United States Patent [19]

Feldman

[11] **3,823,549**

[45] **July 16, 1974**

[54] **ELECTRONICALLY ACTUATED LIQUID CRYSTAL WATCHFACE WITH CONVENTIONAL TIME FORMAT**

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[73] Assignee: **Transparent Conductors, Inc.,** Goleta, Calif.

[22] Filed: **Mar. 8, 1973**

[21] Appl. No.: **339,340**

[52] **U.S. Cl.** ..... **58/50 R,** 58/127 R

[51] **Int. Cl.** **G04b 19/06,** G04b 19/30

[58] **Field of Search** ..... 58/4 R, 4 A, 50 R, 126 R, 58/127 R, 152

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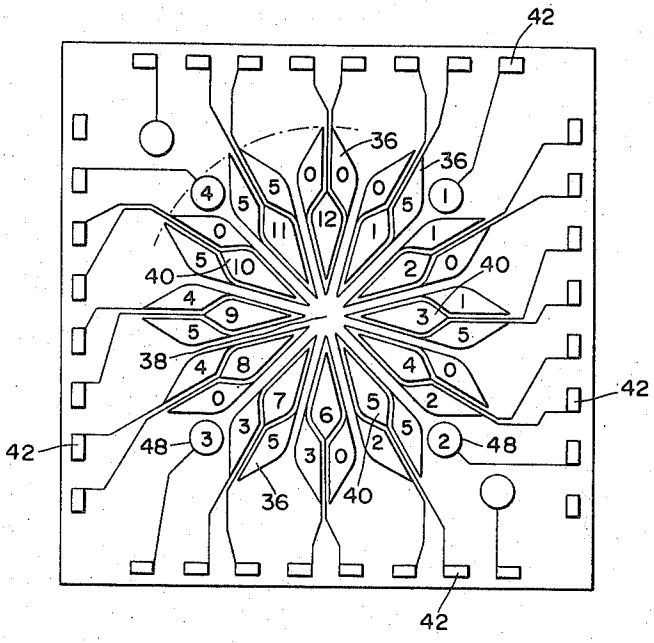
Primary Examiner—Edith Simmons Jackmon

Attorney, Agent, or Firm—Weigarten, Maxham & Schurgin

[57] **ABSTRACT**

An electronic watch having a liquid crystal display and presenting time information in a substantially conventional format of hour and minute hands. A set of 12 hour and minute hands in a nested relationship are provided as thin film transparent conductor patterns in the liquid crystl display and are electronically actuated to provide visible indication of time to the nearest 5 minutes. Additional liquid crystal conductor patterns are provided as interpolation elements to indicate each minute. A control logic system is provided for sequentially activating and setting the hands to a particular indication and for additionally providing calendar data employing the existing pattern of hands.

20 Claims, 12 Drawing Figures



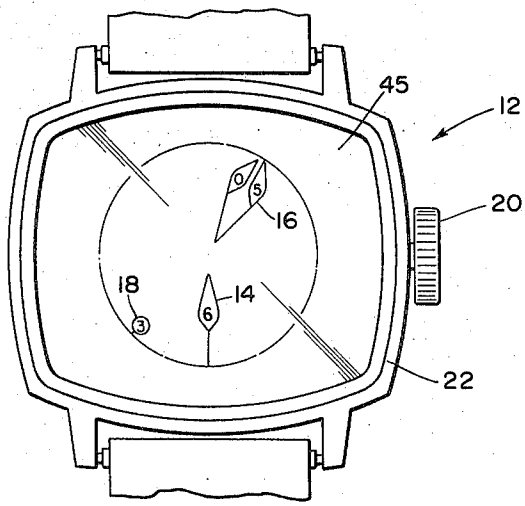


FIG. 1

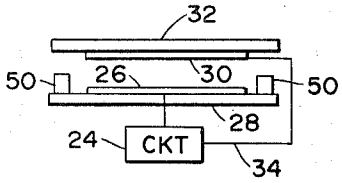


FIG. 1A

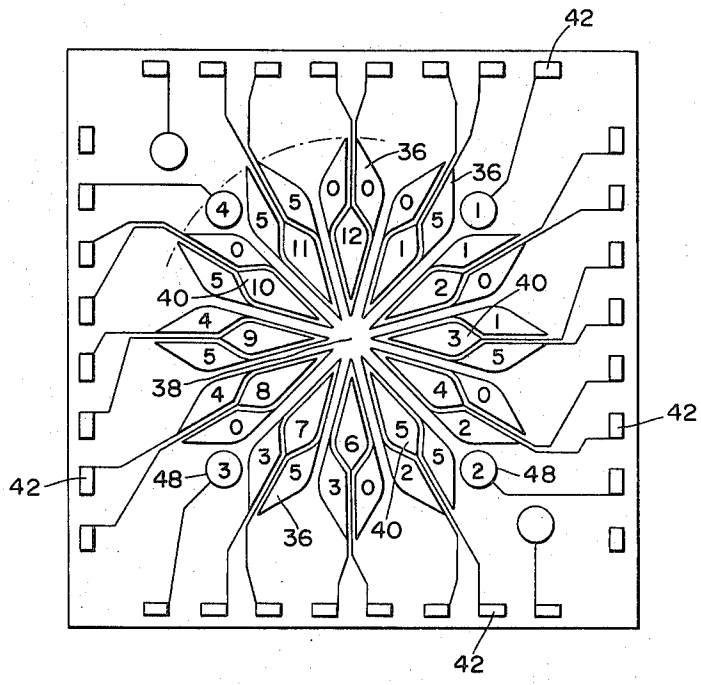


FIG. 2

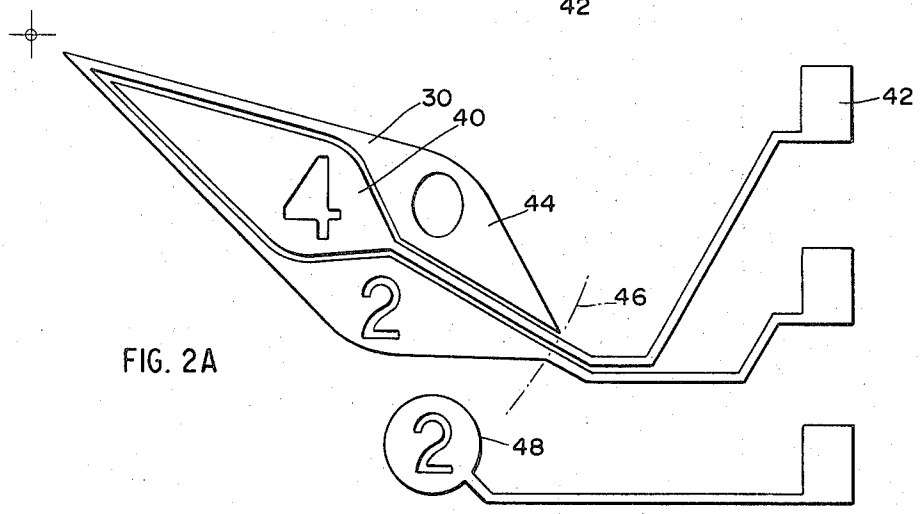


FIG. 2A

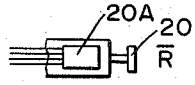
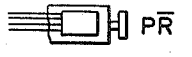
FIG. 3A 

FIG. 3B 

FIG. 3C 

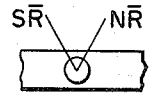


FIG. 3D

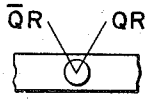
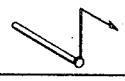
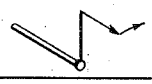
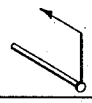
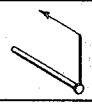
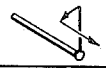
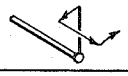


FIG. 3E

FIG. 4

POSITION NUMBER	CONTROL POSITION	STATUS S1 N/S	S2 R/R̄	S3 Q/Q̄	S4 P/P̄	CODE
1		1	0	0	0	NRQ̄P̄
2		0	0	0	0	SR̄Q̄P̄
3		1	1	1	0	NRQ̄P̄
4		1	1	0	0	NRQP̄
5		1	0	0	1	NP
6	 + ≃ 15 SECS.	1	0	0	1	NP + TIME
7		0	1	0	0	SR
8		0	1	1	0	SQ/SQR
9		0	1	0	1	SP

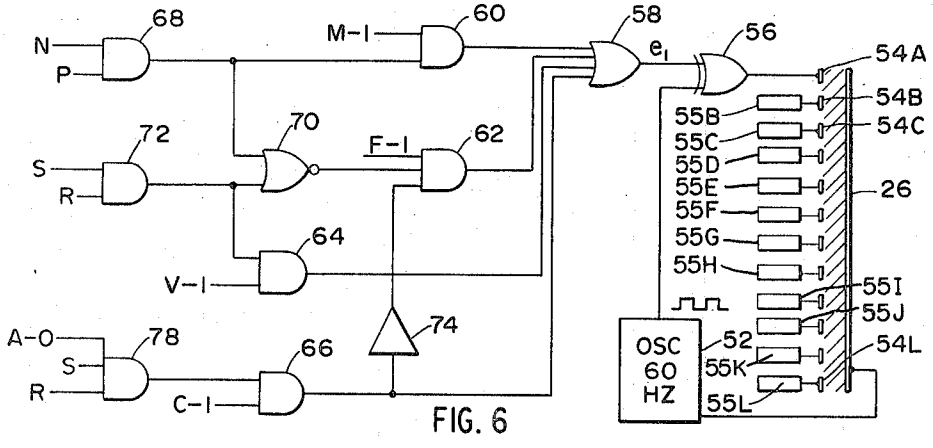


FIG. 6

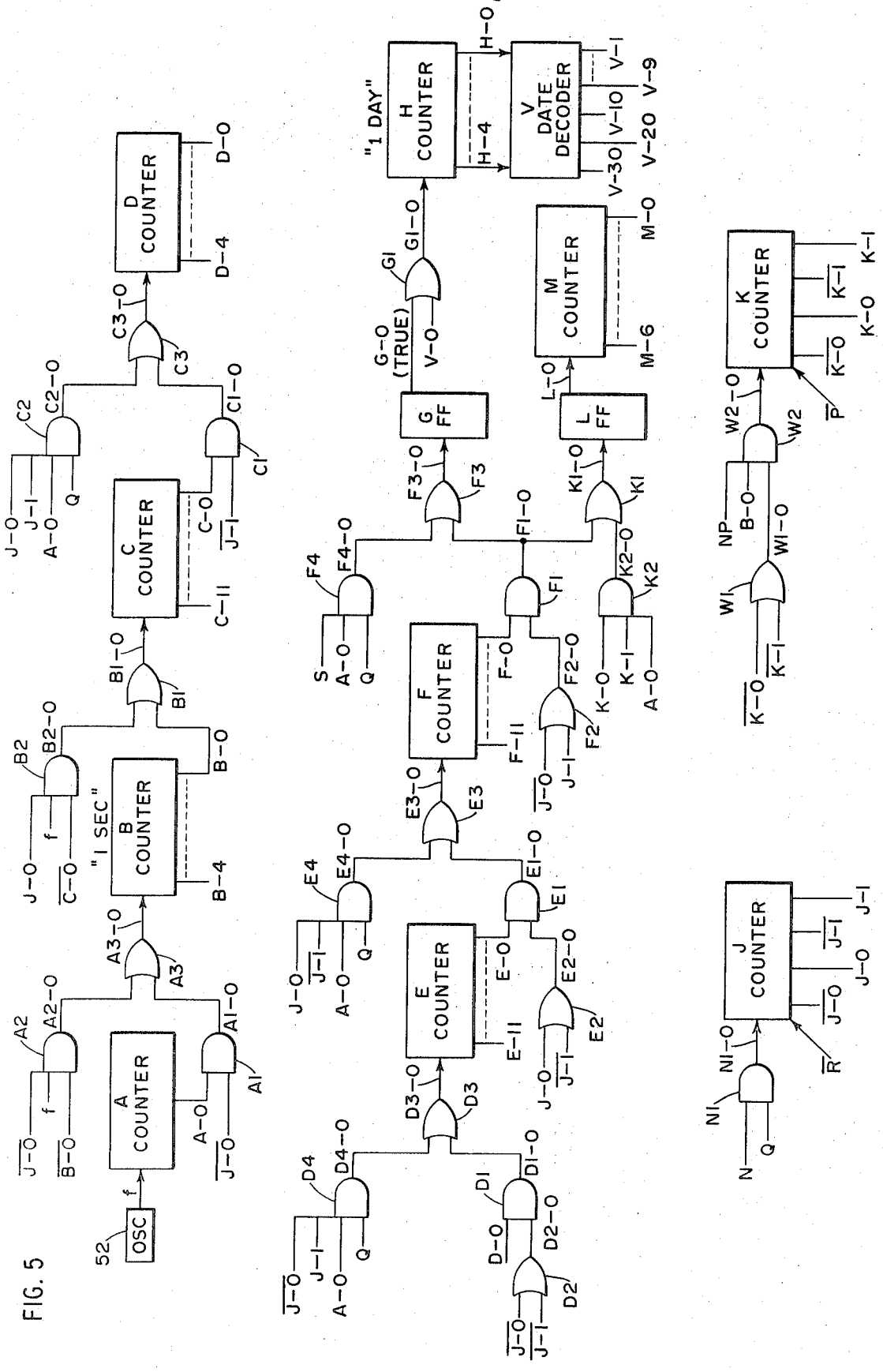

OSC
52
A COUNTER
B COUNTER
"1 SEC"
C COUNTER
D COUNTER
E COUNTER
F COUNTER
G FF
H COUNTER
"1 DAY"
V DATE DECODER
M COUNTER
L FF
K COUNTER
J COUNTER
(TRUE)

FIG. 5

ELECTRONICALLY ACTUATED LIQUID CRYSTAL WATCHFACE WITH CONVENTIONAL TIME FORMAT

FIELD OF THE INVENTION

This invention relates to horology and in particular to a liquid crystal time display having a substantially traditional display format.

BACKGROUND OF THE INVENTION

The traditional mechanical watch movement has in recent years been joined by designs having varying degrees of electrification for the watch time standard, drive mechanism or readout device. In a fully electronic system, time information may be provided by an electronic frequency standard with suitable output for hour, minute and second intervals to illuminate appropriate digits in a segmented display. The display may be either a liquid crystal device or any other selective display. Where a digital seven segment display is employed, the watch bearer is forced to re-educate himself to accepting a new format for the presentation of the current time as well as the passage of time. In addition, such a digital display typically requires the illumination of at least three digits and thus has a significant power drain for the limited capacity batteries used in small electronic watches. Moreover, the failure of one or more segments in the digital display may not be immediately apparent to the watch bearer and might lead to an erroneous indication of time.

The conventional analog presentation permits the watch owner to automatically conceptualize future or past time by direct visual comprehension without having to make a mental arithmetic subtraction as is the case with the digital format. Fewer details are necessary to be viewed for determing time in the conventional format and it is easier to read with less illumination.

Designs which overcome these and other problems of empolying digital time displays for wrist and pocket watches have occasionally resulted in the provision of a more conventional hand configuration for the time display such as shown in U.S. Pat. No. 3,540,209. To provide the equivalent of the analog function of continuously moving watch hands with discrete, selectively actuated display elements on a watch surface, has, in such cases, produced substantial complexity not only due to the large number of electrical connections which must be made to each element of the display, but also in providing a mechanism to avoid hour ambiguity when the minute hand approaches the hour marking.

SUMMARY OF THE INVENTION

In accordance with the present invention, an instrument for indicating time is provided having a substantially traditional hour and minute presentation for ease in reading the time. A preferably solid state electronic time base is provided to sequentially activate an array of 12 hour and 12 minute hands in a liquid crystal display which provide a visible indication of time to the nearest 5 minutes with minute interpolations between each 5 minutes provided by a set of additional electronically actuated time markers.

In the specific implementation of the present invention, a glass substrate is coated with a patterned transparent conductor. The pattern comprises 12 hour hands in a radial design with each hand separated by 30°. A similar plurality of 12 minute hands are provided, each hour hand nested within a corresponding minute hand in the same radial pattern. Electrical conductors are applied to the 12 minute and 12 hour hands from a border arrangement of electrical contacts to provide selective application of potentials thereto. The pattern of hour and minute hands on the glass substrate provides one set of electrodes for energizing a liquid crystal, the opposing common electrode being provided by a conducting plate. Application of electric potential between the common electrode and each of the hour and minute hands provides a visible time indication in 5 minute intervals therein. A further series of dots may be actuated to indicate minute intervals between each 5 minutes.

Electronic circuitry, including an oscillator, logic and frequency division functions, provides respective output signals for actuating the hour and minute hands and the minute indicators for indicating the appropriate time. A multi-function switch system operates through a conventional watch stem to permit setting of the time indication, display of calendar data and the display of seconds of time. Time setting may be conveniently achieved in one hour changes for time zone differences.

DESCRIPTION OF THE DRAWINGS

These and other features of the present invention will be more fully understood by reference to the detailed description of a preferred embodiment presented below for purposes of illustration and not by way of limitation and to the accompanying drawings of which:

FIG. 1 is a pictorial view of an operating wristwatch according to the invention;

FIG. 1A is a general block diagram of the watch system according to the invention;

FIG. 2 is a pictorial view of the pattern of hour and minute hands and minute indicators which are displayed according to the invention;

FIG. 2A is an exploded view of a nested hour and minute hand and minute indicator from FIG. 2;

FIGS. 3A–3E indicate possible positions of the watch stem for providing various functions in the invention;

FIG. 4 is a table which correlates stem position to switch logic states for application in the circuitry employed with the invention;

FIG. 5 is a block diagram of circuitry employed in the invention to provide selective display of portions of the pattern of FIG. 2; and

FIG. 6 is a further presentation of circuitry employed in the invention.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, a time indicating instrument, typically a wrist or pocket watch, is shown having a generally traditional indication of time through a low power liquid crystal display which is typically activated by a solid state electronic system. In particular, with reference to FIG. 1, a wristwatch 12 is shown presenting the time 6.08 by way of an hour hand 14, a minute hand 16 and a 5 minute interval interpolation minute indicator 18. A stem 20 is fitted to the case 22 of the wristwatch 12 to provide setting and other control functions.

With reference to FIG. 1A, a generalized block diagram of the system is shown. Circuitry 24 is connected to a bottom conductor 26 of the liquid crystal time display, the conductor 26 being on a substrate 28. A pattern of transparent conductors 30 is apllied to a front transparent substrate 32 and provides the hour and 5 minute hands as well as the minute indicators. It is activated by the circuitry 24 through a set of cables 34 which typically comprises 29 leads to contact all hands and indicators. The substrates 28 and 32 will be peripherally sealed as for example shown in copending application Ser. No. 176,633, filed August 31, 1971, and assigned to the same assignee as this application, then filled with a liquid crystal material in the region between the conductor 26 and pattern of transparent conductors 30. Gas discharge or electrophoretic devices or other electro-optic devices may also be used.

With reference now to FIG. 2, the patterned transparent conductor 30 is more clearly shown. Twelve minute hands 36 are oriented around a central point 38 in a radial pattern at 30° intervals to reflect each 5 minutes of time. A plurality of hour indicating hands 40 are nested within each of the minute indicating hands 36 but insulated therefrom. Numeric indicators or other information may be included in hands 36 and 40 to show appropriate hours and minutes. A plurality of electrical contacts 42 surround the conductive pattern 30 and have corresponding leads therefrom to each of the minute and hour hands 36 and 40. The configuration of the minute and hour hands is more clearly shown in FIG. 2A where it is indicated that the respective leads from the contacts 42 are applied to outer portions of the minute hands 36 and pass in isolation between portions 44 of the minute hands 36 to contact the interior hour hand 40. A bevel or mask 45 on the watchface has a radius such that activation of the minute and hour hands provides a visible pattern which outwardly terminates at approximately the circle 46 indicated in FIG. 2A. With respect to FIG. 2, and as more expansively shown in FIG. 2A, four minute indicating dots 48 are provided at approximately the 45°, 135°, 225° and 315° positions of the watchface to indicate or provide interpolations for minute intervals between each of the 5 minute readings from the minute hands 36. The minute indicators 48 may also have apertures patterned as digits to provide respective indications of 1, 2, 3 or 4 minute increments to or interpolations between the major 5 minute intervals indicated.

Before describing the circuitry which controls the application of electrical signals to the contacts 42 to make selective ones of the minute and hour hands and minute indicators visible, it will be useful to discuss the various functions which are controlled by the stem 20 as shown in FIGS. 3A–3E and FIG. 4. The stem 20 activates a set of four switches 20A within the case 22 which are in the preferred embodiment, single pole, single throw switches. The designations S1, S2, S3 and S4 represent the four switches having binary states 0 or 1. As is shown in FIG. 3A, stem 20 will have a normal axial position designated by the logic symbol $\overline{R}$. In FIG. 3B the stem is pulled out switching switch S2 to a stable position defining the logic function R, while in FIG. 3C the stem is pushed in against a return force of switch S4 to define the logic function $\overline{PR}$. The stem 20 may be rotated clockwise or counter-clockwise and as shown in FIG. 3D. Counter-clockwise rotation at the normal position defines the logic function $\overline{SR}$ of switch S1 whereas clockwise rotation defines the logic function $\overline{NR}$ of switch S1. With the stem pulled out in the position of FIG. 3B, switch S3 is engaged, and as shown in FIG. 3E, counter-clockwise rotation against a return force defines the logic function $\overline{QR}$ whereas clockwise rotation defines the function QR.

The corresponding logic signals provided from the switches S1, S2, S3 and S4 are further indicated in FIG. 4 under the code heading and are the signals applied to the logic circuitry of FIGS. 5 and 6. Position 1, the normal position, provides the indicated switch states and logic code. In position 2, the stem is rotated counter-clockwise from the normal position to yield the indicated switch and code states. In position 3, the stem is pulled out from the normal position (engaging spring loaded switch S3 but not rotating it) and yields the indicated switch and logic codes, while in position 4, the stem has been rotated clockwise from position 3. In position 5, the stem has been pushed in while in position 6, the stem has been pushed in with 15 or 20 seconds delay. In position 7, the stem has been rotated counter-clockwise from the normal position and pulled out while in position 8, the stem, in engagement with S3, has been rotated clockwise against the S3 spring loading switch of position 7. In position 9, the stem has been rotated counter-clockwise and pushed in.

Before describing the logic circuitry which responds to the stem positions and control of the time displayed, it will be useful to indicate the operative result of the nine switch positions indicated in FIG. 4. In position 1, normal time is presented in the standard sequence. In position 2, a sweep second time presentation is provided wherein an additional hour hand is illuminated to seve as a sweep 5-second hand and is pulsed one per second to indicate each second of time. It rotates one position every five seconds. In position 3, normal time is presented in position ready for reset. In position 4, a reset function is provided. The first time this position is reached, the hour hand changes position once a second around the watch face until the stem is released. The second actuation resets the minute hand in the same pattern and the third actuation resets the 1 minute indicator. Returning the stem to the normal position $(\overline{R})$ after the individual minute indicators have been reset, restarts the time piece at the indicated time. In position 5, the normal time information is suppressed and the day of the week is presented in accordance with the position of the first seven hour hands which reflect respectively Sunday through Saturday. In position 6 after the 15 or 20 second delay, the day of the week is reset 1 day 2 seconds with the 12:00 o'clock hand illuminated in between each shift to signify the half day. In position 7, the normal time information is suppressed and the day of the month is presented in accordance with the code shown in Table 1 below:

TABLE 1 – DATE DECODER TRUTH TABLE

Day of month	Hr. hand	5 min. hand	H-0	H-1	H-2	H-3	H-4	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10	V-20	V-30
	FORBIDDEN		0	0	0	0	0												
1	1		1	0	0	0	0	1											
2	2		0	1	0	0	0		1										

TABLE 1 – DATE DECODER TRUTH TABLE – Continued

Day of month	Hr. hand	5 min. hand	H-0	H-1	H-2	H-3	H-4	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10	V-20	V-30
	FORBIDDEN																		
3	3		1	1	0	0	0			1									
4	4		0	0	1	0	0				1								
5	5		1	0	1	0	0					1							
6	6		0	1	1	0	0						1						
7	7		1	1	1	0	0							1					
8	8		0	0	0	1	0								1				
9	9		1	0	0	1	0									1			
10	–	10	0	1	0	1	0										1		
11	1	10	1	1	0	1	0	1									1		
12	2	10	0	0	1	1	0		1								1		
13	3	10	1	0	1	1	0			1							1		
14	4	10	0	1	1	1	0				1						1		
15	5	10	1	1	1	1	0					1					1		
16	6	10	0	0	0	0	1						1				1		
17	7	10	1	0	0	0	1							1			1		
18	8	10	0	1	0	0	1								1		1		
19	9		1	1	0	0	1									1	1		
20	–		0	0	1	0	1										1	1	
21	1		1	0	1	0	1	1										1	
22	2		0	1	1	0	1		1									1	
23	3		1	1	1	0	1			1								1	
24	4		0	0	0	1	1				1							1	
25	5		1	0	0	1	1					1						1	
26	6		0	1	0	1	1						1					1	
27	7		1	1	0	1	1							1				1	
28	8		0	0	1	1	1								1			1	
29	9		1	0	1	1	1									1		1	
30	–		0	1	1	1	1											1	
31	1		1	1	1	1	1	1											1

In position **8**, the day of the month is advanced one-half day every second using the 12:00 o'clock minute hand to represent half days. In position **9**, the sweep second hand function is activated and an auxiliary light source such as a baffled LED **50** shown in FIG. **1A** is activated to permit reading of the watch in the dark.

With this functioning in mind, reference is now made to FIG. **5** for description of the logic circuitry using positive logic. It is to be noted that accordingly the positive transition effects changes.

With reference to FIG. **5**, it can be seen that an oscillator **52** has an output frequency of *f* Hz. which is applied to a binary counter labelled A. The oscillator **52** is typically a quartz crystal oscillator. The counter A is typically a feedback counter with an output at 1Hz. This output, A–O, from the counter A is applied to an AND gate A1, the output A1–O of which is applied to an OR gate A3. A second input to the AND gate A1 is the $\overline{J\text{–}O}$ output of a binary counter J. A second input of the OR gate A3 is provided as an A2–O reset output of an AND gate A2 having respective inputs $\overline{J\text{–}O}$, f and $\overline{B\text{–}O}$.

The output of the OR gate A3, A3–O, is applied to a five-stage ring counter B, the outputs of which are labelled respectively B–O through B–4. The B–O output of the ring counter is applied to an OR gate B1. A second input of the OR gate B1 is the B2–O output of an AND gate B2 having respectively the inputs J–O, f and $\overline{C\text{-}0}$. The B1–O output of the gate B1 is applied to a twelve-stage ring counter C having respective outputs C–O – C–11. The C–O output is applied as one input to an AND gate C1, another input thereto being provided by the $\overline{J\text{–}1}$ signal. C–0 through C–11 outputs of the ring counter C are applied to respective hour hands **36** for the sweep second mode through logic governed by Table 2 and illustrated in FIG. **6**. The B2–O signal from the AND gate B2 is used as a rapid reset for the ring counter C.

The C1–O output of the AND gate C1 is applied as an input to an OR gate C3 along with the output C2–O of an AND gate C2. AND gate C2 has four inputs which include J–O, J–1, A–O and Q. The output C3–0 of the OR gate C3 is applied to a five-stage ring counter D. The respective outputs D–O through D–4 provide 1-minute indications by application to the 1-minute indicators **48** under control of the Table 2 logic. The D–O output is applied as one input to an AND gate D1. The other input to AND gate D1, D2–O is from an OR gate D2 which has as inputs the $\overline{J\text{–}O}$ and $\overline{J\text{–}1}$ signals. The D1–O output of the AND gate D1 is applied to an OR gate D3 which receives as a second input a D4–O output of an AND gate D4 having as input thereto the signals $\overline{J\text{–}O}$, J–1, A–O and Q. The D3–O output of the OR gate D3 is applied to a 12-stage ring counter E which has respective outputs E–O through E–11 with the E–O output applied as one input to an AND gate E1. The outputs of the ring counter E activate the minute hands **36** of FIG. **2** in the normal time mode and for that purpose its outputs are applied thereto through the logic circuitry of FIG. **6** and Table 2.

The AND gate E1 has applied to a second input thereof an E2–O output of an OR gate E2 which receives as inputs the J–O and $\overline{J\text{–}1}$ signals. The E1–O output of the AND gate E1 is applied as an input to an OR gate E3 along with an E4–O signal from an AND gate E4. AND gate E4 has respective inputs J–O, $\overline{J\text{–}1}$, A–O and Q. An E3–O output of the OR gate E3 is applied to a 12-stage ring counter F having respective outputs F–O through F–11 to provide normal mode activation of the hour hands **38** in FIG. **2** employing logic of FIG. **6** and Table **2**. In addition, the F–O signal is applied to an AND gate F1 along with an F2–O output of an OR gate F2. OR gate F2 has as inputs the $\overline{J\text{–}O}$ and J–1 signals. An F—O output of the AND gate F1 is applied as inputs to respective OR gates F3 and K1. The OR gate F3 has a further input, F4–O, from an AND gate F4 which receives respectively as inputs the S, A–O and Q signals. An F3–O output of the OR gate F3 is applied to a flip-flop G having a true output G– O to an OR gate G1. The OR gage G1 receives as a further input a V–O singal and provides a F1–O output to a five-stage binary counter H for providing date indications. The five outputs of the binary counter H, H–O through H–4, are applied to a date decoder V having respective outputs V–1 through V–9, V–10, V–20 and V–30 for indicating

calendar date in accordance with Table 1 through the FIG. 6 and Table 2 logic.

Returning to OR gate K1, an additional input is provided from an AND gate K2 which receives as inputs the K–O, K–1 and A–O signals, to be described below. The K1–O output of the OR gate K1 is applied to a flip-flop L which, like the flip-flop G provides a half day identification. Its true output L–O is applied to a seven-stage ring counter M for the week day indication and has respective outputs M–O through M–6.

The J signals are provided by a two-stage binary counter J having the outputs J–1 and $\overline{J–1}$ as well as J–O and $\overline{J–O}$. The input to the counter J is provided from an AND gate N1 as the N1–O signal and exists in response to the N and Q signs provided as inputs to AND gate N1. The $\overline{R}$ signals is applied to counter J as a reset signal. The K output signals are provided from a two-stage binary counter K in response to a W2–O signal from an AND gate W2. The AND gate W2 receives as inputs the NP, B–O, and W1–O signals. The W1–O signal is produced by an OR gate W1 receiving as input the $\overline{K–1}$ and $\overline{K–O}$ signals. The $\overline{P}$ signal is applied to the counter K as a reset signal.

The several C, D, E, F, V and M signals are applied to the electrical contact 42 in accordance with a logic system which is illustrated in FIG. 6 and governed by Table 2. Specifically shown in FIG. 6 is the logic system for illuminating the "one" hour hand contact 54A and is exemplary of the eleven other hour hand contacts through similar circuitry 55B–55L. In particular, a 60 Hz output from the oscillator 52 is applied to the common electrode 26 and also to one input of an exclusive OR gate 56 whose output is applied to the "one" hour hand electrode 54A. A further input to the exclusive OR gate 56 is provided from an OR gate 58 which has four inputs comprising the outputs of AND gates 60, 62, 64 and 66. The AND gate 60 is supplied with the M–1 signal as an input from the counter M along with the output from a further AND gate 68 which receives on first and second inputs the N and P signals respectively. The AND gate 62 receives on a first input the inverted output of an OR gate 70 which receives respectively the output of the AND gate 68 and the output of an AND gate 72 which has as inputs the S and R signals. The AND gate 62 also receives the output of an inverter 74 from the AND gate 66 and the F–1 signal from the counter F. The AND gate 64 receives the output of the AND gate 72 as well as the V–1 signal from the counter V. The AND gate 66 receives the C–1 signal as well as the output of a AND gate 78 which receives three inputs, the A–O, S and $\overline{R}$ signals respectively.

The purpose of the circuitry of FIG. 6 is to determine which of the functions governed by the position of the stem 20 is to be applied to the 1 hour hand electrode 54A. The remaining 11 electrodes 54B–54L are driven by corresponding circuitry 55B–55L with the exception that the appropriate M, F, V and C signals are applied for the electrodes concerned.

The illumination circuitry for the 5-minute hand is governed by similar logic. In particular, Table 2 provides the logic equations for not only the hour hand as illustrated in FIG. 6 but the 5-minute hand as well as the 1-minute indicators. The specific circuitry for activating the 5-minute hands and the 1-minute indicators based on FIG. 6 is routinely implemented by employing the techniques of Hellerman, *Digital Computer System Principles*, Wiley, 1967, Chapter 3.

TABLE 2 — ILLUMINATION LOGIC

Hour Hands	
F-1 $\overline{(NP+SR)}$ $\overline{(ASRC-1)}$ + ASRC-1+(V-1)SR+M-O NP	=1 hour hand
F-2 $\overline{(NP+SR)}$ $\overline{(ASRC-2)}$ + ASRC-2+(V-2)SR+M-1 NP	=2 hour hand
F-3 $\overline{(NP+SR)}$ $\overline{(ASRC-3)}$ + ASRC-3+(V-3)SR+M-2 NP	=3 hour hand
F-7 $\overline{(NP+SR)}$ $\overline{(ASRC-7)}$ + ASRC-7+(V-7)SR+M-6 NP	=7 hour hand
F-8 $\overline{(NP+SR)}$ $\overline{(ASRC-8)}$ + ASRC-8+(V-8)SR	=8 hour hand
F-9 $\overline{(NP+SR)}$ $\overline{(ASRC-9)}$ + ASRC-9+(V-9)SR	=9 hour hand
F-10 $\overline{(NP+SR)}$ $\overline{(ASRC-10)}$ + ASRC-10	=10 hour hand
F-11 $\overline{(NP+SR)}$ $\overline{(ASRC-11)}$ + ASRC-11	=11 hour hand
F-0 $\overline{(NP+SR)}$ $\overline{(ASRC-0)}$ + ASRC-0	=12 hour hand
5 Minute Hands	
E-0 $\overline{(NP+SR)}$ + GSRQ+LK-0 K-1	=00 minute hand
E-1 $\overline{(NP+SR)}$	=05 minute hand
E-2 $\overline{(NP+SR)}$ + (V-10) (SR)	=10 minute hand
E-3 $\overline{(NP+SR)}$	=15 minute hand
E-4 $\overline{(NP+SR)}$ + (V-20) (SR)	=20 minute hand
E-5 $\overline{(NP+SR)}$	=25 minute hand
E-6 $\overline{(NP+SR)}$ + (V-30) (SR)	=30 minute hand
E-7 $\overline{(NP+SR)}$	=35 minute hand
E-8 $\overline{(NP+SR)}$	=40 minute hand
E-9 $\overline{(NP+SR)}$	=45 minute hand
E-10 $\overline{(NP+SR)}$	=50 minute hand
E-11 $\overline{(NP+SR)}$	=55 minute hand
G=G-0; L=L-0	
One Minute Hands	
D-O $\overline{(NP+SR)}$	=O minute indicator
D-1 $\overline{(NP+SR)}$	=1 minute indicator
D-2 $\overline{(NP+SR)}$	=2 minute indicator
D-3 $\overline{(NP+SR)}$	=3 minute indicator
D-4 $\overline{(NP+SR)}$	=4 minute indicator
PS Auxiliary Light On	

What is claimed is:

1. An electronic watch comprising:
a watchface having a plurality of hour and 5-minute hands;
means for providing selective visibility of said plurality of hour and 5-minute hands in response to applied electrical signals whereby one of each of said hour and minute hands may be made visible to indicate time to the nearest 5 minutes;
a plurality of minute indicating elements; and
means for applying an electrical excitation to said minute indicating elements whereby the minutes between each of the 5 minutes represented by said hour and 5-minute hands may be indicated;
means for applying electrical signals to one of said hour hands for generally the period of an hour and for applying an electrical signal to the next sequential hour hand for the next succeeding hour in a cyclical pattern which provides activation of each of said 12 hour hands;
means for providing electrical signals to one of said 5-minute hands for 5 minute interval and for sequencing from one to an adjacent one of said 5-minute hands in a cyclical pattern encompassing all 12 of said five-minute hands; and
means for applying electrical excitation to each of said plurality of minute indicators in a predetermined sequence during the application of said electrical signals to each of said 5-minute hands.

2. An instrument for indicating digital subdivisions of time in a substantially conventional clock format comprising:
an oscillator providing an output signal of a first frequency;

means responsive to said oscillator output for providing electrical signals representing time information;

a substrate having a viewable area;

a first plurality of selectively energizable, fixed position electrically conductive hands formed on said substrate over a range of positions including said viewable area;

a second plurality of selectively energizable, fixed position electrically conductive hands formed on said substrate generally over the range of positions of said first plurality of hands;

said first and second plurality of hands being shaped such that a hand of said plurality substantially surrounds a hand of said first plurality;

electro-optic means for selectively inducing visibility in one or more hands of said first and second pluralities of hands in response to electrical energization thereof;

first electrical connections each associated with a corresponding one of said first plurality of conductive hands and disposed peripherally thereof, said first connections providing electrical connection between said means for providing electrical signals representative of time information and said first plurality of hands through said second plurality of hands; and

second electrical connections each associated with a corresponding one of said second plurality of conductive hands and disposed peripherally of said first and second pluralities of hands and substantially outside of said viewable area, said second connections providing electrical connections between said means for providing electrical signals representative of time information and said second plurality of hands.

3. An instrument for indicating digital subdivisions of time in a substantially conventional clock format comprising:

an oscillator providing an output signal of a first frequency;

means responsive to said oscillator output for providing electrical output signals representing time information;

an instrument face defining a viewable area;

at least one electro-optic cell having first and second substrates and electro-optic material disposed intermediate said substrates and including:

a first plurality of selectively energizable, fixed position electrically conductive hands formed on said first substrate over a range of positions thereon;

a second plurality of selectively energizable fixed position electrically conductive hands formed on said first substrate over a range of positions thereon;

a conductive layer formed on said second substrate;

said first and second plurality of hands being shaped such that a hand of said second plurality substantially surrounds a hand of said first plurality;

first electrical connections each associated with a corresponding one of said first plurality of hands and disposed peripherally thereof, said first plurality of connections providing electrical connection between said means for providing electrical signals representing time information and said first plurality of hands through said second plurality of hands;

second electrical connections associated with said second plurality of hands and disposed peripherally of said first and second pluralities of hands and substantially outside of said vewable area, said second connections providing electrical connection between said means for providing electrical signals representing time information and said second plurality of hands;

said electro-optic material being operative in response to an electrical potential established between ones of said hands electrically energized by said means for providing signals representing time information and said conductive layer to provide a visible indication thereof.

4. The instrument of claim **3** wherein the hands of said first and second pluralities of hands and said electro-optic material are components of a liquid crystal display.

5. The instrument of claim **3** wherein said electrical connections associated with said first and second pluralities of hands include:

electrodes contacting said first and second pluralities of hands and operative to provide electrical connection thereto for selectively including visibility thereof;

the electrodes contacting the hands of said first plurality including portions which pass in isolation along a channel between sections of the hands of said second plurality of hands.

6. The instrument of claim **3** further including a third plurality of conductors; and

means for activating said third plurality of conductors to provide indication of time units intermediate the time units represented by the hands of said first and second pluralities.

7. An electronic watch according to claim **1** wherein said plurality of hour and 5-minute hands and said plurality of minute indicating elements are components of a liquid crystal display.

8. An electronic watch according to claim **1** wherein said hour and five-minute hands are shaped such that each 5-minute hand substantially surrounds an hour hand.

9. An electronic watch according to claim **8** wherein said means for applying electrical signals to said hour hands includes electrodes which pass in isolation along a channel between sections of the 5-minute hands.

10. An electronic watch according to claim **1** wherein said plurality of minute indicating elements include four elements each located in a separate quadrant of said watchface.

11. The instrument of claim **2** wherein the hands of said first and second pluralities have numerical indicia thereon which are visible when the corresponding hand is visible.

12. The instrument of claim **2** wherein the hands of said first and second pluralities of hands and said electro-optic means are components of a liquid crystal display.

13. The instrument of claim **2** wherein said electrical connections associated with said first and second pluralities of hands include:

electrodes contacting said first and second pluralities of hands and operative to provide electrical connection thereto for selectively inducing visibility thereof;

the electrodes contacting the hands of said first plurality including portions which pass in isolation along a channel between sections of the hands of said second plurality of hands.

14. The instrument of claim **2** further including a third plurality of conductors; and

means for activating said third plurality of time indicators to provide indication of time units intermediate the time units represented by the hands of said first and second pluralities.

15. An instrument face for indicating time and defining a viewing area, comprising:

a first plurality of time indicating hands arranged radially about a center;

a second plurality of hands arranged generally about said center in a radial pattern such that each hand of said second plurality substantially surrounds a hand of said first plurality;

a first plurality of peripheral electrodes providing electrical connection to said first plurality of hands between portions of said second plurality of hands;

a second plurality of peripheral electrodes providing electrical connection to said second plurality of hands and disposed substantially outside said viewing area;

means for electrically energizing said first and second pluralities of electrodes in a cyclical time pattern thereby to energize one or more hands of said first and second pluralities of hands;

an electrically conducting surface; and

a material electrically sensitive in its optical properties positioned between said first and second pluralities of hands and said conducting surface whereby energization of said first and second pluralities of electrodes provides a visible indication of the first and second pluralities of hands to which the energized electrodes conduct.

16. A watchface comprising:

12 hour hands arranged at 30° intervals about a point;

12 minute hands arranged at 30° intervals about said point;

said hour and minute hands comprising conductive depositions on a substrate;

electro-optic means operative in response to electrical energization of said conductive depositions to provide a visible indication of the energized hands;

a first plurality of electrodes each contacting a corresponding one of said hour hands to provide electrical connection thereto and passing between portions of said minute hands to contact said hour hands;

a second plurality of electrodes contacting said minute hands to provide electrical connection thereto;

said first and second pluralities of electrodes leading from said respective hour and minute hands to peripheral regions for electrical energization of said hands thereby to selectively achieve a visible indication of said energized hands; and

means for electrically energizing said first and second pluralities of electrodes to cause said hour and minute hands to indicate time.

17. The instrument of claim **2** further including:

means for representing day intervals; and

selectively actuating means for applying electrical signals to the hands of said instrument to provide an indication of data in response to the representation of day intervals.

18. The instrument of claim **2** further including:

selectively actuable means for increasing the cyclical rate at which said first plurality of hands are visible apart from the second plurality whereby those hands may be reset to a new indication without affecting said second plurality of hands.

19. The instrument of claim **18** further including:

selectively actuable means for increasing the cyclical rate at which said second plurality of hands are made visible whereby the visible hands may be adjusted.

20. The electronic watch of claim **2** further including selectively actuable means for inducing visibility in at least some of said hands at a rate corresponding to seconds of time.

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