United States Patent [19]

Culley et al.

[11] **3,922,847**

[45] **Dec. 2, 1975**

[54] **VLED SOLID STATE WATCH**

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[73] Assignee: **Texas Instruments Incorporated**, Dallas, Tex.

[22] Filed: **May 6, 1974**

[21] Appl. No.: **467,350**

[52] **U.S. Cl.** ..... **58/50 R**; 58/23 R

[51] **Int. Cl.**[2] **G04B 19/34**

[58] **Field of Search** ..... 58/23 R, 50 R, 127 R; 313/498, 512; 357/17

[56] **References Cited**

UNITED STATES PATENTS

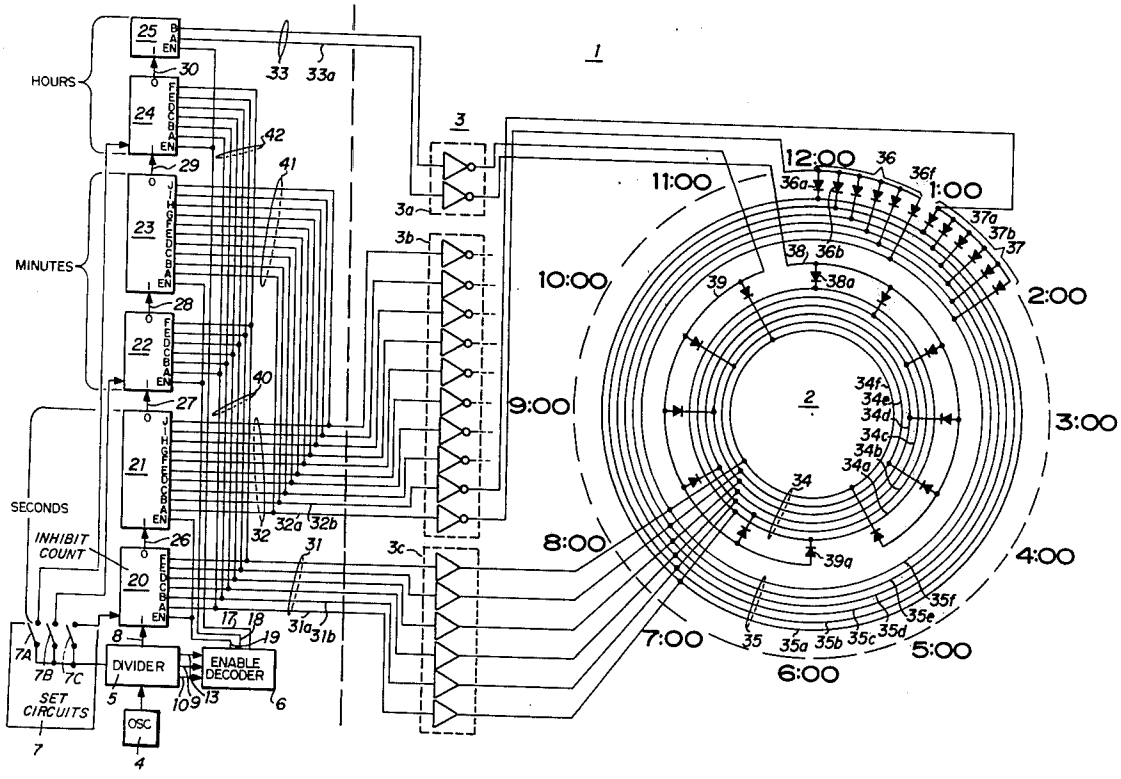
3,544,827	12/1970	Witterick et al.	357/17 X
3,754,392	8/1973	Daniels	58/127 R
3,757,511	9/1973	Burgess et al.	58/127 R
3,765,163	10/1973	Levine et al.	58/50 R
3,805,347	4/1974	Collins et al.	357/17 X

Primary Examiner—George H. Miller, Jr.
Assistant Examiner—U. Weldon
Attorney, Agent, or Firm—Harold Levine; Edward J. Connors, Jr.; Stephen S. Sadacca

[57] **ABSTRACT**

An electronic watch with minimal power requirements having two concentric rings of visible light-emitting diodes (VLEDs) to display hours in a color different from that of minutes and seconds, wherein time-share circuits related to the geometry of the display elements obviate the need for multiplexers and line decoders.

14 Claims, 7 Drawing Figures



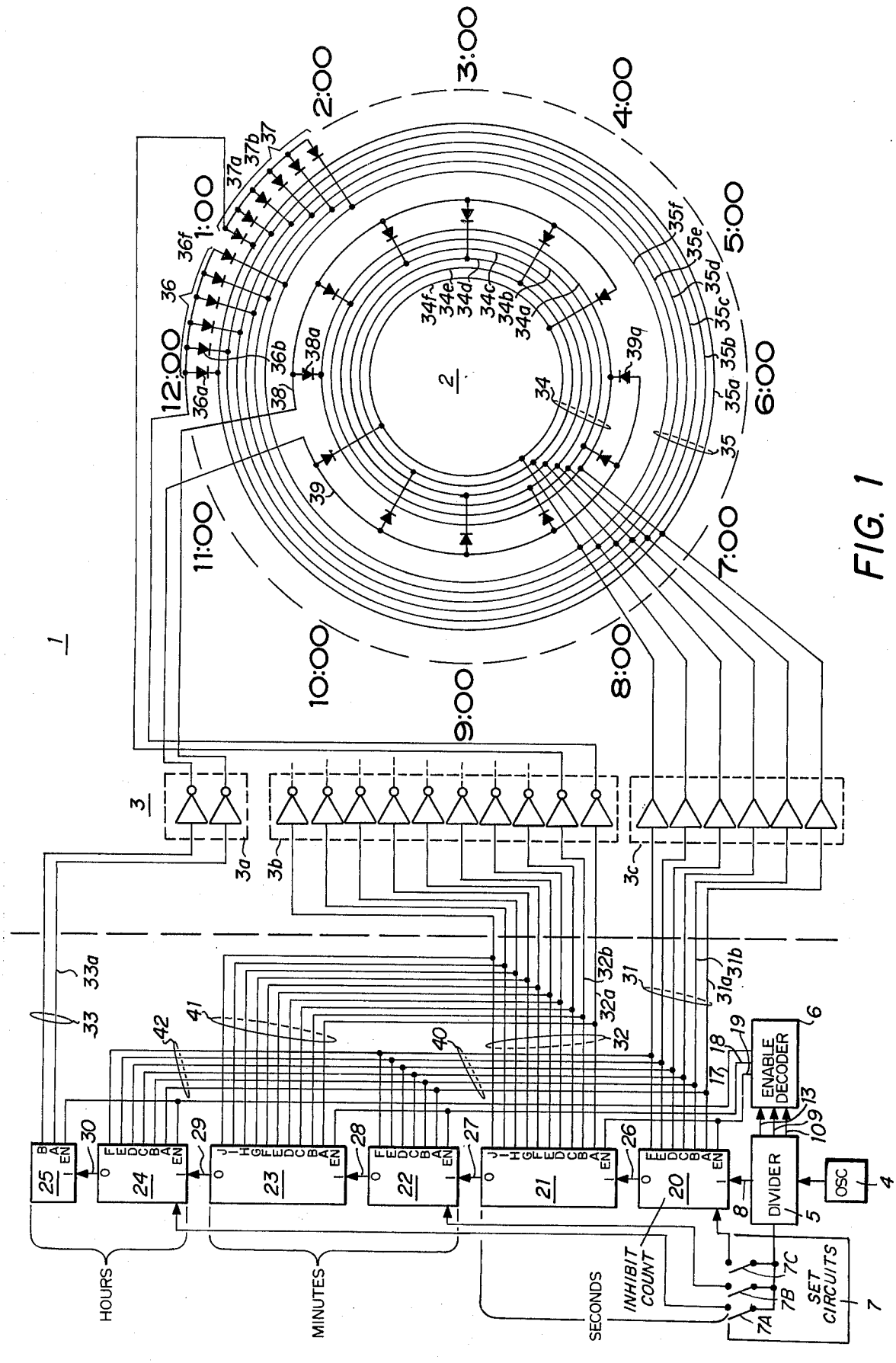

12:00
1:00
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4:00
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6:00
7:00
8:00
9:00
10:00
11:00
HOURS
MINUTES
SECONDS
INHIBIT COUNT
SET CIRCUITS
ENABLE DECODER
DIVIDER
OSC

FIG. 1

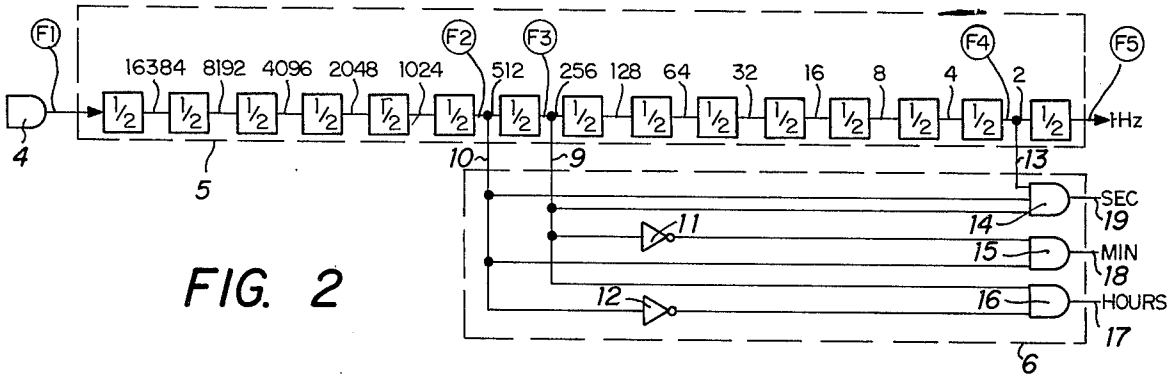


FIG. 2

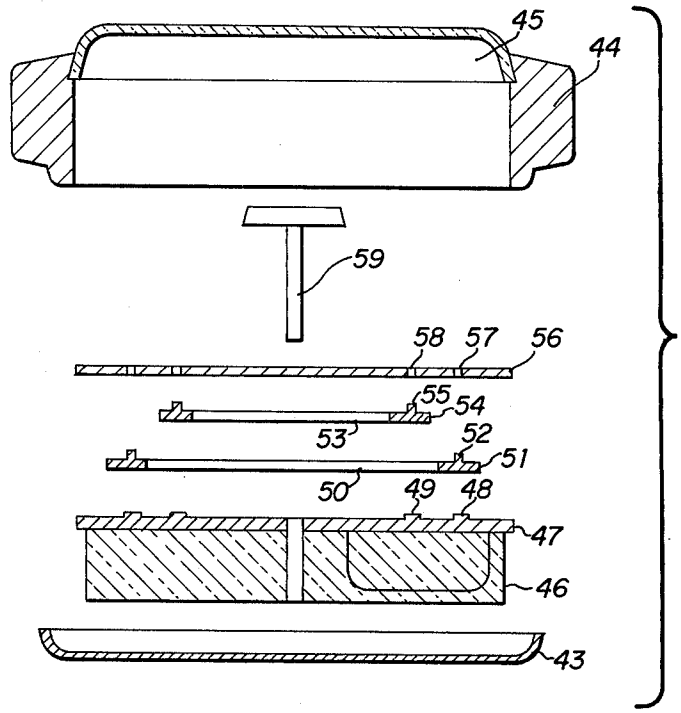


FIG. 4

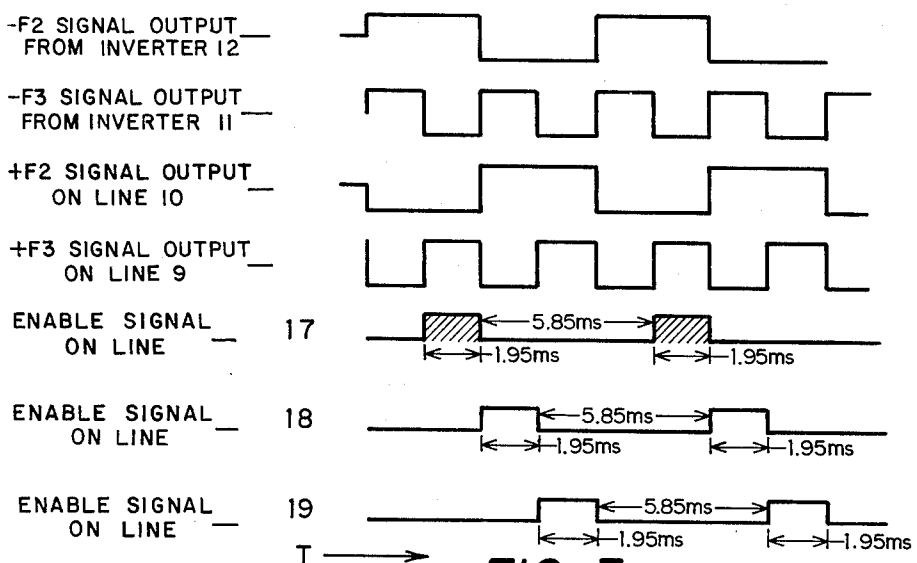


FIG. 3

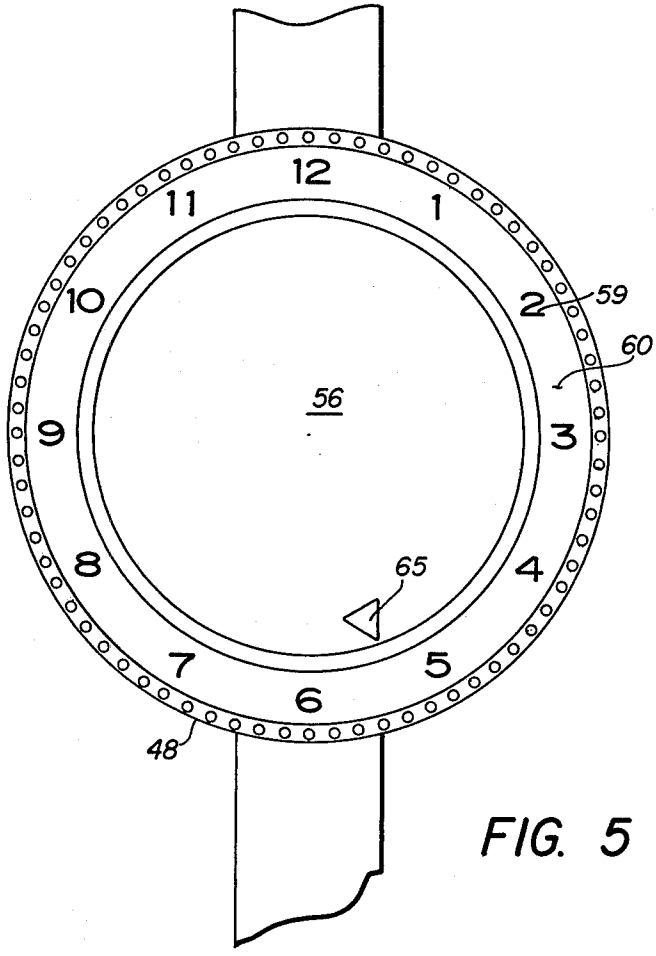


FIG. 5

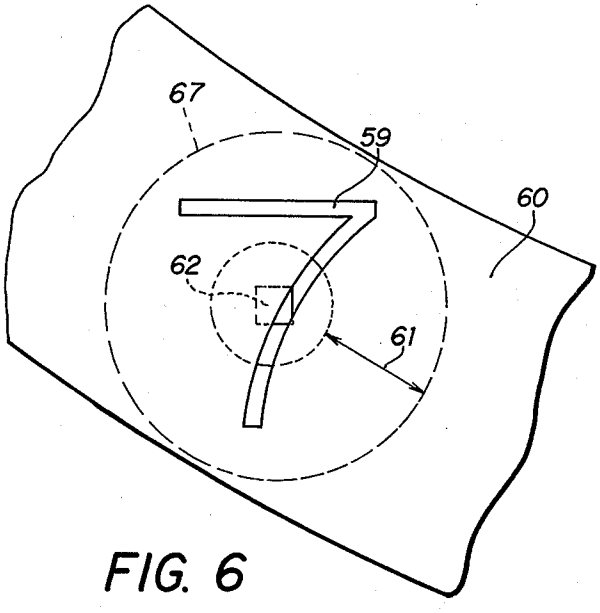


FIG. 6

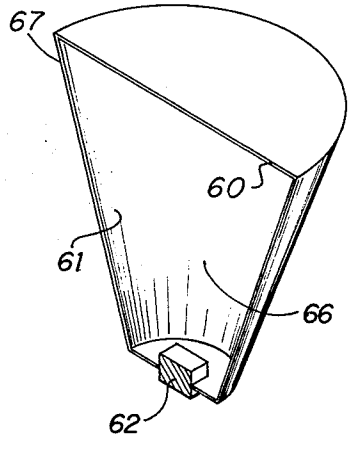


FIG. 7

VLED SOLID STATE WATCH

FIELD OF THE INVENTION

This invention relates generally to a timepiece combining the accuracy of an electronic watch with a display analogous to that of conventional mechanical watches, and more particularly to an electronic watch utilizing time-share circuits to drive two rings of VLED display units of visual contrasts.

DESCRIPTION OF THE PRIOR ART

Electronic or digital watches are known in the prior art which comprise a basic clock frequency driving an array of digital counters.

U.S. Pat. Nos. 3,754,392 and 3,757,511 disclose an electronic watch featuring displays comprising 72 light-emitting diodes (LEDs) arranged in two concentric circles to indicate hours, minutes, and seconds. U.S. Pat. No. 3,754,392 minimizes power consumption by employing low power CMOS components, and by controlling the duty cycle of a display in which a maximum of only three LEDs may be energized in any given second. Minimal power consumption is sought in U.S. Pat. No. 3,757,511 through the use of structural embodiments and narrow bandpass filters placed over the LEDs to enhance their light output.

No electronic watches are known in the prior art which employ display related time-sharing techniques to selectively actuate light-emitting elements without the use of multiplexers and line decoders, or which employ VLEDs in a multicolor display enhanced by the diffusing structure disclosed in the present invention.

SUMMARY OF THE INVENTION

The present invention comprises an electronic watch which selectively actuates two concentric rings of display elements to display time in contrasting color with minimal power consumption. More particularly, an oscillator drives a chain of serially connected shift counters, whose outputs time-share sets of display drivers in a manner which obviates the need for multiplexers and line decoders. A maximum of three display elements may be energized at any given time to display hours, minutes, and seconds.

An inner ring of twelve elements indicates hours in one color while an outer ring of sixty VLEDs indicates minutes and seconds preferably in a color different from that of the hours ring. The hour and minute indicators are continuously energized, while the second indicator is pulsed at a half second rate and stepped at a one second rate.

Reduced power consumption is achieved by minimizing interconnections between the shift counters and the display, controlling both the duty cycle and the scan rate of the display, and relating the display interconnections to the chain of counters.

In accordance with the invention, a chain of counters are pulse enabled sequentially in pairs to selectively energize two concentric rings of VLEDs. An inner ring of 12 VLEDs display hours, while an outer ring of sixty VLEDs display minutes and seconds preferably in a different color. A single array of display drivers are time-shared to reduce the number of interconnections between the shift counters and the display elements.

In another aspect, the VLEDs are covered by diffusing mediums in combination with structural embodiments to enhance visual contrast.

DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further objects and advantages thereof, reference may now be had to the following description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a schematic diagram of the electrical circuit of an illustrative embodiment of the invention;

FIG. **2** is a functional block diagram of a divider in combination with an enable decoder used in one embodiment of the invention;

FIG. **3** is a time diagram of output waveforms of the enable decoder of FIG. **2**;

FIG. **4** is an exploded sectional side view of the illustrative embodiment of FIG. **1** with components distributed along the longitudinal axis;

FIG. **5** is a pictorial view of a second illustrative embodiment from the top of a watch housing with transparent numbers formed in an other wise opaque crystal;

FIG. **6** is a view from the top of a reflecting cone enclosing a VLED, with the opaque crystal of FIG. **5** truncating one end of the cone;

FIG. **7** is an elevated sectional view of the reflecting cone of FIG. **6**.

DESCRIPTION OF PREFERRED EMBODIMENTS

In FIG. **1**, electronic watch generator **1** is connected to a display **2** through an array of drivers **3**. Generator **1** comprises a crystal oscillator **4** driving an array of shift counters, preferably CMOS shift counters. A frequency divider **5** receives the base frequency from oscillator **4**, and by means of serially connected flip-flops produces the frequencies to be output to the array of shift counters, an enable decoder **6**, and set circuit **7**.

In FIG. **2**, the base frequency F1 is fed into the first of an array of serially connected flip-flops through which the frequency is sequentially divided down. For example, where oscillator **4** is a quartz crystal with a natural frequency of 32.768 Kilohertz, a 512 Hertz waveform is obtained at F2, a 256 Hertz waveform at F3, a 2 Hertz waveform at F4, and a 1 Hertz waveform at F5.

Enable decoder **6**, a one of three decoder, receives three inputs from divider **5**. A waveform at F4 is led by way of line **13** to an input of AND gate **14** to produce a flashing seconds indicator. The waveform on line **10** is fed to one input each of AND gates **14** and **15**, and to one input of AND gate **16** through inverter **12**. The waveform on line **9** is fed to one input each of AND gates **14** and **16**, and to one input of AND gate **15** through inverter **11**. The waveform on line **10** is utilized to control the duty cycle of the shift counters, while the waveform on line **9** is utilized to control the counter scan rate. Thus, both the duty cycle and the scan rate may be halfed or doubled by moving the tie points to lines **10** and **9** one flip-flop to the left or one flip-flop to the right, respectively.

Decoder **6** is connected to the enable input of counters **20** and **21** by way of line **19**, to the enable input of counters **22** and **23** by way of line **18**, and to the enable input of counter **24** and flip-flop **25** by way of line **17**. By controlling the enabling cycles of the counters, decoder **6** time-shares the common counter output lines **31** and **32**, and consequently controls the duty cycle of the display.

Completing the electronic watch generator **1**, divider **5** of FIG. **1** is connected to the I input of a shift counter **20** by way of line **8** and to set circuit **7** by way of line **8***a*. Counter **20** outputs A–F are connected by way of lines **31** to an array of cathode drivers **3***c*. The 0 output of counter **20** is connected to the I input of a shift counter **21.**

Counter **20** is a base **6** counter having six discrete states. As the counter is driven by a 1 Hertz signal, the counter will change states once each second to complete a cycle in 6 seconds. Thus the waveform on line **26** will have a frequency one-sixth that of the 1 Hertz input frequency, and a digital pulse will cycle through outputs A–F in 6 seconds.

The A–J outputs of counter **21** are connected by way of lines **32** to an array of anode drivers **3b.** The 0 output of counter **21** is connected to the I input of a shift counter **22.**

Counter **21** is a base **10** counter having **10** discrete states. The counter is driven by a one-sixth Hertz signal and will change states once each 6 seconds to complete a cycle in 60 seconds. Thus the waveform on line **27** has a one cycle per minute frequency, and a digital pulse cycles through outputs A–J in 60 seconds.

It is seen that counter **20** in combination with counter **21** has **60** discrete states, changes state each second, and performs a divide-by-60 function. Thus this combination may be used as a seconds counter.

The A–F outputs of counter **22** are connected by way of lines **40** and **31** to cathode drivers **3c.** The **0** output of counter **22** is connected to the I input of a shift counter **23,** whose A–J outputs are connected by way of lines **41** and **32** to anode drivers **3***b*. The **0** output of counter **23** is connected to the I input of a shift counter **24.**

Counter **22** is a base **6** counter while counter **23** is a base **10** counter. Further, a digital pulse cycles through the A–F outputs of counter **22** in 6 minutes, and through the A–J outputs of counter **23** in 60 minutes. In a manner similar to that described for counters **20** and **21,** the combination of counter **22** and **23** has **60** discrete states, changes state once each minute, and performs a divide-by-60 function resulting in a one cycle per hour signal on line **29.** The combination, therefore, may be used as a minutes counter.

Counter **24** is a base **6** register having six discrete states. The counter changes state once each hour and performs a divide-by-6 operation resulting in a one cycle per 6 hour waveform on line **30.** Once each 6 hours, a digital pulse cycles through the A–F outputs of the counter, which are connected by way of lines **42, 40,** and **31** to the cathode drivers **3c.** The 0 output of the counter is connected to the I input of a flip-flop **25.**

Counter **24** in combination with flip-flop **25** has 12 distinct states, changes state once each hour, and performs a divide-by-12 operation on the driving signal on line **29.** Thus the combination may be used as an hours counter.

The A and B outputs of flip-flop **25** are connected by way of lines **33** to anode drivers **3***a*. As the flip-flop is driven by a one cycle per 6 hour signal, a digital pulse shifts from one output to the other every 6 hours.

Display **2** comprises 72 VLEDs arranged in two concentric circles. An outer ring of sixty VLEDs are circumferentially spaced 6° apart to represent minutes and seconds. An inner ring of 12 VLEDs are circumferentially spaced 30° apart to represent hours.

The VLEDs in the minute-second ring are arranged in 10 sectors, 6 VLEDs per sector. In each sector, the anodes of the VLEDs are joined in common to a single anode driver of the array **3***b*. The cathodes of like VLEDs in each sector are joined to a common conductor. For example, the cathode of the first clockwise VLED in sector **36,** VLED **36***a*, is connected with the cathode of VLED **37***a* of sector **37** to a common conductor **35***a*. Similarly, the cathode of VLED **36***b* is connected in common with the cathode of VLED **37***b* to conductor **35***b*.

The VLEDs in the inner hours ring are arranged in two sectors, six diodes per sector. The anodes of the VLEDs in each sector are connected in common to an anode driver of the array **3***a*. The cathode of a VLED in one sector is joined by means of common conductor **34** to the cathode of a VLED similarly located in the second sector. For example, the cathode of VLED **38***a* in sector **38** is joined with the cathode of VLED **39***a* in sector **39** to common conductor **34***a*.

Thus the concentric conductors **35** join the cathodes of minutes-seconds VLEDs, while concentric conductors **34** join the cathodes of hours VLEDs. The outer rings **34***a* and **35***a* of conductors **34** and **35** are connected to the output of a common cathode driver of array **3***c*, whose input is connected to the A output of counters **20, 22,** and **24.** Rings **34***b* and **35***b* are connected in a similar manner to the B output of counters **20, 22,** and **24.** The remaining ring pairs of *c–f* are connected to outputs C–F of counters **20, 22,** and **24.**

In operation, the watch is first synchronized by means of set circuit **7,** which in the present embodiment comprises three push buttons **7A–C** external to the watch housing. By depressing the set-hours button **7***A* or set-minutes button **7***B*, a 1 Hertz signal provided by decoder **5** on **8***A* **82** is coupled to either counter **24** or counter **22,** respectively. Thus the hours or minutes indicator will be advanced at a one second rate to a proper setting. By depressing the set-seconds button **7***C*, the 1 Hertz signal on line **8,** FIG. **1,** is removed from the seconds counter to hold the seconds indicator stationary for proper synchronization.

After synchronization, the operation is free-running. Divider **5** derives the 1 Hertz clocking signal and decoder input signals from the waveform supplied by oscillator **4.** The 1 Hertz signal drives the array of serially connected shift counters **20–24** and flip-flop **25** to count seconds, minutes, and hours. Decoder **6** controls the duty cycle of the counters so that the seconds counters, the minutes counters, and the hours counters are enabled sequentially. Thus driver array **3,** and conductors **31** and **32** are time-shared, reducing the number of circuit interconnects.

The interconnection between generator **1** and display **2** allows the sequential selection of VLEDs without the use of line decoders or multiplexers. For example, in displaying 12 hours 5 minutes 12 seconds, decoder **6** first enables the seconds counters, counters **20** and **21.** Output A of counter **20** is energized to drive the cathodes of VLEDs connected to conducting rings **34***a* and **35***a*. Output C of counter **21** is energized to drive the anodes of those VLEDs in the sector next following sector **37.** Thus the first clockwise VLED of the sector whose anodes are energized will be illuminated. To display 5 minutes, the minutes counters, counters **22** and **23,** are enabled, and output F of counter **22** is energized to drive the cathodes of those VLEDs connected to conducting rings **34***f* and **35***f*. Also output A of

counter **23** is energized to drive the anodes of sector **36.** Thus, VLED **36***f* is illuminated. Decoder **6** next enables the hours counters, counter **24** and flip-flop **25,** to display twelve hours. Output A of counter **24** is energized to drive the cathodes of VLEDs connected to conducting rings **34***a* and **35***a*. In addition, output A of flip-flop **25** is energized to drive the VLEDs of hour sector **38.** Thus, VLED **38***a* is illuminated.

In a continuing operation, decoder **6** sequentially enables the seconds, minutes, and hours counters to selectively actuate the VLED display **2.** To minimize power consumption, the shift counters of generator **1** are enabled in a pulsed manner as shown in the embodiment illustrated in FIGS. **2** and **3,** where the counters are enabled for 1.95 milliseconds out of each 7.8 milliseconds. The frequency of the enable signal is such that the minutes and hour displays do not flicker, but appear continuous. However, the two Hertz signal superimposed upon the seconds enable line **19** produces a flashing second indicator which is energized a half second each second. During the time that the seconds indicator is off, the minute and hour displays are continuous as before, and the entire display is strobed at a 500 to 1000 Hertz rate. When the minute and second displays coincide, a VLED is energized by both a minutes and a seconds driver and appears brighter than ordinary for a half second. Thus, there is no ensuing confusion.

An embodiment of the invention is further illustrated in FIG. **4** where the outer casing has been broken into two parts **43** and **44** to better view the internal construction. The upper casing **44** encases a clear crystal **45.** The batteries and crystal oscillator are housed within a container **46** which is seated in lower casing **43.** Superimposed upon container **46** is a logic substrate **47** on which the minutes VLEDs **48** and hours VLEDs **49** are arranged in concentric circles.

It is to be understood that the divider, enable decoder, counters, and drivers could comprise a single integrated circuit.

Placed upon substrate **48** is a plate **50** comprising a red filter ring **51** with filter guides **52** which are aligned with VLEDs **48.** Plate **53** comprises a green filter ring **54** with filter guides **55** which are aligned with VLEDs **49.** To be superimposed upon plate **53** is the face plate **56** with apertures **57** and **58** through which the VLEDs will glow. Interlocking screw **59** secures plates **47, 50, 53,** and **56** to lower casing **43.**

The VLEDs, when energized, emit colors corresponding to their dye mixture as shown in Table **1.** In the present embodiment, the hours VLEDs preferably are composed of the more expensive galium phosphide to emit a green color when energized, while the more numerous minutes-seconds VLEDs preferably are composed of less expensive galium arsenide phosphide for a red display. The contrast of the energized VLEDs is enhanced by the use of narrow bandpass filters **51** and **54,** which allow only an energized VLED to be seen.

TABLE I

Material	Color	Wavelength (Angstroms)
Ga P	red	6900 to 7100
Ga As P	red	6300 to 6700
Ga As P	amber	5950 to 6300
Ga P	yellow	5750 to 5950
Ga P	green	5600 to 5750

An alternative to the filtered VLED display of FIG. **4** is the embodiment illustrated in FIGS. **5, 6,** and **7,** where VLEDs illuminate the set of twelve transparent numbers **59** on an otherwise opaque crystal **60.** A truncated reflecting cone **67,** FIG. **7,** having an inner reflector surface **61** provides an optical interface between VLED **62** and a transparent number **59** indicating hours. For an optimum visual effect at minimal power consumption, the enclosed volume **66** of the cone preferably is filled with a mixture of a diffusing epoxy base material with index **1.52,** and concordial shaped pyrex particles of index 1.47. More particularly, the selection of materials will depend upon their optical properties. It is known that the ratio between the intensity I of a reflected beam and the intensity I_0 of an incident beam for natural, unpolarized light perpendicularly incident within a medium of refractive index r_1, upon a transparent substance of refractive index r_2 is

$$\frac{I}{I_0} = \left(\frac{r_2 - r_1}{r_2 + r_1}\right)^2$$

Apertures capped by a diffusing lens heretofore have been used in electronic displays. If the diffusing lens is a typical thermoplastic of refractive index 1.5, and the index of air is 1.0:

$$\frac{I}{I_0} = \left(\frac{1.5 - 1}{1.5 + 1}\right)^2 = .04.$$

Thus, when an intermediate air chamber exists between the light source and the lens, 4 percent of light perpendicularly incident upon the diffusing lens is reflected. Greater losses occur to that portion of the light which is reflected from the sides of the optical interface to strike the lens surface at an angle.

If a transparent base material is used in combination with a filler to completely fill the aperture between the VLED and the watch face, transmission losses are reduced. Although perfect transmission of perpendicularly incident light occurs when the base material and filler have identical indices, a difference of indices is desired to obtain a less brilliant diffusion which is more pleasing to the eye. Preferably, the filler has a lower index than the base material.

The most readily available transparent substances which may be used as base materials are the thermoplastics and thermo-setting epoxy materials having an index of approximately 1.50. It can be shown that optimum diffusion is obtained when a filler with index of approximately 1.47 is used in combination with these base materials. Thus, pyrex particles with an index of 1.47 may be used as may materials such as alpha quartz with indices 1.44 and 1.48.

Using an epoxy base with an index 1.52 in combination with a filler with an index 1.47, a direct interface between a VLED and the diffusing medium is obtained in the system of FIG. **7** without an intermediate air column. Thus,

$$\frac{I}{I_0} = \left(\frac{1.5_2 - 1.47}{2.99}\right)^2 = .000289,$$

and only a negligible loss of perpendicularly incident light occurs.

When VLED **62** as shown in FIG. **7** is energized, reflector **61** gathers the emitted light and directs it through the diffusing medium toward the transparent number. Reflecting cones similarly constructed enclose VLEDs in ring **48** indicating minutes and seconds. Thus, visual contrast is enhanced with an increase in light-emitting efficiency, and the brilliant emission is replaced by a soft glow more pleasing to the eye.

A further modification may be understood by again referring to FIGS. **5-7.** The numbers **59** may be stamped on the crystal **60,** while reflector **67** may be configured to any shape to interface with watch face **56.** As shown in FIG. **5,** the top surface of a reflecting cone may be seated in face plate **56** and shaped as a pointer **65** to more nearly approximate the conventional clock face display.

It is to be understood that the electronic and optical techniques disclosed are equally applicable to other displays including planar gas discharge panels, direct view filaments, vacuum fluorescent tubes, LED, LCD, and electrochromic displays.

In accordance with the invention, there is provided an electronic watch in which time-sharing is employed to obviate the need for multiplexers and decoders, to decrease the number of interconnects between the electronic watch and the VLED display, and thereby to decrease power consumption.

Minimal power consumption is also sought through control of both the duty cycle and scan rate of the display, and through optical interfaces which increase the light-gathering efficiency of the display.

A maximum of three VLEDs may be actuated at any given time to display hours, minutes, and seconds with color contrast. Preferably twelve VLEDs are equally spaced circumferentially along an inner ring to display hours in one color. Sixty VLEDs are equally spaced circumferentially along an outer ring to display minutes and seconds in a color different from that used to display hours. Hours and minutes appear as continuously energized VLEDs, while seconds appear as a pulsed VLED advancing at a one second rate.

Having described the invention in connection with certain specific embodiments thereof, it is to be understood that further modifications may now suggest themselves to those skilled in the art and it is intended to cover such modifications as fall within the scope of the appended claims.

What is claimed is:

1. An electronic timepiece in which display elements are energized to display time which is comprised of:

a. oscillator means for generating electrical time base pulses of a predetermined frequency;

b. means coupled to said oscillator means including a plurality of counter means driven by said time base pulses for counting said time base pulses and for producing counter outputs indicative of the second, minute and hour, each of said counter means including a pair of counters with one counter in each pair being a base-six counter serially connected to a second counter with the second counters for seconds and minutes being base-ten counters and with the second counter for hours being a base-two counter;

c. means including sequential enabling means coupled to said counter means for multiplexing said counter outputs;

d. a plurality of display elements each having first and second terminals arranged in predetermined patterns with twelve display elements in a first of said patterns for individually indicating one of 12 hours and 60 display elements in a second of said patterns for individually indicating one of 60 minutes and alternately one of 60 seconds, groups of said display elements of said second pattern being interconnected at one terminal thereof by common interconnects to form ten groups of six elements and the other terminal of each of said display elements of said second pattern being connected to one of six conductors in the order of each Nth element of each group connected to the Nth conductor; and

e. a plurality of sets of drivers with a first of said sets selectively coupling said counter outputs to said common interconnects and a second set selectively coupling said counter outputs to said six conductors to selectively display hours, minutes and seconds in accordance with the multiplexing of said counter outputs.

2. The electronic timepiece according to claim **1** wherein said six conductors are coupled to the counter outputs of both the second and minute base-six counters by means of said second set of drivers and wherein the common interconnects of each of said groups are coupled to the second and minute base-ten counters by means of said first set of drivers.

3. The electronic timepiece according to claim **1** wherein the first terminal of each of said display elements of said first pattern are interconnected to form two groups of six elements and the other terminal of each of said display elements of said first pattern are connected to one of a second set of six conductors in the order of each Nth element of each of said two groups connected to the Nth conductor of said second set.

4. The electronic timppiece according to claim **3** wherein said six conductors of said second set are coupled to the output of said base-six hour counter by means of said second set of drivers and said two groups are individually connected to the output of said base-two hour counter by means of another set of drivers.

5. The electronic timepiece according to claim **1** wherein said first and second patterns of display elements are generally in the shape of concentric rings.

6. The electronic timepiece according to claim **1** wherein said display elements are comprised of visual light-emitting diodes.

7. The electronic timepiece according to claim **6** wherein said display elements further include cone-shaped optical reflectors filled with a diffusion medium with a small diameter end of each reflector adjacent to one of said light-emitting diodes and a large diameter end interfacing with a timepiece face.

8. The electronic timepiece according to claim **7** wherein said diffusion medium includes a mixture of an epoxy base material with an index of about 1.52 and a plurality of concordial-shaped pyrex particles with an index of about 1.47.

9. The electronic timepiece according to claim **1** wherein said counter means, sequential enabling means and drivers comprise an integrated circuit.

10. The electronic timepiece according to claim **1** wherein said means including sequential enabling means multiplexes said counter outputs at a sufficiently high rate to energize said display elements so that said display elements visually appear to indicate the hour, minute and second simultaneously.

11. The electronic timepiece according to claim 10 wherein said sequential enabling means is coupled to and driven by said oscillator means.

12. An electronic timepiece in which display elements are energized to display time which is comprised of:

a. oscillator means for generating electrical time base pulses of a predetermined frequency;

b. means coupled to said oscillator means including a plurality of cascaded counter means driven by said time base pulses for counting said time base pulses and for producing counter outputs indicative of the second, minute and hour, each of said counter means including a pair of counters with one counter in each pair being a base-six counter serially connected to a second counter with the second counters for seconds and minutes being base-ten counters and the second counter for hours being a base-two counter;

c. a plurality of display elements each having first and second terminals arranged in predetermined patterns with twelve display elements in a first of said patterns for individually indicating one of twelve hours and sixty display elements in a second of said patterns for individually indicating one of sixty minutes and alternately one of sixty seconds, groups of said display elements of said second pattern being interconnected at one terminal thereof by common interconnects to form ten groups of six elements, groups of said display elements of said first pattern being interconnected at one terminal thereof by common interconnects to form two groups of six elements and the other termianl of each of said display elements of said first and second patterns being connected to one of six conductors in the order of each Nth element of each group connected to the Nth conductor; and

d. a plurality of sets of drivers with a first set of drivers coupling the respective outputs of each of said base-ten counters to a respective one of the common interconnects to said first pattern of elements, a second set of drivers coupling the outputs of said base-two counter to a respective one of the common interconnects to said first pattern of elements and a third set of drivers coupling the respective outputs of each of said base-six counters to respective ones of said six conductors to selectively display hours, minutes and seconds.

13. The electronic timepiece according to claim 12 including means including selective enabling means for multiplexing the outputs of said counter means to said drivers.

14. A method of controlling from a chain of counters the duty cycle and scan rate of light displays in an electronic watch to decrease the number of interconnections and devices required in energizing light displays arranged in two concentric circles for hours, minutes, and seconds, which comprises:

a. repeatedly dividing a base frequency waveform by half steps to produce waveforms of a plurality of different frequencies;

b. applying one of said plurality of waveforms to control the duty cycle of said counters;

c. applying a second of said plurality of waveforms of lower frequency than said one of said plurality to control the scan rate of said counters;

d. applying a third of said plurality of waveforms of lower frequency than said second to produce a flashing seconds indicator;

e. controlling the operation of said counters counting seconds with the logical sum of all three of said applied waveforms;

f. controlling the operation of said counters counting minutes with the logical sum of said one and the inverse of said second of said plurality of waveforms;

g. controlling the operation of said counters counting hours with the logical sum of said second and the inverse of said one of said plurality of waveforms; and

h. applying the outputs of said counters through three sets of said drivers to ten sectors of six of said elements per sector in the outer of said circles to display minutes and seconds, and to two sectors with six of said elements per sector in the inner of said circles to display hours.

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