effects created when U1A is in transition between being totally high and totally low. This way the input to pin 9 is a clean signal.

The second stage of U1, namely U1B, is set up as a voltage comparator. Anytime the voltage input on pin 9 becomes greater than that set on pin 10, the output of U1B, pin 8, switches from high to low. Potentiometer P1 controls the detection sensitivity by setting the reference switching point for U1B on pin 10. Using the R4 value of 100KΩ, pin 5 is adjustable between 0 and 1.1 volts. When pin 8 is low it lights the L1 monitoring LED to show the block as occupied.

The product of R8 and C5 determines the turn-off delay, and the product of R3 and C5 determines the turn-on delay as long as R3 is considerably smaller than R8. Thus you can easily change the delay times if you wish. I enjoy the rather long 3.5 second turn-off delay, which not only solves the problems of intermittent contact, but also simulates the massive, slow-moving relays in prototype track circuits.

The third stage of U1, U1C, is set up as another voltage comparator with its input being the output of the time delay circuit. With equal values of R5 and R6, the switching point of U1C is set at half the supply voltage or 6Vdc. The output of U1C, pin 14, drives the open collector output transistor. When pin 14 is low, block clear, transistor Q1 is off resulting in its collector terminal, the output of the detector, being an open circuit. When pin 14 is high, block occupied, the base of Q1 becomes positive causing the transistor to conduct resulting in the collector being effectively connected to ground.

Assembling The DCCOD

The parts layout drawing is shown as fig. 13-13 and the parts list in table 13-1.

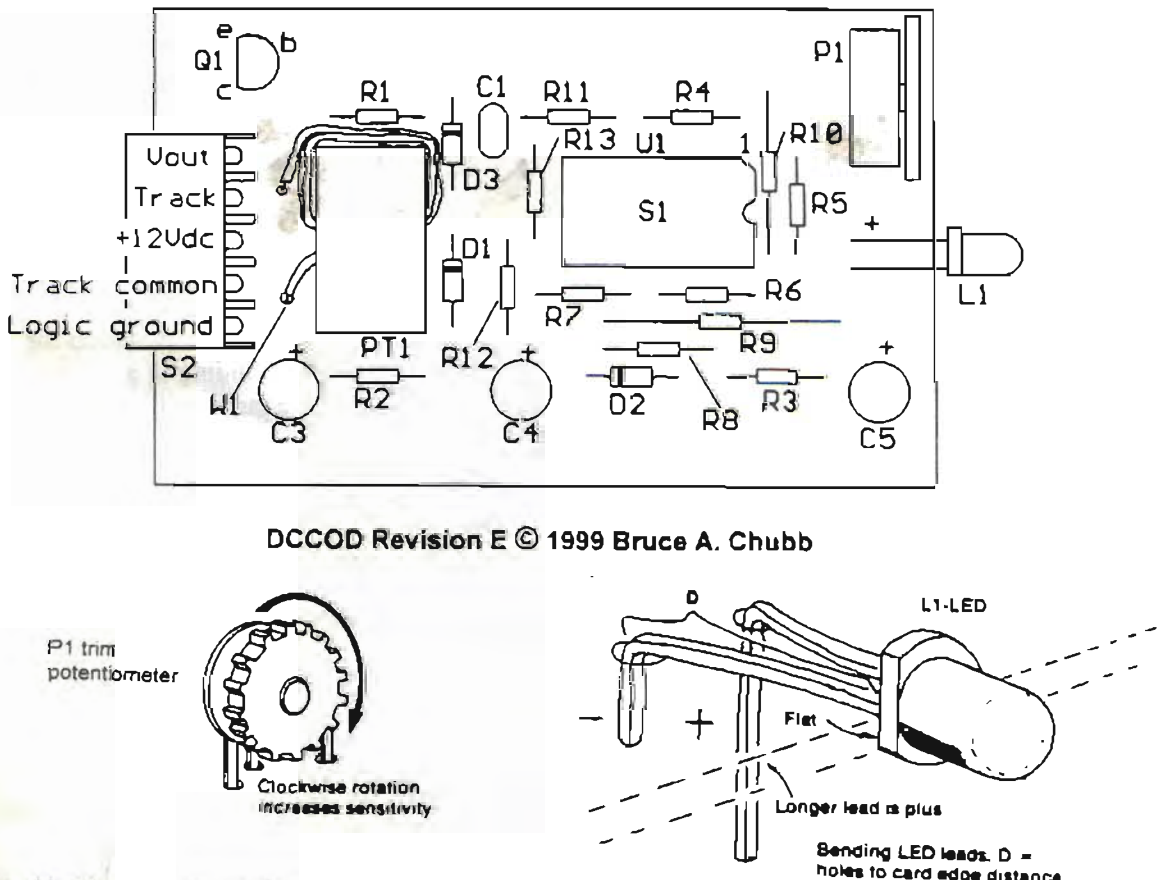

Fig. 13-13. Parts layout for DCCOD card

Table 13-1. DCC Optimized Detector Parts List (Revision E)
(In recommended order of assembly)

Qnty.	Symbol	Description
2	R1,R2	1.0KΩ resistors [brown-black-red]
1	R3	220KΩ resistor [red-red-yellow]
3	R4-R6	100KΩ resistors [brown-black-yellow]
1	R7	10KΩ resistor [brown-black-orange]
1	R8	3.3MΩ resistor [orange-orange-green]
2	R9,R10	1.0KΩ resistors [brown-black-red]
2	R11,R12	10KΩ resistors [brown-black-orange]
1	R13	1.0MΩ resistor [brown-black-green]
1	D1	Fast Schottky barrier rectifier (Digi-Key SD103ACT) 625-SD103C MOUSER
1	D2	1A, 100V diode (Digi-Key 1N4002GICT)
1	D3	1A, 100V high speed diode (Digi-Key 1N4934CT)
1	S1	14-pin DIP socket (Digi-Key A9314)
1	S2	5-pin Waldom side entry connector (Mouser 538-09-52-3051 or Digi-Key WM3302)
1	C1	.01µF monolithic capacitor (JDR .01UFMONO)
0	C2	Not used in Revision E detector
3	C3-C5	1.0µF, 35V tantalum capacitors (Jameco 33662)
1	P1	10KΩ potentiometer (Jameco 94713) or (Mouser 320-1510-10K)
1	Q1	2N3904 small signal transistor (Jameco 38359) or (Digi-Key 2N3904)
1	L1	Red diffused size T1 LED (Digi-Key P363)
1	U1	LM324N quad op amp (Jameco 23683)
1	W1	No. 22 solid insulated hook up wire or equivalent (see text), cut as required (JDR WJW22R with .045-inch insulation OD gives you 6-turn capability)
1	PT1	Current-sensing pulse-transformer (JLC PT1)

Author's recommendations for suppliers given in parentheses above with part numbers where applicable. Equivalent parts may be substituted. Resistors are ¼W, 5 percent with color codes given in brackets

Ready to assemble DCCOD circuit boards are available from JLC Enterprises along with the PR1 transformer or you can purchase assembled and tested boards from AIA and EASEE Interfaces. AIA also supplies DCCOD kits

For those wishing to assemble their own, the basic skill required is PC-card soldering. If that's a new one for you, make doubly sure that you have thoroughly digested the information on PC card soldering in Chapter 1 of the Second Edition book **Build Your Own Universal Computer Interface**.

The order of parts assembly is not critical, but for the sake of having a plan, follow the steps in order and check off the boxes as you complete each one. I've included a [+] after the symbol for each part where polarity of installation is important. As a further aid to assembly, the positive pad for polarity sensitive capacitors, the LED and pin-1 of the IC socket are square. Also, the longer lead, on capacitors and the LED, is the positive lead. Once you have one DCCOD assembled and operating correctly, you can use it as a pattern for assembling additional cards. Here's the recommended assembly steps.

☐ **R1-R13.** Make 90-degree bends in the leads of each resistor so it is centered between its two holes and the leads just fit. Insert and solder while holding the part flat against the card, then trim the leads.

☐ **D1-D3**[+]. Install same as resistors but make certain that the banded end of each diode is oriented as shown in fig. 13-13. Diodes D2 and D3 look pretty much alike except for the part number so double check the part numbers and make certain that you install the high-speed diode, the 1N4934, in the D3 location. The banded end of the fast Schottky barrier rectifier, a special glass diode, is sometimes hard to see. Take special care in locating the band and if required use a magnifying glass to double check the band orientation.

☐ **S1**[+]. Making certain that you have all 14 pins properly in their respective holes with the correct orientation for pin 1, hold the socket tight against the board as you solder the pins. If you are not sure of the correct orientation for pin-1, see fig. 1-8 of the Second Edition book. As with any multi-pin part, solder only a couple pins first, those on opposite corners of the socket. Reheat as necessary to make certain that the socket is firmly against the board, then solder the remaining pins.

☐ **S2**. Install this 5-contact side-entry connector by first hooking the nylon retaining fingers over the card edge, then feeding the metal contact pins through the card holes. Make sure all five pins pass through the holes. Hold the connector shell tightly against the card as you solder.

☐ **C1**. Insert this component with capacitor standing perpendicular to the card, solder, and trim leads.

☐ **C3-C5**[+]. Insert these components with capacitor standing perpendicular to the card. Make sure that the + leads go into the + holes as shown in fig. 13-13. Incorrect polarity will damage these capacitors. Solder and trim leads.

☐ **P1**. Install this trim potentiometer as in fig. 13-13, push the three prongs all the way into the holes as you solder. You may need to adjust the back, single, prong a bit so the potentiometer dial stands up perpendicular to the card.

☐ **Q1**[+]. Spread the leads of this transistor slightly to fit the three holes, making sure the center (base) lead goes into the hole closest to P1, and that the flat side of Q1 faces the direction shown in fig. 13-13. Push it in only far enough for it to fit snugly without stressing the leads. Solder and trim the leads.

☐ **L1**[+]. Note orientation of flat side and + hole (longer lead) in fig. 13-13. With needle-nose pliers, hold the leads securely next to the housing and bend at right angles as in fig. 13-13 detail. The LED sticks out over the edge of the card so you can see it when the detectors are plugged into their motherboard. Once bent and properly fitted to the cards, solder leads and trim.

☐ **U1**[+]. Insert the LM324 IC making sure you have the correct pin-1 orientation and that all pins go into the socket. If unsure of the correct procedure for inserting, and extracting, ICs see fig. 1-7 of the Second Edition book.

☐ **W1**. Start the primary winding for PT1 by cutting a piece of AWG 22 insulated wire about 12 inches long. I use solid wire as once in place it holds its position better but you might prefer stranded wire as it bends easier. Also, you might desire to use heavier wire, especially in O-scale and above, so I'll explain this option after the assembly steps. Thread one end of the wire through the center opening in PT1, the core, just like you would thread a needle. Wrap the wire tightly around the side of the transformer and back through the center hole.

Repeat this process until you have six passes through the core. Form the two wire ends so they are in position to fit into the holes next to connector S2. Cut the two leads so they extend about .25 inches below the base of the transformer and strip away the insulation about even with the base of the transformer. Note: Keep the turns going around the side of the transformer, and not over the top, or curved surface. Doing the latter makes the completed assembly too tall when multiple DCCODs are plugged into the ODMB.

☐ **PT1.** Insert the two leads of the transformer into the holes furthermost from connector S2 and the two primary lead wires into the two holes closest to S2. If required, readjust and/or re-trim the primary leads to get a proper fit. Once set, and with the transformer held firmly against the card, solder the two transformer leads. Pull snugly on the two primary leads, from the trace side of the board, to remove slack in the wires. Then solder and trim the two primary leads. Polarity orientation of the transformer and its primary wiring is not important.

☐ **Cleanup and inspection.** For a professional-looking job and to help ensure that your card functions properly, follow the specific steps covered in Chapter 1 of the Second Edition book regarding cleanup and inspection. This is a most vital step, so don't cut it short!

That completes the assembly steps for the DCCOD. If you are building up a large number of detectors, as for a club or large personal layout, you might want to hook up a detector power supply and a short piece of track at your workbench for detector testing. However, I find an adequate test is to simply plug each completed detector into an ODMB on my layout and make sure it detects occupation and clear correctly. Also, turning the sensitivity potentiometer all the way up, i.e. maximum clockwise, should result in an unoccupied block showing up as occupied. Turning the adjustment counterclockwise should yield a point where the detector shows a clear block as unoccupied. The normal setting for the detector should be about 1/8 turn below the point where an unoccupied block shows up as occupied. This setting gives you maximum usable sensitivity.

The DCCOD card layout uses wide traces and spacing between traces so soldering problems should be minimized. There are only two active components, the IC and the transistor, so debugging is easy and especially since the IC is in a socket.

Connections To ODMB When Using DCCOD

Fig. 13-14 shows how to hook up ODMBs when using the DCCOD. Simply run the detector power bus to each ODMB, whether located together or distributed around your layout. To power the DCCODs you need a power supply that provides a +12Vdc output. To protect the LM324 from voltage spikes, etc., this supply voltage needs to be well regulated and filtered so don't try to use a power-pack output set to 12Vdc.

I show how to build supplies in the Second Edition book but a simpler way is to use a surplus computer power supply. These typically supply the needed +12Vdc, as well as an unneeded -12Vdc, along with the +5Vdc you will be using to power the I/O cards, LEDs etc.

Using the DCCODs there are no connections between track wiring and logic wiring. Since the wiring is totally independent it makes no difference whether you use or do not use common rail, or common ground wiring on your DCC equipped railroad. You can double gap your booster section boundaries or you can single gap. You are free to use any brand of booster, optoisolated or not optoisolated. Any track ground you may have is totally separate from your logic ground.

The layout wiring diagrams presented in Chapter 11 show further examples of how the DCCOD is integrated into DCC-equipped layouts