Perfboard and Soldertail?

Definitely. What is commonly done is never written up (until now) but always appreciated.

L. B. Cebik W4RNL
2514 Dereck Drive, H-1
Knoxville TN 37912

Many ham authors specify perfboard construction for their one-time projects. Then they say almost nothing more about the mechanics of building the circuit on the board. Photos and sketches give us a general idea of the construction methods, but very few articles exist on using perfboard construction effectively. In the spirit of sharing some ideas that have worked well for me over the years (along with some cautions about a few things that lead to trouble), let's see how we can improve our perfboard projects.

Printed circuit boards for transistor and IC projects make construction a breeze. Unfortunately, PC boards are not practical for every project. If an author does not provide us with a source for ready-made boards (and we should not expect every author to make a PC-board layout for his own one-time project), then our willingness to generate our own boards depends on many factors, including time, ability, and desire to design and fabricate the etched pattern. For many small-to-moderate-size one-time circuits, perfboard construction is more practical.

Many types of digital circuits which use few passive components call for wire-wrap techniques. Most ham circuits, however, will require soldered connections. Therefore, we will concentrate on soldertail techniques applied to perfboard construction. Adaptation of these ideas to wire-wrap projects should be easy.

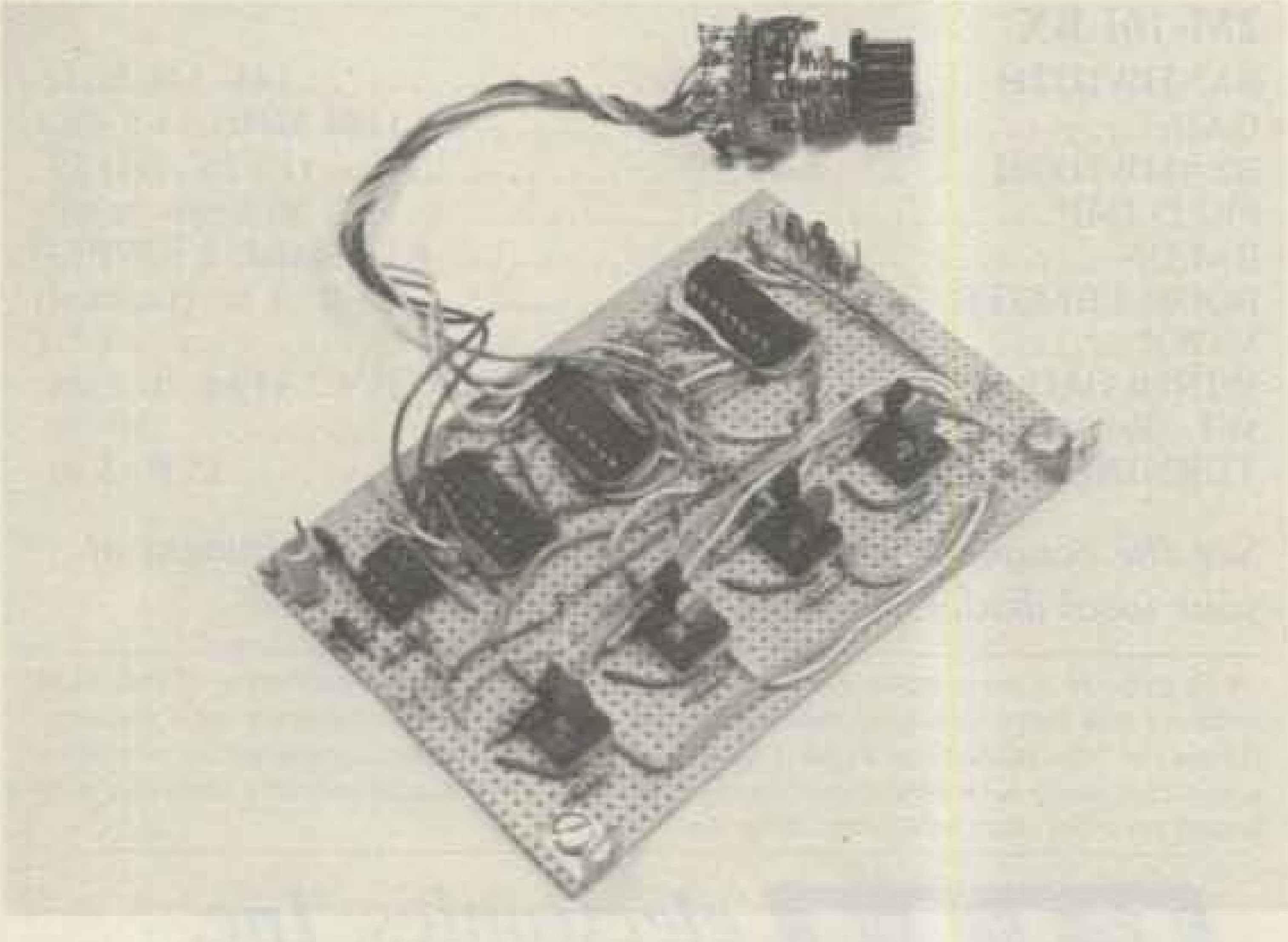

Photo A. An IC and transistor perfboard project with L-brackets for vertical mounting.

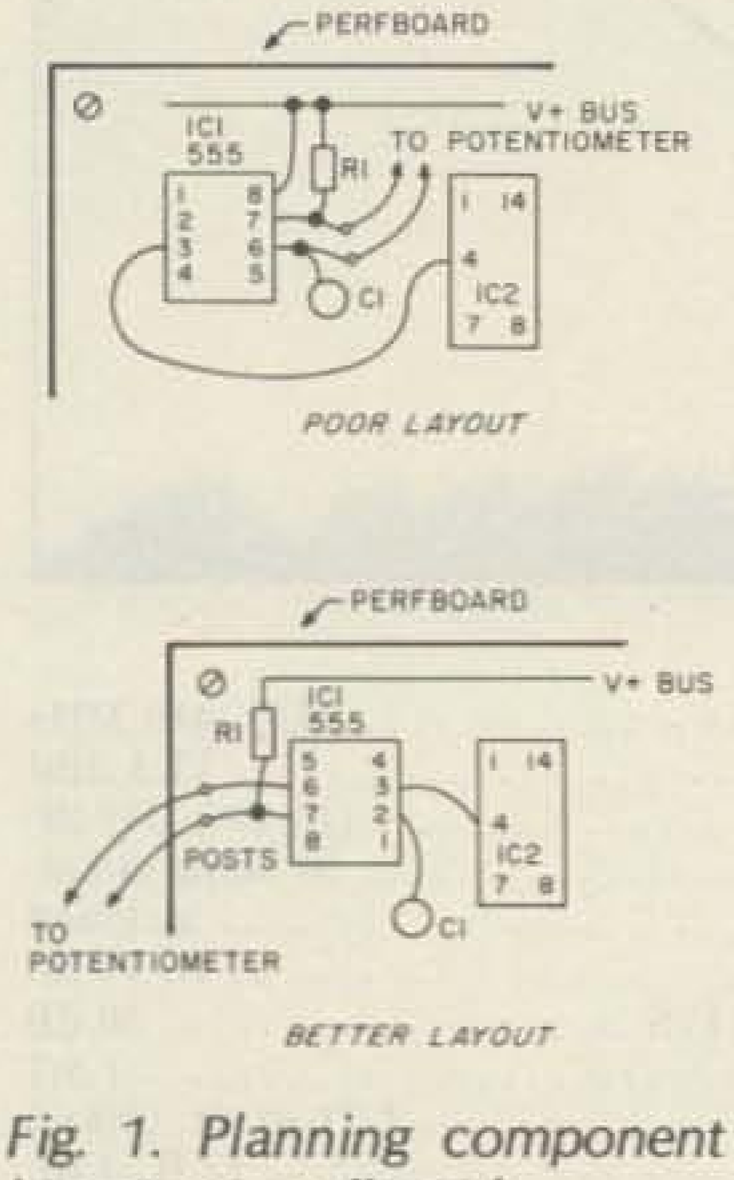

Fig. 1. Planning component layout on perfboard.

Handling Perfboard

Perfboard is generally made from a phenolic material, usually about 1/16th of an inch thick. This immediately limits its utility since it is prone to slight warps in readily-available grades. For PC boards, use the more stable epoxy glass material. For point-to-point wiring on perfboard, the warp is usually not significant in boards up to 5 by 7 inches.

There are several hole patterns for perfboard. Hole separations of .1, .187, and .2 inches are common, but .1-inch hole spacing is the most practical for ICs. For most uses, .042-inch hole diameters are best, although .062-inch hole diameters are available. The smaller holes again work best for IC projects. In fact, the .042-inch holes on .1-inch centers precisely fit the needs of ICs and their sockets. Conveniently, Radio Shack carries this type of board in three sizes: 2.75, 4.5, and 8 inches long, all by 6 inches wide. My own preference is to buy the larger sizes and cut the precise size board my latest project requires.

Phenolic material has some of the properties of mica in that it chips in jagged layers and does not break cleanly. However, with only a little care, it cuts and drills easily. A hack or coping saw with a fine tooth blade cuts perfboard well if you align your cut with a row of holes. Keep the saw blade as parallel to the board as possible, with no more than a 30-degree angle. This technique reduces binding as you pass holes, and the result is fewer broken phenolic scraps. For safer sawing, I clamp the perfboard between two quarter-inch-thick lath strip scraps with a bench vise. The edges of the lath strips are within a row or two of the holes I intend to cut along, which stabilizes the perfboard, and the vise cuts into the wood and not the phenolic. I keep any leftover pieces of perfboard more than one inch square, since I never know when I might need one for a miniature project or a small circuit addition.

Drilling perfboard for screws and other hardware is fairly simple. Use a scrap of wood to back up the perfboard when drilling; this prevents drill-bit snags that can shatter a small board. In general, a 1/8-inch diameter drill bit clears 4-40 screws nicely, while 9/16 is the correct drill-bit size for 6-32 screws. I usually avoid drilling holes larger than 9/16-inch diameter in one try since the large drill bits tend to snag the phenolic material more easily. For larger openings, drill out the perfs inside the desired perimeter until the scrap falls out and then file the material to the final opening size. Another technique is to drill the corner holes, insert a coping saw blade, and saw the opening. You will usually still need a bit of finish filing. One of the advantages of perfboard is that you can add larger openings for relay sockets and other components more readily than with PC boards.

Generally, I try to do all necessary drilling and cutting at one time before mounting components to get in the way of clamping and backing. There are few more frustrating accidents than to have your complete circuit wired, only to watch the perfboard crack or shatter as you try to drill just one more mounting hole.

Perfboard Layouts

One secret to easy electronic construction is paper. The more complete your plans, the more smoothly the project will go together. Even if you are reproducing an author's circuit exactly and have good photos to guide you, paper planning still can save you time and frustration. As inexpensive as many of today's components are, paper is still cheaper.

Example 1. Being able to cut and drill all holes before wiring is a matter of knowing just where they all go and what size they must be. Making some trial paper templates using the real components you have on hand will allow you to determine their size and spacing.

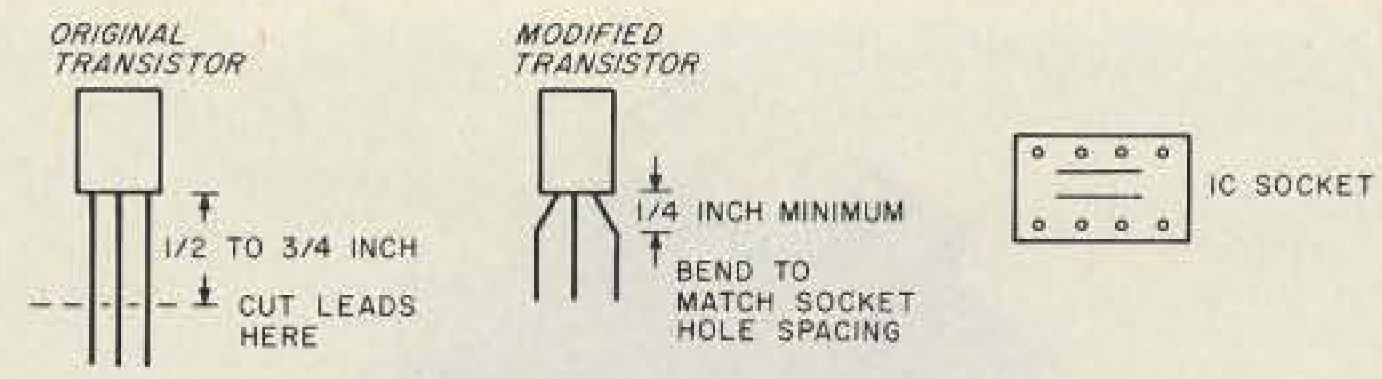

Fig. 2. Trimming transistor leads to fit IC sockets.

In addition, the practice also will let you revise the project and spot errors or neglected needs. You can see how much room you need to clear the mounting brackets or posts, how much space the transformer mounting foot requires, and how much filing you will need to do after cutting a hole for a relay socket. Then you can plan the circuit details so that everything will fit conveniently.

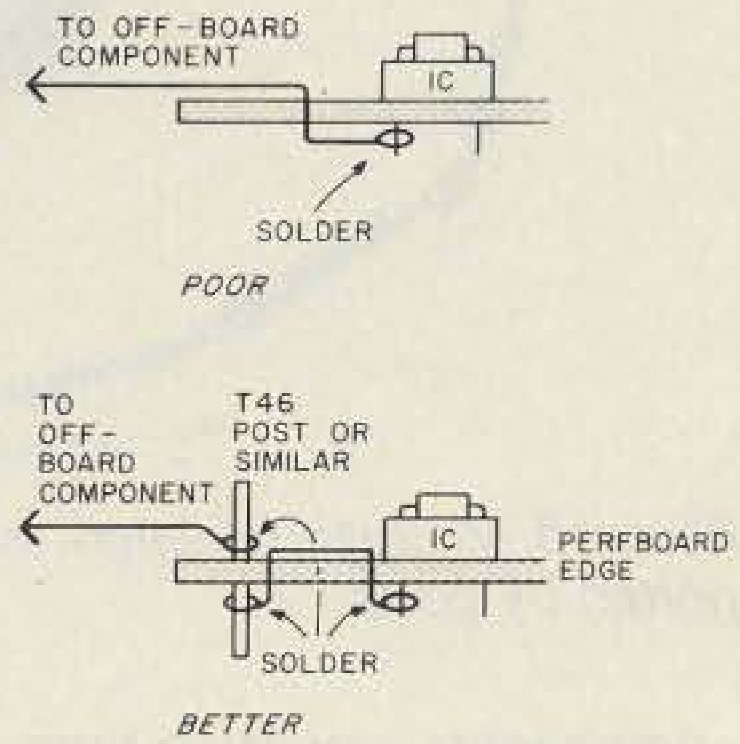

Fig. 3. Using posts for off-board connections.

Example 2. Equally important is the component layout. Fig. 1 illustrates two important considerations: socket pin orientation and component placement. The IC timer, a 555, runs its timing components to pins 6 and 7, while the output emerges from pin 3. Even though we conventionally think of "upper left" as the proper place for pin one, this project calls for an "inverted" placement of the 555 socket. Now the timing components are near the board edge so that leads to the potentiometer are conveniently reached. Too, the output pin is close to the input pin of the next IC.

In digital circuits, socket placement can make jumper wiring either easy or a jumbled nightmare. In counting and readout circuits, you may have several outputs to several inputs. Aligning the jumpers neatly makes short work of the wiring. Having them go over and around an IC to reach the input pins invites undetectable open circuits and other typical building problems.

Leave room enough for the components that go between sockets. Perhaps the best way to be sure your plan will work is to trial-fit all components on uncut perfboard. This practice often reveals unnecessarily long leads and other minor wiring problems before you cut leads. The result is often a revised layout plan. Sometimes, when I am smart enough to have a large extra piece of perfboard on hand, I place all components on the supplementary board. Using this model, I mark the project board for cutting and drilling. Then I move the

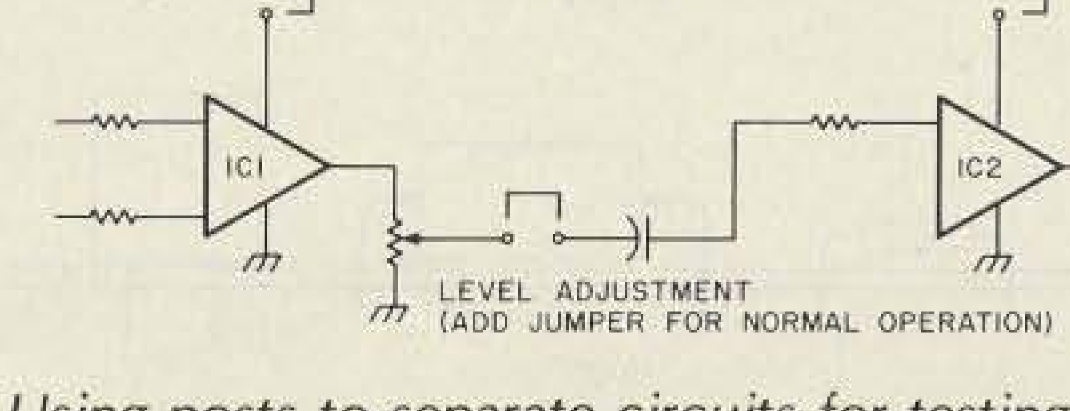

Fig. 4. Using posts to separate circuits for testing and adjustment.

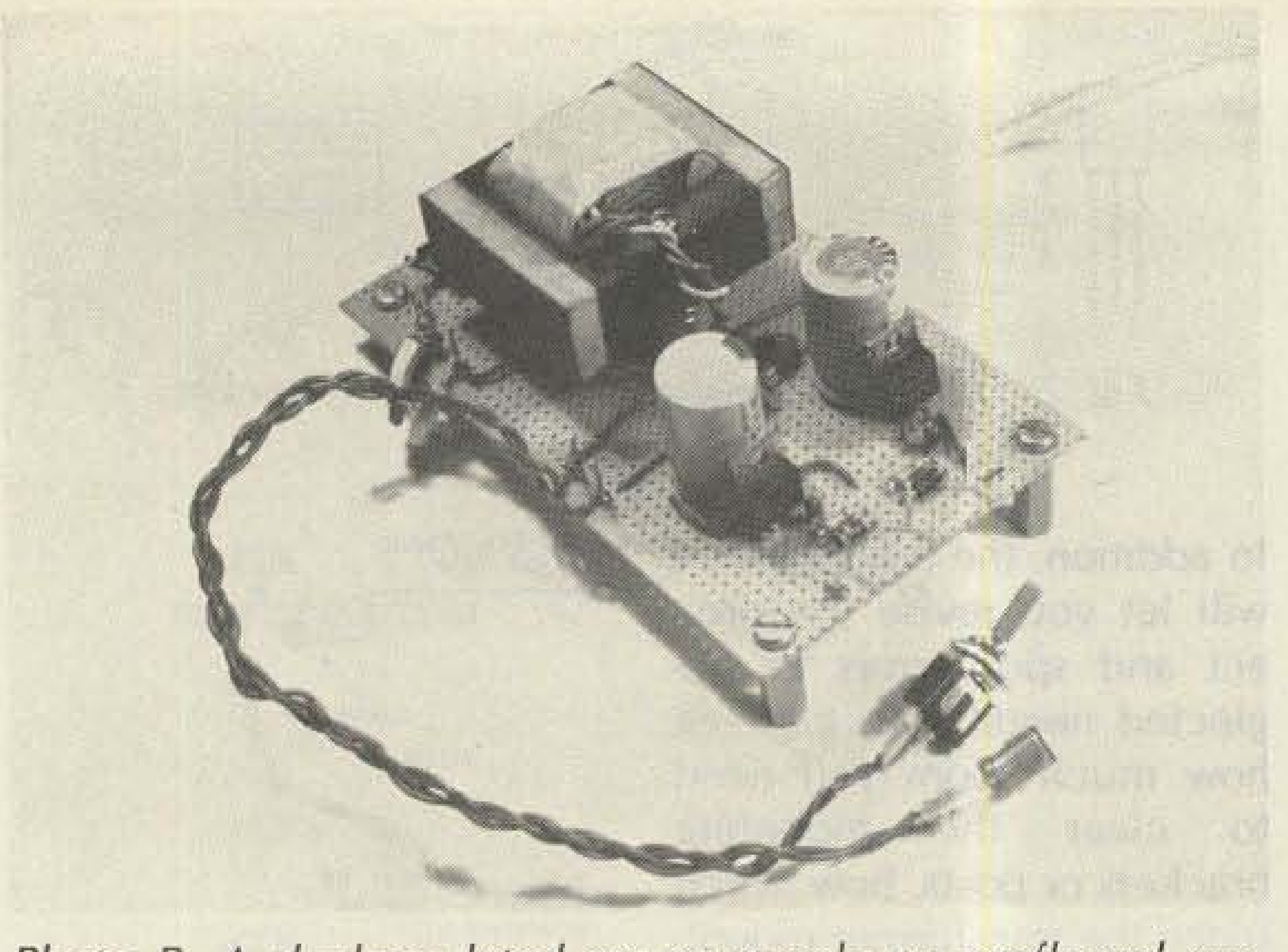

Photo B. A dual-regulated power supply on perfboard supported by posts.

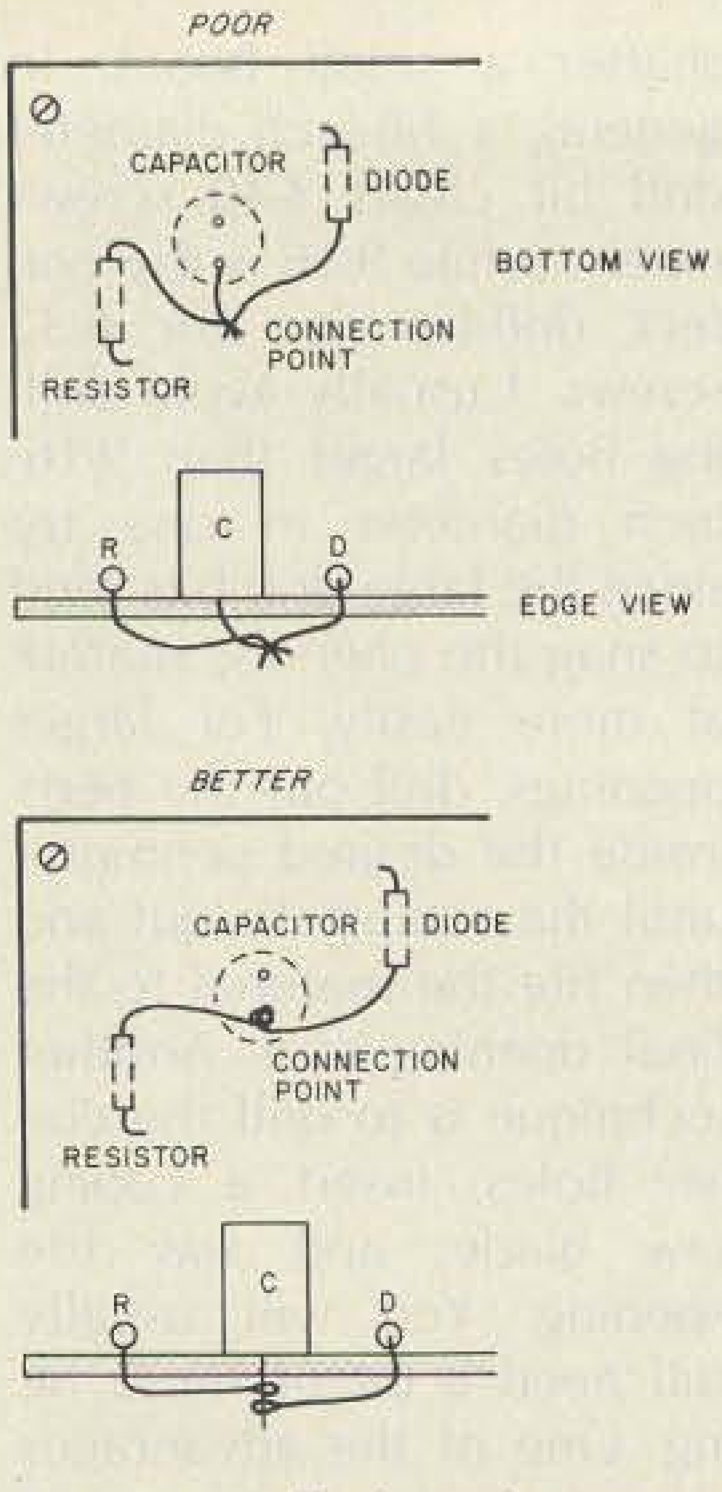

Fig. 6. Under-board component-lead junctions.

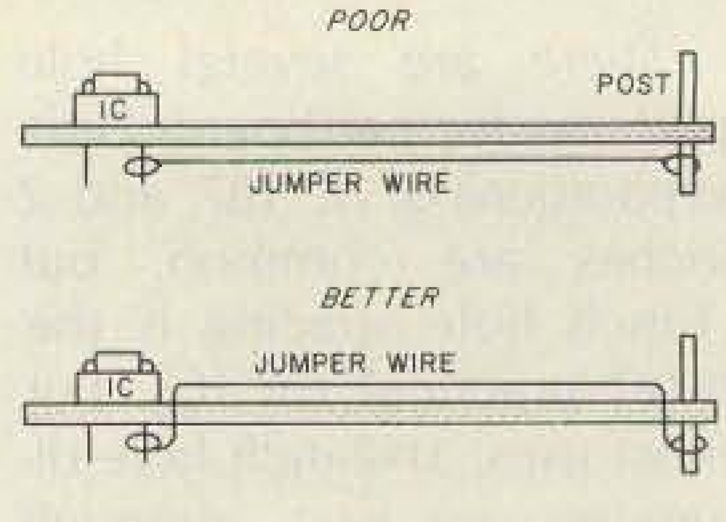

Fig. 7. Mounting jumpers on perfboard.

components, one at a time, to the project board. This technique tends to cut considerably both assembly time and errors.

Transferring a layout plan to perfboard requires only a pencil and ruler. Measure and lightly mark the positions for holes. You also can mark the corners of IC sockets and large components for reference. The only precaution here is to eliminate pencil markings completely before covering them with components. Pencil lead is a conductor: not a good one, but good enough to have given me an additional input to a CMOS IC in one project. Erase pencil marks thoroughly just before mounting components.

Handling and Wiring Components

It would be impossible to establish guidelines for handling every kind and combination of components you might encounter, but the following ideas are adaptable to most projects.

First, use IC sockets wherever possible. Use them not only for ICs, but for switching transistors as well. An 8-pin DIP socket will handle two small transistors if you trim and bend the leads as shown in Fig. 2. The advantage of IC sockets over readily-available transistor sockets is that the latter require a fairly large hole through the perfboard. The IC socket rides atop the board with its pins sticking through.

Second, use posts for all off-board connections. Do not run off-board wires directly to components or socket pins. The strain may be too much. Fig. 3 shows the right and wrong way to connect off-board wires. An added advantage of posts is that you can connect and disconnect off-board components from the top side, which makes final assembly of the project a much easier matter.

There are many additional uses for posts, a few of which are illustrated in Fig. 4. You can separate stages of a circuit until after testing by using a pair of posts at the output/input point; a jumper then connects the two circuits for normal operation. This technique permits you to adjust interstage signal levels with no danger of overloading the next device. Paired posts, again jumpered for normal operation, also permit current measurements during the test phases of a project as well as during troubleshooting. I prefer Vector T-46 wire-wrap posts, available through Jameco and other mail sources. The T-46 extends .4 inches above the board and .56 inches below. Its square shank and flare give it good holding power in the perfboard hole. After all soldering, trim the above- and below-board lengths. Below-board, be sure that the post does not touch the chassis or cabinet base. Above-board, cut the post to the height of the tallest circuit component. Wire cutters do the job nicely.

Third, do not crimp components when bending their leads. Some builders prefer to top-mount all components. For this technique, Vector T-42 posts (or similar) permit soldering up to about three leads per junction. However, this method usually requires more space than making direct connections with component leads bent to pass through the board. Fig. 5 shows some right and wrong ways to handle components such as resistors, diodes, and capacitors. Axial-lead components such as resistors require curved bends to avoid eventual lead breakage. Often this takes one more hole, but that is a small price for circuit reliability. Where space is at a premium and component interaction is not a problem, vertical mounting is practical. Wherever you take care in smoothly bending component leads, you will encounter fewer cases of component strain or breakage, even if your layout does not permit instant solder support.

Fourth, when you use component leads to make connections, decide in advance for every junction which lead will serve as the key or post lead. Fig. 6 illustrates the idea. The capacitor lead serves as a post to which the resistor and diode connect. The reasons for choosing the capacitor lead

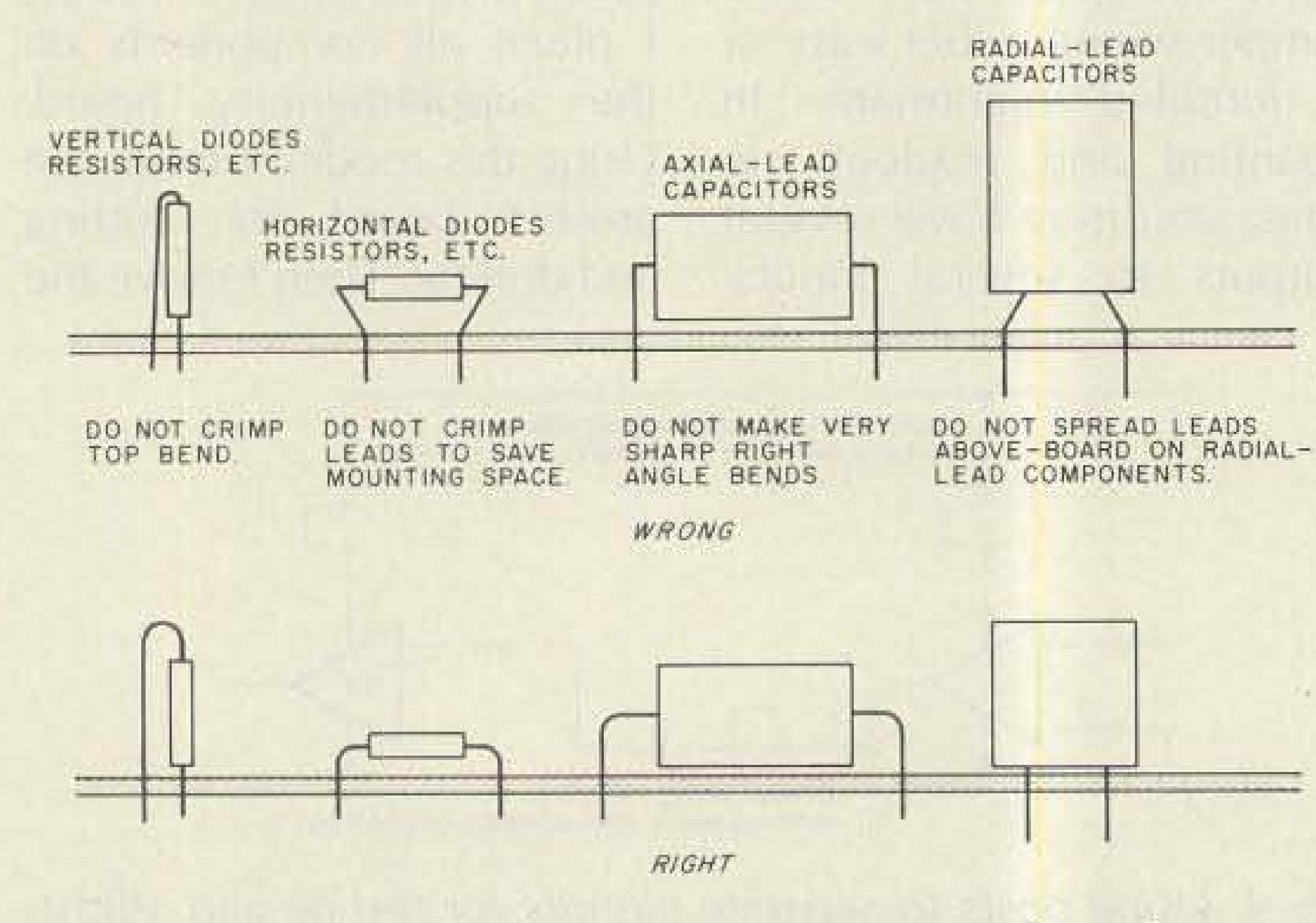

Fig. 5. Mounting components to perfboard.

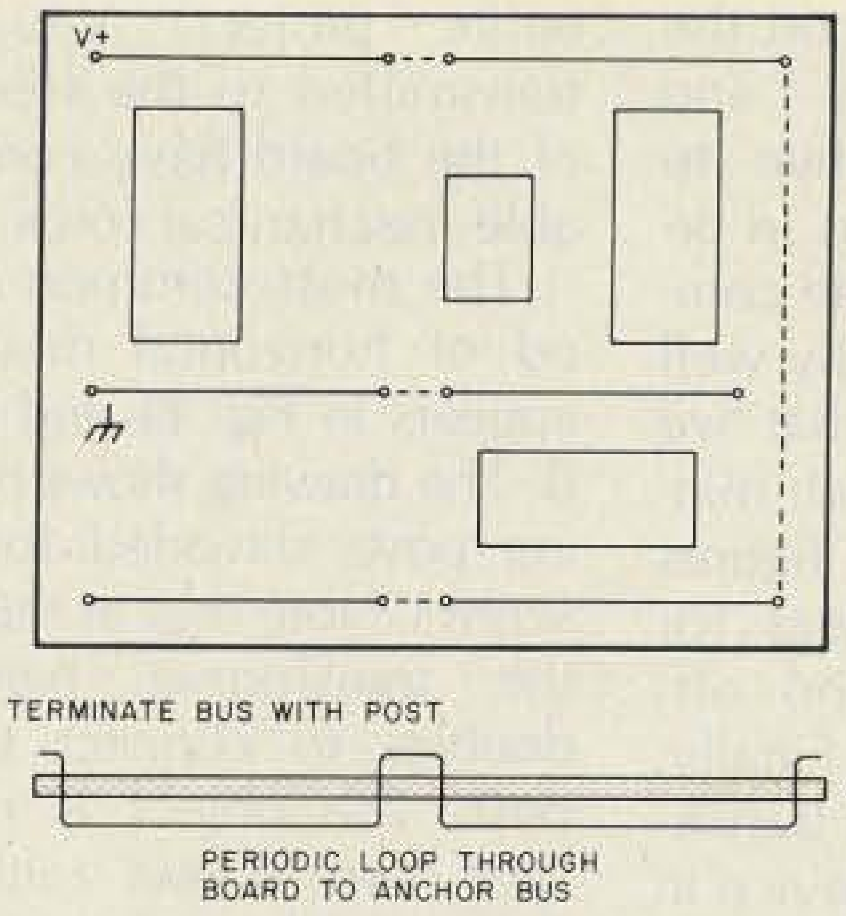

Fig. 8. Perfboard power and ground buses.

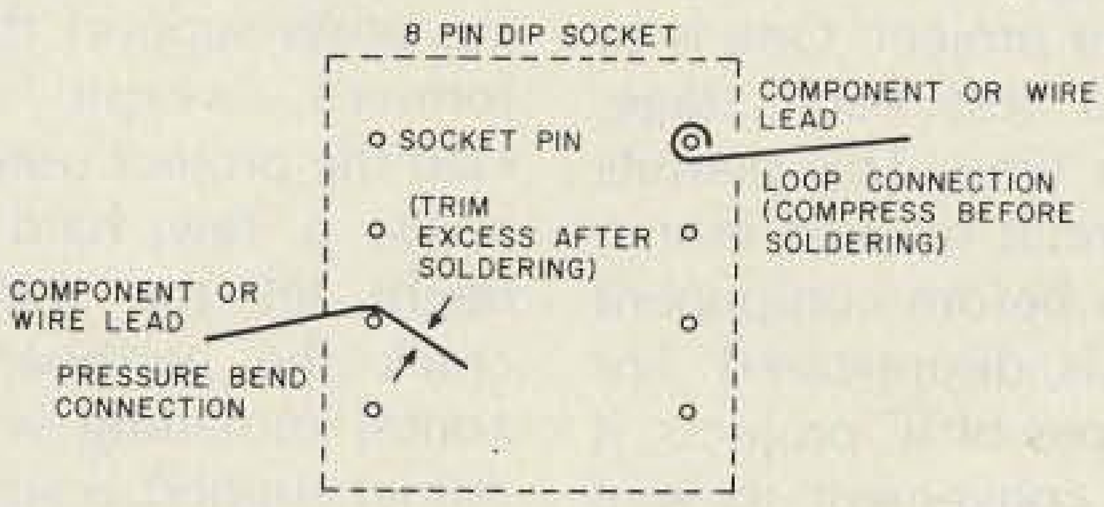

Fig. 9. Soldering leads to IC sockets.

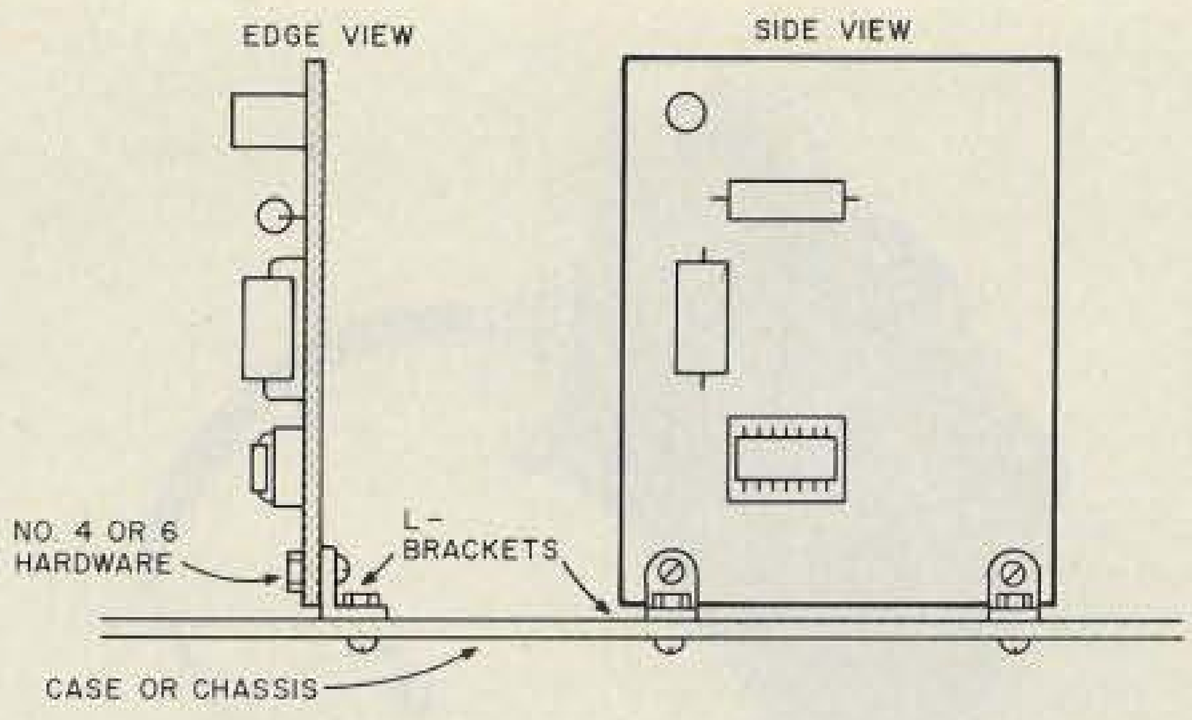

Fig. 10. Mounting single perfboards vertically.

in this example are three. The capacitor lead is the fattest and strongest and thus makes a better post. Too, the capacitor is permanent, whereas the resistor may require another value after testing the circuit. Finally, the capacitor can stand soldering heat somewhat better than the diode.

This case gives only a small sample of the reasons why one or another component may become the junction post; each will have its own rationale. Nevertheless, avoid bringing leads from many directions and simply twisting them together. The under-board layout may be as crucial to reliable circuit operation and ease of revision as top-board component placement.

Fifth, run jumpers topside and through the board at their ends, as shown in Fig. 7. This technique serves several useful purposes. It permits you to trace wiring after the board is mounted. It also takes the strain off the jumper wire, especially if you happen to snag it during construction. Standardizing on top-wire runs also reduces the chances of losing track of jumpers while building. Although excessive looping of jumpers creates an unsightly project board and potential trouble in sorting through the maze, do not put excessive strain on the wires to pull them flat against the board. Leave enough slack to prevent wire breakage, either immediate or later. Then press the wires into place.

These simple guidelines to component handling are mostly matters of common sense. You can add to the list according to your own building experiences. Unfortunately, we often forget these rules while building, usually through either haste or distraction. There is nothing like a soldering iron burning a hole in the test bench to cause us to mishandle a component. If we could only remember which component we were installing during the incident, we would know the first place to look when the circuit malfunctions. If you do not believe it happens, I have two look-alike IC voltage regulators, one positive, one negative, that I once installed under just such conditions. That neither works is proof that I put each where the other should have gone.

Wiring Perfboard Projects

Wiring and soldering a perfboard project can be one of two things: easy or frustrating. Easy wiring requires that we figure out the best way to handle the peculiarities of attaching components and wires to a phenolic board with a hundred small holes per square inch. I wish that I had known what I now know (through experience) back when I miswired my first perfboard.

No. 18 copper wire is the largest that will fit through the .1-inch holes of IC perfboard. For most purposes, No. 18 wire is too large for all but heavy current buses, such as voltage and ground lines on a TTL project. No. 22 or 24 solid hookup wire works best for most wiring. Anything smaller grows hard to handle and solder. We can make off-board connections with stranded wire of the same size.

If we have made a good layout plan, the wiring task should be straightforward. For non-rf projects, I usually begin with voltage and ground buses, arranged as shown in Fig. 8. Long runs pass above and below the board at least once to anchor them in place. Rf projects that require large areas for the ground plane may not be the best projects for perfboard techniques. For dc and lower ac frequencies (up to a few MHz), perfboards and buses work well. Jumpers provide voltage and ground connections to the individual components.

Wiring IC sockets presents problems to many builders. Whether working with PC or perfboard, we manage to lose the sockets as they fall off the board the moment we turn it over to solder. There are many tricks to hold the sockets in place. If there will be unused pins, bend them inward so that the socket lightly grips the board. Some builders put a tape loop under each socket to secure it during construction. Alternatively, you can use a small flat box on which to lay the inverted board for the first socket pin solder job. Whatever the technique, solder all the power and ground jumpers first; this will lock the socket in place for the rest of the project.

The traditional rules of soldering state that every solder joint should first be a solid mechanical connection over which we then flow solder. The solder seals the joint, ensuring a long-lasting electrical connection between wire and terminal. PC boards, of course, violate the old rule as a matter of course. Component and socket leads pass through the holes and, in fact, may not touch the pad. Solder, electrically and mechanically, connects the two. So long as we do not exceed certain weight and vibration limits, the connection will be good for a long time.

Perfboard construction requires that we connect jumpers and component leads to socket pins. Fig. 9

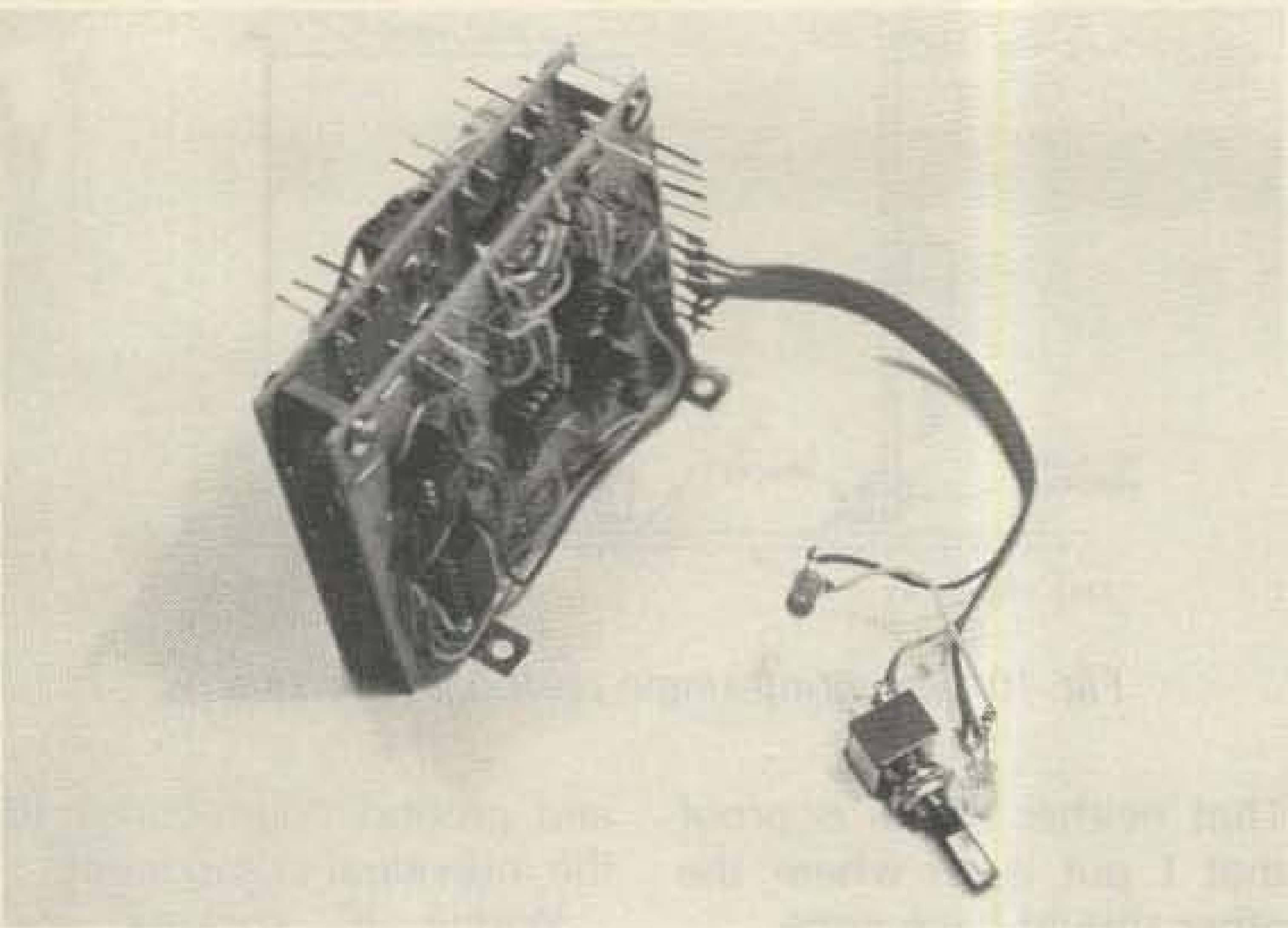

Photo C. A two-board IC and transistor project ready for vertical mounting.

shows two common techniques, and most builders use both in the course of wiring a single IC socket. No. 22 or 24 wire will bend in a loop around IC socket pins with room to spare for the loop to the next pin. However, circumstances often dictate that the partial-bend connection is most practical. Ensuring a good connection is a matter of making sure that the wire in fact touches the socket pin with natural tension before soldering. Unless the lead is under considerable stress, the connection will hold indefinitely. Use a small jeweler's awl to test each such connection before being satisfied that it will hold.

Whatever the construction method, small components used in modern circuits require careful handling. Radial-lead capacitors, such as the small electrolytic type, should be flush with the board. Unless we are careful, they will fall out of position when we flip the board to solder. Resistors, disc capacitors, and diodes should be close to the board, but not necessarily pressed too tightly lest we crimp the component lead. In many cases, the lead is stronger than the component itself. Where this is true, let the lead support the component. Diodes and transistors are sensitive to solder heat, so care is in order. Being sure that the component is mechanically well connected ensures that we can solder quickly with minimum heat. Earlier figures showed the techniques for handling jumpers and off-board connections. Finally, never solder an IC or transistor socket with the device in place.

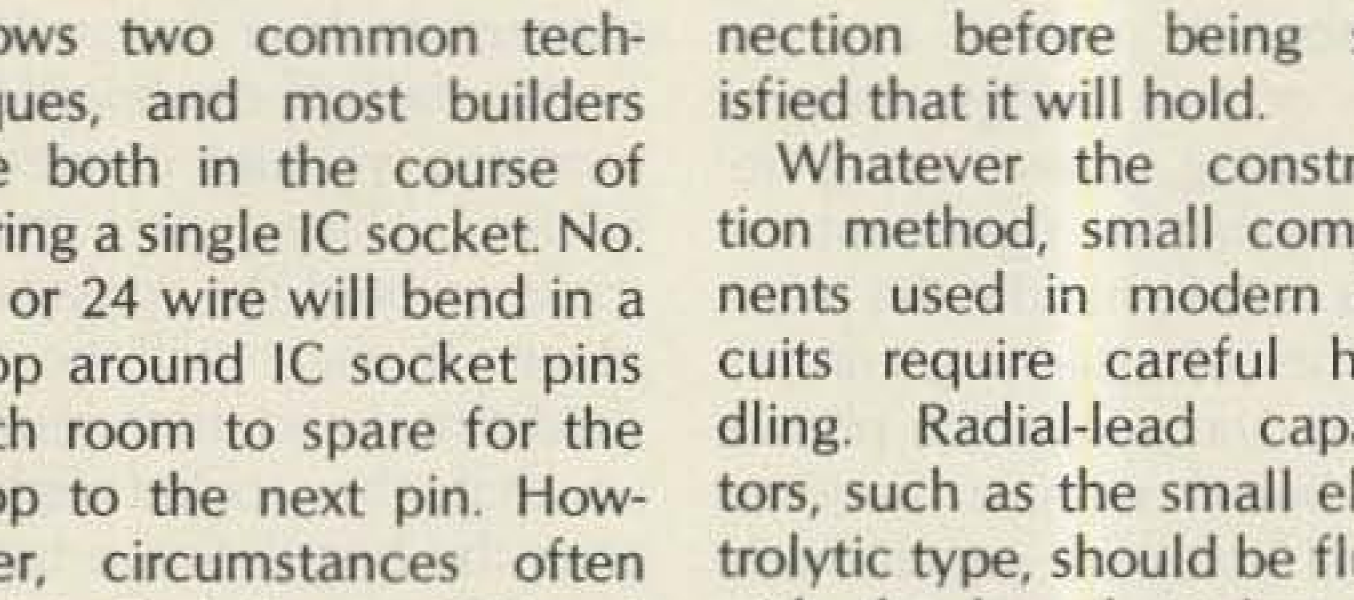

Fig. 11. Mounting perfboards horizontally.

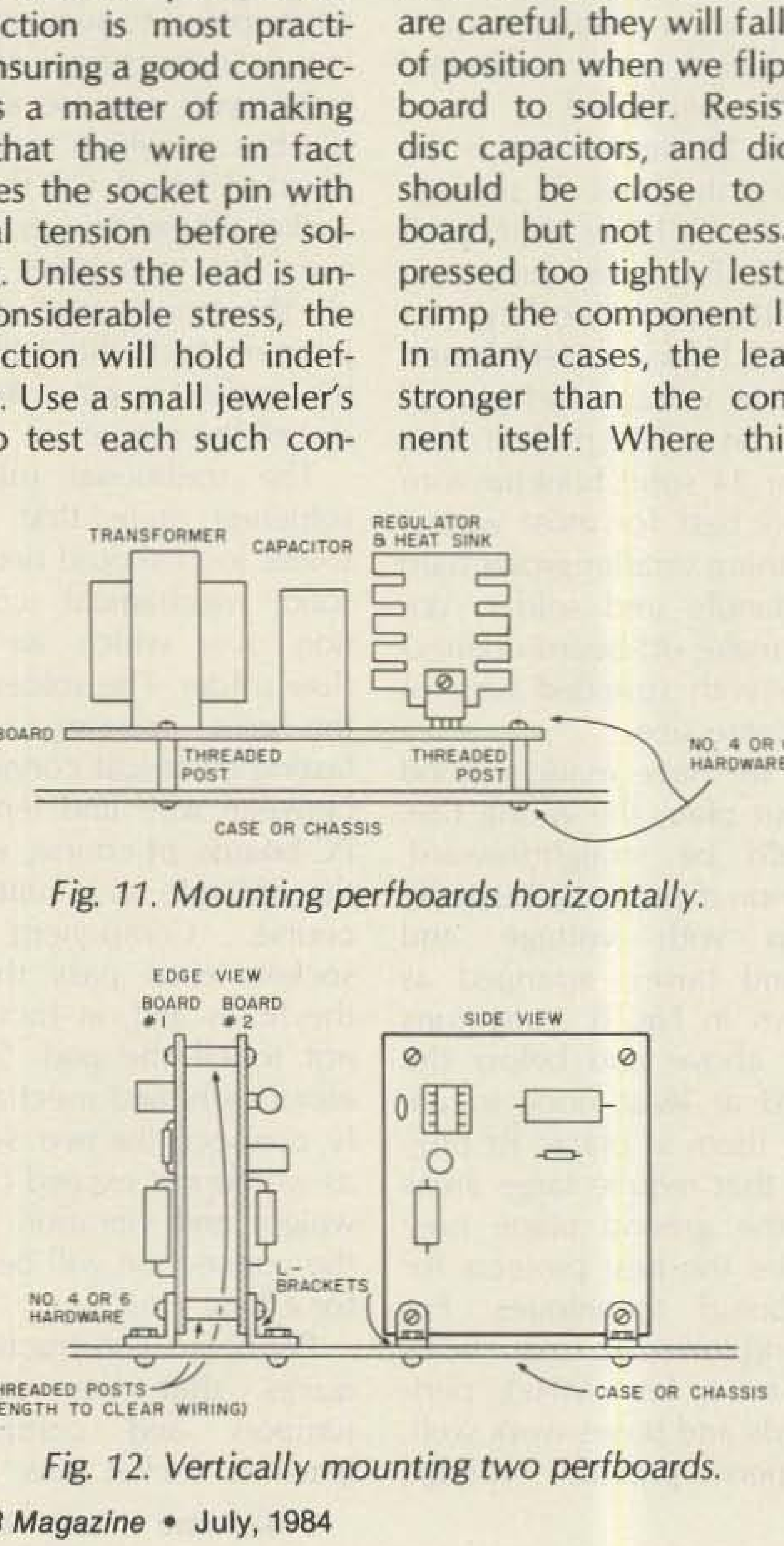

Fig. 12. Vertically mounting two perfboards.

There are two methods for wiring and testing a solid-state project. One is to wire and test each stage, one at a time. This permits ready circuit revision in early stages before component space has disappeared. For many types of IC projects, it is more convenient to wire the entire circuit and then test the stages by plugging in one or two ICs at a time (with power off and capacitors discharged). With either method, it is safer to remove ICs while making circuit additions or revisions. The IC that will fry due to static charge or excess heat is the unit of which we have only one.

Mounting Perfboards

The photos, besides illustrating perfboard construction generally, show different types of mounting schemes. Basically, there are only about five ways to handle the attachment of perfboards to your project case.

Fig. 10 and Photo A illustrate simple vertical board mounting using L-brackets. Digi-key and other mail sources carry this common but surprisingly hard-to-find bracket. Be sure that the board clears the case with about an eighth of an inch to spare so that you have room to align the L-brackets with the case and board holes. This is perhaps the simplest vertical mounting scheme, but it is limited by the weight and size of the project board as well as anticipated rough handling of the entire project. Vibrations transmitted to the free end of the board have considerable mechanical force.

The most common method of horizontal mounting appears in Fig. 11 and Photo B. The drawing shows mounting posts threaded for 6-32 screws. Note that in this case the transformer hardware doubles to connect to the post. The object is not to save two screws (although the space they take might be handy for other circuit components). Instead, the mounting posts support the transformer's weight directly. Had the project used corner posts, a few hard knocks might let the transformer crack the perfboard. Horizontal mounting with four-corner support is superior to L-bracket mounting only if the expanse of perfboard does not support too heavy or too dense a weight.

In most cases, hollow pillars and long screws make a perfectly acceptable substitute for threaded posts. We need not buy commercial posts, but can make our own from rigid plastic tubes. In fact, exploring the plastic packaging and worn out parts of many household items is a good way to build a stock of very useful plastic pillars, standoffs, and other items.

We can achieve superior vertical-mounting stability using two boards with a combination of L-brackets and posts. Fig. 12 and Photo C show how. Each board has its own L-brackets for four-point support. Posts connect the two boards at the four corners. With this technique, the builder can remove each board independently for repair or revision. Photo C shows separate automatic voltage- and current-measuring circuits (for a bench supply) back-to-back. The only cautions to observe with this mounting method are to ensure that the two circuits will not interact through radiation or capacitive coupling.

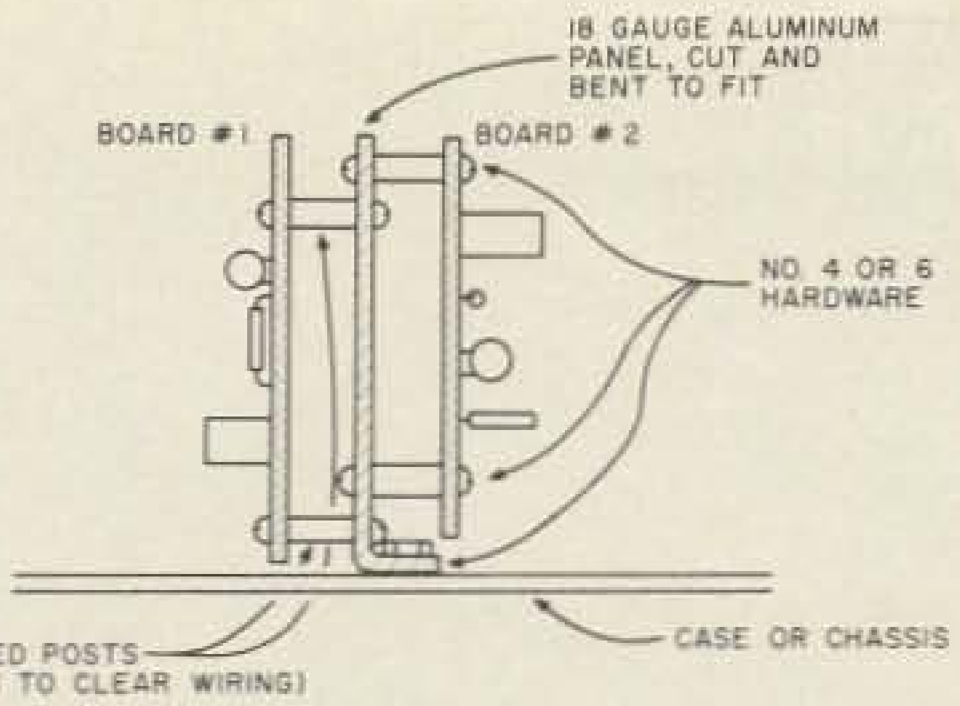

Fig. 13. Perfboard mounting with interface shielding.

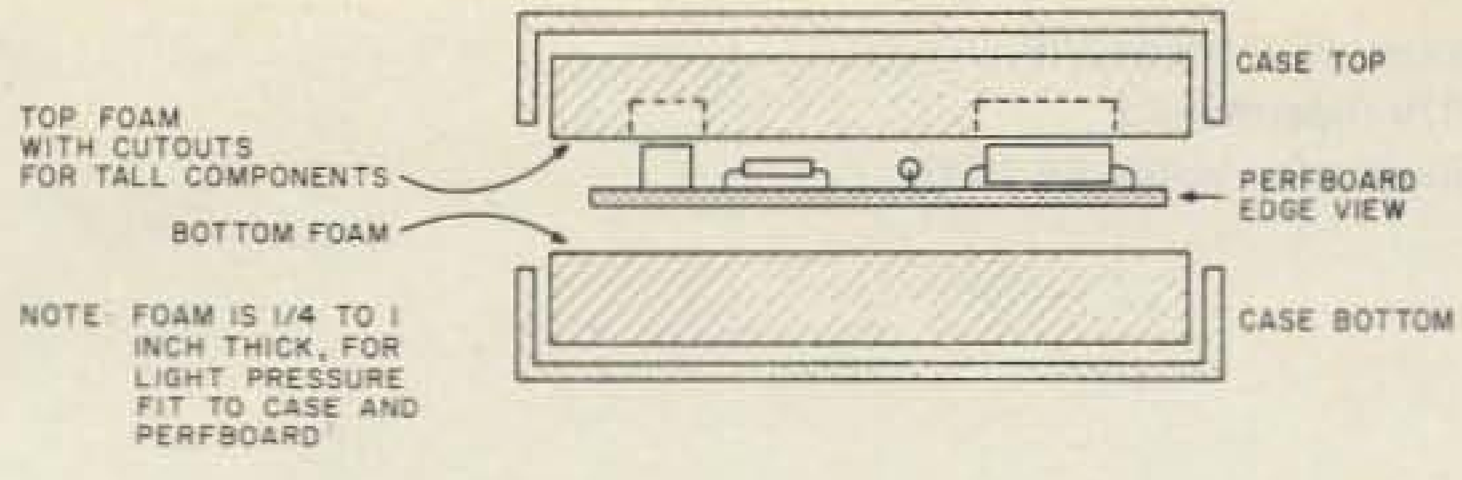

Fig. 14. Packaging perfboards in foam.

Where circuit isolation is important, Fig. 13 comes into play. Two boards conveniently fit to one aluminum shield panel. The 18-gauge or thicker aluminum panel supports both boards and the builder can remove each independently. This technique is limited to cases where a simple interface shield is adequate to prevent unwanted interaction between circuits, which includes most low-power receiving and test equipment applications.

Modern packaging techniques have taught us that rigid physical mounting is not the only route to good circuit protection in the project case. For small projects, a floating mount may be both simpler and more effective than nuts and bolts. Fig. 14 illustrates the general principle. The circuit board rides between two foam pads within the case. The case presses the foam lightly to hold it in place. The light pressure also holds the perfboard securely in its place. If there are some projecting components, we can cut a few indentations into the top foam panel. This form of mounting works very well as long as the foam can exert enough pressure to lock the perfboard in place without over-stressing any of the components.

These sample mounting methods may add to your repertoire of packaging techniques. In any event, plan your packaging during the layout stage of the project, since perfboard mounting will determine some of the cutting, drilling, and wiring requirements. Of course, these mounting techniques also apply to numerous other construction techniques.

Although perfboard is handy, it is not the ideal construction base for all projects. As noted, some rf projects may require ground planes that perfboard alone cannot provide. Where PC boards are available for projects you do not want to modify, use them. However, for the one-time ham project of moderate size, perfboard construction can be as satisfactory and durable as any other. It all depends on how you handle the material. Hopefully, the collection of ideas out of my experience will spur you to share some of your own with the rest of us who regularly build with perfboards and soldertails.■

✓ See List of Advertisers on page 98