LED Sandglass: an electronic eggtimer

Have you ever tried to boil an egg in free fall or during a lunar orbit and found that your old sandglass eggtimer didn't work? Well your problems are now over with our new LED Sandglass. It measures time intervals of up to five minutes, giving you a perfect hard or soft boiled egg every time, and even sounds a buzzer when it's finished timing.

by RON DE JONG

The old sandglass or "hourglass" is a convenient way to measure short time periods such as when boiling eggs (or timing TV programs between commercial breaks). Unfortunately it's hardly in keeping with all the advances made in electronics so we've come up with an electronic version that's completely solid-state, uses a LED display, and features a buzzer to indicate when the set time has elapsed.

No longer must you put up with "runny" eggs that turn your toast into a soggy mess, or one that is so hard that Professor Julius Sumner Miller would prefer to squeeze it into a milk bottle using atmospheric pressure ("fire goes out . . . reduction in pressure . . . egg on top" – kerplop! What a stupid ad). Our LED Sandglass is much more sensible.

As can be seen from the photograph, we have arranged 30 LEDs in the shape of a sandglass. When the unit is first turned on all the LEDs in the top "bulb" will be on. As time passes, the topmost LEDs will turn off in sequence and the corresponding LEDs in the bottom bulb will turn on, giving the impression of sand dribbling from the top bulb to the lower.

As an added feature we have included a mercury switch so that, at the completion of timing, the unit can be turned upside down just like a real sandglass. This automatically resets the circuit and the "sand" begins to pour back into the other bulb – figuratively speaking, that is! You can also reset the circuit in mid-cycle by turning the unit upside down, with all the "sand" immediately going back to the top bulb.

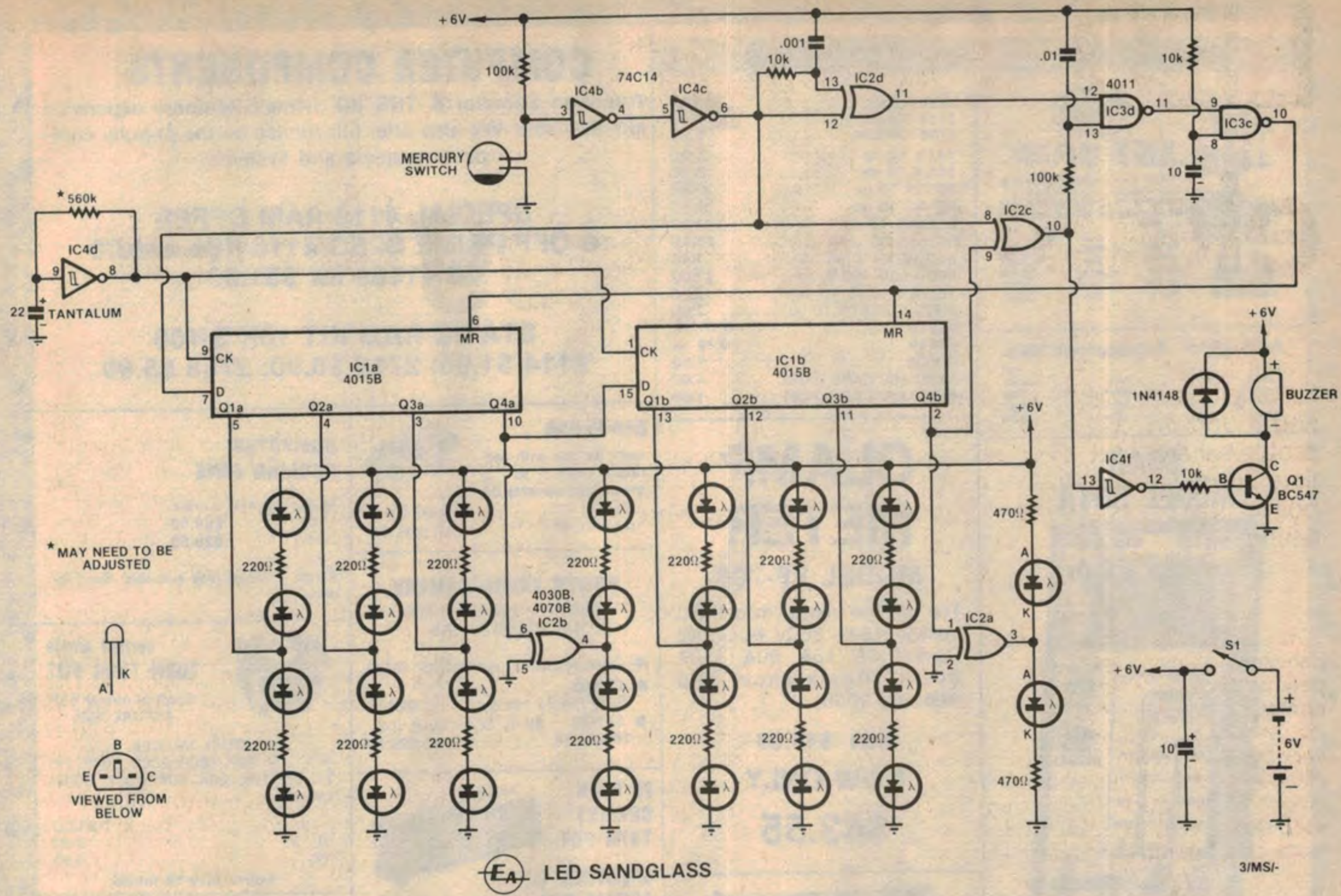
So in some respects our LED Sandglass is actually better than a real sandglass. After all, a real sandglass cannot be instantaneously reset in mid-cycle, doesn't have a buzzer, and cannot be seen in the dark! Mind you, we have yet to meet the person who wishes to boil an egg while free-falling in pitch darkness, but you never know!

THE CIRCUIT

The circuit of the LED Sandglass is straightforward, using just four low-cost CMOS ICs, 30 LEDs, and a handful of other components. Heart of the circuit is the 4015B IC, which contains two independent 4-bit serial in/parallel out shift registers. Each shift register has a clock input, data input, reset and four parallel outputs.

We have wired the 4015B to form a single 8-bit shift register by connecting the clock and reset inputs together and the last output of the first shift register (IC1a) to the data input of the second register (IC1b). The eight outputs of the resulting 8-bit register, Q1A to Q4B, are connected to an array of LEDs, each output driving two LEDs to the positive sup-

> We estimate that the current cost of parts for this project is about
>
> **$25**
>
> including sales tax.



The mercury switch provides an instant reset function and enables the LED Sandglass to be used either way up.

ply rail and two to ground via current limiting resistors.

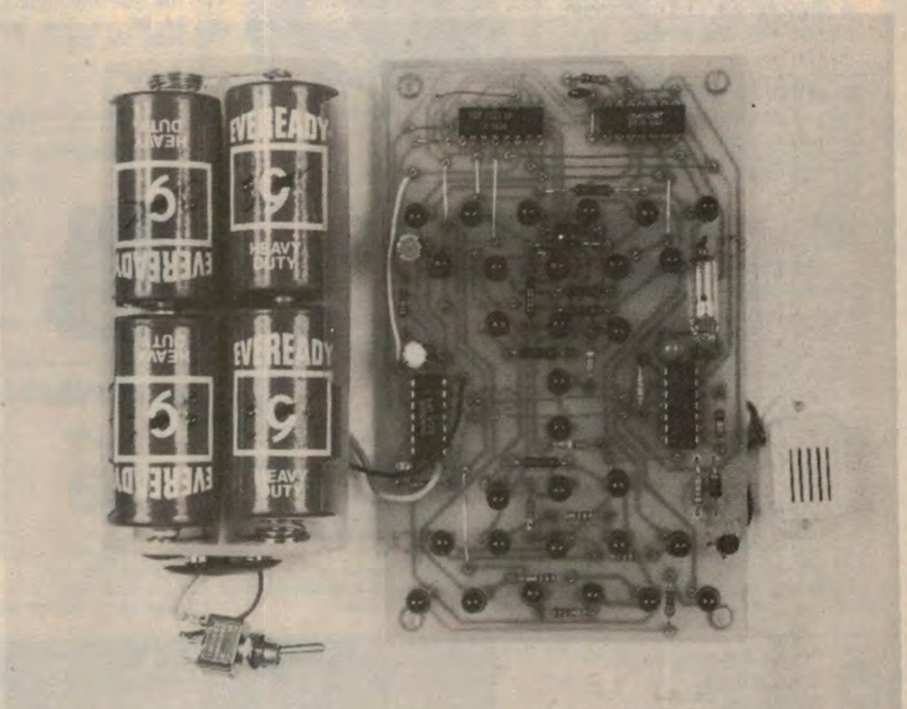
While the visual arrangement of LEDs on the circuit differs from the front panel layout, the basic scheme is really very simple: the LEDs going to the supply are arranged in the "top" bulb and those to ground are in the "bottom" bulb.

When the unit is first turned on a brief reset pulse is applied to the register, setting all the outputs to zero. This will cause all the LEDs connected to the supply to turn on, and those to ground to turn off – in other words all the LEDs in the top bulb are on and those in the bottom bulb are off. A logic high is then clocked into the shift register at the data input, pin 7 of IC1, which causes the first output (Q1A) to go high, turning two of the LEDs in the top bulb off and two in the bottom bulb on. Effectively two "grains" of sand have fallen from the top bulb to the bottom bulb.

As the shift register is further clocked the remaining outputs, Q2A to Q4B, will go high in sequence until eventually all the LEDs in the top bulb are off and all those in the bottom bulb are on.

What has happened is that the 8-bit register has been progressively filled up with logic highs (or ones). When the sandglass is subsequently turned over, the register is progressively filled up with logic lows (or zeros).

Whether zeros or ones are loaded into the register is determined by the data input, pin 7, of IC1a which is driven by Schmitt trigger IC4c. IC4c, in turn, is controlled by IC4b and a mercury switch. When the mercury switch is closed, the output of IC4c will be low, and when the switch is open the output of IC4c will be high.



The mercury switch is mounted so that it lies flat against the PCB.

WIRING DIAGRAM

One other aspect of the shift register circuit which should be mentioned is that the pin 10 and pin 2 outputs of IC1 do not directly drive the LEDs but go via XOR gates IC2a and IC2b. This was done because the LEDs represent an appreciable load to the CMOS outputs, preventing them from switching to the correct logic levels to drive the data input (pin 15) of IC1b and (pin 9) of IC2c.

Actually the transition voltage of CMOS is ½Vcc and this, coupled with the output characteristics of buffered or "B" series CMOS, means that the circuit would probably still work. However, because we had the two XOR gates to spare, we decided to play it safe.

Note also that we have only used one LED to ground and supply on the Q4B output of the shift register. This is simply an artistic requirement since only 15 LEDs are required in each "bulb".

The oscillator connected to the clock input of the shift register is comprised of IC4d, a Schmitt trigger using just one resistor and a capacitor. Because of the very low frequency required we have to use correspondingly large resistor and capacitor values, in this case a 560kΩ resistor and a 22μF tantalum. To ensure that leakage current in the capacitor does not load the 560kΩ resistor, we have specified a tantalum or low leakage electrolytic.

Due to variations in the trigger levels of the Schmitt there may be some variation in the frequency of the oscillator from unit to unit. We therefore suggest that the unit be calibrated by timing and the 560kΩ resistor adjusted accordingly. The time taken for the sandglass to empty is proportional to the resistor value and increases with increasing resistance. On our unit, the values shown gave a time interval of three minutes.

So far we have a circuit that works as a LED sandglass. We now have to add additional circuitry to reset the unit when it is turned upside down in the middle of timing, ie while the "sand" is still flowing. First off, we have to detect when the sandglass has "emptied", and this is done using IC2c, an XOR gate. One input of IC2c is connected to the data input of the shift register and the other is connected to the output. When the data input and final output are the same, ie the register has fully shifted and the glass is empty, IC2c will go low.

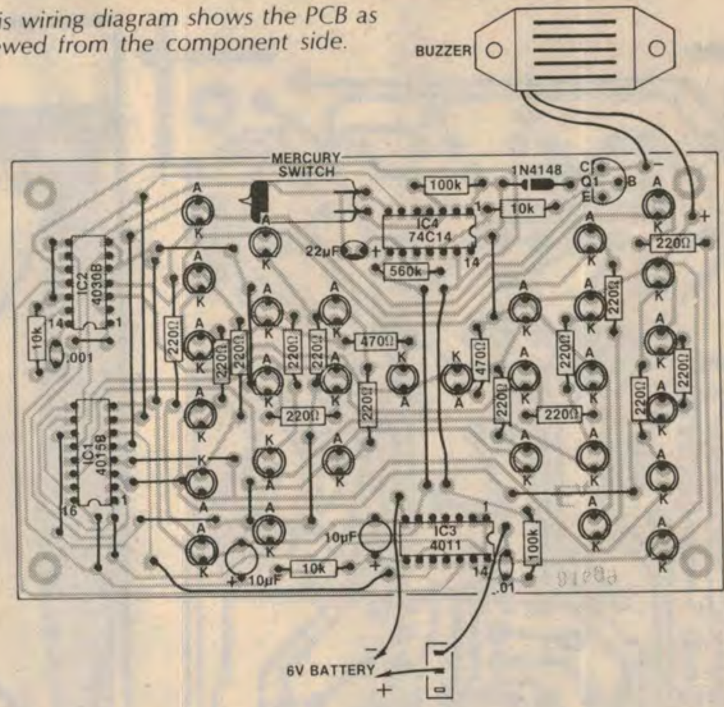
Another XOR gate, IC2d, is used to detect when the unit is turned over. One of its inputs is connected to the output of IC4c which, as we mentioned earlier, is low or high depending on whether the unit is right way up or upside down (ie whether or not the mercury switch is closed). The other input of IC2d is also connected to IC4c, but via an RC delay network consisting of a 10kΩ resistor and .001μF capacitor. The effect of this is that when the unit is flipped over IC4cs output changes, changing the pin 12 input of IC2d immediately and the pin 13 input after the RC time delay. Since the output of an XOR gate is high when the two inputs are at different logic levels a brief high pulse will be generated by IC2d.

The two outputs of IC2d and IC2c are NANDed together by IC3d. Since IC2d goes high briefly when the unit is turned over and IC2c is high when the unit is still counting, the output of IC3d will go low when the unit is turned over during counting. IC3c effectively ORs this signal with a power on reset signal to pin 8 and generates a reset pulse which is applied to the master reset pins of the shift register. This "OR" function results because if either the output of IC3d or the power on reset is low, IC3c's output will go high causing a reset.

The power on reset circuit consists very simply of a 10kΩ pull-up resistor and a 10μF capacitor to ground. The 10μF capacitor is initially discharged so when power is first applied the low logic level causes the output of IC3c to go low, resetting the shift register. After a short period, given by the time constant of the resistor and capacitor, the 10μF capacitor will charge up to a voltage above the ½Vcc transition point and the pin 8 input of IC3c goes high.

Finally, we have added a buzzer which is turned on when the LED Sandglass has finished counting. This is done by connecting the output of IC2c to Schmitt inverter IC4f. IC2c goes low when counting finishes so the output of IC4f will go high, turning on transistor Q1 via a 10kΩ current limiting resistor. The transistor

This wiring diagram shows the PCB as viewed from the component side.



PARTS LIST

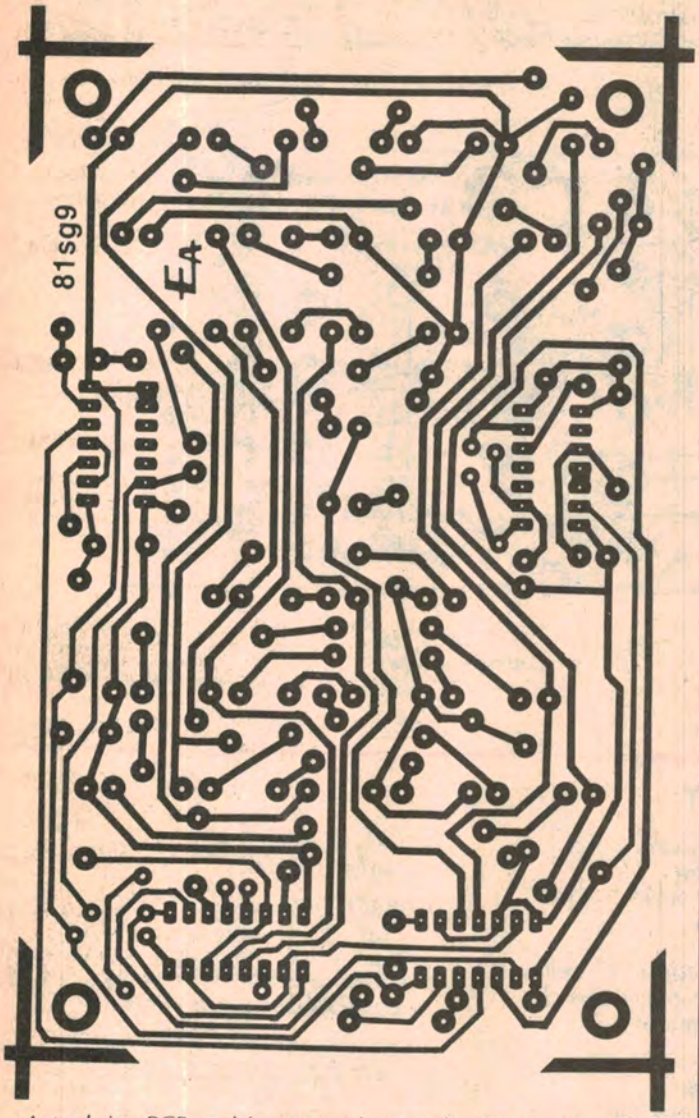
1 printed circuit board, 81sg9, 132mm x 82mm
1 zippy box, 159 × 95 × 51mm
1 mercury switch
4 1.5V "C" cells
1 battery holder for 4 "C" cells
1 SPDT miniature toggle switch
4 25mm brass standoffs
1 6V buzzer

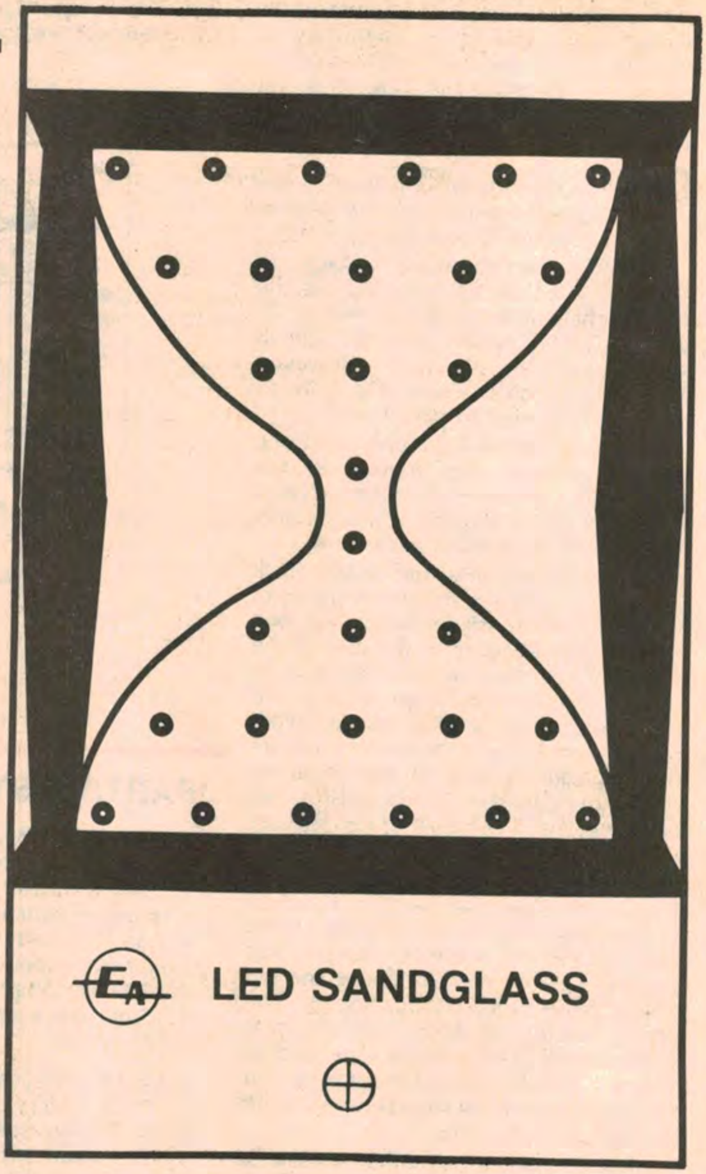
SEMICONDUCTORS
1 4015B CMOS dual shift register
1 74C14 Hex Schmitt trigger
1 4011 quad NAND gate
1 4030B or 4070B quad XOR gate
1 BC547 NPN transistor
1 1N4148 diode
30 large red LEDs

CAPACITORS
1 22μF 16VW tantalum
2 10μF 16VW electrolytic
1 0.01μF greencap or ceramic
1 .001μF greencap or ceramic

RESISTORS (all ¼W, 5%):
1 × 560kΩ 2 × 100kΩ, 3 × 10kΩ, 2 × 470Ω, 14 × 220Ω

NOTE: The "B" suffix on a CMOS IC part number indicates that it is a buffered device. Where specified, buffered devices must be used.





Actual-size PCB and front panel artworks. Finished boards and panels are available from the usual retail outlets.

drives a 6V buzzer, while a diode across the buzzer suppresses inductive spikes which could damage the transistor.

Power is obtained from four "C" cells and switched via S1. Current consumption of the unit is about 40mA, giving an expected battery life of about 80 hours or about 1600 hard-boiled eggs.

CONSTRUCTION

Construction of the unit is simplified by having most of the components including the LEDs, mounted on a single printed circuit board (PCB), coded 81sg9 and measuring 132mm x 82mm. Mount the resistors, links and capacitors first, leaving the CMOS ICs and mercury switch till last. Use the overlay diagram included in this article as a guide to component placement and orientation. Note particularly the orientation of the LEDs, remembering that the anode lead of most LEDs is slightly longer than the cathode lead and that there is a flat on the rim of the LED near the cathode.

When mounting the CMOS ICs take special precautions to avoid damage due to static electricity. Use an earthed soldering iron and solder the supply pins first (usually 7 and 14 or 8 and 16) to enable the internal input protection diodes. The mercury switch is mounted last of all, taking care not to break the glass bulb.

With all the components mounted the board can now be mounted inside a suitable case. We used a standard plastic zippy box measuring 159 × 95 × 51mm, and mounted the board using 25mm brass standoffs. Due to the height of the "C" cell battery pack, we had to add three nuts to the brass standoffs to clear the board from the batteries. The battery pack should be secured using a suitable clamp made from scrap aluminium.

Actual size artwork for a front panel is shown elsewhere in this article and can be used to produce a Scotchcal front panel. Finished front panels can also be obtained from the usual retail outlets.

After sticking the Scotchcal panel onto the aluminium lid of the box drill holes for the LEDs using a small diameter drill, then ream out the holes from the Scotchcal side of the panel.

Next mount the on/off switch and buzzer and complete the wiring to the board. Briefly recheck the orientation of the ICs, electrolytics and LEDs and also check for solder bridges between tracks. If all is well switch on the unit right side up. All the LEDs in the top bulb should initially be on and they should gradually turn off over a period of about three minutes with the corresponding LEDs on the bottom turning on.

If longer or shorter times than three minutes are required the 560kΩ resistor connected to IC4d should be increased or decreased proportionally.

So that's it. Now you can cook the perfect egg every time!