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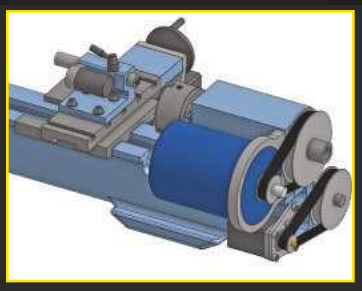
Peter Barker on Scraping Lathe Headstock Bearings



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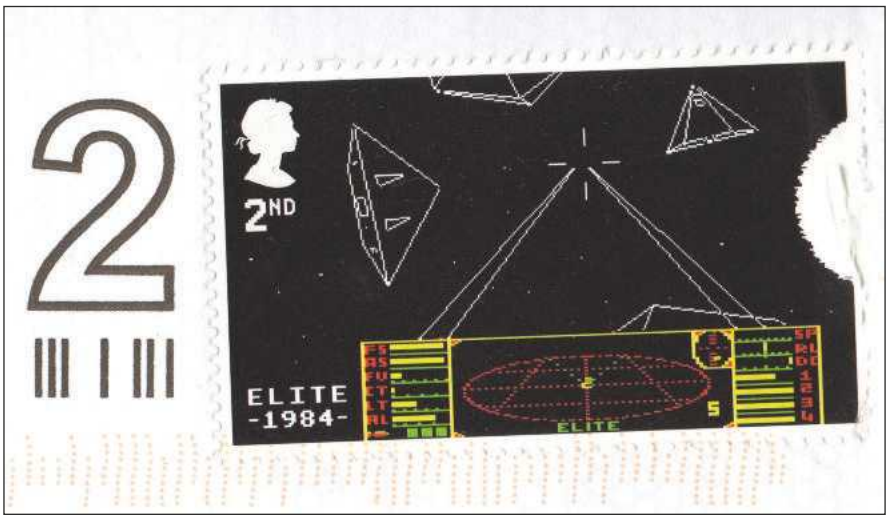
On the Editor's Bench



Computers

A few days ago, I was watching a news report on my phone; and it made me remember seeing the Sinclair portable pocket TV, with its 'bent' cathode ray tube as a teenager. Haven't things changed! I was reminded again of this when opening an envelope with a 'reader's ad' inside – the stamp caught my eye. It was a screen grab from 'Elite', a 1984 game for the BBC Microcomputer. At the time it was revolutionary, with three-dimensional display and a huge number of planets created using a new 'procedural approach' – and excellent gameplay. It was so successful that successor version of the game is still available today.

How well do you remember your first introduction to computing? We had one locked in a room at school that no-one hade ever used! The first one I saw properly was when my dad took to me to a 'Computer Fair' in Porthcawl, and a friend of his got an Acorn Electron. I was absolutely amazed at what I saw. I also remember a less successful session with a schoolfriend when we painstakingly copied a program for 'Life' into his ZX80, which ran for several minutes before it overheated (or we knocked the RAM pack...).

I was fortunate to be able to learn several programming languages at university, including Algol, the wonderful Pascal and FORTRAN 66, an abomination which ought never to have been inflicted on human brains. A friend worked in a computer shop, so got the chance to use all sorts of machines including the Dragon, ORIC and Sinclair QL as well as later coming across the Commodore 64 and Atari machines. Of all the home computers, the one I really enjoyed using the most was the BBC Micro, and I ended up having a Model A with extra RAM and still have a Model B and a 'BBC Master Series Microcomputer'.

I suspect that most readers of MEW started a similar journey and have also gone through seeing computers at work and now at home go through various iterations (remember CP/M?), to the point where the phone in our pockets packs more punch than the computers we worked with in the 1990s!

Despite this extraordinary change, I feel it's only over the last decade, or even the last five years, that new tech seems to be really taking root in our hobby, rather than being a specialised interest. What do you think?

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in our next issue

Coming up in our May issue, number 293, another great read

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THIS MONTH'S BONUS CONTENT

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www.model-engineer.co.uk/42tooth
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Any questions? If you have any questions about our recent Alibre Atom3D or current Lathework for Beginners or Milling for Beginners series, or you would like to suggest ideas or topics for future instalments, head over to www.model-engineer.co.uk where there are Forum Topics specially to support these series.

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A Model Engineers' Fantasy Lathe Concept Design

Alex du Pre shares his thoughts on what might make an ideal lathe

The editor's challenge in MEW285 to design a lathe of the future certainly got me thinking. I am lucky enough to own a Myford Super 7B lathe, a design that is considered by many to be the ideal model engineering lathe and one that has stood the test of time. But it is not without its shortcomings and since it was introduced in the 1950s, technology has moved on. Electronics and computing are now being widely adopted in the maker community with the advent of affordable 3D printers, laser cutters and the like. Many people have fitted CNC upgrades to their lathes and mills and are exploiting the possibilities of programmable microcontrollers such as the Arduino, which have broad application in machine control. Digital read-outs (DROs) are a commonly-used machine tool upgrade.

In this slightly tongue-in-cheek piece, I have set out to propose a concept for a thoroughly modern model engineers' lathe that takes full advantage of this new technology but retains the convenience and versatility of the Myford. My main aim is to provoke thought. I don't claim to have any particular skill in machine design and certainly don't have the knowledge to design the electronics in detail. But as someone who has spent countless hours operating my workshop machine tools, I know all about their best and worst features and which accessories are useful, so I hope my ideas are grounded in some sort of reality.

Please hold on tight as I attempt to reinvent the hobby lathe.

Why is the Myford so good? And bad?

Let's start with a few words about what makes the Myford a great hobby lathe and flag some of its limitations. I also own a combined lathe/milling machine, which is a good basis for comparison. The Myford is a compact and accurate machine with considerable thought given to convenience of use. The drive belts are easily accessible so spindle speeds can quickly be adjusted (I need two spanners, several minutes and a bucketful of patience to do this on my other lathe; consequently it usually runs at inappropriate speeds). The back gear allows a very slow, high-torque spindle speed and also offers a means of indexing the spindle for dividing operations. I love the clutch, which prevents a constant stop-start of the motor. The gearbox gives almost instantaneous access to a wide range of threads and feeds; the changewheels make this a 20 minute job on the other lathe, hence one I rarely bother with. The gap bed, slotted cross slide, power cross feed and flat bed are all great conveniences enhancing the machine's versatility.

On the negative side, the Myford has a small spindle bore (bigger on later models) and it is not particularly rigid, needing careful levelling to remove any twisting in the bed. Minor transgressions, you might say, but when considered alongside the opportunities that modern electronics provide, its shortcomings appear starker. The range of possible threads is limited, and it requires spectacularly rare and expensive extra change wheels to achieve metric threads (on my imperial machine at least). It cannot work fluently across both metric and imperial without further accessories or error-prone calculations by the operator. Without the luxury of the quick change gearbox, you will spend your life calculating gear trains and juggling changewheels. Spindle speeds are adjustable only in fixed steps and the top speed is quite low. Accurate work by reference to the handwheel dials requires a certain amount of mental dexterity and memory. Above all, a range of expensive accessories is needed to permit jobs like long tapers, profile turning, ball turning, milling, repetition work and so on.

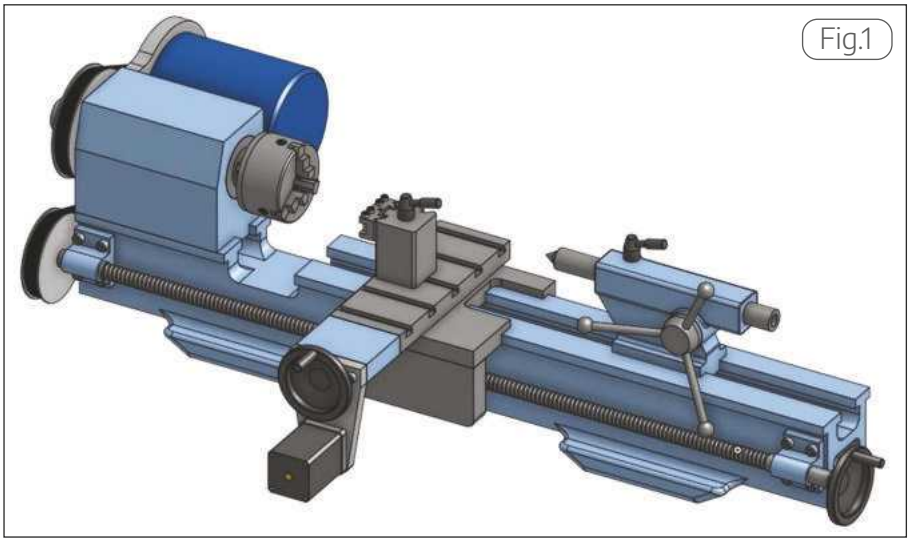
So, let us consider how a modern lathe could alleviate all this misery.

Electronics

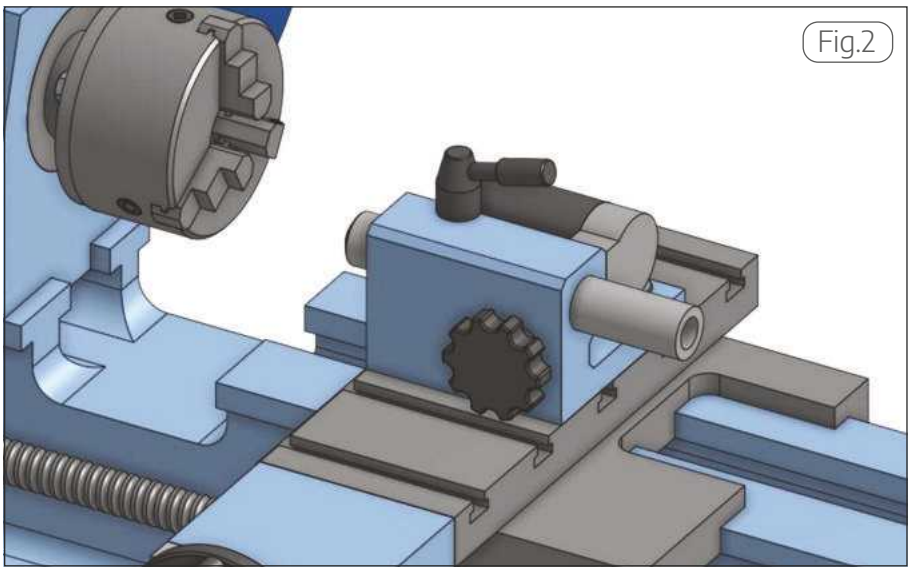
I remember my university lecturer once saying that things which are very complex to achieve by mechanical means are often straightforward to achieve electronically. As a case in point, compare the internal combustion engine and gearbox of a petrol car with the motor and electronic speed control of an electric car; the latter has far fewer components and moving parts. So, on my fantasy lathe, I am going to do away with such horrors as gearboxes, changewheels and adjustable drive belts and achieve the same effect and more with electronics and electrical machinery.

My CNC fantasy lathe

My fantasy lathe, **fig. 1**, is primarily operated by CNC (Computer Numerical Control), which



General view of the lathe with the toolpost and tailstock fitted. The electronic controls and display have not been modelled but are described in the text.



showing the milling spindle attached to the cross slide, aligned with the lathe's spindle axis.

operates the X and Y feeds and controls the position and speed of the spindle (for reasons that I will come back to). CNC means that complex shapes can readily be achieved automatically without the need for some of the aforementioned accessories. The top slide also becomes unnecessary, so is gone. Goodbye also to the screwcutting gearbox and goodbye changewheels (hooray!). At a stroke, our lathe is mechanically far simpler, yet we can turn stepped parts, chamfers, tapers, curves, threads, radii and more with ease, thanks to the CNC. Furthermore, we can let the lathe get on with its work while we do something else, in theory at least, although there is much to be said for watching the machine work while we don't have to. The range of cutting tools needed is also greatly reduced as a reasonably-pointy left-hand and right-hand turning and facing tool, a boring tool and a parting off tool will do for the majority of jobs. We don't need that chamfering tool and all those nasty radius and profiling tools can also go in the bin. Think of the time saved making those!

The X and Y axes are driven by motors connected to zero-backlash ballscrews. Since a DRO is fitted, the positions of the carriage and cross slide can be measured by the electronic brain of the machine, so the precise position of the cutting tool can be confirmed and adjusted, without simply relying on electronically counting the steps of stepper motors.

The spindle is under CNC control too, so that screwcutting operations are fully automated via the synchronisation of the spindle rotation and X and Y axis movements. This also permits a spindle indexing capability that I will tell you about in just a moment.

Manual control and DRO

As this is a CNC machine, there is a computer under the cabinet and a shelf for the keyboard and mouse. The screen is positioned alongside.

For simple, one-off jobs and for convenience, I still want some manual capability on my lathe, so I have added a couple of controls for forward and reverse variable speed power feed to the X and Y axes and similar for the spindle control. The digital read out displays on the computer screen rather than on a separate console and does not require the computer to be fired up to operate. As the manual control is via these power feed controls, we could also say au revoir to the handwheels and handwheel dials and spare ourselves the stress and exertion of winding them by hand, but for convenience I have left a handwheel on each axis but there are no dials. For those who would shun the convenience of metric measurements, no problem, the DRO will switch over to imperial at the touch of a button.

The spindle is fitted with a variable speed control, allowing infinite speeds between zero and full speed, forwards and backwards, when under manual control. As this system allows the motor to be gently ramped up to speed when restarting the spindle, I am happy to dispense with the spindle clutch, giving a further saving in hardware and component count.

I feel it is important to be able to operate the lathe manually without going through the CNC interface. All computer users will be familiar with the 'installing update 1 of 30,000, come back another day' type of message and we certainly don't want to have to put up with this, or indeed the time taken for a normal boot up, when sneaking out to the workshop for a five minute job. So the lathe can be worked in an electrically-assisted manual mode using the aforementioned controls.

A lathe is a lathe

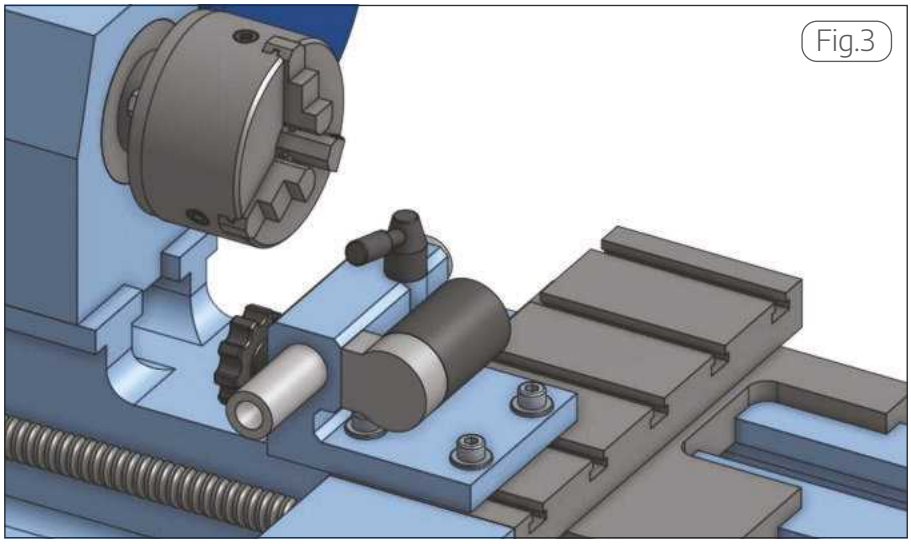
Despite, or perhaps because of, being the owner of one myself, I am not a fan of combined lathe/milling machines. The design of such a machine is inevitably a compromise and much time can be wasted setting up and converting from lathe mode to milling mode and back. Such an arrangement does not make for productiveness. The main reason I have kept my combined machine is that it has a much more powerful motor than my X3 mill and the Myford, so is good for roughing out work on large lumps of steel when the need arises, saving time and preserving the other machines for more delicate work.

I have not, therefore, tried to make my fantasy lathe double as a milling machine, i.e. where the cutter is held in the lathe's spindle. If you want to do meaningful milling, you really need a dedicated milling machine in my view. However, a normal lathe does have some inherent milling capability and a large, T-slotted cross slide is useful for mounting accessories and workpieces so I have retained this feature. A vertical slide could also be fitted for small milling work. But you are going to have to buy a milling machine too, I'm afraid.

That said, I do want my machine to allow a full range of milling and dividing operations on the turned work. This is where CNC offers some significant extra capability, through the ability to index the spindle.

Dividing

Milling operations on work held in the lathe chuck is something that I want to take full advantage of in my design. Construction articles often say things like 'transfer the workpiece and chuck bodily to the mill for



The milling spindle fitted perpendicular to the lathe's spindle.

dividing operations'. Well, thanks but no thanks, I say. Who needs the hassle? A standard centre lathe has the majority of the features necessary to turn it into a dividing head so my design goes the extra mile in this regard. The necessary electronic trickery is provided to index the spindle through any number of divisions or angular spacings; there none of the impossible divisions of the mechanical equivalent. The dividing is controlled from the CNC interface. The electrical machinery will be sufficiently robust to withstand machining forces, but a mechanical spindle lock is also provided for good measure.

The computer control of the spindle also permits it to function like a rotary table, in that the spindle can be rotated through known angles for machining features like curved slots, equally-spaced or otherwise. Even more complex 3D shapes can be machined by synchronising the spindle rotation with the X and Y feeds, all thanks to the CNC control.

Milling spindle

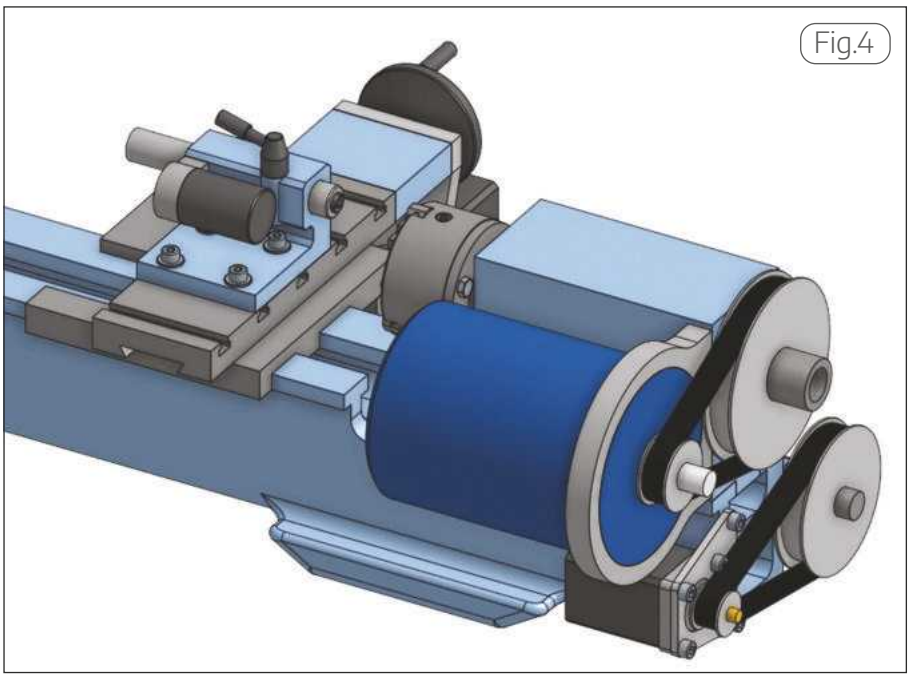
To apply the cutting tool for dividing and milling work, a milling spindle is provided. This is a removable attachment fitted to the cross slide in place of the toolpost. The spindle is horizontal and can swing about a vertical axis through any angle from 0 to 90 degrees or more for milling axial and radial features, **figs 2** and **3**. At the 0 and 90 degree positions, the cutter can be applied by the X and Y feeds respectively, but at intermediate angles this doesn't work so the milling head needs its own travel. For simplicity, this is a manual feed controlled by a fine-feed handwheel and graduated dial (just when you though such things were obsolete). I have left the automation of this feed as a potential upgrade for the hackers and tinkerers.

The milling spindle is bolted to the cross slide in place of the tool post and the side and front edges of the base are machined square to the spindle axis to allow it to be accurately set at the required angle. For work like gear cutting, the spindle must be mounted vertically via an angle block. Helical gears may be cut by mounting it at an angle and using it in conjunction with the CNC. In case you were wondering why I made the milling spindle swing around a vertical axis rather than 'up and over' around a horizontal axis, it is because of the extra movement that is available by exploiting the cross slide movement, allowing greater capacity.

The milling spindle nose is compatible with ER20 collets which give a holding capacity of 1 to 13mm. It is unlikely that a machine of this size will be able to drive a milling cutter much above 10mm in diameter, but ER20 gives a bit of room for holding gear cutter arbours and the like. A boring head can be mounted instead of the collets.

Ideally, the milling spindle needs to be able to operate at high speeds, say 5000rpm, for drilling very small holes, but also needs slow speed and high torque for things like gear cutting at about 100rpm. Modern brushless motors perform well in this regard, but if a compromise is needed, top speed will be sacrificed in favour of slow-speed torque.

> The main drive motor must provide sufficient grunt to power the lathe to its top speed of at least 3000rpm for small work but maintain high torque down to the slowest speed of 30rpm for large-diameter turning work.



rear view of the headstock showing the spindle motor and the carriage feed motor. The drive is via toothed belts in both cases.

Lathe motor

The main drive motor, **fig. 4**, must provide sufficient grunt to power the lathe to its top speed of at least 3000rpm for small work but maintain high torque down to the slowest speed of 30rpm for large-diameter turning work. It must also be hooked into the CNC control for the indexing, screwcutting and taper-turning operations. Regrettably, my knowledge of how to achieve this is somewhat cloudy, but I am confident that it is readily achievable using today's CNC technology. Perhaps others can fill in the gaps here?

Specifications and features

As you can see from the illustration, the layout and proportions of the machine are based on the Myford, but the lines are simpler than the Myford's slightly organic shape. The bed and headstock are massive and rigid iron castings. The bed is a box section to give greater rigidity than the somewhat bendy ladder shape of the Myford's bed. The lathe will still need to be levelled properly so as to remove any twist as the mounting bolts are tightened down.

I have stolen the Myford's flat bed in preference to the double-vee approach of some lathes as it gives a convenient flat surface which is useful for various purposes. I imagine it is also comparatively easy to make and regrind, should this become necessary.

The carriage and cross slide are also based on the Myford, since they warrant no improvement. Locks are fitted to these items. The headstock runs in a pair of good quality tapered roller bearings, as appears to be the general practice for modern hobby-level lathes.

I don't intend to give detailed dimensions since I am only presenting a concept design, but the approximate specification is as follows, which, in my opinion gives a good capacity and a convenient size for a typical small home workshop. The machine is similar in size to the Myford, on which the general dimensions are loosely based. It could be scaled up or down.

Centre height above bed	150mm
Centre height over gap	200mm
Distance between centres	600mm
Spindle bore	26mm
Spindle taper	No. 4 Morse taper
Tailstock taper	No. 3 Morse taper

A gap bed is a handy feature that allows larger discs to be machined. The spindle bore of 26mm is selected as this will allow up to 1in diameter barstock, still a standard size, to be accommodated. This dictates a No. 4 Morse taper for the headstock, and the slightly smaller No. 3 taper is selected for

›

the tailstock. Morse tapers allow commonly-available tooling to be used.

Spindle nose

I love the convenience of the Myford's threaded spindle nose, but alas, it will not be suitable for this concept as a more secure and unscrewable method of mounting the chucks is needed due to the milling capability. So I have gone with a simple flange mount, whereby the chuck is secured with three bolts. This is a bit of a pain in practice as it takes longer than simply unscrewing the chuck, but it is a reliable and secure approach, compatible with hobby-level chucks. A cam lock arrangement could be used as a better, but more expensive, alternative.

Collets and other tools can be held in the MT4 taper, either directly or via a chuck or arbor.

Accessories

Standard accessories remain suitable, including three- and four-jaw chucks, faceplate and collets. Conventional travelling and fixed steadies may be used, depending on the work in hand.

Toolpost

Since the top slide can be consigned to history, the toolpost is a simple, rigid structure. I have specified a Dickson-type quick-change tool post since this is convenient in use and allows for rapid tool changes. Fewer tool holders should be required, for the reasons explained above.

Tailstock

The tailstock is to a standard pattern, with the exception that it has a lever-feed rather than a handle. This is something I have yearned for on my own lathe as it is convenient for drilling operations, particularly when it is necessary to peck at the work to remove swarf, as it generally is for drilling. The tailstock does not need to be able to be set over for the purposes of turning slow tapers as this is done by the CNC, but set over is needed for aligning the tailstock precisely with the spindle so this feature remains.

Capstan

I have specified a capstan attachment for this lathe, **fig. 5**, possibly as an optional extra. This is fitted in place of the tailstock and allows up to six tools to be presented to the workpiece in quick succession, for example centre drill, drill, tapping size drill, tap, when making a tapped hole. The tools required are fitted to the turret on the capstan and are brought to bear by indexing the capstan. They are applied to the work using a lever feed, as for the tailstock. A multi-stop is fitted to the turret to control the feed for each tool. Broadly the same effect can be achieved using a tailstock turret, but this is a slightly less robust solution to the capstan.

Although by no means a new invention, I felt that a capstan was compatible with this lathe as it allows for higher levels of productivity than manual tool changing in the tailstock chuck and it is easy to envisage that the capstan's feed and indexing movements could be readily automated by an intrepid fettler, which is in keeping with the CNC ethos.

Item	Cost min, £	Cost max, £
Basic lathe and motor	2000	4000
Stand	100	200
Chucks and accessories	300	500
Toolpost and holders	200	400
DRO fittings	300	400
Stepper motors	200	400
Ball screws	200	400
CNC electrics	300	500
Milling attachment	500	1000
Capstan attachment	500	1000
Computer and hardware	300	500
CNC software	150	250
Total	5050	9550

Control interface and computer

A basic desktop computer is required to drive the CNC functions of this lathe. A CNC software package is also needed of course, and several suitable options are available for the hobbyist, so this will be down to personal choice. Other hardware is standard too; keyboard, mouse and screen of a size to suit your preference. And remember that the screen also shows the DRO feed, so some kind of switch box will be needed.

Cost estimate

It seemed only fair that I should have a go at working out the cost for this lathe and so defend my assertion that it should be within reach for the amateur. The yardstick is, again, the Myford, which sold for about £10,000 at today's prices. On the basis that many Myfords demonstrably were sold to amateurs, this might be considered to be within the realms of the affordable, but considering the sorts of machines that are available from today's mass market, ten grand should buy you a fair bit of machinery and is an absolute upper limit.

CNC machines such as 3D printers are prevalent these days, selling for hundreds, not thousands, of pounds at the lower end and show that CNC electronics can be very inexpensive. Large, good quality lathes of eastern build are now available new at prices that would make a Myford blush and electronic bits and pieces sell for peanuts via on-line retailers.

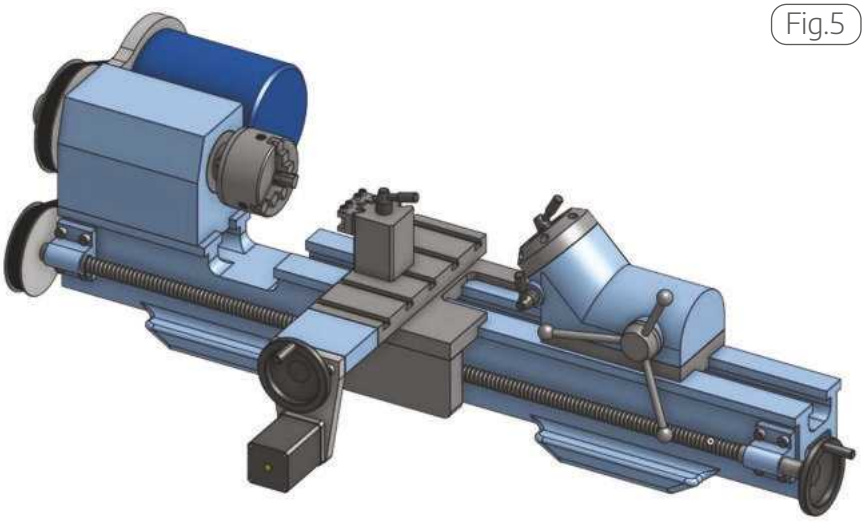
So here's how I think the cost might break down, remembering that the basic lathe is mechanically very simple.

I think even the minimum cost estimate is reasonably conservative and I have built in a large fudge factor to the maximum costs. This crude estimate, briefly researched, suggests that £5000 is realistic and that even at the outside, the fully equipped machine should be within the costs of a new Myford.

Conclusion

I hope this article has met the brief to propose a fantasy lathe. By all means throw stones at it, it is meant to stimulate debate. If it is not already plainly apparent, I am no expert in the finer points of CNC machinery so it would be really interesting to see my ideas given a wire brushing by someone with greater knowledge. A machine like this could be produced from a suitable donor lathe by a competent amateur. ∎

Fig.5



the lathe with the capstan attachment fitted in place of the tailstock.

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Metric Myford Threads

Dear Neil, the literature on cutting metric threads on a Myford 7 Series lathe refers to the use of a 21 tooth change wheel which is now effectively extinct. I have prepared a table showing gear trains for all the ISO metric series threads in my copy of the Dormer Tap and Die Handbook using the readily-available 42 tooth change gear instead. I have attached it as a PDF.

Please feel free to print this if you think it will be of interest.

I have not carried out a check that all these trains are immediately useable – some of the tooth counts may need massaged to fit.

This table refers to lathes without the QC gearbox.

Peter R Hastings, Skye.

Thanks Peter, I will also make your table available at www.model-engineer.co.uk/42tooth -Neil

Metric threads on a Myford 7/Super 7 lathe using a **42** tooth change wheel

Leadscrew pitch = 3.175mm (8 TPI)

metric pitch	Driver	driven	D	d	D	d	ISO thread series	
0.20	24	50	28	80	30	80	coarse pitch	fine pitch
0.25	25	50	27	75	35	80	M1.1, M1.2	
0.30	24	50	27	60	35	80	M1.4	
0.35	27	50	28	60	35	80	M1.6, M1.8	M1.7
0.40	24	50	35	75	45	80	M2	M2.3
0.45	27	50	35	70	**42**	80	M2.2, M2.5	M2, M2.6
0.50	30	50	35	75	45	80	M3	M4, M5,
0.60	30	50	**42**	75	45	80	M3.5	M3
0.70	35	50	**42**	75	45	80	M4	
0.75	27	40	35	60	45	75	M4.5	M4, M6, M8, M10
0.80	30	50	**42**	60	45	75	M5	
0.90	27	40	35	50	45	75		M5
1.00	40	50	**42**	60	45	80	M6, M7 & 0BA	M8, M9, M10, M12, M16, M20, M24
1.10	27	40	35	50	55	75		
1.20	30	40	**42**	50	45	75		
1.25	35	50	45	55	55	80	M8, M9	M12, M14
1.30	39	40	**42**	60	45	75		
1.40	27	30	35	50	**42**	60		
1.50	27	40	35	45	45	50	M10, M11	M12, M14, M16, M18, M20, M22, M24, M25, M32
1.60	45	50	**42**	55	55	75		M20
1.75	35	40	**42**	50	45	60	M12	
1.80	27	40	**42**	45	45	50		
2.00	**42**	50	45	55	55	60	M14, M16	
2.25	**42**	40	45	50	60	80		
2.50	**42**	40	45	50	50	60	M18, M20, M22	
2.75	**42**	40	45	50	55	60		
3.00	**42**	40	45	60	60	50	M24, M27	
3.50	**42**	40	45	50	70	60	M30, M33	
4.00	45	40	60	50	70	75	M36, M39	
4.50	**42**	40	60	50	45	40	M42, M45	
5.00	**42**	30	45	50	50	40	M48, M52	
5.50	**42**	30	45	40	55	50	M56	

DISCLAIMER

Although I have checked the mathematical accuracy of this table I have not assembled or tested the gear trains themselves. They may require idlers or they may require rearranging to give a workable gear train.

Peter Hastings
January 2020

peter_at_muclocks.co.uk

additional change gears

39T	once
28T	twice
24T	3 times
27T	10 times

idler gear

repeated gears

Another Ham Workshop

Dear Neil, The January issue #289 just arrived and my first read was from Shaun O'Sullivan. The opening few paragraphs pretty much describe myself, except I am a Chartered Electrical engineer!

I also had to do a short workshop course at the beginning of my university studies, and fell in love with the machines, and nearing the end of my working time, I decided to purchase a mill/drill and lathe – to 'have a play', and support my various hobbies.

Like Shaun, I gained my amateur license while at school when I was 16, but unlike Shaun, I allowed mine to lapse while at university. However, a few years back, I met a couple of local 'hams', who then pestered me to renew my license, so I am now the holder of and Advanced Amateur license with my old callsign VK3ZUS. That has meant building antennas and obtaining a couple of towers (which still are laying horizontal L). I am yet to try microwave comms and am more interested in HF for its potential range, and I was surprised Shaun didn't list his callsign.

My machinery has been involved making LED lights, automated windows on a greenhouse, repairing a water pump engine, milling a modified bellhousing for a mate, with a bunch of projects in the pipeline for 'when I get some free time'. It's interesting to read the range of interests your readers have, with mine starting from electronics, and moving through music making, astronomy, and photography.

I look forward to more varied articles from your talented contributors.

Regards (or should I say 73)

Brian Sala, Pigoreet, Australia

Collectible Lathe Brochures

Dear Neil, In reply to the letter about Machine of the future, MEW March 2020:

Everybody is hastening himself to the latest State of the Art future proof equipment, CNC and Water-Jet et cetera.

This leaves room for hobbyists to restore and collect older Lathes.

Within this field of interest, a new niche has also developed, many people are already familiar with the collecting of vintage classic car brochures, which is now broadened to collect older brochures of (sometimes defunct) Lathe companies, these can be regarded as industrial heritage.

Henk de Ruiter, Giekerk, Holland.

Tapping with a Safe -D-Speeder

Dear Neil, I refer to the article in MEW 291 on "Repairing a "Safe-D-Speeder". Readers may like to know that, in addition to the slow drilling of larger holes, these useful gadgets also work very well for tapping smaller holes, say up to about M6, depending on the material being tapped.

They work well as used both in the lathe and the milling machine. I attach a couple of (posed) photos - one showing the 3/8" model set up for tapping a brass bar M5 in the lathe and the other showing the 1/2" model set up for tapping a brass flange M6 on the milling machine (note: on the milling machine, I would be using the DRO to obtain the exact PCD hole positions both for the drilling and tapping operations).

The reduction is 4:1 for both models which very nicely reduces the slowest milling machine speed to a more comfortable tapping figure. There is no speed reduction when used in the lathe, but in my case, the lowest speed obtained with the back gear is already low enough for tapping. Importantly in both cases, the need to grip the housing of the epicyclic gearbox to put the drive through enables one to retain a good "feel" for the torque being exerted on the tap which greatly helps to avoid breakage - the really good feature of this system being that the drive stops immediately one lets go of the housing. So, if you feel or hear the tap struggling, you simply let go! And if the milling machine has reverse rotation, then the friction in the epicyclic gearbox is often sufficient to remove the tap at 4X the tapping speed which is rather nice. It is of course necessary to do up the chuck pretty tightly to avoid the tap slipping. But, all-in-all, this is a very quick and reliable method for creating smaller tapped holes.

I don't have much call for tapping larger holes, but when it arises I either use a JSN-12 reversible tapping head in the milling machine, thread cut them on the lathe or do them by hand the old-fashioned way - with a tap wrench.

I use HSS spiral flute machine taps for blind holes which bring the swarf out of the hole backwards, and HSS spiral point machine taps for through holes (as shown in the milling machine photo) which project the swarf out of the hole forwards. These taps are a bit more expensive than ordinary ones but are well worth it - I have never yet broken one. I have successfully tapped stainless steel flanges using the above, but should there have been a problem, then I would have had to move to specially hardened HSS-E machine taps (with an accompanying pain in the pocket - eg £16.50 for one M5 tap!).

Hope this will be of interest to those with lots of otherwise tedious tapping to do. As far as I can tell, the Mason Master Safe-D-Speeder is no longer made (shame), but ebay will produce several used models (which some vendors now class as "vintage" - I remember it well, so perhaps I'm vintage too!).

Thanks for a splendid magazine - I learn at least one new thing in every issue!

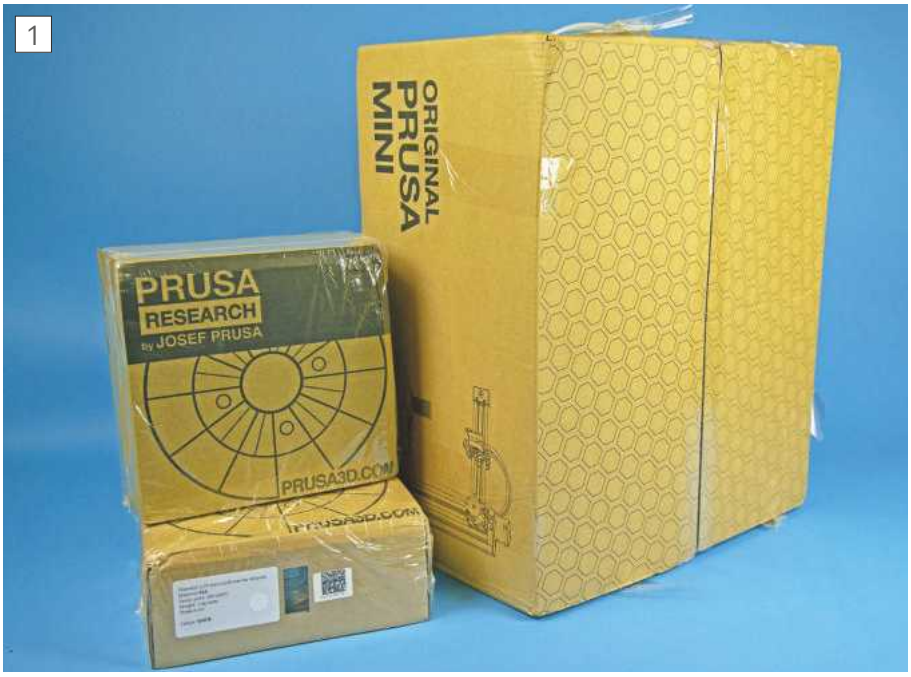
Nigel Morgan, by email.

The Prusa Mini, a small but versatile 3D-printer

Martin Petersen reviews a new, compact 3D printer

Prusa Research are well known for their I3 series 3D-printers, the current model is I3Mk3S that has been in the market since spring 2019. In October Prusa released the new Prusa Mini Printer, a somewhat smaller 3D printer with a price tag that is less than half of the Prusa I3Mk3S kit. The Prusa web shop opened for pre-orders on October 24 and got more than 1000 orders during the first 24 hours, although the lead time was about 6 weeks, **photos 1** and **2**. In various 3D-printing forums the design was discussed and there were a lot of questions regarding the single Z-column design, is it stable enough to get a good printing quality? After running the printer day and night for several weeks I can confirm that stability is no problem, the print quality of the Prusa Mini is even better than the I3Mk3, **photos 3** and **4**.

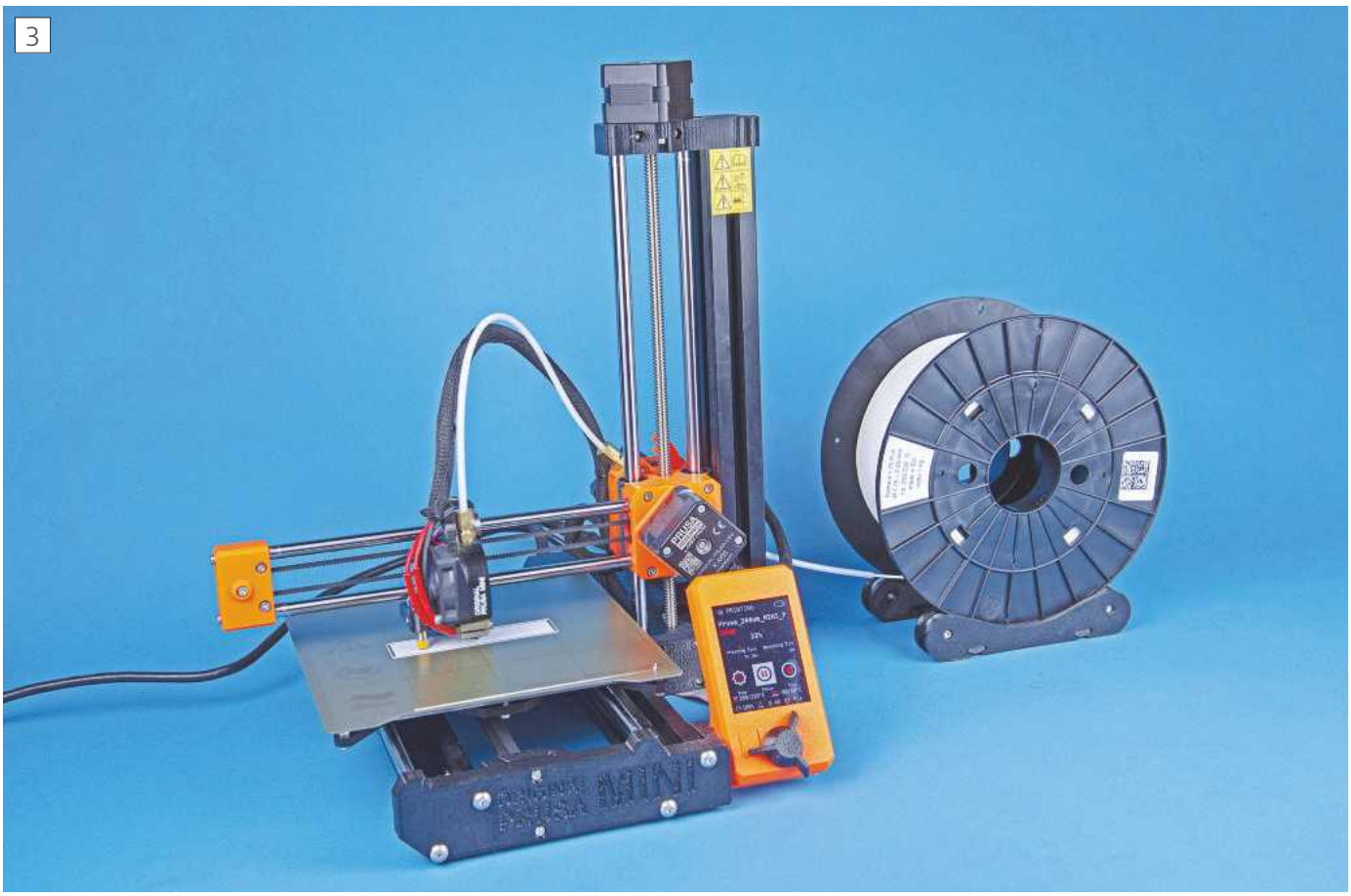
The specification for the printer is quite promising. Print volume is 180x180x180 mm (7 x 7 x 7"), magnetic heat bed with removable spring steel sheet, maximum nozzle temperature of 280 °C and maximum bed temperature of 100 °C enabling printing in the most frequently used 3D materials such



The printer came in a sturdy box, I added two rolls of filament to my order.

The box content, note the bag of candy, the gummy bears are strongly associated with the Prusa printers.

3

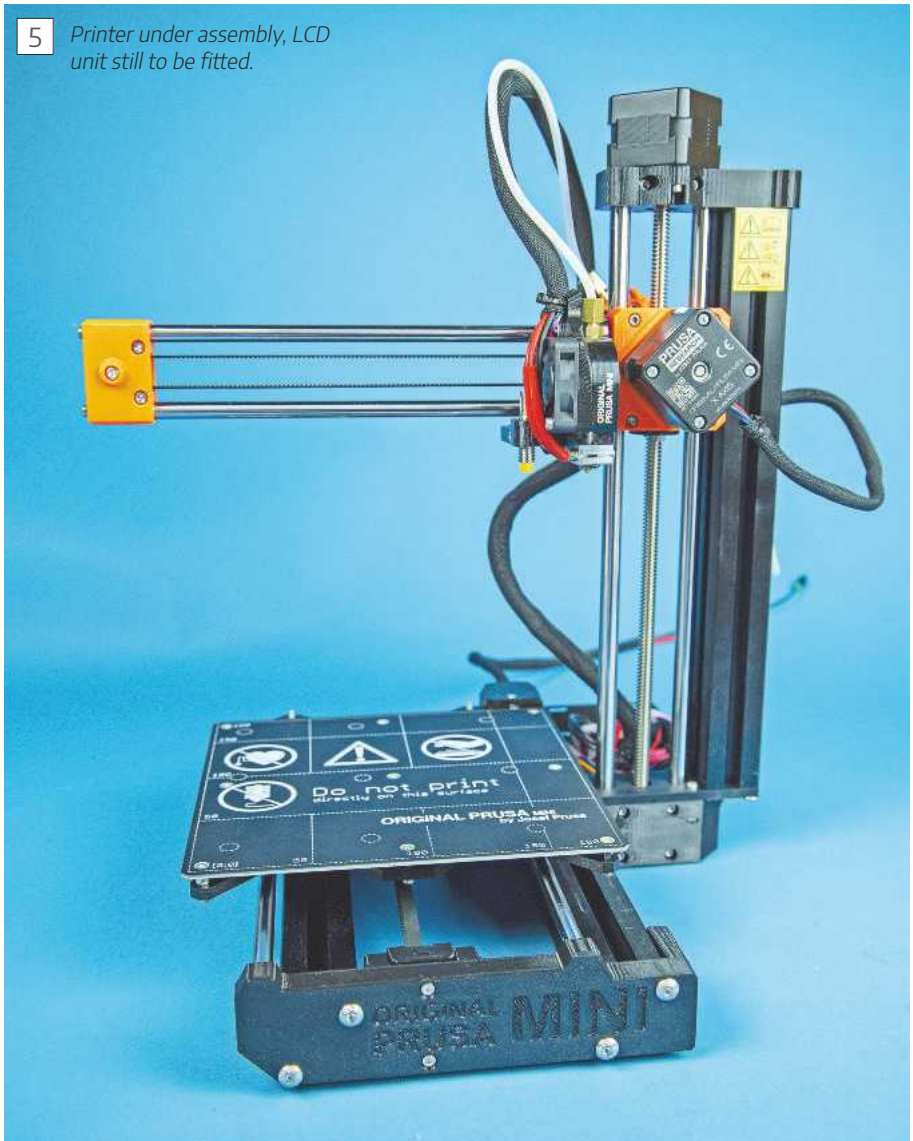


First print running in the printer

4

The sheep is a test model that is presliced by Prusa and shipped on the USB-stick

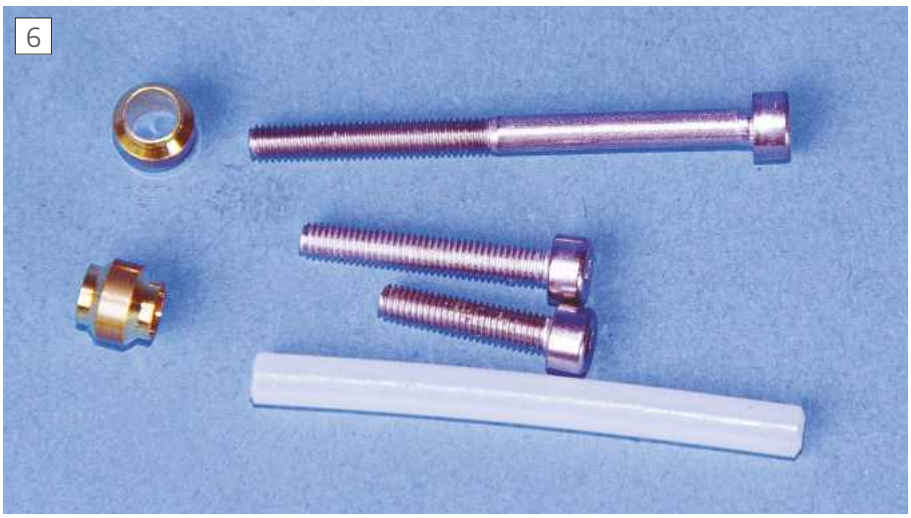
5 *Printer under assembly, LCD unit still to be fitted.*



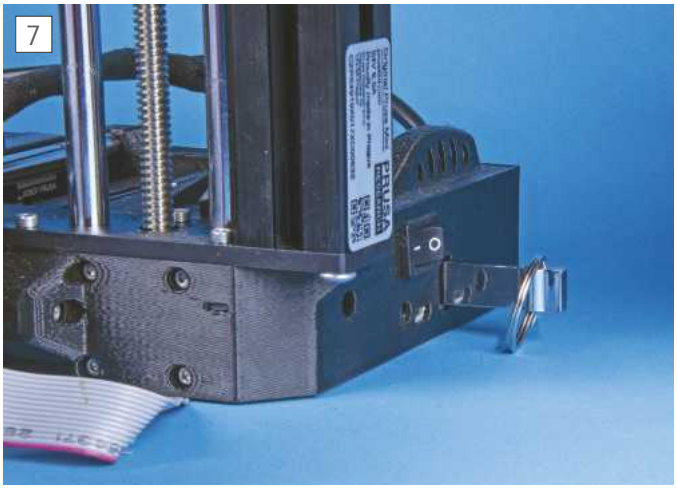
as PLA, PETG, ABS, ASA and flex, but too low for some exotic materials. The extruder uses V6 standard nozzles with a diameter up to 1 mm. A brand new 32-bit motherboard named Buddy controls the printer. The user interface is handled by a rotary encoder on the LCD-module that has a 65k colour LCD. The Mini uses USB as print medium but can also be connected by LAN and Wi-Fi (this needs a separate module that is yet not available). The software is prepared for external control for running the Mini in print farms, but this feature is yet not enabled.

I received my printer a few days before Christmas and my first impression was that the printer is rather cute, is very small compared to the I3Mk3S although the print area is only 27 % smaller than its bigger brother, **photo 5**. The colour LCD with

Ideally the bearings should be filled with grease, but then partial disassembly of the machine is needed, I just added some light machine oil on the steel rods.



Spare parts shipped with the printer



The USB position is a bit awkward.

The spool holder is a bit weak

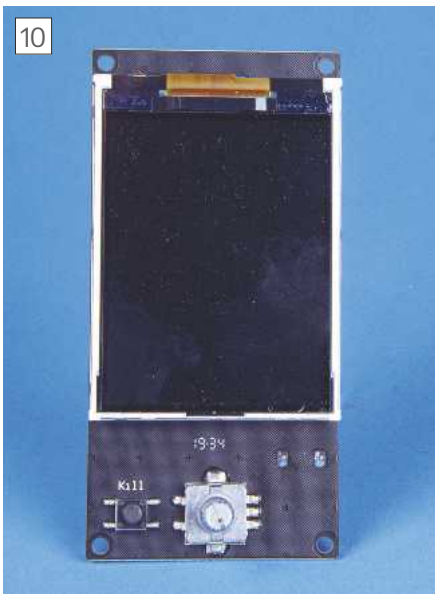
graphical user interface looks fashionable, it's just a pity that it is not a touch screen, but I guess that is a cost issue. The printer is supplied with a few spare parts, **photo 6**. Other things I do like with the Mini are the automatic bed levelling and the exchangeable print sheets. The smooth PEI sheet is standard, but for 30€ extra you get the powder coated sheet too, the powder coated sheet is wonderful for PETG prints as no separator (glue stick, hair spray, painters tape etc.) is needed and its fairly easy to get good adhesion of prints. The filament sensor is also an add-on, that costs 20€. If printer is bought without the add-ons they can be purchased separately and added later. The footprint of the printer is 330 × 370 mm (13 × 14.5") but as filament feeding is from the right side in the original set up the spool holder occupies almost the same space, but there are ways to solve this. Designs for top feeding of filament are available at Thingiverse, just search for Prusa Mini. The Bowden tube can also be replaced with a longer one if needed, it is a standard PTFE tube available in shops selling pneumatic/hydraulic hoses.

The Mini is a quiet printer, when I measured with my iPhone, I got the reading 40 dB at a foot distance. Although some lubrication is needed to get it this quiet, initially the machine was louder as the bearings are delivered dry. Ideally the bearings should be filled with grease, but then partial disassembly of the machine is needed, I just added some light machine oil on the steel rods.

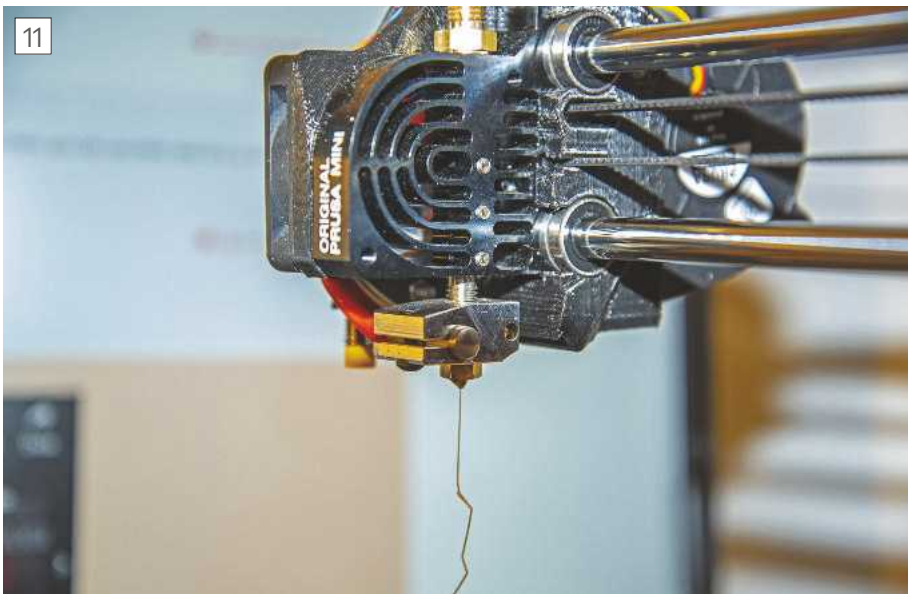
Some things that I do not fully like with the Mini are that the USB socket is quite far back at the right side of the printer, the same side as the filament feeding and is a bit tricky to reach, **photo 7**. I have seen solutions to this too - a USB extension cable that moves the socket to the LCD unit, designs are available at Thingiverse and Prusaprinters.com. When working with the printer it is easy to touch the hot end by mistake as it is not very well protected, I have burnt my fingers several times. The MINDA probe used for the bed levelling has no temperature compensation and this makes the printer sensitive to surrounding temperature. If temperature changes, a new first layer calibration may be needed. The lack of temperature compensation is a cost issue, Prusa has made every effort to give the printer an attractive price tag and that need some compromises. The spool holder is another of those compromises, it is flimsy, **photo 8**, but printing a better one is an easy task, there are many spool holder designs on the net.

The user interface is brand new, the colour display presents the selections as graphical icons, quite like a smartphone and at next level the selections are presented in lists, **photo 9**. When inserting an USB stick with new firmware the printer requests to install it. When the printer is started it offers to print

The graphical user interface



The rotary encoder broke down at second print.



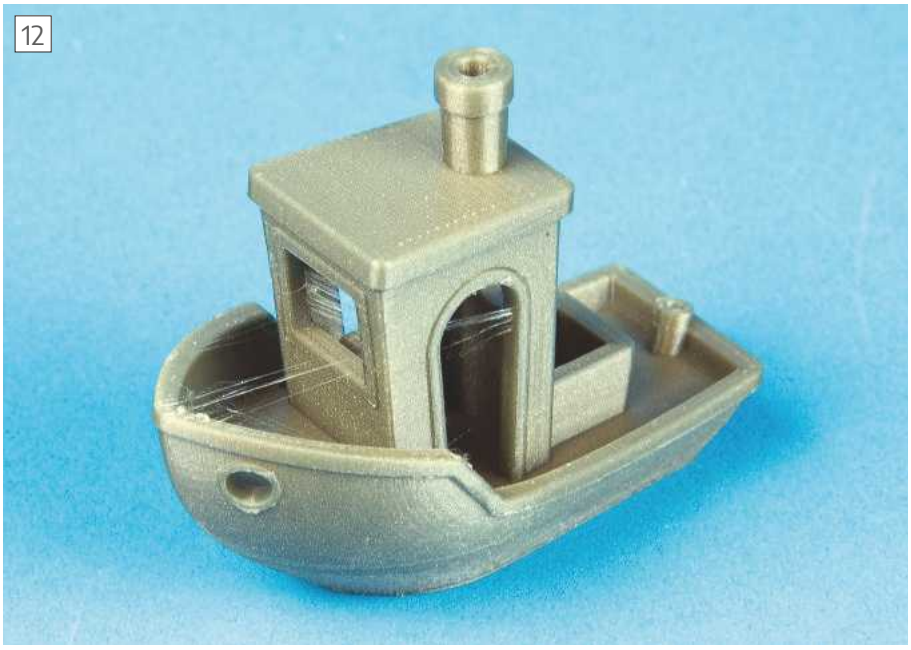
The extruder problem, the unthreaded part of the heat break should not be visible.

> The printer can handle most of the materials used for hobby purposes and the planned software functionability enabling remote control for print farm use seems very interesting.

the most recent file on the USB stick, very convenient. As the firmware is a new design all features are not yet activated, I miss the statistics and the possibility to store calibration for several print steel sheets. I assume those functions will be added in firmware upgrades together with bugfixes. Currently the printer is very sensitive to changes in bed temperature. If the steel sheet is removed, I frequently get thermal runaway. Sometimes the printer needs a restart before a print will start. Prusa has said that there will be frequent firmware upgrades during beginning of 2020.

The early produced printers did have some hardware issues, my printer has serial number 632 and I did run into some problems. The rotary encoder on the LCD module broke down at the second print and the printer could not be used, **photo 10**. The Prusa support was helpful as always and a new LCD module was shipped the next day, but due to Christmas it took two weeks until I received it. Prusa have now changed to another brand of encoders as several defect units were found. Then I got severe problems with jamming and under extrusion, a problem that happened to a lot of the early Minis and was intensely discussed in the forums. It was figured out that this was caused by the hot end in the wrong position, causing a gap between PTFE-tube and heat break in the hot end, **photo 11**. The hot end is kept in position by three grub screws, most likely those were not tightened correctly in manufacturing. Correcting the problem took me just five minutes when I understood the problem. Some printers have got a stress break in the MINDA-cable due to a mispositioned zip tie, Prusa claim this to be a transportation issue, but I am not convinced, I think it is incorrectly mounted in the factory. The design is now updated to prevent this problem. Other problems reported in forums are screws under the electronics box that have scratched the table, this has now been corrected by Prusa by moving one of the printer's feet giving more clearance to the table. A few printers have arrived with broken electronic encapsulation, transport damage that has been resolved by a minor change of the packaging making it more robust.

Overall the Prusa Mini is a very good printer, **photo 12**, at a low cost, there are cheaper printers available but not with this print quality and ease of use. The print area is smaller than most other printers on the market, but enough for 95% of my prints, bigger parts can easily be split in the slicer and printed in sections. The printer can handle most of the materials used for hobby purposes and the planned software functionality enabling remote control for print farm use seems very interesting. On the downside is the current order backlog, orders placed in January are planned for shipping in May. The printer's price is 379€ including VAT but without shipping. A filament sensor is 20€ and dual print sheet (smooth PEI + textured powder coated) is €30 extra. The printer is only sold through the Prusa web shop. ■



Print quality visualized by the classical test model Benchy

Readers' Tips

CHESTER MACHINE TOOLS

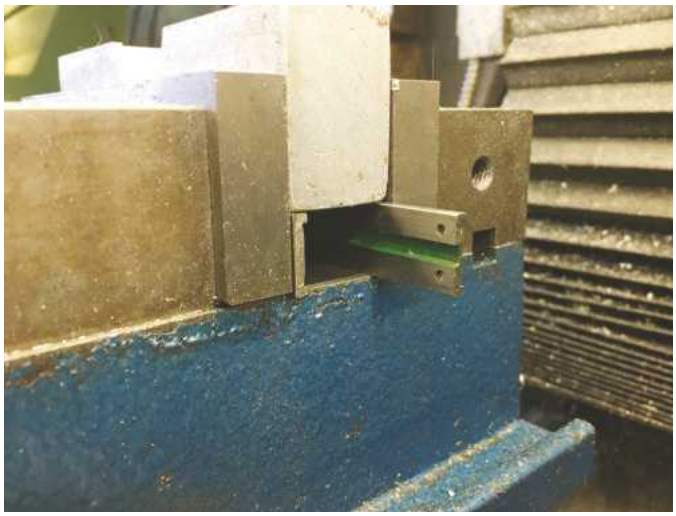
Inexpensive Parallels

TIP OF THE MONTH WINNER!

This month our lucky winner of £30 in Chester gift vouchers is Keith Matheson-McLaughlin with a useful solution for making a pair of inexpensive but accurate parallels.

Here's my tip on producing a pair of narrow parallels for almost nothing. Many of us have a pair cheap digital callipers from Aldi/Lidl. At around £7.99 mine get used rather harshly and get replaced every now and then. Don't throw them away there's some precisely ground material in there! Take apart and Dremel one end off and then cut into two. They are incredibly parallel (less than 0.01mm). I would recommend colour coding them as one calliper is slightly different to the next. I just splashed some Hammerite paint in the recessed groove. Total cost - next to nothing.

I have two pairs so do occasionally stack them in the vice.



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

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

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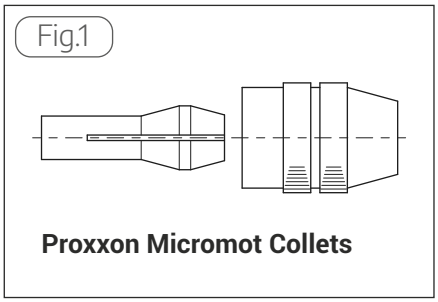
A Tapping Attachment for Small Taps

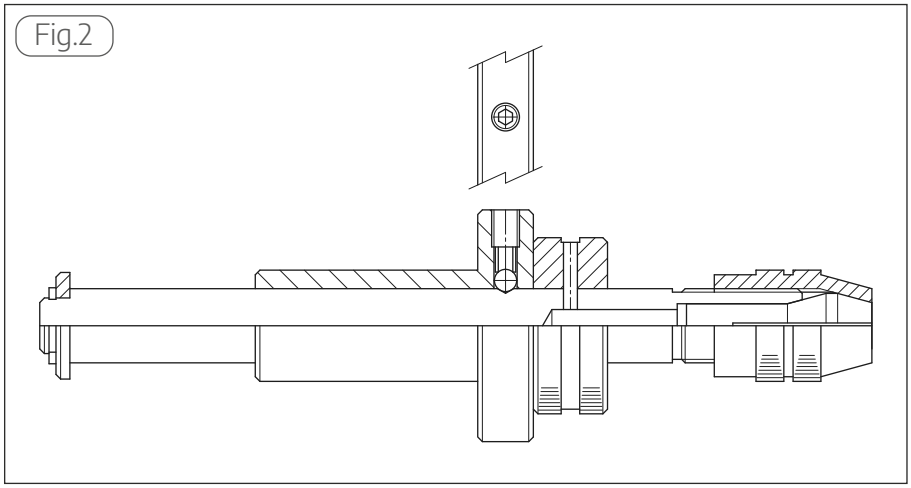
Graham Meek

During my engineering apprenticeship and while working as a toolmaker spanning 40+ years I would imagine I must have tapped countless thousands of holes. During that period, I count myself lucky in that I never suffered a broken tap at work. At home however that is a different matter. I remember the first tap that I broke was a 6BA, I was 16 and had just started work. The job in question was a Stuart 10 V steam engine cylinder casting and I was tapping the cylinder cover retaining holes. The tap was coming through the cylinder flange and I was about to remove the tap, but wanted just one more thread, (big mistake). Below the flange there was a cast radius that blends the flange to the cylinder outer wall. The tapping drill had probably wandered a little as it met the radius and the tap was probably being forced to the one side, hence the breakage. Luckily for me the broken tap was removed on the Toolroom "Disintegrator", what we used to call "Spark eroders" when they first came out, as this was their primary role at that time.

I seemed not to suffer any more tap breakage calamities through the intervening years until I retired about 7 years ago. When in quick succession I manage to go through about one set of 10BA and two individual 8BA taps like they were going out of fashion. I then recounted the 6BA tap saga above, it is funny how these things stick in one's mind. I was beginning to think that BA taps and I were "Jinxed". Recalling the breakage instances, in every case I had been tapping freehand with no support, this was one of my problems. The other I was not to find out until some months later, when I was told I had been suffering some minor muscle spasms which were producing a hardly perceptible involuntary twitch in my arms.

Eclipse 160 Pin Chuck with Phos Bronze bush & 12BA tap





However, before I knew that, and thinking about how I used to tap holes during my career. These tapped holes were more often than not done using the drill chuck in the machine spindle to hold the tap or the use of a spring loaded centre support to follow a Tee Handle tap wrench when tapping smaller holes. The holes usually being tapped as they were drilled so alignment never was an issue. By smaller I am thinking about the M2 to M3 range, or the Imperial equivalents. Recently to avoid bankruptcy when having to use BA taps, I started using my Eclipse 160 Pin Chuck, with a phosphor bronze guide bush held in the collet chuck, **photo 1**. This stopped the run on the bank account, but this approach did have some serious drawbacks.

One of which is the fact that as the pin chuck is extended during the tapping operation the location in the bush is

Fig.3

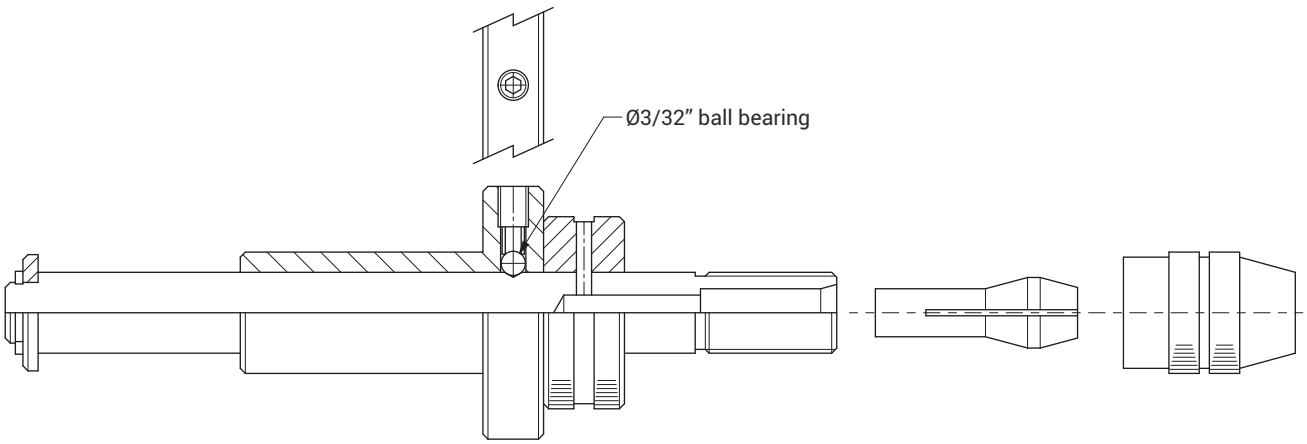
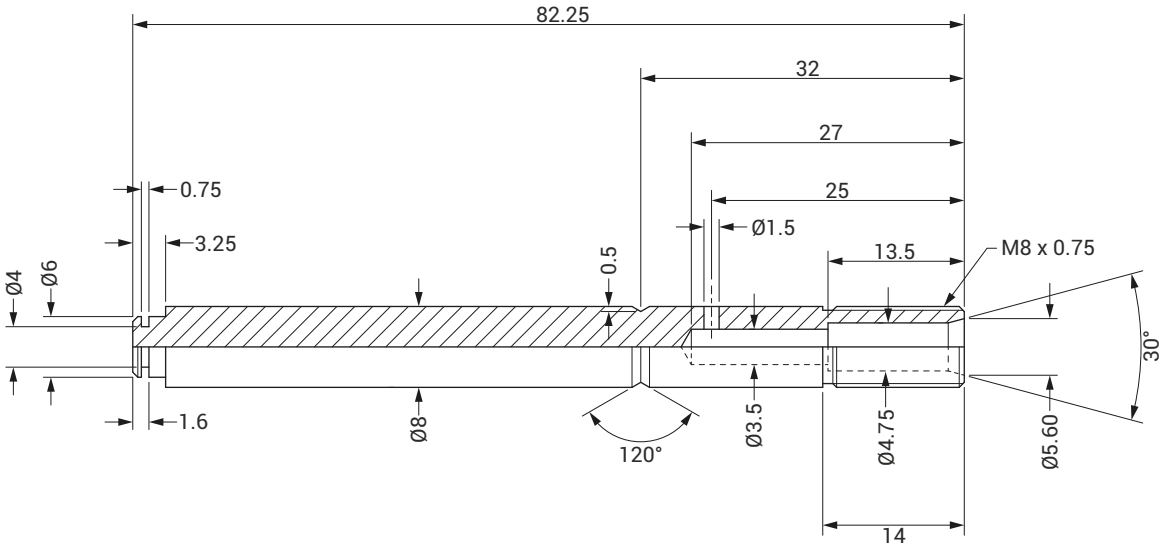
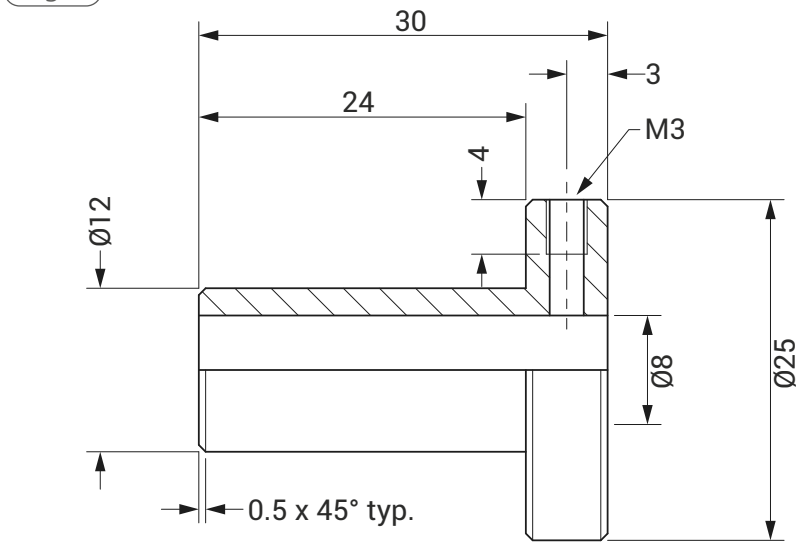


Fig.4



reduced. The other was that the knurled collet nut of the pin chuck also provided the means to turn the tap, this would frequently come undone at the most inappropriate moment. Trying to balance the tightness of this nut so that it just held the tap and provided a certain amount of slippage when an obstruction was met. With having this nut tight enough to provide enough torque to drive the tap was a tall order. Plus, in all honesty the diameter of the collet nut could have done with being just a little larger, especially when using 8BA taps. The final nail in the coffin of this approach to using small taps came when I came close to breaking another tap due to the pin chuck dropping out of the bronze bush whilst traversing the table. While I had been holding the pin chuck in the "up" position at the time a momentary loss of grip due to the above spasm allowed the pin chuck to fall. The outcome of this approach is typical of using something off the shelf which was not really intended

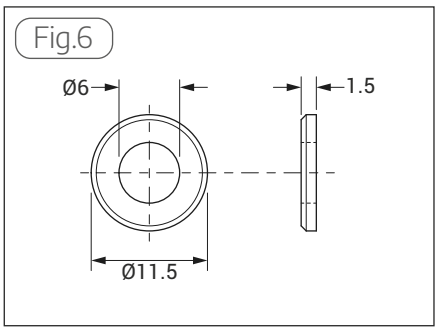
Fig.5

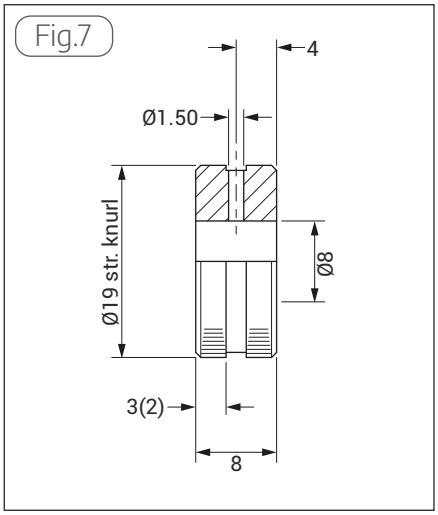


to do that particular function, it is a compromise. Like all compromises, one compromise usually leads to several more. The only thing to do was to start with a clean sheet of paper.

Inspiration came one afternoon when using my Proxxon Micromot handheld drill. These use a nice set of collets and the collet closing nut is fairly compact. The collets and closing nut are also available as a separate item so a sample set were purchased. A few hours at the drawing board followed by an afternoon in the workshop and the finished item was produced, **photo 2**, **figs 1** to **7**. To stop the risk of the whole ensemble falling out completely the shaft is retained by a flat washer on the end of the 8 mm diameter silver steel shaft. I used an "E-Clip" to retain the washer, but a countersunk screw, (Loctite in position), could easily be substituted with a suitable countersink in the washer.

The shaft is also provided with a "Vee Groove" which has a 120° included angle. This combined with a spring loaded ⅛" bearing ball ensures the tap is retained in the "up" position. This removes the risk of breakage when traversing from one co-ordinate location to another. Anyone with access to a suitable Vliers or spring loaded ball plunger could make this substitution with advantage. This may entail making the head of the guide bush thicker as well as increasing the diameter. A 90° included angle vee groove was considered but thought to be too aggressive when it comes to lowering or disengaging the shaft from the grip of spring loaded ball. The last thing needed is a sudden release of the shaft and a 12BA tap is hurtling towards the work, another recipe for disaster. The only thing that needs particular care is the concentricity of the collet location in the end of the 8 mm diameter shaft. The use of a collet attachment in the lathe or the 4-jaw chuck would be recommended. The thread will probably need to be screwcut as this is M8 by 0.75 pitch. One other thing that I did find, was that some of my taps would not enter the 2.4 mm diameter collet. These

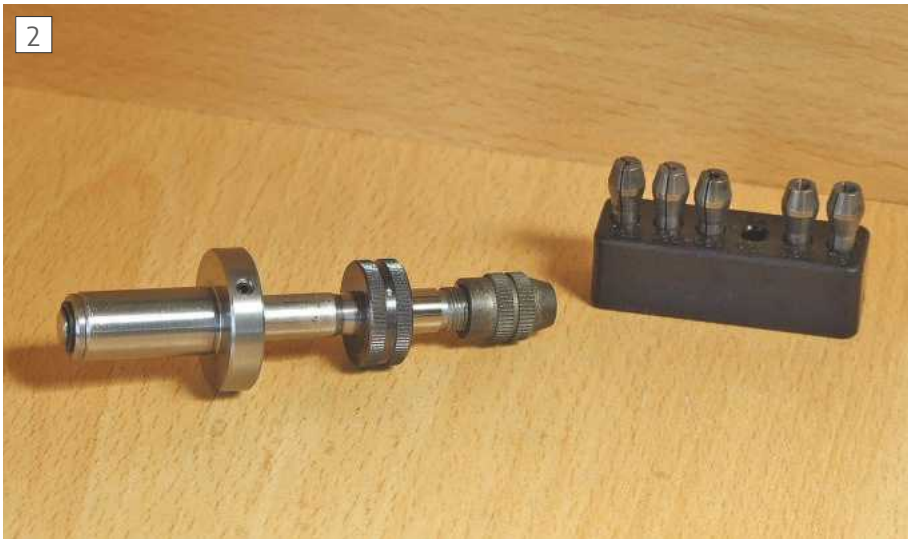




taps being 2.5 mm diameter, so before the shaft was removed from the lathe the offending collet was popped into the machined location with the collet closing nut and the hole attended to. However, before this can happen the slits in the collet need filling with some short lengths of suitable thickness brass shim. Care needs to be taken to ensure these scraps of shim do not interfere with the locating cones of the spindle or the collet nut, as this will affect the concentricity of the finished hole. It will do no harm if they extend into the bore. The shim will stop the collet "closing in" under the influence of the collet nut. A 2.5 mm diameter slot drill was used in the tailstock drill chuck to true the front of the collet hole. The slot drill was fed in only as far as the length of the flutes. This was followed with a 2.5 mm diameter "D-Bit", made especially for the task which passed through the collet length. Although the collet is hard it is not that hard it cannot be machined. This method produced a good result in that when I gripped a 12BA tap in the collet and clocked the end I had 0,025 mm (0.001"), Total Indicator Reading, (TIR). I would not advise the use of a drill to perform this operation as the likely outcome will be that the bore has spiral lands running down the length of the collet. The intermittent cut due to the slits in the collet, combined with the helical, or spiral form of the twist drill all conspire against a successful outcome.

The hole in the mild steel, (BMS), guide bush was bored a good fit on the silver steel shaft, but while there does not want to be any sideways play, there does not want to be any binding either. Any binding will inhibit the ability to feel the tap cutting, a silky smooth sliding action is the goal here. The larger 19 mm diameter knurled ring above the collet closing nut provides ample torque for 8BA taps and the ability to set the collet closing nut to provide some degree of slippage for the tap when an obstruction is felt has already paid dividends. However, it may be found with coarser pitch to diameter small taps that this knurled ring could with advantage be made 25 mm diameter. The knurled ring is located endwise with a 1.5 mm (1/16") diameter pin and retained to the shaft using Loctite 603 or similar, **photo 3**.

When it comes to tapping holes now, the workshop rule is that these are always done on the machine as the tapping size hole is produced, if it is a single hole. Or all the tapping size holes are produced via coordinate location and the tapping sequence follows the same coordinates. If use is made of the end stop on the 8 mm diameter shaft, then this can be set to limit the depth of the tapped hole. To do this the the shaft is fully extended, so that the end stop abuts the guide bush and the tap brought into contact with the edge of the hole. By lowering the head of the milling machine or raising the knee. After retracting the tap, the head, or knee of the milling machine is adjusted to give the required depth of thread. While the primary intention was to use the attachment solely in the ESX collet chuck on the milling machine. I have also started using this on the lathe using a tailstock drill chuck, although depending on the type of drill chuck, (Jacobs or Keyless), some loss of shaft travel is inevitable. There not being such a large cavity available in the drill chucks, (the Keyless chuck being the worst), when compared to the ESX collet holder. The time spent making this attachment has more than paid for itself, and while I do not like to tempt fate, I have not suffered any further tap breakage despite tapping several hundred BA holes in the interim, **photo 4**. ■



The complete attachment with collets

The attachment with 12 BA tap, note the small pin to locate the Knurled ring

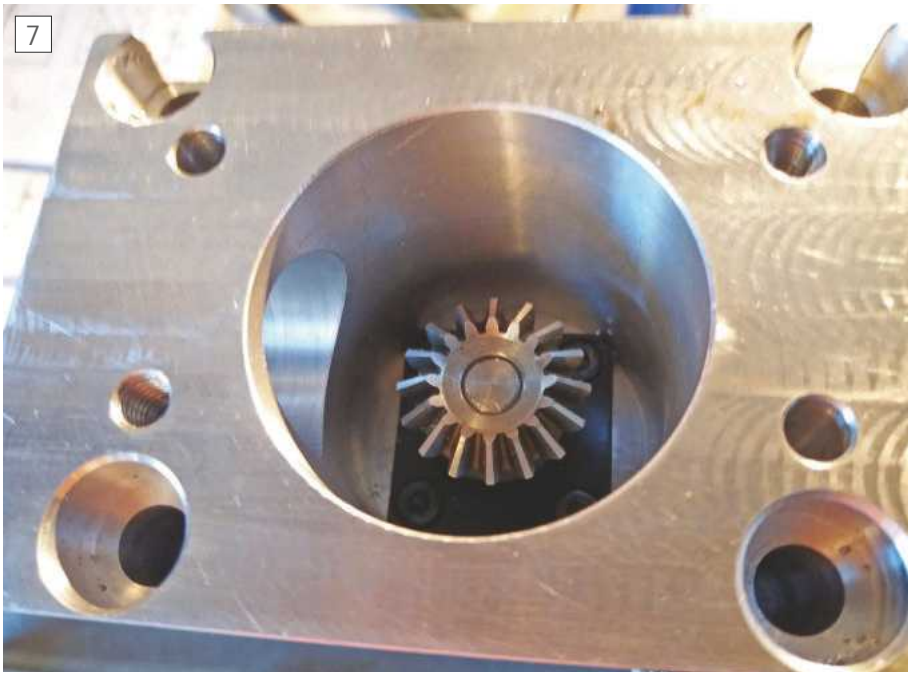
Proxxon Small tap attachment, tapping 12BA threads in my Fiat 702 Tractor Engine

Motorising the Z Axis of a Chester Champion 16v Mill

David George carries out an extensive upgrade to this popular bench milling machine. Part 2

I did a prior assembly to try the parts together to see if it fitted so far and found no problems yet, **photo 7**.

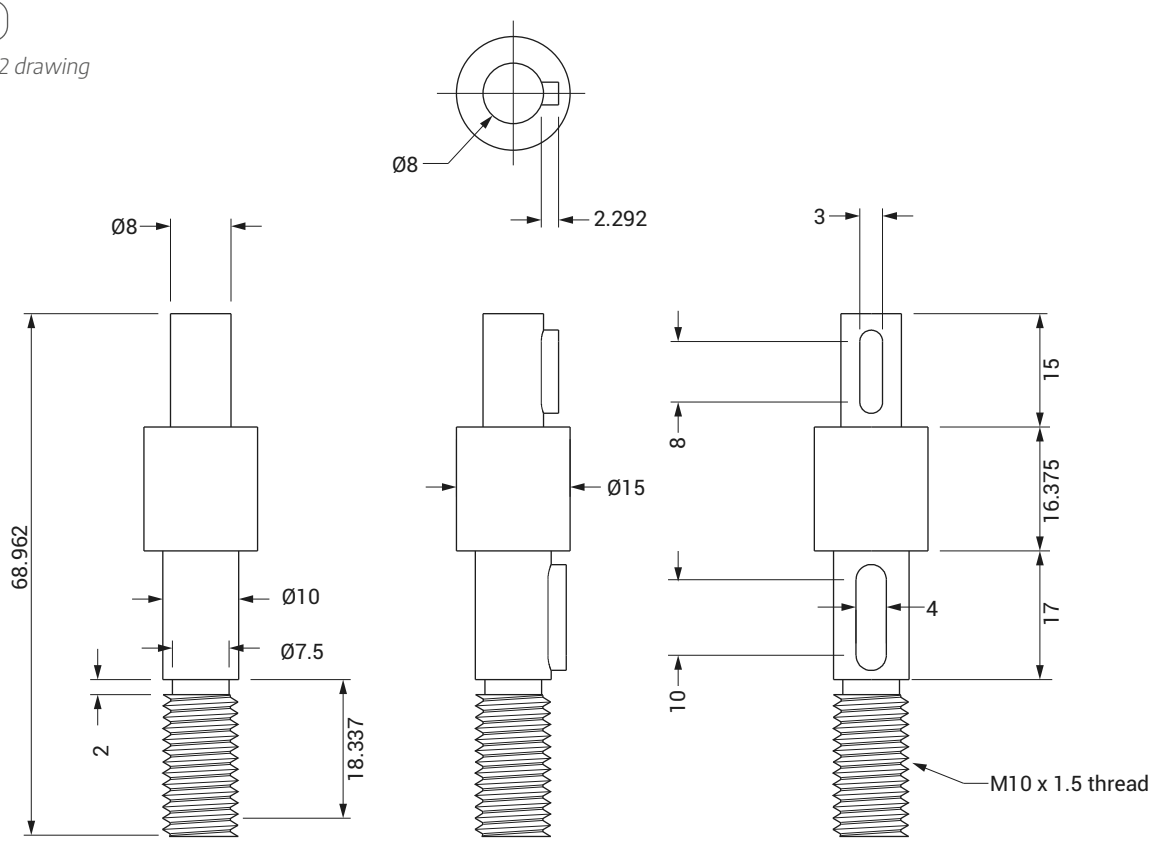
The side shaft was made from an ejector pin (from toolmaking days) so that the bearing area was hard as it is case hardened and ground and I could turn and mill the rest of the shaft (softer core material) although it could have been made from silver steel etc., **photo 8**, **figs 9** & **10**. The gears had to be keyed, so I bought a 3mm broach and cut both gears and cut the keyway in the end diameter of the ballscrew shaft making keys



Trial assembly.

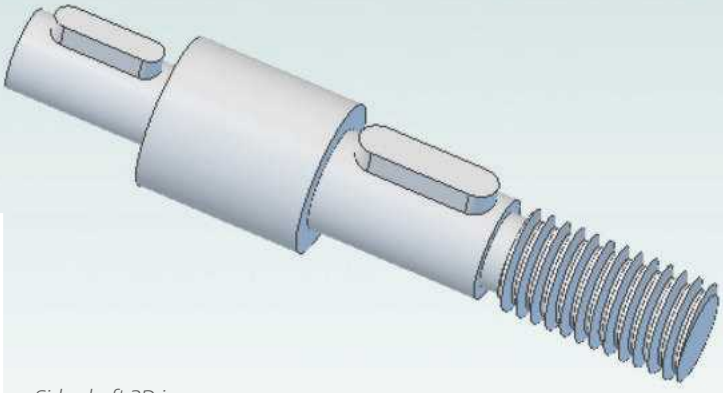
Fig.9

Side shaft 2 drawing



to suit. I couldn't get the ballscrew into my lathe as it wouldn't pass through the spindle, so I took it to a friend's workshop and used his larger lathe to drill and tap for the 4mm retaining screw to hold down the lower bevel gear. I then reassembled the parts including the bush and shaft and measured the end float on the gears to machine the spacer washer to remove any backlash. I had a thought that whilst moving the handwheel

Fig.10



Side shaft 3D image

Side shaft.

I could also fit a motor to the top and so investigated motors and bought a small but solid DC motor, **photo 9**, and variable drive. I added extra plates to the top of the body and tried the motor but at slow speed the motor had insufficient power.

I could have fitted a gearbox or pulleys and a drive belt but it didn't fit what I wanted to do and so had a look at stepper motors and found that it could be done although a bit more expensive.

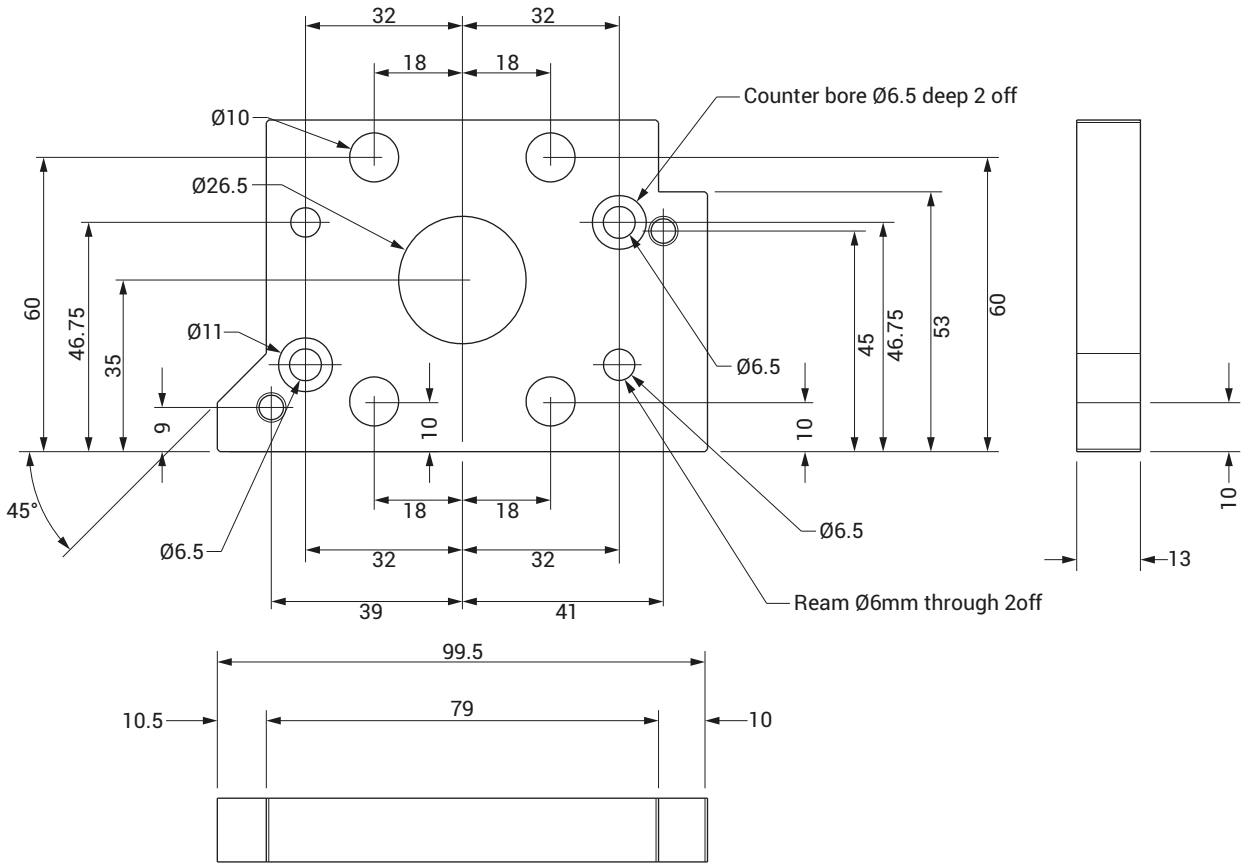
I found that I would have to disconnect the motor when using the hand wheel as stepper motors don't like being hand driven and after looking at clutches being expensive came up with the idea of spring loading the

DC motor.

Machining dog clutch.

Finished clutch.

Fig.11



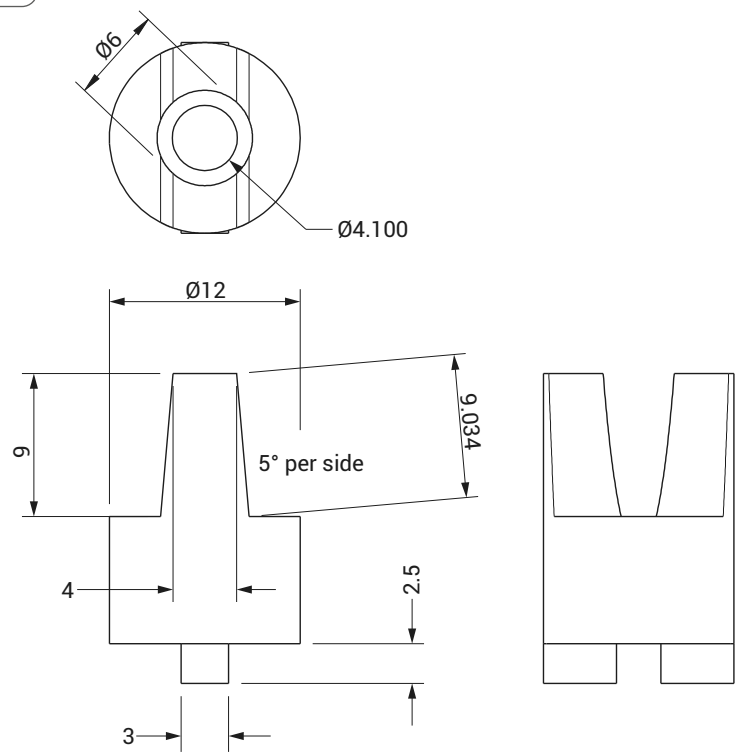
Intermediate plate drawing

top plate and a dog clutch, **photos 10** & **11**, to disconnect it which seems to work well. The intermediate plate, **fig. 11**, is doweled to the main body and the top plate also has dowels to locate in the same holes from the top but the dowels are polished to give a slight taper to the front, so they release easily.

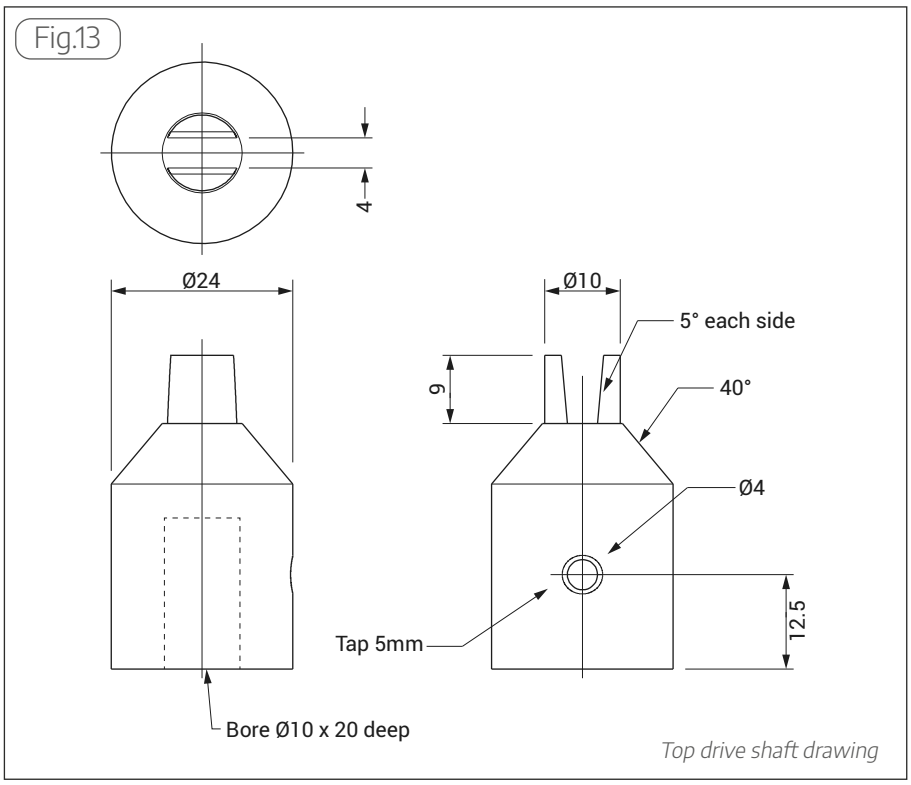
The dog clutch, **fig. 12** & **13**, was made from silver steel with a key on the bottom and taper location sides so that it locates easily and comes out easily as well. It has a 5 degree a side angle and the bottom piece is held in place with a 4mm cap screw down

The motor is fitted with the top drive shaft and screwed to the top plate, the springs are fitted to the intermediate plate.

Fig.12



Lower drive shaft drawing



Top drive shaft drawing

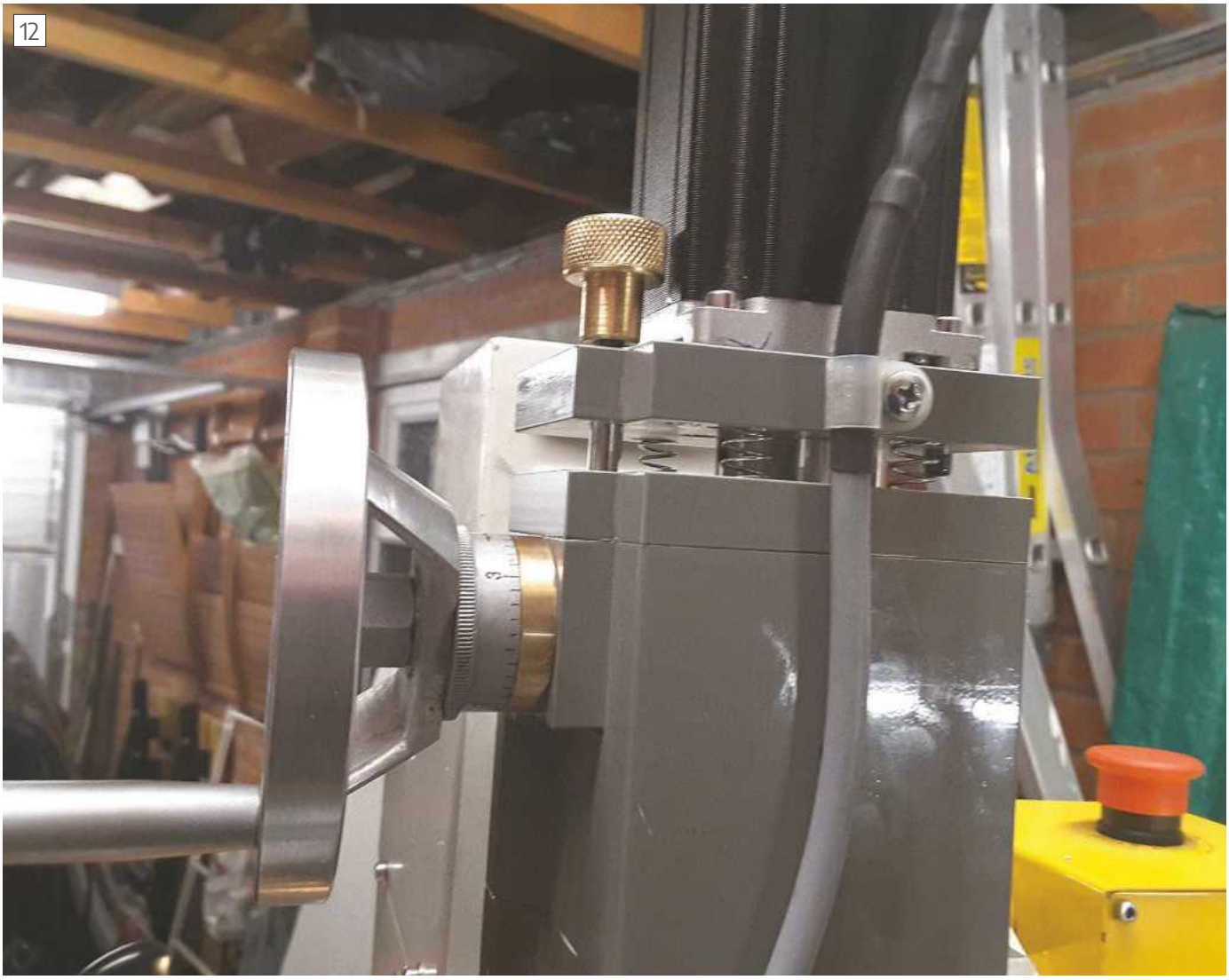
centre whilst the top is held in place by 5mm grub screw on to flat on motor shaft as well as the keys.

The top motor plate was sprung loaded, **photo 12**, and held down by two brass knurled thumb nuts, **fig. 14**, on 6mm studs as the nuts are tightened, I rotate the handwheel a little just to make sure location is easy.

In the body there are two 6mm tapped holes these are for an Allen key to tighten the grub screw in the ballscrew tension nut and the grub screw in the lower bevel gear on assembly these are to be plugged by a couple of screws after assembly. The original leadscrew nut support is bolted to the front of the head by two 8mm cap screws these are found by rotating the head to 45 degrees, **photo 13**, I used the same fittings for the ballscrew support bracket which was made from steel bored and screwed to suit the ballscrew nut, **photo 14**, **fig. 15** & **16**.

The end of the new support bracket has an angle machined on the outer end to allow the bracket to pass by the casting on assembly, **photo 15**.

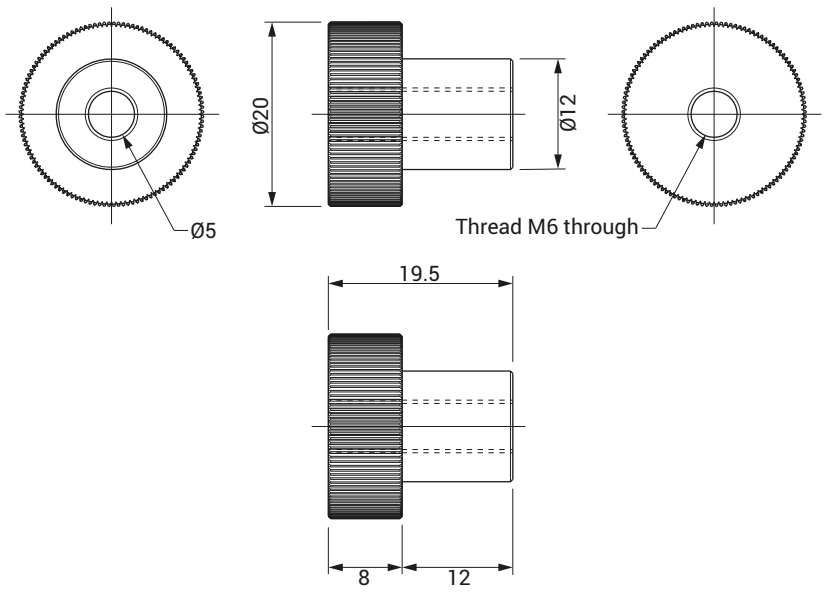
The head is assembled firstly putting in the support bearings and the bottom seal. The top bearing plate is screwed in with 4x 4mm



Spring loaded motor plate.

Original nut support screws

Fig.14

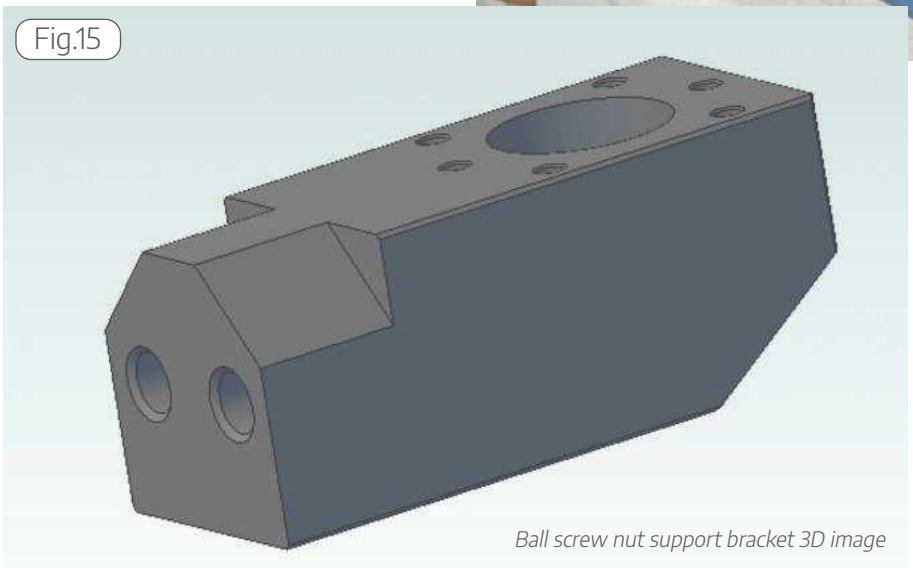


Clamp thumb nut drawing

cap screws and then the shaft is inserted. The spacer is then placed on the shaft and the nut screwed on and tightened. The nut has a grub screw in the side, and it is tightened through a hole in the side of the body. The drive key is fitted using a pair of snipe nosed pliers (I use a small amount of grease to hold) and the lower bevel gear slides over and in order the lower drive shaft, is inserted and itself held down with a 4mm cap screw. There is another grub screw in the lower bevel gear which is tightened through the other side hole. The side bevel gear is put in place with the spacer in as well and the side shaft slides in to locate them. The grub screw in the gear is tightened to retain the shaft and the handwheel slid on and retained by outer nut. The intermediate plate in fitted with short dowels which only use half the thickness of the plate and two 6mm cap screws. The 6mm studs, **fig. 17**, are screwed into the

Ballscrew assembly.

Fig.15

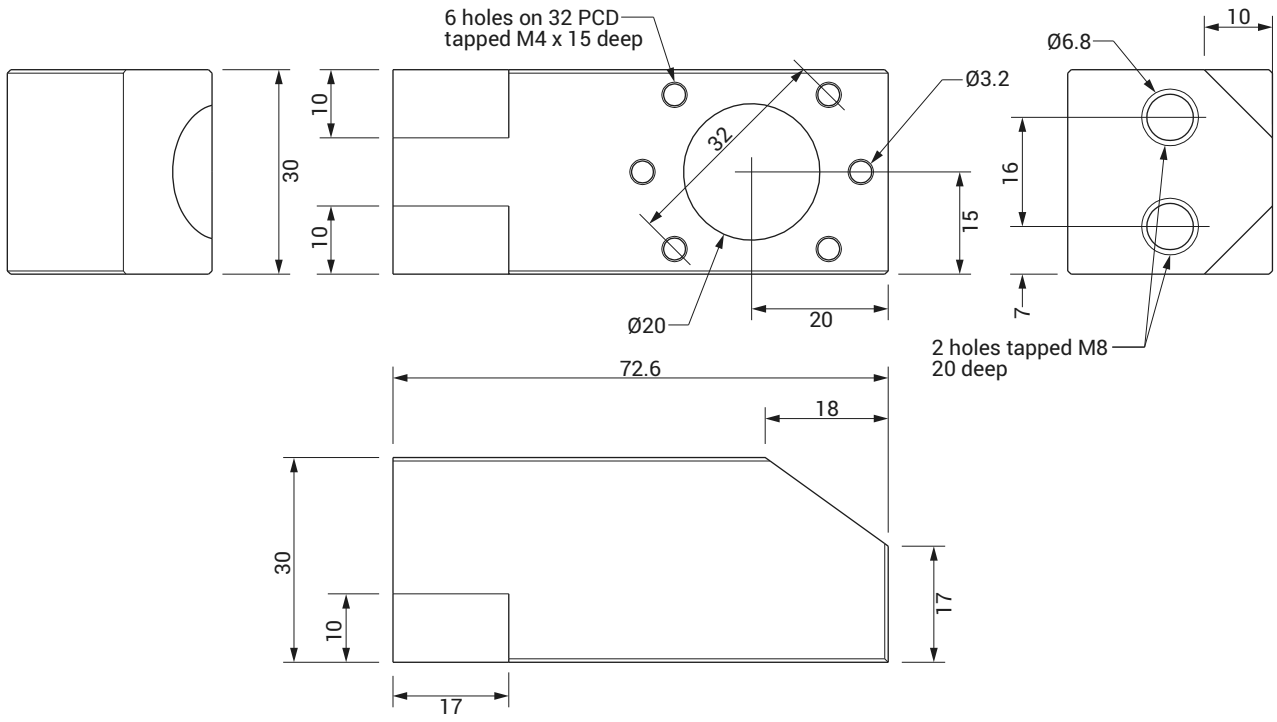


Ball screw nut support bracket 3D image

intermediate plate as well. The motor is fitted with the top drive shaft and screwed to the top plate, **fig. 18**; the springs are fitted to the intermediate plate. The top drive shaft is extended, and the grub screw just nipped up and placed over the springs and studs. As the brass nuts are tightened down the top drive shaft is pushed up and makes sure that the location is to its maximum. The grub screw in the top drive shaft tightened to prevent it moving. The ballscrew nut is screwed on to the support bracket and it is ready to assemble on to the mill, but I remove the motor and top plate to make it lighter to hold.

The main body was assembled on the bench, and after the head was near to top of its limit, and a piece of wood to prevent the

Fig.16

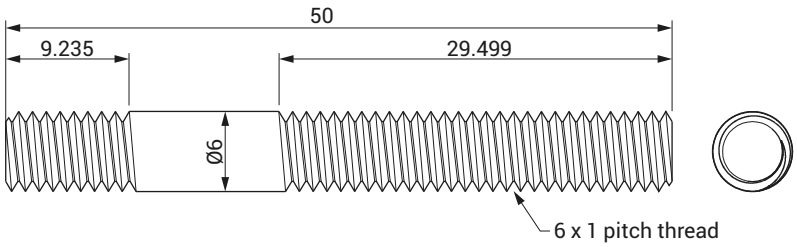


Ball screw support bracket drawing

head dropping, the old parts were removed. The new support bracket has to be near to the end of the screw to get it in and when in place the two 8mm screws screwed loosely in place. The head was then lowered by winding down the handle to just above the column and the main 10mm bolts screwed in place loosely to align the main body. The 8mm support bracket screws were then tightened the head wound down to take up slack and the top 10mm cap screws tightened. The head was unclamped and the wood removed and the head wound up and down with no problems.

The control box was fastened to the support bracket for the DRO that I had

Fig.17

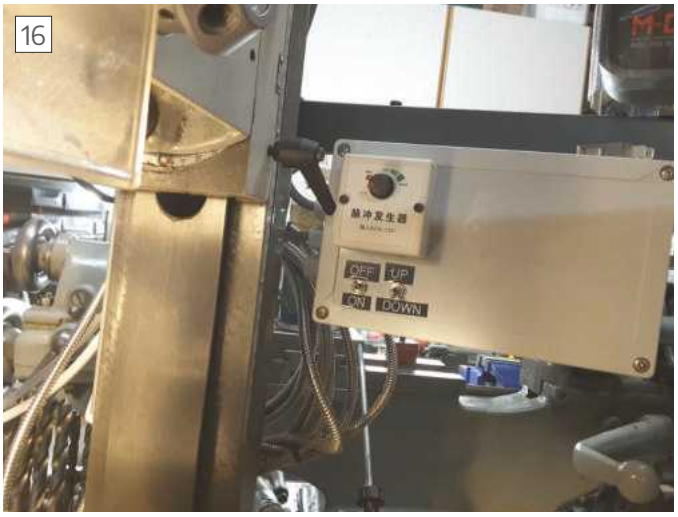


Stud drawing

15

Nut support bracket.

16



Control box.

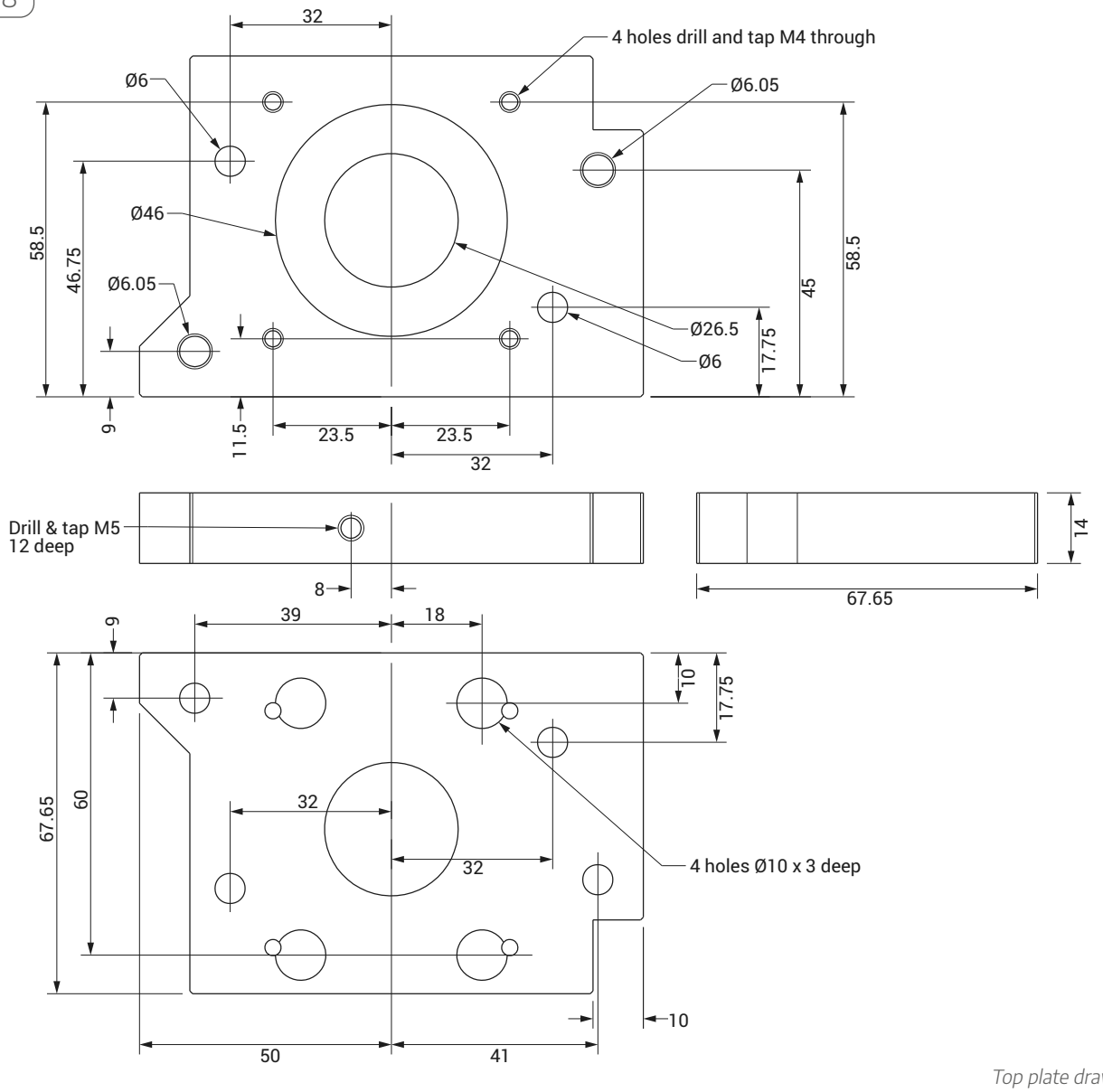
previously fitted and it was in a most convenient place for me to operate it from and well placed to run the cable to the motor and from the power supply under the bench, **photos 16** & **17**. The power supply for the stepper motor needed 5 volts for signals and 24 volts for the motor itself, so as it was bulky, I installed it under the bench and ran a multi core cable up to the enclosure I had chosen for the stepper driver switches and variable signal generator for motor speed. I am also fitting a limit switch to prevent running the ballscrew drive up into the casting. I have painted the body and plates with an etching primer and motor grey top coat as it was not far from original mill colour.

The motor succeeded in all my expectations and could be powered quite fast and very slow and with power and I could reach the handwheel with no bother and as I had used a ballscrew there was no backlash to eliminate.

You can see a video of the modified machine in action at **www.model-engineer.co.uk/ZAXIS** ■

Power supply box.

Fig.18



Top plate drawing

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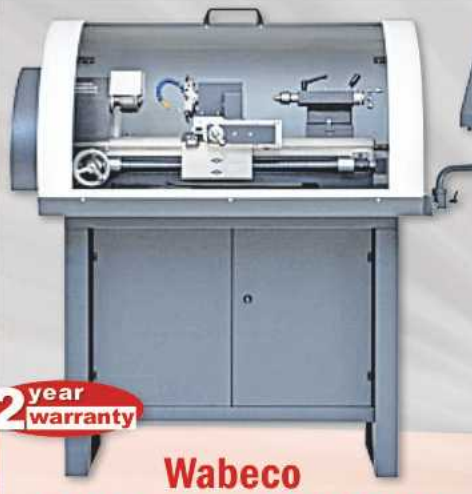

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Wabeco Lathe D6000

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- Speed – 30 to 2300rpm
- Power – 1.4 KW
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- Weight – 150kg

5 year warranty

Wabeco Lathe D4000

- Centre Distance – 350mm
- Centre Height – 100mm
- Speed – 30 to 2300rpm
- Power – 1.4 KW
- Size – 860 x 400 x 380mm
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- Table – 700 x 180mm
- Z axis – 280 mm
- Speed – 140 to 3000rpm
- Power – 1.4 KW

- Size – 950 x 600 x 950mm
- Weight – 122Kg
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A Modified Bench Grinder

Chris Taylor decided to improve his tool grinding

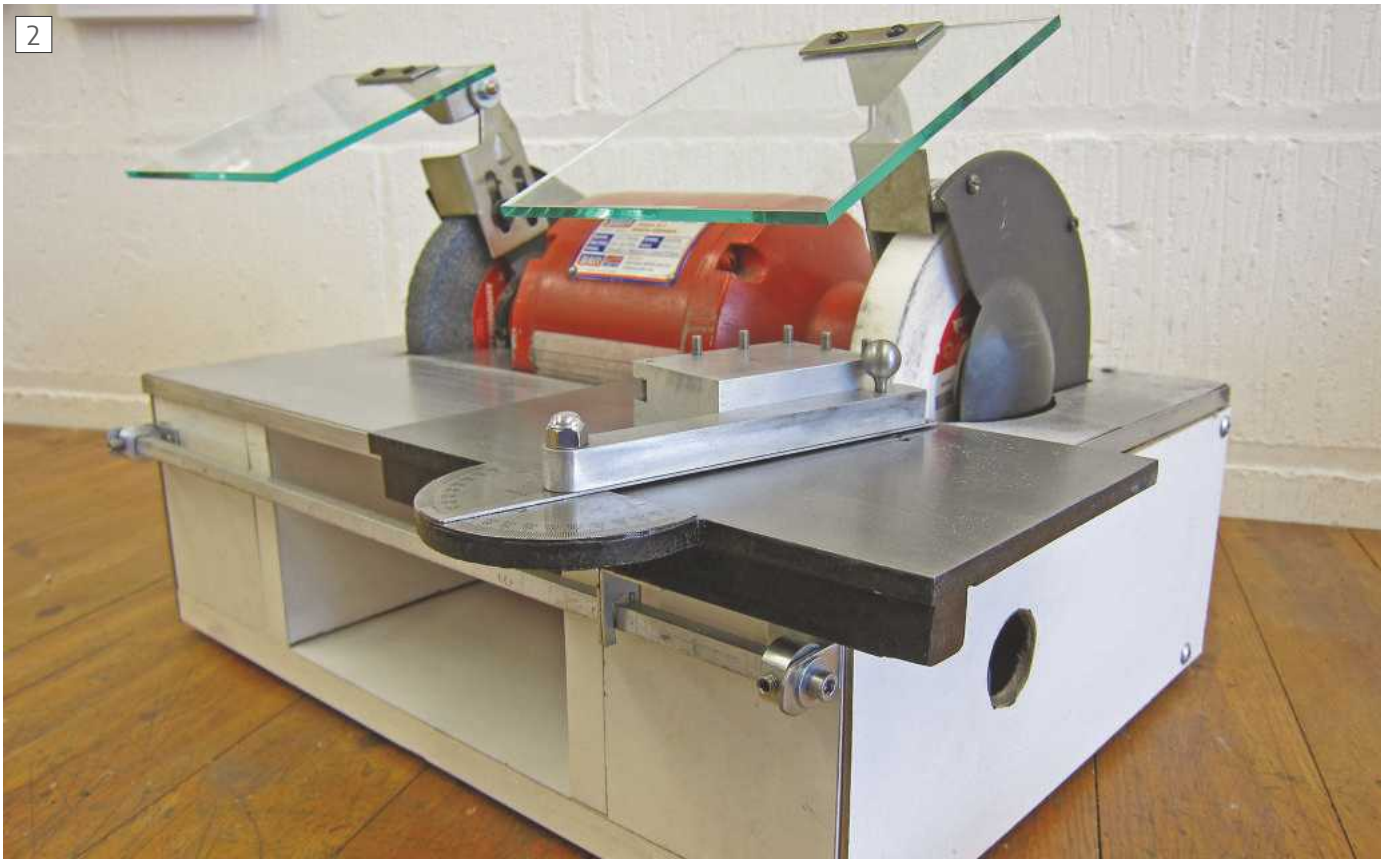
Grinding HSS tools is a messy business, especially in a small workshop with no space to segregate the grinder from the other machines (other than going outside), and I've always had difficulty grinding tools accurately, particularly when re-sharpening to the same profile, so I was inspired when I read Graham Sadler's articles in Model Engineer (4597 - 4599). I decided to modify my 30 year old Sealey machine to solve both problems.

Graham Sadler's concept is that the angle ground on the wheel is a function of height of the tool relative to the wheel centre line, thus by setting the blank at a specific height, different angles can be achieve with good repeatability, combine this ability with an accurate protractor to swing the blank in the XY plane and all surfaces can be accurately ground.

The modified grinder.

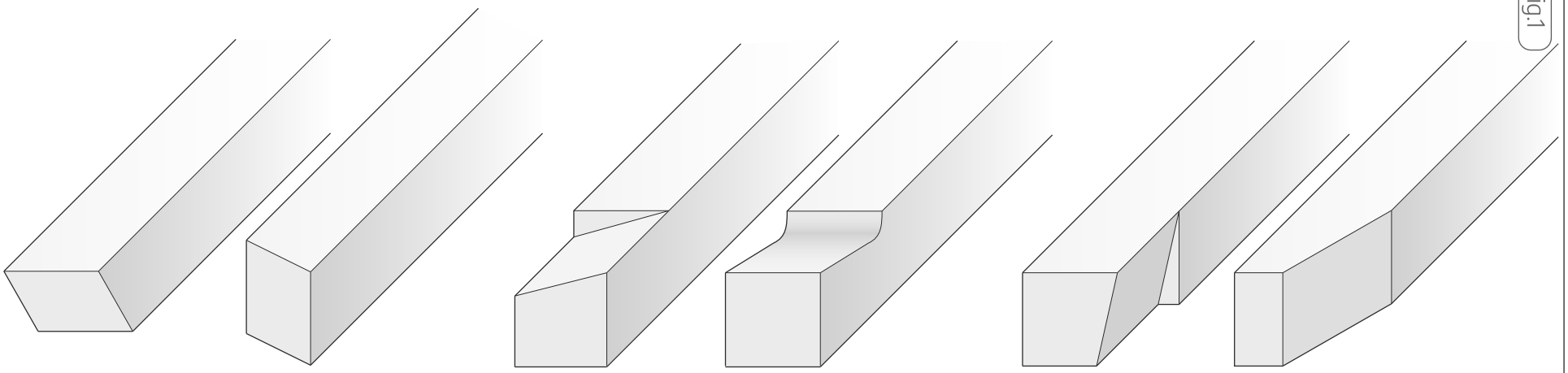
Geometry

Depending on the diameter of your wheel and the size of tooling used you need to



The slider arrangement.

Fig.1



Front Clearance
6 or 8

Front Relief
or Trial Angle
6, 8, 12 or 18

SideRake
10, 12, 16 or 18

Bake Rake
or Top Rake
2, 6 or 8

Side Clearance
2, 6 or 8

Side Relief or
Approach Angle

Compound Angles
Ground together using block for front clearance & protractor for front relief

Material	Cut	Front Clearance	Front Relief
Aluminium	Rough	8	5° - 6° for straight profiles & up to 45° for corner tool
	Finish	8	
Brass or bronze	Rough	6	
	Finish	6	
Steel	Rough	8	
	Finish	8	
Cast iron	Rough	8	
	Finish	8	
Copper	Rough	8	
	Finish	8	
Stainless steel	Rough	8	
	Finish	8	

Compound Angles
Ground at 90° pointing left using block for side rake & protractor for back rake

Material	Cut	Side Rake	Back Rake
Aluminium	Rough	18	8
	Finish	18	8
Brass or bronze	Rough	0	0
	Finish	0	0
Steel	Rough	16	8
	Finish	0	18
Cast iron	Rough	12	8
	Finish	0	8
Copper	Rough	18	12
	Finish	18	12
Stainless steel	Rough	12	6
	Finish	0	12

Compound Angles
Ground at 90° pointing right using block for side clearance height & protractor for side relief

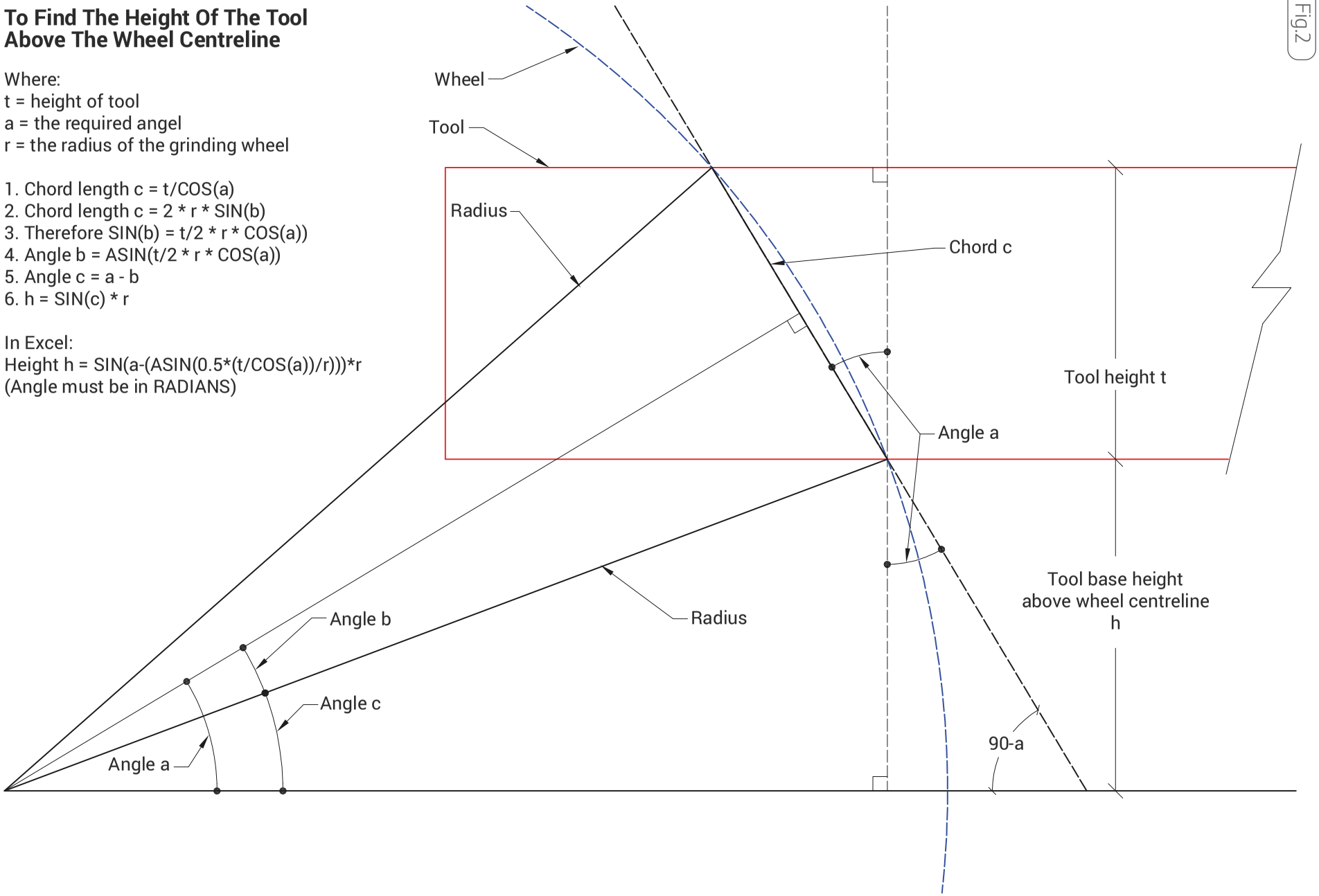
Material	Cut	Side Clearance	Front Relief
Aluminium	Rough	8	6°, 10°, 12° & up to 30° depending on tool type
	Finish	2	
Brass or bronze	Rough	6	
	Finish	6	
Steel	Rough	8	
	Finish	2	
Cast iron	Rough	8	
	Finish	8	
Copper	Rough	8	
	Finish	8	
Stainless steel	Rough	8	
	Finish	2	

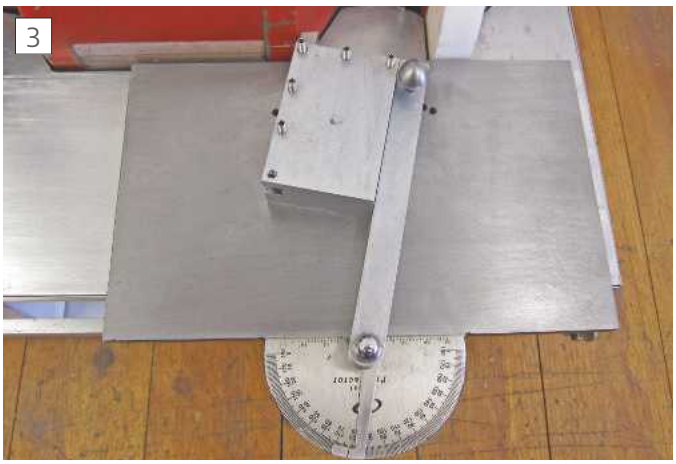
To Find The Height Of The Tool Above The Wheel Centreline

Where:
t = height of tool
a = the required angel
r = the radius of the grinding wheel

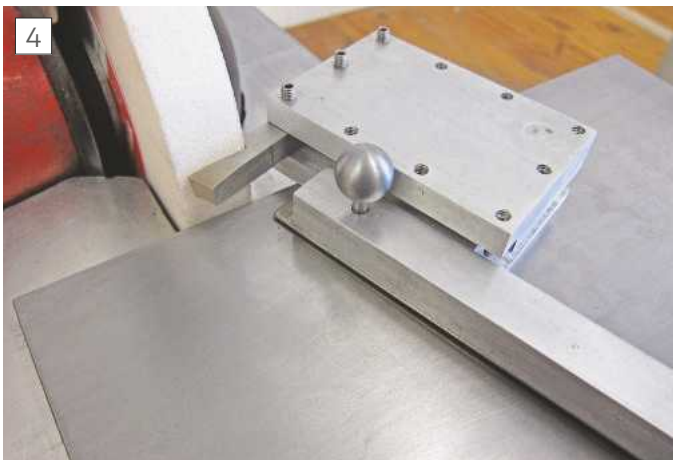
1. Chord length c = t/COS(a)
2. Chord length c = 2 * r * SIN(b)
3. Therefore SIN(b) = t/2 * r * COS(a))
4. Angle b = ASIN(t/2 * r * COS(a))
5. Angle c = a - b
6. h = SIN(c) * r

In Excel:
Height h = SIN(a-(ASIN(0.5*(t/COS(a))/r)))*r
(Angle must be in RADIANS)





The protractor for setting angles.



Set up for simultaneously grinding side and back rake.

calculate the tool height relative to the wheel centre line, the geometry is shown on the drawing and if you use Microsoft Excel, the expression for the height of the bottom of the tool above wheel centre is:

SIN(a-(ASIN(0.5*(t/COS(a))/r)))*r

The angle required is a, t is the height of your tool and r the radius of the wheel. Knowing this relationship it is possible to set the base of the tool rest low enough below the wheel centre line to suit your wheel diameter and tool size and allow packing up to give the angles you require, **fig. 1**.

Angles

Advice given in the various textbooks on grinding angles for HSS tools can be confusing, even the nomenclature varies – Front Relief/Trail Angle, Top Rake/Back Rake, Side Relief/Approach Angle etc., all very confusing, so to clarify this I drew some diagrams and combined these with a table giving the average angles gleaned from the various authorities. The six types are grouped in pairs which can be ground together as compound angles, **fig.2**.

Although I have a few carbide tools I mostly use 5/16" HSS on my mini-lathe, which simplified my design of the for tool blanks holder, I only need front clearance angles of 2, 6 and 8 degrees, so I machined holders specifically for these out of aluminium.

Casing

I don't have space for an extraction cabinet, and I store the grinder out of the way when not in use, so it needs to be portable. My solution was to combine the tool rest jig arrangement with a casing partially enclosing the wheels and with extraction holes both sides, the gap in the front centre is to access the switch, **photo 1**.

The top of the casing and sliding part are made from 0.5mm steel sheet (from B&Q) bonded to plywood, and the base and sides are fabricated from some scrap plastic-faced chipboard. I set the stop of the slider 5mm below the wheel centre line (which is marked on the motor casing, **photo 2**. The measurement from the top of the table to the wheel centre line determines the position of the tool needed for each specific front clearance angle, the 8 degree holder is shown, a second holder has slots for both 2 and 6 degrees and both have slots at right angles for grinding side relief and back rake etc. Photograph 2 also shows the arrangement for stopping the slider movement to give a clean edge when using the right angle slots.

The protractor, **photo 3**, is a cheap one from eBay, accurately aligned and bonded to the plywood slider, the arm is a piece of scrap aluminium and holes are drilled in the slider plate at commonly used angles with a tapered pin to lock the arm, this makes for easy repeatability. **Photograph 4** shows the arrangement for simultaneously grinding side rake and back rake using the combined 2 and 6 degree tool holder.

The whole thing works well to contain the dust spread and achieve repeatable and accurately ground tools. Many thanks to Graham Sadler for the original idea. ■

In our Next Issue

Coming up in issue 293

On Sale 17th April 2020

Content may be subject to change

Look out for our May issue, number 293:

We pay a visit to **Patrick Cubbon's** workshop.

Make **Peter Shaw's** Mandrel Indexer.

Bob Edney shares his experience of starting 3D Printing.

Shortening a Chain

Will Doggett makes a special link to shorten the Hand Chain on a lifting block

The fitted link

This article is about shortening a continuous hand chain on a chain block and shortening must not be done this way on a load chain under any circumstances as this would be very dangerous. To shorten a load chain the hook is removed the chain is then cut to the required length then the hook is replaced it is making it longer that you must not do.

The concept and history

Photo 1 show the finished article, actually this is not the one that is described in this article, it is one I made earlier. After sorting out and moving things in the workshop I found a feed bag with my chain block in it, I open the bag to find to my shame that both the chains, load and hand chain, had some

The drill plate

Chain orientation

The two links

Marking out

Machining the link

The links after machining

rust on them. The rust most likely accrued in winter when the temperature changes from cold to hot in a very short time causing condensation in the bag, as it was stored in unheated building – well this is my defence.

To clean them up I was going to use a Citric acid and water bath this required the chains to be removed from the block. The hand chain was removed first it seamed long. I remembered that when I used the block the last time to put the Mill/Drill on its stand the hand chain was too long and getting in the way as it piled up on the floor but in the rush to use the new toy the block was put away and forgotten about. The answer to this problem was to make the chain shorter before cleaning the chain as there was no point in cleaning the bit that was not required.

Many years ago I looked after the maintenance shops lifting equipment this included chains and as such I knew that chain connectors were available as I had used them before, but at this point there was a problem the size I required being imperial was not available, only metric.

Moving on, the only way forward was to make the link myself out of two links from the chain that was going to be removed. The problem with making it my self was how to hold the links that are to be modified. The answer was a flat piece of steel that I could clamp the link to so that the flat part could be formed by hand or machine. This took the form of a Drill plate that I had made as an apprentice in the first year in the training

The link is cut

Horn pieces removed

›

File to size

Fitting together

Drilled holes

Counter sink

workshops. The clamp piece is not the original this went missing some time ago, the original plate and replacement clamp are shown in **photo 2**.

The process

The length for the chain was measured and the piece that was not required was cut out, but I had to make certain the two ends links that were left came together the same way i.e. either vertical or horizontal as the new link will put the chain orientation right. **Photograph 3** shows the ends of the chain held in a vice vertically the link laying flat on the vice represents the new link before it is made I hope this explains what I am trying to show, if this is not done the chain will have a twist in it.

The next step was to make the link this required two links from the old chain these were cut out from the chain as two separate pieces these are shown laying on the drill plate in **photo 4** the next step is to make them out to show what is to be removed and also more importantly what is not to remove, I use a black felt tipped marker as a layout material. When this was dry a scriber was used to mark the lines then a small centre pop was used to show the lines before machining a small line was made with a junior hacksaw this saw line was to help see the line when machining, the marking out can be seen in **photo 5** before the saw was used to enhance the lines.

At this point you can choose to machine the waist away or you can use a file I have done it both ways, there is not a lot to choose between them as you do end up using file to final finish anyway and it is a way of gaining filing skills.

The first link was clamped to the drill plate and the waste was removed from one end the link was then turned around on the drill plate and the other end was machined in the same way. **Photograph 6** shows the second end being machined. The other link was machined in the same way, the two links are shown in **photo 7**. You will see there are two original sections left in the middle of the links, these were left a little long so that they can be fitted to the slots after cutting the slot. One will be removed when this section is cut out of the link and the other will go into the section that is formed when the cutting of both links is finished. They will look a bit like a letter C. All this will become clear later when the two links are ready to assemble.

The slot size is the same size as the chain link diameter there is no point making it larger as this will only make the joint weaker so the slot is marked out on both pieces and cut. This was done with a hacksaw, the slot was cut a little under size and finished to size with a file., The side nearest to the camera in photo 7 is the section to be removed this is the same on both pieces of link.

The first link was put in the bench vice and the slot section was removed as can be seen in **photo 8**, this also shows the horn pieces that are left after the section was removed. Then the other link was also cut in the same way. The next operation was to remove the horn pieces, the links were put in the drill plate and clamped so that the horn pieces could be filed down. **Photograph 9** shows them after this was done.

The pieces were then held in the bench vice and the opening was filed to size and square so the chain link will go through.

The full size section that fits into the sawn away section is now filed to size and fit in the other link piece, as shown in **photo 10**. If the filing and fitting has gone well the two sections should look a bit like **photo 11**.

The fixing holes are now marked out on the centre line of the links and about the same from the end and drilled. I used a 2mm drill on this size of link this is shown on **photo 12**. The holes are now lightly countersunk to

A rivet

Ready for riveting

receive the rivets as **photo 13** shows.

The four rivets I made in the lathe as I did not have the right size it is rather a fiddly job but if you take you time and use a sharp tool it should be ok, **photo 14**.

Assembly

The parts that are required are now made, the next task is to assemble the new link in the chain; the two ends of the chain are hooked into the slot in the first link then the second link is also hooked in and the two parts are closed together **photo 15**. After checking they are seated the two links can be riveted together.

Cleaning

Both chains were soaked over night in a solution of citric acid and water when the rust had dissolved the chains were then washed in water then I used an air line to remove most of the water. After this I used a water displacement spray to protect the chains when not being used and in storage. All this treatment was done away from the block, as the spray would not do the clutch in the block much good. After this treatment the chains were united with the block and reassembled.

Storage

The finished cleaned and oiled chains and block are now stored in a wooden box with a lid so I don't think I will have to clean them again well I hope not **photo 16**. ∎

Storage box

On the Wire

NEWS from the World of Hobby Engineering

An international science competition for young people

Students aged 7-21 have just one more month to register for a competition which gives them the opportunity to win £5000 to develop STEM [Science, Technology, Engineering and Maths] education in their school, college or university. Working as a project team with the support of a teacher or lecturer, students are asked to come up with innovative technological solutions for how they could help clean up the world's waterways and oceans.

The competition which was launched at the Royal Institution in London last month by the British International Educational Association, asks young people to use their imaginations and enthusiasm for STEM to combat the problem of plastic pollution. Inspiration comes from encouraging projects like The Ocean Cleanup, a giant arm sitting on the surface of the ocean clearing up the Great Pacific Garbage Patch as well as The Seabin Project, a simple device which sits in the water and collects rubbish in ocean marinas.

The BIEA's STEM Chairman David Hanson says, "young scientists, technologists, engineers and mathematicians can think outside the box and could invent extraordinary solutions to the global problem of plastic pollution."

Teams from 45 countries have already signed up to take part in 2020 including students from UK, USA, Australia, China, Finland, Mexico, Pakistan, UAE, India, Malaysia, Nigeria and Poland.

Finalists will be invited to a grand international event in London on the 1st of July 2020. In keeping on the theme, they will also take part in a truly international plastic clean-up!

In the first stage of the competition, teams must submit written via email by 31st March 2020 5pm (UTC).

For more information and full details about the STEM Youth Innovation Competition visit **www.bieacompetition.org.uk** or follow BIEA @BIEAeducation on social media.

Visitors flocked to 24th London Model Engineering Exhibition

Thousands of visitors flocked to Alexandra Palace last weekend to attend the 24th annual London Model Engineering Exhibition.

The exhibition showcased the full spectrum of modelling and was packed with over 2,000 models built by individuals, clubs and societies, from traditional model engineering such as locomotives, steam and internal combustion engines and steam road vehicles, as well as scale model ships, aircraft, and tanks to remote controlled trucks and James Bond and Star Wars models.

Over 45 clubs and societies were in attendance, each vying to win the prestigious Society Shield as voted by the clubs and societies themselves. First place was awarded to Harlington Locomotive Society for their superb recreation in miniature of a railway locomotive works, second place was awarded to the West London Meccano Society and in third place was Eastleigh Young Engineers.

This year the Exhibition paid a special tribute to the emergency services and armed forces. Making his debut was Warwick District Councillor and retired chartered Mechanical Engineer George Illingworth with his magnificent display of hand-built large 1/12 scale Meccano Fire Engines. The collection provided visitors with a visual history of the fire engine over the last 100 years and also featured an 18th century horse drawn engine which would've assisted during the great fire at Alexandra Palace in 1873.

George said "Each model takes between two months to two years to complete. Each replicates a fire truck from its period in history".

He continued "my favourite is the Dennis F12 from the 1950s, popular at the time with fire brigades across the country for its speed. When launched it really was at the forefront of technology".

As usual, all the leading specialist suppliers were represented providing an excellent opportunity to seek advice from industry experts. Visitors could purchase virtually anything they needed for their next modelling project or to get their hobby started.

Dates for the 2021 show will be announced shortly

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With 6ft diameter driving wheels and a tractive effort of 25,445lbs the Black 5 proved itself a highly capable "go anywhere, do anything" locomotive. In service the locomotives were always in black livery. In LMS days a thin straw coloured lining was used. In BR service red/white/grey lining was standard. Early, or later BR crests were carried according to period.

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Summary Specification

Length approx 71"

- Coal-fired live steam
- Safety valves
- Two outside cylinders
- Sprung axle boxes with needle roller bearings
- Silver soldered copper boiler
- Piston Valves
- Walschaerts motion
- Mechanical lubricator
- Reverser
- Tender brake
- Etched brass body work with rivet detail
- Boiler feed by axle pump, injector, hand pump
- Working drain cocks
- Stainless steel motion
- Multi-element superheater
- Bronze cylinders with steel pistons and valves
- Ready-to-run
- Fully painted and lined
- Choice of liveries
- Length 71"
- Height 13"
- Width 9.5"
- Weight (inc tender) 105kg

Delivery and Payment

The model is the subject of a single batch production for delivery by the end of 2020. There is unlikely to be any further production until 2024 at the earliest. The model represents excellent value at £10,995.00 + £195.00 p&p.

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A stage payment of £3,500.00 will be requested in June 2020 as the build of your model progresses, a further £3,500.00 in September, and a final payment of £2,000.00 in advance of delivery.

The Model

The Black 5 is a coal-fired, two cylinder, engine for 5" gauge. The model offers a good level of fine scale detailing and is to a high engineering standard. This combination of appearance and performance is rarely matched by our competitors.

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We have presently reserved capacity for the production of 25 models only. With the Black 5 being such an iconic and popular locomotive we are confident the edition will sell out quickly. It may be possible for us to extend the production run a little, but this cannot be guaranteed.

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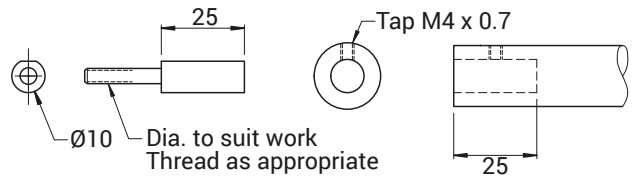
The Modular Dividing Head

Ted Hansen makes a flexible system for dividing using standard change gears, including an explanation of its use with various popular lathes. Part 4

Fig.11



Inserted Arbour Spindle End for Smaller Work

Fig.12

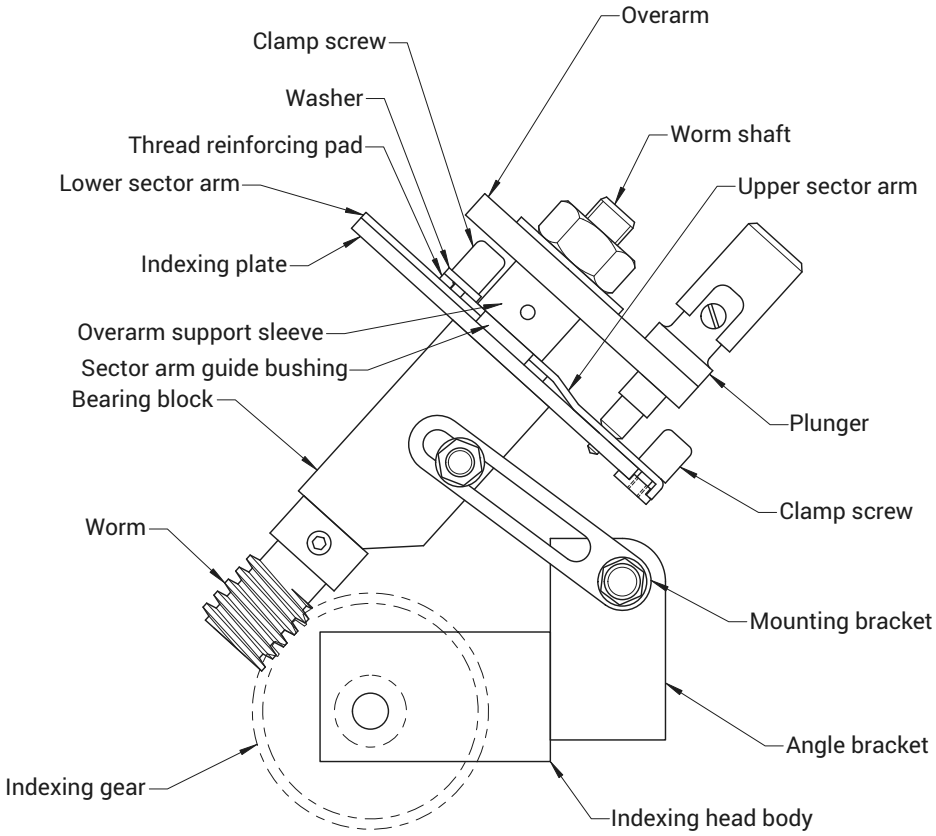
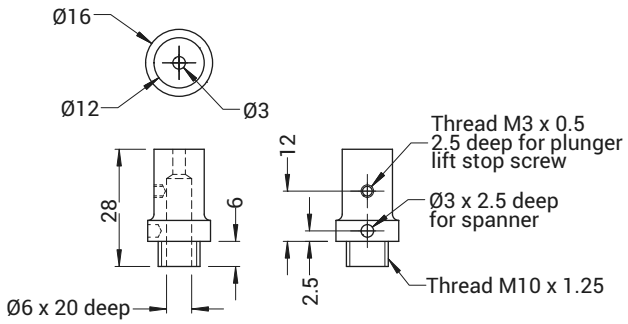
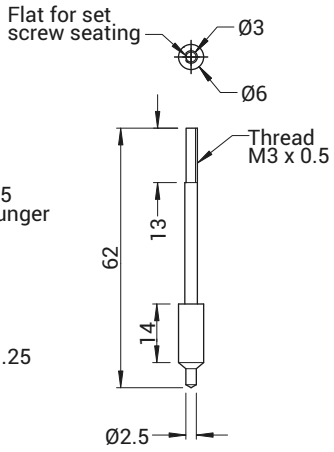


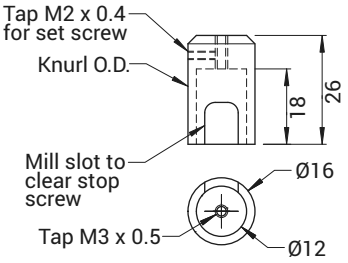
Fig.13



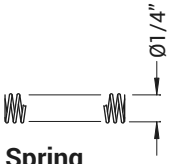
Plunger Body
Mat'l: Steel



Plunger
Mat'l: Steel

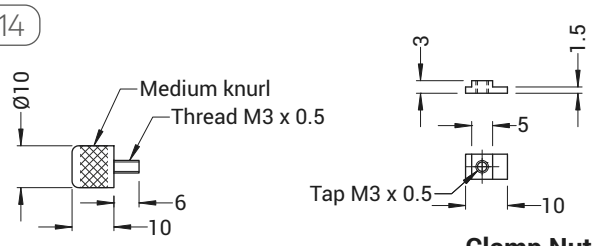


Plunger Handle
Mat'l: Optional



Spring
Mat'l: 18 turns 0.6mm wire
Free length 30mm, substitute
as appropriate

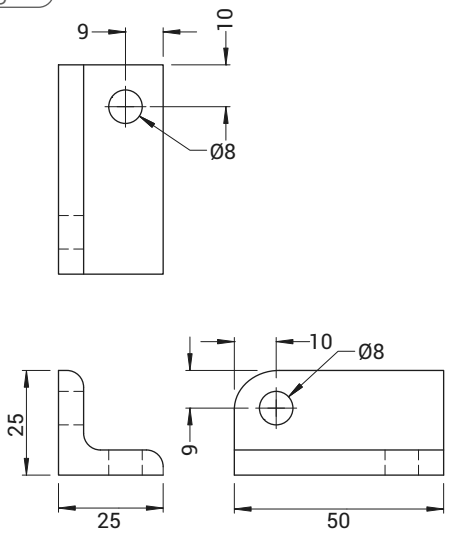
Fig.14



Clamp Screw
Mat'l: Steel, 2 req'd

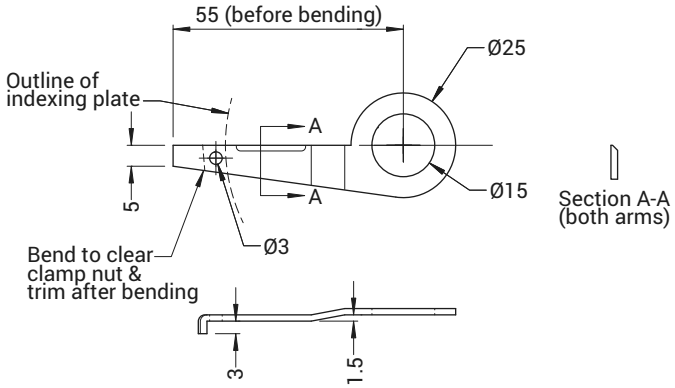
Clamp Nut
Mat'l: Steel

Fig.15

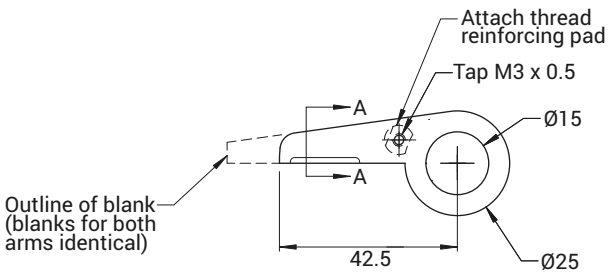


Angle Bracket
Mat'l: Steel

Fig.16

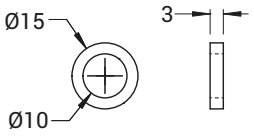


Upper Sector Arm
Mat'l: 1.5mm (1/16") steel plate

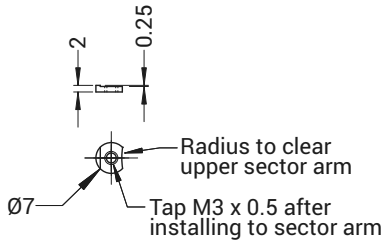


Lower Sector Arm
Mat'l: 1.5mm (1/16") steel plate

Fig.17

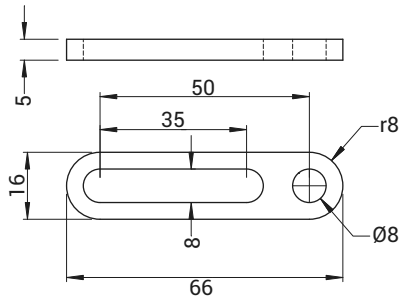


Sector Arm Guide Bushing
Mat'l: Bronze

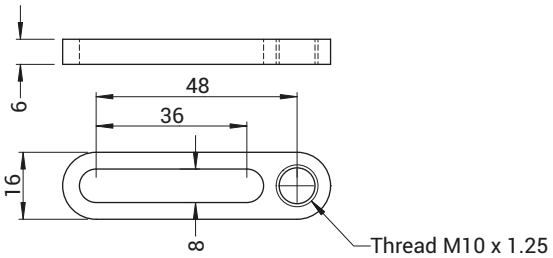


Thread Reinforcing Pad
Mat'l: Steel
Epoxy or solder to lower sector arm

Fig.18

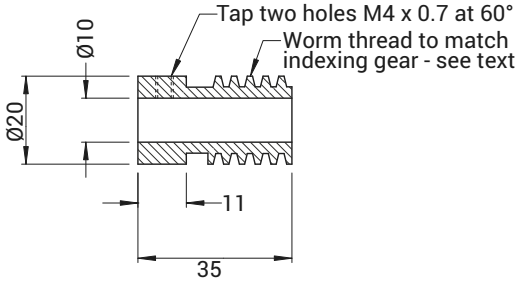


Mounting Bracket
Mat'l: Steel



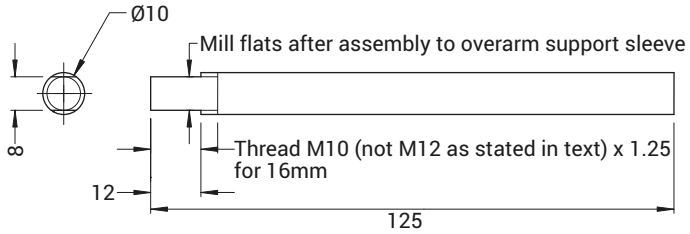
Overarm
Mat'l: Steel

Fig.19



Worm Gear
Mat'l: Optional

Fig.20



Worm Shaft And Overarm Support Sleeve
Mat'l: Steel

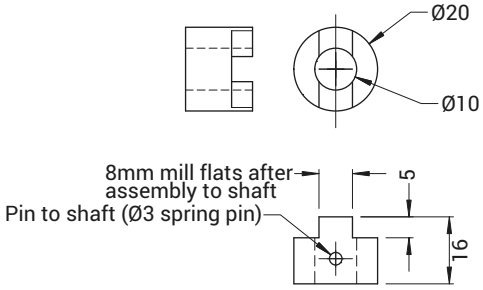
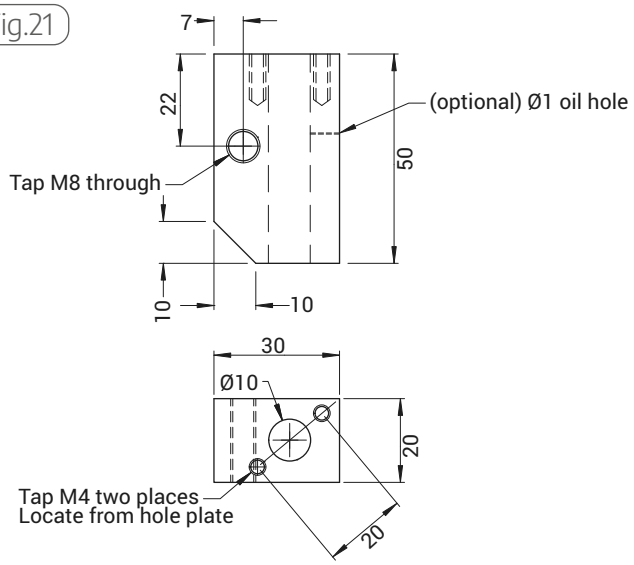
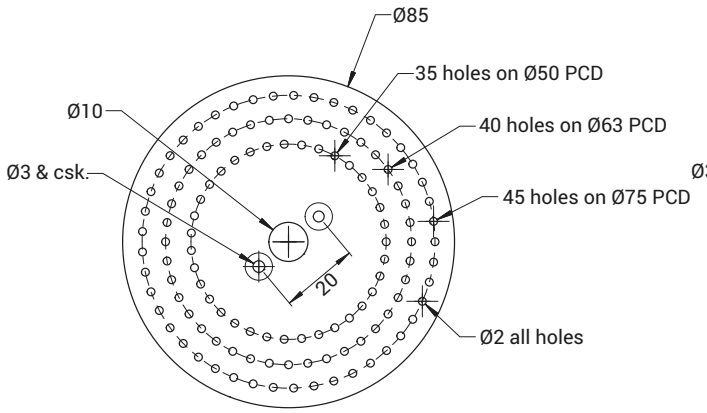


Fig.21

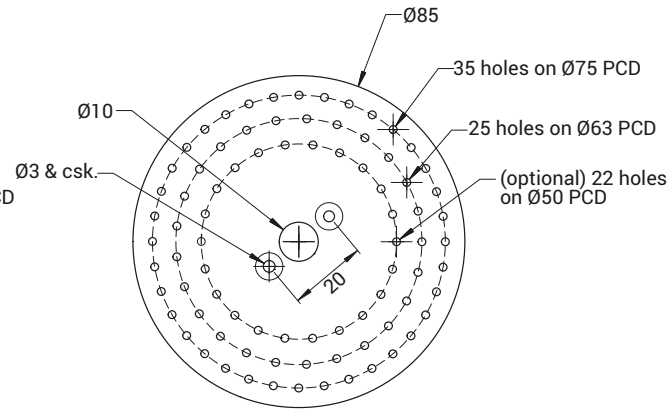


Bearing Block
Mat'l: Steel or cast iron

Fig.22

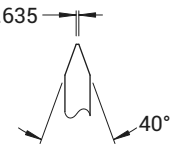


Myford And Mini Lathe Indexing Plate
Mat'l: 3mm steel plate

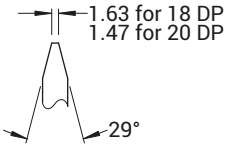


South Bend And Similar Lathe Indexing Plate
Mat'l: 3mm steel plate

Fig.23



Toolbit For Module 1 Worm



Toolbit For Imperial Gears

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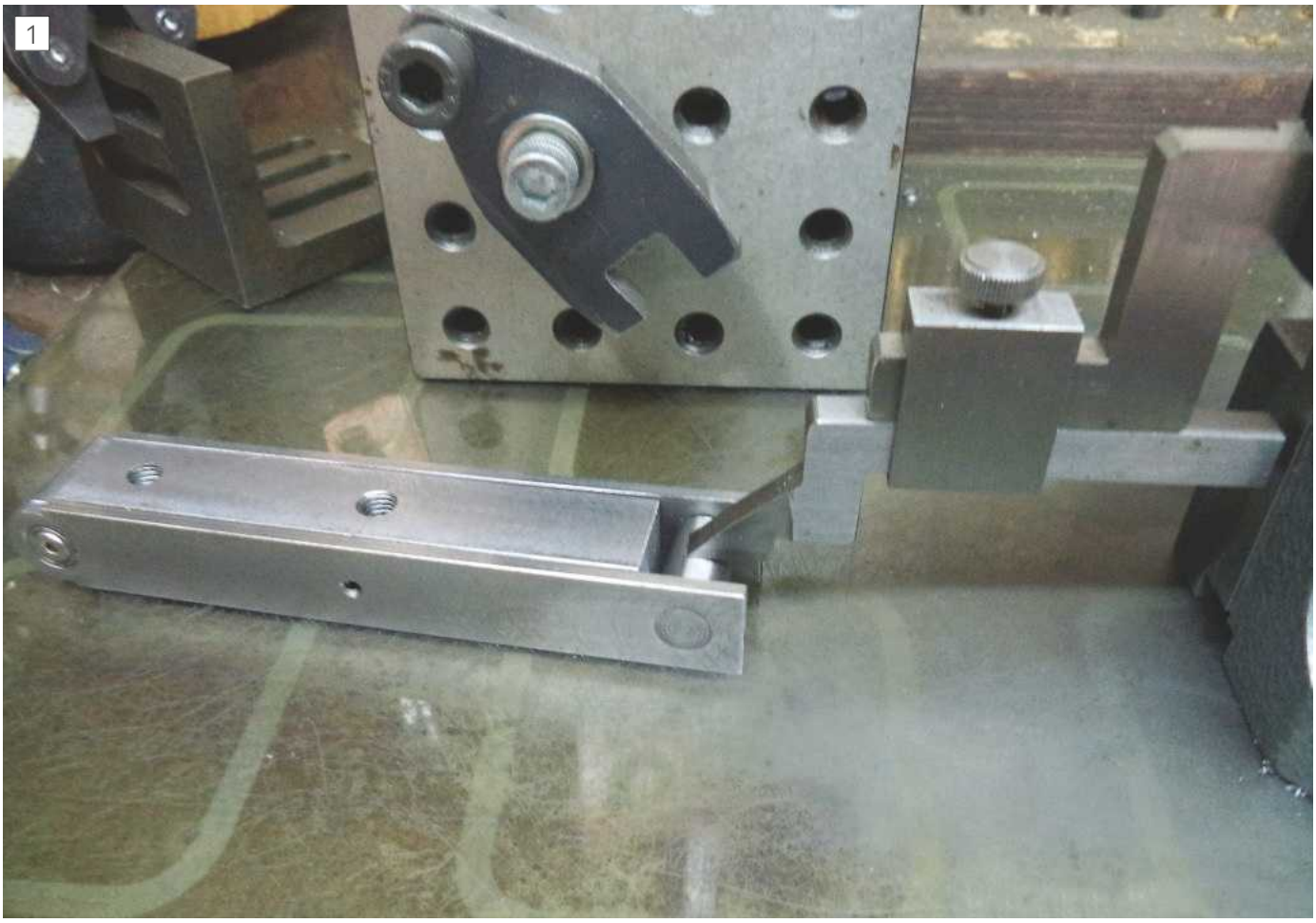
Sine Protractor

Stewart Hart explains how to make a useful device for setting accurate angles



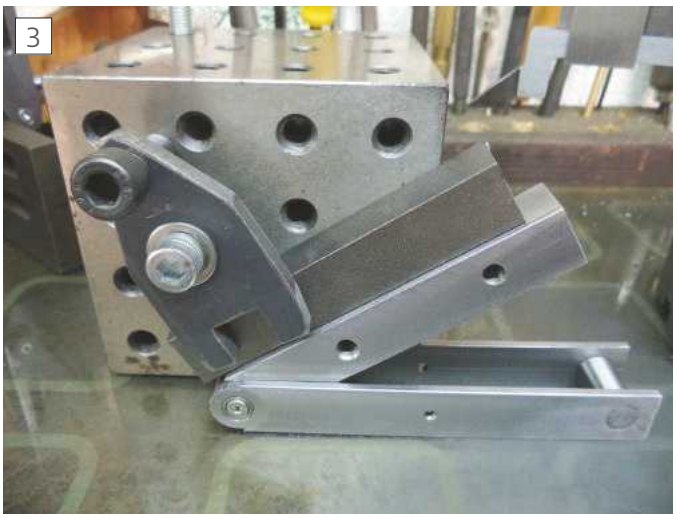
Zeroing the height gauge

From time to time you are faced with setting a part accurately to an angle for machining, for this you need a protractor, there are many different commercial protractors available, but there is far more satisfaction in making your own instrument. This sine protractor uses the trigonometry equation Sine of an angle*Hypotenuse = Opposite:- if you make the Hypotenuse = 100mm all you have to do is look up the Sine of the angle move the decimal place 2 spaces to the right and you have the Opposite height. Assembly Drawing

Setting the protractor for an angle of 30 degrees:- Sine 30 is 0.5, so 0.5 *100=50mm. With the protractor on a flat surface you zero your height gauge on the top of the roller, then adjust the height of the roller to 50mm it is now set at 30 degrees, and you can use it to set your part up, **photos 1**, **2** and **3**.

One thing to keep in mind when you're making an instrument like this is that you will be transferring any errors in it to your work, and the same can be said for the equipment that you use to make it, so it pays to check

Height gauge 50mm sets protractor at 30 degrees



Part set at 30 degrees

Traming the mill head square

Checking the vice jaws

Using a round bar to eliminate the effects of jaw tilt

out your machinery you are going to use, particularly your mill and its vice.

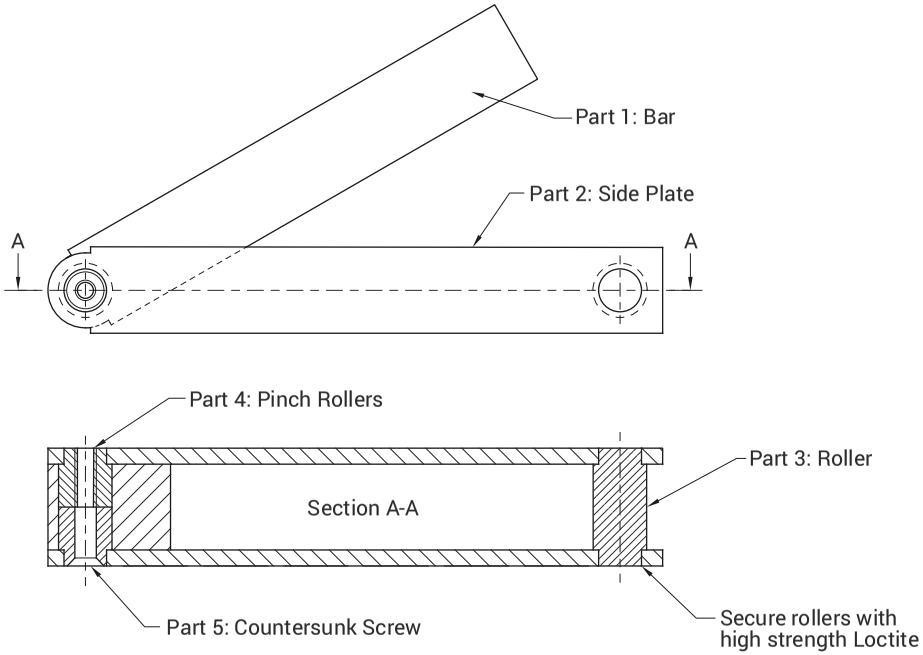
So the first job was to tram the mill head square to the table, there are quite a few ways to do this and we all seem to have our own preferences, I used my home made two clock tram, these can be bought commercially but there's nothing like using your own creation. Next the vice jaws were clocked up square and level to the table, **photos 4** and **5**.

Bar, Part 1

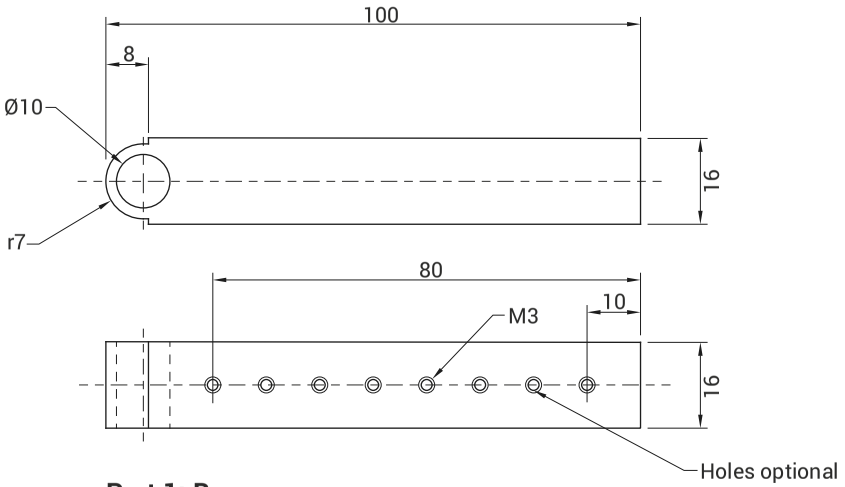
Make from 5/8" square cold rolled mild steel bar, I was using a piece that had some pre-existing M6 holes, but I figured that these holes may come in useful for fixing stops or for clamping, so I decided to work around them. You'll find that rolled steel will have a slight camber across the direction it was rolled, and it may not be quite flat. So first take a light skim off each side. The moving jaw on most vices tip slightly when you tighten them up, pushing the work out of square, for most classes of work this is of no consequence, but in this case we won't to avoid this, and the best way to eliminate it is to place a round bar between the work and

Witness marks confirming the mill is set up square

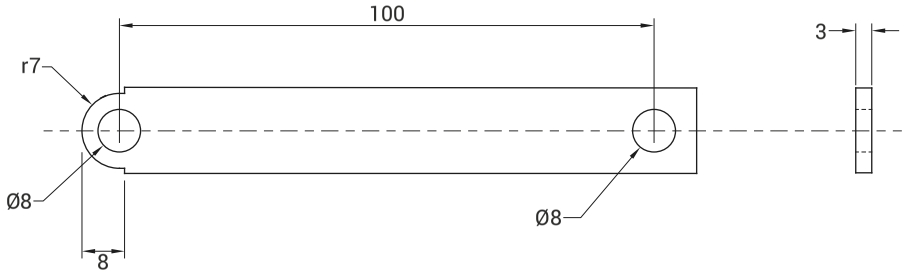
Centre drilling and rough drills



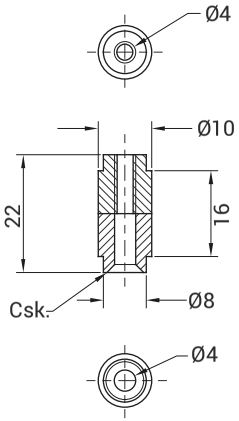
General Assembly Of Depth Gauge (One-handed Operation)



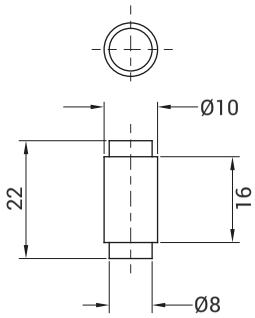
Part 1: Bar
Mat'l: Mild steel, 1 off



Part 2: Side Plate
Mat'l: Mild steel, 2 off



Part 4: Pinch Rollers
Mat'l: Silver steel, 1 set
Make combined 16mm slightly less
than bar thickness to achieve pinch



Part 3: Roller
Mat'l: Silver steel, 1 off

the moving vice jaw. When you take the light skim check that you get a crisscross witness mark from the cutter this is evidence that you have the mill head perfectly square to the table, **photos 6** and **7**.

With all sides trued up put in a nice deep centre and put through a roughing drill then a 9.5mm drill and finish off with a 10mm hand reamer ensuring that it goes through square. You can now add any additional hole you think you will require, **photos 8** and **9**.

Side Plates, Part 2

Make from 3mm thick Mild Steel strip. It's important that the 100mm hole centres is as accurate as possible and that both plates are exactly the same, to ensure this at their centre drill and tapped one plate M3 and the other 3mm and fastened them together with a cap screw. Put in a nice deep centre drill and rough drill then finish with an 8mm drill, using the DRO or the dials move the table over 100mm and drill the second hole, **photo 10**.

Pinch Rollers, Part 4

From 10mm diameter ground silver steel. Drill and tap the first Roller M3, check the size of the hole in the Side plate and turn a 3mm step so that it is about 0.5mm interference fit, and part off, repeat for the other roller but this time drill it through 3mm and countersink. Measure the thickness of the Bar and face the rollers off so that their combined width is

With all sides trued up put in a nice deep centre and put through a roughing drill then a 9.5mm drill and finish off with a 10mm hand reamer ensuring that it goes through square.

Using a hand 10mm hand reamer to finish

Drilling side plates together

Tapping pinch roller

Countersinking pinch roller

Checking combined width of pinch rollers

about 0.3 less, so that they pinch up, **photos 11**, **12** and **13**.

Roller, Part 3

This is similar to the Pinch Rollers except that it's one part, again make an interference fit in the side plates and but this time make the width about 0.3 greater than the Bar.

Press the pinch rollers into Side plates in the vice using a drop of high strength Loctite just for good measure, slide them onto the bar then press to rollers into the side plate so that everything lines up. Then take a light skim across the assembly so that everything cleans up and matches, **photos 14**, **15**, **16** and **17**.

Just one final bit of machining remains to radius the pinch roller end so that the corner doesn't lift the bar and throw the angle out. The best way to do this is to make a couple of 14mm diameter filing buttons, hold them in place with a couple of M3 cap screws then resting the buttons on the top of the mill vice mill a series of facets and finish off with a file and a rub of emery cloth just to tidy up any sharp edges, if you can beg, steel or borrow a digital protractor set your sine protractor and validate its accuracy: - that's it job done, **photos 18**, **19**, **20** and **21**. ■

Turning the roller

Press fitting the pinch rollers

Press fitting the rollers

Taking a light skim to bring everything level

Milling facets to rough out radius

Finish off radius with a file

Validating accuracy

Completed Sine Protractor

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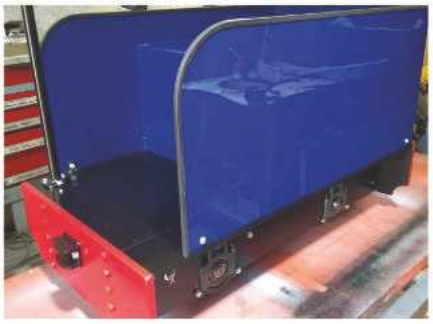




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Toolholders for a Myford M Lathe

Finished tool holders showing the broad range of tools that fit can be held.

David Smith makes a batch of toolholders for one of these well-regarded old lathes

I was delighted to see the article on tool holders for a Myford/Drummond M type lathe. This is because after more than 15 years of struggling with the original tool holder on my Myford, I finally got around to making some new ones of my own design earlier this year, **photo 1**. They are not as elegant as those made by Geoff Walker, but I find them to be extremely functional. The holders are made from mild steel blocks 3 x 2 x 1¼" that I purchased cut to size and the construction is straightforward.

I drilled the hole for the post to my largest size of 1" with a large Chinese mill/drill I have for such purposes because it can accept drills with a No.3 Morse taper. Drilling a 1" hole in mild steel takes a lot of torque. This was then bored to a final size of 1¼" in the lathe with an additional chamfer on the underside to fit the tool post. I could have done all this work in the lathe, but my Myford has a No1 Morse taper and this limits the drilling capacity.

I spent much time pondering how to hold the tools so, working on the keep it simple

Close up showing construction detail

›

approach, I drilled a standard ¾" hole to mount the tools on all 4 tool holders, **photo 2**. This is much simpler than a square hole (Where do you buy drills for square holes?) but retains the strength, unlike an open slot. It will accept a wide range of tool shapes and holds rectangular shapes remarkably level and secure. All my current tools fit, and if the need arises, I can always modify one of the holders.

A similar standardisation was taken with the machine screws used for both the tool post and the tool clamps. These are all M8 socket head cap screws, so only 1 tool is needed for clamping. I find that a 17/64" drill is perfect for tapping M8. I used M6 for the height setting screw and lock nut as, from my supplier, I could get one in brass which is kind to the top slide, **photo 3**. It is only tapped for 1/4" of the depth with the untapped section below so that it can't fill with swarf. After much drilling and tapping, all that was left was to do was cut a slot in the holder so that it would clamp to the tool post. This was done with a slitting saw in my Hayes Diemaster mill, but could have been done in the lathe. After some trials with the prototype holder (the one that was one operation ahead of the other 3) I found that a combination of poor tolerance with my boring operations and lack of length of my Allen keys meant that I needed to cut extra slots in the sides of the tools to facilitate clamping. I could have done a lot more to refine the finished results, but they went to work as soon as ever they could, and for me that was what it is about.

Once the height is set for a particular tool and holder, it means that tool/holders can be swapped for different operations in a few seconds. It was in fact the lack of such a height setting screw on the original tool holder that set this project in motion. More importantly the original tool holder is hardened and so all my drills bounced off!

These tool holders have completely transformed how I work with my lathe as I can swap tools quickly and know that the centre height is correct. It was only a matter of a few evenings work and I should have made them years ago!

Underside showing chamfer needed to fit the tool post and brass height adjustment screw.

Anyway, perhaps it may inspire some MEW readers to make something similar that is effective but quick and easy to make. ■

Scraping and Shimming Myford Headstock Bearings

The heart of every lathe are its headstock bearings. If these are sloppy, the whole machine will perform poorly. Pete Barker shows how he tightened up a badly worn Myford ML7 white-metal bearing set

It was a bit of a shock to find .010" up-and-down shake when my son and I put a dial indicator on the headstock spindle of the recently acquired Myford ML7. We knew the machine had been sorely abused in its life in an electric motor rebuilding shop but this much wear was unexpected. Side-to-side shake was a similar amount. Fortunately, the ML7's white-metal bearings are almost infinitely repairable. They are in the form of two half-round shells made of an alloy of tin and other ductile metals including usually antimony, copper and lead. The Myford's white metal is quite thick, more than 1/8", so there is scope to re-scrape it many times.

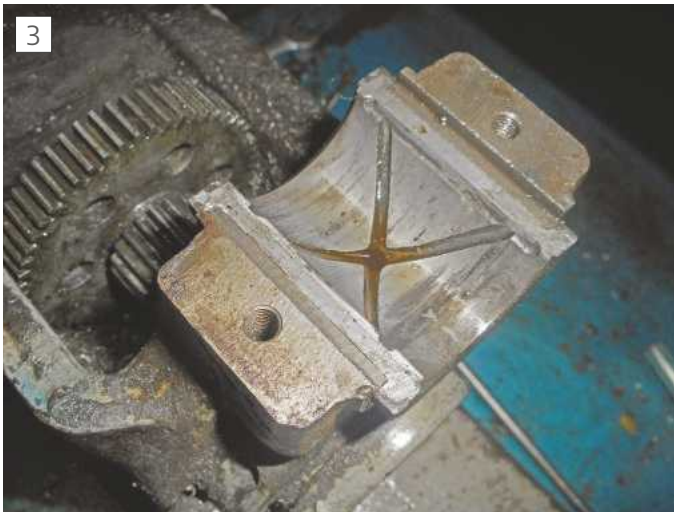
However, in many cases, scraping is not required. Most often, wear can be taken up by reducing the thickness of the pair of shims between the two bearing halves. This reduces the spindle-to-bearing clearance to the desired half to one thousandth of an inch, just enough room to allow an oil film between the parts. So, the first step is to determine what needs doing: simple shimming or scraping and shimming combined.

Two bearing caps hold white-metal split bearings in place.

Inspect, measure and clean

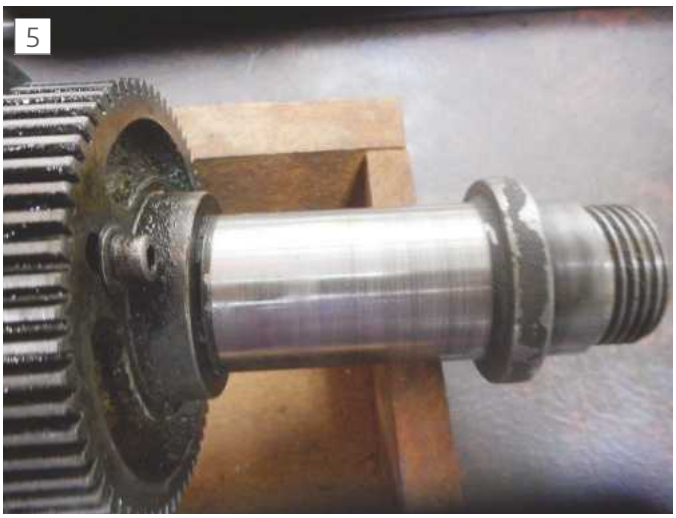
As mentioned, the first inspection step is to

Shims between halves set bearing clearance.



Bearing shell was scored and burned.

Put spindle in a clean, safe place.



Light scoring or ridging can be dressed with emery tape.

Don't overdo the blue. A thin smear is enough.

Poor contact is shown by unblued areas.

measure spindle movement in the vertical and horizontal planes with a bed-mounted dial indicator. Make sure the dial indictor bears on the spindle, not the chuck, but use a piece of bar held in the chuck to wriggle the spindle up and down. If movement is less than one thou, leave the bearings well alone.

If movement is more than one thou, remove the two cast-iron bearing caps shown in **photo 1**. This is a simple matter of unscrewing the oiler and the two Allen-head screws from each cap and lifting them clear. The job can be done with the lathe completely together, minus the change-gear guard. Take care not to lose track of the small square shims under each cap, **photo 2**, and where each goes. Also, centre punch one side of the right-hand bearing cap so it will be refitted the same way around each time. The left-hand cap fits only one way.

Photograph 3 shows the state of our already-stripped-down example machine. Scoring and burning can be seen on the bearing surfaces, mostly to the pictured more highly stressed right-hand unit, which is also obviously bell-mouthed from the excess spindle slop.

The spindle should be lifted out and sat in a clean, safe place, **photo 4**. It is not necessary to remove the pulley and bull gear from the spindle for this job, but it makes life easier to remove the small gear, sleeve and thrust bearing from the left-hand end. If you do need to remove the pulley and bull gear, as we did, they tap off easily with a soft hammer once all grub screws are released.

Inspect the spindle for wear and damage on the journals, **photo 5**. Light scoring or ridging that can be felt with a thumbnail can be dressed down by holding the spindle in the vice and working evenly back and forth around the journals with a long strip of fine emery tape, just to knock the ridges down flat. Don't do it in another lathe under power as that can easily take off too much metal. The carbon steel spindle is much harder than the soft bearing material so even in this very worn machine, damage to the spindle was minimal and easily smoothed down.

Using bearing blue

At this stage, everything should be given a good clean. Then the spindle is given a thin coat of non-drying bearing blue, also known as engineer's blue or micrometer blue and not to be confused with quick-drying layout blue dye. Don't lay the blue on too thick or it will give a false reading as it oozes through the gaps between spindle and bearings. Rub it on with one finger and then rub the excess off with another. About like **photo 6** is right for most stages, (although it is hard to show in a magazine depending on how the printers ink their press). A tad more blue can be used at the beginning when roughing.

The spindle is carefully lowered into the bearing halves in the headstock, both bearing caps placed on top and the Allen screws done up light finger tight. It is good practice to set the gap equal at both sides with a feeler gauge. This also gives an idea of what thickness shims may be needed. Rotate the spindle about half a turn then carefully remove the caps and spindle.

Now is the moment of truth. For good bearings, there should be blue marking on at least 85 per cent of the bearing surfaces, spread evenly over the length and breadth. On our example, it can be seen, **photo 7**, that contact is largely missing on the rear side of the bearing, the direction the spindle is pushed by cutting forces. Also, the right-hand bearing's bell-mouthing was obvious. There is no doubt these bearings need scraping.

If yours show a better reading (and most will!) you can skip the following sections on scraping and go straight to the shimming procedure.

Scraping

Internal bearings are scraped with a hardened

Scraper second from left was small enough for the job.

Use both hands to hold the scraper and use a diagonal motion.

Scraper marks in diagonal criss-cross pattern.

Thin layer of blue gives very fine spotting of highest points.

steel scraper with curved blade. Cross-section can be either a half-round shape or triangular. Both types are hollow ground on the bottom and sharpened by rubbing flat on the bench oil stone with a rocking motion. **Photograph 8** shows a selection of scrapers, of which the smallest, second on the left, was found best suited to this size of bearing. The others were all used in a previous life scraping power-station turbine bearings big enough to put your head inside.

The technique to hold the scraper is shown in **photo 9**. It is scrolled around the diameter of the bearing gently with a curved motion, all the while pushing or pulling on the handle so the cutting edge in contact with the bearing travels in a diagonal path. The blue high spots are scraped off with a series of overlapping diagonal tiny cuts, first in one direction, and then the other, **photo 10**. A light touch is needed as the white metal is soft and we wish to remove at most a thou at a time.

While we need to remove the blue high spots, it's also important to try to scrape the two lower bearings evenly so the spindle moves downwards evenly. When you scrape the right-hand lower bearing, do the same to the left-hand lower. This will help avoid tilting the spindle. You can scrape both bottom halves until they are good before starting work in the caps if you prefer. Or you can do them all together.

As the bluing and scraping operation is repeated... and repeated, and repeated... the blue area should increase. Try not to put any extra blue on the spindle between checks so the layer of blue gradually becomes thinner. This will cause only the very worst high spots to be highlighted, **photo 11**, and then scraped. Look out too for the extreme high spots that can show up as shiny polished spots, **photo 12**, where the blue has been squeezed out of the way and metal-to-metal contact made. Scrape these down more aggressively than the other spots, **photo 13**.

This stage requires great patience and gentleness of touch as the process is repeated over and over until an even reading of blue is seen over most of the bearing surface, **photo 14**, on all four half-shells. Spread the job over a number of days if you feel impatience creeping in. At the end, scrape a little extra clearance about 1/4" either side of the shell join lines to provide space for oil on these near-vertical surfaces where shimming will not add clearance.

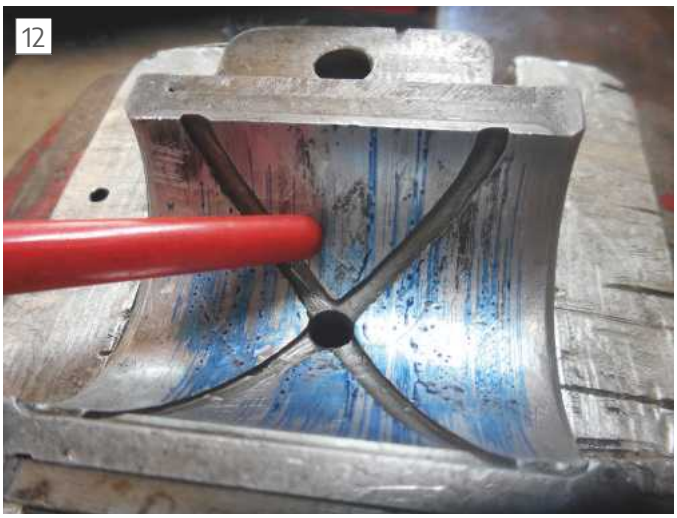
Adjust the shims

When you are happy with the blue reading on the bearings, the gaps between the upper and lower halves should be measured and shims made up to this figure plus half to one thou to allow for working clearance.

The factory shims in later years were made from laminated material where a two thou layer could be peeled off at a time to effect adjustment. This is certainly the most convenient way and worth the extra cost. However, we had no such luxury available to us, so shims were made in the traditional manner, cut from brass shim stock with scissors and a hole punched with a wad punch. Be sure to tap the burred and bent edges down flat with a hammer on a flat steel plate, **photo 15**.

Sometimes getting the final fine fit is difficult with shim stock in increments of two thou. Two dodges help with this. One, remove a two thou shim from one side of the bearing cap and not the other. This closes the gap by about one thou and does not affect alignment measurably. Or two: set the shimming a tad tight, so the spindle turns but with some drag, then scrape the bearings one last time to create the needed clearance.

During the shimming process, take care that there is still a gap between the two halves of the white-metal shells in the stepped area at the join. Extensive scraping can cause this gap to close up completely,



Shiny spot indicates very high spot with metal contact.

Very high spot is aggressively scraped.

Good overall reading of blue on this bearing.

stopping the cap from tightening down on the shims properly. The bearing cap will have to be filed or milled in this area to create clearance again.

Final fit and measure

Bearing cap screws should be tightened down firmly during shim fitting. When all is done, a final check of the spindle movement up and down and left to right is made with a dial indicator. Do this without oil on the bearings because it can take up the slack. When happy, fit the oilers and let the bearings fill with oil before use.

It may be that the spindle has been moved slightly out of alignment during bearing scraping. If so, the headstock will have to be re-aligned. It is held down by four Allen screws inside the casting. Alignment is adjusted by scraping or shimming the surfaces where the headstock butts against the bed, clamped in position by three screws at the front base of the headstock. A test bar in the spindle is clocked with a dial indicator mounted on the carriage as it is racked back and forth. More detail of that process will be in a future article on bed reconditioning with the Wide Guide conversion.

Conclusion: Patience pays off

On our example machine, no headstock re-alignment was needed after scraping the bearings carefully and evenly as described and the bed was converted to use the factory-fresh Wide Guide surfaces.

Final testing showed no measureable misalignment of the spindle and a turning test showed no taper. The bearings withstand taking a .100" deep cut in steel with no chatter or rough finish.

So it can be seen that a machine apparently in the worst of condition after years of abuse and wear can be brought back to as-new if one takes the time and care to scrape the bearings to match the spindle closely and then shim the halves to provide the thou or less gap for an oil film to fill in use. The generous thickness of the white metal on the Myford bearings means the originals should last the lifetime of the machine and longer if cared for. ■

Tap shim edges down flat with a hammer.

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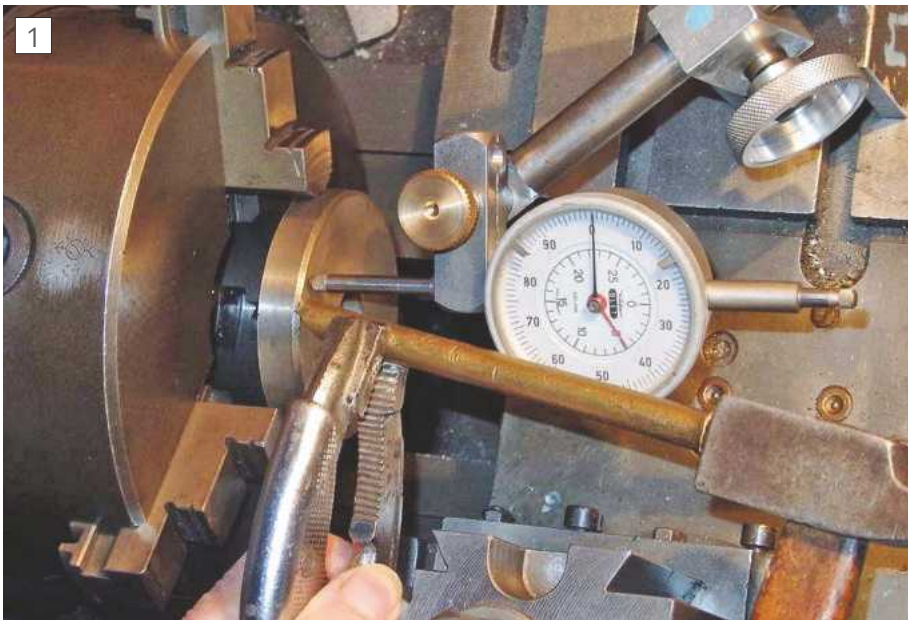
“Coax”- Achieving Accurate Coaxial Chucking

Jacques Maurel looks at various ways of making standard three jaw chucks easily adjustable

A very frequent job in lathe work is to take an already machined part in the chuck and we make it run true and so get it **coaxial** (having the same axis) with the machine spindle, for further machining. The usual way is to use the 4 jaw chuck for this purpose, this works but is not very convenient. An adjustable 3 jaw chuck is far more efficient for this.

The job is not the same if the part is long (length more than 0.8 x diameter) or short (length less than 0.25 x diameter).

Short part: (example a gear blank see **photo 1**), first take out the wobble (chuck slightly tightened), this is described in my article “Truing Roller” ***Model Engineer 4501***. It’s possible to get 0.02mm wobble, for best results use a DTI and gently strike the part with a soft punch and hammer, as shown on the photo and then tighten the chuck.



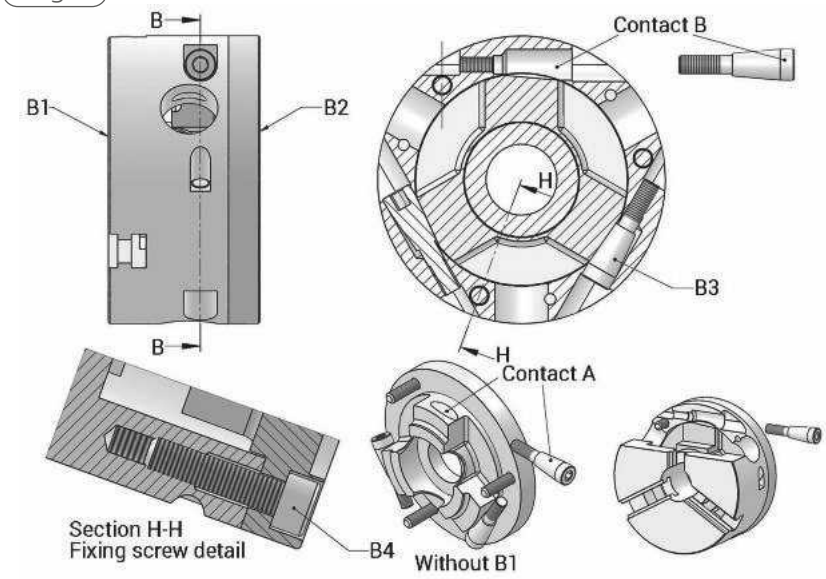
Removing wobble from a short workpiece.

After that we have to adjust the concentricity that can be done with an adjustable chuck (see **photo 2**) as described later.

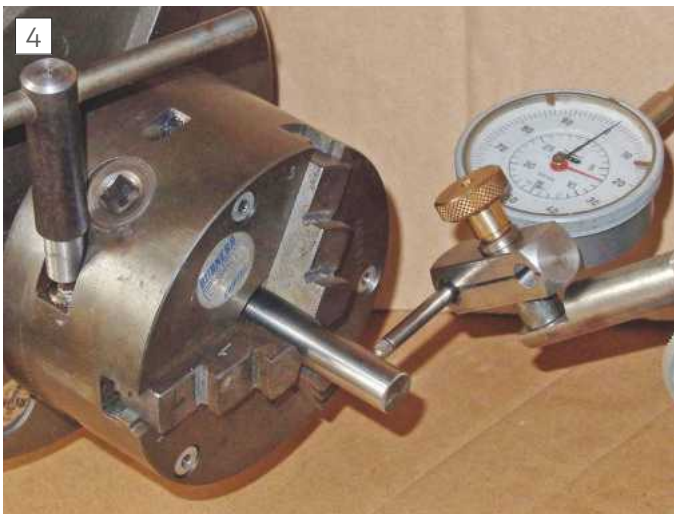
Long part: Use first a “truing roller” and/ or soft hammer strokes to set the part axis parallel with the spindle one : The part being

Adjusting concentricity.

Fig.1



Grip-Tru chuck.



Using the Grip-Tru

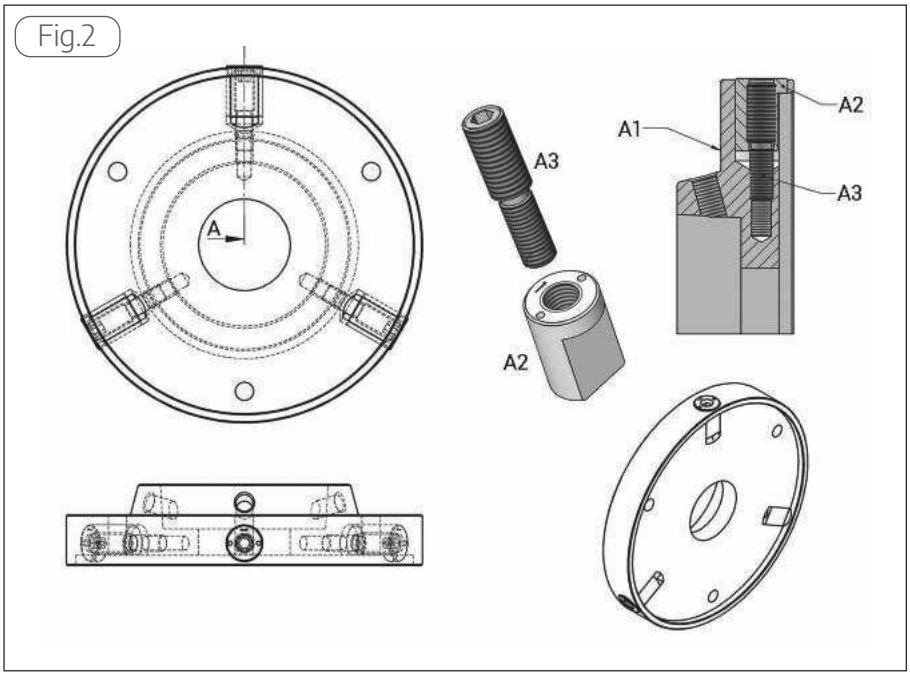
slightly tightened in the chuck (on a short length of the part). Adjust for the same run out in the same direction for two different sections of the part checked with a DTI, and then tighten the chuck. Only a short part of the workpiece is held in the chuck, so some support should be added (centre and/or steady) after the last adjustment has been done. The last adjustment is the concentricity that can be achieved with an adjustable chuck. If a centre is used, the centre hole in the workpiece must be made after the coaxiallity adjustments and not before!

Notes

A centre is a point, an axis is a line so to get coaxiallity, we must set first the part axis parallel with the spindle one (this is easily done with the "truing roller") and then set one point of this line concentric with the spindle axis this being done with the adjustable chuck.

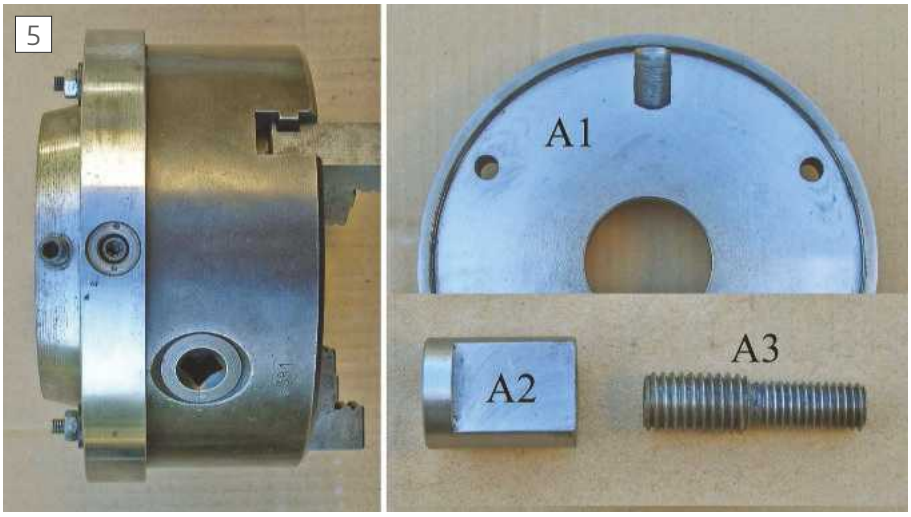
As two adjustments must be made, it's common when using a 4 jaws chuck to lose the first when trying to achieve the second! Moreover, the chuck screws' pitch is quite great so the adjustment very sensitive.

The adjusted chuck could be out of balance, so vibrations could occur at high speed.



Adjustable chuck:

With this chuck the concentricity can be adjusted after the part has been clamped inside the jaws.



Modified chuck, version 1.

The best known is the "Griptru" chuck from Burnerd brand see **fig 1** and **photo 3** of a 4" Griptru chuck, in fig 1 the scroll pinions and jaws have been removed for a clearer drawing.

There is a small radial average play (0.3mm) between the front body **B1** and the rear part of the body **B2** (so the difference of diameter between B2 register and B1 recess is 0.6mm), this back body B2 must be linked to a back plate that should suit the lathe spindle.

Three adjusting screws **B3** are used to move the front body radially, these screws have a cylindrical contact "**B**" on the front body B1 and a line contact "**A**" between the screw taper and a cylindrical surface machined on the back body B2. The screw thread is a standard 1/4" 20TPI, the taper conicity is 20%, hence the "wedge sloping" is 10% so one turn of the screw moves the front body by 0.1xpitch = 0.127mm (so 4.7 turns of the screw for the whole 0.6mm possible throw). This is of course far more convenient than the 3.62mm pitch (7TPI) found on the screws of my 4 jaw's independent chuck.

This problem is not so acute , as the adjusting screws are all tightened before machining, this gives a strong grip on the chuck body.

maintained by 3 M6-25 ISO screws **B4**, it can be seen on the detailed cut HH that 10mm of the screw shank is in a recess to allow for the adjusting movement.

Use of this chuck (see **photo 4**): As shown on the photo, the DTI must be set at the rear of the workpiece, its stem perpendicular to the lathe axis, in a horizontal plane, and at center height. This position is the most convenient for the adjusting Tee wrench. Tighten the part, slacken all the screws B3, check the runout with a DTI, "0" the DTI for the lowest point, turn the chuck to the highest point, tighten the nearest opposite (to the DTI) adjusting screw by half the runout and slacken, renew the routine until "0" runout, and tighten all the adjusting screws while still checking for "0" runout. This works well, but the great mystery is how much to tighten the B4 screws? Nothing is said in the operating instructions.

Making your own adjustable chuck (from a standard one using a backplate):

Many other solutions have been proposed, I'll show the solutions I've used. There are two problems to solve:

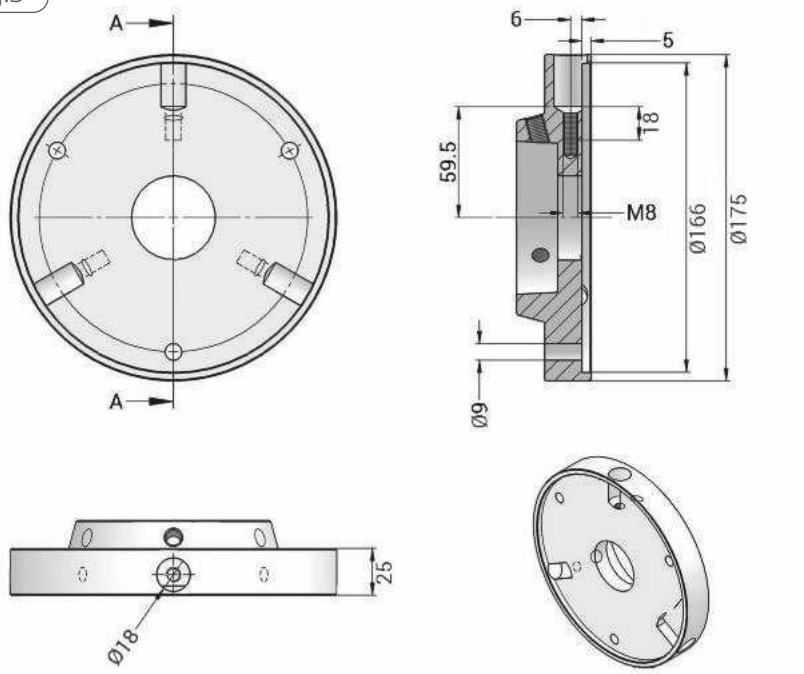
- First – how to give a micro movement to the chuck body.
- Second – how to maintain the good contact between the 2 bodies.

Giving a micro movement to the front body:

First solution (see **fig 2** and **photos 2** & **5**): making a special back plate A1 holding 3 plungers A2 (for pushing the chuck body) driven by a differential screw A3, two threads are machined on this screw, the bigger that fits the plunger is M10 (1.5mm pitch), the smaller that fits the back plate is M8 (1.25mm pitch), for one turn of the screw, the plunger is moved by the difference of the screws pitches so 0.25mm; surprisingly, it's necessary to turn the screw leftwards for pushing down the plunger, of course I've discovered this at the first use.

Machining (see **fig 3** and **fig 4**): turn the rear part of the back plate A1 to suit your lathe spindle, rough out the front part, but don't machine the front recess. Mark out and drill the plunger holes (it's not necessary to use a dividing head), drill and tap the screw holes at the same setting for each hole to get the best coaxiallity, it's possible to drill these holes on the lathe, the part being held in a toolholder or in the vice of a vertical slide, **photo 6**, with the drill and tap held in the lathe spindle. Set the back plate on your lathe spindle and machine the recess. Screw cut the 2 threads on A3 (or rough them by screw cutting and finish with a die) to get the best coaxiallity, the hex bore is then punched (see Model Engineer 4310). Turn and tap the plungers on the lathe, mill the shoulder and drill the two driving holes. The play between plunger and back plate should be quite generous, say 0.15mm as it's difficult to get a good coaxiallity on the different parts for the

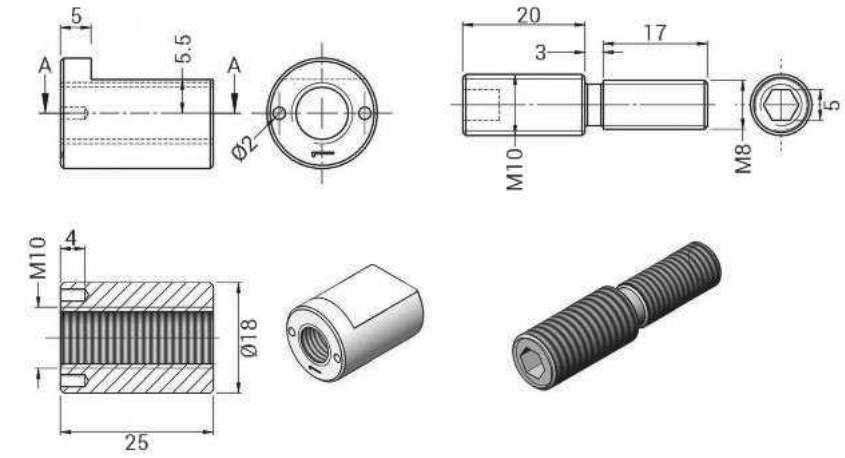
Fig.3

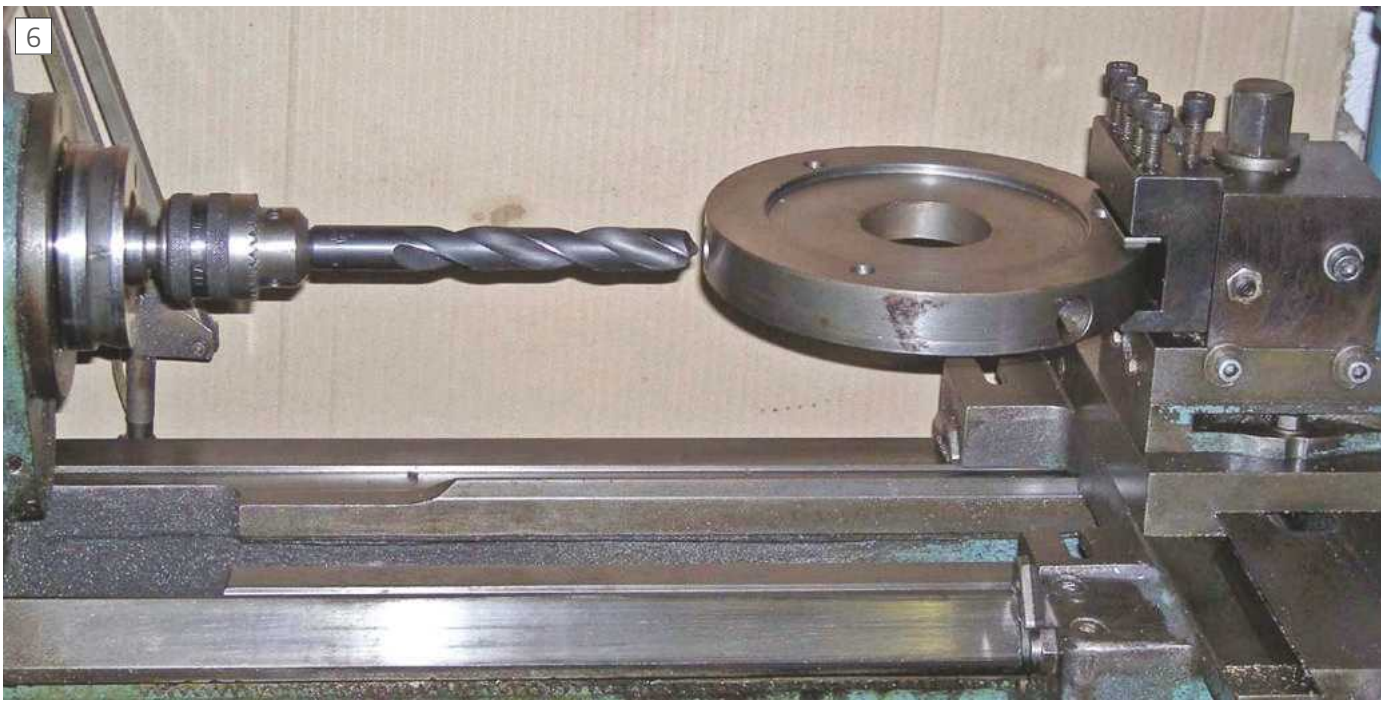


Parts list:

Part	No.	Name	material	remarks
A1	1	Back plate	steel	0.5% carbon
A2	1	plunger	steel	0.5% carbon
A3	1	Driving screw	8-8	

Fig.4





Drilling plunger holes.

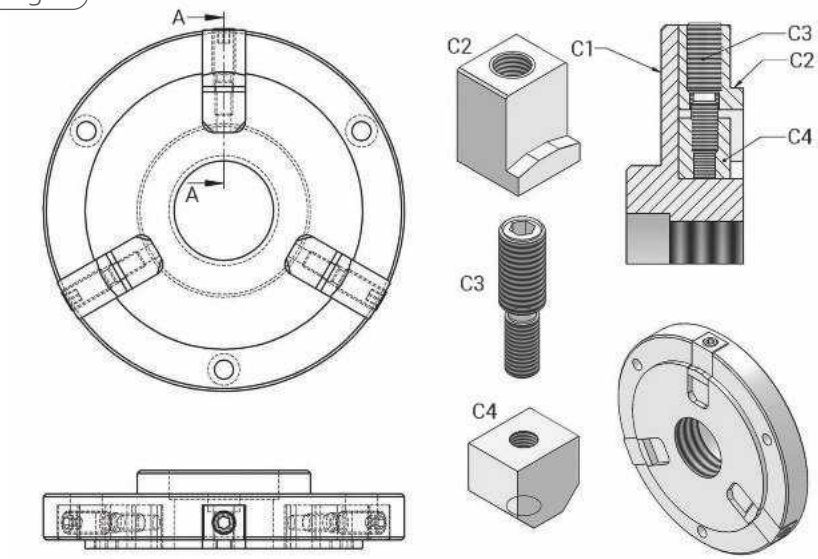
tapped holes.

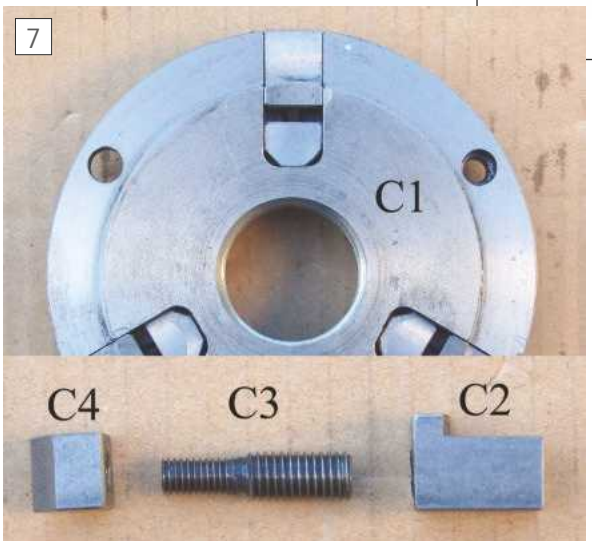
Setting: seems simple but it's not so easy as when the plunger touches the chuck body (in the centered position), the screw must be able to move 2 turns forwards and backwards, so some fiddling is necessary. Screw first A3 on A1 until the top of A3 is about 2mm under the outside cylinder of A1 lock A3 with a 5mm hex wrench and screw A2 on by hand and/or with a pin spanner until the distance between the plunger shoulder and the opposite part of the recess is slightly more than: 166-0.5 = 165.5mm (as the chuck body diameter is 165mm and the average play 0.5mm). Note that one turn moves A2 by 1.5mm to A3, one turn moves A3 by 1.25mm to A1, but one A3 turn moves A2 (if no turning) by 0.25mm to A1 hence the "fiddling". Don't forget to lubricate all the moving parts with a good grease (the ones with molybdenum disulfide are the best for this).

Advantages: The machining can be done on the lathe, the only milling job is the shoulder on the plungers that can be made on a lathe with a vertical slide.

Drawbacks: The coaxiallity is difficult to achieve between A1,A2 & A3; due to the tapped hole in A1.

Fig.5





Version 2.

Notes:

- If you feel it's difficult to machine a back plate that fits the spindle, it's possible to make an intermediate "adjustable plate" set between the spindle one and the chuck body, to carry the plungers, but of course it's much more cumbersome.
- It's worth marking a number (on A1 or A2) to know which plunger has been moved when making the adjustment.

Using the attachment (photo 2): As shown on the photo the DTI must be set on the top of the workpiece, its stem perpendicular to the lathe axis, in a vertical plane cutting the lathe axis, this is easily done by moving the cross slide to find the highest point. Tighten the part in the chuck and slacken all the plungers, check the runout with a DTI, "0" the DTI for the lowest point, go to the highest point, tighten the nearest (to the DTI) plunger until half the runout and slacken, renew the routine until "0" runout, and tighten all the adjusting screws while still checking for "0" runout.

This problem is not so acute , as the adjusting screws are all tightened before machining, this gives a strong grip on the chuck body.

Notes:

As seen in photo 2, a Tee hex wrench is very convenient for this purpose. I made it by setting a piece of 5mm hex wrench in a 5mm hex bore (obtained by punching see Model Engineer 4310) the bottom chips are cleared with a 5mm drill, a taper is made by off-hand grinding at one end of the hex tip and then the tip struck in place with a hammer.

- When the runout is about 0.07mm or less, it's not necessary to slacken the screw. The screws will force against the others.
- The adjustment will be difficult if the spindle bearing play is more than 0.01mm.

Second solution (see **fig 5** and **photo 7**): here also a special back plate C1 is used but the 3 plungers C2 are pulling the chuck body (from inside its back recess) in place of pushing, a differential screw C3 is also used, but the smaller thread is now set in a separate nut C4.

Machining (see **fig 6** and **7**): same remarks as for the previous solution, here the play can be given on the part C4.

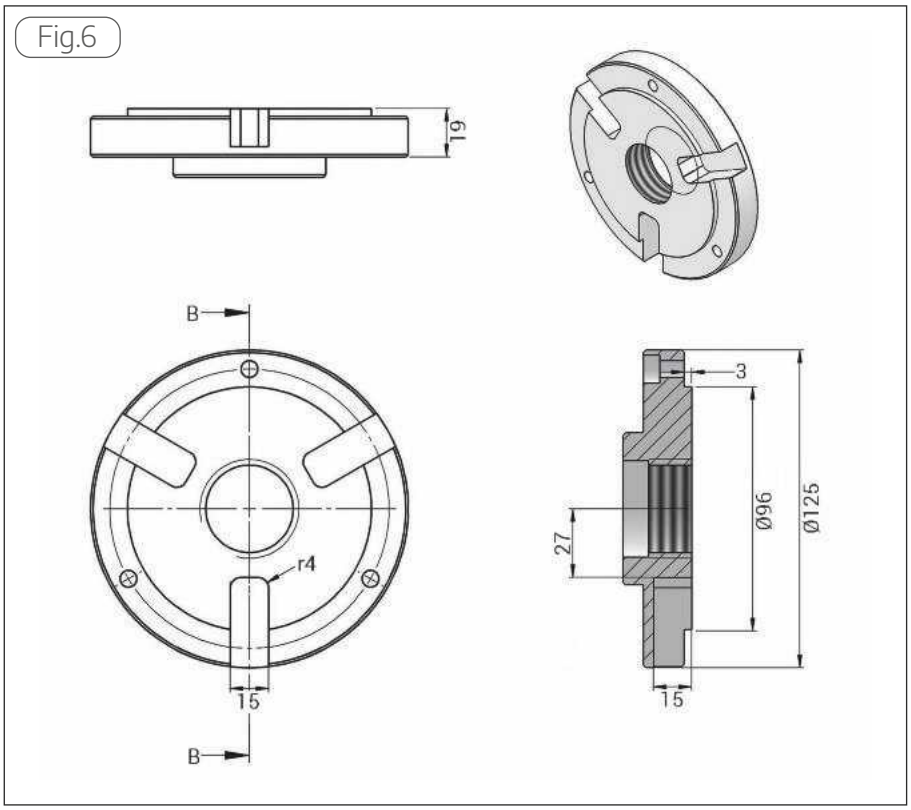
Setting: make three sub assemblies (C2, C3, C4), fit them on the backplate and adjust the distance between the plunger shoulder and the opposite part of the register to slightly less than 96+0.5=96.5mm (as the chuck recess diameter is 97mm and the average play 0.5mm) see **photo 8**.

Advantages: The back plate is of the same diameter as the chuck one, very often it's possible to use directly a standard back plate and machine it (see later for a "Präzimat" lathe). The separate C4 nut eases the setting (fewer coaxiallity problems and half a turn possible for it so less fiddling.

Drawbacks: It's necessary to use a milling machine.

Using the attachment: The opposite of the previous one as we are now pulling the chuck in place of pushing. Tighten the part in the chuck and slacken all the plungers, check the runout with a DTI, "0" the DTI for the highest point, go to the lowest point, tighten the nearest (to the DTI) plunger until half the runout and slacken, repeat the routine until "0" runout, and tighten all the adjusting screws while still checking for "0" runout.

Adjusting plunger to shoulder distance.



Parts list:

Part	No.	Name	material	remarks
C1	1	Back plate	steel	0.5% carbon
C2	3	Plunger	steel	0.5% carbon
C3	3	Driving screw	8-8	
C4	3	Nut	Steel	0.5% carbon

Fig.7

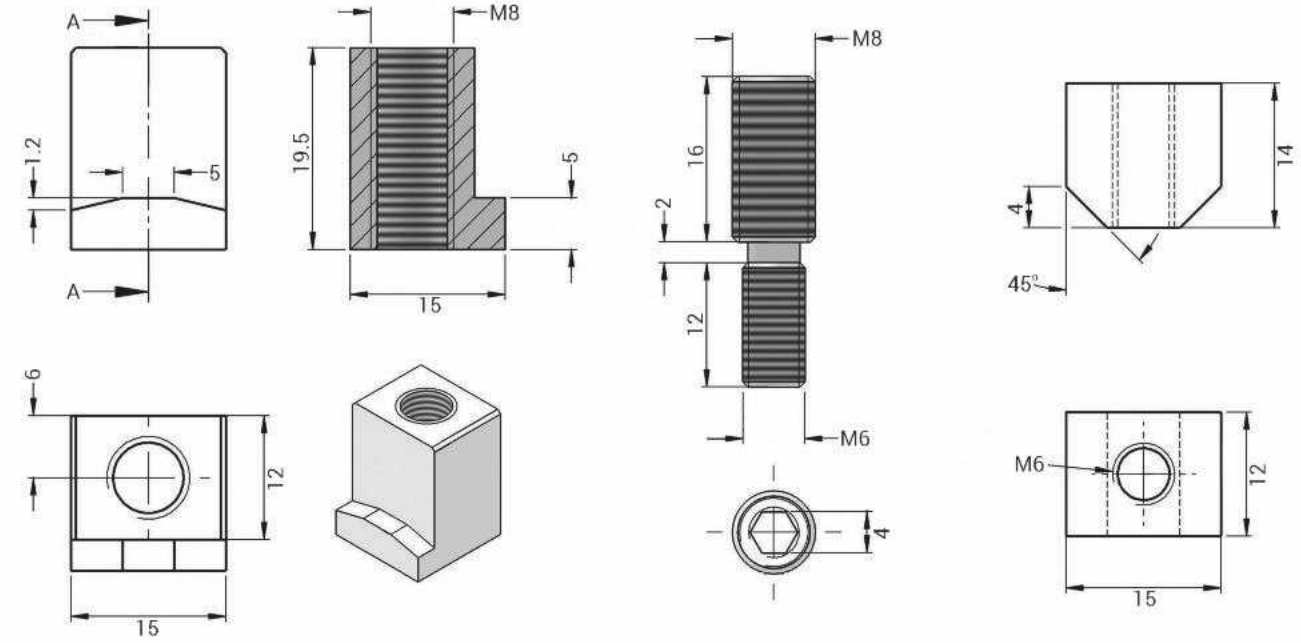
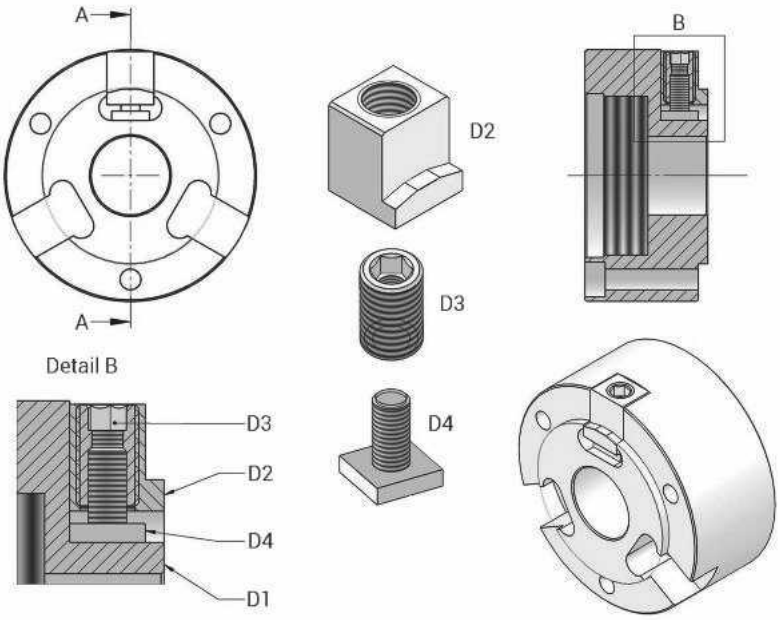
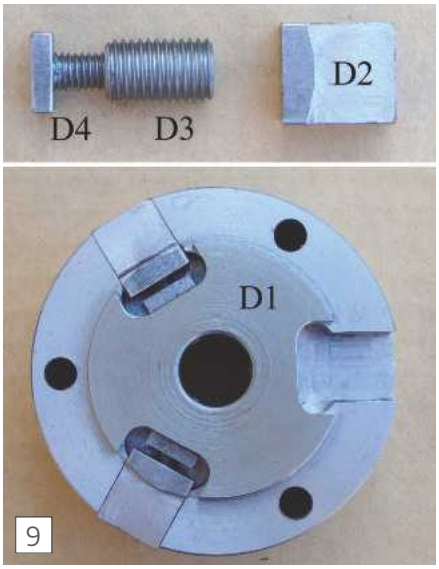


Fig.8





Third solution.

Third solution (see **fig 8** and **photo 9**): nearly the same as the second one, but when there is not enough room to fit the differential screw, a "Screw nut" D3 is used, its outside diameter being here M10 but with the fine 1.25 pitch, the inside diameter being M6 (1mm pitch) so the equivalent pitch is still 0.25mm. This screw nut is driven by a 6mm hex bore.

Advantages: easy setting as one quarter turn is possible for the screw D4. Less cumbersome than the second solution.

Drawback: A special tap is needed for the fine M10 pitch.

Parts list:

Part	No.	Name	material	remarks
D1	1	Back plate	steel	0.5% carbon
D2	3	Plunger	steel	0.5% carbon
D3	3	Screw nut	steel	0.5% carbon
D4	3	Fixed screw	Steel	0.5% carbon

To be continued

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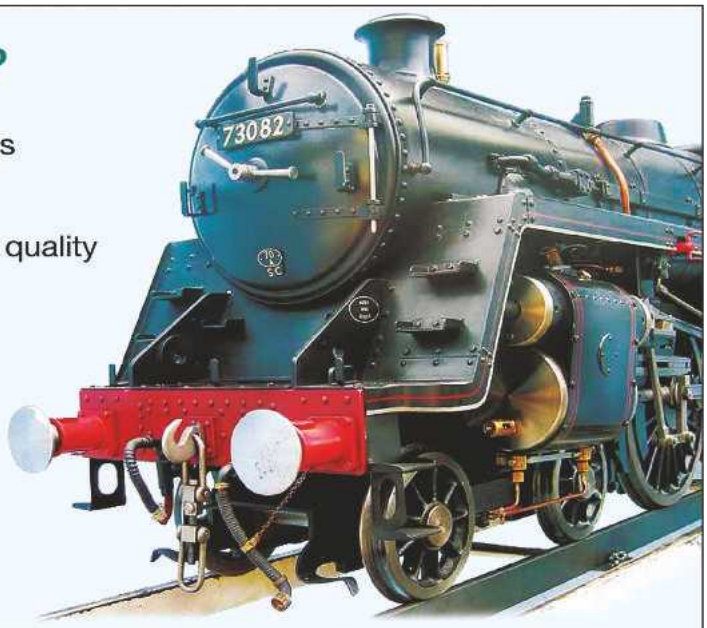

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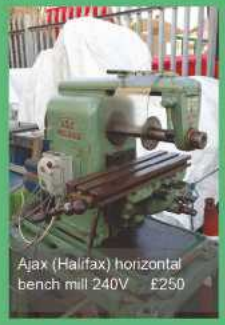
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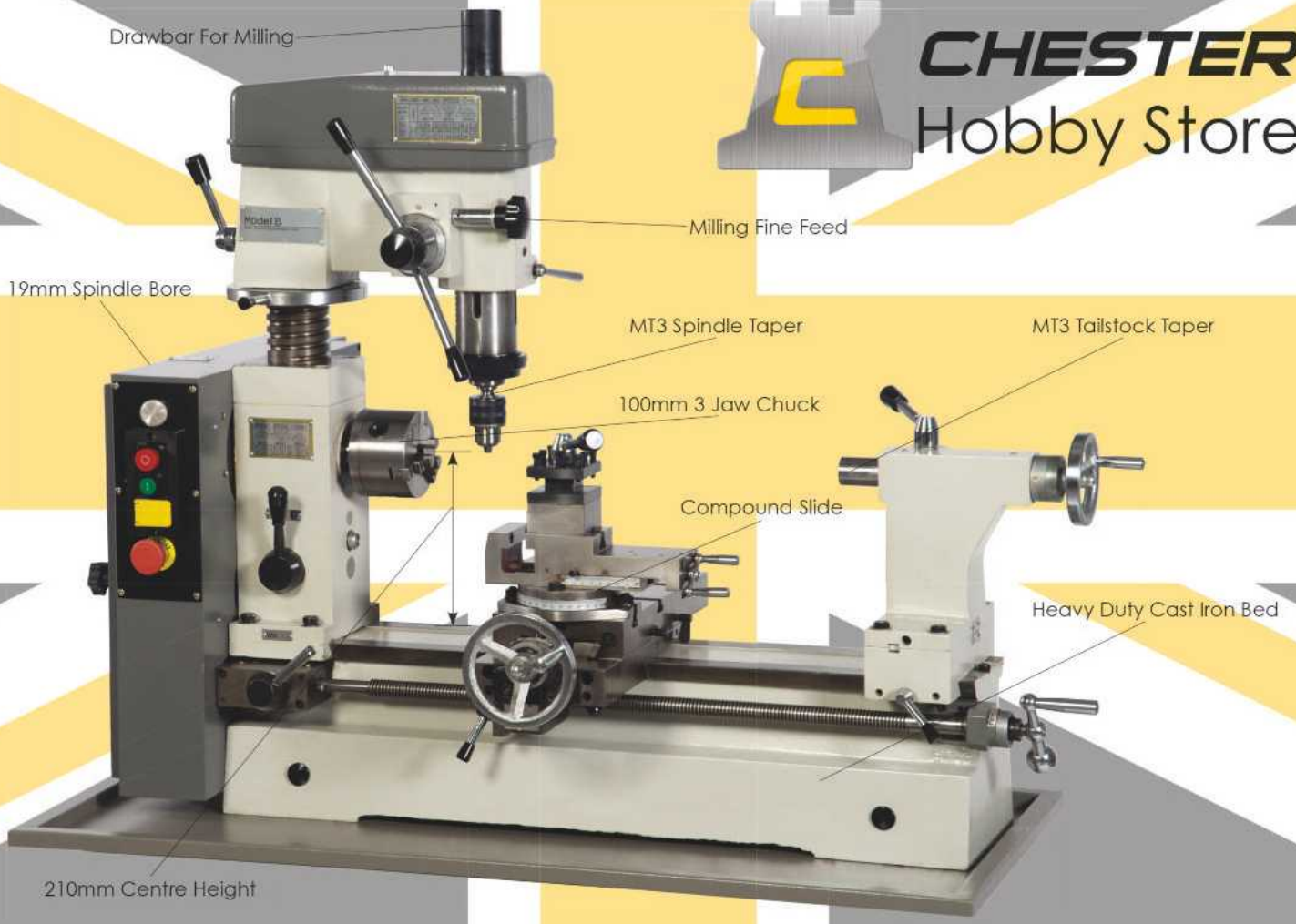

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- Manual and parts list

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Swing Over Cross-slide	130mm
Between Centres	520mm
Width of V Bed	139mm
Tool Size	12mm
Spindle Bore	20mm
Spindle Taper	MT3
Spindle Speeds	Lathe:160-1360rpm Mill:117-1300rpm
Metric Threads	0.2-3mm
Imperial Threads	8-120TPI
Copound Slide Travel	80mm
Cross-slide Travel	185mm
Tailstock Quill Travel	80mm
Tailstock Taper	MT3
Headstock Bearing	Tapered roller
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