip-flop 8*c*. Q-output terminal of flip-flop 8*c* is connected to another input of NAND-gate 31D. In the similar way, $\overline{Q}$-output terminal of flip-flop 8*c* is connected to another input of NAND-gate 32D.

The positive pole of the voltage source 1, FIG. 8, is connected through a diode 25 to positive terminal of the inverter 21D as hinted at VDD, while the negative terminal thereof is earthed as hinted at VSS. Across this inverter 21D, a capacitor 24 is connected. The outputs of NAND-gates 31D and 32D are connected to inputs of NOR-gate 32C, the output of the latter is connected to a driver 35D, preferably an amplifier, the structure of which is similar to that denoted 35 in the foregoing. The output of the driver 35D is connected

to illuminatable display element 5D which is similar to that denoted 5 in the foregoing.

The operation of the fifth or last embodiment shown in FIG. 8 is as follows.

As seen especially from at *e* in FIG. 6, the flip-flop 8*a* produces a sampling signal extending for 2.5 sec once per day. By application of this sampling signal, the inverter 9*c* will act as a conducting switch so that the VDD-terminal of the voltage source 1 is connected to the series-connected resistors 22; 23, through the latter, thus, current flows. Since, in this case, the practical resistance values of these elements 22, 23 have designed and adjusted to substantially lower levels than those which were set in the foregoing embodiments where no such sampling job is performed, the flow current is stronger than before. For this purpose, certain preparatory experiments are executed beforehand, so as to set the passing current positioned on the curve B in FIG. 7, as nearly as possible.

The resistance value at 22 in FIG. 8 has been so adjusted that the voltage appearing in this case at the intermediate junction 112 positioned between the resistors 22 and 23 is slightly higher than the threshold voltage of the inverter 21D. At the substantial operating period of the battery 1, FIG. 8, signals are implied at the both inlets S and R of RS-flip-flop 8*c* and the output $\overline{Q}$ becomes binary 1, since the signal pulse implied at the R-input has a longer period than that appearing the other input S, thereby seconds pulse series being supplied to the element 5D for flashing the latter as an discriminating visual symbol to show the electronic watch operates in its regular operating mode with the battery 1 kept at its regular voltage level along the effective voltage level as shown by the flat portion of the voltage curve A′ shown in FIG. 7.

On the other hand, when the battery 1 is about to be consumed up, the voltage delivered through junction 112 becomes insufficient to reverse the state of the inverter 21D and thus, input signal will appear only at S-input terminal of the flip-flop 8*c*, thereby its output Q representing binary 1. Therefore, the quicker frequency 1/*n*-second period pulse series will be applied to the element 5D. In this way, the element 5D flashes at this rather quicker frequency for the display of the about-consumed condition of the battery 1 as shown at 100′ on the dotted line curve B, in advance of the occurrence of the point 100 appearing on the full line curve A′ in FIG. 7 by a certain advance period Δt which may be 10 days as an example.

The provision of the condenser 24 is for the purpose of keeping the established operating voltage level at the inverter 21D than otherwise. In this way, the voltage VDD-VSS as applied to the inverter 21D can be maintained substantially at a predetermined constant level, if the battery voltage should drop for a short time period such as 5 seconds as an example.

The provision of the toggle type flip-flop 8*b* is for the purpose of making the duration terms of the input signal at S-terminal of RS-flip-flop 8*c* to be shorter than that of the input signal at R-terminal of the same flip-flop 8*b*.

With the design and arrangement of the present last embodiment so far shown and described, such efficient and advance alarm means may be provided for the battery-driven electronic watch with least possible current consumption for such alarm means which consumes an appreciable power only for each sampling period. Naturally, the above-specified sampling period of 5 seconds per day may be modified to any selected more economic value.

The embodiments of the invention in which an exclusive property or privilege is claimed are as follows:

1. In a battery driven electronic watch comprising a watch driver circuit, a battery for feeding current thereto, and a time-indicator operatively connected with said driver circuit, the improvement comprising a binary detector circuit connected to said battery for detecting when the source voltage falls below a predetermined level, a selector and drive circuit connected with the output of said detector, and an electrically illuminatable means connected with said selector and drive circuit, the brightness of said illuminatable means being modified from its normal state when said source voltage drops below said predetermined level in response to the binary logic output of said detector, said electrically illuminatable means being mounted on the front and normally visible surface of said watch.

2. In a battery-driven electronic watch comprising a source battery, an electronic watch driver circuit fed current therefrom and a digital time display means comprising a plurality of electrically illuminatable elements driven by said circuit, the improvement comprising a detector for sensing an abrupt voltage drop at the said battery, and a selector for selecting either a first signal series demonstrating the normal operating voltage kept at said battery or a second signal series of a different signal frequency from that of the first signal series and demonstrating a voltage-dropped condition of said battery, depending upon the state of said detector and derived from said driver circuit, at least one of said elements being supplied with either of said both signal series depending upon the state of said selector.

3. Electronic watch as set forth in claim 2, further comprising a sampler coupled with said detector and said selector, for impressing for periodically established short time periods a higher current to said detector than that of the normal operating current derived from said battery.

4. Electronic watch as set forth in claim 3, wherein said sampler comprises two series-connected toggle type flip-flops and an RS-flip-flop arranged downstream thereof.

5. The electronic watch as set forth in claim 1, wherein said electrically illuminatable means comprises an optical display element which is normally in its non-illuminated state but is caused to illuminate when said source voltage drops below said predetermined level.

6. The electronic watch as set forth in claim 5, further comprising a sampler coupled with said detector and said selector for impressing for periodically established short time periods a higher current to said detector than that of the normal operating current derived from said battery.

* * * * *