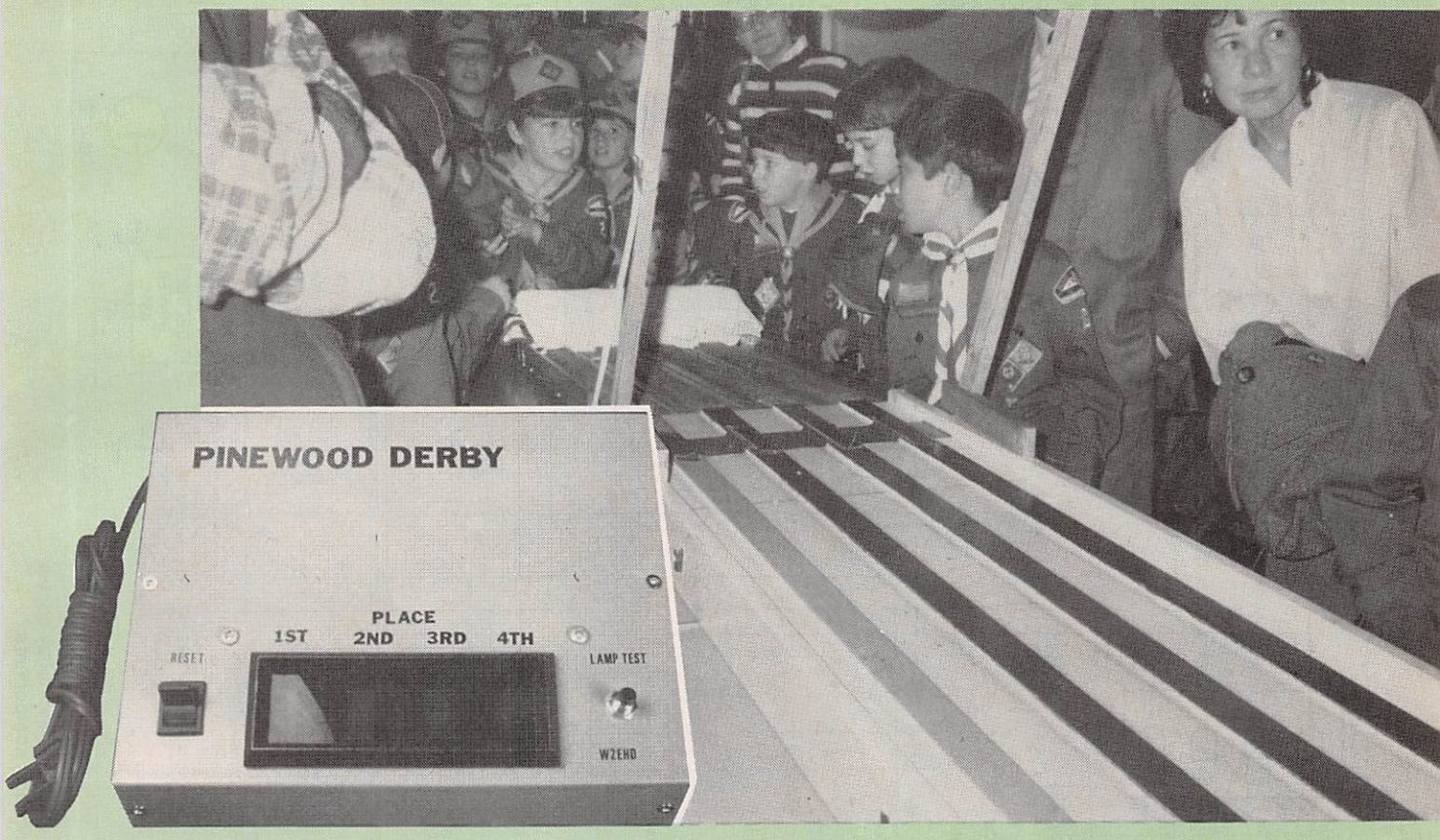


PINEWOOD DERBY SCOREBOARD

A goof-proof position indicator takes the guessing out of judging!

By John B. Meagher, W2EHD/Ex-W8JGN

THE PINEWOOD DERBY IS AN ANNUAL COMPETITION conducted by many Cub Scout Packs around the country. The Cubs are given a rough-cut block of pine, four round-head nails, four wheels, and good wishes. With those, they can carve their own race cars, assemble the wheels in place, paint them to their taste, and let them whiz down a gravity race track.

Parents are usually pressed into service as finish-line judges; it is not always an easy job! The little racers zip across the finish line at velocities of three to five feet-per-second.

Pity the poor judges who must try to remember the lane numbers for first, second, third, and fourth place! Some honest difference of opinion frequently occurs!

Having been pressed into service on the judging team several times, the author concluded that some method could be devised that will call even the closest of races.

The device shown here will determine the order of finish among as many as four lanes even if the racers are milliseconds apart!

How It Works

Basically, the Pinewood Derby Scoreboard (refer to the schematic diagram in Fig. 1.) simply waits until the finishing race cars darken the phototransistors (Q1–Q4) that are mounted just below the finish line in each lane.

Before the race starts, the Scoreboard operator hits the RESET switch S2, which zeros all the displays and enables U8, the 4511 decoder-driver that will show the first place winning lane number. As each car crosses the finish line, the number of the lane is flashed in BCD code onto the common input bus to the decoder-drivers (U8–U11). Note that only the A, B, and C input lines are used; since the Scoreboard is required only to count up to four, the D input line (8 in BCD) is grounded. Only one of the 4511 chips (U8–U11) can be enabled at a time. The chip that happens to be enabled gets a 47-microsecond "peek" at the lane number on the input lines, displays it and is locked, preventing any change, until the RESET switch S2 is pressed.

In addition to pulsing the lane numbers onto the BCD input

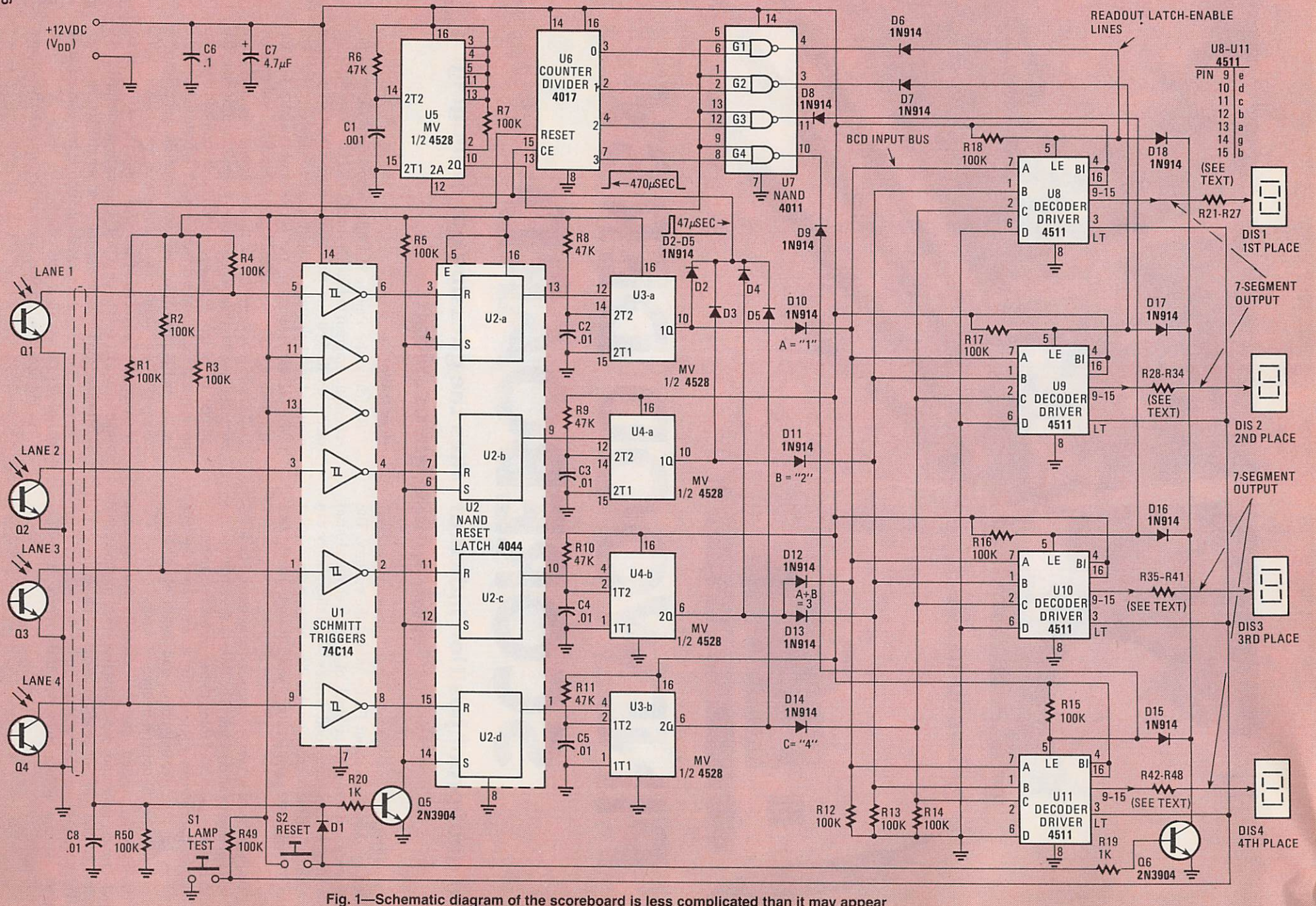


Fig. 1—Schematic diagram of the scoreboard is less complicated than it may appear at first glance. Much flexibility is permitted in non-critical components.

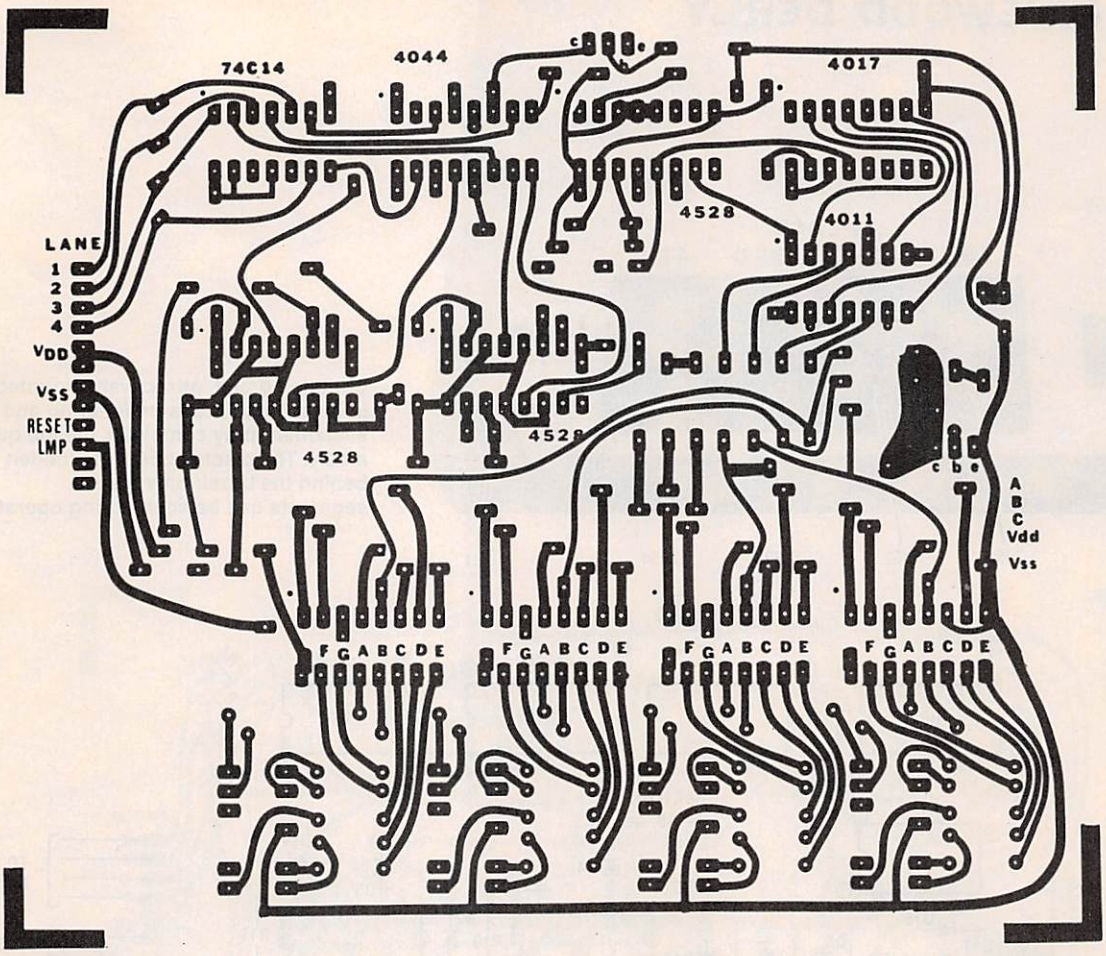
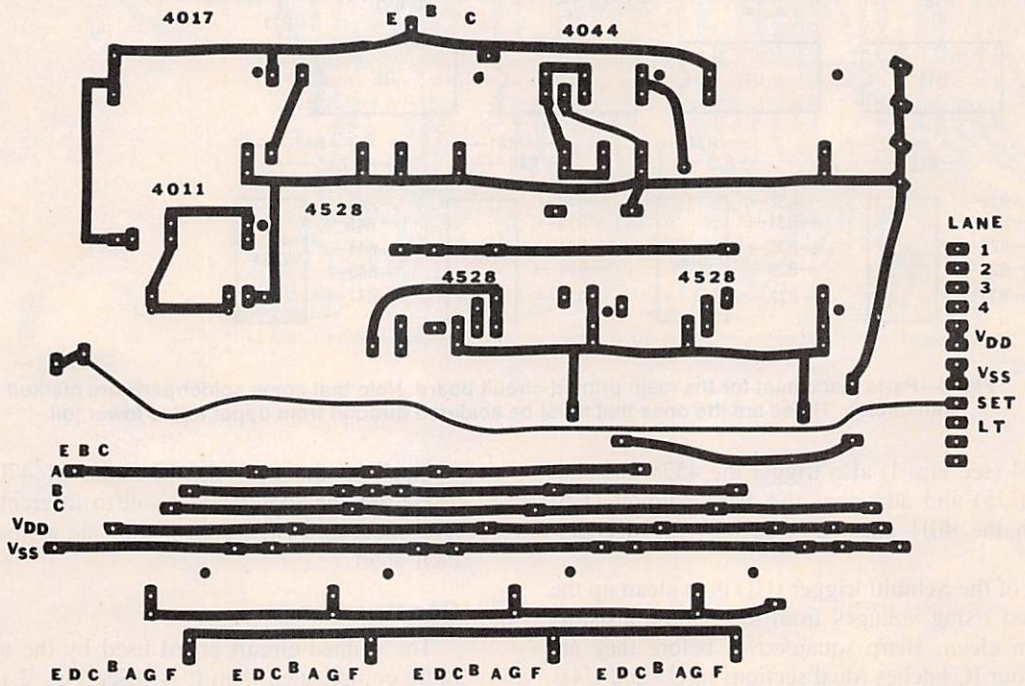
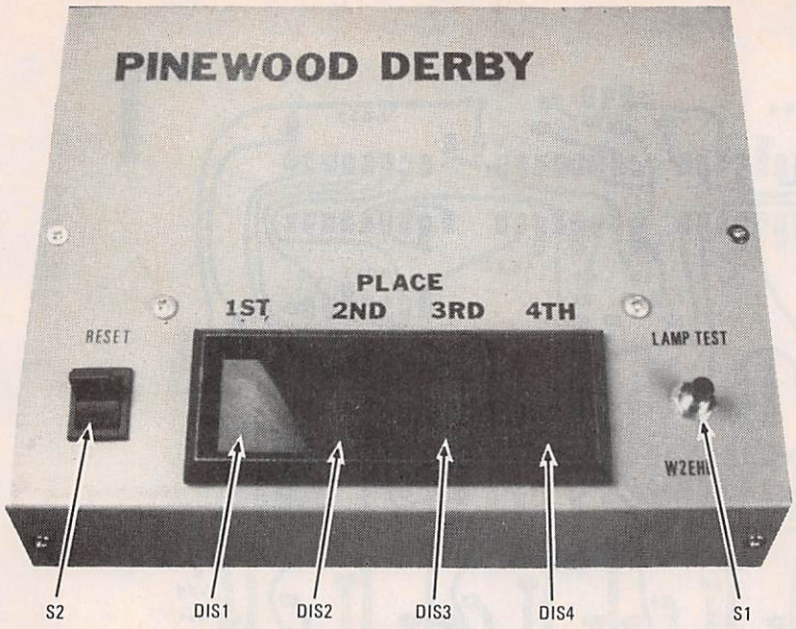


Fig. 2—Printed-circuit board templates are provided here for the Scoreboard's main circuit board. Foil side is shown above, component side below. Note that both sides must be etched, and some holes require soldering through.





Completed unit, attractively mounted in its cabinet. Press-on lettering and a lacquer spray completes the job quite nicely. The display LED's are hidden behind the bezel; only their lit segments can be seen during operation.

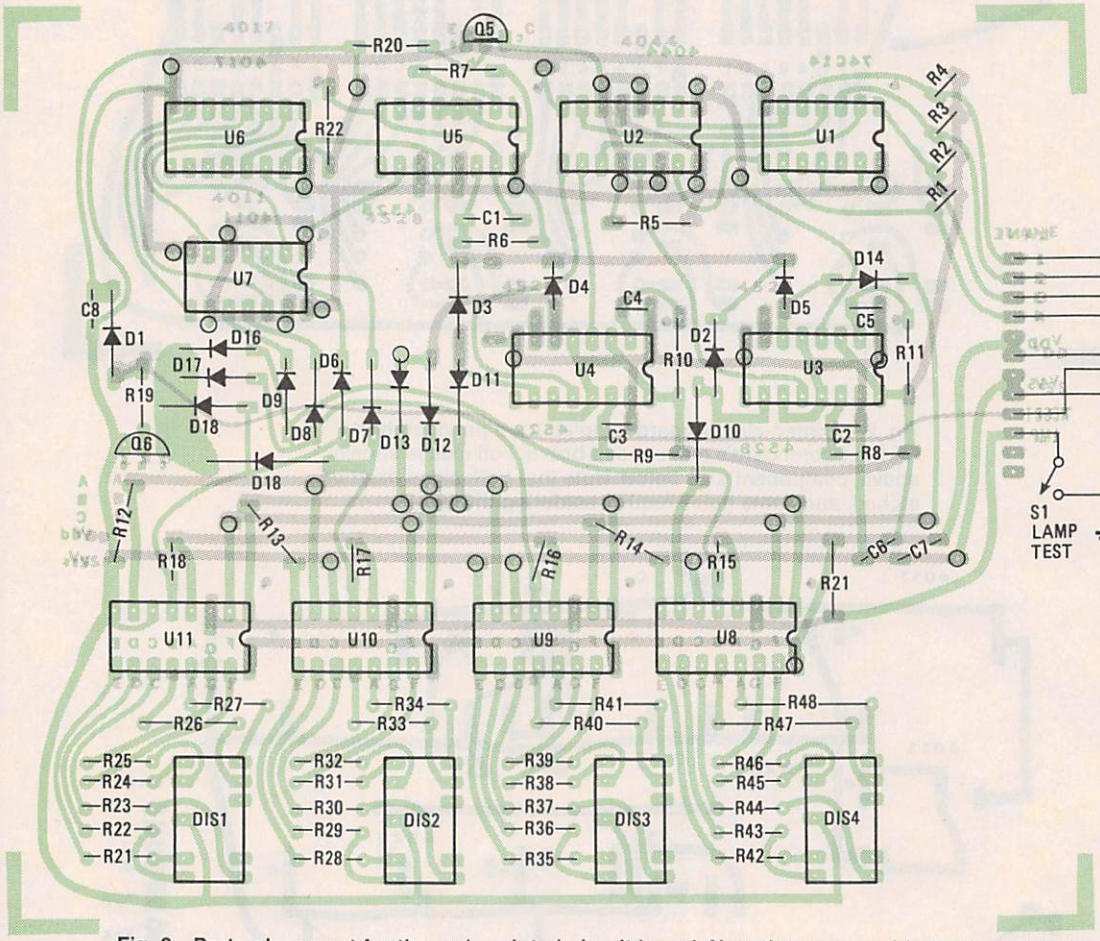


Fig. 3—Parts placement for the main printed-circuit board. Note that some solder pads are marked with circles. Those are the ones that must be soldered through from upper foil to lower foil.

bus, U3 and U4 (see Fig. 1) also trigger the 4528 one-shot multivibrator (U5) and advances the 4017 counter (U6) which, through the 4011 gate (U7) enables the decoder-drivers in turn.

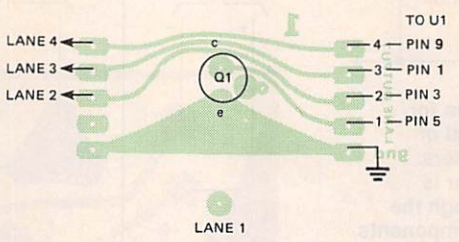
The purpose of the Schmitt trigger (U1) is to clean up the relatively ragged rising voltages from the phototransistors and make them clean, sharp squarewaves before they are applied to the four IC latches (dual sections in U3 and U4).

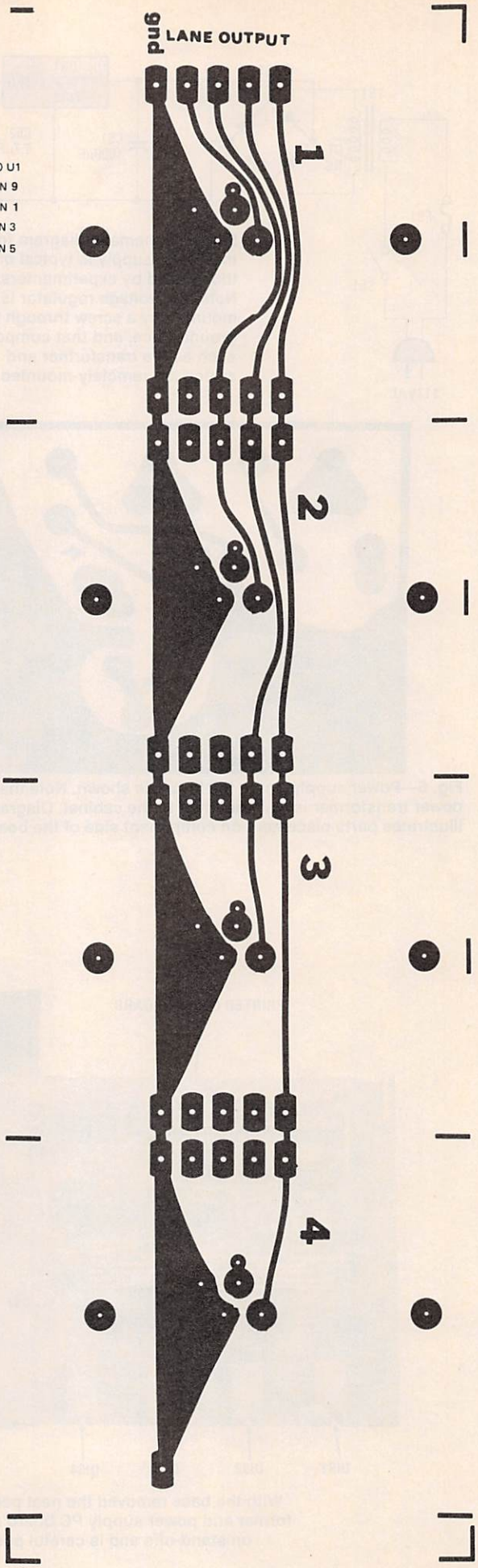
The Pinewood Derby Scoreboard transitions from one "place" to the next on the order of 470 microseconds. Therefore, the Scoreboard is able to differentiate between two rival racecars easily, even if they are a small fraction of an inch apart.

Construction

The printed-circuit board used by the author may seem more complicated than it is. (See Fig. 2.) The board is of double-foil construction; circuit traces are on both sides. The

Fig. 4—Foil side of phototransistor printed-circuit board layout is presented fullsize. Note that for spacing the phototransistors under pinewood car tracks, the sections can be sawed apart and connected by jumpers. The inset shows one section of the foil with connections made to it for lane one. Be sure to position the phototransistors in the center of the lane that they are judging.





PARTS LIST FOR PINEWOOD DERBY SCOREBOARD

SEMICONDUCTORS

U1—74C14 hex Scmitt trigger integrated circuit
U2—4044 quad NAND reset latch integrated circuit
U3, U4, U5—4528 dual monostable multivibrator integrated circuit
U6—4017 decade counter/divider integrated circuit
U7—4011 quad 2-input NAND gate integrated circuit
U8–U11—4511 BCD-to-7-segment latch/decoder/driver integrated circuit
Q1–Q4—NPN silicon phototransistor (Radio Shack 276-130)
Q5, Q6—2N3904 NPN transistor
D1–D18—1N914 silicon diode
DIS1–DIS4—Seven-segment, light-emitting diode display (Radio Shack 276-067)

RESISTORS

(All resistors 1/4-watt, 10% fixed units)
R1–R5, R7, R12–R14, R21, R22—100,000-ohm
R6, R8–R11, R15–R18—47,000-ohm
R19, R20—1000-ohm
R21–R48—820-ohm

CAPACITORS

C1—.001-μF. C2–C5, C8 .01-μF, ceramic
C6—.1-μF, ceramic
C7—4.7-μF, 16-WVDC, tantalum

ADDITIONAL PARTS AND MATERIALS

S1, S2—SPST, momentary-contact, pushbutton switch
Cabinet: 7-7/8 × 5-7/8 × 2-3/4 (Radio Shack 270-265); bezel/lens 3-9/16 × 1 (Radio Shack 270-301); (Note: The bezel comes with a polarized red filter. For use with yellow readouts, author found and used amber filter), printed-circuit materials and/or perfboard, power line cord, decals, wire, solder, hardware, etc.

PARTS LIST FOR POWER SUPPLY

BR51—Bridge rectifier; 1.4-A, 100-PIV (Radio Shack 276-1152)
C51—1000-μF, 18-WVDC, electrolytic capacitor
C52—4.7-μF, 25-WVDC tantalum capacitor
F51—1/2-A fuse
S51—SPST, toggle switch
T51—Power transformer; 12-V CT, 1.3-A (Radio Shack 273-1505) Note: Since this project draws only 200 milliamperes, the transformer is well-overated.)
U51—7812 voltage regulator, 12-VDC, 1-A (Radio Shack 276-1771)

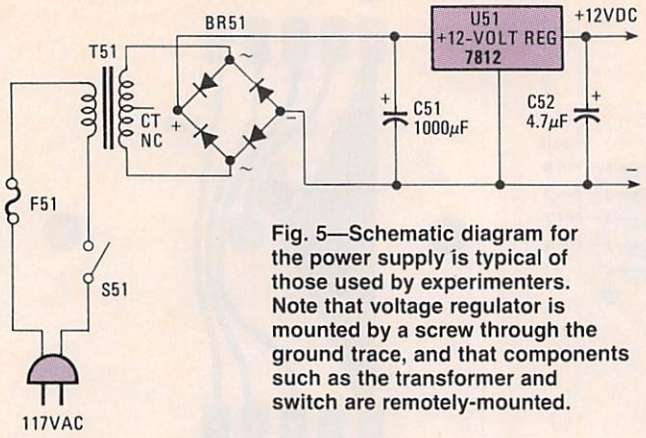


Fig. 5—Schematic diagram for the power supply is typical of those used by experimenters. Note that voltage regulator is mounted by a screw through the ground trace, and that components such as the transformer and switch are remotely-mounted.

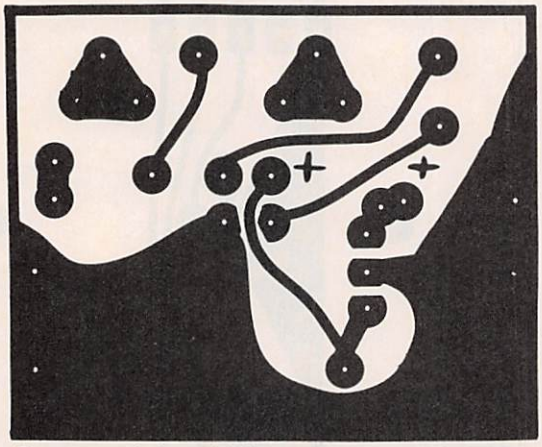


Fig. 6—Power supply board foil layout is shown. Note that the power transformer is wall-mounted to the cabinet. Diagram above illustrates parts placement on component side of the board.

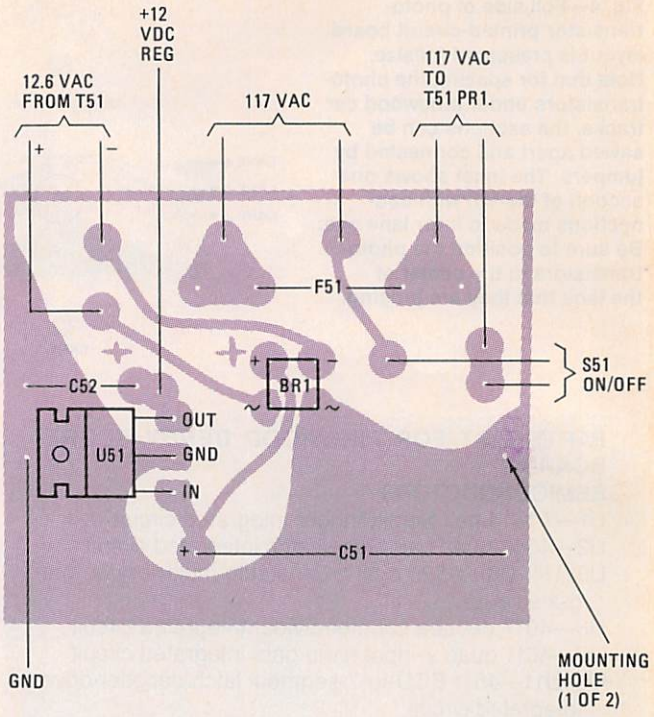
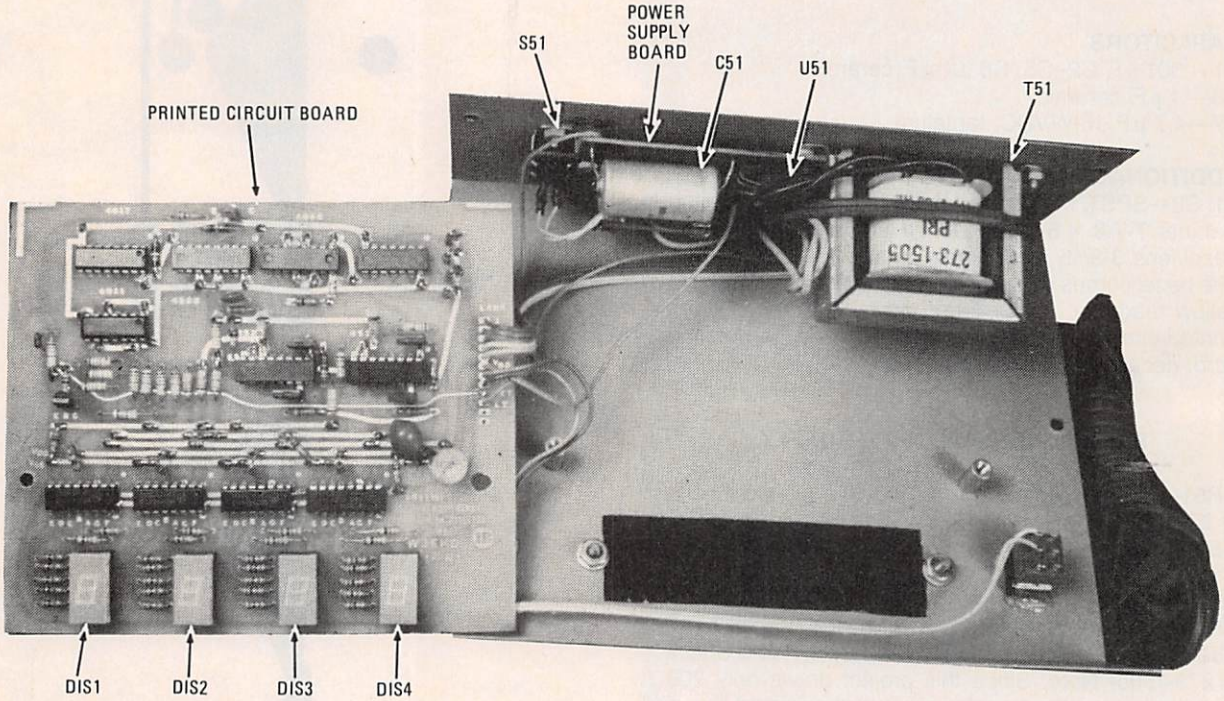


Fig. 7—Here is an x-ray view, foil-side down, of the board shown in Fig. 6 of parts location shown. If you have the 1N4000 series of diodes, you can construct your own BR1 (diode bridge) circuit.



With the base removed the neat package is revealed. Note placement of power-supply transformer and power supply PC board on back wall of cabinet. Main printed-circuit board mounts on stand-offs and is careful positioned beneath the window cut in the chassis cover.

Put it all together it spells "love!" At the extreme left volunteers and scouters work to assemble the Derby gravity track as Cub Scouts look on. In the center, excited Cubs wait at the finish line just before the cars are released. Why is the Pinewood Derby Scoreboard needed? In the right photo, we see the Cubs get excited as the cars go by. The action was so quick that the photographer missed the cars crossing the finishing line. That's why the human judge is not as reliable as the electronic eyes and circuitry of the Pinewood Derby Scoreboard.

The view of the back panel shows the power cord with strain-relief, the power supply on/off switch (S51) and a ribbon cable connector that the author used. That connector interconnects the external photocell transistors on their printed-circuit board with the internal circuitry of the Scoreboard. Any connector will do, or you may elect to hard wire the ribbon cable directly to the Scoreboard eliminating the need for a connector. Exactly how you do it is up to you!

ideal technique would be to use plated-through holes. Should you not have that technology in your shop to so assemble a double-sided board, a number of soldered jumpers will be necessary to make through-the-board connections. Whenever possible, use component leads (refer to Fig. 3) to make the connections. At some spots that interconnection is not possible so those locations are marked with circles to denote feed-through jumpers.

If you choose to solder the IC's to the board, then many jumpers can be avoided by using the IC pins, soldered top and bottom, to make the connections. (Caution: Be sure to use either a battery-powered or a well-grounded soldering iron before you do that.) In any case, those who fabricate their own printed-circuit board must give careful attention to the registration of the holes to make sure that they are within a few thousandths-of-an-inch of each other, front to back on the board.

The original Pinewood Derby Scoreboard used Hewlett-Packard yellow LED displays that were obtained from a mail-order surplus house. This version of the Scoreboard is designed to use Radio Shack yellow LED displays that are difficult to find. Almost any yellow LED display may be used,or even change color!The author chose 1000-ohm resistors (R21–R48) for the segment's current limiting resistors, because the device is fed from a 12-volt DC supply. An amber filter was cut to fit the bezel over the display LED's.

Figure 4 shows the printed-circuit board for the phototransistor layout. That board is optional, because you may elect to hard-wire the phototransistors (Q1–Q4) under the lanes of the gravity track.

The Power Supply

The power supply is a simple full-wave bridge that feeds a three-legged, 1-ampere regulator. (See Figs. 5, 6, and 7.) The parts in the power supply are identified in the fifty series of part numbers solely for identification purposes.

The connection cable from the cabinet to the phototransistors (Q1–Q4) mounted beneath the Derby's finish line is a 5-conductor, unshielded ribbon cable about 12-feet long. That permits the operator to remain out of the way of the crowd at the finish line. It is not necessary to duplicate the author's version exactly. It is possible, for example, to remotely locate the LED readouts, decoder-drivers, and the RESET switch, S2. The LAMP TEST switch (S1) is not mandatory; however, in case of a problem, it is convenient to verify that all LED segments of the four displays (DIS1–DIS4) are functional. If they don't all light up when the LAMP TEST switch (S2) is pressed it may be a clue to the glitch.

The lighting of the finish-line sensors is not critical. A 60-watt incandescent bulb about 25 to 30 inches over the finish line worked well. The aim of the illumination is to turn on the phototransistors fully. The collector voltage should be close to zero under the illumination; certainly it must be less than half V_{dd} if U1 is to make any logic decision when the sensors are darkened, turning them, off and permitting their collectors to rise to V_{dd}.

Do not use fluorescent lamps for finish line illumination because of the strong AC component in their light output. They'll work; but incandescent lamps are much better.

The Scoreboard had its full-scale trial at the Closter, New Jersey Cub Scout Pinewood Derby and acquitted itself admirably. That year, there were no knots of perplexed judges, no conflicting race calls, no discussions among judges and parents as to which car finished in which place. It made the event go lots faster, too!

There seems to be no problem in using the Scoreboard on a slotcar racetrack. Since slotcars make more than one circuit of the track during a race; however, the officials would have to make sure they zero the display during the final lap. It's also possible to attach other "bells and whistles" such as an elapsed timer. Other modifications can be dealt with as you encounter them.

My thanks to Neil Abitabilo, WA2EZN, for the photographs. ■