I'll bet there isn't a single reader of *Nuts & Volts* who isn't addicted to the nitty-gritty of whipping up a new circuit at the workbench. Soldering, etching, loading circuit boards, wiring, and even troubleshooting are the passions of just about all of us electronics aficionados. And, yet many builders shy away from mastering the one aspect of our craft that the layperson notices first: making the thing look nice.

noticed how common rack-mounted equipment is. There's a good reason for this. Rack panels and rack mounts have been standardized by the Electronic Industries Association (EIA). This guarantees that you can mix and match gear, and it'll always fit properly within your cabinets.

Virtually all pro-equipment comes this way. As it turns out, fabricating nice-looking rack panels is actually fairly painless and less expensive than you might imagine.

I can't begin to count the times I've seen a wonderfully designed circuit tossed together helter-skelter into some tattered box with labels looking like they were done by a kindergartner with a crayon!

Secrets of Making *Attractive* Rack Panels

by Thomas Henry

I can't begin to count the times I've seen a wonderfully designed circuit tossed together helter-skelter into some tattered box with labels looking like they were done by a kindergartner with a crayon! There's no call for this slipshod approach, if you know the secrets.

This article, then, addresses the problem of making your projects look fabulous, and reveals practical techniques developed over the course of 20 years.

There are many different ways to house your creations. But if you've been involved in electronics for any length of time, then you will have

So, let's dive right in and learn all about it.

RACK PANEL BASICS

As mentioned above, the EIA has specified a standard set of dimensions for rack-mounted gear. These measurements are spelled out in a document entitled, "Racks, Panels, and Associated Equipment," which has been given the reference number of RS-310. (A letter appended to this reference number indicates the current revision of the specification.) If you'd really like to read this document for yourself, you can probably find it at a local engineering college library. However, it's not exactly the most lively prose in the world! So, we'll extract the pertinent information here and present it in a more user-friendly fashion. In fact, we'll rely heavily on illustrations to make the details even simpler to grasp.

Standard rack panels are 19 inches wide, but the heights can vary. These heights are specified by the term "unit" or more simply by the symbol "U," which is nothing more than an increment of 1-3/4 inches. So, a 1U panel is 1-3/4 inches high, a 2U panel is 3-1/2 inches high, and so on. See Figure 1.

By the way, one of the reasons the RS-310 document is so tedious to read is that the authors have worked in some "slop factors." As an example of the language you'll encounter there, a 1U panel is dictated to have a height of 1.750-0.031 inches. What this is really saying is that a mass-produced item should be just a little less than perfect. The idea is that if you mount a bunch of these guys next to each other, you want to shave them down a bit so that your cabinet doesn't burst at the seams as you plop them in. Since we're handcrafting our panels (not mass-producing them), we can be a little more exacting and careful. Hence, all of the measurements used in this article are precise, and completely bypass the "slop factor."

As intimated earlier, you'll be securing rack panels into some sort of overall enclosure. The EIA spec indicates that the mounting holes in the rack panel can be either a "closed slot" (an oval hole) or an "open slot." We'll use open slots since making them only requires commonplace tools like a drill, hacksaw, file, and so on.

Rack panels bolt or screw onto the side railings of a rack cabinet. The railings may be nothing more than one inch by one inch pine strips if you're using wood screws to secure the panels, or might be more sophisticated metal strips tapped to accept 10-32 machine bolts. The mounting holes are separated from each other alternately by 1/2 inch and 1-1/4 inch spacings as shown in Figure 2. A moment's reflection should convince you that this arrangement can handle any combination of standard rack panels.

Figures 1 and 2 give us all of the basic theory we need; let's put the theory into practice!

MEASURE TWICE AND ...

The number one secret of making attractive rack panels can be summed up in a single word: planning. In the old days (i.e., more than 10 years ago), this meant hauling out the mechanical pencil, T-square, and draftsman's triangles. You would then come up with some sort of a layout on a large piece of butcher's paper and hope for the best before your

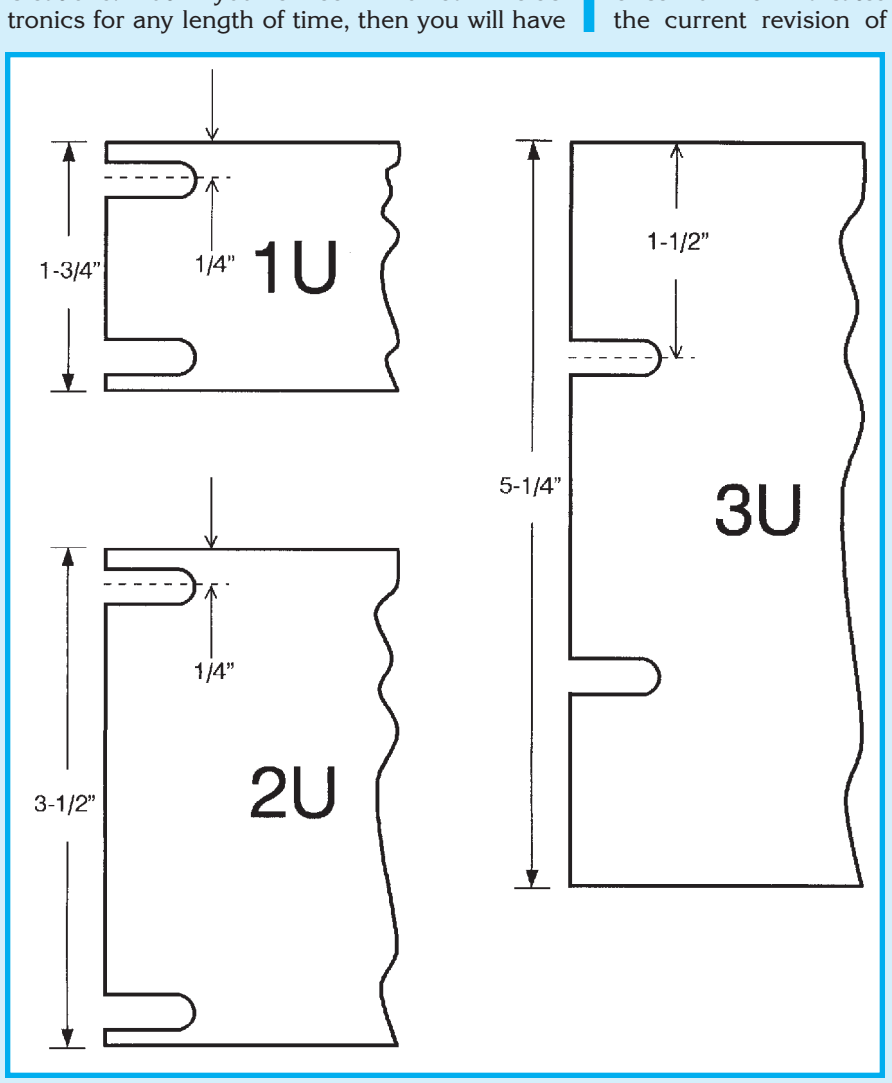

FIGURE 1: Rack panels are always 19" wide, but vary in height by increments of 1-3/4" (called a unit or simply "U"). The three most common are the 1U, 2U, and 3U panels, shown here along with their respective notch spacings. Larger panels follow the same pattern. For example, the next two would be 7" and 8-3/4" in height. The notch spacing from the top and bottom edges is 1/4" for the 1U and 2U panels, and 1-1/2" for the larger panels.

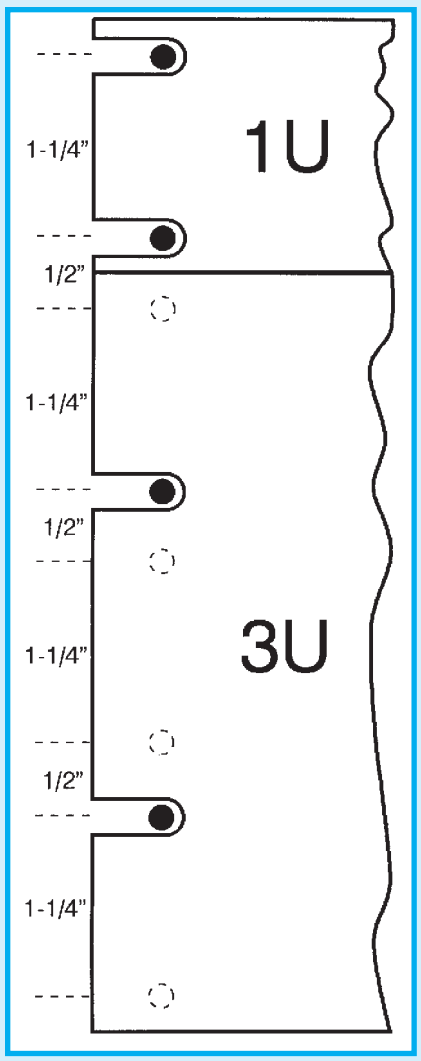

FIGURE 2: This figure depicts a portion of a rack mount with two different sized panels installed. Notice how the mounting holes, alternating at 1/2" and 1/4" spacing, accommodate the two panels. In fact, this arrangement can handle any combination of standard rack panels, no matter what their respective heights.

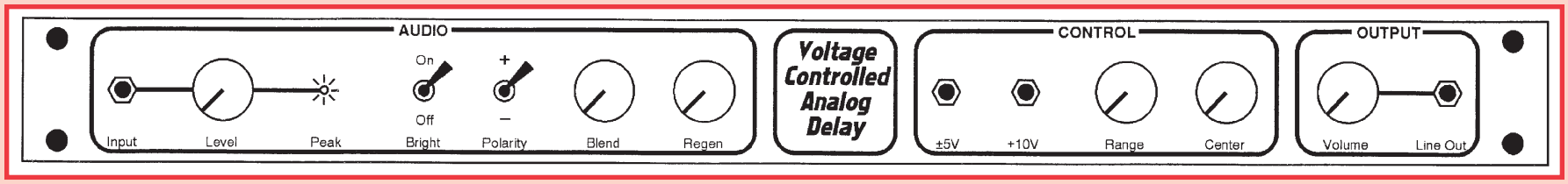

FIGURE 3: With a computer artwork or drafting program, lay out your front panel as in the example shown here. Use reasonable representations of the knobs, switches, jacks, LEDs, and so forth so that you can get a feel for the "ergonomics" of the panel. Allow plenty of finger room between the various controls.

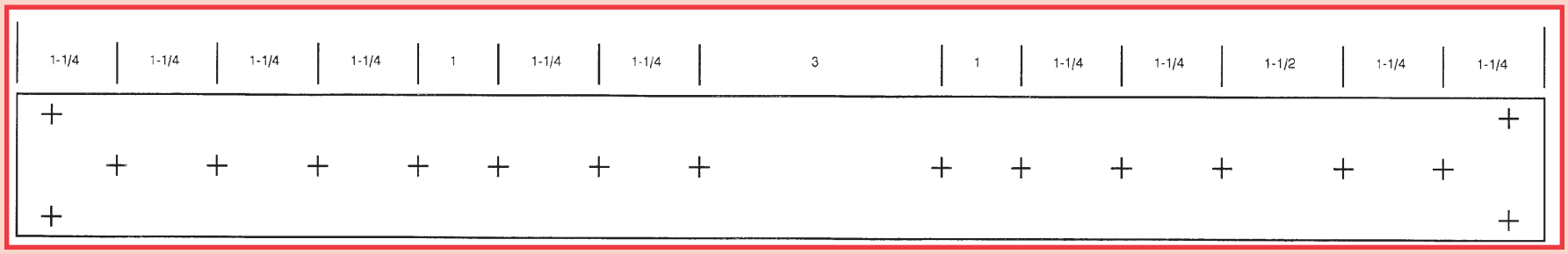

FIGURE 4: Once you are happy with your panel design (see Figure 3), replace the representations of the controls, switches, jacks, etc., with cross-hairs, as shown here. This then becomes your drilling guide. If you print it out full-size, you can attach it directly onto a raw panel with masking tape. Use a metal punch to tap a starter divot at the center of each cross-hair, which will keep the drill bit from "walking."

eraser wore out.

Nowadays, of course, we can use the computer to make things really fly along. So, boot up your favorite artwork or drafting program and start planning now! There's scads of drafting software out there (just do a quick search on the Internet and see), but be sure to pick a program that is accurate, includes alignment grids, and can easily place or center geometrical objects.

My number one choice is GeoDraw, which is part of the Geoworks Ensemble package. It's fast, small, and produces superior scaled or 1:1 hardcopy on just about any printer. If this appeals to you, too, check around the World Wide Web where you'll find many links to the program.

So, with your software running and your mouse all warmed up, start trying out some sample rack panel layouts. You'll probably want to have the actual knobs, switches, and other control paraphernalia nearby so that you can check on the spacings. Figure 3 gives you an idea of what you're shooting for. Use lifesize dimensions if your drafting program permits it. This lets you adjust the "ergonomics" as required.

For example, in my own work, I always allow 1-1/4 inches between potentiometer knobs; this leaves plenty of room for your thumb and finger to twiddle a knob without bumping into the next one. Mini-toggle switches are smaller, as are phone jacks, so only one inch is needed to separate these from their neighbors. By the way, all of your projects will benefit if you choose a standard set of "separation dimensions" and use them consistently.

This is also the time to start putting the panel legends or labels into place. Assuming your drafting software has the capability, experiment with different type styles and fonts. Arrange the labels on the layout as though this were the actual unit. Again, using a lifesize representation makes things simpler, since you can tell beforehand if the knobs or mounting nuts will foul up or obscure the lettering. Take an extra moment to look over Figure 3 once again, which illustrates these concepts. (This is an actual layout from one of my designs.)

Once you are happy with your layout, print it out full-size and examine it from a variety of angles. Since rack panels are 19 inches long, this implies that things will be simpler if you print the hardcopy lengthwise down a continuous sheet of tractor feed paper. But if you're using a laser printer with single sheet feed, you can always tape successive pages together. In any event, spend some time now convincing yourself that the layout looks right.

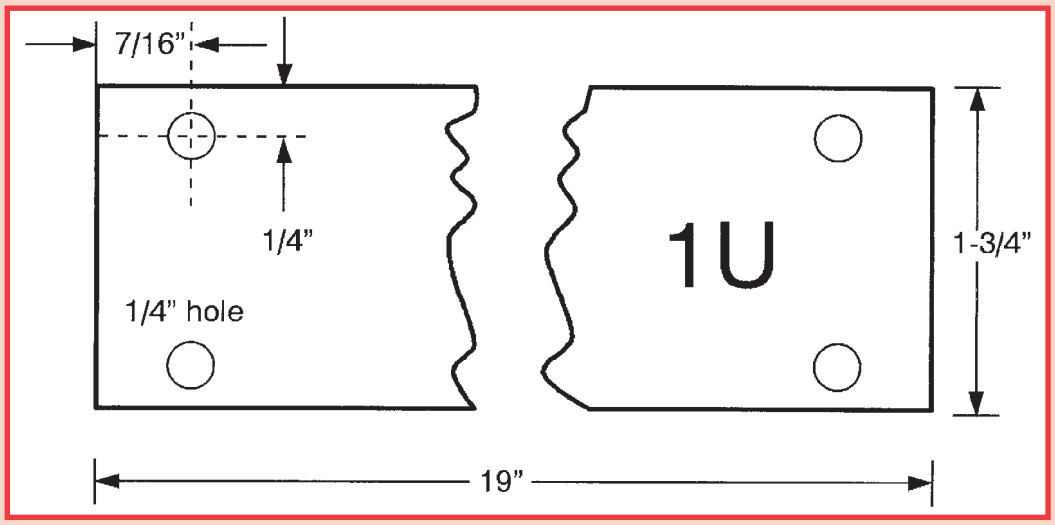

FIGURE 5: The first step in notching a rack panel is to drill 1/4" holes in the four corners. The alignment of the holes is always 1/4" or 1-1/2" from the top or bottom edges (see Figure 1 for details). The 1U panel shown here has its holes 1/4" from the edges.

... DRILL ONCE

If you like what you see, then save your design to disk. Now make a copy of it with a new name. Alter this copy by replacing the various controls, switches, etc., with cross-hairs showing the center points of each. This becomes your drilling template. Figure 4 gives the general idea.

Now, print this version out lifesize. With scissors or a razor knife, cut out the entire drawing and secure it to a blank rack panel using masking tape. With an ordinary metal punch, tap divots into the center of each set of cross-hairs. The starting divot is essential when you begin drilling; this will guide the drill bit confidently and keep it from skating all over the place. When you've completed punching the divots, remove the template sheet and discard it.

And this is probably a good time to pause and say something about the blank rack panel mentioned above. If you check the catalogs, you can find a number of mail order houses willing to supply you with painted and/or punched rack panels in either steel or aluminum. First off, avoid the steel ones completely — your drill bits and hacksaw will thank you! Aluminum panels, 1/8-inch thick, are plenty sturdy and yet easy to work with.

Next, the prices demanded for painted or punched panels will alarm you so much that you might suspect they've been cast in gold! Instead, go for a completely blank panel, 19 inches wide by whatever height you require. You'll cut your own mounting notches and save money, and by painting the panel yourself, you'll not only save again, but get to choose the color scheme you like best. By the way, don't be concerned if the raw panel has surface blemishes or oxidation on it; a later step will clean these up

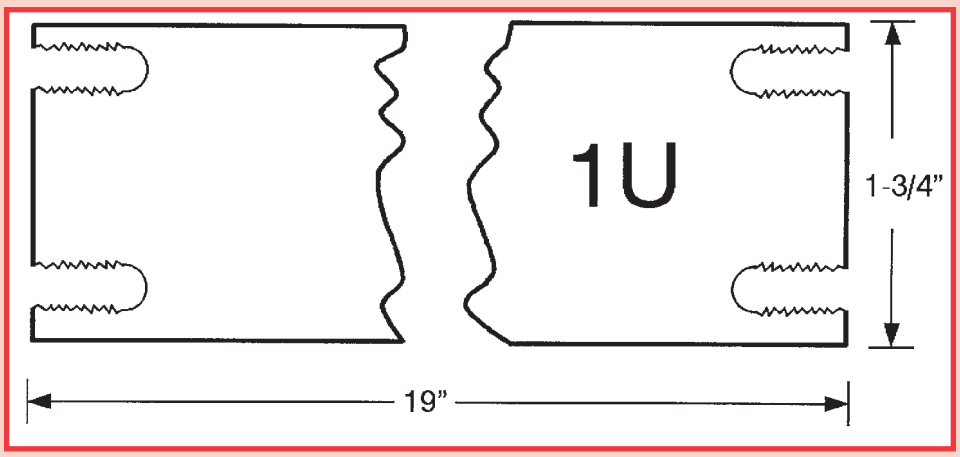

FIGURE 6: Next, the slots are cut out roughly using a hacksaw. Be sure to make them slightly smaller than required. Then with a flat metal file, smooth out the cuts and enlarge the slots appropriately. Keep them neat, straight, and free of burrs.

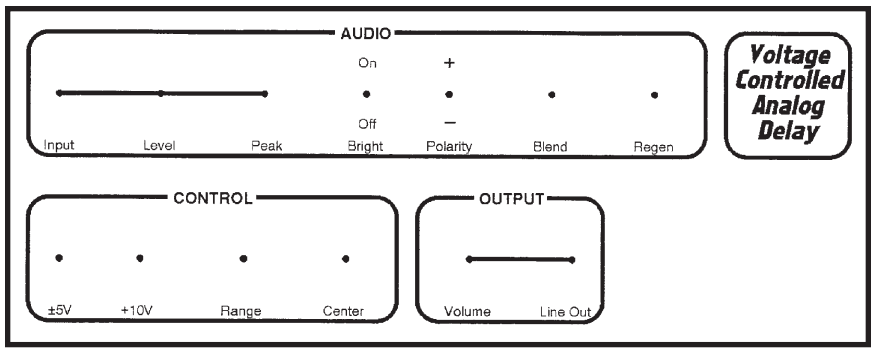

FIGURE 7: Using your original design (see Figure 3), replace the representations of the controls, switches, jacks, etc., with dots, as shown here. Make a hard copy of the page, and then have your local printing house photocopy it onto a sheet of clear stick-back material. Using a razor knife, cut the decals out. Remove the backing, then apply them to the drilled and painted panel. Line-up the decals properly by centering the dots over the various holes in the panel.

completely. A mail order source of inexpensive blank rack panels is listed in the Resources.

But back to the workbench. You're all set to start drilling the holes required by the project. Your first step should be to drill pilot holes in the center of each of the divots you punched earlier. A small bit, like a 3/32 inch, is good for this. And be sure to secure the rack panel firmly in place to a piece of scrap lumber using a C-clamp before beginning to drill. Once the pilot holes are in place, you can then drill the actual control fittings; the pilot hole will keep the larger bit centered and preclude it from walking around the panel.

So, you've now got the holes for the switches, pots, LEDs, and other components taken care of. What about the rack panel mounting slots? Another 15 minutes will dispatch these. Refer to Figure 5 which shows the first step. As illustrated there, you begin by drilling a 1/4-inch hole in each of the four corners.

Then, with a hacksaw, cut notches into the four holes you just drilled. (A workbench vise is a great aid here.) Figure 6 gives the general idea. These will be a little rough around the fringes, and so should be sawed just a trifle smaller than required. Now with a flat metal file, straighten out and smooth up the mounting slots. You might also want to use a rat tail file to neaten up the curvy part of the notch.

CLEAN IT UP!

Well, if everything has gone according to schedule you now have an aluminum panel fully cut and drilled to accept the various controls and switches. And the mounting slots permit it to be slipped into a cabinet for permanent use. The only trouble is that the front surface is a bit scuffed here and there, and other blemishes may detract from the general appearance. That's easy to deal with!

Slip a piece of fine grit sandpaper into an electric sander and have at it! After three minutes of work, you should have buffed the panel quite nicely. Now take a piece of 000 ("triple-aught") steel wool to the panel and remove any swirls left by the sander. At this point, your panel is probably starting to look pretty silky. We'll paint this guy in just a moment, but first we need to take an important intermission to clean it up.

Start off by washing the panel with ordinary soap and water. This will remove any grit or debris left from the sanding and steel wool steps. Really suds it up well, and rinse it thoroughly afterwards. Give the panel a quick dry off with a soft towel.

We need to get rid of any remaining soap film or residue now. So, using cotton balls and 90% alcohol (available at any drug store), give the panel a thorough cleansing. The alcohol will remove any lingering soap scum completely. Let the panel air dry, then buff it down one more time with a soft, dry towel. Check for any lint or cotton ball strands before proceeding.

CHOOSE YOUR COLORS

The next step is to apply a layer of gray primer to the rack panel. The primer not only provides a good surface for the colored paint to stick to, but also tends to smooth out and fill in any minor imperfections. Be sure to read the label on the can so that you'll get the best possible results out of the gray primer.

Once the primer is dry, you can apply the colored spray paint layer. The top choice here is probably epoxy paint (the kind used on household appliances). Epoxy paint provides an extremely tough surface, immune to most chipping and scuffing. Again, be sure to follow the instructions on the can carefully, and allow plenty of drying time.

LABELING THE PANEL

Let's head back to the computer. Boot up your drafting program again, and load in your original layout. We'll use this to whip up some nice looking decals which will provide a legend for the various controls. Figure 7 gives the details. What you do is replace all of the representations (pots, jacks, switches, etc.) with black dots centered over each fitting. The reason for

this will become clear in just a moment. Now using the "cut and paste" command within your software, rearrange the major groupings so that they'll all fit on an 8-1/2-inch by 11-inch sheet of paper. If you're satisfied with how things look, print it out, using a laser printer for best results.

Take the page to your local photocopy shop and have the folks there reproduce it onto a sheet of clear sticky-back material. (This is a self-adhesive transparent plastic sheet which comes in either shiny or matte finishes.) Alternatively, if you have a stock of blank sticky-back sheets yourself, you could run them through your laser printer directly and skip the photocopying step.

Next, using a sharp razor or X-acto knife, cut out the decals in logical blocks. For example, in Figure 7, there are four logical blocks, or you could lump the top two together and the bottom two together. In any event, peel off the backing of the decal and press it down on the panel. The dots help you line it up over the holes you've already drilled. To avoid trapping air bubbles under the decal, it's usually best to start at one end and carefully work your way along the length of the decal. Then place a sheet of paper over the decal, and with the back of your thumbnail rub it down smoothly to press out any air bubbles.

At this point the decals cover everything, including the holes! So, with a pointed X-acto knife carefully cut out the center of each one. That is, stab the knife into a hole, then slide it around the perimeter trimming away the sticky-back material. When you make it all the way around, a disk will pop out which you then discard. Repeat for all of the remaining holes.

To really protect your handiwork, you need to apply a layer of clear plastic spray paint. But here's an important point. Spray it on in many, many thin layers (allowing time to dry between each layer), instead of several thick layers. This not only keeps the "ink" from running, but also prevents swirls and runs from rearing their ugly heads.

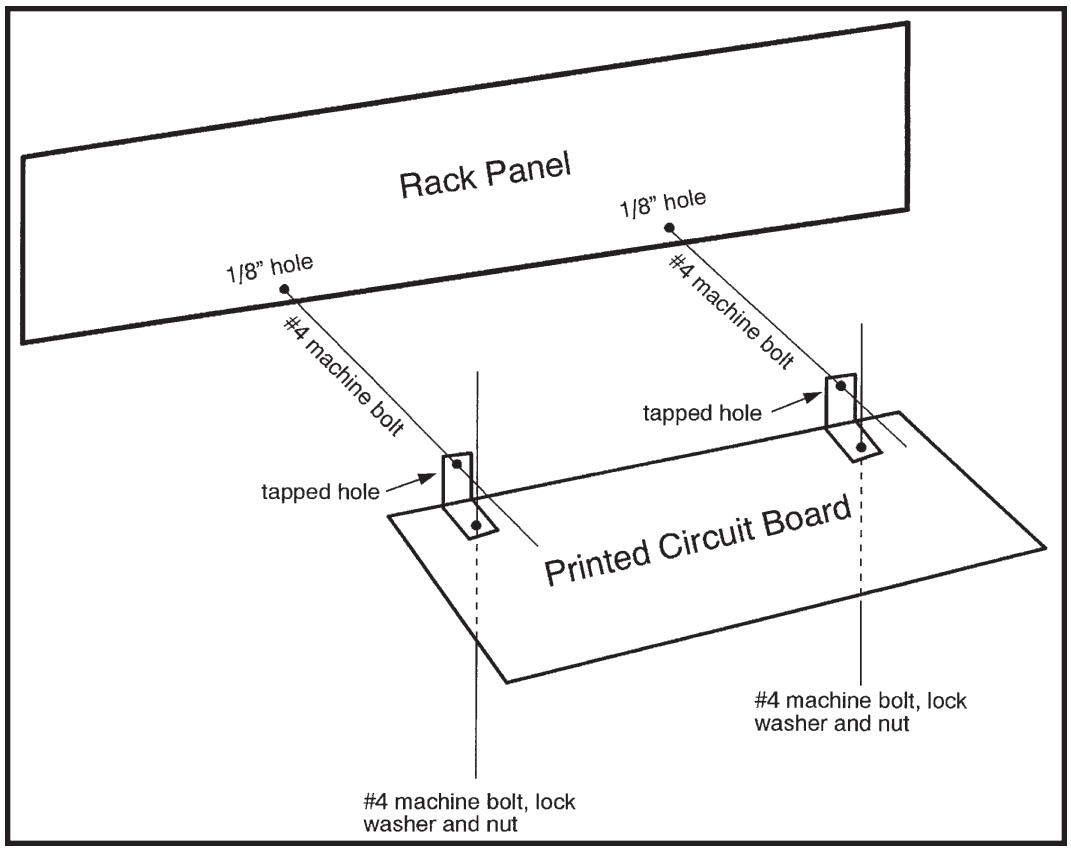

FIGURE 8: A printed circuit board mounts behind the front panel by means of two small angle brackets. The front holes of the brackets have been tapped to take #4 machine bolts, while the bottom holes accept #4 bolts, lock washers, and nuts.

USING YOUR PANEL

Give the clear coat a couple days to really dry, and then you're all set to start building with your new rack panel. For most common circuits, you can simply mount the circuit board behind the rack panel on little angles. Figure 8 illustrates how to do this. (On the other hand, RF or high-voltage circuits should probably be housed in something that isolates them completely from the outside world.)

When you're all done with the wiring and testing, you can mount the completed unit in a cabinet. As mentioned earlier, if your cabinet has wooden rails you can use wood screws for this; tapped metal rails require a 10-32 machine bolt. If you have a choice of head type, pick the oval style. That way, you can use cup washers between the screw or bolt and the front panel; the oval head "settles in" to the center of the cup washer quite nicely and looks very professional. They are available in several sizes and materials (brass, aluminum, nickel-plated, etc.) at most hardware stores.

And here's an idea I came up with to keep the cup washer from marring the front surface of the rack panel. While you're still at the hardware store, head over to the plumbing department.

There you'll find a large range of rubber O-rings (for fixing faucets and so on). I discovered that there are sizes of these that fit perfectly in the back (hollow) side of the cup washer!

Thus, when you secure the panel in place, the screw passes through the cup washer, then the O-ring, then the panel, and finally the cabinet rails. The rubber cinches everything together nicely and protects the panel from the sharp edges of the cup washer.

If you've come this far, then you now know the secrets of making truly decent-looking rack panels for your own equipment. Over the two decades that I've been using and refining this process, I have had a steady stream of compliments from people on how attractive my gear appears.

If I (with a total lack of a background in art) can do it, then so can you! **NV**

RESOURCES
BLANK RACK PANEL KITS

Blank rack panel kits are available from **Midwest Analog Products** in either 1U or 2U sizes. Each kit includes: blank aluminum rack panel, 1/8" thick tapped miniature angles zinc plated #4 machine bolts, lockwashers and nuts
#K901 1U (1-3/4" by 19") Rack Panel Kit $8.95
#K902 2U (3-1/2" by 19") Rack Panel Kit $10.95

Note the following ordering information:
Minimum order of $15.00. Please add shipping and handling of 10% of merchandise total or $5.00 (whichever is less).
Shipping is by First Class Mail.
Prices shown in US dollars. Remit US funds only. Write or E-Mail for shipping information to other countries.
MN residents add 6.5% sales tax.
Money orders and checks only.
Prices and terms subject to change without notice.
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