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Reese

[11] **3,803,834**

[45] **Apr. 16, 1974**

[54] **WRISTWATCH CALCULATOR**

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[73] Assignee: **Time Computer, Inc.,** Lancaster, Pa.

[22] Filed: **Feb. 6, 1973**

[21] Appl. No.: **329,973**

[52] **U.S. Cl.** ..... **58/152 R,** 58/50 R

[51] **Int. Cl.** **G04b 47/06,** G04b 19/30

[58] **Field of Search** ..... 58/4, 23 R, 23 A, 50 R, 58/127, 152 R; 235/152

[56] **References Cited**

UNITED STATES PATENTS

3,653,204	4/1972	Miwa	58/42.5
3,613,351	10/1970	Walton	58/23
3,328,954	7/1967	Miller	58/23
3,668,861	6/1972	Mitsui	58/50 R
3,166,742	1/1965	Sherwin	58/50 R X

Primary Examiner—Richard B. Wilkinson
Assistant Examiner—Edith C. S. Jackmon
Attorney, Agent, or Firm—LeBlanc & Shur

[57] **ABSTRACT**

Disclosed is a combination wristwatch and wrist calculator. The wristwatch comprises an eight digit electro-optical display indicating time and calendar information when in the time display mode and indicating the result of a computation when in the calculate mode. A manually operated mode switch controls the display and calculations are entered by way of a miniature keyboard on the watch face.

22 Claims, 7 Drawing Figures

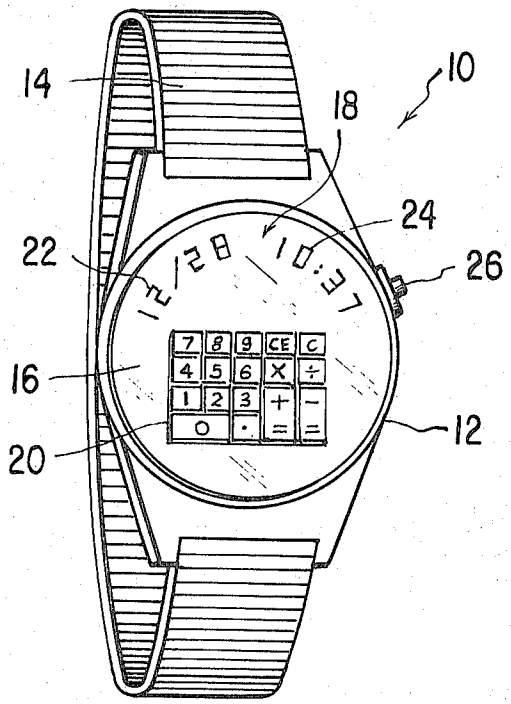


FIG. 1

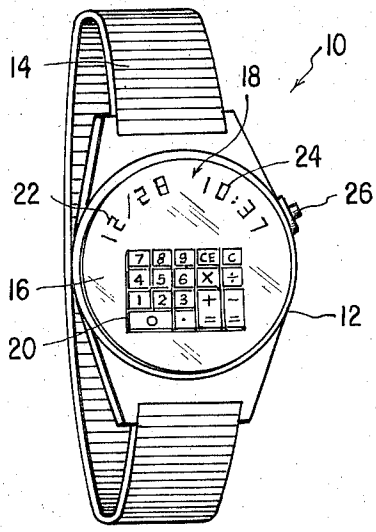


FIG. 3

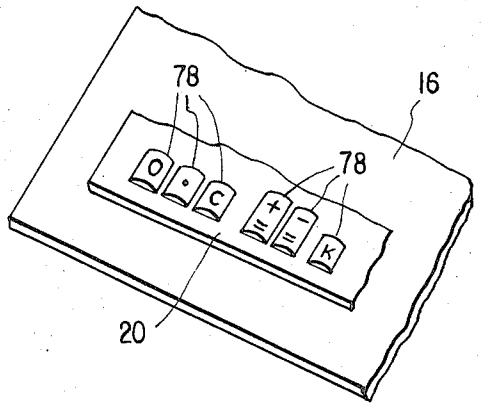


FIG. 4

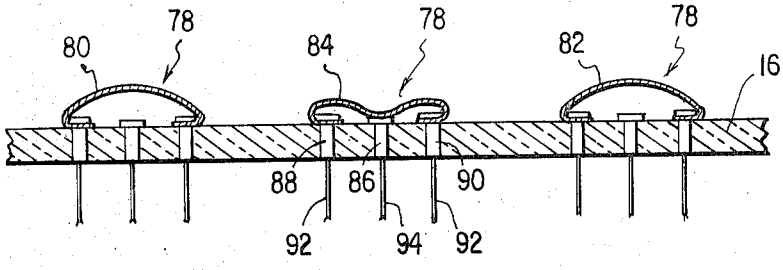


FIG. 5

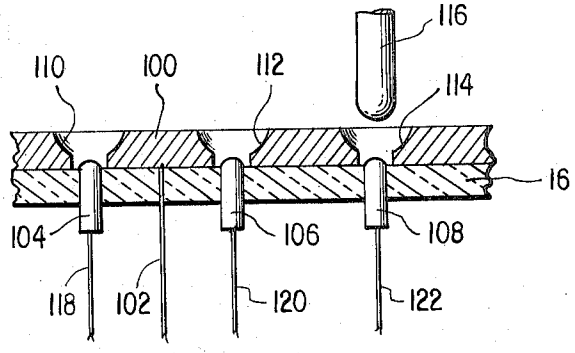


FIG. 2

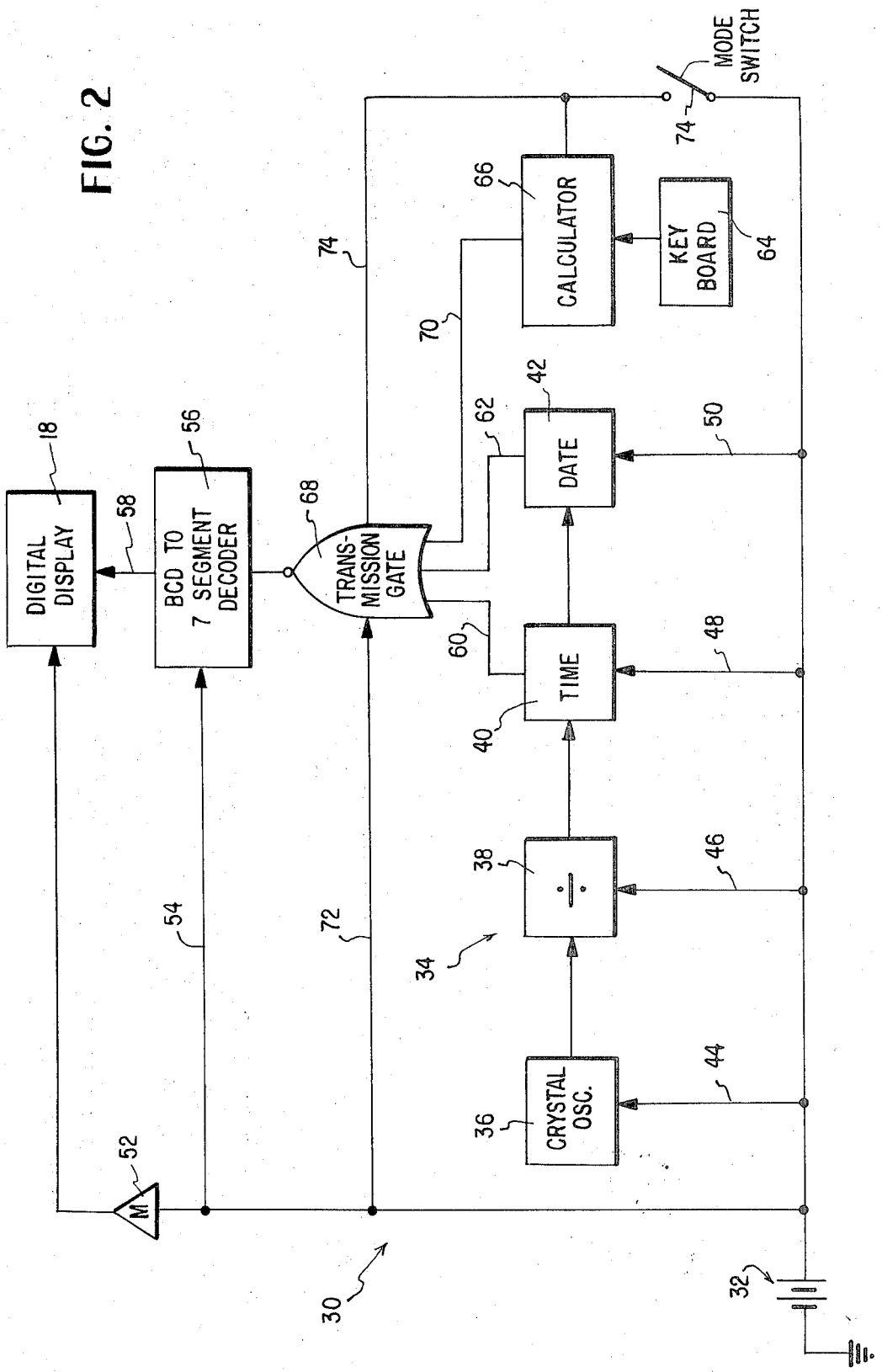
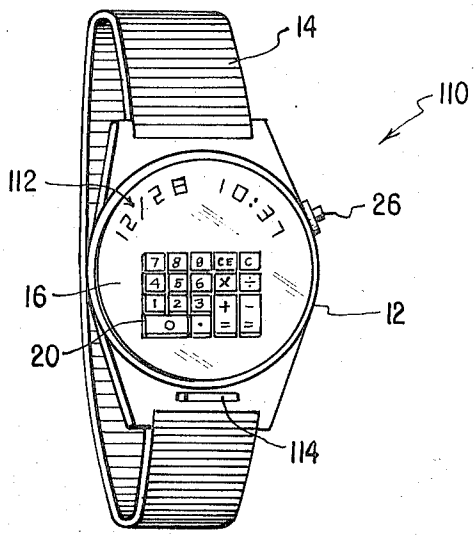

MODE SWITCH
74
66
CALCULATOR
KEY BOARD
64
74
70
42
62
DATE
50
18
56
58
DIGITAL DISPLAY
BCD TO 7 SEGMENT DECODER
68
TRANS-MISSION GATE
60
48
TIME
40
38
46
54
72
34
44
36
CRYSTAL OSC.
52
M
30
32

FIG. 6


14
110
112
12/28 10:37
26
16
12
20
114

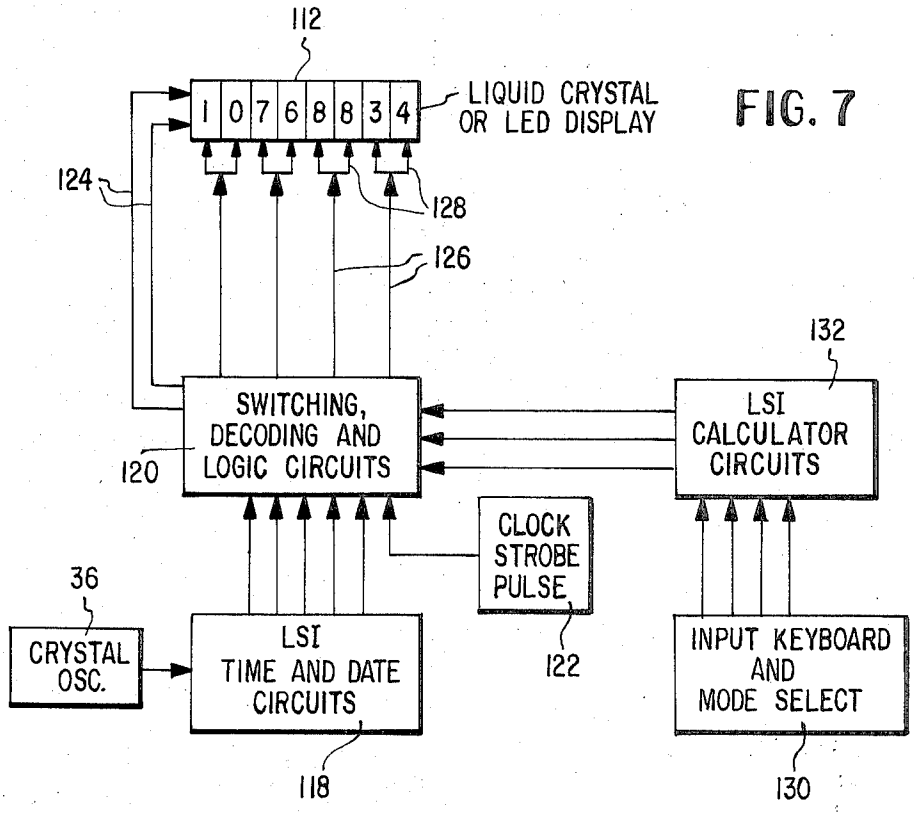

112
1 0 7 6 8 8 3 4
LIQUID CRYSTAL OR LED DISPLAY
124
128
126
132
SWITCHING, DECODING AND LOGIC CIRCUITS
120
LSI CALCULATOR CIRCUITS
CLOCK STROBE PULSE
122
36
CRYSTAL OSC.
LSI TIME AND DATE CIRCUITS
118
INPUT KEYBOARD AND MODE SELECT
130

FIG. 7

WRISTWATCH CALCULATOR

This invention relates to a combination wristwatch and calculator and more particularly to a combination solid state wrist calculator and crystal controlled precision timepiece incorporating a miniature keyboard array and an eight digit electro-optical digital display in the form of a plurality of liquid crystal elements or light emitting diodes. The time display and the calculate operations are mutually exclusive and are selected by a mode switch.

In recent years there have been developed a variety of new wristwatches generally referred to as "electronic" watches. In many instances these devices use as a timing source a crystal controlled electronic oscillator whose frequency is divided down to produce timing signals at a frequency of 1 Hz and less by a low power solid state divider often incorporating complementary MOS transistors. In some instances the wristwatches have incorporated an electro-optical digital display in the form of liquid crystals or light emitting diodes. A wristwatch of this general type incorporating light emitting diodes is disclosed in assignee's U.S. Pat. No. 3,672,155 whereas a similar wristwatch construction utilizing a liquid crystal digital display is disclosed in assignee's U.S. Pat. No. 3,701,249. Through the use of large-scale integrated circuits it is possible to form most of the active components of the wristwatch from a single large-scale integrated circuit chip or at the most only a few chips.

Recent years have also seen the development of a new family of electronic calculators generally referred to as pocket calculators. These calculators have taken a wide range of forms depending upon size and complexity but in many cases have incorporated integrated circuitry in combination with a digital numerical display. While in some instances the pocket calculators have been sufficiently small to be readily held in the palm of one hand, they have in all instances been quite large and bulky in relation to a modern sized man's wristwatch. One of the limiting factors in further reduction in size of a pocket calculator has been the necessity for a readily accessible keyboard which can be easily and accurately operated without placing undue requirements on the manual dexterity of the operator to perform the desired mathematical calculations.

The present invention is directed to a novel wristwatch device which combines the features of both a precision timepiece and a very small or miniature electronic calculator. This is made possible by combining in a novel manner certain features of the newer type wristwatches with certain features of the so-called pocket calculators and by providing an improved and unique miniature keyboard on the watch face.

In the present invention time, which as used herein includes calendar information such as the day and month of the year, is constantly kept. This time information is displayed when desired on the face of the watch in the form of a digital numerical display. In the preferred embodiment the display takes the form of an eight digit electro-optical display using two digits to display minutes, two digits for hours, two digits for the day of the month and the last two digits for the month of the year. By manually depressing a mode switch on the wristwatch the calculator portion of the device is actuated and the eight digit display made responsive to the digital calculator circuitry. By depressing appropriate

keys on the face of the wristwatch the desired mathematical calculations are performed by the calculator circuits within the watch and the result is displayed on the same eight digit display previously used to indicate time. Important features of the present invention include the fact that time is constantly being kept in the wristwatch even when operating in the calculate mode so that accurate time may be displayed at any instant. In addition, when the device is being utilized to display time, i.e., is not in the calculate mode, the calculator circuits are de-energized so as to minimize the power drain on the small size energy source or battery provided in the wristwatch case. In one embodiment of the present invention the display is formed by a plurality of liquid crystals preferably of the newer field effect type while in a second embodiment of the present invention the display is an active one incorporating light emitting diodes.

It is, therefore, one object of the present invention to provide an improved wrist calculator.

Another object of the present invention is to provide a wristwatch incorporating a digital calculator.

Another object of the present invention is to provide an improved wrist calculator having a novel miniaturized calculator keyboard.

Another object of the present invention is to provide a combination wristwatch and calculator which both share a common digital display.

Another object of the present invention is to provide an electronic wristwatch having a novel miniaturized calculator keyboard on the wristwatch face.

Another object of the present invention is to provide a combination wristwatch and calculator including a calendar time display.

Another object of the present invention is to provide a combination wristwatch and electronic calculator incorporating a common electro-optical display in the form of liquid crystals or light emitting diodes.

Another object of the present invention is to provide a combination wristwatch and electronic calculator in which time is constantly kept and in which the calculator circuitry is only energized when the calculate mode is selected by the wearer.

These and further objects and advantages of the present invention will be more apparent upon reference to the following specification, claims and appended drawings wherein:

FIG. 1 is a perspective view of a combination wristwatch and electronic calculator constructed in accordance with the present invention;

FIG. 2 is a block diagram of the electronic circuitry forming the device of FIG. 1;

FIG. 3 is a perspective view of a portion of the calculator keyboard of FIG. 1;

FIG. 4 is a cross section through a portion of the keyboard of FIG. 1;

FIG. 5 is a cross section through a modified keyboard construction which may be used in the device of FIG. 1;

FIG. 6 is a perspective view similar to FIG. 1 showing a modified combination wristwatch and electronic calculator constructed in accordance with the present invention; and

FIG. 7 is a block diagram for the circuitry of the modified device of FIG. 6.

Referring to the drawings, the novel combination wristwatch and electronic claculator of the present in-

vention is generally indicated at **10** in FIG. **1** as comprising a watch case **12** to which is attached a wristwatch band or bracelet **14.** Mounted on the face **16** of the watch is an electrical digital display **18** and a calculator keyboard **20.** The display includes a four digit calendar portion **22** with the numerals 12/28 indicating the date of Dec. 28 and with a four digital time portion **24** showing the numerals 10:37 indicating that it is 37 minutes after 10 o'clock. Keyboard **20** is provided with keys for the decimal numbers 0 through 9, with a decimal point key, and with keys for addition, subtraction, multiplication and division and additional keys for either constant or chain operation.

In operation, the hours and minutes of time as well as day and month of the year are continuously displayed at the display stations **18** and appropriately advance in indication with a change in time. The digital display stations are each preferably formed from a plurality of liquid cyrstals either of the light scattering type or preferably of the newer field effect type. Since liquid crystals draw little power the time may be continuously displayed at the display stations without unduly loading the watch battery incorporated in the display case. When it is desired to operate the device in a calculate mode a push button **26** mounted on the watch case is depressed closing a switch which clears the calculator and causes the display to display all zeros. The keyboard is then operated to perform the desired calculation of either addition, subtraction, multiplication or division through binary calculator circuitry incorporated in the watch case in a well known manner. When calculations have been completed the result appears on the display **18** and once the result has been noted, the display may be returned to its time display function by again depressing the push button **26** to open the mode switch.

FIG. **2** is a detailed block diagram of the electronic circuit for the device **10** of FIG. **1.** The electronic circuit generally indicated at **30** comprises a power source **32** which by way of example only may comprise a pair of conventional 1½ volt wristwatch batteries connected in series to provide a nominal 3 volt power supply to the various components of the device **10.** Energized from the battery is a time-keeping circuit generally indicated at **34** which comprises crystal oscillator **36,** a divider **38,** a time circuit **40** (hours and minutes) and a calendar circuit **42** (days and months). These elements are connected to the positive side of the power supply **32** by respective leads **44, 46, 48** and **50.** This connection is continuous so that time is constantly being kept by the time circuit **34** irrespective of whether time information is displayed or the device is operating in the calculate mode. In the preferred embodiment, oscillator **36,** divider **40,** time circuit **42** and calendar circuit **44** are formed of complementary MOS transistors utilizing large-scale integration circuit techniques. The digital display **18** in FIG. **2** is shown as connected to the positive side of the power source through a voltage up-converter **52** which converts the three volt output of battery **32** to the approximately 15 volts or more necessary to drive the liquid crystal elements of the display **18.** As previously indicated, the liquid crystals draw very small current and, therefore, may be continuously illuminated without resulting in an undue amount of current drain from battery **32.**

Battery **32** also has its positive side connected by a lead **54** to a decoder **56** which by way of example only may be a binary coded decimal to seven segment decoder and whose output drives the digital display **18** by way of lead **58.** Decoder **56** is preferably formed from low power complementary MOS transistors and receives timing information from time circuit **40** by way of lead **60** and calendar information from calendar circuit **42** by way of lead **62.** This information passes to the decoder from the time circuit **40** and the calendar or date circuit **42** by way of a transmission gate circuit **68** receiving energy from the power supply over lead **72.** The time-keeping portion of the circuit **34** as well as the decoder **56** and transmission gate **68** by way of example only may be of the CMOS type shown and described in assignee's copending application Ser. No. 219,953 filed Jan. 24, 1972 entitled SOLID STATE WATCH WITH CALENDAR DISPLAY.

The keys of the keyboard **20** of FIG. **1** are connected to corresponding keyboard switches **64** of FIG. **2** which are in turn connected to an electronic calculator circuit **66.** This circuit is preferably formed of complementary MOS transistors and is provided with sufficient storage to perform the addition, subtraction, multiplication and division previously described. The output of the calculator circuit **66** which is preferably in the same BCD form as the time and date information is passed to the transmission gate **56** over lead **70.** The output from calculator **66** as well as the outputs from time circuit **40** and calendar circuit **42** are preferably encoded in accordance with the 8421 bcd code.

Calculator **66** and transmission gate **68** are energized from the power supply **32** through a mode switch **74** which is actuated in response to depression of the push button **26** of FIG. **1.** When mode switch **74** of FIG. **2** is closed, energy is supplied from the power supply **32** to the calculator and to the gate. Closure of mode switch **74** switches the gate so that instead of passing time information from the time leads **60** and **62** to the decoder it passes the calculator output information on lead **70.** Depression of the keyboard keys cause the calculator to perform the desired operation and its output which is internally converted into 8421 bcd signals passes through decoder **56** to energize display **18** with the desired answer or result. Once calculations are completed, push buttom **26** is again depressed opening switch **74,** de-energizing the calculator circuits and removing the signal on lead **74** to the transmission gate so that the decoder again displays time information from time circuit **40** and calendar circuit **42.**

FIG. **3** shows a portion of the keyboard **20** including a plurality of keys **78** and FIG. **4** is a cross section through three of these keys. The keys **78** are preferably formed of electrical conductive plastic of the snap acting type having sufficient resiliency to snap back after depression into the arcuate shape illustrated by keys **80** in FIG. **4.** By way of example only the conductive plastic for the keys may be formed of a composition of micron-size copper particles dispersed in a cross linked polymer classified as a conductive polymer. Volume resistivity and thermal elasticity are a function of the metal loading by weight. When one of the keys such as key **84** in FIG. **4** is depressed as by the end of a standard ball point pen or similar device, the central portion of the key engages the head of an electrically conductive pin **86** passing through the face **16** of the watch. Similar pins **88** and **90** secure the edges of the key and each of these pins is connected to an electrically conductive lead **92** while the center pin **86** is con-

nected to a corresponding lead 94. It can be seen that depression of key 84 into engagement with the head of pin 86 establishes an electrical circuit between leads 92 and the central lead 94 so as to complete a circuit in the calculator circuitry 66 of FIG. 2. When the key is released the inherent resiliency of the plastic material from which it is formed causes it to snap back into the arcuate position illustrated by the keys 80 and 82, thus breaking the circuit to the calculator.

FIG. 5 shows a modified keyboard construction involving no moving keys. In this embodiment the electrically insulating watch face 16 has secured to it an electrically conductive metallic layer 100 having suitable key indicia imprinted on it. This layer is connected to the calculator circuit 66 of FIG. 2 by a common lead 102. Passing through face plate 16 of the watch are electrically conductive pins 104, 106 and 108 and the upper ends of these pins extend above the face plate 16 and are received in concave hollows or cavities 110, 112, and 114 etched out of or otherwise suitably provided in conductive metal layer 100. An electrical circuit is completed from the common lead 102 through layer 100 to the appropriate one of pins 104, 106 or 108 by inserting conductive metallic stylus 116 into the appropriately labelled aperture or cavity so that the stylus is in contact both with the metal layer 100 and with the appropriate pin such as the pin 108. This completes a circuit to the calculator by way of lead 102 and the corresponding one of the electrical leads 118, 120 and 122 of the pin 104, 106 and 108.

FIG. 6 shows a modified embodiment of the combination wristwatch and electronic calculator of the present invention with like parts bearing like reference numerals. In the embodiment of FIG. 6 the liquid crystal display 18 is replaced with an identical display 112 except that the display 112 employs light emitting diodes rather than liquid crystals. That is, whereas the liquid crystal display 18 in the embodiment of FIG. 1 is a passive display, the display 112 of FIG. 6 is an active one. Furthermore, since the light emitting diodes forming the display 112 draw a significant amount of current from the wristwatch battery when they are illuminated, the device 110 of FIG. 6 also incorporates a demand push button 114 so that the time information is only displayed, that is, the light emitting diodes are only energized to display time when the push button 114 is manually depressed.

The operation of the calculator portion of the device 110 of FIG. 6 is the same as that in the embodiment of FIG. 1 previously described. However, in order to further conserve the energy drawn from the battery by the light emitting diodes in the embodiment of FIG. 6, the diode stations forming the display 112 are preferably strobed so that only two digits of the time display are on at any one time. However, this strobing is at a sufficiently high rate or sufficiently high frequency so as to give the appearance of a continuous light emitting display at all stations whenever the demand push button 114 is depressed. FIG. 7 shows an overall block diagram of the electrical circuit for the embodiment of FIG. 6 including the arrangement for strobing the light emitting diode display 112. Reference made be had to assignee's copending application Ser. No. 219,956 filed Jan. 24, 1972 for a detailed disclosure of an arrangement for strobing a light emitting diode time display which may be utilized in the embodiment of FIGS. 6 and 7 of this invention.

Briefly, with reference to FIG. 7, the crystal oscillator 36 is connected to the time and date circuits 118 which correspond to the time circuit 40 of FIG. 2 and the calendar circuit 42 of FIG. 2 but which in the embodiment of FIG. 7 are combined into the single circuit 118. Again the circuit is preferably formed of large-scale integrated circuits comprising as active elements only complementary symmetry MOS transistors. The time information in binary coded decimal form according to an 8421 bcd code is supplied to the combined switching, decoding, and logic circuits 120 again formed solely of active elements in the form of CMOS. Also forming a part of the LSI time and data circuit 118 of FIG. 7 is the CMOS divider 38 of FIG. 2 and from this divider is derived a clock strobe pulse signal generally indicated in FIG. 7 by the clock strobe pulse source 122 feeding a strobe pulse into circuit 120. The strobe pulses generated in circuit 120 are applied by lines 124 to strobe the display 112. Timing information in suitable form for driving a seven bar segment array of light emitting diodes at each station is supplied to the display over leads 126. These are applied through discrete bipolar driver transistors 128 to the eight stations of the display 112. The keyoard and mode circuit 130 operates in the manner previously described in conjunction with the embodiment of FIG. 1 as does the LSI calculator circuit 132. As in the previous embodiment when the mode button 26 of FIG. 6 is depressed, the calculator circuit is energized, the calculator memories are cleared, and the light emitting diode display stations are all energized to display a zero at each station. The desired problem is inserted by the keyboard and the result of the addition, subtraction, multiplication or division is numerically displayed by the eight digit display station 112. When the calculation is completed and the result noted the push button 26 of FIG. 6 is again depressed opening the mode switch, de-energizing the calculator portion of the device and switching the decode circuit over to receive the input from the combination time and date circuit 118. As previously indicated in the embodiment of FIGS. 6 and 7 although timing information is supplied to the display, the display is not actually energized to display timing information until the demand button 114 of FIG. 6 is depressed.

It is apparent from the above that the present invention provides an improved wrist calculator and in particular provides a wrist device which combines the features of both a wristwatch or timepiece and a miniature calculator. Important features of the present invention include a novel miniature keyboard which is incorporated on a wristwatch case and also includes the utilization of common decoding circuitry for displaying both time and the results of mathematical calculations. Since all active electrical elements of the combined device with the exception of the bipolar drivers for the light emitting diode display in the embodiment of FIGS. 6 and 7 are preferably formed of complementary symmetry MOS transistors, substantially the entire electrical circuitry for the device of this invention may be formed using large-scale integrated circuit techniques and may consist of only one or at the msot only a few large-scale integrated circuit chips. The use of complementary symmetry MOS transistors insures that there is only a small power drain on the wristwatch battery forming the sole power supply for the device since complementary symmetry MOS transistors draw only a

minimum amount of current. Based upon a normal number of operations per day a conventional two cell wristwatch battery should have a life in the device of the present invention of from 6 months up to as much as a year and one half before it need be replaced.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A combination wristwatch and wrist calculator comprising a wristwatch case, an electro-optical digital display on said case, a timing circuit in said case, means for coupling said timing circuit to said display, a calculator keyboard on said case, an electronic calculator circuit in said case coupled to said keyboard, and means for coupling said calculator circuit to said display.

2. A device according to claim **1** wherein said display comprises a plurality of light emitting diodes.

3. A device according to claim **1** wherein said electro-optical display comprises four display stations for displaying the hours and minutes of time.

4. A device according to claim **3** wherein said display comprises additional display stations for displaying calendar information.

5. A device according to claim **4** wherein said additional stations comprise four stations for displaying day and month in numerical form.

6. A combination wristwatch and wrist calculator comprising an electro-optical digital display, a power source coupled to said display, an electronic timing circuit including a reference frequency electrical signal source, a decoder coupling said timing circuit to said electro-optical digital display, a calculator keyboard, an electronic calculator coupled to said keyboard, and a manually operated switch for coupling said electronic calculator to said decoder, said decoder coupling the output of said calculator to said display when said switch is operated.

7. A device according to claim **6** wherein said reference frequency electrical signal source comprises a crystal oscillator.

8. A device according to claim **6** wherein said power source comprises a battery.

9. A device according to claim **8** including a voltage up-converter coupling said battery to said electro-optical display.

10. A device according to claim **6** wherein said switch is actuated by a mode button on said device.

11. A device according to claim **6** wherein said switch also couples said power source to said electronic calculator whereby said calculator is only energized upon operation of said switch.

12. A combination wristwatch and wrist calculator comprising a wristwatch having a watch face, an electro-optical digital display on said watch face, a power source coupled to said display, an electronic timing circuit including a crystal oscillator and divider normally coupled to said display, a keyboard mounted on said watch face adjacent said display, an electronic calculator coupled to said keyboard, and a manually operated mode switch coupled to said timing circuit and to said calculator for uncoupling said display from the output of said timing circuit and coupling said display to the output of said calculator.

13. A device according to claim **12** wherein said keyboard comprises a plurality of flexible and resilient keys.

14. A device according to claim **13** wherein said keys are made of an electrically conductive plastic.

15. A device according to claim **12** wherein said keyboard is made entirely of stationary elements.

16. A device according to claim **15** wherein said keyboard comprises an electrically conductive metallic layer on said face, said layer including a plurality of apertures, and an electrically conductive pin passing through said face and into each of said apertures whereby an electrical circuit may be completed between said layer and one of said pins by inserting an electrically conductive stylus into one of said apertures.

17. A device according to claim **12** including a common decoder coupling said timing circuit and said electronic calculator to said display, said mode switch switching the input of said decoder between the output of said timing circuit and the output of said calculator.

18. A device according to claim **17** including a transmission gate coupling said calculator to said decoder.

19. A device according to claim **18** wherein said mode switch is coupled to said transmission gate.

20. A device according to claim **1,** wherein said display is a liquid crystal display.

21. A device according to claim **20,** wherein said display is a field effect liquid crystal display.

22. A device according to claim **12,** wherein said display comprises a plurality of display stations, each formed of light-emitting diodes, a strobe signal source, and means coupling said strobe signal source to said display for sequentially energizing at least some of the stations of said display.

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