ELECTRONOTES MUS. ENG. GROUP
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APPLICATION NOTE NO. 14

November 11, 1976

HOW TO ACTUALLY BUILD SOMETHING

Part 1: PARTS AND SUPPLIES

The first step in building any electrical circuit is to carefully study the schematic diagram and the circuit description to be sure you have a clear picture of how the circuit is supposed to function. The second thing is to be sure you have a clear idea of everything you will need to complete the project. These items fall into six general categories: electrical components (resistors, capacitors, IC's, transistors, diodes, etc.), control components (pots, switches), hardware (nuts, bolts, jacks), packaging (cabinets, panels, knobs), supplies (blank circuit board material, wire, solder, resist paint, etch solution, etc.) and tools (soldering iron, fingernail clippers, alligator clip for holding small parts during soldering, plastic dish for etching solution, drill, etc.).

ELECTRICAL, CONTROL COMPONENTS, AND HARDWARE:

Unless you live in a large city or are only building a small project, you will probably find it easiest and cheapest to obtain the parts you need by mail order. To get addresses, start with ads in the back of magazines like Popular Electronics and Radio-Electronics. Also, get addresses from other builders. Electronotes also has a list of suggested suppliers. You will probably be able to obtain the semiconductors you need by mail in a week or two. You can also obtain resistors and capacitors in this way, but it is usually better to stock many of these items. Controls (pots and switches) are usually quite expensive as "new" items so it is well to watch for these on surplus lists and then buy some extras for your stock. Likewise, hardware items are not general surplus items so be sure to grab some when they do appear.

SUPPLIES:

Items like circuit board material, wire, solder, paint, and etch solution are items which you are not likely to buy very often since you usually will be buying much more than you need for an individual project. Probably the best circuit board material is that which has fairly heavy copper, is coated on only one side, and which is already cut to some convenient size (4½ by 6½ is common for example). It is not particularly easy to cut smaller pieces out of a very large board, so try to get smaller ones. It is convenient to get hookup wire that is of relatively small gauge (#24 or #26, and possibly stranded is most useful). Test the insulation. It should not melt under normal soldering iron heat, or at least should not melt easily. Yet the insulation should be soft enough so that you can easily strip it off with a thumbnail, as this will save much time and frustration looking for a wire stripper. Choosing a good grade of solder is very very important. Solder is expensive, but the better grades are well worth the extra money as easier soldering means less time spent and fewer soldering errors due to awkward technique with poor grade solder. The solder should be rosin core, 60% tin 40% lead (or better still, 63% tin 37% lead true eutectic solder), and in a size of 1/16 to 1/32 inch diameter. Again we stress, do not buy cheap solder, as you will pay the price later.

You will need some sort of resist paint to paint up your circuit boards. It should be a paint of some sort - none of the "pen" type devices are good for more than about six square inches of board space, and when they dry out, you will uncover as much copper as you cover. You should rely on some kind of paint, and possibly press on tape if you happen to like the nice shapes and straight lines and don't mind the expense. You have a choice of paint, laquer or acrylic. Probably a lacquer paint is the best all around, but its biggest drawback is that the fumes of the solvent will irritate during an extended painting session. Acrylic paint is water base and can be thinned with water and thus you don't have the solvent fumes, but the water base is less effective at coating the copper surface, especially if the surface is a little greasy or oily. In either case, the paint should be thinned down quite a bit before use. For laquer paint, add about 50% extra solvent *(laquer solvent is available with laquer paint in most hardware stores)*. For acrylic paint, add about 25% extra water to start with, and possibly a drop or two of dish washing liquid as this will make the paint spread better. Acrylic paint is available at artist supply stores in tubes. Any color will work, but avoid browns, reddish browns, and dark yellows (which are similar in color to the etching solution and etching residues), and any color similar to the insulating material of the circuit board. The etch solution should be ferric chloride (the standard item) and you can get this in electronic supply stores. You can get this on your hands for a short time, but it should be washed off soon, and will stain just about anything, so be careful. Avoid "anhydrous" ferric chloride powder as mixing this with water is highly exothermic and fumes and dust can be most irritating.

TOOLS AND THE LIKE:

A pencil type soldering iron is best for IC work. The wattage of the iron should be quite low (the 27.5 watt size is good). It is extremely important that the iron and tip be kept in top shape. Of course, a new tip should be tinned with solder as soon as it gets hot. But you should also file and retin it if it becomes misshapen, which will generally happen in a matter of a couple of hours. Iron tips may last a little longer, but we generally suggest using the copper ones. A properly shaped tip is shown in Fig. 2 while a badly burned one is shown in Fig. 1. Often the burned one will have a concave tip and possibly a hooked needle like point that will make soldering stranded wire a nightmare. The properly formed convex tip will be easy to use. When the tip becomes misshapen, there is no need to cool the iron. Just twist out the tip with a pliers, allow to cool, file properly, *replace, and tin immediately. Even if you don't have to* refile the tip, it is a good idea to loosen the tip and retighten about every half hour to make sure it does not set up, and so that good thermal contact is maintained (many people think they need a hotter iron while all they need is better thermal contact between the heating element and the tip).

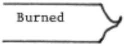

Fig. 1

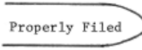

Fig. 2

Two simple "tools" will be very useful. A fingernail clipper is probably the best of all possible cutters for small copper wire. It is much easier to use than a "diagonal cutting pliers" and is much cheaper (and often right in your pocket instead of somewhere on your bench). An ordinary alligator clip is the most useful device for holding parts while soldering (you hold a resistor in the clip and the clip in your hand and you don't burn your fingers!).

It's nice to have an electric drill handy for drilling holes when mounting boards and controls. A "rat tail" file is very handy for enlarging holes if you don't have the correct size drill. If you drill holes or file while some electrical components have already been installed, be sure to get the "chips" out. It is good to use an ordinary vacuum cleaner to catch the chips, and to clean up afterward.

The paint brush you use for etch resist paint should be found by trying several different ones. It is a good idea to get a fairly stiff one or to use one which has a little paint dried into it. Thus, it is sometimes desirable not to clean the brush after you use it.

Finally, it is necessary to have something to clean up the copper circuit board. This can be steel wool, or scouring powder, or something of that sort. All copper board you get will need to be cleaned both before you paint it and afterward. Be sure to shine it up well in both cases. If it is not cleaned well, it will be hard to get a good even coat of paint. If it is not again cleaned before soldering, the solder may not stick easily. A circular cleaning motion is best, This will also make it easy to mark the board with a pencil before painting.

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APPLICATION NOTE NO. 15

November 18, 1976

HOW TO ACTUALLY BUILD SOMETHING

Part 2: CIRCUIT BOARDS

After obtaining all the necessary parts and studying the circuit to be built, it is usually necessary to build a circuit board for the circuit. The circuit board serves as a mount for many of the components. Obtaining circuit boards presents a problem of a level of difficulty that varies with the individual builder. Some builders never prepare their own, but only buy them (and thus have a restricted number of circuits to work with). Others take days with photographic methods, and strive for professional looking boards. Some builders use a type of "instant circuit board" which is a prepared board set up for a general type of circuit. Still others simply paint and etch their own boards in a matter of hours. We tend to favor the last two of these methods because they get you going fastest even though the circuit may not be particularly efficient in the case of the "instant circuit board" and the results may not look as professional in the case of the hand painted board.

In our view, a fundamental mistake that many builders make when preparing a circuit board is that they look at commercial boards and decide that theirs should look as much as possible like the commercial ones. In particular, commercial boards have the components on one side, and the solder and traces on the other. This is fine, and often essential for production circuit boards (some commercial soldering techniques would prevent the placement of components on the foil side of the board). However, for the individual builder, use of both sides of the board in the commercial manner just serves to obscure half the circuit. In our view, it is absurd to go to the trouble of drilling a lot of small precisely placed holes so that you can hide the components from your view during construction and testing. Rather, we suggest placing all the components on the foil side of the board, and not drill any holes except those necessary for mounting the boards.

With the above paragraph in mind, we will describe a simple printed circuit board fabrication method that is fast and easy (and inexpensive). All that you will need to do this is blank circuit board material, some kind of etch resist paint, a paint brush, and some kind of cleaner such as steel wool or scouring powder. Next, one should adopt the view that the board he is about to produce will serve to mount the components, and to provide much of the interconnecting circuitry, but will not be the ultimate in efficiency for the particular circuit. Most likely, there will be a need for a few wire jumpers (which are the resistor lead clippings you would otherwise throw away). Also, there will probably be a need for a longer wire (or two, or three, ...) to do the job of a missing trace which you just could not find a path for. Of course, you can always find a better layout for any circuit if you keep trying, but if you do keep trying, you will never get the thing built.

So the first step is to insure proper mounting of the components. There will probably be no real need to worry about the board space for resistors, but only for IC's, large capacitors, and such items as trim pots. When this is determined, select a blank board large enough for the components in the circuit, and lay out the major components on the foil side of the board. Mark the positions of the leads of the IC's with a small pencil dot. Be a little careful about the layout of these major components. You should allow no more room than is necessary for the various sections, but then again you might as well use the whole board. Once you have the major components on the board and marked, make a quick check to see that everything is going to fill in well and adjust accordingly. Be sure to provide an area of the board for foil pads which will serve to receive wires from inputs and outputs, and from panel switches and controls.

Once the IC positions have been marked, you will know where the power supply lines must go. We suggest that these be penciled in using a straight edge. Later on, these straight lines will serve as references for other traces so that they can be made neater. With this done, the circuit board will look something like the one in Fig. 1. Actually, at this point it is just a copper clad board with pencil marks. You should note the following: (1) There is a ground path around the entire outside of the board, and at the corners this gets wider to provide mounting surfaces. (2) The dots represent the points where the IC pins will make contact with the copper surface. (3) At the left, a number of rectangular areas are provided to serve as in/out tabs. (4) The power supply lines have been penciled in for all the IC's.

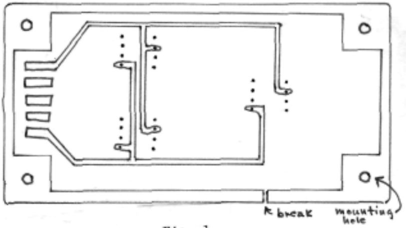

Fig. 1

The next step is to paint the board with either a lacquer paint (solvent base) or acrylic base paint (water thinner), and a thin artist brush. The paint should be quite thin, and the brush should be fairly stiff (just don't clean it out after each use). You of course paint the penciled in areas you have prepared. Then, you are pretty much on your own as far as completing the circuit is concerned. You just start painting in the necessary traces. Actually, you will soon find that many of the configurations you will need will become routine. The procedure is illustrated in Figures 2, 3, and 4. Fig. 2 shows an inverting amplifier circuit to be constructed. Fig. 3 shows the pattern the etch resist paint will take. In arriving at this pattern, you have in mind a mental picture of how the finished circuit will look (see Fig. 5).

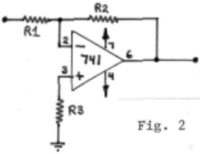

Fig. 2

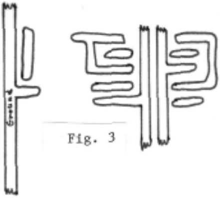

Fig. 3

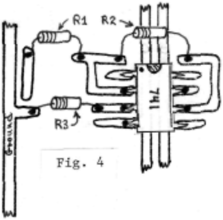

Fig. 4

Once all the paint is on and all the paint is dry, you etch the board in ferric chloride solution. It is usually possible to do this by floating the board on top of the solution. Touch the board to the liquid surface at a slight angle to prevent bubbles from being trapped underneath. Check the board after about 10 minutes, and replace if necessary. Once etching is complete, rinse the board with water and remove the paint with solvent or steel wool. Then thoroughly clean and shine the board with steel wool or scouring powder. Rinse with water and dry.

You can begin soldering parts to the board immediately if you wish, or you can take a little time to tin the board first. To tin the board, you just coat all the copper with a thin coat of solder. This will repair any small cracks in the copper, and will serve to make part mounting easier. If you wish, you can then invert the board and remove excess solder by letting it run down the soldering iron tip. This leaves a very thin coat which can be polished with steel wool to look like a tinned board.

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APPLICATION NOTE NO. 16

November 25, 1976

HOW TO ACTUALLY BUILD SOMETHING

Part 3: SOLDERING IN PARTS

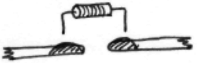
Whether or not the actual soldering in of parts is easy or hard depends to a large degree in how successful you were at preparing a circuit board. If we assume that you had a good mental picture of the way the parts were to fit in when you painted the board, this part of the job is just a realization of the mental picture. In this note we will be talking about the best techniques for soldering, some of the things to do when things don't go exactly as planned, and a few of the nice things you can do to make testing easier.

We talked in an earlier note about the importance of good solder and an iron in good condition. These are the first of the important "rules" of good soldering. The third rule is to not use too much solder. If you get big blobs of solder on a circuit board where IC pins are close together and circuit board traces are also close, you are going to have problems. Not that you are likely to miss seeing a blob that would short the circuitry, but they are very hard to get rid of. The best thing is to avoid them by using only small amounts of solder, but if you do get one, you may be able to get rid of it by holding the board upside down and trying to get the excess solder to run down the iron tip. The fourth rule of good soldering is to not use too much heat. It is not likely that excess heat will damage any components, but the point is that you should not have to use it. You should only have to touch the soldering iron to the connection for a period of a second or two. By the way, there used to be instructions for soldering that said you use the iron to heat the metal to be soldered, and then touch the solder to this metal (instead of touching the solder to the iron). This never really was too successful, and it took too much time. Thus, even when these stories were going around (as in Heathkit instructions), no one really did this. It is much more realistic to touch the iron to the metal, and push the solder in between the iron and the metal, letting the solder flow. If you then get the soldering iron out fairly fast (before all the rosin flux burns off), you will get a smooth connection. The fifth rule of soldering is that things are easier to solder if they are tinned first. That's one reason why we suggest tinning the board first. Now, you probably know that the leads of resistors and capacitors are already tinned, so you might think that there is nothing more to do with these. Actually, a freshly tinned layer will work much better than just relying on the original tinning. The same goes for IC pins which will be much easier to solder if you retin them before attempting to mount them.

At risk of boring the reader, we will go into a detailed discussion of how a single resistor may be mounted. Assume that you have a position for the resistor and an uncut resistor as shown in Fig. 1. The first step is to tin the end points of the circuit board traces with a little blob of solder. Next you bend over the resistor leads and cut them at a point about 1/4 inch beyond the bend. The spacing between these cut ends should be the same as that between the mounting points (Fig. 2). Next, grasp the body of the resistor with an alligator clip. Hold this in one hand and the soldering iron in the other. You should also have a coil of solder with a free end sticking out. Touch the cut end of the resistor, the soldering iron tip, and the solder all together at the same time, and then pull them apart. Done

Fig. 1 Mounting position and uncut resistor

Fig. 2 Tinned mounting position and cut resistor leads



properly, this will result in a deposit of solder on the lead end that ranges from a heavy coat to a small blob. Then you place the resistor (still holding with the alligator clip) above the mounting position and press down slightly. Touch the soldering iron tip to the junction for a period of about one second, and then remove. Hold the resistor in place until the solder hardens. Now, the other end of the resistor is held in approximately the right position by itself. If there is enough solder at the junction, you just heat the junction and remove the iron. If not, bring up a little more solder. Then, after this second junction hardens, if there is any doubt at all about the first one (you may have moved your hand slightly while waiting for it to harden), you should reheat the first one, perhaps adding another bit of new solder. Be sure you don't have both ends in liquid solder at the same time or the resistor falls over. The entire mounting may take as little as 20 seconds. The final soldering procedure is illustrated in Fig. 3.

Fig. 3a First Connection

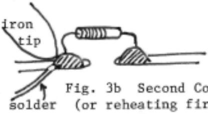


Fig. 3b Second Connection (or reheating first one)

IC's and other components are mounted in much the same way. You first tin all the metal parts, then get the part "tacked soldered" in place, and finally reheat and add solder to any additional connections or poor connections. Eight-pin "Mini-DIP" Ic's can generally be mounted flush with the board. For 14 and 16 pin DIP packages, it may be a good idea to mount them slightly above the board surface by first adding a larger blob of solder to the corner mounting positions, and not forcing the IC to the board as solder is added. This makes it easier to remove should this become necessary. This elevated mount is shown in Fig. 4.

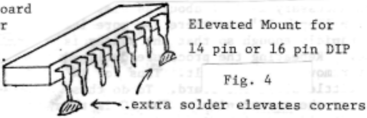


Fig. 4

So far we have assumed things have gone as planned. They won't always. If you have an improper trace, you can usually break it with a pointy knife blade. If you are missing a trace, use some wire. If you forget to leave mounting tabs, you may be able to sneak a component in "upright" (Fig. 5), or may even have to establish a "floating" tie point (Fig. 6). It is even possible to "piggy-back" an IC to another (using common supply pins) as shown in Fig. 7. This is usually easy to do, and can be made quite neat and mechanically sound. There are numerous other ways to improvise and get the job done. If most of the circuit is correctly prepared, you should be able to get out of a few tight spots.

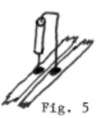


Fig. 5

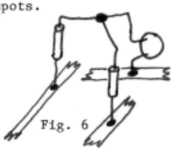


Fig. 6

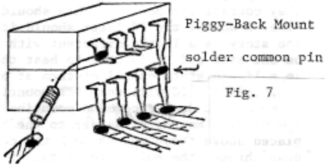


Fig. 7

It is a good idea to give some thought to the testing phase that will follow. At certain critical points in the circuit, a resistor lead mounted straight up may be a useful point to clip on a test lead (Fig. 8). You can remove these later or just leave them in. At certain points, it may be best to leave a jumper which can be removed to isolate major sections of the circuitry during testing. These jumpers can be looped up so that a test clip can be attached to them as well.

Fig. 8

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APPLICATION NOTE NO. 17

December 4, 1976

HOW TO ACTUALLY BUILD SOMETHING

Part 4: PACKAGING

By the time you get this far, you probably have a circuit board built and tested and are looking for something to install it in. Or, you may be waiting to test it because you need to connect it to certain panel controls that will be mounted as part of the package, and not on the circuit board. If at all possible, test the board outside. You can often do this by temporarily soldering in a fixed resistor or two as a substitute for a panel pot. It will help a lot if you know the board going in does work, or at least is not totally unknown as far as its operation is concerned.

So what is packaging? It is just putting the circuit board inside some sort of box or enclosure to protect it from damage and make it easy to use. You may be proud of your circuit, but the advantages of putting it in a box are obvious. Or, you may want the box to hide a circuit that is electrically perfect but otherwise not what you would call a work of art. You will probably find that enclosures are not as easy to come by as are the components inside, and you may well end up spending more for the box than for the rest of the circuit. Naturally you will want an enclosure that is big enough to contain the circuit board, the power supply, and whatever else must go inside. It should also provide the necessary mechanical support and shielding. Other than that, you will only have to consider the ease with which you can finish the project (and of course the price and availability). You could easily spend $10 or more for an enclosure, or you may find a thrown away box that will work.

Let's assume that your board is of the general form shown in AN-15, Fig. 1 (a board with mounting areas and holes in the corners. Since you have all the parts on the foil side, nothing on the back, and have drilled no holes other than the mounting holes, all you have to do is drill matching mounting holes in the enclosure and mount the board with four nuts and bolts. If your enclosure is metal and serves as ground, you have grounded your board. Next, you will run up the wires from the power supply to the board. It is often a good idea to add a bypass capacitor to these supply lines at the point where they come on the board. This helps to keep noise from entering the board through these lines, and noise generated on this board off the lines. It is often the case that individual circuit boards may work just fine when tested separately, but fail when mounted in an enclosure with other boards on a common supply. These bypass capacitors (which should be 5 to 10 mfd electrolytic for example) will help to assure you may not have this problem.

Now, for a typical device, you probably have a front panel that has on it pots, switches, jacks, and possibly pilot lights and other indicators. If you have a power supply that runs on the AC line, you should do your best to place the power supply switch out of the way (perhaps under a chassis) so that you won't accidently come in contact with high voltage. Once high voltage lines are soldered, make sure the power supply is functioning properly, and then mix up some epoxy glue and coat the exposed terminals. Let this glue dry, and then cover the terminals with electrical tape as well. There is no sense taking chances, and builders these days have a tendency to forget about high voltage because they are usually using only low ones. If a wire end strays to the AC line, even if you don't get hurt yourself, you may have components that will object. If you take these steps, you have a safe supply setup, and your board is powered properly much as it would be on the test bench. You can then install the additional control wires and test them one at a time as you go.

Once the board is installed, and all control pots, switches, and jacks are installed, you will be faced with the obvious problem of connecting the controls to the boards, and wire of some sort are the obvious solution. It is well to do at least a little planning at this point. One of the major rules here is that there is generally no reason to run a wire from a tab on the board to the panel more than once. That is, you run to the panel once, and if you need the same line again, you jump from one panel location to another. Probably stranded wire is best for connections from the board to the panel as it is flexible. On the panel however, solid wire is best for jumping from one point to another as it stays in place better. A couple of examples will illustrate the above points. Fig. 1 shows a pot acting as a voltage divider providing from +15 to ground. It is often the case that the panel is grounded, and thus, so is the case of the pot. We simply bend terminal three over and solder it to the case, leaving us with only two wires to run to the board. In Fig. 2, we show two voltage divider pots between +15 and -15. We run the +15 and -15 to the panel at only two points (one for + and one for -) and jump from there to the various pots. Thus, for each additional pot we connect up, there is only one additional wire running back to the board.

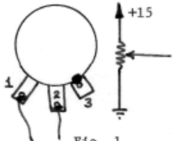

Fig. 1

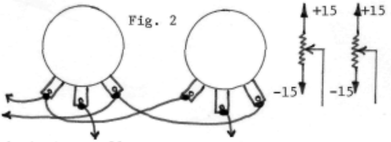

Fig. 2

As the wires come off the board, it is usually a good idea to route them through certain paths so that they don't jump all around. There are probably plenty of places where you can do this. Fig. 3 shows three possible paths. At A, the wire runs along and under an IC which is mounted on the foil side of the board with its leads flush. At B, we have used any handy resistor and run the wire underneath. At C, we show how a loop of wire can be used as a threading point. It is just a small loop of solid insulated wire (or just an uninsulated resistor lead clipping) which is looped over and soldered in two places to the same conducting path. This may be a jumper you are already using. Short wires soldered only at one end are also useful for collecting loose wires and lacing it around them holding them in place. Threading points on the panel will not be quite so easy in general. You can loop a wire and connect both ends to a pot terminal for example. Or, you may have a panel jumper wire which is too long as is. Give it a little twist as shown in Fig. 4, and you tighten this up and provide a threading point as well.

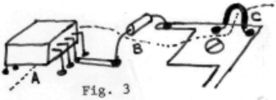

Fig. 3

Fig. 4

You should also consider the possibility that you can mount components on the panel. Fig. 5 shows a common situation where a rotary switch selects one of seven possible resistors. If the resistors are on the board, you need eight wires between the panel and the board. If you mount then on the switch, you have all the resistors comming to a common floating point which is just a solder blob, and only two wires between the panel and the board (x and y).

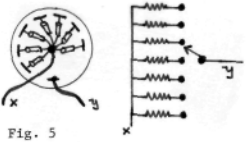

Fig. 5

There are many other tricks which you will surely devise. Also consider the use of twisted pairs or ribbon cable. To make a twisted pair, just streatch out two wires across the room securing the far end. Put the near ends in an electric drill chuck and pull the trigger - instant twisted pairs!

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APPLICATION NOTE NO. 18

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HOW TO ACTUALLY BUILD SOMETHING

Part 5: MISCELLANEOUS HINTS

In preparing parts 1 to 4 of this series (AN-14 to AN-17), we had a specific phase of construction in mind for each note. Here we want to clean up a few loose ends which are also important. These are presented in no particular order.

UNUSED (N.C.) IC PINS: *When a pin of an IC is a real NC (no connection), there is of* course no reason to solder it down, as this will just make it more difficult to remove. On the other hand, it is a good idea to leave a blank tab on the board for it. Why? It serves as a reference to the eye when installing IC's on the board. A typical op-amp may use only 5 of eight pins for example. It is much easier to place this if there are two parallel rows of eight pins than it is if there are only three on one side and two on the other. This is especially important if you have IC's in a row with spaces in between as otherwise a blank space may look like the space between IC's. When installing round IC packages however, it may be a good idea to solder down all NC pins as well as this prevents these wires from flying around, and they are not hard to desolder.

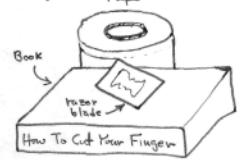
MARKINGS ON PANELS: When you have to put lettering on panels, rub off type letters are a good choice. You will have to put these letters on before mounting any controls on the panel however. Be sure the panel is clean of any grease or oil or you will have a very hard time with these. Once on, several light coats of clear lacquer will prevent them from rubbing off. A coating of clear nail polish is also good for protecting these letters, but brush this on very lightly or you may dissolve the letter.

HOLDING ETCHING SOLUTION: The best thing I know of for etching solution is a plastic freezing dish with press-on cover. This allows you to keep the solution covered when not in use. The dish should be big enough for your biggest board, and not too deep.

CUTTING CIRCUIT BOARD: If at all possible, avoid cutting circuit board. When it is necessary, it should be sawed and not sheared unless you have a shop type sheet metal shear available. An ordinary "tinner's shears" will not work as it will leave a ragged edge, will warp the board, and leave cracks in the copper. A hack saw will work as well as anything if you don't have a band saw available. If this sawing leaves an uneven edge which you don't like, set a sheet of sandpaper on a flat surface and rub the edge on the sandpaper. This results in a very nice even edge.

PRESS-ON TAPE FOR CIRCUIT BOARDS: For making straight edges, press on resist tape usually beats painting. This is expensive. Electricians plastic tape works just as well but is too wide as it comes. A good way to cut this to a proper width is to start with a wide roll such as 3/4 inch and place this on a flat surface. Bring up a thin board, writing pad, book or whatever such that the top surface of the book is flush with the surface at which you would cut the roll. Then place a razor blade flat on this surface, and hold it slightly over the edge. Rotate the roll of tape against the blade and you will be able to make a fairly even cut. Don't try to cut the whole roll at one time - cut some and use it and then go back for more. When you get into the top slice a ways, get a thinner book and work on the next slice a while, and so on. This procedure is illustrated by Fig. 1.

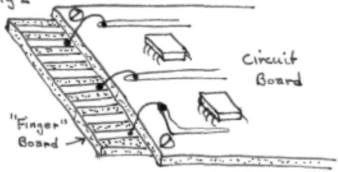
Fig 1



MORE ON PREPARING CIRCUIT BOARDS: We mentioned that it is often useful to tin the entire circuit baord after preparation. In general you just use it as is after it is tinned, but if you wish you can make the board look as though it were solder plated. To do this, you must have removed the excess solder from the tinning process by holding the board upside down and letting it run down the soldering iron. This leaves a shiny and possibly "grainy" surface appearance. The board can then be washed with alcohol to remove excess rosin flux. Next, you use steel wool to smoothen up the board. This would also remove any excess rosin flux, but the flux tends to clog up the steel wool so it is best to get it off first. After getting the grain off the surface, polish the board with scouring powder, and you get a nice looking "plated" board for your efforts.

FINGERS FOR EDGE CONNECTORS: If you are mounting your PC boards in edge connectors, there must be a matching set of fingers on the boards. These can be painted on, but it is difficult to measure properly each time you need these. One easy way is to just insert the board in the connector once or twice and this will leave a mark on the board showing where the connector contacts will meet the fingers on the board. You can then paint them them in. Another thing that is useful is to make a whole board of fingers by using press on tape. This is especially useful if you have some type of instant breadboard which you prefer but which does not have fingers. You can then cut off a slice of the finger board and bolt it to your board. The general idea is shown in Fig. 2.

Fig 2



OPTIMUM USE OF PANEL SPACE: With electronic music equipment, and with other types of equipment as well, panel space is at a premium because there are so many controls we need to have available. If we have a chassis mounted directly to the back of a panel, there is a line on the front of the panel along which we are not able to mount any controls because the chassis top is directly behind it. For this reason, it is often desirable to recess the chassis back from the panel so that every inch of available space can be used to maximum advantage. In doing things this way, we can just lay out the panel from the front and not have to think much about what is to go behind. We also avoid problems of drilling mounting holes through both the panel and the chassis and having to worry about whether or not they will line up. The chassis may be recessed by a set of brackets which you can buy as side braces for a flush chassis, or you can probably make them yourself. The basic idea should be clear from looking at Fig. 3.

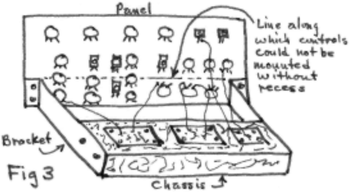


Fig 3

GROUNDING AND BYPASS: If you are making your own circuits, you do not have a tried and tested layout to work with. If you are building high level signal handling gear such as synthesizer modules, you should have few layout problems. Digital circuits may be a little trickier, but again probably no real problem. The major problems with layout will occur with low level audio circuitry, and with radio-frequency devices. Many problems are avoided by proper grounding and bypass techniques. The major rule with grounds is to make them heavy, direct, and all to the same point. That is, all grounding paths radiate out as a star from a central point. Often, low current grounds should take different paths than those carrying large currents. In many cases, any old ground will do, but it is well to play safe. You can always make grounds heavier with an extra coat of solder, or by solderind down an extra wire to the trace. Supply lines should by bypassed at critical points. Often these points are located by noisy waveforms. Always bypass lines in digital circuits, and bypass the supplys to op-amps that are handling low level signals as close to the chip as possible.