

No.242

FULL OF WORKSHOP PROJECTS AND IDEAS

MODEL ENGINEERS' WORKSHOP

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JUNE 2016

COVER FEATURE

Robert Knox and his
MYFORD ML10

Tony Hill's
**DIGITAL
DIVIDING
DEVICE**



A Versatile
Grinder
from Scrap

TOOLROOM TECHNIQUE



**Button
Boring**



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On the Editor's Bench

Manage your Subscription Online

I have been surprised by the number of readers who are taking advantage of the opportunity to use the online website for managing their subscriptions, especially for renewals. There is one recurring problem, though. Because many people access the website via the subscribe link on the forum, they assume that their forum password will work for the subscription site – it won't!

The site <http://me.secureorder.co.uk> contains a separate HTTPS (secure) area once you have logged in, to keep your financial details safe. You access it by clicking 'my account' on the green bar at the top of the screen. This means the first time you log on you must tick the 'I haven't got a password' box and create a new account, just for managing your subscriptions.

My apologies to anyone who has been caught out by this – we have added a message to the log on page of the forum and I have posted several reminders, so together with this note I hope fewer readers will struggle in future.

Turn the Screw

Peter Nicolson has got in touch with me in reference to Richard Wilson's email published in Scribe a Line in the May issue. He confesses that "In going from the Metric multi start thread example,

to the Imperial multi thread example I transposed the 36tpi and 12tpi numbers." The text in question should read :

For a 36 tpi three start thread set the lead screw to cut at 12tpi. In other words, the tool must traverse the work faster than when cutting a single start thread. Doubled for two start threads, and tripled for three start.

Beware of Scammers

I have recently had several reports on the *Model Engineer* forum of a rather nasty scam, where an overseas buyer makes a rather long winded offer to pay extra for an item to cover expensive courier costs. It seems the scam involves claiming the goods never arrived and cancelling the payment – the poor seller is left without the goods and having to cover inflated carriage costs. I have also been rung up by a suspicious reader who's alarm bells rang when he was sent a cheque for far more than the value of the item he was selling. It seems that both website and magazine ads are being targeted.

Please visit the forum at www.model-engineer.co.uk and put 'scammer' into the search box to find out more. We want to help readers through our free reader adverts in the magazine and on the website, but if you do use them, please take care and do not respond to any suspicious approaches. - report them at www.actionfraud.police.uk

A Strange Scope

By the time you read this, a transit of Mercury across the face of the sun will have happened on the 9 May. I'm hoping to photograph its progress, with a telescope specially adapted for solar use with a special filter fitted to the 'big end'. Naturally looking at the sun with any sort of unmodified telescope is worse than foolhardy, it's downright stupid! Eye damage or complete blindness is virtually inevitable. But while the scope filter allows me to use the camera, how do I accurately point the telescope at the sun, if I can't use the finderscope? Well, I've made a neat little solar finder that involved some boring, turning, knurling and milling. It fits in the same place as a normal finder, but has a pinhole at one end, and a translucent screen that can be viewed from either side at the other. I'm pleased to say it works very well.



Mini Live Centres



Code	Morse Taper	Price
030-010-00000	MT0	£11.00
030-010-00001	MT1	£12.00
030-010-00010	ø10mm Straight Shank	£11.00

Tailstock Die Holders



Code	Die Size	Shank Dia.	Price
060-260-20100	13/16"	12.7mm (1/2")	£9.00
060-260-20200	1"		£9.50
060-260-20300	1.1/2"	19mm (3/4")	£11.00

Fly Cutter Holders

Tool Bit Size: 8mm or 5/16"
(available separately)



Code	Shank	Head Dia.	D/B Thread	Price
060-280-99090	MT2	38mm	M10	£13.60
060-280-99095	MT3	(1.1/2")	M12	£14.00
060-280-99100	R8	63.5mm (2.1/2")	7/16"	£17.42

ALL PRICES INCLUDE VAT

62mm Boring Head Set - R8



Code	060-290-10628
Body Dia.	62mm
Arbor	R8 (Integrated)
Boring Tool Shank	12mm
Boring Dia. Range	12mm - 130mm
Price	£74.60

Sliding Tailstock Die Holder Sets



Code	Shank	Die Holder Sizes Included	Price
060-260-25200	MT2	16x5mm, 20x5mm, 20x7mm, 25x9mm, 30x11mm, 38x14mm	£45.00
060-260-25300		13/16", 1", 1.5/16" & 1.1/2"	£42.00
060-260-25400		16x5mm, 20x5mm, 20x7mm, 25x9mm, 30x11mm, 38x14mm, 13/16", 1", 1.5/16" & 1.1/2"	£56.50
060-260-25500	MT3	16x5mm, 20x5mm, 20x7mm, 25x9mm, 30x11mm, 38x14mm	£45.00
060-260-25600		13/16", 1", 1.5/16" & 1.1/2"	£42.00
060-260-25700		16x5mm, 20x5mm, 20x7mm, 25x9mm, 30x11mm, 38x14mm, 13/16", 1", 1.5/16" & 1.1/2"	£56.50

Spring Tapping Guides



	Code	Description	Shank	Guide Pin	Length	Price
A	060-250-03100	Micro Spring Tapping Guide	12.7mm	ø4.75mm	83mm	£4.50
B	060-250-03200	Spring Tapping Guide	(1/2")	ø9.5mm	81mm	£6.80

30mm & 38mm Boring Heads with Tool Sets and Arbors



Head Code	Body Dia.	Mounting Thread	Boring Tool Shank	Boring Dia. Range	Price
060-290-10302	30mm	M14 x 1.0mm	6mm	7mm - 52mm	£46.50
060-290-10380	38mm	M14 x 1.0mm	8mm	9mm - 60mm	£59.00
Arbor Code	Taper		Mounting Thread	Drawbar Thread	Price
060-290-10012	12mm Straight Shank		M14 x 1.0mm	None	£11.50
060-290-10020	MT2			M10	£12.80
060-290-10030	MT3			M12	£13.40
060-290-10080	R8			7/16" UNF	£14.00

62mm Boring Head with Tool Set, and Arbors



Head Code	Body Dia.	Mounting Thread	Boring Tool Shank	Boring Dia. Range	Price
060-290-10620	62mm	M16 x 1.5mm	12mm	12mm - 130mm	£76.50
Arbor Code	Taper	Mounting Thread		Drawbar Thread	Price
060-290-10022	MT2	M16 x 1.5mm		M10	£12.80
060-290-10032	MT3			M12	£13.40
060-290-10082	R8			7/16" x 20 UNF	£14.00

Square Head Protractor



Code	Price
100-080-00510	£5.30

Centre Squares



Code	Max. Work Diameter	Price
100-090-01100	60mm (2.36")	£7.50
100-090-01200	100mm (4")	£11.95

Radius Gauge Set - Key Ring



Code	Range	Inc.	Price
100-110-01100	0.75mm - 5mm	0.25mm	£8.80
100-110-01200	5.5mm - 13mm	0.5mm	£11.90

Twist Drill Grinding Gauge



For drills with an included angle of 118° and up to 50mm diameter.

Code	Price
100-120-17300	£3.89

Morse Taper Open Ended Sleeve MT3 - MT2 with Release Nut



Code	Outside Taper	Inside Taper	Price
120-010-00370	MT3	MT2	£8.95

Adjustable Swivel Table 4x5"

Supplied with 4x M8 Slim T-Nuts



Code	Table Size	Height	Price
130-020-01080	4"x5"	3.1/8"	£61.00

Morse Taper Parallel Test Bars



Code	Taper	Overall Length	Parallel Length	Max. Run-out	Drawbar Thread	Price
100-140-10400	MT2	280mm	208mm	<0.01mm	M10	£25.00
100-140-10500	MT3	335mm	245mm		M12	£30.00
100-140-10600	MT4	385mm	270mm		M16	£37.00

Vertical Slide 5x4" - Fixed Base

Supplied with 4x M8 Slim T-Nuts



Suitable for Myford

Code	Table Size	Price
090-035-00100	4x5"	£85.00

Vertical Slide 5x4" - Tilt & Swivel

Supplied with 4x M8 Slim T-Nuts



Suitable for Myford

Tilt & Swivel 60° - 0° - 60°

Code	Table Size	Price
090-035-00200	4x5"	£95.00

Mini Sheet Metal Cutters



Cutting capacity in mild steel: 16 swg (1.6mm)

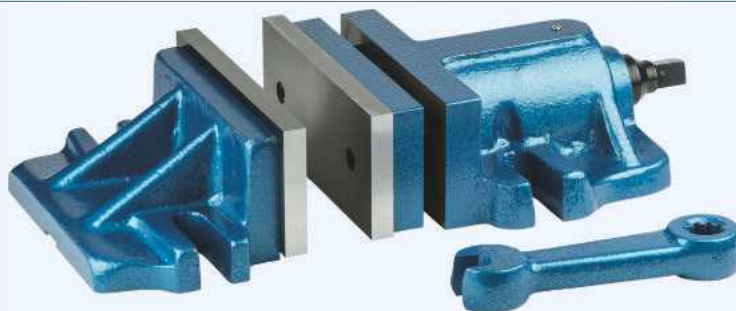
Code	Price
150-010-10100	£36.00

Bench Shear Cutters



Code	Size	Capacity - M.S. Sheet	Price
150-010-10200	5" (125mm)	2.0mm	£61.80
150-010-10300	6" (150mm)	2.0mm	£68.00
150-010-10400	8" (200mm)	3.0mm	£93.50

Two Piece Milling Vice 6"



Code	Jaw Width	Jaw Depth	Jaw Opening	Price
130-040-03700	6" (156mm)	2.75" (70mm)	ANY	£95.00

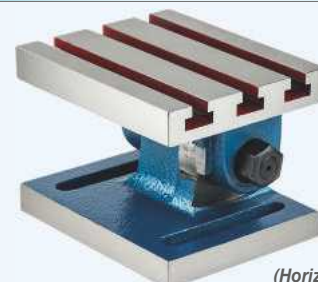
Tee Slotted Angle Plate 6.5x5x4.5"

Supplied with 4x M10 Slim T-Nuts



Code	Table Size	Height	Price
130-020-01300	6.5x5x4.5"	6.5"	£47.00

Swivel Angle Plate 5x6"



Swivel 0° - 90° (Horizontal to Vertical)

Code	Table Size	Height	Price
130-020-01400	5"x6"	4.5"	£63.00

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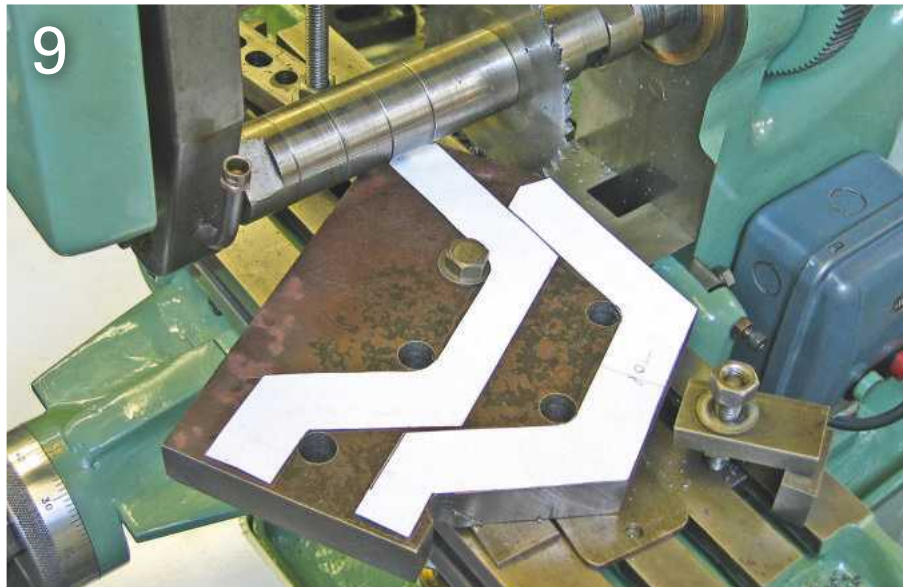
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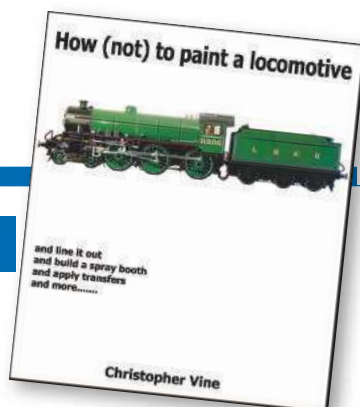
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See page 23 for details.

in the July issue

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MORE TOOLS AND TECHNIQUES!**



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41.5	40.0	38.6	37.2	36.0	34.8	33.8	32.7	31.8	30.9	30.0	29.2	28.4	27.7	27.0
55.4	53.3	51.4	49.7	48.0	46.5	45.0	43.8	42.4	41.1	40.0	38.9	37.9	36.9	36.0
69.2	67.7	64.3	62.1	60.0	58.1	56.3	54.5	52.9	51.4	50.0	48.6	47.4	46.2	45.0
83.1	80.8	77.1	74.5	72.0	69.7	67.5	65.5	63.5	61.7	60.0	58.4	56.8	54.4	52.5
96.9	93.0	89.0	86.0	84.0	81.3	78.8	76.4	74.1	72.0	70.0	68.1	66.3	64.6	63.0
110.8	104.7	102.9	98.3	96.0	93.9	90.0	87.9	84.7	82.3	80.0	77.8	75.8	73.8	72.0
124.6	120.0	115.7	111.7	108.0	104.5	101.3	98.2	95.3	92.6	90.0	87.8	85.3	83.1	81.0
138.5	133.3	128.6	124.2	120.0	116.1	112.5	109.1	105.9	102.9	100.0	97.4	94.7	92.3	90.0
152.3	146.7	141.4	136.6	132.0	127.7	123.8	120.0	116.5	113.1	110.0	107.2	104.2	101.5	99.0
166.2	160.0	154.3	149.0	144.0	139.4	135.0	130.9	127.1	123.4	120.0	116.8	113.7	110.6	108.0
180.0	173.7	167.1	161.4	156.0	151.1	146.3	141.8	137.6	133.3	130.0	126.5	123.2	120.0	117.0
193.8	186.7	180.0	173.8	168.0	162.8	157.5	152.7	148.2	144.0	140.0	136.2	132.6	129.0	126.0
207.7	200.7	193.9	188.2	182.0	176.2	169.8	163.6	158.4	154.0	150.0	145.9	142.1	138.3	135.0
221.3	213.7	206.7	199.6	192.0	185.8	180.0	174.5	168.8	164.0	160.0	155.7	151.6	147.7	144.0
235.4	227.1	219.8	212.1	204.0	197.4	191.3	185.5	180.0	174.9	170.0	165.1	161.1	156.8	153.0
249.2	240.4	232.4	223.4	216.0	209.0	202.5	196.4	190.6	185.1	180.0	175.1	170.5	165.7	162.0
263.1	253.3	244.9	235.9	228.0	220.6	213.8	207.3	201.2	195.4	190.0	184.8	179.5	174.1	170.0
276.9	266.7	257.1	246.2	236.0	225.3	215.2	205.2	199.2	193.0	188.0	182.6	177.0	171.5	167.0
290.8	280.0	269.7	258.7	248.0	236.3	226.1	220.2	214.0	210.0	205.0	199.8	194.4	188.8	184.0
304.6	293.7	282.9	271.1	260.4	248.5	247.5	240.0	232.9	225.3	220.0	214.1	208.4	202.1	198.0
318.5	307.7	296.5	284.5	272.7	260.8	250.0	243.5	236.6	230.0	223.8	217.9	212.3	207.0	201.0
332.3	320.9	308.9	297.0	285.0	273.0	270.0	261.8	254.1	246.5	240.0	233.5	227.4	221.5	216.0
346.2	333.3	321.0	310.0	300.0	290.0	281.5	273.2	264.7	257.1	250.0	243.2	236.8	230.0	225.0
360.1	346.7	334.3	322.0	312.0	301.1	292.5	284.0	275.3	267.4	260.0	253.3	246.3	240.0	234.0
		347.1	335.2	324.0	313.5	303.5	294.5	285.9	277.7	270.0	262.9	256.9	249.3	243.0
		347.8	336.0	325.2	315.0	305.5	296.5	288.0	280.0	272.4	265.3	258.3	250.2	244.0
			348.0	336.8	326.3	316.4	307.1	298.3	290.0	282.2	274.7	267.7	260.1	253.0
			348.5	337.5	327.5	317.6	308.5	300.0	291.9	284.2	276.8	270.0	262.0	255.0
			348.8	338.2	328.2	318.0	310.1	301.5	293.2	285.6	278.2	271.0	263.0	256.0
			349.1	338.8	328.3	318.0	311.4	302.5	294.0	286.3	278.9	271.6	263.6	256.6
				349.4	339.4	329.0	320.1	312.1	303.6	295.9	288.4	281.0	273.0	266.0
					349.5	340.0	329.8	321.1	313.6	305.9	298.4	290.8	283.0	275.0
						350.0	340.5	331.6	323.1	315.0	307.3	300.0	292.0	284.0
							350.3	341.1	332.3	324.0	316.1	308.3	300.5	292.5
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									350.6	341.9	333.0	325.0	317.0	309.0
										350.7	342.3	333.3	325.3	317.3
											350.8	342.7	333.7	325.7
												350.9	343.1	334.1
													351.0	343.5
														351.1

Tony Hills' Dividing Tables

Download
the PDF
tables that
accompany
Tony's
article in this
issue.

Other hot topics on the forum include:

➤ Mounting a Rotary Table

Not always as easy as you might imagine – lots of pictures of readers' different approaches.

➤ AcuteTool Sharpening System

John Haine has blogged his build of the Eccentric system from the kit of parts.

And:

Basic Clock Design

The debate on design has moved to 'what is a basic clock?' and 'why do people make clocks?'

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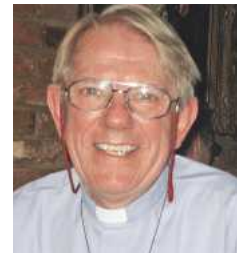


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A Four Inch Fixed Steady for A Myford ML7



Ian Strickland describes a robust steady for his lathe.

I have an old Trident horizontal mill, which I have recently refurbished, but it lacked a vertical head. I had seen a series of articles in *Model Engineer* some years ago for a design of a vertical head. The housing for the spindle requires machining a 3-inch diameter piece of steel down to 2.875 inches. The Myford fixed steady has a capacity of a little over 2 inches, so a larger steady was required.

Inspiration came from an article in ME Back in 1984 for just such a fixed steady ([ref 1](#)). Although not for a Myford, it could easily be adapted to fit the ML7, or any other 3½ inch or larger lathe, by fitting an appropriate foot and adjusting the depth of the lower frame.

The basic shape of the frame is hexagonal and cut out of ¾ inch steel plate and nominally 1 inch wide. **Figure 1** shows the general layout. The final sizes are not super critical. Start with two circles as shown, and then set out the horizontal and 60 degree inclined lines of the frames as shown, to just touch the circles. The foot is also ¾ inch thick. I have shown a few key dimensions as related to the ML7. The bold open rectangles represent the lathe ways as measured from my lathe. Yours may vary, so do check.

My method was to draw it out full size, and then cut out the two parts of the frame as paper patterns, which were laid out on the steel to decide the best positioning. I happened to have an off cut of ¾ inch thick steel plate, so I positioned the paper patterns to suit (**photo 1**). The outline was then marked out on the steel and cutting



Setting out to mark out for the frames.

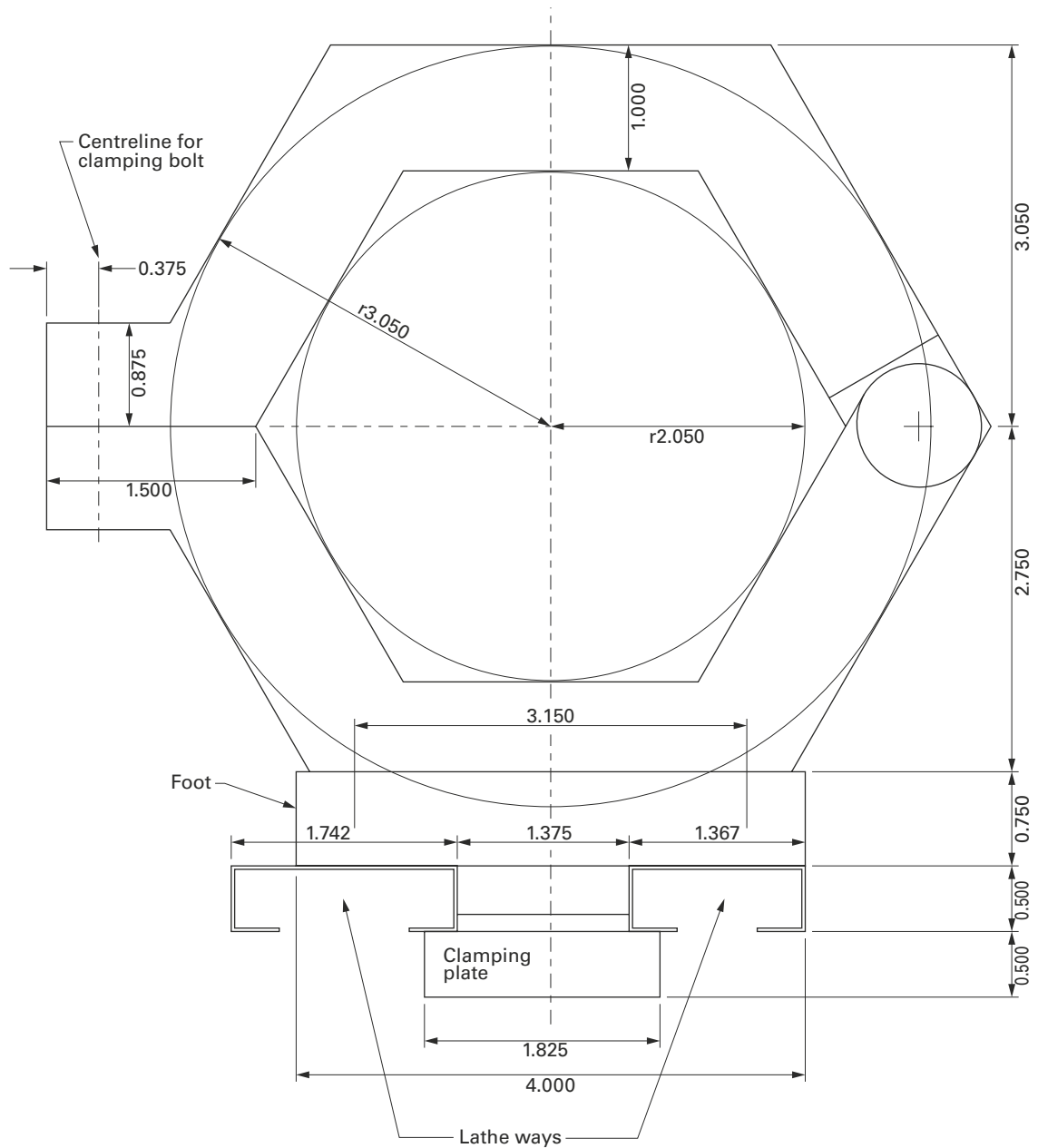
Cutting out to scribed lines.

out proceeded on the milling machine by lining up the circular saw with the lines.

Not knowing whether the steel was black or bright, due to the rust covering, it was normalised in our wood-burning stove one winter evening. Surprisingly, it was easy to get the metal red hot, and it was left to cool overnight in the ashes. The proof of the pudding was in the machining. The metal was wonderfully stress relieved and there was no hint of warping or winding when machining it.

Half-inch, or 13mm, diameter holes were drilled in the corners where the various angles met, not only to soften the outline, but also to provide a curve around which the stress lines could pass. Some of the holes were used for clamping using short bolts into T nuts beneath, as clearance for the milling arbor was tight. All the major cutting was carried out on the horizontal milling machine (**photo 2**) using a 4 inch dia saw 0.0625 inch, or 1.5mm, thick. This tended to wander, so a change to 0.09375

Fig. 1



4in Nominal Diameter Fixed Steady

All sizes to suit Myford ML7 & to be checked from your lathe



Using chuck jaws for marking out the finger slots.



First cuts for bronze finger slot. Finished slot at lower left.



Drilling for clamp bolt hole.



Milling out the slot for the clamp bolt.



Tapping lower frame for foot fixing.



Forming pivot end of clamping bolt.

inch, or 2.5mm, saw pretty well prevented this. The final cuts into the corners were carried out in the vice with a hand held hacksaw. All edges were rounded with medium and fine files.

The position of the slots for the fingers were inchspotted inch from the jaws of the 3 jaw chuck with the lower frame resting on the embryonic foot, also cut from the $\frac{3}{4}$ inch thick steel plate 2 inch wide and about 4 inch long (photo 3). The slots are 120 degrees apart. Centre lines are shown in fig 1.

The slots for the bronze fingers were cut with the 4-inch diameter saw, making multiple passes, but to leave the fingers proud of the surface by 0.0625 inch, or 1.5mm (photo 4). One of the finished slots is visible in the foreground of the photo.

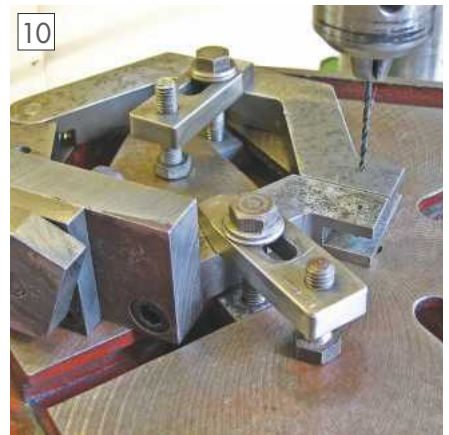
The hinge bolt was similar to the Myford design, the hinge being in the form of a half lap joint - to use a wood working term. It was turned from 0.825 inch, or 21mm, diameter steel bar. The main diameter was 0.5 inch, or 12.5mm, dia, and threaded M10. The holes for the clamping bolt were drilled in the drilling machine (photo 5) and slotted in the upper frame so the bolt could be swung clear to open the steady (photo 6).

The base of the lower frame was drilled and tapped M10 and the foot secured with two socket head cap screws (photo 7). I still call them Allen screws. Approximate centre lines are shown in fig 1. My method



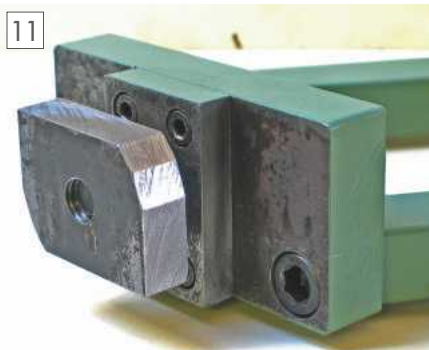
Drilling pivot hole in clamping bolt.

for ensuring that the tap enters the drilled hole squarely, is to use the 3 jaw chuck jaws to act as the guide, with the jaws just touching but not clamped to the shaft of the tap. A hefty tap wrench made out $\frac{5}{8}$ inch, or 16mm, square stock, and clamped with two $\frac{3}{8}$ inch BSW, or M10, bolts provides ample grip on the ground shaft of the tap. An extension tube is used over one of the handles of the wrench to turn the tap. I use a 9 inch length of old iron water pipe. I claim no originality for this idea, which I probably got from M.E. in years past.



Drilling lower frame for pivot pin.
Note foot fixing Allen screws.

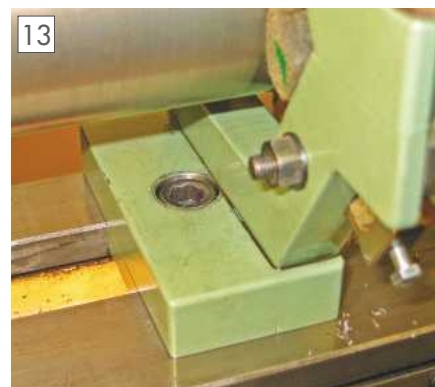
The clamping bolt was made from 16mm diameter, steel, part turned down to 8mm diameter, and threaded M8. The bottom of the bolt was drilled $\frac{5}{16}$ inch, or 8mm, and the corresponding holes in the lower frame were reamed to the same diameter. The drilled hole was slightly oversize so a steel pivot pin when pressed into the reamed holes was a sliding fit for the bolt. The thicker end was reduced to $\frac{5}{16}$ inch, or 8mm thickness in the milling machine to fit the slot (photo 8 & 12) and the cross hole drilled in the bench drill (photo 9).



Underside of foot, guide block and clamp.



Clamping bolt detail.



Mod 1, counter sink Allen screw.



Mod 2, fit screw adjusters to fingers.



Turning 3 inch diameter.

The pivot holes in the lower frame were drilled in the bench drill, and hand reamed in the bench vice (**photo 10**).

Photograph 11 shows the details of the underside of the foot, the guide block, and the clamping plate. The guide block is fixed to the underside of the foot with four M6 Allen screws, and is a sliding fit

between the lathe ways. The clamping plate is about 0.050 inch, or 1.5mm narrower than the gap between the lathe ways, and is secured with an M12 Allen screw. Two corners are knocked off so the clamp plate can be turned to the locking position under the lathe ways.

In use, it proved impossible to access the

M12 clamping Allen screw with the work piece in place, so the head of the Allen screw was recessed into the foot (**photo 13**). The Allen key was shortened so that it could be used under the work piece.

Bronze fingers were made following the Myford pattern, together with the clamps. The second modification was to provide fine adjustment of the bronze fingers with M4 high tensile steel screws (**photo 14**). The last modification was to bevel off the left hand side of the foot to facilitate introducing the steady under the workpiece when it is supported by the chuck and supported by a centre in the tailstock having been set up to run true with a DTI.

Photograph 15 shows the completed steady in use. Note the felt wad to hold oil for lubrication. Although designed to accommodate a 4-inch diameter, in practice in a 3½ inch lathe there is insufficient clearance for the Allen key below the workpiece. 3 inch is the largest practical workable diameter, fortunately sufficient for my purposes. Should I ever get a larger lathe, a taller foot can be made which would allow supporting larger diameters. ■

REFERENCE

1. 'Fixed and Travelling Steadies', by C. Jones, ME 3732, 6 July 1984, p 14.

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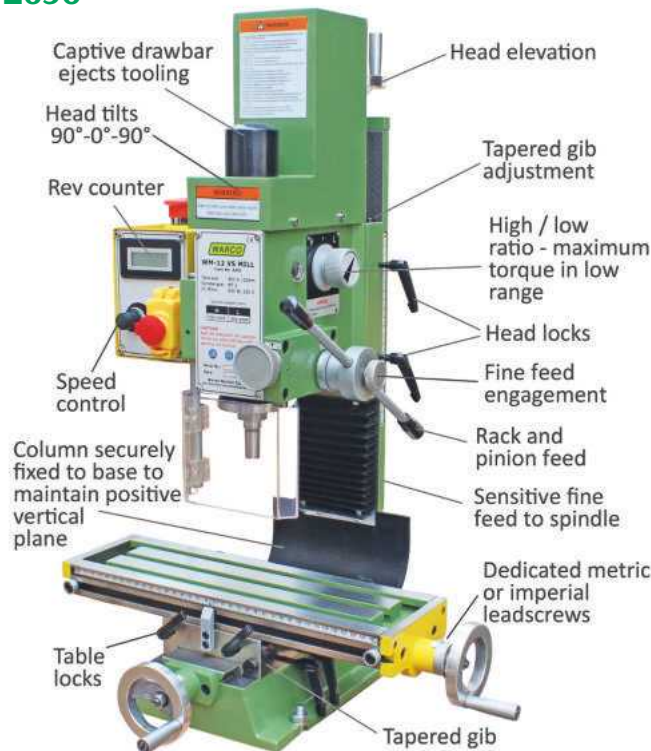


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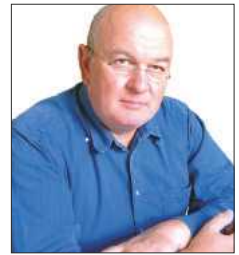


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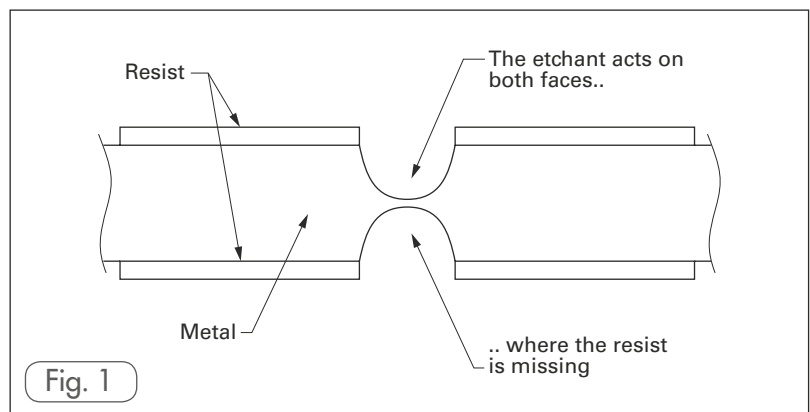
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Photo Etching in the Workshop



Tony Hagon details a step by step approach to etching brass parts.

I read with interest the article by Richard Castle in *Model Engineer* (vol 210 issue 4447) regarding photo etching. I found nothing wrong at all in the article, and the methods Richard proposes are tried and tested and very effective. However, I would like to offer an *alternative* method, which I hope may be of interest to modellers.



When I attend various model engineering exhibitions, I frequently have cause to regret that models that have obviously taken many months or years to complete have, for me, been ruined by a poor finish. Sometimes this is an inaccurate paint finish, very frequently the wrong typeface or colour used for the fleet numbers but, occasionally, the model pays only lip service to some of the decorations such as work plates, name or number plates.

I have a set of exquisite brass plates created for me by *Model Engineer* Editor, Diane Carney, for my very long term 7.25 inch 'Britannia' project and I don't believe that a home-based etching process could hope to come anywhere near the quality that Diane achieves. But I have often needed a specific piece of metalwork for which the etching process is ideal and which would be very expensive to get done commercially. Creating an image that can be sent to an etching house is only part of it. The cost of a mask and other costs levied by the commercial outlet would only be viable for a run of many copies.

I am going to describe this alternative method without recourse to Richard's article, and thus there may be some commonality between his description and this. I shall describe the complete method in this article.

In outline the method is this:

1. Print the image to be produced on a laser printer.
2. Iron the image on to a thoroughly clean piece of metal.

3. Etch the image using sodium persulfate (as opposed to ferric chloride) in an aerated tank.
4. Clean the resulting component.

That's the process, now for the detail and the reasons for choosing it.

You will need the following equipment and materials and I will add details during the narrative.

- A computer running software that can generate an image of the required etching
- A laser printer (connected to the computer or in a commercial print shop)
- Photographic paper
- An electric iron
- A clear plastic storage jar
- An aquarium tank heater
- An aquarium bubble generator
- A plastic washing up bowl.
- A thermometer with maximum 60 or 70 degrees celsius scale
- Sodium persulfate
- Nail varnish
- Acetone
- Steel wool, 00 and 000 grade
- Lots of paper kitchen towels
- Masking tape
- 3 pins or needles
- 2 plastic pegs or menu holders
- Long wooden or plastic spoon
- An empty plastic or glass container, e.g. a used milk bottle.
- Safety goggles
- Rubber gloves
- Respirator

It may sound like a huge list but a lot of it will already be found at home or in the workshop, plus if you are going to be serious about this and will regularly be making etched parts, the following optional, but highly recommended components:

- A hot laminator
- Di-limonene solvent
- A computer with CAD software
- Adobe Photoshop or equivalent

First, of all a bit of background to the etching process. Many people think that the etchant is an acid which eats away the metal. In fact, in this method it's the opposite. The etchant is sodium persulfate (I have never seen it spelt with a 'ph' in place of the 'f'!) and it's an alkali. The etching process is actually a chemical reaction between the etchant and the material being etched and takes place at the atomic level. The etchant reacts with the metal, causing its atomic bonds to break down and thus to fall away. Since the etchant is a liquid, it also acts as a carrier to carry away the metal that has been etched. This is a very important point since the etchant should be regularly circulating to present the metal face with fresh etchant. Not circulating the etchant is a major cause of failed or irregular etchings. The etchant which bears the metal that has been etched from the parent material is less effective in carrying out the etching reaction, which is why it should be circulated. This is true also of *ferric chloride* as an etchant.

The etchant will remove any exposed metal over time, leeching away atoms of

the metal, layer by layer. To prevent this happening to the metal that you do not want to be etched away, that metal must be shielded from the etchant with a material impervious to the etchant. We call this a 'resist' and there is nothing particularly special about it, it's simply a substance with which the etchant does not react.

You will need to etch away the borders of the part you want to have etched and you may want an aperture in the metal. In either case, you will etch from both sides of the metal at the same time and the etchant eventually meets in the middle (**fig 1**). This process leaves 'lands' which may need to be filed away depending on how the part is to be used. I normally file away lands with a needle file as a matter of course. If you are going to etch out a through hole aperture, you are going to prepare a drawing to create the resist mask that has to be in two parts to apply to the front and back of the metal. These two images must be in *perfect* alignment ('registration') or else the two halves of the aperture will be offset. I will discuss how to achieve this shortly.

You can produce relief in the etching such as lettering on a nameplate. This is called 'half etching' because you are only going to etch half the thickness of the metal i.e. from one side only, the metal to be etched is bare, the side not to be etched is coated with resist.

The process I am going to describe is effective on metal such as brass of thickness up to 1mm (.040 inch) but I rarely etch anything thicker than 0.5mm (.020 inch). If I was going to etch a 1mm thickness plate with a through aperture I would expect the process to be measured in several hours. Typically, it takes around 30 minutes to etch a plate thickness of 0.25mm (.010 inch).

Creating the resist

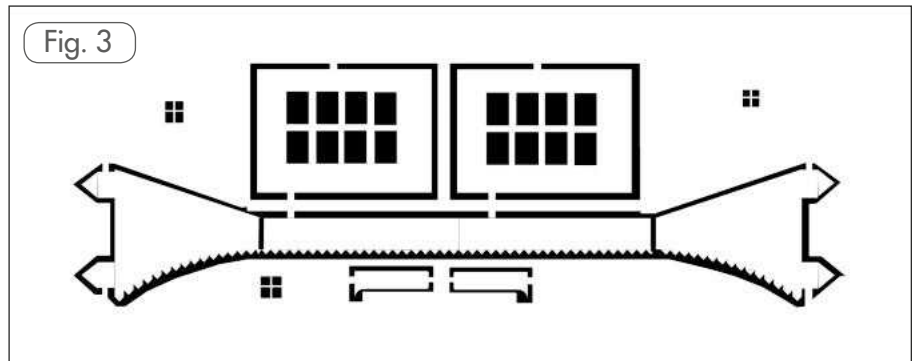
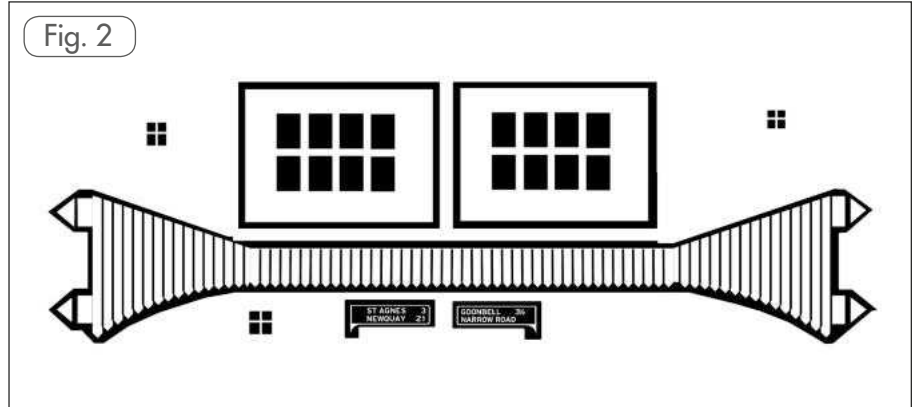
You can use a photoresist and an ultra violet exposure tube as a highly effective method and this is the method described by Richard Castle. This method shows an alternative.

You *could* get a Magic Marker (permanent marker), thoroughly clean the metal to be etched and draw your image of the component you want on the metal. Let it dry and you have a piece of metal ready for etching! It works up to a point, but it isn't necessarily very accurate. I have to confess now, my model engineering extends right downwards to the model railway scales (1:43 and 1:76) and I still want detail to be crisp.

Preparing the drawing

We are going to prepare a drawing of the part you want etched which is then printed on a laser printer – it's the toner used to produce the black image that we need. You could use good old fashioned drawing paper and draw the image that you want by hand, using black indian ink and gouache. Once drawn, you could then the image to a High Street print shop for them to make a photocopy for you, which has to have the greatest toner intensity they can produce.

However, having used a computer for the last 45 years, I find it a lot easier to use



software. I have a laptop on which I have a copy of a programme for Computer Aided Design aka CAD. I use TurboCad DeLuxe (version 20, although its advanced features are not necessary for this process and you can probably obtain an earlier version which will be quite good enough). There are other 2D drawing packages, but you will need one that scales accurately to your required scale.

Figures 2 and 3 show a pair of drawings I made for the valencing and windows for an O gauge goods shed. I also had some spare space on the drawing to include a street finger signpost! (the lettering is a scale 2.5 inch at 1:43 scale! The great thing about CAD is that I can draw the rear face in perfect alignment by using layers, the front on one layer and the rear on another. I simply copy the components from one layer to the other and remove the parts I don't need on the second layer. In summary, the black areas are the ones you want to remove. If you want to remove all the metal, the same black area should appear on both drawings and if you want to create recessed detail, you only want a black area on one of the faces (half-etch). Alongside the window frames and below the valance you can see three little window frames. These are actually registration marks and I usually put them on asymmetrically so that you don't match them up wrongly, where what you want to etch might itself be symmetrical.

If you have never tried CAD, or indeed computers, do you remember how you learnt to use a lathe or milling machine? The learning curve is no steeper for CAD (especially two dimensions) and the satisfaction of seeing the end result no less than for a perfectly machined component - and you don't have spinning machinery to avoid! Unless your Editor wants me to write a tutorial, I'll only cover some of the general principles here.

The drawing space (i.e. what you can fit

on your computer screen) is to all intents infinitely 'zoomable'. This means in English that you can seem to move the drawing away from you and, in principle, you should be able to have the size of the world on your computer screen! This wouldn't be very practical, so let's work out what is reasonable.

For my goods shed I wanted to have a valance about 20 full sized feet long. The wings of the valance are around 4feet and would be folded off the main valance, so the overall length is 28 feet which in O gauge (7mm/ft) is 196mm. Add a couple of fixing tabs to each end and the length is around 210mm.

An A4 sheet of paper is 296mm and the limit of my computer laser printer, so that is fine. If, like me, you are also modelling 7.25 inches (1/4 scale) and you want to etch a plate which on the real thing is 8 feet, the scale length is 12 inches which is too long for an A4 sheet, so you'd either have to buy an A3 printer or take your drawing to a print shop in the High Street to print on their A3 printer. And if you are etching something that big, you're going to need a bigger tank than I will describe later on.

I prefer to draw in full sized units, so I set up the worksheet at a scale of 1:1. You can use metric or imperial scales. So, when I draw the window frames, for example, I am using full size feet and inches. When I print the drawings, I set the scale to 1:43 but I could set the scale to anything. I could even set the scale to 1:8 and print out the drawing on several A4 sheets which I can then stitch together.

The principle I (and many home etchers) use, is to create a black rectangle so that an edge border of around 3-4mm of what will be the etched of the metal being used remains (**fig 4**). The black rectangle forms the background and I then draw the shape of the what I want in white inside the black rectangle. You can then move the components around the screen to

minimise the amount of black showing. Where a lot of black space remains (say more than 10mm), create white fill images to take up the black space. This will save etchant as well as metal. However, you will need to leave a black border around all the components you want to retain on the metal sheet. Usually, the black space should be no less than three times the thickness of the metal.

Where you want a half etch (i.e. on either the face or the rear but not etched right through), it is easier to show the half etch in a different colour on each layer. My convention is that a full aperture (through etch) is black, and a half etch from the face in red, and half etch from the back in green. I then print the master drawing to two separate drawings, one for the rear and one for the face as we will see in a while. For the face drawing I change all the red components to black and delete the green ones. For the rear drawings I change all the green components to black and delete the red ones. You can see that now I have a face drawing and a rear drawing with all the components to be etched to the half thickness in black. Where they correspond I get an aperture, and where they don't I get a half etch.

You need to make some tabs on each of the components or else they will fall out of the fret as they are being etched. I leave a few rectangles spanning between a component and the surround. These acts as the tabs to hold the etched component into the fret. You will later cut through these tabs to release the component from the fret. The rule of thumb is that the width of the tab should be no less than three times the thickness of the metal. I usually make it a bit wider where it is retaining a large slab of metal to the fret. Note that these tabs do not appear in the corresponding drawing in figure 2, because we want to half etch these tabs, to make them easier to cut through.

Unfortunately, the drawing is now a negative and we want a positive. We are going to print out the drawing and because the printer toner will stick to the

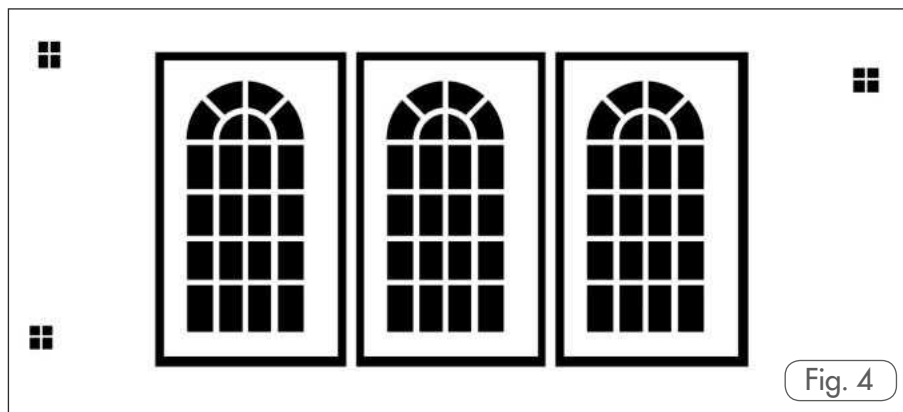


Fig. 4

metal and act as the resist, the white should be black and the black should be white. Again, a piece of free software comes to the rescue on two counts. Another problem is that if you stick the face image to the metal it will be reversed and be etched effectively inside out. You need to create a *mirror image* of the drawing. This only applies to the face, the rear is okay as it is.

The piece of software you ideally want is the redoubtable *Adobe Photoshop* which has been a relatively expensive but very comprehensive piece of software. At the end of last year Adobe was rumoured to be permitting free download and use. The website is http://www.adobe.com/downloads/cs2_downloads/index.html

The version you want is the Photoshop CS2 at the foot of the list. If you are going to download this product and you don't already have a CS2 licence, you should satisfy yourself that your use of the product is legitimate and as with any software you should ensure that your operating system supports it. However, if you manipulate a lot of digital photos, you may want to buy a proper licence anyway – thoroughly recommended.

The alternative is to use the GIMP program, which is definitely open source and therefore free to use for non-commercial purposes. It has a

significantly greater learning curve, but it has a huge range of extras known as plug-ins.

So having Adobe Photoshop or GIMP on your system, you can now load your saved CAD face and rear drawings in turn. Selecting Layer – New Adjustment Layer and Invert turns the black to white and the white to black. For the face drawing you can create a mirror image with Edit – Transform – Flip Horizontal. It takes much longer to read this than to do this.

You can crop the image to reduce the print output to avoid ink wastage.

Before we print it out, let's create our 'Etching Station'!

Since most of my etches can be laid out on a piece of metal no more than 200mm long and 100mm wide, I selected a long thin plastic container to use as my etching tank (**photo 1**). For the method I am describing, it is best to etch the metal when the metal is held vertically in the tank rather than laid down. A long thin tank also reduces the amount of etchant to be made up and I wanted to limit it to 1 litre. There is another important reason why vertical is better than horizontal which I will come to shortly.

The tank I chose is a 'Lock & Lock' 2 litre vertical stackable airtight container with lid and I bought it on line, although you should be able to get a similar one on the High Street. If you are going to make longer or wider etches you will need a larger tank, and this will obviously need more etchant.

Also on line, I bought two components from an aquarium supplier. One is an aquarium heater that is secured to the side of the tank with rubber cups. The other is a 'bubble curtain'. This is a pump that blows air into a flexible tube full of holes. The flexible tube is wound around and placed at the bottom of the tank, so that when the tank is full of etchant, and the pump is switched on, it circulates the bubbles around the tank and most importantly over the etching. This is why the vertical tank is important, the bubbles rise! It prevents metal-laden etchant staying in one place and slowing down the etching process, leading to irregular etching.

I measured 1 litre of water in the tank and to my dismay, the water came about 50mm short of the top of the heater (which should be covered to the indicated mark). So I found a piece of scrap perspex on one of the auction sites on line about 100mm square and 20mm thick. I dropped this into the tank on one side and the water level rose to the required mark, still leaving plenty of room for the etching (**photo 2**).



The etching bath, showing the spaghetti jar with the aquatic aerator in place. The bath is placed in a bowl to catch any etchant splashes. The all-important rubber glove is at the ready!



A 12mm thick piece of perspex has been placed in the spaghetti jar both to add weight (to prevent the bath being top heavy when the etchant is added) and to take up volume to reduce the amount of etchant needed to cover the work.



Inserting the prepared work into the converted laminator. The tape that holds the printed photopaper in place will be melted but does not seem to adversely affect the laminator. Two or even three passes will ensure that the toner has melted on to the copper satisfactorily. Only apply the fixing tape to the leading edge of the prints and workpiece as they will enter the laminator. A piece on, say, the trailing edge may well come adrift in the hot laminator and be the very devil to remove!



The hot iron (not quite at its hottest setting but almost) pressed firmly on to the work after it has been through the laminator will add to the assurance that the toner has adhered to the copper.



The paper on which the image has been printed can now be removed to leave the melted etchant adhered to the copper. Soften the paper with warm (but definitely NOT hot!) water and GENTLY rub the wet paper to remove it. Take your time!



The tank has a removable lid which will be required during the etching process.

Back to the computer: when you are happy with the images, print them to the laser printer with the highest quality setting (typically 1200dots per inch), but first select the paper. You need to print your image on *photographic paper* - ordinary paper won't do. Also you must print this on a laser, an inkjet won't do. For the best paper for this exercise, I have evaluated a lot of different makes and types and by far the best has been Value photo paper from Tesco. It was by far the cheapest but that wasn't a consideration. What is important is that it accepts the laser toner well and sharply in the first instance, which it does, but even more important is that it releases the toner on to the metal cleanly, which it also does. **DO NOT USE** photo paper which is 'PE coated'. This is a plastic film which is great for making photos on an inkjet, but quite useless for our purposes.

If you have designed a nice clean border all round your components, you can crop your image on Photoshop and, as mentioned earlier, I normally leave a 3mm margin all round anyway - you'll see why later.

After printing the two images (face and rear - you will need two images even if you aren't half etching anything), trim them to size (including my 3mm extra margin) to include the registration marks. Take a pin or needle and prick a hole in one of the registration marks on one print out. Now take the other print out and prick a hole in the equivalent registration mark.

Repeat for the other two pairs of marks. Bring the two print outs together facing each other (printed side innermost). Line up the registration holes and run the pins through all three. Make sure the two printed papers are together and secure with masking tape at the top and bottom edges. Put this to one side.

Cut your metal to the size of your cropped image. The registration marks should lie outside the metal but your metal should have a 3mm or more margin outside the width of the cropped printed pages on both side edges. Thus if the width of your printed image is 50mm, your metal should be 56mm or more wide.

Clean the metal

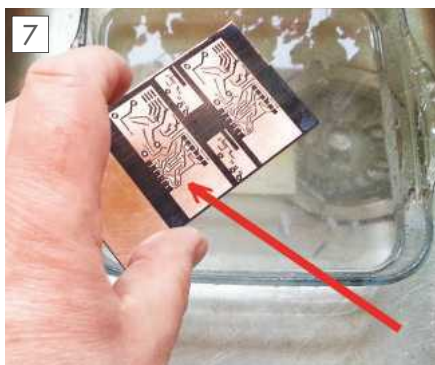
Cleaning the metal is a *vital* process, to ensure that the toner will melt effectively on to the metal. After experimenting with several processes I have decided that using steel wool is the best, the coarse 00 grade first, and the 000 to finish. Get both sides of the metal really clean. You don't need to use any solvents and in fact I would recommend against it as you might leave residues on the surface. When you are satisfied that the metal is as clean as you can get it, gently insert it between the two printed sheets so as not to scratch the printed images and so that the metal protrudes evenly on both edges. With the pins still in place flatten the papers against the metal and secure the paper to the metal with a piece of masking tape on each edge. You can now remove the pins.

Now the heavy work.... switch on the flat iron to just below its maximum heat setting. If you want to go "Rolls Royce", then I thoroughly recommend investing in a heated laminator, used for encapsulating a piece of paper in a plastic 'coat'. My recommendation, and that of many etching enthusiasts, is the GBC H220 model which you can find from a range of suppliers by typing 'GBC H220' into Google. To use the laminator, a more even and intense heating is achieved if you reduce the speed of the rollers, so that the piece is fed through at half the normal speed. However, to do this you need to butcher it according to the guidelines at the website <http://www.youtube.com/watch?v=ZBM7p78B27k>. Beware, by doing this you invalidate your warranty, but if you don't do it, the piece goes through too fast and the toner does not fuse to the metal properly (**photo 3**). Trust me, it works!

However, you can achieve results using the hot iron. Place the piece to be etched secured to the printed sheets on a firm flat and heatproof surface. Hold the iron flat on the piece for at least ten seconds (**photo 4**). Without burning yourself (the piece will now be very hot), turn it over and iron the other side. You want to put a lot of pressure on the iron during the pressing process. Repeat the process on both sides a couple of times.

To be honest, I use belt and braces and run the piece through the laminator and iron it!

Allow the piece to cool by running it under cold water which will also have the effect of softening the backing paper of



7

Beware! Where the copper between parts of melted toner is thin, some of the coating of the paper may remain (arrowed). This may act as a resist to the etchant, so carefully remove it with a sharp scalpel or pin.

the photo sheet. GENTLY, rub off the paper from both sides (**photo 5 & 6**). It is far better to rub off little pieces gradually than trying to peel off the whole thing in one go. If you have applied proper pressure and left the iron on long enough, the toner should have stuck completely to the metal. If not, and there are big chunks of toner left on the paper, we have to start again. You can remove the toner that did not stick with the acetone, and you need to print off two more images, clean the metal again and try again. I have to say that with the iron only method I used to get about 70% success rate, with the modified laminator, I now get 100%, well, 98%.

You may find that the photo paper has left a thin film on the exposed metal sections, which will come off fairly easily if scraped with a wooden cocktail stick

(**photo 7**). If left on, it will act as a resist. Be careful not to damage the rest of the resist.

Clean and dry the piece and inspect it carefully for exposed bits that should be covered. The side margins will be exposed so to prevent them from being etched and wasting metal and etchant, take the nail varnish and paint over the exposed edges. The reason why I only get 98% is that the toner may show tiny holes in places. You can also repair these and small pieces of wrongly exposed areas with a cocktail stick dipped in the nail varnish (**photos 8 & 9**). Let the varnish dry completely.

To be continued...

NEXT TIME: Tony details the etch process and we see the results!



8

This photo shows a piece of brass which will be through etched as well as etched from one side only. This requires separate prints for both sides and careful alignment. Not shown in the photo, the two prints have registration marks to align them before running them through the laminator. Note that the edges are blacker than the rest. This is black nail varnish liberally applied as a resist. Note also that small holes appear in the toner resist showing the copper beneath. Where this is important, dab nail varnish to obscure the unwanted hole.



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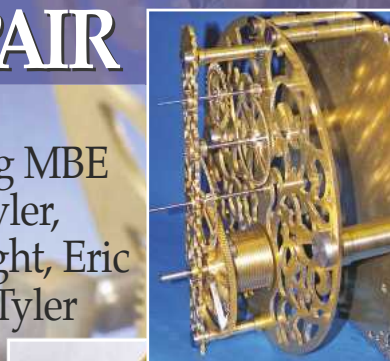
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Button Boring

Georgineer explains an alternative hole placement technique.

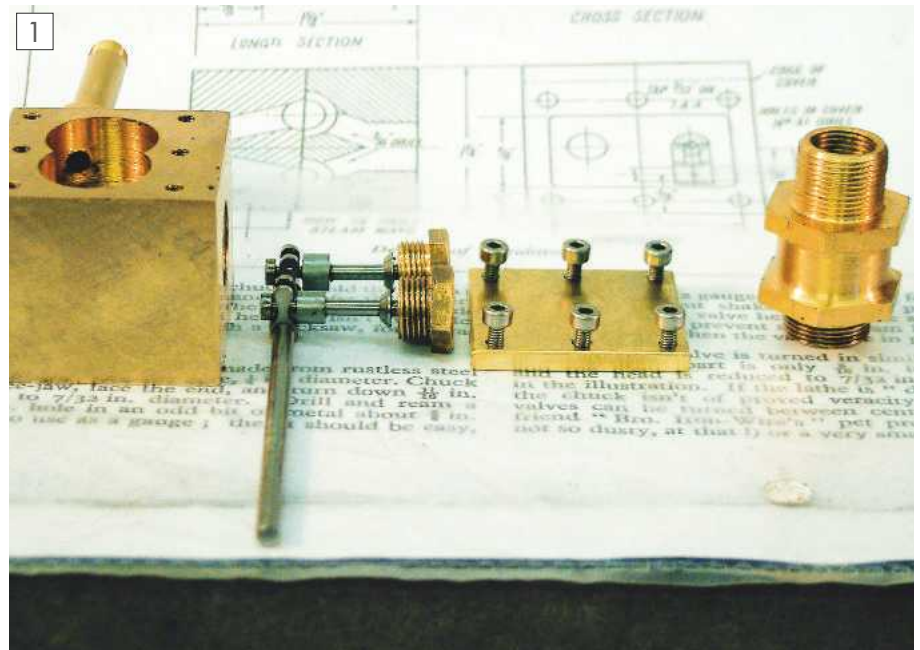


I'm making a poppet valve regulator for my 3 1/2 inch gauge LBSC Britannia, and this article describes how I produced the regulator block without using a milling machine.

The regulator block requires two parallel holes to accommodate the two poppet valve shafts, tapped 3/8 inch x 32 ME by 3/8 inch deep, then through reamed or bored 3/16 inch and 7/32 inch respectively (**photo 1**). Just for fun I'm using toolmaker's buttons to accurately position these holes. This is a technique that we used to use before those expensive electronic DRO gadgets arrived. I should add that I don't have one, and have no intention of getting one either.

Principle of Button Boring

The work piece is marked out conventionally and drilled and tapped where holes are required. Hollow silver steel buttons are positioned over these tapped holes and lightly held there by suitable screws. Slip gauges are used to accurately position the buttons relative to datum faces and each other, and the screws tightened. The work piece is put in the four jaw and each button in turn is



Regulator parts.

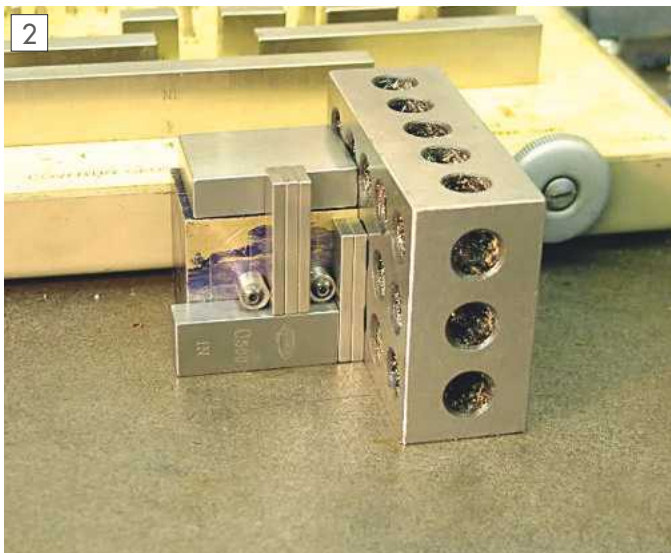
set up to run true in the lathe, the button removed, and the hole bored to size. Done properly, positional accuracy of +/- 0.0002 inch can be achieved quite easily.

Hopefully **photo 2** is self-explanatory: the block was drilled and tapped where the holes are required, and 1/4 inch hollow silver steel buttons held lightly in place with, appropriately enough, button head screws. It's simple arithmetic to calculate the required gauge dimensions, although with small buttons such as these it's a bit tricky to hold them in place whilst

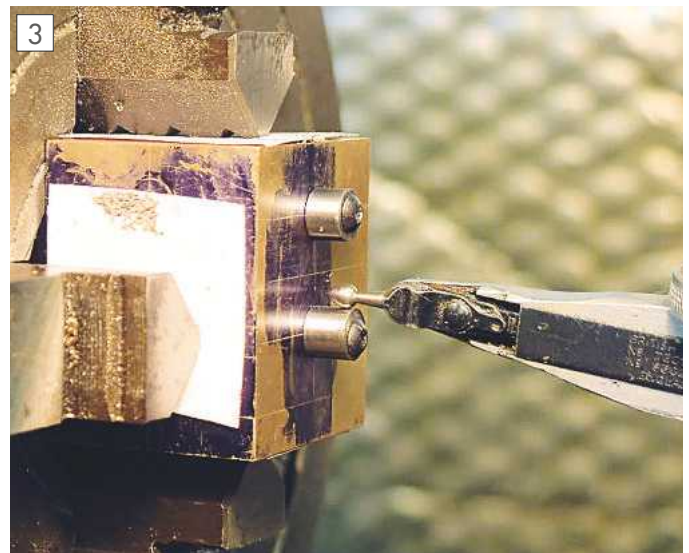
tightening up. If you were really serious the piece would be held against the 3-2-1 block with a toolmaker's clamp.

The piece is put back in the lathe, set to run true roughly by eye, and trued up using the DTI (**photo 3**). I set this to a total runout of 0.0003 inch as any closer would be quite unnecessary!

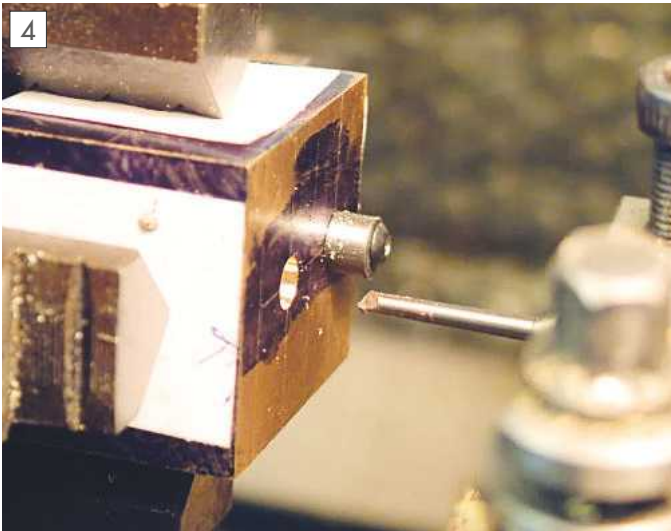
Button removed and a small bore started to get rid of the 2.5mm tapped thread and to provide an accurate start for the drill, as you can use one to get rid of bulk material before finish boring (**photo 4**).



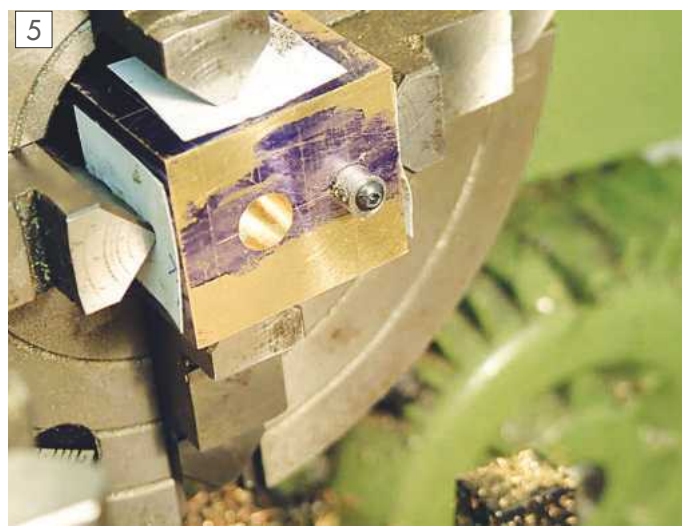
Button setup.



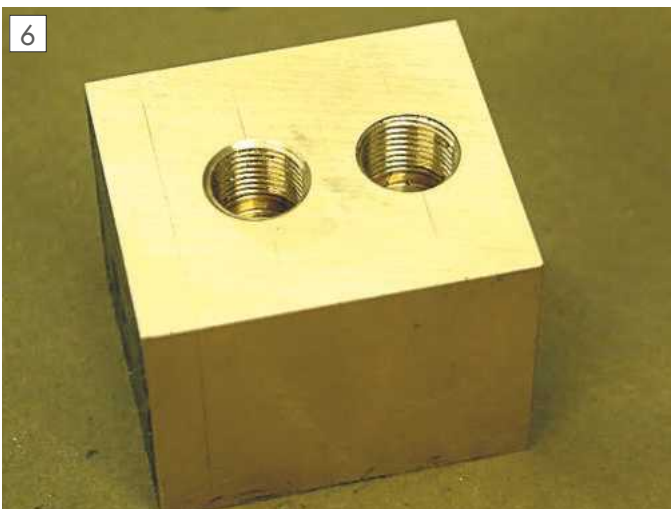
Clocking up.



Initial boring.



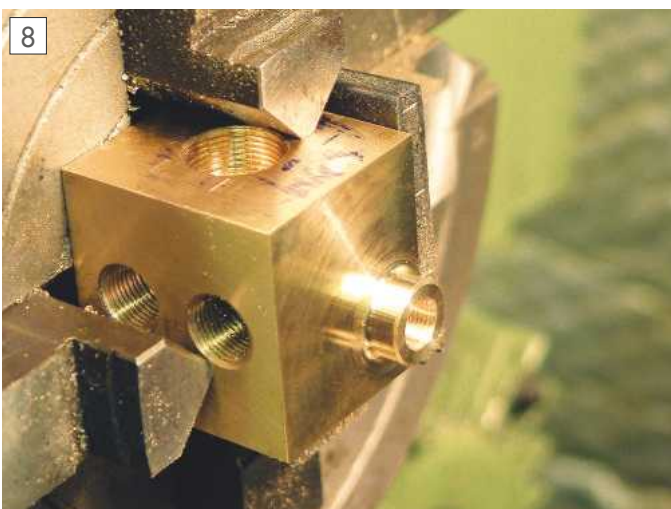
Bored to tapping size.



Tapped block.



Waggly pin setup for boss.



Finished boss.



Completed block.

Photograph 5 shows the hole bored 8.8mm for $\frac{3}{8}$ x 32 ME. The use of a small boring tool enabled me to machine a flat face at the bottom of the hole at precisely $\frac{3}{8}$ inch deep, and go on to bore the $\frac{7}{32}$ inch hole for the poppet valve. I'll tap it and repeat the ops for the other hole.

Photograph 6 shows the second hole completed. They are in-line to within 0.00025 inch, measured from the sides. Just shows what can be done with

primitive, old fashioned equipment, in my case an Emco Maximat V10P lathe.

Next job is the boss to take the actuating shaft. It is reamed thru $\frac{1}{8}$ inch and tapped $\frac{1}{4}$ inch x 40. This is set up using the waggly pin in the tailstock approach (**photo 7**). If you've got an optical punch outfit, you'll be pretty close to the buttons in accuracy (**photos 8 & 9**).

To be fair, if you are confident in your centre-popping, this whole piece could

have been set up using the 'waggly pin in the tailstock chuck' method shown above instead of the buttons, but this was an opportunity to show an alternative method.

That's button boring. It's much easier to do this job on a jig borer or precision milling machine, but if you haven't got either, the lathe is a jolly useful alternative, and shouldn't be forgotten or ignored. Try it sometime! ■

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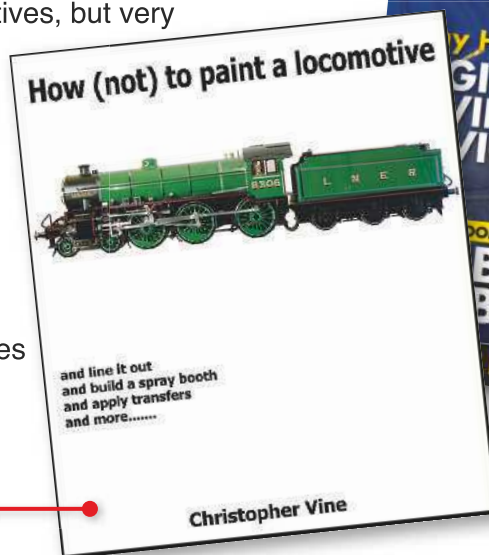
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A Beginner's Guide to Digital Read Outs



Peter King offers some words of advice.

For the benefit of those who 'have to know' there are three basic systems in use, one is similar to the internals of the familiar 'Mouse' and counts teeth on a wheel or engraved lines on a glass bar. Another is magnetic and relies on detecting the profile of the magnetic flux either in or created in steel balls or a strip with magnetic stripes. Finally, many are like a digital caliper and use an etched strip as a sort of variable capacitor.

These devices are very nice to use but alas are also expensive, but one is buying precision. There are several advantages:

The display has large figures and is easier to read with middle aged sight than is the engraving on a hand wheel dial.

The display is usually directly convertible from Imperial to Metric mensuration at the push of a button.

The display can be either 'Absolute' or 'Incremental' measure. This means you get either + or - figures increasing from a datum or a series of 'steps', 'Absolute', is easier for most jobs! 'Incremental' is great for spacing grooves in a turned bar or with a mill, holes or gear teeth along a bar to form a rack.

If you prefer to retain your ghastly pile of shims and a plain tool-post or clamp on a top-slide then these systems are probably a monumental waste of your time and money.

The 'lathe' Y display can be UK 'radial' measure which shows exactly that - .01 mm movement shows a .01 mm reduction on radius - i.e. it is simple linear. The alternative is USA 'diameter' measure, this means that a .01 mm movement of the cross slide on a lathe shows as a .02 mm on the feed screw dial and that same reduction in diameter. Most of the world now uses this system, as no metal arithmetic is required. The lathe X display - longitudinal - is normally linear measure. For those who are now thoroughly confused - a classic 'Myford' shows 'radial' .001 inch division on feed screw dial is .001 inch movement of the cross slide and .002 inch off diameter, an 'Atlas' shows 'diameter' .001 inch division on feed screw dial is .0005 inch movement of the cross slide and .001 inch off diameter.

Milling machine systems are all simple linear measure and are available as either two axes (X, Y) or three axes (X, Y, Z).

The addition of a Digital Read Out (DRO) to either a lathe or a milling machine, dramatically up-rates the precision of the work produced by the machine IF certain requirements are met. It is not necessary for the operator to know how the particular system works, just what it is capable of. The 'Computer Reactionary' need not worry as there is no large keyboard and those dreadful 'digits' are all trapped internally, there is only a display like a pocket calculator.

The average system usually has an inherent accuracy of about .005 mm. this means the accuracy of work can with care now exceed that of the machine dials which are probably engraved for .025 mm intervals - i.e. about a 'thou' - .001 inch. Higher cost systems are often of an accuracy of .002 mm - 2 'microns', 2 thousandths of a millimeter which 5/8ths of 3rds of 'very, very' small! The lowest cost units are 'get what you pay for'...

The system will very quickly show up sloppy slides and saddles in need of gib-strip adjustment and if you push and pull on the slide the display will show how much back lash there is in the feed screws.

There are usually several 'Bells & Whistles' incorporated into the various systems, typically the 'Vertical Mill' versions have a 'bolt hole on pitch circle' facility. This facility means that you can drill any suitable size and number of holes accurately on any size of pitch circle without a dividing device. The lathe version often has a multiple tool option allowing several tools to each be 'zeroed'. Both versions often have a very useful 'centre find' facility of great accuracy.

Sometimes there is a facility to correct the readings of the display where, for example, you find that over 150 mm there is a +.0005 mm error (if you can detect that by heck you're good!) then that can be keyed in as a standing correction.

These are so accurate that you can detect tool wear by 'miking' repetition jobs and see a gradual increase of work size as a +.001 mm then + .002 mm appears whilst the DRO display is showing a constant machining size.

As ever there are some 'BUTS':

But the Lathe tool holder must not be rotated or you lose the zero for that and any other tool you have programmed for, if this suits you then it is usually simple to re-zero as you move from tool to tool.

But the same thing happens if you rotate, retract or extend the top slide.

But the system works best with interchangeable pre-set tool holders that attach to a carrier on a column directly mounted on the cross slide, retiring the top slide for screw and taper cutting only.

But if you switch the device off for more than so many days, then the internal battery goes flat and you lose any zero that you have entered.

But it is not a miracle worker and fitting one of these devices to a sloppy old worn out machine is a waste of your time and money.

The 'BUTS' are followed by some 'IFS':

If you are contemplating installing one of these devices then have a really good look at what is available and the cost, having regard to future service. A supplier who is cheap but 'here today gone tomorrow' will be a pain in the butt as you may find you own an irreparable system.

If you are also considering going down the CNC road, then there are some combined systems which may be more advantageous than others and you will have to be rather more selective.

If you buy cheap then you will get a less robust piece of equipment. The systems are not indestructible and some will not tolerate heavy magnetic fields from magnetic chucks, or having large heavy things dropped on them. Some will not tolerate suds or oils - these being most

inconvenient are disappearing off the market.

If you prefer to retain your ghastly pile of shims and a plain tool-post or clamp on a top-slide then these systems are probably a monumental waste of your time and money.

Once you have got your system operational - and you will find that your normal practice of only reading the handbook as a last resort will delay that happy event, you can get down to learning how to use it. I found when using the lathe that I very quickly became used to looking at the display rather than hand wheel dials or the work. There are some changes in your normal practice that are required, it will be necessary to adopt a practice of always taking the same size of final cut. That is, that cut that will finish the job to size; if you do not do this you will find that the indicated size on the display is somewhat different from the actual size of the work. This is due to 'spring' in the tool mounting and is substantially reduced by replacing the top slide with a plain tool holder (like the Tubal Cain *Gibraltar* fitting). I usually take a finishing cut of .075 mm / .003 inch with a good sharp tool, which is NOT the same tool that was used for 'roughing down'; this roughing tool gets a lot of wear and does not produce an accurate finished job.

All these tests are a nice extra that a DRO allows you to do, all of which will improve the accuracy of your machine.

When using one of these devices on the milling machine, this will also produce rather more accurate work, but only if the gib strips are correctly adjusted. Effectively the conversion changes your 'Mill/Drill' or Vertical Mill into something a bit like a Jig Borer. The display is a very obvious warning of table 'wander' when milling as figures will change that are not supposed to - it pays to lock any slide(s) that are required to stay where they were set. Watch out for changes in the display when tightening a slide lock, I finally found a slightly bowed gib strip that way (after a lot of puzzling). I also found that a very useful accessory was an electrical edge finder, the sort with a little light. The very fine adjustment possible with the DRO display means that it is possible to just get the light glowing dimly and be able to zero very precisely in two axes on a job for subsequent 'jig-boring' or milling activity. If you consider that this positioning with a dim light is probably accurate to .001 mm or thereabouts and that 'spring' in the tool and the rest of the machine when in use is probably of the order .005 - .03 mm then something must be done to use that DRO accuracy. This tool 'spring' depends on the mass of the machine's parts, cutting speed, feed rate etc., etc. A little thought will suggest that a closer attention to said speed, feed and how sharp the cutters are may just possibly reduce the 'spring' and increase the accuracy of the finished product. This will, as mentioned above also require regular attention to gib strips and occasional checks for slop in the quill bearings.

There have been several articles in *MEW* and *ME* on the subject of digital read-outs, both on techniques for using them and on making your own unit. I cannot speak for 'home made' units as I have no experience of them, mine is a commercial product (Newall) and has proved to be absolutely satisfactory apart from one glitch when probably a surge in the power supply did an 'Ooh Nasty' to the programming and it started giving strange readings. The local agent re-programmed the unit overnight and I fitted a surge protector in the supply and the glitch has never recurred. A few members of the local Club have fitted these devices and the consensus is that they are a great improvement to the machines, particularly if like me you have elderly eyesight that makes reading feed screw dials difficult. There is also considerable advantage in being able to switch from Imperial to Metric measure at the push of a button and directly read the dimensions machined on the job without any 'mental arithmetic' of adding up multiple .02 or .025 mms or 'thous'.

The most important factor is that of proper mounting, irrespective of which make or type is used. These are accurate pieces of equipment and must be fitted 'as per the book' to get consistent results. The Newall of which I have experience has an excellent set of instructions that come with

holder on the top slide of the lathe and whilst looking at the display (do switch it on first!), pull, push, twist and generally heave at the whole saddle assembly, the display figures will 'run' and show how much slop there is in:

- The cross-slide feed screw.
- The cross-slide gib strip.
- The saddle gib on flat bed lathes.
- How worn the 'vees' are on a vee-bed lathe.
- The top-slide feed screw.
- The top-slide gib strip.
- The tool holder

Engage the half nuts with the lead screw and push and pull on the saddle to find how much slop there is in:

- The half nuts / lead screw engagement.
- The lead screw mountings.

REMEMBER - there must be some movement left by the 'Gib' strips or the saddle is locked, the amount is small and when adjusting you will find there is a point where there is a sizeable increase in the 'drag' when the saddle or top slide are moved - that's just too far enough!

You will now have an interesting time adjusting all these things to reduce the slop, when you have done this then you can fit a boring bar to the tool holder AND clamp it in the chuck. Push and pull on the chuck and that will move the saddle and show how much movement there is in the lathe mandrel. A radial check other than horizontal will require the use of an old fashioned DTI set up on the top of the chuck whilst you heave vertically at right angles to the mandrel.

Do remember that these adjustments need to be done with the lathe 'warmed up', so run it for about half an hour before adjusting anything. Please don't try this with the boring bar still in the chuck!

All these tests are a nice extra that a DRO allows you to do, all of which will improve the accuracy of your machine. With luck you may find that that elusive 'chatter' pattern that annoyed you for years has now disappeared along with a few other problems of unwanted patterns in the 'finish'.

Installation to a milling machine is more or less the same as for a lathe, i.e. the two horizontal axes have detectors mounted. The difference comes with the vertical 'Z' axis where you have a choice, either a third axis on the DRO read out with another detector or a battery powered unit a bit like the column of a vernier caliper.

The checking of a mill is very similar to that on the lathe, switch on the DRO and then heave and shove the table about and watch for the display figures 'running'. Adjustment of the gib strips will reduce the slop dramatically - BUT NOT COMPLETELY as there must be some clearance to allow the table to move. The same test as for a lathe will find the 'too far enough' point but also watch for the figures changing when the table locks are applied. I found that there was a fine point where there wasn't a 0.0002 thou change when they were tightened. The mandrel cannot be checked the same way, but only by using a DTI set against a test bar mounted in the mandrel socket and then heaving the mandrel about. ■

One Man and his Lathe

Robert Knox and his

Myford ML10

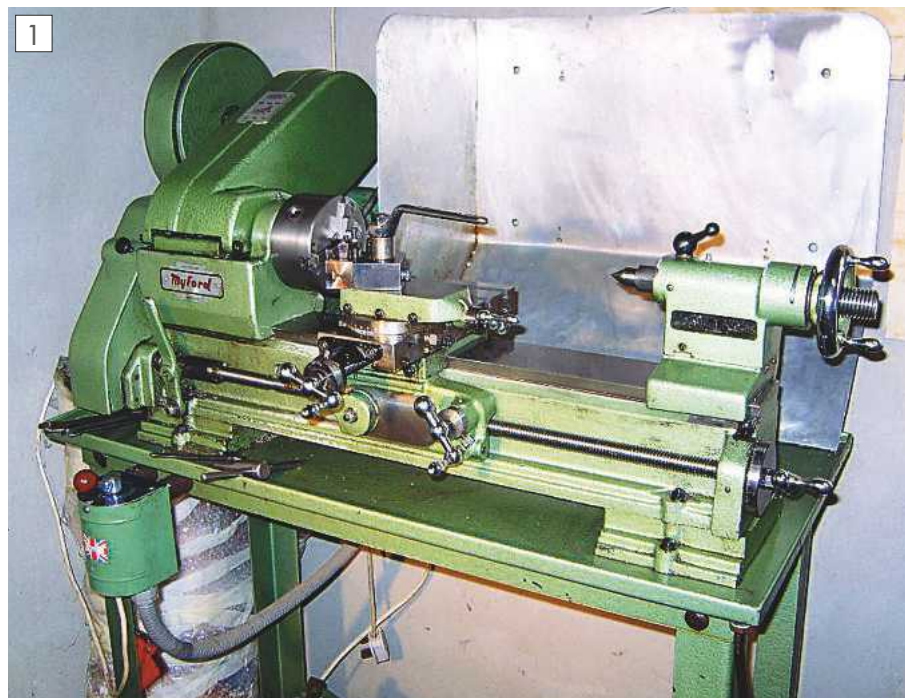


I have had an interest in steam engines and other machinery since I was old enough to walk to the local railway station with my grandfather to see the steam trains, and sometimes to have a short footplate ride from the station platform to the engine shed if the loco was coming off its train. This interest resulted in a career in mechanical engineering which kept me occupied for a long number of years.

In the late seventies I discovered model engineering, and started reading *Model Engineer* magazine now and again, and joined the Model Engineers Society of Northern Ireland based at Cultra near Belfast, then in January 1984 I bought my Myford ML10 lathe, the metric version, from N. Mole & Co.

The lathe has a spindle height of 3¼ inches over the solid dovetailed bed, and can take up to 13 inches between centres. It has six spindle speeds from 48 rpm to 840 rpm, three direct drive and three using backgear.

When I bought the lathe I also ordered a 3 jaw concentric chuck, a 4 jaw independent chuck, a fixed steady, a leadscrew dog clutch, a leadscrew dial, a



The Myford ML10 looks rather different from the 7-series lathes.

swivelling vertical slide, a long cross slide, a drip tray, raising blocks, and a proper Myford stand (**photo 1**).

The ML10 has taper roller spindle bearings, which are grease lubricated, as standard and these have proved to be trouble free over the last thirty years of use, only needing adjustment once, when they had settled in.

When I assembled the lathe in my home workshop and set up the alignments, I found it to be an excellent machine, consistently accurate, as it still is today.

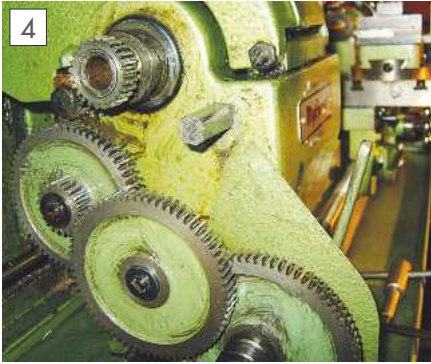
The first project that I tackled with the Myford was a small machine vice for the vertical slide. This was made from a set of castings that I obtained from College Engineering Supply (**ref. 1**) Then using



Collection of quick-change toolholders.



The QCTP fitted.



4
Metric conversion gears.

the vice, vertical slide, and some borrowed milling cutters I made a quick change toolpost and toolholders from a design that I saw in *Model Engineer* magazine. This made life so much easier, no shims to lose, and screw centre height adjustment. This gave me a boring toolholder for ½ and ⅝ inch boring tools, a dedicated parting toolholder, a knurling toolholder, and three ordinary toolholders for ¼ inch square cutting tools (**photos 2 & 3**).

The ML10 doesn't have a quick change gearbox for the leadscrew but uses gears to give the required pitch of movement to the lathe saddle. When it was bought I had got the full set of standard gears, and I also bought the metric/imperial conversion set so I could use my metric lathe to screwcut imperial threads (**photo 4**).

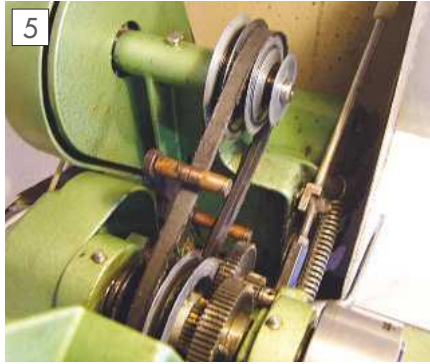
The coarsest thread that it has cut so far has been 11Tpi on 22m/m brass pipe for the water connections to the boiler on my Parkray Duet solid fuel range.

No clutch was fitted to the lathe when it was new and I worried about the life of the drive motor starting and stopping under load using the Dewhurst switch which was supplied with the lathe. However, *Model Engineer* magazine came to my rescue again in the form of an article about modifying the spindle drive belt tensioner to use as a sort of a clutch. **Photograph 5** shows the drive in the disengaged position, and **photo 6** shows the drive engaged with the control lever with the white knob in the forward position. It is really very simple and uses a strong tension spring to hold the lever in either of the two positions. The belt can be slipped just like a proper clutch for fine movements. It works well, the original belt and pulleys are still in use.

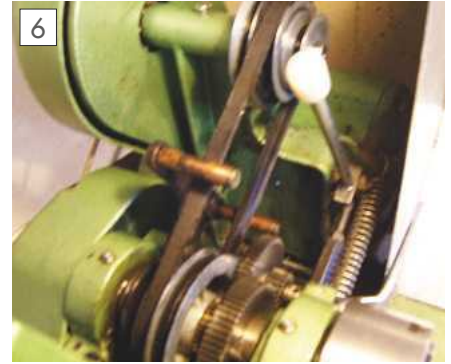
The leadscrew dial that I fitted at the tailstock end of the bed has proved to be very useful during milling operations with the vertical slide, and also when turning parts up to a shoulder or parting off to length (**photo 7**).

Backgear is engaged by slackening a nut behind the chuck in **photo 8** (you can just see the end of the attached ring spanner) and sliding the gears into engagement. However, you have to be careful to disengage the lock on the bullwheel just behind the front spindle bearing using the special short allen key supplied in the toolkit.

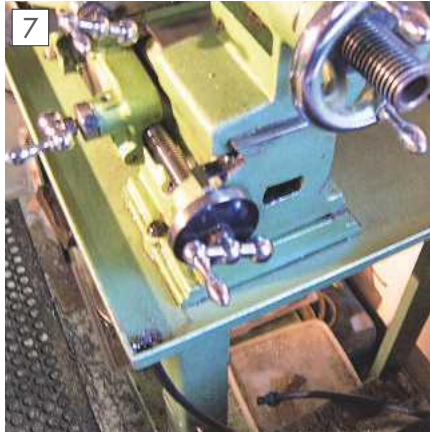
Using this lathe, which was my only machine tool apart from a Black & Decker power drill in a stand, and a small bench grinder, I have made a lot of interesting things varying from small oscillating cylinder steam engines, Stuart 10V and 10 H engines, Stuart Twin Compound Launch



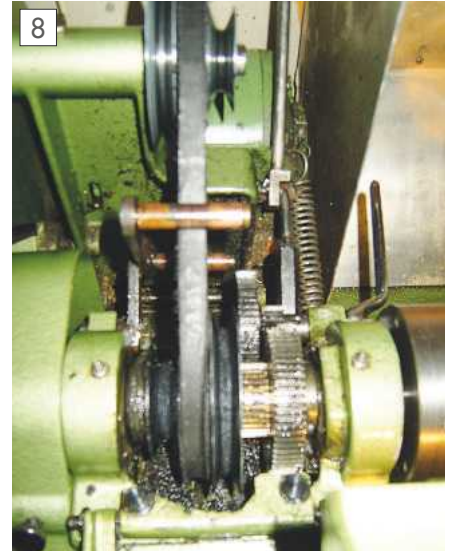
5
Belt tensioner 'clutch' disengaged.



6
... and engaged



7
Leadscrew dial fitted by Robert.



8
Engaging backgear requires care.

engine, Stuart Steam Boiler Feed Pump, various boilers and fittings to drive these, a Rex Nicholls battery electric tram loco in 5 inch gauge, and a two bogie braked driving trolley to match the tram loco. Even now when I have a Warco BH600 lathe and a Warco VMC turret mill to keep the ML10 company I still use it for most of the smaller turning jobs for the like of the current project which is a Stuart Twin Victoria mill engine (**photo 9**).

The little Myford ML10 has survived being stripped down and rebuilt during five house moves, everything still works, the paintwork is a bit worn, the leadscrews have some backlash now, but it is still accurate and capable of doing what it always has done. For what Myford marketed as a basic lathe it has been good value for money and will probably outlast me.

If anyone out there is thinking of taking up model engineering in whatever form I would definitely recommend buying one of these, it just keeps on going as long as you are kind to it and use proper oil and grease in the appropriate places. ■

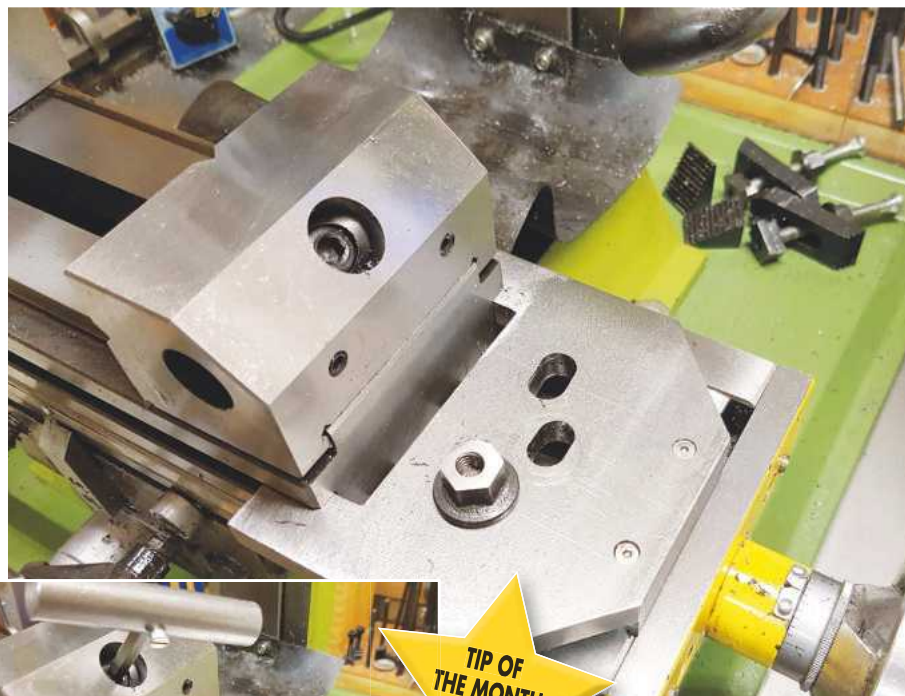
REFERENCE

1. The College Engineering Supply.
Telephone 0121 530 3600. Email
sales@collegeengineering.co.uk



9
Robert's Victoria mill engine, complete but unpainted.

Readers' Tips



We have £30 in gift vouchers courtesy of engineering suppliers Chester Machine Tools for each month's 'Top Tip'.

Email your workshop tips to neil.wyatt@mytimemedia.com marking them 'Readers Tips', and you could be a winner. Try to keep your tip to no more than 400 words and a picture or drawing. **Don't forget to include your address!** Every month we will choose a selection for publication and the one chosen as **Tip of the Month** will win £30 in gift vouchers from Chester Machine Tools. Visit www.chestershobbystore.com to plan how to spend yours!

Please note that the first prize of Chester Vouchers is only available to UK readers. Other prizes are at the discretion of the Editor.

Our winning tip from Walter Allen is a neat way to clamp small vices.

Precision Vice Clamping

I have recently bought a precision tool vice type 2 from ARC euro trade knowing that it did not have a recess at the ends for clamping (it comes with side clamping recesses). The type 2 comes with springs in for easy opening and closing, but does not have a recess on the ends like type 1. I have a narrow table on my mill, so I've had to devise a clamping arrangement for the ends. I purchased some 10mm steel plate and cut out a recess on the steel to fit the ends of the vice and milled three clamping slot holes so that the vice moves across the three T slots on my mill table.

Our runner up is Michael Matthews who wins a set of ten Shaviv deburring blades with a Mango II handle for a couple of handy cleansing tips.

Clean Up

When I worked as an Electrical Engineering Officer in the Merchant Navy before the general use of the thin rubber gloves, we relied on barrier cream and hand cleanser to keep our hands reasonably clean and supple. This often was less than satisfactory particularly when exposed to heavy residual fuel oil. One uses more and more hand cleaner that removes the natural oils and makes the hands susceptible to getting dirty again.

My Father advised me to put a teaspoonful of table salt in the cup of my palm and then to put a similar amount of olive oil to make an abrasive paste that was worked into the hands.

The salt cleaned the pores and the oil lifted the grease, when the hands were clean they could be washed under hot water using normal soap leaving the hands soft and supple.

The second tip concerns washing brushes that have been used for painting Hammerite, the special thinners are about £7.00 for 250ml and really it is cheaper to throw away the brush! I read the other day on a website devoted to UK ex-pats living in France that normal vegetable oil cleans the brushes. I tried it and it works! as long as the brush has not hardened. I used ordinary sunflower oil and as soon as the brush was in the oil it changed to the colour of the paint. Soak overnight and wash out with hot water and detergent.



No more than one prize with a value of £30 will be given each month. By entering you agree your entry can be freely published and republished MyTimeMedia on paper or electronically and may be edited before appearing. Unpublished tips may be carried forward to future months. You will be acknowledged as the author of the tip. There is no guarantee that any entry will be published and if no publishable tips are received a prize will not be awarded. The decision of the editor is final.

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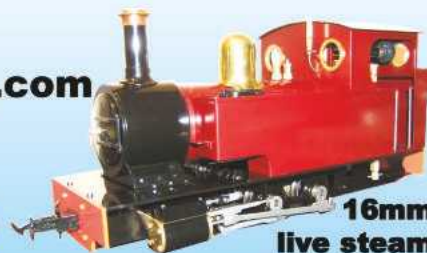
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A Digital Dividing Device for the Lathe

Tony Hills describes an interesting approach to dividing on the lathe.

The 'right tool for the job' is something I subscribe to. On many occasions I have tried to use the wrong or a general purpose tool for a particular job and regretted it afterwards. So when I needed to drill some holes around a circumference, I eventually ended up thinking about a dividing device for the lathe, as the piece was easier to mount in the lathe chuck than on the miller. However, the lathe's basic purpose is to turn a circumference at speed and it required a special attachment to perform dividing which I did not possess.

I started researching how I could create the attachment and read all the standard works on the subject which included George Thomas's beautiful swan-like worm drive onto the bull wheel, as well as the latest *MEW* articles on the subject. All of these either required engineering skills I do not possess or extensive time to build them.

By chance at my engineering club a pile of *Axminster Tool Centre* catalogues had been left on the counter and I took one to browse. There I saw a digital rotary angle encoder and immediately thought this could be the basis of a simple but effective dividing device for the lathe.

I set about designing the divider with the rotary encoder at its heart and this article describes the final outcome. My lathe is a Southbend 9A and I have not included dimensions as it will require scaling up or down to suit other types of lathe. I see no reason why it cannot fit other types as its simple principles should apply to most. It is shown assembled in **photo 1**.



Assembled unit.

Construction

All material was located in the scrap box and is of BMS (bright mild steel). Of course, it could be aluminium as no great forces are involved when in use. The device consists of four main parts:

Spindle attachment

This is made of three parts, shown as such in **photo 2** and assembled in **photo 3**. The complete unit is inserted into the spindle at the gear end of the headstock. The internal draw bar is pulled backwards through the attachment by tightening the nut on a 1/2 inch BSF thread, forcing the attachment against the internal wall of the spindle and locking the unit to the spindle.

At the other end of the draw bar is a 6mm reamed hole with a grub screw that locates the spindle of the sensor.

Plate holder

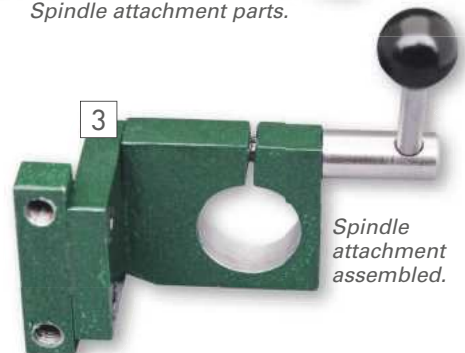
This is a three-part unit (**photo 4**) which is mounted on the extremity of the gear banjo and can be left in place if it does not interfere with the cover or gears.

Plate

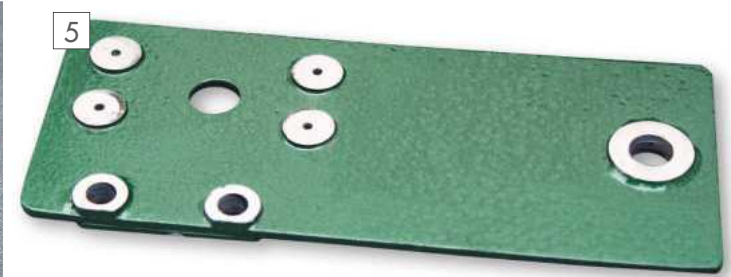
This holds the rotary encoder (**photo 5**) and is prevented from rotating by locking it to the plate holder. It is nothing more than a plate drilled as appropriate. I have brazed



Spindle attachment parts.



Spindle attachment assembled.



The plate.

Plate holder parts.

washers to the plate and these remain unpainted to allow easy dismantling.

Brake

I spent some time trying to develop devices for locking the spindle when the correct position had been achieved, mostly involving detents engaging with gearwheels etc, but none were accurate enough or required backlash eliminators. I then thought of a band going around the bull gear wheel which gripped and held this in position. Finally, it occurred to me that at the gear end of the spindle was a machined area that could be used and I created a simple clamp that was attached to the plate and had a lever for applying and releasing as required (photo

6). Its effectiveness surprised me as it is a very simple device and when applied it does not move the spindle at all, thereby maintaining registration.

The digital encoder

This was purchased from Axminster for £35.70 (ref 1). It consists of two units and a connecting cable (photo 7). There are other suppliers of similar devices but at the time Axminster was the best deal I could find. The encoder unit is fixed to the plate and the readout unit has a magnetic upper surface which allows it to be placed under my readout for the lathe (photo 8). I screwed a small steel plate under the readout to use the magnetic

facility on the encoder readout, but it could be fitted in many other ways and places.

The encoder and readout is accurate to one tenth of a degree, which is accurate enough for the type of engineering I undertake. It is a simple matter to rotate the chuck until the desired angle is achieved and I found that putting the chuck key in the chuck and gently tapping this allows spot on accuracy to be attained quickly. Note: When doing this I always disconnect the power to the lathe at the isolator on the wall to prevent accidental turn on which would prove very dangerous with a chuck key in the chuck.

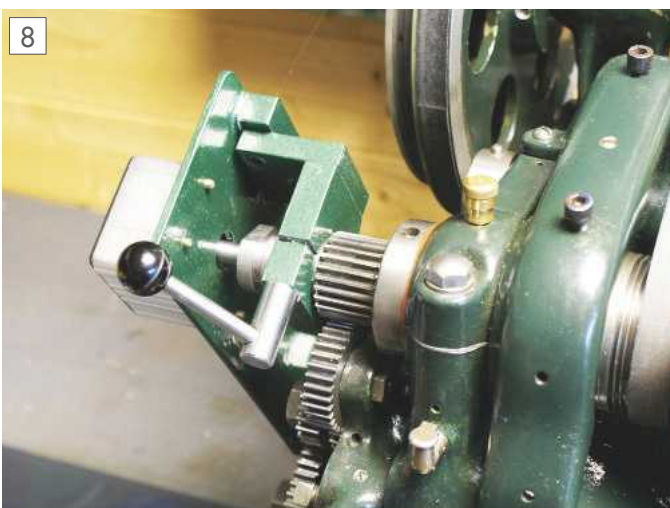
The assembled device on my lathe is shown in photo 9.



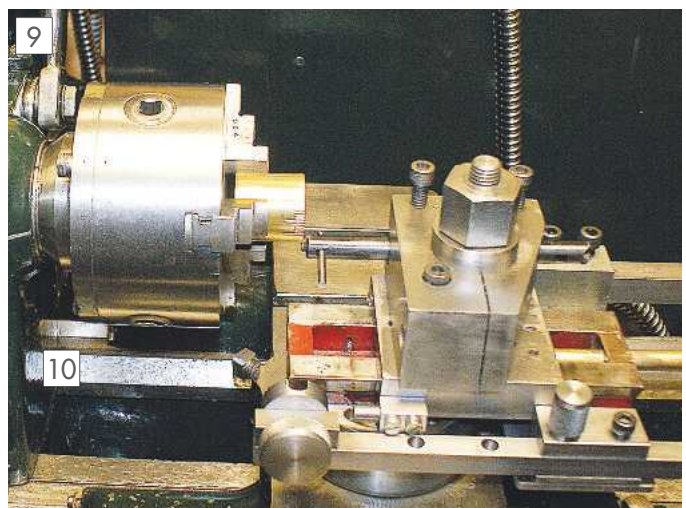
The brake.



Digital rotary encoder.



Readout in position under lathe DRO.



The device attached to the lathe.

Dividing by angle

Of course, the device does not rely on worm wheels and dividing plates. In order to divide by a specific number, the angles from zero are required. I created a set of angles for every number of divisions from 2 to 50 using an Excel spreadsheet and these are reproduced in this article. In practice, I find it easier to print off the required angles for just the number of divisions required each time as this avoids constant confusion reading between sets of angles when they are all shown together.

Although I have provided angles for up to 50 divisions, there is no upper limit. In practice, as the device is only accurate to one tenth of a degree, there is little point in going above 720.



The device being used to graduate a collar.

The spreadsheet is very simple and I am quite willing to supply it to anyone by email. See **ref 2** for my email address.

Adapting for other types of lathe

The simplicity of this device lends itself to most lathes. The main consideration is whether there is a banjo on which to anchor the plate. Some other point may be suitable if not. Clearly, the diameter of the spindle attachment will need to match the spindle bore.

If there is no machined area at the end of the spindle to accept the brake, then the solution is to make the spindle attachment 12mm longer between the locating chamfer and the locknut, with flats at the chamfer end milled on to accept a spanner when tightening. The brake can then fit over this.

Conclusion

Although I own a rotary table and its dividing attachments, it is almost impossible to mount this properly on the lathe. The digital divider has worked very successfully within the limits described above and at a modest cost. You simply set the readout to zero for the first hole or line and go from there. It can be seen being used in conjunction with a line tool that is graduating a collar (**photo 10**). I also have the rotary angle encoder for use in a number of other applications away from the lathe. ■

Tony Hills has produced his tables as a pdf; this will be available on the website www.model-engineer.co.uk

REFERENCES

1. Axminster Tool Centre. T. 0800 371822. Branches around the country. www.axminster.co.uk
2. Email tony@hills-uk.com

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Milling Leadscrews in the Lathe

PART 2



John Pace gives full build instructions for his self-contained milling spindle, together with advice on its use.

Although, in the past, I have cut several replacement leadscrews for machines during conversions and have not encountered any problems, a recent experience has made me look at an alternative method of production.

The cutter shaft

For the shaft I used En8 is a simple turning between centres, refer to **fig. 5**. **Photograph 14** shows the taper being cut. Make the shaft a close fit to the bushes in the mounting block. The shaft should be case hardened, as it is very short there should be no problem with distortion providing it is quenched vertically. The worm gear is mounted on a taper and requires no key as the taper is sufficient for the driving load. I use the CNC on my Myford to turn the taper on the shaft, the mandrel to hold the gear for



Set-up for Milling leadscrews.



Turning the cutter shaft taper.

hobbing and to turn the matching internal taper for the worm wheel. The taper is turned 1 in 10, I turn tapers using this basis as it makes for an easy and quick file for CNC, the angle is 5.71 deg. However this is done, the tapers should fit well together. The flats are $\frac{3}{4}$ inch across, either grind a $\frac{3}{4}$ AF spanner thin enough to fit the width of the flat or make a spanner from gauge plate. This spanner is required to hold the shaft to fit and remove the cutters to avoid straining against the worm/wheel (**photo 15**). The shaft is held in a collet to avoid damaging the surface and the spanner flats are cut.

Fig. 5

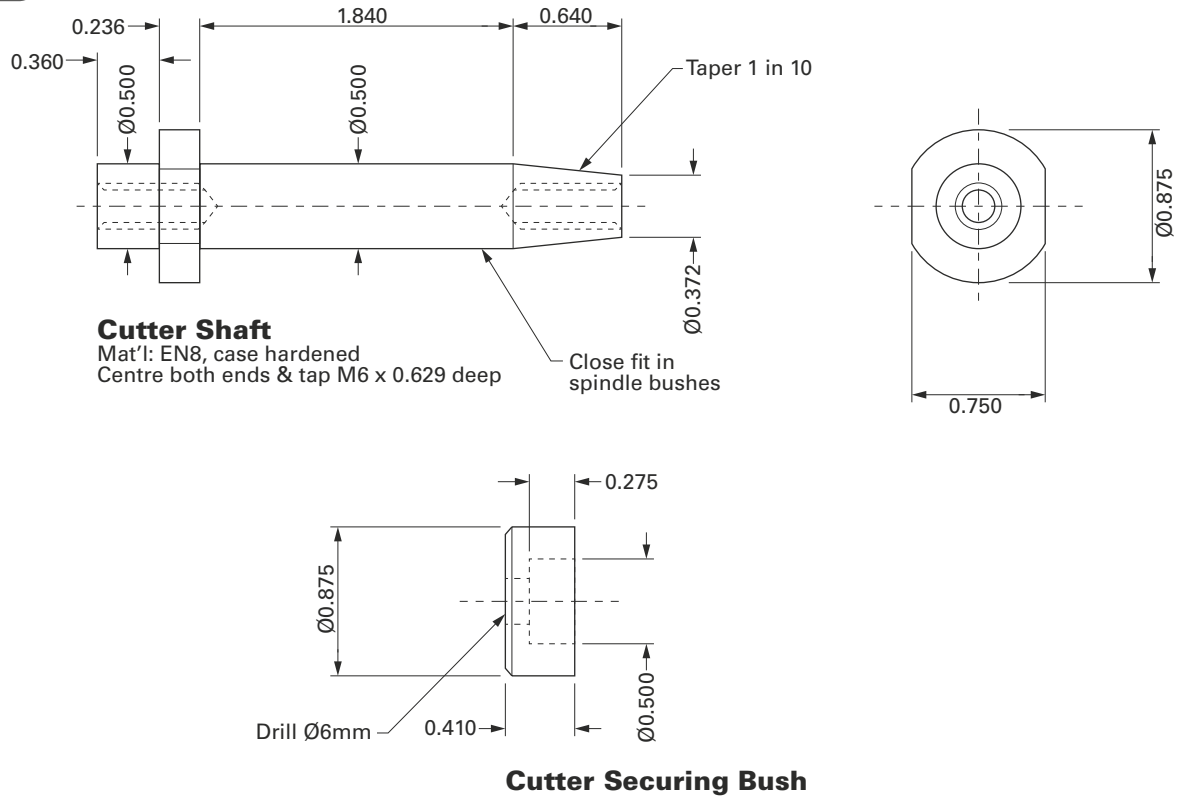
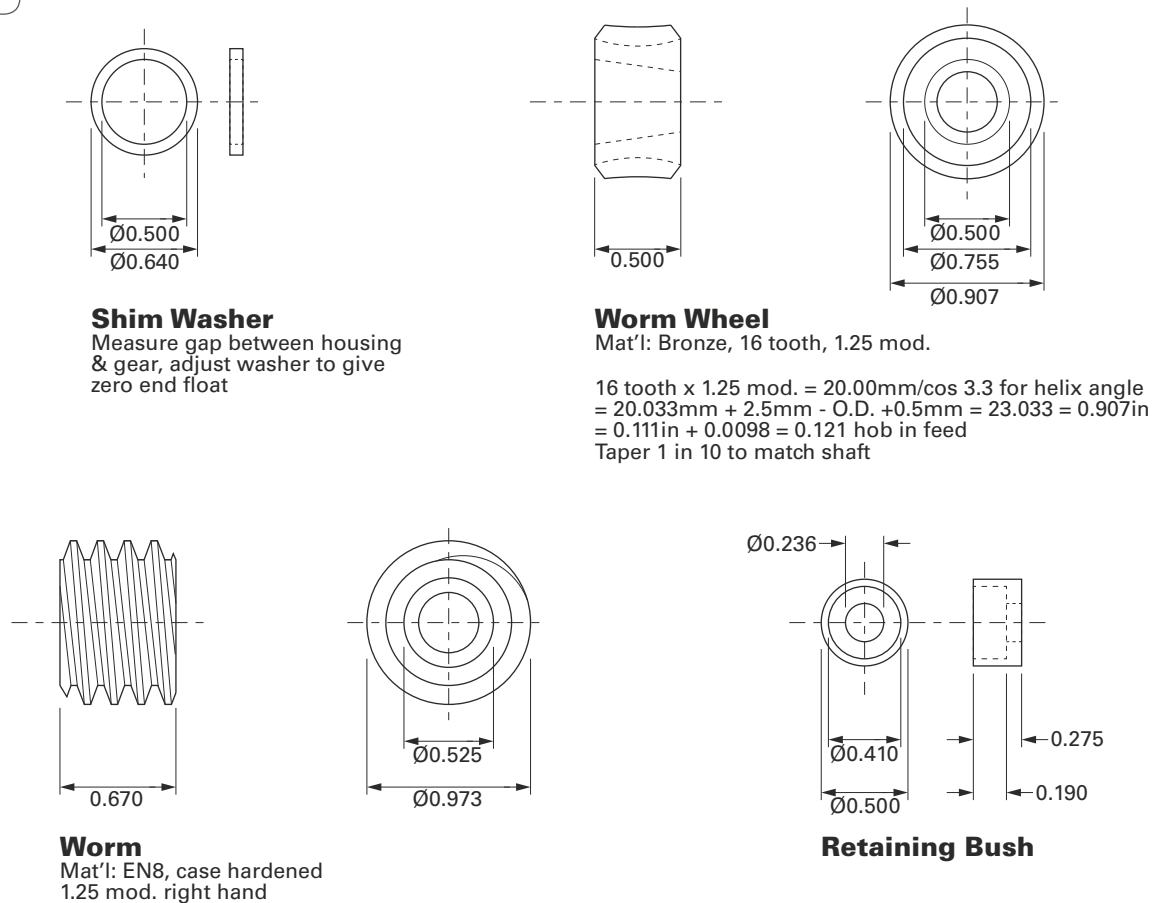


Fig. 6





15 Milling the spanner flats.



16 Boring out the taper on the wormwheel blank.



17 Three wormwheel blanks and turning mandrel.



18 Hobbing the wormwheel 1.25 mod.

The wormwheel

The worm wheel is shown in **fig. 6** and is made from hard bronze. **Photograph 16** shows the wormwheel blank taper being bored. The boring tool is mounted upside down in the back toolpost and the taper cut using CNC (**photo 17**). Three wormwheel blanks were bored and the tapered mandrel was cut at the same time as the shafts. The blanks were fitted to the mill and hobbled using an electronic system devised by Richard Bartlett (**ref. 2**) (**photo 18**). The hob is from Arc Euro trade (1.25 module). A suitable worm and wheel pair are available from HPC gears (**ref. 3**), the centre distance is slightly different from my drawings and obviously the wormwheel will be plain bored. This may mean that the shaft will have to be made with a parallel fixing with a key or the gear modified to have the taper. HPC part numbers for these are for the wormwheel M 1.25-16 and for the worm W 1.25-1 for a soft worm or WH 1.25-1 for a hardened unit.

The worm and shaft

I have made the worm as a separate unit from the shaft so that it may be casehardened, it is of course possible to make this as one unit but may distort if it is hardened. The worm is in **fig. 6** and **photo 19** shows the worm being milled



19 CNC milling the 1.25 module worm.



20 Two sets of finished worms and wheels.

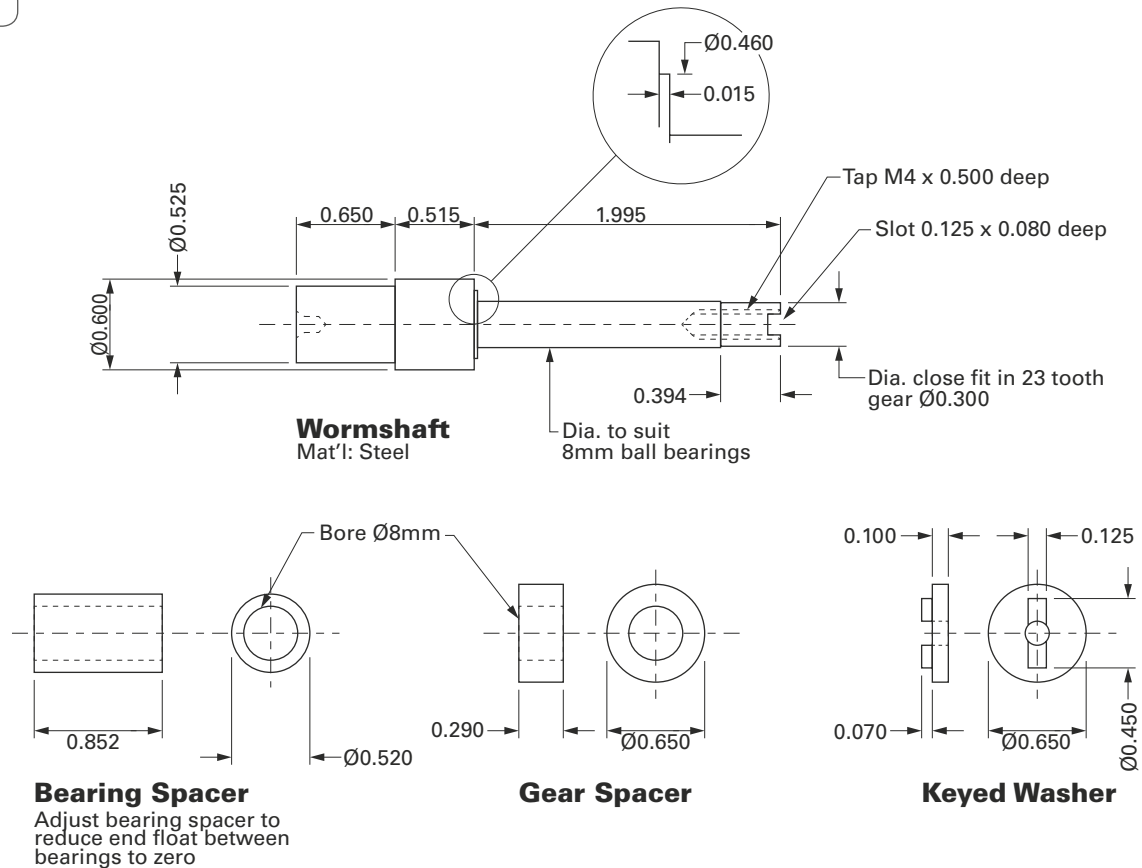
using CN. As can be seen the finish is completely burr free and this is the basis for this article to be able to cut similar thread forms in this way, the cutting action is much kinder to the workpiece than cutting with a normal screwcutting tool. **Photograph 20** shows the finished worms and wheels, note the ground off sharp lead in on the worm.

The worms are case hardened and polished with a buffing wheel. The worm shaft is shown in **photo 21** and is a piece of simple turning between centres shown in **fig. 7**.



21 The wormshaft and worm.

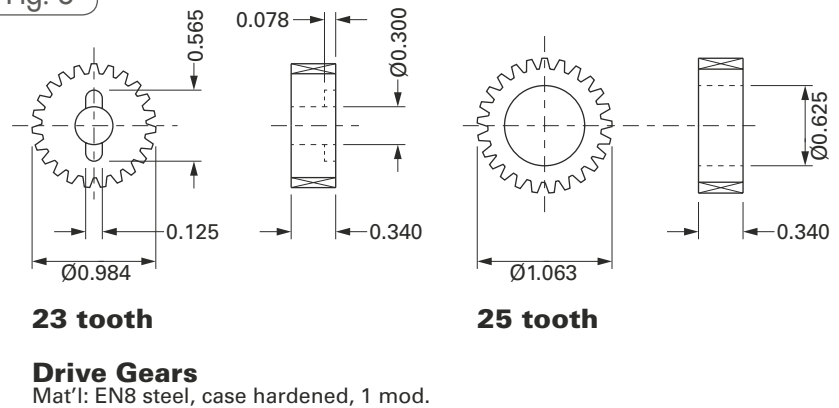
Fig. 7



The drive gears

The motor drives the worm through two 1 module spur gears, 25 tooth on the motor and 23 tooth on the wormshaft. The 25 tooth gear is drawn with a large bore and is fixed to a hub machined in situ on the motor shaft, shown in **fig. 8**. The gear is secured in place with some high strength Loctite, see photo 35 later on. The 23 tooth gears have a slot cut across one end of the bore, this slot lines up with the slot at the top of the shaft as seen in photo 18 the washer also shown in the drawing engages in these slots to transmit the drive, **photo 22** will show the slot being cut in the gear. The gear blanks are prepared and fitted to the mill for hobbing, as I was making two of these units I was able to hob two 25 tooth gears at the same time as the arbor was long enough to fit both gear blanks,

Fig. 8



22



Milling the slot in 23 tooth gear blank.

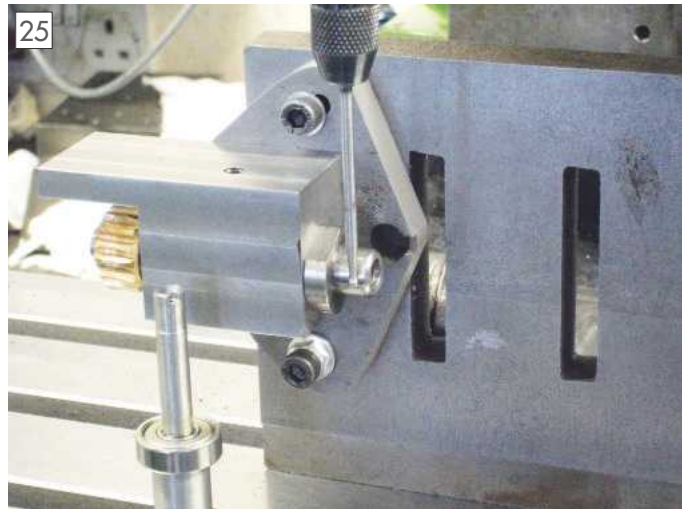
23



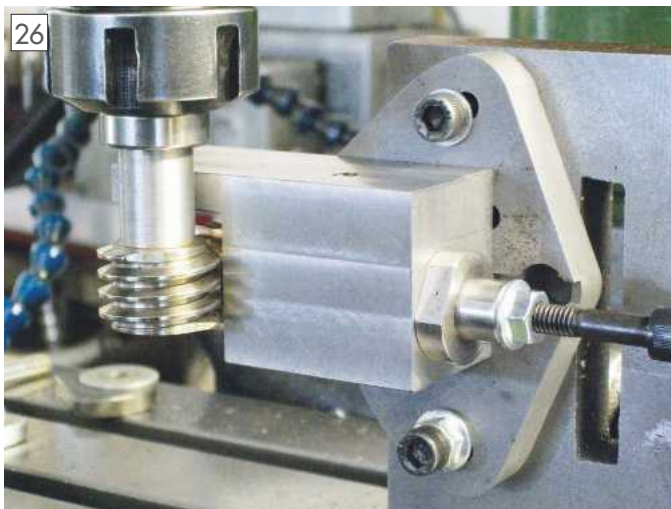
Hobbing a pair of 25 tooth gears.



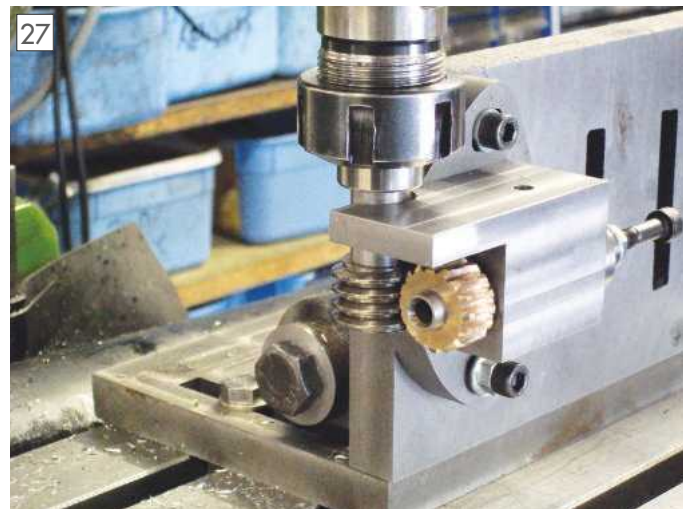
Hobbing the 23 tooth gear.



Picking up the centreline of the cutter shaft.



Meshing the worm and wheel ,the shaft held in a collet.



Cut out made on other side of block ,worm and wheel meshed again to check position.

photo 23 shows the 25 tooth gears and **photo 24** the 23 tooth gear.

Most of the main cutter block has already been machined, now the rest of the main parts are made the block can be finished. The dimensions are not shown on the blockdrawing as it is much easier to determine the position directly on the milling machine. The reason for this is that the individual components, however well made, will accumulate errors. For instance, a 0.001 inch diameter error in the taper mounting will move the gear 0.010 inch sideways.

A sequence of photos shows the steps to align the two gears. The spindle mounting block is fitted to the mounting plate. The plate is secured to an angle plate bolted to the mill table. The spindle block is clocked true in both planes. The shaft is fitted and the centre picked up using a wobbler (**photo 25**). Make note of the position of the centre or zero DRO. The worm wheel is fitted to the shaft and the wormshaft with the worm fitted is mounted in the machine spindle in a collet. The worm is carefully positioned until the gears are in mesh make a note of the position (**photo 26**). At this time you will note the worm is on the wrong side of the block and it is not possible to mesh the gears on the correct side as the part of the top of the block has to be machined away. The worm shaft is removed from the spindle and a 3/4 inch



Final cut for location diameter.

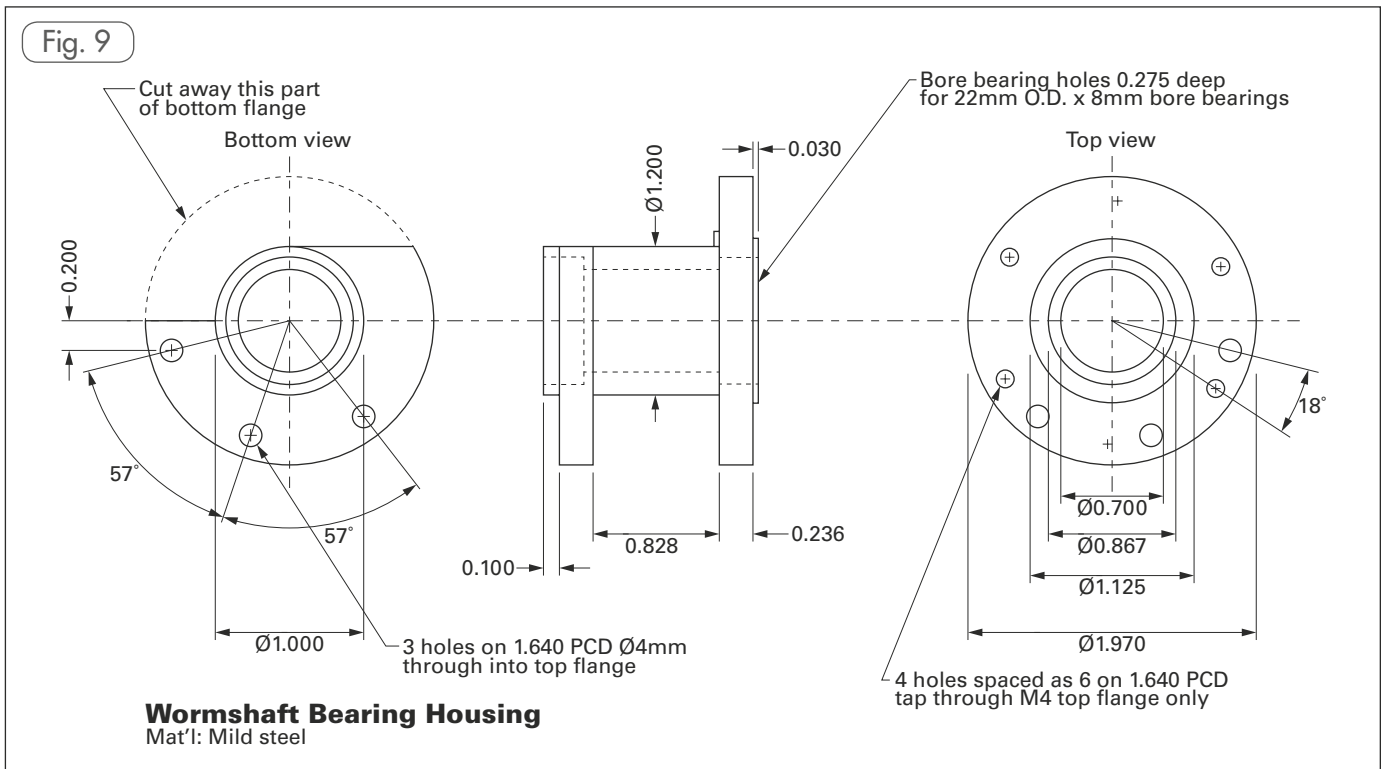
end mill fitted. The spindle is repositioned the equivalent amount on the opposite side of the wormwheel. A half circular cut out is machined in this position - don't try to do this in one bite. When this is done refit the wormshaft back in the collet and re-mesh the gears, aim for the minimum amount of backlash and accurate centring. Make a note of the position (**photo 27**). Remove the wormshaft and fit a 1.000 inch end mill or use a boring head and machine out the half circular cut out, again only take small cuts to correct position (**photo 28**).



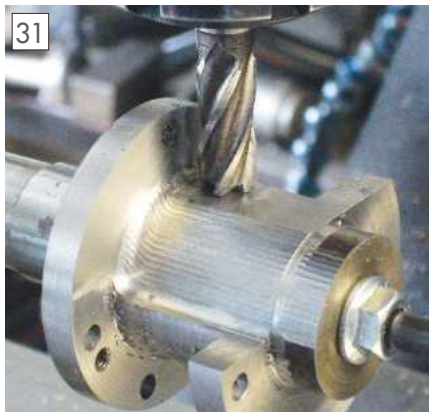
Milling the keyed washer.

The wormshaft housing

The wormshaft housing is a simple turning job and does not require much work to complete and is shown in **fig. 9**. The holes are drilled 4mm diameter as the drawings. through the top and bottom flange the M4 tapped holes are in the top flange only. Measure the distance across the inner bearing races when fitted in the housing and make the bearing spacer to take up the end float make also the gear spacer and the keyed washer (**photo 29**). Ensure the end faces of the spacers are parallel this is important as the shaft will



Spotting through wormshaft mounting holes into spindle block.



Milling clearance on wormshaft housing.



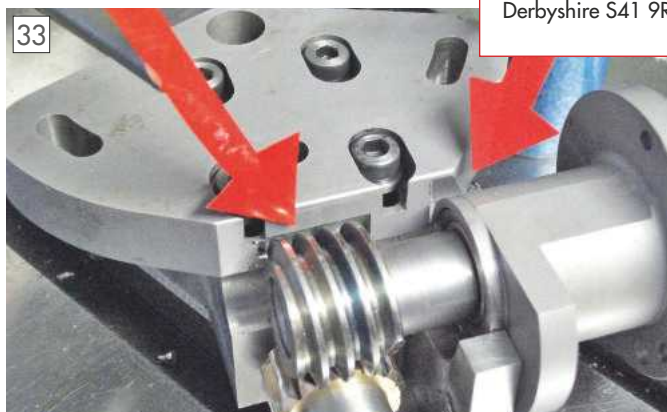
Milling clearance for worm and housing on mounting bracket.

bend when tightened and the gear will run out. The main block is fitted in the vice; the holes are spotted through the wormshaft housing with the gears in mesh. The front hole should be done first and the drill is positioned. 200 inch from the edge, the housing is held in position and the table adjusted to line up with the hole. Drill and tap the hole, secure with a cap head bolt. Drill and tap the other two holes with care as the drill is close to the worm wheel (**photo 30**). The drawing shows the cut away portions of the housing to clear the mounting plate, this is much easier to do after the housing has been secured to the main block.

The position of the cut away portion can be scribed on the housing and machined away and checked by re assembly ensuring that there is enough clearance for the mounting bracket to slide on the key. **Photograph 31** shows milling the clearance on the housing held on a spindle in the dividing head. Some additional material will have to be removed from the mounting plate, this is shown on the drawing and can be done now checking for clearance with the worm when the

plate is at the rearmost position, only remove the minimum amount of metal to obtain clearance. **Photograph 32** shows the mounting plate held in the vice, the vice is mounted on an angle table set over at 27 deg. In the foreground the first plate has been machined. **Photograph 33** shows the assembled plate, the arrows indicating the positions of the cut outs.

To be continued...



Only just enough material is removed on mounting plate as seen arrowed.

REFERENCE

2. Compucut. Synchron gear Hobbing system, Compucut CNC system and CNC machines. 17 Lime Tree Avenue, Tile Hill, Coventry CV4 9EY
www.compucutters.com
3. Hpc gears Unit 14 Foxwood Industrial Park Foxwood Road, Chesterfield, Derbyshire S41 9RN, www.hpcgears.Com

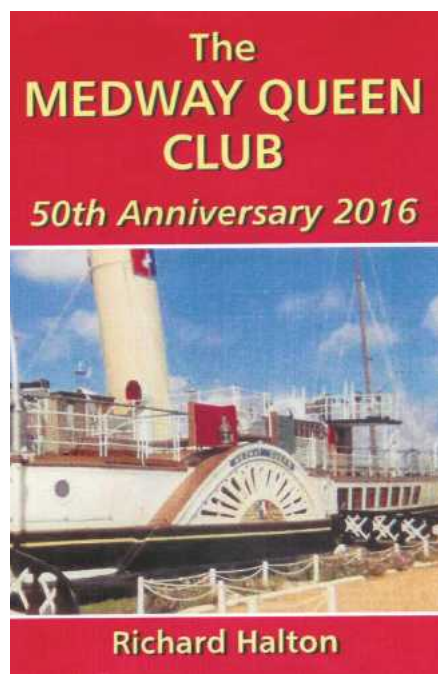
On the **Wire** **NEWS** from the World of Hobby Engineering

The Medway Queen Club

The restored paddle steamer Medway Queen was used as a restaurant and nightclub on the Isle of Wight from 14th May 1966 until late in 1974. It built up an enviable reputation in the 1960s as the place to go and was host to numerous special occasions such as wedding receptions and celebratory parties. The history of the club was closely intertwined with that of the marina and, in the 1970s, with the paddle steamer Ryde Queen which was moored in the next berth.

This year marks the 50th anniversary of the club (14th May), so that's the excuse for the book. This book concentrates on the human side of the story in the words of those who were there. Musicians, staff, management and visitors have all contributed memories and photographs. If you remember the '60s the book is an exercise in nostalgia, if you were there but don't remember much it's a reminder

If instead you are too young to remember then it's educational!



The book has glossy card covers and is packed with photographs, many not previously published. All proceeds will go to the Medway Queen Preservation Society. To get your copy go to www.medwayqueen.co.uk and fill in the order form. Cost of the book is just £7 plus £1-40 for UK P&P. The book is also available at the Medway Queen Visitor Centre on Gillingham Pier.



Parting Glance

Here's a quick update to Stub Mandrel's look at Arc EuroTrade's parting tools in the last issue. Stub now has the tool block holder for the 'blade' NCIH tooling that Ketan from Arc was demonstrating on the forum. It out today, too late for the magazine. He reports:

I've found that the tools are unhappy if you don't make them work hard. At 618 rpm, winding in about 1 1/2 seconds per turn (40 thou), which is about as fast as I can manage, it went through one-inch EN1a (non-pb) like butter and left a mirror finish. Too slow and it makes a howling noise that makes you want to slow down – which is NOT the right thing to do. I would use even more RPM, but it is hard to feed the tool in fast and steadily enough by hand.

The bottom line is, if you have these inserts DON'T pussy-foot about. The photo makes the surface finish look poorer than it really is. Aside from a couple of marks when I started the cut, it feels perfectly smooth! This was done on my mini lathe.



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Tidying Screw Threads

Dear Neil, in response to the tip in issue 241, there may be an even simpler way of preserving the thread whilst shortening a screw.

Screw a nut onto the screw. Put in vice. Cut. Clean up end with file. Unscrewing the nut will push the ends of the thread back into shape.

Jonathon Cary, by email.

Thanks David

Dear Neil, I have just read in the April MEW the moving 'Signing off' letter from David Piddington, and couldn't help feeling a little sad that we will no more have the benefit of his workshop experience. Thank you David, and best wishes for the future.

John Edwards, Brisbane Australia.

John's note sums up many heartfelt expressions of goodwill to David, expressed directly to me and on the forum; I know David greatly appreciates the readership's good wishes – Neil.

Competition Winner

Dear Neil, many thanks for publishing my tip for a pillar mill. I hope it is of value to other readers. I have just received my vouchers from Chester Tools and look forward to adding some money to it to buy a boring head. As a newcomer to model engineering, I am slowly learning and look forward to my monthly magazine. I am lucky in that, as a volunteer at Bolton Steam Museum, there are many others there who are retired engineers and give me tips and help when I get stuck on a problem.

Roland Varley, by email

Backhanded Compliment?

Dear Neil, May I compliment you upon bringing a much fresher outlook to the *Model Engineers' Workshop*. MEW really does complement your sister magazine *Model Engineer*. Which brings me neatly

Close Enough for Jazz

Dear Neil, a recent job to repair the paraffin heater from a yacht required making an adapter from solid brass that had two internal and two external threads all of which were different; the factory original burner being a bit of a bodge having had a pipe fitting welded to it. The replacement

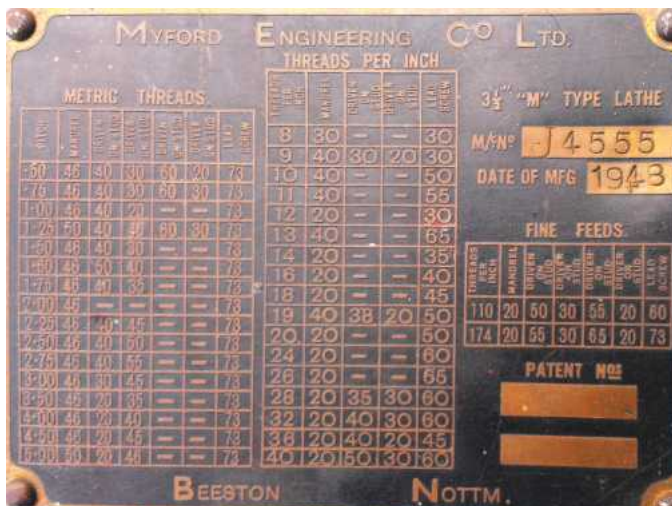
burner for the heater is of the 'Primus' stove style which those of us in the Scouts back in the 60s and 70s may remember for their somewhat temperamental nature requiring a certain amount of caution in order to retain one's eyebrows. These burners have a rather obscure thread being $\frac{1}{16}$ inch by 34 t.p.i. (I found this out from a website devoted to the Primus stove).

After a bit of pondering I realised that 34 t.p.i. is pretty close to 0.75mm (0.7470). A quick look at the change-wheel cover on my trusty Myford M type gave me everything I needed to know to set it up and the change wheel combination based on 46/73 results in a pitch of 0.7502 which I think is good enough for most situations.

I know that this topic comes up on a regular basis, so for the benefit of anyone trying to cut metric threads on an imperial lathe with an 8 t.p.i. leadscrew, I have attached a photo of the change-wheel cover from my lathe.

Regards

David Smith, South Brent



on to the bane of my past professional life: I ran my own jobbing printers for over 40 years and we were forever correcting customers' copy. Words are tools. For instance, one - hopefully - would never use a wood chisel as a turnscrew or indeed a drill as a punch but compliment and complement are frequently transposed to the detriment of the text.

The article introduction for 'Fitting a 4 Jaw Chuck' on page nine shows the word compliment used incorrectly.

It is always easy to criticise another's work and apart from the odd typo both magazines are produced to a very high standard indeed so please don't feel in any slighted by my comment.

Keep up the good work, it is much appreciated

Shaun Trewinnard, by email.

Thank you Shaun – I think! Alas the days of an army of proof readers are long gone, so I can only admonish myself! – Neil.

We would love to hear your comments, questions and feedback about MEW

Write to The Editor, Neil Wyatt, Model Engineers' Workshop, MyTimeMedia Ltd., Enterprise House, Enterprise Way, Edenbridge, Kent TN8 6HF. Alternatively, email: neil.wyatt@mytimemedia.com

Power Feed for a Marlow Milling Machine



Power feed is a popular add-on for larger milling machines. David Shrimpton equips his machine.

My first milling machine was a 'Warco Minor' mill drill, which gave me many years of good service. However, a constant frustration was the inability to raise the head and maintain its position over the work piece. I finally sold this machine and bought one with a knee that could be raised and lowered. The machine I purchased was a second hand Marlow milling machine, which is sturdy, accurate and a pleasure to use, but regrettably a version without a power cross feed. This is something that I subsequently decided to fit.

There are various commercial units available, but none specifically for my machine and I do not have the time or inclination to design and make a custom unit. After much thought and research, I finally settled on one that was intended for a Bridgeport milling machine, accepting that some modifications would be needed to both my machine and the power feed unit. What follows is the method by which I fitted the power feed unit to my particular miller, but it could be easily adapted to a variety of different machines. **Photograph 1** shows the Marlow milling machine with the power feed unit fitted.

New End Plate

Photograph 2 shows the detail at the point where the power feed unit will be fitted, consisting of a handle attached to the end of the feed screw, which runs in a plain bore in the cast iron end plate. There is a division disc on the handle and a pointer providing a mark for reading off values. **Photograph 3** shows the parts of the power feed kit, some of which were



The milling machine showing power feed unit in place.

not used in my particular case. The main unit is on the left, complete with cables for the power supply and the limit switch already wired in. On the right is the end plate casting for attaching the unit to the end of the table, surrounded by the limit switch plungers and brass drive gear. In the centre are various shims, screws and other miscellaneous items. The major difference between my machine and the Bridgeport, for which the kit was intended, was the dimension between the table top and the centre of the feed screw, mine being much smaller. It was clear that the end plate supplied would be of little use, neither matching the fixing holes in my

machine's table or the position of the feed screw. A new one would have to be made.

I was fortunate in this respect to have a piece of $\frac{5}{8}$ inch thick aluminium, which was the thickness of the existing end plate on my machine. This was about the right size and **figure 1** shows the design upon which I decided. It was cut out on the bandsaw and finished with the linisher, with edges and corners radiused where necessary for appearance and safety. The fixing holes needed to be drilled first and were required to be a perfect match to those in the Marlow end plate. This was therefore used as a template and clamped onto the blank. They were drilled directly



The original winding handle assembly as fitted to the machine.

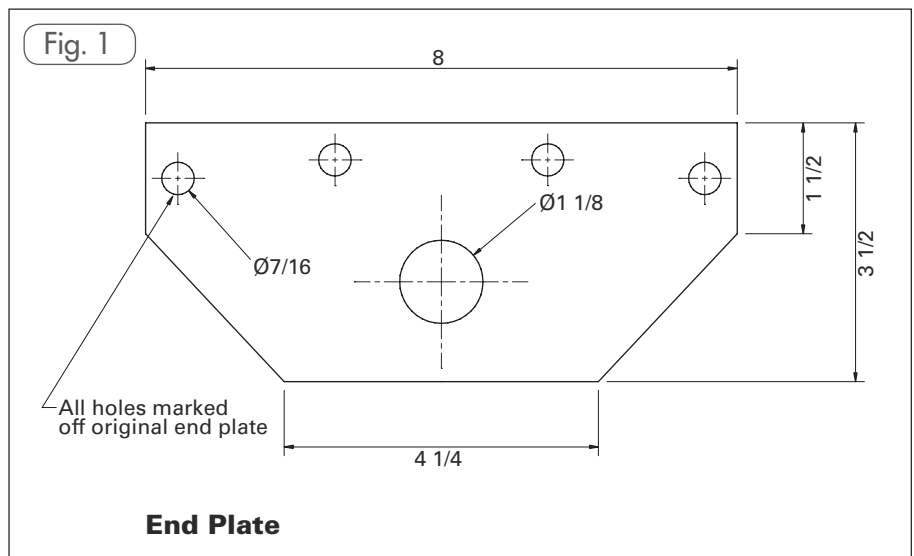


The parts of the power feed unit kit as supplied.



Placing the bush into original end plate to ensure accurate location of the hole for the power feed unit bearing.

through at full size, to ensure accurate positioning. In the case of the hole for the feed screw, as it was quite large, a bush was made to fit snugly inside the existing hole in the end plate. This bush had a small hole in it, which was then drilled through and into the aluminium plate. **Photograph 4** shows this bush being placed into the hole. The end plate was then removed and this hole enlarged in stages, finally with a 1 inch drill in the milling machine. It was then opened out to 1 1/8 inch using a machine reamer I happened to have. This size was not



critical, as it just needed to be of a size that cleared the bush that held the inner ring of the bearing for the feed screw. That bush would be 1 inch diameter.

Power Unit onto the End Plate

The next task was to fit the power unit to the new end plate. If the plate supplied was used the unit would be pushed onto

two roll pins fitted in that plate and then secured with cap screws into two tapped holes. It was a simple matter of replicating the required holes in the new end plate. The supplied plate was clamped over the new one, being held in the correct position by a bush, which fitted snugly in each of the large holes in the two plates. **Photograph 5** shows this, together with the roll pins and tapped holes with the

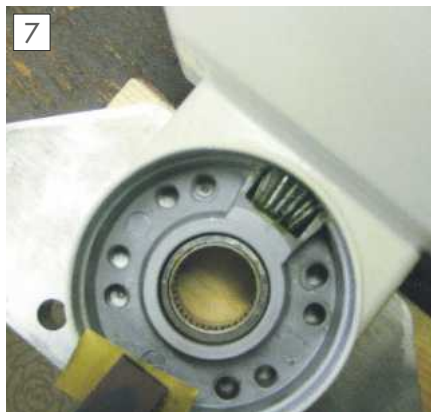


The supplied end plate located over the new plate by means of the bush, thus ensuring the fixing holes are accurately positioned.



Drilling holes for the roll pins, using the original roll pin holes as a template.

bush in the centre. The roll pins were then removed and **photograph 6** shows the new holes for the roll pins being drilled, using the existing roll pin holes as a guide. The roll pins were then fitted in the new plate and the unit was then positioned in place using these pins. I decided to use four screws to attach the unit rather than the two suggested. A transfer punch was used to locate the centre of the holes and the resultant centre marks can be seen in **photograph 7**. The angle of the camera does make some of the punch holes appear to be off centre, although this was not the case. The drive unit was then removed, to avoid swarf entering the space around the gear wheel, and the holes were drilled the correct tapping size, in my case for 1/4 inch BSW screws and finally tapped. I felt the coarser thread of the Whitworth type was preferable in the soft aluminium rather than the finer metric ones supplied. **Photograph 8** shows the unit fitted to the plate, which was in turn fitted to the machine.



The drive unit located on the new end plate with the centre marks visible.

a challenge, as the screw was very long, necessitating removal of the tailstock from the lathe. It was held in the 3 jaw chuck by the small diameter at the handle end, which meant the part to be machined was now adjacent to the chuck. So far so good! The problem was that there was now about one metre sticking out of the chuck. This considerable overhang was dealt with by using two steadies. I attached a fixed steady well along the bed and a travelling steady near the section being machined. **Photograph 9** shows the setup.

There was one final operation required on the feed screw before fitting it back into

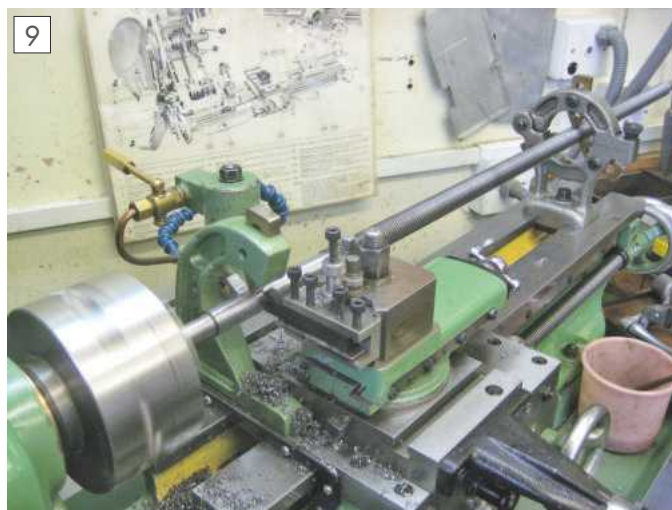
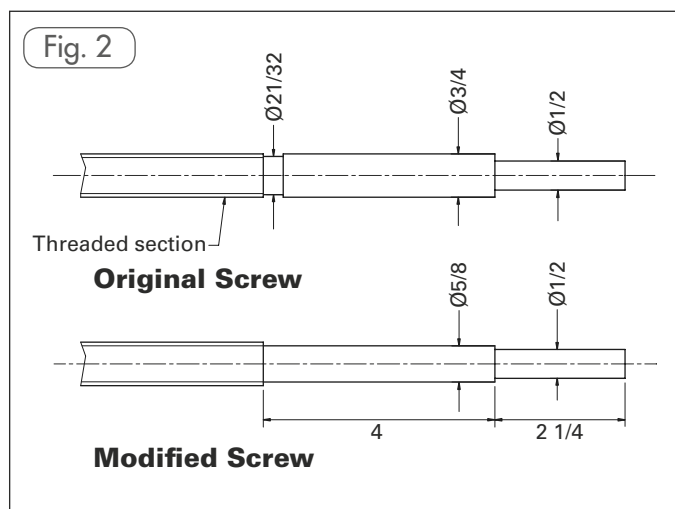


The unit bolted in place on the end of the table, using the original bolts.

the milling machine. A woodruff key was needed to lock the drive gear to the shaft, so this was tackled next. **Photograph 10** shows the keyway being cut on the milling machine and **photo 11** shows the finished shaft. It will be noted that there are two keys. The outer one already existed and is for the handle and the new one is further along. The woodruff key was not supplied because the Bridgeport

Feed Screw

It was now necessary to modify the feed screw. **Figure 2** shows the dimensions of the original screw and the required modification. Essentially the larger 3/4 inch diameter section needed turning down to 5/8 inch diameter, to suit the bore of the gear in the power unit. This proved to be quite



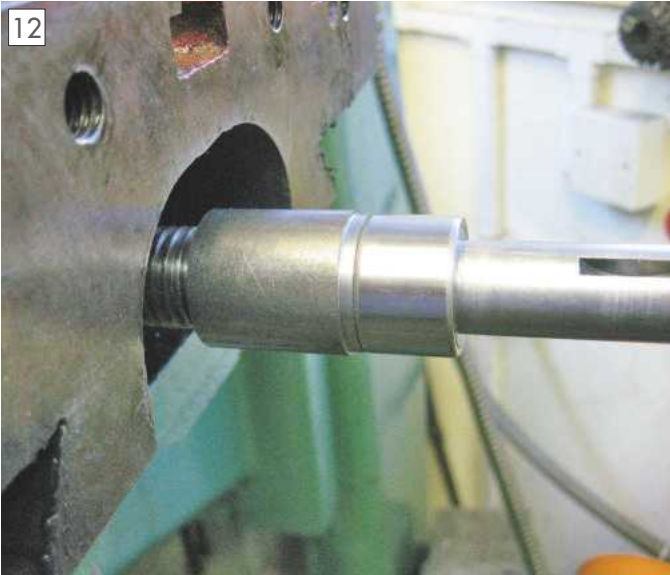
Machining the feed screw, with the two steadies in place.



Machining the woodruff keyway on the milling machine.



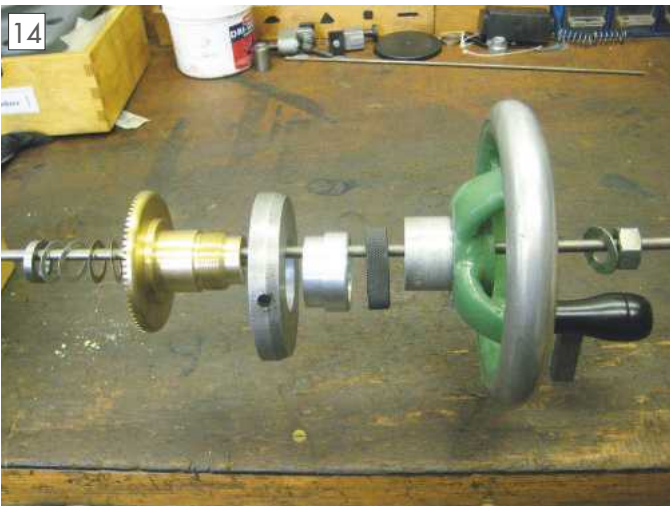
The finished shaft, complete with the two keys and keyways.



The bearing bush in place on the end of the feed screw.



The power feed unit in place, with the bearing seated on its inner ring.



The parts ready to be refitted onto the end of the feed screw comprising the shims, gear wheel, division disc with its bush, securing ring nut, handle, washer and nut.



Parting off the gear. Note the stationary mandrel which supports the end of the gear.

machine appears to use the existing one for both drive gear and handle. I made the key by turning a disc in the lathe of the correct diameter and thickness and filed it to fit. I felt that mild steel would be suitable for it as the load is quite small. The feed screw was then refitted to the machine. The thrust bearings were at the other end of the table, which was an advantage, as there would be no conflict with the power feed unit.

Bearing Bush

Referring back to photo 7 a needle roller bearing can be seen. This supports the feed screw at the drive end. The next item to be dealt with was making a bush to support this bearing. **Photograph 12** shows this bush pushed onto the feed screw right up to the thread. It was just a piece of mild steel, 1 inch diameter, reduced at the end to take the inner ring of the bearing. This is the shiny part on the right hand end of the bush and was a nice push fit onto the shaft, just enough to grip it lightly to prevent it rotating. The main part of the bush was relieved to the left of the bearing ring to ensure it did

not contact the rollers in the bearing. The length was designed to place the inner ring exactly in line with the main part of the bearing when the unit was in position. **Photograph 13** shows the unit in place and the bearing can be seen sitting on its inner ring. The cap screws securing the unit are also clearly visible.

The Main Drive Gear

It was now just a matter of modifying parts as necessary and assembling it all together. **Photograph 14** shows the parts involved. The shims on the left were needed to adjust the large brass gear, next in line, so that it meshed correctly with the final gear in the train of gears driven by the motor. This can be seen in photo 7 just above the bearing. This adjustment was critical and obtained by trial and error. I went for minimal backlash when everything was tightened up. The shims are supplied with the kit, although I made the wider one on the extreme left as it saved a large number of thinner shims. With hindsight my bush for the bearing inner ring could have been slightly longer. I assume that the Bridgeport would not

need this thickness of shims. In fact, if the kit was to be fitted to a Bridgeport machine, an adapter shaft was available, which would fit over the end of the existing feed screw and give the correct profile for the unit to be attached without any modification necessary to the screw. There was no advantage in obtaining that for my machine.

The gear was preloaded by the handle pressing against it, so it was essential that the gear was proud of the larger diameter on the feed screw. The gear was, in fact, much too long and meant that the handle would not fit properly on the shaft. It was therefore necessary to shorten the gear but having in mind the previous mentioned criteria. This was done by parting it off and **photo 15** shows the set up for this operation. The gear was supported in the 3 jaw chuck and on a stationary mandrel in the drill chuck. This meant that as the parting off cutter broke through it contacted the mandrel and everything stayed secure. The gear was then pushed onto the shaft, after putting the woodruff key in place.

To be continued...



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To help you get the best from The Model Engineer Exhibition

These notes are written purely for guidance. Full information is contained in the Competitors' Information booklet which is sent to every entrant as part of the information package. If you have an item and are unsure as to the Class into which it should be entered, leave that section blank and we will take care of it. The Judges have the right to move any competition exhibit into another class if they feel that by doing so its chances of gaining higher marks or a more appropriate award are improved.

If the item is offered as a Loan exhibit please indicate this by writing Loan on the form in the box identifying the Class. Loan models are not judged but carry all other privileges associated with competition entries.

Part built models are particularly welcome in the Loan Section; visitors like to see work in progress, and entry does not preclude the item being entered in competition when completed.

The classes listed below are those associated with mainstream model engineering.

Club exhibits

Where a club is exhibiting, each model should be entered on a separate entry form and clearly identified as a club exhibit by entering Loan/Club in the class section box. This ensures that we have a full record of all models on display during the show and facilitates matters of administration and insurance.

Additional forms

If you do not wish to deface your copy of the magazine we are happy to receive photocopies of the entry form, one for each model. We will be pleased to send out extra forms if required, so if you know of a modeller who is not a reader of one of our magazines but who you think may wish to participate, please advise them to contact our Exhibitions Office, or simply photocopy the entry form for them. The success of the show depends largely on the number of models on display. Your work could well be the stimulus which inspires someone else to start in the hobby. There can be no doubt that this event is our showcase on the world of modelling in all its aspects. Every modelling discipline needs more and more participants, and it is by displaying not only the crème-de-la-crème, but also examples of work of a more achievable standard, that people are encouraged to join into the wonderful world of modelling, in whatever aspect. We look forward to seeing a sample of your work at the show!

Engineering Section

- A1 Hot air engines.
- A2 General engineering models (including stationary and marine engines).
- A3 Internal combustion engines.
- A4 Mechanical propelled road vehicles (including tractors).
- A5 Tools and workshop appliances.
- A6 Horological, scientific and optical apparatus.
- A7 General engineering exhibits – not covered by the above

Railway Section

- B1 Working steam locomotives 1" scale and over.
- B2 Working steam locomotives under 1" scale.
- B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
- B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered steam prototypes.
- B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
- B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
- B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
- B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
- B9 Passenger or goods rolling stock, above 1" scale.
- B10 Passenger or goods rolling stock, under 1" scale.
- B11 Railway buildings and lineside accessories to any recognised model railway scale.
- B12 Tramway vehicles.
- B-K1 Working steam locomotives built from a kit.
- B-K2 Working locomotives other than steam powered. (Any model locomotive in class B-K1 and 2, built from a commercial kit, entered into these classes will not be judged in the medal classes but can receive commended certificates and an award from a trade supplier).

Marine Models

- C1 Working scale models of powered vessels (from any period). Scale 1:1 to 1:48
- C2 Working scale models of powered vessels (from any period). Scale 1:49 to 1:384
- C3 Non-working scale models (from any period). Scale 1:1 to 1:48
- C4 Non-working scale models (from any period). Scale 1:49 to 1:384
- C5 Sailing ships and oared vessels of any period – working.
- C6 Sailing ships and oared vessels of any period – nonworking.
- C7 Non-scale powered functional models including hydroplanes.
- C8 Miniatures. Length of hull not to exceed 15in for 1:32 scale, 12in for 1:25 scale, 10in for 1:16 scale; 9in for 1:8 scale. No limit for smaller scales.
- C9 For any model boat built from a commercial kit. Before acceptance in this class the kit must have been readily available for at least 3 months prior to the opening date of the exhibition and at least 20 kits must have been sold either by mail order or through the retail trade.

Scale Aircraft Section

- D1 Scale radio control flying models
- D2 Scale flying control-line and free flight
- D3 Scale non-flying models, including kit and scratch-built
- D4 Scale flying radio controlled helicopters

Model Horse Drawn Vehicle Section

- G1 Carriages & other sprung vehicles. (Omnibuses, trade vans etc.) Wagons, carts and farm implements. Caravans.

Junior Section

- J1 For any type of model, mechanical or engineering work, by an under 14 year old.
- J2 For any type of model, mechanical or engineering work, by an under 16 year old.
- J3 For any type of model, mechanical or engineering work, by an under 18 year old.

All entries will be judged for standard of craftsmanship, regardless of the modelling discipline, i.e. a boat will not be competing against a military figure. Providing a model attains sufficient marks it will be awarded a gold, silver or bronze medal.

Model Vehicle Section

- K1 Non-working cars, including small commercial vehicles (e.g. Ford Transit) all scales down to 1/42.
- K2 Non-working trucks, articulated tractor and trailer units, plus other large commercial vehicles based on truck-type chassis, all scales down to 1/42.
- K3 Non-working motor bikes, including push bikes, all scales down to 1/42.
- K4 Non-working emergency vehicles, fire, police and ambulance, all scales down to 1/42.
- K5 Non-working vehicles including small commercial vehicles (e.g. Ford Transit,) scale from 1/43 or smaller.
- K6 Any available body shells including Concours, in any scale or material, to be judged on appearance only.
- K7 Functional model cars/vehicles which must be able to move under their own power of any type. Can be either free-running, tethered, radio controlled or slot car, but must represent a reasonable full size replica.

DUKE OF EDINBURGH CHALLENGE TROPHY Rules and Particulars

- 1. The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.
- 2. The trophy remains at all times the property of MyTimeMedia Ltd.

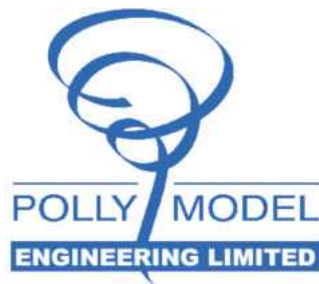
- 3. The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of MyTimeMedia Ltd., in his/her possession until required for renovation and display at the following Model Engineer Exhibition.
- 4. Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by MyTimeMedia Ltd
- 5. A model may be entered more than one year but if the model wins it will be permanently retired.
- 6. Entry shall be free. Competitors must state on the entry form:
 - (a) That exhibits are their own bona-fide work.
 - (b) Any parts or kits which were purchased or were not the outcome of their own work.
 - (c) That the model has not been structurally altered since winning the qualifying award.
- 7. MyTimeMedia Ltd. may at their sole discretion vary the conditions of entry without notice.

COMPETITION RULES

- 1. Each entry shall be made separately on the official form and every question must be answered.
 - 2. Competition Application Forms must be received by the stated closing date. LATE ENTRIES WILL ONLY BE ACCEPTED AT THE DISCRETION OF THE ORGANISERS.
 - 3. Competitors must state on their form the following:
 - (a) Insured value of their model.
 - (b) The exhibit is their own work and property.
 - (c) Parts or kits purchased.
 - (d) Parts not the outcome of their own work.
 - (e) The origin of the design, in the case of a model that has been made by more than one person.
- NOTE: Entry in the competition can only be made by one of the parties and only their work will be eligible for judging.
- 4. Models will be insured for the period during which they are in the custody of MyTimeMedia Ltd.
 - 5. A junior shall mean a person under 18 years of age on December 31st in the year of entry.
 - 6. Past Gold and Silver medal award winners at any of the exhibitions promoted by MyTimeMedia Ltd. are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy'.
 - 7. Past winners at any of the exhibitions promoted by MyTimeMedia Ltd. will not be eligible for re-entry into the competition unless the exhibit has been substantially altered in any way.
 - 8. MyTimeMedia Ltd reserve the right to:
 - (a) Transfer an entry to a more appropriate class.
 - (b) Describe and photograph any models entered for competition or display and to make use of any such photographs and descriptions in any way they may think fit.
 - (c) Refuse any entry or model on arrival at the exhibition and shall not be required to furnish a reason for doing so.
 - 9. Entry into the competition sections is not permitted by:
 - (a) Professional model makers.
 - (b) Anyone who has a financial interest in the direct supply of materials and designs to the public.
- NOTE: If unsure, please contact the Competition organisers prior to the show.
- 10. The judges' decision is final. All awards are at the discretion of the judges and no correspondence regarding the awards will be entered into.
 - 11. Exhibitors must present their model receipt for all models collected at the end of the exhibition and sign as retrieved.
 - 12. The signed release for each model must be presented to security staff when leaving the exhibition complex with display model(s) after the close of the exhibition.

IMPORTANT NOTE: PLEASE MAKE COPIES, INCLUDING PHOTOGRAPHS, OF ALL INFORMATION RELATING TO YOUR MODEL, AS MYTIMEMEDIA LTD WILL NOT ACCEPT LIABILITY FOR ANY LOSS.

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A Versatile Grinder from Scrap



Mark Noel finds inspiration at the tip and Creates the MincerMultiGrind from a redundant food processor.

I had been waiting weeks for a reason to visit our local amenity site but the loft was already cleared of rubbish and there simply was no need to go. Then at last my neighbour provided an excuse by offering some empty paint tins and a bag of hedge clippings and, yippee, I was soon away with his debris in the back of my car. It was a Sunday afternoon and the place was busy with people depositing bicycles, fridges, TVs and printers, etc., having 'upgraded' to the latest widget, completely oblivious to the impact of their consumption on our planet's finite resources. Over the year I had already salvaged and dismantled at least a dozen printers, marvelling at the (disposable) technology inside, while recovering stepper and servo motors, laser engines, toothed belts, encoders and precision shafting. Yet still more had arrived, only to await their fate in the crusher. The kitchen utensils recycling bay had shelves laden with enough china to furnish an hotel, while next door you could collect sufficient books and CDs to fill a village library. But suddenly I spotted something that ignited my wombling gene - a grubby Morphy Richards food processor, so caked in gunge that it seemed fit to trigger a pandemic. Ignoring threats to my wellbeing, the machine was bundled into



The completed MincerMultiGrind, with Proxxon flexible shaft attached using the high speed wheel collet fixture.

the car, together with another printer-scanner-copier (why not?) and an old hairdryer for good measure. You can see from my author photograph that the latter has been put to good use! Back at Mission Control I dried and permed my hair with this new thermodynamic acquisition (it had been raining at the tip) and then set about examining the food processor with

a view to 'repurposing' this machine into a novel workshop tool (**photo 1**).

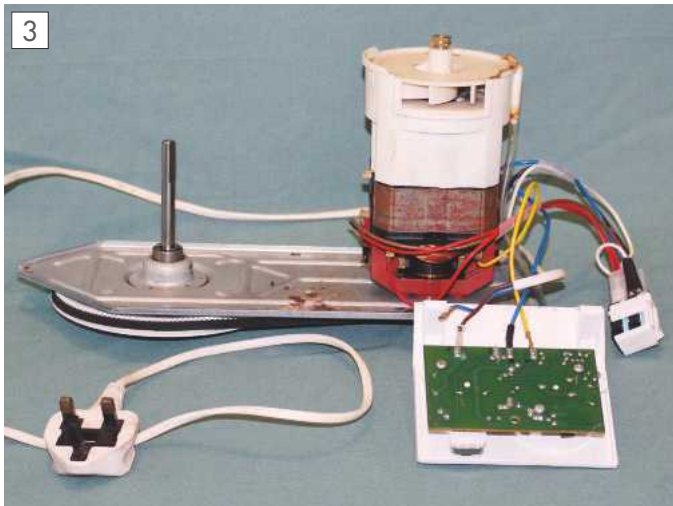
What follows is a description of the project, the details of which should apply to similar food processors from Morphy Richards and other manufacturers. Most of the units I have seen contain a 500W variable speed motor driving two sets of cutting blades: one spinning at motor-revs inside a jug for making soups, etc; the other geared to a lower speed inside a larger jug designed for mashing vegetables. Both jugs are removable, with bearings and seals sufficient for the purpose, but being plastic these are fragile and not high precision. Both jugs are usually made of clear acrylic and liable to shatter, for example when the high speed unit is used to mince ice or nuts. This explains why my processor and others similar arrive at the amenity site with this component missing (**photo 2**).



The 1998 Morphy Richards food processor as recovered from the amenity site. Note that the high speed blender jug is missing. The surviving low speed jug was used as the basis for a wet grinding vessel.

Planning the project

Before connecting the unit to the mains I made a rigorous inspection of the internals to check for electrical safety, wear and tear (**photo 3**). This showed that the motor turned freely, with negligible erosion of the carbon brushes, toothed belt and pulleys, suggesting that the missing jug had broken early in the machine's life. Like many domestic appliances no connection to earth is used, the isolation of live parts relying instead on careful internal design and wires routed away from the plastic



Electromechanical internals of the original food processor. A 500W AC motor by Simtech drives the high speed spindle directly and is geared 8:1 via a toothed belt and pulley to the low speed spindle. Motor speed controller is in the foreground.

casing. The motor control board was removed and checked for corrosion, loose connectors or fried components. Then, with everything seemingly in order, the machine was re-assembled and connected to a source of pressurised electrons. Switching on ... nothing happened, until I realised that both jugs include tabs which depress microswitches that feed power to the motor. Pressing one of these tabs with a screwdriver brought the machine to life with a vibration-free hum from the motor, belt and spindles, and with the speed control working perfectly. I could now chop carrots!

Using a handheld laser tachometer, I found that the direct drive shaft had a maximum speed of 4100 r.p.m., with the belt-gear, low speed shaft reaching 540 r.p.m. It struck me that the torque and speed of both spindles were ideal for tool grinding, provided that the discs were properly supported on precision spindles. Affordable diamond grinding wheels are now available from various suppliers, and perfectly suited to the speeds available, while inexpensive shielded ball bearings can sustain well in excess of 4000 r.p.m. My design therefore envisaged mounting an 80mm diameter fine grit wheel on a ball bearing spindle in place of the high speed blender, with a coarser 125mm coarse grit wheel mounted on a similar spindle inside the surviving acrylic jug. The high speed wheel would be air-cooled with dust extraction via my workshop Henry vacuum, while the slow wheel would have provision for wet grinding, with waste water collecting in the removable bowl. Below the food processor's controls is a flat panel printed with menu suggestions and this area provides a perfect site for mounting a tachometer. Some changes to the speed controller and wiring would be needed to remove the 'pulse' facility of the original machine and to make space beside this circuit board for the tachometer module. Speed sensing of each spindle would be achieved using a Hall effect sensor and magnet, and somehow room would have to be found to include a power supply. Careful measurements of the machine's internals showed that this should all be possible and the tip had even provided a

9V phone charger to power the tachometer.

Rubber-shielded ball bearings and two grinding wheels were ordered from Arc Euro Trade and a 0-9999 r.p.m digital tachometer purchased from a Hong Kong supplier via eBay: this is the same unit which I have successfully installed in my milling machine and other projects. Full details of these parts are listed at the end of this article. The phone charger is a typical miniature wall brick type with regulated output, many of which I have collected over the years in case they might come in handy. With a bit of juggling it might just have been possible to squeeze it inside the food processor alongside the motor. However, this would have filled the space needed to route wires from the Hall sensors, tachometer and motor windings. Consequently, it was decided to fit the charger into the rear of the case where it protrudes as a 'power bulge' that hints at the vitality of this machine!

Making the spindles

After looking at the space available I decided to design the spindles around Arc Euro Trade's 16003-2RS shielded ball bearings, which are 35mm in diameter, with a 17mm bore and rated to a maximum of 7000 r.p.m. These economy sealed bearings are not high precision types and therefore feature a small amount of axial and radial free play. Therefore, a spindle fitted with only one ball bearing cannot support a grinding wheel with stable runout, possibly leading to wobble when coming under load. The solution is to mount the wheel on a shaft supported by a pair of bearings spaced sufficiently far apart that the maximum runout can be held within limits set by the wheel's manufacturer (typically 0.02mm or 0.001 inch). If this can be achieved then the entire periphery of the spinning wheel will come to bear on the tool being sharpened, with negligible chatter during the grinding process.

For the spindle to perform correctly it is essential that the free play in the bearings is constrained by pre-loading the balls into their races. In other applications this is often achieved by incorporating wave



Components of the high speed spindle (the low speed is similar). When assembled, compression of the O-ring pre-loads the ball bearings, minimising free play of the shaft.

washers or coil springs into the spindle design, with compression of the compliant part being set during manufacture. Restorers of classic motorcycle engines will be familiar with the method of pre-loading crankshaft ball bearings by incorporating shims that ensure a calibrated pressure when the crankcase halves are bolted together.

In my spindle design the bearings are housed in a 50mm diameter casing, spaced 8mm apart, supporting a 17mm diameter brass shaft with a flange at one end. Provision for pre-load is provided by a nitrile O-ring on the shaft between the lower bearing and the flange. Screwing the grinding wheel carrier onto the other end of the shaft compresses this O-ring by about 0.2mm, virtually eliminating bearing free play (**photo 4**). Incidentally, a useful tip for cleaning out blind threaded holes, as in the spindle casing, is to use interdental brushes which are available in a range of sizes. Larger tapped holes can be cleaned using mascara brushes which you can buy next time you visit the cosmetics counter (**photo 5**).

Domestic food processors and blenders all use a nylon 'cog' that engages with the blade-drive at the base of the removable jug. This cog is deliberately chamfered and compliant to accommodate misalignment between the drive and



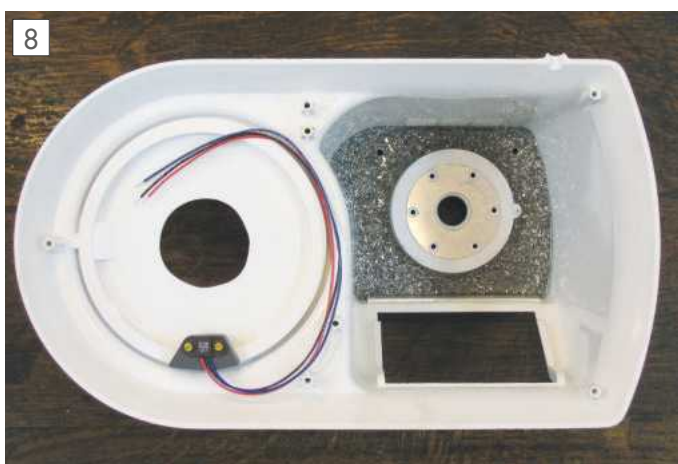
Cleaning blind threaded holes in the spindle casing using an interdental brush. For larger tapped holes a mascara brush comes in handy.



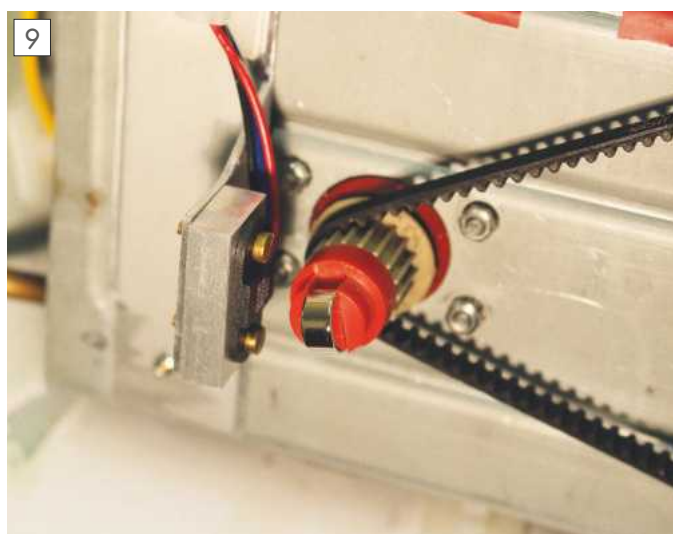
Close-up of the components for coupling drive from the motor to the shaft of the high speed spindle. This is based on an 8mm socket screw and matching ball-ended Allen key.



A stiff mixture of Gedeo epoxy casting resin and aluminium powder made a sturdy filler for strengthening the machine body.



Interior of the machine casing showing epoxy-powder filling and aluminium disc for strengthening the casing around the high speed spindle mounting. The black Hall sensor for measuring rotation of the low speed spindle has been attached to the body of the machine.



Hall sensor and magnet used to measure the speed of the motor shaft, i.e. the high speed spindle.

driven spindles, and to absorb torque pulses in the food being scrambled. Our modified design must also allow for misalignment between spindles, since the food processor's plastic chassis is not perfectly rigid. However, absorption of torque pulses will not be an issue because grinding of a lathe tool will impose a steadier load. The solution I adopted was to design a coupling that involves fitting an 8mm ball-ended Allen key to the end of both driving shafts (**photo 6**). Each key engages with a corresponding 8mm hex socket screw in the end of each spindle shaft. The result is a robust all-metal drive that permits a degree of axial and rotational misalignment, and which does not chatter when the machine is running. The transparent 3D model in **fig. 1** shows the internals of the final design which could easily be scaled and adapted for other machine conversions.

Mounting the spindles

Both spindles are mounted on aluminium discs that form flanges for mounting in the low-speed jug and in the recess above the motor where the blender jug was once installed. A 3mm thick sheet of scrap aluminium plate salvaged from a

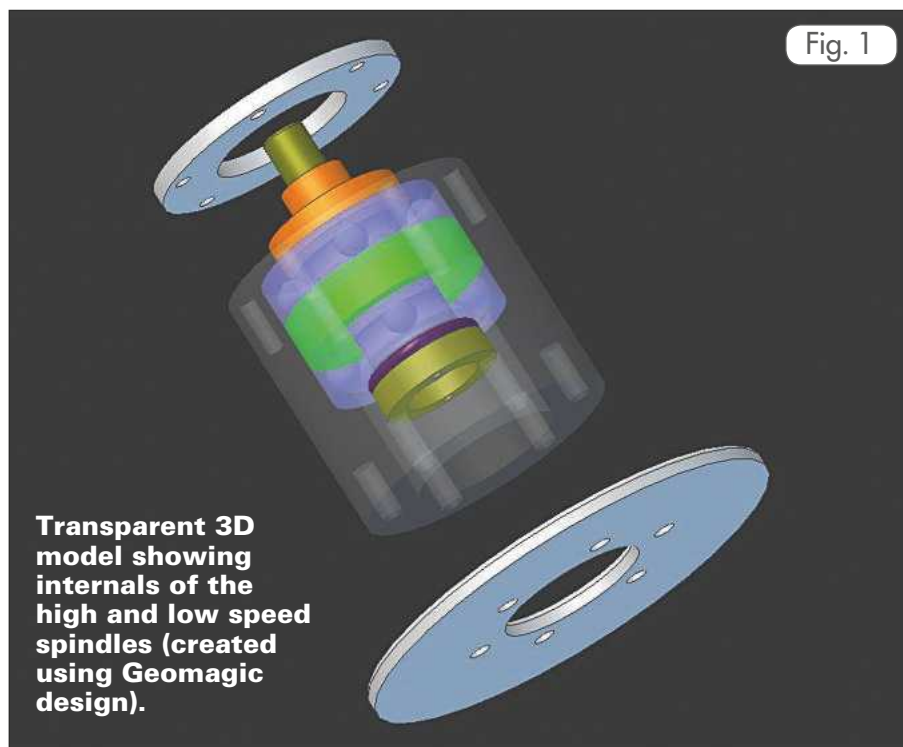
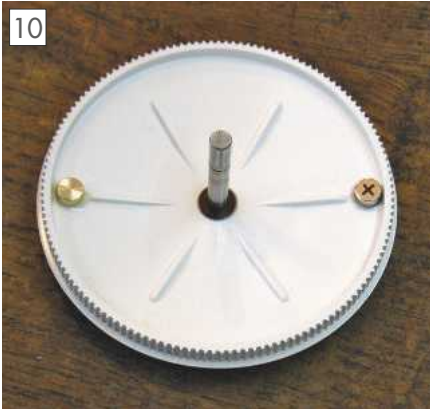


Fig. 1

Transparent 3D model showing internals of the high and low speed spindles (created using Geomagic design).



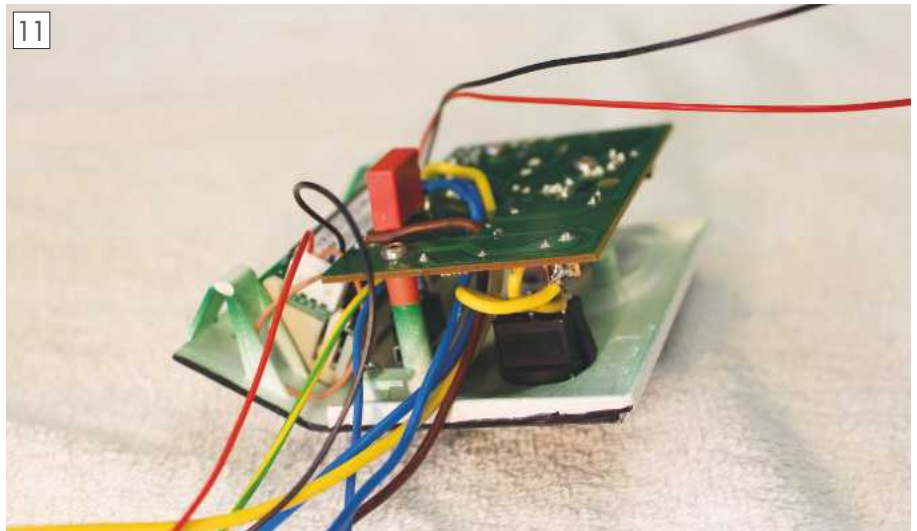
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Topside of the low speed pulley showing the rare earth magnet used for r.p.m. sensing and the brass counterweight.

laboratory instrument was used to make the low-speed spindle flange and this was fixed into the base of the jug with M3 screws passing into another plate beneath, thus adding strength and weight to the otherwise weak acrylic. Several coats of nail varnish were applied to the screw and spindle-flange joints to achieve a water tight seal. Finally, the flange-jug annular gap was sealed by running Gedeco crystal resin into the space using a syringe. This wonder compound is water-clear, very fluid, sets hard in 48 hours, and is mainly used for casting objects into paper weights.

A 2mm thick disc of aluminium was turned to make a flange for the base of the high speed spindle, with an array of six holes for M3 screws to mount onto the food processor's casing. However, the ABS moulding is only 2.5mm thick at this point and obviously too weak to provide a stable foundation. The solution was to cast a 15mm thick layer of Gedeco resin mixed with aluminium powder collected from my bandsaw into the plastic casing (**photos 7 & 8**). For added strength a 2.5mm thick disc was glued onto the underside of the face where the spindle was to be mounted. These modifications created a very sturdy foundation on which to bolt the spindle.

Adding the tachometer

I have incorporated a tachometer readout in several other projects, most recently when making improvements to my Myford VMB milling machine. Inexpensive digital tachometers are available from eBay, most being supplied with a matching Hall effect sensor and magnet, but in all cases these sensors are too bulky to fit



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Tachometer module and motor speed controller fitted onto the front panel. The controller board has had to be moved outwards by 10mm by adding the red pillars.

inside the current machine. Therefore, I sourced a module from another retailer that measures 0-9999 r.p.m., supplied without sensor, providing more scope for a custom solution.

Hall sensors are responsive to magnetic fields and are available in either 'analogue' (i.e. proportional output) or 'switch' (i.e. ON/OFF) versions. For detecting shaft rotation, we require a switch-type sensor, with triggering by a revolving magnet. The MincerMultiGrind incorporates two Hall sensors to detect the speed of either spindle, with selection via a switch on the front panel that connects to the tachometer input. Rotation of the high speed spindle is detected by a Hall sensor adjacent to a 10mm magnet mounted on an extension of the motor shaft (**photo 9**). This sensor is triggered by the alternating field caused by passage of the magnet's north and south poles. Hall sensors must always be oriented correctly with respect to the polarity of the changing field, i.e. either rising positive or rising negative with respect to the sensor's face. However, in this configuration it is not necessary to consider the sensor's orientation since the field alternates through both polarity extremes.

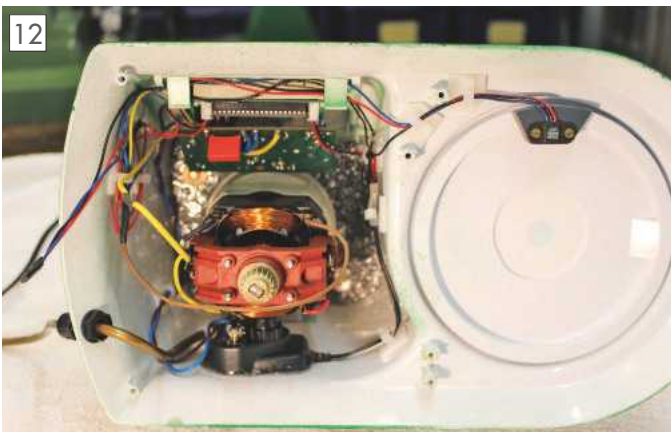
Detection of the low speed belt pulley is via a similar Hall sensor glued to the machine casing and a magnet glued on the rim of the pulley (**photos 8 & 10**). A brass disc of similar weight was glued diametrically opposite as a counterbalance

to prevent vibration. In this configuration it was important to align the magnet with the appropriate pole facing the sensor to ensure triggering at each rotation: the relevant pole was found and marked following a simple bench test involving the sensor, a power supply and voltmeter.

In order to accommodate the tachometer in the menu panel it was necessary to reroute wires from the motor control board and to move it back 10mm by adding pillars to the casing mounting points. Following these modifications, the electronic assemblies could just be squeezed alongside the motor (**photos 11 & 12**). Finally, wiring was fed from the integrated mobile phone charger to the tachometer and a switch added to the mains supply.

Dust extractor and water cooling units

Visitors to my workshop will know that I have a dust obsession, where even a single pollen grain is fervently hunted down! This may be a slight exaggeration but we all appreciate that grinding dust is the enemy of precision machine tools and efficient dust extraction systems are beneficial if they can be incorporated. With this in mind, dust from the high speed wheel is collected by a simple slotted tube made from the centre of an old fax paper roll, which happens to be a perfect fit to the hose of my Henry vacuum cleaner (**photo 13**). This tube is mounted on



13
Dust extractor module for the high speed spindle, made from the centre tube of a fax paper roll.

The completed electrical installation, showing the mobile phone power supply, motor controller and tachometer, all squeezed in beside the drive motor.

14



Close-up of the MagnaDrip control valve on the guinea pig water bottle. A rare earth magnet slides up and down the exit tube, positioning the steel ball that controls the flow.



15



An aquarium air valve is fitted to the top of the water bottle to control release of the vacuum, thus adding another means of regulating the flow. This valve is enclosed by a plastic radiator cap.

16



Tool rest bar in the lower position for tool sharpening on the high speed wheel.

pillars secured to the machine body by threaded inserts heat-sunk through the ABS plastic into the epoxy-powder matrix described earlier. I am currently working on a vortex-molecular sieve which will extract diamond dust from the air stream, melt it using waste heat from the motor, and then deposit nuggets of gem-quality stones in a tray at the base of the machine. You can follow development of this amazing technology on the MEW Forum.

In a former life I made use of a geological workshop where precision thin sections of rocks were prepared by wet grinding using emery slurry on a steel turntable. A minimal water supply makes a dramatic difference to the final result by clearing debris and cooling the petrological sample. This experience inspired the wet grinding facility in my machine, the aim being to enhance the finish of lathe tools and drills I will be sharpening. Construction of the removable, sealed jug incorporating the low-speed spindle has made this possible.

I pondered various schemes for providing a minimal, controllable water supply, including miniature peristaltic, diaphragm, Archimedean and swash plate pumps. I leave others to explore these techno-options but wisdom prevailed over

fantasy, and instead a simple gravity drip feed was chosen based on a recycled guinea pig feeder bottle (photo 1). In use, the bottle is filled and then hung inverted on the cage door (by a human), whereupon juggling the ball bearing in the spout (by a guinea pig) releases the fluid and vacuum inside the bottle. To regulate the flow precisely I collaborated with Patch to produce a design in which the ball valve opening is set by a magnet sliding along the metal spout. **Photograph 14** shows this revolutionary *MagnaDrip* system in close-up, with the ball valve held part-open by the magnet-slide unit. A second fine control of the water flow is provided by a needle valve fitted to the top of the bottle: this was once part of an aquarium air supply and is enclosed in a cover made from an old radiator valve cap (**photo 15**). In practice a flow of 1-2 drips per second onto the wheel is optimal for wet grinding, with the rate being adjusted using the *MagnaDrip* and *VacuBleed* controls. Alongside the diamond recycling system mentioned earlier, a future MincerMultiGrind *Pro* machine will use solenoid valves, flow sensors and a neural-network algorithm to automatically control the water drip rate. Another reason to visit the forum!

Tool rests and the flexishaft coupling

The MincerMultiGrind is intended mainly for sharpening lathe tools and perhaps drills, these being manipulated by hand and supported on suitable tool rests. For the time being a tool rest for the wet grinding wheel has been created simply by shaping the bowl to form a flat lip protected with a rubber edging strip. This lip is formed at a height about 3mm above the periphery of the wheel to ensure that any water flung off is retained inside the bowl. If experience finds that this arrangement is too limited then a revised rest will be made that allows for differing tool heights and/or angles, while somehow still capturing water leaving the wheel.

An adjustable tool rest for the high speed wheel was constructed using a recycled retort clamp and two lengths of ½ inch aluminium round bar. One piece was fitted to a 25mm flange and screwed to the top of the mixer casing, using a deep threaded M4 insert hot-pressed into the epoxy-powder fill that had been cast inside. This pillar provides a firm support for the cross bar that can be clamped horizontally at any angle or height to provide the tool rest (**photo 16**).



17
Tool rest bar in the upper position with a retort clamp for holding the Proxxon Flexishaft body. A Permagrit file collet fitted to the wheel nut provides drive to the shaft.

Some readers will already be aware that a flexible drive shaft from an electric drill is sometimes handy for grinding, polishing or carving in confined spaces, since the light hand piece is easier to manipulate. A facility for driving a Proxxon Flexishaft is incorporated in my machine's design, by using an additional retort clamp and a removable collet fixture (**photo 17**): the cross bar tool rest is raised and rotated, and a second retort clamp attached to hold the Flexishaft body. The 3mm diameter driving spigot at the end of the shaft is held in the collet that screws onto the grinding wheel securing nut, as seen in the photograph. By jiggling the pair of clamps it is easy to align the Flexishaft with the axis of the grinding wheel.

I discovered that the 3mm brass collet moulded into a Permagrit file handle provided a shortcut to making the Flexishaft adapter. The plastic handle was simply cut away and the brass component turned back and soldered to a length of 18mm AF brass stock, with a 2BA stud extension that screws into the high speed shaft. The tricky bit was ensuring concentricity between these three components such that there would be minimal runout (and thus strain) of the Flexishaft spigot when the grinding wheel was turning.



18
Major components used in converting the Morphy Richards food processor into the MincerMultiGrind.

Conclusion

The major components used in converting the Morphy Richards food processor are shown in **photo 18**, with the casing painted Myford Green. Developing the MincerMultiGrind has been a most satisfying adventure - seeing a grubby kitchen appliance gain a new life as a valuable workshop tool, instead of being

crushed to oblivion in the depths of a landfill. Since completing this project I have acquired yet another Morphy Richards machine - one with only a single spindle and mincing jug, but with a fancy keyboard control and more extensive menu suggestions! In perfect working order, it awaits a new purpose in my workshop: all ideas on a postcard please! ■

RESOURCES

Laser tachometer: www.cpc.co.uk Part No. IN05250
Henry workshop vacuum: www.numatic.co.uk Part No. HVR200-12
Ball bearing, 17x35x8mm: www.arceurotrade.co.uk Part No. 160032RS
Grinding wheels: www.arceurotrade.co.uk Part numbers 070-060-0110 and 070-060-01500
Gedeo crystal resin: www.modelshop.co.uk Part No. CP00016
Geomagic Design software: www.mintronics.co.uk
Tachometer module: www.eBay.co.uk
Search for 'Red LED panel digital frequency speed revolution meter'
Hall sensor & magnet: www.rapidonline.com Sensor Part No. 50-0365.
Magnet Part No. 67-1105
Proxxon Flexishaft: www.amazon.co.uk and several other suppliers
Permagrit file handle: www.permagrit.com
Aerosol plastic paint similar to Myford Green: Valspar Hunter Green 10608 available from B&Q.
Stainless steel fasteners: www.westfieldfasteners.co.uk
Aluminium & brass stock: www.m-machine-metals.co.uk

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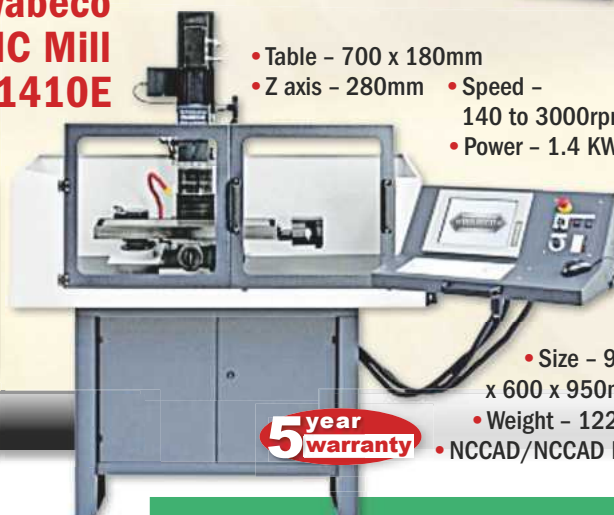
- Centre Distance - 350mm
- Centre Height - 100mm
- Speed - 30 to 2300rpm
- Power - 1.4 KW
- Size - 860 x 400 x 380mm
- Weight - 71kg

**5 year
warranty**



Wabeco CNC Mill CC-F1410E

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- Z axis - 280mm
- Speed - 140 to 3000rpm
- Power - 1.4 KW



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An Improved Single to Three Phase Converter

Frank Brown achieves smoother running with his three-phase converter.

I bought a second hand milling machine with a single to three phase converter with it. The phase converter was faulty (the start contactor was seized) and after replacing it, the machine was put into service. My single to three phase converter consisted of the following:

1. A transformer to step the incoming 230 V to 440V, this is an auto-transformer, that is to say it has one winding, with a tap at 230V and another at 440V. with these transformers there is NO isolation from the mains so ALL the wiring may be considered to be potentially dangerous!
2. To start the motor a 150 Volt winding was switched in via a large (50 uF) capacitor with a contactor, with a voltage detecting relay to switch the winding out when the motor started.
3. The virtual phase was fed via a capacitor selectable (10,15,25 uF) by a front panel switch.

The motor used with the phase converter, burnt out after about 50 Hours running, so after having it rewound, the three phase converter was viewed with great suspicion. Whilst looking on the web for any references to how it may work, I came across an article, ref. 1, which used two capacitors to achieve the phase shift, so I decided to get out my multimeter and try to compare the two different circuits (fig 1).

As supplied my converter only had C1 and did not have C2 fitted. I first tried various values for C1 (bearing in mind that the capacitors must be proper motor types - unpolarised and of suitable voltage rating). Please do not try this unless you have experience of working safely at the high voltages involved. See **Table 1**. Particularly unbalanced phases are marked with an 'X'.

From the results, it becomes obvious, that there is no single value of C1 will make all the phase to phase voltages the same, like wise the phase currents are widely unbalanced. As an experiment I now used a 3 uF capacitor for C2, my results are shown in **Table 2**.

Having only a small number of capacitors, I decided that 15 uF for C1 was the best fit, so I then tried some different values for C2. See **Table 3**.

So I found that with my motor, a single capacitor method of generating the virtual phase is not very good, leading to a large current imbalance, adding the second capacitor significantly improves the current balance. 15uF for C1 and 10uF for C2 were certainly much better than any single capacitor setup. I suppose with

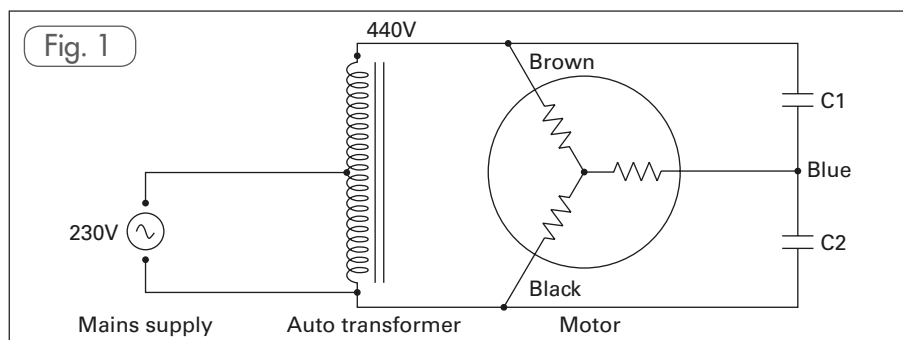


Table 1

C1 uF	Br/Bk Volts	Br/Bl Volts	Bk/Bl Volts	Bl Amps	Bk Amps	Br Amps
10	439	356 X	418	1.2	3.6	2.4
15	439	387 X	448	2.1	3.7	2.4
18	435	403 X	466			
25	440	440	490 X			

Table 2

C1 uF	Br/Bk Volts	Br/Bl Volts	Bk/Bl Volts	Bl Amps	Bk Amps	Br Amps
10	437	375 X	415			
15	440	406 X	448	2.4	3.5	2.4
25	440	446	491 X			

Table 3

C2 uF	Br/Bk Volts	Br/Bl Volts	Bk/Bl Volts	Bl Amps	Bk Amps	Br Amps
6.6	438	420 X	447	2.6	3.3	2.6
10	440	448	442	2.4	2.1	2.6

Table 4

C1 uF	C2 uF	Br/Bk Volts	Br/Bl Volts	Bk/Bl Volts	Bl Amps	Bk Amps	Br Amps
15	0	440	473	482 X	1.9	0.3	0.6
15	10	440	515	115 X	1	0.8	0.2
10	0	444	440	460 X	0.6	0.5	0.4
10	3	444	460	460 X	0.6	0.5	0.4
7	3	440	442	442	0.5	0.6	.5

further experimentation a perfect balance could be achieved.

Note that balancing on the current is more sensitive than balancing on the voltage.

The motor I used was a Dahlander for two speeds (2.2 / 3 kW rating) all the above results were in the 4 pole mode and running off load. I thought I would have a go at the same experiment with the motor in 2 pole mode. See **Table 4**.

Well, It would seem that the optimum capacitors are very different! The running currents are also very different. While I do not know exactly what is going on with the motor, the spirit of optimising the two capacitors does seem to bring better phase balance.

Naturally, probing around in a high-voltage system like this requires considerable care – if you are not experienced in dealing with such voltages, find a friend who is. I would like to thank Rick Christopherson for the incentive to use the two capacitors. ■

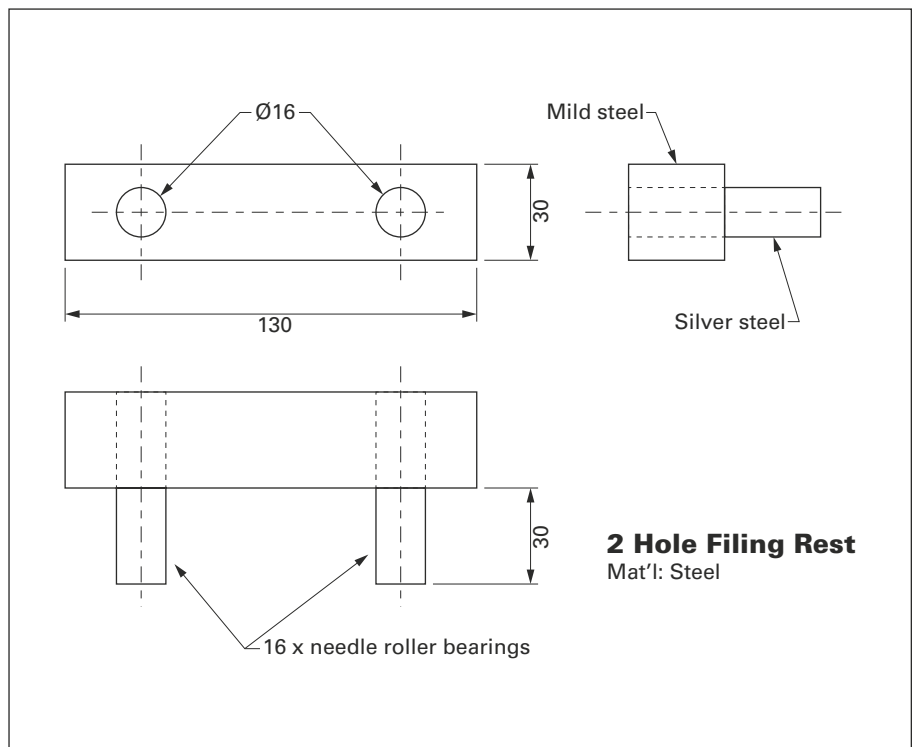
REFERENCES

1. www.motionnet.com/cgi-bin/search.exe?a=cat&no=4215 then the article by Rick Christopherson – Note this is an American article so voltages are different.
2. www.home.att.net/~waterfront-woods/Articles/phaseconverter.htm direct

The Two Hole Filing rest

Robert Bailey introduces a simple accessory.

The two-hole filing rest was quickly constructed to fill an instant need to file the 8 sided flats on a cylinder gland nut for a Stothart and Pitt engine. I had looked at various filing rest devices and kits available on the market, but they all looked quite complicated and time consuming to manufacture. Most of these rests require an angled slot to raise and lower the filing platform with its own leadscrew and graduated wheel for adjusting the cuts accurately.



The device about to be described incorporates the existing vertical slide that has its own graduated dial with it, **photo 1**, (except the one in the photo does not!) The design uses ready to hand bar stock that is available to most workshops and I used inch square bright MS and 16mm silver steel, the needle roller bearings were also to hand. So Two holes were dreamed (drilled and reamed),

the silver steel Loctited in place and the bearings slid on. The device was then put in the vice and the nut then filed to shape.

The device can be modified with 2 more holes 'drapped' (drilled and tapped) to keep the bearings from sliding about too much, but I found it worked ok without. When in use I found the rather bulky vertical slide did not get in the way of my hand as I am right handed (**photo 2**). One

can also put different sleeves on the bearings - with a shoulder for instance, or other shapes if required. The drawing and photos should be self explanatory to make this quite and easy permanent addition to the workshop inventory. I have not seen this tool before in print anywhere and it is not copywrited or patented, at least not by me so please emulate at will. ■



The filing rest is very simple.



Filing rest in use.

CNC without Numbers



Glenn Bunt introduces conversational programming.

CNC programming in G code – Argh! There I’ve said it! It’s been discussed many times on the Model Engineer Website Forum with many people expressing - shall we say - not a positive view! With some contributors saying you need to learn G code in order to run a CNC machine, others expressing a view that they don’t want to be stuck in front of a computer screen calculating end points of lines and circles but actually be working on a machine creating swarf!

Now I don’t want to get involved in the argument of the pros and cons of manual verses CNC machines, both have their merits and uses. My milling machine and lathe are manual and CNC – and I use them in both modes. I want to describe some of the benefits using of software to design and generate part program code. I want to indicate that there are software tools available that will help the Model Engineer make parts from their designs, rapidly, accurately and without complex calculations or a degree in G Code part programming.

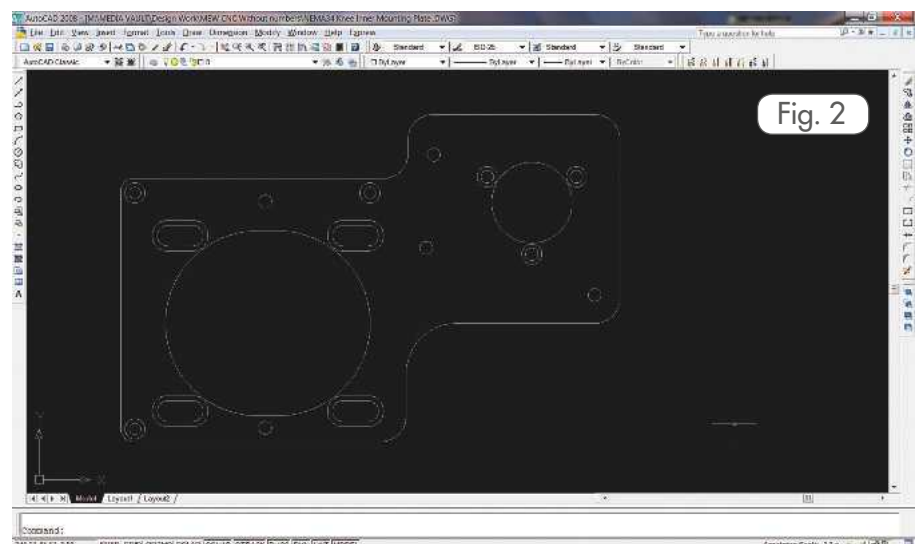
My Background

I was working in engineering when ‘the change’ occurred during the 1980’s, the old mechanical cam driven machines were replaced with CNC machines. I went back to college and learnt how to program CNC machines, first with G code and then using conversational programming. I still remember the first evening at college, the lecturer asking for a volunteer to programme an Emco Compact 5 lathe running from a BBC computer and me turning around to find everyone else had stepped back away!

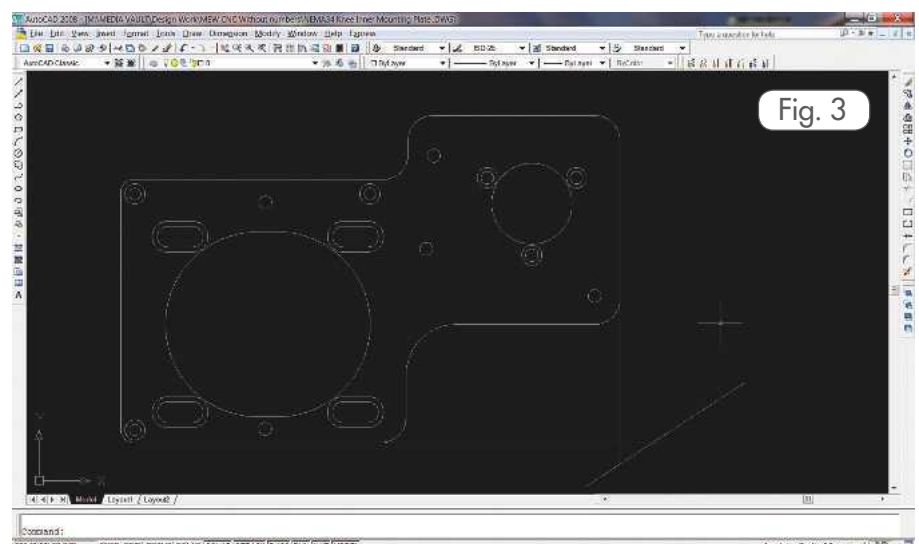
Eventually, years later, I ended up getting involved with postprocessors – the software that generates G code and later again using full machine simulators

generating and testing part program code offline so that valuable machine time was not used to dry run and test a program.

That was many years ago and I had moved to pastures new and a different career. It was my hobby which brought me back to CNC machining. I enjoy restoring old clocks and I was looking to engrave a chapter ring for a brass clock face; I looked at hand engraving but thought the process and manual dexterity beyond me. My search for a possible solution led me to look at equipment for CNC engraving, which to my amazement was affordable and after further internet investigation I eventually purchased a Taig CNC Micro Mill.



The part was saved as a .DWG file and loaded into AutoCad.



Inserting a point for my ‘program zero’ to be used as a reference in BobCad.

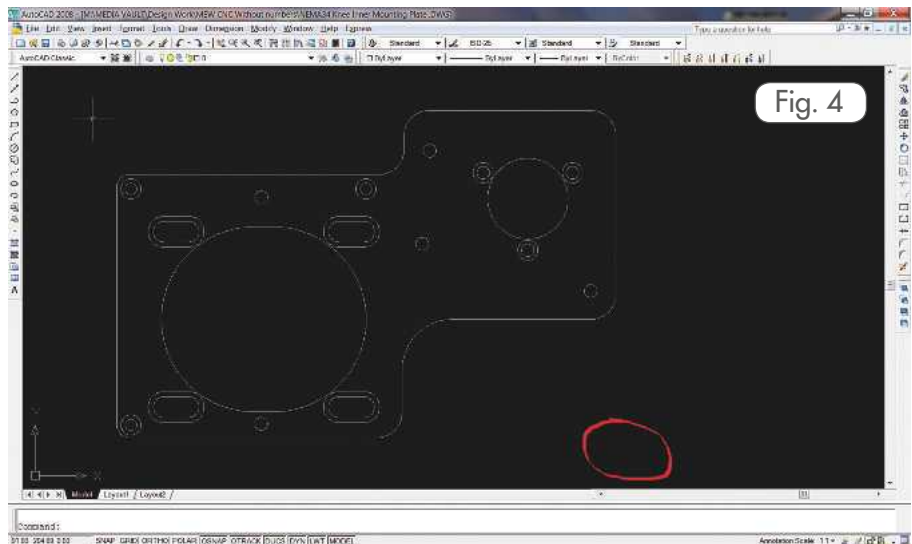
Here I describe some of the software tools I use to generate CNC 'G Code'. The example I use is a motor mounting plate which was one of the many components I designed to convert my Tom Senior Light Vertical milling machine to a CNC machine. The plate is made from aluminium and measures 200mm x 130mm by 12.7mm thick and the feature I will discuss as part of this article is the stepper motor cut-out. The plate was originally designed in Solidworks 3D Parametric CAD package but the reader doesn't need this complexity or expense of software to get started. There are many lo-cost or free CAD packages out there on the market place, a good example of this is Draftsight. The package is available free from the internet from Dassault Systemes at www.3ds.com/products/draftsight/free-cad-software/ It functions identically to and contains most of the features of AutoCad. I have used this software previously and can recommend it.

I have for years used AutoCad in industry and I find it difficult to change old habits and use new software, so the reader must allow me the indulgence of using AutoCad to make any geometric changes.

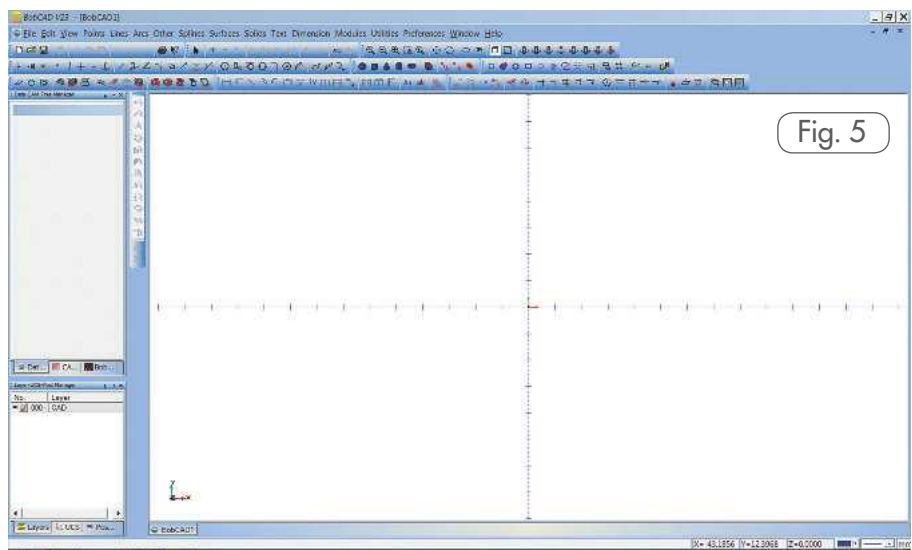
For this article I use software called BobCad to generate the 'G code' used to machine the part and I use AutoCad to prepare the design ready for this process. In fact the user may find it convenient to use BobCad to create the design and generate the CNC code. BobCad is perfectly capable of being used to design components but personally I find it 'clunky'. This is not a fault of BobCad but me, I have for years used AutoCad in industry and I find it difficult to change old habits and use new software, so the reader must allow me the indulgence of using AutoCad to make any geometric changes.

Figure 1 is a 3D view of the 'Nema 34 Inner Mounting Plate' This figure shows the finished part after all the machining has taken place. **Figure 2**, the part saved as a .DWG file and loaded into AutoCad. **Figure 3**, in AutoCad I extend the lines defining the part so that they intersect, here I insert a point. This will be used as my 'program zero' to be used as a reference in BobCad and will help me set up the plate on the Taig main table when I'm ready for machining. **Figure 4** shows the zero point inserted into drawing.

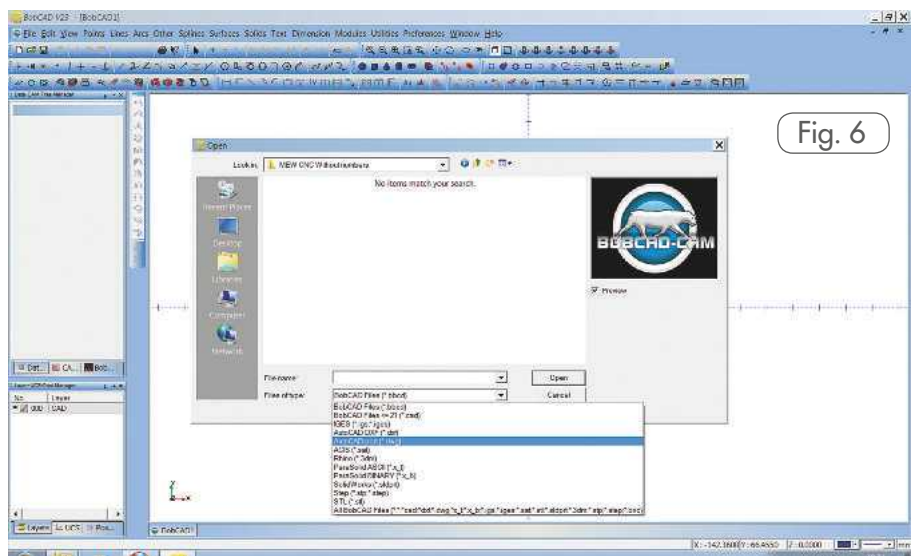
I now load the BobCad software, **figure 5** shows the BobCad software main screen. The screen is divided into four sections, along the top are icons dedicated mainly to geometric functions i.e. line, circle and points etc. On the top left hand side



Zero point inserted into drawing.



Shows the BobCad software main screen.



BobCad supports many CAD software file types.

resides the Data CAM Tree Manager, below this is a window used for layers, UCS and displaying generated G Code. The main window is the work area which is used to display drawings and illustrate toolpaths.

The first thing I need to do is load my 'Nema 34 Inner Mounting Plate' AutoCad file into BobCad. As you will see from **fig. 6** BobCad supports many CAD software file types.

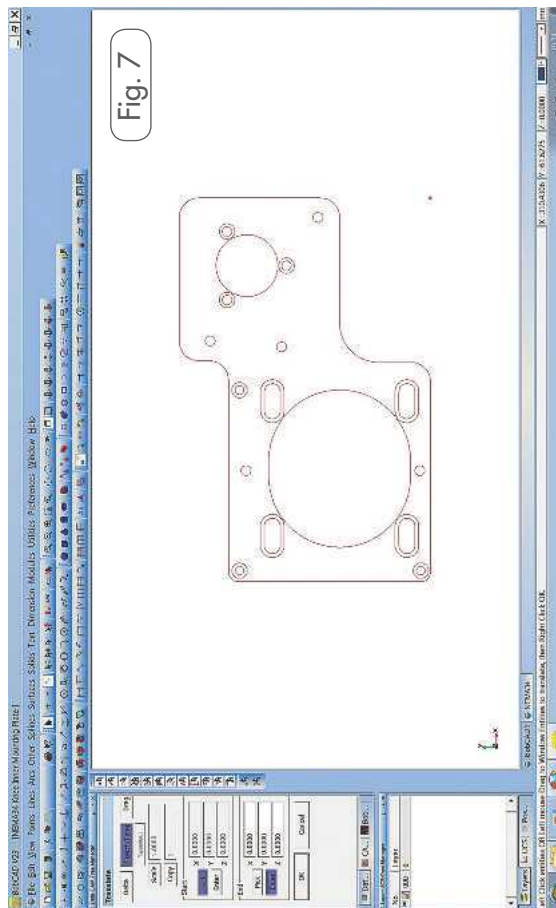


Fig. 7

The Translate function.

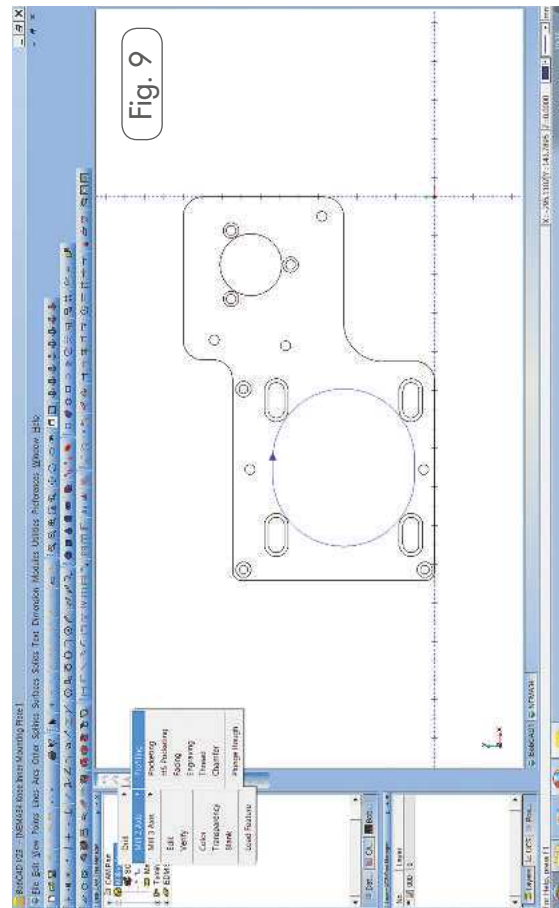


Fig. 9

Selecting 2D profiling.

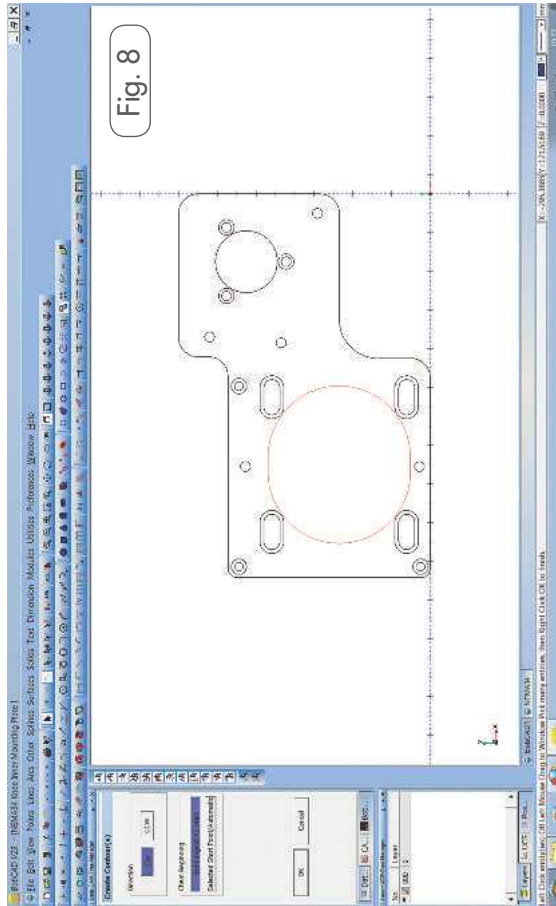


Fig. 8

Part is now aligned with the X and Y scale within the software.

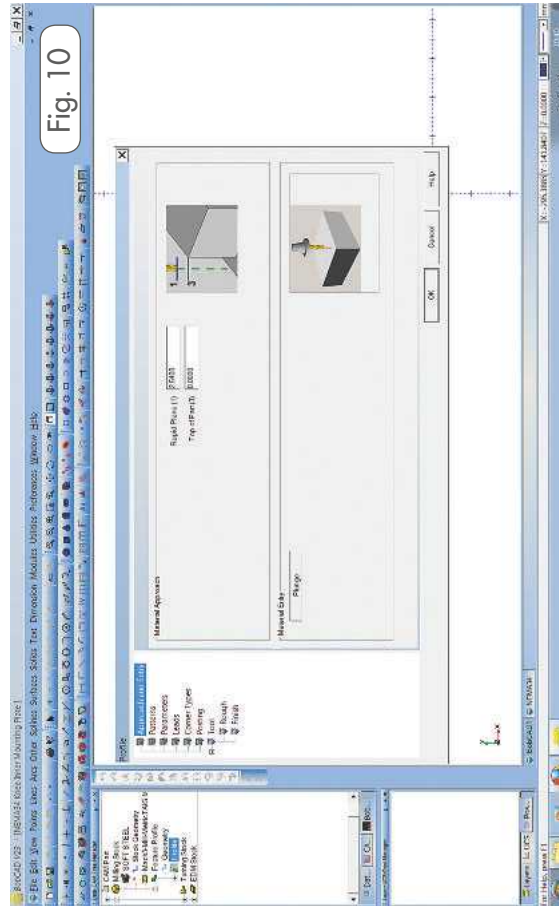


Fig. 10

Feature Profile Parameters.

My first operation in BobCad is to align the part in relation to both X and Y axis. This is where I use the zero point defined earlier. I select the Translate function, highlight the part and pick the 'zero' point as my datum. **Figure 7** shows the Translate function.

The feature that I am going to machine is a large circular slot. A Nema 34 stepper motor will bolt onto this plate and this feature will enable clearance for the protruding barrel which is located around the motor shaft and allow some adjustment in motor position, **fig. 8**. Notice that the part is now aligned with the X and Y scale within the software. I select the circular feature as a 'contour'. This groups all the elements, lines and circles etc., as an entity and enables me to define the direction of machining.

In the top left hand window, I select the type of machining function I want to conduct. There are many options but I choose 2D profiling to machine the feature, **fig. 9**. Selecting 2D profiling. Notice the blue line around the feature, indicating the direction of the tool path. I select the feature geometry to be machined and then define the parameters for machining the tool path by selecting Feature Profile Parameters.

Figure 10 shows Feature Profile Parameters, the first option defining approach and entry of the tool are left to the software default settings.

There are menu options for Tool compensation, **fig 11**. Left and Right (G41 & G42) and Offset Left / Right. The Offset Left / Right option will generate G code for a tool path using a chosen tool diameter input into BobCad, there is no requirement to input the tool diameter into the machine controller. The G41 & G42 selection generates a tool path which is independent of tool diameter as it is the machine controller which calculates the tool compensation for a given tool diameter and tool path. If you intend to repeat the operation / program using different tool diameters then this is the menu selection you should pick. For one off parts I find the Offset Left / Right option the best but if you should need to change the tool diameter then it is just as quick to regenerate the tool path within BobCad and create a new CNC part program.

I'm going to leave the tool compensation as default, I can change it later if I find the tool path generation is incorrect and the tool is on the wrong side of the circular feature.

Figure 12, using the Parameters menu option I define the total stock to remove and how much to remove per pass. As my Taig micro mill is only a hobby machine, I input a maximum of .5mm per pass and thickness of material at 13mm, the software automatically generates the total amount of passes. I will be effectively cutting the feature out of the plate so I have selected a .0508mm (.002 inch) finish profile cut to remove any milling marks. Notice that there are additional options for spring cuts and finishing the bottom of a feature (if required).

Leads, as I am going to plunge cut a profile out of a plate; I have left the settings as default, **fig 13**. There are many options available to define the run-in to a profile including parallel, circular and right angle tool-paths.

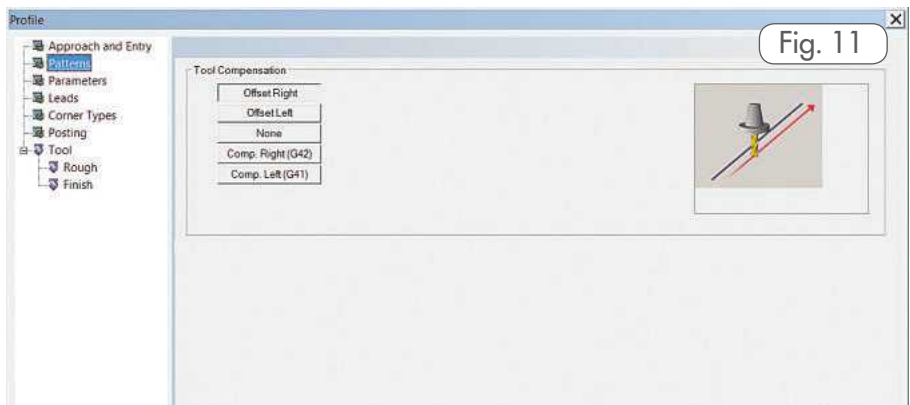


Fig. 11

There are menu options for Tool compensation.

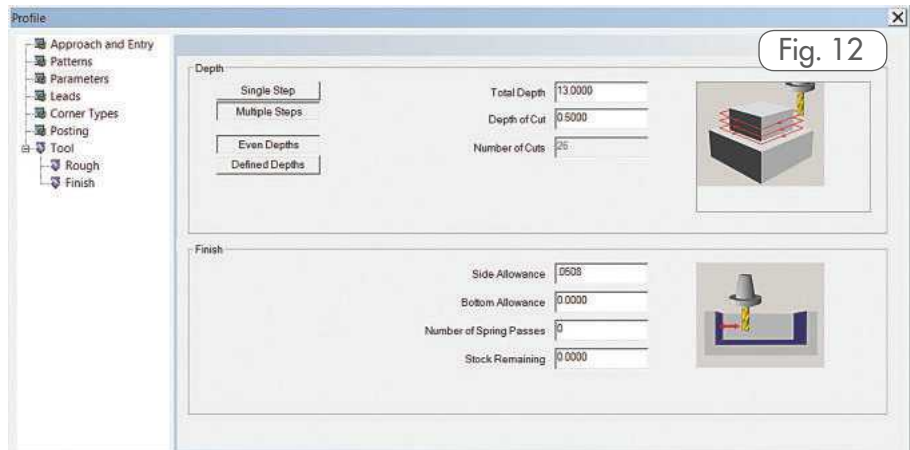


Fig. 12

Using the Parameters menu.

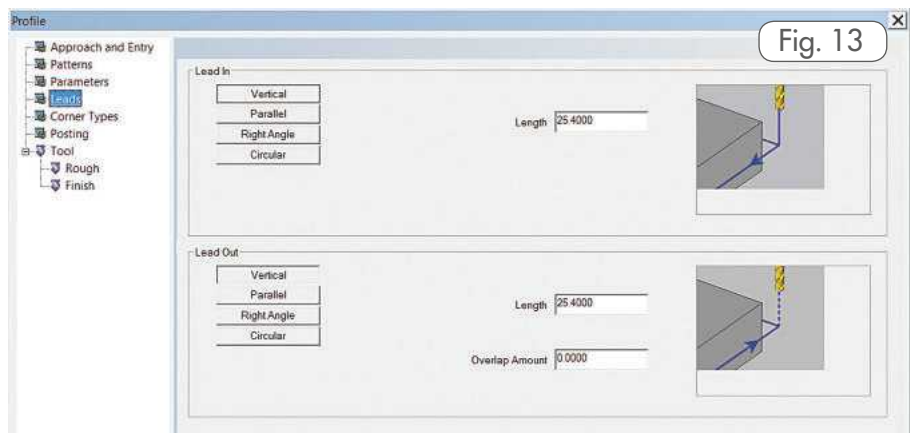


Fig. 13

Leads.



Fig. 14

Corner Types.

Figure 14 shows Corner Types, again, as I am going to plunge cut a circular profile I will leave the software at its default setting. These options demonstrate the software's flexibility especially if you are profiling the outside of a square or

rectangular part and wish to keep the integrity of the sharp corners or generate radiuses on them.

I'm going to use a 10mm carbide slot drill for the machining. In **fig. 15** I have input the tool diameter and overridden the

automatic speed and feed rates to suit my Taig CNC Micro mill. I am not concerned with the spindle speed as this is set manually on the machine by belt selection. The Finish Tool dialogue window is set up identically to the Tool Rough settings. The arc slow down feature is very useful if the tool diameter is very close to the generated circular contour diameter. It works by overriding the set feed rate and helps reduce tool deflection or poor finish on circular interpolations (Circular moves).

Having defined all the cutting parameters, I select 'Compute Tool path'. BobCad will indicate each tool path by a green line on the drawing profile. If the tool path is shown incorrectly, I will go back into the 'Profile Parameter' settings and select one of the other tool compensation offset options and then re-check by regenerating the tool path.

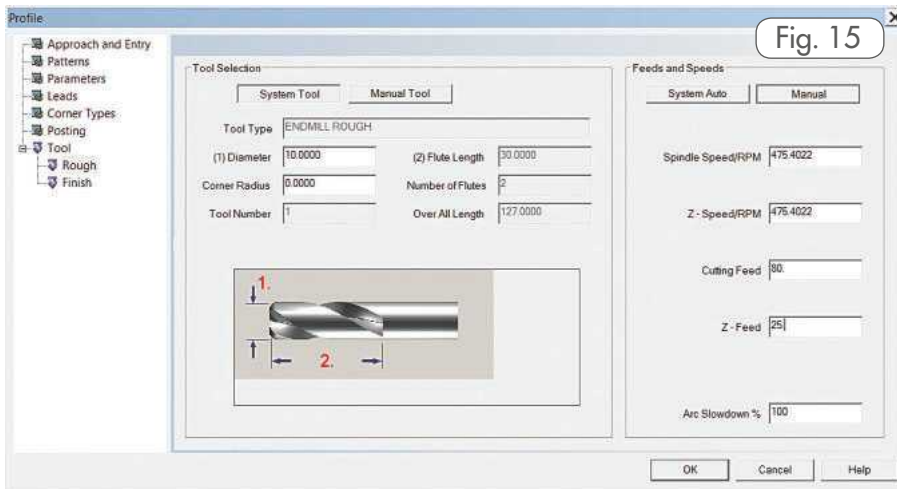
Figure 16 shows the tool path generated by BobCad.

In order to give me some assurance that the generated G code is correct, BobCad has a very useful feature called 'Verify'. This is a facility which uses the generated G code and runs a basic simulation of the tool path showing where stock is removed. To enable me to run this facility I need to define the stock material.

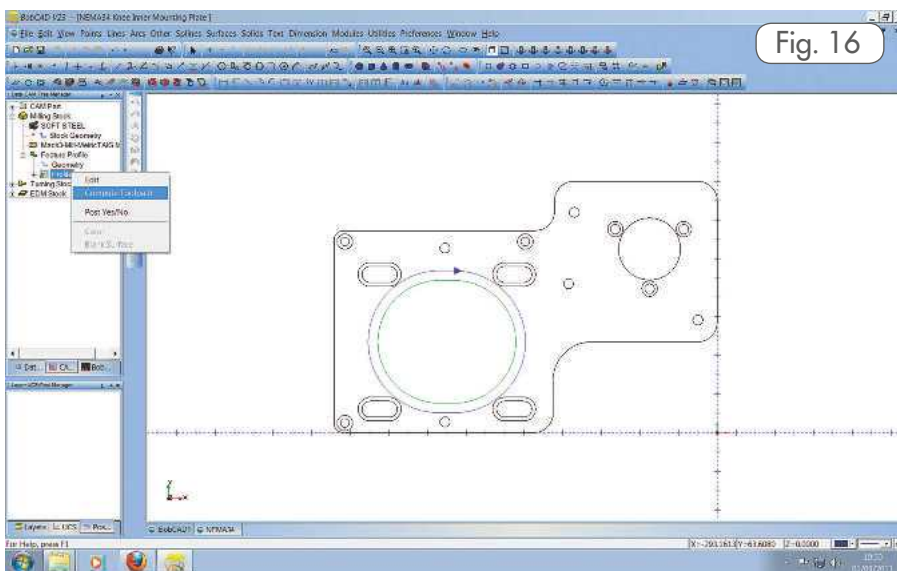
Figure 17 shows the stock dialog window, I input the basic dimensions of the aluminium plate and BobCad indicates the stock material by colouring the area blue. The software has an option for the user to design or import a stock geometry. This allows for odd or complex shapes to be used as the base material. It can also be used to verify the generated G code against a feature already machined.

Figure 18 Shows the verify software feature simulating the generated G code after I have 'posted' and saved the file.

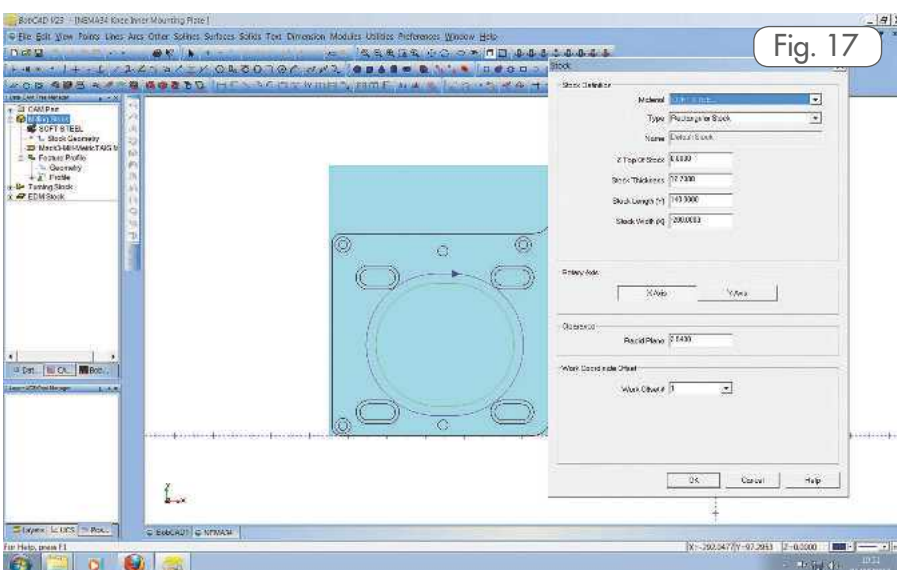
Finally, I have included **photo 1** of the circular feature being machined on my Taig CNC Micro Mill and **photo 2** of the completed part being assembled on my Tom Senior milling machine.



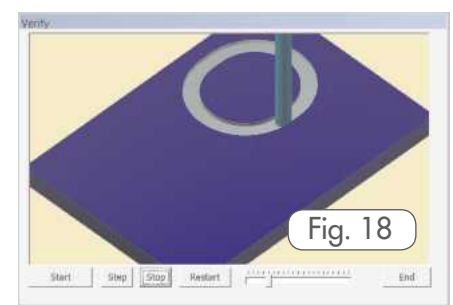
Inputting the tool diameter.



Tool path generated by BobCad.



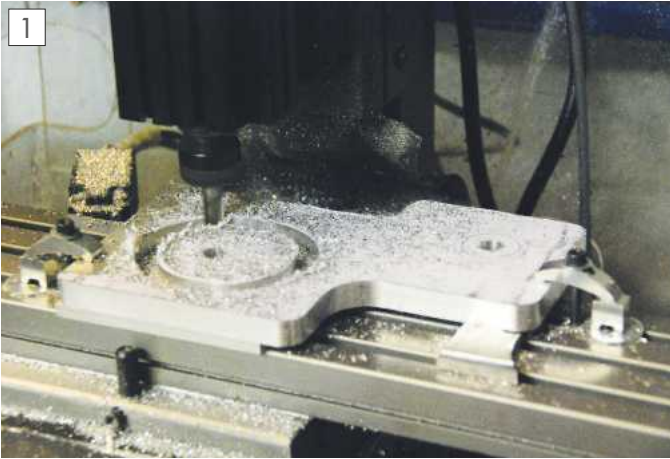
The stock dialog window.



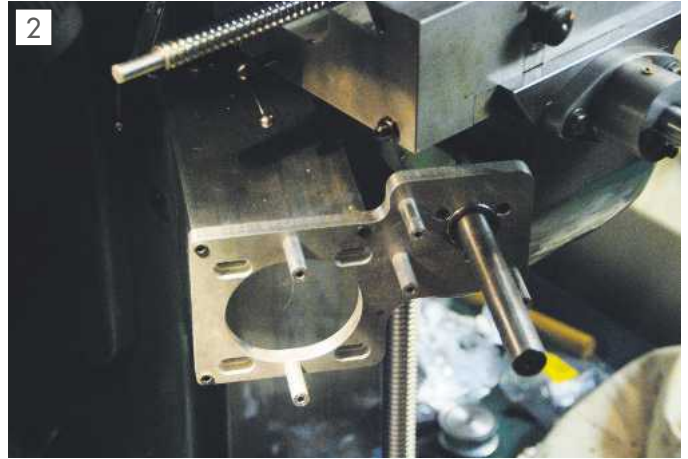
The verify software feature.

Summary

I hope I have shown how easy it is to generate G code using one of the many available software packages on the market. Indeed, I may have put you off by showing you the many menu options that are available to generate the code. Hopefully that's not the case, in practice once the software package has been used a few times you will be surprised how quickly code can be generated for a new machining operation. I am very pleased with the BobCad software package, having used it to machine many components;



Machining the stepper motor cut-out on my Taig CNC Micro Mill.



The completed part being assembled on machine.

I have found it very reliable generating concise and accurate G code with no 'devastating' surprises. I cannot vouch for the other software packages available but I am sure they are just as good. You may

be put off by the price of such software; I know from experience that BobCad is very 'flexible' and competitive on its software pricing and I am sure that other companies are also as accommodating.

It is also worth contacting suppliers as most have available older versions of their software at lower cost which still has all the features an aspiring Model Engineer CNC Machinist could want or need. ■

In our Next Issue

Coming up in issue 243

On Sale 17th June 2016



Michael Green explains how to machine convincing 'castings' from solid material



Rod Jenkins looks at wood in the metalworking shop



Howard Winwood details modifications to his X2 mill

Doors for a Workshop Extension



Stan Nesbitt describes his workshop with particular attention to the task of making and fitting secure doors.



The area for the new annex.



The roof 'tin' went on first!

When I accepted early retirement from the Public Service, aged 52, in 1995 I started the manufacture and sale of hardwood garden furniture. I retired in 2007 aged 65.

Photograph 1 shows the area in front of the building which I used as drying area, subject to suitable weather of course. The existing concrete block building consisted of two 12ft by 12ft loose boxes and a 12ft by 8ft tack room. Whilst this may seem adequate, when machines and benches are installed space becomes tight especially when machining 8ft lengths of timber.

Annex

The framework for the annex, 26ft by 10ft, consists of 40mm by 40mm hollow section which has a wall thickness of 4.5mm with rounded corners. I bought this material from a scrap yard in 1988 and made up a kit of parts for a large dog compound. It cost £60 to have it all galvanised and now some 27 years later it remains as good as new. Of course some cutting, joining and welding on of securing plates was required to suit its new purpose. Timber battens of 2inch by 2inch were fixed lengthways on top of the metal frame to provide support and easier fixing of the roofing sheets.

One may walk on the roof during assembly but it is advisable to use a piece of plywood to avoid damage to the tin. This material is now a popular choice and comes already painted. The self tapping screws have rubber washers and can be readily driven with a slow speed electric drill fitted with a socket. I also needed to make a 3 inch by 3inch angle from the same material to weather proof the small gap between the existing fascia board and the new roof.

When we built our house, using direct labour, I purchased an old Lister half-bag mixer which had an old petrol engine. I removed the petrol engine and installed an electric motor geared down using pulleys and a lay shaft. This mixer was in daily use by the builders for months and saved on hiring costs. Having this machine, still operational allowed me to lay the concrete floor which consists of 4 inches of concrete topped with one inch of

mortar mix. The framework uprights were first embedded in a 6 inch wide wall to the correct floor height and this provided a guide for my single handed 12 foot long tamping board. The floor was laid in four sections butting together to allow for expansion etc.

The ground falls away from the entrance door and it was necessary to lay a concrete ramp to allow wheeled access. This sloping ramp needed a rough finish to ensure an anti-slip surface.

The overlap of the transparent top section of the sheeting may seem excessive but the full sheets divided into 3 equal parts and this was the most economical solution. The bottom tin sheets were sold cheaper as they were offcuts, but they suited my needs fine.

The gap for the doors measures 88 inches wide and 84 inches high. I considered alternatives but decided that two conventional doors would be the most suitable. The larger door, 48 inches wide may remain closed most of the time and the 40inch door will adequate for most daily activities.

The heavy duty hinges are welded to the door edge and bolted to the framework with 8mm roofing bolts, the heads of which are reduced to allow full closure of the hinges. The door frames are made from 30mm square box section, galvanised, but the pieces available had to be joined as necessary to achieve the 84 inch lengths. This material was originally a giant roof rack which I purchased from a local farmer. Some care was required to



Laying the concrete floor.



Mixing concrete.



Concrete floor complete.



Entrance ramp.



The sheeting almost complete.



The gap to be filled by the doors.

ensure that the correct pieces were welded together, hence the markings. Careful clamping was also necessary to minimise distortion from welding.

As I am always single handed and knowing the expected weight of each door I took the precaution of marking the hinge bolt positions using only the upright clamped in position. Metal workers usually work on the floor but at 73 I find it more comfortable to operate on trestles. Being able to accommodate such a large frame

was a challenge but having already the use of the annex, this worked well.

The 'Evolution' saw coped very well with this material allowing quick and accurate 45 degree cuts which resulted in neat welding. It should be stressed that when cutting metal with this saw it is essential to wear a full face plastic mask and preferably a hat because tiny slivers of hot metal may be sprayed towards the operator.

Before any further work on the door frame I thought it prudent to make sure it

was going to fit. Although there is a small gap around the frame this is acceptable to me as during most of the year I will be glad of the ventilation.

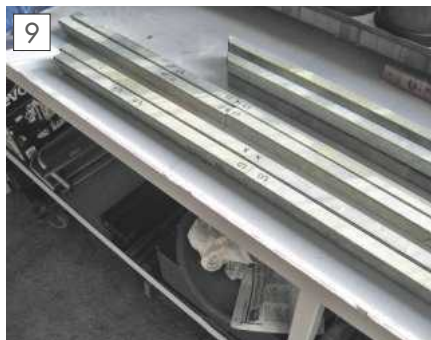
When taking measurements, I find that the home made measuring stick is more reliable than tape measures. Large structures can be a few millimetres out and the adjustable stick will quickly show this.

The timber support pieces 1½ inches by ¼ MS were pre-drilled before assembly as I preferred to use my large bench drill to

drill the 96 by 8mm holes. I was anxious to position the holes about 1 inch from the ends of the planks and I needed to mark the timber supports top and bottom. The centre timber support piece was drilled along the centre line. You will often see this type of gate or door with the timber bolted unto the outside of the frame but I opted to insert the planks into the frame. The 1 ¼ inch timber supports assist in stiffening the frame and the ends of the planks are better protected from the weather. It also provides for a slimmer door with increased strength as the planks are a close fit in the frame. Bearing this in mind, I decided that diagonal bracing was not necessary.

The timber as obtained from the supplier was 5¼ inch wide, 16ft long and ¾ inch thick with sawn finish. Whilst I could have easily run it through my planer, I decided not to reduce the thickness any more. The Evolution saw has a laser guide which is a great aid to accurate cutting.

Each plank was fitted to the frame and clamped in position, for drilling, backed by a piece of scrap hardwood to avoid break out. I used a brad point 8mm Bit passing the drill through the existing holes in the metal timber supports. The coach bolts were tapped home, embedding the square section into the wood, which prevented rotation when tightening the nuts. The first door required the addition of a 10mm strip on



Frame pieces ready for welding.

the last plank and this was ripped using my 12inch contractor saw, then nailed and glued to the last plank.

The first door 48 inches by 84 inches when fully assembled weighed about 80 lbs and working single handed required assistance of wooden blocks to provide support until I was able to insert the roofing bolts into the pre-drilled holes. Top and bottom bars were fitted to anchor this door in the closed position. I will normally leave this door closed as the other 40-inch wide door will allow daily access.

The manufacture of the second door seemed to go quicker with the last piece of timber having to be ripped to size. A small draw bolt was fitted to the inside to secure the door in the closed position when I am working inside in poor weather.

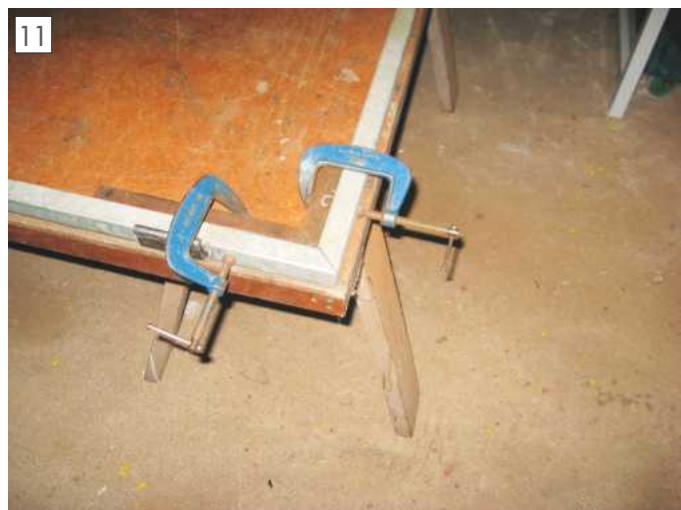


Setting hinge hole positions.

I fitted a stay on the outside wall and a bracket on the outside of this door to use when it will be fully open. Although there are no windows in both doors, the transparent side panels provide adequate vision and light.

The design selected for the locking bar depended upon what was available in my scrap box. The 1 inch solid mild steel bar is a nice sliding fit in the galvanised tubing. Each piece of tubing is welded to half of a piece of 30 mm hollow section which houses the head of a coach bolt. This is bolted through the door using the existing holes. The coach bolt is free to slide up and down about 5 mm to allow adjustment for alignment of the locking bar.

Finally, I applied two coats of wood stain to give extra weather protection. ■



Frame jugged in place.



The first frame, welded up.



A tryout of the bare frame.



Use of a measuring stick.



Timber supports.



Drilling the supports.



Cutting the timber to length.



Timber fitted to the frame.



First door installed.



Second frame tryout.



Both doors installed.



Locking bar.



Internal view of the new extension.

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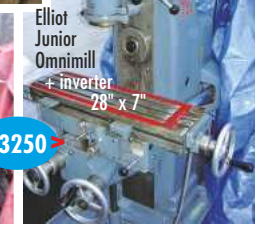
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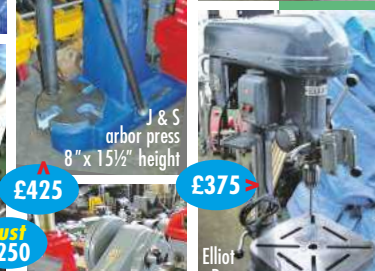
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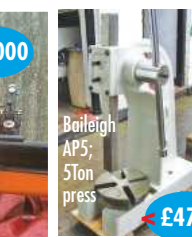
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DN2 6BB



Conquest Lathe

325mm Between Centres
180mm Swing Over Bed

£399



DB10 Super Lathe

550mm Between Centres
250mm Swing Over Bed

£1,225

Champion 20VS Mill

20mm Milling Capacity
700x180mm Table Size
MT2 Spindle Taper

£836



D19 Drilling Machine

20mm Drilling Capacity
120-2580rpm Spindle Speed
0.65kW Motor

£226

H80 Band Saw

Horizontal Band Saw
85x85mm Rectangle Capacity @ 90°
90mm Round Capacity @ 90°
0.4kW Motor

£195



HV128 Band Saw

Horizontal and Vertical Band Saw
128mm Round Capacity
115x150mm Rectangle Capacity
0.25kW Motor

£329



Clamp Kits

Model	Stock Code	T Slot	Thread
CK1	071-100	10mm	M8
CK2	071-101	12mm	M10
CK3	071-102	14mm	M12
CK4	071-104	1/2"	3/8"

£35



3 Jaw Chucks

Size	Stock Code	Price
80mm	010-101	£53
100mm	010-102	£55
125mm	010-103	£60
160mm	010-104	£91



End Mill Sets

Model	Stock Code	Sizes	Price
5pc	074-104	2,3,4,5,6mm	£15
6pc	074-105	2,4,6,8,10,12mm	£24
20pc	074-103	3,4,5,6,8,10,12,14,16,20mm	£95



MT2 & MT3 Live Centres

Taper	Stock Code	Price
MT2	055-123	£17
MT3	055-124	£17



Morse Taper Collets

10 for £45

MT1, MT2 & MT3 collets available



Magnetic Base and Dial Gauge Set

Stock Model	Code
Metric	081-415
Imperial	081-416

£30



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