Make ECL wire-wrapped panels reliable with proper routing and tough insulation

It's not enough merely to be concerned with the operational-performance problems of large wire-wrapped panels at emitter-coupled-logic (ECL) speeds. They can be solved with proper lead terminators, short paths, multilayer voltage-distribution planes and convenient discrete resistor and capacitor mounting arrangements.[1] But you'd better be prepared to take care of several additional problems of wire routing and insulation damage before you can expect reliable performance. They include:

- *Wide variations of IC-lead dimensional tolerances*, which can result in poor contacts or lead-receptacle damage.
- *Wire crowding*, which prevents proper dressing and the safe placement of wires.
- *Wire "curl,"* which makes wires difficult to route and place.
- *Nicked or gouged wire insulation*, which leads to shorts, some of which are intermittent, thus, hard to find.

Nevertheless, don't be put off by these problems. The advantages of ECL wire-wrappable panels justify the generally small efforts needed to solve them. The major advantages over multilayer PC boards include:

- Significantly shortened first-customer shipment cycle—weeks instead of months or years.
- Easier initial debugging and circuit modifications.
- Easier field maintenance and updating.

These important features far outweigh the extra process control that might be needed when making the wire-wrappable boards.

A typical panel (Fig. 1) specially designed for ECL logic has three controlled-impedance voltage-distribution planes—for V_{cc}, V_{tt} and V_{ee}—and pluggable sockets for both dual in-line (DIP) and single in-line (SIP) packages. Plane-to-plane filter capacitors are optimally spaced throughout the panel. Signal interconnections are wire wrapped to the 0.025-in.-square post extensions of individual DIP and SIP sockets. And individual DIP and SIP lead receptacles (Fig. 2) are arranged in 24-pin clusters on 0.1-in. grid increments, which also accommodate the 0.025-in. increment requirements of automatic wire-wrapping machine spacing.

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Lead receptacles are critical

These individual lead receptacles are the most critical part of a panel. If improperly treated, they'll severely compromise circuit reliability. Their spring contacts, limited in size by the socket barrel and panel-design factors, can't accept large variations in DIP and SIP lead sizes and at the same time maintain the minimum required contact mating force.

The recommended mating force for good electrical contact between the usual tin-plated IC-lead surface and the receptacle's gold spring-contact surface is 100 g. Unfortunately, the range of dimension of IC-lead sizes presented by ordinary DIPs and SIPs is generally more than the receptacles can safely accommodate.

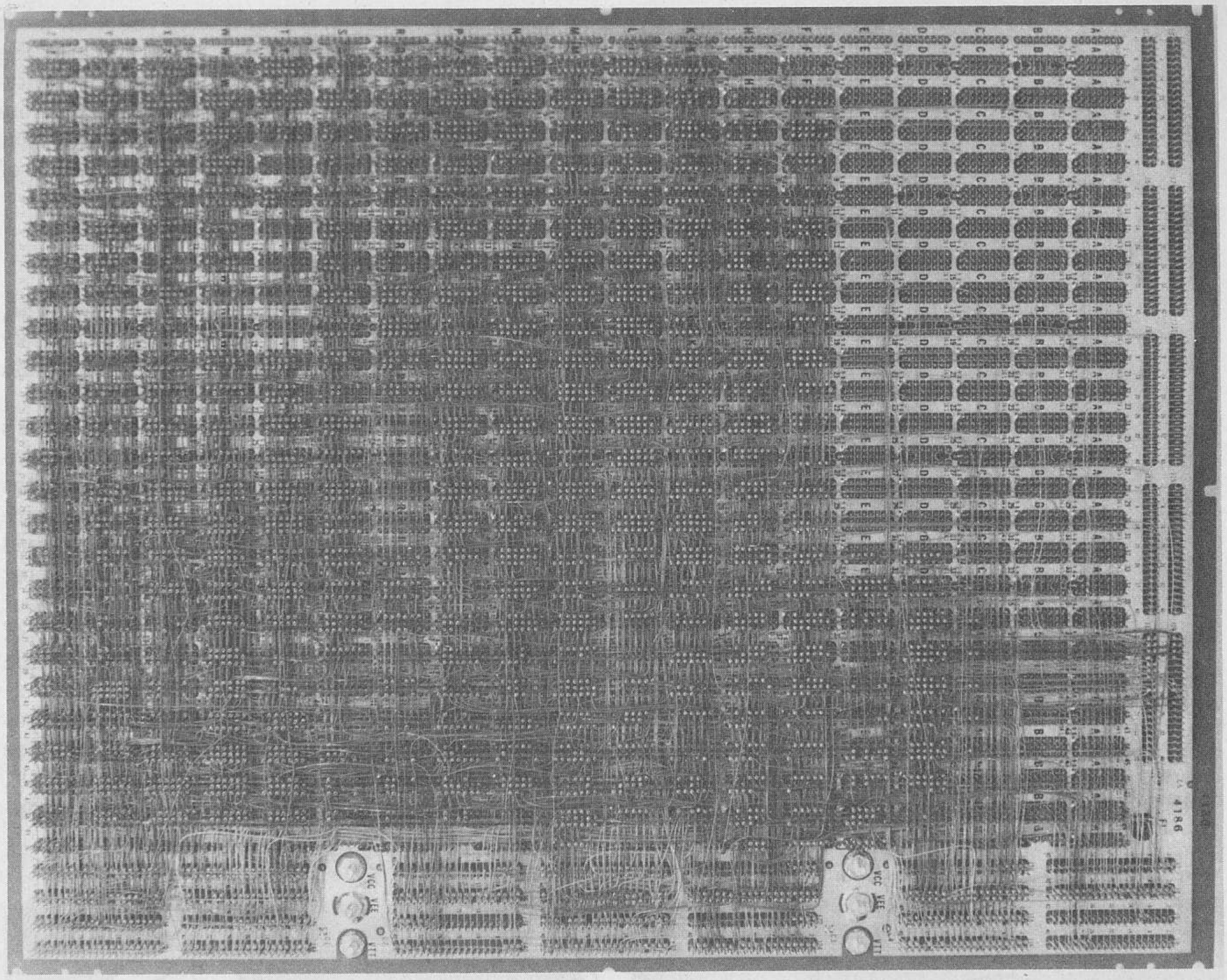
Table 1 contains a compilation from three major IC ECL suppliers—Motorola, Signetics and Fairchild—as well as the recommended range for wire-wrapping panels like those in Fig. 1. For reliable performance, run-of-the-mill DIP/SIP units should be checked and selected (or specified) to confirm that lead sizes conform to this range.

IC-lead dimensions larger than the Table 1 maximums can permanently distort the spring—and produce inadequate contact force when subsequently replaced with ICs having smaller sized leads. On the other hand, dimensions less than the minimums won't develop the recommended 100-g contact force.

Some IC manufacturers, recognizing this problem with pluggable sockets, are now attempting to control IC lead-size variations on selected IC packages, however, widely recognized standards are still several years away.

Nevertheless, heeding the recommendations of Table 1, together with good quality control of the lead-receptacle manufacturing process, can produce connections with reliability equal to that of well made wavesoldered connections of IC leads through good plated-through holes.

What's more the wire-wrapped connection on the other side of the receptacle adds very little more to



1. **Special three-layered wire-wrappable circuit boards** for high-speed logic DIPs can handle a high density of wires—over 6000, as shown on the wiring side of this densely packed board.

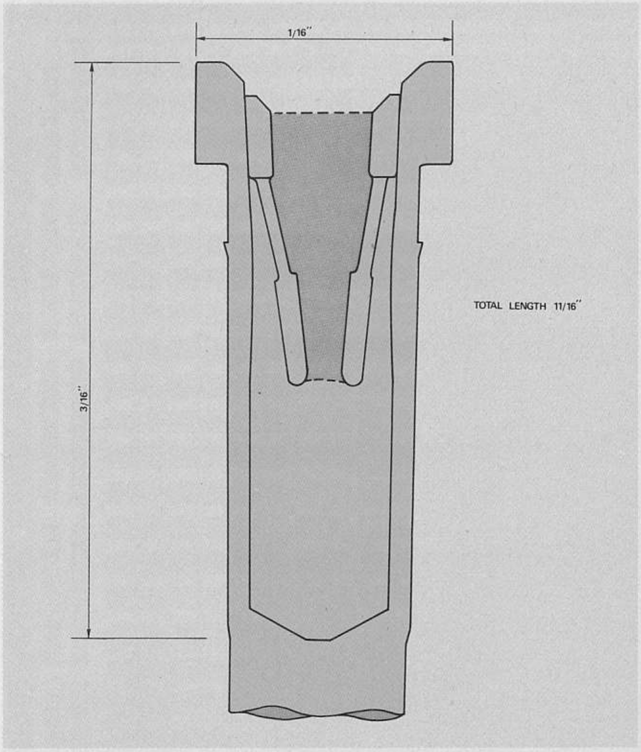
Table 1. IC lead sizes

Dimensions	*Actual size range		Recommended sizes	
	min	max	min	max
Length (L)	0.100 in.	0.165 in.	0.125 in.	0.150 in.
Width (W)	0.015	0.023	0.016	0.020
Thickness (T)	0.008	0.015	0.009	0.011

*Compiled from Motorola, Signetics and Fairchild ECL ICs.

Table 2. Connection failure rates

Connection type	Average failure rate (failures/10^6 hours)
Wire wrap (Gardner Denver Corp.)	0.0000037
Solder, reflow lap to PC boards	0.00012
Solder, wave to PC boards	0.00044
Weld	0.002
Other hand-solder connections (wire-to-terminal board)	0.0044
Crimp	0.0073



2. **Individual receptacle pins** arranged in fields to accept the leads of standard DIP and SIP units are the main and most important parts of the circuit board. The leads inserted into the receptacles should be within specific dimensional limits to ensure contact reliability.

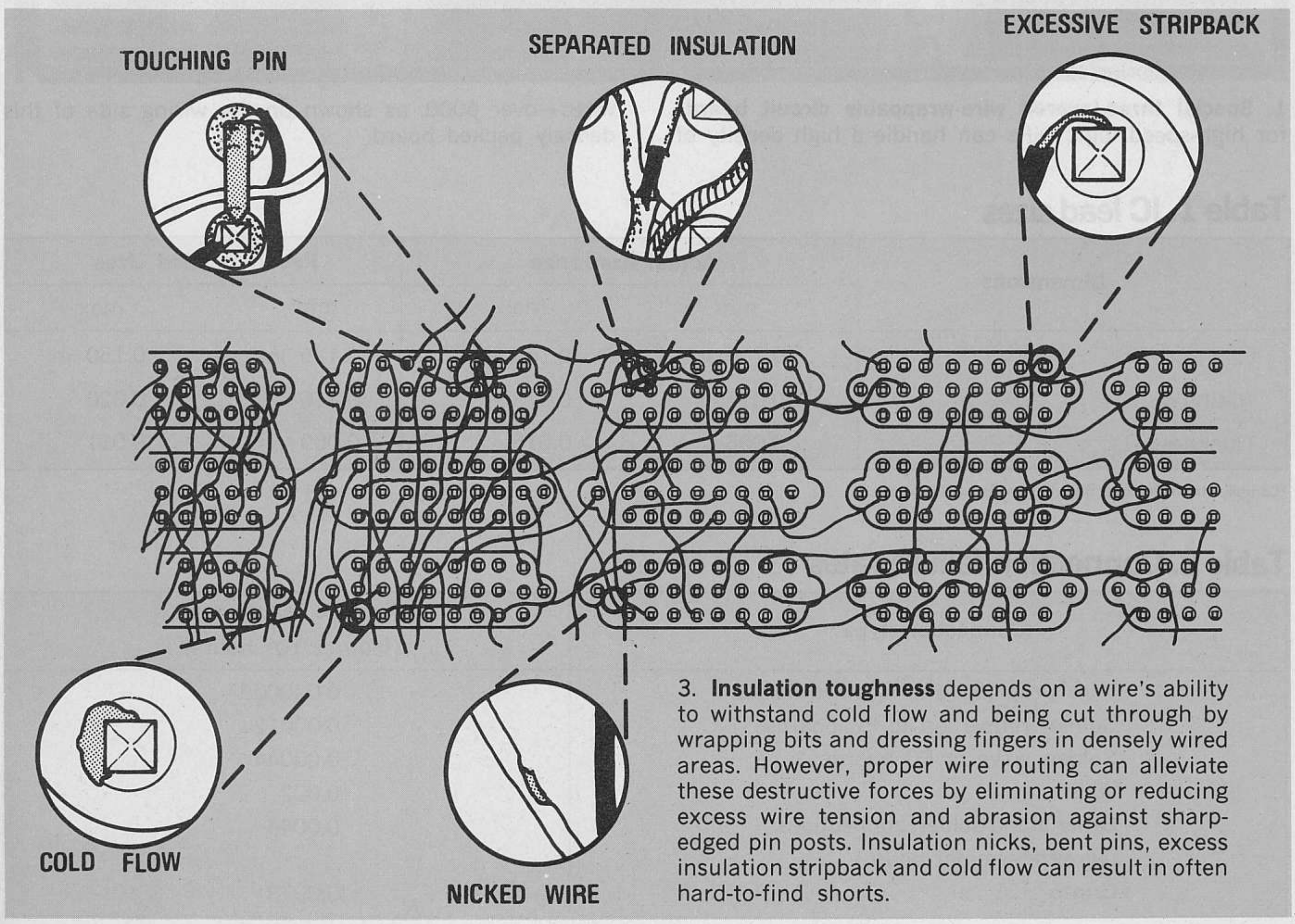
the over-all failure rate. It's considered one of the most reliable connection methods. Table 2 compares the average failure rates from MIL-HDBK-217B (*Reliability Prediction of Electronic Equipment*). Note that the wire-wrapping failure rate is about 1/40 that of the next best method—reflow lap soldering of component and socket terminals to PC boards.

You still need tight control

Despite the reliability inherent in wire wrapping, the process, especially for high-speed logic on densely wrapped panels, must be carefully controlled to attain its ultimate potential.

Wire-wrapping problems increase with a panel's wire-density. Problems such as wire-insulation cut-through, shorts due to tight wires and signal cross talk because of wire bundling get worse the more wire you pack onto a panel. Crowded-in wires stressed against the sharp 0.003-in.-radius wire-wrapping post corners can nick or gouge insulation unless the layout allows sufficient slack to accommodate the action of dressing fingers and the wrapping bits of automatic wire-wrapping machines.

Dressing fingers, which temporarily hold wires while routing along predetermined patterns, can lose control of the wire in dense wire bundles. As a result, the wire-wrapping machine's counter-rotating wrap-



3. **Insulation toughness** depends on a wire's ability to withstand cold flow and being cut through by wrapping bits and dressing fingers in densely wired areas. However, proper wire routing can alleviate these destructive forces by eliminating or reducing excess wire tension and abrasion against sharp-edged pin posts. Insulation nicks, bent pins, excess insulation stripback and cold flow can result in often hard-to-find shorts.

ping bits on each end of the wire can pull the wire taut around one or more post corners that may be in the path and the wire insulation can be cut. Moreover, the potential for insulation damage is compounded by the stresses of several wires stacked onto the snagged post corners.

However, proper programming of the wire routing can reduce these density-related problems:

- Use additional wire-distribution subroutines to augment commercially available routines.
- Use an extra "wrap-Z" level.[1]
- Specify wire-routing that employs two dressing fingers on the majority of wire runs.
- Specify tough wire insulation.

Using two dressing fingers (instead of one) restricts getting the basic one-finger L-pattern routing, which produces the highest wire-cut-through rate. Two-finger dressing forces most runs into "U" patterns. Moreover, should a wire become dislodged from one of the two dressing fingers, the second can still provide some margin of slack.

A more severe restriction in the route programming would limit the dressing fingers to locations only over open channels, thereby prohibiting their placement over (or near) a post. Although this restriction introduces additional wire-routing slack, wire density goes up. Also, wires so placed have more opportunity to "pop up" because of the longer runs.

This pop-up tendency stems from "curl"—a wire's memory of its former shape on its spool. Curl forces the automatic wire-wrap machine operator periodically to stop and push the wires back onto the panel surface to prevent them from snagging on rapidly moving wrapping bits and breaking. Of course, this slows production.

Tough insulators curl most

But curl depends mainly on memory in the wire's insulating material. And unfortunately, one of the toughest insulating materials—a laminated Mylar tape—curls the most. Nevertheless, its superior resistance to cutting through and cold flow is worth this annoyance during wire wrapping.

Cold-flow and cut-through resistance are difficult to specify precisely. These properties generally are established by reputation based upon experience (mostly bitter) with a variety of materials. On the other hand, other insulator properties—including temperature range, solvent resistance, dielectric constant, strength and leakage resistance—are much more easily specified in standard ways. Likewise, the copper wire—its conductivity, mechanical strength and annealed properties—also are easily specified. Of course, they must be selected to be suitable for wire wrapping.■■

Reference

1. Grossman, M., "Fast Logic No Problem for Wire-wrapped Boards," *Electronic Design*, Dec. 6, 1978, p. 34.