By John J. Yacono

Derby Stuff

We are still in the midst of our pinewood-derby exploration, and there is a little more to go. So this month, like last, we'll skip our usual tutorial and present only some reader's circuits, as those circuits will take up a lot of space by themselves. The contributors will be rewarded with a "Think Tank II" book and, as a bonus for taking part in the derby round-up, an MCL1010 chip. For now, let's take the day . . . .

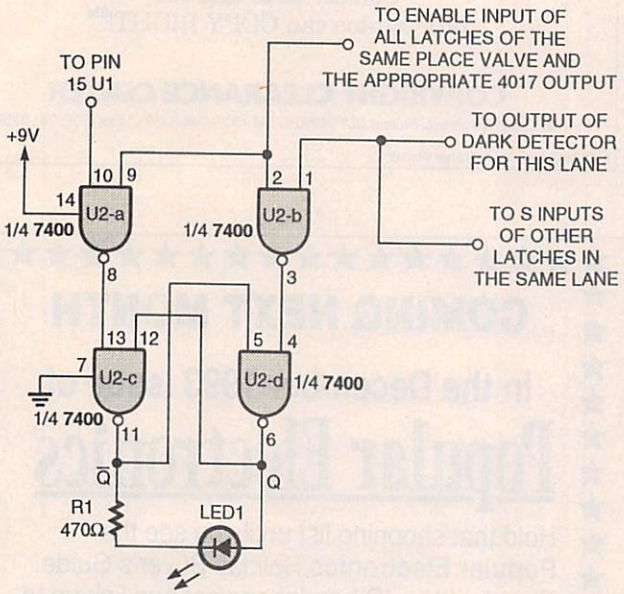

Fig. 1. This is one of 36 latch circuits ready to light its LED when triggered by a detector circuit (not shown here).

LATCHES GALORE

With regard to Stephen Guye's problem of which pinewood derby car finishes first, second, third, fourth, fifth, and sixth, here's my solution: An array of (six rows of six) subcircuits made from super-bright LED indicators that are each connected to a 7400 quad two-input NAND gate that is configured as an RS (set/reset) latch (see Fig. 1). Each subcircuit is connected to the five others in its lane, and the five others in the other lanes that hold the same place value (as you can see by the terminal circles).

Arranged to form a matrix like the one in Fig. 2, each column of subcircuits forms the display for a lane, and each row represents a finishing place. Each row of RS latches (representing a place value) is enabled by a 4017 CMOS decade counter (see Fig. 3).

As a car passes over the finish line, it interrupts the light to a phototransistor embedded in the center of its lane at the finish line. The phototransistors are used to form six dark-detector circuits, one for each lane as shown in Fig. 4. The light interruption causes the circuit to produce a positive-going pulse that causes pin 6 on whichever RS latch is enabled by the 4017 to go high, turning that subcircuit's particular LED on.

At the same instant that a particular car has been registered at a place (let's say that the sixth car passes the finish line first, the sixth LED lights in the first row to indicate a first place winner), a pulse is also received at pin 14, of U1 (4017), causing the first row (first place) to be disabled, and the next row of latches (second place), to be enabled and ready for the next car to trigger one of the sensors in the remaining lanes and, in turn, register the second place winner, and so on. The detection is so accurate that there cannot be any ties. An SPDT reset switch is connected to pin 15 of U1 (4017) and pin 10 of U2 through U37 to reset the decade counter and the RS latches so you're ready for a new race!

P.S. I didn't seem to have any problem using a 9-volt power source for both the CMOS IC and the TTL IC's. The circuit worked fine without providing a special 5-volt source for the TTL's.

—Denny Gregg, Oroville, CA

It might not work without the extra voltage! If the 7400 IC's aren't the special 7400-S6 variety (which can handle up to 15-volts), they are likely to burn out. Further, a straight TTL chip is not designed to source the current needed to light an LED. That's why the extra voltage has worked to your advantage thus far; it's forcing excessive current through the 7400's outputs.

I would recommend replacing the 7400 IC's with CMOS equivalents. Otherwise, drop the voltage to 5 volts, re-calculate the current-limiting resistor values, and disconnect the anodes of the LED's from pins 6 and 12 of the latches, and connect them directly to the 5-volt source instead.

HYBRID DERBY

Since some sections of this circuit are reproduced six times, the explanation will be confined to the circuitry used by track one. Each track uses a 74373 transparent latch with six LED's at its outputs to indicate which "place" its car held when it crossed the finish line (see Fig. 5). The first six inputs of all the latches are tied to the six least-significant outputs of a CMOS 4017 decade coun-

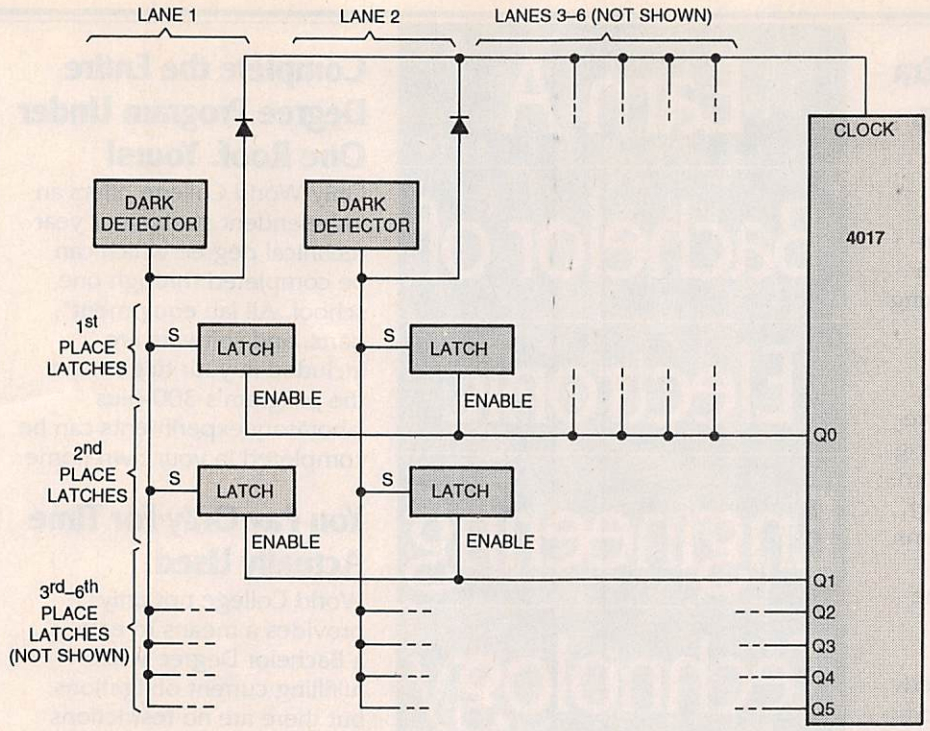

Fig. 2. Arranged to form a matrix, each latch is connected to other latches in the same lane and to the latches that hold the same place in the other lanes. For simplicity, on the first- and second-place latches for the first two lanes are shown.

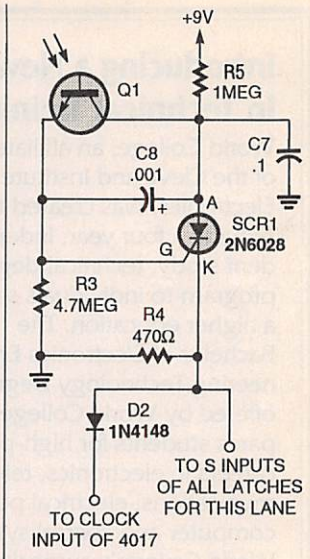

Fig. 4. There is one dark detector/clock-pulse generator (like the one shown here) for each lane of the derby. Each detector/generator circuit sends a pulse to the latches in its lane and clocks the 4017.

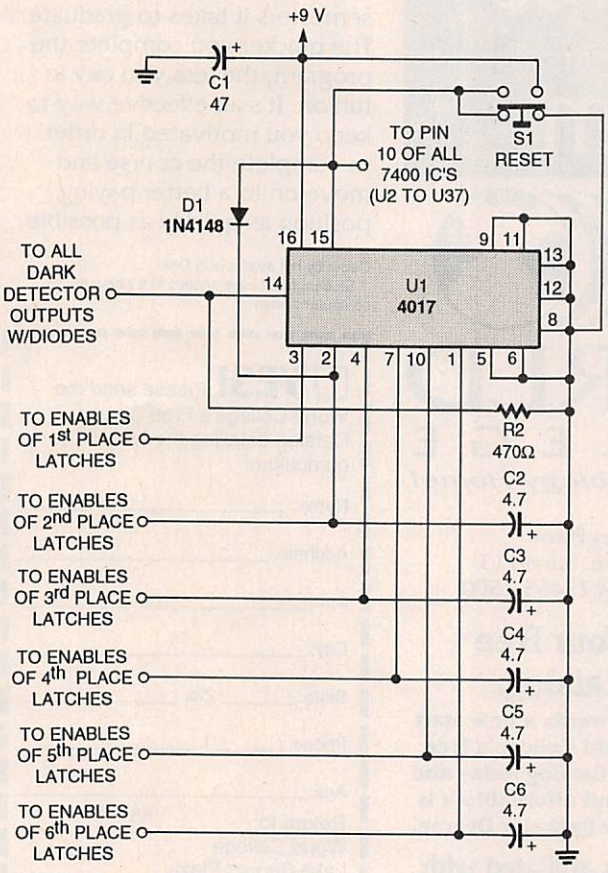

Fig. 3. The 4017 receives clock pulses from all of the dark detectors in order to enable the appropriate set of running-place latches. An SPDT switch (S1) is used to reset the circuit to prepare for the next race.

ter (see Fig. 6), which is set up to advance one count each time the finish line is crossed by a car.

Each track has an IR LED/detector pair (see Fig. 7) that triggers an SCR when its light path is interrupted by a car. When any SCR is fired, its anode is pulled low (to about 0.75 volts). That low is fed to the latch-enable (LE) input pin of the appropriate data latch, causing its outputs to freeze and hold the data from the 4017 appearing at its inputs. A voltage divider, consisting of R8 and R9, is used to scale down the voltage at the SCR anode to a level that is suitable for the 74373 (which is a TTL device). In addition to latching the 74373, when any SCR is fired, the 4017 is

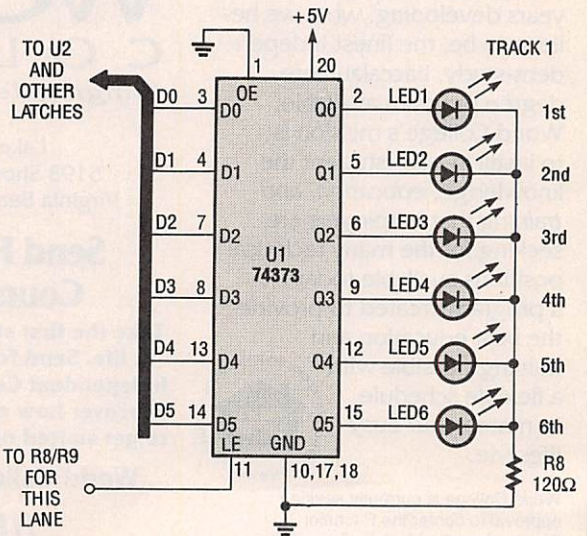

Fig. 5. The display circuit is designed to show the finishing position of the lane's car with discrete LED's.

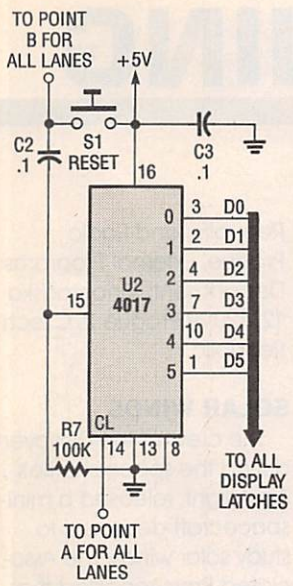

Fig. 6. The decade counter/divider is responsible for counting the cars as they finish, thus providing the place of each car to its latched display (look back at Fig. 5).

clocking the 4017. All increment circuits are isolated from each other by a diode to prevent damping of the pulses.

For proper operation, the appropriate latch must by set before the 4017 advances. That is not a problem as the TTL device is inherently faster and the pulse to the 4017 is delayed by the increment circuit.

When the reset button is pressed and released all six SCR's are left nonconducting due to the interruption of their holding current. The large-value base resistor on the increment circuit will not pass enough current to hold the SCR on. The reset button also resets the 4017 via C2 and R7. Since all of the SCR anodes are now high, all of the latches are transparent, causing them

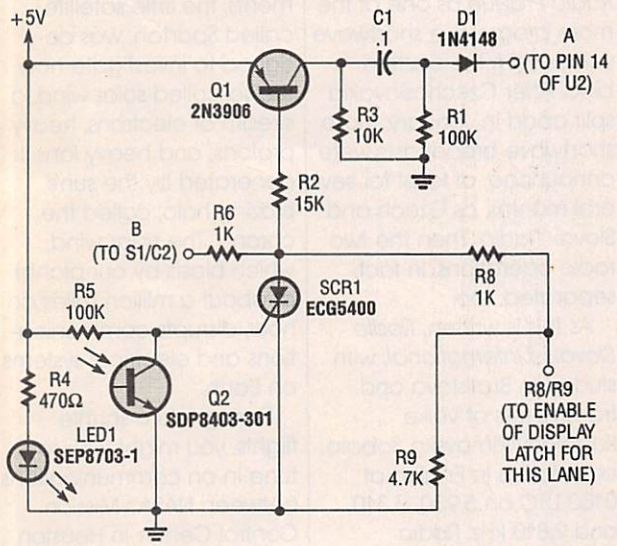

Fig. 7. This circuit detects a passing car, clocks the 4017 (back in Fig. 6), and activates the latch for its lane.

clocked, causing it to advance by one count.

Transistor Q1 has its base tied to the anode of its respective SCR and, so, it is turned on when the SCR is fired. When Q1 switches on, a rising pulse is generated at the junction of C1 and R1, which lasts as long as it takes C1 to charge. That pulse forward biases D1, to pass data from their inputs to their outputs.

When the circuit is reset and in the standby mode at the beginning of a race, all latches will have a logic high on their Q_0 (first place) outputs and so the corresponding LED will be lit. As the first car breaks the light path, the latch for its track will hold the high on its Q_0 output. The 4017 will advance one count, as will all latches except for the one that is latched.

As the second car crosses the line, its latch will hold Q1 high and all other latches will advance one place. After all six cars have crossed the finish line, the LED display will graphically show the relative position of each car as the finish line was crossed.

—Jay Stevens, Columbus, OH

Nice blend of CMOS and TTL logic. Note that Jay kept the supply at 5 volts to accommodate the TTL IC's in the circuit.

Well, we've run out of space for this month. Until next month, be sure to send your creations (in letter form anyway) here to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■