No. 335

MAKE A MACHINIST'S JACK

A handy accessory with many uses around the workshop.

MODEL ENGINEERS' WORKSHOP

THE MAGAZINE FOR HOBBY ENGINEERS, MAKERS AND MODELLERS JANUARY 2024 ISSUE 335 WWW.MODEL-ENGINEER.CO.UK

EazyCNC

A straightforward approach to CNC control.

A SENSITIVE DRILLING ATTACHMENT

Peter Barker brings a century-old design to life.

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Brian Woods ergonomic solution for easier dividing.

INSIDE THIS PACKED ISSUE:

- 3D SCANNING – WE TRY CREALITY'S SCAN FERRET.
- HANDY WORKSHOP TIPS.
- COTTERS AND WEDGES FOR SECURE FITS.
- A SHOP MADE DIGITAL READOUT.
- COMPLETING CHRIS HALLAWAY'S DIVIDING HEAD.
- MAKING CASTING CRUCIBLES.
- QUICK RELEASE GEAR COVER FOR MINI LATHES.
- COMPUTER AIDED DESIGN TO MAKE A FILE STORAGE SYSTEM.

Jan 24

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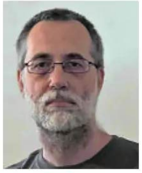
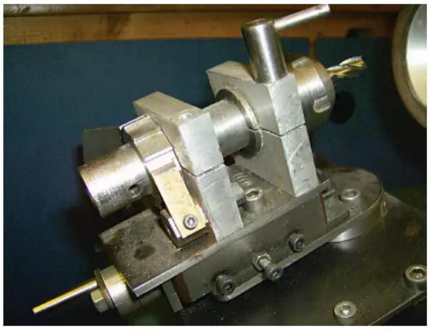


On the Editor's Bench

If it Looks Right, is it Right?

Beauty is in the eye of the beholder is a cliché, but is that true? Or are there deeper aesthetic rules that can mean elegant design is also good engineering? There's no argument that many boats, planes, trains and automobiles combine elegance with efficiency, but to what extent should we allow our aesthetics to influence the things we design and make in our own workshops.

There are three ways I look at this in my own projects. The first is economy of material; when a load bearing part is designed for industry calculations will be done to ensure that a shaft, beam bracket or whatever is strong enough for its purpose without being over engineered. In the workshop we generally rely on a combination of 'it looks right' and experience. Sometimes with do a bit of non-destructive testing (a good tug). This is fine for applications with no dire implications for safety or failure. Often it's obvious that a part is adequate because we can use proportions that still look OK, but are way stronger than what is needed. There are times when it is worth doing some proper calculations – or buying in a 'rated' part, such as a beam for an overhead crane, for example. Fortunately, it's often possible to download datasheets or use manufacturer's calculators to get the right answer.



The second is efficiency of manufacture; if you are making thousands of items the cost and time differences between casting, fabrication and machining from a solid block are very different from making a one off. Efficiency also includes choice of material; we might choose steel or polycarbonate where aluminium alloy or Perspex would do, either because it's what we have to hand or from an abundance of caution.

Finally there are aesthetics. I'll be honest, my shop made tool and cutter grinder is the ugliest I've ever seen – the polar opposite of the 'Quorn' with its neat castings and good proportions. I've seen shop made toolmakers' clamps with an engine turned finish – not for practical necessity, but for fun.

Ultimately, our projects have to do the job we want them to, so the choices are ours. I'm interested to hear how readers make these choices and any advice they have for beginners.

Errata: *Apologies to photographer Steve Macdonald for omitting his by-line from this photo used in our Steam Bikes article in issue 334.*

Neil Wyatt

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SPECIFICATION:
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Taper of spindle bore: MT3
Spindle bore: 20mm
Spindle speed: 50-2500mm
Weight: 43Kg

Price: £595

AMABL210D BRUSHLESS MOTOR 8x16- LARGE 38mm spindle bore

SPECIFICATION:
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Spindle bore: 38mm
Number of spindle speeds: Variable
Range of spindle speeds: 50~2500rpm
Weight: 65Kg

Price: £1,185

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SPECIFICATION:
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Spindle bore: 26mm
Number of spindle speeds: Variable
Range of spindle speeds: 50~2500rpm
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Price: £1,904

VM25L Milling & Drilling Machine Belt drive & Brushless Motor

SPECIFICATION:
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T-slot size: 12mm
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W DRO – Price: £1,921
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Forward Reverse Function
750W BRUSHLESS Motor
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W 3 AXIS DRO- Price: £955

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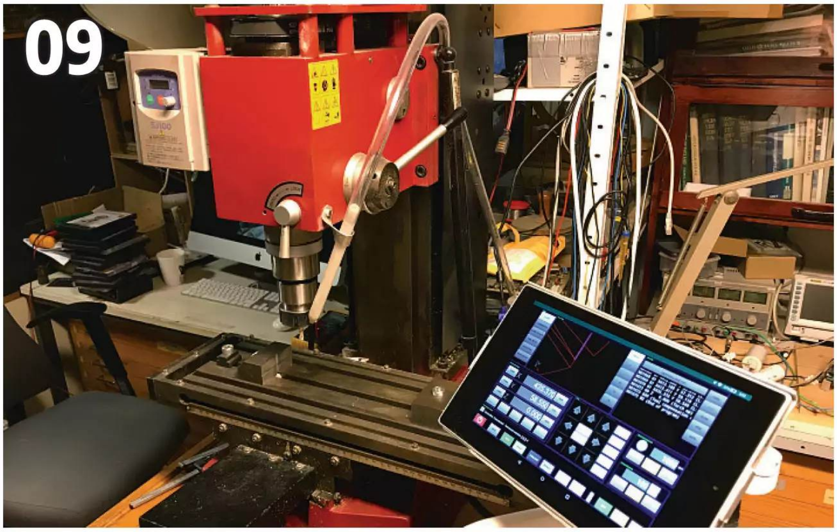

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INSIDE THIS PACKED ISSUE:
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Coming up...

in our next issue

Graham Meek makes a start on an improved boring head with detailed plans and instructions.

Regulars

ON THE COVER

Our cover features Kusti Nyholm's EazyCNC control system. For more details, see pages 9-14.

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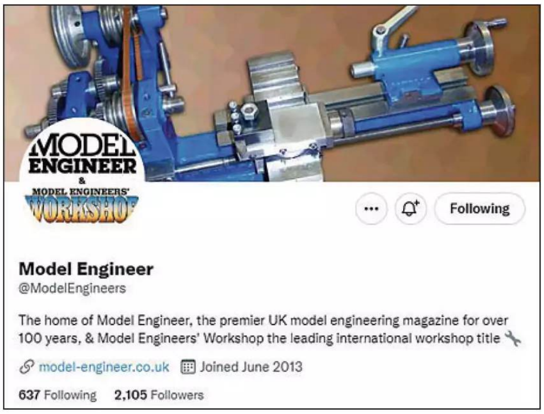


THIS MONTH'S BONUS CONTENT

The Forum has changed!

You can log on to the new forum using your existing details, you can recover your password to the email address associated with your account. There have been issues with getting the forum working smoothly again, but there is help and assistance available if you have any questions or issues getting to know your way around the new forum software. We have also set up 'practice' threads so you can try posting images and documents. www.model-engineer.co.uk

Hot topics on the forum include:

Tool geometry for gunmetal boring bar What are the best angles for a boring tool? By Dave Shedman.

Surface plate refurb What's the right approach to restoration? By Wayne Ollerenshaw.

Myford Super7 toolpost/modification for 12-mm/1/2-inch tooling How do I get larger tools to sit at centre height? By malleusmagnus.

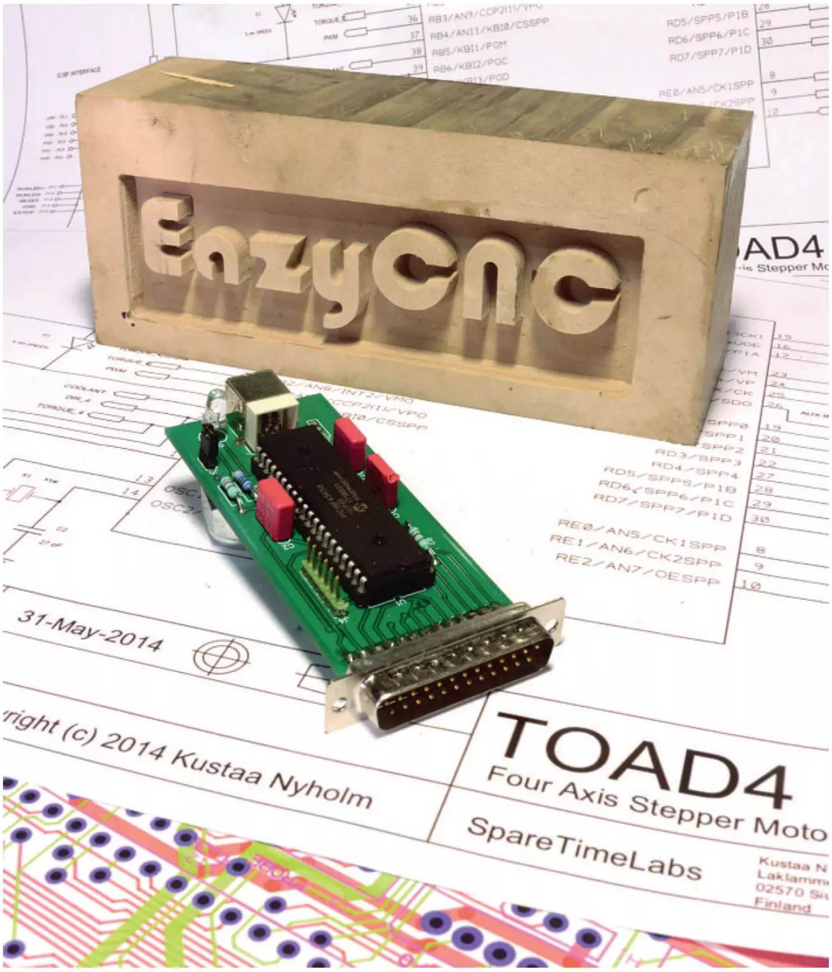
Casting rubber / urethane parts What is involved in casting flexible parts? By Derek Cottiss.

Come and have a Chat!

As well as plenty of engineering and hobby related discussion, we are happy for forum members to use it to share advice and support. Come and join us – it's free to all readers!

EazyCNC

Kusti Nyholm introduces his EazyCNC software project, and the accompanying hardware called TOAD4.



CNC parts by Erik Baetens, made using EazyCNC.

When I started my CNC project a typical hobby installation was based on Mach3 or EMC2 (now called LinuxCNC) software and a parallel port on which various breakout boards were attached. Now, some ten years later, the hobby CNC landscape has changed quite a bit, though I expect those two programs still are the major players, but you also might want to check out 'grbl'.

Today parallel ports have become rare, so USB based parallel port replicators have surfaced.

Also a few newer generation boards and some newer software offerings are now visible in the radar and some of the new ones have already faded away. Cheap and tempting Chinese hardware on eBay is also shaking things around.

EazyCNC is not a commercial product, nor is it fully open source though I've kept both possibilities in mind, at this time I'm offering it as a hopefully interesting alternative for implementing a CNC system.

I've been actively working on this project on my spare time for more 10 years and I think I can be modestly proud of the state of the project. The greatest testimonial is that there are real people who use it for actual real production work!

Erik Baetens from Belgium uses EazyCNC to produce parts for his wonderful ship models, a sample of his handy work can be seen in **photo 1**. For more of his work go to his web site at www.modelships-beagle.eu.

Nicolas Denquin from France is using EazyCNC and TOAD4 to create Art (see **photo 2**) from steel with his custom built plasma cutter, **photo 3**. For plasma cutting the 'fluidity of movements' (as he describes them) of EazyCNC tool path planner are vital.

I don't really know how many of my systems are in actual daily use, not that many I suspect, but I've delivered some fifty PCBs and components to people

CNC cut artwork by Nicholas Denquin.

Custom built plasma cutter by M. Denguin.

The EazyCNC main interface.

from Madagascar to Canada, from Russia to USA.

You can download the software and start playing with it in minutes, it includes a step level accurate simulation of the stepper motors and the machining process so you don't need any hardware to get a feel what it would be like to use it in anger.

Even if you are never going to build a TOAD4 the EazyCNC software can used to verify your toolpaths and benchmark other software, so I encourage everyone to have a go.

What makes EazyCNC different?

Of course, like all software, it claims to be easy and intuitive to set up and use. But really, I've got some good feedback on those aspects. In fact, several people have specifically commented that they prefer EazyCNC for its clean looks. I wonder why many of those people are Mac users ... ;)

Photograph 4 shows the main screen of EazyCNC. The top half of the screen shows the G-code on the right and the corresponding planned tool path on the left. These are updated in real time as machining progresses.

On the bottom are the main buttons that are used to control machining, such as starting and stopping the 'cycle', manually controlling spindle and coolant and last but not least whether you want to run a simulation (without the TOAD4 hardware) or the real thing.

The simulation actually runs the same algorithm that is on the TOAD4 firmware, so it produces step accurate simulation of the machining process and is very handy for verifying that the G-code and toolpath are correct.

Above the main buttons are Digital Read Outs (DROs) that show the axis positions, jog controls to manually move the axis and on the right side are buttons and displays to control the spindle and feed rate. Sandwiched between the main buttons and the jog controls there is a single status/message line which also doubles as command line entry field where you can manually give the system G-code should you need to do that.

The screen layout and indeed all of the software is designed so that all features including configuring the system can be done using a touch screen, if you have one, without a mouse and keyboard.

There is of course much more to a software like EazyCNC than can even be touched in a magazine article. The detailed manual is over 100 pages long, so I just conclude this very brief introduction by mentioning that feature wise EazyCNC compares well with offerings like Mach3/4 and LinuxCNC and supports more or less same G-code set and aims to be compatible with both.

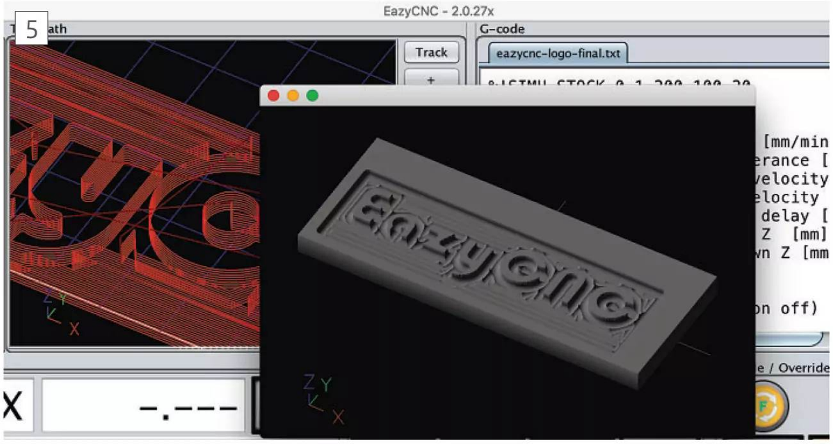
While the software is more or less feature complete, I have various ideas for further development. At the moment I'm working on a GPU based 3-axis 3D machining simulation to be used for verification of the G-code programming, see **photo 5** to get an idea.

Oh, as Steve would say, one more thing. A lot of customization can be done by writing plugins in Java.

EazyCNC has a built in Java compiler so all it takes to write a plugin is a text editor. The plugin-in interface can be used for almost anything from writing a simple script to re-creating the user interface and extending G-codes. You can even create a plugin to interface with your favorite motor controller.

Under the hood

But the main differences between EazyCNC and others CNC software are so to speak under the hood and like we say in product development nobody cares what's inside the box. On the other hand, I believe in what Steve Job's father



Simulated machining.

taught him about caring about the parts that don't show too.

But before I tell you about the hidden beauty let me tell you one of the main visible differences between EazyCNC and the others: EazyCNC runs on Mac OS ... and on Windows ... and Linux ... and even on Android. In other words it is cross platform. I realize that for many people this may not be a big deal cause people tend to like and use a single platform and if what they need is available for that platform that is all they care. Still this opens up some interesting possibilities.

A growing number people are using Macs and Mac OS users are not blessed with embarrassment of riches when it comes to CNC software. At the same time not all Mac users are willing to install a relatively pricy Apple computer in the workshop subject to all the hazards it implies.

So, with EazyCNC you can run the same software both in the shop (on Windows/Linux) and in the office (with Mac OS), which is convenient as a key part of CNC workflow is producing G-code files and testing and dry-running them without the actual NC-machine.

The Android tablets are becoming more and more powerful, and the prices are racing to the bottom, so this is an interesting possibility. A TOAD4 board and an Android tablet would make a nice and compact controller for a CNC machine.

EazyCNC running on an Amazon Fire tablet.

A tablet or a pad is in some respects the ideal computer for this kind of work. The touch screen gets rid of the need for a keyboard which is not well suited to workshop environment and the EazyCNC software was designed with touch screen in mind, everything can be controlled with a single finger without mouse or keyboard. The low power nature of the tablets means they have no fans to suck in chips and debris onto the delicate electronics.

A word of caution here, while I've demonstrated that EazyCNC works as intended on one particular Android tablet this is largely an un-explored territory so if anyone fancies this I suggest they talk to me first.

Having said that see **photo 6** which shows an Amazon Fire HD 10 (2015) running EazyCNC.

That is a $100 tablet (purchased used but looks pristine) interfaced with a $20 board to my second hand mill conversion! You can get a 4 Axis TB6560 CNC board from eBay for $50 that is compatible with my setup if you want to take that route and don't fancy the Geckodrive G540 at $269 which I happened to have. Which one is more reliable and has better after-sales support I leave it for you to decide.

Real-time and Java

Under the hood EazyCNC is based on Java which with its "write-once-test-everywhere" mantra makes it feasible for me to support multiple platforms. What is more, internally Java code is very robust and unlikely to crash spectacularly and some of the insidious bugs, such as memory corruption, simply are not possible in Java. The downside of Java is that is really not suited to real-time programming! So how does this then work out when CNC is something where real-time performance is needed, even critical?

The solution is division of labor, the hard real-time tasks of precisely and timely controlling the motors are handled by the MCU and its firmware which is written in C running on the TOAD4 board and the less time critical but computationally more demanding stuff like the graphical user interface and cut path planning takes place in the host computer running EazyCNC written Java. In between stands a ›

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Even top of the range CNC can do strange things sometimes.

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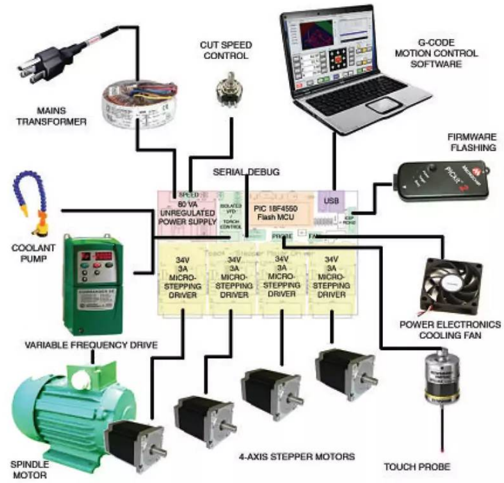

The TOAD4 working environment.

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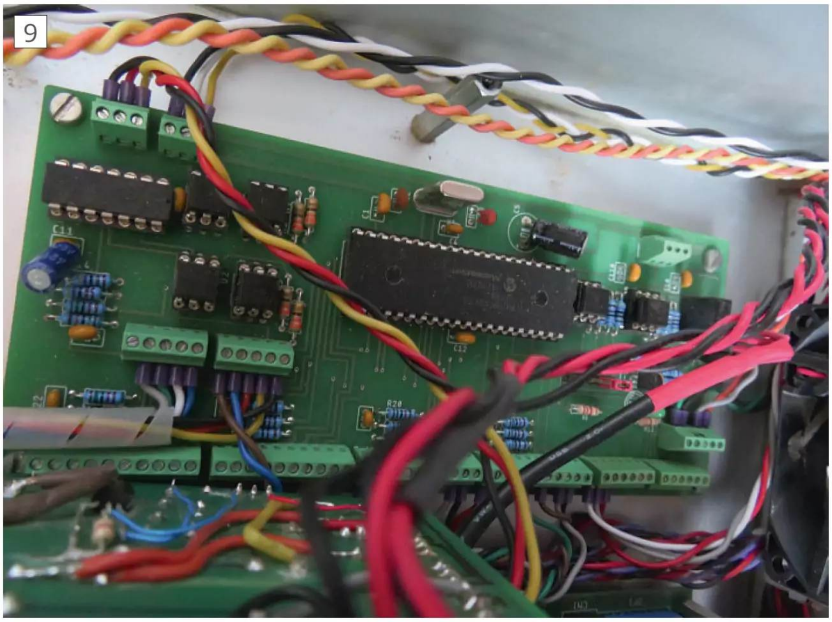


Custom implementation by Eric Baetes.

command queue which allows the two sides of the solution to run with different real-time constraints.

Those who understand real-time probably say that this is still not 100% guaranteed to work as if the Java side cannot keep up with the MCU then there may be a sudden pause is step generation which might be a problem if the stepper speed at that point in time is beyond stepper motor pull-in rate.

On theoretical level I agree, however I take the practical approach and view this as the probability of this non-real time aspect causing a failure, that is a ruined machining job or tool breakage. According to my measurements and experience the chances of that are very low.

So far, I've not I've not seen any evidence of that although me and my pilot users have had our share of other failures, which is sort of the point, so many things can go wrong in machining that in a hobby shop you can't hope to get 100% success anyway.

Mysterious software failures also happen with big name professional systems too, see photo **photo 7** which is a part modelled 'at work' in Pro/Engineer, the toolpath created and verified by simulation and which while on the screen was perfect was ruined during machining by a weird crazy cut which I can only attribute to some glitch or bug in the software.

So it is not like there is a bug free system out there guaranteed to "just work"!

So what makes TOAD4 different

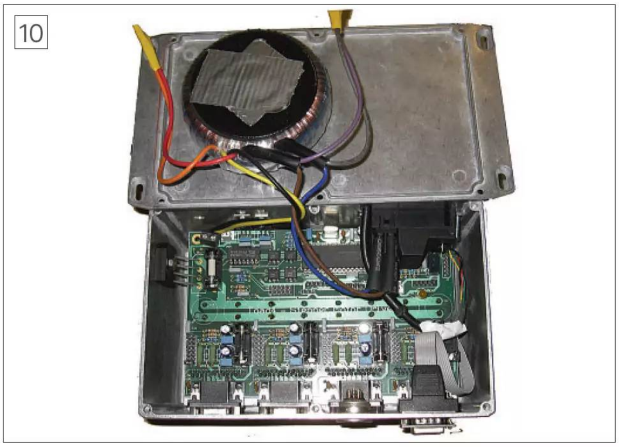
Most hobby systems are based on number of breakout boards and stepper driver modules.

This adds to mechanical complexity, expense, wiring and space requirements and increases the chance of errors and mistakes. In my almost 40-year career in mechatronic product development the number one failure mode in the field and in production in all the products I've been involved with is wiring and connectors.

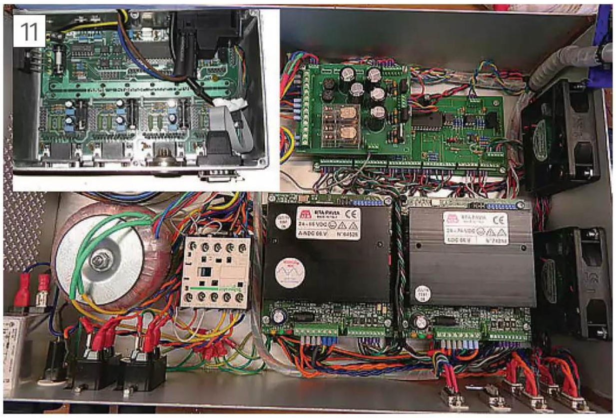
So I designed TOAD4 to be an all in one system on a single PCB board which includes the power supply, motor drivers and reference switches, I/O for Variable Frequency Drive unit and coolant control and of course a micro controller to connect a PC via USB. All in one compact 100 mm x 160 mm board. **Photograph 8** tries to illustrate what I'm talking about.

True, single board approach reduces flexibility and some may argue that in case of component failure, especially the motor drivers, the whole board may have to be scrapped. The later one is not true, replacing a motor driver is perfectly viable, been there done that.

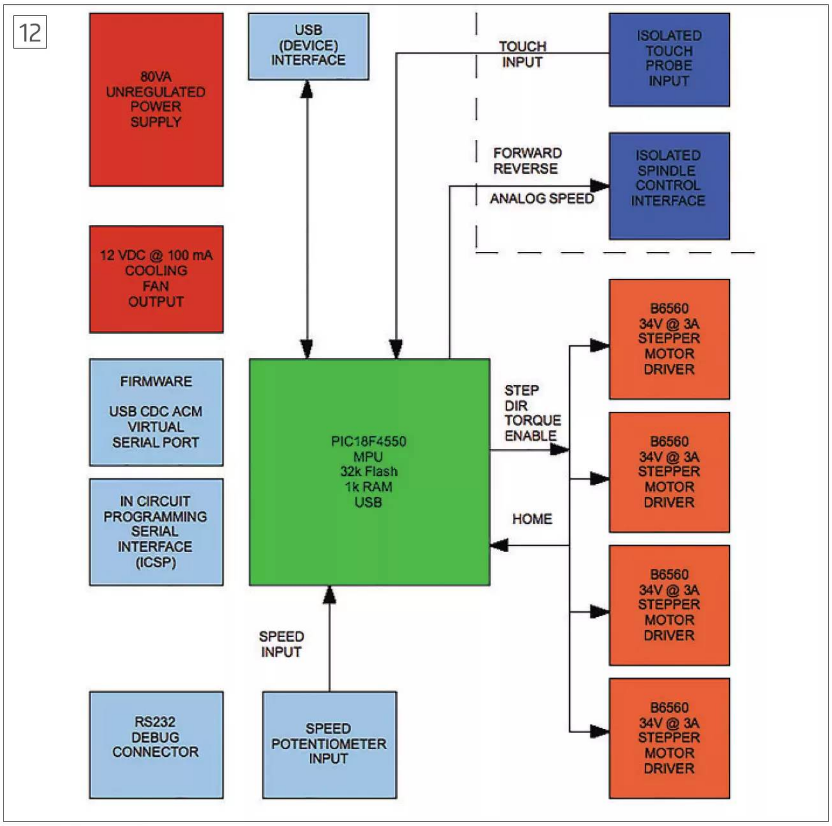
Further, consider what are the chances of needing to replace a part, with little care there should be no need to replace anything. The drivers are over-current



The single board implementation of TOAD4.



Single board implementation compared with the high-current custom version.



Block diagram of TOAD4.

and over-temperature protected and all the I/O is optically isolated. I've yet to damage a single motor driver, the one I did replace turned out to be misdiagnosed.

Flexibility is all very well but it adds to complexity and one of my design goals was to make this system easy to deploy. Also, for a large number of use cases the requirements are the same so I figured that a board that targeted that user base would make sense.

As to expandability, the hardware and firmware are all "open source" so there is nothing to prevent you from making your own PCB board. For simple expansion needs you can use a cheap and cheerful USB controlled relay from eBay and write a plug-in to control it.

In fact, some people already have gone even further, have a look at **photo 9** of Erik Baetes custom PCB which he created because he needed beefier stepper motor drivers than what is available on a TOAD4 board.

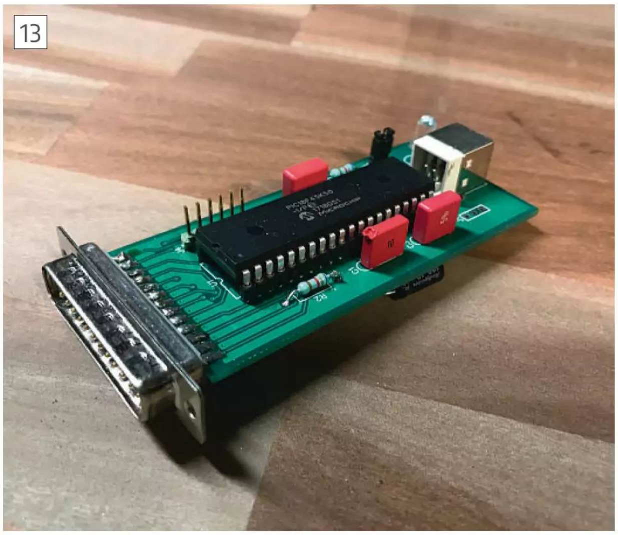
TOAD4 is rather compact when you consider that it packs all the electronics of a CNC machine on one board with minimal wiring as witnessed by **photo 10** where it has been installed with transformer and all in a Hammond 1590E enclosure which is just 4" x 4.5" x 7.5" in size. Contrast that with Erik's 'customized' incarnation in **photo 11**. The PCB design files and schematics are available for those who want to produce their own boards.

Photograph 12 shows the block diagram of what is on the board. Basically, it contains stepper drivers for up to 4 axis CNC machine, speed and control for a spindle motor or plasma torch, a control output for coolant system and an optional input for touch probe. You can also 'twin' the drivers so that you can use two stepper motors on a single axis for more torque.

The board is a simple two-sided design using all plate through hole components for easy manual soldering with basic equipment and moderate skills, no surface mount components.

The board and firmware could also be used as a starting point for something completely different non-CNC activity where a compact, strong and robust stepper motor controller is wanted.

I'm not producing the TOAD4 as a readymade tested product for a number of reasons, but the empty PCB boards are available and I've got some limited number of kits of parts available as I purchased a lot to keep the costs down. TOAD4 is really aimed for people who are interested in building the electronics ›



Parallel port version of TOAD4 for machines with integrated stepper drivers.

TOAD4 plugged into Geckodrive.

-- if you just want to buy hardware off-the-shelf then this may not be for you.

USB to Parallel Port with TOAD4

As I mentioned the TOAD4 board is not the only option for taking advantage of my work. A year or so ago I realized that I needed a proper CNC machine (talk about the footwear of shoemaker's children) to further develop, test and debug EazyCNC. So, I acquired a previously loved manual mill that had been converted to CNC with ball screws and all.

This came with Gecko G540 4-axis parallel port controlled integrated stepper driver. My first inclination was just to scrap that and use TOAD4 board instead. Then I thought, hold on a minute, if I would do a simple board with the PIC MCU on it running TOAD4 firmware I could just plug that right into the G540 parallel port interface without re-wiring the mill.

And that is what I did, let me introduce my parallel port variant of TOAD4, **photo 13**.

This is a super simple board that just hosts the PIC18F45K50 MCU with USB connection and the 25-pin sub miniature parallel/printer port compatible connector that plugs into the Geckodrive, **photo 14**.

Key features

If you made it through here, you probably also want to know the hard facts so here are the key features:

- USB interface, no parallel port required
- No special software drivers, not even USB, uses HID protocol
- Firmware upgrades via USB
- Cross platform, MacOS, Windows, Linux, Android
- Acceleration and Jerk controlled path planning algorithm
- Touch screen support
- 2 phase stepper motor drives
- 4 axis support (the software supports up to six axis)
- 3 Amp / phase at 34 Volt DC drive capability
- 100 kHz max step pulse generation
- Single board design, minimum wiring
- Outputs to control a spindle VFD or plasma torch
- Touch probe input

Conclusion

All throughout this article I've tried hard to give a true overview of what EazyCNC / TOAD4 are and what they are not. While I'm rather proud of them I'm not claiming that they are comparable with professional systems, at least not yet!

At its heart this project is an adventure and passion which I want to share at some level and in some form. Some people begin their day by reading a newspaper or fill their spare time with Sudokus or cross words -- I write software (before I commute to work to write more software) !

What the future holds I do not know but either open sourcing or commercialization in some form or other is likely. After all closed source free software (free as in free beer) is not a viable support model indefinitely.

If you want to join the ride you are more than welcome but don't say I've not warned you. Full disclosure of the project is always available at the project website www.eazycnc.com.

You can get the software, firmware, manuals, schematics etc. from the website.

TOAD4 PCBs are available from me and I've got a limited number of complete set of parts for them if you do not want to get them yourself. I also have PCBs for the 'parallel port' TOAD4 available.

The firmware is available both as open-source code or as a pre-programmed PIC18F45K50 chip which has two advantages: it does not require a PicKIT2 programmer and the chip contains a licensing key that allows me to include some non-free features in an otherwise free software.

At the moment, I'm supplying the firmware and chips on at-cost bases so get yours while the going is good, $10 + S&H. The PCB adds another $10, the kit of parts is negotiable as long as the stock lasts.

In two future articles I will describe TOAD5, an evolution of TOAD4 in response to feedback from users.

● **To be continued**

BEGINNERS WORKSHOP
These articles by Geometer (Ian Bradley) were written about half a century ago. While they contain much good advice, they also contain references to things that may be out of date or describe practices or materials that we would not use today either because much better ways are available of for safety reasons. These articles are offered for their historic interest and because they may inspire more modern approaches as well as reminding us how our hobby was practiced in the past.

Beginner's Workshop

Cotters and wedges

By Geometer

As SECURITY DEVICES, means of making adjustment or of exerting force. cotters and wedges find innumerable applications in mechanisms and techniques.

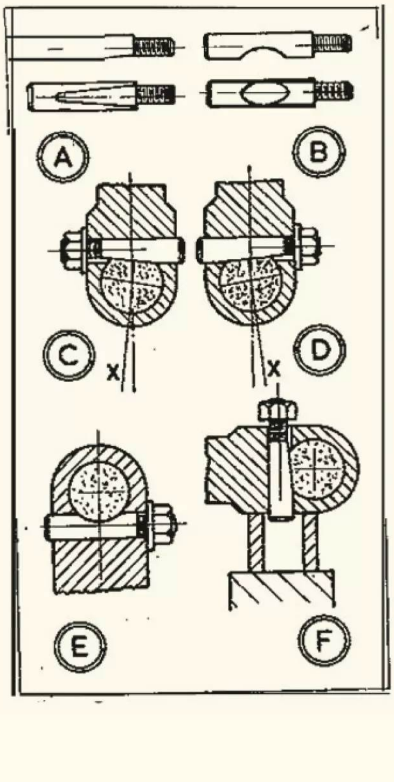
Cotters are mainly used for securing arms or cranks to spindles, or pins into bosses, and function on the wedge principle through tightening of a nut. There are two types-the flat-sided or cycle type, *A*, and the grooved type, *B*. For the flat-sided cotter the spindle has a flat with which the cotter engages, providing a firm hold and positive location. For the grooved cotter the spindle or pin is uniformly circular: and although the cotter grips and holds firmly for the purposes for which it is used, its action is less powerful than the other and it does not positively locate.

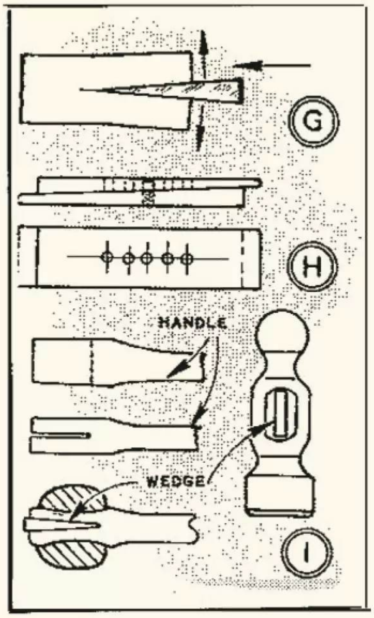
These differences are important, not only technically, but in assembling and, particularly, in dismantling-especially if one is not sure which type of cotter is used, and on occasion it is not certain. The flat-sided cotter is fitted after the spindle is in place and must be knocked right out before the spindle can be removed. The grooved cotter, however, must be fitted before the spindle, and can only be loosened and tapped free (not right out) with the spindle in position. With the spindle out the cotter can. of course, be removed. Old type Austin Sevens and other models of this make employ grooved-type cotters for securing king-pins.

Fitting and removing

Depending on the way a flat-sided cotter is fitted the angular relationship with the spindle varies slightly-C and *D*. Here the centre line is vertical, but a line at right-angles to the flat on the, spindle is to the left (X) at C, and to the right (X) at *D*. In the case of cycle cranks, cotters are generally fitted opposite to keep them in line. The fitting of a grooved cotter is as *E*.

For fitting a flat-sided cotter the spindle is carefully aligned in the boss, with the flat inclined to the side of entering the cotter. Too much inclination, and the cotter thread will be damaged, while with too little the cotter flat " digs in." As always, the cotter should be tapped in firmly with a hammer, then the nut fitted. Flats of new cotters often require filing to fit. A grooved cotter on the contrary is usually ready to fit, and is only tightened by the nut.





To remove a flat-sided cotter, *F*, the nut is removed and the washer extracted, then the nut run on to the end of the thread; supporting the boss or crank from the opposite side with a piece of heavy tubing and a weight the cotter can be tapped free.

The ordinary wedge, G, is a means of increasing force or making adjustment with a long endwise movement for a much smaller increase in the spearation of its faces. It can be employed for opening a long " hugging" saw-cut-and is used in tree-felling to support the trunk as the cross-cut saw goes through. Tough logs may be split, and machine tools raised to bring the beds level by wedges under the feet for bedding with concrete.

Two wedges together, *H*, of the same taper form " parallels " used in packing blocks as a means of fine adjustment. In the example shown the lower one has a fixed pin and the upper a number of holes, which are placed over the pin to vary the adjustment-as for centre setting a turning tool on a lathe.

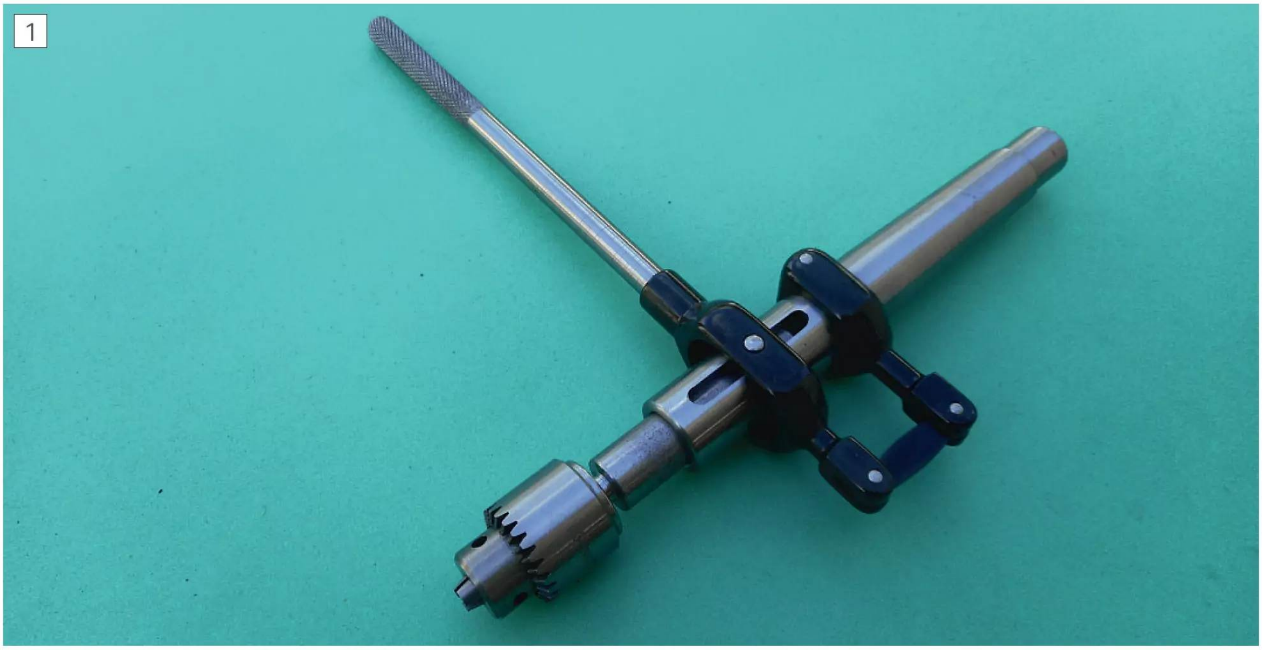
As a security means the wedge is used for hammer, axe heads, etc. Initially, the handle should be a good fit in the head, being filed or otherwise shaped to enter, and any excess length cut off. If not provided with a narrow vertical slit, one can be made with a hacksaw for about half the depth of the head. The bore in the head is larger each end than in the middle, and when a hardwood or steel wedge is driven in the outer end of the handle is expanded, I, for the head to be firmly secured.

Make a sensitive drilling attachment Part 1

Pete Barker recreates a useful project that has stood the test of time – for 93 years. This accessory from 1929 makes drilling small holes in any lathe a breeze and not a snap. He uses nothing but the lathe itself and basic hand tools, in the spirit of the age.

The small sensitive drilling attachment seen in **photo 1** was recently made to the drawings originally published in Model Engineer at the close of the Roaring Twenties by one Herbert Dyer, **fig. 1.** H. Dyer, as he signed himself, was a prolific contributor to the magazine, publishing more than fifty articles from 1923 to 1962. So, I assumed he knew his stuff and set out to build his sensitive driller using as much as possible the simple methods he describes in his article of August 15, 1929. A drill press was in those days an unobtainable luxury and a milling machine unthinkable for the home workshop, so all was done in the lathe and the bench vice. H. Dyer's instructions were easy to follow, being written in a breezy conversational manner, unlike many of the staid articles of his day. Of course, it was still easy to be cheerful then. He was writing a month before the Great Crash of the world's stockmarkets, leading to the Great Depression that ended only with World War Two, so the Roaring Twenties were still roaring. And H. Dyer was cheerfully treadling away at his 4'' ETA lathe in Mousehole, Cornwall, writing that he much preferred such motive power "for small delicate jobs, as one's foot seems to work in unison with one's mind and sort of senses trouble before it actually comes along, which is more than can be said for a [motor-driven] countershaft".

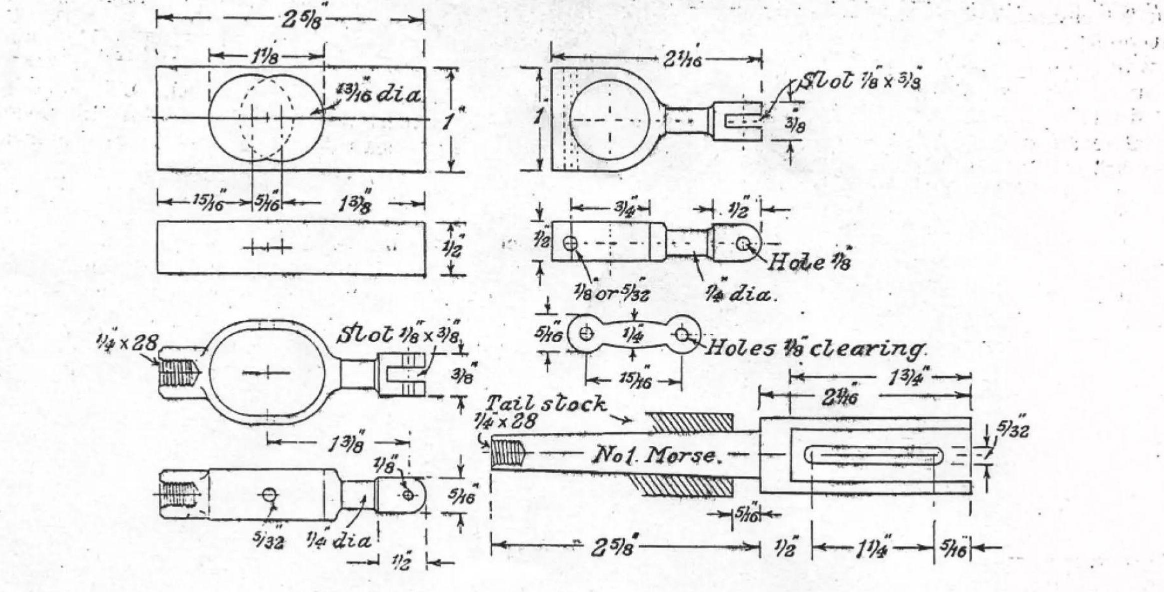
I did not go quite that far in sticking with the traditional methods, allowing myself the luxury of electric motor drive on my 1957 Myford. But H. Dyer reported that he had no trouble drilling No. 75 holes (.021'' diameter) with his attachment under his own motive power.



1

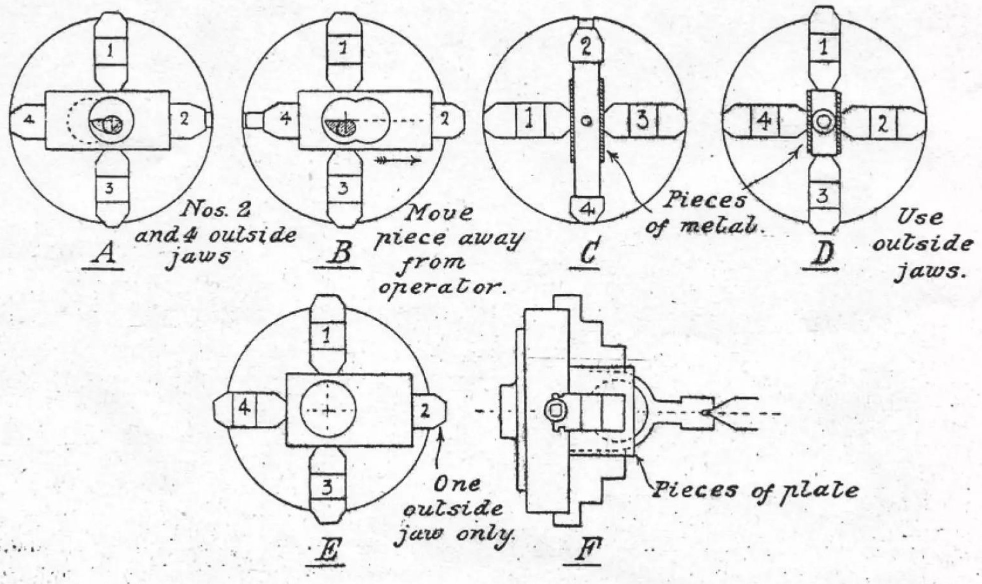
The sensitive drilling attachment provides force but fine control via its lever handle

154 **The Model Engineer and Light Machinery Review.** August 15, 1929.



Details of Precision Drill for Lathe.

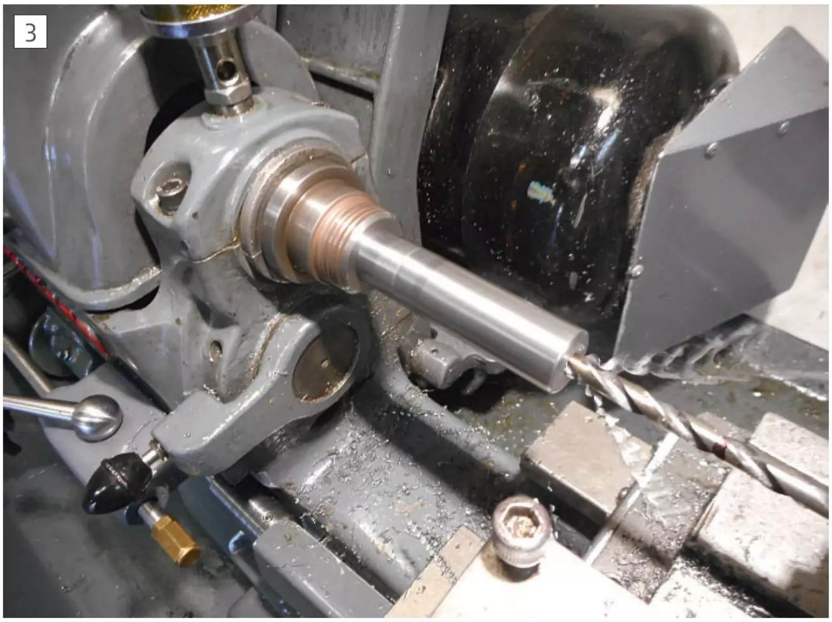
ing up the slots. Test now and then, during this operation, with a piece of 5/32nd-in. silver steel for a nice sliding fit. That's finished! The actuating lever link is cut from 1-in. by ½-in. by 2⅝-in. B.D.M.S. Square up and mark off as per sketch. Centre drill for, and lightly pop all round the two circles 13/16th in. diameter and 5/16th in. apart between centres. One circle is marked off 15/16th in. from one end and the other 1⅜ in. from the opposite end. Mark off centre line around the thin edge of stock and pop the two centres for pin, this to be at the point of intersection of the two circles. Place in your four-jaw chuck with jaws easy all round, bring up tailstock with a centre in and locate in one of the Slocombed centres, spin the lathe to settle piece of stock nicely in chuck and clamp as in chuck sketch A. Run a ¼-in. drill through from the tailstock, then ditto a ⅜-in., 7/16th-in. and ½-in. Then take your smallest boring tool, or at least one that will work in a ½-in. hole, and enlarge to 13/16 in. as in sketch. Slack off two jaws, 2 and 4, gripping the ends of stock—just to say easing the other two—and slide along



Methods of Machining Components.

Figure 1

Felt pen marks show contact along full length of the taper before finishing cuts are taken



The tapered shank is mounted in the headstock spindle for drilling then boring and reaming.

Turn and ream the Morse taper shank

The first thing I did was deviate from H. Dyer's drawing by enlarging the taper from Morse Taper 1 to MT2 to suit my more modern 1940s-design lathe. You can tailor yours to suit your tailstock. Otherwise, all went according to the best laid plans of 1929. A piece of ¾" diameter BMDS was perfect for the job. I faced and centre-drilled each end so it could be turned between centres. This allowed me to take the piece out and test the taper for fit in the lathe's tailstock as work progressed.

From measuring a spare tailstock centre, I knew I wanted the large end of the taper to measure .706" diameter, so I reduced the outside diameter to that dimension and marked where the taper should start. Setting the 1.43 degree angle precisely on the topslide was done by taking a dial indicator reading off the freshly turned parallel surface. An MT2 taper requires a reading of .025" on the dial gauge per inch of movement of the topslide, as measured by 10 turns of the graduated dial. A bit of fiddling and tapping back and forth with a brass bar and the topslide was nipped down in position.

At about two thirds the way through turning the taper by hand feeding the topslide, I took the job out and test fitted it into the tailstock. Felt pen lines drawn along the taper showed up the points of contact as the job was rotated back and forth a quarter of a turn, **photo 2**. Luckily contact was even along the length so no further adjustment of the topslide was needed. I carried on with fine cuts until the large end of the taper met the mark I had made earlier. A good polish with emery cloth finished the job.

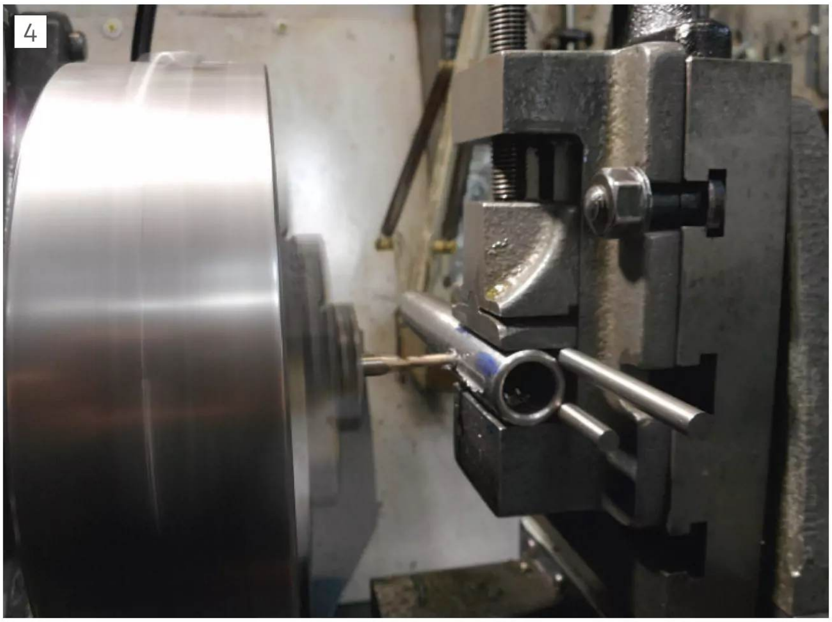
I then removed the chuck and inserted the freshly minted taper into the headstock spindle's MT2 taper and tapped it home firmly with a brass bar. This allowed me to drill, **photo 3**, bore and ream the ½" hole in the shank that the drill chuck arbor would eventually slide in. You could get away with skipping the boring step, but I like to do it to get the hole running nice and straight and true. Drilled holes do tend to wander, and reamers do tend to follow the drilled hole. If I want to match H. Dyer's drilling of No. 75 holes, everything needs to be dead true in line.

I left the topslide at the same setting to next turn the tiny JT0 taper on the chuck arbor, which is for all practical purposes the same angle as MT2. The difference over the short JT0 taper is a matter of fractions of a thou.

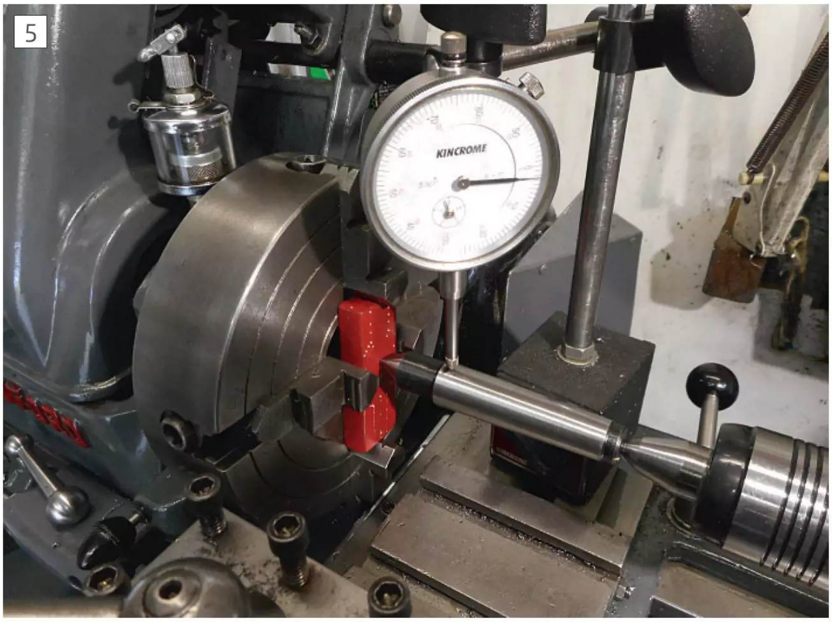
Tiny taper turning on the chuck arbor

The chuck arbor started life as a piece of ½" BDMS round bar. Normally this would be a nice, neat sliding fit in a standard reamed hole with little more than a polish with some fine emery paper and oil in the lathe. But my only local supplier leaves his BDMS out in the monsoonal weather until it is heavily rusted. Some of the pitting was left after a quick polish down to size so I left it at that in order to maintain size. Perhaps it will help with oil retention. Hopefully, yours will arrive nice and smooth and shiny -- bright in fact!

The JT0 taper to fit the 0-4mm chuck I bought was made by the same method as the MT2 on the main shank. This time I tested my topslide setting on a piece of scrap and made sure it was right before setting the arbor in the four-jaw chuck to run true and turning down the end to provide the tiny taper, just 7/16" long and only ¼" diameter at the large end. Be careful



Pieces of round HSS used as parallels to locate the shank for through-drilling then slot milling.



Setting the block so the first of the two holes to be drilled and bored is dead on centre.

when test fitting the chuck to check the taper. Mine got stuck and needed wedges to remove! Quite remarkable for such an innocuous taper.

I assembled the chuck onto the taper all held nicely in alignment using the tailstock as a guide and press. First, I turned a spigot on a piece of scrap held in the lathe chuck. Then I clamped the tiny drill chuck jaws on to the spigot, thus holding it true and straight. By clamping the arbor in the lathe's tailstock chuck I was able to guide it straight and true into the tiny drill chuck's body. A sharp rap on the tailstock quill's far end with a brass lump drove the arbor home into its taper.

The cross hole in the chuck arbor is drilled later, during the final stages of assembly. After preliminary assembly and determining the most rearward position of the actuating lever link, place the arbor in the shank and mark the position for the hole to be drilled. Then place the bare shank on the vertical slide again, with chuck arbor in situ and drill and ream the 5/32" hole through the arbor using the slots in the shank as a guide. This assures good alignment and free sliding action of the whole mechanism.

Cut the slots in the shank

Before that, we have to clamp the shank to the lathe's vertical slide with the parallel section laid in a T slot for alignment. Set the shank on spindle centre height and drill a 1/8" hole through right through the shank at the marked out position. Then switch to a 1/8" slot drill. This is best held in the four-jaw chuck and set to run dead true, or in a good collet chuck. Running at full revs, taking about 15 thou deep cuts and feeding carefully by hand on the cross-slide, mill the slot to the other end of its marked-out run, **photo 4**. Repeat until the slot is all the way through the first wall of the shank. Then rotate the shank 180 degrees and align the drilled hole in the other wall with the slot drill. "Ditto repeato" as H. Dyer said in the cool-cat patois of the Jazz Age in Mousehole. Clean up the slots with a file, and Robert is your mother's brother.

Mark out and machine the actuating lever link

This piece was the trickiest part of the whole operation, albeit somewhat breezily dismissed by H. Dyer and thus light on detail, so I had to find my own way. On a piece of 1" by ½" steel flat bar 2 5/8" long, marking out was easily done the traditional way with scriber block on a sheet of glass, aided by the usual dividers, jenny leg callipers, rule and scriber. Then on to the interesting bit.

After setting up the job in the four-jaw chuck on the bench for convenience, it was moved to the lathe, where a tailstock centre and dial indicator showed me the last few thou to get the centre pop mark running dead true **photo 5**. I drilled the first of the pair of overlapping large holes in stages up to slightly less then finished size. The largest boring bar I could fit in the 11/16" hole then opened it out to finished size of 13/16" with a good finish. So far so good.

● To be continued

Compact Dividing Head Part 4

Chris Hallaway designed and made this Compact Dividing Head (CDH) about thirty years ago for use with hobby size milling machines.

7 Gear Dial

Figure 26. The turning is straightforward. The division lines are spaced at 2 degree intervals and therefore 180 lines per revolution are needed. Depending on your lathe this could be set up as a 3 to 1 increasing train driving a 60 tooth wheel on the output as the count wheel, **photo 8**.

30 & 31 Zero Brackets

Figures 27 and **28**. These are profiled and bent up from sheet material.

13 Gear Dial Retaining Plates

Figure 29. These are simple profiling jobs subsequently bent to the approximate form shown so that they induce the desired friction setting torque on the Gear Dial.

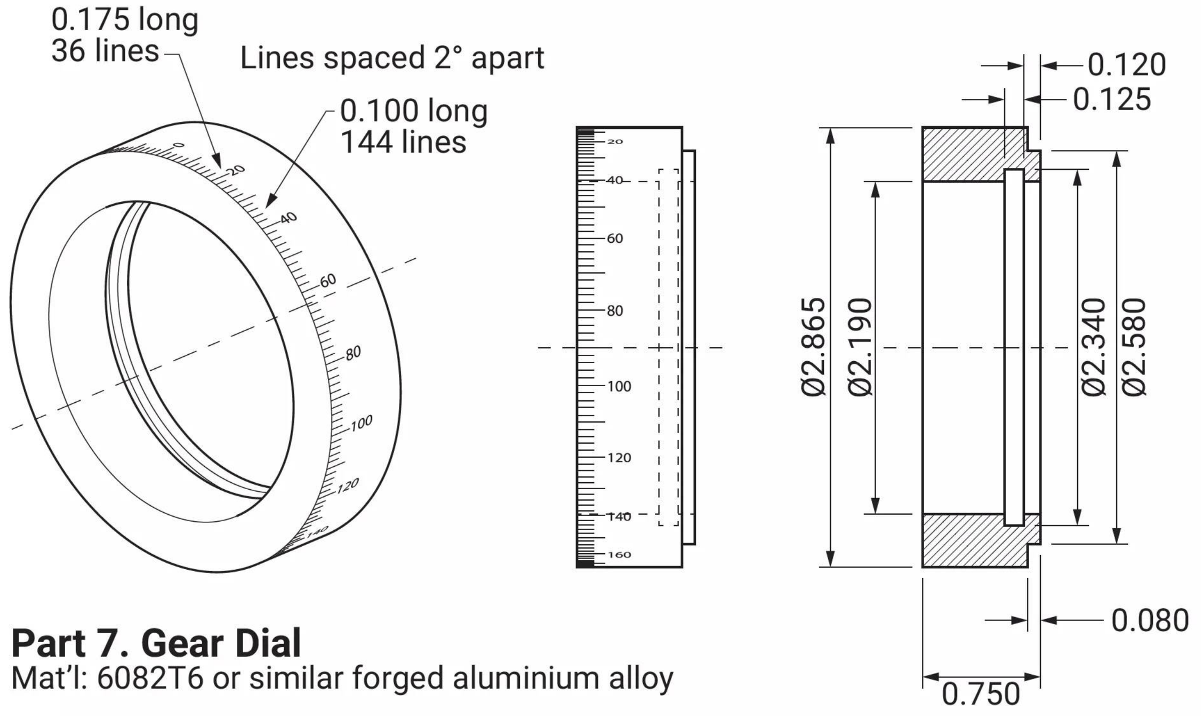


Figure 26

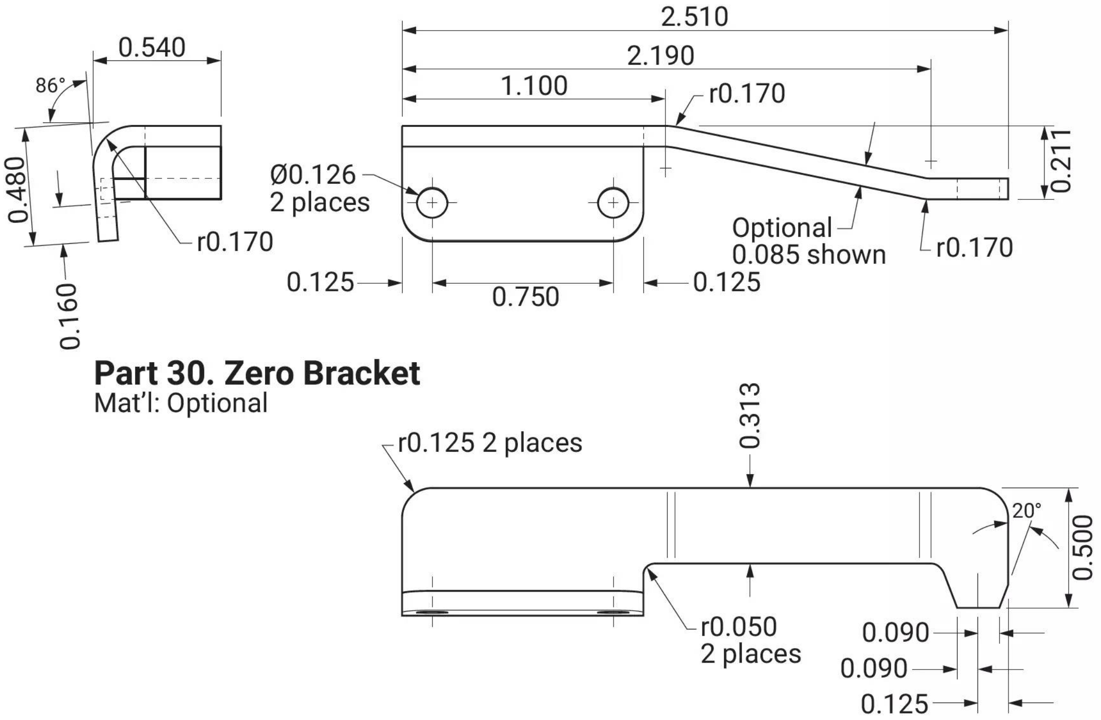
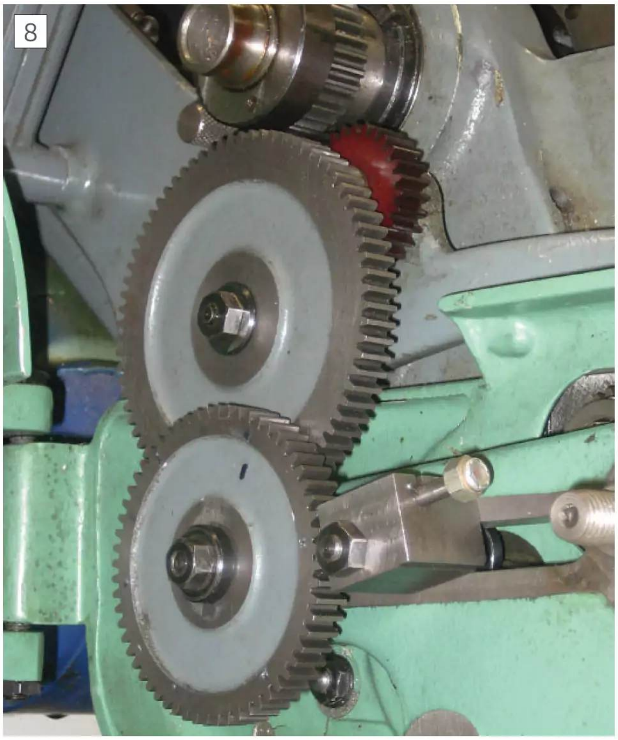


Figure 27



Gear Train for stepping 2 degrees

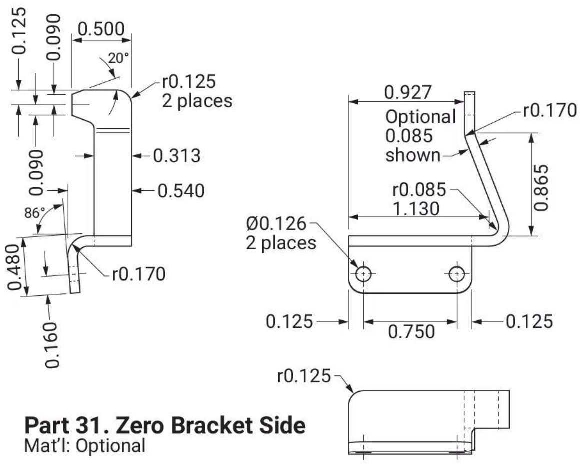


Figure 28

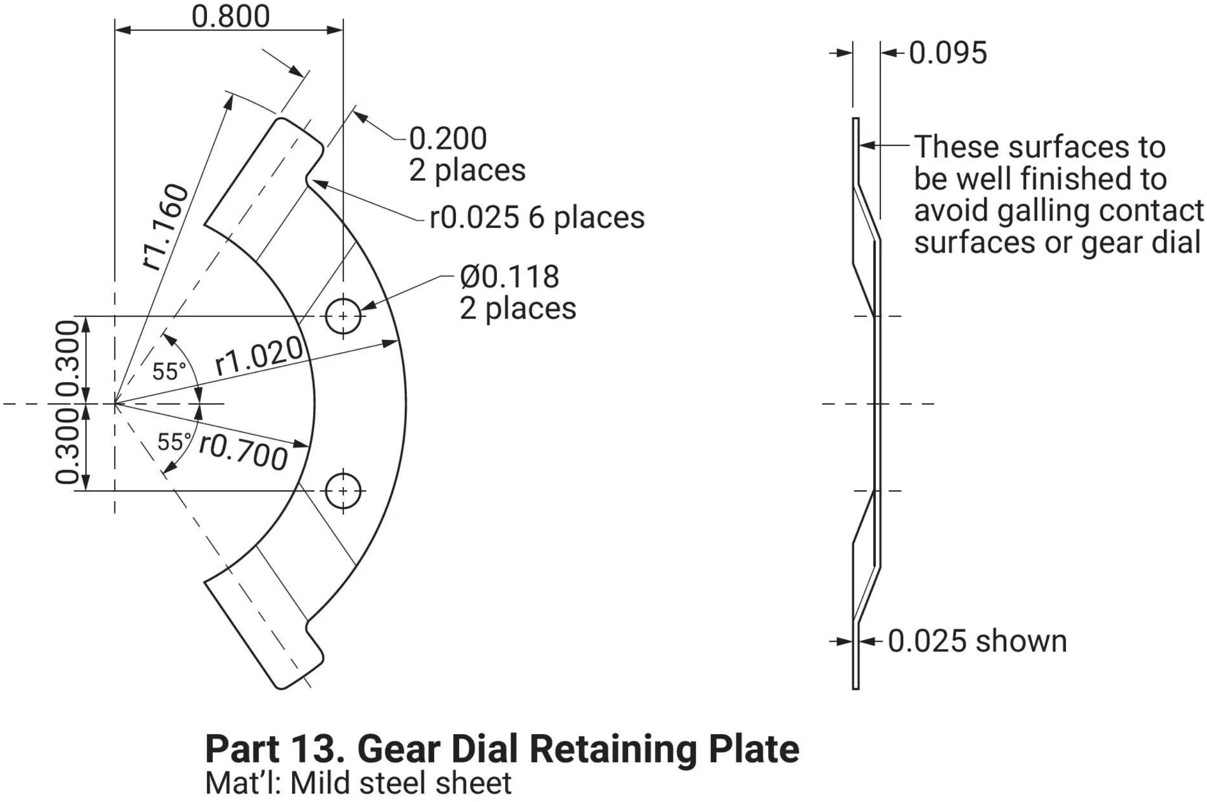


Figure 29

15 Tube Nut

Figure 30. Turn and thread in the lathe to an easy fit on the Mainshaft threads

The remainder of the parts are simple turning, drilling and threading jobs needing no explanation beyond that given by the drawings.

Assembly

Lubricate in the obvious places and note the following:

• Position of the Handwheel Dial Collar **(part 37)** should be adjusted to minimise axial play in the Wormshaft **(33)** prior to locking with Grubscrew **(38)**.

• Friction setting for the Handwheel Dial **(36)** is provided by compressing the BS 1806 -116 'O' ring **(39)** with the Handwheel **(35)**. Once positioned to provide suitable friction torque, the Handwheel should be locked in position with Grubscrew **(38)**.

• Final adjustments of Zero Brackets **(30 & 31)** can be made using clearances in fixing screw holes, small rotations of the Zero Bracket Clamp **(27)** and judicious bending.

• End thrust is applied to the Mainshaft Assembly through contact between Thrust Washer **(11)**, Thrust Pins **(14)**, Circular Lever **(6)**, Pivot Screw **(9)** and Thumbscrew **(10)** the latter providing the means of thrust adjustment. Because all these points of contact allow limited articulation in all directions small inaccuracies in length of components will not affect the ability of the mechanism to apply thrust along the centre line of the Mainshaft **(5)**. Note that the Thrust Pins **(14)** should slide freely in the Wormwheel **(8)** and that adjustment of Thrust Pin **(14)** lengths may be required if the Circular Lever **(6)** is seriously off parallel to the face of the Wormwheel **(8)**.

• When securing and releasing chucks, etc. on the Myford thread, always clamp the Mainshaft to avoid damaging Wormgear and Wormshaft teeth.

A spreadsheet to assist use of the dividing head will be uploaded to the forum at www.model-engineer.co.uk. ■

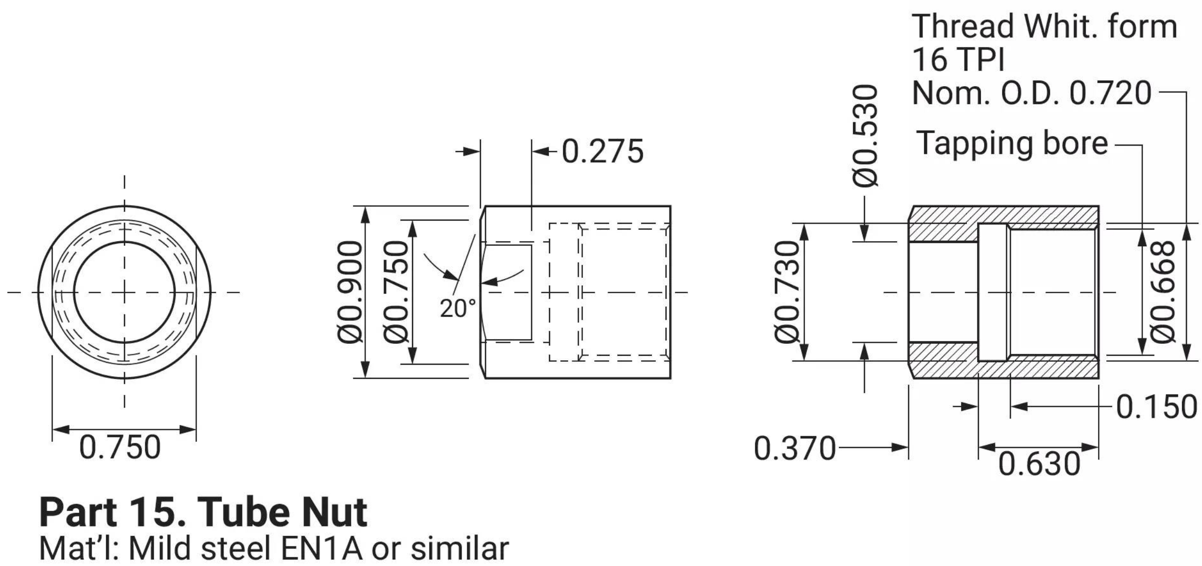


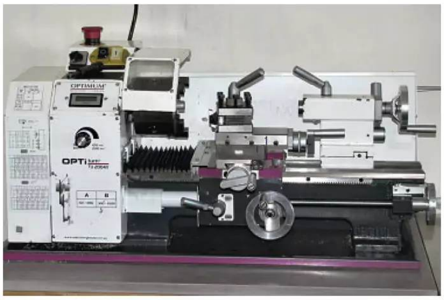
Figure 30

In our Next Issue

Coming up in issue 336, February 2024

On sale 24 January 2024

Contents subject to change



Ron Sharp shares his experiences with an Optimum Lathe

Graham Meek starts a series on his new boring head with detailed plans.

Chris Gill makes a pair of headstock steadies.

On the Wire

NEWS from the World of Engineering

QEV Technologies to join forces with Formula G as Technical Partner

QEV Technologies, front runners in electric mobility, has been formally announced as the technical partner behind the all-new Formula G series.

Formula G is a global all-electric motorsports series that will race as a support series, using the world's first dual powered race car Formula G's inaugural season, commencing in late 2024, will feature independent championships in four regions, each with 10 team franchises.

By using Formula G's revolutionary open-wheel all-electric race car with the unique ability to be raced at reduced power by one driver, and then at full power by a more experienced driver, each race event will see 40 drivers on track, 20 competing in the reduced-power race "F-G2", and 20 professional drivers competing in the full powered "F-G1 Championship".

Already prolific within motorsport, QEV Tech builds and runs the FIA RX2e Championship – the stepping stone category in the all-electric World Rallycross series – as well as running Carlos Sainz Snr.'s ACCIONA | SAINZ XE Team Extreme E squad, as along with working with several Formula E teams and manufacturers. They also took part in the development of the FC1 with a battery-powered SUV platform. It is the most powerful Rallycross vehicle ever built for Nitro RX.

QEV Tech is exclusively focused on electric racing, renowned for its work in EV motorsport development and technology, offering clients its cutting-edge innovations in R&D as well as full vehicle engineering and development.

In this exciting partnership with Formula G, QEV Tech will put all its development expertise into play, by leading all the technological project and undertake the development of the powertrain and battery, unquestionably standing as the ideal technological partner.

Epping Forest Horology Centre

Have you ever fancied using your engineering skills on something a little different? EFHC has been running courses and practical sessions in clock and watch construction and repair for over 15 years. The Centre is a charity dedicated to 'the preservation and development of horological skills through practical and theoretical teaching in a sociable atmosphere'.

The workshops are located in rural Essex and attract students from a wide area in the South East of England. On site there is a dedicated workshop for watch repair and servicing and another for work on clocks. Sessions run weekly, approximately following the academic calendar year, with three terms totalling 40 sessions. This is similar to adult education courses at local colleges, although courses on this specialism no longer exist in any Local Authority area, making the Centre a unique resource for those interested in this activity.

Sessions are supported by expert tutors and are of 2.5 or 4.0 hours duration with a maximum of 14 students per session. Students have access to a well equipped machine shop, all of the necessary specialist tools and equipment and an extensive library of specialist books.

Short courses are also on offer on a regular basis including machine shop skills – lathe and mill work etc. – alongside topics specific to clock and watch work.

More information at: https://efhc.org.uk/wordpress/

Fast fabrications from KMT

Sourcing quality steel fabrications on short lead times is a challenge for any construction or engineering project. To provide customers with a streamlined option, bespoke engineering business KMT supplies UKCA standard brackets, flanges and other structural elements suitable for farm, residential and commercial buildings.

"We have state-of-the-art machinery including a high-speed laser cutter and a 320-ton press brake, which means we can offer a quick service that caters for projects with short lead times for fabrications," says Adrian Degg, Group Engineering Director at KMT. "This is especially beneficial for construction, where any delay risks the project schedule. To save site managers a potential headache, we have been fabricating steelwork for low consequence structures for several years now."

KMT provides UKCA structural steelwork accredited to BS EN 1090 Execution Class 2. This ensures suitability for farm, residential and commercial developments – encompassing most construction projects. Typical applications include supporting elements for stairways and access walkways.

As a turnkey provider of engineering services to industry, KMT has extensive workshop capacity. The laser cutter's ability to quickly cut 3000 mm x 1500 mm sheets of stainless and mild steel up to 25 mm thick, combined with the large press brake, allows KMT to offer faster turnaround times than traditional fabricators. Additional services such as welding, assembly, and testing ensure a complete approach. For more information see www.kmt.tools.

New Evidence Suggests Synthetic Eals are Behind increase in Stern Tube Seal Failures

Seawater-lubricated bearings pioneer Thordon Bearings has welcomed the publication of Gard's latest research into the potential hidden costs of synthetic Environmentally Acceptable Lubricants (EALs).

Gard's research, published in October 2023, has taken a deep dive into the data around the shaftline damage claims it has processed over the last 10 years. Its research shows that as many as 80% of the incidents investigated involved stern tube seal failures where an EAL was in use.

Thordon Bearings' VP of Business Development, Craig Carter, said: "It appears that the introduction of a synthetic EAL as a means of mitigating the risk of mineral oil pollution has had unforeseen consequences. Seawater alone is the only 100% pollution-free means of lubricating a ship's propeller shaft bearing."

Under high load operations, such as hard turns at high speeds, EALs can operate with a lower safety margin of the minimum oil film between the propeller shaft and the bearings. Secondly, EALs typically operate with lower viscosity under lower temperatures, in situations like mooring trials and cold start-up.

There have also been countless reports in the international trade press suggesting that the increased incidences of discarded fishing nets or rope are adding to the aft seal damage of oil-lubricated shaftlines.

"This research from Gard underscores our own findings that the most environmentally acceptable lubricant is seawater as was recommended by the US EPA in the Vessel General Permit (VGP)" said Carter.

"Thordon's COMPAC bearings are at the heart of our award-winning open seawater-lubricated propeller shaft bearing system, which means zero oil pollution into the marine environment. And let's not forget any oil leak, big or small, can be catastrophic to the marine environment and marine life, with some EALs found to be only slightly less damaging than the phased-out traditional oils."

The compound angle problem

Nigel Beal was inspired to do a mathematical workout by R Finch's recent article on machining a complex angle.

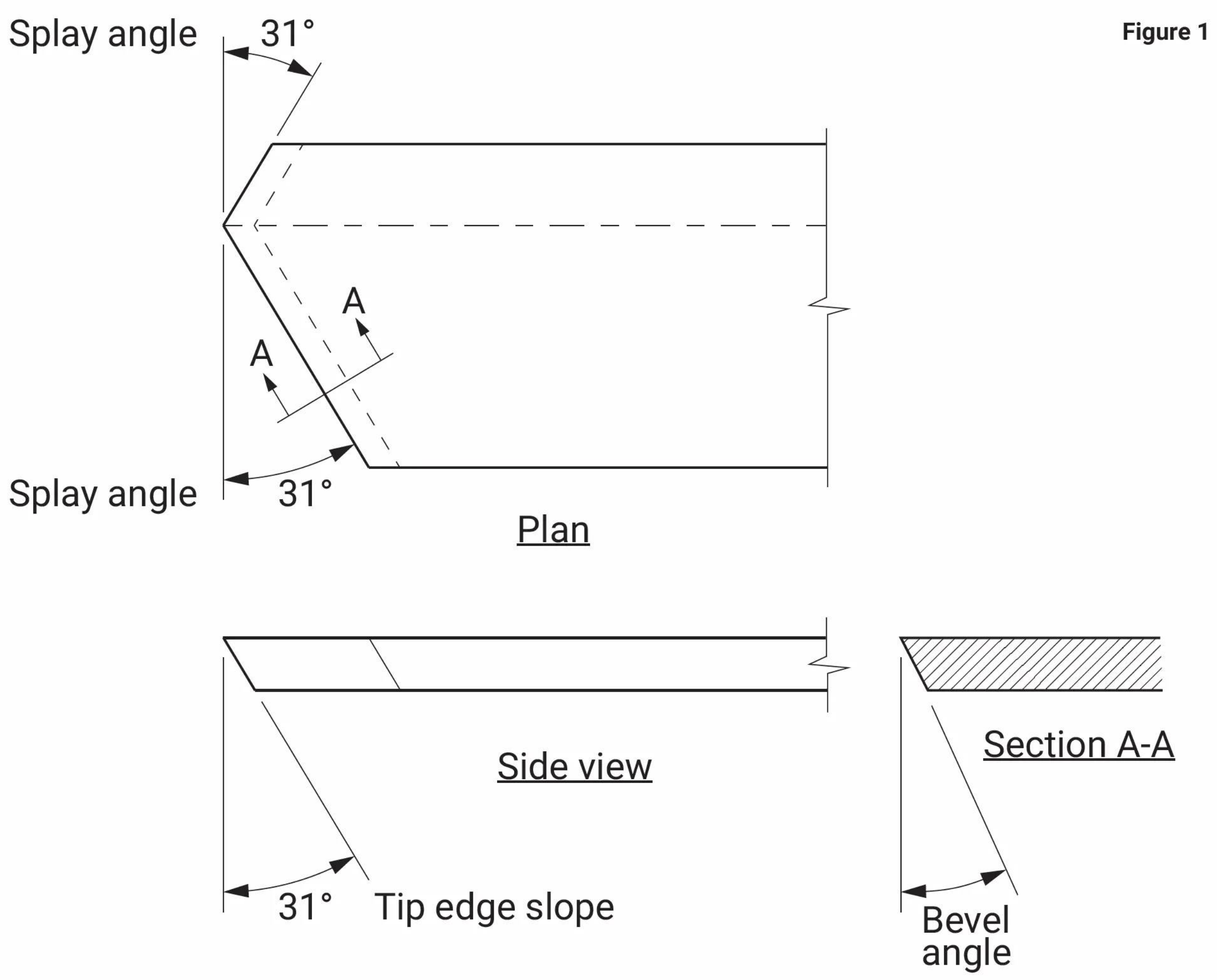


Fig.1 The Two 31° Angles As Drawn

The article in MEW 331 by Mr R Finch about his compound angle problem certainly gave my decrepit grey matter a workout. Initially my curiosity was sparked when I noticed that Mr Finch's solution would not have produced the tip edge slope that is specified in the side view of the workpiece in his **fig. 1**. I wondered why there was no comment about the discrepancy. I had difficulty in following the derivation of the solution in the article, so I worked through my own solution. Then upon revisiting the derivation in the article, it appears that a rather cryptic fundamental error has gone unnoticed in the derivation presented there. The error, as I see it, is elaborated below. I apologise in advance if I have somehow misconstrued Mr Finch's exposition of the problem or if I am otherwise mistaken.

The workshop task that was the genesis of the article is the milling of the splay edges of the workpiece in order to produce the angles specified in **Figure 1**. In my understanding of Mr Finch's machining setup, the workpiece is held with its long axis at right angles to the tilt axis of a tilting vice. In the setup, the vice is set to a prescribed tilt and the whole vice is rotated to a non-orthogonal setting on the mill table so that the splay edges can each be machined in turn using the side of a vertical milling cutter. This leads to the question at the heart of the article, which is what vice tilt and rotation angles should be set in order to achieve the specified angles on the finished part. It doesn't matter whether the workpiece is held face up or face down for machining. The essential geometric question remains the same.

The indication that there is a problem with the solution in the article is manifested in the equation that appears 17 lines down in the third column on page 56. The equation is supposed to relate the desired splay angle of 31° on the workpiece to the other variables, which are the vice tilt and vice rotation angle. Adopting my labels for the angles, the equation in the article is as follows:

tan(splay) = tan(tilt) /cos(rotation)

It is easy to test the general validity of this equation by considering the simple case where the vice tilt is set at zero. In which case, the workpiece will be horizontal and the resulting splay angle will be equal to whatever vice rotation angle has been set. Thus, for zero tilt, the equation should be saying that the splay angle is equal to the rotation angle, but this is not what it predicts. Rather, when tilt is zero, the term tan(tilt) will also be zero and consequently, the equation is saying that tan(splay) is zero and hence the splay angle must be zero. The vice rotation angle gets no say in the result at all. This is plainly incorrect. Anyone relying on this equation as a general solution for the splay angle question would be inviting disappointment into their lives. However, the equation can be rendered correct if the occurrences of "tilt" and "rotation" are transposed, so that it becomes:

tan(splay) = tan(rotation)/cos(tilt) ✓

It appears that the problem with Mr Finch's equation arises from his figure 2. His equation is a correct solution for his figure 2. However, I cannot reconcile his diagram with the actual problem unless the labels for the tilt and rotation angles are transposed. With the labels transposed and the figure laid over on the face that is defined by the corners, ABC, the whole figure, BCDA, exactly matches my figure, EGFtH, which is shown in the derivation further below,

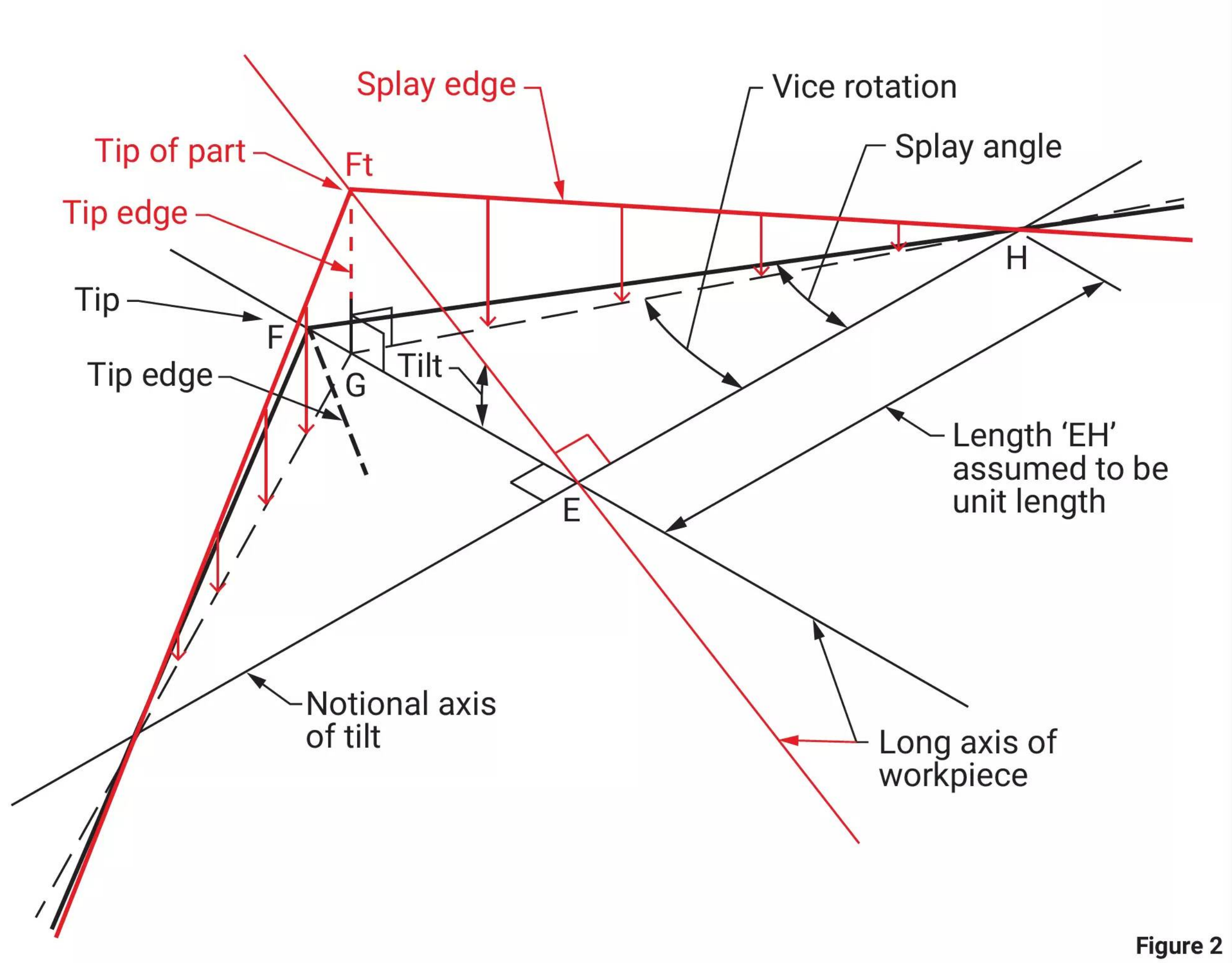
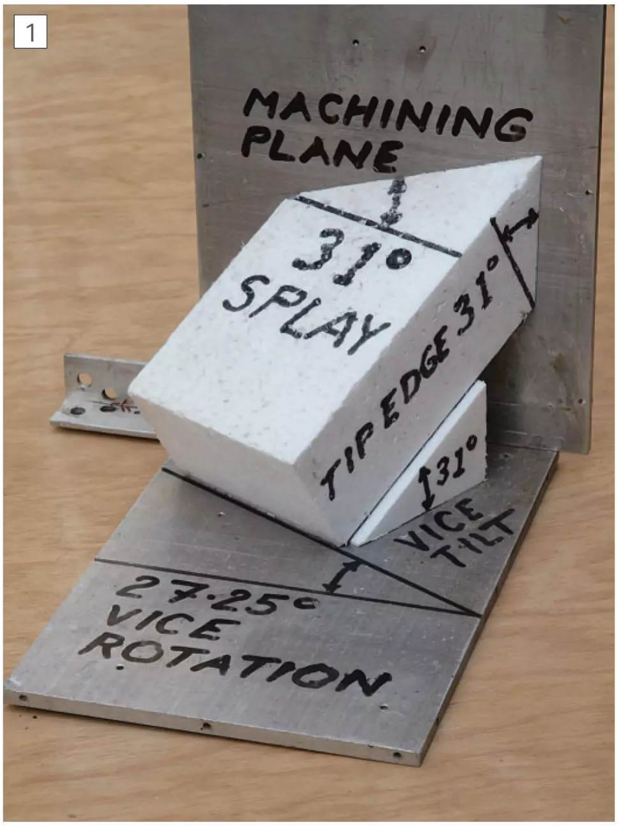
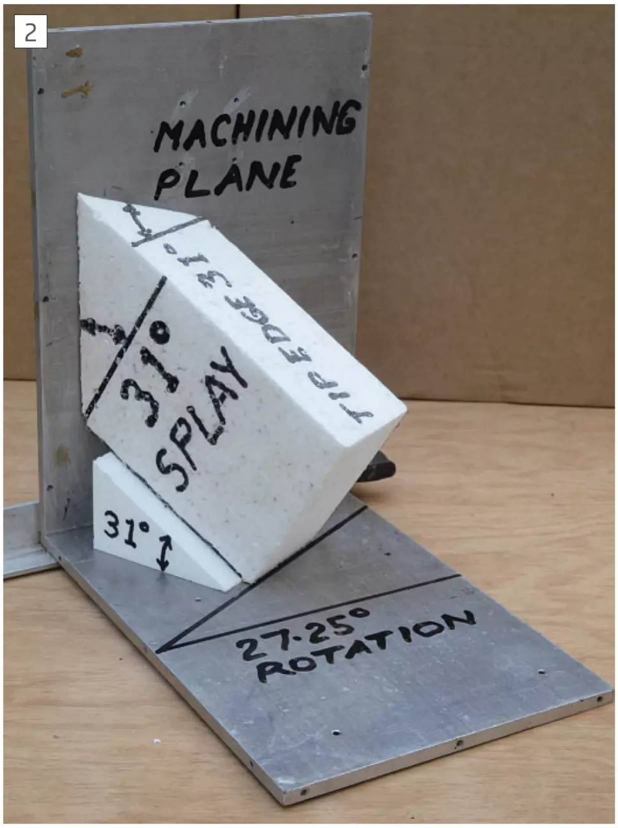


Figure 2



Trialling the angles with a polystyrene block.



Setup with workpiece on edge.

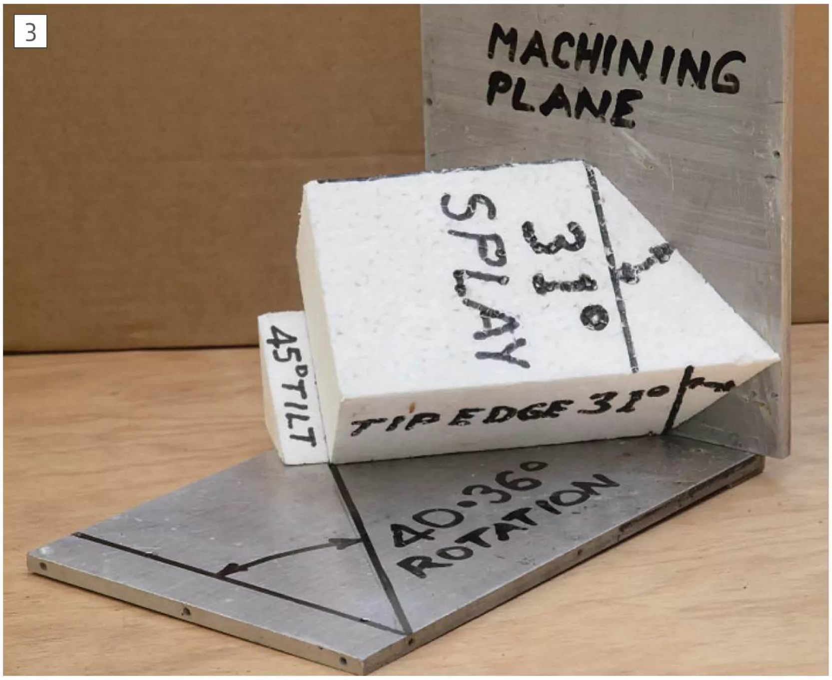
albeit that the figures are seen from widely different viewpoints. (The letter D was omitted from the figure 2 in the article but it is reasonable to presume that it was meant to appear at the only unlabelled vertex.) Thus, the problem with the derivation in the article appears to be that it has effectively treated rotation as if it is tilt and tilt as if it is rotation. However, they are not actually interchangeable in this machining setup.

I sympathise with Mr Finch because the incorrect equation has a beguiling trick up its sleeve. It actually gives the right answer for one special case. The special case is when the vice tilt and rotation are equal, in which case the erroneous transposition of the angle variables doesn't affect the result because the angles both have the same value. As it happens, Mr Finch used the equation to solve for that special case with the result being a setting angle of 28° for both the vice tilt and rotation, which would indeed have produced the requisite splay angle of 31° on his workpiece. However, the tilt of 28° would have produced a tip edge slope of 28° rather than the 31° specified in figure 1. This is the discrepancy that first attracted my attention. Mr Finch did not comment on whether he was aware that the tip edge slope would turn out to be 28° or why 28° was considered acceptable. I wondered whether Mr Finch assumed that if the tilt and rotation angles are equal, that that would make the splay and tip slope angles equal. It doesn't work that way.

It may be that the tip edge slope is not important to the function of the finished part and that Mr Finch is happily sharpening his drill bits with his completed device. However, as the compound angle problem is a legitimate workshop problem, and its correct solution was the raison d'être for the article, it is worth pointing out that it is possible to calculate a pair of vice setting angles that will satisfy all the requirements of figure 1. Furthermore, the path to the answer is rather more direct than what the approach taken in the article might suggest.

There is an infinity of pairs of vice tilt and rotation angles that will produce the requisite splay angle on the workpiece. However, the requirement that the tip edge should slope at 31° necessarily dictates that the vice tilt angle must be set at 31°. With that settled, the only question remaining is what angle the vice needs to be rotated to on the mill table in order to achieve the desired splay angle of 31°. The diagram in my **figure 2** below shows how I derived the required vice rotation angle. The diagram is a representation in isometric projection of the top surface of the finished tip of the part. The tip is pointing towards the top left of the diagram. It is shown in both the horizontal position (black), and in the tilted position for machining (red).

The key point in figure 2 is that when the splay edge of the tilted part is projected vertically down onto a horizontal reference plane, we get the dashed line, GH, which defines the necessary machining path for that edge of the workpiece. The alignment of the dashed line defines the requisite vice rotation angle for each splayed edge. It only remains to relate the rotation angle to the tilt and splay angles by



Another alternative solution.

utilising the relevant trigonometric relationships. For simplicity in teasing out the relationships, it is convenient to assume that the length EH is of unit length, in which case the other relevant lengths and relationships are given by the equations below. Also, note that the splay angle, along with the length EF, does not change when the part is tilted about the tilt axis; consequently, the length EF is equal to the length EFt and thus the two are interchangeable.

From triangle EFH   EF = tan (splay)
From triangle EGH   EG = tan (rot)
From triangle EGFt   EG = EFt x cos(tilt)
Equivalent to EG = EF x cos(tilt)

If we substitute the first two results into the fourth equation and then substituting the actual values for tilt and splay, which in this case are both 31°, we get:

tan(rot) = tan(splay) x cos(tilt)
tan(rot) = tan(31°) x cos(31°) = 0.515

Thus, the required vice rotation angle = arctan(0.515) = 27.25°

Thus, with a tilt of 31° and rotation of 27.25°, the tip edge slope will be at 31° to vertical and the splay angles will also be 31°, all as specified in figure 1. As a "solid" proof of the solution, I sanded a block of polystyrene foam according to the calculated settings. The block represents one half of the workpiece, as if it had been split longitudinally and so it exhibits just one splay edge. Subject to the limitations of the material and method, all the angles did indeed emerge as expected as can be seen in **photo 1**.

The bevel angle on the splayed edges is not called up in figure 1. Rather, the bevel angle is a geometrical consequence of the other angles that are specified. The determination of the bevel angle from the other specified angles is another compound angle problem. The formula for the bevel angle as measured at right angles to the splayed edges is:

bevel angle = arctan(tan(tip edge) x cos(splay))

For the angles specified in figure 1, the bevel angle is 27.25°. Mr Finch's 28° settings should have resulted in a bevel angle of 24.50° and a tip edge slope of 28°. Perhaps Mr Finch could check these angles on his finished part.

Instead of holding the workpiece either face up or face down in the vice, an alternative work holding setup would be to turn the workpiece on its edge but still with its long axis at right angles to the tilt axis of the vice. In which case, the bevel angle becomes relevant to the necessary settings. In this setup, a tilt setting of 31°, both up and down in turn, would take care of producing the splay angle of 31°. However, the vice rotation needs to be set so as to produce the correct bevel angle on the splay edges in order that the tip edge slope will be the 31° that is specified in figure 1. For this, one needs to have determined the bevel angle that is implied by the angles that are specified in figure 1. The bevel angle and hence the required vice rotation angle for this alternative workpiece-on-edge setup is 27.25°, which is the same as for the workpiece-on-flat setup. This reflects the symmetry that is present because the tip slope and splay angles are equal, **photo 2**.

Lastly, a further alternative would be to hold the workpiece with its long axis parallel to axis of tilt of the vice. This might be a more convenient way to clamp the workpiece in the vice but this arrangement would require resetting both the tilt and rotation in order to machine the second spayed edge. It's either that or take the workpiece piece out of the vice and replace it in an inverted position in order to machine the second splay edge. I found that the solution for the setting angles in this arrangement was harder to get my head around. It can be solved by developing an appropriate diagram in similar vein to that in figure 2. One needs to come up with a diagram that defines the question, then get the diagram correct in all respects and avoid mixing up the specified angles with their complements, which I found is an easy mistake to make. In this setup, with the workpiece held either face up or face down in the vice, the formulas for tilt and rotation are as follows:

tilt = arctan(tan(tip edge)/tan(splay))
tilt = arctan(tan(31°)/tan(31°)) = arctan(1) = 45°
rotation = arctan(tan(splay)/cos(tilt))
rotation = arctan(tan(31°)/cos(45°)) = 40.36°

The tilt angle of 45° reflects the symmetry due to the tip slope and splay angle being equal, which becomes rather obvious when one looks at the apex of the workpiece in **photo 3.** Until I worked out the settings for this setup, I hadn't really appreciated that this symmetry lurked within the problem.

Anyway, I can hear the reader saying, enough already with all this trigonometry! ∎

Mini-Lathe Gear Cover

Stub Mandrel offers a simple way of making the gear cover of a mini-lathe easily removable.

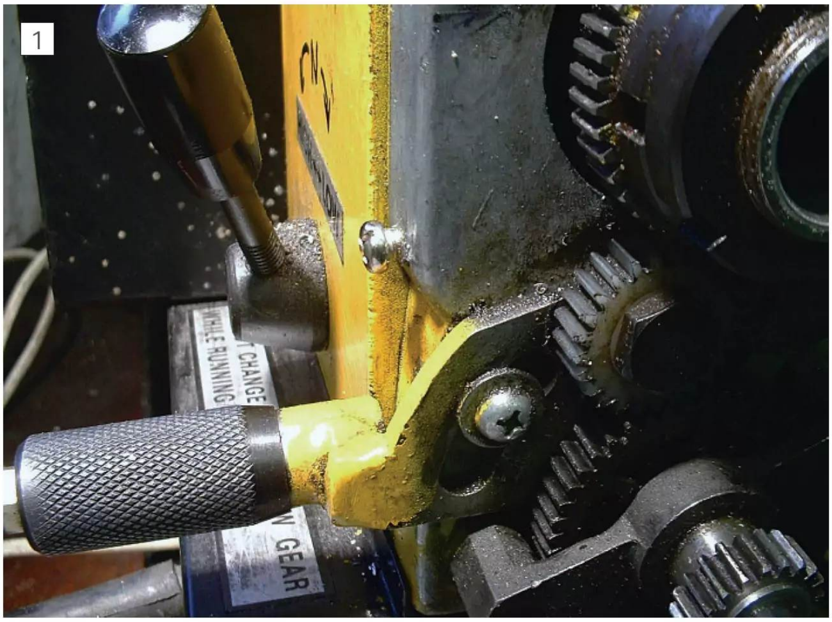
The gear cover of the CL300M and other mini lathes is held in place by two bolts. Removing and replacing these bolts to change the gear ratio is tedious, yet the temptation to operate the lathe with the cover removed should be resisted for (hopefully) obvious reasons. In long past issues of MEW two solutions have been offered – both involved replacing the M5 cap screws with an easier to release alternative, such as thumbscrews. However, these ideas still mean having to undo screws, and there remains the risk of losing a fastener in the swarf or under the bench!

May I suggest an alternative approach? It is literally a ten-minute job to perform an instant-release modification.

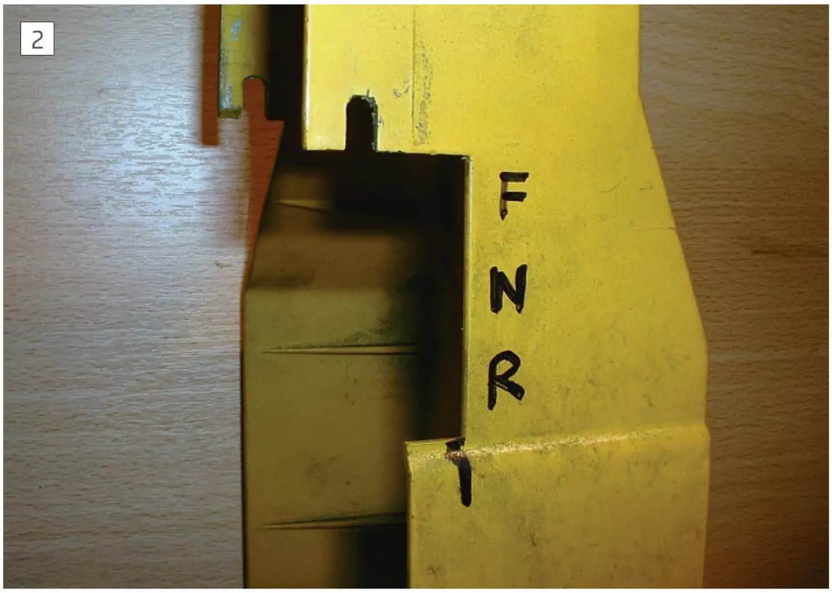
Remove the guard retaining screws and identify and mark locations for two fixing lugs. These should be just above the bottom of the vertical sides of the reverse gear mounting plate. Carefully drill the guard tapping size for M4. Replace the guard and, using a hand drill, spot through to the reversing gear mounting plate. Remove the gear plate then drill and tap an M4 hole on each side of the plate at the spotted marks. Fit two round headed screws (they do have some uses!) in place, using retainer and leaving them 2mm from 'home', photo 1. Now open the holes in the cover up to 4mm and with a razor saw or junior hacksaw, extend them into vertical slots, photo 2. The letters stand for Forward, Neutral and Reverse.

It now takes only a moment to remove the cover, with an up and out motion. Even with the largest changewheels fitted, there is no interference, and the guard is quite secure in normal use. As an added bonus I found that that one of the existing mounting holes in the guard can be used to run a speed sensor cable into the guard, far from swarf and without any risk of fouling the gears.

While on the subject of mini-lathe change gears, it is unfortunately possible to strip the keyway if the leadscrew is jammed. This happened to me. I found I was able to save the day by boring out the gear oversize and fitting a 'top hat shaped' steel sleeve from standard hex stock, slotted for the keyway. Without the flange, the sleeve would have been too flimsy, unless made so thick that the hub of the gear would have been weakened. I used two-pack epoxy to fix the sleeve in place, and the gear continues to give good service. ∎



The gear cover mounting screw.



Slots in the gear cover.

An angled mounting platform for a dividing head

Brian Wood describes his solution to improving the ergonomics of using a dividing head.

A restoration job done some time ago on the screwcutting gearbox for an old lathe led to a big session of gear cutting. During this work I found out the hard way just how easy it is to place the indexing peg into the wrong hole of the disc on a dividing head, especially when the viewing conditions are less than ideal. Especially frustrating is that the error may not be discovered until the last tooth is being cut.

In two articles published in MEW, **refs 1** and **2,** I described the restoration of an original Norton screwcutting gearbox that was fitted to a 1902 US made Hendey lathe. The gearbox was severely damaged and unusable.

All the gears, a total of fourteen, needed replacement, with tooth counts that ranged from 28 to 96. One needed to be re-cut when I discovered that I had pegged one hole in error in the indexing while roughly halfway round the cutting, leaving me with a useless "fat" gear tooth at the end of the process.

Photograph 1 shows the fat tooth on the right-hand gear of the pair, ignore the failure on the left which was caused by me pinching time to avoid sharpening the cutter. They were photographed together for convenience.

That error brought the total number of teeth needing to be cut to 784 and this operation became rather tedious. Assuming a strike rate of about two minutes per tooth, that part of the work alone totalled a little over 26 hours of concentrated effort. I was very glad when that stage was finished.

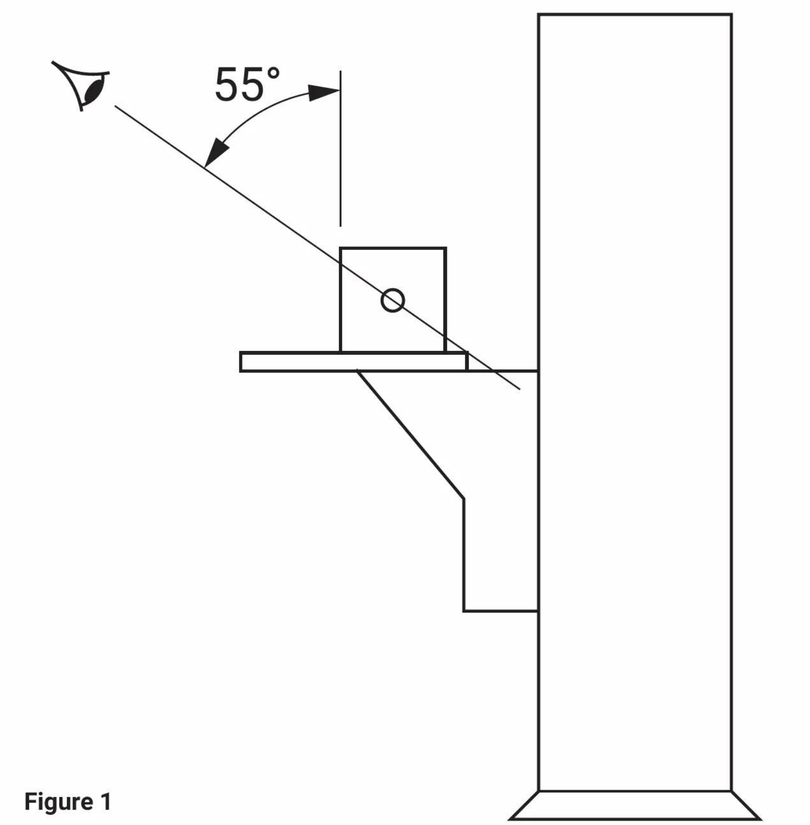


Figure 1

Mistakes like this have happened to me on other work, caused I am sure by cramped or awkward viewing with non-ideal lighting, and to avoid mistakes like this happening again in the future it was clearly time to try and improve matters.

Just by examining the geometry involved, the viewing of the all-important indexing disc, quadrant arms and location peg would be made much easier if they were presented straight on to the operator.

Figures 1 and **2** illustrate this point and I hope show the difference a comfortable view makes for work of this sort. The lighting is easy to put right, the viewing angle less so as it is dictated completely by the design of the dividing head.

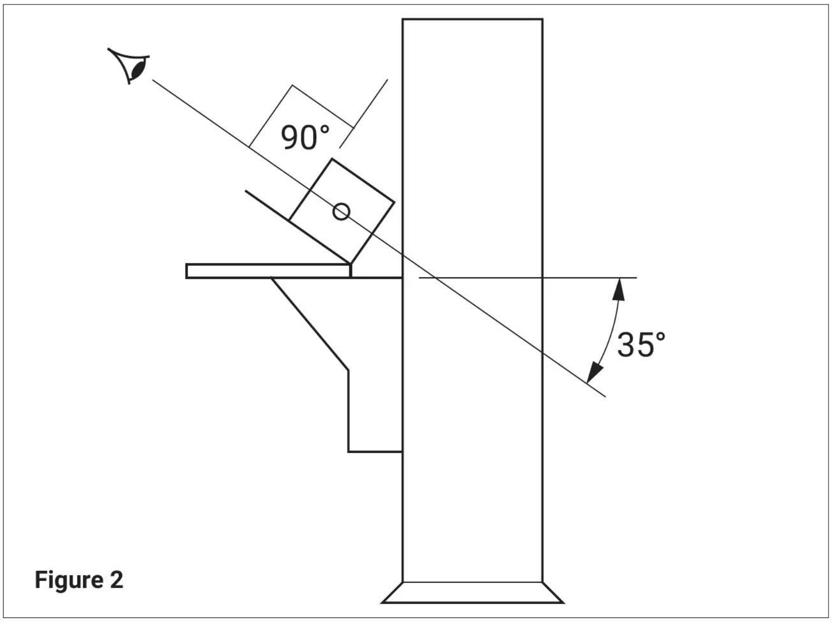
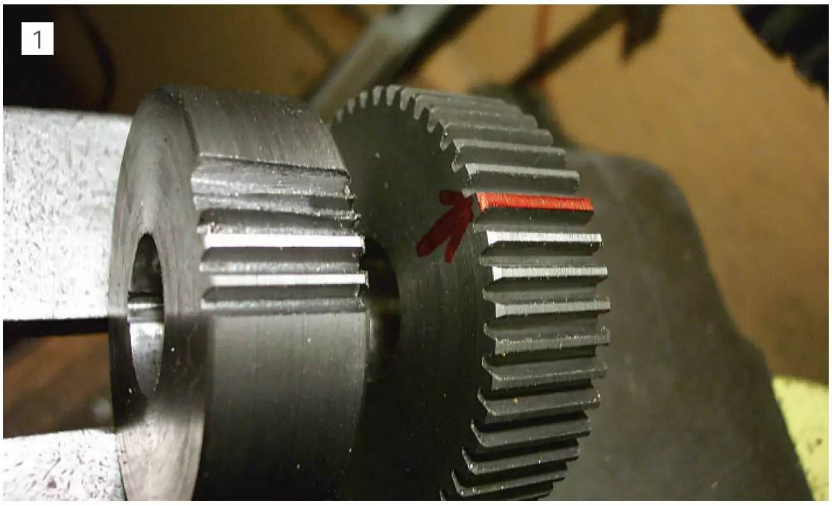


Figure 2



Fat gear tooth, the reason for making this fixture

The angled mounting platform

Just by mounting the dividing head on an angled mounting platform immediately improves the geometry for most plain spur gear cutting. Bevel and spiral gears would be the special cases for which it may not be suitable.

Construction.

I have not made any drawings of this piece of tooling, it was put together on the hoof as I went along, using materials to hand.

It was built to suit my Junior model Tom Senior horizontal mill, but the general idea is easy enough to follow and can be copied or adapted as necessary to suit other equipment.

I had a length of 100 x 50 x 3 mm rectangular box section steel left over from another job; from this I cut a 7-inch section to contain the length of the Vertex dividing head.

One of the 50 mm sides of this piece was cut down its length with a slitting disc on an angle grinder at roughly mid-section, after which it promptly closed up again with the cut edges curling inwards!

Clearly there was a lot of stress locked up in this material.

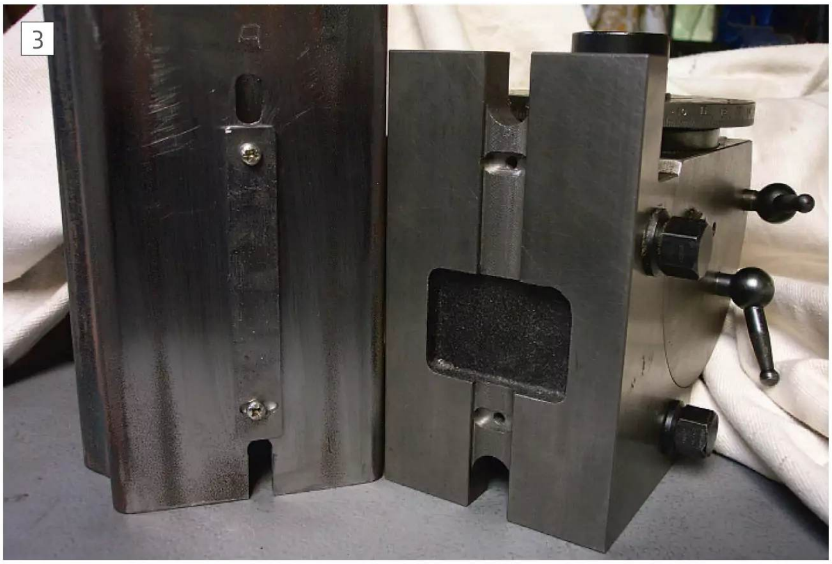
With it gripped over its length in a big vice, I was able to force it open again with steel log splitting wedges and then use a wrecking bar to prise open the gap while simultaneously heating the opposite side with an oxy-acetylene torch to bend it back outwards like a hinge to something near 35 degrees.

When it was cool, the major sides were hammered back reasonably flat again with a rubber faced dead-blow hammer, [what useful tools those are for "persuasion"], after which they were faced flat on a belt linisher.

The actual angle achieved was measured later at 37 degrees up from the horizontal and quite close enough to the sort of angle needed to improve the viewing.

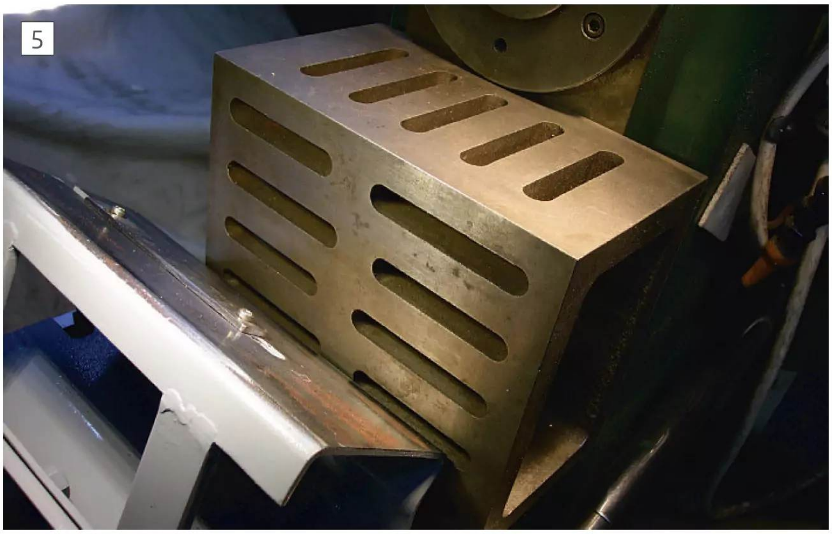
With the gap held open by two small machinist's jacks, I welded two 6 mm thick strips across the opening to restore the rigidity and make it capable of resisting cutting forces, or so I thought at the time. **Photograph 2,** with it now painted, shows the new shape that was created.

The reality of the rigidity I so fondly hoped was sufficient turned out to be



Underside of the Vertex dividing head

The front face of the angled fixture with 'gib' screws



Initial rough alignment of the angled fixture

very different as I discovered much later when it was first used; we will return to that part of the story a bit further on

Photograph 3 shows the underside view of the Vertex dividing head with the factory milled 16 mm wide location slot for a guide key. The photo also shows the shallow key which I made to be a snug fit in the keyway, screwed onto the face of the angled mounting.

One screw hole of the key is slotted to allow angulation for alignment later. Note also the two pockets I milled into the base of the dividing head to contain the heads of these screws.

Photograph 4 shows a section of flat 6 mm strip, bolted along the face of the fixture, with two fine pitch screws and lock nuts to act as an adjustment gib bearing on the front face of the milling machine table. These were to slew the fixture about to square up the angled platform to the rear reference face of the mill.

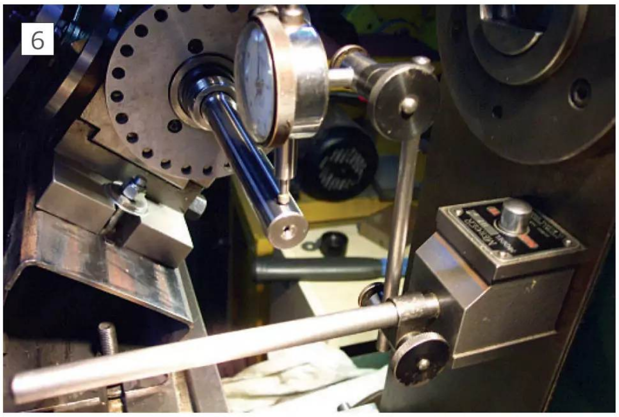
Photograph 5 shows the initial alignment method I used to get the bolting slots for securing the fixture down onto the table in the right sort of position.

With the dividing head mounted on the angled platform, somewhat more precise methods of alignment were now possible to get the head centreline true to the rear face of the mill and parallel with the surface of the table. I used a good quality test bar for this as shown in **photo 6** and finally achieved alignment within 0.002 inches on both axes over the 5-inch working length of the bar.

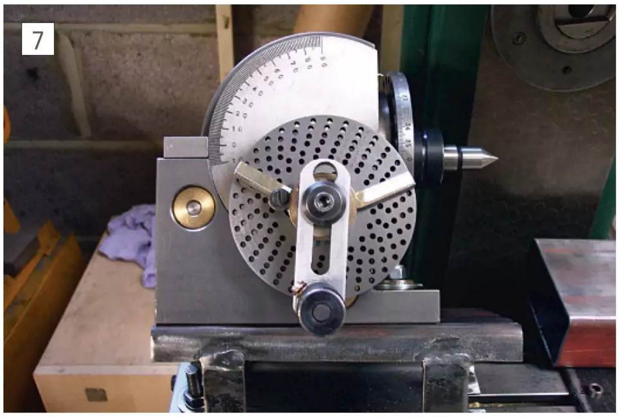
The process was rather protracted as it involved slewing the fixture and independently moving the dividing head on it, checking the effect at each stage. When things were to my liking, the adjustment screws were secured by the locknuts [front set] and Loctite was applied to both those and the ones holding the 16 mm guide.

Photographs 7 and **8** show the effect of the angled platform has had on the view, taken from the same viewpoint. I have raised the table knee for the 'flat' mounting of the dividing head to compensate for the extra height it gained when it was fitted on the platform so that the views are properly comparable.

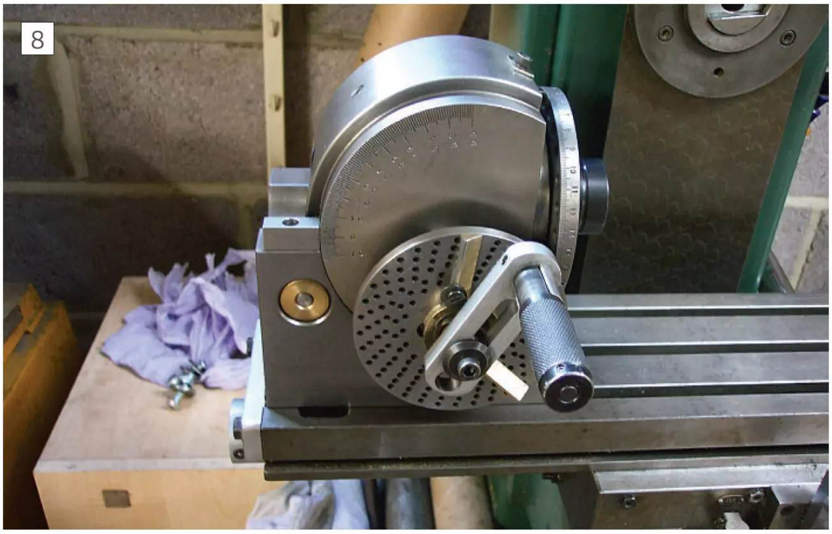
To complete the whole fixture the tailstock needed mounting as well.



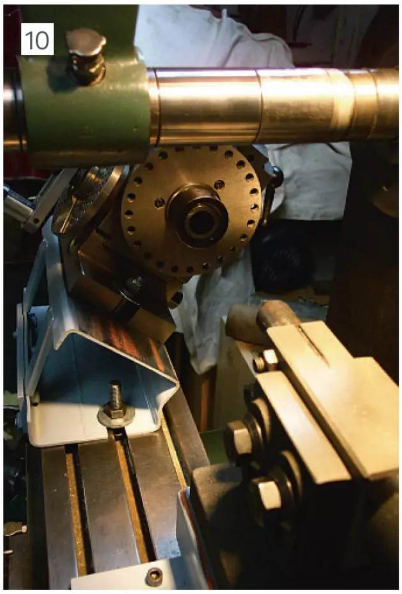
Precision alignment



The improved view the platform provides



And without it from the same viewpoint



Tooling ready for work

The angled fixture complete with the tailstock platform

This of course didn't need angling, just packing up to roughly the right height to leave the final setting to working height by using its own clamp bolts.

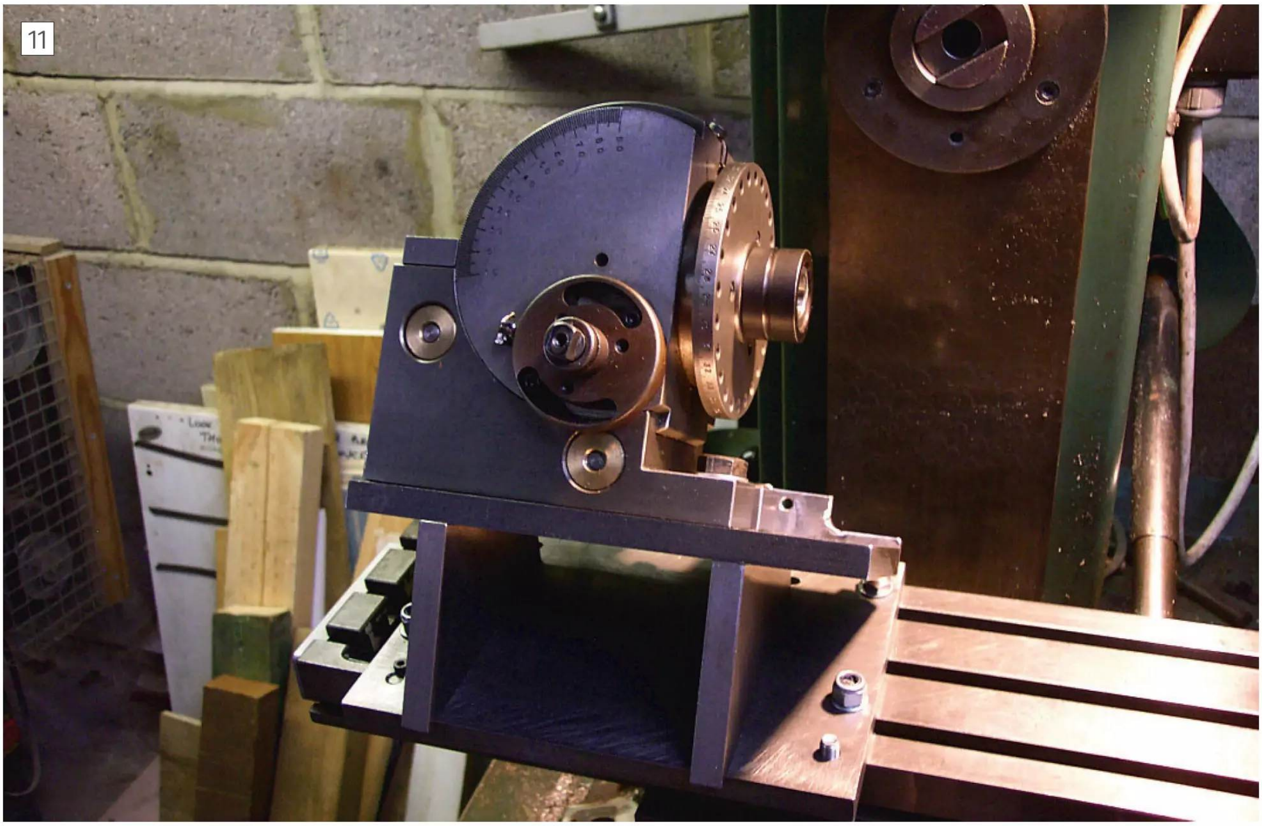
Because I didn't have a plate available in the right size, I made the mounting from a fabricated 6 mm plate using two strips welded together, onto which was mounted another piece of the box section.

The underside of the tailstock also has a shallow 16 mm wide location slot machined into it, the fitting face on the box section was accordingly fitted with another close-fitting strip of steel, secured in the same way as in the angled plate version with a slotted end to allow for angulation.

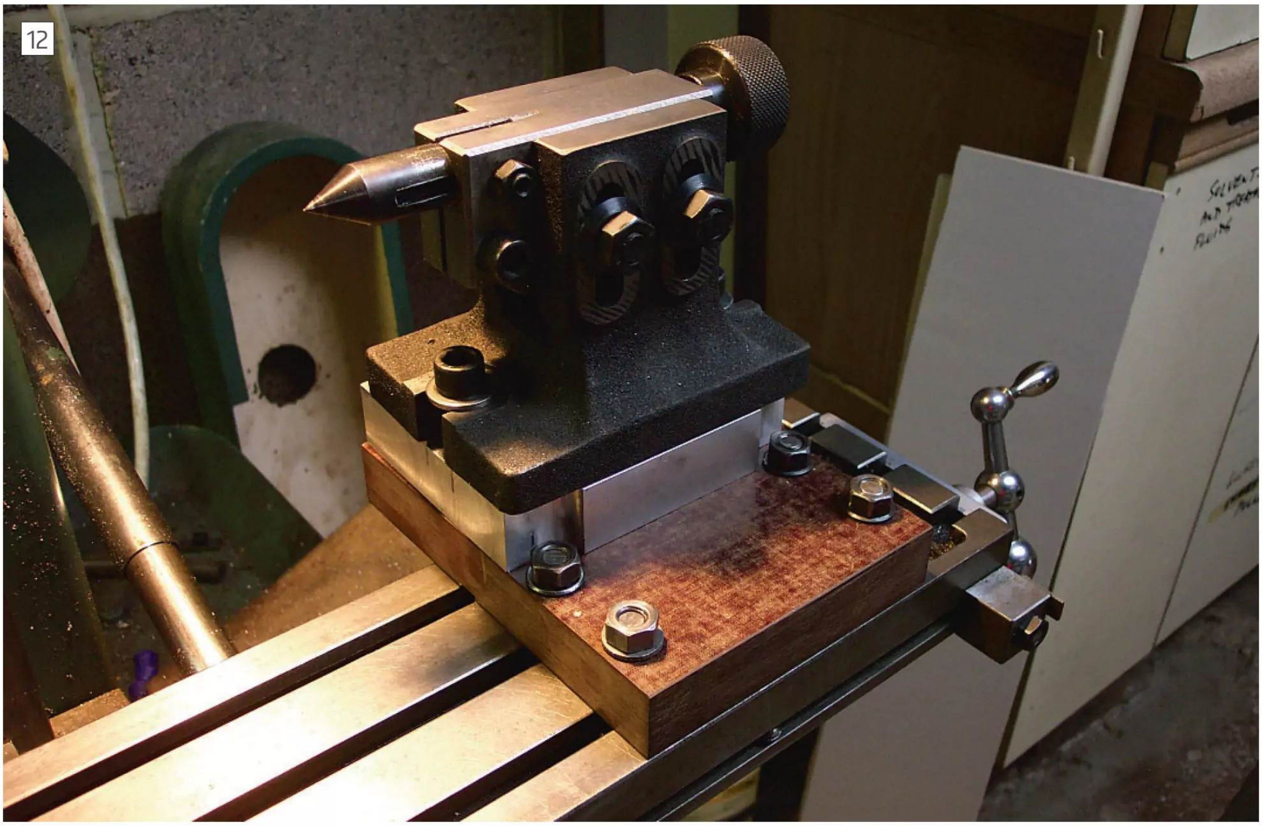
The underside of the welded plate was fitted with a key that locates in the last Tee slot on the table and the plate is held down to the table surface with two M6 Tee nuts and cap head machine screws.

By slackening those bolts the tailstock, on its mounting, can be slid along to any location on the machine table and quickly secured in place.

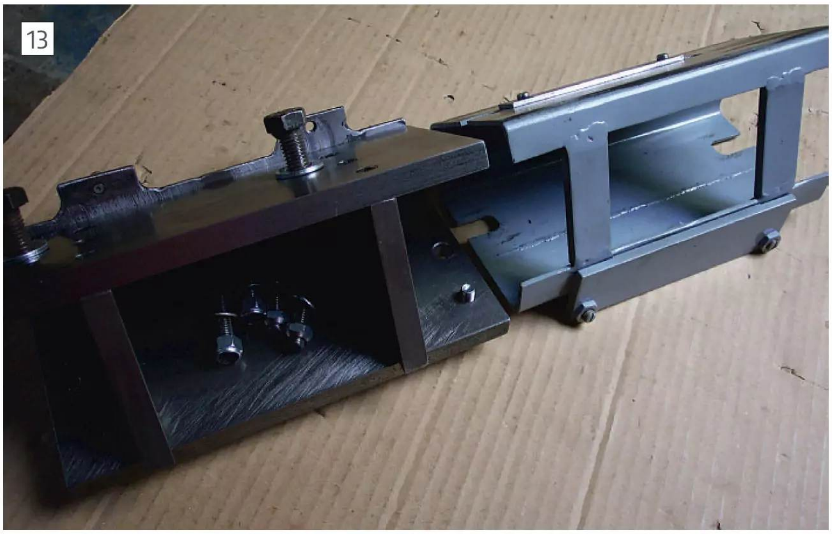
Photograph 9 shows the two parts of the fixture and **photo 10** with them ›



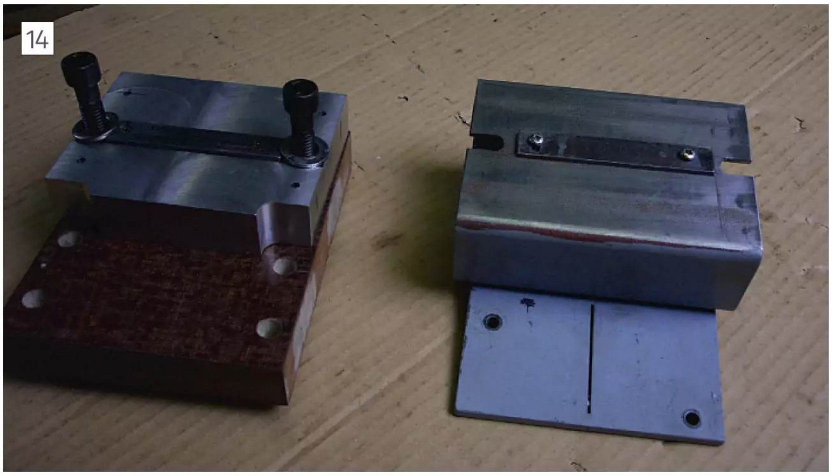
An altogether more substantial version.



And another for the tailstock



The two angled platforms displayed together



The two tailstock supports

in place on the milling machine, ready for use. A final job, which is not shown in photo form, was to fix the position of both the 16 mm wide location keys with 3 mm diameter dowels at each end.

So much for the making, how did it work out in practice?

I am sad to say that when it was put to the test to do some real work, the results were anything but satisfactory. Some two years had elapsed between finishing the device and using it on a real job. This was to cut a 15 tooth 16DP pinion, in EN8 steel, for the shaft of a capstan on a milling machine head.

The fixture for the indexing head was obviously far too flimsy for the job. Initially all seemed well when the first few teeth on the pinion blank were being cut, but the vibration from the gear cutter began to set up sympathetic vibrations in the fixture and they in turn began to blunt the cutter which induced further vibration. The feedback effect very quickly built up into a vicious cycle. Reducing the feed rate to a crawl only prolonged the agony as did reducing the depth of cut.

I stopped the work and sharpened the cutter but by now I think the initial alignment of the angled jig had become distorted, although with it bolted down to the table it was not obvious where the distortion was.

At this stage, the job was less than half-way completed. Cutting was again recommenced, but almost Immediately, things began to go from bad to worse.

The fixture began flexing visibly, the noise was becoming alarming, metal was being torn out of the gear blank in a series of savage scallops and I pulled the plug on it before something broke.

What did I learn?

The most obvious lesson from the whole experience was that fixtures and fittings for work of this kind are usually made from hefty castings or strong and thick welded sections for the very good reason that they will resist the forces involved.

Cast iron is good at absorbing vibration as well and a lightweight fabricated fixture of this kind is simply not up to the job of handling the cutting forces involved.

Despite the obvious problems that developed, the initial aim of setting things up to view the indexing and the pegging were much easier to carry out. Even the first few teeth that were cut in the job went smoothly and quietly and I feel that those results are positive endorsements for the design concept.

I was not able to source a casting so have instead re-built the whole fixture on similar lines to the earlier one as another fabrication but this time in ½ inch thick steel plate, bolted together with M8 cap screws. **Photograph 11** shows the more substantial version.

The new platform finished up at a slightly lower height than the original and rather than try to adapt the tailstock support to suit the change, it was altogether easier to build a new tailstock platform as well.

This version is fabricated from a slab of Tufnol and one of thick aluminium plate. **Photograph 12** shows the new version and **photos 13** and **14** are views of the Mk1 and Mk2 versions seen side by side.

Just out of curiosity, I checked the flatness of the original mounting. It now rocks on the table surface about the bolting holes where they have been pulled and distorted out of shape. If nothing else, this experience has made me appreciate only too well the magnitude of the cutting forces involved, even in what was really a modest job. ▮

References

1 **MEW 279** Restoring an old Norton screwcutting gearbox on a Hendey Lathe Part I.
2 **MEW 280**. Part II

A Machinist's Jack

Derek Lane explains a simple accessory that is easily made and has many uses.

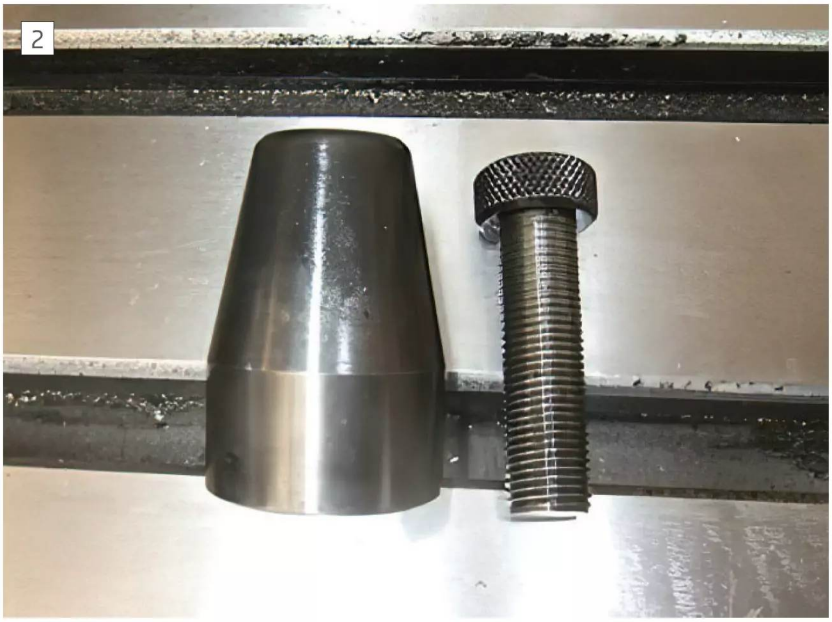
Coming from a hobby woodworking and turning (I'm still doing these) background but being new to model engineering and a total novice I have found that there are many things that I have had to either buy or make(If they are simple).

One of those being a small machinist's jack, **photo 1**, which I found I needed to support a thin rod to drill a cross hole. I set to and made one, which being of a simple design would not take me long.

Being new, my stock of raw material is still quite small, I am sure that will grow over time. I found some cold rolled round bar of 1 3/8" diameter which was a nice size to make a small jack and also big enough that it would cross any t slots in the milling table. First, I needed to decide the height of the jack in the closed position so that I could get the most out of it as well as the height when fully extended and still leave enough of the screw thread in contact from the top and bottom to give good support.

The proportions can be seen in **photo 2**.

1



2

First job was to tackle the base by cleaning up the outside and end, followed by drilling and tapping a through hole. I decided on 1/2" UNF giving a fine enough thread for adjustment (I have a good supply of tap and die sets from my plant mechanic days, I'm glad I did not get rid of them when I had to pack up due to medical reasons).

Next on the job was to taper the top down so that the top was ¾" I felt this was a nice size for the top, not too small and yet not too big. The taper was at any set angle, I did this until it looked right. I gave the top a chamfer and tidy up with a file before parting off and cleaning the bottom so it sat flat. This part was complete except a quick rub on a Scotchbrite wheel and blackening for looks, as well as added protection.

The top was a simple job of threading a ½" cold rolled bar for a length of 2" and the very end was turned down to 3/8" for a press fit into the top pad. Parted off and cleaned up the bottom and chamfer.

The top was a simple case of adding knurl to a ¾" bar drilling and reaming for the top of the screw thread. I parted it off only part way before chamfering the top and bottom of the piece. Finally I parted off completely, turning it around to clean off the parting off face.

I pressed the screw thread section into the top with a little Loctite retainer. I was not sure if the tight fit would just push the Loctite out but it can't hurt to use it.

The height when assemble is 2 ¼" and fully extended (with enough thread for a good support) is 3 3/8", **photo 3**. ▮

Digital Readout Controller/Displays

I designed and made my Digital Read Outs (DROs) in 2008, they work with (most) generic capacitive scales and calipers, **photo 1**. They are still working (subject to a little maintenance) fifteen years later so I must have done something right. My aim was to make a reliable, easy to use unit.

I originally planned to sell these as a kit, so I used easily obtained parts and avoided surface mount (which to my mind makes life a lot easier – no holes to drill!) Most importantly, I chose big (yet affordable) digits that would be visible from a great distance. I also selected decent-sized buttons that require only a round hole in the fascia, have a good service life and yet are inexpensive.

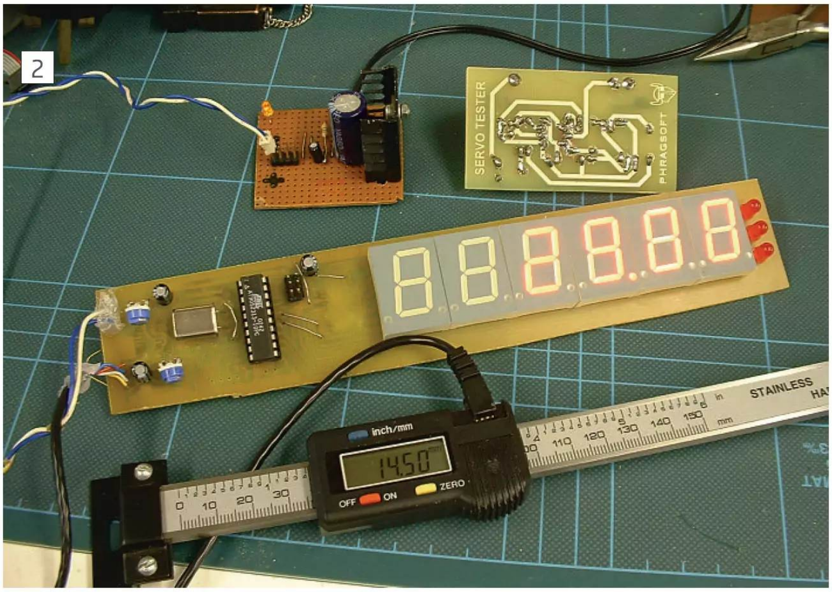
The circuit is based around an AVR microcontroller, a very simple one, the Tiny 2313, programmed in assembler. This has a fraction of the complexity of the AVR chips used in the popular Arduino modules. Programming it to read the signal from the scales was not particularly difficult. The entertaining part was writing the code to detect corrupted data packets, do various mathematical conversions (e.g. metric to imperial, generating fractions) and implementing a usable menu structure.

In case users didn't have a suitable power supply, I included a simple linear 5V regulator circuit that can be used with what we used to call a 'wall wart', seen powering the prototype in **photo 2**. I expect most readers still have a supply of these from old phones, but these days we all have plenty of 5V 'USB chargers' that are ideal for supplying such projects.

Three axis digital read out with tachometer.

A special lead for the scales was used to connect the scale read head to the DRO, this has an awful plastic connector, see photo 2, with three brass contacts that 'wave in the wind'. So the scale can operate without a cell fitted, the DRO supplies 1.5 volts to the unit. This is positive earth (unusual, but this is how the DROs are made). This does not cause any earth faults when connected to a DRO that is bolted to the earthed body of a machine. To make sure there would be no issues I used a double insulated power supply (with no earth connection).

When switched on, a boot message scrolls across the display, and it waits for a DRO or calliper to be connected if I have not already done so.



Prototype circuit board – this had some components surface mounted below.

The controls are, from left to right:

- Zero –this button works directly on the DRO, zeroing its reading (or selecting special functions in certain modes, see below). The readout will automatically zero when the DRO is zeroed. Some DROs will not zero when in fast mode or some other special modes.
- Special function – this typically selects fast mode on a DRO, but with calipers it may put the device in various hold or tolerance modes, which can be changed by using this button in conjunction with the zero button. Because these functions depend on the measuring device, not the readout, one has to experiment and confirm how this works with their unit. The readout automatically detects fast mode (and lights an indicator LED – the

Cable soldered in place and sealed with hot melt adhesive.

middle one – to show this). It will reflect the reading on the DRO whatever its mode (i.e. if the DRO is on hold, the readout will hold too).

- Mode – this button enters and cycles through a series of display options, see below.
- Select – this button has two functions. Normally it switches between metric and imperial units (without affecting the DRO setting). The top LED will light to indicate inches. When mode has been used to select a menu function, it cycles through the available options.

The menu options are:

- Dia. On/Dia.Off – in diameter mode the reading is doubled. This can be used for a lathe cross-slide or similar and for some unconventional milling operations (such as where work is held in the spindle). In diameter mode the bottom LED lights up.
- Dir.Pos/Dir.Neg – positive or negative direction. This allows you to choose 'which way is up' whichever way round you mount your DRO.
- Bright – there are sixteen brightness levels. It steps through them to the maximum, then returns to the minimum if the button is released and pressed again.
- Fractn./Deci. – this is my little bit of fun. Decimal mode is normal. In fraction mode the display gives a reading in inches such as 10.11.32 (10 11/32). It reads down to 64ths. The upper 'inch' LED lights when the reading is within approximately 0.002" of the exact fractional measurement. There should be no cumulative errors and is very useful for drilling a line of rivets at fractional spacing (or making Meccano). Fractional mode is always imperial, the readout will return to the default imperial/metric mode when fractional mode is left.

To recap, the three LEDs at the right-hand side are (first option is LED lit):

- Inches/mm (or fraction within 2 thou of nominal)
- Fast mode/normal
- Diameter mode/normal

At power on the reading should be zero. This may not be the case if power is interrupted briefly. If the DRO 'freezes' on startup switch off, this usually meant the lead was not properly inserted, I would have to wait a half a minute and restart. The poor contact made by the crude DRO plugs caused these problems. Once I had the system working properly, I cut off the plugs and soldered the leads directly to the read heads, **photo 3**. I also fitted small electrolytic capacitors across the power connections at the read head, this considerably reduced any glitches.

When you cycle through the menu the settings are saved to eeprom, and they are reloaded on switch on. The eeprom life is 100,000 cycles, which should be sufficient for all but the most manic of button pressers.

I have designed the boards to use an off-board connector socket is used. The boards were easily mounted behind a metal or plastic panel with a window for the LEDs and display and four holes for the buttons.

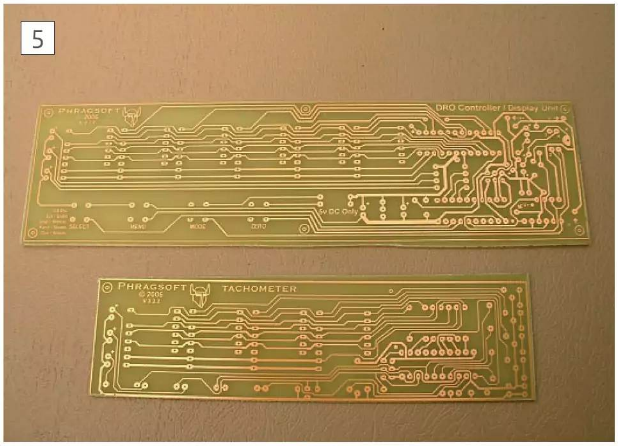
I stacked three boards to display a series of axes one above the other, each connected to one of three scales fitted to my X2 mill, **photo 4.**

To help with this I included pads to link the power supply between adjacent boards. The boards are otherwise independent. There is a 'power LED' that on all the boards as it is used to regulate the voltage the DRO (saving complexity and a few pence!) It doesn't have to be displayed, so there is only one displayed through a hole on the fascia).

Some time before I made a tachometer for my lathe and mill. I revised the design circuit to use the same displays as the readout and fitted it into the same case, **photo 5** shows my home-brewed boards for a readout and tachometer.

Over the years the readout has been incredibly useful, although occasionally it has 'glitched'. If I was doing this again, I would probably use a single Arduino, program it using the C language, and fit a display shield that would allow for a more meaningful text interface. That said, I still like my big, clear LED digits!

X-axis readout attached to base of mill.



Circuit boards.

Readers' Tips

TIP OF THE MONTH WINNER!

Making use of abandoned cylinders.

This month's winner is James Spray, whose tip arrived some time before possession of nitrous oxide without a legitimate use became illegal.

We had better add two disclaimers: First it is essential to make sure any cannister is fully depressurised before cutting into it – a good way to do this is to fill it with water. Secondly, visit www. homeofficemedia.blog.gov.uk/2023/10/18/media-fact-sheet-nitrous-oxide-ban/ for details of the law!

I would humbly proffer my idea for utilising the Nitrous Oxide cylinders used/misused and often discarded. These thick-walled cylinders make robust crucibles for home casting.

I unscrew the brass valve after checking the cylinder is empty then cut the top off the empty cylinder. A second cut creates a 1/2'' deep ring that is tack welded to the curved base, allowing it to stand freely. Adding a couple of lugs allows the crucible to be lifted from the furnace.

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 600 words and a picture or drawing. Don't forget to include your address! Every month we'll choose a winner for the *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.

Fifty Years of George H Thomas' Universal Pillar Tool Part II

Warren Williams addresses the correction of errors and introduces some new developments

In Part I the origins and development of the UPT were described. In Part II errors and information missing from the construction information, Workshop Techniques, Geo. H. Thomas, TEE Publishing, 1998 (ref. 1), are addressed and an improved method for machining the arms is suggested as well as some design enhancements. To fully understand Part II, the intended main audience, the prospective UPT builder, should have ref. 1, on hand.

To clearly distinguish between ", as in drawings produced for this series of articles, and those cited from ref. 1, the following convention is used. "Figure or fig. x" in bold means a figure appearing in this series of 50 years of UPT articles. In contrast, "fig. Y.Z" is the citation of a figure appearing in ref. 1, fig. 1.1 being the first figure (the General Arrangement drawing in this instance) found in ref. 1. Adoption of this convention avoids unnecessarily repetitive citation. Figure numbers carry over from this Part II and into Part IV.

ref. 1 identifies UPT components is one of two ways, and sometimes both schemes are used. Some components are given an Item number and some a fig. number, a drawing number in effect. Some fig. numbers include several Item numbers. Rather than attempt to rationalise this situation, and risk any further confusion, the following sections refer to components in a way the author feels is least ambiguous.

Now, each of the UPT components which the author believes a prospective builder might benefit from a better explanation than is found in ref. 1, is treated.

The castings – In general

There are five iron castings excluding the rotatable stake base, which in my view, is more conveniently machined from solid. The castings are the two plain arms, the sensitive drilling attachment arm, the base, and the table. A case for machining the table from solid is also advanced here. An additional casting, in aluminium, is the "alloy base casting".

Reference 1 includes a combination of casting drawings, a machining drawing for every casting, and a pattern drawing for one casting. The assumption is that the castings will be supplied from a nominated supplier, who in collaboration with the designer, has all the casting dimensions. In this case the supplier is Hemingway and there is evidently a direct lineage between the current Hemingway castings and GHT's original intention to make his design accessible to any model engineer desirous of a UPT. It would however be useful to the builder to know the dimensions of the castings. That information can only be obtained though, except for the sensitive drilling arm, the drawing of which appears twice in ref. 1 (first as fig. 1.5 then, duplicated as fig. 7.2), by measuring up the castings.

Virtually all workholding techniques cause the workpiece to become somewhat distorted by clamping forces. When the clamping forces are removed the carefully machined part then adopts a permanently deformed shape. The setup should be carefully devised to minimise distortion of important dimensions and this applies especially to the arms. If clamping forces cause the bores of the arms to become out of parallel, then their usefulness is greatly diminished. GHT relates in ref. 1 that his first attempt at machining arms resulted in an out of parallel defect because of excessive clamping forces. In my case I first rough machined the top faces of the arms and then scraped those surfaces to a surface plate. One of the great advantages of scraping is that clamping forces can be almost negligible. The action of scraping does not generate high cutting forces so there is no need for the work to be restrained by high clamping forces. A similar benefit arises when surfaces are ground rather than turned or milled. The scraped flat surfaces were then used as both a datum for machining and as the clamping faces for final machining. This additional step is easily and quickly accomplished, and one can proceed knowing beyond doubt the basis for further machining is sound.

The Pillar – ref. 1, Item 4

Photograph 4, in Part I, showed the pillar, base, completed plain arms (as distinct from the sensitive drilling attachment arm), clamp pads, and ball handles.

Reference 1 contains no drawing for the pillar. Rather the pillar, there are two variants in fact, is described in words. There is a plain type and an alternative type fitted with a keyway along its length. The overall length of the pillar is 15". I suggest making a second, short pillar, for use with the alloy base when mounting the UPT on the lathe or mill. Such a pillar, 10" long (or whatever dimension suits the user) is shown in the lower right corner of Photo 2. As to the depth of the keyway, page 17 of ref. 1 states 0.050" deep whilst page 265 says 3/32" (0.938") deep, the former dimension being more in keeping with conventional keyway design.

The Arms – ref. 1, Item 1A

Figure 1.4, the arm drawing, erroneously instructs the builder to shorten the cast lug located at the large diameter bore end of the arm when a slotted (keyway type) pillar is used, when in fact the converse is true. The lug must be retained on the arm if a slotted pillar is used, because the key which engages the keyway, a 4BA screw with a "dog point" end, is screwed into this lug. Page 24 of ref. 1 describes the key although, as with the pillar, there is no drawing. If the keyway is added retrospectively,

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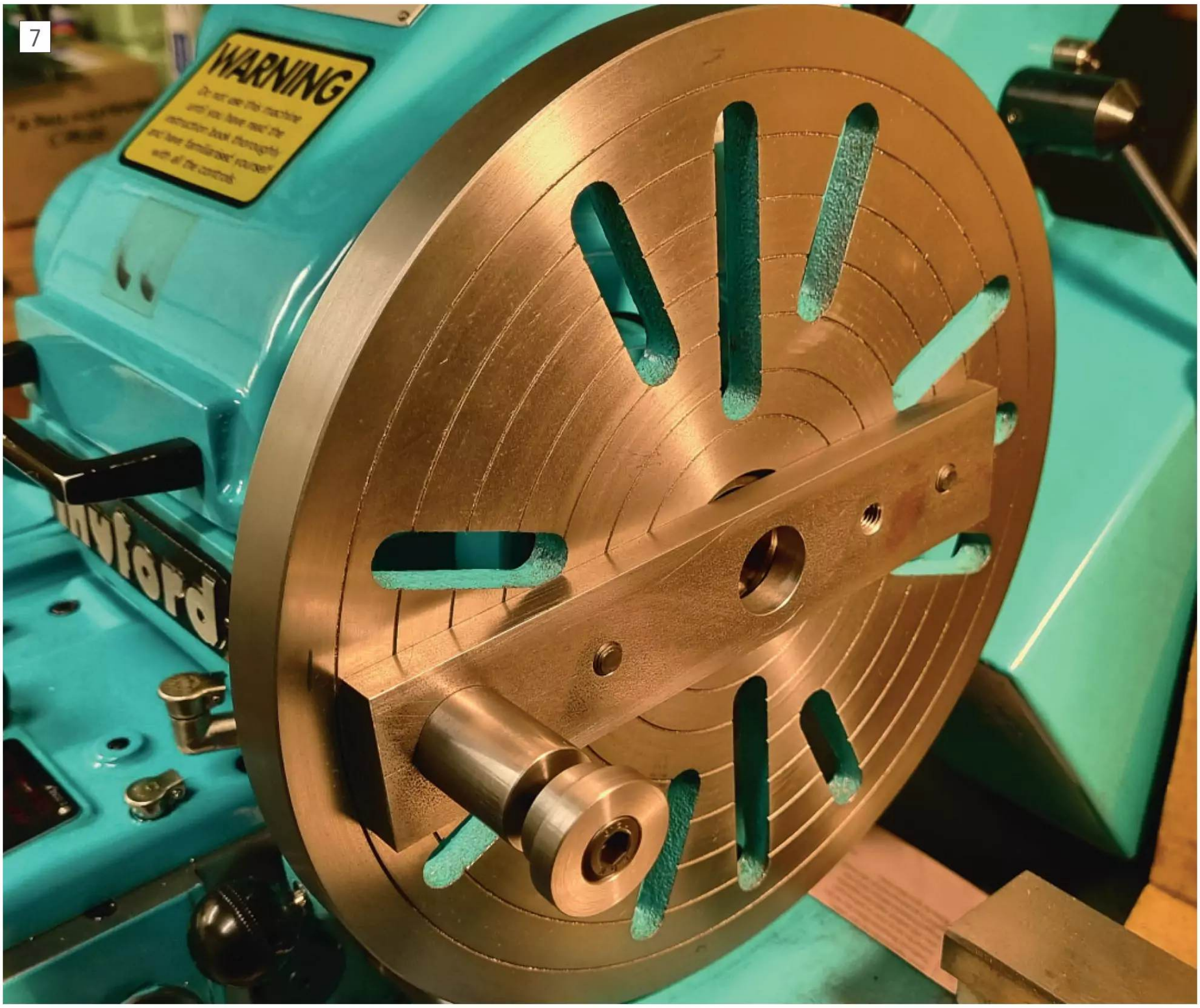
Grooved clamp pads ready for temporary insertion into arms for machining pillar matching radius. The quantity of clamps shown in the image exceeds the number required for the project.

meaning the lug on the arm has been removed, then fig. 29.2 shows a means of restoring this feature, and also a design for the key which should suit the intact lug situation. Reliance on the keyed pillar to accurately align arms carried on the pillar might be somewhat optimistic for the same reasons that a keyway on a round column milling machine could only ever be relied on an approximate alignment tool. A better way to align the arms is to pass a close-fitting straight bar through the small ends of the arms, although there may be some setups precluding use of this method.

The plain arm and sensitive drilling arm castings should be machined together for they have much in common. ref. 1 mistakenly calls up fig. 1.5 as the machining drawing for the sensitive drilling arm. The correct drawing is fig. 7.3.

The current design has the arms and base fixed to the pillar using clamp pads whereas the original design was, as described in Part I, of the somewhat troublesome "slit it and nip it" type. The castings for each type are different, so be careful to obtain castings which suit the current design if that is what is desired. It may not be obvious upon a first reading of ref. 1 that the clamp pads, shown in fig. 1.6 are partly machined first, and then inserted into partly machined arms, so that the radiused clamping surface on the pads closely matches, i.e., is conformal with, the contour of the pillar. That order of machining is necessary for an accurate fit, unless of course a machining fixture is made. There are few assembly drawings in ref. 1, and one of the most important ones, albeit a small drawing, is obscurely located in the text. This is Section A-A of fig. 1.4, page 18, which appears as fig. 1.7 on page 20. There is one dimension shown on fig. 1.7, the clamp pad anti-rotation pin centre

Drilling the clamp pad anti-rotation pin holes in the sensitive drilling arm.



Fixture for machining arm bores mounted on lathe face plate.

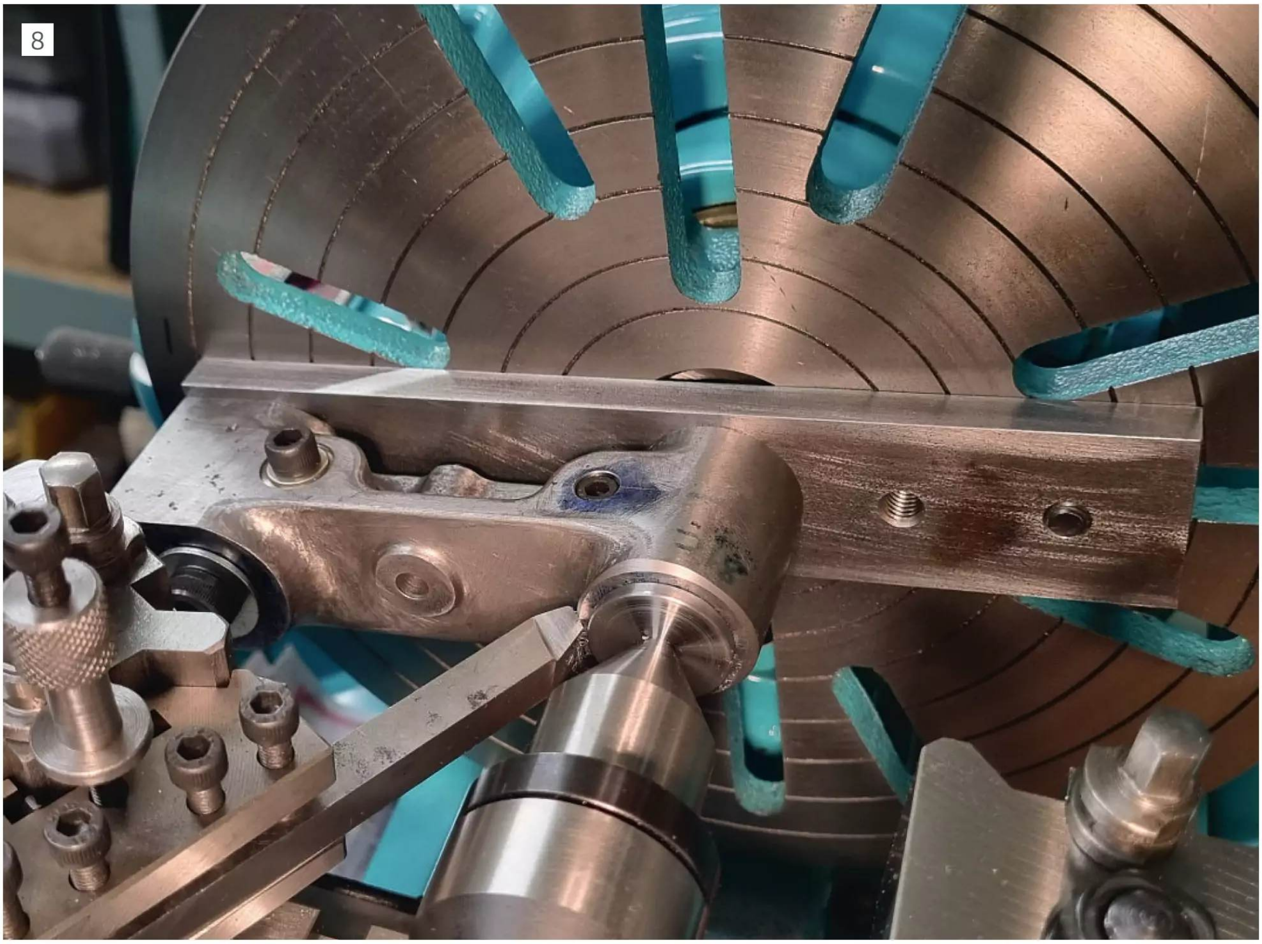
line of 5/32" from the side face of the casting. I found the pin centre line is far better placed at 0.25" from the side face.

The clamp pads may be "grooved" as GHT describes it, i.e., cut with a keyway, or left plain. The purpose of the groove is to engage with the aforementioned anti-rotation pins in the arms which prevent a pad from rotating out of correct orientation when the pillar or bush passing through the relevant end of the arm is withdrawn. GHT opines the groove is a useful although somewhat unnecessary refinement. I prefer the refinement because the innate versatility of the UPT has it that the machine is often being reconfigured, which means removal and re-attachment of the arms and base. The grooved pads allow for trouble-free rapid assembly and reassembly.

Clamp pads pre-machined for temporary insertion into the arms for boring are shown in **photo 5**. The pads are retained in the arms for boring with a cap screw as shown in fig. 8 (to appear in part III). After the pillar matching radius of the pads is machined the pads, initially machined over-length, so that they can be conveniently temporarily clamped in the arms, are shortened to the dimensions shown in fig. 1.6. The pads should be individually numbered because each is matched to the arm hole in which it was machined.

Photograph 6 shows the sensitive drilling attachment arm being machined on the mill, held using a simple fixture made from a straight piece of 2" x 3/8" BMS (Bright Mild Steel). The same fixture is also used to machine the plain arms. This fixture was subsequently turned through 90 degrees on the mill table, using an angle plate, to allow the clamp pad bores to be machined. The fixture was thereafter transferred to the lathe, as shown in **photo 7**, to complete the main bores, at which time the partly machined and temporarily inserted clamp pads have their clamp surfaces radiused during the final boring operation. The main bores in the arms are initially reamed to 3/8" diameter, with the two holes in each arm and the fixture, located at precisely the same spacing using the DRO. The two locating holes in the fixture lie on a centre line which is parallel to one edge of the fixture. Accuracy of these two features greatly simplifies and improves accuracy of all machining which follows.

When the fixture is transferred to the lathe, one of the two 3/8" diameter datum holes has a snug-fitting pin ›



Sensitive drilling arm, both bores finished, with drill spindle end boss being chamfered.

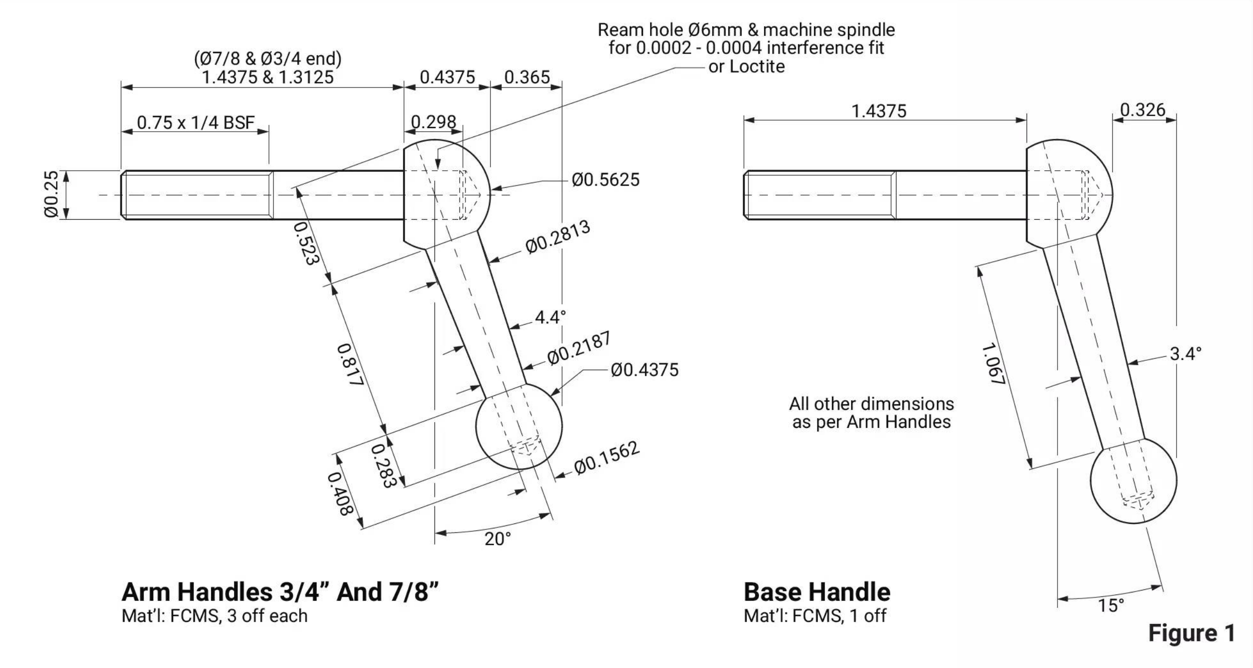
inserted to use with a DTI (Dial Test Indicator), so the fixture can be set up on the lathe face plate with the centre of that hole aligned with the lathe spindle. After clamping the fixture to the face plate, the 3/8" hole in the fixture is then opened up to 7/8" clearance, to allow both the large and small ends to be bored and or reamed. The other 3/8" datum hole is used to locate a close-fitting mandrel with which to clamp the far end of the arm being bored. This arrangement all but guarantees the bore centres of all arms will be very close to the same dimension. I prefer to finish the bores with a single point tool rather than a reamer. Reamers, even sharp ones, have been known to do strange things in cast iron, and the final size is revealed, only when it is too late to do anything about it if oversize. A single point boring tool has the great advantages of far better dimensional control than a reamer and the bore does not drift off the axis of the lathe spindle, which can happen with a drilled and reamed hole. The ideal bore to pillar diametral clearance is of the order of 0.0005", and certainly no greater than 0.001". Few of GHT's drawings are toleranced although the more important dimensions are mostly discussed in the text.

When attached to the faceplate mounted fixture, the outer end of each arm will swing below the bed of a Myford 7 series lathe. The combined thickness of the fixture and the arm must therefore swing clear of the gap in the lathe bed. This is where GHT's method of machining the arms became difficult. On a pre-big bore Myford, the bed gap limited the thickness of the fixture to 18 SWG (0.048"), sheet metal, in other words, barely adequate for the final boring operation, although not suitable for the work shown in photo 6. If a lathe with this limitation is all that is available, great care could be used to overcome this difficulty, however it would be better to find an alternative if at all possible. Jig boring the arms on a milling machine is of course one such alternative provided one has access to a suitable machine.

The final arm machining operation is to chamfer the ends of the arms and this is shown in **photo 8**. The tapped hole to the right of the boss being chamfered is for the (removed in the image) stud and clamp required when the 3/8" pilot hole is being opened up to ¾" for the small end, and to 7/8" for the large ends of the plain arms, both ends being 7/8" diameter for the drill arm. The clamp cannot be used during the chamfering operation, so a stub mandrel holds the arm firmly against the fixture with pressure applied from a centre in the tailstock. The centre also aligns the bore of the arm with the lathe spindle.

Ball handles – ref. 1, Item 6

The clamp pads are pulled up against the pillar with rather elegant ball handles, although some builders might prefer a simpler commercial item for



Ball handles for arms and base

the handles. The clamp handles for the arms and their washers are shown in fig. 3.1 and that for the base in fig. 3.2. The thickness of each washer must be adjusted so that the handle to which it is fitted lies in the desired orientation when locked. Accordingly, the 1/8'' thickness dimension for the washers is only nominal, and it is therefore sensible to start with a thicker washer. The adjustment process can be more scientific than trial and error by making use of the knowledge that the ¼'' BSF screwed spindle rotates one degree for every 0.0011'' of washer thickness.

The ref. 1 handle drawings show sufficient dimensions to fully specify the handles but require further dimensions to be calculated for convenient machining. Additional dimensions useful for machining are shown in **fig. 1**. There are three types of ball handle, a long spindle and a short spindle type for the 7/8'' bore and ¾'' bore ends respectively, and a longer handle type for the base. Figure 9 (Part III) describes all three types.

The handles are all set at an angle to their respective spindles. Although it matters not, that the angle is no precise figure, a professional look demands all handles are similarly angled. The angles and offsets are shown in fig. 1, and in **photo 9**, a simple means of setting the angle prior to boring for the interference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Setting up ball handle for boring spindle hole at correct angle.

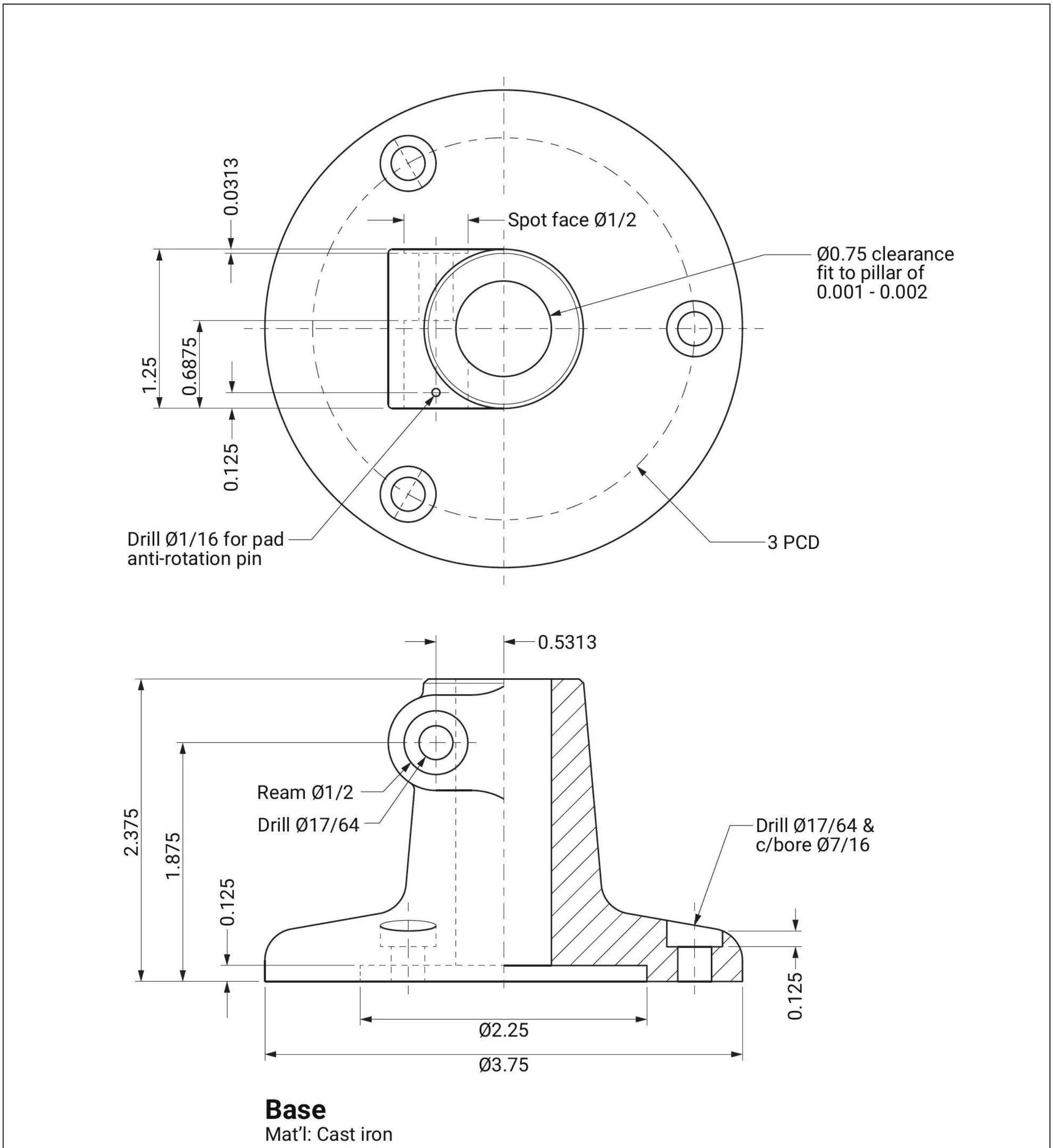

Figure 2

Main base machining drawing

fit spindle is shown. The author's ball handles were machined and clamped in the lathe chuck using equipment made to the Radford-Thomas design.

Main Base – ref. 1, Item 3A

There are two kinds of base which could carry the pillar, what might be termed the main base, which is an iron casting, and what GHT refers to as the alloy base, an aluminium casting, for mounting the UPT on other tools. The drawing of the main base, fig. 2.2, is somewhat incomplete. **Figure 2** contains all the information a builder needs to machine the main base casting.

The radius of the base clamp pad which clamps the pillar is machined with the ¾" diameter bore in the main base in the same way the clamp pads are machined for the arms.

Next, in Part III, we continue looking at errors and new developments.

● To be continued

Scribe a line

YOUR CHANCE TO TALK TO US!

Readers! We want to hear from you! Drop us a line sharing your advice, questions or opinions. Why not send us a picture of your latest workshop creation, or that strange tool you found in a boot sale? Email your contributions to **meweditor@mortons.co.uk.**

Mystery Tool 1

Hi Neil, I'm sure this is not the answer you are looking for but I use a similar clamp to hold a strip of Velcro backed sandpaper for light sanding. The sandpaper strip is folded over a piece of aluminium and the clamp holds everything together.

I never did find out what it is really used for so I'm very interested in the answer.

Super magazine. Keep up the good work.

Mervyn Karwot, Glasgow

Mystery Tool 2

Hello Neil, the mystery item photos 24 and 25, page 51 of issue 334 is a watchmakers hand vice. The hole through the clamp screw is to allow for work on pin wire.

I believe I have a small calliper as in photo 23 which again I believe was used in watchmaking.

David carne, by email

Mystery Tool 3

Dear Neil, in the Model Engineering review article , on page 51 you enquire about the nature of the "thing" in photos 24 and 25 - it is a common form of hand vice of an old type.

Such vices were made by various firms - in the distant past – the purpose of the hole through the clamping screw is to allow a good length of small diameter rod to be passed through the jaws and then through the hollow handle to allow one to work on the end of something like a long stay / cycle spoke etc.

In Buckman's Catalogue for 1953 there is an illustration of a very similar tool - copy is attached.

Malcolm Leafe, by email

Mystery Tool 4

Dear Neil, I inherited two of these from a friend a few years ago. He was interested in watch repairs, and I have always thought of them as watchmaking hand vices. They both have serrated jaws, and one has a small hole and "countersink" on the jaw without the hole through the handle.

I presumed that the one with the hole through the handle was to hold lengths while they were being worked on - I have found it useful for holding silver solder wire from a coil right through to the short ends. It is also really good for shortening small ba bolts on a fine disc sander. If you put a nut on first it keeps the thread clean and also gives a parallel piece to grip.
I don't know what the "countersink" on the other one is for but I'm sure someone will enlighten us.

If there is a watch repairer out there who knows what it is for and genuinely would be able to make use of it they are more than welcome to it.

Bob Lamb, by email

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Mystery Tool 5

Hi Neil, in the article on the 2023 Midlands Model Engineering Exhibition you show on page 51 photo 24 a Pin Vise. The hole through the clamping screw is to allow the pin or wire being held to pass through into the handle if it is long enough. They usually have a shallow groove in each clamping face to centre what is being clamped.

There are plenty of examples on the internet.

I expect you'll get many replies. The one I have was bought in Germany by my grandfather shortly after WW1.

Michael Shelley, Australia

Thanks to everyone who has got in touch regarding this object. The original owner had assumed a standard pin vice had been modified with a hole right through the handle and a deep groove in the jaws. It was hypothesised that this arrangement could have been used for winding small springs. It seems that the holes and groove are standard, although that doesn't preclude what could be a handy use of such a tool.

Neil.

Compact Dividing Head

Dear Neil, I have been checking the details of my dividing head. There's a couple of problems on the Body detail drawing which I won't go into detail about just now. What occurs to me is that there will, in all probability, be other niggles (happens in all the best firms even Rolls-Royce) so I suggest after the final part of the article we publish some errata. I can't think that anybody would have made bits before the last part is published!.

Chris Hallaway, by email

Unfortunately, our draughtsman had to work from rather faint scans of Chris's original pencil drawings. This seems to have led to some mistakes we didn't pick up before printing. We will publish a list of any errors that have come up with the dividing head as soon as possible.

Neil.

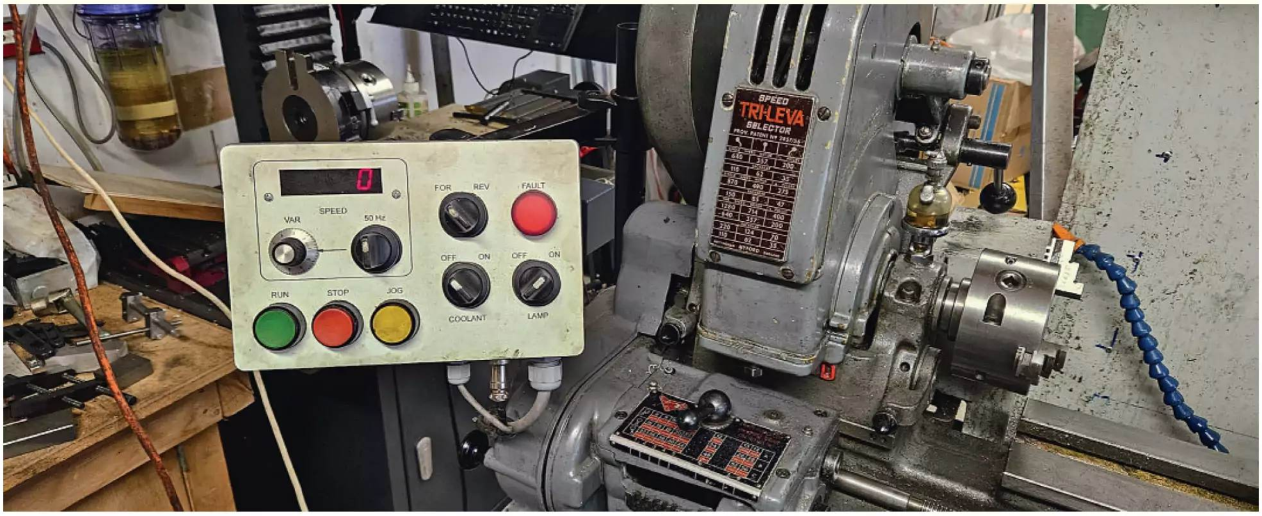
Hall Effect Sensor Tip – More Details

Hi Neil, the hall effect sensor is connected to a tacho that I built myself from a Microchip 16F690 PIC 41262A.book (microchip.com) and four 7-segment LED displays. I wrote the software with the Microchip XC8 compiler in the MPLAB development environment nearly 10 years ago as my first attempt at writing something in "C". Source code has 288 lines. I have attached a photo of the tacho which is built into a VFD control box that I made. Power for it comes from the 24 Vdc supply that is part of the VFD that I installed on my lathe.

Quicker and easier hardware might be to use one of the small Arduino boards. There are also cheap ready-made tachos sold online. I did try one of these before building my own but couldn't get a nice stable display from it. If you do buy one it needs to be able to accommodate a division factor of 65 to account for the 65 pulses per revolution generated by the 65 teeth on the bull gear of the ML7.

A Google search for "lathe tacho" or similar will find lots of examples of similar projects.

Keith Fisk, by email



3D Scanning

The editor takes a look at the possibilities offered by 3D scanning and tries out the Creality Scan Ferret.

3D scanning is a technology that digitally captures the three-dimensional geometry of physical objects, converting them into detailed and accurate computerized representations. It employs various methods such as laser-based distance measurement, structured light projection, or photogrammetry to record the spatial dimensions and surface characteristics of an object. By collecting a multitude of data points across the object's surface, a point cloud is generated, **photo 1**, ideally forming a highly detailed and precise digital model. This digital representation can then be further processed and refined to create a 3D mesh or solid model, providing a virtual counterpart to the physical object. 3D scanning finds applications in diverse fields, including manufacturing, design, healthcare, cultural heritage preservation, and virtual reality, offering a versatile and efficient means of capturing real-world objects in a digital format for analysis, modification, or reproduction.

Using the Scan Ferret in Creality Scan. At left are the visible light and infra-red depth images, to the right is the emerging point cloud.

Like many of the 'new' technologies that find their way into our hobby, 3D scanning has actually been around for some time. The earliest forms of 3D scanning emerged in the 1960s alongside technologies such as Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM). These technologies laid the groundwork for digitizing physical objects and creating 3D models. In the 1980s, laser-based technologies began to play a crucial role in 3D scanning. These early laser scanners were typically large, expensive, and had limited accuracy.

Advancements in computing power and the miniaturization of technology led to the development of more compact and affordable 3D scanning devices. Structured light scanning, which projects a known pattern onto an object and uses the deformation of the pattern to calculate 3D coordinates, also gained popularity during this period. In the 21st century the 3D scanning industry continued to expand with the introduction of more sophisticated scanning technologies. Time-of-flight (TOF) scanners, which measure the time it takes for a laser signal to travel to the object and back, became more common. This decade also saw the integration of 3D scanning with other technologies, such as photogrammetry, which involves using multiple photographs to create a 3D model.

The last decade or so has seen handheld and portable 3D scanners became widely available, making it more accessible for individuals and smaller businesses to incorporate 3D scanning into their workflows. There are even photogrammetry apps that use mobile phones to capture and process multiple images.

Advances in software, particularly in the realm of point cloud processing and mesh generation, also contributed to the growth of the 3D scanning industry. The technology is becoming more precise, faster, and easier to use. Applications of 3D scanning range from industrial design and manufacturing to healthcare, cultural heritage preservation, and virtual reality. Machine learning and artificial intelligence are also being integrated into 3D scanning processes to enhance automation and improve the accuracy of data interpretation.

Such scanners find applications from engineering and architecture to film making and computer game production. In our workshops, this potentially allows us to work with objects that are otherwise difficult to measure or reproduce. In particular, 3D scanning allows us to capture and reproduce 'organic' or decorative shapes. There are numerous potential uses, but some of them are:

- Scanning existing objects in order to produce patterns for castings.
- Scanning irregular shapes to allow 3D printing of mating components.
- Rescaling real-world objects (even people) to use with scale models.

Making unusual or awkward shapes using modelling clay, card or other items to make a mock up object which can then be scanned and manufactured in a more durable material.

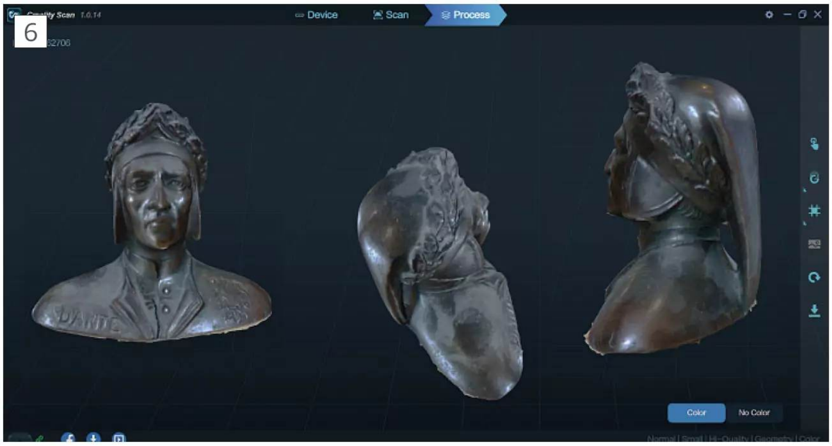
Scanning generally produces output as STL or OBJ files to a good degree of accuracy (potentially within a fraction of a millimetre). These can be edited

The Creality Scan Ferret on its tripod/ power grip.

The Scan Ferret in its storage case.

Contents of the case.

The texture map creates a surreal perspective of an object.



Three views of a scanned bust in Creality Scan (composite image).

Original and 3D printed object.

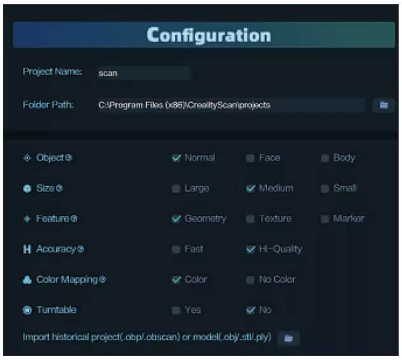


Figure 1

in programs such as Blender and (with a fair amount of fiddling) even imported into most 3D CAD programs - although this can involve exporting via another format.

The scanned and edited object can be reproduced. The obvious approach is 3D printing, but in you could cast metal objects from 3D printed patterns or use a CNC milling machine.

The Creality Scan Ferret

The curiously named 'Scan Ferret' is a compact scanner aimed at the hobby market, that uses a combination of depth sensing IR and visible light cameras, **photo 2**. It can be used in combination with a turntable or in a handheld mode attached to a mobile phone.

The scanner comes in a nicely presented case, **photos 3** and **4,** together with a handgrip/tripod (which contains a rechargeable battery to power the scanner if used with a mobile phone), a phone clamp, a gimballed mount for the scanner itself and several leads. There is also a USB key with the necessary

Using a book and lazy susan to aid scanning. This steel bench block did not show up well in infra red.

This doubled up scan of a 1/32 figure lacked detail.

Good old Action Man! Realistic hair, eagle eyes and gripping hands all in working order.

software, although Creality recommend downloading the latest version.

I found that patience and practice are required to get the best results, it's important to adjust the settings to suit the subject, **fig. 1**. The scanner can capture a 'texture map', **photo 5,** alongside the 3D information. This is used to 'wrap' the scanned data. **Photograph 6** shows a composite image with various views of a scan, and **photo 7** compares the original object with a 3D print of the scan. Dimensionally they are almost identical, but the 3D printed scan is not as crisp in the detail and smooth surfaces are slightly uneven. I think it's fair to say that the result on this little bust of Dante Alighieri was a success (although I'm not sure what use I have for one, let alone two Dantes...)

For use with a mobile, the phone holder fits between the tripod/grip and the scanner mount and a three-way cable joins power source, mobile and scanner. I was able to load the Android version of the app and it worked with my phone. However, I had problems using the Scan Ferret with my mobile phone. The first issue was that my SD card was short of space, so I had to move a fair bit of data to my computer to free some up. But the real problem was that my phone just wasn't fast or powerful enough, despite being a fairly recent Samsung Galaxy (my model isn't on the list of compatible phones). I was able to make captures, but it was tricky, and I generally ran out of capacity before completing a scan. Hopefully my next phone will be powerful enough to use with the scanner.

I had much more success using my PC to capture scans, although I found that the process isn't always straight forward. The biggest issue was scanning small objects steadily, and the solution was getting a kitchen turntable or 'lazy susan', **photo 8**. It's certainly worth watching the Creality tutorials online as well, note that they recommend a manual, not automated, turntable. With an object centred on the turntable, the software guides setting the scanner at an ideal distance. You then start scanning and rotate the object until its image turns green, see photo 1.

If the scanner loses its way you have to backtrack. I also found that it was worth

The scanned figure printed well.

doing a second rotation to fill in any gaps, and to move the scanner by hand to bring any hidden surfaces (such as the top of the model or overhangs) into view. This can be a frustrating process if parts of the object are not clearly visible to the infrared cameras.

My biggest mistake was starting on small objects; the scanner works best on larger objects. Creality demonstrate it scanning a sofa, although it will scan objects down to smaller than your fist. The first serious project I attempted was to try and scan a 1:32 scale crewman for an ASRL, with the intention of printing a double sized version at 1:16. This took many attempts, and the final result was very lacking in detail when printed, **photo 9**.

I remembered that somewhere in my father's house were my brother's old Action Man figures. I managed to find them and dress one appropriately for a 'turret gunner', **photo 10**. Scaled to fit, I was very happy with the result, **photo 11.** The print even has a slightly flattened nose, the result of an accident in the 1970s! The larger figure scanned much better, although I found his shiny black plastic boots would not scan – until I dampened them then coated them with flour! This is something of an issue for engineering subjects as I've found steel won't scan either. In professional scanning it's not unknown to spray objects with a coating of grey primer or similar.

After 3D resin printing a Brodie helmet for the figure and making a 'buoyancy jacket' out of felt I was able to scan a second crewman. The big advantage of such a figure is that you can adapt them to any pose you want. I should mention that the capacity for the Scan Ferret is such that you can scan whole human beings, so the option of getting someone to 'dress up' and scanning them is there. My limited experience of larger scans is that they are faster and easier to achieve.

I should draw attention to some of the limitations of this process. The scan of a 3D printed spaceship model in **photo 12** shows some of these**.** The clear canopy was not transparent to IR and scanned as a surface, yet the texture map shows a model figure inside, as if printed on the surface. The loose canopy dislodged during the scan and this shows up as some raggedy glazing bars. The four small 'cannon' on the nose did not scan well and some of the lower edges are rather rough. You may also see that part of the surface on which the model was standing has scanned as well. These are not fatal flaws, but would need to be corrected in a 'post scan edit' – a skill in need to work on!

Full details of the Scan Ferret can be found at www.creality.com/products/cr-scan-ferret-3d-scanner. I've found it a fun and useful device, even if I did get frustrated at times. My overall impression is that 3D scanning has much promise, but that at the moment it is almost as much of an art as a science. ∎

This scan shows some of the capabilities and the limitations of scanning.

A Metalwork File Storage System, Part 3

Alan Bryan completes the process of design and planning behind his file storage system.

Cutting To Size – nearly!

Once I had all six of them glued-up and dried it was back to the table-saw.I have an extrusion which clamps onto the rip fence on my saw which is around 15mm high so I could use this as a guide for the top edge of the sheet which was assembled with the strips on it and subsequently trimmed flush. It enabled me to make a parallel cut along the bottom edge through each complete step to create a square and clean edge. Thus, if the second glued on sheet had projected over the edge of the first one, it did not affect the straightness of the cut which sliced through the entire step.

I used a fine-toothed blade to give a clean and splinter-free edge to the entire step. It was a clean-up cut which removed only a minimum amount of material, but it meant that I could then take a second clean-up cut through the entire step thickness along the top edge to produce a second mono-planar surface, parallel to the bottom edge. I performed that sequence of operations on each glued-up step sub-assembly. I also hand-sanded the top face of each step with 120 grit aluminium-oxide abrasive on a 150mm-long, rubber-faced sanding pad.

With that done, I mounted my cross-cut sled on the saw table and reduced each side edge equally to produce a mono-planar surface, square to the top and bottom which reduced the overall length of each step to 425mm. I used a stop block on the sled to ensure that all steps were cut to the same length. When all six were cut to equal length of 425mm, it was time to do more gluing.

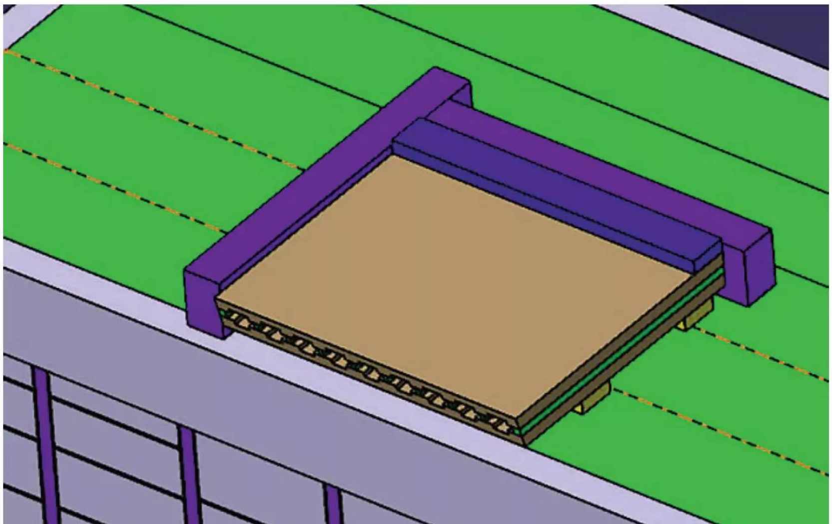


Figure 22

Two Steps Are Better Than One

When I designed it, my aim was to produce glued sub-assemblies of a thickness that I could just pass through my table saw. That meant that I could glue two steps together and still cut through both cleanly in a single cut. So, starting with the 14-inch step, I marked a line 50.8mm or 2 inches below the top edge. I then applied adhesive over the entire mating side of the 12-inch step and aligned the top edge of it with the line. I again used the fences secured to the bench, but with a 50.8mm wide by 45mm high spacer strip placed along the edge to ensure that the top edge of the steps would be parallel, as illustrated in **fig. 22**.

Then, I pushed two sides of the smaller step against the fence and spacer to locate it with it sitting on blocks on the bench thick enough to allow clamps to be inserted. I then carefully placed the larger step on top of it, pushing it into the corner created by the two fences. I began to clamp the two blocks together whilst attempted to compensate for the tendency of one block to float away on a film of adhesive as previously mentioned. After much tapping with the plastic mallet and continually loosening and tightening the clamps I finally had it gripped together securely. It was then placed into my 6-inch bench vice with pieces of 18mm plywood to spread the clamping force against each vice jaw and slowly tightened. I then added more clamps until I had approximately twelve employed to try to spread the clamping load equally. I did that with all six steps, producing three sub-assemblies. Each sub-assembly was then allowed to dry overnight.

That produced three step sub-assemblies looking like **fig. 23** but without the angled cut at the bottom. That will be the operation after the riffler and needle file step is constructed.

A Home For The Rifflers

For the riffler and needle file step I had to produce a three-sheet

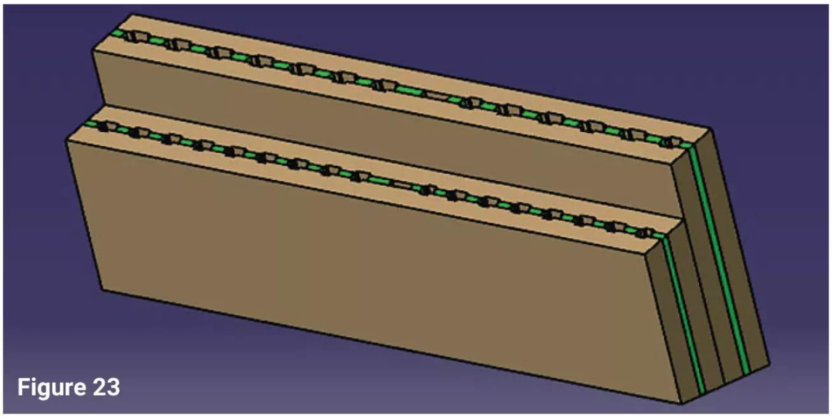


Figure 23

lamination which was a much simpler process in comparison to the stages that I had to go through to produce the 4-inch to 14-inch steps. I cut each lamination to the same 430mm length and width before gluing them together whilst aligning them using the two-fence principle already practiced on the larger steps. They were all clamped up and allowed to dry overnight. Once dried into a solid lamination I cut the bottom edge squarely parallel to one of the top edges using the reduced height fence on the table saw. That edge was then used to permit the top face to be cleaned up into a 54mm nominal width co-planar surface. It was sanded as were the others and then the block was reduced in length to 425mm using the crosscut sled along with the other steps.

I now had a rectangular prism of laminated plywood that was ready to be drilled to accept the riffler and needle files. I did that on the Bridgeport mill using the DRO to position each hole, not forgetting that the block was still 5mm overlength. Once all the holes were drilled, I sanded the top edge again and removed all thin strands of wood left behind by the drilling process. It produced the block shown in **fig. 24**.

Final Trimming

I now had three glued-up pairs of steps, plus the three-sheet-lamination for the rifflers and needle files. It was time to reduce the overall length of each glued-up pair to the finished 420mm. As previously mentioned, I had calculated that my saw had an adequate cut depth to allow me to cut through the thickest sub-assembly and also to cut the 15-degree angle on the bottom of each. Or at least I thought that it did, but I'll get to that in a minute. So, the length reduction was simple to do, using the cross-cut sled with a clamped on stop

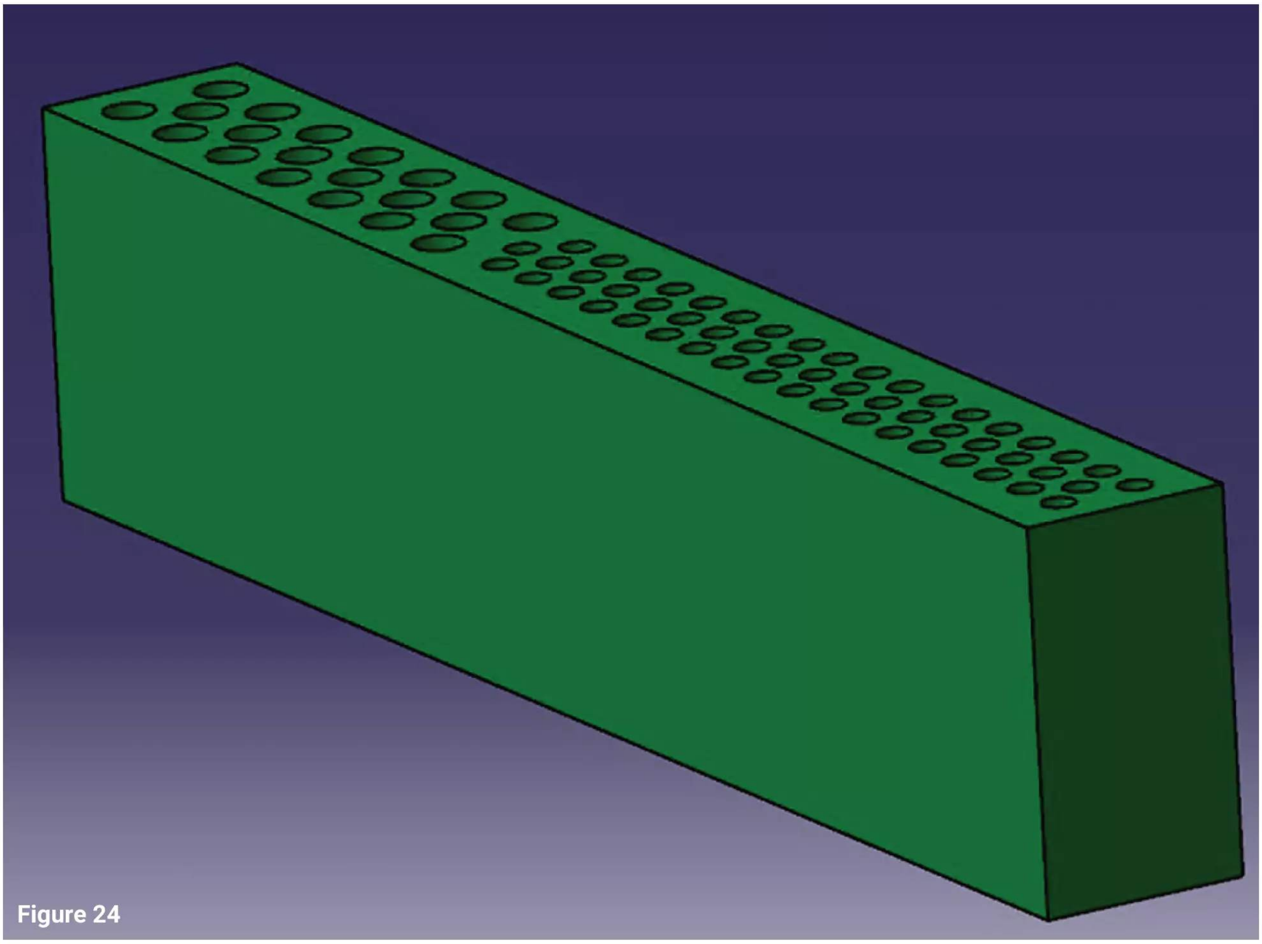


Figure 24

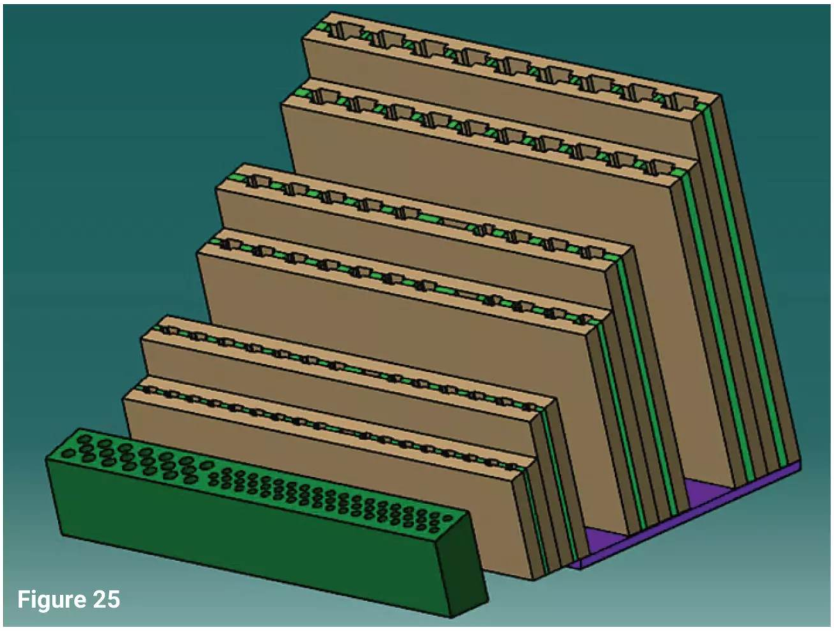


Figure 25

to enable repetition. However, when it came to the 15-degree cut, I was only able to perform that on the riffler and needle file step and on all the steps up to and including the 10-inch. I had miscalculated the depth of cut that was achievable with the blade arbor angled and it failed to completely sever the bottom on the glued-up pair of 12-inch and 14-inch blocks.

Not to be put off, I made a cup of tea and exercised some grey matter. I wanted to achieve a coplanar surface at 85 degrees off-square to the front surface of the step pair and I didn't fancy edge planing plywood by hand to true it up if I cut it off using a handsaw down the kerf left by the table-saw. Therefore, I moved the rip fence to the other side of the saw blade to see if I had adequate room to cut through from the back face of the step and found to my relief it I did. It was then a simple matter to align the edge of the cut with the saw blade to achieve a surface that was a pretty good approximation of what I needed. I now had all my pieces ready for a final glue up, **fig. 25.**

Overcoming A Slight Headache

At this stage I should have been feeling quite pleased with myself because I'd overcome several problems which mainly centred around alignment of the pieces whilst clamping things together, but it suddenly dawned on me that I didn't have that many suitable sized clamps to handle the completed block assembly. Plus, by now the kit of parts was gaining weight and, whilst not being excessively heavy, was somewhat awkward to manoeuvre

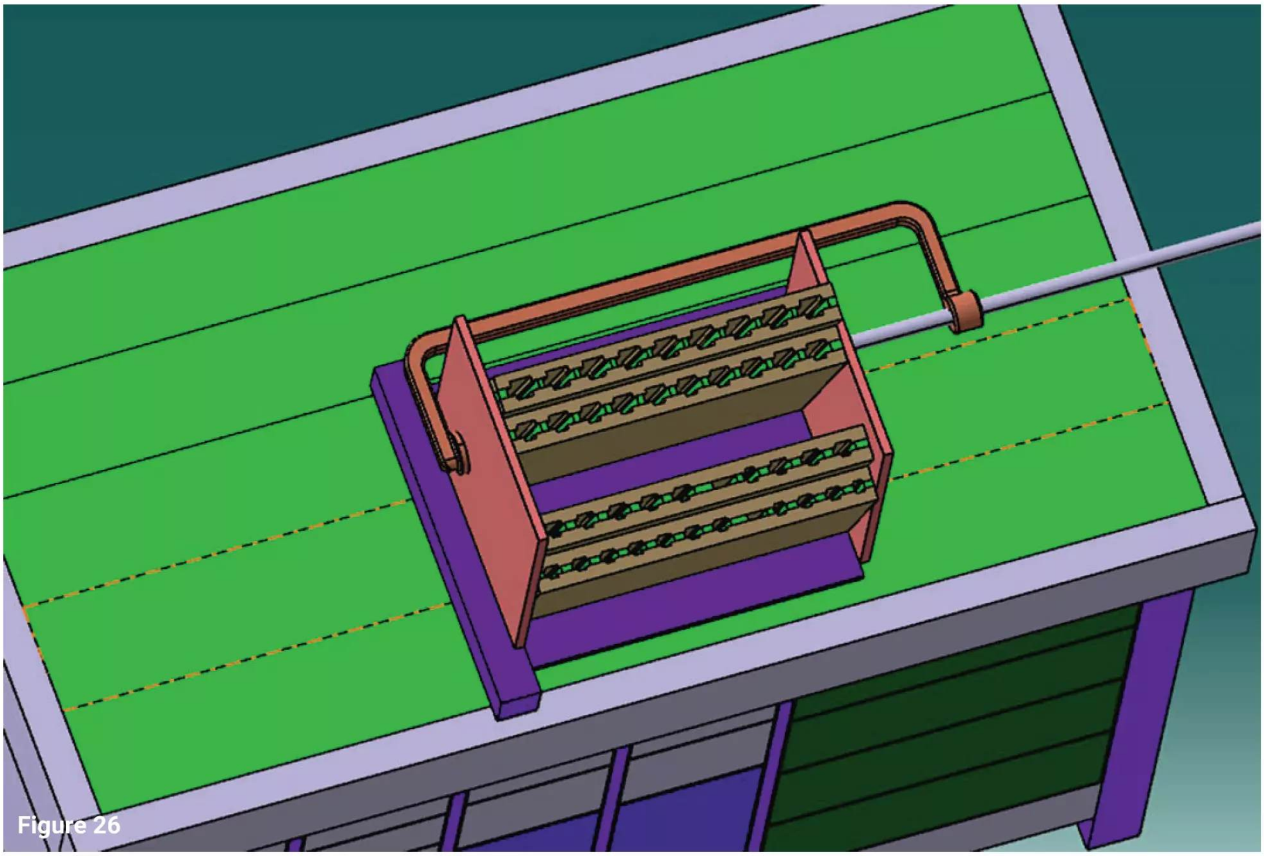


Figure 26

when weighted down by the addition of six heavy wood-working clamps. As always, it came down to ensuring that parts remained aligned whilst tightening up the clamps. How was I going to do it? Again, the principle need was to eliminate the tendency of the parts to float out of alignment when tightening the clamps and nothing came to mind as a method. I seriously contemplated quitting the project at this point.

I don't like to give up though and eventually decided to let gravity assist me by sitting the angled faces of the two sub-assemblies being bonded onto the base to align the sub-assemblies vertically whilst ensuring the blocks couldn't slip lengthways by clamping a sheet of plywood at each end of the 12-inch and 14-inch sub-assembly. Thus, it was straightforward to butter the mating back-face of the 8-inch, 10-inch sub-assembly with adhesive and then I slid it between the clamped-on end plywood sheets whilst keeping the angled face in contact with the baseboard. **Figure 26** illustrates the procedure.

Final Assembly

Now I encouraged the smaller sub assembly rearward towards the larger one until the back surface of the 10-inch set it sat back against the front face of the 12-inch step I could then carefully and gradually clamp both sub-assemblies tightly whilst keeping the angled faces hard against the baseboard by tapping them with the plastic hammer. Fortunately cutting all the pairs of steps blocks to the finished length of 420mm had produced blocks of equal length so the smaller step didn't stick or bind between the clamped-on sheets as it moved rearwards. **Figure 27** shows it clamped up.

Once I had both sub-assemblies aligned and the clamps reasonably tight, I carefully removed the two end alignment boards and added more clamps. Then I fully tightened them all whilst constantly checking that nothing moved. I allowed them to dry overnight.

The next morning, I removed all the clamps and checked how the alignment had held. To my relief it was very good indeed. That proved to me that the principal was sound, so I set off to repeat it by clamping the riffler and needle file block to the 4-inch and 6-inch sub-assembly. I won't repeat it because it was done virtually identically to the first process. After it had dried, I again checked the alignment and was pleased to find that it had remained well aligned during the assembly process.

That left me with two somewhat larger sub-assemblies shown in **fig. 28**. which I encouraged into alignment by repeating the process.

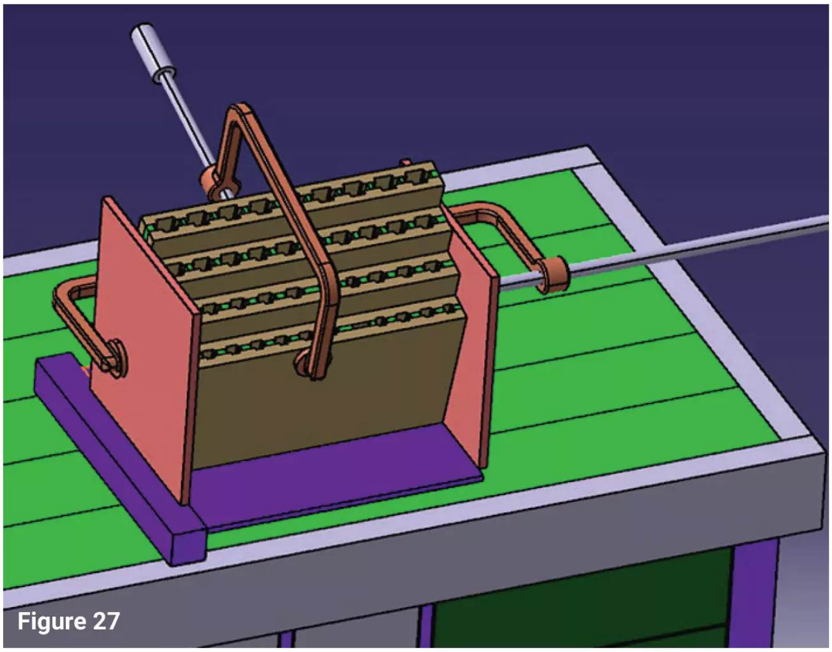


Figure 27

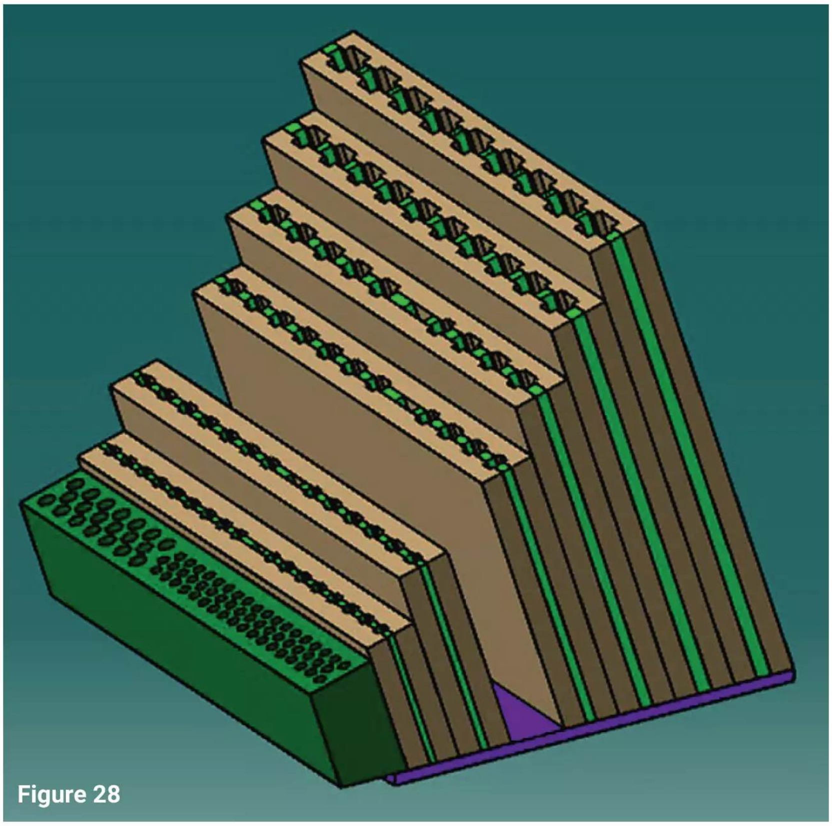
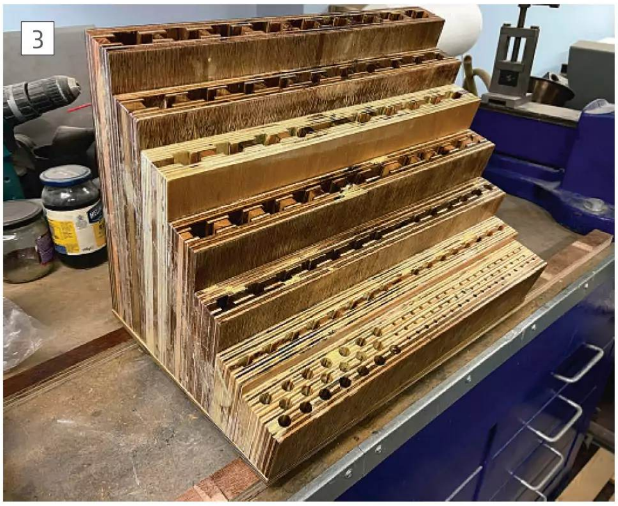


Figure 28



Success

I'm pleased to announce it was successful as **photo 3** Shows.

I finished the block assembly by hand sanding it using 120 grit aluminium-oxide paper. Where the plywood had inevitably splintered or voids in the laminations had occurred, I filled the imperfections, along with the saw-cut marks that the table-saw had left behind, with epoxy wood filler before sanding. The entire block and the base separately were then given three coats of linseed oil. Each coat had the surplus removed after application and the final coat was buffed up by hand. Hopefully it will prove to be fairly oil resistant. I then screwed the base on and fixed 3 plastic feet, so it sits on the bench without rocking, **photo 4**.

I had several chest handles which I'd purchased several years before as a package from Screwfix. Considering that the block and files weigh nearly 36kg I decided that for safety's sake there needed to be handles that could be easily gripped to move it. Those chest handles, one is shown in photograph, **photo 5**, fit the bill very well, folding away neatly when not in use.

Pictured filled with files in **photo 6**, it sits firmly on the bench, occupying a minimum of bench-top space with each file readily to hand.

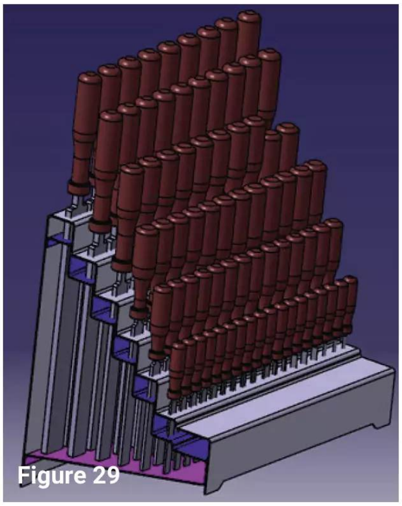


Figure 29

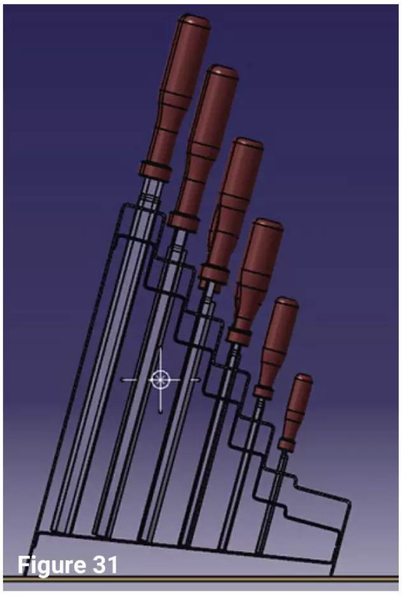


Figure 31

With The Benefit Of Hindsight

Since completing the storage block, I've had a rethink about how it could be made.

Examples are: -

1. 3D Printing from plastic materials-I haven't got a 3D printer yet! It's on my list of future desirable purchases but I haven't yet got around to buying one. If I had one and decided to use it, I would perhaps design it around the principle of printing a number of modules, each consisting of several steps or parts of the steps. The size of each module would obviously depend on the build volume of the printer of course. Material choice will be quite

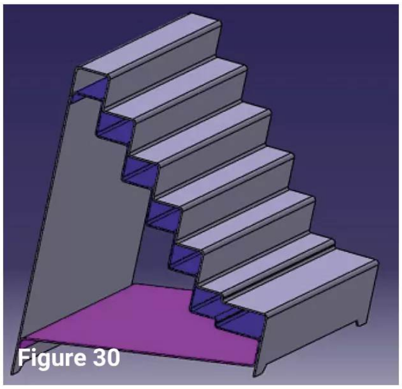


Figure 30

important because it will need to possess a reasonable resistance to the abrasion caused by inserting and withdrawing files but that shouldn't be a problem given the number of different filaments now available. The finished modules could then be bonded together or perhaps a design could be realised which allowed the modules to clip or snap together. I haven't gone into the concept in detail because I haven't yet got a 3D printer, but who knows maybe I might get one someday.

2. Fabrication from laser or waterjet cut and folded blanks in aluminium or steel as **fig. 29** shows.

This would have been my favourite; had I been prepared to source new materials and farm out some of the work. My proposal consists of three sheets of 2.5mm thick aluminium. I haven't shown the slots necessary to accommodate the files, but the patterns would have been like that adopted for the wooden block that I made. I would have specified laser cut blanks and since I don't possess a metal folder, I would have asked the laser cutter to score all the fold lines to permit clean bends. I would then have positioned the parts within each other and TIG welded them after tacking it together.

The complete fabrication weighs-in at just over 4kg after making an allowance for the slot piercings, which is a big reduction on the 13.6kg of the wooden block. The blue inner stepped profile controls and stabilises the position of each file as well as stiffening the whole fabrication whilst the pink base profile controls the depth that the files are inserted into the storage block.

At 420mm long by 335mm wide it's a similar footprint as the wooden version so it still uses the minimum of bench space. With the same quantity of files to the wooden fabrication the overall appearance of the selection is as shown in **fig. 30**. **Figure 31** illustrates that the Centre of Gravity hasn't moved much either.

Postscript

If you've got to this stage in the text, then I'm extremely grateful to you for reading this far. Hopefully, I've been able to whet your appetite for adventure in several different directions. Whether it's setting out to streamline your storage of precious files, which face it are no longer a cheap item and therefore deserve proper care in our workshops. Or maybe I've encouraged you to use your CAD system for more than just basic 2D drawing and modelling single components. Possibly I've also persuaded you that it pays to select different materials from items that you and others decide to discard and instead, store them for future re-purposing. But then you already do that. Don't you? The solution that I have designed and constructed performs well for my needs, it should prove to be very durable, and hopefully it will for you also if you decide to make something based on it. It's especially encouraging to note that the only item which I had to buy before commencing the project was adhesive. That's a completely new experience because I usually have to place orders for material or fasteners etc. before starting a new project because I always lack something specific from the BOM (Bill of materials) that I always create before starting. Actually, I don't create it because the CAD System does it for me automatically and I only need to format it into an Excel Spreadsheet. I have produced a full set of drawings for the block and I can make them available in PDF format if there are any readers that would like a set. I can also provide 3D solid models in STP format which can be read in most 3D CAD systems if there is a demand for it. Please contact me via the editor if you wish to acquire further data.

Two Tips for the Workshop

Jaques Maurel offers a couple of interesting ideas.

M. Maurel's Fly Trap.

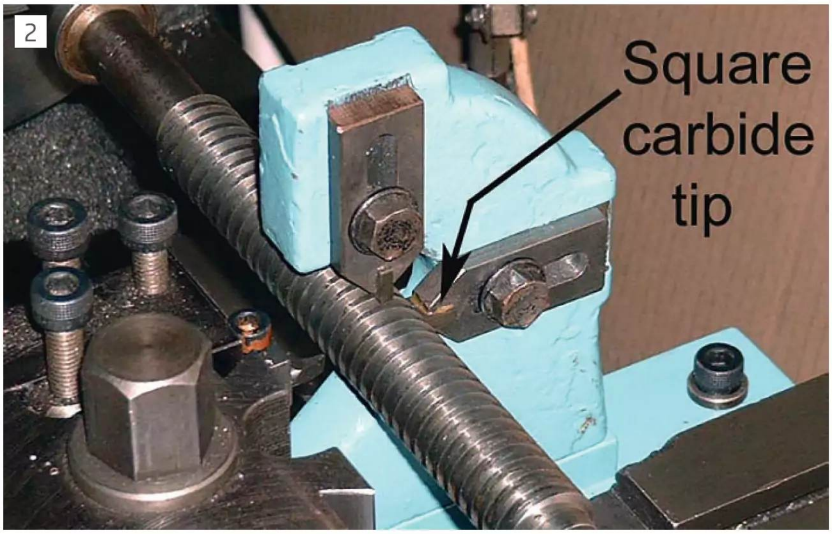
A dam for coolant (and more...)

Usually the coolant crawls slowly along the vice until seeping down out from the machine, and preferably on your feet! A piece of double sided tape (the thick type with a foam center layer) makes a very efficient dam to force the coolant back to the machine table. Don't remove the outside layer, unless there are many flies in your workshop in which case this will make a very efficient fly catcher too as you can see in **photo 1**.

Hard pads for the travelling steady

I use small square carbide tips stuck on mild steel with epoxy glue, **photo 2,** to get hard travelling steady pads. This was made after a great scare when screw cutting, the carriage was still moving while the half nuts was opened! The soft pads of the steady, slightly machined by the cut screw crests, was acting as a nut on the machined screw.

It's possible to use HSS tips – easier to find or make than carbide ones, even hardened carbon steel can be used, while not as hard as the carbide ones.



Fixed steady modified with hard pads.

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■ Myford ML7 240V, motor re-ground bed and saddle, new tailstock barrel, half nuts, Oilite bushes, engraved dials, 3&4 jaw chucks, 3 way tool posts Jacobs chucks etc, etc, could possibly deliver, West Yorkshire area, £1250. **T. 01988 500645. Newton Stewart.**

Models

■ For sale due to health conditions. 3 ½ gauge Doris, part made, comprising cheddar boiler with manufacturer's certificate, rolling chassis with wheels, cylinders, valve gear etc. plus a quantity of fittings and brass sheet to aid completion. £1,150. **T. 01772 322 073. Preston.**

Parts and Materials

■ Part built Stuart No 10 vertical steam Engine, plus parts to finish the model. Complete with parts list, instruction leaflet and plans for suitable boiler. £50. Buyer collects. **T. 01952 257816. Telford Shropshire.**

Magazines, Books and Plans

■ Disposing of a collection of Model Engineer and Model Engineers' Workshop magazines. Believed to be a complete set of all editions from 2008 to 2023. Free but must be collected from my home in Surrey. **T. 07802 291166 or Email bob.ely@gmail.com. Surrey.**

Wanted

■ Wanted for Pultra Microlathe 1750 a 3 jaw self centring chuck with integral collet/spigot. Also spigotted slotted faceplate for same machine, will collect upto 100 miles, cash paid. **T. 07903 856407. Cambridge.**

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