No.294

THE BEST MAG FOR MAKERS, MODEL AND HOBBY ENGINEERS

MODEL ENGINEERS' WORKSHOP

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JUNE 2020

Cherry Hill's Workshop - 2008 Interview in MEW for the first time

Harold Hall's Grinding Rest - a Versatile Classic

INSIDE

COVER STORY

Alan Jackson's Benchtop Surface Grinder

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On the Editor's Bench

I have corresponded with several readers who are 'shielding' and I'm glad to hear that as well as finding plenty of workshop time, getting their issues of MEW and ME is helping deal with the challenge of an enforced stay at home.

It's also been gratifying to see how busy our online forum, at www.model-engineer.co.uk has been. We have seen literally hundreds of new members to the website and very many of them are already active contributors. I am especially grateful to all the long-standing forum members who have been so welcoming and positive in their reception of these 'new faces' who range from complete beginners to experienced engineers and modellers. The amount of discussion on the forum has been extraordinary and the range of topics covered has been exceptional. Don't feel you need to be active in your workshop to post, although much of the discussion is about such things, we also have the 'Tea Room' for discussion of issues of broader interest.

Due to the vagaries of international deliveries, many of our overseas print subscribers find themselves without their magazines, I'm pleased to say that we have been able to open up access to the online archive for them. If you are reading this on an electronic copy for the first time, I hope you haven't found the process too involved.

I don't suppose a huge number of you reading this will have bought your copy at a newsagent, but if you have or if your subscription expires soon, you might well wish to look at our '3 for £1' offer on page 22. It's a good time to try electronic access at no extra cost, and who knows, you may prefer to stick with this in the future.

Electronic magazines are certainly better for the environment, and I have recently exchanged several emails with a reader who has asked why we don't change the envelopes for the magazine to compostable potato starch based polymer? Unfortunately, these appear to cost about ten times as much as standard plastic envelopes and so are an unlikely choice while we are dealing with all the impacts of coronavirus on the magazine. When things are back to a more normal situation, I will print some of our exchange in Scribe a Line and seek some feedback from readers on such issues.

Finally, as for my own workshop, readers won't be surprised that my relocation has been put on hold for some months with the housing market not being particularly active! I have unpacked most of my tooling and recommissioned my lathes. Although I have some work other than MEW to get on with (not least a couple of books) I am hoping to do some anodising next week, once MEW has been 'put to bed'.

Stay safe and well,

Contents

See page 40 for details.

Coming up...

in our next issue

Coming up in our June issue, number 294, another great read

Regulars

ON THE COVER

Our cover shows Alan Jackson's benchtop surface grinder, see page 16 for more details. Many readers will remember Alan's medal-winning Stepperhead Lathe.

HOME FEATURES WORKSHOP EVENTS FORUMS ALBUMS

Visit our Website

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Why not follow us on Twitter: twitter.com/ModelEngineers hashtag #MEW

THIS MONTH'S BONUS CONTENT

Log on to the website for extra content

Visit our website to access extra downloads, tutorials, examples and links.
www.model-engineer.co.uk/extracontent
Any questions? If you have any questions about our recent Alibre Atom3D or current Lathework for Beginners or Milling for Beginners series, or you would like to suggest ideas or topics for future instalments, head over to **www.model-engineer.co.uk** where there are Forum Topics specially to support these series. Our Web forum has been exceptionally busy over recent weeks and we have been pleased to welcome many new members. The forum is a 'safe space' for anyone with an interest in model and hobby engineering to come and join one of the busiest and friendliest model engineering forums on the web at **www.model-engineer.co.uk** As well as plenty of engineering and hobby related discussion, we are happy for forum members to use it to share advice and support. If you feel isolated or lonely do join us and be assured of a warm welcome.

Setting up a Mini Mill & Stuart 10V Machining
This thread will be useful to other beginners starting a first build.

Sharpening Files
Interesting observations on this tricky subject.

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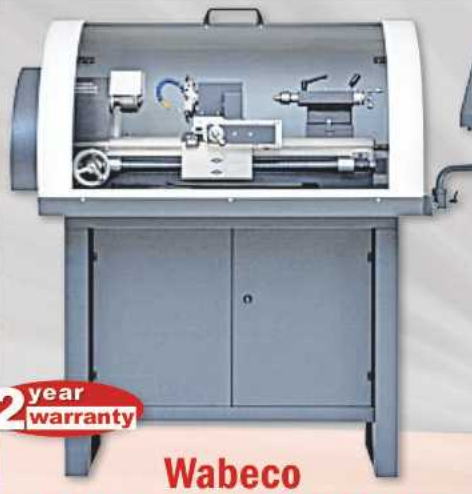

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- Speed – 30 to 2300rpm
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Starrett-Type Clamps for Model Engineers

Stewart Hart recreates an historic tool that's still useful today

These Model Engineer Clamps are based on Starrett No 160 Tool Makers' Clamps, I'm calling them model engineer clamps because the constraints and compromises of home workshop construction will mean that they would not be made to the same exacting standards you would expect from commercial manufacture, never the less they will prove more than adequate for home workshop use.

I first came across these clamps in a digital archive of American Machinist magazines from the 1890s, so they have been around for a long time, in fact they are still marketed by Starrett and occasionally they come up for sale on online auction sites. When originally sold they came as a matching set of clamps each clamp having two jaws of different lengths, **photo 1**.

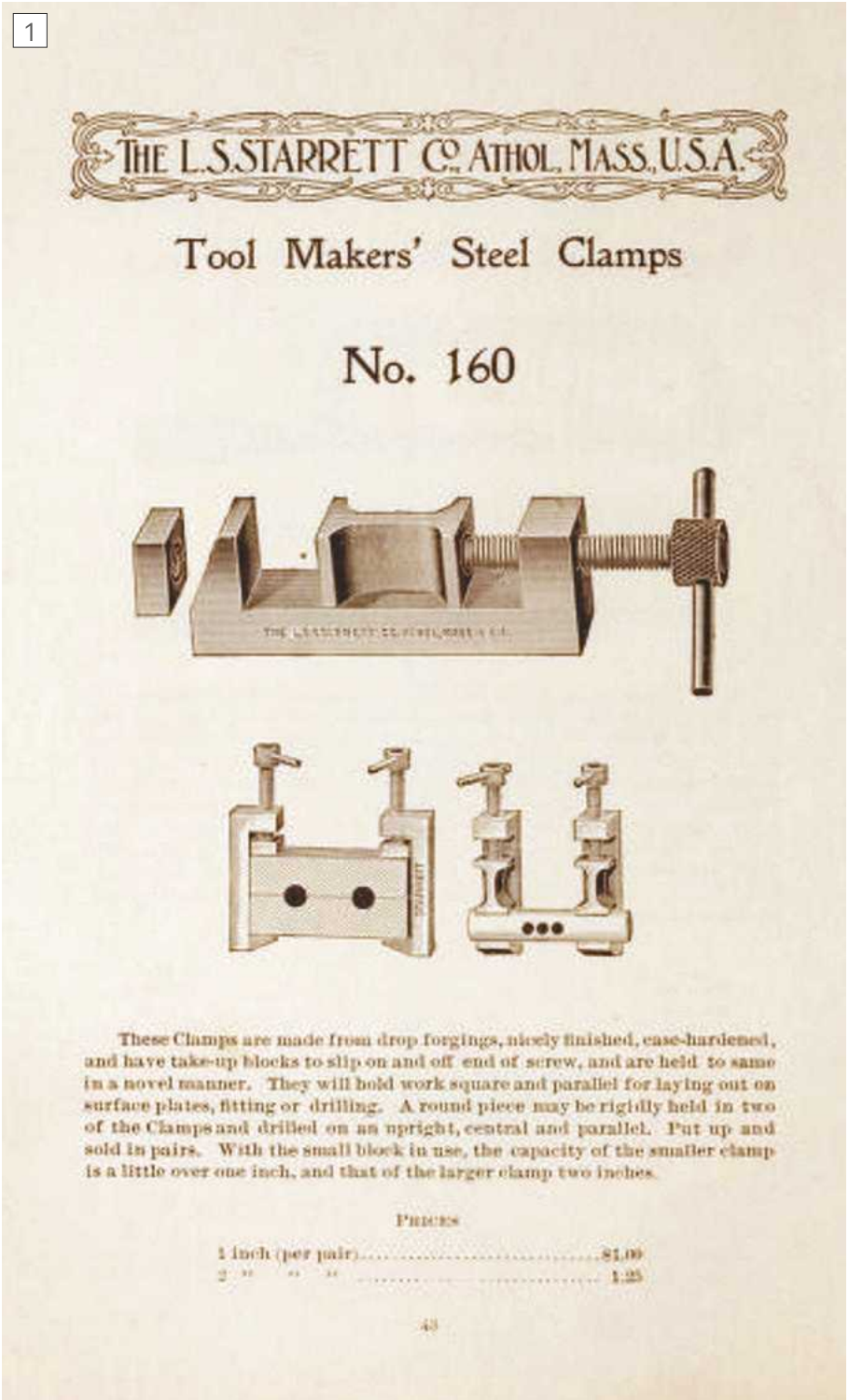
These model engineer clamps are designed for ease of manufacture in a home workshop, using standard sized cold rolled mild steel bar, **photo 2**, with a clamp bolt fabricated from an M8 coach bolt that is secured to the jaw using a simple keep made from an M3 cap screw. **Figure 1** shows the parts.

The cold rolling method induces high levels of stress in the bar, machining releases these stresses causing warping, this will be a particular problem with the body. In industry they would deal with it by stress relieving the bar, by soaking it at 600 – 700 Deg C. Not having this facility we'll have to try and deal with this differently.

Starting with the body: cut two lengths of bar each 70mm long then square up the ends, **photo 3**, and mark out the hole position and centre pop, also centre pop the line for the cut out, **photo 4**. Drill the corner of the cut out 2mm diameter, this will give a good sharp corner for the jaw to slide up to. In order to make them as a matching set, the two bodies need to be clamped together, so drill and tap one M4 and drill the other 4mm, **photo 5**.

With the two bodies clamped together, **photo 6**, chain drill three

1


THE L.S.STARRETT Co. ATHOL, MASS., U.S.A.

Tool Makers' Steel Clamps

No. 160

These Clamps are made from drop forgings, nicely finished, case-hardened, and have take-up blocks to slip on and off end of screw, and are held to same in a novel manner. They will hold work square and parallel for laying out on surface plates, fitting or drilling. A round piece may be rigidly held in two of the Clamps and drilled on an upright, central and parallel. Put up and sold in pairs. With the small block in use, the capacity of the smaller clamp is a little over one inch, and that of the larger clamp two inches.

PRICES

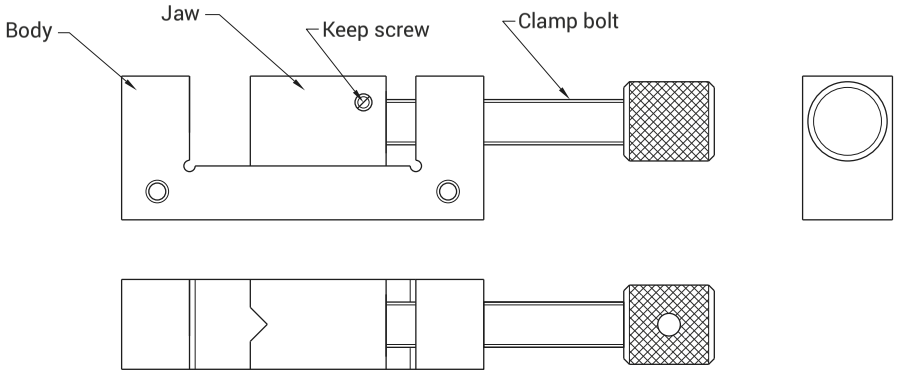
1 inch (per pair) $1.00

2 " " " 1.25

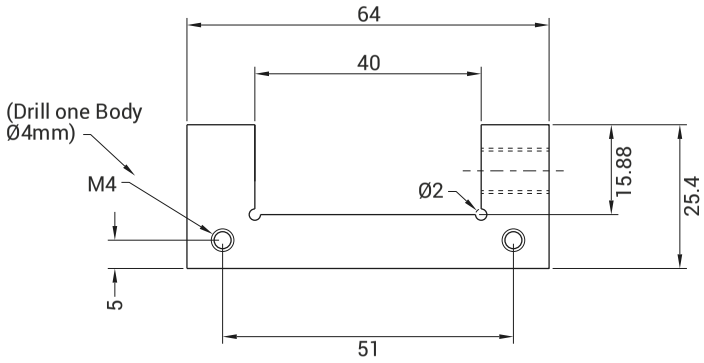
43

Starrett clamps of 1890.

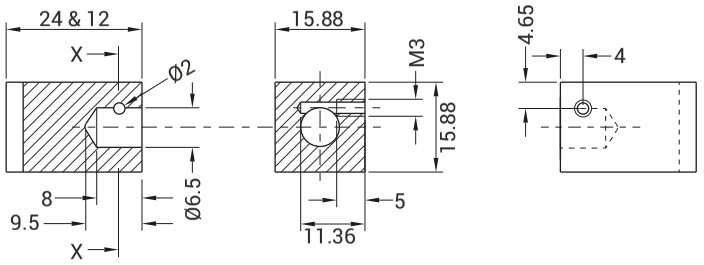
Fig.1



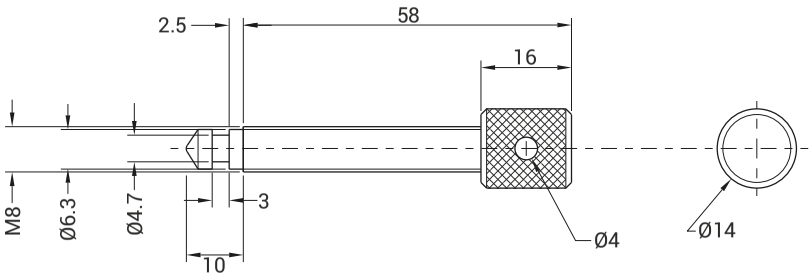
General Arrangement



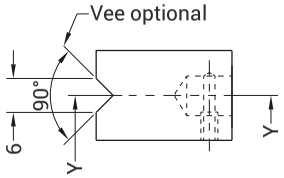
Body
Mat'l: 1 5/8" mild steel, 2 off
Make as a matching pair by clamping together using M4 screws



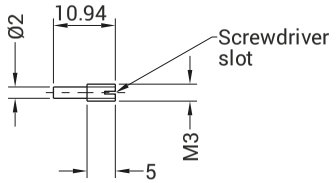
Section Y-Y Section X-X



Clamp Bolt
Mat'l: Fabricated from M8 mild steel studding or bolts with knurled handle welded or silver soldered in place
2 off
Note: clamping load to be taken on the nose of the bolts



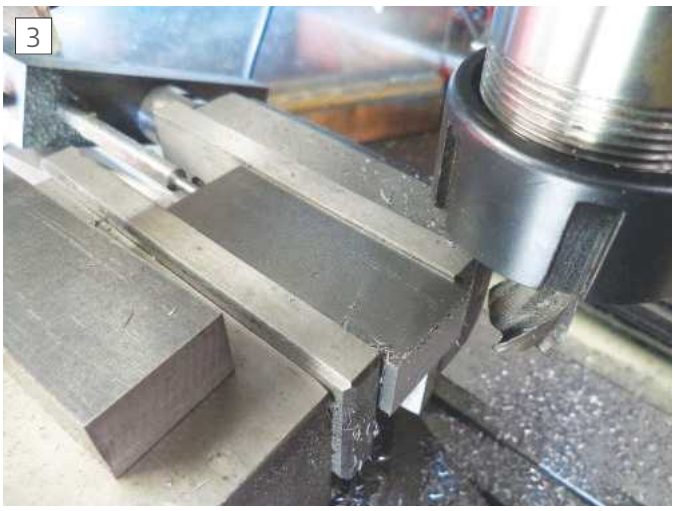
Jaws
Mat'l: 5/8" sq. mild steel
2 at 24mm & 2 at 12mm long, made as matching sets
Note: drill & tap M3 hole before drilling Ø6.5mm hole



Keep Screw
Mat'l: Make from M3 cap screw, 2 off

Modelmakers Clamps
Design based on Starrett No.160 Toolmakers Steel Clamp
Make as two matching pairs of clamps, each clamp having two jaws 24mm & 12mm long

Standard stock size cold rolled mild steel bar.



Squaring up the ends of the bar.

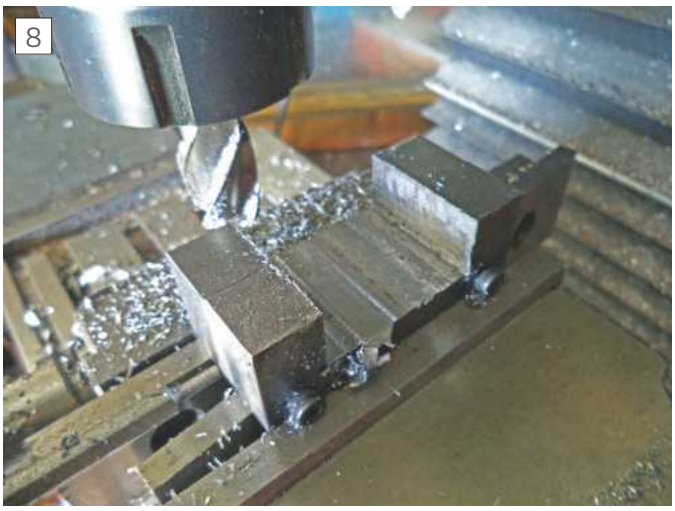
Marking out the bar with centre pops.

Drilling and Tapping.

Both bodies clamped to together for rough drilling.

›

Excess material quickly removed.



Rough out using end mill.

Checking vice is square.

12mm diameter holes spaced so that they just overlap each other, then using a hacksaw cut the waste away. This is a quick way to remove metal and will save you from blunting your expensive milling cutters, **photo 7**. Next rough the body out using an end mill, **photo 8**, and set the part aside for a few days to let the stresses take full effect. You will find that the back of the body will arch slightly. I also put my pieces into the domestic oven set at its maximum temp of 240 Deg C this is probably too low, but I reasoned that it would not do any harm, and it just might do a bit of good. You could have used stress free hot rolled bar or find a supplier of normalised bar but this would either increase the amount of machining or push up the material cost.

Before finishing off check that your vice is set square on the mill by clocking up the fixed jaw, **photo 9**, as you don't want to pass any errors onto the clamps.

●To be continued

On the Wire

NEWS from the World of Hobby Engineering

Ultimaker 3D Printing Podcasts

Ultimaker, the 3D printer manufacturer has announced the launch of its new podcast series, "Talking Additive." The first season of "Talking Additive" features guests from Ultimaker's network of partners, customers and allies, including decision makers from leading manufacturing companies, third-party Materials Alliance partners and Ultimaker.

Ultimaker's "Talking Additive" provides an interactive avenue to explore the impact of adopting additive manufacturing. The podcast, hosted by Matt Griffin, Director of Community Development at Ultimaker, aims to uncover new details about the evolving paradigm for the future of manufacturing, engineering and design through stories and experience from top innovators from around the globe.

Now available, the first three "Talking Additive" episodes feature:

- **Matthew Forrester, Additive Manufacturing Technical Manager, L'Oréal** - Ultimaker virtually visits the L'Oréal headquarters in Clichy, France to discuss the three stages of adopting additive manufacturing: Prototyping, Plants, Production.
- **Danielle Glasbergen-Benning, Application Development Specialist, DSM Additive Manufacturing** - Glasbergen-Benning explains the process for translating application needs into material solutions, with insights into recent cutting-edge projects made possible by their portfolio of materials available for open platform professional 3D printers.
- **Paul Heiden, Senior Vice President of Product Management, Merijn Neeleman, Portfolio Development Manager, and Rohit Jhamb, Director Global Research & Analytics, Ultimaker** - three Ultimaker experts dive into the role of additive manufacturing in LEAN manufacturing, digital distributed manufacturing, the future of supply chain and how production processes are already changing for those adopting 3D printing in their product development and fulfilment pipelines.

Following the initial launch, Ultimaker will release one new "Talking Additive" episode on a bi-weekly basis. Listeners will have access to each episode on the Talking Additive website, as well as on various podcast platforms, including Spotify, Google Podcasts and Stitcher.

To learn more about Ultimaker's new podcast and to subscribe to "Talking Additive," please visit **talkingadditive.com.**

Stevenson Trophy 2020

Regular readers of MEW will already know the Stephenson Trophy competition for workshop-made tooling is running again this year. If you missed the announcement in issue 293, full details of the competition and how to enter can be found at:
https://www.model-engineer.co.uk/stevenson

Coronavirus Update

The news I have from a number of our advertisers is that virtually all of them are continuing to trade for courier or mail deliveries and are accepting orders online or telephone. The consistency of deliveries is patchy across the country, and although in some areas it is almost as normal in other areas things are quite slow.

Please bear in mind that even if you appear to be getting prompt deliveries in your area, goods may be sent from or pass though places where there are problems, also some of our suppliers are under-strength having had to furlough staff. So please be patient if you don't seem to be getting service that is as quick as usual, but in general you can expect purchases to arrive relatively promptly.

Uddeholm Idun

Readers may be interested in this new steel for making toolholders from Swedish steelmaker Uddeholm. This is what they tell us:

Uddeholm Idun, offers a safe and reliable fast forward button to finished tool holders for indexable inserts. Uddeholm Idun is a pre-hardened and corrosion resistant steel grade, which makes the production a one-stop-shop where heat treatment and coatings will no longer be necessary.

In today's market, time is of the essence for tool producers. Recent years have seen an increasing trend in machining more tools in hard condition, not only to meet the market demand and shorter delivery times, but also to save both time and money on less heat treatment. Naturally, the next step to further decrease the production time is to dispose of costly and time demanding coatings. Until now this has not been possible. Uddeholm Idun changes this by being the first patented corrosion resistant tool holder grade on the market.

Corrosion resistance is requested both for its pleasing aesthetics, as well as to protect the tool holder from corrosion attacks. Uddeholm Idun has undergone comparison tests in a salt spray chamber according to SS-EN ISO 9227 in 0.1M salt solution at 35°C for 3.5 hours. The steel showed no corrosion, which proves that the corrosion resistance is at least in parity with nickel coating or better.

Uddeholm Idun is meeting the market demands by being pre-hardened to 42-46 HRC, a hardness range used for milling cutters. The steel is manufactured by electro slag remelting, which gives it an even microstructure with small carbides in a martensitic matrix. The hardness is even from the surface to the centre. Although delivered in hard condition, Uddeholm Idun still offers good machinability. Uddeholm Idun can be induction hardened to 55 HRC on the surface if wear resistance needs to be improved locally.

Uddeholm Idun has much better softening resistance than standard P20 type materials at a constant temperature of 450°C and it keeps a high hardness at 500°C for a long time. Competing materials tend to get a soft surface due to the temperatures created when in production. When losing the surface hardness, the function of the steel is of course lost.

In addition, Uddeholm Idun will give a lower impact on the environment compared to competitor steel grades. Nickel coating is applied for the majority of tool holders and this has a negative impact on health and the environment.

- Starting material from recycled steel scrap
- Corrosion resistant steel, no need for nickel plating
- Delivered in pre hardened condition, no need for heat treatment
- No need for transportation for heat treatment and nickel plating

It will be interesting to see if and when toolholders become available to hobbyists in such new materials.

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A Bench Top Surface Grinder

Alan Jackson describes his shop-made surface grinder - Part 2

First table drive & original motor

Guide bars mounted on the cross slide block

Table operation

The original table screw drive, as mentioned earlier, was repurposed for the vertical feed. A screw drive would not have been suitable for the table drive anyway. The existing cross feed screw arrangement, however, was perfectly ok as is. Apart from the removal of the gib locking screw, as there would be no requirement to lock the cross slide.

My first attempt at the table drive was to fit a single strand of 8mm roller chain to the underside of the table. It was stretched taut and secured at each end with screws to the table. I made a matching chain wheel and mounted it on a shaft supported on a bracket extending out from the righthand side of the cross slide block. This positioned the chainwheel below the table. A handwheel about 6" diameter with a single handle was mounted on the shaft, **photo 12**.

Table belt drive, without table

This sort of worked but showed up some problems. First of all, the travel was a bit too short. Limited by the amount of table that could be left to support itself on the righthand side travel and the need to access the chain on lefthand travel. Secondly it was not as smooth as I had hoped, that may be my engineering, the truth hurts, but it did just not feel good enough. Thirdly the handwheel just about cleared the bench top, creating a perfect opportunity to scrape one's knuckles as the cross slide is moved along its travel. At the beginning of the cross

Toothed belt fitted to table

slide movement the handwheel was not over the bench top but as the cross slide moved towards the column it passed over the bench with little clearance. Finally, the ratio was too low, it took about four rotations to complete the full travel of the table.

While some of those problems could be overcome there was even worse to emerge. I hoped, or maybe better to say dreamed, that the original guiding system for the Dore Westbury table would be good enough for its new repurposed role. Well it worked ok for a short while until... (I am sure you have guessed it before I tell you) it just got stiffer and stiffer as the grinding dust penetrated the sideways. Once again the project was on hold, awaiting a rethink.

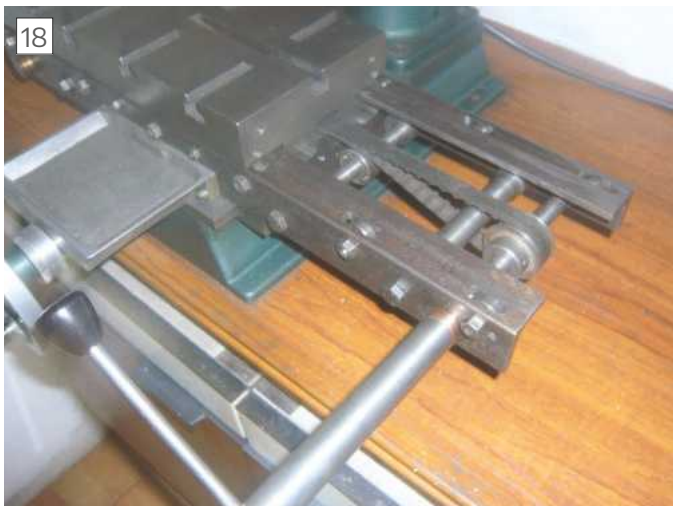
This is one of the main problems with surface grinders, grit in the sliding surfaces. A long time ago I tried the table operation on a second hand Eagle surface grinder, for sale at a model engineer's exhibition. The slide could be moved by the handwheel but, to my mind, it was so stiff that you would need Popeye type forearms. This may not be fair, for it might just have needed adjustment or oil to the dovetail slides, or it may be why it was for sale.

The next step required drastic changes, there was no going back. I proposed to extend the available travel by adding steel angle support rails to each side of the table. The table guide block was cut away to fit the angle sections so that it was flush with the outer block surfaces on both the sides and top. The angle sections were machined to remove their tapered inner surfaces and corner radius, so as to fit snugly on the block. Countersunk ¼" whit screws secured the angle sections to the block at the top, with hex. head bolts to the sides, **photo 13**.

This extended the table travel massively. I chose a full travel distance of about 13.5", but of course this could be made more or less as desired. I was going to use six ball bearings per side, spaced at 90mm intervals for the table to travel on. Slots were cut in the upper surface of the support rails to just allow the top surface of the bearings to protrude above the guide rails. The cross slide block was also recessed

Toothed belt clamping point

Toothed belt clamp block



Righthand side of table drive

Lefthand side of table drive

locally to clear the bearings. With the bearings spaced like this, there would always be about four bearings per side supporting the table, as it moved along its travel. I used 8 mm bore x 22mm o/d ball bearings type 608ZZ with double side metal seals, they are quite cheap and easily available. They are used in skateboards and roller skates etc.

The bearings were mounted on spindles with the 8mm dia. 0.015" eccentric to the mounting dia. of 0.250" threaded M6 at the end. A screwdriver slot is cut in the M6 end. The idea is to be able to rotate the spindles to set them to just touch the table underside sliding surface. This sounds difficult to do, but all I had to do was rotate the spindle until the bearing just about rotated as the table moved over the bearing. As the table is moved it is possible to put your hand underneath and feel if the bearing is rotating. Well this is only possible for the outside six bearings, the six inner ones can be seen only when the table exposed them, but this is sufficient to see if they are rotating with the others. The spindles are then locked in position with the hex nuts. This process was repeated a few times until I was satisfied that all the bearings were participating.

The bearings lift the table up about .015" above the top surface of the rails. The original rectangular guides, fixed to the underside of the table, were removed and machined down .030" along their upper sliding area to allow the table to be lifted and to clear the underside surfaces of the guide rails. The guides do not now contact any above or below surfaces, but they do act to guide the table in the direction of travel. The original gib screws have been loosened slightly to allow the table to move easily. The table now could move freely along the ball bearing

Grinding wheel with front cover removed

surfaces, with no limit to its travel, with just a light push from a finger.

Table drive

I proposed to use a toothed belt to drive the table. At the extreme lefthand end of the rails, an idler pulley fixed centrally on a cross shaft, rotates on bronze bushes mounted on each side of the support rails. A similar arrangement was used at the righthand end with the idler pulley replaced by a toothed pulley, fixed centrally to the shaft. The shaft is rotated to drive the table by a three pronged capstan handwheel. The shaft is extended towards the operator sufficiently enough to avoid the capstan spokes ever contacting the benchtop, even when the table is at its full inward travel there is good hand clearance. Lessons have been learned!

Idler wheels, consisting of two, 12mm bore, ball bearings side by side, fitted centrally on an eccentrically mounted cross shaft, are positioned on each side of the cross slide block. They are rotated to tension the toothed belt and also lift the lower belt horizontal run to just clear the upper horizontal run so that it can pass under the table in the central zone which, was once occupied by the feed screw. The upper and lower belt sections have to be set to avoid passing contact which could cause the belt teeth to interlock. **Photograph 14** shows the belt drive arrangement without the table in position.

The upper section of toothed belt is secured to the table, at an underside, central position along the table, by a clamp plate contoured to fit the belt, **photos 15**, **16** and **17**. This also slightly lifts the upper run of the belt. A bolted 19mm dia. cross spacer is added to the,

more extended, righthand side rails to stiffen the rail assembly up, **photos 18** and **19**.

Sheet metal covers are fitted to each end of the table to shield most of the grinding dust from the table drive. Full protection would be very difficult to achieve and, so far, it does not seem to be that necessary.

This arrangement works very well. The table can be moved quite effortlessly, virtually by fingertip. The weight of the table, magnetic chuck and whatever is being ground are easily managed. The capstan rotates three times for the full table travel.

The grinding (46 grit) wheel in use was 5" diameter when it was new. It is now about 3.5" dia. after a lot of use and dressing operations, **photo 20**. The substantial Dumore wheel guard allows for up to a 6" dia. wheel, but I am quite happy with what I have because the lower flat cut away, on the guard, can be rotated so that it just clears the working surface, reducing grinding dust being spread.

Wheel dressing and operation

I have mounted a dressing diamond as shown in **photo 21**, which can be quickly mounted on the magnetic chuck for wheel dressing. Only small (0.001") cross cuts are taken to sharpen the wheel, which is needed occasionally. When the machine was finally finished, the wheel was dressed and, the first job was to grind the magnetic chuck over its full surface. This operation is really only needed once, to enable any item mounted on the chuck to be ground flat and parallel.

The machine can handle cuts up to about 0.003" deep, but this makes for a slow process, with only small transverse increments possible with the cross slide, without slowing down the wheel too much. It is also concentrating all the cutting on just the edge of the wheel, which is not good. I find it far better to take separate smaller passes of 0.001" or less, to achieve the same result, which then uses more of the wheel face than just the edge. I have been grinding most items dry, but have tried brush applied white spirit with a small improvement in finish

All in all, I am very pleased with this machine, it has had much use and makes jobs like trying to get a nice flat surface finish, removing machining marks or grinding a spacer to fit etc. easy. It is also an advantage to be able to remove the part from the magnetic table for inspection or measurement and then be able to put it back to continue grinding etc. One job I would like to mention was grinding a new tapered dovetail gib to fit on a lathe cross slide. To make it fit along its length of 9" the magnetic table had about a 0.100" spacer lifting it at one end, like a sine bar. This produced a taper to the cast iron gib strip that matched the cross slide and fitted the dovetail along its length. This made a difficult operation easy to do. The final **photos 22** and **23** show a spacer being ground, showing it half ground and then completely finished.

In retrospect it seems that one of the problems I had was due to the motor and how balanced it was. It seems that it is possible to get motors that have a high spec. balance, but they do not seem readily available and I suppose the corollary to that is the price. I managed to stumble through and find a solution but that was just luck. ∎

Dressing diamond mounting

Spacer- surface half ground

Spacer- surface fully ground

Simplicity Jig No. 2

John Harding presents the second in his suite of easy to use grinding jigs, this one is for grinding and sharpening lathe tools

Jig set up for screw cutting insert

Profile of jig to obtain side rake

Jig set up turning tool insert

4

Grinding flat on top of insert

5

Grinding insert for boring bar, rake obtained by rotating holder

The purpose of this jig is to produce a tool bit where each face has one facet and overcoming any inability to grind tooling freehand.

The jig is simply a table on which the tool jigs are mounted to keep them in alignment.

This set up is "designed" for sharpening HSS lathe tool inserts and is mounted on a sliding table with a screw traverse for in feed.

The starting point was an article by Gary Wooding (MEW 159) on sharpening points for screw cutting.

Subsequently its main use has been for sharpening turning tools designed by Jacques Maurel (MEW 239).

Construction

The prototype is a 150mm length of channel section, the base and top required fly cutting flat. While in the milling machine the front edge was squared off and on the same setting a line of "pin" holes was drilled and tapped M3. The width of the top face needs to be a minimum 50mm wide.

Setting up

With the jig table aligned square to the grinding wheel, the jig holding the insert is positioned on the table using template cut to half the included angle. The jig itself incorporates the other angles to produce the correct side and top rake. **Photographs 1** and **2** shows the set up for a screw cutting insert and **photo 3** is for turning. It is just possible to grind a point for Acme thread. The holder for a boring bar insert is round bar with hole drilled in the end and angles set to what suits the user, **photos 4** and **5**.

Both Messrs Wooding and Maurel provide tables giving the required angles in their articles.

Photograph 6 shows a selection of tooling. The turning tooling is carved from hot rolled plate and left as sawn, all utilitarian.

Conclusion

Result, one face, one facet and easy to hone. Simplicity itself. ■

6

The tools and jigs, top right blank for holder

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CODE: 341FP

Readers' Tips

Mini Drill Chuck

TIP OF THE MONTH WINNER!

This month our lucky winner of £30 in Chester gift vouchers is Clive Cassel who suggests a way to make a mini-drill more flexible to use.

Maybe this is a useful tip for other readers?

I got really cheesed off with my mini-drill fiddling around with all the little brass collets. I bought a Dremel chuck on the web and re-threaded it to fit my mini-drill. In this case the mini-drill thread was M8 X .75. It's a really useful and well used tool now and can be adjusted easily to take all shanks. No more fiddling around with little brass collets that get lost, etc.

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.

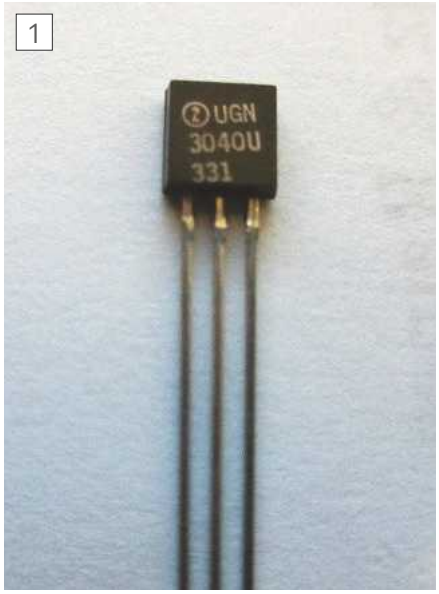
An Arduino Tacho

Duncan Webster makes a custom tachometer for his Centec milling machine

I can hear you all asking, 'why would you bother making a tacho when you can buy one ready made from China for a few pounds?" Well in my case the reason is that the most sensible place to fit the sensor on the vertical head of my Centec is on the pulley which drive the horizontal input shaft. This shaft is then connected by bevel gears to the main spindle with a ratio of about 8:7, the horizontal shaft going faster, so I wouldn't get an accurate readout. The second reason, which I discovered when I actually bought one of the Chinese ones to fit to my lathe is that the update rate is really slow, making it difficult to adjust the speed.

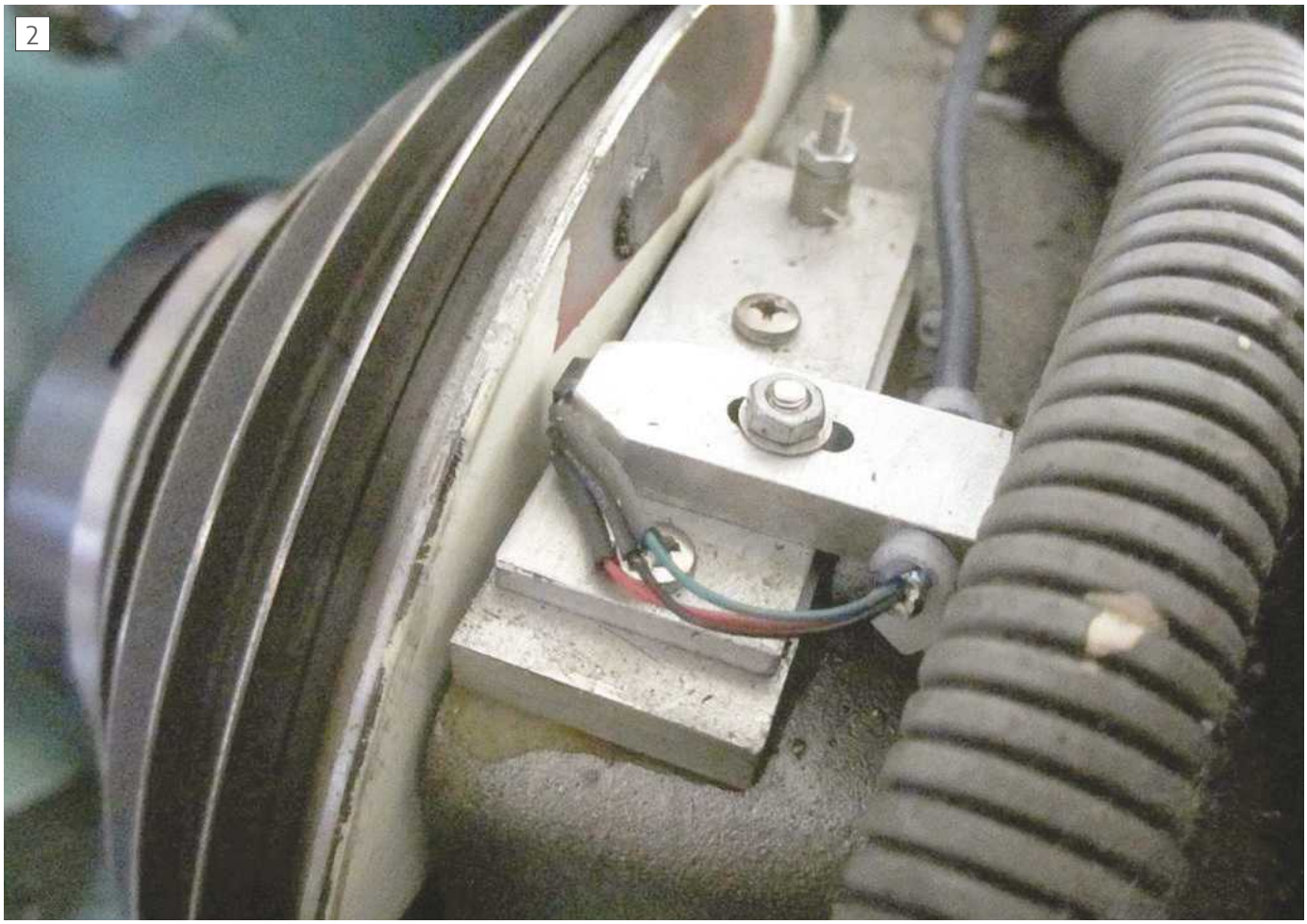
This is one of the simplest Arduino projects I've ever done. I chose to use an Arduino Nano and a MAX 7219 display. This display uses LED characters which are bigger and brighter than the LCD displays, although it can only display numbers and a small range of letters (and those not very well!). The Nano is smaller and cheaper than the UNO, and requires soldering, but that makes for more reliable joints anyway. The same code and pins can be used for either. The whole thing is built on a small piece of stripboard, and is very simple, one resistor, one capacitor, the Nano and the display. I mounted the display on the reverse side of the stripboard using plastic standoffs and M2.5 screws, and then the whole thing is mounted in a plastic box (ex-much-missed Maplins). I make the standoffs from the blue ballpoint pens I find abandoned outside the local bookies, no doubt by people frustrated at losing yet more money. Power comes from a

1



The UGN3040 sensor.

2



Sensor mounted, in this case on a lathe.

18+

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5v wall wart, ex-mobile phone charger.

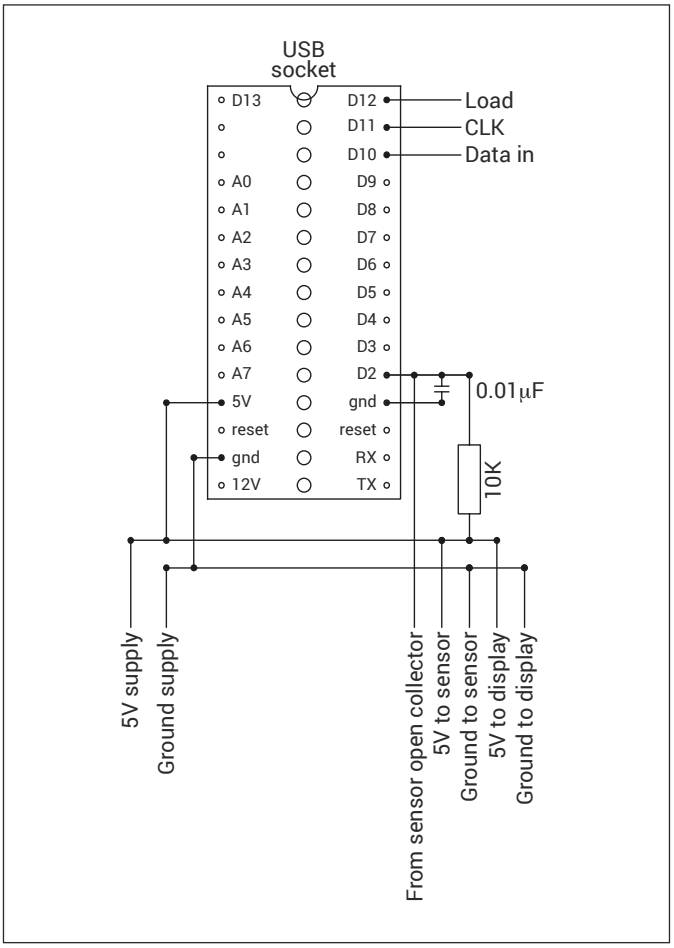
For a sensor I used a Hall effect switch UGN3040, **photo 1**, really compact and easier to mount than the sensor that comes with the Chinese display, but almost anything with an open collector output will work. The one in **photo 2** is actually on a lathe, the one on the milling machine is somewhat inaccessible. It is simply glued to an aluminium block positioned facing the magnet. You have to get the sensor the right way round, but the datasheet is very clear (Google 'UGN3040'). I used aluminium as it is nonmagnetic, I'm not sure if this matters. **Photograph 3** shows the complete job, and **photo 4** is the circuit board. The schematic/board layout is in **fig 1**.

Important points to note when making it:

- Make sure you have broken all the tracks as indicated by a large ring on the schematic.
- There is no need to solder all the nano pins, this makes it a lot easier to get out if ever needed.
- Make sure there are no solder bridges between adjacent tracks. I use a loupe and examine each one.
- For the connecting wires I enlarge one of the close by holes in the strip board and poke the wire back down to give some strain relief. When the wires have been soldered, they don't bend well and can easily be broken by repeated flexing.
- A good source of multicoloured wire is old printer cables, the ones for parallel ports have lots of cores.
- If it doesn't work first time, try turning the magnet round.
- Don't run the sensor wire next to the main motor cable, you can get interference especially if using a VFD.

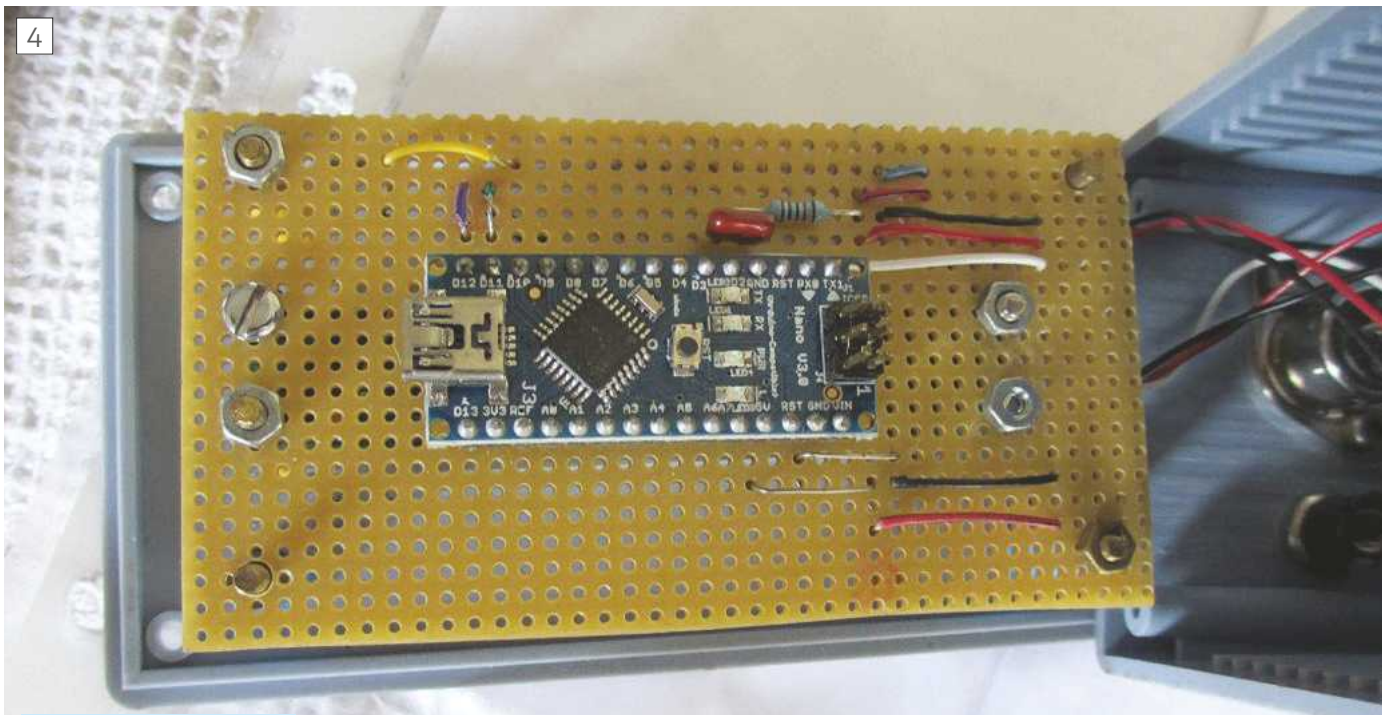
When this is published I will post the code in a message on the ME forum, from where it can be cut and pasted into the Arduino IDE.

Happy soldering! ■



The display box (can it really count up to 99,999,999 rpm?)

4



The simple circuit board.

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- **Projects**
  John Moorhouse explains how you can take steps to ensure that your next project is a success and actually gets finished!
- **Murdoch Engine**
  Geoff Spedding constructs a Dean Myers Murdock oscillating engine.
- **Milestones**
  Roger Backhouse spends an engineer's day out at Hampshire's living history museum at Basingstoke.
- **GWR Pannier Tank**
  Doug Hewson makes the grate and ashpan for his 5 inch gauge GWR pannier tank.
- **Watt Governor**
  Mitch Barnes makes a brave attempt to explain the workings of the Watt governor.
- **Night Owl**
  John Arrowsmith visits Premier Patterns in Birmingham to inspect the polystyrene patterns to be used for casting the cylinders for the new-build GWR heavy freight locomotive, 4709 *Night Owl*.

Content may be subject to change.

ON SALE 5 JUNE 2020

From the Archives:

Cherry Hill's workshop

Former MEW Editor, Geoff Sheppard, accompanied by photographer Justin Lambert visited this talented and prolific builder of intriguing models.

Photos by (JL) Justin Lambert, (CH) Cherry Hill and (GS) Geoff Sheppard

The remarkable thing about Cherry Hill's workshop is that it is quite unremarkable – except that it is so clean and tidy. For a facility that has produced a succession of models that have been awarded eight Duke of Edinburgh Trophies as well as many Gold and Silver Medals, trophies and other awards, this is a workshop which is modestly equipped. True that all the machine tools which populate it are of excellent quality, but it is just a small collection of nice lathes, milling machines and drilling machines plus a bandsaw, a couple of off-hand grinders and a filing machine. All this goes to emphasize the point that the quality and complexity of the items produced there are a tribute to the skill of the operator and her ability to manipulate these machines and the hand tools which augment them.

Cherry picked up these skills in her younger days because her father had established a home workshop, the centre piece of which was a 1913 Pittler lathe which has had a chequered history. Its previous owner had used it to produce parts for munitions, probably under the Amateur Ordnance Volunteer (AOV) Scheme, which made a significant contribution to the war effort. It was reported that, at one stage this scheme was producing 47,500 fuse screws and 5,000 sockets per week, leading to complaints from engineering firms that they were losing business to these volunteers! When the Second World War came along, its new owner again volunteered its services and it was transferred to a Ministry establishment in the Farnborough area, complete with George Hinds (Cherry's father) to operate it. Later it re-located to another facility in the West Midlands, and on 'demobilisation', back to the Hinds family workshop. The machine still has pride of place in Cherry's workshop, now frequently set up in dividing mode and fitted with its cutter frame to produce such things as hexagonal items (nuts, bolts etc) which are all specially made.

With a Degree from St. Andrews University, Cherry joined the family firm, a small organisation which designed and made agricultural equipment, including hop-picking machinery. Here she was expected to participate in all aspects of the operation, becoming as familiar with the works activities as she did with the design side. The extensive knowledge gained during this phase obviously equipped her well to meet the challenges encountered in her modelling activities. These started when, on the return journey from a business trip to Kent, she and her father stopped off at Bond's, this being in the days when it was still possible to park outside the shop on Euston Road. Of the designs on offer, the Bassett-Lowke 1in. scale traction engine was considered, but father thought that this

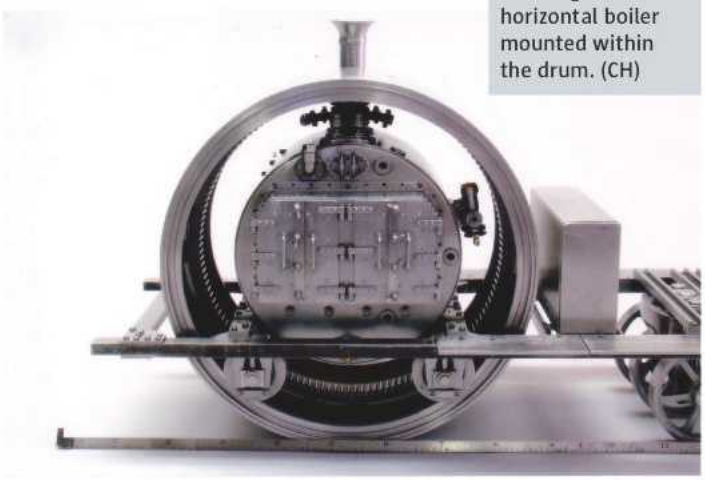


Photo 2: Cherry's current project, the 1863 Robert Blackburn Agricultural engine, showing the horizontal boiler mounted within the drum. (CH)

Photo 3: Cherry points out some of the finer details of the design. (JL)

Photo 4: Drawings are still made in the traditional way, without the aid of electronic equipment, drawn at either full size or ten times full size. (JL)

Photo 5: A view of the machine shop with the Centec 2A milling machine in the foreground and the Myford Connoisseur lathe to the rear. The Pittler lathe is beside it and the Wabeco milling machine is largely hidden. (JL)

Photo 6: This room is mainly used for fitting work, but also houses the IME lathe and Meddings drill. The chassis bedplate of the latest project is covered by the cloth. (JL)

was, perhaps, too complex a task on which to start, so a Stuart Turner No. 9 Horizontal Engine became the first project. Bill Hughes' version of the Allchin traction engine 'Royal Chester' was the next to attract attention, but at 1½in. scale it was felt to be a bit on the big side, so it was re-worked at half size. This ¾in. to 1 foot scale has now become the norm for all Cherry's modelling projects. Cherry felt that some of the details on the Hughes design did not accurately reflect those of the prototype, so sought out the full-size engine in order to improve the fidelity of her model. This, of course, generated much favourable comment when it was displayed at the 1964 Model Engineer Exhibition, winning a Silver Medal, with the Stuart Turner No. 9, also displayed, gaining a Bronze Medal. Cherry's skills were now, well and truly, attracting the attention of the model engineering world, with an editorial in 'Smoke Rings' in the 15 October 1964 edition of Model Engineer and an article by Bill Hughes in the following issue. Hughes mentioned that the next planned project was a model of a steam propelled Merryweather fire engine, a 2in. scale version of which was to be found in

the National Museum of Wales, in Cardiff.

There then started a process cycle which is now well established – a research phase, followed by detail design, followed by manufacture. The detail design activity is often accompanied by the construction of what might be called a 'feasibility model', a prototype in aluminium, brass and whatever other material is appropriate to allow a check to be made of the practicality of the evolving design. Hence there are often two models, both to the same high standard! It's just that one is produced from materials not employed on the prototype.

Some of the projects chosen by Cherry have been of little-known pieces of road machinery or agricultural equipment, the only source of information being patent applications or reports in technical journals of the first (and perhaps only) appearance of the device at some early agricultural show. The feasibility model sometimes shows that the full size machine was anything but feasible. For example, the latest design exercise has shown that the valve gear of the steam engine section of the machine could not have been mounted where the only available drawing depicts it because it would have resulted in totally inadequate bearing scantlings. Changes must have been made to the prototype, so Cherry has schemed out something which is likely to have been adopted. This approach is essential because, despite observations to the contrary, all Cherry's models are capable of being

Photo 7. Cherry gathers some of the smaller items for assembly to the Blackburn bedplate. (JL)

Photo 8: The 1913 Pittler lathe is set up for dividing and milling, having been motorised at some stage of its career. (JL)

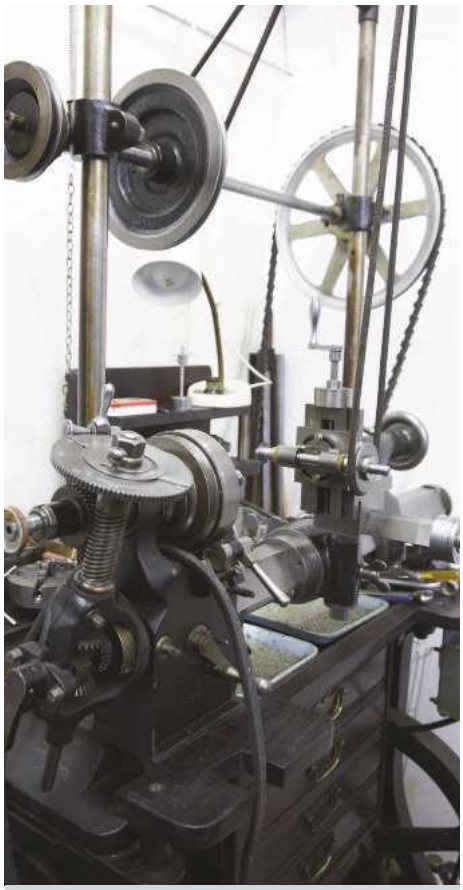


Photo 9: The Pittler overhead drives the cutter frame. (JL)

Photo 10: An elegant piece of Edwardian engineering. (JL)

Photo 11: Right up to date is the Myford Connoisseur lathe. (JL)

Photo 12: A micrometer saddle stop adds even more precision to the Connoisseur! (JL)

Photo 13: Cherry at work at the largest machine in the shop, the Myford VMC mill. (JL)

Photo 14: The Centec 2A has been fitted with dial gauges to measure travel on the X and Z axes. (JL)

Photo 15: A simple collar clamped to the quill bears against the plunger of the Z axis clock. (JL)

operated and video footage is taken of each one performing when connected to a compressed air supply. They would be capable of being steamed, but the inaccessibility of fire hole doors on some of the prototypes would make stoking very difficult and the subsequent task of cleaning the model to bring it back to pristine condition doesn't bear thinking about.

Incidentally, the Merryweather fire engine brought Cherry another Silver Medal, her first Bradbury Winter Trophy and an appearance on the cover of 'M. E.' (16 February 1968). Her subsequent model, an Aveling and Porter road roller captured the supreme award, the Duke of Edinburgh Trophy in 1971 after having won the Championship Cup for Road Vehicles and the Crebbin Memorial Trophy in 1970.

The latest model is of a Robert Blackburn Agricultural Engine of 1863, a follow-on from the 1857 version which won Cherry her eighth 'Duke of Edinburgh' when it was exhibited at the 2007 Model Engineer Exhibition. This prototype had a horizontal boiler, **photo 2** rather than the vertical boiler of the earlier one.

So, what of the workshop in which these masterpieces are produced? The one we visited is only in use for part of the year because Cherry and her husband Ivor also have a home in Florida where the manufacture of some parts is also possible. At their British base, the workshop occupies two ground floor/basement rooms of a bungalow built on a steep slope. This location allows each room to have the benefit of natural light, essential when the model reaches the painting stage, a process which is always carried out in this country. A further small room on the floor above is equipped as the drawing office,

●To be continued

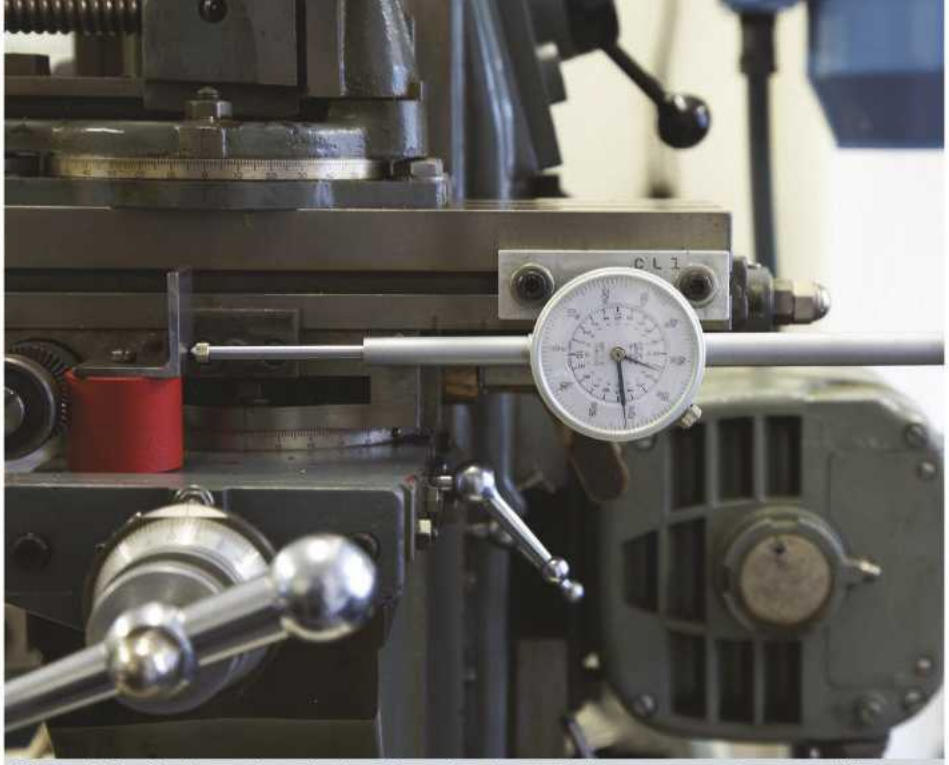
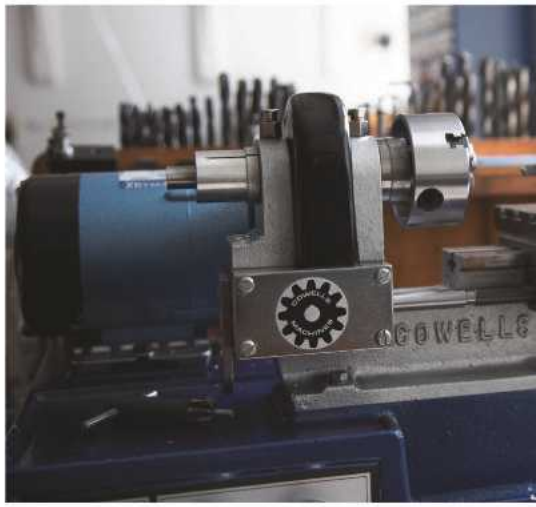


Photo 16: The X axis reaction point is a piece of angle attached to a permanent magnet. (JL)

Photo 18: IME lathes were made by The Ideal Machine Tool and Engineering Company of Kingsland Road, London E8. Cherry's is one of the Model 100 Series. (JL)

Photo 17: Another survivor from the Hines family original workshop is this small sensitive drilling machine. (JL)

Photo 19. The "Raw Material Store" is well stocked and easily accessible. (JL)



Scribe a line

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Drop us a line and share your advice, questions and opinions with other readers.

Tailstock Turret

Dear Neil, this came about because I had just finished a Tailstock turret from a design in MEW.

I make my small parts on a Peatol Lathe which is a very capable machine. On occasion I have a call to make quite a few parts (30 to 50) which require several tailstock tools to be used to make the part so the germ of an idea to have a scaled down version for use on the Peatol.

The big difference was not just the size but the tail end, the Peatol does not have a taper socket in the tailstock but a parallel 1/2inch bore which has a slit at the rear to enable it to be locked with a screw. The parallel shaft was milled with a slot and a full length key screwed in place with 10 ba c/sunk screws, this made sure that the turret did not rotate while in use. As space is at a premium on a lathe of this size using things like drill chucks to hold centre drills, taps etc. was not an option as they are too unwieldy, so either dedicated holders are used or the er11 collet chucks are used. The collet chucks are made in my favourite material USACUT55 but the nuts are a bought in item. If they are made in the right order they will be accurate to less than a thou.

Bernard Towers

Bernard sent several photos of this well finished tool, I'm also impressed by his woodworking skills.

Social Distancing

Dear Neil, as soon as I saw the social distancing cartoon Something seemed wrong! Perhaps Mr Theasby used a pattern makers rule to measure his wavelength. I would suggest that if he wants a wavelength of 2 metres. He tunes to 149.896MHz. 144 MHz will not only give a very generous shrinkage allowance but ample for machining as well!

Noel Shelley (Kings Lynn).

Geoff's a radio Ham and their 'two metre' band runs from 144 to 148MHz! -Neil

A Drummond Lathe Extension

A query from a reader for Alan Hearson reminded me to enquire after an extension for a Drummond Lathe which he had mentioned to me, he's kindly agreed I can publish his reply here:

Dear Neil, The purpose of the lathe extension was to complete the repair of a combine harvester on a local farm near Tideswell. It saved the farmer spending a lot of money. Since then someone turned up in my workshop and bought everything I had collected and worked on for over 30 years. I could not give as much time to workshop activity as my wife Anne was very ill. The offer I could not turn down as I knew I could rebuild my workshop. Anne died she was a great influence on me and made it clear you must go on helping people as a practical engineer.

I found a Myford Drummond lathe in Scotland for sale. The man who is interested in the history of lathes and machine tools praised me for buying the Myford Drummond 1946. He wants a photograph he only as a diagram of this lathe. His website is lathes.co.uk I attach a photograph of the Myford Drummond Lathe. This photograph is the first stage of its refurbishment. This lathe is virtually new. Hardly any wear a real gem to find.

Of course, you know that Drummond was the approved supplier of small lathes, particularly treadle lathes for the war effort, both world wars. I sense Myford were miffed when they were not asked to take the lead. The Myford Drummond was Myford's way in to the war effort but a bit late in 1946. When you look at the photograph attached you will see how complete as a package the lathe is. The Drummond lathes since the early 1900s had a drive either treadle or motor attached as a complete machine ready to run. We may laugh at the treadle, but it could be used immediately. Myford woke up to this concept with introduction of the ML7 in 1946. Its introduction still did not convince government that it was a lathe as robust as the Drummond M lathe.

So, the answer to your question about my extension is that it provided a lathe for practical use.

Alan Hearsum

Four Facet Grinding

Neil, It was good to be reminded of the late Giles Parkes simple approach to four facet drill grinding in MEW 293.

I believe that Derek Brown has done further work on drill point geometry which has improved drill performance over the four facet method. I wonder if Derek could be persuaded to explain how his improved geometry could be achieved using Giles simple tooling.

Barry Robinson,by email

Choosing Steel

Dear Neil, an excellent magazine last week. Having had stored on the bedroom floor all the copies of Model Engineer from my fathers day - pre-war - 'till today, and that changed to MEW as soon as it came out, it became necessary to go through and tear out and retain some articles and dispose of the rest. The article on choosing steels and the old article on stick welding were definitely ones to keep. The magazine for me is a fund of skills information. Being old school, I am afraid the computery things and 3d printing leaves me cold. I look forward to Stub Mandrel's further article on special steels. I have two excellent books by Alexandra G. Weygers from the 1970's on the making of tools in the home workshop. He uses all recycled steel from scrapyards. Can Stub shed some light on identifying the different steel we may come upon?

Bob Le Marchant, Paignton.

I will ask Stub! I know he relies upon the advice in Tubal Cain's excellent Model Engineer's Handbook – Neil

Coincidence

Dear Neil, just thought I would share a coincidence with you, I hope you don't mind. You may recall that in the article I submitted I alluded to the fact that I had got the bug from assisting a neighbour in his shed. I also mentioned that he had built me a bench from a photograph I showed him. Well the other day I was sorting through some paperwork and lo and behold I found the original catalogue (Photo attached). What is perhaps more revealing is the price of the bench that my pocket money could not stretch to, it was 40 years ago according to the date on the catalogue. Like us all I horde things and they turn up quite coincidentally

Stuart McPherson

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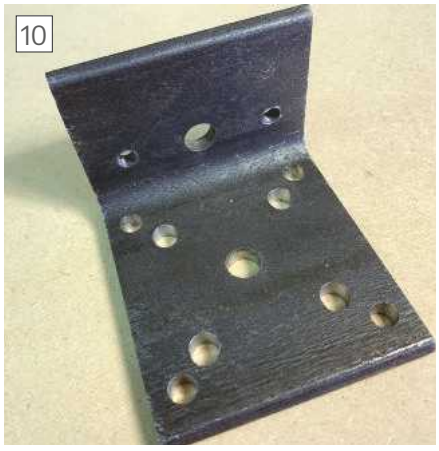
Desktop Gear Hobbing

Spindle assembly mounting plate bolted to crosslide.

Toby Kinsey has designed this fascinating piece of gearmaking equipment - Part 2

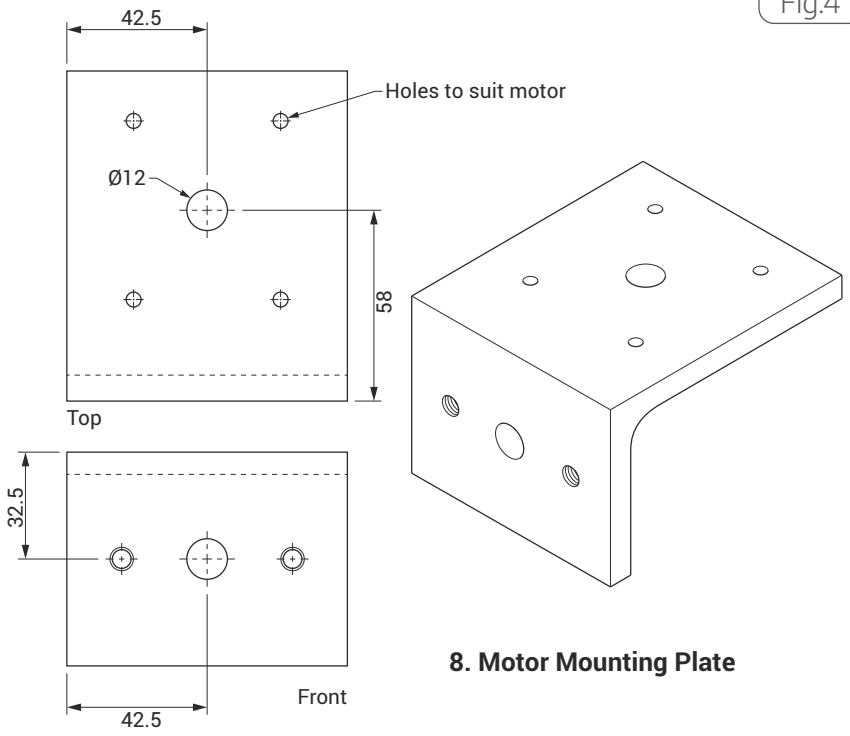
I obtained a cast angle plate from an online auction site to use as a mount for the spindle assembly. This turned out to be way too mighty and in the end I used some 65 x 100 x 8mm steel angle I had hanging about from another project. I was initially concerned about the rigidity of the angle, but it seems not to cause any problems in use. It might be a bit different hobbing steel gears, but it is fine for the nylon and acetal plastics I generally use.

The four holes are drilled in one piece of angle to match the spacing of the t-slots on the cross slide. On the other face of the angle, a hole is drilled the same size as the spigot on the back of the back plate. Then two slots are milled radially from the first hole, the same spacing as the bolt holes on the faceplate to allow for rotation of the back plate, **photo 9**, **fig. 4**. Another section of the angle is drilled to match the spacing of the motor bolt holes. The bolt holes were elongated to allow some movement for tensioning the drive belt by moving the motor fore and aft. Initially this was for the repurposed headstock drive motor from the lathe but as the project progressed was changed to a stepper motor. I will cover why this happened later (hence the extra holes. The angle was then drilled on its other flank for the back plate spigot and then drilled and tapped for the two M8 x 25mm socket headed mounting bolts, **photo 10**. The bearing block and back plate could then be bolted to the motor carrying angle, sandwiching the mounting plate in the middle, **photo 11**. Thus, by loosening

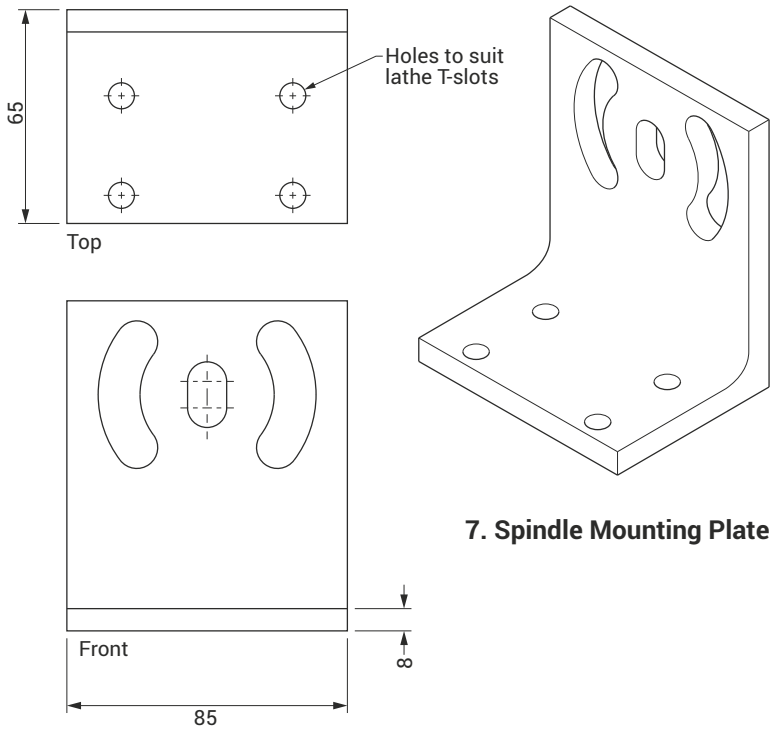


Spindle assembly stepper motor mounting plate

Fig.4



8. Motor Mounting Plate



7. Spindle Mounting Plate

Spindle shaft.

Spindle backplate and motor mount bolted sandwiched either side of mounting plate.

the clamp bolts the spindle assembly could be rotated either side of the vertical, with the motor maintaining its alignment with the spindle.

All that remained was to turn the spindle and tap the M10 thread on the pulley end. The hobs I was using had an 8mm bore so the bottom part of the spindle was turned to match and the end tapped M8, **photo 12**, **fig. 5**. Then I milled the two flats to allow a 10mm spanner to hold the spindle when changing the cutter. Two dust cups were turned to be a push fit into bearing block. A small collar was turned to keep the pulley from interfering with the dust cover, **fig.6**.

The bearings were pushed into the recesses in the bearing block. Making sure they the right way around, as they can take axial loading from only one direction so must be fitted "back-to-back". The dust caps where fitted in the bearing block over the bearings. The spindle can be fitted and the collar fitted on the pulley side.

The drive between the motor and spindle is by two timing pulleys of 5mm pitch and connected by a 10mm width timing belt, length 270mm bought from HPC, **photo 13**. I decided to use a 3:1 reduction on the spindle drive to make sure there would be enough torque at the relatively low speeds I was planning to use. The 30-tooth pulley was fitted onto end of the spindle and the two locknuts tightened so the spindle rotated freely without any lateral movement. The grub screw in the pulley was also tightened to make sure there isn't any slip. Probably should really key the pulley to the spindle but it has worked without slipping for me so far.

Spindle timing belt and pulleys.

The motor was mounted and the 10-tooth pulley fitted. The timing belt was fitted and tensioned by sliding back the motor in the slots and tightening the four motor bolts, **photo 14**.

Fitting a Stepper Motor

Next up was fitting a stepper motor where the original lathe motor was positioned. To go into any depth about stepper motors and their wiring and use would require another article, so what follows is only an overview of what I did.

The steppers used are NEMA 23 hybrid types, with a holding torque of 300Ncm and a max current per phase of 4.2A, **photo 15**. I originally purchased them from Arc Euro Trade, but unfortunately, they don't stock them anymore. Again, the Internet is your friend and many similar motors can be found online. NEMA is National Electrical Manufacturers Association and they have specified various standardised mounting sizes for stepper motors. The 23 bit means the diameter of the motor or in this case as the motors are square, the size of the side of the motor is 2.3inches or 56mm. The shafts are 8mm diameter. NEMA 23 only specifies the size of the mounting flange and the length of the motor can vary. Effectively the longer the motor the greater the torque it develops and greater the amps in can handle. The motors I used were 87mm long. The Hybrid bit means the way the internal coils in the motor are wired means it can operate as either a Bipolar or Unipolar motor, (**ref. 5**). Stepper motors when connected to a driver and powered hold themselves in position when they are not being stepped. You can spin the shaft of a stepper motor when they are not powered but when energised will take a significant amount of effort before the shaft moves. This is the holding torque. The 4.2amp figure is the maximum current they can handle.

To fit the motor, I needed to reduce the size of hole where the original lived, which was a plate, bolted onto the back of the headstock. I was therefore able to remove it and weld in what was effectively a large washer into the space where the original motor lived and drilled new holes to match the stepper motor, **photo 16**. Again, the holes were elongated to allow the motor to move to tension the drive belt to the lathe

Fig.5

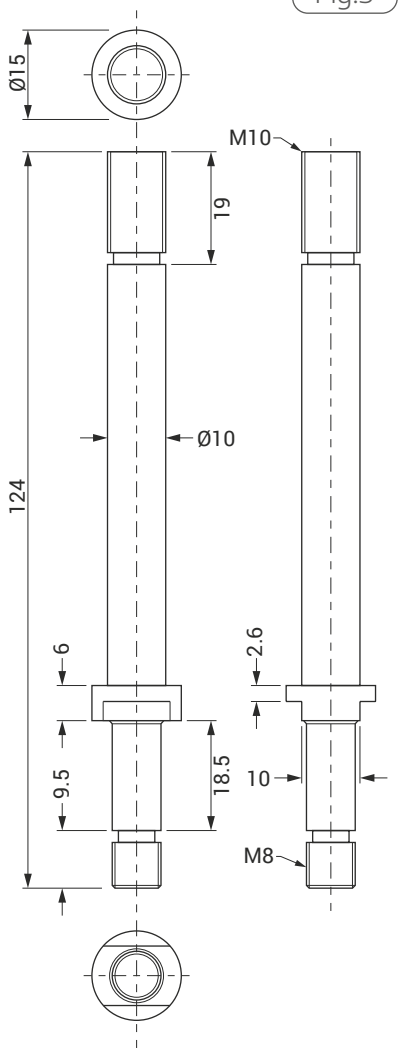
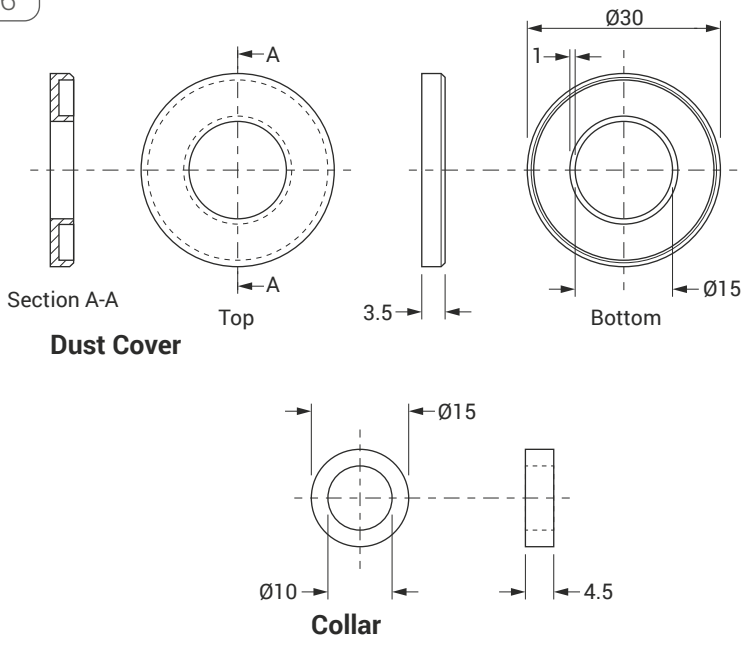
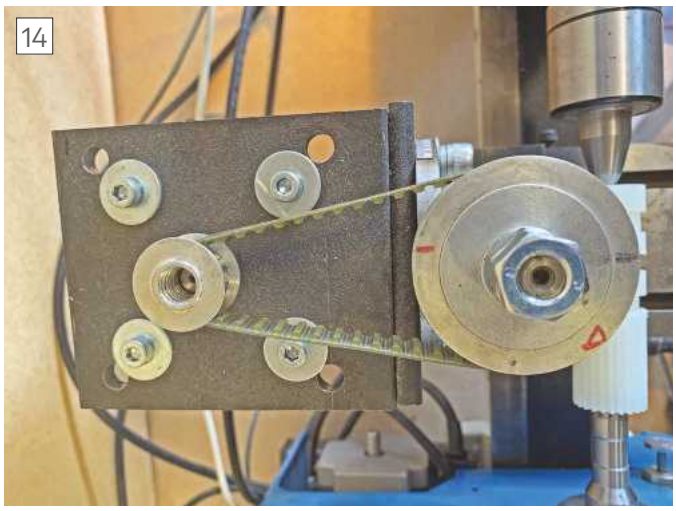


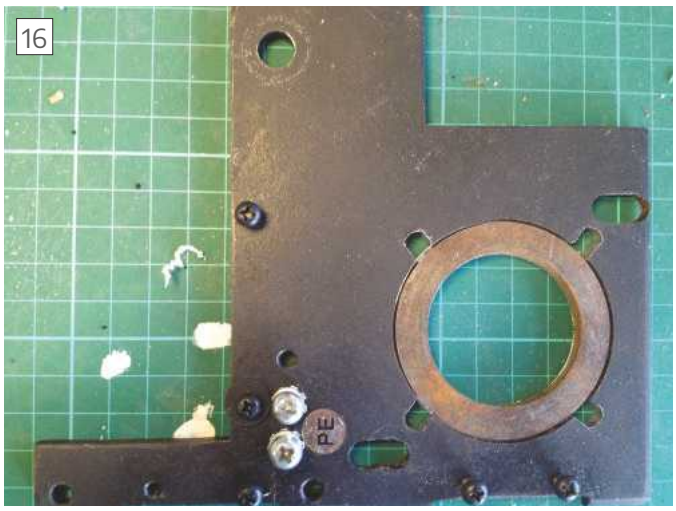
Fig.6



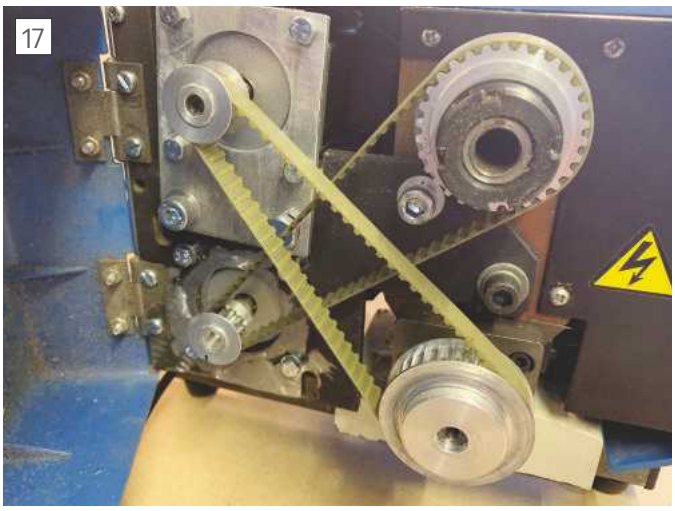


Timing belt and pulleys fitted.

Stepper motor.



Washer fitted into plate ready to weld to hold stepper motor.



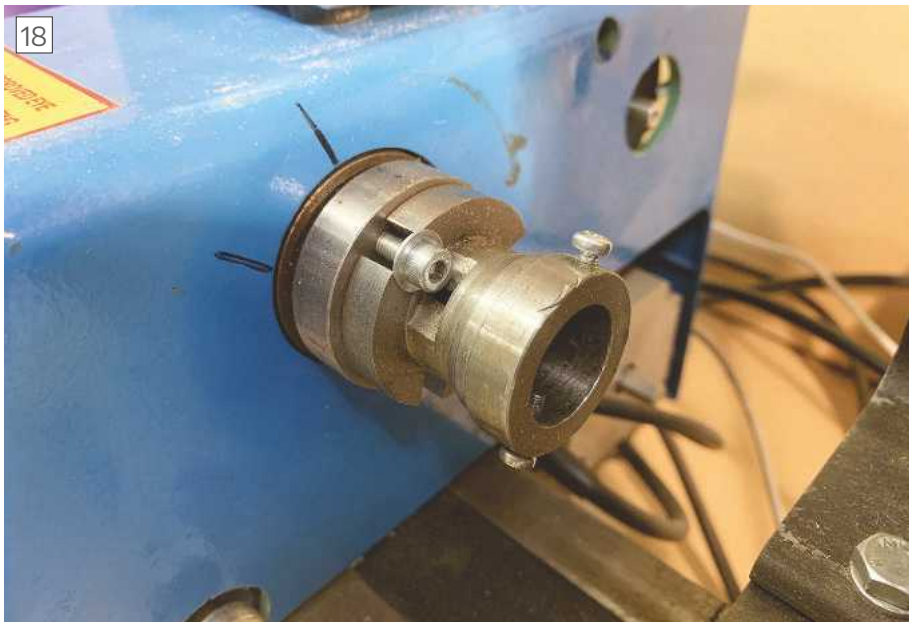
Stepper motors and belt drives to headstock and leadscrew.

headstock. Using the same size pulleys as the spindle drive to give the same reduction ratio of 3:1. The larger was pulley bored out and fitted to lathe mandrel, **photo 17**. You will notice in the picture that there is another stepper motor that drives the lead screw. This was done so I could use power feed when cutting gears and also opens up the possibility of cutting helical gears. More about this later. As I motioned earlier, my ideas were evolving as the project developed and I hadn't thought initially about using the lead screw. Hence the crossing over of the toothed belts where it would have made more sense for the top stepper motor to drive the headstock and the lower stepper motor to drive to lead screw. It is as not as elegant as it could be, but it works.

Workholding

To hold the work, I initially made up a holder, **photo 18**, that bolted onto the flange on the lathe mandrel with a 2 Morse taper centre fitted into the headstock taper. The gear blank was drilled through the centre and turned to the correct size for the gear being cut, (**ref. 6**). The blank was then located onto the centre in the headstock and the tailstock centre brought up into the other end of the blank.

●To be continued



The first idea for work holding.

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An Invicta Shaper

Peter King describes a rather large shaping machine

I have a larger but similar shaper to the "Alba" depicted in MEW 278, mine with the name "Invicta" cast into the base. These shapers, 'Alba', 'Invicta' etc. are all very similar, they were made apparently by sundry different manufacturers for "Elliott Machine Tools Ltd". Somewhere years ago I read that Elliott designed them. Mine is a 14" stroke by 28" cross travel unit weighing in at about two tons with a 5hp three phase motor – see the various photos. As will be seen from the photos, the "Made In England" plate and the 'Travel Pointer' are identical to those of the 'Alba'. When in 'full cry' it easily cuts 0.050" deep by 0.025" thick and fires (PINGGG) red hot chips all over the place. I have been told that it would easily cut much bigger chips – however, a sense of self-preservation prevents experiment! For 'finishing' I used a 0.005"deep 'cut' and about 0.002" each pass – it is a bit mesmerising with its regular "sshhooonk, click,click... the drawback is sweeping up all the chips and dust – it pays to have a steel deflector plate to limit the travel of the chips. The tools I use were given to me by an elderly (i.e. older than me!) retired machinist and were ground for a similar machine from ¾" HSS - a long time ago. Note the 'finishing' cutter with the large radius cutting edge, this leaves cast iron with a slightly shiny surface and is not the 'as per the book' finishing cutter.

I came across this unit when trying to find a small 'shaper' (very) of the sort Model Engineers wish for, for planing the mounting faces of small (2.25" bore) cast iron steam cylinders, this one was offered at a very, very low price – much, much less than I would have paid for what I was looking for. It did a superb accurate job and has since shaped (planed) a number of castings for me and refurbished a bowed truck cylinder head for another. Getting its two ton mass back to the farm on a trailer was a 125+ mile trip – slowly – with heavy timbers under it to spread the load on the deck and lots of rope. On arrival I had to get a neighbour with a much bigger tractor than mine with a bigger front-end loader to lift it off the trailer and on to the load-out deck of the ex-woolshed I use for a workshop – machinery 'skates' did the rest.

The Invicta Shaper

Manufacturer's plate

I know the history of my shaper, it was manufactured sometime around 1926-9 (apparently by a 'traction engine' manufacturer somewhere between Essex and Durham – surprisingly not the one in Kent, despite the name cast on it), it was imported to New Zealand in 1930 to Invercargill in the far south for "Melhops Ltd". The company was an engineering company who manufactured 'Bush Locos' for the timber felling industry, mostly using Swedish single cylinder diesel engines that they manufactured under licence. They are now an automotive engine re-conditioning company. Mine alas is rather dirty despite a canvas cover as wind-blown dust from glaciers to the west is a problem where I live in NZ, this forms the "Loess" clay that coats Banks Peninsula to the east of Christchurch and the deep "Wakanui Silt Loam" of my farm some 40km to the west. 'Tarpaulin' covers over machinery would have to be 'all enclosing' to prevent it settling – everywhere! ■

Speed settings

Tool head and clapper box

From the Archives:
Grinding Rest

Harold Hall, MEW Issue 89, April 2003

Ask a group of Model Engineers' Workshop readers what they think are the best tool builds to appear in the magazine over the years, and you will get many different answers, but you can be sure that one particular article will be mentioned over and again: Harold Hall's grinding rest.

Of all items of machinery purchased for the workshop, the bench grinder almost certainly falls short in terms of precision requirements by more than any other. The rest supplied is always too small and frequently insufficiently robust, making it totally inadequate for serious use.

The significant feature of the rest, seen in **photo 1** and the General Arrangement, is that it gives fine adjustment both to and from the front face and to and from the side face of the grinding wheel. This makes it possible to remove very small amounts whilst at the same being able to grind close up to a point, such as an adjacent cutting edge, without any fear of damaging its edge. To make use of this feature the item being ground has to be held in an appropriate accessory rather than ground totally free hand.

MANUFACTURE

The 50mm Square items

To economise on effort, first cut the material for parts 4, 8, 9, 17 and 18, machining the cut faces of these as in **photo 2**. However, machine one side only of item 9. Item 8 is made from 32mm square material to benefit from free cutting material, 230M07.

Slide Swivel Pieces (9)

Drill hole A and use this to mount both as in **photo 3**. Use an engineer's square to ensure they are accurately placed for a later operation. Machine both edges, 16mm thick and about 14mm wide. So as not to lose position, clamp to the machine table as in **photo 4** before removing the screws, also add end supports. Using a large slot drill, mill a slot down the centre to a depth of 7.9mm. An end mill is also acceptable as the slot is open ended, for me though I prefer to use a slot drill. However, to widen an already made slot, I prefer to change to an end mill and widen to give the dimensions of 10mm and 26.5mm.

I am assuming that by now your confidence in using your milling machine is sufficient for you to justify

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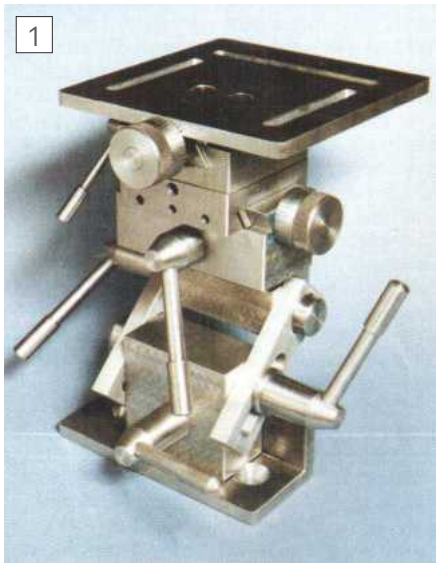
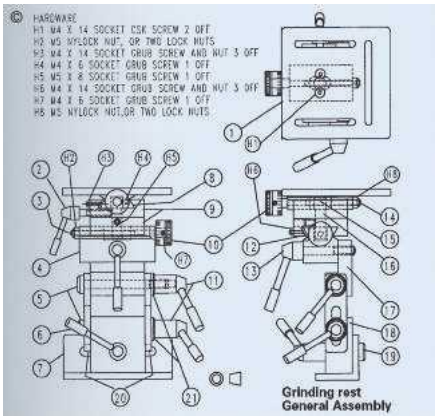


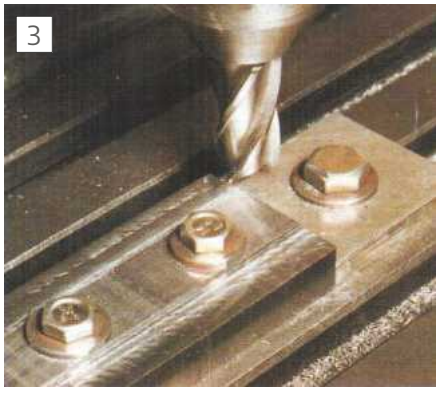
The complete grinding rest.



2

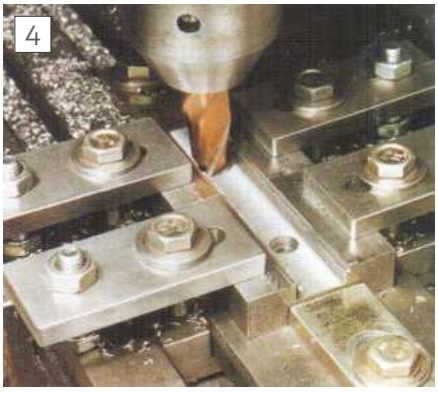
Machining the ends of parts cut from 50mm square bar.

3



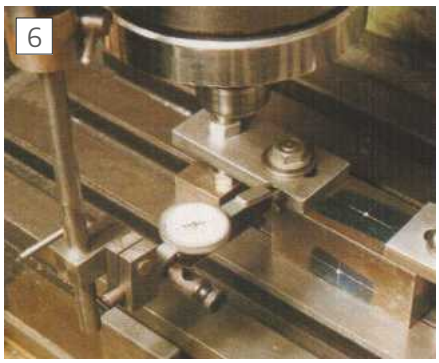
Machining the edges of the slide swivel pieces.

4



Preliminary work on the dovetails.

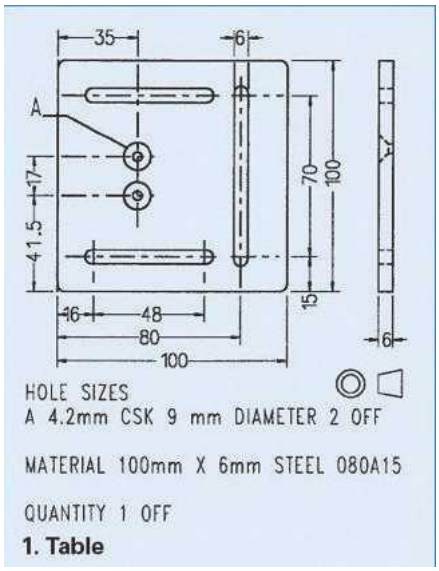
Finishing the dovetails in the slide swivel pieces.



Positioning the lower slide prior to cutting the dovetails.

Setting the depth of dovetail using distance pieces.

the purchase of a dovetail cutter. If not, you will have to follow the method of angling the work and using a narrow end mill to cut them. Lower the dovetail cutter into the slot by about 4mm and start machining the dovetail, removing metal in stages until a flat of about 0.5mm remains along the top. Repeat this on the second side. Next lower the cutter and skim the base of the slot to establish the 8mm dimension. Using the same process as for the top half of the dovetail, machine the lower half until it becomes level with the half already produced. Norm moving the cross slide by only 0.1mm for each pass, continue until the flat is machined away. Leaving the cutter set at this height repeat the process on the first side, **photo 6**. Mark out and drill and tap the remaining holes. Lower Slide (4) Position the part on the table using a dial test indicator to ensure that it runs parallel with the table traverse and securely clamp in place, **Photo 5**. Do equip yourself with some form of mounting a dial test indicator such as seen in the photo as it is so much more convenient than mounting it in the drill or cutter chuck. Set the height of the dovetail cutter using a stack of distance pieces (ref. 1) 20 + 3 + 0.5 giving 23.5 as seen in **photo 7**. Produce the dovetail as in **photo 8**. Ideally do this in two stages as was done for the slide swivel pieces using the distance pieces for the second stage, and not one stage



as photo 7 and B indicate.

Fit a 12mm slot drill and machine slot, **photo 9**, do not forget to set the table stops, when machining closed end slots. Having positioned one end, distance pieces to the value of 14mm will enable the other stop to be easily set. Mark out and drill holes A and B but making B tapping size for M5 at this stage.

Top Slide (8)

To reduce to 12mm thickness, after sawing to 12mm plus, clamp to the machine table with clamps on one side only and reduce half the width to 12mm. Before removing clamps fit further clamps on the already machined half and then remove first clamps. Reduce thickness of second side, without altering the cutter height between machining the two halves. The remaining operations on this part are now virtually as for the lower slide so repetitive detail will be omitted. The slot goes completely through the part so make sure you align the part with the T slot or use packing to raise it from the table. A little inattention here could result in a beautifully machined slot in your mill table. Again, hole A should initially be tapping size for M5.

Upper Arm Spacer (17)

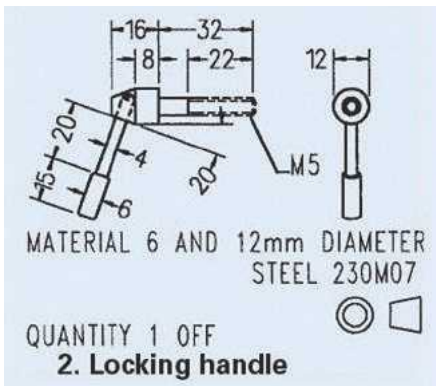
Set this up as shown in **photo 10**, only a single clamp has been used as there is insufficient space to take a second, the support pieces are therefore absolutely essential. Mill step as shown ensuring that you cut towards the support. Then mount onto an angle plate and machine the two angled faces. Mark out, drill and tap holes A and B.

Lower Arm Spacer (18)

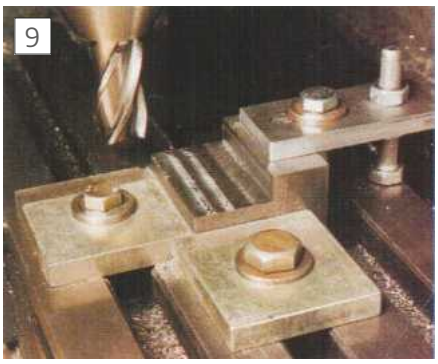
Mark out and drill holes.

Side Arms (20)

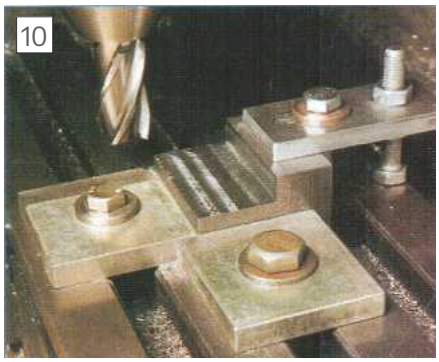
Position a clamp on the angle plate using an engineers' square as shown in **photo 11** using this to support the arms whilst machining their ends. Remember to machine towards the support as shown



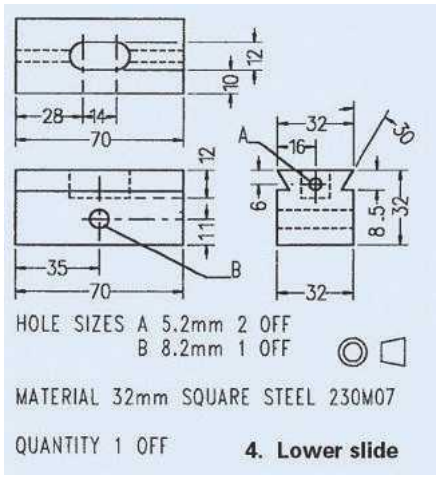
Cutting the dovetails in the lower slide.



Cutting the slot in the lower slide.

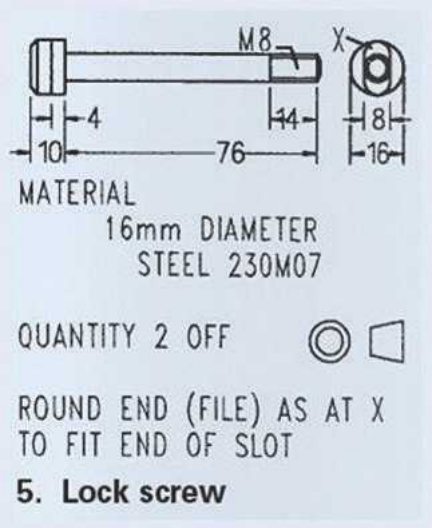


Machining the lower arm spacer. With only one clamp being used the supports are essential for added security whilst machining.

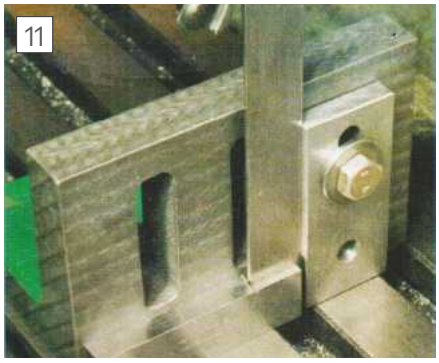


IMPORTANT SAFETY REQUIREMENTS

- Do wear safety glasses or a face mask, and ensure wheel guard is fitted.
- Due to the item being ground often being unsupported close to the wheel when using the accessories, only take very light Cuts. The depth of cut should be controlled by the fine feed and the fence rather than manually.
- Make multiple passes rather than try to remove a great depth at a single pass.
- Keep the overhang of the tool from the accessory holding it to a minimum.
- In view of the overhang do ensure the accessory is held firmly down on the rest's table.
- Keep the table and the sliding surfaces of the accessory as free of grinding dust as possible. This results in easier hand feeding and makes for safer working.
- The rest can be used as a conventional off hand grinding rest in which case ensure that the front edge of the table is no more than 1mm from the grinding wheel and the item being ground supported by the rest's table.
- When the grinder is running do not make adjustments to the rest, other than using the table's fine feeds.
- Make sure that all locking levers are firmly tightened before starting grinder.
- As the grinding rest is not directly mounted off the bench grinder it is essential that both are mounted on a very robust base. If this is not done the rest will be able to move relative to the off-hand grinder when in use. At best this may result in inaccurate results but much worse be the cause of a serious accident.



in **photo 12**. However, the photographs show that I had second thoughts having moved the angle plate and the clamp is fitted higher. This does though remind me to comment that much



Setting up a support for machining the side arms.

mounting work on the angle plate can be carried out remote from the machine. This can be on the surface plate, or even mounted in the bench vice with the working face horizontal, making positioning parts very much easier in many cases.

Table (1)

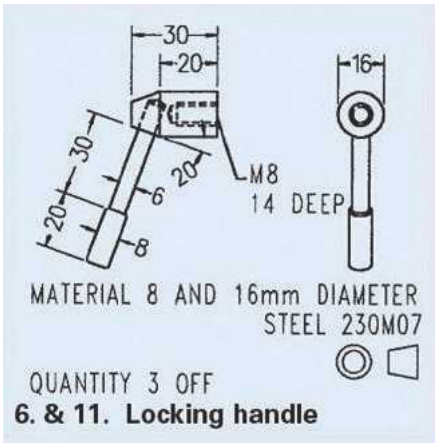
Cut a piece of 100 x 6mm, 100mm long plus an allowance for machining and place this on the machine table as shown in **photo 13**. Line up the edge to be machined with the gap of a T slot so that the cutter will not damage the table and machine the edge, **photo 14**. An improved finish can result if a light finishing cut, say 0.1mm, is taken where the traverse direction and cutter rotation are the same. This is a chance to try this out for yourself. Mark out, drill and countersink the two holes and once more accurately position the part on the machine table. This time packed up to allow for milling the through slots, **photo 15**. Set the table traverse stops, and cross feed stops if your machine has them, (typically as seen at bottom of photo 15) enabling the slots to be cut without continual reference to the table traverse dials. At 6mm diameter you will need a speed on the high side, say 1000rpm plus.

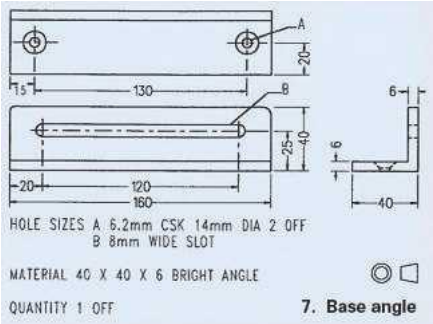
Base Angle (7)

Photograph 16 shows the set up for machining the slot.

Lock Screws (5 and 19)

The turned parts are all quite simple and I do not intend therefore to go into the lathe work involved in these. However the lock screws do have a



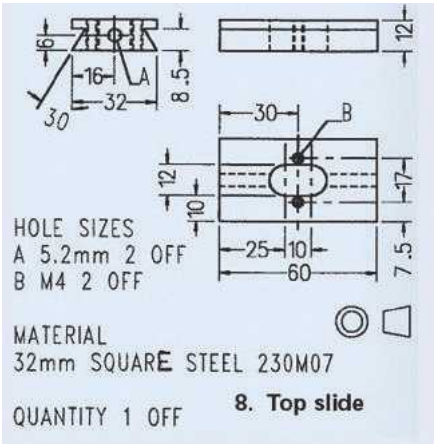


7. Base angle

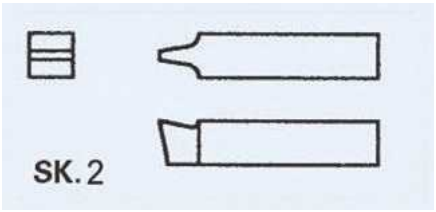
little milling activity that could present a problem to the novice. The lesson to be learned is that what may be a problem when attempting to use the available methods for holding a part (angle plate, vice, etc.) can become a very straight forward operation if aided by a simple home-made fixture. Make the two items shown in Sk. 1 taking note that the hole must be central in item A, all other dimensions can suit available material and a length of tube will also be required. Set these up on the mill table and with a 4mm mini mill running at maximum speed mill the flat as shown in photo 17. Now turn over the lock screw with part A and relocate against the stop in part B making the operation of milling the second side, and the remaining two screws, a very simple operation.

Gib Strips (12)

These may appear to present a problem if a tilting vice is not part of your kit, you have though already made the ideal fixture for holding these. Clamp one of the slide swivel pieces to the machine table and with a round rod and a piece of packing use this to hold the gib strips for machining, **photo 18**. Turn over, and machine the second side. What appeared a problem has turned out to be very simple.



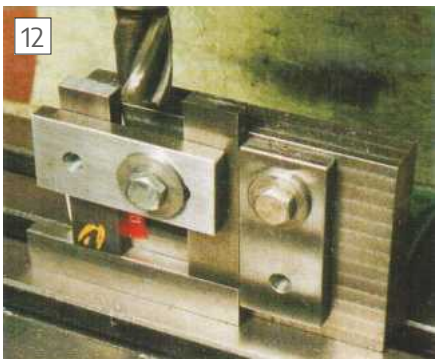
8. Top slide



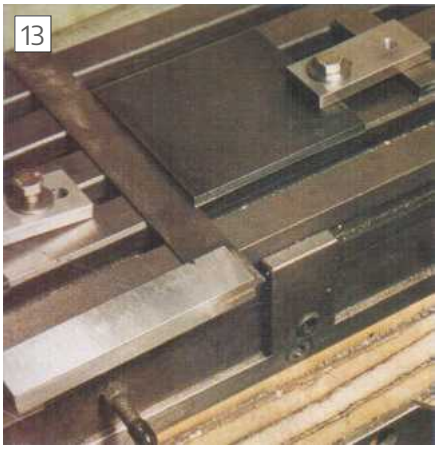
Feed knob (10)

Calibrating the feed knob can done with a dividing head, or by indexing using a gear fitted at the back of the lathe spindle. After boring and making the knurl whilst mounted in the chuck, mount on a taper stub mandrel and turn the portion to be calibrated. Do ensure that the knob is very firmly pushed onto the mandrel. Without removing from the chuck, transfer chuck, mandrel and knob to the dividing head and mount this on the lathe as shown in **photo 19**.

It is easy to fall into the trap of thinking that a pointed cutter should be used to make the lines on the dial. However, an error in concentricity will cause the line to change in width as the dial rotates. Make a cutter as **Sk. 2**, I would suggest a lip width of 0.2 to 0.3mm. Depending on the error in

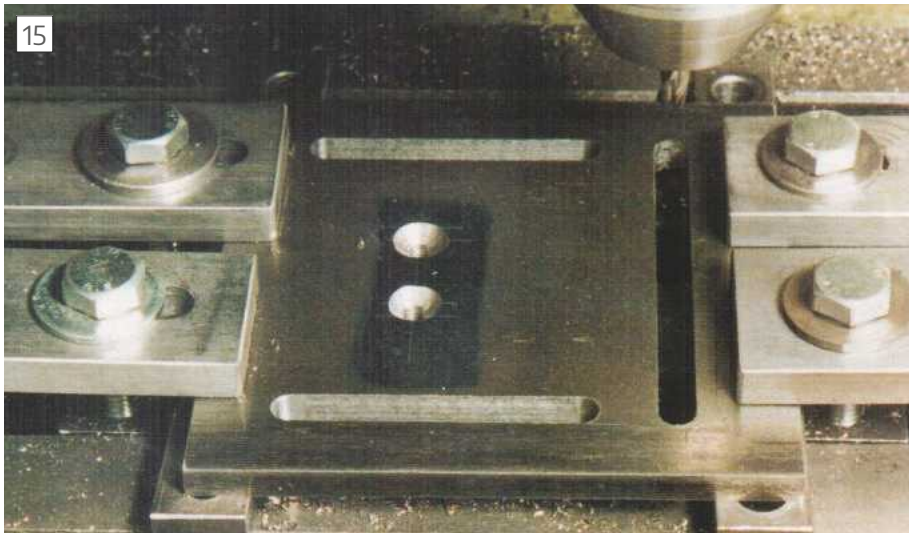


Machining the ends of the side arms. Some second thoughts obviously resulted in the setup being changed between photos 11 and 12.

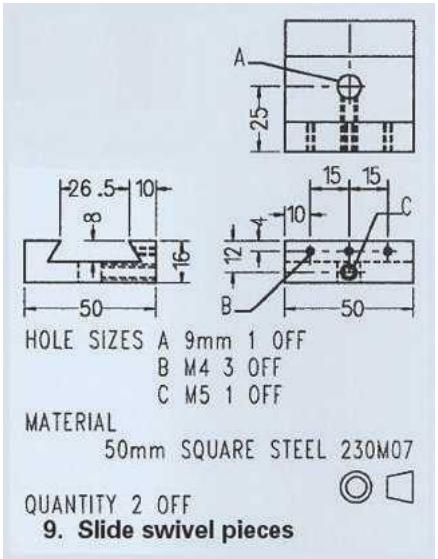


Positioning the table in preparation for machining its edges.

Machining the table's edges.



Milling the table slots.

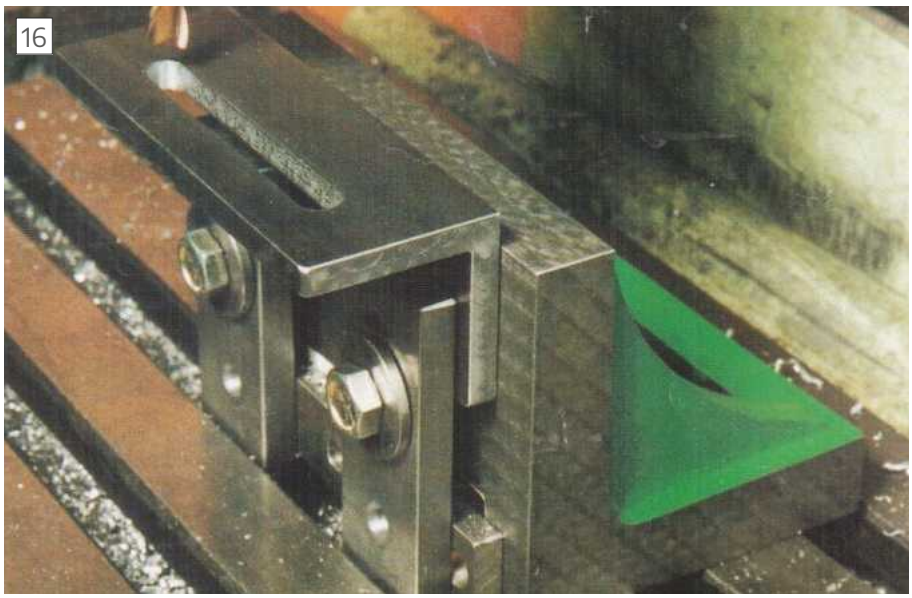


9. Slide swivel pieces

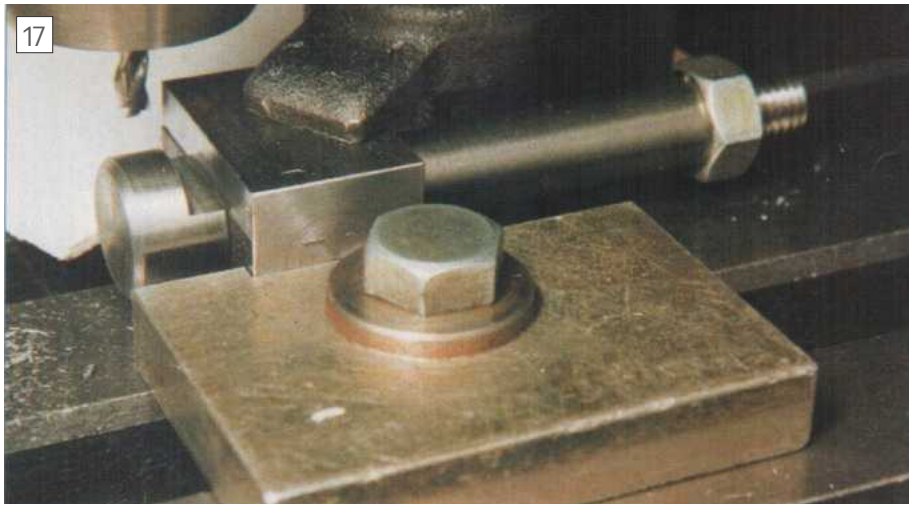
concentricity you may still need to make slight changes in the depth of cut as the dial rotates. I would suggest you find the mid-point of any error and set the depth of cut at this point to be 0.1mm. Make sure the tool is firmly clamped on the top slide and use its calibration to set the line lengths. With an M5 thread having a pitch of 0.8mm, 40 calibrations will give increments of 0.02mm.

Assembly

First, assemble both items 9 together with item 16 and fit and lightly tighten the screw H5. Take apart and drill dimple C in part 16 as indicated by the mark made by the screw. Reassemble with items 4, 8, 12, and 15 added making sure that screw H5 locates in the dimple and tighten gib strip screws so that the slides are firmly fixed. Drill through items 4 and 8 into the leadscrew nuts, items 15 and 16, using an M5 tapping size drill. Open up holes in items 4 and 8 to 5.2mm diameter and tap the leadscrew nuts M5 through the holes just drilled. This will ensure satisfactory alignment. Dismantle and drill the dimples in the gib strips as indicated by the screw marks. Assemble the parts involved in using the locking handles and mark the preferred position for their arms, remove, drill and fix the arms using two-part resin adhesive. You will see from the photo 1 that I chose to fit the top locking handle 11 on the left rather than on the right as shown in the assembly drawing. This helps to make them both more accessible. Also, it is important to take note that items must return to the same position as variations in the position of their threads will cause handle arm positions to vary. I would suggest marking them with one, two or three, etc., centre punch marks in some obscure position, such as on the threaded ends of the lock screws. Assemble for the last time applying a little oil in appropriate positions and the rest is complete.

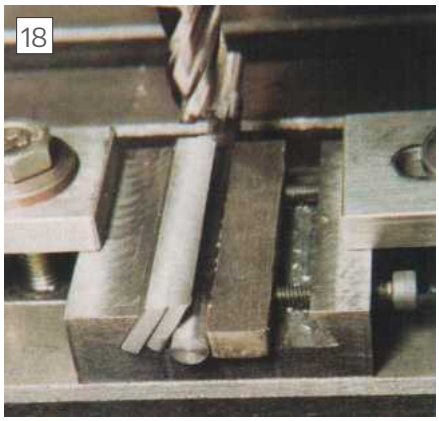

16

Milling the slot in the base angle.

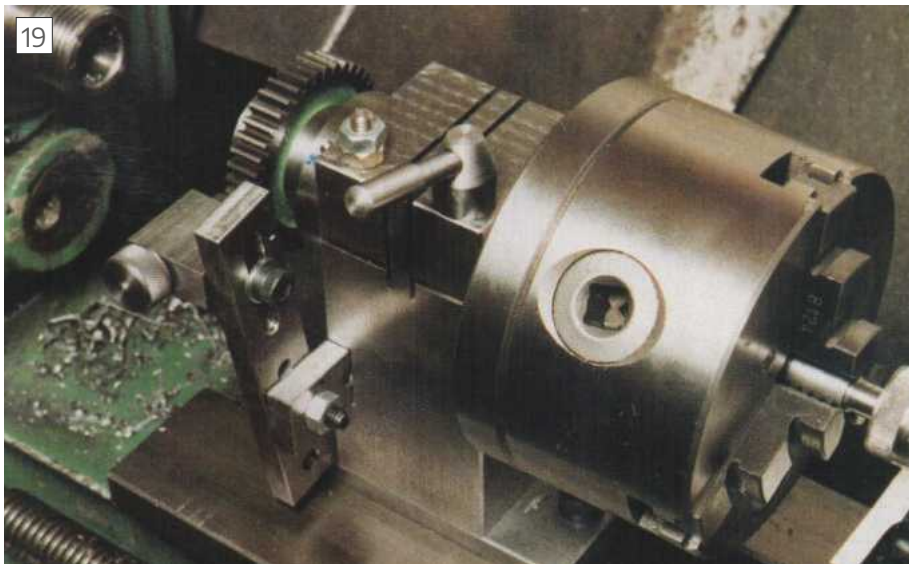

17

Set up for machining the lock screw using the parts illustrated in SK3.

●To be continued


18

Using one of the slide swivel pieces as a fixture for holding the gib strips for machining the angle on their edges.


19

Calibrating the feed knob using a dividing head described by the author in an earlier article.

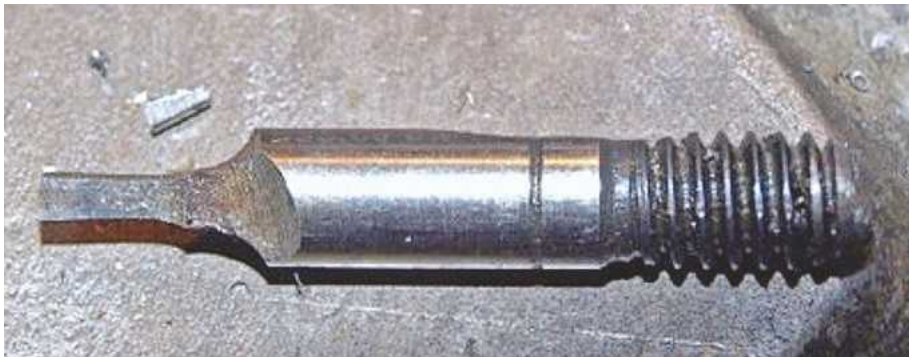
Rotary Broaching

Malcolm Leafe shares his experiences of this useful technique

The comment and photo by Bernard Zaegel in **MEW 284** which concerned the article by Mike Cox on this topic caught my attention as I was at the point of needing to produce small square recesses in some ¼ in diameter studs.

Some years ago, I had tried the technique after reading an article in "Home Shop Machinist". In that issue the writer achieved his aim by making a free-running tailstock mandrel which presented the broach at a small angle to the job. The (then hexagonal) tools were made from Allen key stock by grinding a taper relief and hardening. I too made a tailstock mounted ball raced tool holder with the capability of holding the broach pressed into a stub mandrel which was, in turn, a press fit in the rotating part of the gadget. The rotating part of my creation was attached so that the tool angle could be altered with shims. Disappointment set in after trials when, it seemed, my version did not work – possibly my version of the device demanded too much torque transfer via the very small area of contact between the "broach" and the workpiece– but I did manage to break a number of small Allen keys.

A few years later, working on a different project I became aware of the article by Mike Cox in in **MEW 241** on the same subject but, alas my copy of the magazine was not to be found. Thus, issue 284 by Mr Zaegel commenting on Mike Cox's original MEW article caused me to spring into action (well, saunter really). After my early HSM based effort which occupied and wasted quite some time (but it is quite a nice gadget), I sought to simplify things. A few pieces of sacrificial studding were accommodated in the lathe 3-jaw (one at a time) using a convenient stud box and drilled with the appropriate A/F size drill (0.070 in) followed by countersinking with a 3/16 drill. The tool was ground off-hand from a broken Clarkson end mill and the tailstock pivot was a 5 inch piece of ½ in diameter MS rod with a 7/16 in countersink recess produced by poking such a drill into the end of the bar. The "broach" ex-end mill was placed between the pivot and the drilled stud and hey presto! It did nothing much. Two reasons, I had overlooked the lack of rotation due to the screwed end of the Clarkson cutter being firmly gripped by the tailstock end cone and the lack of the angle necessary to wobble the cutter end, this combined to produce a mangled hole in the sample stud. So close and yet so far, the screwed end of the cutter was then ground off-hand to an imperfect hemisphere and the tail-end offset was adjusted by placing two slips of 20g steel sheet between the rod and one of the jaws of the tailstock drill chuck which was being used to provide the pressure. A few drops of neatsfoot oil on both ends of the broach and I pressed the lathe on button (at about 200 rpm) and stood back in amazement – the lash-up produced a rectangular closed end bore in the work piece (the cutter had been, after all, ground by eye).



Broach ground from Clarkson end mill.

Broach in action.

So to the real job, time for a spot of precision – my Royal Oak tool and cutter grinder was set up and another stub of broken ¼ in Clarkson cutter was ground to the required 0.070 in. square with 4-degree taper producing a flat ended 5/16 in long broach profile at the business end with a hemisphere at the other end plus two spares, just in case. It was baptised with neatsfoot oil and put to work with the same two slips of 20g steel sheet in the tailstock chuck providing the wobble. In a few anxious seconds, success - at last. Neat 0.070 in. square recesses to order.

Aren't broken end mills useful? They also save all that heat and quenching business with a silver steel cutter.

I offer my thanks to Mike Cox. ■

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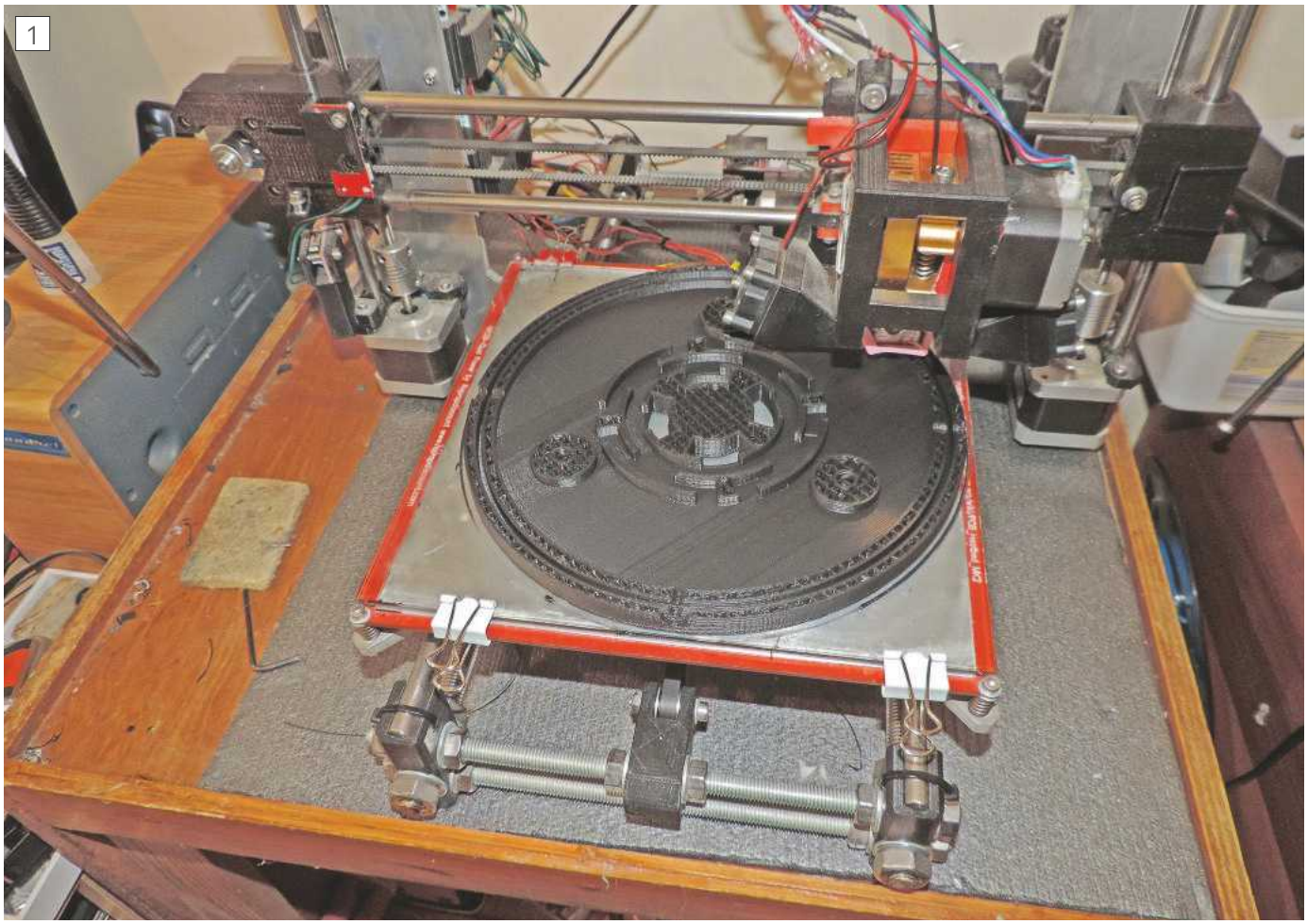
3D Printing with PLA Plus

Stub Mandrel has been experimenting with some different types of filament



Printing the base for the mirror cell.

To date I have used a very wide range of filament materials in my 3D printer, a Prusa i3 clone from Factory3D. I have been able to print successfully in PLA, ABS, Nylon 66, and PETG as well as the flexible filament, TPU. I have had the greatest success with PLA, TPU and PETG. There are many different brands of filament out there and I have tried a good number, usually at the budget end of the market.

One aspect of reviewing a filament is that there are huge differences between printers; not just their construction but also things like how well they have been constructed and set up, are they in a damp, drafty shed or a warm dry room. There are also operator differences, what settings do they prefer, do they use adhesion promotors and how do they apply them and when do they renew them? This means one person's experiences may be quite different from another's. One example of this was one of the filaments with the highest reputation on the market. They sent me some PLA filament for review and although the prints were lovely and crisp, every single one warped away from the build plate, even one where I used a generous brim. Despite extensive help from their technical department I was unable to make a single print that didn't warp away from the build plate. In contrast I was able to get consistently better results across a wide range of settings from budget filament using the same setup.

In view of the fact that several of my 3D printing colleagues and mentors used to use this very filament with near 100% success and overwhelmingly positive review online, I did not feel that my experiences were typical, so I didn't write a review. Incidentally, the company have ceased to produce filament as their policy of producing many specialist, premium filaments proved unsustainable in the face of much bigger competition.

This complex two-part print in PLA Plus looks great and fulfils its function.

The underside of an aborted print of a 3D Benchy shows warping and poor adhesion on the overhang.

PLA Plus

Readers who have 3D printers have probably come across a new type of PLA (polylactic acid) filament, often styled as 'PLA +' or PLA Plus', with little information aside from claims that it is 'superior to standard PLA'. So is it just a rebranding exercise, or a real improvement?

Some internet research didn't turn up a great deal of detail as it seems there is no standard formulation or agreed specification for PLA Plus -it simply means that this is a filament with extra additives to improve its performance. One such additive is TPU (thermoplastic polyurethane) – used on its own for printing strong, flexible parts. One description was giving PLA the easy printing properties of ABS (acrylonitrile butadiene styrene) while retaining its better strength and without the smell!

Typically, these additives may include other plastics, fillers or plasticisers and are generally claimed to improve properties such as strength, flexibility, adhesion, surface finish, ability to print overhangs and that intangible quantity 'printability'. Perhaps the biggest claimed benefit is that it is supposed to absorb less moisture from the air – this makes ordinary PLA brittle, although it rarely absorbs enough to spoil prints (in contrast to Nylon which spits, hisses and bubbles unless it is dry). During the winter if my printer stands idle for a week it's not rare for the section of filament between spool and print head to break spontaneously, though cutting back to the spool itself usually gets past the brittleness. Hopefully, PLA Plus will be resistant to this.

Some users report that PLA Plus requires a slightly higher temperature, but aside from this it seems to be happy with essentially the same settings as ordinary PLA. Most reviews of PLA Plus suggest it is tougher – less brittle and stronger – than ordinary PLA. Many versions are reported to be glossier in appearance. Comparison photographs often show little difference to standard PLA, but there seem to be very few reports of bad performance. It does seem that with PLA Plus/PLA+ there is much greater variability of performance than with standard PLA.

I decided to try out PLA Plus and bought two reels from a popular supplier and gets generally good review. It came in a narrow format reel with a reduced centre spindle; my first impressions were that the filament was more flexible with a softer feel and a satin, rather than gloss, finish. Best of all, it didn't appear to be any more expensive than budget price PLA at about £17 for a kilogram reel.

I first tried it out on a large print -a prototype mirror cell for a 6" telescope, **photo 1**. I used my standard PLA settings and a new 0.4mm nozzle. The z-height was zeroed a bit high, so I did get a little lift at some challenging sharp corners, for the second print (a revised version of the prototype) I dropped the z-height by a fraction and got excellent adhesion so this wasn't an issue with the filament.

Initial results were good; the appearance of prints was excellent, **photo 2**. For the 0.2mm layer height these were far and away the best looking prints I have ever produced and the equal of any professionally printed parts I have seen. There was virtually no stringing and what was there was literally finer than a hair. There were no gaps whatever despite a high speed of 100mm/s for infill and 120mm/s for the inner wall layers. The finish was smooth without any blemishes and no sign of the infill pattern showing through vertical walls (although I was using three-layer walls for strength). Upper surfaces printed smoothly without any 'quilting' and it coped well with building structures over infill.

Despite the 'shiny' reputation of PLA Plus, I got a satin finish that was much less reflective than standard PLA, and the parts felt more pleasant to touch. I didn't test the parts to destruction, but my initial impression was that they were at least as rigid as standard PLA parts.

It was only when I moved on to some different printing challenges that thinks started to go downhill. I found two problems – it is very difficult to print large overhangs with this filament, despite many attempts I could not print a '3D Benchy' test print with a clean bow overhang, **photo 3**. Benchy is a little model tugboat that is used as a standard test across different printers and filaments. The problems I had were curling up and poor adhesion.

I have also been 'brutal' with some apparently perfect prototype parts and discovered that although less flexible than PLA the PLA PLUS is much more brittle, with a tendency to split along the print layers, **photo 4**. Despite the assumption that for prints will easily split along the layers, with standard PLA prints I have found that the strength can be almost independent of print direction. The splits were very clean and suggested that I was printing at too low a temperature, stopping the layers bonding. I did various test prints at increasing nozzle temperatures and also tried slowing and even not using the build plate fan. Increasing temperatures only had a small effect

›

Firm hand pressure was enough to snap this prototype part along the layers.

on strength, but as the PLA was more fluid, they increased stringing and warping of unsupported edges. This was a disappointing finding and I have had to decide this particular filament is best for items that are not subject to flexing, high static or shock loads.

I won't name this filament, as looking online I've seen that reviews seem to fall into two camps -one that finds it brittle, both prints and the raw filament (even when care is taken to keep it dry) and another that reports that it is significantly stronger than ordinary PLA. This make me wonder if different colours have different properties, a not unknown issue with some brands or even if there are different batches of filament. At least one reviewer got strong prints at 200-205C, while even at 220C I could not get strong layer adhesion.

Most people print lightly loaded parts and for these my impression is very much a positive one and I will continue to use this filament for such purposes, but I will stick to other filaments for more critical engineering parts.

Conclusions

I have to add the caveat that just because this particular filament showed these properties, it might perform differently with other printers. Also other types of PLA Plus/ PLA+ could well show greater strength and better layer adhesion than standard PLA. A website that attempts to compare filaments objectively is toms3d.org run by Thomas Salanderer who review many different types under tightly controlled conditions.

I can't stress strongly enough that PLA Plus/PLA+ covers a very much wider range of potential materials than stock PLA. For me this means it looks like I need to try some other makes as well – although this is likely to hurt my pocket when I try upmarket versions. In particular I will look one brand that is available in some high transparency and metallic finishes that appear to give impressive results.

As I write this, my printer is forming a large object in flexible TPU, it includes overhanging operating threads and has four parts printed simultaneously. It seems to be printing without any defects or stringing. Many people find TPU the most challenging of filaments, yet I have always found it reliable – once I had fitted a filament guide between pinch rollers and the heat break tube. This just underlines how FFD 3D printing is really still in its infancy and we are a long way from 100% reliable, consistent machines that perform equally well for all users -at least at the budget end of the market.

Most people are still using 3D printing for decorative and lightly loaded applications, but MEW readers like to push the limits a bit! If you have tried PLA Plus/PLA+ or other new or unusual printer filaments particularly for 3D prints in more demanding applications, let me know which filaments you have used and the results you have got. While I don't want to 'name and shame' on the basis of my experience alone, I think it would be useful to share the names of brand which have worked well for readers. ■

In our Next Issue

Coming up in issue 295
On Sale 10th July 2020
Content may be subject to change

Look out for our July issue, number 295:

Mark Noel introduces the 'MEWSonic', an advanced ultrasonic cleaning tank designed especially for Model Engineers' Workshop.

Plus:
Adrian Rawson's computerised Divider

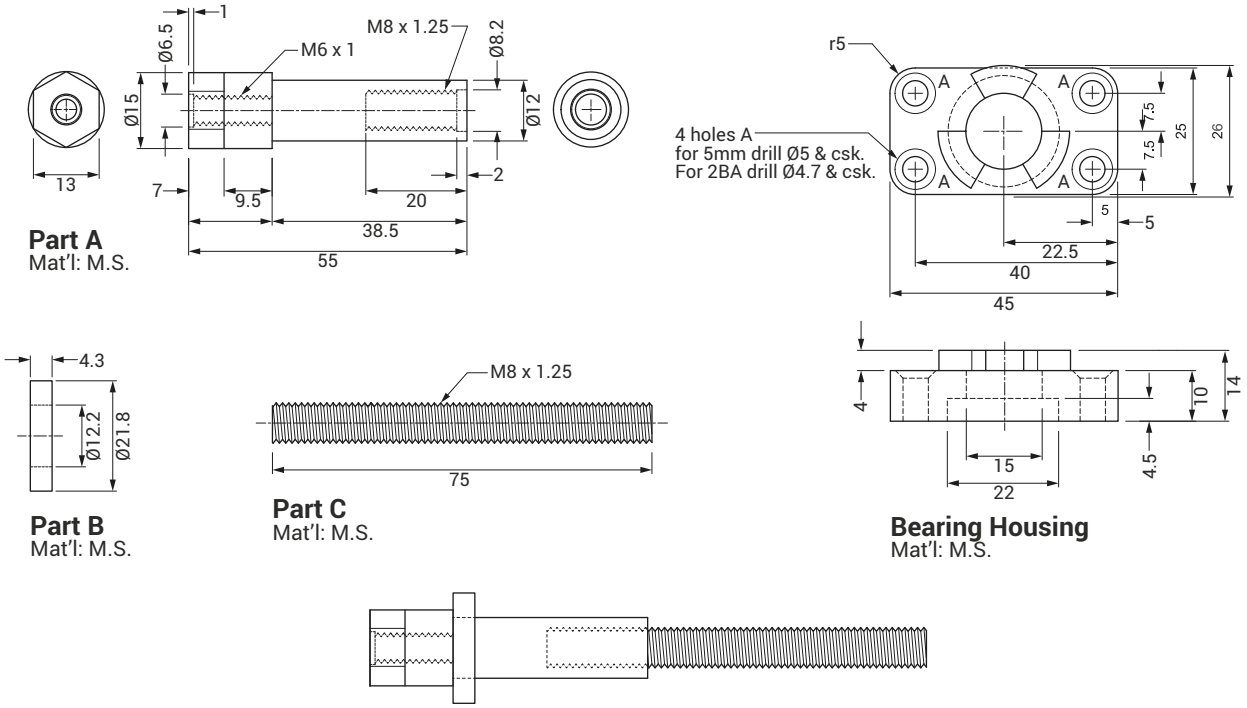
Laurie Leonard works on his Tom Senior Mill

Inside **Andrew Johnston's** workshop
Jim Binnie's scratch gauge

Dividing on the Warco 220 Lathe

Peter Shaw describes a mandrel dividing attachment for this popular lathe that can be adapted to fit many other benchtop machines

Fig.3



General Arrangement Of Expander Bolt

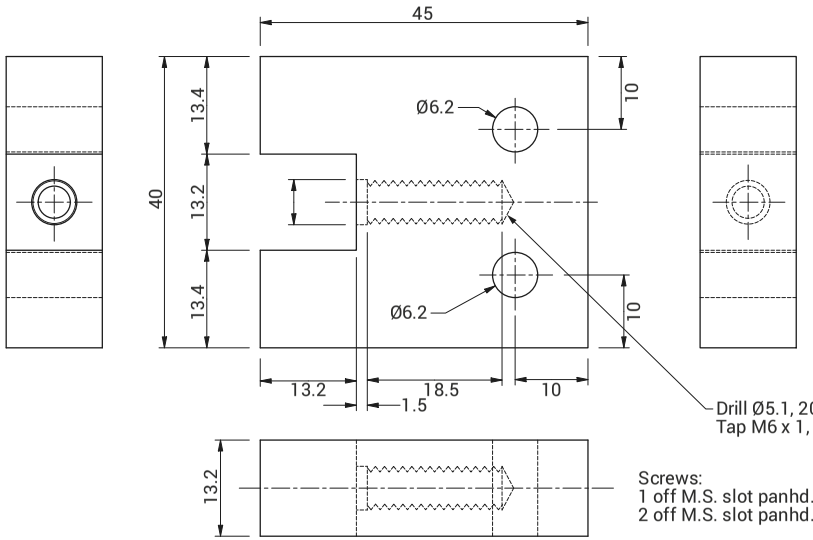
Other hardware for use with expander bolt:
1 off screw, M.S. ch.hd. 6mm x 1mm, 10mm long
1 off washer, M.S. OD 26mm, ID 6.5mm, 2mm thick

Bearing Housing (Fig. 3)

Clean up the glued surface and drill the four corner holes with the appropriate clearance drill. Mount in a 4-jaw independent chuck with what will be the outer surface set for machining and using parallel packing as necessary. Set to run true using the previously drilled hole as a reference. Now mount a sharp pointed tool, e.g. a screw-cutting tool, on its side in the tool post, parallel to the lathe axis and adjust such that its point is level with the small hole in the part. Using one of the 12 holes in the mandrel, lock the mandrel against further movement, then using the cross-slide for movement, scribe a reasonably deep line directly across the 26mm circle previously marked. Repeat for another two lines 60 degrees apart by rotating the mandrel by two holes of the mandrel divider. Change the tool for a left hand knife tool, again mounted parallel to the lathe axis and face away the unwanted material leaving a raised boss 4mm deep x 26mm diameter with three scribed lines across its surface set 60 degrees apart. Finally reverse the part in the chuck, set to run true by the small hole, face down to the required thickness and bore the central hole and recess ensuring that the smoothest possible surface is produced. On completion, remove the part to the drilling machine and countersink the four corner holes. If there is insufficient room for the countersink then it will be necessary to either convert an old, sufficiently small drill into a small countersink, or use an unmodified drill but this will look untidy and the screw may not fit particularly well.

Expander Sleeve and Cone (Fig.2)

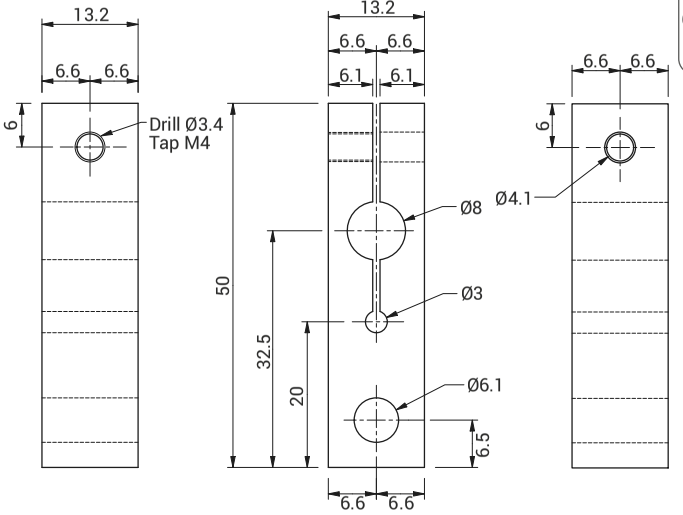
The Expander Cone shown in Fig.2 poses no difficulties, being a straightforward turning, drilling and threading job. The included angle of the cone is shown as 5.2 degrees, but it will not matter if it is not exact – as long as it forces the expander tube to open sufficiently to grip the inside of the mandrel. Simply rotate the compound slide to about 5 degrees and cut using the top-slide.



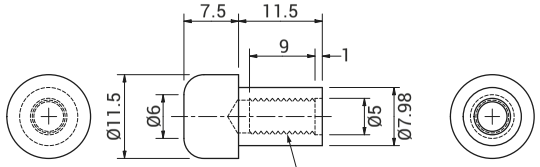
Screws:
1 off M.S. slot panhd. M6 x 1 x 30 or equiv.
2 off M.S. slot panhd. M6 x 1 x 27 or equiv.

Washers:
3 off M.S. 12.2 x 6.4 x 1.5

Baseplate
Mat'l: Aluminium

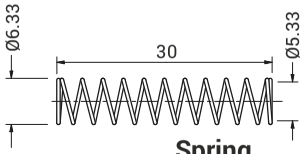


Pillar
Mat'l: Aluminium

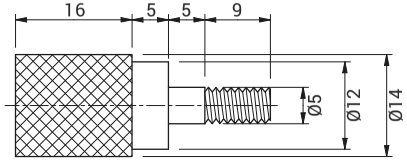


Detent Knob
Mat'l: M.S.

Detent Guide
Mat'l: M.S.

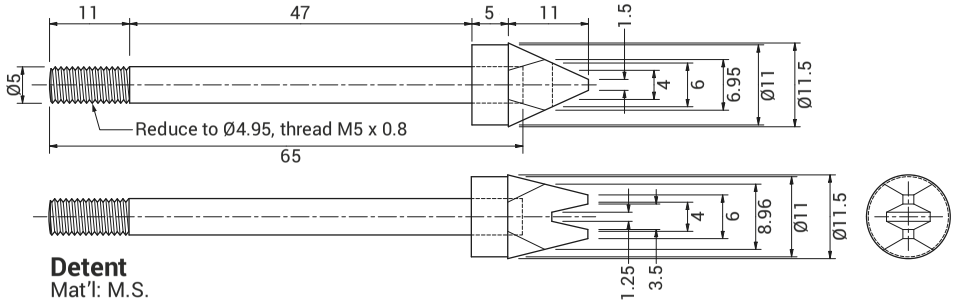


Spring
10 coils

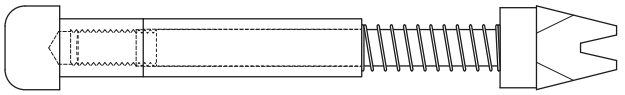


Clamp Screw
Mat'l: M.S.

Washers:
1 off M.S. Ø9.85 x 5 x 0.88



Detent
Mat'l: M.S.



Detent G.A.

Fig.4

Baseplate, Pillar and Detent.

The Expander Sleeve shown in the General Assembly (G.A.) of Fig.2 should not be difficult to make. It consists of two parts – the Sleeve itself and the Plate – which are soft soldered together.

The four slots in the sleeve would best be made by means of a slitting saw for neatness, but a hacksaw will be satisfactory. Note that the diameter of the hole in the plate is larger by 0.1mm than the spigot on which it sits: this is to allow room for the soft solder when the two parts are fastened together. Note as well that one side of the Plate forms part of the Bearing Housing (Fig. 3) and thus should be prepared with the smoothest surface possible.

Expander Bolt (Fig. 3)

The expander bolt is made up from three items, although there is no reason other than economy of material why it could not be turned from the solid. Part A is silver soldered to Part B and Part C is cut from a length of studding and fastened in place using a suitable stud locking compound. Note that the external surfaces of both Parts A and B rotate inside the Bearing Housing and the Plate (Fig. 2) and thus should have the smoothest surface possible.

Milling the Changewheel Coupling (Fig. 3)

The outer surface of the Bearing Housing is designed to mate with the matching parts on the lathe changewheels, and therefore needs three segments to be removed to create the coupling. With care, and a small enough milling cutter, it is possible to cut straight across, but there is a very real danger of going astray and accidently cutting into the required segment opposite.

The Bearing Housing is difficult to hold, specifically because it needs to be rotated into different positions for milling. It is suggested that the Expander Sleeve be completed first as it may then be used to support the Bearing Housing for milling.

Fasten the Bearing Housing onto the Expander Sleeve and set in a milling vice with the Bearing Housing uppermost and with one of the previously scribed lines set in line with the proposed direction for milling. Mill away the unwanted material and rotate the Bearing Housing/Expander Sleeve to the next scribed line. Continue until all three gaps have been created.

Also described on Fig 3 is a mild steel washer, 26mm od, 6.5mm id and 2mm thick, the purpose of which is to hold the changewheel in place. I suggest that the washer should be dished, and this may be achieved by supporting the rim on a suitable piece of tubing and hitting the centre with the ball end of a ball-pein hammer. The amount of dishing is irrelevant, it merely serving to ensure that the rim is in contact with the changewheel and thus clamping the changewheel tightly in position.

Baseplate and Pillar (Fig. 4)

The Baseplate, **photo 3**, is straightforward, the only points worthy of note being the two 6.2mm holes which should match the two 6.0mm tapped holes in the Gearbox Cover Adaptor Plate, and the width of the slot, shown as 13.2mm, which needs to be the same width as the Pillar.

The Pillar, also photo 3, is relatively straightforward too, the only point worth noting is the height of the 8mm diameter hole shown as 32.5mm. This height is dependant on the position of the lathe changewheel when in position (see photo 1) in relation to the thickness of the Gearbox Cover Adaptor Plate. It is therefore recommended that before making the Pillar, this height be determined by mounting the Gearbox Cover Adaptor Plate, and the complete Expander/Bearing assembly complete with a suitable changewheel and measuring the height from the Gearbox Cover Adaptor to the centre of the teeth on the lathe changewheel. The 32.5mm dimension should be adjusted as necessary.

The Clamp Screw may be made from one piece, or from two parts soft soldered together.

Detent (Fig. 4)

The Spring came from an old ball-point pen compressed to a length of 19mm. The Detent Tube and Detent Knob are straightforward turning, drilling and tapping operations about which nothing more need be said.

The Detent proper consists of two parts: the rod which is soft soldered no more than 7mm into the actual detent head itself. The detent head has to locate between two teeth, and across a tooth. The first objective can be done by filing the sides to a V shape, taking care to achieve best accuracy of the two sides, whilst the second objective requires that a V shape be accurately made across the end, or base, of the first V.

Using the Divider

As with any adaptor, there will be a certain amount of slack in the mechanism, and it will therefore be necessary to take up this slack by the time-honoured method of wrapping a cord around the chuck, anchoring it with the chuck key or a peg into one of the keyholes, and suspending a weight from the other end.

The Divider was designed to be used with a 40 tooth changewheel and in recognition that other sizes may be used, the Pillar, Detent Guide and Detent are designed to provide some leeway. Should this be insufficient, then by drilling and tapping one or more pairs of holes in the Gearbox Cover Adaptor Plate, further adjustment may be made as needed.

An idea for further amendment

The Detent has straight sides to engage between the changewheel teeth. Possibly a better idea may be to make these sides slightly concave thus creating better, and more reliable, contact between the Detent and the changewheel. This could be done using a half round file.

Similarly, the V in the Detent may benefit from having its sides made concave using a small half round file. ■

From the Archives:

This article originally appeared in Model Engineer, 8th September 1955.

Types, sizes, materials and techniques are dealt with by GEOMETER in this article on

BEGINNERS' WORKSHOP

DRILLS

AND HOW TO USE THEM

THE TOOL COMMONLY used for boring holes in metal is the twist drill, the diameter of which can vary in size from a few thousandths of an inch up to several inches. The working part of the drill comprises two spirals or flutes (twists), and these are ground at the end to a vee point (included angle 118 deg.), and given clearance or backed off from the cutting edge, so they will bite into the material. The twist drill has a much freer and more rapid cutting action than other types, which may be called flat drills, or diamond point drill.

Drill sizes

Twist drills are made in a wide range of sizes and sets, dimensions of which can be obtained from catalogues and tables; these are fractional inch sizes such as 1/16 in., 1/8 in., etc.; millimetre sizes; wire gauge sizes and letter sizes. These are necessary for the different diameters of holes for tapping and clearing sizes for different ranges of screws and bolts, etc. Drills generally found in the small workshop are fractional inch sizes, and wire gauge or number sizes.

Small twist drills have parallel shanks, but to fit in drilling machines or chucks with taper spindles, all but the smallest drills can be obtained with taper shanks. These are generally Morse taper in sizes numbered 1, 2, 3, 4 or 5 according to the size of the drill. Square taper shanks are also used to enable twist drills to be mounted in a type of brace.

The cheap twist drill is made of carbon steel, and will break fairly easily if wrung or subjected to rough treatment, and will soften if overheated. The better class of twist drill is in high speed steel-this is much tougher, and does not lose its cutting powers so easily if allowed to get hot. These drills are more expensive, but because of their superior performance usually prove more economical.

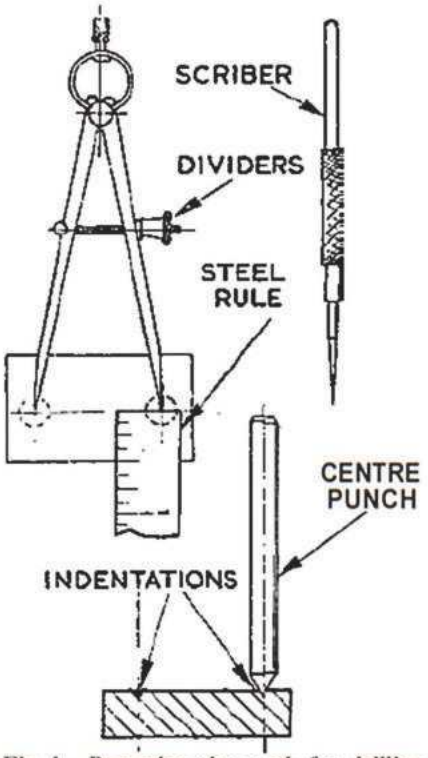


Fig. 1.-Preparing the work for drilling

Types of machines

The small hand drill takes parallel shank drills up to 3/16 in. or 1/4 in. These are placed in the chuck and the chuck is tightened by rotating the body, thus causing the jaws to grip. There is a correct theoretical speed for all drills according to the size and the material drilled, but with this type of drill,. small drills are turned as fast as possible, and the larger ones more slowly.

A larger machine of this type is the breast drill which has a pad to come against the chest. This drill may be supplied with a standard drill chuck or the spindle may be tapered to accept taper shank drills. These are simply pushed in and tapped on the end; they are extracted with a flat key. Small electric hand drills are available in different makes and sizes, and there are also bench-mounted machines for hand and power operation.

Marking off for drilling

It should be checked that a drill is not wobbling before it is applied to the material, but even so the point may run from the desired position, if this is not marked.

There are many methods of marking the positions of holes. For most occasions, the tools required are a steel rule, a scriber, dividers, and centre punch (Fig. 1). the last three have hardened points which will mark metals. When the positions of holes have been made, the centre punch is tapped in. and the drill will start correctly in these small indentations.

Fig. 2 shows points in drilling. A correctly-sharpened drill will cut to size, while a drill ground off-centre will cut oversize and leave a shoulder. Burrs are commonly left top and bottom in drilling. If removed by filing, an internal burr may result in a tight hole.A larger drill or countersinking tool should, therefore, be used to produce a chamfer. Oil may be used to lubricate steel in drilling; paraffin for duralumin and aluminium; while brass, cast-iron, fibre, etc., should be drilled dry.

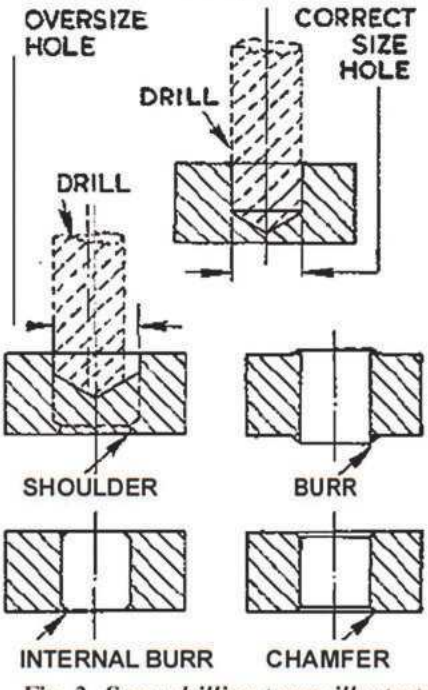


Fig. 2.-Some drilling terms illustrated

From the Archives:

A Ball Turning Attachment for the Smaller Sizes

David Fenner, from MEW Issue 127, July 2007

Former MEW Editor Dave Fenner ran a jobbing machine shop for many years, and as a result is happy to make jigs, fixtures and tools to get a job done with more regard to function than fine finish. Though he proudly describes himself as a 'blacksmith', this very practical and well-proportioned ball turning attachment for smaller balls shows that he's hiding his light under a bushel.

Many overhead valve engines have some form of spherical location for the cam follower - pushrod - rocker connection. In the case of the model Bentley BR2 engine, the pushrods incorporate adjusters with spherical ends, the ball diameter being 1/8 of an inch, and the adjuster thread 6BA. Having nine cylinders, the engine would therefore require 18 pushrods, and 36 adjusters. Consequently, I felt that the subject deserved a little fiddling around or should we call it research, before diving in and creating swarf.

In general, one may separate ball-turning methods into four main categories. The first and probably most popular relies on sweeping a cutting tool around an arc whose centre coincides with the work centre to generate the sphere. Within this category, some versions employ a sweeping action in which the turning tool moves around a horizontal axis, while others use a vertical pivot as in **photo 1**.

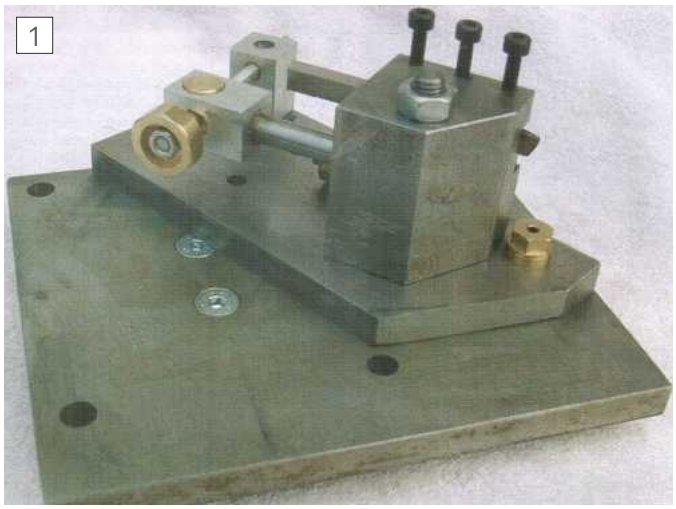
A second method is to use a form tool. Here the length of cutting edge actually in contact with the work becomes relatively large, with consequent high forces on the tool and the work. With careful set up, it would probably be possible to use two form tools, say one for the front and one for the rear, thus reducing the cutting forces to more manageable levels.

The third method uses a tubular tool with a sharpened edge; however this is likely to be of more use for finishing rather than roughing. Descriptions of these techniques will be found in several of the well-known books, **Refs 1**, **2** and **3**.

The fourth method is more appropriate to the milling machine and was described by Charles Woodward in **Ref 4**. Here the cutting tool is mounted, typically in a boring head so that its cutting radius may be varied. The work is set at a suitable angle to the cutter, and then rotated slowly in the dividing head or rotary table to generate the spherical shape.

Over the years, other authors have presented suggested designs for ball turning tools, most working with a vertical axis. Some have controlled the cutting radius by sliding the tool bit, either within or together with its holder, while others have designed the tool holder to rotate on its base and thus vary the radius cut. **Refs 5** to **10** list a number of articles on this topic, which have appeared in earlier issues of MEW.

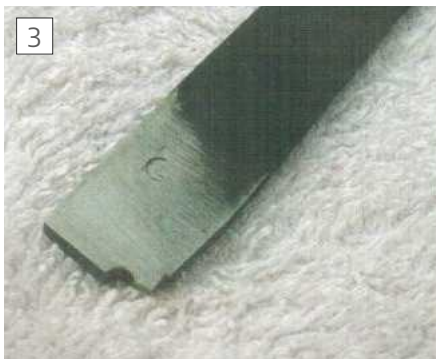
Some time ago, I did construct a ball turning tool after seeing one built by a friend from the excellent Hemingway kit. The intended duty at the time was to turn aluminium automotive gear lever knobs at about 1.5 to 2 inches in diameter on the Colchester Chipmaster or Herbert 2D. This design operates by rotating the cutting tool about a horizontal axis. An adjustment screw operating via a dovetail slide provides for varying the cutting radius, and there is a convenient advantage in that the


1

The completed accessory.


2

A ball turning tool based on that marketed by Hemingway kits.



A form tool made from gauge plate.

A sharpened tool from silver steel.

'Scientifically' determining the pivot position (by eye) and marking with a drill.

device may be moved to cut on the work axis by means of the cross slide.

For turning small parts though, I felt that this device, illustrated in **photo 2**, was somewhat on the large side, and that its general geometry meant that cutting would have to take place some distance from the chuck.

Initial trials

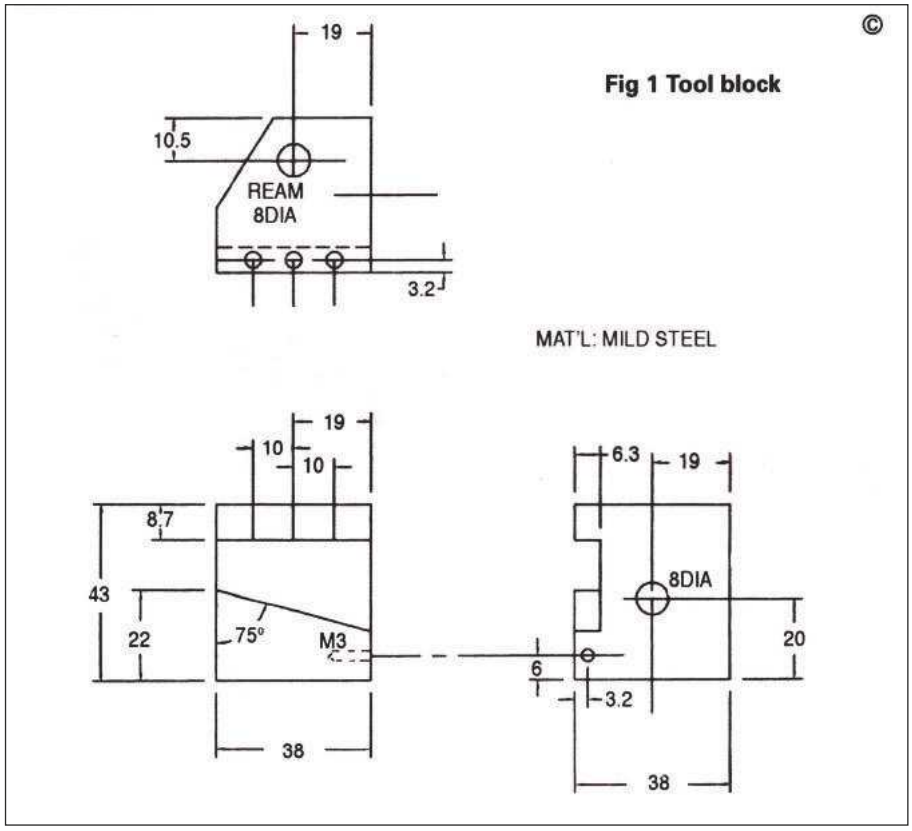
Before spending time and effort constructing a new tool I first tried two of the methods that required rather less in tool making effort, namely the form tool and the sharpened tube. To create the first, the recommended procedure is to produce a tapered hole, by drilling and reaming, to give clearance below the cutting edge. As I did not have a taper reamer to give the necessary 1/8 inch diameter, I resorted to drilling

Initial marking out by felt tip pen although the c/s hole spacing was accurately controlled.

a hole of that size, through a piece of gauge plate, at a slight angle, probably about 5deg. The plate was then cut and filed as shown in **photo 3**, leaving the required form. It was then hardened by heating red-hot and quenching in water. Tempering was omitted. On an initial trial, this tool worked well, but when work on a real component was attempted, the forces caused fracture at the screw thread.

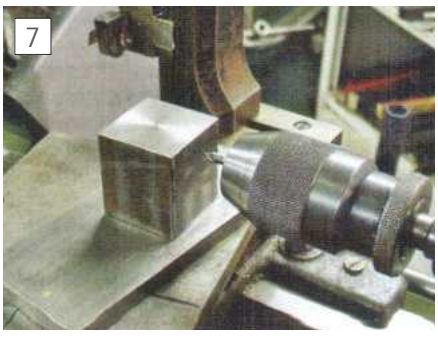
The sharp tube tool was made by drilling through a short length of ¼ inch diameter silver steel, which was then hardened as above. It was then located on a holder for easy freehand grinding as shown in **photo 4**. While this could not be used for working from scratch, it could be used quite effectively to tidy up a rough shaped part machined with a form tool.

After the breakage noted earlier, I decided to bit the bullet and build a new ball turning device, with these small size components in mind.



Design

As with almost all of my projects, the process starts with a trawl around the scrap box cum material store. One likely looking candidate emerged as a strong possibility for a base plate, which did in fact have a slightly related history. And here I digress! Some years ago a customer, for whom I produced small stainless parts at about a pound or so a piece, sent to me in error, an order



The easy way to scribe the centre height.

intended for another supplier, for half a dozen Perspex concave lenses, priced at some five hundred pounds each - three thousand pounds for six bits of plastic! These would be destined for a submersible camera system. The concave form was spherical and about three-inch radius. After forwarding the order to its intended recipient, I first wondered if I was in the wrong job, then experimented to see if these lenses would be hard to make, in the process, concocting a concave spherical turning device. The upshot was that cutting the form was not difficult, however

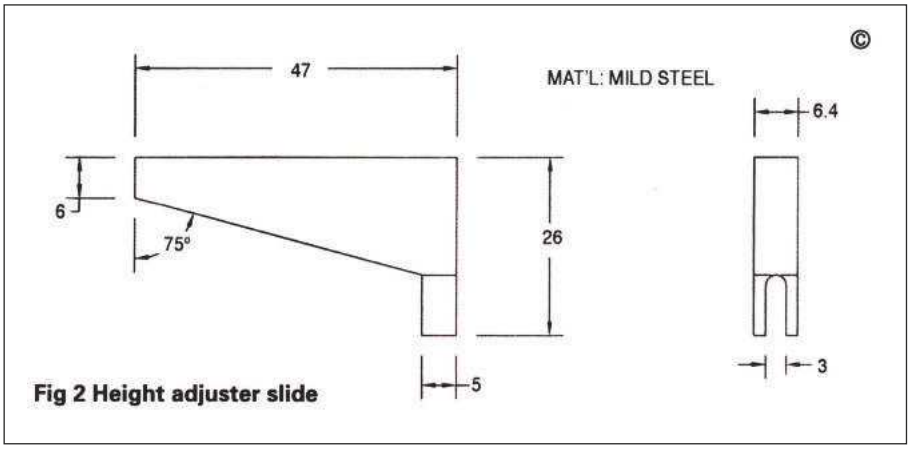
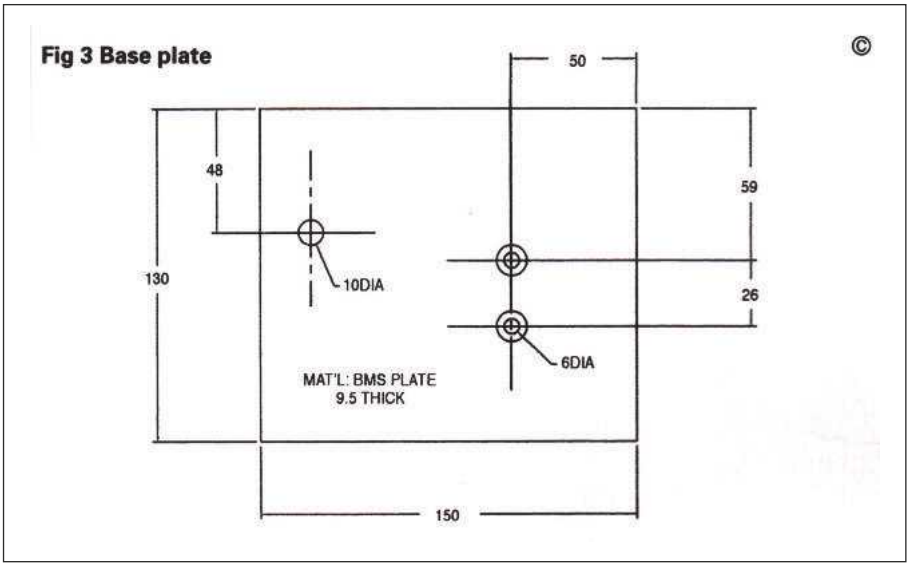


Fig 2 Height adjuster slide

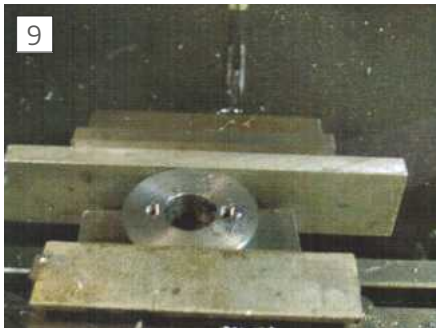


achieving the required degree of polish whilst still retaining the accuracy was entirely another matter. I eventually admitted defeat and stayed with the stainless parts. Now some fifteen years later the experimental gadget has been dismantled and partly recycled.

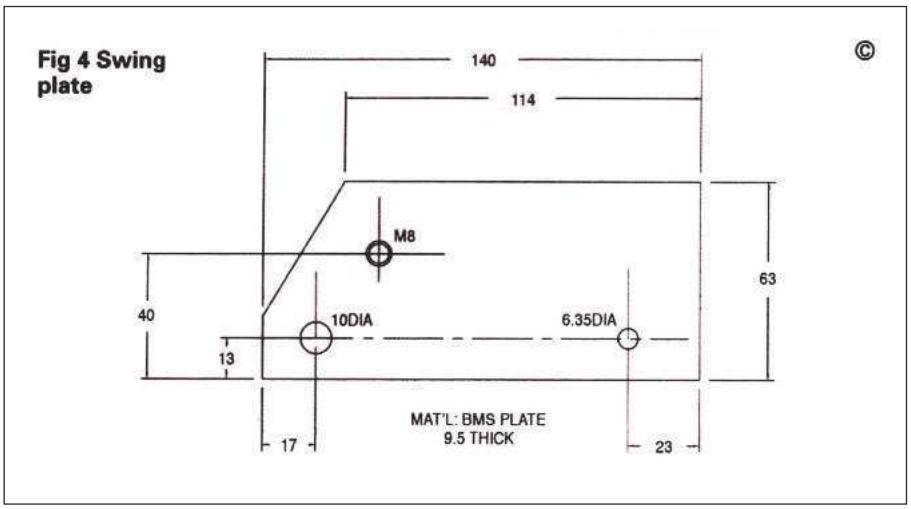
The general thinking follows established practice in locating the cutting tool in a block, which can be rotated to vary the spherical diameter. An adjusting screw controls the size variation. For added convenience, having worked for some years with quick-change tool posts, which dispense with the need for shim packing for height adjustment, I felt that this was a feature worth incorporating. I cannot claim any originality for the method chosen, having seen something similar on a large industrial tool post some years ago. However, I have not seen the principle adapted to a ball turning application, though no doubt, someone will prove me wrong. The photos show a ¼ inch square high-speed steel cutting tool supported on a sliding tapered block. The position of the block, on a fifteen-degree ramp, is controlled by an adjusting screw, which allows accurate setting of tool height.

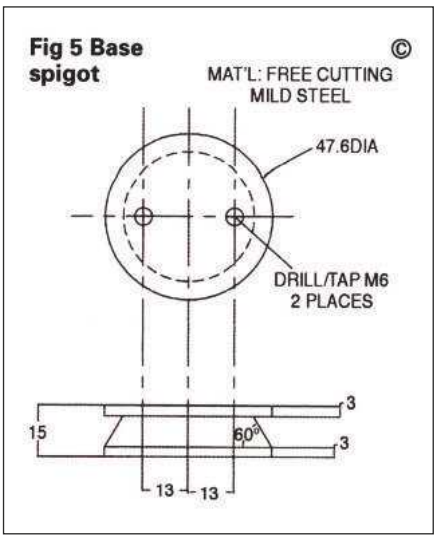
Whereas the original gadget had been set up on the Chipmaster, (legacy mounting holes are visible), it was intended that the new device should be fitted to the Myford Super 7. While it could have been attached by say, four bolts, I figured that if the existing Myford topslide hold down system could be used then this would add flexibility in positioning. Note that for the ML7, a conventional bolting arrangement would be needed, probably using countersunk screws.

The spigot located on an expanding mandrel.



Drilling and tapping the boltholes. Note the aluminium packing to avoid marking work.





The choice of most of the components was influenced (even dictated) by what was found lying in the scrap box, notably the M3 and M5 screwed rod and the 1.5in. square bar used for the tool block. Although much of the material was to imperial standards, the drawings have been presented in generally metric form.

As may be deduced from careful examination of **photos 5** and **6**, which show evidence of a black felt tipped pen, some parts of the marking out procedure were not accomplished with great accuracy. As the parts started to come together, they were placed in what looked like suitable locations, and the positions marked. This is also true of the Heath Robinson method, **photo 7**, used to establish the required tool centre height by scribing from a centre drill in the tailstock. While the drawings reflect accurate measurement of what was eventually made it will be obvious that a fair amount of latitude may be taken on many parts.

Construction

The conical Spigot, fig. 5

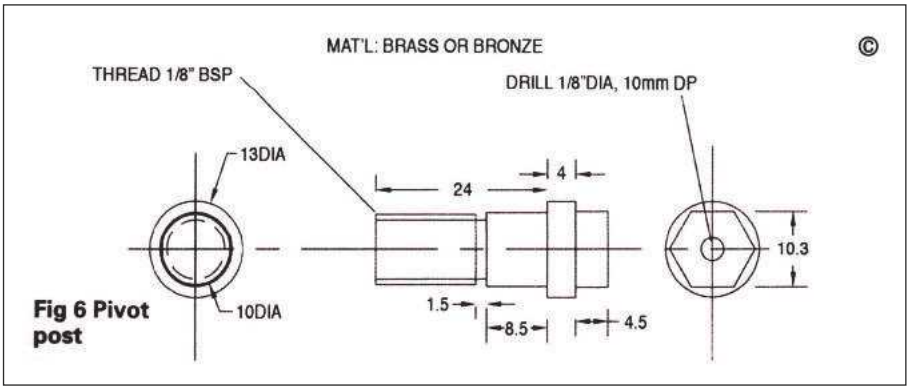
Measuring up the Myford Super 7 topslide gave a spigot diameter a thou or two shy of 1.875in. So a piece of two-inch diameter bar was faced on one side then bored to closely fit a convenient expanding mandrel. This was then mounted in the collet chuck and the work clamped in place with the unfaced end outermost. It was then turned to diameter, faced to thickness and the conical profile cut, **photo 8**. The abutment face was part relieved a few thou to assure stable contact over the outer ring. This was then transferred to the mill to drill and tap the positions for the M6 screws, (**Photo 9**). The finished item is shown in **photo 10**.

The finished spigot showing the relieved inner area of the abutment face.

Tapping using a pump centre for alignment.

The base Plate, fig. 3

As noted above, this was a conveniently sized piece of 3/8 inch thick bright mild steel plate. The work on it requires no special mention, except to ensure that the depth of countersinking is sufficient to take the screw heads below flush. If they are proud, then expect interference with the swing plate. Also ensure that the pivot thread is accurately vertical.

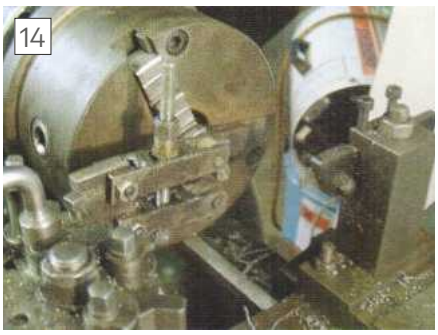


The vice has been set over at 15 degrees to cut the lower section of the slot.

Swing Plate, fig. 4

Again, a convenient length of 3/8 inch thick bright mild steel plate, this time left over from the set up for reboring motorcycle barrels (with thanks to Alex Fairbairn). The work is all pretty straightforward, but it is worth making sure that the thread for the block pivot rod is truly vertical. Here I did all the drilling and started the tapping in the mill. If your mill does not have a suitable low tapping speed, then several choices are available. You can fit the tap to the chuck, lower the quill and rotate by hand, or run the machine, hit stop, then lower the quill and let the residual inertia tap the

Cutting the slot in the adjuster slide with a slitting saw.



Knurling the adjuster knob.

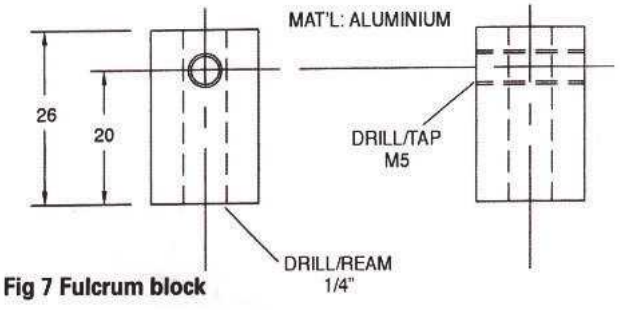


Fig 7 Fulcrum block

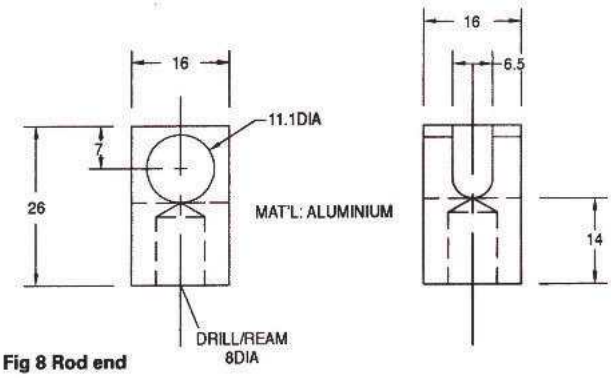


Fig 8 Rod end

first few threads. Alternatively, use a tap wrench and a spring-pump centre.

Tool Block, fig. 1

A length of 1.5 inch square BMS bar was first cut a shade over length, then faced in the four jaw. The slot for the tool bit and taper slide was cut in two stages. During stage one with the vice set in line with the table, the upper edge of the slot was formed down to a depth of a quarter of an inch. The vice was then set over 15 degrees to cut the lower section, as in **photo 11**. Further work included drilling and tapping the three M4 holes for tool clamping, and the M3 hole for the height adjuster rod. **Photo 12** shows a pump centre in use to ensure vertical tapping. The 8mm dia. hole for the block pivot was drilled and reamed to ensure a neat fit. Slicing off one corner (viewed in plan) was a modification in the light of experience, to give better access close to the chuck.

Adjuster Slide, fig. 2

No great difficulties here, just a piece of quarter thick BMS, cut-milled to shape, having a 15 degree angle to match the block. **Photograph 13** shows the screw slot being cut by slitting saw, the work being clamped to a suitable chunk of steel held in the vice. This is probably one of those situations where it might have been preferable to leave the work attached to the main bar for easier clamping.

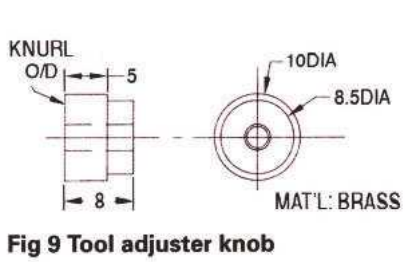


Fig 9 Tool adjuster knob

Set up using rotary table to mill hex on pivot post.

Fulcrum Block and Pivot Rod End, figs 7, 8 and 11

These need no special comment and may well be made from alternative materials. It was convenient to use these pieces of aluminium, as they came from the scrap box, ready cut to size, being left over from a batch of earth blocks made many years ago.

Knobs, figs 9, 10 and 12

Turned parts are needed for the tool adjuster knob, the radius knob, and its associated stop. I chose to knurl the outside diameter of the small knob **photo 14**, but made the larger knob from hexagon material, merely turning off the corners. Here the 12.5mm diameter recess is to accommodate an M5 locknut, the diameter quoted being sufficient to clear a socket spanner.

Pivot post, fig. 6

This carries out several functions, the main being to provide the pivotal location for the swing plate. Using the Math. BSP thread and a locknut allows fairly fine adjustment of the vertical clearance. Make sure that the 10mm diameter is a close fit in the swing plate. The post is also drilled to take a centring pin. Here I did not drill through, and with the benefit of hindsight, this will be a sensible mod, to avoid a build-up of swarf in the blind hole. If necessary, the same hole might be used to accept a height gauge for off-machine tool setting. As may be seen in **photo 15**, I chose to mill a hex on the post for easy adjustment with the locknut. Others

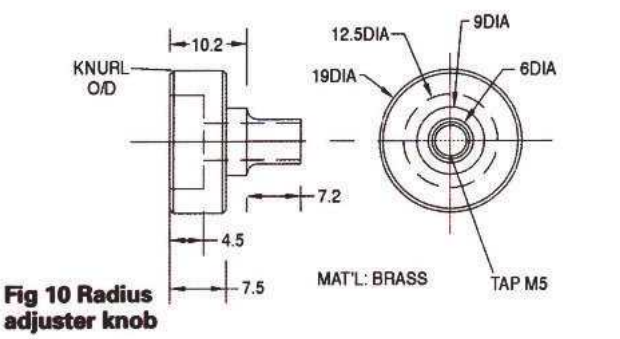
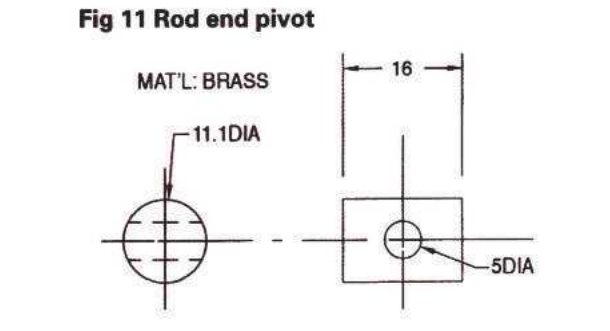
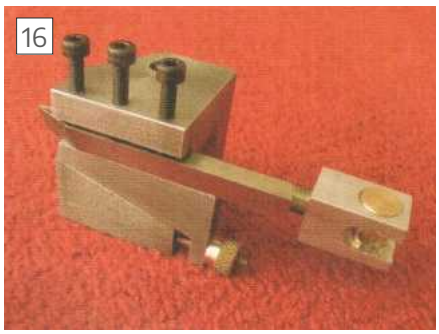


Fig 10 Radius adjuster knob





Tool block assembly.

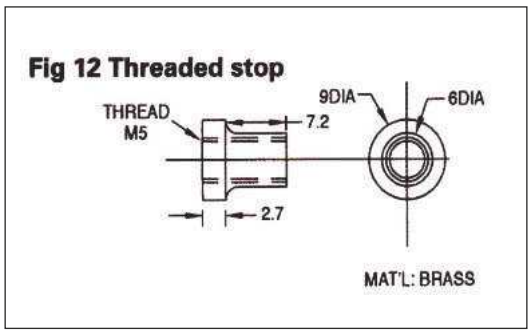
might prefer a couple of cross drillings for a tommy bar.

Other parts

No drawings have been given for the block pivot, 8mm bar 60mm long, threaded M8 both ends or the two lengths of screwed rod, one M5 - 80mm, the other M3 - 30mm.

Assembly

I chose to Loctite in the threaded block pivot bar, noting that if the bar protrudes on the underside of the swing plate then this must be filed off to give a flush surface. In a similar manner the connection of 8mm rod and aluminium rod end to the tool block was also a Loctite job. For reference, after assembly, as in photo 16 the distance between rod end and tool block was measured as 32mm.



Operation

Prior to use, it may be useful to examine the position of the tool tip with reference to the size of sphere to be produced. As the size goes down, it becomes more necessary to establish that the tool overhang and the lateral position of the point will be satisfactory. For cutting the small 0.125 inch balls, I found it useful to be able to cut on two edges of the tool, on both the clockwise and anticlockwise swing. Adjustment of the tool height is clearly straightforward.

The assembly is then positioned on the lathe in such a way that an eighth inch dia. setting pin fitted to the pivot post lies on the machine axis and at the required spherical centre. This would typically then involve a saddle stop for longitudinal position and a noted dial reading for cross slide travel, so that clearance may be obtained for placing/removing work in or from the chuck. The tool is wound out on the radius adjuster, to just clear the work, then progressive cuts are taken, incrementing the adjuster knob at each cut. ■

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Ref 3 Lathe Accessories - how to make and use them. E.T.Westbury, TEE Publishing ISBN 1-85761-120-9
Ref 4 MEW Issue 111p 48 Machining Ball Handles by Generating on the Mill - Charles Woodward
Ref 5 MEW Issue 6 p 44 A Ball turning Tool
Ref 6 MEW Issue 11 p 44 An Elegant Ball Turning Tool - G.W. H. Swallow
Ref 7 ME W Issue 26 p 52 A Ball Turning Tool- Phil Thomas
Ref 8 MEW Issue 28 p 68 Machining Spherical Surfaces - David Turner.
Ref 9 MEW Issue 80 p 55 Basic Tools for Radius Turning - J. Lait
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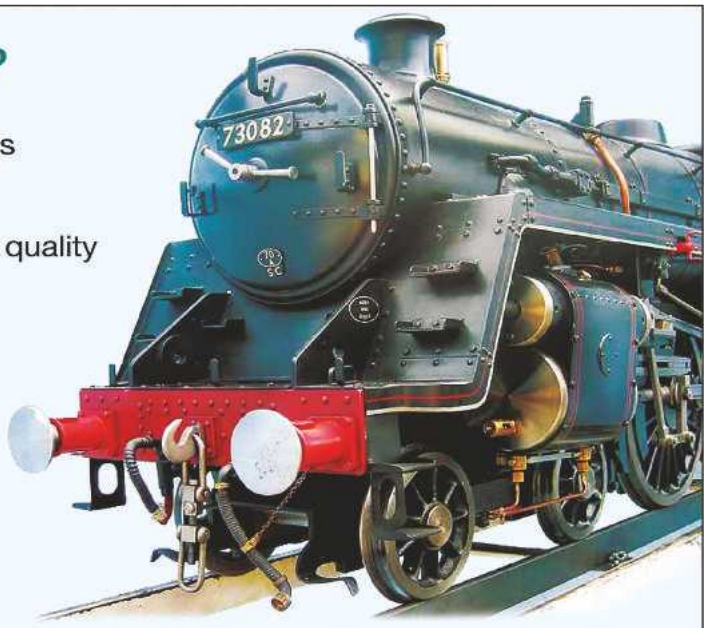

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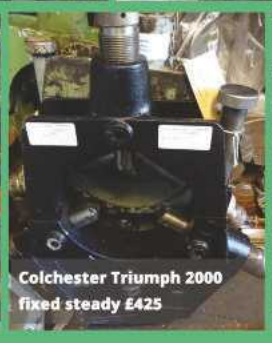
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