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NOVEMBER 2017

INSIDE

- A Beginner's Guide to Jacobs Gear Hobbing
- Making Meccano Gears
- Carbide Tooling
- Power Feed for an X1 Mill

COVER STORY

Graham Meek's Screwcutting Clutch

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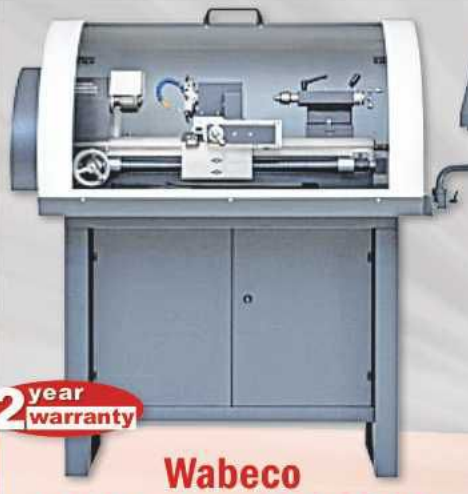

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On the Editor's Bench

HSS versus Carbide

In this issue Mike Haughton takes an in-depth look at carbide tooling. It has been interesting to see, over the last ten or fifteen years, how attitudes to carbide tooling have changed. It used to be written off as an expensive extravagance for those with powerful, heavy and rigid machines. Like many others, I have discovered that using the right sorts of tips and having the confidence to 'make them work' gives really good results on even light machines like mini lathes.

That said, carbide has pitfalls for the beginner who hasn't yet developed the confidence to dial in a hefty cut and wind up the rpm. That means there's still an important place for high speed steel tooling, which also has the added asset of being easy to grind into custom shaped tools for special tasks.

Even carbon-steel; tools still have their place. I occasionally make my own form tools out of gauge plate or silver steel. Treated with respect to avoid overheating they take a good edge and last well. One of the joys of our hobby is that there are so many different ways of doing the same task!

A Light-Hearted Competition

There's a very informal competition on the forum at **www.model-engineer.co.uk** in the run up to Christmas. The 2017 Christmas Challenge is to make a pair of candlesticks. They can be as big or small as you like (cake candles to church candles), of at least two suitable materials.

Judgement will be arbitrary, but might take into account:

1. Finish - are they well made.
2. Design - do they work properly and look nice.
3. Match - how well do they match each other.

You don't have to send the candlesticks in, just post a picture of the completed items on the forum. A useful prize of a workshop multimeter has been donated by Chester Machine Tools.

Entries must be made for the competition and photos posted up by 10 November.
My Halloween candlestick fails on all three judging criteria:

1 Suitable finish - stone effect paint!
2 Great design - 3D printed in flammable plastic!
3 Match? There's only one!

If you can do better than me, and I'm sure you can, why not have go, at the worst you will be left with some nice hand made Christmas presents.

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Contents

See page 32 for details.

Coming up...

in our next issue

Coming up in our next issue, MEW 262 another rewarding read.

An update on **Peter Shaw's** filing rest.

Regulars

ON THE COVER

*This month's cover shows an example of a **Screwcutting Clutch** for a **Myford lathe** made to the design by Graham Meek. Although Graham describes the ML7 version on **page 34**, the sharp-eyed will notice this example, with Tufnol gears, is for a **Super 7.** It was made by Phil Proctor, who took the photo.*

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THIS MONTH'S BONUS CONTENT

You can also visit our website for extra content and join in our online forum

Any questions?
If you are a beginner and you have any questions about this month's **Milling for Beginners article**, or you would like to suggest ideas or topics for future instalments, head over to **www.model-engineer.co.uk** where there will be a new Forum Topic especially to support the series.

But in any case, why not come and join one of the busiest and friendliest model engineering forums on the web at **www.model-engineer.co.uk?**

Unstick ML7 Chuck
- What's the safest way to loosen a stuck chuck, without risking breaking any backgear teeth?

Armstrong Gun
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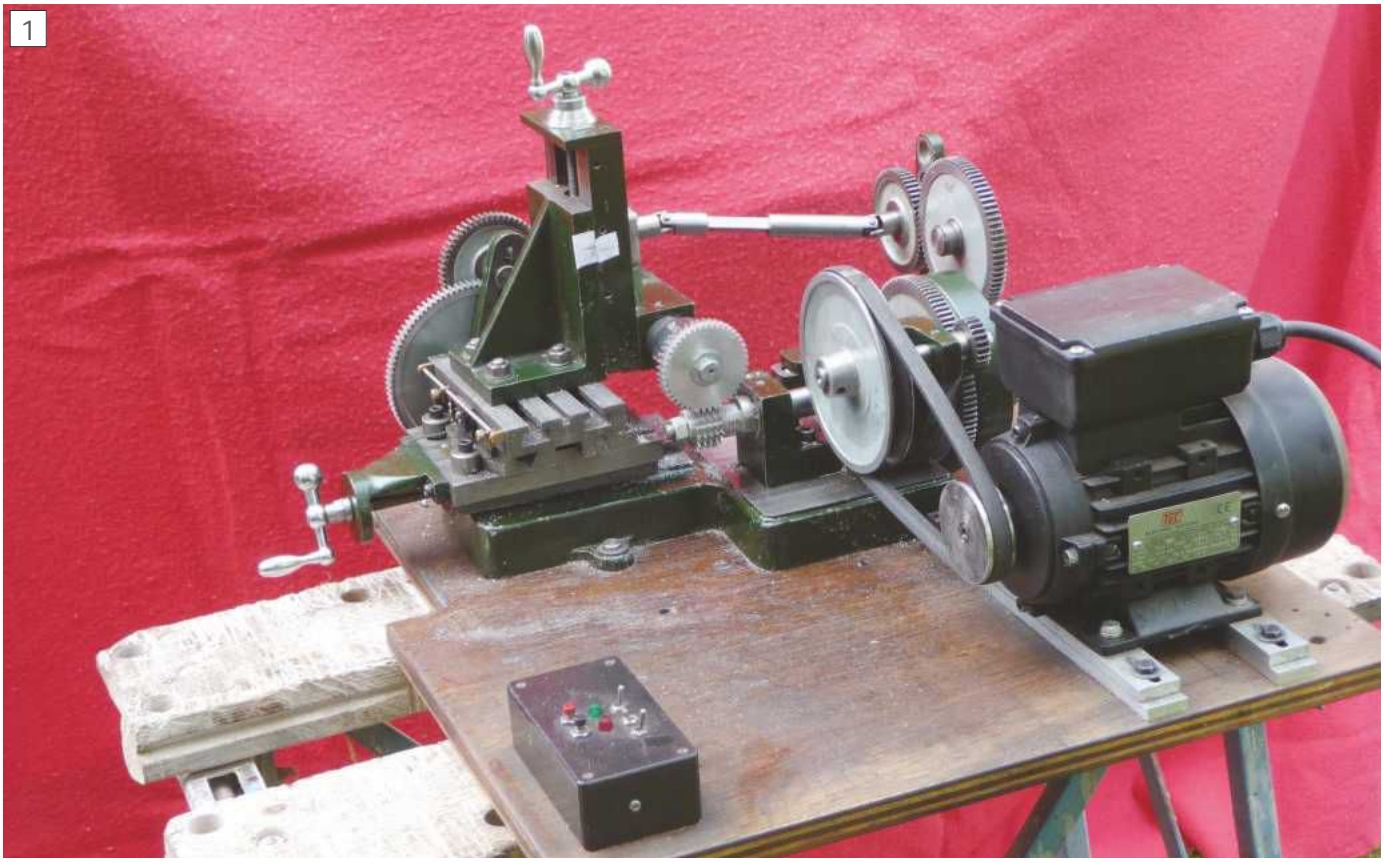
A Guide to **Making Spur Gears With The Jacobs Hobber**

Forty years after the Jacobs Hobber was first described many people are still put off by its apparent complexity. Christopher Robinson has written this clear and helpful guide to its use especially for Model Engineers' Workshop.



The Jacobs hobbing machine

Introduction

This little machine, **photo 1**, was developed by Tom Jacobs in the early 1970s to demonstrate the gear hobbing process and was described by him in an article published in the Model Engineer, ref. 1, in 1976 and for quite some time a set of iron castings and plans has been available from College Engineering Supply, CES – ref. 2, as a project for the home workshop. A series of articles by Ivan Law, Giles Parkes and Harold Hall appeared in MEW in 1999, ref. 3, which covered gear hobbing fundamentals, the making of hobs and the building of the machine from the CES supplied parts and plans. Two articles written by myself and published in MEW during 2010/11, ref. 4, and 2017, ref. 5, describe modifications to extend the capabilities of the machine to make helical gears, gears having prime numbers of teeth with a differential, worm gears and more. MEW's editor, Neil Wyatt pointed out that none of these articles contained a step by step procedure for making spur gears to act as a user's manual and asked me to write one, so here goes.

Gear making processes

The essentials of gear geometry and hobbing are well covered by Ivan Law in part 1 of the 1999 MEW article, ref. 3, and his excellent Workshop Practice Series - Gears and Gear Cutting, ref. 6. The latter covers gears based on both the cycloidal and involute curves. Apart from horology involute gears meet nearly all of today's engineering needs so we will only consider these. Gears can be made by straight cutting, usually on a mill but also on a lathe one tooth at a time by profiled gear cutters, usually referred to as 'Brown & Sharpe' cutters after the American company that developed a standard for them. In this process the involute tooth profile is formed into the cutter. Since the tooth profile for gear teeth of each tooth number gear is unique, this theoretically demands a separate cutter to make each

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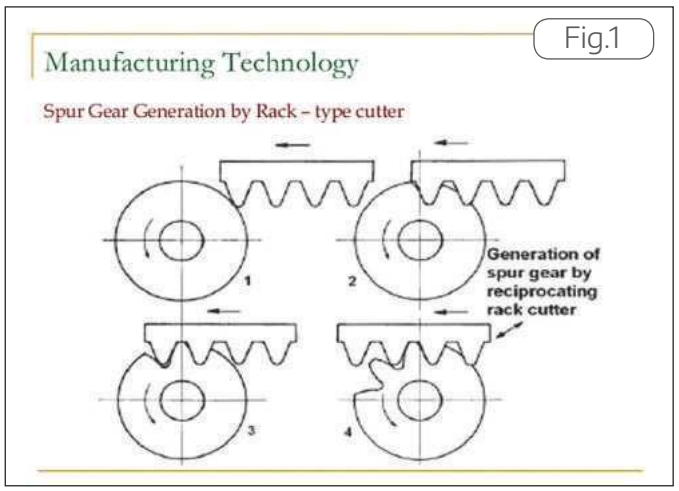
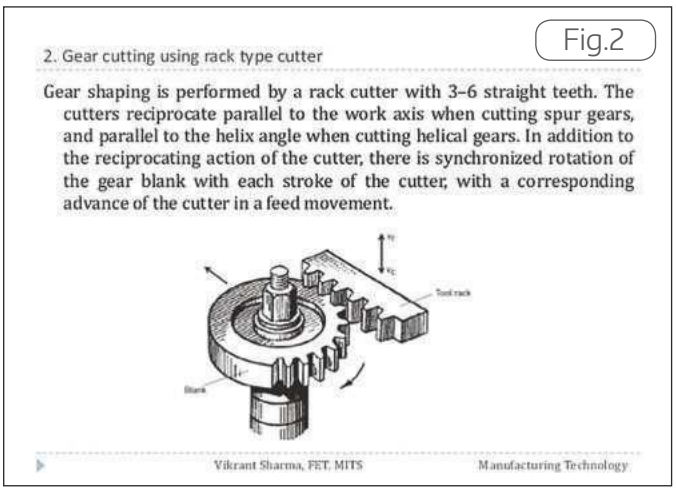


Rack tooth generation, 1,



Gear planing

tooth number gear. The B&S standard developed a series of eight cutters, numbers 1 to 8 for making gears from a rack down to 12 teeth, where the profile for each range was a close enough approximation to be satisfactory for all but the most exacting needs. For extra precision the standard specified a further seven '½ number' cutters, making a total of fifteen. I have never seen any of these intermediate cutters. Imported involute gear cutters are now available to model engineers at reasonable prices.

Herring bone gear

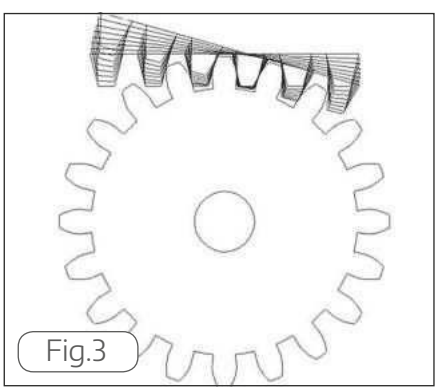
A more flexible process for forming gear teeth is gear generating. This generally uses a cutter in the form of a rack. A major advantage of the involute system is that a rack has straight sided teeth that can be easily made. Referring to **fig. 1**, if we have a cutter in the form of a rack with relieved teeth reciprocating perpendicular to the page, and moving towards a gear blank rotating in such a way as to be indexed to the linear movement of the rack, just as the rack and pinion would mesh normally, then the teeth will be cut with the correct involute profile. In other words, the correct tooth form is generated. **Figure 2** also shows this process. Moreover, only one cutter is required to produce gears of any tooth number. This process of generation is better illustrated in **figs 3** & 9. This is termed gear planing and is used in industry for large gears. It is the only process of which I am aware which can make seamless 'herring bone' helical gears, **photo 2**. Machines of this type are not generally suited to the home workshop but a fellow named Graham Howe has shown just what can be achieved by building a superb gear planer in a home shop, ref. 7.

Now, instead of a rack cutter, if the rack profile is screw cut to create a worm and the worm is gashed axially to form teeth, then we have a cutter referred to as a hob, **photo 3**, an axial section of whose teeth is a rack. The teeth have, of course, to be form relieved so that they will cut. If the hob is now rotated the rack form will move axially and if a gear blank with correctly indexed motion is fed into the hob normal to its axis, corrected for the hob lead angle, then correctly profiled involute teeth will be generated, **fig. 4**. Again, only one hob is needed to produce gears in its pitch of any tooth number. This is the basis of all gear hobbing machines including the Jacobs.

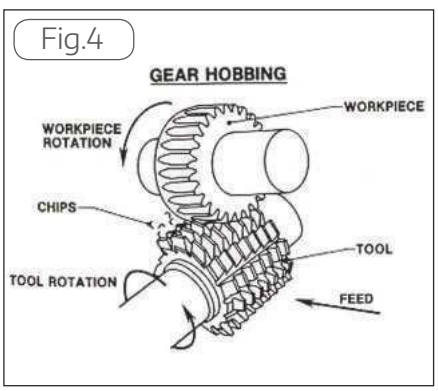
Apart from requiring only one cutter the other major advantage of the hobbing process is that it is continuous requiring no pause between cuts. This makes it highly productive compared with other methods and the great majority of industrial gears are made in this way. It also allows, along with gear planing, gears to be profile shifted. More on this later.

The Jacobs machine is somewhat limited compared with industrial machines, particularly in terms of rigidity. As stated earlier, Tom Jacobs developed it to demonstrate the principles rather than it being a production machine. The largest pitch gears that it can practically cut in steel is 20DP or Mod 1.25. To cut gears of this pitch in steel requires 3 passes, so it is not a quick process but as model engineers we are not as short of time as commercial producers. 20DP gears in brass or aluminium can be cut easily in 2 passes. However, it can cut gears up to 7" outside diameter (OD). With care and patience, it can cut totally acceptable gears up to this size. I have cut 16DP brass change gears for my Colchester Student lathe with my machine.

Typical hob



Rack tooth generation, 2,



Gear hobbing process

Fig.5

Hobs

DP	PA	λ	WD	OD	Bore	L
14[tc]	20	2°58’	4.354	40	10	25
16	20	2°33’	0.1406”	40	10	25
18	20	1°35’	0.1330”	50	22	40
20	14½	1°34’	0.120”	50	22	40
20	20	2°30’	0.120”	32	10	20
22	20	2°15’	0.1023”	32	10	25
24	20	2° 5’	0.100”	32	10	20
27	20	1°46’	0.088”	33	13	30
30	20	1°36’	1.905	32	10	25
32	30	2° 3’	0.071”	23.7	8	11.5
32	20	2° 4’	0.071”	23	8	11.5
32	14½	1°57’	0.071”	25.4	8	20
34	20	1°25’	0.0662”	32	10	25
36	20	1°20’	0.0667”	32	10	20
36	20	1°50’	0.0625”	24	10	15
38	20	1°15’	0.0632”	32	10	25
40	14½	1°40’	1.369	23	8	8.2
40	20	1°12’	1.524	32	10	20
40[tc]	20	1°12’	1.524	32	10	20
40	20	1°30’	1.52	24	8	16
44	20	1°5’	0.0545”	32	10	20
46	20	1°2’	0.0469”	32	10	20
48	14½	1°20’	1.15	24	8	9.2
48	20	1°	0.050”	32	10	20
48	20	1°20’	1.27	24	8	10
48	20	1°17’	1.20	24.6	5/16”	24
48	25	1°	0.0489”	32	10	15
56	20	51’	0.0402”	32	13	15
60	20	1°5’	0.041”	24	8	8.2
64	20	45’	0.0375”	32	10	15
64	20	1°	0.953	24	8	10
80	20	48’	0.0295”	24	8	11.5
80	20	47’	0.0296”	24	8	11.5
90	14½	43’	0.0302”	25	8	8

DP	PA	λ	WD	OD	Bore	L
96	20	39’	.0249”	24	8	11.5
100	20	28’	0.024”	32	10	15
127	20	29’	0.47	25	8	20
Mod	**PA**	**λ**	**WD**	**OD**	**Bore**	**L**
1.25	20	1°24’	2.97	56	22	40
1.25	20	3°18’	2.97	25	8	20
1	20	2°	2.37	32	13	30
1	20	2°33’	2.37	25	8	20
0.9	20	2°18’	2.14	25	8	20
0.8	20	2° 3’	1.90	25	8	20
0.7	20	1°46’	1.66	25	8	20
0.62	20	1°20’	1.36	31	10	20
0.6	20	1°29’	1.42	25	8	20
0.5	20	1°14’	1.19	25	8	20
0.4	20	58’	0.95	25	8	20
0.4[tc]	20	51'	0.95	28	8	15
0.35	20	39’	0.83	32	13	15
0.3	20	43’	0.71	25	8	20
0.2[++]	20	29’	0.47	25	8	20

ACME & Trapezoidal taps for worm wheels

TPI (P)	PA	λ	WD	OD	Shank	Mod
6RH	14½	4°33’	.0833”	19.05	1/2"	1.35
6LH	14½	4°33’	.0833”	19.05	1/2"	1.35
8RH *	14½	6°25’	.0625”	19.56	1/2"	1.01
8RH	14½	4° 5’	.0625”	16.15	1/2"	1.01
8LH	14½	4° 5’	.0625”	16.20	1/2"	1.01
10RH	14½	4° 5’	.05”	13.10	9	0.81
10LH	14½	4° 5’	.05”	13.50	11	0.81
M2RH	15	4° 3’	1mm	10Tr	8	0.64
M2LH	15	4° 3’	1mm	10Tr	8	0.64
16RH	14½	4° 3’	0.031”	7.90	8	0.51
M1.5LH	15	3°46’	0.75mm	8Tr	6	0.48
12LH**	14½	10°25'	0.035”	8.35	1/4"	0.67
12LH*+	14½	5°10’	0.035”	8.23	1/4"	0.67

[tc] = Tungsten Carbide

* 2 Start ** 2 Start 2/3 STUB ACME *+ 2/3 STUB ACME ++ 127DP

Hobs and cutting speeds

Hobs can be made in the home workshop though it is not a straightforward task and requires tooling for form relieving the hob teeth. Full details of this process and a tool for this with drawings are described in part 2 of the 1999 article written by Giles Parkes, ref. 3.

Hobs for the Jacobs machine ideally need to be around 25mm to 30mm OD. Hobs in this size have standard bores of 8, 10 and 13mm. Larger hobs of around 50mm OD can be used but are somewhat on the large side. These usually have a 22mm bore.

In the past the company Arc Euro Trade of Leicester, ref. 8, offered a range of gear hobs suitable for the model engineer at modest prices but these are no longer available. A search of eBay reveals hobs available from China at reasonable cost but they tend to be 50mm OD & 22mm bore though some 30mm OD, 13mm bore hobs are available. Used hobs in smaller sizes, the best made by the Swiss Mikron company, come up from time to time and I have sourced most of my hobs, **fig.5**, in this way. You should find the following key information engraved on each hob: Pitch, usually either module, Mod, or diametral pitch, DP, occasionally circular pitch, CP, pressure angle, PA, in degrees, lead angle, λ, in degrees and minutes and working depth, WD, which is the depth of cut in inches or mm.

4

Feed screws

As for cutting speeds, Ivan Law recommends about 40 feet per minute, fpm, for a commercial HSS cutter when making gears in steel. This equates to 150 rpm for a 25mm OD hob and 75 rpm for one of 50mm OD. My machine is run by a 1/4HP 1400rpm single phase induction motor with a 2:1 vee belt drive to the input shaft. Using a drive train of 22T/100T for 25mm hobs and 12T/112T for 50mm hobs gives speeds of 154rpm and 75rpm respectively. Drive train gears should always be in steel as they transmit considerable power, particularly for the larger pitches.

Index gears

The worm drive to the gear blank arbor on the Jacobs machine has a ratio of 40:1. The number 40 here is usually referred to as the machine constant. This means that if the index ratio between the hob shaft and the shaft driving the worm is 1:1 then it is set up to hob a 40T gear. To hob a gear of T teeth we require an index ratio of 40/T. So to hob a 20 tooth gear it must be 2:1 and for an 80 tooth gear 0.5:1. The train of gears must also be sufficient size to bridge a centre distance of 5½". **Figure 6** shows the index gear trains required to hob gears from 5T to 100T. The gears on the machine are specified the same as Myford lathe change wheels, i.e. 20DP 14½° PA, 5/8" bore with a 1/8" keyway

Fig6

Index gears for hobbing spur gears from 5 to 100 teeth (M = 40)*

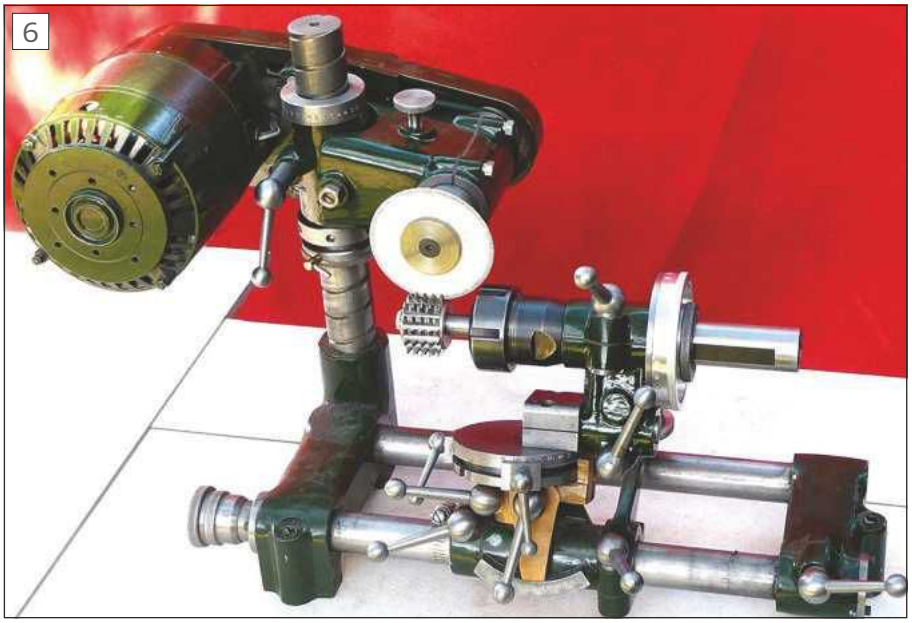
T	Dr1	Dn1	Dr2	Dn2	T	Dr1	Dn1	Dr2	Dn2	T	Dr1	Dn1	Dr2	Dn2
5	80	50	100	20	37	Prime				69	32	90	75	46
6	80	50	100	24	38	40	100	100	38	70	20	100	100	35
7	80	50	100	28	39	80	90	60	52	71	Prime			
8	80	50	100	32	40	50	100	80	40	72	25	100	100	45
9	80	90	90	18	41	Prime				73	Prime			
10	80	90	90	20	42	40	100	100	42	74	20	100	100	37
11	100	35	70	55	43	Prime				75	24	100	100	45
12	100	70	70	30	44	50	80	80	55	76	20	100	100	38
13	100	50	80	52	45	40	100	100	45	77	28	99	90	49
14	80	100	100	28	46	40	90	90	46	78	20	100	100	39
15	80	90	90	30	47	Prime				79	Prime			
16	50	100	100	20	48	50	80	80	60	80	20	100	100	40
17	80	80	80	34	49	40	90	90	49	81	20	90	100	45
18	100	60	60	45	50	40	90	90	50	82	20	100	100	41
19	80	70	70	38	51	80	60	40	68	83	Prime			
20	60	90	90	30	52	40	90	90	52	84	20	100	100	42
21	100	75	60	42	53	Prime				85	24	100	100	51
22	100	75	60	44	54	20	100	100	27	86	20	100	100	43
23	100	75	60	46	55	40	90	90	55	87	40	58	60	90
24	100	70	70	60	56	25	100	100	35	88	25	90	90	55
25	80	70	70	50	57	Prime				89	Prime			
26	80	70	70	52	58	20	100	100	29	90	20	100	100	45
27	40	100	100	27	59	Prime				91	20	70	80	52
28	40	100	100	28	60	40	80	80	60	92	20	100	100	46
29	Prime				61	Prime				93	40	62	60	90
30	40	100	100	30	62	20	100	100	31	94	20	100	100	47
31	Prime				63	40	84	80	60	95	16	100	100	38
32	50	90	90	40	64	20	100	100	32	96	25	90	90	60
33	60	90	80	44	65	40	100	80	52	97	Prime			
34	40	100	100	34	66	20	100	100	33	98	20	100	100	49
35	40	100	100	35	67	Prime				99	40	66	60	90
36	50	90	90	45	68	20	100	100	34	100	20	100	100	50

*** M = Machine constant, the ratio of the worm drive for the workpiece arbor**
Driver 1 (Dr1) is the gear fixed to the hob spindle
Driven 1 (Dn1) and Driver 2 (Dr2) are keyed together on the rotating bush fixed to the banjo arm except where Dn1 and Dr2 are equal when this denotes a single idler gear
Driven 2 (Dn2) is fixed to the shaft driving the index worm via universal joints
Where "prime" appears, these are prime number gears and a gear of this tooth number is required. The necessary gear train is 40, idler, prime number or 80, idler, prime number x 2

Fig7

Cutting teeth in several passes - % full depth

Pass	2 passes	3 passes	4 passes
1	59	47	33
2	100	74	59
3		100	81
4			100

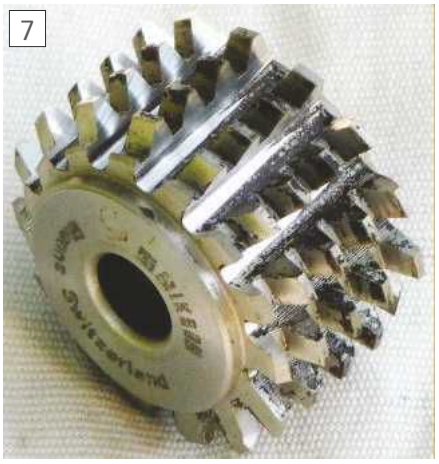


Hob sharpening

and a 3/8" width. If you are fortunate in having a full set of Myford change wheels this comprises 20T to 75T in steps of 5, plus a 21T and a 38T. This still leaves you short of many of the gears required for full flexibility. All prime number gears need that number gear to hob one unless you fit a differential, details given in ref. 5. The alternative is to make the necessary gears by milling the teeth as described above. They can be made in a soft material like aluminium for use as index or feed gears as they transmit very little power.

Feed and depth of cut

The feed gears you need to link the blank arbor and the cross feed screw will depend on what cross feed screw you have. The CES plans call for a 3/8" x 10 tpi ACME feed screw as used on the Myford lathe cross slide. This is a pitch of 2.54 mm and I found it too coarse. Instead I made all three feed screws with an M10 x 1 thread, **photo 4**. The uppermost item in this photo is a LH feed screw and nut for use when making gears with a LH hob. These were all screw cut on the lathe for accuracy. A good feed to start with is 0.1mm per revolution of the gear blank. This requires a 10:1 reduction between the blank arbor and the 1mm pitch feed screw which is quite easy to arrange. With the 10 tpi feed screw you need a 25:1 reduction which is less convenient and requires some very small pinions.



Sharpened 16DP hob

The full depth of cut to produce the required tooth profile will vary between hobs depending on the clearance design and will be engraved on the hob itself. **Photograph 5** shows a 20DP Mikron hob and the working depth, h0 in their terminology, is 0.12", 3.05mm. To cut a gear with this hob in steel in one cut is too much for the rigidity, or lack of it, of this machine. Experience has shown that three cuts are needed. Because we are cutting with a vee shaped tooth the three cuts will not be equal for constant metal removal. **Figure 7** shows the percentage of full depth for

Mikron 20DP 20 Deg PA hob

multiple cuts up to 4 passes for equal metal removal. So for this hob the 3 cuts will be 1.43mm, 2.25mm and 3.05mm. If we were to cut the same gear in aluminium two cuts, 1.80mm and 3.05mm, would suffice.

There is no easy formula for feed and depth of cut. It is a matter of trial and error to find out what the machine is comfortable with. For small gears, say 32DP and smaller they can be made in mild steel in one cut without difficulty. However, the hob needs to be sharp and they can be sharpened fairly easily on a tool & cutter grinder. **Photograph 6** shows a 16DP hob being sharpened on my Quorn grinder and **photo 7** shows the sharpened hob.

Mounting the hob and the gear blank

The plans with the CES castings specifies a design for both the hob and the gear blank arbors to be fixed to their respective spindles on a 60° taper and held by screwing them into a blind tapped hole.

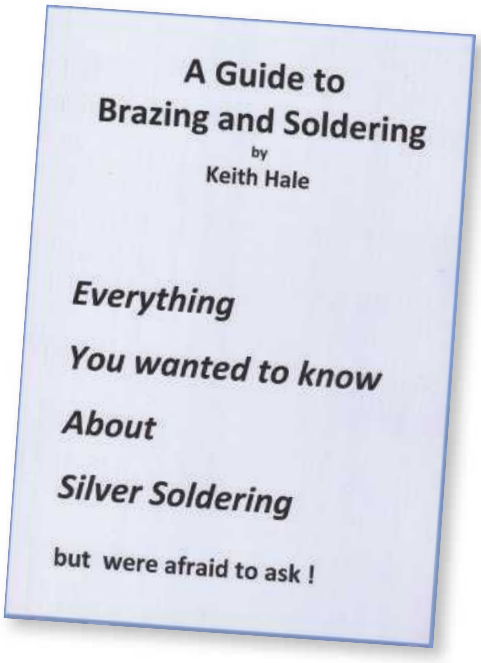
It is very important in hobbing that both the hob and the gear blank run true. It is particularly critical for the hob to run true when hobbing gears of small pitch. Harold Hall was not too impressed with this design, ref. 3, and proposed a design also on a 60° taper with an anti rotation pin and fixed with a draw bar which is a big improvement. However, as there are only 4 different bore sizes for the hobs I decided that for the hob arbors a solid shaft for each size was justified, **photo 8**, to ensure true running.

To be continued

Hob arbors

On the Wire NEWS from the World of Hobby Engineering

A Guide to Brazing and Soldering

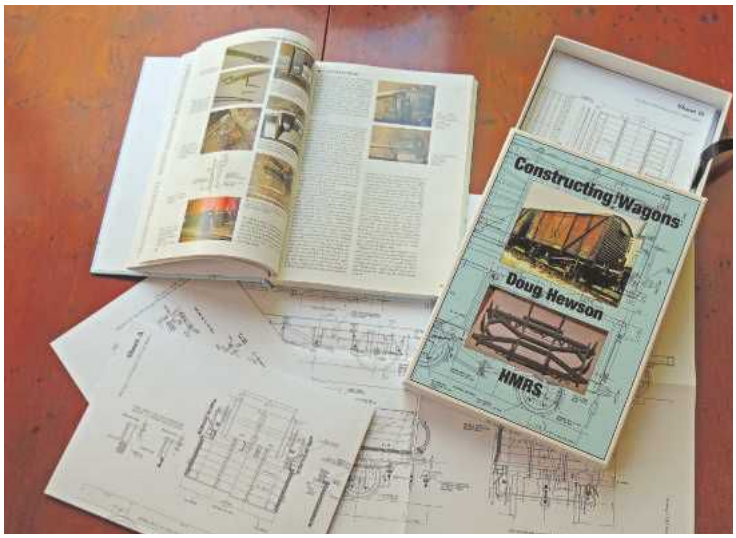


Subtitled "Everything you wanted to know - but were afraid to ask!" this is the book an awful lot of MEW readers have been waiting for. Written by Keith Hale, who many people will have met on the CuP Alloys stand at exhibitions around the country, this excellent book really is a comprehensive guide to every aspect of the art and science of silver soldering.

Keith learned silver soldering as a jewellery maker but went on to work in industrial joint-making at all scales, although he confesses he has never actually made a loco boiler! Users of the forum at www.model-engineer.co.uk may also be familiar with Keith as a regular source of help and advice for people with questions and queries about the subject. The book covers every aspect of silver soldering: brazing torches; designing joints and choosing the right alloy and flux. Written in Keith's accessible style, it also covers areas such as safe working practice, 'step soldering', using different alloys and how to set up a hearth. There are plenty of useful and informative pictures.

For anyone who wants to improve their silver soldering or who has always wanted to try it but was put off by the apparent complexity of the subject, this book is a must. The book is available from **www.cupalloys.co.uk** for £17.95.

Constructing Wagons



There is really only one way to describe this 'book' by Doug Hewson, it's a real magnum opus. It is actually a boxed set comprising a 316-page hardbacked book as well as highly detailed sheets of double-sided A2 plans on heavyweight stock for thirteen different wagon types. The first thing you notice on leafing through is the difficulty of distinguishing the photographs of models from those of the real thing!

Doug is well known for his outstanding craftsmanship and attention to detail, particularly in the construction of 5" gauge rolling stock. The book documents decades of work by Doug and others to document the astounding variety of wagons that dominated the British railway network during the twentieth century. Originally intended as a collection of articles written by Doug for Engineering in Miniature over nearly three decades, in the event it turned into a complete re-write to avoid needless repetition and produce a much more coherent whole. It does, however, retain Doug's informal style with the feel of someone addressing a group of fellow enthusiasts.

It covers the methods of construction of working models wagons in every detail. For example, a considerable amount of attention is given to the brake systems that are so visible and important to the character of any model. But besides this practical instruction, a bewildering assortment of different types of wagon are detailed, not just as long lists but as excellent photographs supplemented with lots of fascinating background information.

The accompanying plans are remarkably detailed and beautifully drawn, and this truly is a resource for anyone modelling British railway wagons in any gauge, from 00 up. In truth, I imagine that one day this collection will be sought after by those restoring and preserving full size wagons!

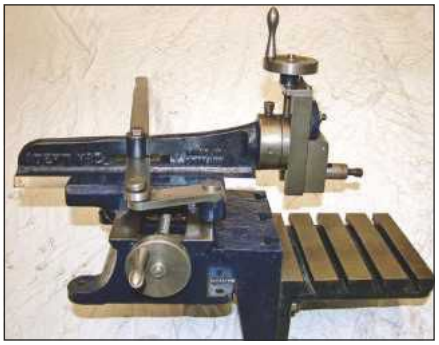
Constructing wagons is published by the Historic Model Railway Society, **hmrs.org.uk**. For such a detailed and extensive work, the £50 price tag seems very reasonable.

Given the steam hammer series running in Model Engineer at the moment, readers may be interested in this handy piece of workshop equipment I photographed a couple of years ago. It can be found on the Dudley Road in Stourbridge, opposite the junction with Badger Road. Remarkably, it seems impossible to find any information about it on the internet. I'm always interested to receive pictures of unusual machinery, large or small, Neil.

In our Next Issue

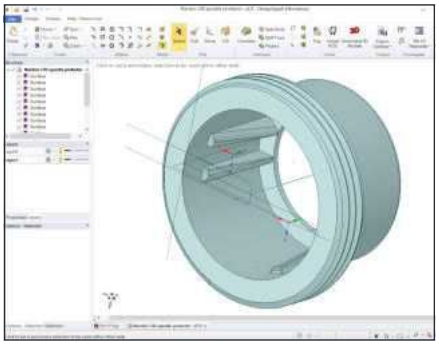
Coming up in issue 262
On Sale 1st December 2017
Content may be subject to change

Look out for the December issue, 262, of Model Engineers' Workshop, for even more fascinating tales from the workshop:



Using a shaper with **Bill Morris.**

An update on **Peter Shaw's** filing rest.



Darren Conway prints a spindle nose protector

DON'T MISS THIS GREAT ISSUE - SEE PAGE 32 FOR OUR LATEST SUBSCRIPTION OFFER

Carbide Tooling

Mike Haughton takes a wide-ranging look at the benefits of the tough stuff.

Carbide tips for brazing.

We are all getting used to using carbide inserts in our lathe and mill tools. Some even will have embraced solid carbide milling cutters and other solid carbide tooling.

However, I often hear or read comments that are very negative about carbide tooling. They don't think carbide is for them! It's expensive and can't compete on price and re-sharpening with good old High-Speed Steel. Inserts are not sharp. Older machines weren't designed to utilise carbide tooling, carbide needs higher speeds and more rigidity than my machines have. Carbide is expensive and very easily chipped, there are so many confusing grades, tooling shapes and sizes etc.

Carbide is of course Tungsten Carbide (chemical symbol WC. The old name for Tungsten was Wolfram hence the chemical symbol W). Tungsten is an expensive metal with a very high density, nineteens time that of water, almost as dense as gold; a very high melting point and boiling point, hence its use in incandescent filament lamps, which is obviously declining under the LED lighting onslaught.

Most of the World's tungsten ore is mined in China and recently they have cleverly placed export restrictions on the metal ores, concentrates, and basic tungsten products to encourage the national manufacture of downstream, higher value products. Where have we heard that before?

Those who live in SW England will probably be aware that Wolf Minerals have opened a new mine producing tungsten and tin concentrates at Hemerdon, Plymouth. Tungsten in this deposit averages 0.2% metal and tin 0.02%! That's going to be a big opencast pit.

Although we see many, many, carbide insert and solid carbide manufacturers names on our carbide insert tooling, the reality is that a high proportion that appear in the hobby trade were probably

Carbide tipped sawblade and router cutters for wood.

manufactured in China, whatever name is on the box. The professional tooling is likely to be sourced differently, as I will explain later.

Carbide Technology

Carbide tooling is, more correctly, a 'cemented carbide' made of WC plus a metal binder such as Cobalt or Nickel. Put simply, tungsten carbide powder and powdered binder are mixed, pressed into a shape and sintered (heated) to melt the binder metal which whets the tungsten carbide particles and fills all the voids between the carbide particles.

The result is very wear resistant because of the hard and tough carbide particles and impact resistant due to the binder, often likened to road stone embedded in asphalt.

Although carbide or 'hard metal' has been around since the 1920s its performance as a cutting tool has improved out of all recognition in recent years, principally due to smaller particle size, better chemistry and better pressing and sintering methods. Hot pressing (HIP, Hot Isostatic Pressing) of the powder mixture helps remove voids from the composite and smaller carbide particle sizes reduce cracking and cratering when the tool is used. Fine grain or micro grain carbide are descriptions often applied by some manufacturers and are fairly meaningless as commercial carbide powder mixtures for pressing, are tailored to the end application. For example, Carbide buttons for mining bits are relatively coarse (microns) and milling tools fine (sub-micron).

It won't be a surprise to read that Cobalt is a common binder, up to 15% in carbide metalworking carbide tools. Cobalt is also a costly key ingredient in quality high speed steels and its supply is currently very problematic, the Congo being a major world source. Other metal carbides can be added to the TC powder mixture e.g. titanium, tantalum, niobium, and hafnium to improve properties of the final products. The result of all this mixing of carbides and binders is a plethora of carbide grades with properties tailored to specific cutting applications. Professional carbide inserts are often colour coded on the box to indicate which workpiece they will work best with and, sometimes, recommended feed rates and speeds.


3

Glanze™ 12mm square shank lathe tool set.

You may have seen P, blue: M, yellow: K, red and perhaps N, green; S, brown and H, grey.

This information may well be critical to Industry running CNC machining centres 24/7 with 'lights-out' unattended operation on difficult materials, but it's not too relevant to my 'maker shop'.

New CNC machining centres are often bought against guaranteed performance on specimen jobs that often bring with them a tie-in to specific inserts, tool holders and manufacturers. If you are investing £1m in a new CNC machining centre you will want


4

Carbide lathe tool inserts I currently use.


5

Internet starter set for lathe turning.

›

SDJ lathe tool holders, left and right.

the security of a performance guarantee!

HSS is worked in a soft annealed state then hardened by molten salt baths before a final finish grinding and chemical coating. Sintered carbide is completely hard throughout and requires no further hardening after sintering. HSS tools often have carbon steel butt welded to the HSS to cut costs. This explains why morse taper shank hss drills have relatively soft tapers, you can cut them off and reuse the taper shank.

High speed steel in its hardened state is up to about 65 Rockwell C hardness. Carbide is considerably harder at 85 to 90 Rockwell C, calculated from Rockwell A for comparison purposes. Carbide tooling is considerably more abrasion resistant than HSS and stays sharp longer, even when worked at high temperatures where HSS will lose some of its temper.

Brazed carbide lathe tools

Photograph 1, bottom, shows a number of 'ancient' carbide tips intended to be silver soldered (brazed) to carbon steel supports and 3 typical brazed tip lathe tools. Brazing is very effective because the brazing alloy forms alloys with the cobalt binder. The brazing temperature has no effect on the carbide tip hardness and the braze supplies excellent support to the tip.

As you can see these inserts are very simple shapes and are just as they were sintered. The lathe tools of this type can be sharpened, preferably with a diamond embedded resin wheel. Personally, I avoid the often-recommended green grit, silicon carbide, grinding wheels for carbide inserts and stick with the diamond type. CBN (cubic boron nitride) also works very well but isn't readily available in the sizes our shops might require.

These brazed carbide tools were always advocated for taking the very abrasive outer later from sand-cast iron castings. They work well, are cheap for basic shapes and you can re-sharpen them quite easily. I have also had good success with brazed carbide lathe tools in a shaper machine on cast iron.

Photograph 2 shows a carbide tipped circular saw blade with brazed carbide inserts for wood cutting. I have placed a couple of ½" shank router bits designed to cut wood on top of the blade.

These inserts have been ground post brazing to give very sharp cutting edges. The grinding angles and carbide composition are selected for the material being cut. This saw blade is intended for wood, but I have others that fit a sliding bevel saw that can cut nail embedded wood, aluminium, steel and even plasterboard. Industrially, carbide tipped chop saws (cut off saws) are re-ground according to the material they will be cutting. They normally run slower than the domestic/hobby stuff and have a coolant supply to extend their life.

Lathe and mill insert tooling.

Photograph 3 shows a set of Glanze Indian made 12mm square shank lathe tools that take CCMT 060204 carbide inserts. It's looking a bit worn; I bought this set in 2010 and it has served me well. In hindsight, I now regard it as a starter set, because it doesn't cover grooving, parting off or screw cutting. Sadly, the cost of this set has escalated since I bought it. If I were starting out again with carbide I would search the internet for alternatives. Note: I shall use ISO codes for tool inserts and tool holders where ever possible. ANSI and DIN codes are different.

The same CCMT06 inserts fit smaller tool holders, 8x8 and 10x10mm that I use on my Myford lathe. Over the years I have consumed a lot of boxes of inserts from many manufacturers in these lathe tools. The supposed advantage of this insert shape and holder set is that it allows the use of both the 80°and 100° edges in different holders; It didn't really materialise for me and most of the supposedly stronger 100° edges remain unused!

Over the years I have had several Torx screws break or get a mangled head recess. These are supposed to be Swiss quality screws, but you should regard them as consumable items, wherever they are made. I bought replacement M2.5x 6mm screws and other sizes, direct from China, at a fraction of the UK price and a set of M2.5 taps from Arc Euro Trade to clean up any thread damage and to allow me to make my own custom tool holders. I have found that I can carefully mill out the broken screws from the back with a 1.5mm solid carbide 4 tooth end mill and hence return the tool back to service. In most instances, the end mill bites into the end of the broken screw and unscrews it from the holder rather than milling it out.

Experience has shown that these inserts are a little small for some turning operations on my 6" centre height lathe and subsequent purchases use bigger

Two Myford rear tool posts, parting.

8

MGEHR style parting tool holders.

inserts, with bigger screws and in some instances 16x16mm shanks. In most cases I find the next size up insert and its holder is worth searching for. For example, CCMT inserts are made with 6, 9,12, 16, and 19mm insert size. These are the cutting-edge lengths in mm.

Photograph 4 shows a collection of carbide lathe insets that I am currently using for general turning. These have been both sintered and coated. HIP pressing can produce quite intricate shapes without the need for grinding. Note the different chip breaker styles even for the same insert shape. Some inserts are thicker, being double sided and potentially more economical e.g. the trigon shaped, code w shaped inserts can have 6 cutting points that are particularly strong for heavy turning.

Coated carbide tooling

Photograph 4 shows inserts with a number of coatings applied after sintering by vacuum deposition. Usually coatings are applied in layers, each different. E.g. TiAlN Titanium Aluminium Nitride. Conveniently these coatings show distinct colours and wear points can easily be picked out with a magnifying glass or loupe.eg TiN is golden coloured.

Why coat? The coatings can be harder and even more abrasion resistant than the base Tungsten carbide; they can insulate against high cuttings temperatures and can prevent cuttings welding to the tool. Will I notice any difference in my Workshop? Probably not, unless you are working difficult nickel based heat resistant alloys and some aluminium alloys that can stick to the tool tips.

Do I need to use coolant? If you want industrial production feeds and rates, yes and lots of it. For most metals dry is fine but cutting oils or water based emulsions/ micro emulsions will definitely improve the turned surface finish. As with all turning, try it, and vary the conditions to optimise the results on your machine. The colour of steel turnings is a good indication of the stress you are placing on the tool and the machine. Silver, brown and blue, in increasing temperature of the turnings. The shape of the turnings from long chipping steels can also be an indication of the effectiveness of the chip breaker shape of the insert. Look at the spoon shaped tips of the three parting off inserts in photo 4.

I find there is a visible difference in the appearance of coated carbide and, come to that HSS tools, depending on its source. Chinese stuff can be dull and this usually indicates the item wasn't properly cleaned and honed/polished before vacuum coating.

Internet Purchasing

Most of our regular suppliers now have a presence on the Internet, especially eBay and their own in-house websites, all of which have on-line purchasing facilities.

There are also Chinese selling sites like Alibaba.com and Banggood.com where you are, apparently, dealing with Chinese Factories and distributors.

Because most carbide inserts and tool holders for turning and milling follow an international ISO naming convention it's easy to put a full or part description into these sites' search engines. E.g. CCMT. Try it! You will probably be amazed at the range of stuff available and the range of prices.

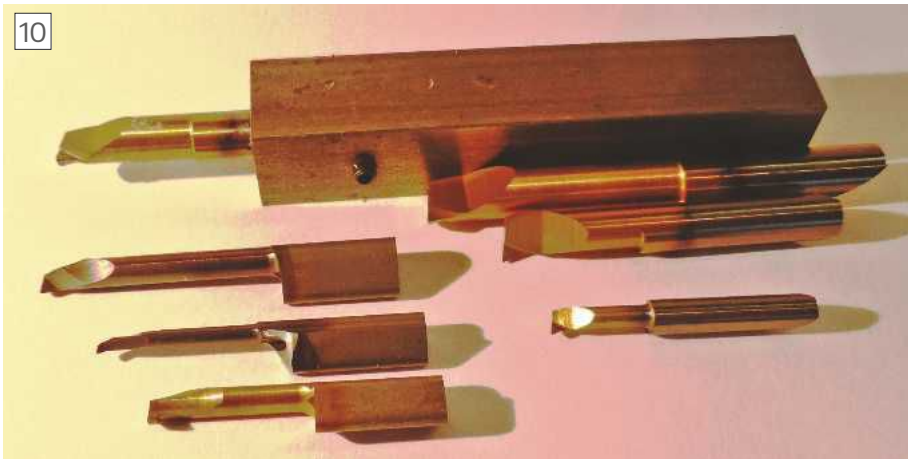
Remember many inserts and tool holders are made in China and you will find Chinese manufactured and supplied stuff and Chinese stuff supplied from UK or EU warehouses. The UK warehouses should be a safer bet for fast delivery but I have sometimes found a UK warehouse can often be a post box for a supplier in Hong Kong or Guangzhou; in which case air delivery times can be 1 to 3 weeks. Look out for delivery charges and look for those offering free postage. What If I want to return the item? Most UK internet suppliers and warehouses offer a returns system. For low value items, who cares, you just won't buy from them again?

My online buying experiences has been pretty positive so far, things arrive on time and generally work as expected.

Photograph 5 shows a typical 'starter set' for lathe Turning. 7 tools with inserts for general turning, boring, screw cutting and

9

R8 Face Mills



Solid carbide tools for internal boring etc.

PCB carbide drills and engraving bits.

grooving / parting off. The quality has proved to be good, the tools are clearly marked with ISO codes and they were individually boxed with Torx flag style wrenches.

Commercial escapees

On occasion, I get gifts of small parcels of inserts and tools from a local CNC engineering company that makes medical, defence and aerospace components. Often, I have had to find or make lathe tool holders to fit these inserts. Often the inserts I receive have loads of life left in them, some don't appear to have been used at all; they are always professional big-name quality. A case in point; around a year ago a gift contained 55° DCM and 35° VCMT inserts for which I had no tool holders. The inserts are not in boxes and unmarked, except for laser marked grade numbers on some. The CNC machining centres, of course, don't use simple holders of the type I use, they have magazines of up to 250 tools mounted in holders for their autochangers.

On my lathes, I have adopted Quick change tool posts and holders and wouldn't voluntarily return to shims and 4-way tool posts. I think I have about 30 tool holders for the 6" lathe and a lot less for the Myford.

I measured the longest side of each of the DCM and VCMT insert type and its thickness in mm and worked out the shape. You need to have access to reference works such as The Engineers Black Book or Mechanical and Metal Trades Handbook. Warning, some of the more unusual industrial escapee tooling does not appear to conform to International standards, maybe the standards have yet to catch up?

In general, I find positive tool holders work best in my hobby machines coupled with inserts that have a 7degree or larger relief angle and have a sharp edge. You need to be able to interpret all 10 fields in the Tungsten carbide turning and milling insert codes.

In the case of my gift inserts, a quick internet search produced left and right handed 12x12mm holders at a very low price delivered from a UK warehouse. **Photograph 6** shows a pair of left-hand and right-hand holders, their packaging, and inserts. The quality was good and everything fitted together well and turned beautifully. At the time, 2016, I struggled to find a neutral holder, (the insert pointing along the axis of the holder) which I find useful for roughing out Whitworth and BSF threads. The tool holders in photograph 5 are left and right respectively.

The only problem I have encountered with one import tool holder, out of many, was that the insert didn't sit squarely on the floor of its recess in the holder. I corrected it with a small carbide end mill, clamping the tool to the mill table. These holders have definitely been hardened, about 40 Rockwell, at a guess.

Inserts for parting off

If you cannot part off with HSS tools on your lathe there is little point in moving to carbide insert tooling. Sort out your problems with HSS first. From experience, parting off and any heavy force turning, like grooving and chamfering, is more likely to work, without chatter, if you remove the tool from the top slide and use a rear tool post or a tool post block attached to the carriage cross slide. For example, Tubal Caine's Gibraltar Toolpost.

Photograph 7 shows a pair of rear tool posts for a Myford lathe. The left-hand item is an original Myford fitted with an Eclipse tool holder and high cobalt 3/64" wide (ca 1mm wide) HSS blade. The right-hand item is a blade type holder with 3 mm wide carbide insert from RDG. The inserts used in these blades are usually coded GTN 'X' where x is the width in mm. For a smaller lathe GTN2 would be a better choice. For some reason, the Chinese will code these 200, 300 etc. I use similar bladed parting off blades in a quick change toolpost (QCTP) on my 6" lathe. It's more stable and I can get away with 2mm and 3 mm inserts and blades.

Be aware these blade holders don't last for ever, they have a hard life, and you need a 3mm blade for a 3mm insert. The insert cutting edge must be at centre height or fractionally above, to allow for tool movement under load.

More recently MGEHR style tool holders, which take double ended inserts have become available, see **Photo 8**. Here I show 2mm and 3mm wide inserts and their respective holders. My experience with these is very mixed. They seem to work best upside down in a rear tool post and will cut external groves and part off small components.

Holders for internal grooving, using the same double ended inserts are available, code MGMN; as yet I have not tried these.

Inserts for thread turning

If you have mastered single point thread cutting with HSS you might be tempted to go for internal and external thread cutting carbide inserts.

Tungsten carbide inserts for screw cutting have their own eight-field codes and their holders for internal and external threading.

These holders usually have negative angle seats, so called 'lay down' style and are widely available on the internet. See photo 5 of the starter set, where there are holders and inserts for internal and external threading. You will find carbide inserts for 60-degree thread angle Metric and US threads. Imperial thread inserts are much more difficult to find. Stick with HSS and re-sharpen regularly, we are not in a production environment!

Inserts for Milling

Face milling is a very versatile method of producing flat surfaces and, in my opinion, superior to fly cutting. **Photograph 9**

shows the 3 face mills I use with carbide inserts. As you can see my mill uses R8 tool shanks which I prefer to Morse taper, I have had both.

The 65mm diameter face mill, right, came from Arc Euro Trade and uses four triangular inserts and rather unusual clamp screws. It appears to be no longer listed. The two triangular insert, 30mm diameter, mill came from Glanze. See their respective catalogues. Of course, I use all these R8 tools with a drawbar.

Both these face mills work well and the larger one has machined many iron castings and used very few inserts.

The third mill in the photograph is an internet purchase and has a detachable head that utilises four APMT 1604 carbide inserts. This mill works well for me on a variety of metals. The internet deal comprised an R8 shank, BAP style 50mm diameter head and a box of 10 Taiwanese inserts, all for the 'normal' cost of a box of inserts. Should I want to change to round inserts later, I can just change the face mill head. Search face mill and your favourite shank style.

Solid Carbide Drills.

Solid carbide solid end / slot mills

I long ago dropped Morse taper in favour of R8. Import R8 tooling used to be a bit of a lottery on the fit, this example fits perfectly. My only gripe is that the supplied Allen head bolt wasn't long enough, easily sorted. The only downside to this style of detachable head face mill is the overall length, it robs height (table to tool tip) that my 6x26 mill doesn't have in abundance. Otherwise, I'm very happy with it.

Ground Carbide Tools.

The sintering process, described above, can also produce carbide rod up to 300mm length, that is then ground to very close tolerances. This material is traded, you can buy it from the internet sources quoted above. The cheaper stuff is often ungraded but it makes great tool bits for boring bars and tangential lathe tool holders. Remember that if you can cut and grind carbide rod, old milling cutters can also make great tool bits. Cutting and grinding carbide is relatively slow on home workshop equipment with diamond wheels, but worth doing. Avoid the dust.

Solid Carbide rod is the raw material for numerous tool makers who turn out drills, end mills, slot mills, boring bits, reamers etc. by grinding on CNC machines. If you are interested, search for five-axis Walter Helitronic machines. Flat and square carbide rod is commercially available and some of it makes great scrapers.

Photograph 10 shows examples of solid carbide tools intended for internal boring, grooving, recessing and screw cutting. These are really sharp and appear to come from Sandvik and Paul Horn and are clearly ground from solid carbide rod. As you can see, at the back, I have made simple holders for them from BMS square rod with grub screws.

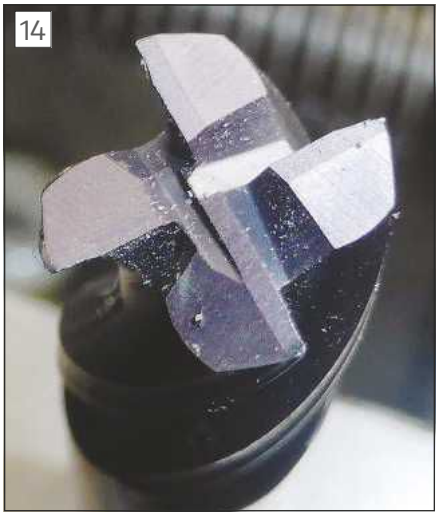
The Sandvik style have round shanks and are easier to mount than the Horn which have elliptical shanks. I have found it necessary to install a push rod and Allen grubscrew, through the square holder to eject the carbide tool. I normally drill and ream a suitable hole for the carbide tool. In use, the carbide will work its way into the low carbon steel holder, hence the ejector.

All these tools have through the tool cooling directed at the cutting point. I wonder how they get the through coolant holes through the carbide? Presumably it's put in before sintering.

Photograph 11 shows a number of solid PCB drills and engraving bits that mostly have 1/8" diameter shanks. These are very inexpensive on the internet. The PCB drills have very wide flutes to eject glass fibre debris but seem to work OK on soft steels. The engraving bits are extremely sharp, they really need those red tip protectors! They are shaped rather like a D bit and are available with different cone angle, 15, 20 and 30 degrees at least. At the bottom of photo 10 are 2 solid carbide end mills which work well on steel at normal mill speeds and feeds. One downside to all these small PCB tools is the speed has to be high and you may need a spindle to achieve the required rpm, 5k to 20K. PCB drills have to work on glass reinforced boards, which are very abrasive. These drills are normally colour coded for diameter, the largest in this set is 3mm.

Photograph 12 shows some larger solid carbide drills. These are very costly at the professional quality level and normally have 1 or 2 coolant holes running the full length of the tool. Useful if you want to bore holes in very hard materials. These will easily drill through file carbon steel and work fine without the coolant.

Photograph 13 shows a collection of solid carbide end mill/slot drills. I use them in preference to HSS whenever I can. I find the 4 flute centre cutting style the most useful on my mill. Some of these have been reground on the flutes and the end before I got them.



End cutting solid carbide cutter

Photograph 14 shows the end of one of these tools. They can be resharpened, this one looks like it needs it!

These tools are super tough and will even cut high speed steel provided you provide plenty of lubricant and slow down the feed rate and depth of cut. A power feed on the mill is essential for this operation.

Photograph 15 shows a piece of 200 x 25 x 4mm HSS being milled across with a 2.5mm carbide bit. This is hardened HSS as you may buy for lathe tool making, by grinding.

This piece was too long to be cut in half with my Clarkson T&C grinder with a diamond wheel and I didn't want to attack it with an angle grinder to avoid losing its temper. After cutting the HSS in several shallow cuts at 400 rpm, the end mill could still cut softer steels and leave a reasonable surface finish. They are tough!

Larger end mills can be used to profile HSS lathe tools, but that's another story, for another article, maybe!

Industrial carbide

Photograph 16 shows a collection of exotic carbide tools that escaped from CNC machine shops. Sadly, I cannot ISO code name them, maybe they don't have ISO codes. However, such things often turn up at UK ME shows, JB Tools for example often have a good selection of this sort of stuff. The 4 inserts to the left in 16 have 3 drive grooves, with screw fitting, and it's a fairly simple matter to make tool shanks to use these shapes in the mill. The other 2 are for turning grooves and small part, parting off.

Recycling Carbide

Industrial carbide users save up all their spent carbide and sell it back to the manufacturers/ recyclers. It's worth around £10/Kg in the UK. The WC and binder metal can be recovered and used again. I collect all my used carbide stuff and give it to a local small machine shop who adds it to his collection. It's worth brownie points, metal bar ends! I'm not aware of anybody recycling HSS in the UK. Outside the UK, HSS eventually goes back to China for re-melting.

So, I use carbide for everything?

Definitely not, Screw cutting is easier with HSS on home workshop manual lathes. You can easily pull the tip off a carbide threading insert if you don't make a recess for the tool to run into at the end of the thread. Screw cutting inserts ground from HSS are available so others must have had the same problem.

For dovetail and tee slot milling, I still use HSS, after removing the bulk of the material with carbide end mills.

Parting off with HSS in a rear tool post works well, even with a smaller lathe. 2mm wide carbide parting off inserts in a blade type holder also work in a rear tool post on the smaller lathe. Unless you have mastered screw cutting and parting off with HSS tooling you shouldn't expect carbide to be the answer to your machining prayers!!

Some aluminium alloys cause problems with carbide. The chips tend to work harden and weld themselves to the cutting tip and ruin the finish and dimensions of the part. Lubricant and polished inserts can help.


15

Milling hardened High Speed Steel.

For most hole drilling I use HSS drills. Split point HSS drills of decent quality are available on the web and most, I suspect, originate from China. Professional quality small HSS drills from the likes of OSG, Japan, are a delight to use on home maker equipment, especially if you can re-sharpen them.

Small hole boring, up to about 20mm deep, is best done with solid carbide boring bits, for example housings for bearings. These bits are really sharp and are available in a range of lengths and diameters. Some are definitely designed for micro machining.

The makers of quality HSS have adopted powder pressing and sintering technologies developed for carbide manufacture. Grades are often called HSS-E-PM, PM= powder metallurgy. These are very high cost premium options and solid carbide may well be a more economical solution for many cutting problems.

Conclusions

If you are a beginner, starting out with manual lathe work, refine your techniques to get good results with HSS tools, then give carbide a try, experiment with cutting conditions. Buy some pre-ground HSS lathe tools to get you started. Import carbide is definitely cost effective and it should cut a lot of metal, because it's so wear resistant. If you can get professional cast-off stuff, all the better.

If you are starting out with a manual mill it makes sense to dispense with the HSS stage and get a small carbide insert face mill and some solid carbide end cutting slot mills held in a collet chuck. You will probably still need HSS dovetail cutters and tee-slot cutters and these can be found on the internet.

For the romantically inclined 'tungsten' rings are thing. They are actually made of tungsten carbide, are virtually as dense, heavy, as gold and extremely wear resistant.

You can contact me by email with your comments, good or bad. mikehaughton@btinternet.com. Remember to recycle your used carbide! ■


16

An Indexer Control Map

Bob Reeve has made a function map for an Arduino Controlled Indexer

When Carl Wilson's article appeared in MEW 249 it was just what I had been looking for. Some years ago I converted my 4" dia. X3 rotary table to CNC operation to provide a 4th axis for the machine. It did what it was supposed to do, but it could no longer be used on my Thiel milling machine which is most definitely manual. There was a 9.5" diameter manual rotary table for the Thiel but it was too large for small jobs. The main difficulty being that the horizontal spindle would foul the rotary table unless there was a lot of packing to raise the job well clear of the table.

The Arduino controller was built and tested, **photo 1**, with Gary Liming's impressive software. It was then set aside to await the next suitable job. When it eventually came I had, of course, forgotten the intricacies of the software and had to re-learn it all again. By way of a learning aid I drew up the chart in **fig. 1** which is a combination of flow diagram and site map. I was surprised at the complexity and I would not be surprised if there are some intricacies that have escaped me. It did however reveal some idiosyncratic features buried away in the software, but more of that later. I hope that others will find it as useful, both as a guide and as a diagnostic tool when the unexpected happens.

My index controller was built pretty much following Carl's words and music. As in his, the temperature sensors were omitted. The software is version 2.3. My controls were biased switches which return to the centre position when released. These are shown in detail in **photo 2**. Holding the switch in position generates multiple steps through the menu. Anyone using it for controllers that are slightly different e.g. the number of steps or different ratios will need to make the necessary allowances. For example, the options that appear when the 'Ratio' option is selected will depend on what ratios were entered at setup and the sequence in which they were entered. The conventions used are as follows:-

Boxes represent a switched action (or button push for those using push buttons)
Single arrows represent steps that are not immediately reversible.
Double arrows alongside each other represent reversible actions
Double arrows sequentially represent multiple switch actions
Curved arrow representing clockwise motion
Curved arrow representing counter-clockwise movement

Features that were not immediately obvious (to me) were:-

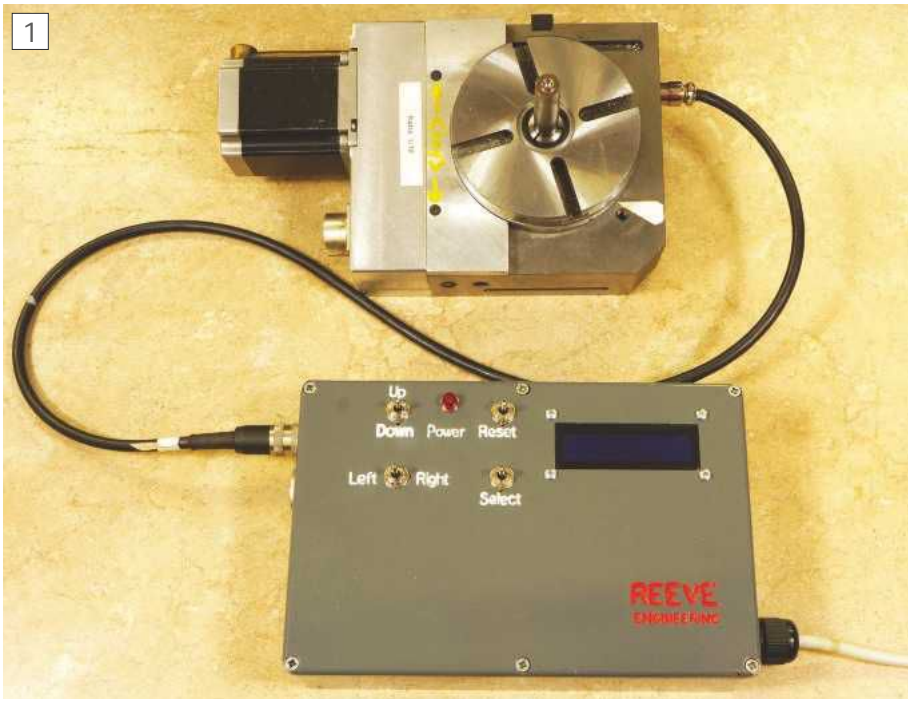
The select command used after an initial 'Select' to leave the main menu loop will usually return the programme to the same position in the loop.

The maximum speed of continuous running is designated Zero, higher numbers are lower speeds.

Continuous rotation always starts clockwise at maximum speed. Anti-clockwise rotation is achieved from the clockwise rotation, then reversing it.

From the 'Speed=0' position, any of the four directional keys and 'Select' will all initiate rotation

Having now used the device in anger, it occurred to me that there were a few extra features that might make it feel a bit more like Mach 3. Top of the list would be the ability to set zero with a 'Goto' command to return to it. Second on the list would be the ability to read the position directly in degrees. If someone has already carried out these modifications the details would be most welcome.



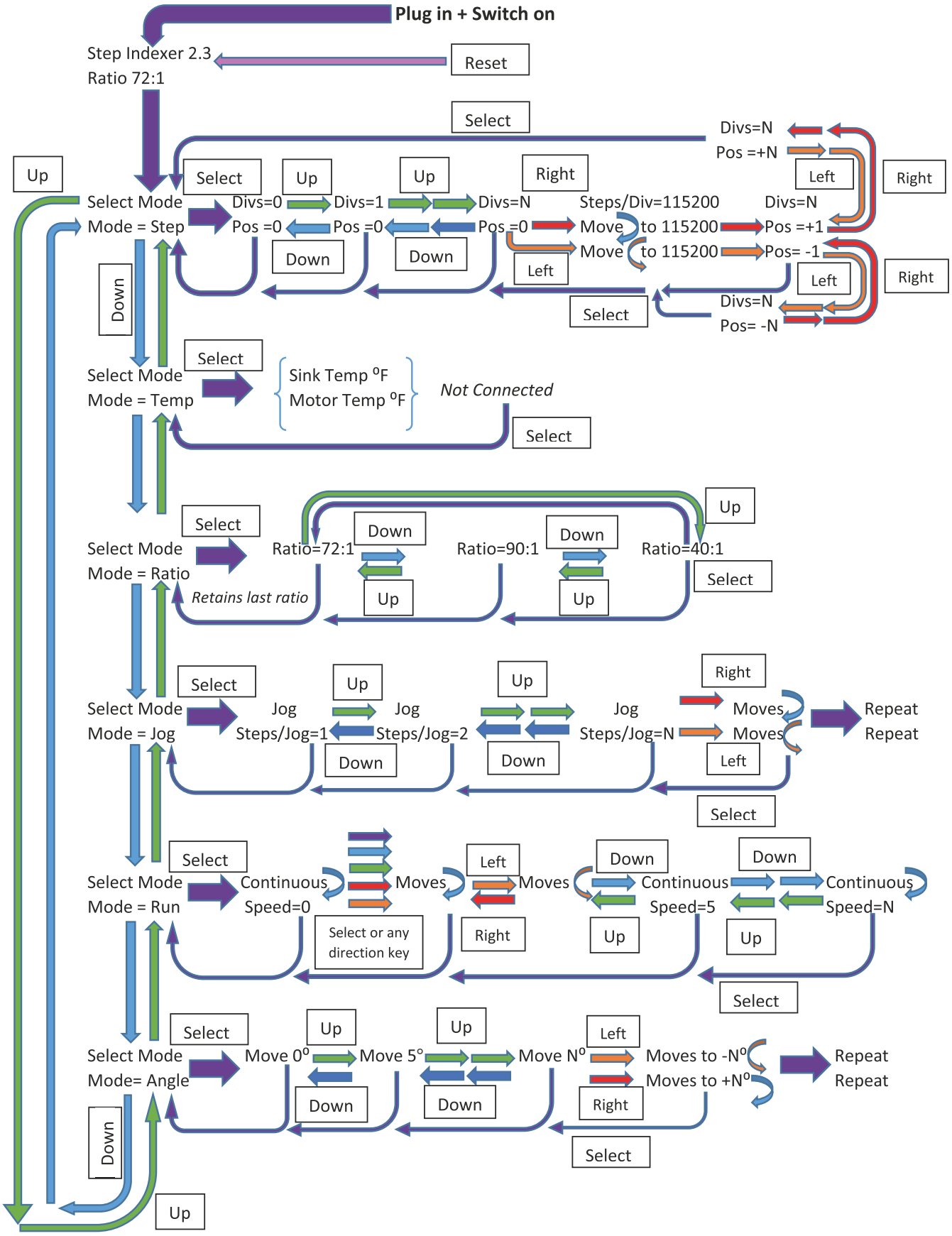
1

The author's Arduino indexer.

2

The control switches

Fig. 1. Arduino Controller



FOR SALE

A Dream (Steam) Home

Beautiful four-bedroom bungalow situated near the picturesque Gloucester and Sharpness canal with its own 370m ride on railway set within a large, well-kept garden.

The house is in beautiful decorative condition throughout and has four bedrooms, a kitchen Diner, a large heated workshop (approx. 6m x 6m), double garage and extensive parking.

The property also benefits from solar panels, eco insulation and RHI heat pump.

Outside there are well kept gardens with a greenhouse and an all year-round swimming pool.

The railway is a 5" gauge, ground level, ride-on railway with some 370m of aluminium track and PNP sleepers, a station/engine shed, turntable, passing loops, four sets of points and a loading ramp for visiting locos. There is a steam loco, three electric locos and several wagons and scale carriages. It passes through the garden and an area of woodland.

The asking price is £799,500 (which does not include the rolling stock) and is subject to contract.

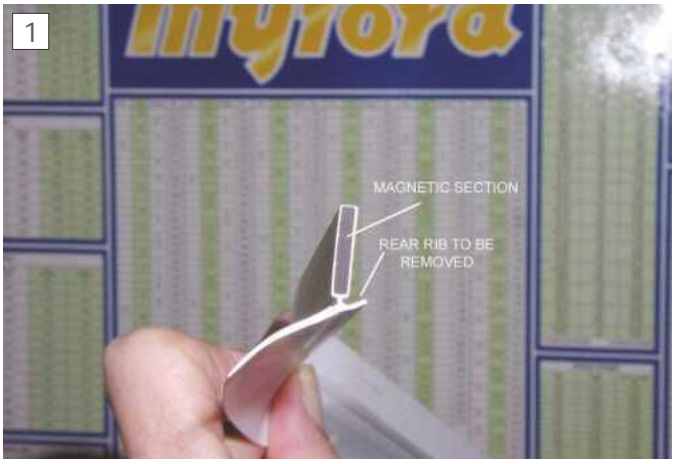
Please call on 01452 741410 or 07941 519689 for more details

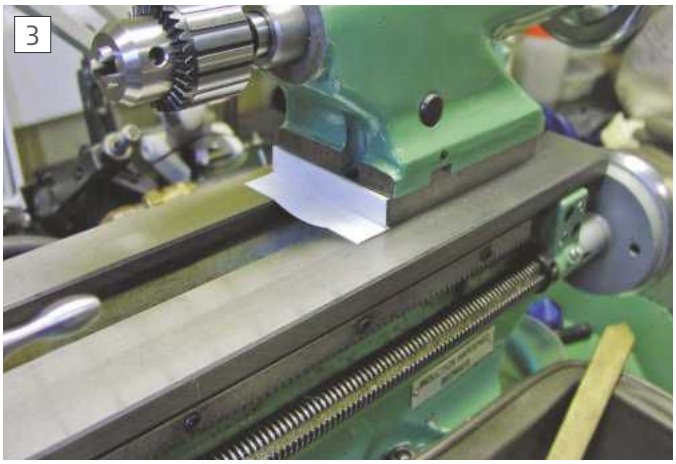
Readers' Tips

CHESTER MACHINE TOOLS

Magnetic Wipers

TIP OF THE MONTH WINNER!





Peter Reeve wins this month's Chester Vouchers with a tip for keeping swarf where it belongs, although applied to a Myford it should suit most flat bed lathes.

Over the years I have seen several articles in MEW referencing felt bed-wipers, for Myford lathes. I find them costly, fiddly to fit and prone to absorbing minute particles of steel swarf which are almost impossible to remove.

If the machine is not used for a period of time, these particles can quickly cause pitting of the bed way. (I speak from bitter experience).

I would therefore like to offer the following tip that can be applied to any machine.

I have abandoned the felt for a piece of magnetic sealing strip, salvaged from a defunct fridge freezer. It is made from flexible plastic and was originally used to seal between the freezer and its wooden carcass.

The piece I used had a small rib that I removed with a scalpel so that it would sit flat, **photo 1**.

It cost nothing; can be cut with scissors and clips magnetically to the front of the lathe cross slide and tail stock, **photos 2** & **3**.

It can be removed and wiped clean in a couple of seconds and has functioned flawlessly for more than 2 years.

I have also adapted it for my milling machine, **photo 4**. Hope other readers find this useful.

Keep up the good work.

Peter Reeve.

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 I'll chose 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.chesterhobbystore.com to plan how to spend yours!

Please note that the first prize of Chester Vouchers is only available to UK readers. You can make multiple entries, but we reserve the right not to award repeat prizes to the same person in order to encourage new entrants. All prizes are at the discretion of the Editor.

Milling for beginners

PART 1 - GETTING TO KNOW YOUR MILL

This new series will build into a complete guide to using a milling machine. This month Jason Ballamy starts right at the beginning by taking you on a tour of the new SX2.7 bench top Mill

Being quite active on the Model Engineer Forum and one or two others it is apparent that there are a good number of people buying hobby mills who have very little knowledge on how to equip and use them. For the older buyers it may have been many years since they used one for a limited amount of time at school, for the younger purchaser then they may not even have had any hands-on experience of using machine tools. I hope that this new series of articles will give the new mill owner or prospective owner a basic understanding of how to get the best out of a hobby milling machine.

Although I did metal work at school, actual hours on the mill were quite limited and not being from an engineering background what I write will be based on my experience as a home engineer using hobby type machines and not something based on industrial practice and industrial sized machines. I'm also of the opinion that if you put your mind to it a lot can be achieved with basic machines and tooling

There is a mill in there somewhere

Additional accessories shipped with the mill

so you don't need to rush out and equip yourself with masses of toolroom spec equipment to produce good work. Having said that I will be covering items that can make life easier or open up further machining possibilities though adding them to your tool collection can wait until the need arises.

The tools and methods described during the series will apply to most milling machines but concentrate on the bench top size as that is most likely what new comers to the hobby will purchase so don't feel things won't apply to you if you have just got a second-hand ex-industrial or educational machine and don't know what to do with it.

I will be using a SEIG SX2.7 mill supplied by the series sponsor ARC Euro Trade Ltd. This is a fairly recent addition to their range of bench top hobby milling machines and one down from their largest offering. Like several of the newer hobby machines this one uses a brushless DC motor which has

the advantage over the earlier DC motors of a lot more torque at lower revs. This in turn allows the machines to be built with out the need for an additional gearbox between motor and spindle which keeps the noise down and also substantially reduces the weight of the head assembly making winding the head up and down far easier then the DC/Geared combinations.

The mill comes packed in a plywood crate, **photo 1**, with blocks on the bottom so it can be moved by forklift or pallet truck, luckily my driveway is quite smooth so it was easy enough to pull it from the lorries tail lift and into my garage with the driver's pallet truck. If you have a gravel path or steeply sloping drive you will need to give some though prior to delivery as to how you will move the crate as having a large heavy 120kg box stuck at the end of your drive is not ideal. My workshop is in the back garden so after removing the top and sides of the crate the mill was slid onto a simple bogie made from a sheet of thick ply with a caster on each corner, this keeps the centre of gravity low so there is no risk of things toppling over if the ground is uneven, making it safe and easy to wheel round to the workshop. You will probably have to lay ply or similar over lawns or gravelled areas to allow wheels/ casters to turn if you need to cross them to get to your shop.

There are two options for mounting the mill. The quickest is to purchase a dedicated metal stand, these are best ordered at the same time as the mill as delivery can often be combined into one pallet which keeps costs down, the same applies to any accessories which can also be packed inside the crate with the basic machine, **photo 2**. There is storage in the bottom of the stand for tooling and a tray to catch the worst of the swarf. Or you can stand them on a sturdy bench, this can either be a timber framework with some shelves between the legs and countertop or as in my case a run of draw units with a kitchen worktop spanning the top. If you are tempted to use old kitchen units do fit a solid back to them as the usual hardboard backs don't offer much in the way of triangulation to stop the carcases twisting. Fitting a batten along the wall that the worktop can be fixed to will also help stiffen things up and stop the mill jumping about if using an out of balance cutter. If using the stand fix that to the floor and the mill to the fixings provided as the stand footprint is quite small not fixing it to the floor could see the whole lot topple over if something heavy is placed on the table when fully extended to one side. If on a bench it can be bolted right through with some large washers and nuts below. Don't get too worried about getting the mill exactly level so long as it does not rock you will be OK, the base casting is far more rigid than the top of the stand or your bench so they will deform as things are tightened rather than the machine.

If you are on your own an engine hoist is probably the safest way to lift the machine into position, a nylon strap around the head close to the column being the best option for getting a good grip of it, just make sure you don't trap any wires. A few strong friends or family may also be able to lift it into position, easier with the stand than a bench as you can get people down either side of it. The final option if you are mechanically minded is to break the machine down into 2 or 3 parts that can be lifted

3 *In its new place on the bench*

4 *Cleaned, Lubricated and ready to go*

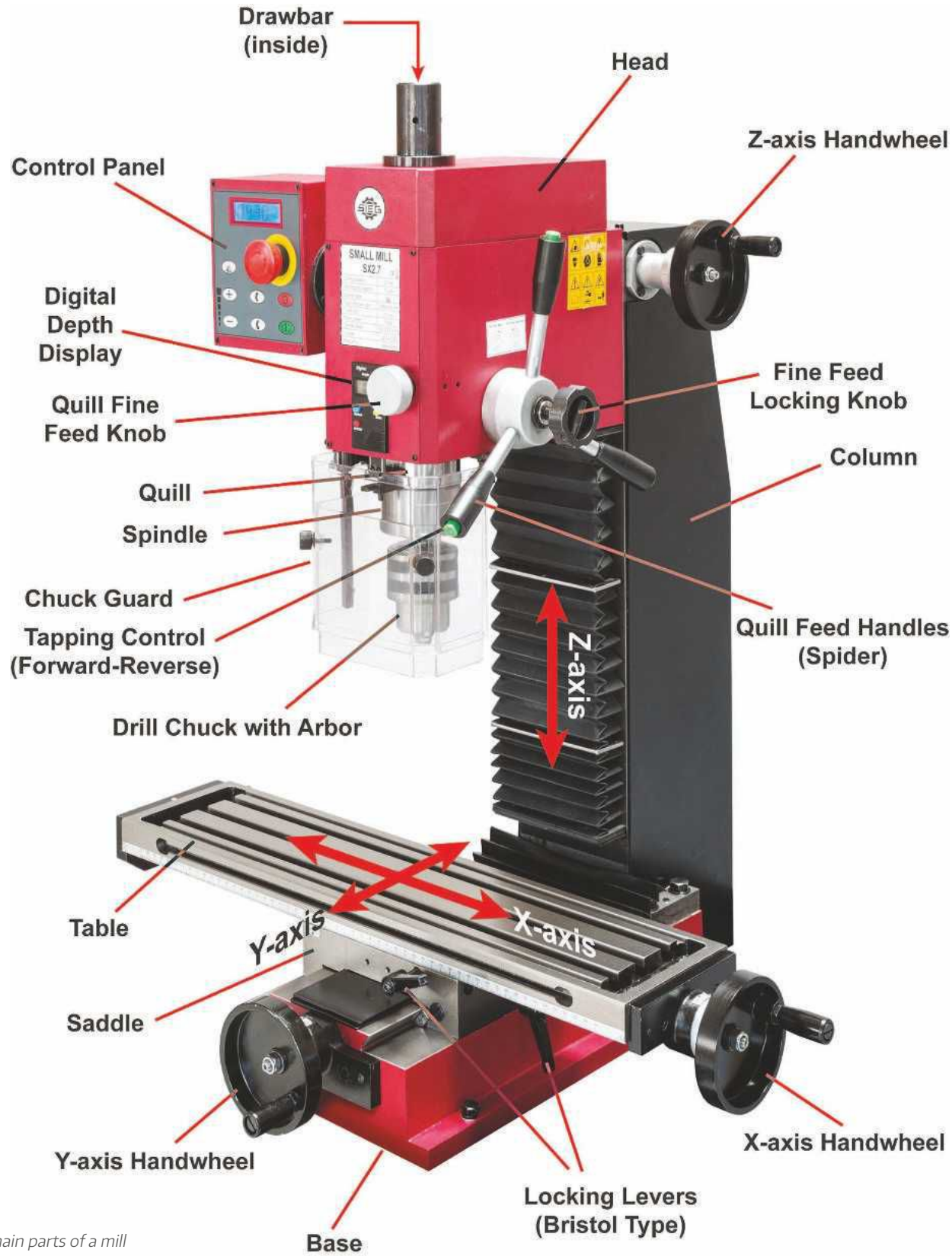
Positioning the Mill

When deciding where to place the mill make sure you allow sufficient space either side so that the table can fully traverse either way, on the SX2.7 this is approximately 200mm either side of the central position with a bit more to the right so the x-axis hand wheel can be turned without scraping your knuckles.

The height you mount the machine at will depend to some extent on how tall you are, aim to be able to look at the work on the table without having to bend down too far but also bear in mind you will have to reach up to turn the Z-axis hand wheel and having the table too high can make it difficult to lift heavy work or large tooling such as rotary tables onto the machine. The other height issue to think about is being able to remove the drawbar should you need to use one with an alternative thread. This is less common on a machine with a R8 spindle, as the tooling generally all has the same thread, rather than on a machine with a Morse taper where you may find three different thread sizes can crop up.

I have my own machine positioned diagonally across a corner which gives useful bench space either side so small tools and drawings can easily be place on the bench within easy reach. Part way along a straight wall is the other option and does allow longer work to be placed on the table provided there is clear bench space either side.

5



The main parts of a mill

and reassembled in position but you do risk upsetting the tram of the head which will need checking and adjusting if needed so not the best option if you are unsure. I removed the column/head from the base/table and with the help of my father lifted the two parts onto the bench, **photo 3**.

By now you will have discovered that these new machines come with a copious layer of anti-rust coating on the bright metal parts, this is best removed with old rags and a drop of paraffin or WD40. Once removed make sure you protect the clean metal with a wipe of an oily rag or better still a treatment such as Metalguard Ultra, lubricate the dovetail "ways" with a machine lubricant like 'slideway 68' and the leadscrews can have a smear of grease such as Molyslip MLG, **photo 4**.

Now the mill is in place it's time to get to know what is what, as I give a brief description of each part in bold refer to **photo 5** to see which part I am describing. The table is the main surface that work and holding fixtures are attached to, there are three "tee" slots along the length of the table that take shaped nuts or bolt heads to anchor things down. The table can be moved sideways by turning the X-axis hand wheel and front to back by use of the Y-axis hand wheel. Both hand wheels have a graduated scale on them that can be rotated independently to set the scale to zero against the fixed marker. The table can be locked in either direction by Bristol type levers as can the head, **photo 6**.

The column has a dovetail slide which the head moves along by turning the Z-axis hand wheel, this hand wheel can be positioned in various places depending on the particular make and model of mill. On the SX2.7 the motor is housed towards the rear of the head and drives the spindle directly via a toothed belt, this layout is certainly a lot quieter then my own X3 mill where the gearbox can get a bit noisy particularly when the cut is interrupted. The quill is used to move the spindle up and down in one of two ways, either by rotating the three-levered spider at the side which is the usual way when drilling, or by engaging the quill fine feed, the height of the tool can be adjusted more accurately to specific position. Some quill feed handles (spider's hubs) have a scale to give basic depth indication when drilling. However, this is not the case with the SX2.7. Instead there is a digital display on the front of the head which displays the feed depth for both the quill feed handles and the fine feed knob. The SX2.7 also has a tapping feature which is basically a quick forward - reverse-forward switch that allows you to back off a tap when threading and this is controlled by the green buttons on the ends of the levers, **photo 7**.

The lower end of the hollow spindle has a taper to engage with matching tooling, in the case of the machine used here that has an R8 taper, though a Morse taper is also quite common on this size of machine. (tapers will be covered more when we look at tool holding) At the other end of the spindle you will find a long bolt which is known as the drawbar and as the name suggests it is used to draw the tooling into the taper, on the SX2.7 the top of the drawbar is covered by the black cylinder you see sticking out the top of the head.

Mounted on the left side of the head is the control panel. This features a prominent red emergency stop button with the regular stop and start buttons below. To the left of those are the forward/reverse buttons and at the far right the speed up and down adjusters and above them the tapping button. Quite a few other variable speed machines will use a rotary knob to adjust speed rather than buttons. Finally, along the top is a digital speed readout to give an indication of what revs the spindle is rotating at, **photo 8**.

Other useful items

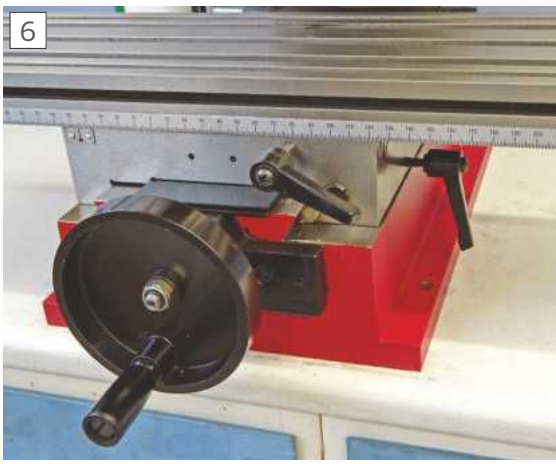
There are a few other items that will be needed useful when operating the mill which are not usually listed in the ME suppliers' catalogues:
12mm paint brush, an essential item to remove swarf from the working area and clean out the vice before mounting work.
6mm craft paintbrush and non- spill pot to apply and contain cutting fluid
Copper/hide hammer used to knock work firmly down into the vice and also tap the drawbar to eject tooling.
Work light, something like a small LED lamp on flexible arm will give good directional light to the workpiece

The mill comes with a 1-16mm drill chuck and selection of basic tools needed to operate it as well as a couple of tee nuts and bolts to get you started, **photo 9**.

Lastly a clear Perspex chuck guard which needs to be in the closed position before the machine will start. This is probably a good time to mention safety, although it is up to the individual when working in a home environment the supplied safety guards do serve a purpose so are worth using, if you find the ones fitted to your machine makes it hard to use and gets in the way it is worth investing in a separate safety shield on a magnetic base that can be positioned where it suits. I would also advise investing in a pair of wrap around safety glasses as chips will always find their way past any fixed guard and it soon becomes second nature to put them on before switching on any machine.

Well that is the basic introduction to a bench top hobby mill which hopefully has given an insight into the machine and getting it into position and ready to use. Over the coming months I will start to cover such things as Tool holding, cutting tools, work holding, etc and how to use these things to shape metal. ■

Quill lever feed and tapping switches



Y-axis hand wheel and locking levers

The SX2.7 mill and lubricants mentioned are available from Arc Euro Trade, www.arceurotrade.co.uk, who also sell the X series mills if you want something larger or smaller.

Control panel, quill DRO and fine feed knob

Supplied drill chuck and tool kit

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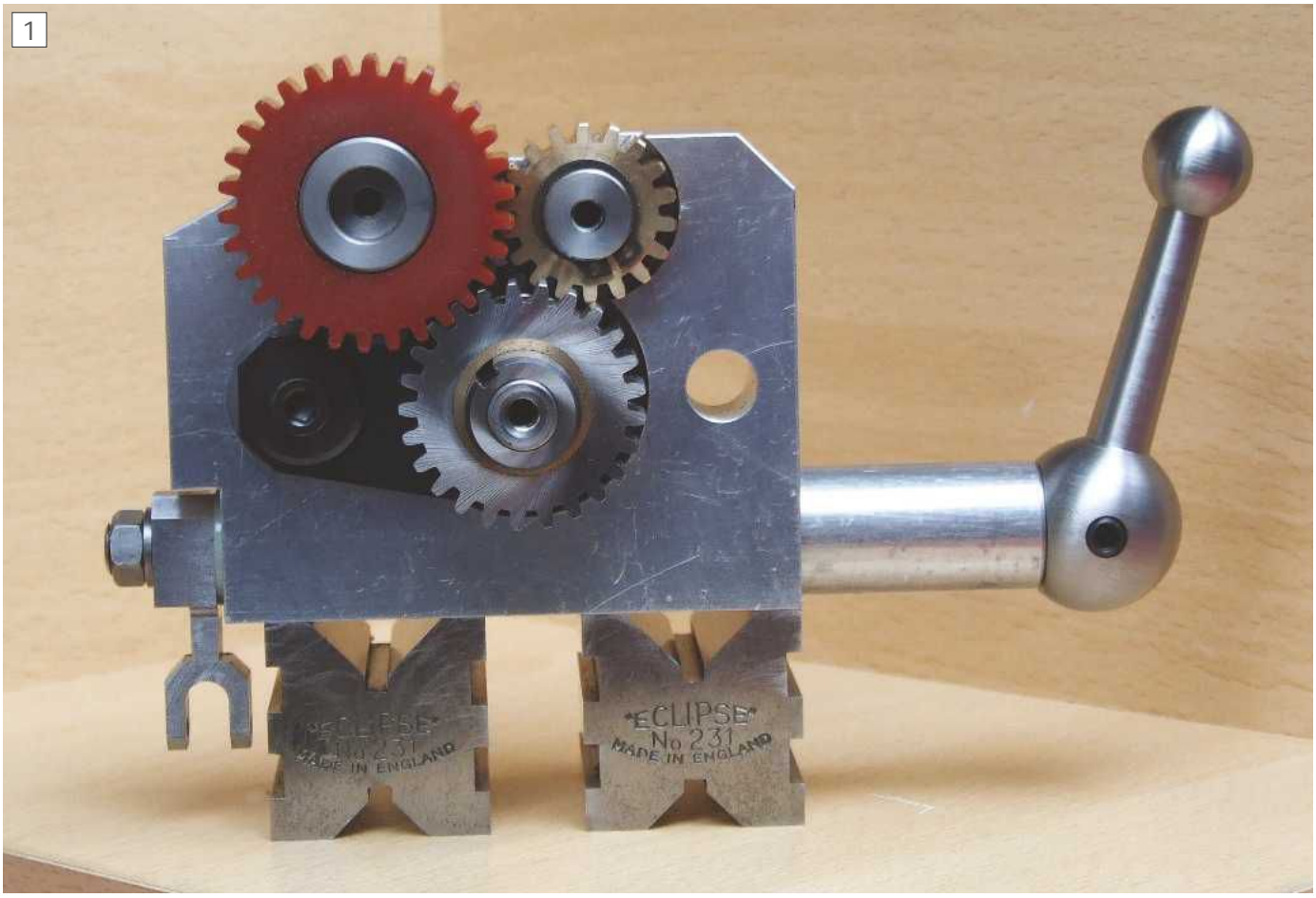
The development and design of a **Screwcutting Clutch for the Myford ML7**

Graham Meek recounts how he came to revise his design for the ML7 and gives advice on its making and use.

The screwcutting clutch for the Myford Super 7 was designed in the early 1980s. It came about from a conversation I had with Neil Hemingway concerning a metric feedscrew for George Thomas's Retracting Topslide. Neil said he did not supply metric feedscrews, to which I replied I would have to make one on the Hardinge at work in that case. At that time I did not have the Myford Metric conversion set for my 7B. The next comment from Neil was that he wished he had the same screwcutting facility on his Myford S7. This started me thinking about a screwcutting clutch design for the S7. Several years pass due to work pressures before the final design reached fruition. Initially 3 units were made, one for Neil, one for Ken Swan and one for myself. The last unit was never fitted as in between times I had changed from the S7 to my Emco Maximat Super 11. My unit was sold to a local engineering works, as at that time they had no Hardinge and needed this facility. The unit is still in use today by their apprentices, 30 years on. Despite being used on a production basis initially and later by apprentices the unit



ML 7 Prototype

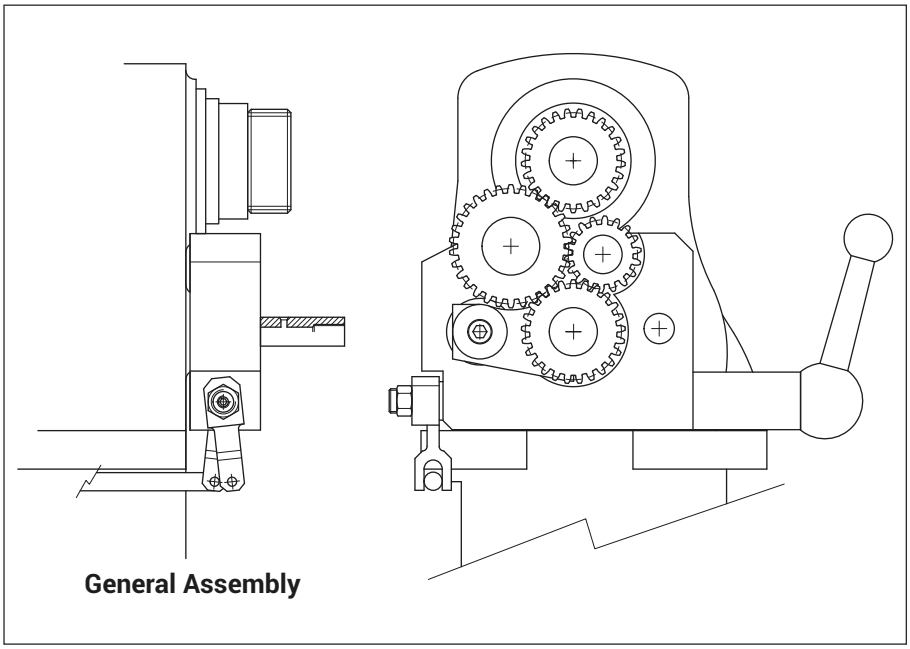
has not suffered any breakages. Whilst I was familiar with the operating principles of the Hardinge at the time I designed the initial S7 units, it was not until some 20 years later that I saw the inside workings on an actual machine.

Many people have stated that my design is a follow on from Martin Cleeve's design. I would like to set the record straight and say this is not the case. Martin's design although known to me at the time of designing my own unit, has the drive in one direction only, towards the headstock. From memory of his design, (which incidentally I greatly admire for its ingenuity), has a spring-loaded clutch with several levers actuating this clutch. Return to the start position of the thread was done manually by disengaging the clasp nut, on a stationary leadscrew and returning the carriage to a predetermined position towards the tailstock and then re-engaging the clasp nut. This distance was exact multiples of the thread pitch being cut. The correct return position was ensured each time by a large tension spring and a bed stop. The modification was so extensive at the headstock that the original guards could not be fitted. At this point the reader will have realised it is not possible to cut a left-hand thread using Martin's device.

The 'Meek' screwcutting clutch as many have come to call it works exactly like the Hardinge. Stops are set to the required length of the thread in relationship to the workpiece. After selecting the correct pitch and touching the tool onto the diameter; the cross-slide is set to zero. After engaging the clasp nuts the spindle is started and screwcutting commences by whichever method the operator prefers, ie, 'plunge in' or 'offset topslide'. To move the carriage towards the headstock the ball handle is pushed in the direction of travel. The tool will then move across the work until the carriage trips the dog clutch. The tool will at this point make its own undercut, unless one is provided. Withdraw of the tool and flicking the ball handle towards the tailstock will return the carriage to the start position ready for the next cut to be applied. This procedure is repeated until the thread is finished. There is no need to use backgear on normal ME pitches; stop and start the motor as with a Metric thread or disengage the clasp nuts until the thread is finished. A more detailed setting up procedure for the trips follows at the end of the article.


2

Main Shaft




3

Super 7 Tumbler Gear retention, courtesy of John Slater

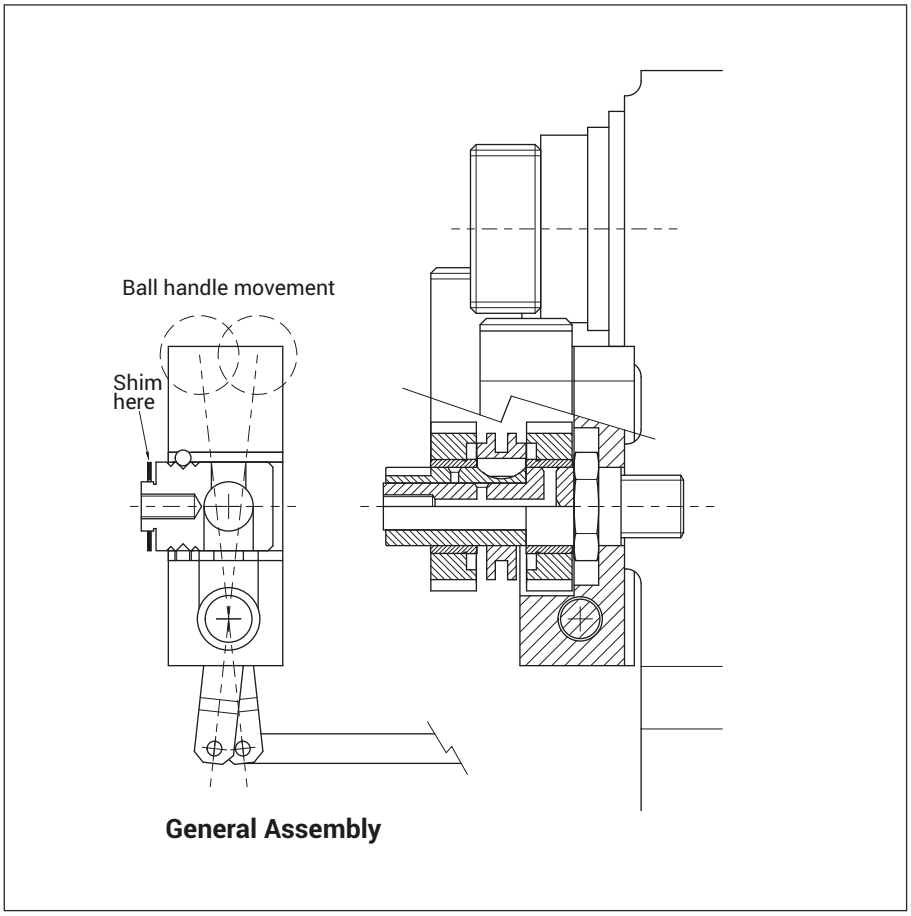
The design for the ML7 version did not come about until much later. This design only materialised following many requests from the ME Forum members for me to design a unit for the ML7 following the debut of the S7 unit on the forum and in print. Work on the ML7 screwcutting clutch finally started in 2011. Thanks to the help of several Forum members I was able to glean enough dimensional information to complete the design. As with the S7 I was also fortunate to be loaned an ML7 headstock assembly. This greatly assists in the sculpting of the main body and ensures there are no fouling issues with the headstock casting. One particular member of the forum wanted to purchase the prototype which you see in **photo 1**. The fact that I have not heard from him since seems to indicate the design was a good one. This has been borne out by the large number of PDF's I have sent around the world, (free of charge), to those who have asked for them.

One might think that fitting the screwcutting clutch to the ML7 would just be a simple matter of adapting the existing S7 unit. However, the differences between the two lathes are quite significant. For one thing the 'Tumbler Reverse Shaft' is

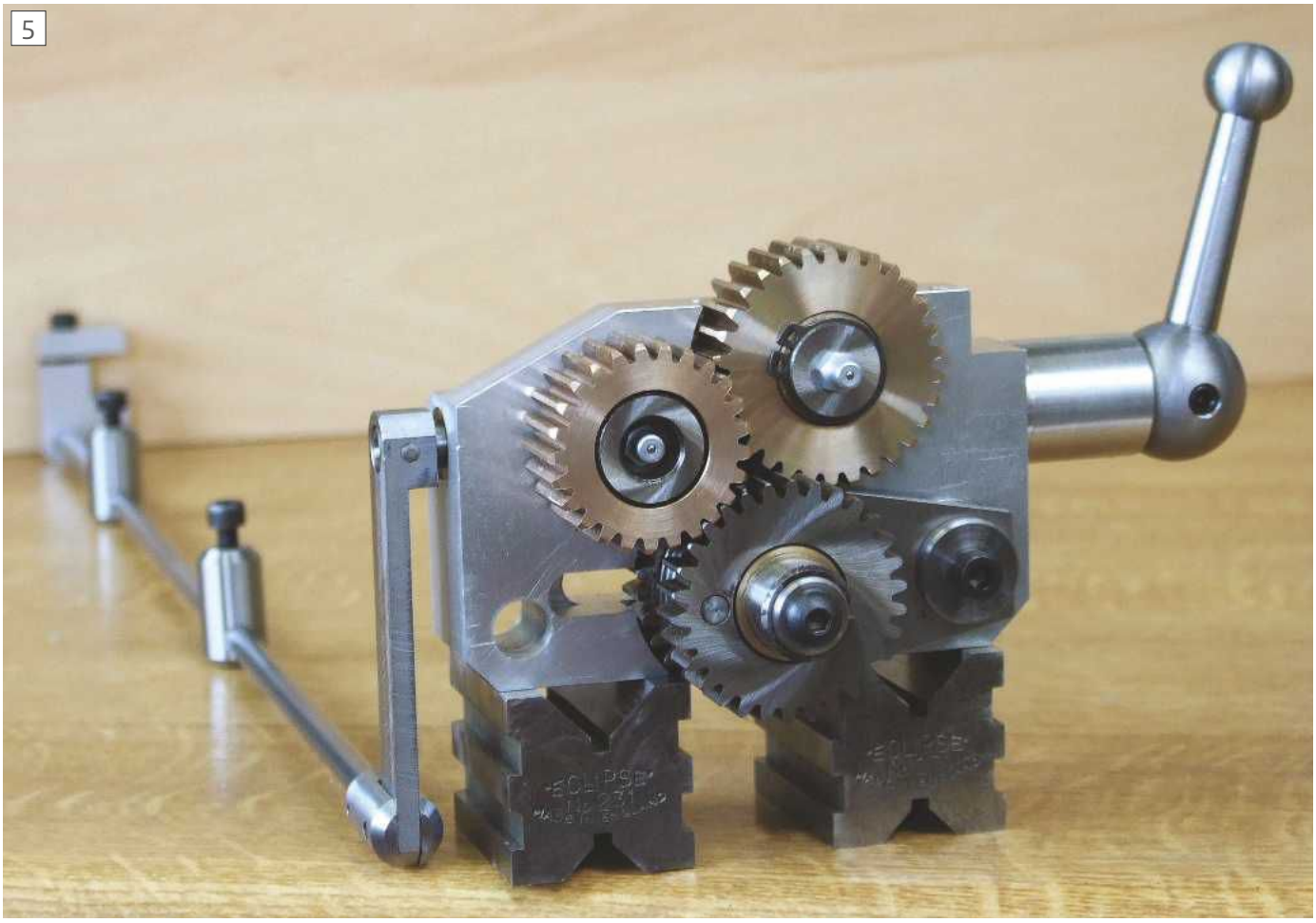
›

S7 Screwcutting Clutch shaft, note angled undercut, courtesy of Phil Proctor

retained by a thread on the ML7, **photo 2**. While on the S7 it is retained by an angled adjustable bolt which sits in an angled undercut, **photos 3** & **4**. A further complication is the gears used on the S7 are 20 DP with a 20 degrees pressure angle (PA), while those on the ML7 are 20 DP but have a 14.5 degrees PA. Further complications arise from the position of the tumbler shaft relative to the spindle centre-line. There was also the hexagon head on the tumbler shaft to cater for, which is not present on the S7. This alone severely restricts the amount of space available to fit the necessary parts of the clutch into. It was decided in the end that the design needed a complete start from scratch approach. By comparing photos 1 & 5 the reader will

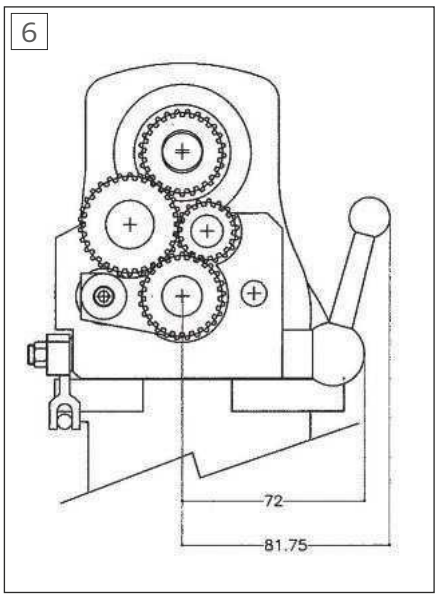


General Assembly



The Finished S7 Clutch Unit.

6



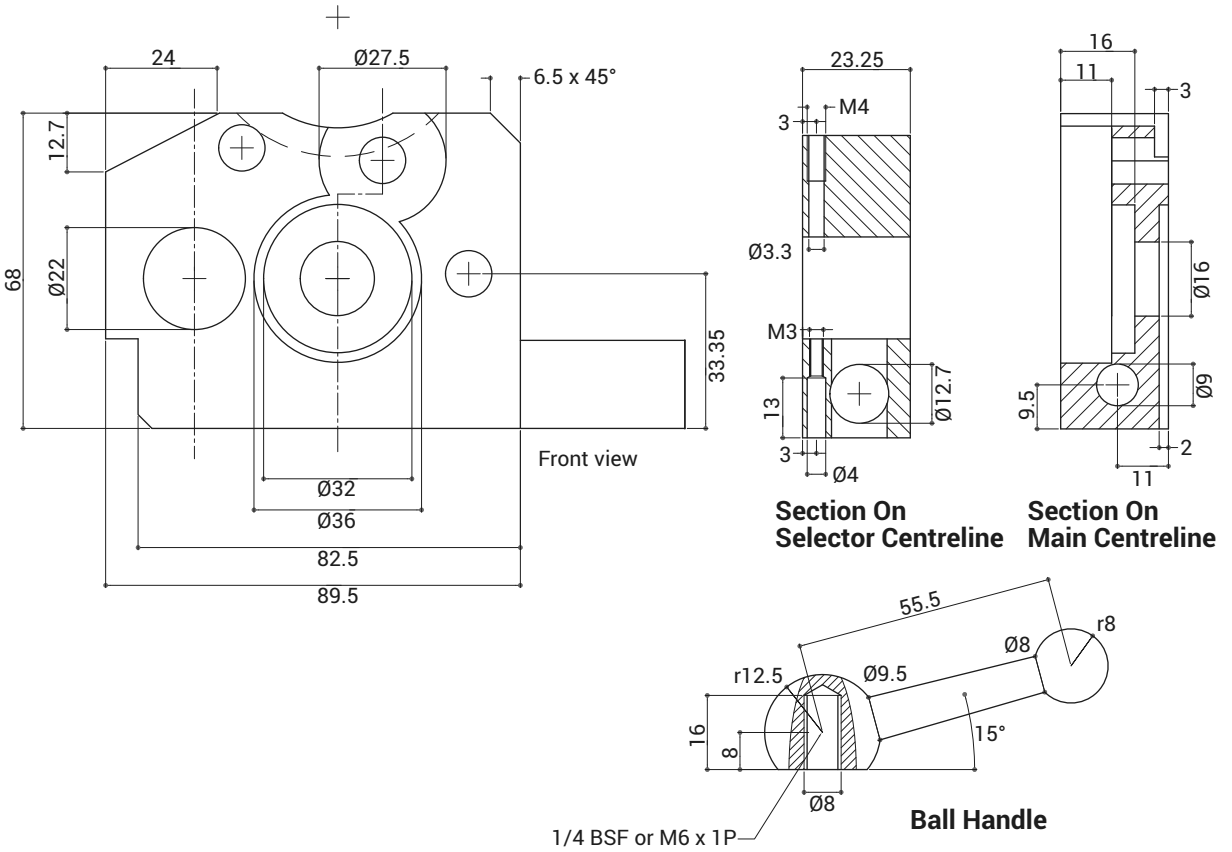
ML7 For Sparey Box

7

Dog Gears

soon realise some of these differences. On the ML7 version the selector shaft sits below the tumbler shaft position while on the S7 it is above. This in itself prompted a further ML7 modification requiring the shortening of the original selector shaft to miss the gearbox on those lathes equipped with a 'Sparey' type screwcutting gearbox, details of this mod are provided in **photo 6**. The input gears of the ML7 are radically different for the S7, necessitating one small bronze input gear on the ML7, so as to miss the spindle gear and the inside of the cover casting. It will also be seen that the position of the selector has moved to the rear of the unit on the ML7 version.

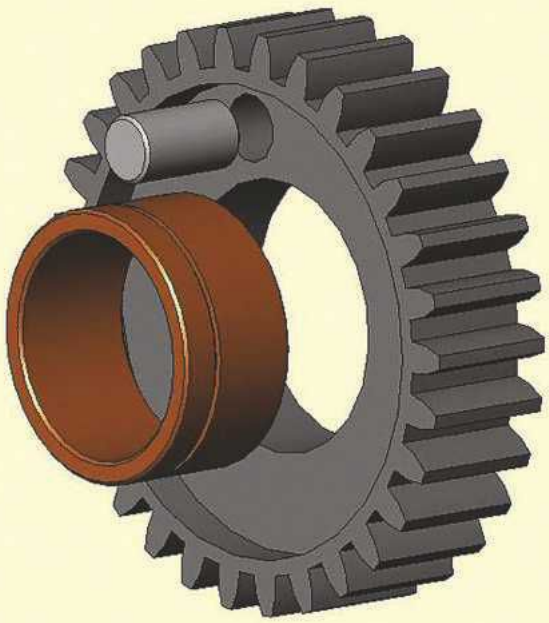
In order to get the dog clutch unit into the space available due to the hexagon head on the new tumbler shaft, and the smaller diameter gears involved, it was necessary to move away from the circular dog used on the S7, see **fig. 1**. The ML7 output gears therefore use an integral machined dog photo 7. The proximity of the head of the bearing bush shows there is little room to spare. The machined dog on the output gear means the circular track used for the clutch on the S7, see **photo 8**, was no longer possible. Instead the design on the ML7 is shown in **photo**



9. It will be noticed that the dogs are machined such that the keyway utilises the additional bearing area afforded by the material available because of the dogs, and thereby helps to stop the thin clutch from tipping on the output shaft during the selection process. Ideally the keyway needs to be the first machining operation after turning. That way the keyway can be used in conjunction with a simple jig that locates in this keyway to provide the necessary orientation when it comes to machining the dogs. This will ensure they are symmetrical about the keyway, not that this is critical, it just looks better.

Work started on the prototype with the main body, **photos 10** & **11**. On the S7 and the ML7 versions this was made from aluminium. While I used aluminium, there are others who have deviated from this and used cast iron or mild steel. Nothing is written in stone; however the latter does seem to me to be hard work. Other than careful workmanship to ensure that all faces are flat, square to one another; as well as all

Fig.1



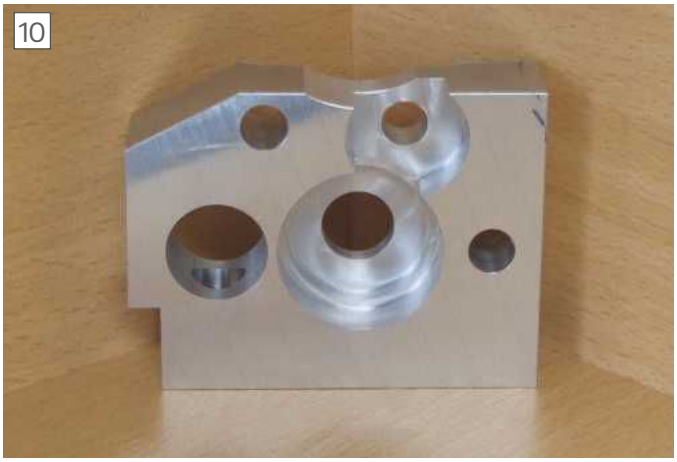
8

Finished S7 Selector Ring

9

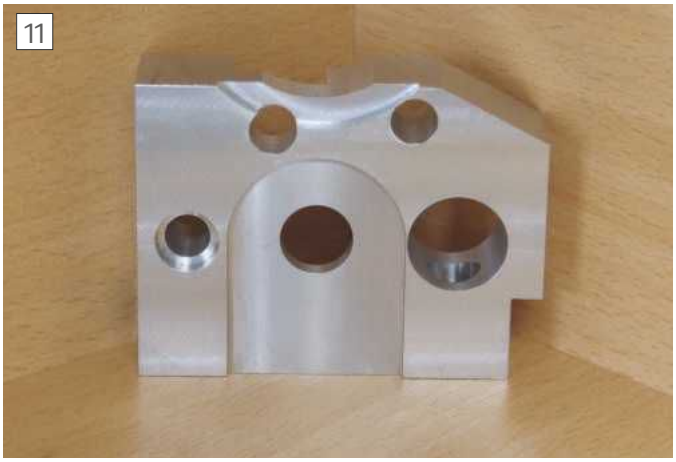
Dog Clutch and Output Shaft

10



Front view of ML 7 Screwcutting clutch body

11

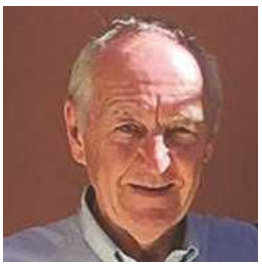


Rear view of ML 7 body

bores are perpendicular to those faces and at right angles where necessary this part requires no comment from me. This main body does benefit from a separate boss piece, rather than a machined integral boss. This is another method of construction used by a constructor of the S7 version which I thought would save a lot of material on the ML7 version. There are two dimensions for the head of this extension boss. One is for the standard-length selector shaft and the shorter one is for the Sparey Gearbox. There is no reason why the reader cannot use the shorter version if he or she prefers.

To be continued.

Making Meccano Gears



Chris Taylor makes a return to the hobby

Fig.1

Teeth	Blank Size (OD)		Cutter	DP: 38		Depth of Cut: 1.44	Meccano Part No.	Angle: 360/Teeth	Turns	Plate	Turns / Holes	
	mm	ex "		Pitch Circle Inches	Face	Meshes With						
7	6.02	1/4	-	0.184	1/4"	70t Gear	26z	51.43	12.8571	B 21	12	18/21
10	8.02	3/8	-	0.263	1/4"	30t Pinion - 66t Gear	26m	36.00	9.0000	-	9	-
11	8.69	3/8	8	0.289	1/4"	26t Pinion - 66t Gear	26n	32.73	8.1818	B 33	8	6/33
13	10.03	1/2	8	0.342	1/4"	26t Pinion - 65t Gear	26r	27.69	6.9231	C 39	6	36/39
15	**11.36**	1/2	**7**	0.395	**1/4"**	**22t Pinion - 60t Gear**	**26c**	**24.00**	**6.0000**	-	**6**	-
16	12.03	1/2	7	0.421	1/4"	22t & 24t Pinion - 60t Gear	26g	22.50	5.6250	A 16	5	10/16
17	12.70	**1/2**	6	0.447	1/4"	20t Pinion - 50t Gear	26h	21.18	5.2941	A 17	5	5/17
19	**14.04**	5/8	**6**	0.500	**1/4"**	**19t Pinion - 57t Gear**	**26**	**18.95**	**4.7368**	**A 19**	**4**	**14/19**
19	**14.04**	5/8	**6**	0.500	**1/2"**	**19t Pinion - 57t Gear**	**26a**	**18.95**	**4.7368**	**A 19**	**4**	**14/19**
19	**14.04**	5/8	**6**	0.500	**3/4"**	**19t Pinion - 57t Gear**	**26b**	**18.95**	**4.7368**	**A 19**	**4**	**14/19**
20	14.71	5/8	6	0.526	1/4"	17t Pinion - 56t Gear	26l	18.00	4.5000	A 20	4	10/20
22	16.04	3/4	5	0.579	1/4"	15t & 16t Pinion - 55t Gear	26f	16.36	4.0909	B 33	4	3/33
24	17.38	3/4	5	0.632	1/4"	15t & 16t Pinion	26p	15.00	3.7500	A 20	3	15/20
25	**18.05**	3/4	**5**	0.658	**1/4"**	**13t Pinion - 50t Gear**	**25**	**14.40**	**3.6000**	**A 20**	**3**	**12/20**
25	**18.05**	3/4	**5**	0.658	**1/2"**	**13t Pinion - 50t Gear**	**25a**	**14.40**	**3.6000**	**A 20**	**3**	**12/20**
25	**18.05**	3/4	**5**	0.658	**3/4"**	**13t Pinion - 50t Gear**	**25b**	**14.40**	**3.6000**	**A 20**	**3**	**12/20**
26	18.72	3/4	4	0.684	1/4"	13t Pinion - 50t Gear	26q	13.85	3.4615	C 39	3	18/39
27	19.38	7/8	4	0.711	1/4"	10t & 11t Pinion - 50t Gear	26s	13.33	3.3333	A 18	3	6/18
28	20.05	7/8	4	0.737	1/4"	10t & 28t Pinion - 50t Gear	26t	12.86	3.2143		*	
30	21.39	7/8	4	0.789	1/4"	10t Pinion - 45t Gear	26k	12.00	3.0000	-	3	-
38	**26.74**	1 1/8	**3**	1.000	**1/4"**	**38t, 76t & 152t Gears**	**31**	**9.47**	**2.3684**	**A 19**	**2**	**7/19**
45	31.42	1 1/4	3	1.184	2mm	30t Pinion	27g	8.00	2.0000	-	2	-
50	**34.76**	1 3/8	**3**	1.316	**2mm**	**25t & 26t Pinions**	**27**	**7.20**	**1.8000**	**A 20**	**1**	**16/20**
55	38.10	1 1/2	2	1.447	2mm	22t Pinion	27e	6.55	1.6364	B 33	1	21/33
56	38.77	1 5/8	2	1.474	2mm	19t & 20t Pinions	27j	6.43	1.6071		*	
57	**39.44**	1 5/8	**2**	1.500	**2mm**	**19t & 20t Pinions**	**27a**	**6.32**	**1.5789**	**A 19**	**1**	**11/19**
60	**41.44**	1 3/4	**2**	1.579	**2mm**	**15t & 16t Pinions**	**27d**	**6.00**	**1.5000**	**A 20**	**1**	**10/20**
65	44.78	1 7/8	2	1.711	2mm	11t & 13t Pinions	27k	5.54	1.3846	C 39	1	15/39
66	45.45	1 7/8	2	1.737	2mm	10t & 11t Pinions	27h	5.45	1.3636	B 33	1	12/33
70	48.13	2	2	1.842	2mm	25t & 7t Pinions	27t	5.14	1.2857	B 21	1	6/21
76	52.14	2 1/8	2	2.000	2mm	38t Gears	27m	4.74	1.1842		*	
95	**64.84**	2 5/8	**2**	2.500	**1/16"**	**19t Pinion**	**27c**	**3.79**	**0.9474**	**A 19**	**0**	**18/19**
133	**90.24**		**2**	3.500	**1/16"**	**19t Pinion**	**27b**	**2.71**	**0.6767**	-		
152	102.94		1	4.000	2mm	38t Gears	27p	2.37	0.5921		*	
171	115.64		1	4.500	2mm	19t Pinion	27r	2.11	0.5263	A 19	0	10/19

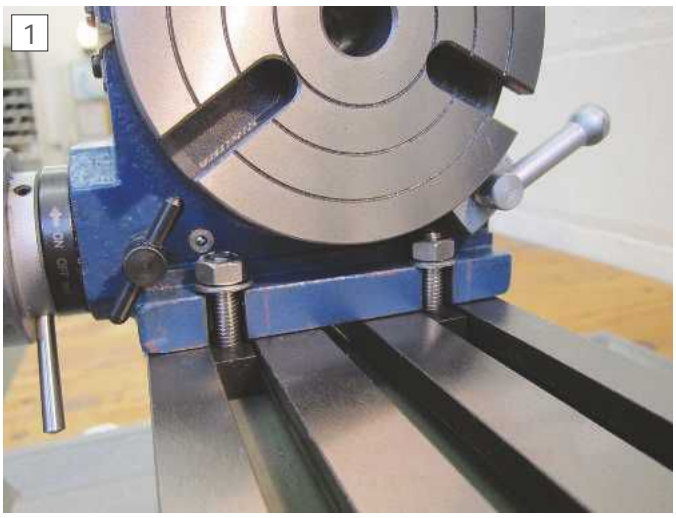
Thirty years ago, I was restoring Austin Sevens, I had a Myford 254 Plus lathe and an Emco mill drill and an engineer friend gave me an Engineering Training Board Instruction Manual (*Turning 1*). I taught myself to use the lathe and the mill by making many parts for the Austins, including spending six months machining a set of broaches for splining new steering wheel boss castings. I eventually moved on and the cars and the machines were sold, but the satisfaction of machining stayed with me and in retirement I decided it would be a good hobby to revive.

I took out subscriptions to ME and MEW and bought a Chester DB7VS mini-lathe and Conquest mill drill and after setting them up and messing about for a bit, I looked for a project that would involve a lot of different machining aspects to get my hand and eye back in. There are several 'project' books, but I needed to do something from scratch that would be useful. Being a Meccano enthusiast, I thought of gears. Pinions and gears with non-standard numbers of teeth have been available for years from replica suppliers but I had never acquired any for my collection, so that was the plan.

I studied Ivan Law's book and familiarised myself with the geometry involved, diametral pitches and pressure angles (there has been some debate about this but I decided on 38 DP and 20° PA. I acquired a Vertex rotary table with a 1:90 ratio and calculated all the reasonable possibilities, from 7 to 171 teeth, stuck it all on a spreadsheet, **fig. 1**, and added the data necessary to set everything up.

There seemed to be three main challenges:

1 How to make or acquire 38 DP/20 PA cutters.



Mounting the Vertex rotary table on the milling machine using slots milled in the base.

Turning a 20t blank in the lathe using a parting/grooving tool.

2 How to make multiples of each type but minimise repetitive setup operations.
3 How to accurately and repetitively cross drill and tap the bosses.

The project nearly ground to a halt with the cutter problem. I decided I was not skilled enough (just yet to make my own and was quoted £984 for a set of 8 from a UK company! This was nearly as much as the lathe and mill cost together.

A selection of blanks after the teeth had been cut.

Cutting the teeth on a 26t blank

I was saved by the internet and bought a new set of 8 cutters from an Indian tool company! These are standard 2¼" diameter Brown & Sharpe type, and they do the job.

Mounting the dividing head vertically on the milling machine table also caused me some thought, but after consulting the MEW forum, a solution was found by milling a couple of slots in the front edge for clamping in the Tee slots, **photo 1**, and using a simple clamp in the slot in the casting on the back. The head was set up parallel to the x-axis by using a dial gauge on a test bar in the chuck.

To maximise the output from each setup, I turned multiple blanks on the lathe, each formed with between 2 and 6 gears, **photo 2**, using a parting/grooving tool. The factor limiting the number of gears on each blank, learnt from experience, was the distance between the dividing head chuck and its tailstock to avoid cutting teeth in either. The larger the gear diameter, the more blanks could be cut as shown on **photo 3**. The smaller gears needed a different approach in order to maintain the standard boss diameter; these had the teeth cut from the centre or the ends.

The first operation was to machine the brass bar to the exact outside diameter

›

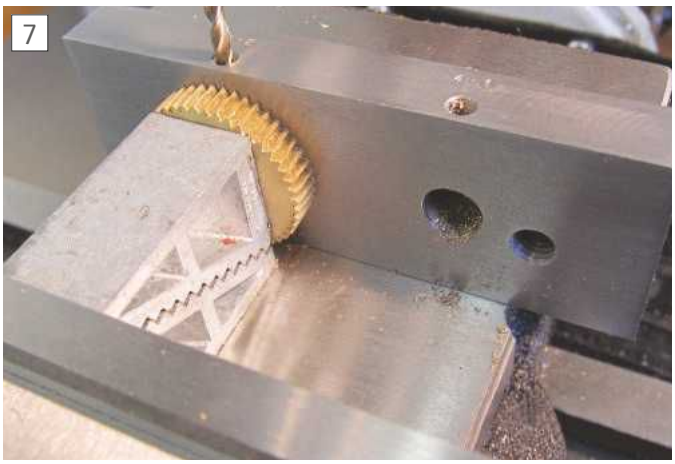
Cutting 5 gears on a 45t blank, the sixth was cut after reversing the blank.

and then groove the spaces between the pinions leaving enough for the ¼" boss together with a sufficient length on the opposite side for temporary holding in the chuck when finishing the boss side, plus the waste needed for the parting tool. A mistake I made initially was to leave the pinion width slightly oversized intending to finish them to size after cutting the teeth, but I found that trimming them after cutting the teeth left a slightly ragged edge between the teeth which was difficult to tidy up.

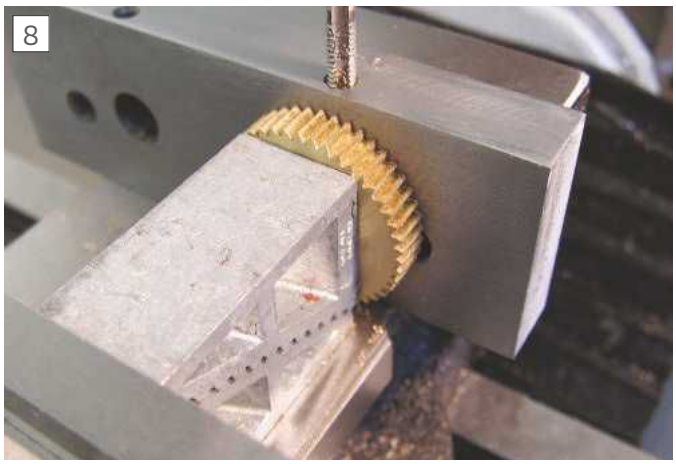
Cutting the teeth in the blanks was fairly straightforward, the most critical and difficult part was setting the cutter depth correctly, or to be more precise, zeroing the cutters to just touch the blank before winding in the 1.44mm depth of cut, getting this just slightly wrong ruined the job. In the end I found the wet tissue paper method to be the most reliable.

Photograph 4 shows a selection of blanks prior to parting off and finishing on the lathe. **Photograph 5** shows a large 45 tooth blank being cut and **photo 6** a thirteen-tooth blank being cut from the centre out. One feature I missed on the milling machine was adjustable carriage stops on the X axis, instead I had to rely

Cutting the teeth on a 15t blank from the centre outwards in both directions.



Cross-drilling the boss of a 45t gear in the jig.



Tapping the boss thread in the jig.

on being able to stop in the right place using the graduations. Improvement needed here.

After laboriously winding the carriage up and down several hundred times the blanks all had their teeth cut and were returned to the lathe for parting off and finishing to size.

The final process was to cross drill and tap the bosses for the grub screws quickly and easily but in such a way that accuracy could be preserved. After some thought I came up the idea of removing the rear jaw from my milling vice, which was simply screwed to the casting, and making a replacement plate from ½" steel drilled to receive the bosses in two positions and with holes drilled at right angles, one 32mm for the tapping drill and one drilled and tapped 5/32 BSW. This worked a treat, pop a gear in the hole, slide the spacer blocks across, a little turn of the vice to clamp it, and drill to the stop, **photo 7**, take it out, stick it in the second position and tap the thread, **photo 8**. Where the gear diameter was less than the boss size, a ¼" spacer was inserted to make sure the hole was correctly positioned.

I ended up making over 80 gears (a selection is shown on

A selection of the end result.

Fig.2

Meshing - Pitch Circle Diameters

Teeth		7	10	11	13	15	16	17	19	20	22	24	25	26	27	28	30	38	45	50	55	56	57	60	65	66	70	76	95	133	152	171
	PCD	0.18	0.26	0.29	0.34	0.39	0.42	0.45	0.50	0.53	0.58	0.63	0.66	0.68	0.71	0.74	0.79	1.00	1.18	1.32	1.45	1.47	1.50	1.58	1.71	1.74	1.84	2.00	2.50	3.50	4.00	4.50
7	0.18	0.37	0.45	0.47	0.53	0.58	0.61	0.63	0.68	0.71	0.76	0.82	0.84	0.87	0.89	0.92	0.97	1.18	1.37	1.50	1.63	1.66	1.68	1.76	1.89	1.92	2.03	2.18	2.68	3.68	4.18	4.68
10	0.26	0.45	0.53	0.55	0.61	0.66	0.68	0.71	0.76	0.79	0.84	0.89	0.92	0.95	0.97	1.00	1.05	1.26	1.45	1.58	1.71	1.74	1.76	1.84	1.97	2.00	2.11	2.26	2.76	3.76	4.26	4.76
11	0.29	0.47	0.55	0.58	0.63	0.68	0.71	0.74	0.79	0.82	0.87	0.92	0.95	0.97	1.00	1.03	1.08	1.29	1.47	1.61	1.74	1.76	1.79	1.87	2.00	2.03	2.13	2.29	2.79	3.79	4.29	4.79
13	0.34	0.53	0.61	0.63	0.68	0.74	0.76	0.79	0.84	0.87	0.92	0.97	1.00	1.03	1.05	1.08	1.13	1.34	1.53	1.66	1.79	1.82	1.84	1.92	2.05	2.08	2.18	2.34	2.84	3.84	4.34	4.84
15	0.39	0.58	0.66	0.68	0.74	0.79	0.82	0.84	0.89	0.92	0.97	1.03	1.05	1.08	1.11	1.13	1.18	1.39	1.58	1.71	1.84	1.87	1.89	1.97	2.11	2.13	2.24	2.39	2.89	3.89	4.39	4.89
16	0.42	0.61	0.68	0.71	0.76	0.82	0.84	0.87	0.92	0.95	1.00	1.05	1.08	1.11	1.13	1.16	1.21	1.42	1.61	1.74	1.87	1.89	1.92	2.00	2.13	2.16	2.26	2.42	2.92	3.92	4.42	4.92
17	0.45	0.63	0.71	0.74	0.79	0.84	0.87	0.89	0.95	0.97	1.03	1.08	1.11	1.13	1.16	1.18	1.24	1.45	1.63	1.76	1.89	1.92	1.95	2.03	2.16	2.18	2.29	2.45	2.95	3.95	4.45	4.95
19	0.50	0.68	0.76	0.79	0.84	0.89	0.92	0.95	1.00	1.03	1.08	1.13	1.16	1.18	1.21	1.24	1.29	1.50	1.68	1.82	1.95	1.97	2.00	2.08	2.21	2.24	2.34	2.50	3.00	4.00	4.50	5.00
20	0.53	0.71	0.79	0.82	0.87	0.92	0.95	0.97	1.03	1.05	1.11	1.16	1.18	1.21	1.24	1.26	1.32	1.53	1.71	1.84	1.97	2.00	2.03	2.11	2.24	2.26	2.37	2.53	3.03	4.03	4.53	5.03
22	0.58	0.76	0.84	0.87	0.92	0.97	1.00	1.03	1.08	1.11	1.16	1.21	1.24	1.26	1.29	1.32	1.37	1.58	1.76	1.89	2.03	2.05	2.08	2.16	2.29	2.32	2.42	2.58	3.08	4.08	4.58	5.08
24	0.63	0.82	0.89	0.92	0.97	1.03	1.05	1.08	1.13	1.16	1.21	1.26	1.29	1.32	1.34	1.37	1.42	1.63	1.82	1.95	2.08	2.11	2.13	2.21	2.34	2.37	2.47	2.63	3.13	4.13	4.63	5.13
25	0.66	0.84	0.92	0.95	1.00	1.05	1.08	1.11	1.16	1.18	1.24	1.29	1.32	1.34	1.37	1.39	1.45	1.66	1.84	1.97	2.11	2.13	2.16	2.24	2.37	2.39	2.50	2.66	3.16	4.16	4.66	5.16
26	0.68	0.87	0.95	0.97	1.03	1.08	1.11	1.13	1.18	1.21	1.26	1.32	1.34	1.37	1.39	1.42	1.47	1.68	1.87	2.00	2.13	2.16	2.18	2.26	2.39	2.42	2.53	2.68	3.18	4.18	4.68	5.18
27	0.71	0.89	0.97	1.00	1.05	1.11	1.13	1.16	1.21	1.24	1.29	1.34	1.37	1.39	1.42	1.45	1.50	1.71	1.89	2.03	2.16	2.18	2.21	2.29	2.42	2.45	2.55	2.71	3.21	4.21	4.71	5.21
28	0.74	0.92	1.00	1.03	1.08	1.13	1.16	1.18	1.24	1.26	1.32	1.37	1.39	1.42	1.45	1.47	1.53	1.74	1.92	2.05	2.18	2.21	2.24	2.32	2.45	2.47	2.58	2.74	3.24	4.24	4.74	5.24
30	0.79	0.97	1.05	1.08	1.13	1.18	1.21	1.24	1.29	1.32	1.37	1.42	1.45	1.47	1.50	1.53	1.58	1.79	1.97	2.11	2.24	2.26	2.29	2.37	2.50	2.53	2.63	2.79	3.29	4.29	4.79	5.29
38	1.00	1.18	1.26	1.29	1.34	1.39	1.42	1.45	1.50	1.53	1.58	1.63	1.66	1.68	1.71	1.74	1.79	2.00	2.18	2.32	2.45	2.47	2.50	2.58	2.71	2.74	2.84	3.00	3.50	4.50	5.00	5.50
45	1.18	1.37	1.45	1.47	1.53	1.58	1.61	1.63	1.68	1.71	1.76	1.82	1.84	1.87	1.89	1.92	1.97	2.18	2.37	2.50	2.63	2.66	2.68	2.76	2.89	2.92	3.03	3.18	3.68	4.68	5.18	5.68
50	1.32	1.50	1.58	1.61	1.66	1.71	1.74	1.76	1.82	1.84	1.89	1.95	1.97	2.00	2.03	2.05	2.11	2.32	2.50	2.63	2.76	2.79	2.82	2.89	3.03	3.05	3.16	3.32	3.82	4.82	5.32	5.82
55	1.45	1.63	1.71	1.74	1.79	1.84	1.87	1.89	1.95	1.97	2.03	2.08	2.11	2.13	2.16	2.18	2.24	2.45	2.63	2.76	2.89	2.92	2.95	3.03	3.16	3.18	3.29	3.45	3.95	4.95	5.45	5.95
56	1.47	1.66	1.74	1.76	1.82	1.87	1.89	1.92	1.97	2.00	2.05	2.11	2.13	2.16	2.18	2.21	2.26	2.47	2.66	2.79	2.92	2.95	2.97	3.05	3.18	3.21	3.32	3.47	3.97	4.97	5.47	5.97
57	1.50	1.68	1.76	1.79	1.84	1.89	1.92	1.95	2.00	2.03	2.08	2.13	2.16	2.18	2.21	2.24	2.29	2.50	2.68	2.82	2.95	2.97	3.00	3.08	3.21	3.24	3.34	3.50	4.00	5.00	5.50	6.00
60	1.58	1.76	1.84	1.87	1.92	1.97	2.00	2.03	2.08	2.11	2.16	2.21	2.24	2.26	2.29	2.32	2.37	2.58	2.76	2.89	3.03	3.05	3.08	3.16	3.29	3.32	3.42	3.58	4.08	5.08	5.58	6.08
65	1.71	1.89	1.97	2.00	2.05	2.11	2.13	2.16	2.21	2.24	2.29	2.34	2.37	2.39	2.42	2.45	2.50	2.71	2.89	3.03	3.16	3.18	3.21	3.29	3.42	3.45	3.55	3.71	4.21	5.21	5.71	6.21
66	1.74	1.92	2.00	2.03	2.08	2.13	2.16	2.18	2.24	2.26	2.32	2.37	2.39	2.42	2.45	2.47	2.53	2.74	2.92	3.05	3.18	3.21	3.24	3.32	3.45	3.47	3.58	3.74	4.24	5.24	5.74	6.24
70	1.84	2.03	2.11	2.13	2.18	2.24	2.26	2.29	2.34	2.37	2.42	2.47	2.50	2.53	2.55	2.58	2.63	2.84	3.03	3.16	3.29	3.32	3.34	3.42	3.55	3.58	3.68	3.84	4.34	5.34	5.84	6.34
76	2.00	2.18	2.26	2.29	2.34	2.39	2.42	2.45	2.50	2.53	2.58	2.63	2.66	2.68	2.71	2.74	2.79	3.00	3.18	3.32	3.45	3.47	3.50	3.58	3.71	3.74	3.84	4.00	4.50	5.50	6.00	6.50
95	2.50	2.68	2.76	2.79	2.84	2.89	2.92	2.95	3.00	3.03	3.08	3.13	3.16	3.18	3.21	3.24	3.29	3.50	3.68	3.82	3.95	3.97	4.00	4.08	4.21	4.24	4.34	4.50	5.00	6.00	6.50	7.00
133	3.50	3.68	3.76	3.79	3.84	3.89	3.92	3.95	4.00	4.03	4.08	4.13	4.16	4.18	4.21	4.24	4.29	4.50	4.68	4.82	4.95	4.97	5.00	5.08	5.21	5.24	5.34	5.50	6.00	7.00	7.50	8.00
152	4.00	4.18	4.26	4.29	4.34	4.39	4.42	4.45	4.50	4.53	4.58	4.63	4.66	4.68	4.71	4.74	4.79	5.00	5.18	5.32	5.45	5.47	5.50	5.58	5.71	5.74	5.84	6.00	6.50	7.50	8.00	8.50
171	4.50	4.68	4.76	4.79	4.84	4.89	4.92	4.95	5.00	5.03	5.08	5.13	5.16	5.18	5.21	5.24	5.29	5.50	5.68	5.82	5.95	5.97	6.00	6.08	6.21	6.24	6.34	6.50	7.00	8.00	8.50	9.00

5.00 Standard Meccano centres 5.03 Within 0.03" of standard centres

photo 9) and the whole process gave me a lot of pleasure; it challenged my brain and helped me to re-acquire some former skills. I also discovered some of the limitations of my machine tools, and areas in need of improvement. The forthcoming 70th birthday list includes a quick-change tool post, a set of parallels, and a tailstock turret for the lathe and a forthcoming cataract operation should improve accuracy!

A by-product of the spreadsheet calculations was the ability to calculate the pitch circle diameter of each gear and by arranging these on the X and Y axes of another spreadsheet, calculate the sum of each PCD and thus the meshing spacing for each combination, **fig. 2**. and by doing the same with the teeth numbers, the ratios, **fig. 3**.

For the next project large diameter gear wheels look like an interesting challenge, but how to swage the bosses, perhaps a collet fixing would be better engineering? Helicals and bevels look a bit tricky, but others have made them, and Chris Robinson's recent articles on the Jacobs Gear Hobber really whet my appetite. ■

Fig.3

Teeth	7	10	11	13	15	16	17	19	20	22	24	25	26	27	28	30	38	45	50	55	56	57	60	65	66	70	76	95	133	152	171
	RATIO 1:																														
7	1.00	0.70	0.64	0.54	0.47	0.44	0.41	0.37	0.35	0.32	0.29	0.28	0.27	0.26	0.25	0.23	0.18	0.16	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.09	0.07	0.05	0.05	0.04
10	1.43	1.00	0.91	0.77	0.67	0.63	0.59	0.53	0.50	0.45	0.42	0.40	0.38	0.37	0.36	0.33	0.26	0.22	0.20	0.18	0.18	0.18	0.17	0.15	0.15	0.14	0.13	0.11	0.08	0.07	0.06
11	1.57	1.10	1.00	0.85	0.73	0.69	0.65	0.58	0.55	0.50	0.46	0.44	0.42	0.41	0.39	0.37	0.29	0.24	0.22	0.20	0.20	0.19	0.18	0.17	0.17	0.16	0.14	0.12	0.08	0.07	0.06
13	1.86	1.30	1.18	1.00	0.87	0.81	0.76	0.68	0.65	0.59	0.54	0.52	0.50	0.48	0.46	0.43	0.34	0.29	0.26	0.24	0.23	0.23	0.22	0.20	0.20	0.19	0.17	0.14	0.10	0.09	0.08
15	2.14	1.50	1.36	1.15	1.00	0.94	0.88	0.79	0.75	0.68	0.63	0.60	0.58	0.56	0.54	0.50	0.39	0.33	0.30	0.27	0.27	0.26	0.25	0.23	0.23	0.21	0.20	0.16	0.11	0.10	0.09
16	2.29	1.60	1.45	1.23	1.07	1.00	0.94	0.84	0.80	0.73	0.67	0.64	0.62	0.59	0.57	0.53	0.42	0.36	0.32	0.29	0.29	0.28	0.27	0.25	0.24	0.23	0.21	0.17	0.12	0.11	0.09
17	2.43	1.70	1.55	1.31	1.13	1.06	1.00	0.89	0.85	0.77	0.71	0.68	0.65	0.63	0.61	0.57	0.45	0.38	0.34	0.31	0.30	0.30	0.28	0.26	0.26	0.24	0.22	0.18	0.13	0.11	0.10
19	2.71	1.90	1.73	1.46	1.27	1.19	1.12	1.00	0.95	0.86	0.79	0.76	0.73	0.70	0.68	0.63	0.50	0.42	0.38	0.35	0.34	0.33	0.32	0.29	0.29	0.27	0.25	0.20	0.14	0.13	0.11
20	2.86	2.00	1.82	1.54	1.33	1.25	1.18	1.05	1.00	0.91	0.83	0.80	0.77	0.74	0.71	0.67	0.53	0.44	0.40	0.36	0.36	0.35	0.33	0.31	0.30	0.29	0.26	0.21	0.15	0.13	0.12
22	3.14	2.20	2.00	1.69	1.47	1.38	1.29	1.16	1.10	1.00	0.92	0.88	0.85	0.81	0.79	0.73	0.58	0.49	0.44	0.40	0.39	0.39	0.37	0.34	0.33	0.31	0.29	0.23	0.17	0.14	0.13
24	3.43	2.40	2.18	1.85	1.60	1.50	1.41	1.26	1.20	1.09	1.00	0.96	0.92	0.89	0.86	0.80	0.63	0.53	0.48	0.44	0.43	0.42	0.40	0.37	0.36	0.34	0.32	0.25	0.18	0.16	0.14
25	3.57	2.50	2.27	1.92	1.67	1.56	1.47	1.32	1.25	1.14	1.04	1.00	0.96	0.93	0.89	0.83	0.66	0.56	0.50	0.45	0.45	0.44	0.42	0.38	0.38	0.36	0.33	0.26	0.19	0.16	0.15
26	3.71	2.60	2.36	2.00	1.73	1.63	1.53	1.37	1.30	1.18	1.08	1.04	1.00	0.96	0.93	0.87	0.68	0.58	0.52	0.47	0.46	0.46	0.43	0.40	0.39	0.37	0.34	0.27	0.20	0.17	0.15
27	3.86	2.70	2.45	2.08	1.80	1.69	1.59	1.42	1.35	1.23	1.13	1.08	1.04	1.00	0.96	0.90	0.71	0.60	0.54	0.49	0.48	0.47	0.45	0.42	0.41	0.39	0.36	0.28	0.20	0.18	0.16
28	4.00	2.80	2.55	2.15	1.87	1.75	1.65	1.47	1.40	1.27	1.17	1.12	1.08	1.04	1.00	0.93	0.74	0.62	0.56	0.51	0.50	0.49	0.47	0.43	0.42	0.40	0.37	0.29	0.21	0.18	0.16
30	4.29	3.00	2.73	2.31	2.00	1.88	1.76	1.58	1.50	1.36	1.25	1.20	1.15	1.11	1.07	1.00	0.79	0.67	0.60	0.55	0.54	0.53	0.50	0.46	0.45	0.43	0.39	0.32	0.23	0.20	0.18
38	5.43	3.80	3.45	2.92	2.53	2.38	2.24	2.00	1.90	1.73	1.58	1.52	1.46	1.41	1.36	1.27	1.00	0.84	0.76	0.69	0.68	0.67	0.63	0.58	0.58	0.54	0.50	0.40	0.29	0.25	0.22
45	6.43	4.50	4.09	3.46	3.00	2.81	2.65	2.37	2.25	2.05	1.88	1.80	1.73	1.67	1.61	1.50	1.18	1.00	0.90	0.82	0.80	0.79	0.75	0.69	0.68	0.64	0.59	0.47	0.34	0.30	0.26
50	7.14	5.00	4.55	3.85	3.33	3.13	2.94	2.63	2.50	2.27	2.08	2.00	1.92	1.85	1.79	1.67	1.32	1.11	1.00	0.91	0.89	0.88	0.83	0.77	0.76	0.71	0.66	0.53	0.38	0.33	0.29
55	7.86	5.50	5.00	4.23	3.67	3.44	3.24	2.89	2.75	2.50	2.29	2.20	2.12	2.04	1.96	1.83	1.45	1.22	1.10	1.00	0.98	0.96	0.92	0.85	0.83	0.79	0.72	0.58	0.41	0.36	0.32
56	8.00	5.60	5.09	4.31	3.73	3.50	3.29	2.95	2.80	2.55	2.33	2.24	2.15	2.07	2.00	1.87	1.47	1.24	1.12	1.02	1.00	0.98	0.93	0.86	0.85	0.80	0.74	0.59	0.42	0.37	0.33
57	8.14	5.70	5.18	4.38	3.80	3.56	3.35	3.00	2.85	2.59	2.38	2.28	2.19	2.11	2.04	1.90	1.50	1.27	1.14	1.04	1.02	1.00	0.95	0.88	0.86	0.81	0.75	0.60	0.43	0.38	0.33
60	8.57	6.00	5.45	4.62	4.00	3.75	3.53	3.16	3.00	2.73	2.50	2.40	2.31	2.22	2.14	2.00	1.58	1.33	1.20	1.09	1.07	1.05	1.00	0.92	0.91	0.86	0.79	0.63	0.45	0.39	0.35
65	9.29	6.50	5.91	5.00	4.33	4.06	3.82	3.42	3.25	2.95	2.71	2.60	2.50	2.41	2.32	2.17	1.71	1.44	1.30	1.18	1.16	1.14	1.08	1.00	0.98	0.93	0.86	0.68	0.49	0.43	0.38
66	9.43	6.60	6.00	5.08	4.40	4.13	3.88	3.47	3.30	3.00	2.75	2.64	2.54	2.44	2.36	2.20	1.74	1.47	1.32	1.20	1.18	1.16	1.10	1.02	1.00	0.94	0.87	0.69	0.50	0.43	0.39
70	10.00	7.00	6.36	5.38	4.67	4.38	4.12	3.68	3.50	3.18	2.92	2.80	2.69	2.59	2.50	2.33	1.84	1.56	1.40	1.27	1.25	1.23	1.17	1.08	1.06	1.00	0.92	0.74	0.53	0.46	0.41
76	10.86	7.60	6.91	5.85	5.07	4.75	4.47	4.00	3.80	3.45	3.17	3.04	2.92	2.81	2.71	2.53	2.00	1.69	1.52	1.38	1.36	1.33	1.27	1.17	1.15	1.09	1.00	0.80	0.57	0.50	0.44
95	13.57	9.50	8.64	7.31	6.33	5.94	5.59	5.00	4.75	4.32	3.96	3.80	3.65	3.52	3.39	3.17	2.50	2.11	1.90	1.73	1.70	1.67	1.58	1.46	1.44	1.36	1.25	1.00	0.71	0.63	0.56
133	19.00	13.30	12.09	10.23	8.87	8.31	7.82	7.00	6.65	6.05	5.54	5.32	5.12	4.93	4.75	4.43	3.50	2.96	2.66	2.42	2.38	2.33	2.22	2.05	2.02	1.90	1.75	1.40	1.00	0.88	0.78
152	21.71	15.20	13.82	11.69	10.13	9.50	8.94	8.00	7.60	6.91	6.33	6.08	5.85	5.63	5.43	5.07	4.00	3.38	3.04	2.76	2.71	2.67	2.53	2.34	2.30	2.17	2.00	1.60	1.14	1.00	0.89
171	24.43	17.10	15.55	13.15	11.40	10.69	10.06	9.00	8.55	7.77	7.13	6.84	6.58	6.33	6.11	5.70	4.50	3.80	3.42	3.11	3.05	3.00	2.85	2.63	2.59	2.44	2.25	1.80	1.29	1.13	1.00

Enhancements to the **Sieg Super X1L**

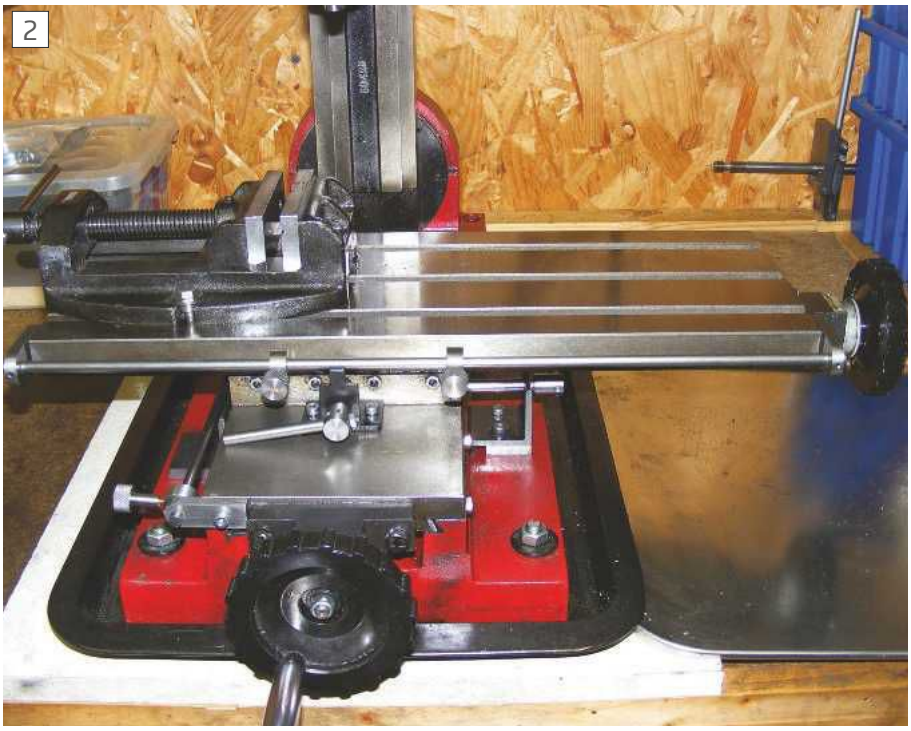
Over the years Mike Cox has added some useful enhancements to his SX1l, focusing on the table.

My Sieg X1L mill is about 10 years old. It is the first and only mill I have ever owned. It is one of the smallest mills on the market but it has done everything that I have asked it to do. The big limitation of a small mill is the power available and the SX1L only has a 150 Watt brushed motor. This means that heavy cuts are not possible but in most cases the same result can be achieved by making multiple smaller cuts. The down side is that to make a deep cut using multiple passes requires an awful amount of feedscrew handwheel turning! This in turn means that you tend to try to maximise the feed rate in order to finish the job in the minimum amount of time and sometimes this leads to a broken cutter.

The SX1L mill table is sturdy and well engineered and it functions very well. The latest versions of the X2 mini-mill sold by Arc Euro Trade use the same milling table as the SX1L.

Sometimes when milling it is good to have a positive stop to define the limits of movement in both the x and y directions. This greatly simplifies some operations like cutting out square and oblong opening in metal panels.

General view of the enhanced mill table.



The front of the mill showing the x axis stop bar.

One infuriating feature of the SX1L mill table is the y axis locking screw which is located under the table. Getting at this with an Allen key is not easy.

The control of backlash on the x and y axis feed screws is physically quite easy using the lock nuts on the feed screw handles. However, it is an all or nothing adjustment. If the lock nut is over-tightened then the handle is very stiff to turn and if too loose then there is excessive backlash.

None of the problems listed above in anyway limit the accuracy or usefulness of the mill. Nevertheless, over a number of years I have made some modifications to the mill table than enhance its ease of use. These modifications are:

1. Adding adjustable stops to the x and y axes.
2. Making lever operated locking screws for the x and y axes
3. Adding ball bearings to the x axis feed screw to eliminate backlash and reduce friction.
4. Adding a power feed motor and auto

The downside is that to make a deep cut using multiple passes requires an awful amount of feedscrew handwheel turning!

stop to the x axis.

These modifications were made in the order stated in this list. To some extent each step down the list depends on the previous improvements made. For example, adding ball bearings to the x axis feed screw reduces the torque requirement of the motor for the power feed.

Photograph 1 shows the mill table with all the added enhancements. Across the front of the table can be seen the stop bar with two movable stops. In the centre just below the table is the stop plate that limits the movement of the table when either sliding stop hits it. In the centre of the stop plate is the lever operated screw to lock the x axis of the table. Underneath the table on the left-hand side can be seen the y axis stop bar whilst on the right-hand side can be seen the y axis lever operated lock screw. Also on the right-hand side is the x axis handwheel and a new bearing block housing the ball bearings. On the extreme left is the box housing the power feed. The small aluminium box on the left-hand end of the x axis stop rod houses the microswitches that automatically stop the power feed when the sliding stop hits the stop plate.

Stops and locks.

Photograph 2 shows the front of the mill table. The x axis stop bar is 6 mm diameter and it is fixed across the front of the milling table. It is held in place by two plates, **fig. 1**, attached to either end of the milling table by an M6 socket head screw. The bar is prevented from sliding in the support plates by an M3 grub screw.

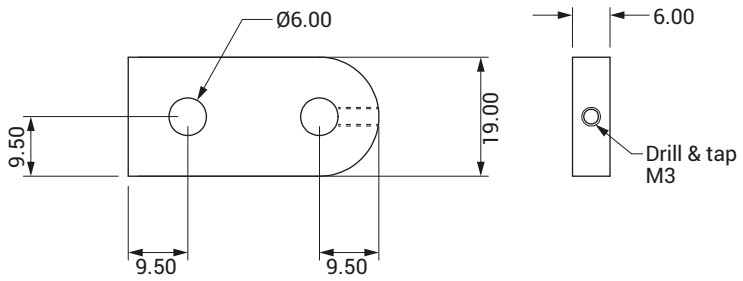
On the bar are two sliding stops, **fig. 2**. These can slide on the bar but can be fixed at any point by tightening the knurled clamping screws, **fig. 3**. Between the two sliding stops is a stop plate cut from a piece of 35 x 35 x 3mm steel angle, **fig. 4**. This stop plate is fixed in the centre of the bottom slide of the milling table using two M4 socket head screws. With the sliding stops clamped to the stop bar then movement of the table will be limited when either of them hit the stop plate.

There is a hole in the stop plate to accommodate a new extended locking screw, **fig. 5**, for the x axis of the table. This screw is operated by the short lever at the head. The lever can be inserted into the screw in one of six positions so that a position can be found where locking occurs with half a turn of the screw.

The y axis stops are similar to the x axis stops, **photo 3**. A 6 mm diameter bar is fixed to two plates, **fig. 6**, attached to the ends of the lower slide of the table on the left hand side. The bar carries two sliding stops. The stop plate is cut from a 40 mm length of 35 x 35 x 3 mm angle attached to the mill base casting.

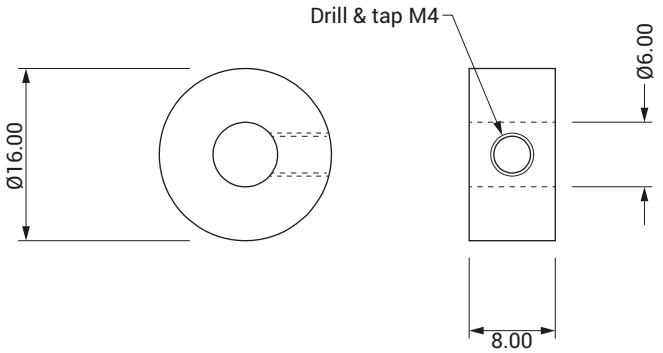
The y axis locking screw is on the other side of the lower slide. The y axis slide has five gib screws along its length. When I purchased the mill the y axis lock screw, an M4 cap screw, was located in the middle gib screw hole. This makes it very inaccessible. After studying the position of the screws and the limits of the table movement I could see no reason why the lock screw could not be positioned

Fig.1



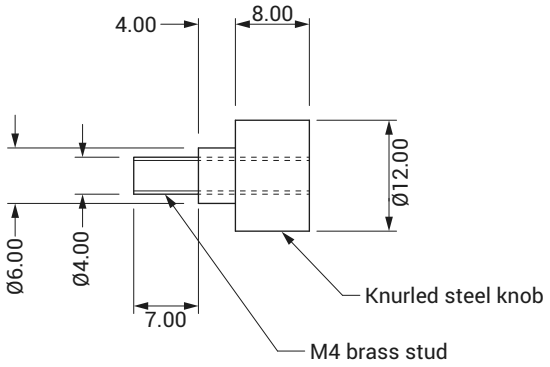
The X Axis Rod Bracket
Mat'l: 6 x 19mm mild steel, 2 off

Fig.2



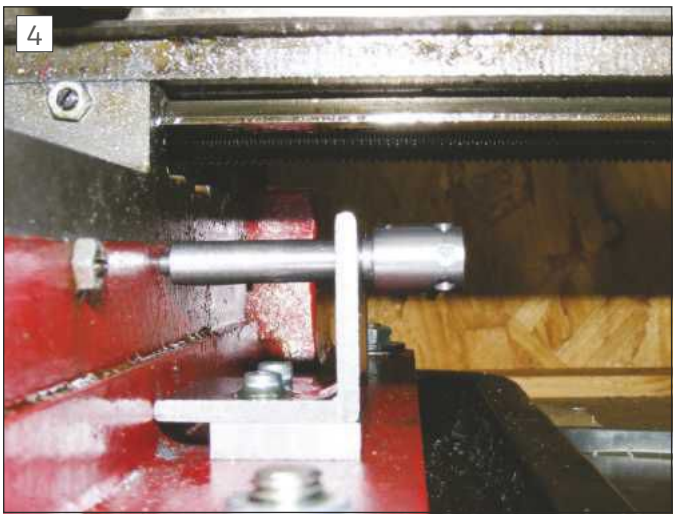
The stop
Mat'l: BMS, 4 off

Fig.3



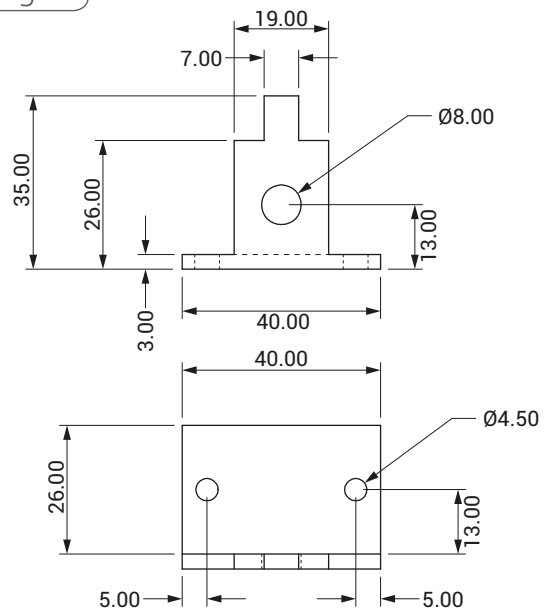
Clamping Screw
Mat'l: BMS for knob, brass stud. 4 off

Left side view showing the y axis stops.



Ride side view showing the y axis locking screw.

Fig.4



The Stop Plate

Mat'l: 35mm x 35mm x 3mm M.S. angle

in the second screw hole from the front. Relocating it to this position makes it much more accessible.

The original lock screw has been replaced by an extended screw with a lever like that shown in fig. 5. A small bracket made from 35 x 35 x 3mm angle with a hole was made to support the extended screw. This locking arrangement can be seen in **photo 4**. Note the small block under the bracket to raise it to the correct height.

These simple stops and locks greatly facilitate certain operations such as cutting slots, and square and oblong cut outs.

At a later date the x axis stop bar was modified to allow it to operate limit switches for the mill power feed, see later.

X axis feedscrew bearing block.

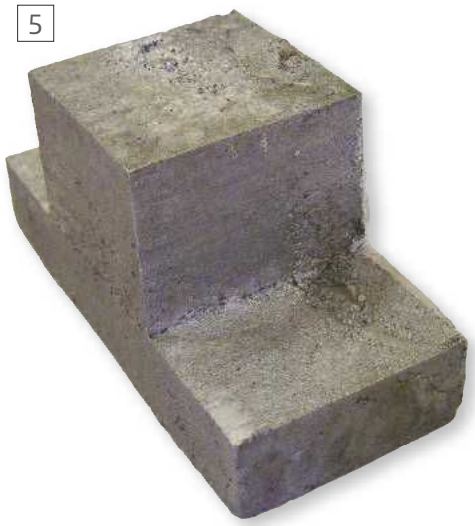
The feed screw bearing block was made from an aluminium lost foam casting, see **photo 5** and **fig. 7**. However, it could easily be fabricated from 12 x 75mm bar and 32 mm square bar and then bolted together with recessed M4 cap head screws.

The casting was chucked in the 4-jaw chuck by the 32 mm square boss and the back of the flange was faced. It was then turned around in the chuck so that the flange face was held and the boss end was faced off. The total length from the back of the flange to the front of the boss was adjusted to be 35 mm. This is the same length as the original bearing block supplied with the lathe.

The centre of the boss was then located and centre punched. This was set up on the lathe so the punch mark was at the centre of rotation and the block was drilled through to 13mm using successively larger drills. It was then bored out to 14 mm using a small boring bar. A recess was then bored for the 608ZZ bearing 7 mm deep and 22 mm diameter. As the final diameter is approached then the fit of the bearing was tested frequently. The aim was to get a nice snug fit of the bearing in the recess. The front bearing recess is shown in **photo 6**.

The piece was then removed from the chuck and the flange side marked out. Firstly, lines were drawn at right angles to the long axis of the flange that were tangents to the edge of the bored hole. The centre line through the hole was then marked at half way between these lines. An easy way to check if the line is well centred is by inserting a two-flute step drill in the hole and the edges of the flutes should line up with the marked line. If they do not then the line is not through the centre. Once the centre line was found two parallel lines 30 mm either side of the centre were marked for the bolt holes. A line 10 mm from and parallel to the long side of the flange was then marked and the intersection of this line with the previously marked lines gives the centres for the bolt holes. These were centre punched and drilled out to 6.5 mm on the pillar drill.

5



The lost foam casting for the bearing housing.

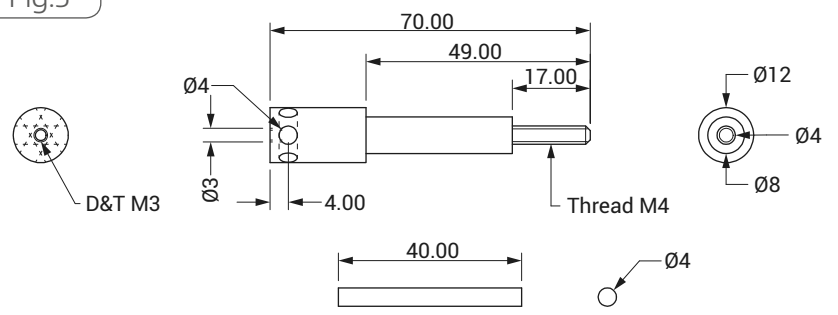
The piece was remounted in the four-jaw chuck gripped by the boss and the four jaw adjusted carefully to centre the hole on the centre of rotation using a DTI. This must be done carefully because it is important that both bearings are concentric. Once the piece was centred then the second bearing recess was bored 22 mm diameter and 17 mm deep, **photo 7**. The piece was carefully cleaned and the two ends covered with masking tape and the casting was sprayed with primer and then black paint.

The tape was stripped off after painting and the 608ZZ bearing were inserted into both recesses. Note 608ZZ bearings are cheap and widely available because they are used in skate boards and roller blades (beware the low grade 608 bearings in fidget spinners! – Ed.)

One last operation was to mount the bearing block in the mill and to mill the paint off in a 6 mm wide band adjacent to the boss bearing. A fiducial line was scribed in the centre of this band for the graduated dial on the hand wheel, **photo 8**.

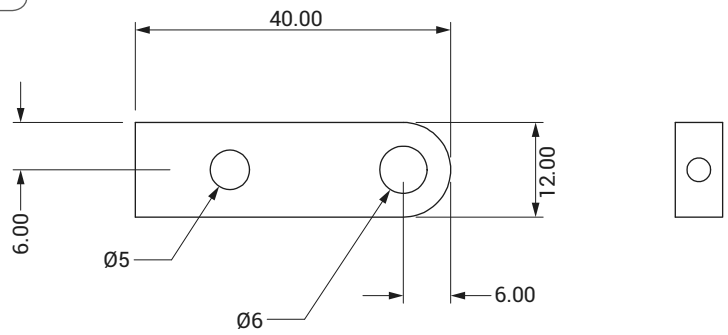
The new bearing block was then bolted onto the mill table using two M6 screws, **photo 9**. The leadscrew hand wheel nut was tightened just enough to eliminate the backlash. This modification to the mill is worth doing because the backlash can be effectively eliminated whilst still having a very low turning torque on the mill handle.

Fig.5



The X Axis Locking Screw And Tommy Bar
Mat'l: BMS

Fig.6



Y Axis Rod Bracket
Mat'l: BMS

Power feed.

The objectives of the power feed project were to provide the following facilities:

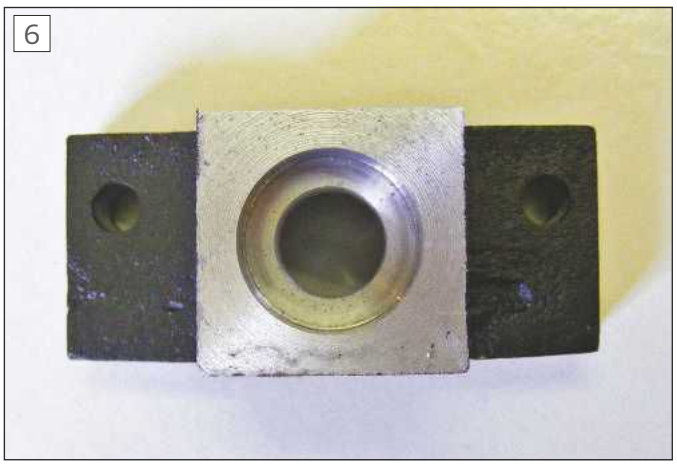
1. To take cuts at a feed rate set by a speed control but (with repeated cuts in mind) to be able to reverse the table back to the starting point as fast as the motor driving it would allow, at the flick of a switch and without affecting the speed control. The feed rate would then still be set ready for the next cutting pass.
2. To be able to switch easily from having the table moving to the left during the cutting passes and returning quickly to the right, on the one hand, to vice versa on the other.
3. An electrical auto-stop arrangement to bring the table to a halt at some pre-determined point by stopping the motor, this arrangement to utilise much of the hardware already in place for manual use.
4. The power feed to be easily disconnected/reconnected so that manual feed could still be used when required with the electrical auto-stop function reverting to a simple mechanical stop.
5. I wanted a small compact unit that could be bolted on the end of the mill table with the minimum of wires floating around.

In addition to eliminating much handle turning it was envisaged that the motorised feed would lead to smoother, constant speed cuts resulting in improved surface finish.

Overview of the power feed.

Photograph 10 shows the completed power feed. Everything, including the motor, is inside the black box with the exception of the auto-stop micro-

6



The boss bearing recess.

7

The flange bearing recess.

switches which are in the small aluminium box at the end of the stop bar. The stop bar fitted along the front of the table passes through this box.

The black box houses the 12-volt motor with integral 120 rpm gearbox, a pulse width modulated (PWM) speed control and associated speed potentiometer, a relay, two switches and a piezo buzzer. The 'Direction' switch sends the table to the left when the lever is over to the left and right when the lever is over to the right. The setting of the 'Cut' switch determines whether the slow cutting passes will be leftward and the fast return rightward, or the other way about. Each switch has a centre off position and either can be used to stop the table manually.

Also visible in photo 10 is the knurled brass dog clutch that is used to connect or disconnect the power feed motor to the feed screw

I wanted to retain the existing manual feed screw hand wheel on the right-hand side of the table and therefore in order to connect the feed screw to the motor it must be extended on the left hand side.

Modifying the feed-screw.

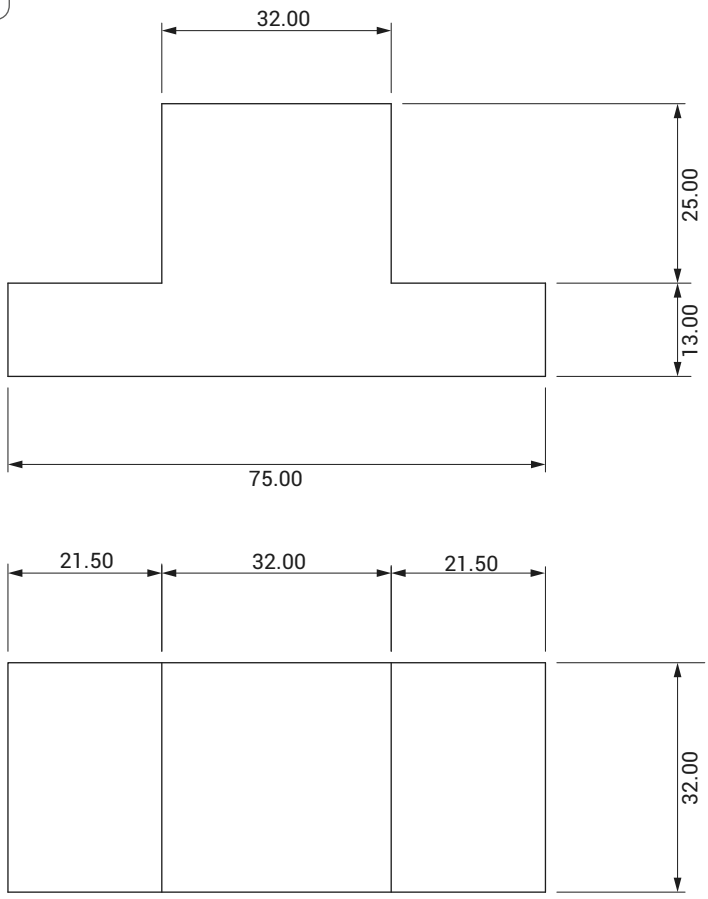
The feed screw was chucked in the lathe and the end was drilled out 5 mm diameter for a depth of 10 mm. This was then threaded M6 using a tap held in the tailstock chuck. The feed screw was wrapped in two layers of 70 gsm paper where the chuck gripped it to prevent damage.

The feed screw extension, is a piece of round 6 mm bar 70 mm long. This was chucked in the lathe, both ends faced and one end threaded M6 using a tailstock die-holder for a length of 12 mm

The extension piece was screwed into the feed screw until it bottomed and the extension marked at 50 mm from the end of the feed screw. The extension was unscrewed and cross drilled 1.5 mm at this point. The extension was screwed gently back into the feed screw with Loctite on the threads. The assembly was immediately chucked in the lathe with the feed screw in the chuck jaws and the extension in the tailstock chuck, **photo 11**. Doing this ensures that the extension is reasonably aligned and concentric with the feed screw axis. Once the Loctite had set the feed screw was removed and screwed back into the milling table nut. It is a good opportunity to adjust the mill table nut, located under the slide, for minimum backlash. The final operation on the feed screw was to secure

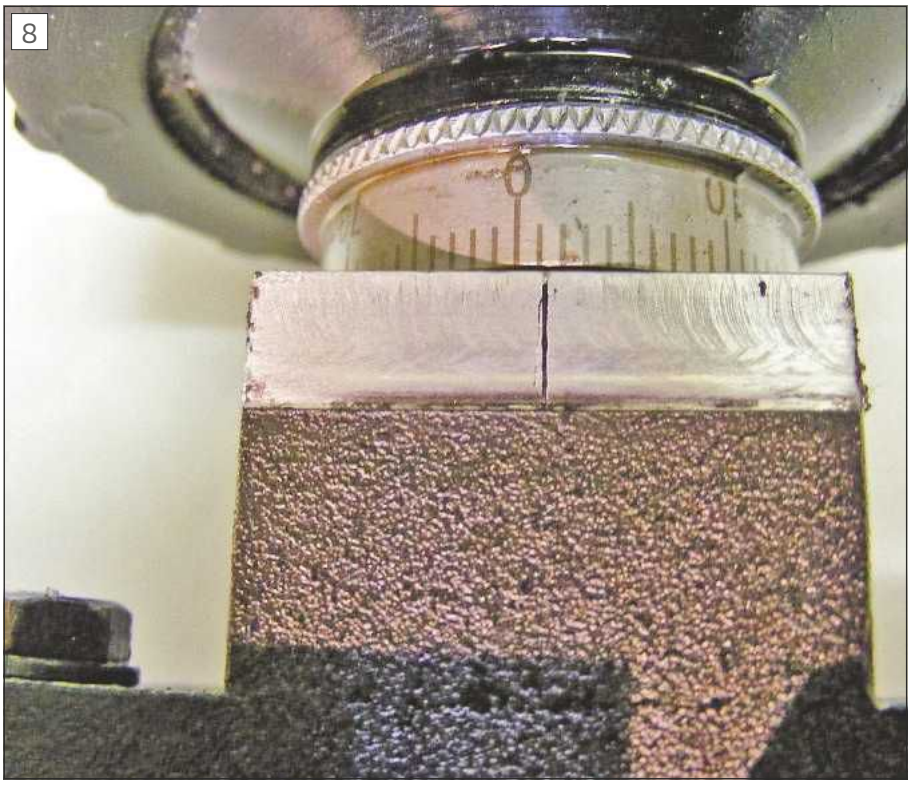
My experience with these motors spans more than 10 years and I have yet to have one fail.

Fig.7

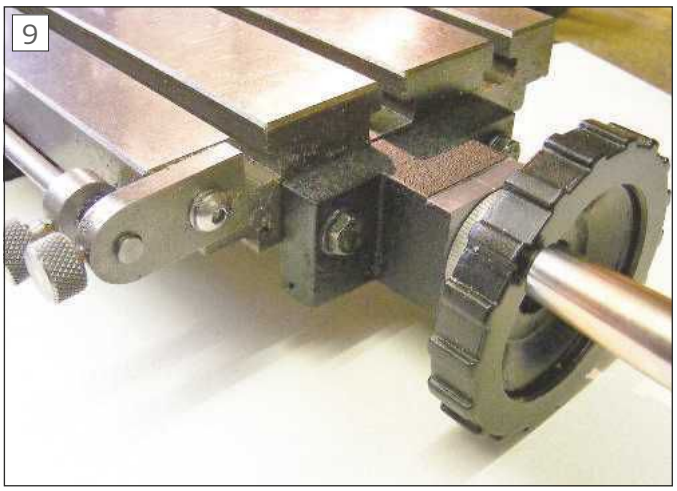


The Bearing Block
Mat'l: Cast aluminium

8



The milled strip with the fiducial line.



The completed bearing block mounted on the mill.

The power feed.

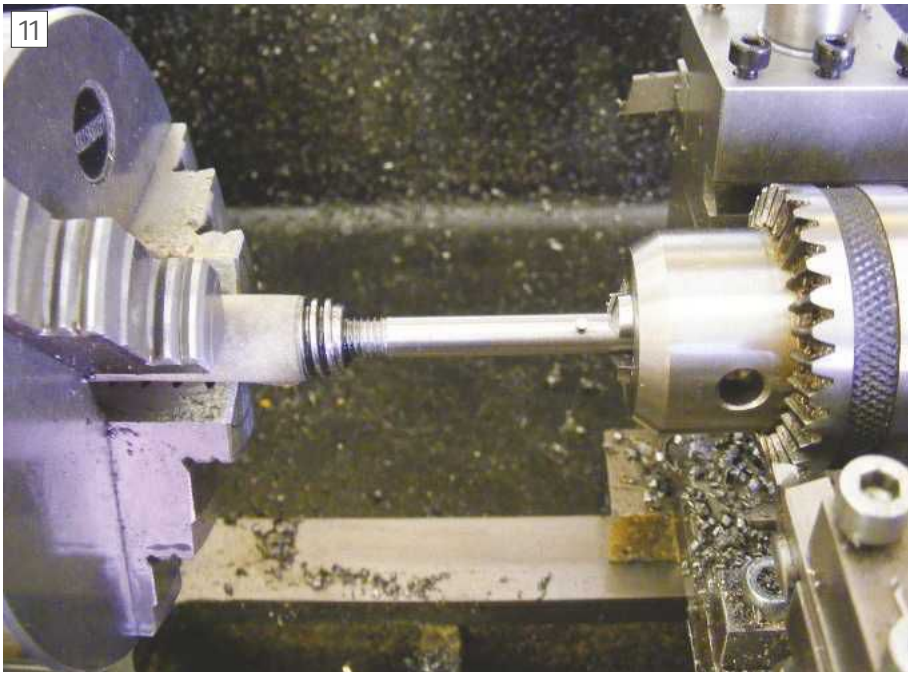
a 1.5 x 9 mm steel pin into the cross hole, using Loctite, leaving 3 mm protruding. The end of the finished feed screw is shown in **photo 12**.

The motor.

The motor I used on the power feed was a 12 volt, 120 rpm geared motor, **photo 13**, that I had purchased on eBay. These motors can be found by putting '12 volt dc motors' into eBay and hundreds of small dc motors will come up. The motors required have a gearbox diameter of 37 mm diameter and have the characteristic offset output shaft that is 6 mm in diameter and 6 equally spaced M3 mounting holes. The price varies greatly but they are usually less than £10. These geared motors are available with output speed ranging from 3 rpm up to 500 rpm. I suspect that the motors all come from the same factory in China but there are a great number of suppliers. There is another series of 12 volt geared motors that are 25 mm diameter and with the shaft centred in the gear box. These are much less powerful and not suited for this application

I have bought many of these motors. I have one powering the lead-screw of my mini-lathe and another driving the power feed on the lathe cross-slide. I have also used them for a number of small machine projects. My experience with these motors spans more than 10 years and I have yet to have one fail.

The motor shaft was cross drilled with a 1.5 mm drill 5 mm from the end. A 1.5 mm pin was inserted into the cross hole and secured with Loctite.



The set up for ensuring alignment of the extension.

To be continued

The end of the feed-screw showing the extension.

The motor.

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A Grinding Head for the Acute System

John Ashton makes a dedicated setup for the Eccentric Engineering's Acute Tool Sharpening System - Part 2.

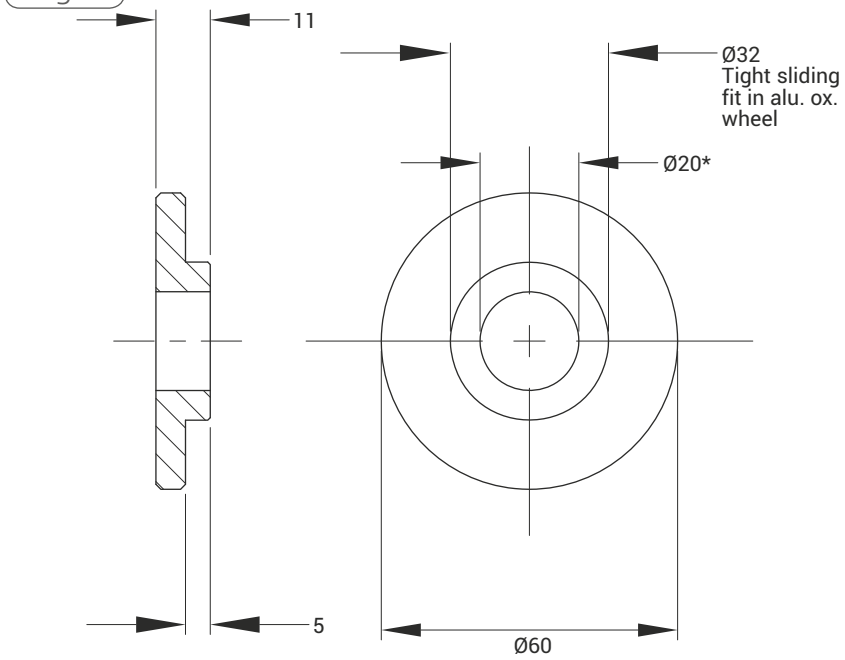
Aluminium Oxide Wheel Clamp Plate – Figure 5

Material: Aluminium Alloy 6082-T6
The billet was positioned in the lathe chuck, faced off and the 60mm outside diameter machined to size. Next, I machined the 32mm diameter x 5mm deep location spigot, using the Aluminium Oxide wheel as a gauge to achieve a tight S/F. I drilled and bored through the 20mm diameter that will be the locating diameter for the Aluminium Oxide Securing Nut/Break Wheel Extension, **photo 22**. Finally, I turned the billet around, in the chuck, and faced off to 6mm thick. **Photograph 23** & **24** show the finished component.

Aluminium Oxide Wheel Securing Nut/Brake Wheel Extension – Figure 6

Material: Aluminium Alloy 6082-T6
I used 1" across faces hexagon bar for this component, for two reasons; one, it automatically gave me spanner flats and two, I already had some in my materials rack. Diameter stock can be used provided you machine a couple of spanner flats; the original securing nut is discarded. The first operation was to turn the 24mm diameter on the bar stock before parting-off the billet, **photo 25**. I changed my 3-jaw chuck for my 5C collet chuck for the rest of the machining operations. First, I machined the 20mm diameter x 9mm deep location spigot using the Aluminium Oxide Wheel

Fig.5



*Close sliding fit on alu. ox. securing nut & break wheel ext. (Drg.6)

Aluminium Oxide Grinding Wheel Clamp Plate
Mat'l: Aluminium alloy 6082-T6

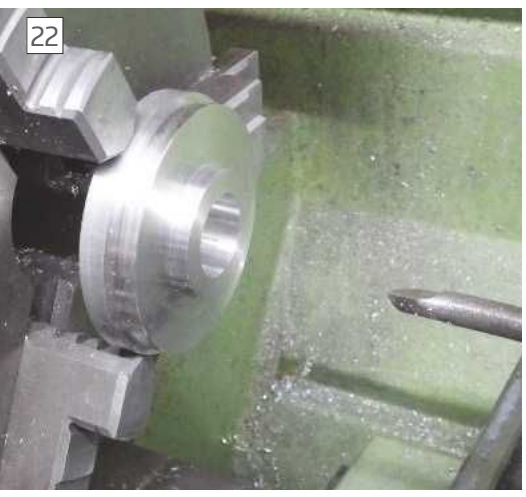
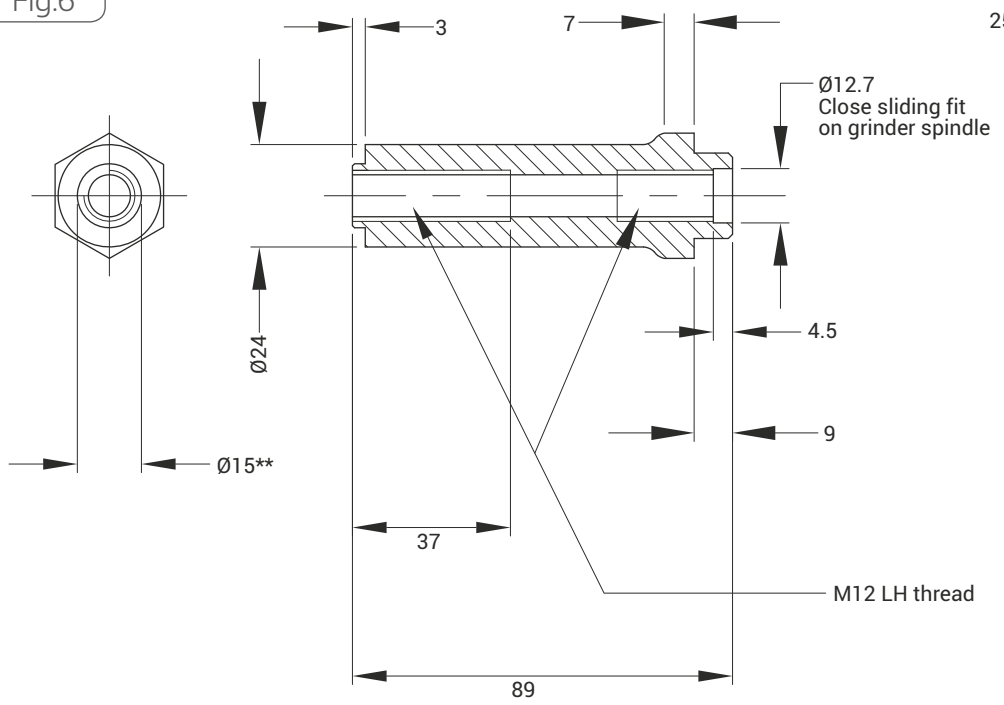
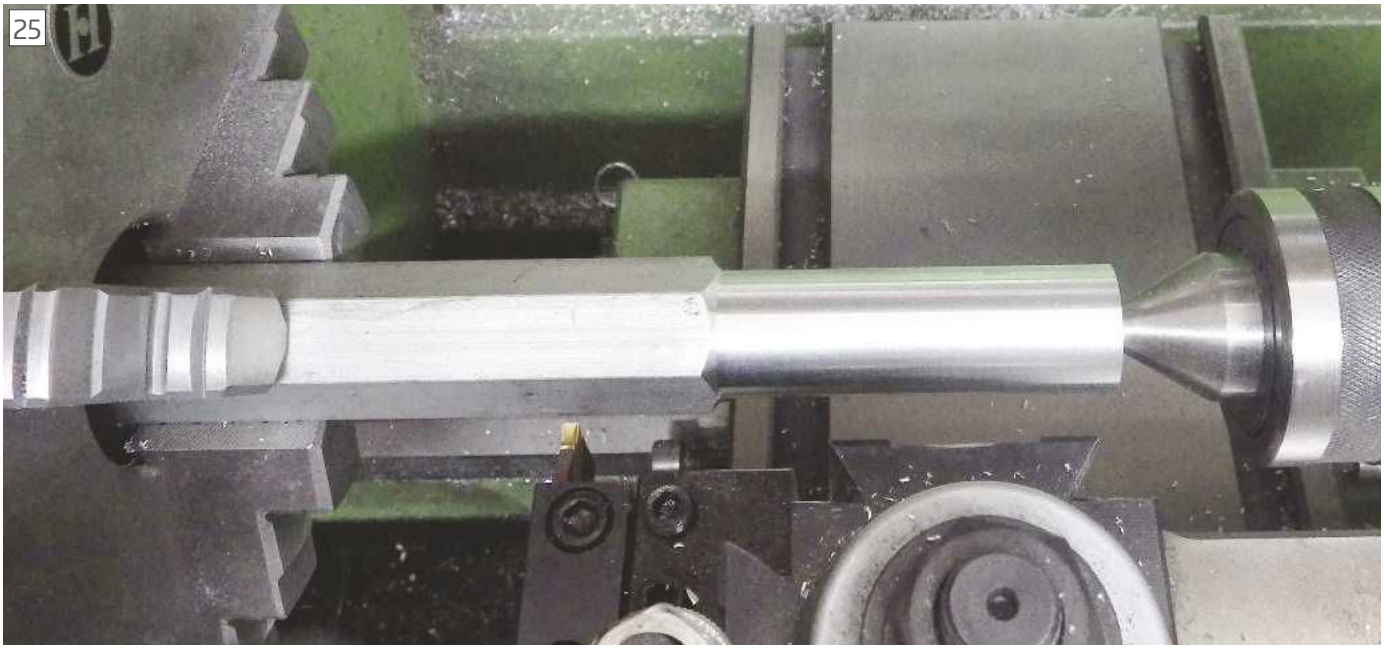


Fig.6



*Close sliding fit on alu. ox. clamp plate (Drg.5)
**Close sliding fit in break wheel (Drg.7)

Aluminium Oxide Grinding Wheel Securing Nut & Break Wheel Ext.
Mat'l: Aluminium alloy 6082-T6



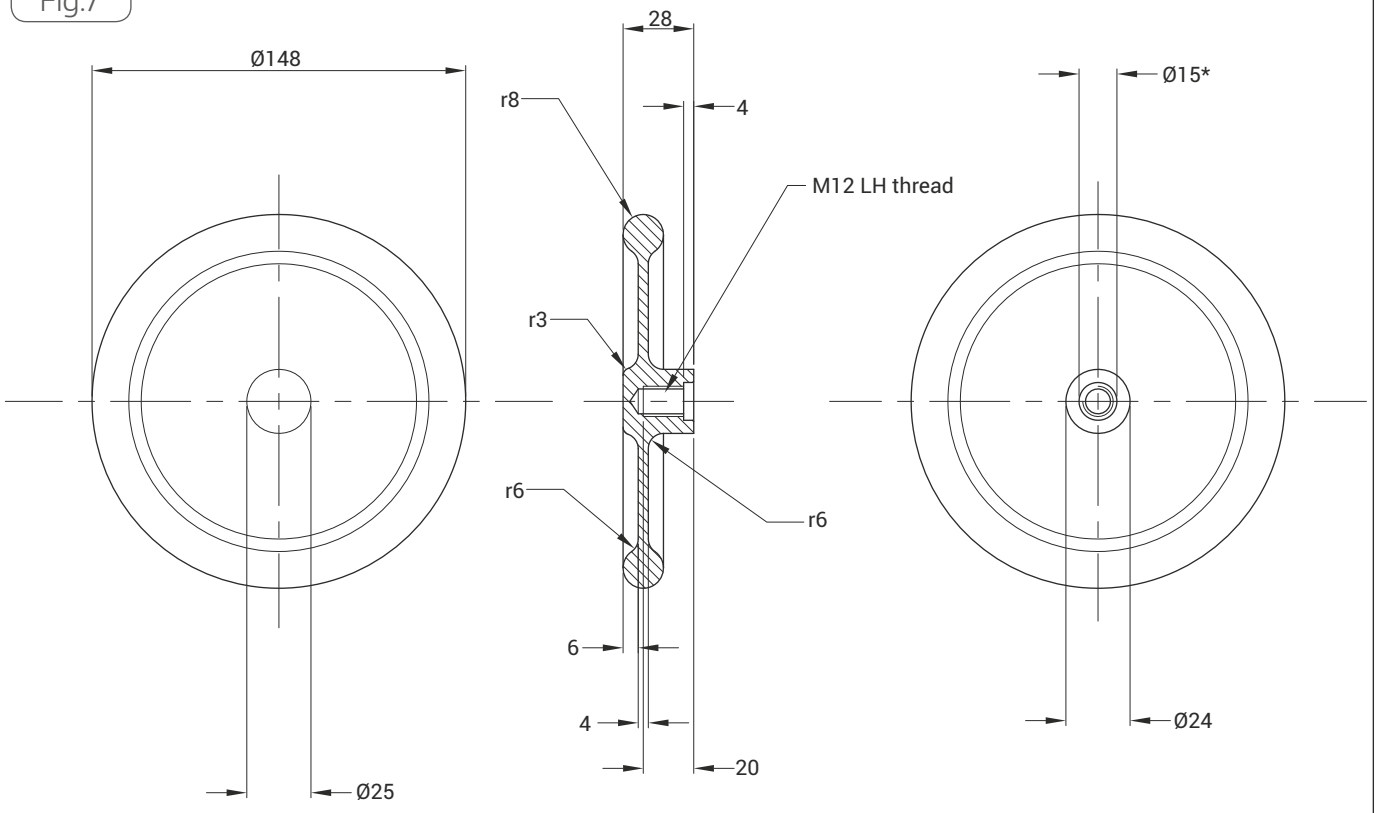
Clamp Plate as a gauge. Next, I drilled and tapped the M12 x 27mm deep left hand thread to fit the grinder spindle. As I was machining aluminium I decided to buy carbon steel left hand thread taps, I did not see the point in paying for HSS taps that probably would hardly be used again. The final operation, on this end was to bore the 12.7mm (0.500") diameter x 4.5mm deep location diameter to be a close S/F on the grinder spindle, photo 26. It is important for the two ends to be concentric with each other; otherwise the brake wheel could run out of true. The way I approached this was to slide the component in from the back of the 24mm diameter C5 collet to drill and tap the thread with a centre drill register, because the component did not protrude out of the collet enough to machine the location spigot for the brake wheel. I held the component between a 20mm diameter C5 collet and a tailstock running centre to enable me to machine the spigot, **photos 27** & **28**. **Photograph 29** shows the finished component.

Brake Wheel – Figure 7

Material: Aluminium Alloy 6082-T6

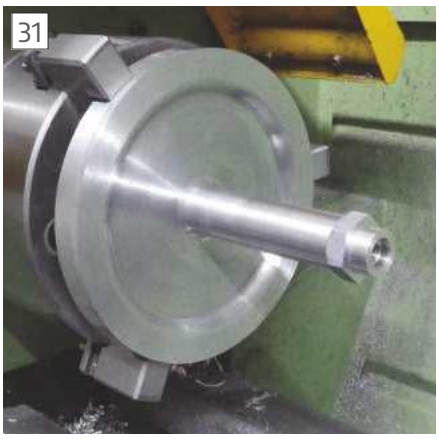
This component was probably the biggest challenge of all, because of all the radius work, especially as its diameter was too large for my radius turning tool

Fig.7



*Close sliding fit on alu. ox. securing nut & brake wheel ext. (Drg.6)

Brake Wheel



to be used, so I had to rely on form tools. The other problem was, as more metal was removed the component took on the features of a bell so I had to slow everything down to almost a crawl to minimise ringing and vibration. First, I held the billet in the external jaws of my 3-jaw chuck and faced off and turned a register diameter. Next, I turned the billet around in the chuck and machined the inside form and spigot. I then drilled and tapped the M12 left hand thread and machined the 15mm diameter x 4mm location counterbore, for the break wheel extension, **photo 30**. Before the next operation I fitted the M12 left hand thread stud and the break wheel extension and ran the lathe up to high speed to ensure that it was a good concentric fit, **photo 31**. The 3-jaw chuck was replaced with the 5C collet chuck for the rest of the machining. This is when the break wheel started to take on bell like features. I first machined the inside form on the outer face, then completed the outer radius on both inner and outer peripheries with a radius form tool, **photo 32**. **Photographs 33** & **34** show the finished component.

Modifications to the Grinder Guard for the Aluminium Oxide Wheel

There were two modifications to carry out on the existing guard, a clearance hole 28mm diameter had to be machined in the outer guard panel to clear the Break Wheel Extension and the tool rest bracket on the inner guard panel had to be removed to make way for the Acute Tool Sharpening System Table. **Photograph 35** shows the setup for machining the clearance hole. **Photograph 36** shows the finished guard panel. **Photographs 37** & **38** show the inner guard panel before and after modification.

Securing Stud

Material: A2 Stainless Steel
This is made from M12 left hand Allthread x 50mm long, **photograph 39**.

CBN Grinding Wheel Assembly:

The parts required are; the CBN grinding wheel, wheel adapter, wheel clamp plate and the wheel securing nut, **photo 40**.

First assemble the adapter into the CBN grinding wheel, photo 14. Position assembly

onto the spindle of the grinder, **photo 41**. Next fit the clamp plate, **photo 42**. Finally fit the securing nut and tighten, **photo 43**.

Aluminium Oxide Grinding Wheel Assembly:

The parts required are; the aluminium oxide grinding wheel, wheel adapter, clamp plate, wheel securing nut/brake wheel extension, the securing stud, the break wheel and the modified guard assembly, **photo 44**.

First assemble the back half of the guard to the grinder, using the existing fixings, **photo 45**. Fit the adapter/mandrel to the aluminium oxide grinding wheel, **photo 46**. Then fit the clamp plate, on the opposite face, **photo 47**. Position the assembly onto the spindle of the grinder, **photo 48**. Screw the securing nut/break wheel extension onto grinder spindle and tighten, **photo 49**. Fit outer guard cover, using existing fixings, **photo 50**. Screw securing stud fully into break wheel, **photo 51**. Screw break wheel assembly onto break wheel extension and tighten, **photo 52**.

The Grinding Head is now ready for use. The grinder was supplied with eye shields, one of them magnified, see photo's 2 & **53**. These may be useful to retain see **photo 54**.

Conclusion

You may have to alter some dimensions to suit your particular grinder. **Photograph 55** shows the finished Grinding Head complete with the Acute Tool Sharpening System.

Acknowledgements:

Eccentric Engineering; My thanks to Gary Sneesby for the help and information he supplied during the writing of this article. www.eccentricengineering.com.au ■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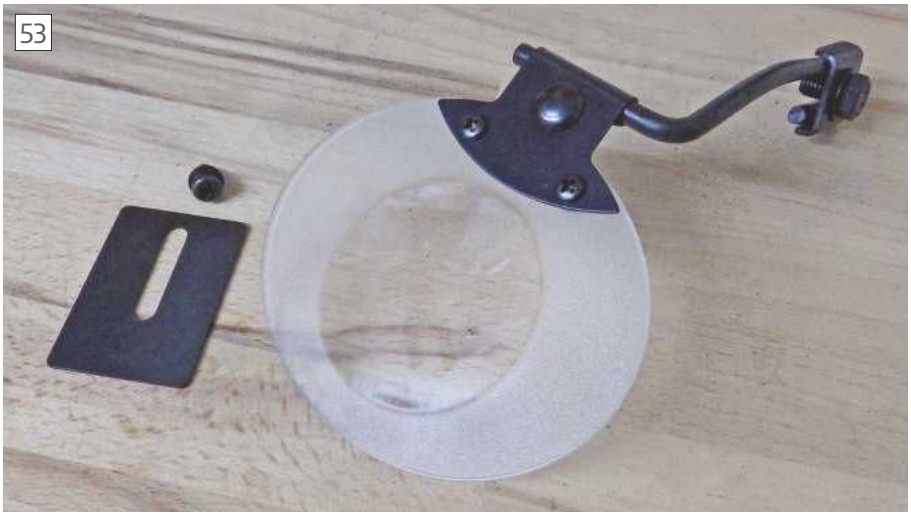
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Proxxon MF70 Mini Mill Competition Winner

Dear Neil. Thank you the Proxxon mini mill arrived this morning. It's a great little piece of kit, I can't believe I was successful in winning. I will say a big thank you to Workshop Engineer and Brimarc.

David Horton, Yorkshire

Congratulations David, anyone who missed out on the competition or was unsuccessful, you can fine the Proxxon mini mill and other great products at www.brimarc.com, Neil.

Screwcutting on a Super 7b

Dear Neil, I was so impressed by Brian Wood's Screwcutting article in issues 212-3 that I immediately on reading it set about modifying my Myford Super7B to his spec and proving its value on a small project. So easy to achieve any pitch merely by changing the mandrel gear and selecting the right gearbox setting - no more stripping down the gear train, sorting out correct combination and re-assembling with desirable gear-tooth clearances.

There followed three years of using only taps and dies until, the other day arose the need to cut a thread of 22.25 mm major diameter and 1.00 mm pitch to match the body of an existing pressure regulating valve. This was done in minutes including adjustment of depth of cut until a smooth close hand fit was made to the body. Very pleasing.

Peter Peters, by email.

Show Us Your Ingenuity

Dear Neil, I just had small idea that I thought I'd share with you, along the 'subtly widening the remit of the mag without undermining its core business' line.

It occurs to me that quite a nice running feature could be something like '101 household objects made with machine tools'. The idea being as it sounds, i.e. that people could submit a photo of something they have made with their machines for their homes or vehicles. There would be no need for a detailed explanation, just a photo with a caption such as 'Shelf support by Gary Ayres', 'Campervan ventilator surround by ...'

and so on. These wouldn't have to be great works of art or engineering, just illustrations of simple objects but ones which couldn't easily be made without workshop machines. The photos might be small, and could even be of a standard size or format to give the feature unity and continuity from one month to the next.

Of course, you may not be particularly drawn to this idea, and if that's the case I will in no way be offended. However, it just popped into my mind so I thought I might as well run it past you as keep it to myself.

Gary Ayres, Guernsey

And why not? If any readers have pictures of interesting, unusual or impressive items they have made in their workshops, email me a photo or two and a short description at neil.wyatt@mytimemedia.com – Neil.

Ball Turning

Dear Neil, I thank Mike Cox for his clever design of the mini-lathe ball turner (MEW 259). Simple and efficient, it works beautifully. I have adapted it to my lathe, a German Wabeco D6000.

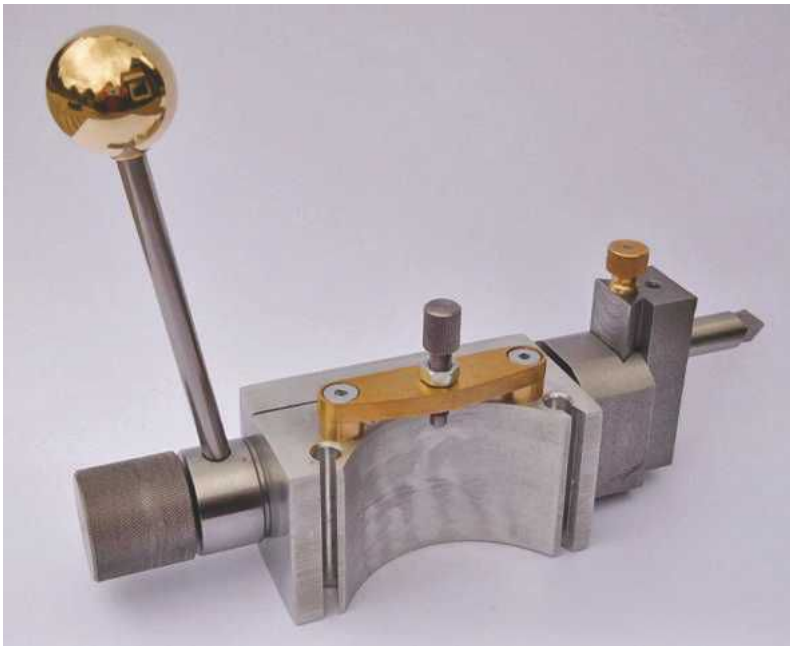
I would like to say that, as an electrician engineer, for me the motor of a modern lathe is electronically controlled with solid state semiconductors in the power circuit. They can be found in vacuum cleaners or even electric locomotives with huge power for decades. The motor can turn in both directions and thus the chuck is positively fixed to the spindle. Further, a commercial quick change toolholder is a nice thing to have, but the toolholder itself is relatively expensive. I made a toolholder from aluminium for my ball turner, as described in the German book Tipps und Tricks für die Metallwerkstatt, by Jörg Burgdorf (editor VTH). With this solution, there is no repeatability of the position in rotation, but in this case, it is not a problem (with M. Cox's solution it is the same).

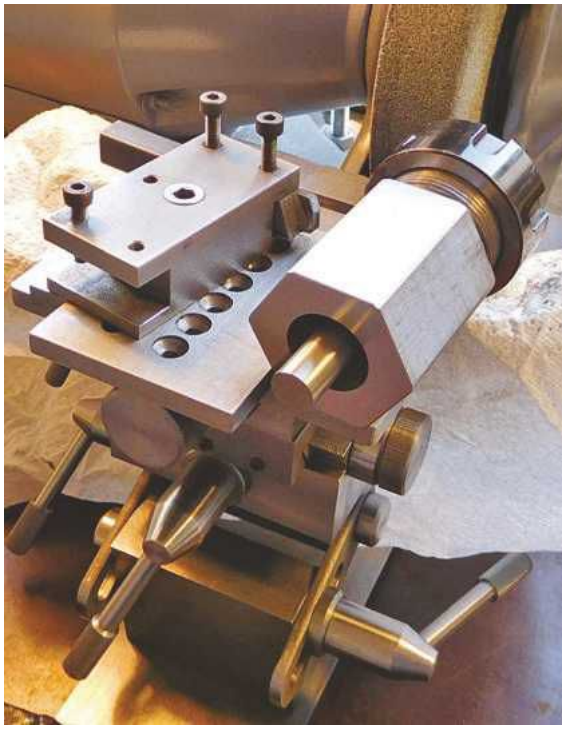
I was also very happy with the article of D. J. Graves (MEW 255) Compound curves in the lathe, even if I don't pretend to do the same. A good preparation before making the ball turner. His triangular tool inspired me to make my own, from a HSS toolbit. I used a hexagonal ER 25 collet from Arc Euro Trade and the grinding rest of M. Harold Hall to machine the toolbit in an inverted triangular pyramid, to obtain 3 points to machine the ball.

I could certainly improve my honing skills, but I was very satisfied with the result, after polishing, you can see the sky in Holland!

I did this myself, at home, I cannot believe it. Thank you for your magazine.

Bernard Zaegel, the Netherlands



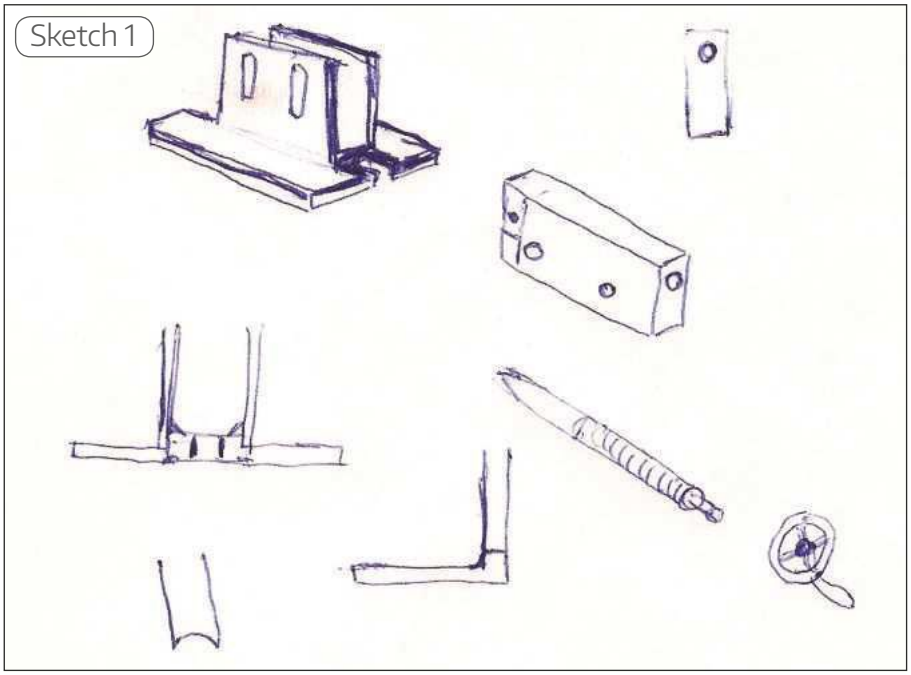


A Dividing Head Tailstock

The finished tool

Will Doggett describes the tailstock he made to complement his dividing head, described last month.

After making the dividing head some years ago more recently I wanted to cut some gears, this would require some support at the other end from the chuck as the gear blank was fitted to a short shaft. This was when the idea was born for a tailstock, **sketch 1, photo 1**. As I also had acquired a rotary table and some dividing plates to go with it more recently, I thought it would be a good idea to make the tailstock so that I could use it on both the dividing head and the rotary table. This required it to be adjustable as the dividing head and the rotary table are at different centre heights. It was made to cover 75mm to 100mm and as you can see from the original sketch, it is a simple affair. The



idea was to make the tailstock from stock materials that I had in the workshop and that are fairly ready available.

If the reader is going to make one for themselves then the height will require changing to suit the tool or tools that it will be used on.

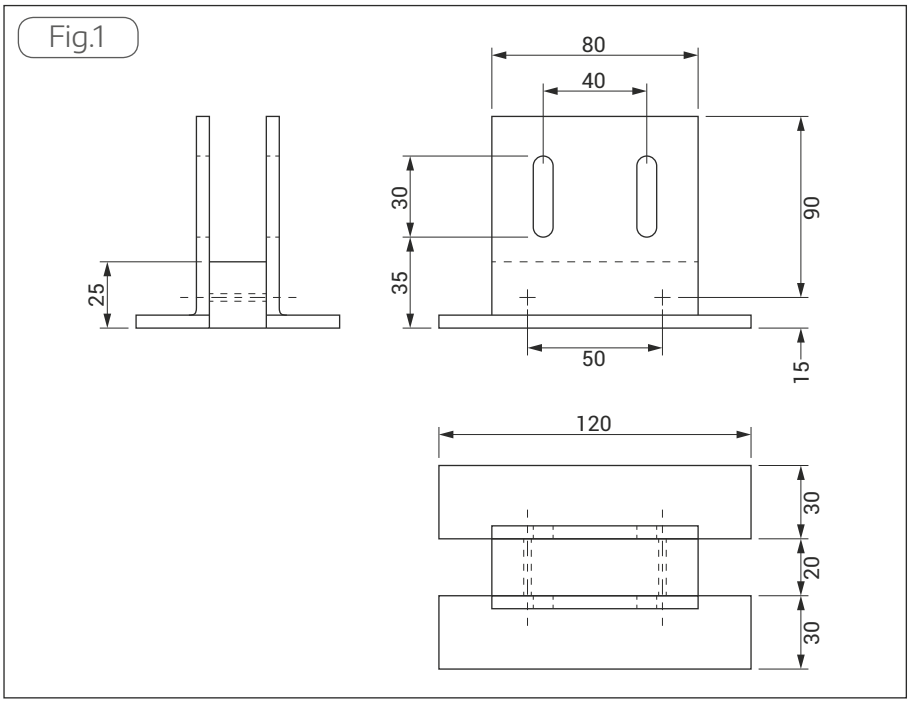
The Base

The base **photo 2** and in **fig. 2** is made from two pieces of 90 x 90 x 6mm angle and pieces of 30 x 20mm and 35 x 35 mm steel. The angles are cut to 120mm long in the band saw. Then clamp one side to the milling table to cut the side of the 90mm to 30mm high; this was done with a slitting saw, and then the other one was machined in the same way. To form what will become the slots in the ends of the base, 20mm has to be removed from both ends of the upright part of the angles, this was also done with the slitting saw. This was to make what will become the fixing bolts slots at the bottom of the sides these can be seen in photo 1 and fig. 1, to hold the two parts together without any packing so they are as one so to speak. This was done by marking out the fixing holes on one of the pieces of angle on the inside vertical face, 15mm up and on 50mm centres then drilling the piece with an M6 tapping drill. When this is done clamp the two vertical faces together making sure the bottom faces are level with each other and flat and then drill the other part though the same drilled holes. Now open up one side's holes to full 6mm and tap the other side's holes M6.

Now, using short bolts clamp the two angles together and put one end in the milling machine vice with the larger part of the angle vertical and cutaway the waste from that end at the bottom of the vertical part of the angle then repeat on the other end as shown in the figures. Now set the angle horizontally in the vice, that is the long side horizontal to the vice and cut the other way to remove the waste on both ends. You will probable have to finish with a hacksaw by hand as the slitting saw will not get into the corners. After cutting away the waste the ends were cleaned up with a file or you could do this on the machine with an end mill if you have one long enough.

Next dismantle the two angles and place one in the machine vice with the 30mm part in the vice and the other longer part over the moving jaw of the vice. This is done this way as the fixed jaw of the vice is usually more accurate than the moving jaw. Put some packing under the overhang between the vice and the angle to stop it flexing. Now you can machine what will become the inside face of the finished tailstock; this should only need a light cut. I used a fly cutter, as its radius was big enough to cut in one pass. Repeat the machining on the other pieces of angle. It is now a good idea to mark out and machine the slots in the angles as shown in fig. 2, because the angle is held in the vice in the same way for the slots as they were to get them level and this will complete the machining on the

The base



sides. This was done with a slot mill on both sides, it is made 8mm for the bolts' shank to go through. The other side is also milled to 8mm. The square on the coach bolts has to be reduced to 8mm to fit the slots. The bolts are shown later in photos 6 and 7.

The packing piece was made next it started as 35 x 35mm and cut 85mm long and was machined down to 20 x 35mm and was finished 80mm long. After milling it was marked out for the 6mm clearance holes and then drilled. After removing the burrs, the base can be assembled. I used thread sealer on the new M6 socket head screws on assembling it.

The only thing to do now is to clean up the bottom of the assembly. So it was back to the machine vice and holding it on the long faces with 20mm packing in-between the sides. At this point it was checked to make sure it was square in the vice and then the bottom was machined with light cut again. After cleaning it up it was put to one side ready for deburring and painting.

Height adjuster

The height adjuster **photo 3** and fig. 2 is made from a piece of 20 x 50mm stock steel the finished length is 100mm. The ends were machined square in the mill then the hole was marked out on the end as shown in the figure. The piece was then set

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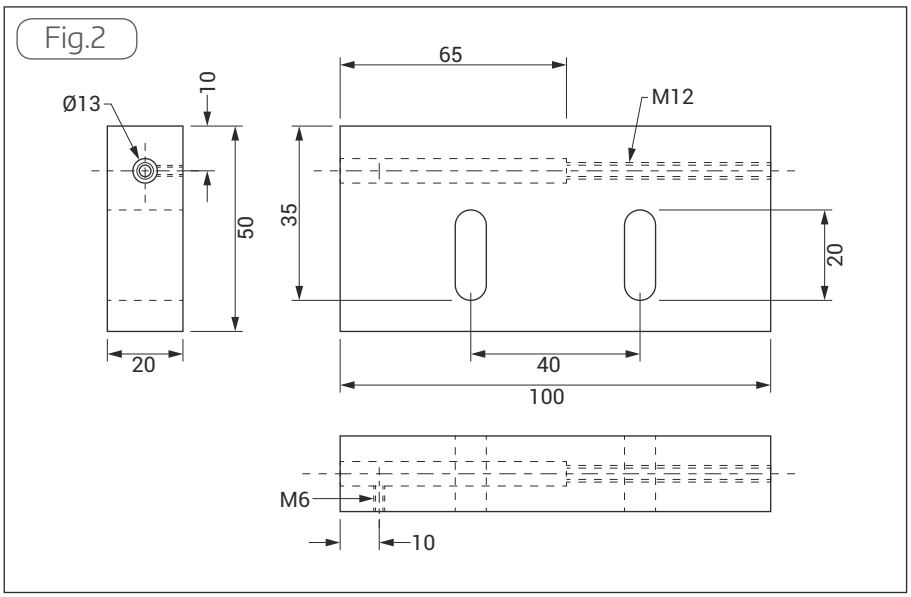
up in the drill (or you could use the milling machine if it's a mill/drill) square to the table and the 8mm hole was drilled all the way through. Next the hole was opened up to13mm for 65mm. This hole should be reamed. It was then removed from the vice and put back in the vice the other way around and set up square again and then drilled and tapped M12 from this end.

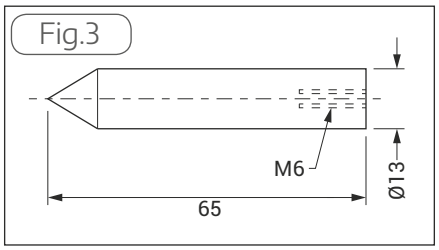
The next bit to do is to mark out the slots, these are 8mm wide and 20mm long, and then machine them. The only other things to do are drill and tap the M6 hole at the front of the block for the locking screw.

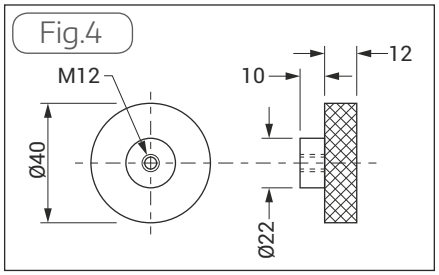
The centre

The centre, **fig. 3** is made from 13mm stock steel. This is put in the chuck of the lathe and a 60 deg angle is machined on the end and then parted off at 65mm long. This is then remounted in the lathe and the parted end is cleaned up and then drilled and tapped M6 and 15mm deep.

The other parts are a piece of M6 threaded rod 60mm long and a piece of M12 threaded rod also 60mm long. The







Height adjustment

The centre

The centre parts

M12 has a M6 thread cut in the end 10mm deep to allow the M6 rod to screw into the end.

The M12 is screwed to the M6 and the M6 is screwed to the centre, this is shown in **photo 4**.

To move the centre out there is a handle, **fig. 4**, **photo 5**, that is 40mm diameter screwed to the 12mm rod. The larger diameter is knurled. To stop it becoming loose there is a locking nut.

The locking nut is a standard nut machined to half its length. The clamping

Clamping bolt reduction

Clamping bolts

bolts, **photo 6**, are 8mm coach bolts with standard nuts with washers the bolt have had the square reduced on two opposing sides to fit in the slots in the side of the base. **Photograph 7** shows the finished bolt.

The base was given a coat of hammer finish paint in black and the other parts were blackened chemically.

The tailstock in use

The tailstock is fixed to the machine table with square washer across the 20mm slots on the ends with short studs into tees nut in the slots of the table. The large gap helps positioning on the table. To set the height a number 2 Morse taper is put in the either the dividing head or the rotary table temporarily. The two points are lined up then the side bolts are tightened.

When I made the dividing head it hadn't occurred to me that putting the Morse taper in the main shaft was going to be so useful. ■

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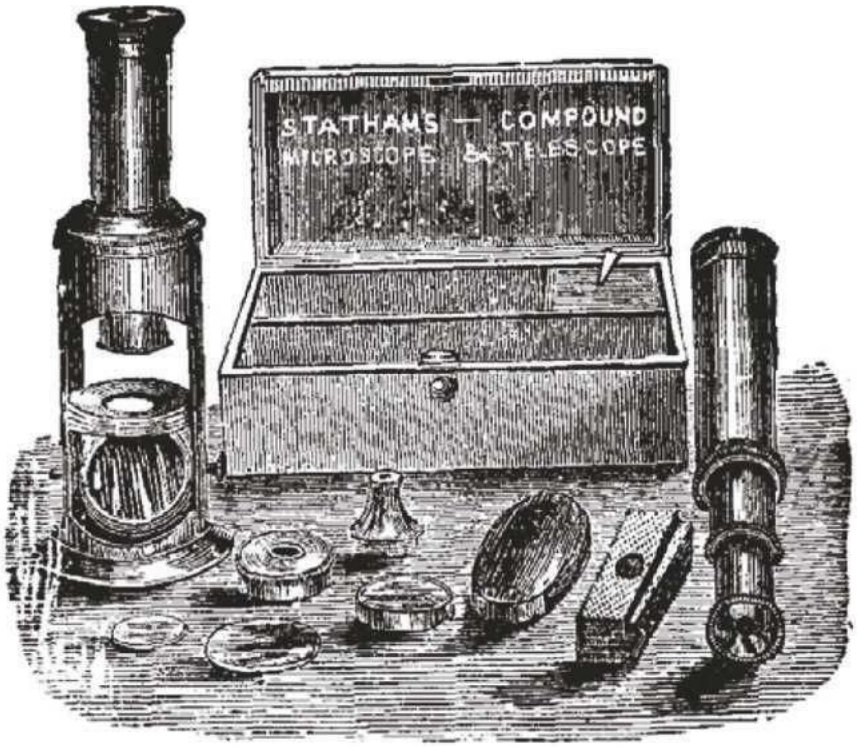
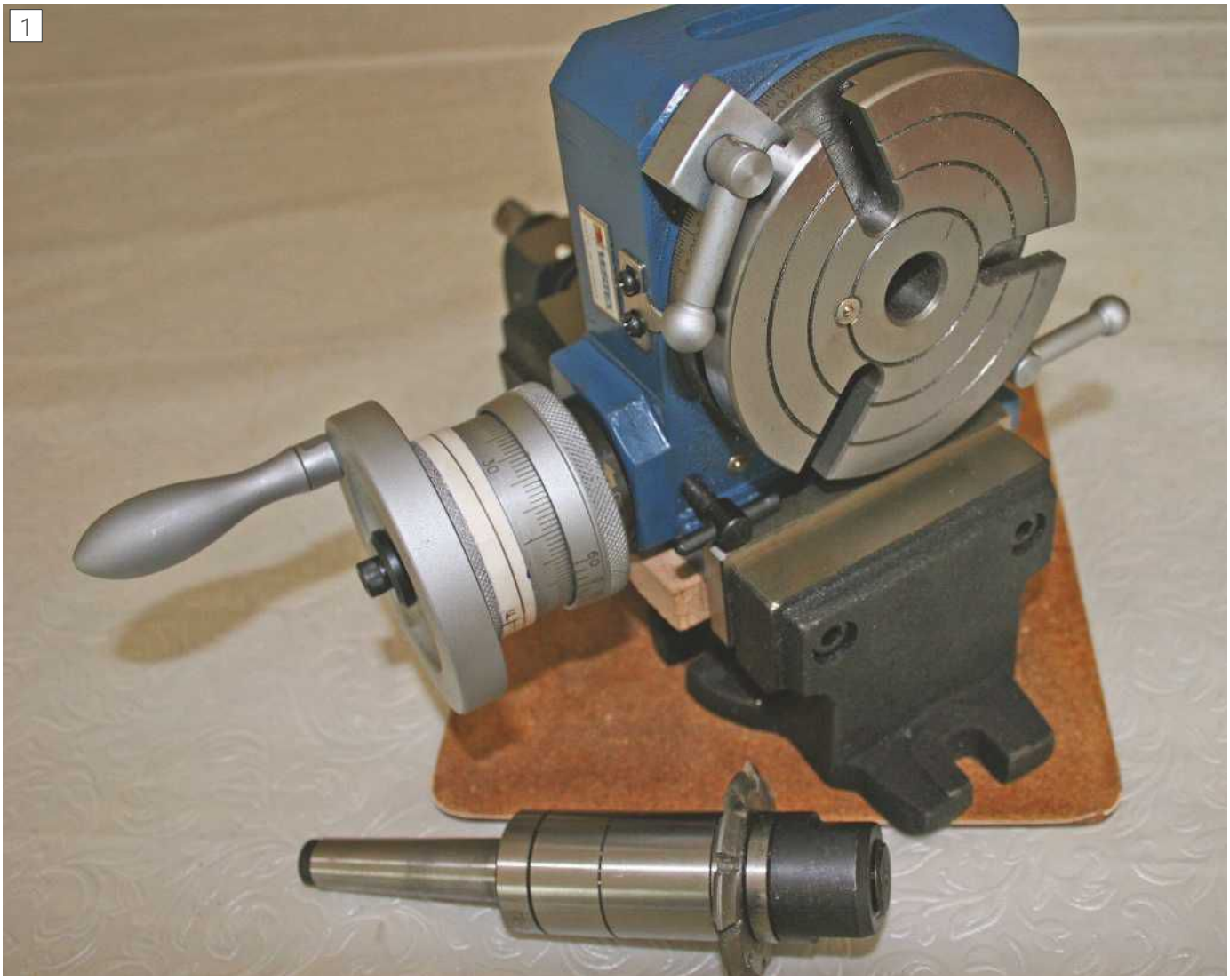


A Gear for a Hanriot

Ian Turney White learns gear cutting to complete his large-scale biplane.



The rotary table (in a vice), arbor and cutter.

Writing something for such an illustrious magazine as Model Engineers' Workshop, I feel a bit of a fraud, never building a steam engine, traction engine, or steam locomotive. The basis of the article was that I needed an 80-tooth alloy gearwheel, I contacted several firms and the cheapest price quoted was £175 which seemed a lot of money to me. Probably in the future I would need a couple more.

Typical of the age, I looked on the internet to see how to cut a gearwheel and ordered a Vertex HV4 rotary table, a 1.75 module involute number 2 gear cutter and a stub machine 22mm arbor plus a one metre length of 6 x 1/4" 6082 T6 Dural bar, **photo 1**. I already have a Warco wm250 lathe and a Chester Champion 16 vs milling machine.

I cut a disc of Dural with a hand hacksaw and turned it on my lathe to the correct diameter and with a central hole plus a register to mount it onto the front of a pulley. I also drilled three 10mm holes so I could fasten it to the rotary table using t-bolts, I found that the easiest way to mount the rotary table and give enough clearance for the gearwheel was to grip it tightly in my K type milling table with a suitable support spacer. The milling table was clamped to the left-hand side of the horizontal table on my milling machine with the jaws parallel with the table. The alloy blank was centralised by using feeler gauges between the base of the gearwheel and vice jaw whilst rotating the table.

The stub arbour was fitted along with the involute cutter and the head height was adjusted and locked, aligned with the centre of the gearwheel.

The perceived difficulty was that I might advance the rotary table incorrectly or under or overcut the teeth, probably

when I had cut most of the teeth!

For 80 teeth, the rotary table needed to advance 4.5 degrees for each tooth.

I worked out that I could make a thin overlapping strip from thin card (shredded wheat cereal box). This could be wrapped on the plain left-hand side of the handwheel on the rotary table (next to the graduations) with a spiral line drawn with a start and end point that corresponded to 4.5 degrees. This was wrapped with a thin strip of Sellotape so it was a snug fit but it was still possible to rotate it on the handwheel, **photo 2**.

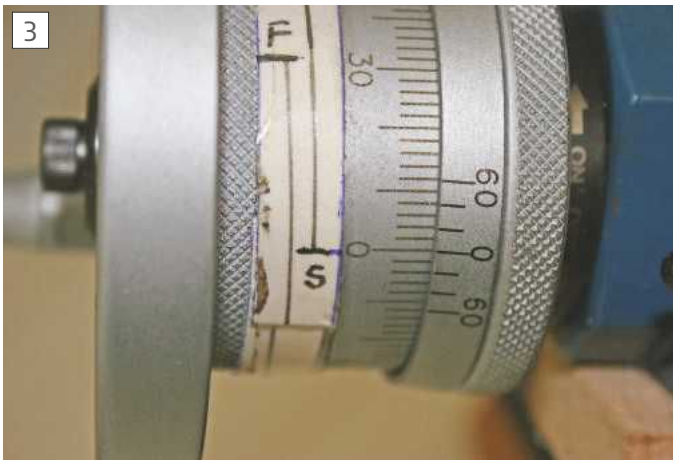
I also made and fitted a mechanical stop to my bench, positioned and clamped down to give a cut of the required 3.94 mm by limiting the horizontal table movement to the right. These two simple things made the cutting of the teeth really simple, with the handwheel at 0 degrees, the card ring 'start point' set at 0 degrees, **photo 3**, and the rotary table clamped, I cut the first tooth, depth of cut limited by the mechanical stop. I unlocked the table and rotated the handwheel to the 'finish point', **photo 4**, using the wheels graduations for final accuracy i.e. 0 or 30 markings and locked the table and cut the next tooth.

The card ring was then rotated so the 'start point' was aligned with the present set point, then unlocked the table and rotated the handwheel to the 'finish point' and locked the table and cut the next tooth. this was repeated for all the teeth and I was delighted (and relieved!) that on the last tooth I had achieved symmetry with all the teeth. It took about 80 minutes to cut all the teeth which I felt was very reasonable. the advantage was that the card ring and end stop made it unnecessary to have to count or add up the required movements of the rotary table and horizontal table.

Without the two guides I would have probably have lost concentration and made a mistake with the maths/settings resulting in a botched attempt, this system could possibly be used for other tooth numbers as a means of taking you to the required position. I realise you can buy dividing parts which can be fitted to a rotary table and achieve the same/better results, but my low/zero cost method appealed to the Yorkshire man in me!

For those interested, the gearwheel fits on the belt drive pulley on my two thirds scale, radio controlled, world war one fighter biplane, a Hanriot HD1, **photo 5**. I have for the last four years started it by hand, rather both hands and arms but

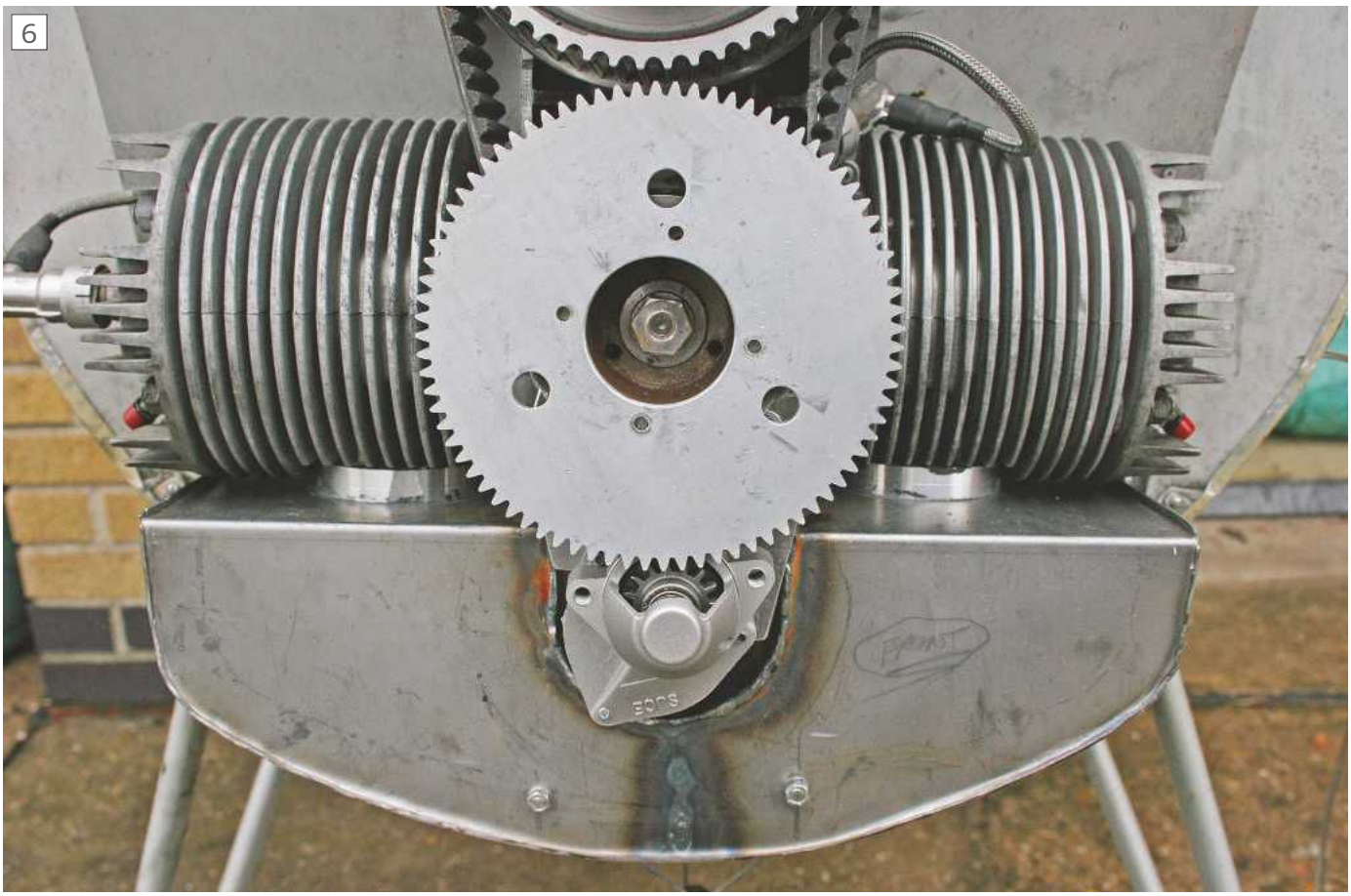
Strip fitted to table handle dial.



Start position.

Finish position.

The Hanriot is not a small model!



The gear fitted to the JPX engine.

sometimes struggled to start it.

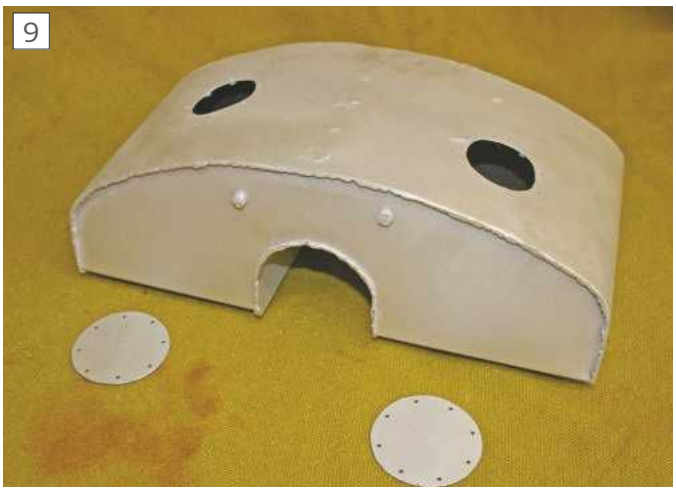
The motor is a French JPX two stroke flat twin cylinder 425cc microlight engine, **photo 6**. it has a reduction drive with a 1.931:1 ratio (ideal for bigger props). It was originally fitted with four vee belts which were forever stretching, which I changed to use a Gates GT3 toothed belt and new pulleys, similar to the timing belt on car engines. Starting it, you have the problem that due to the odd ratio, the 'compression point' moves for each revolution of the prop. This means that often the compression point is in the wrong position and it is difficult to get enough effort into swinging the prop over, the reduction ratio means that with one turn of the prop it turns the engine over almost twice, doubling the effort needed. If it had been a ratio of 2:1 the belt life would be much less due to the same teeth carrying all the load.

The easier and much safer option was to fit an onboard electric starter, a firm in Italy make small 400-watt, 12 volt starters complete with a gearbox and small Bendix drive unit, **photo 7**. One of these was fitted below the engine/starter gear wheel on an alloy bracket using two convenient crankcase bolts. The starter is energised via a 90-amp automotive relay and a three-cell lithium polymer 4,000 milliamp-hour battery controlled by a servo/micro switch from a spring-loaded switch on my transmitter (plus an additional toggle switch for safety in the coil circuit on the relay).

The gear and starter motor.

The longest job was that I had to fabricate a new silencer with a 'tunnel'

Inside the silencer.



Top of the completed silencer

Underside of the silencer.

to accommodate the starter motor from 1.0mm steel sheet with a minimum volume of ten times the capacity of the motor, i.e. 4.25 litres. The body is formed from a "U" piece (front, base and back) with a half round cut out for the starter motor, **photo 8**, all the edges have a small turned over lip so I could TIG weld on the tunnel piece and a cover (bottom and ends) once the internals were fitted. The cover has two screw-on, removable hatches for access to the six Allen bolts which fasten the silencer to the motor, **photos 9** & **10**.

The Hanriot was scratch built over a 30-month build using various three view drawings of the full size plus photos of the original N78 in the Brussels Army Air Museum.

The construction follows the full size, mainly using spruce, the model features scale internal and external rigging wires, the span is 19 feet/5.8 mtrs and it weighs 187lbs/86kg.

The prop is a home designed and produced laminated beech unit with a diameter of 56 inches and 26 inches pitch which is turned at 2500 rpm, **photo 11**. I had about 3.5 lbs of lead noseweight fitted to achieve the correct centre of gravity plus I had to remove part of the dummy engine and along with a lighter silencer. I ended up with the lead removed, the same overall weight/centre of gravity with the electric start system installed.

Dummy engine fitted over the JPX and prop.

For these large models they have to go through a scheme from the Civil Aviation Authority, (CAA), the Large Model Association (LMA) inspects the model during construction and witness 12 test flights, **photo 12**. The CAA then provides an exemption certificate with conditions which allows the model to be flown in front of the public.

Does the starter work? A resounding yes, and it feels so much safer standing behind the wings than in front of such a big prop. For the public displays put on by the LMA such as RAF Cosford and Elvington, it should result in a much more reliable start when its my turn to display the aircraft to the public spectators.

I must admit I feel proud of my gearwheel and pleased that I decided to have a go at making it myself. If any readers are interested, there are some flying shots of my Hanriot and half size Bristol Bulldog on youtube.com/watch?v=ARZp46N_EqY and youtube.com/watch?v=Cu6zZKcRris ■

Test flight of the Hanriot. Photo: John Ricketts

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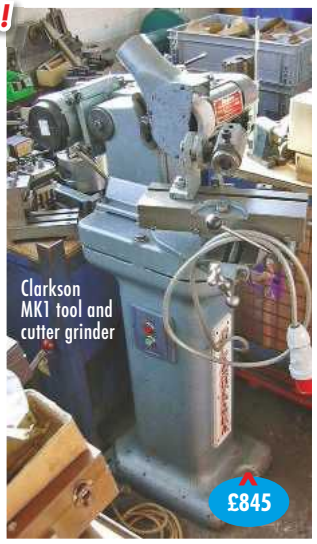

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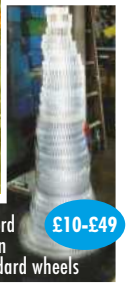

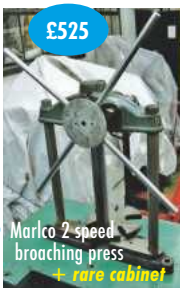

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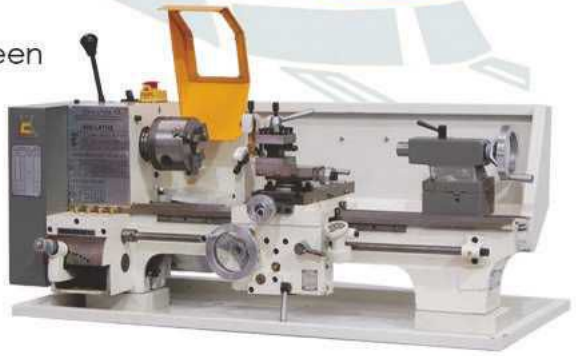

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