A PRECISION SHEET METAL BENDER FOR AROUND $40

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How often have you wanted a custom made box for that special electronic project? If you've ever tried to fold a piece of aluminium in a vice using a couple of bits of angle iron, a lump of wood and a hammer, then you'll know there has to be a better method, because this is a great way to waste good material. The better method is called a finger folder, and professional units cost well over $2000. They are designed to fold 1.6mm steel in widths of up to one metre, and for electronic hobbyist purposes, are complete over-kill. Almost every special purpose box you'll ever want has dimensions of less than 400mm on any axis and can be made of either 0.8 or 1mm aluminium. This folder addresses that need cheaply but very adequately.

Specifications

The folder design following provides the ability to fold U shaped flanged panels with any width between 11mm and 424mm (see appendix). Beyond 424mm, selected widths up to 480mm can be handled, and edge flanges up to 12 mm are accommodated. For the two initial folds on either side of a panel, edge flanges up to 515mm long can be made, and so the maximum size panel which can be formed with flanges is actually 480 x 515mm. The design allows for bend angles from zero to just over 90 degrees. Most importantly, U shaped chassis with edge flanges (the most common electronic enclosure) can be made. The bending comb in the top jaw is unique and until publication, was probably patentable. Because of the slot widths used and the inter slot spacing selected, the continuous width coverage offered above is provided without the need to move any fingers. Extensive tests have been done on 0.7 mm thick aluminium, and no bend imperfections will be seen where the material bridges the 4mm wide slots.

Construction

When I examined the metal folder designs that were around, I found that they are all made of steel (usually angle iron) and without exception involve the skill of precision welding. The real design problem that plagues the bender designer is the provision of robust hinges to take the enormous strains of bending, and of providing structural members which are sufficiently strong to resist significant bending. To complicate the issue further, the centre line of the hinge pins has to coincide exactly with the top of the joint between the front and rear bender jaws. This means specially fabricated hinges and some very nasty set-up problems while they are welded into position with a heavy duty arc welder - not for me- my arc welds are usually very dodgy!

What I wanted was a design which the average home handyman could make with a few basic tools, and by visiting his local steel supplier where all the standard steel sections used could be obtained cut to length. The design which results uses chipboard (NOT MDF!) for the bender jaws, which are shaped using your Triton saw bench. The hinges are very simply made from standard steel plate and attach to the end of these wooden pieces. So you will need a good bench drill press as well as some marking out tools, various twist drills, a spade bit, a 5/16" BSW full taper die and an angle grinder - but no welder…………

The Drawings

You will discover that these are a mixture of metric and imperial dimensions. No apologies are made for this, because I have based this project around items that are easy to obtain, and a visit to your local hardware store will confirm this. It is also worth noting that to avoid using screws of different lengths, the positions of hinge screws have been changed. Those with a keen eye for detail will note that the drawings differ from the photos of the prototype bender in this regard.

Making the beast

Obtain all your steel as well as all nuts, bolts and screws first. Next, fabricate all the steel work shown in Figure 3 so that it is ready and can be fitted exactly to the woodwork. Before fabricating the hinges, measure the shank diameters of the hinge retaining screws you are going to use (13/64" is specified in the drawing but this is a guide only!) and accurately drill the hinge plates to exactly accommodate this diameter. This will prevent slack developing in the hinges as the bender is used. Note that wood screws must be used to retain the hinges. Wood screws have long unthreaded shanks and this design feature allows them to take very big side forces without movement developing (unlike chipboard screws). Also, very carefully measure the diameter of the shanks of the coach screws used to make the hinge pins and drill the hinge holes to match. Slop of any sort should simply be avoided in the bending action.

The method used to make the top jaw is worthy of comment. To cut the 4mm wide slots in this component, space your angle grinder away from a chipboard base plate with a timber spacer so that the cutting wheel is in the same position as the grinding wheel on a bench grinder. (screw the spacer to the base plate, and attach the angle grinder to the spacing timber with long screws and scraps of aluminium) Provide support for the top jaw during cutting with another piece of timber which has been screwed to the base plate and is mounted in front of the cutting disc (providing the same function as the tool rest on a bench grinder). The 1mm thick cutting disc used is normally chosen to trim the ends of the steel sheet used for roofing and fencing and has a staggering life. Believe it or not, one disc (around $2.60) will do all of the cutting in the 5mm thick steel used for the top jaw and will show almost no wear. During the whole cutting process my disc reduced in diameter by about 2mm and this was only because the abrasive grit at the disc edge became dull and would not cut, and a wheel dresser had to be run on the disc edge to remedy this. I cut the outsides of the slots first, and then removed the remaining central web with a thicker metal cutting disc. Note that if the bender is to provide the continuous width coverage advertised, the slots must have a width of 3.5 to 4mm and be precisely positioned about the centre lines specified in the drawing with an accuracy of 0.5mm. Of course, if you have access to a drill/mill, making the top jaw accurately is dead easy.

To drill the holes in the top of this jaw, work from the back of the angle iron. The back of the material normally has a nice radius where the two sides join, which allows easy marking out and drilling. Work slowly and very gently, particularly when the drill is just about to break through. \This is where you will break your drill if you are not working slowly, as you are not breaking through a flat surface. DO NOT drill these holes to their final size of ½" diameter just yet. Instead use a ¼" diameter drill. These two holes will later be used to mark out where the holes in the back jaw lie for the two top jaw retaining screw threads. The holes in the back jaw have to be counter bored with a spade bit to conceal the nut and washer used, and spade bits rarely come with lead ins of much over ¼" diameter.

Finally, excess steel has to be removed from the edge of the angle iron in which the fingers have been cut. This can easily be done by hand with an angle grinder fitted with a cupped grinding wheel, provided a wooden guide is made up of the correct height and angle to fit the rear of the angle iron (see the photo). The correct angle is 50 degrees and the height of the wooden guide is adjusted on your saw so that the absolute minimum of steel has to be removed. Over a large wooden surface a metal grinding disc will basically polish rather than cut, and this handy observation can be used to force the cutting disc (and its operator) to the precise angle and height required. When the grinder starts skidding on the wooden surface rather than cutting into the steel, you have reached the right height. Proceed slowly and evenly, sliding the guide up and down the inside of the angle iron, and checking with a straight edge as you go. You will be surprised at how accurate and easy this apparently crude process is. When you have finished, form a small radius on the leading edge (say 0.5mm) with a file so that the leading edge does not cut into the material being bent.

When all your steel work is complete, start on the woodwork. Both wooden components are fabricated from 5 layers of 18 mm thick chipboard and can be cut from 600mm wide material (half a standard sheet width). If you can't get 18mm thick material then use 5 layers of 19mm (95mm) or 6 layers of 16mm (96mm). Chipboard is the ideal material because its mechanical properties are independent of direction (it has no grain), it is easily shaped, mechanically stable, and is flat and cheap. When I first started thinking about the bender, I contemplated the use of red gum fence posts. I quickly gave away this idea because red gum has grain, and under the huge stresses of bending may split along the grain, with the split starting at one of the hinge retaining screws. Note that MDF (craftwood) is formed in layers and behaves as if it has a grain. It should not be used. To see how weak this stuff is, drive a nail into the edge and observe. It is only mechanically strong through its thickness.

Straightness is everything in this design. The two bending edges should exactly mate to better than say 0.2mm. Likewise the bending comb in the top jaw should be straight and mate with great precision with the hinge centre line in both horizontal and vertical directions. Any old piece of wood can be made straight on a circular saw by using a straight timber or steel guide of the correct length. The correct length for the guide is at least twice the length of the material being sawn plus the saw diameter (at least 1500mm for the timbers used here). This guide is positioned on the saw table so that there are equal lengths of guide on either side of the saw blade To straighten a piece of wood with a banana bend, place the timber on the saw table so that the two ends of the banana contact the guide. Push the timber past the saw blade and this will give you a perfectly straight edge on the saw blade side. Now you can flip the timber over and process the other side of the banana. Use this technique when sawing the pieces of timber for the bender.

When you are glueing the various bits of chipboard together to form the bender jaw pieces, use plenty of PVA glue and a paint brush to ensure that every part of the surface is covered. Use a straight edge during assembly to check that everything remains straight.

Complete all saw operations on the front and rear bender jaws but do no drilling yet.

Fitting the hinges

] This, and positioning the top bender jaw relative to the bend line are the most critical operations in assembling the bender. Take your time and avoid short cuts and the bender will work.

Temporarily place one of the 25 x 3mm reinforcing strips in its rebate in the front bender jaw. Find eight nails with shank diameters of 1/16" and lengths of around 25mm which exactly fit the two 1/16" diameter nail holes provided in each hinge plate. Place a front hinge plate against one end of the front jaw, and position the plate so that the bending line (the front top of the 25 x 3mm strip) lies exactly at the center of the hinge hole. Set the plate into its correct position by driving the two nails into the chipboard. Now use the other holes in the plate as a template to drill the holes for the screw shanks in the chipboard. (about 25mm deep) Last, drill all holes in the chipboard to accommodate the screw thread minor diameter (around 55mm deep). Screw the plate into final position. Repeat this process for the other end of the front jaw.

Once the two front hinge plates are screwed into position, the front and rear jaws are clamped together and the rear hinge plates (held in their final positions by the hinge pins) are added to the assembly. Once again the process detailed above is carried out with the rear hinge plates being temporarily nailed into position and used as templates to accurately drill all the holes for the screws.

Finishing

To finish off the front and rear jaws, the holes for the handles are drilled in the front jaw, and the reinforcing strips for both jaws are screwed into their final central positions in the rebates. The thrust posts and their hardware are added to the back of the rear hinge plates.

The rear and top jaws are placed into their final positions and the retaining rods (180 mm long 3/8" screw threads) then added. To do this the front jaw is first hinged up through 90 deg. into its final position to complete a 90 deg. bend. A piece of 1mm thick material is inserted at either end between the reinforcing strip on the front jaw and the front bottom of the top jaw. The bolts at the top of the thrust posts are adjusted to bring them into contact with the rear of the top jaw (you will need to grind two flats on the rear ends of the top jaw for the bolts). This locks the top jaw into its correct position and the bottom jaw can now be pilot drilled with a ¼" diameter drill, using your bench drill and the pilot holes in the top jaw as a guide.

The top jaw pilot holes are then opened out with a 1/2" dia drill bit. Again work slowly and very carefully from the rear of the angle iron. Next, the bottom jaw is drilled right through using the ¼" drill. Counterbores for the nuts and washers are then completed (approx. 14mm deep top and bottom) with the appropriate spade bit. Last, the ¼" diameter pilot holes in the rear jaw are opened out to 3/8" diameter. As a final touch, the wooden jaws may be given a coat of varnish.

Using the Bender

The 5/16" bolts (with their lock nuts) at the top of the thrust posts should be adjusted so that when the top bender jaw has been pushed back hard, one and a one half material thicknesses exist between the top jaw and the front jaw, when the front jaw has been hinged right up to the 90 degree position. This law applies irrespective of the material thickness being bent and will give excellent bends. Never force the bender. All bends should be set up so that bending is easy. Finally, the top jaw retaining nuts (or wing nuts if you prefer) should only ever be tightened with your fingers.

And now the real fun can begin.

May 2007

Parts List

Steel cut to size
2@ 150mm lengths of 75 X 6 mm mild steel flat bar
2@ 105mm lengths of 75 X 6 mm mild steel flat bar
1@ 600mm length of 75 X 75 X 5 mm angle iron (or 75 X 75 X 6 AA if available)
2@ 530mm lengths of 25 X 3 mm mild steel flat bar
2@ 90mm lengths of 20 X 20 mm mild steel bar
2@ 300mm lengths of 9mm diameter mild steel rod

Hardware

32@ 10 gauge 60mm long countersunk steel wood screws
16@ 4 gauge 25mm long countersunk steel screws
6@ 3/8"BSW steel nuts
6@ 3/8" bore steel washers
2@ ½" (shank) diameter steel coach screws (hinge pins)
2@ 3mm diameter 25mm long split pins
4@ 30mm long ¼"BSW steel bolts
4@ ¼" BSW steel nuts
2@ 40mm long 5/16"BSW steel bolts
2@ 5/16"BSW steel nuts
2 @ 180mm lengths of 3/8"BSW threaded steel rod

Timber

Sufficient 18mm thick chipboard offcuts to make 5 strips 115mm wide X 600mm long and 5 strips 100mm X 600mm long (see text for alternatives)

APPENDIX

JAW NUMBER WITH WIDTH IN MM

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
15	30	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	15	20

INTERNAL WIDTH OF ITEM FOLDED (IN MM) VERSUS JAWS USED

5	-	85	QT	165	MS	245	AJ	325	CO	405	BQ
10	-	90	PS	170	AG	250	CL	330	BN	410	DT
15	A	95	AD	175	CI	255	BK	335	GT	415	CS
20	T	100	CF	180	BH	260	JT	340	FS	420	AQ
25	C	105	BE	185	MT	265	IS	345	AN	425	-
30	B	110	PT	190	LS	270	AK	350	CP	430	BR
35	ST	115	OS	195	AH	275	CM	355	BO	435	CT
40	RS	120	AE	200	CJ	280	BL	360	FT	440	-
45	AB	125	CG	205	BI	285	IT	365	ES	445	BS
50	CD	130	BF	210	LT	290	HS	370	AO	450	-
55	BC	135	OT	215	KS	295	AL	375	CQ	455	-
60	RT	140	NS	220	AI	300	CN	380	BP	460	AS
65	QS	145	AF	225	CK	305	BM	385	ET	465	BT
70	AC	150	CH	230	BJ	310	HT	390	DS	470	-
75	CE	155	BG	235	KT	315	GS	395	AP	475	-
80	BD	160	NT	240	JS	320	AM	400	CR	480	AT

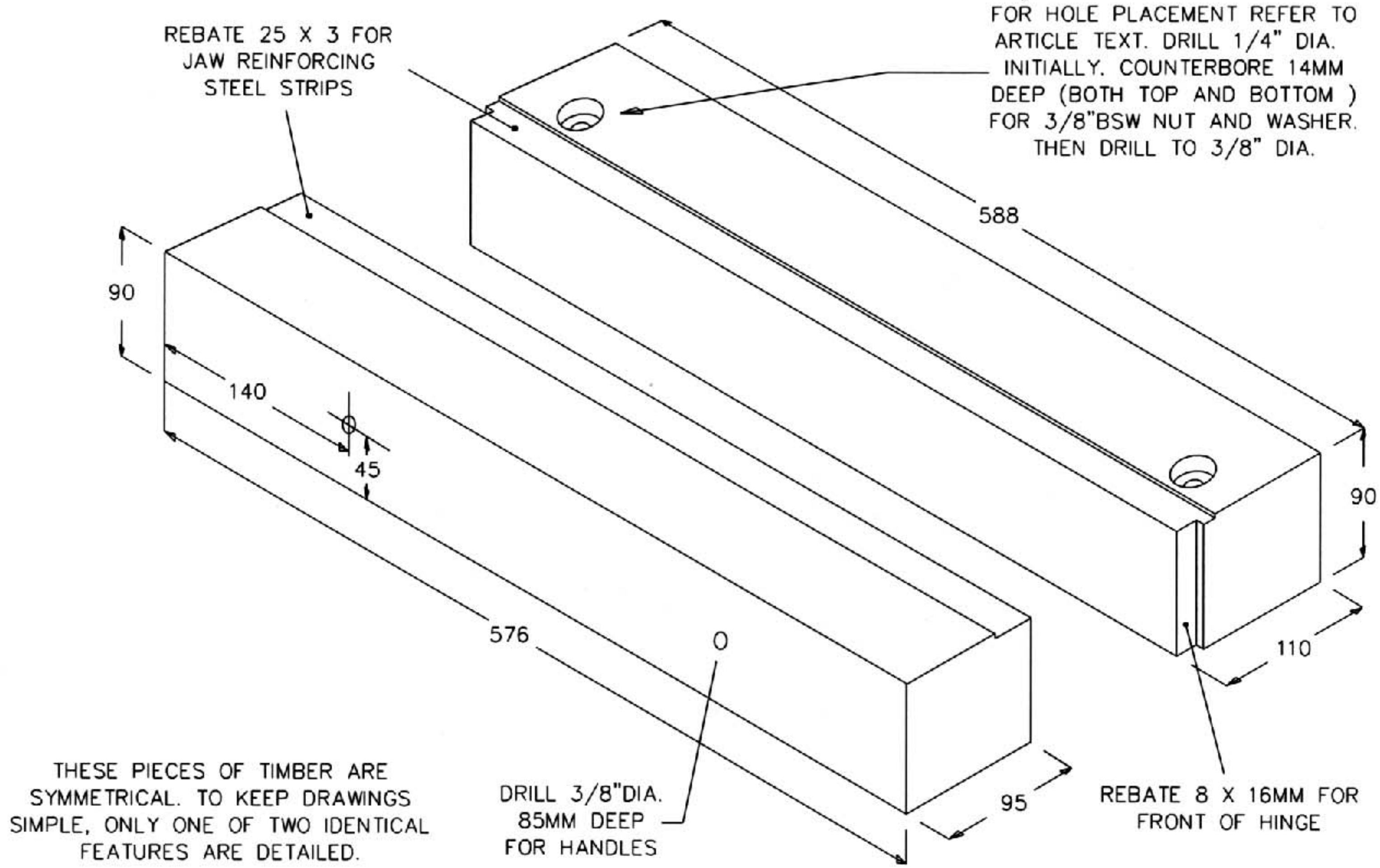


FIGURE 1

DETAILS OF FRONT AND REAR JAWS

MATERIAL ASSEMBLED FROM 5 LAYERS OF 18MM THICK CHIPBOARD

ALL DIMENSIONS IN MM UNLESS OTHERWISE NOTED

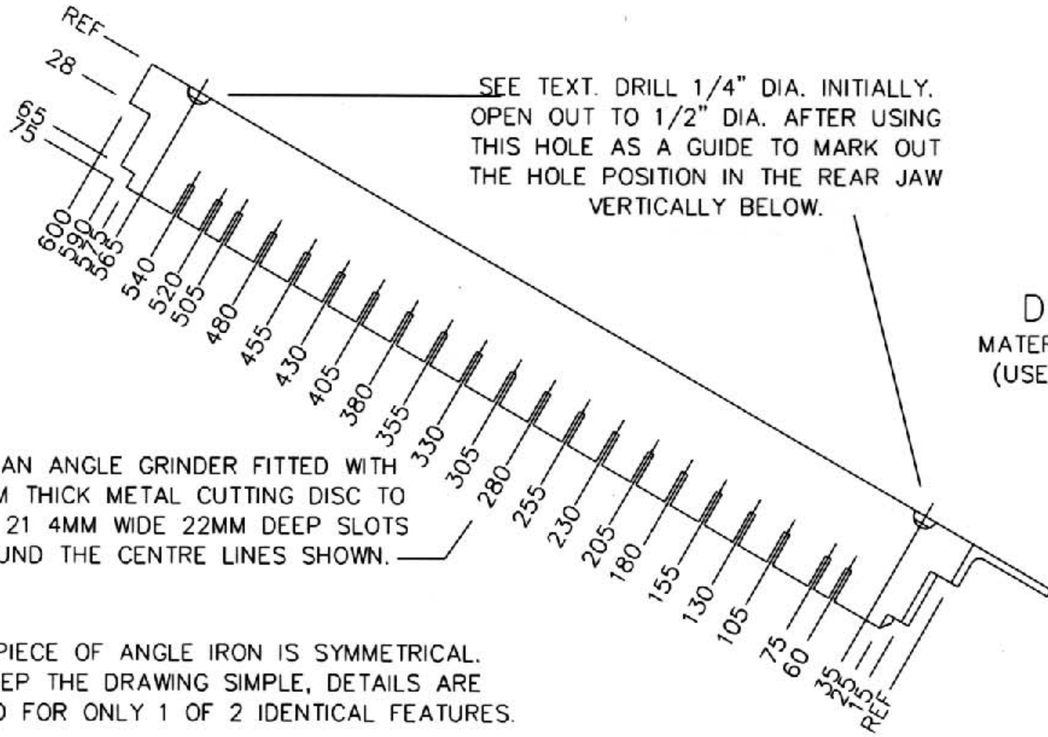
STANDARD AR PAGE WIDTH - 174MM

STANDARD AR PAGE HEIGHT- 236MM

SEE TEXT. DRILL 1/4" DIA. INITIALLY. OPEN OUT TO 1/2" DIA. AFTER USING THIS HOLE AS A GUIDE TO MARK OUT THE HOLE POSITION IN THE REAR JAW VERTICALLY BELOW.

DETAILS OF TOP JAW

MATERIAL: 75 X 75 X 5 MM ANGLE IRON
(USE 75 X 75 X 6 MM IF AVAILABLE)

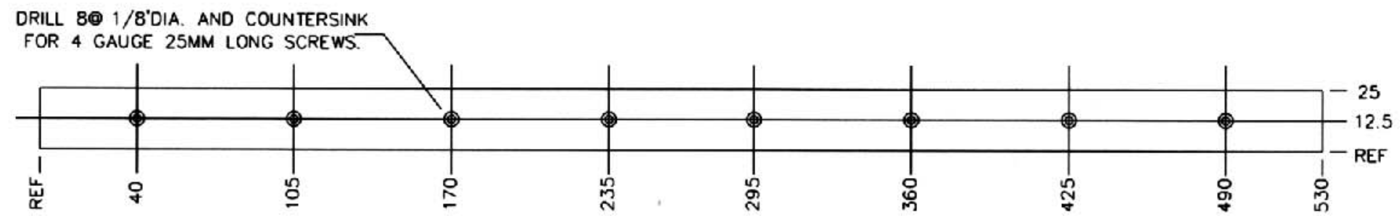


USE AN ANGLE GRINDER FITTED WITH A 1MM THICK METAL CUTTING DISC TO FORM 21 4MM WIDE 22MM DEEP SLOTS AROUND THE CENTRE LINES SHOWN.

THIS PIECE OF ANGLE IRON IS SYMMETRICAL. TO KEEP THE DRAWING SIMPLE, DETAILS ARE PROVIDED FOR ONLY 1 OF 2 IDENTICAL FEATURES.

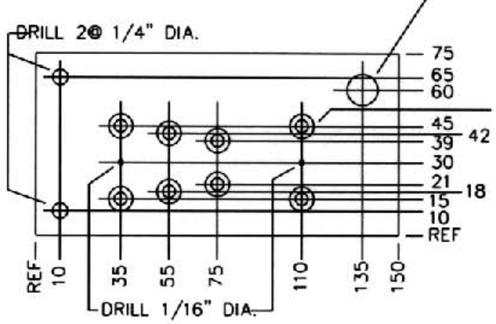
ALL DIMENSIONS IN MM UNLESS OTHERWISE NOTED

FIGURE 2



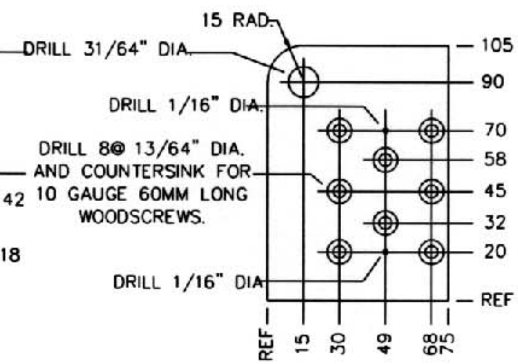
FRONT AND REAR JAW RE-INFORCING STRIPS

2 REQUIRED. MATERIAL: 3 X 25 MM MILD STEEL STRIP



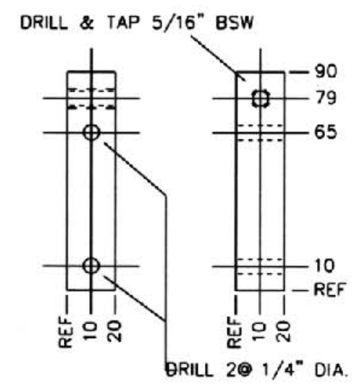
HINGE PLATE– REAR JAW

2 REQUIRED– ONE MIRROR IMAGE OF OTHER
MATERIAL: 75 X 6MM MILD STEEL PLATE



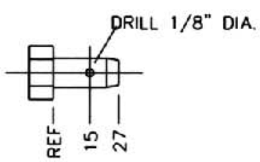
HINGE PLATE– FRONT JAW

2 REQUIRED– ONE MIRROR IMAGE OF OTHER
MATERIAL: 75 X 6MM MILD STEEL PLATE



THRUST POST

2 REQUIRED
MATERIAL: 20 X 20MM
MILD STEEL BAR



HINGE PIN

2 REQUIRED
MATERIAL: HEAD
AND SHANK OF
1/2" COACH SCREW

NOTES
1. ALL DIMENSIONS IN MM UNLESS OTHERWISE SHOWN
2. DRAWN VK5JST APRIL 2007

FIGURE 3

OTHER ITEMS NOT SHOWN
HANDLES– 2 REQUIRED– MATERIAL: 300MM LENGTH OF 9 MM DIA. M.S. ROD
TOP JAW RETAINERS– MATERIAL: 180MM LENGTH OF 3/8"BSW THREADED ROD