Metal work at home

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If, like me, you are into electronics and amateur radio seriously, you will regularly find yourself in the position of having to provide an enclosure for your latest project.

Now there are plenty of great enclosures available at the local electronics shop, but guess what? My projects never seem to fit them. The project is either too large (linear amplifiers, antenna tuning units, transceivers, power supplies, etc) or there are just too many knobs and meters to fit into the front panel space available.

Or there is some other subtle factor which makes the selected enclosure unusable, like too expensive, and so I usually end up rolling my own. Here is how I go about it, using a few simple tools.

Raw materials

Almost any enclosure for large amateur radio equipment can be made from 0.8 – 1 mm thick aluminium sheet. Careful thought must be given to the placement of large heavy items like power transformers. Such items should be placed next to an enclosure wall or near a right angle fold to obtain maximum strength and to avoid flexure. If necessary, this part of the enclosure can be beefed up with a piece of heavier sheet.

New aluminium sections and large sheets can be obtained from suppliers like Capral. Smaller sheets can be had from hardware outlets such as Bunnings, and suppliers of non ferrous metals in your capital city. See the 'Yellow Pages' or check the 'net'. Expect to pay around $12- $17 per kilogram. Capral has a complete catalogue of its products on the 'net'.

My favourite source for powder coated sheet is from the washing machine trade-ins at my local branch of the 'Good Guys'. Older large Hoover washing machines have a very big aluminium lid 1.6 mm thick which is excellent for constructing cases for heavy power supplies. So check out your local washing machine reconditioner or supply house. You will need a Phillips screwdriver to whip out the two stainless screws in the hinges and the lid is yours. The saw described below removes the lid edges and you end up with a very nice piece of powder coated sheet around 400 mm square. Scrap metal yards are also good for aluminium sections and sheet of all sizes and thicknesses too, and the price is usually right (around $2 per kilogram).

Marking Out

The tools for marking out are very basic and should be a part of

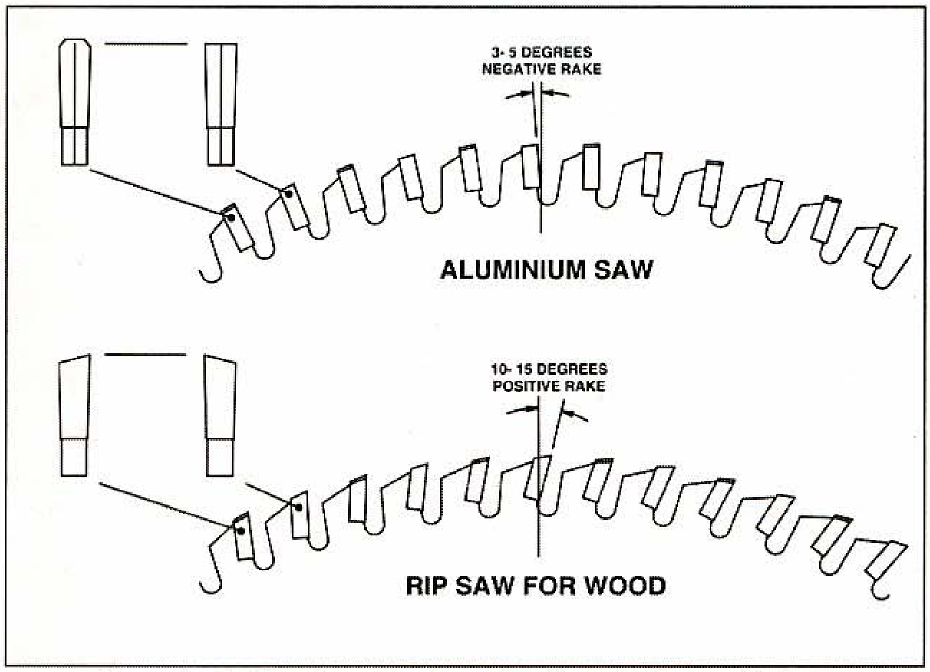

Figure 1: Details of wood and metal cutting circular saw blades.

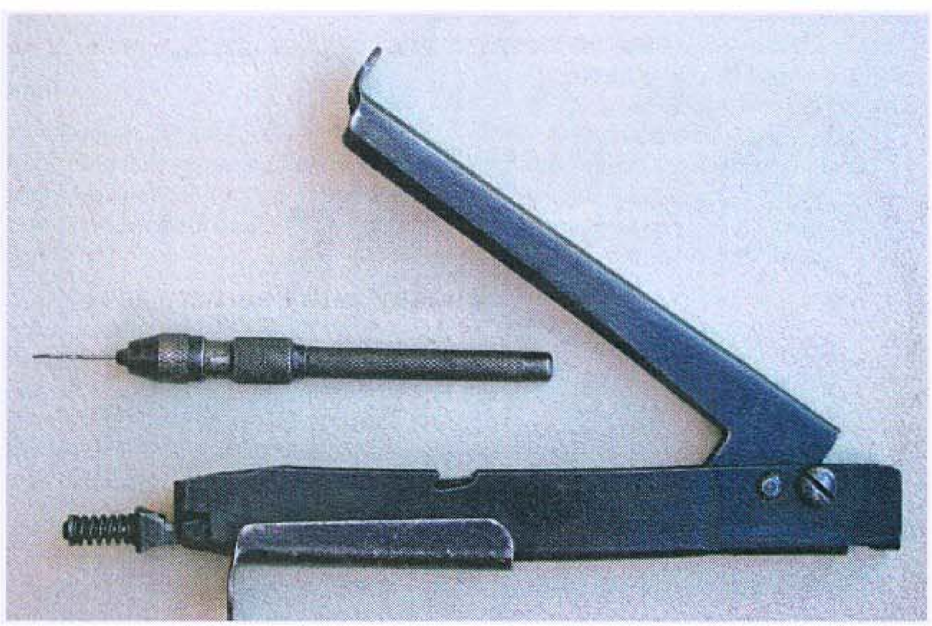

Figure 2: A pin chuck and sheet metal nibbler.

the standard equipment in every workshop. The first essential tool is the simple scriber. The scriber I use is straight. One end is flat so that it can be tapped gently with a light hammer to also serve as a precision centre punch when marking out hole centres.

The other end is carefully ground to a long fine cone shape, with the end millimetre or so being ground to form a sharp 60 degree conical point.

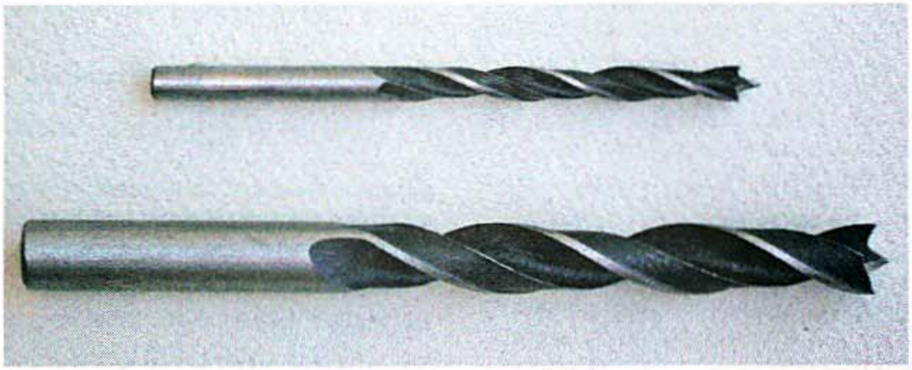

Figure 3: Sheet metal drills.

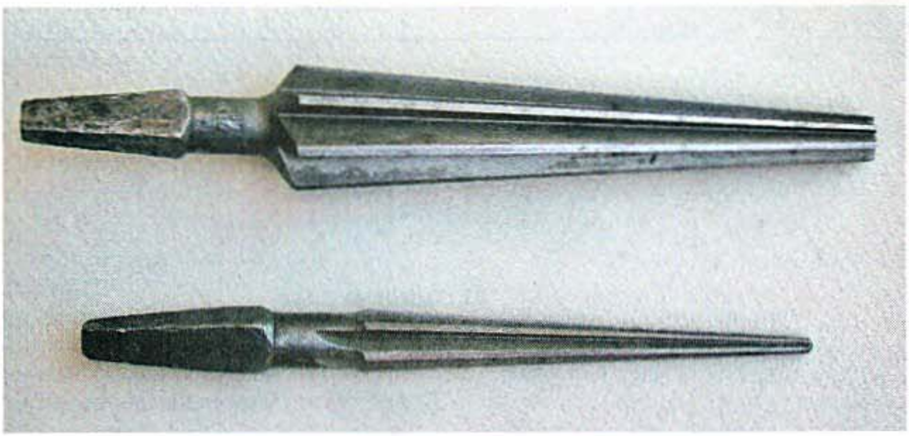

Figure 4: 3-12 mm and 10-25 mm jobbers reamers.

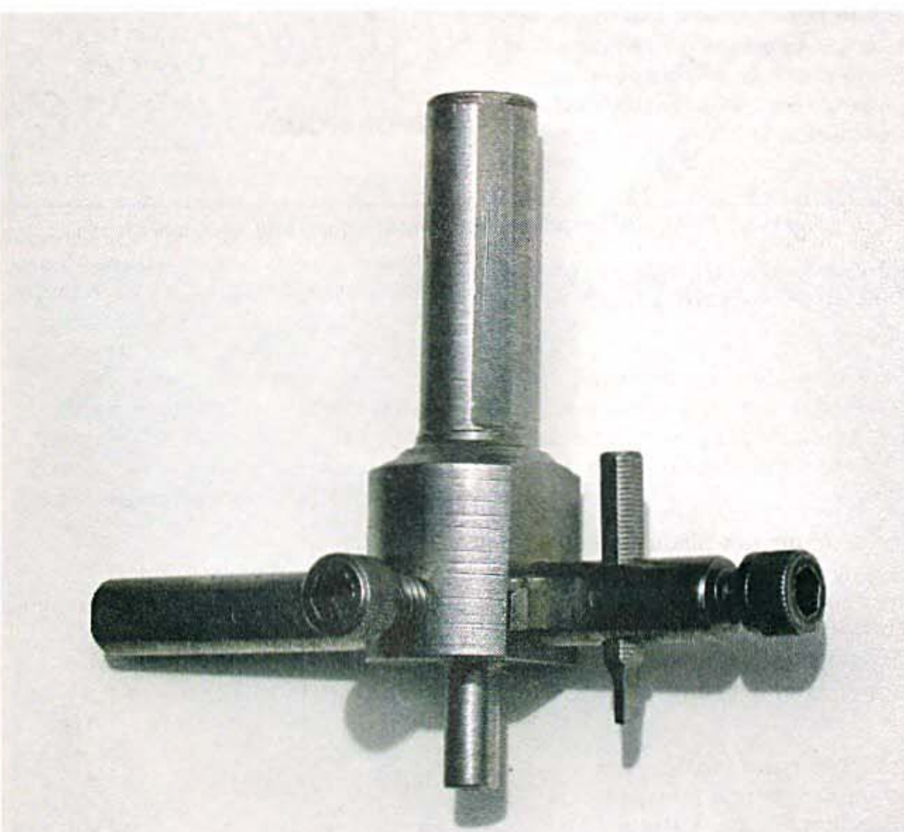

Figure 5: A homemade flycutter.

Unlike the centre punches normally on sale for woodworking, a punch of this form can be used to feel for the intersection of two scribed lines on a metal surface and this makes drilling holes in the right place relatively easy.

Next item is the engineering straight edge. This should have a length of at least 500 mm, but preferably 1000 mm, and will find a myriad of other uses around the workshop. Buy the best you can afford in stainless steel. A 300 mm steel rule with a scale having zero mm at the scale centre is a very useful item too, as it allows symmetrical marking out on either side of a centre line. This makes the marking out of panel holes for items such IEC power plugs almost a pleasure.

The third item is the engineering square, which should be checked for squareness directly after purchase and thereafter handled with kid gloves. An ordinary wood worker's square can be used, but for a few extra bucks, a toolmaker's square is a better investment.

Squareness can be checked with two methods. The first is to find a piece of sheet with a truly straight edge. The square is placed on this edge and a line is scribed at right angles to the edge using the square and a scriber. The square is then turned over and the process repeated. If the square is true then the two scribed lines will be parallel.

A second method is to place the square on a mirror (clean float glass is extraordinarily flat) and sight down the edge of the square at right angles to the mirror surface. If the square is true, the edge and its reflection will form a straight line.

I would suggest buying a square with a top edge length of around 250 mm. If you need to mark out a 1000 mm wide sheet, the upper arm of the square can be extended with your straight edge.

The next essential tool is a set of engineering dividers, used for scribing large and small circles on material. Most units on sale will scribe circles up to 200 mm diameter and this is fine for electronic prototyping. A good quality set will be of rigid construction and have an excellent hinge. The overall utility of this tool can be checked by gently scribing a small diameter circle (say 6 mm diameter) on a piece of sheet. Poor quality will instantly show up, as the legs collapse inwards.

The last essential items for good marking out are a pin chuck and a well sharpened 1 mm diameter drill. Most large drill chucks will not hold small drills, and the pin chuck (Figure 2) overcomes this problem.

A one mm diameter drill fits very nicely into the hole formed by a centre punch, and will centre itself beautifully provided that most of the drill length is out of the chuck allowing it to flex sideways slightly and pick up the exact hole centre. Once you have an accurately centred 1 mm hole in your material, it can be used to precisely centre a larger drill to form a hole of the final desired size in your material. Attempts to centre a large drill on a centre punch mark without a guide hole usually fails dismally.

One millimetre diameter holes are also very useful where cut-outs are required in sheet material. Where a panel has edge flanges, small 90 degree cut-outs are required, and a 1 mm hole in the corner of the cut-out provides a nice stop to the motion of a hacksaw or tin snips. It also reduces stresses during folding, preventing tearing at corners.

Cutting to Size

There are several ways of reducing large sheets to a final size. The first method is to use a sheet metal guillotine but few people have access to these items.

What I use is an aluminium cutting blade fitted to my table saw. Details of this blade are shown in Figure 1. Such a saw will cut thin aluminium alloy sheet like butter due to its special tooth form. Note that all teeth have a negative rake, and that alternative teeth are either square or coffin shaped.

The coffin shaped tooth removes material from the centre of the cut while the following square tooth removes the remaining material at the two edges of the cut. In this way the load on each tooth is minimised.

Never use a wood saw blade on a power tool to cut aluminium as the positive rake will cause digging in, which is extremely dangerous. During cutting, an aluminium saw blade should be occasionally lubricated to prevent small particles of aluminium from welding themselves to the leading edge and sides of each tooth. First, this causes rough cutting and, finally, will lead to the saw blade jamming itself in the material being cut.

The saw blade (and you) can be damaged permanently as lost teeth are a possible outcome of a saw jam. There are special lubricants sold in stick form to overcome this problem, but beeswax, or the stick lubricant sold at your local automotive parts outlet to lubricate car door locks, seem to work well.

Some people suggest reversing a conventional wood rip saw (so the teeth face backwards) to cut aluminium. This is a stupid and very dangerous practice for a number of reasons.

First, wood saws have few teeth and take out great bites of material, while metal cutting demands many fine teeth with each tooth removing a small sliver to reduce tooth load and give a good finish. Second, the weld which bonds the tungsten carbide tooth to the metal saw base is under tension, rather than the compression which occurs when the saw is used properly. So the saw is likely to shed teeth.

Further, if you look down at the edge of the saw, the teeth are wedge shaped and the long edge is supposed to face forward to cut clearance for the narrower rear of the tooth.

So a backward facing saw with backward facing wedged teeth is almost guaranteed to jam, shedding teeth and probably injuring the operator.

An aluminium saw blade generally has quite fine teeth. Both my blades have a tooth about every 10 mm of circumference (80 teeth on a 250 mm diameter blade). It is vital that the blade runs straight and true and is well balanced.

It must be mounted on good bearings so there is no side float. This makes the use of a saw with a ball bearing arbor almost mandatory. Likewise, guides used to feed the material during cutting should be rigid, smooth in operation, and have no float.

The material must be well supported during cutting right up to the edge of the teeth. A lot of saw tables have very wide slots provided for the saw blade and gaps of 6 mm between the saw blade and table are not uncommon. These gaps are just plain dangerous whether you are cutting wood or aluminium. On fine cuts the waste material is likely to disappear into the gap, only to be flung into your face at tremendous speed.

If you have such a table, it is worth covering it with something sacrificial like a 6 mm thick sheet of Masonite and then raising the saw to cut a zero clearance slot in the Masonite.

Finally, the saw motor and electrics must be protected against the ingress of flying aluminium chips. I do not have much of a problem here because my table saw has a fully sealed induction motor, but I have been very careful to ensure that all switches and electrical wiring on the saw are well sealed.

The correct speed for these blades can be calculated from manufacturer's data, which generally recommends surface speeds from 1000- 1500 metres/min (3000- 5000 ft/min) for aluminium alloys. Check the data for your saw blade, but a 250 mm diameter blade will probably run best in the speed range 1300- 2000 rpm.

Last, I would recommend the use of a table saw, as distinct from a radial arm saw. There are a whole bunch of safety issues with the radial arm saw, not the least of which is that it tends to lift material off the table. This is extremely dangerous, particularly with thin materials. Further, if you happen to put any part of your body in the wrong spot, this type of saw will suck it inwards with no place for escape.

All of the above may sound troublesome, but the great advantage of such a saw is that, relative to a guillotine, it is very cheap and much more flexible. You can cut far larger pieces of aluminium than is possible on a typical one metre wide guillotine.

The cuts are dead straight and you can take off fractions of a millimetre if you want, so the technique is suitable for final sizing as well as rough cutting. Unlike the standard guillotine, you can also cut sheets of considerable thickness with good clean right angle edges, and 6 mm of thickness is not a big ask.

There are other techniques for cutting aluminium sheet, and these include a jig saw with a well lubricated blade and, for sheets less than 0.8 mm thick, a Stanley knife with a well oiled blade, and a good straightedge. In this last technique, the material is scored through at least half of its thickness with the knife, and then snapped off by bending it back and forth along the scored cut.

In both of these cases, the edge of the material will have to be cleaned up, and this is best done with an ordinary metal framed wood plane which is sharp, has had its base well oiled, and is set up for a very fine cut. With a little care, and by using a straight edge for comparison, an edge which is clean and dead straight can be produced very quickly.

Note that ordinary wood tools can be used on aluminium alloy sheet without any possibility of damage, because the steels used for cutting blades on wood tools are very much harder than aluminium. In fact, if the aluminium is clean, the tool will remain sharp for far longer than it would if used on wood, as many woods actually contain minute particles of sand distributed throughout the timber by the motion of sap from the plant roots.

If you are really desperate, then aluminium can also be cut with a hacksaw. Tin snips should never be used for cuts longer than about 20 mm. Each time a cut is taken over the full length of the blades, the material will vertically distort into a shallow half moon shape which is almost impossible to straighten out.

Making holes

Holes come in two shapes, circular and awkward, so let's deal with the circular hole first.

In thin sheet of 1 mm thickness or so, circular holes can be broken into three size ranges, which are diameters less than 6 mm, diameters between 6 and 12 mm, and diameters over 12 mm.

For holes below 6 mm diameter there is no problem, and all that is required to form an accurate hole is to first mark out and drill a 1 mm diameter pilot hole, and then enlarge it to size with the appropriate metal twist drill.

For sizes between 6 and 12 mm diameter, ordinary metal twist drills are readily available, but there is a problem. When drilling thin sheet, what happens is that the drill point breaks through the material thickness before the outside diameter of the drill has been able to contact the surface of the sheet to form a circular indentation to guide the drill through the rest of the cut.

The drill loses guidance and the result is that the two unguided drill flutes generate drill chatter. The typical outcome is a hole which is oversize and five or seven sided instead of circular. There are two solutions to this problem.

The first is to rigidly clamp the sheet being drilled to a waste piece of hard wood so that the wood holds the drill centred through the whole cut, and to drill slowly. The second and far more elegant solution is to use a sheet metal drill, of the form shown in Figure 3. Such a drill readily centres itself in the pilot hole previously drilled and cuts through at the maximum diameter first preventing chatter. Yet another method is to drill a small hole and then enlarge it with a jobber's reamer (Figure 4). Whichever method you use, always drill a 1 mm pilot hole first for accuracy

For holes over 12 mm diameter, special tools must be used as normal twist drills are either not available, or, if they are, will require an extension to the house mortgage. If you are into pain and suffering, no special tools are required to make holes of any shape.

An ordinary small diameter twist drill can be used to produce a series of holes which almost touch each other just inside the outline of the hole required. The point where each hole nearly touches the next is then cut through, and everything is then finished off by filing, using either a half round file for circular holes or a flat file for rectangular holes.

There are less painful methods available, however. These include the nibbling tool shown in Figure 4, which is simple to use. A circular hole is first drilled in the sheet to just accommodate the square cutter on the nibbler. Then away you go, covering the floor and your trousers with little bits of aluminium about 1 mm x 6 mm in size which are the result of the nibbling operation.

These are almost guaranteed to end up where they can cause mega damage to any electronics, so be careful. The hole is then finished off as above by filing, and one of the skills you will acquire, apart from an extended command of the English language, is the ability to file a good rectangular hole.

A second tool which is most useful is the fly cutter (Figure 5) which, together with a bench drill, is used for rapidly making large circular holes.

These are singularly dangerous tools which are great for removing fingers or hands and so are not available through the normal electronic supply houses.

They can be easily made if you have access to a lathe, or readily bought from machine tool suppliers. This tool is shown in Figure 2. The sheet in which the hole is required is first placed on top of a scrap piece of three ply, and a guide hole is drilled through both the sheet and its backing. This guide hole must accurately accommodate the central spigot of the fly cutter.

The sheet and its backing are then very firmly clamped to the drill table having first been centred using the tool spigot. The drill is turned on and the rotating cutter is very slowly lowered to create the circular hole of required diameter. The drill shaft speed should be very low (100 rpm or less).

Under no circumstances should the material be hand held on the drill table. Fly cutters have a habit of jamming and when they do unclamped material will be torn from your grip to form a most effective circular saw which will cut through flesh and bone. Jamming can be prevented by lubricating the cut with the same lubricants previously specified for the sawing of aluminium sheet, and by working slowly.

Finally, it is worth describing how burr free holes can be easily produced in thin sheet (1 mm or less) so that cheap heat-sinks can be made for items like power transistors. Any burr is a no-no as it can puncture the mica or silicon rubber insulating spacer used, and drilled holes in softer materials like aluminium will always have a burr. The hole diameter needed for the mounting screws is generally around 3 mm.

In your workshop you probably have a bench (post) drill. In the old days these machines were referred to as a drill press, simply because they can be used for both drilling and pressing operations if they are of sufficiently rugged construction.

It is quite easy to make a simple press tool to punch 3 mm diameter holes in 1 mm sheet. Simply drill a 3 mm diameter hole in a piece of old flat black mild steel sheet or plate (thicker than 1.6 mm).

Remove the drill from the drill chuck and grind the non cutting end of the drill shaft so that it is dead flat and has sharp edges. Place the drill into the chuck backwards, so that the flat end now faces downwards. Carefully lower the drill and centre the drill shaft within the hole in the mild steel plate. While the plate is so positioned, clamp it to the drill table.

You now have a press tool and can punch burr free holes in thin aluminium sheet - try it - you will be impressed.

If you have a very rugged post drill (say a 75 mm diameter post) and grind the end of the drill to a very shallow V shape instead of flat, this technique will easily punch holes of up to 6 mm diameter in thin sheet. Add three circular pegs to the steel base to locate one corner of the aluminium sheet and you have a super cheap press tool which can be used for low volume mass production.

Fabrication of an Enclosure

With the equipment outlined above, some very nice boxes can be made. All you need is some flat sheet and 90 degree aluminium angle cut to size, plus some countersunk aluminium pop rivets, and you are in business.

If you need an enclosure of great strength for a project such as a really heavy duty power supply, then this is probably the best way to proceed. The circular saw detailed previously will make mincemeat of 3 mm thick sheet, and 3 mm thick 90 degree angle too.

For a standard enclosure using 0.8 mm aluminium, however, it is probably far quicker and simpler to make up a box composed of a matching U shaped lid and bottom. So that the lid can be simply attached to the bottom using metal thread screws, the bottom will have to be fabricated with edge flanges of say 10 mm width.

Unfortunately, there are no simple methods or tools available to allow the accurate making of such a box. In fact, there is only one machine that does it well, and is flexible enough to be able to produce a panel with edge flanges, and that is a 'finger' folder. Please see my article on how to build your own cheaply in *Amateur Radio*, October 2007, or buy a second hand unit.

Good fabricating!!!

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