No.155

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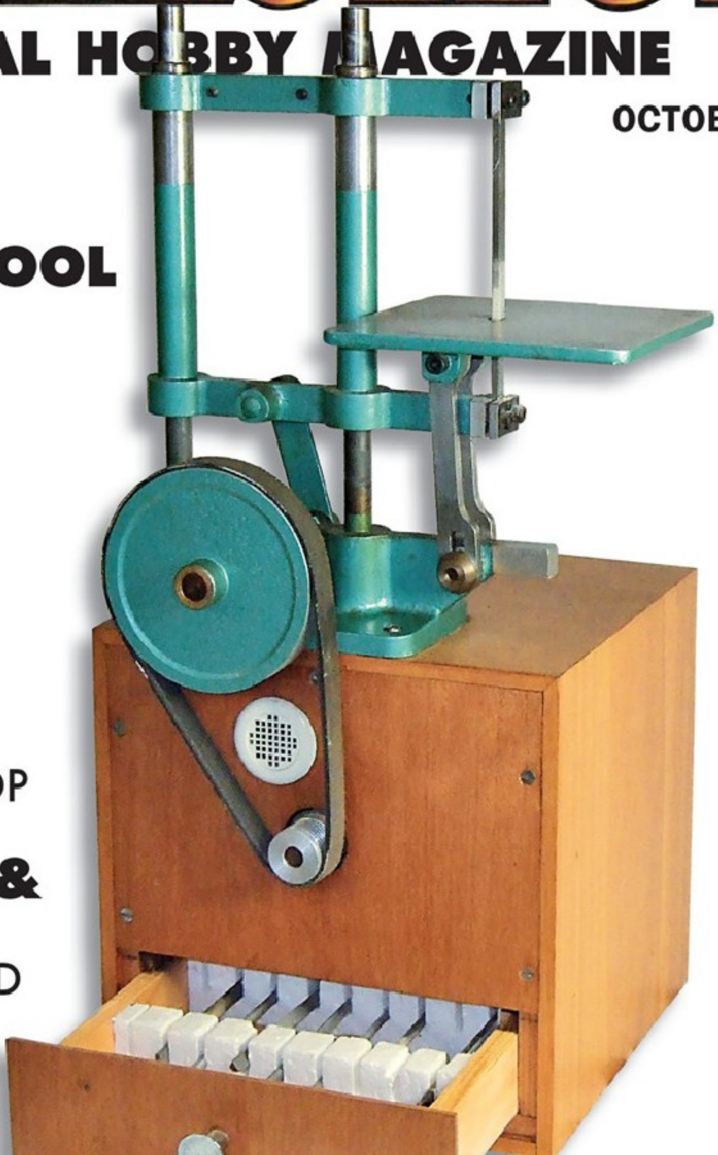
MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

OCTOBER 2009



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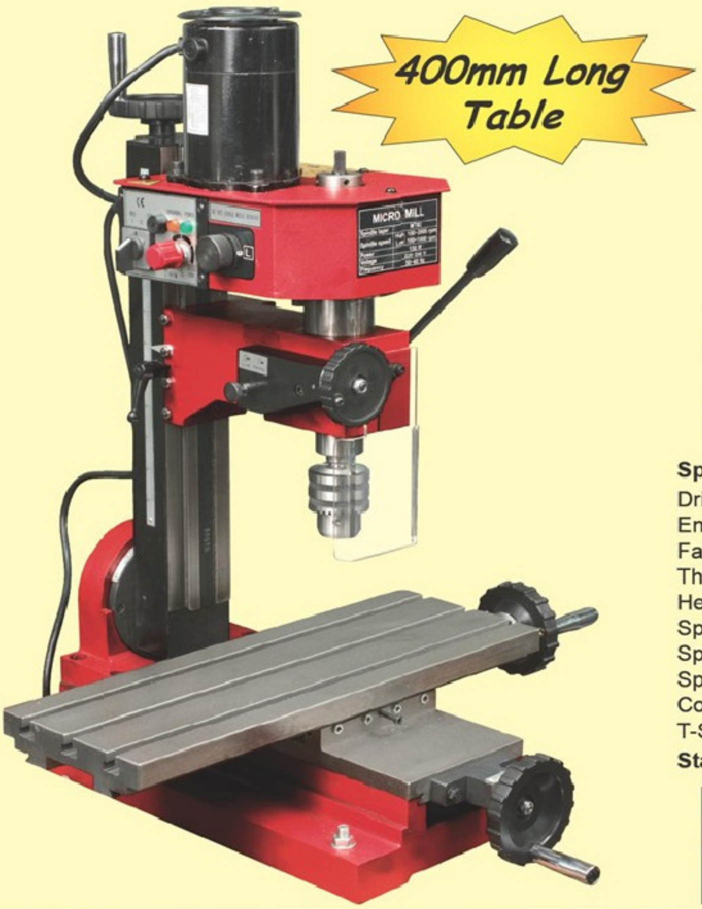

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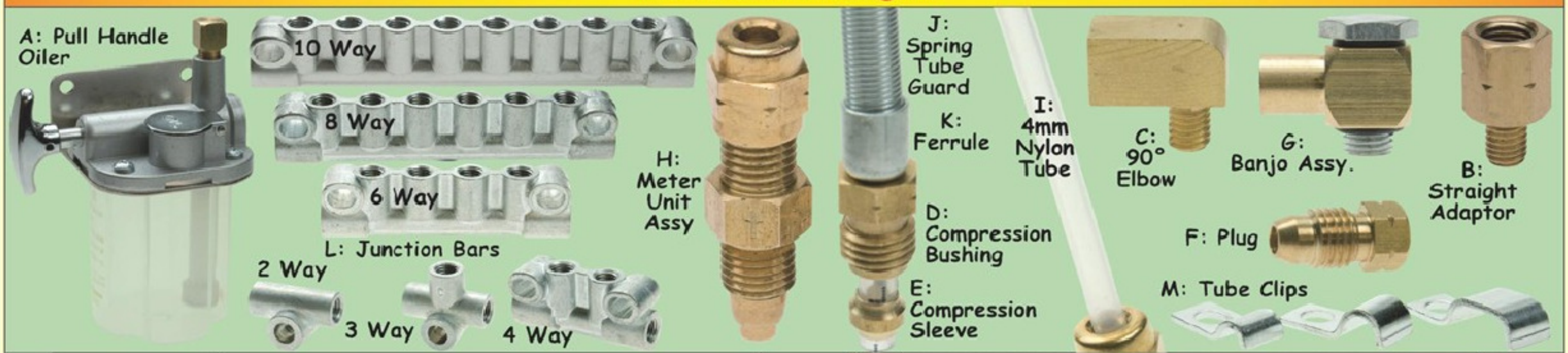

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ON THE EDITOR'S BENCH

The penny has dropped

At long last the subscription renewal letters are being redone! I hope this means you no longer get renewal letters with Dave Fenner's signature or photo on them. (No offence Dave.)

If the email I received about a week ago is correct, the renewal cost will now be lower than the initial subscription cost. I have been requesting this for over two years. You, the loyal subscriber, should not be penalised for choosing to subscribe on an ongoing basis. I know this means new subscribers don't get the first 12 months quite as cheap as the person renewing but they probably will get a useful free gift. Anyway, I think it is a step in the right direction. Long may it continue.

More good reasons to subscribe

Back issues of Model Engineers' Workshop (and Model Engineer), about 3 years worth, have been placed on the Model Engineer website www.model-engineer.co.uk for the benefit of subscribers. These are in digital format and while they are free to read and print out, they are not available to download. (Note: you can only access the back issues of the magazine(s) you subscribe to.) This facility is available worldwide although we have a problem with US and Canadian subscriptions. This should be resolved by the time you read this although you will have to email the customer services team to get your subscriber number that will allow you access. You will need your EWA subscriber number to hand. We will publish details of what to do on the website when it is resolved.

UK subscribers can find their subscriber number on the grey envelope that their magazine arrived in. I will pause for a moment will you all rush out to the rubbish bin - - - - - - now I bet you wish you had not destroyed the envelope!

UK subscriber numbers are in the format 00********R MEW156. Just enter the eight digit code where the * are. Ignore the first two 00s and everything after the last *.

Unfortunately, even if you have a regular order with your newsagent, we can't give non subscribers access to back numbers on the web.

Even more good news for subscribers

Back issues of Model Engineers' Workshop on the web

I am considering asking management to make early issues of Model Engineers' Workshop available on the web at a price. We are legally entitled to do this without fear of copyright as long as the complete magazine is published including the original adverts without any changes. What do you, the reader, think? Is there a demand for this?

Website added value

A percentage of content is being made available for subscribers only. Some of this content will never have been published in ME or MEW. Substantial content will still be left unlocked, usually complete stand alone articles or the first few parts of a multipart article so you can have a look at the first few articles before deciding whether to tackle a project or not.

Cover photos

I have had a letter of complaint from a reader about the photo of a shaper on the cover of 154. He believed he had been conned as there was no article on shaping in the magazine. Cover photos are a major problem. I have plenty of articles in hand although more would be welcome especially CNC and shaping machines. However, I don't have any decent photos suitable for covers that relate to articles inside the magazine.

Finding a suitable cover photo has always been a problem. Every month I submit a selection of two or three covers. Invariably I get told not suitable. Can we have another one? This is why occasionally you get a cover photo of a motorbike. I simply don't have anything else.

The cover this month is no exception; the cover photo relates to nothing inside the magazine. It was accepted as the better of the two supplied this month although it was not perfect by any means. Until I receive decent high resolution cover photos with articles, I will have to continue using unrelated cover photos, much as I would rather not.

Model Engineer Exhibition

I have started to receive exhibition entry forms. It is early days yet but I hope this year's Exhibition will be bigger and better than recent Exhibitions. I would like readers to make an effort and submit a piece of tooling to this year's Exhibition. We have plenty of space to display them as we have both upstairs and downstairs in the Sandown stadium. If you don't wish to enter the competition or if your item is not finished, you could enter it into the loan section for other visitors to enjoy. Failing that, perhaps your club has a stand and you can let them exhibit it on their club stand.

Dave Fenner has agreed to accompany me to the exhibition again this year. As I, no doubt, will be extremely busy talking to people, Dave will be writing a show report for Model Engineers' Workshop and also hopefully, Model Engineer.

Workshop Specials

The Reader's Workshops Special is still available in Smiths for the next couple of weeks. We still have a few left at www.myhobbystore.com but it is unlikely we will have any left for the exhibition. The new best of Model Engineer Vol. 1 should be available in Smiths when you are reading this. (If you are a subscriber, you will have to wait a week.) This is also available through MyHobbyStore although 50% of the stock has already been sold.

Another complaint

I received a letter from Philip Bellamy in Switzerland. Basically he was upset about me not printing his letter about knurling. (See issue 154.) I don't have the letter to hand but seem to remember that censorship was mentioned. This was not the reason I did not publish the letter; rather that not everyone has the bottomless pockets that Mr. Bellamy seems to have when buying workshop equipment. In the interests of right to free speech and not agreeing with censorship myself, I have printed, in full, a letter in reply sent in by a reader about Mr Bellamy's letter.

Cutwel Ltd. tool catalogue

I have received a catalogue from Cutwell Tools. It contains a range of low cost end mills and slot drills, inserted tips and tool holders as well as drills, centre drills and taps. They are happy to send a catalogue to any reader who requests one free of charge with no postage cost. (I have been assured there will be no postage charge at all.) Please mention Model Engineers' Workshop when requesting a catalogue.

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MACHINING INTERNAL AND EXTERNAL FITTINGS FOR A LATHE'S THREADED MANDREL

Harold Hall looks at duplicating and mirror imaging the lathe's mandrel.

I was in the early stages of writing two articles both of which included items that required fitting to a lathe's screwed mandrel and realised that I would be repeating the same explanations for both resulting in unacceptable duplication so I decided therefore to write this mini article on the subject. Another advantage would be that I could afford to be a little more detailed in this free standing item.

The Requirements

There are just two main features to be machined when fitting a device to the lathe's threaded mandrel, the thread and a parallel bore, one needing to be very precise and the other with more scope for variation. Added to these is the face that mates with the mandrel's flange.

Most important is the parallel bore. This must be a very close sliding fit and determines the repeatability of the device returning to the same position each time it is fitted. Also vital, is that the end face is perfectly at right angles to the bore but this is easily achieved providing the face is machined during the same sequence as machining the bore. As the location of the device is achieved by the bore, the thread needs to be a little on the generous size so that it in no way attempts to influence the result. Machining the thread is therefore less critical.

However, both present a problem as the item onto which it is to be fitted is not available for checking as it is holding the device for machining, either in a chuck or mounted onto a faceplate. Even if you remove it for checking and replace it when machining the bore then if the chuck or faceplate mounting is not perfect it may not return to the same position resulting in an oval bore being produced. Remember, at the final stage, depths of cut in the order of 0.002mm (0.0001in.) will be being made so even the slightest error with it being returned will have this effect.

These comments are on the basis that the bore will be made with a size over the mandrel diameter in the order of +0.002mm to + 0.003mm, I have though seen tolerances of + 0.025mm and even 0.05mm quoted and whilst these values may just be acceptable if related to a faceplate they most certainly are not if for a three jaw or collet chuck. These values are hardly precision turning as better is easily achieved, but how do we achieve much better?

Gauges

The first stage therefore is to make gauges for both the bore and thread, **photo 1** so as to eliminate the need to remove the assembly during machining. Check carefully the diameters of the lathe's mandrel and note these before

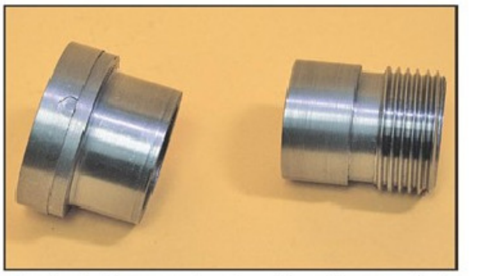


Photo 1. Gauges for checking the parallel and threaded portions of the lathe's mandrel nose fitting.

starting to machine the gauges, neither should be undersize but the parallel bore is by far the most critical. For this I would suggest a gauge tolerance of - 0.0 +0.002mm, for the thread though I would suggest +0.02 to + 0.05mm just to be sure it is oversize. My advice would be to cut the gauge's thread with a chaser or a single point tool that produces a precise thread form, **photo 2** as using a tool that does not produce the radius on the outside of the thread will complicate the issue in terms of the gauge's diameter. However, using a basic single point tool would be acceptable when eventually cutting the internal thread. I will assume the reader is conversant with cutting threads and will not elaborate on the subject. If guidance is though required then seek out further reading on the subject, **Ref. 1** and **2**.

When making the parallel gauge do make a short length, say the first 3mm, 0.05mm undersize as this will give an indication that the bore is close to the required size and at which point considerable care has then to be taken when proceeding.

Having stated a tolerance of only + 0.002mm which is easy to write down but far from easy using normal turning techniques to achieve, how then is this to be accomplished? The lathe's cross feed is likely to be calibrated in 0.02mm or even 0.025mm divisions in which case we are attempting to reliably work to a depth of cut of less than 1/20 of one interval on the dial, virtually impossible!

Achieving precise diameters

Fortunately, the solution is relatively easy to adopt and is to set the top slide to 0.6deg. as this gives a ratio of 100:1 between the axial and radial movements of the cutting edge. My method of achieving the 0.6deg. angle is briefly as follows and can be done quite quickly if the required accessories are available. First, set the top slide precisely parallel with the lathe's axis using a DTI and testing along the length of a *"between centres test bar"* **Sk. 1A**. Next, place a

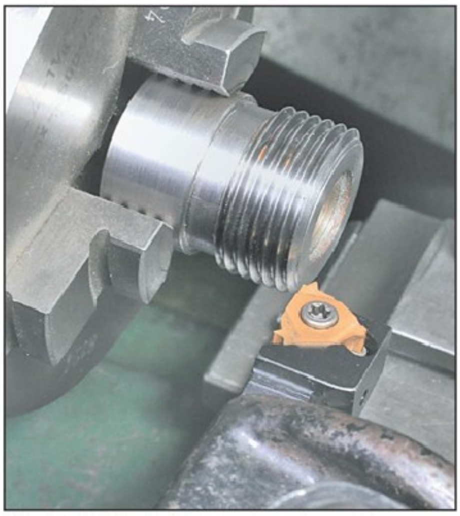


Photo 2. Ideally the gauge should be made with a tool that produces the full thread form.

piece of steel under the top slide clamp and, with its edge firmly against the test bar, clamp in place, **Sk. 1B**. Finally, loosen the top slide to enable it to rotate and at a point 100mm from the left hand end of the piece of steel place a 1mm diameter drill shank between the piece of steel and the test bar with the other end against the bar. With that done clamp the top slide in this position **Sk.1C**, This is shown in **photo 3**.

For less demanding situations an angle of 6deg. gives a ratio of 10:1 between axial and radial movement with the lathe's calibration for setting the angle of the top slide sufficiently accurate for this requirement.

Having got the top slide at the required angle making it possible to place on very small radial feeds all is still not plain sailing. It should be obvious that it is not possible to make a very fine cut if the cutting tool has a blunt cutting edge wider than the amount being attempted to be removed, for the depths therefore being

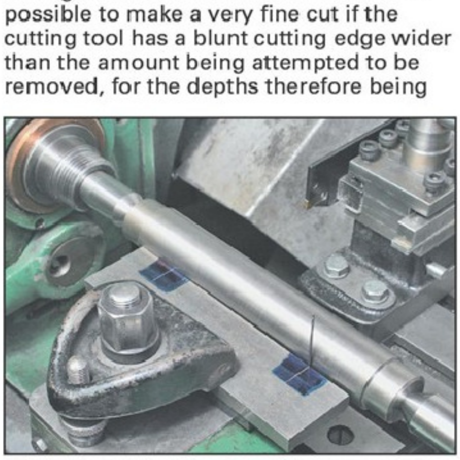
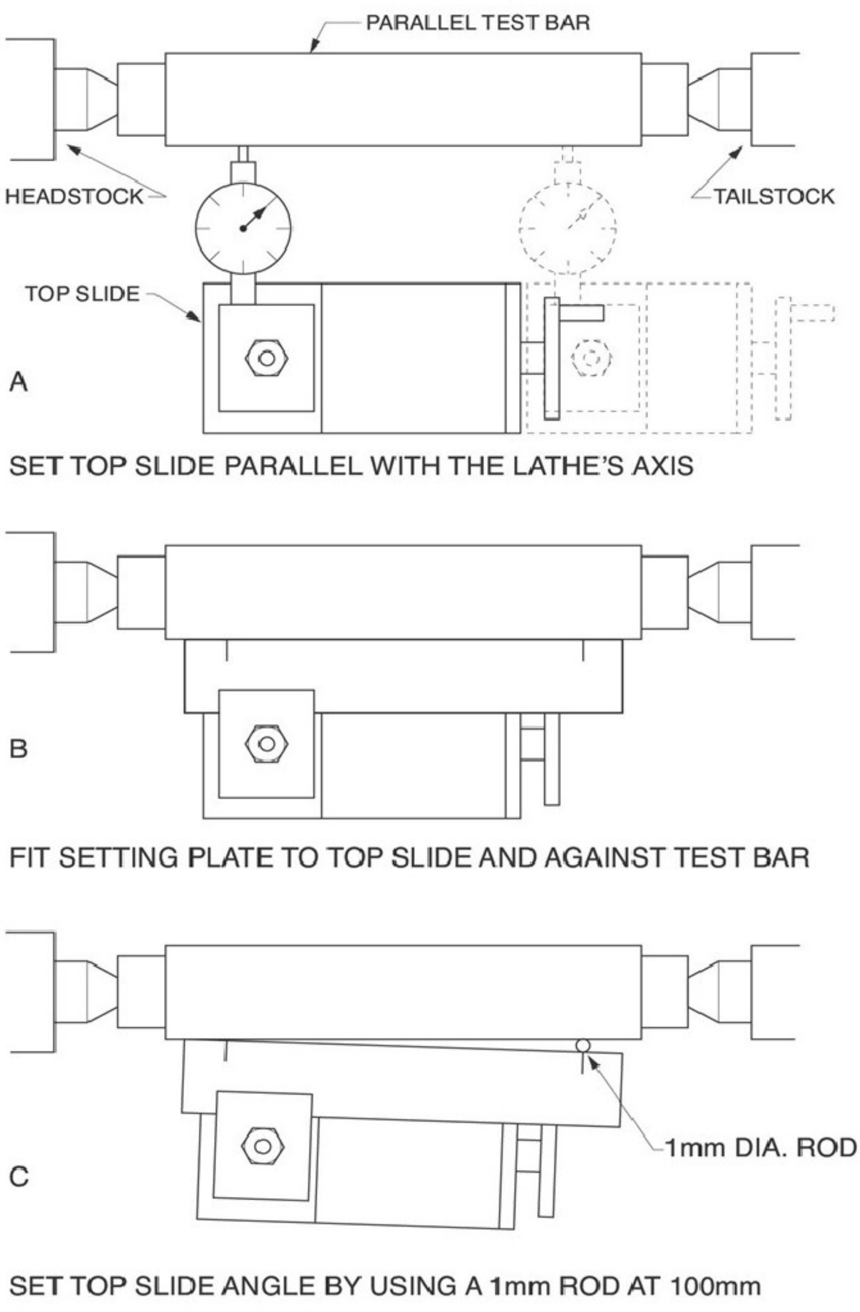


Photo 3. Setting the top slide to an angle of 0.6deg. gives a 100:1 axial to radial ratio.



SETTING TOP SLIDE TO ANGLE OF 1 IN 100. SK.1

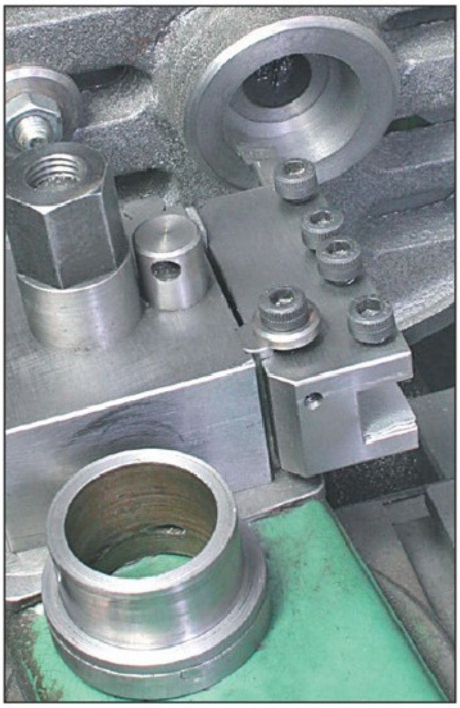


Photo 4. Machining the parallel bore, note the gauge ready for checking the bore.

considered the cutting edge has to be perfect. For this a HSS tool will be required and honed to an extremely fine edge, my preference being a round nose tool but of course this is not practical if machining to a step. The tool should also be set a little below centre height, just to ensure that it is not above, because if above, even minutely, it will just rub at these very shallow depths.

With the top slide set and a finely honed cutting tool in place the process is only a little more complex than normal turning resulting in the gauge for the bore, and eventually the bore itself, being made with comparative ease.

The mounting

From this point in the article I should make it clear that the dimensions now given relate to my Myford mandrel and I am of course giving them as Imperial sizes, the reader will when machining for a different mandrel have to work to his or her own requirements.

With the item needing to be machined suitably mounted, machining can now commence. If at this stage you are machining a casting, machine the mounting face using a tungsten tipped cutter to break through its outer skin as you will not want to carry out this task with a HSS tool. Next, centre drill and drill through with a large drill to avoid excessive work in machining the bore followed by boring to a diameter of 1.045in., the significance of this diameter being explained later.

With that done, set up a finely sharpened HSS boring tool and with the tip of this against the face first machined set your saddle stop for a depth of 5/8in. when machining the parallel bore can now commence, **photo 4.**

Having set the top slide to 0.6deg. for machining the gauge there will be a temptation to reset the angle so that forward movement of the top slide increases the diameter being cut, this though should not be done. When the bore is very close to the final diameter and the top slide advanced to increase this, this will defeat the purpose of setting the saddle stop as the forward movement of the top slide will increase the depth. With the ratio being 100:1 even a very small increase in the diameter being cut will have an appreciable effect on the depth of the bore. The top slide should therefore remain as originally set and the diameter of the bore increased by winding the top slide back.

However, there is a potential problem with this approach that must be taken note of even though the likelihood of it surfacing is very remote. As the top slide is being wound back to increase the diameter being cut the pressure on the cutter will be attempting to take up the backlash and as a result increase the diameter by more than is required. Even so, providing that the top slide is not set to move very freely it is very unlikely that this will occur at such minute depths of cut but if in doubt, use the slide's lock to stiffen up the movement temporarily.

Continue to increase the diameter of the bore using the cross slide and when within say 0.004in. (0.1mm) hone the edge once more. If you do this whilst still on the top slide place a piece of cloth on the bed to catch any particles from the hone, removing the cutter may be safer but you will then have to reset the saddle stop.

When the bore is close to the required diameter, as indicated by the short reduced diameter portion of the gauge, now is the time to increase the depth of cut by winding the top slide back and increasing the diameter in very small steps. Aim to get the bore a very close but not tight fit on the gauge. If the gauge becomes a tight fit make an extra cut

Photo 5. Using a robust boring tool is essential with that on the right being satisfactory for the task.

Photo 6. A simple holder for holding a tap being used for machining internal threads.

without having placed on any more depth, this is particularly important if you are machining the bore with a boring tool having a thin shank. That on the right of **photo 5** is definitely preferred for the task.

Having wound the top slide back to arrive at the required diameter the final portion of the bore will be undersize. To overcome this, remove the saddle stop and hand feed the tool in just once more to bring the bottom of the bore to diameter paying particular care as the tool tip contacts the end of the bore.

Need for accuracy

The need for accuracy with this bore is theoretically dependant on the item being machined. If a backplate for a three jaw chuck, or the body of a collet chuck, then a very close sliding fit is all but essential, if though it is a faceplate then the need for accuracy is somewhat reduced. Even here though, you may find the need to temporarily remove the faceplate with its workpiece later requiring it to return precisely for machining to continue. In any case, attempting to get a very close fit is worth attempting if only for the experience gained.

Finally at this stage, fit a facing tool and lightly machine the outer face. The face should not be machined again and if eventually slightly damaged in use any raised area should be carefully removed with a scraper limiting this action to the smallest area possible.

The Thread

As mentioned earlier I do not intend to go into detail regarding screwcutting on the lathe but will explain briefly the method I use.

For an Internal chaser I use a tap having the required pitch and mounted in a holder that sets the cutting edge at centre height, **photo 6**. The diameter of the tap is unimportant though where the thread form can be obtained in various sizes I attempt, at the finer pitches, to obtain the one with the largest diameter for greatest rigidity. Typically a 20TPI thread with a Whitworth form can be had as a 1/4in. x 20 TPI standard Whitworth or a 3/8in. x 20TPI British Standard Fine, obviously the larger is to be preferred. For a 12 TPI thread where the taps are larger in any case using the largest is less important, I do though use a new ground thread tap as they are not that expensive these days.

In theory the tap, or chaser, should be set perfectly in line with the lathe's axis. However, as perfection cannot be guaranteed and the tap should NOT attempt to cut on its trailing teeth the leading tooth should be set to cut very marginally deeper than the rest. **Photo 7** shows the tap being checked by traversing the saddle along the length of the tap and against the corner of my height setting gauge. As with any form of thread tooth cutter it theoretically can only suit one helix angle but there is some latitude due to the clearance angles provided by the cutter. However, I do find when cutting a large diameter thread that will have a small helix angle with a small diameter tap having a larger angle that this may interfere with the required clearance and the tap fails to cut adequately. This though is overcome quite simply by raising the cutter above the centre height by about 0.5 to 1mm when the curvature of the thread being cut increases the clearance and permits the tap to cut cleanly, **photo 8**. This is not just limited to using a tap as a chaser as I find the same can happen with other forms of thread cutting tool.

Why 1.045in. diameter?

If the reader chooses to cut the internal thread using a basic single point tool this will produce a thread without a radius on the tips of the threads being made which will then foul with the root of its mating thread. When using this form of cutter the internal bore must always be larger than the theoretical value so as to avoid the problem. Similarly, with an external thread the outer diameter should be undersize to prevent a similar situation. The bore diameter given therefore produces a thread depth of 75% a situation that only very slightly reduces the strength of the joint made.

For me, making the thread with a tap, the tips of the thread produced would have the designed radius on their tips. However, as there is very little reduction in strength, it speeds up the process as there is less depth to cut. As cutting an internal thread is a slow process, reducing the number of passes that the cutter has to make is very worthwhile and would suggest that whatever method of cutting the thread you decide to use, that for internal threads a depth of between 65 and 75% should be the norm.

Ready for the next stage

With the parallel portion and the thread now complete the workpiece can at last be tested against the mandrel nose. This should be, if the above process has been worked to, just a formality. You will now be ready to proceed with whatever it is you are attaching to the mandrel, chuck backplate, faceplate or collet chuck, the accuracy of which will benefit from the attention to detail taken in the initial stages of its manufacture. ■

References

Ref 1. Workshop Practice book number 3 "Screw cutting in the Lathe" available from www.myhobbystore.com
Tel: 0844 4122262.

Ref 2. MEW "Lathe Projects for Beginners (11)" Screw Cutting, issue 77 page 31.

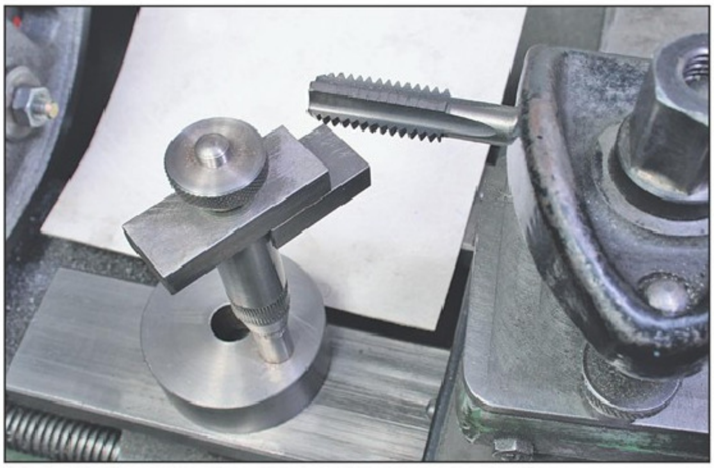


Photo 7. Checking the setting of the tap, the leading edge must cut very marginally deeper.

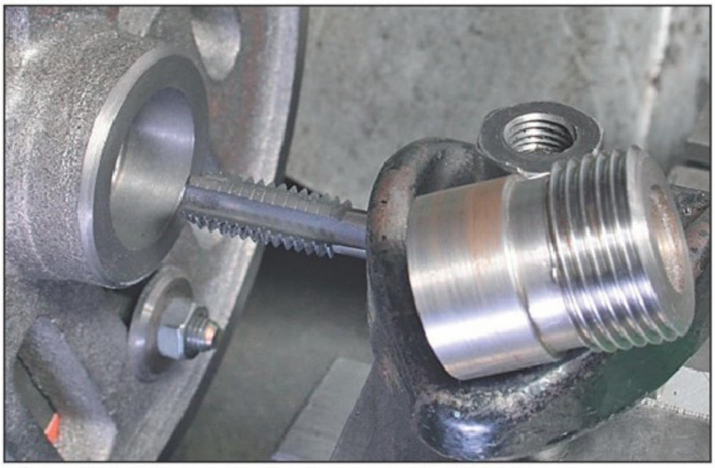


Photo 8. The final operation is cutting the thread; note the gauge for this also.

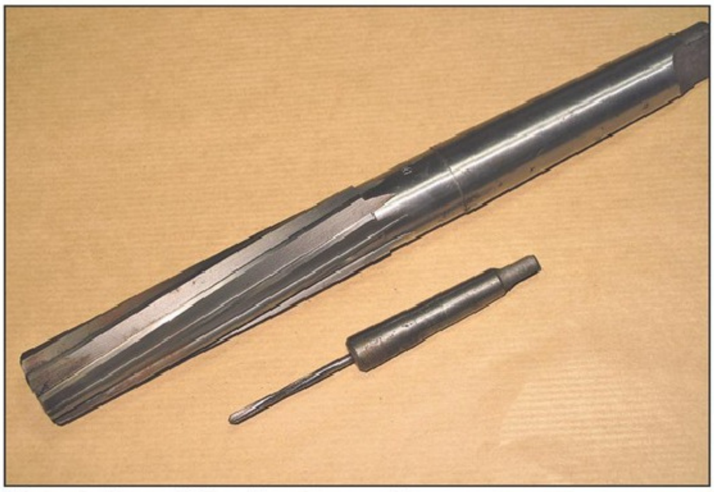


Photo 1. 1in. and ⅛in. diameter machine reamers.

Photo 2. Different sizes of machine reamers, mounted on 2 Morse shanks.

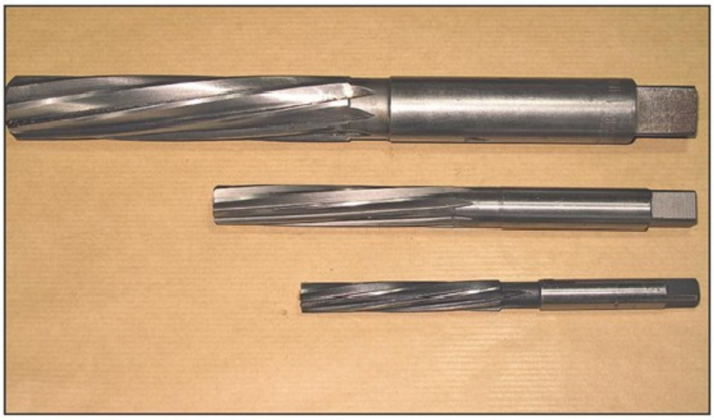


Photo 3. 1in. to ⅜in. diameter hand reamers.

Photo 4. Straight and helical fluted chucking reamers.

REAMING

Mick Knights discusses reaming in the home workshop

Whilst reading a recent "Scribe a Line" section in MEW, I came across a letter requesting information about the black art of reaming and its allied processes.

On the face of it this is quite a simple subject but after some reflection, it made me realise the number of issues needing consideration.

During a working lifetime in various engineering disciplines, I never met anyone who actually carried out an engineering process strictly to the book. Machinists, on the whole, tend to adopt processes, feeds and speeds etc. that they have used successfully in the past and feel comfortable with. However, in this introduction some aspects of the book are a pretty good point of reference.

Before we explore the various types of modern reamers and reaming processes, it might be an idea to look at why many home machinists might not be using reamers to their best effect. I suspect that anecdotal tales of woe are still discussed when two or more machinists share a mug of tea. Most of these stories, I'm sure, stem from earlier times, when situations were a bit different.

Back when the world was young, there where only a couple of things to bear in mind when machine reaming any size of bore. Slow revs and equally slow feed. The mantra of always erring on the side of caution was definitely the only rule to be obeyed. I can remember one of my instructors telling me, that after the war, it was not unusual, when machining a billet of supposedly mild steel, to come across half a ball bearing. *(Not unusual in the early 1970s in certain types of steel. Ed.)*

Along with poor quality materials, the durability of cutting tools was also an issue. Although some very clever, wear resistant alloys for cutting tools had been developed during the war years, the most common everyday tools were still made from carbon steel. These tools would very quickly become blunt if heat built up whilst machining. It was also very unusual to find any machine tools of that era having more than 750rpm top speed as the tools of the day just couldn't cope with the heat generated.

The only widely available coolants were soluble and mineral oil, both of which needed to flood the workpiece. The coolant sump suddenly running dry halfway through a reaming operation usually spelt disaster.

For hand reaming, ordinary lubricating oil or tallow were the only available options. The need for greater wear resistant cutting tools and advanced lubricants was obvious.

Over the years, firstly with HSS and then Cobalt HSS, tool wear at high speed has been greatly reduced. With a range of different cutting compounds and coolants, some dedicated to specific materials, the surface finish of bores could be maintained for prolonged periods of machining while also prolonging the tool life. The majority of engineering cutting tools, including reamers, are also available in far better wear resistance materials, carbide etc. However, the home machinist would probably only ever be using HSS and cobalt HSS.

Nowadays, the selection of free cutting materials will greatly increase the ease of machining and the surface finish of reamed holes. In the home workshop, weldability would be the only consideration for not always choosing free cutting materials and then only in the case of EN 1A or leaded mild steel. Along with the more popular free cutting materials, stainless steel 303, aluminium FC1 and mild steel EN1A, (Brazilian) bronze, has all the mechanical properties of traditional bronze, but is a joy to machine.

Basic types of reamer

Reamers are available in a variety of sizes up to an inch and a half in diameter, **photo 1**. It is unlikely that the home machinist would ever have the need to ream bores larger than an inch in diameter, partly due to the restraints of the hobby milling machine and bench drill with their smaller

Photo 5. Adjustable hand reamer.

Photo 6. Standard chucking reamer.

Photo 7. Small diameter machine reamers.

Photo 8. HSS machine reamer with carbide tip.

Morse spindles, lack of horse power and rigidity. Taking into account the cost of larger diameter reamers, it makes boring a more attractive option for larger diameter holes. With this in mind, I will only address issues relating to reaming smaller diameter bores.

I will describe the basic types of reamers that are in common use. There are however other styles available, but as these are mainly used in production, or other specialised environments, they are generally not suitable for the hobby machinist.

Reamers fall into two distinct types. Machine reamers, **photo 2** and hand reamers, **photo 3**. Straight and helical flute reamers are shown in **photo 4**. The most common is still the helical fluted reamer. I will discuss the reasons for straight and helical flutes a little further on.

Hand reamers are easily recognisable as they have a square milled at the top of the shank for fitting tap wrench jaws. Also the flutes have both a bevelled lead and easy taper lead ground along a portion of their length. This is to allow the bottom flutes clearance in the reaming hole and for easier alignment at the beginning of the hand reaming operation. The hand reamer cuts on both the bevel and taper leads. Besides the standard or preferred sizes, reamers can be obtained from the manufactures in virtually any diameter required. But, as in most things, non standard comes at a cost.

Adjustable hand reamers, **photo 5** are a useful get out of jail option, although a bit fiddly to set. Adjustable reamers usually have six to eight blades. The diameter is controlled by threaded locking rings at the front and rear of the blades. Unlocking the back rings and advancing the bottom ring, will cause the diameter to increase. The process in reverse will, naturally, have the opposite effect. The diameter can be checked with a micrometer, but in practice a few holes need to be reamed in a scrap piece of material of the same type as the workpiece. The bore size can then be checked and further adjustments made until the correct hole diameter is achieved.

Machine reamers are either mounted on a Morse taper, or have a plain ground shank. These are known as chucking reamers, **photo 6** and generally have a shorter flute length. Mostly these are held either in a drill chuck or directly in a spindle mounted collet. Chucking reamers are also available with a Morse shank.

Machine reamers have only a small bevelled lead ground on the cutting face of the flutes. Unlike the hand reamer, this is the only part that does the cutting.

Morse mounted reamers tend to have longer flutes, while chucking reamers have shorter flutes, **photo 7**. Chucking reamers, due to their stubby robust form, will generally operate at higher speeds. Some machine reamers are made with tungsten carbide tips, **photo 8**.

Some chucking reamers are made with size ground shanks, **photo 9** while others are made with relieved shanks, **photo 10**.

Shell reamers are popular in the heaver side of engineering. The reaming shell (which closely resembles a shell milling cutter) comes in all the standard reamer sizes and has the cutting features of a machine reamer, but fits on to an arbor so cutting out the need for several Morse mounted reamers.

Rather more specialised is the socket reamer. This is also a Morse mounted machine reamer that is used for finishing Morse taper sockets. They usually are supplied in pairs. One is used for roughing, while the other removes the minimum amount of material for finishing.

There are adjustable machine reamers, which are available in two distinct types. One is a chucking reamer, which has a countersunk Allen screw positioned in the bottom face. Turning the screw clockwise will increase the diameter, counter clockwise reduces the diameter. The range of this adjustment is only a couple of thousands of an inch. The other type is Morse mounted and used mainly on the lathe. Usually this reamer has only two floating tungsten carbide tipped blades diagonally opposed. The adjustment is made by rotating a single micrometer calibrated ring, which can be locked when the correct diameter is achieved. The diameter range of this type of reamer is usually 0.030in. Like its cousin, the adjustable hand reamer, this also needs a couple of trial runs before one can confidently machine the component.

It's worth mentioning one last type of tool, which the hobby machinist will properly never feel the need to use (or can afford) and is technically not a reamer. Roller reamers are employed when a deep bore with high micron surface finish is required. The business end resembles the inner race of a roller bearing. The head is attached to a Morse mounted shank, which has a clearance diameter. The bore to be produced is first machined with a standard type machine reamer, which has a diameter a few tenths of thou under the finished bore size. The roller reamer is then feed down the bore and effectively swages and burnishes the bore to finish size. *(We always called them roller burnishers. Ed.)*

The reaming process

British Standards 1916 (limits and fits) requires several sizes of reamers to cover a tolerance range that might only amount to 0.0015in. of the diameter. This is to achieve different types of mechanical fit, i.e. clearance, sliding, push and interference.

An ordinary imperial reamer complies with the H8 standard. This will produce a size bore, plus a few tenths of a thou, minus a smaller increment. For example, imperial sizes from 0.039 to 0.118 have a tolerance band of +0.0004 -0.0001 Sizes from 0.393 to 0.708 have a tolerance band of +0.0007 to -0.0003. To confuse matters, the DIN standard for metric reamers use H7 but the class of fit is the same.

The hobbyist really needn't get too worried about this standard as the majority of reamed holes in the home workshop are probably only a push or sliding fit. This would be for locating dowel pins, or to produce a smooth bore for a sliding male component where, if required, the male component can easily be polished to produce the required result if the bore is too tight.

It's always a good idea to bear in mind the amount of torque involved when reaming, especially larger diameter holes. Holding a component freehand while machine reaming is definitely not advised.

Workpieces with holes larger than 6mm diameter to be reamed should, I feel, always be clamped. Either directly to the machine table, or held in a machine vice.

Dave Fenner has written an excellent series of articles regarding the location of workpieces on the milling machine, so I feel no need to repeat them here. Only to mention, that, when the hole centre is positioned directly beneath the machine spindle, of either the mill or bench drill, always insure that all the drills, reamers etc. can be changed without having to move either the slides or the machine head. This, of course, doesn't apply to machines with table rise and fall. When the workpiece is clamped, the reamer must always be in line with the drilled hole. Failure to do so might, in extreme cases, tend to snap smaller diameter tools. Also, it should be remembered that large diameter reamers will act in the same way as a milling cutter if not directly in line with the hole to be machined. Unlike drills, which will always follow the previously drilled hole, the reamer will cut its own path, especially in softer materials. This will in some cases result in partial reaming and an oval hole. In this case, without machining a larger diameter hole, the situation would be irretrievable There are floating reamer holders available, which will align the reamer with the drilled hole, but these are generally only employed on the radial arm drill and production lathes.

If the hole position is not critical, then the centres can be marked out in the usual way. Always centre drill the hole position, so it can be repositioned beneath the machine spindle, either by using a DTI or a centre mounted in the drill chuck, **photo 11** or mill spindle, **photo 12**. Picking up from a centre punch mark is not ideal and can result in misalignment. If the hole position is crucial, then all centres need to be pitched out on the mill and all bores finished at the same set up.

The reaming size hole for the reamer is, in many ways, just as important as the reamed hole itself. The reaming hole, when drilled, may well be 0.005in. smaller than the reamer. But if it was produced using a badly ground drill, resulting in a scored or slightly oval bore, then the finished reamed hole may well be the correct diameter, but it will also be scored.

With holes up to 12mm, I tend to employ the double drilling method. If the finished hole diameter is indeed 12mm. Firstly drill through at 11.5mm dia. Then follow with 11.8mm dia. drill, making sure that drill is still factory ground. This will result in an 11.8mm bored hole, which will be size and smooth, leaving the ideal amount of material in the bore for finish reaming. Most machinists have their own views as to the amount of material to leave in a bore before reaming, this being based on their own experiences. The amounts I will suggest are therefore only a guide. The operator will no doubt find with experience sizes they feel comfortable using. Only a minimum of material should be left to ream out. On holes up to a quarter of an inch, leave no more than 0.005in. Up to half an inch, leave no more than 0.008in. This only applies to smooth double drilled holes. If the machinist uses a single drill, then the amount of stock remaining should be increased by a further 0.004in.

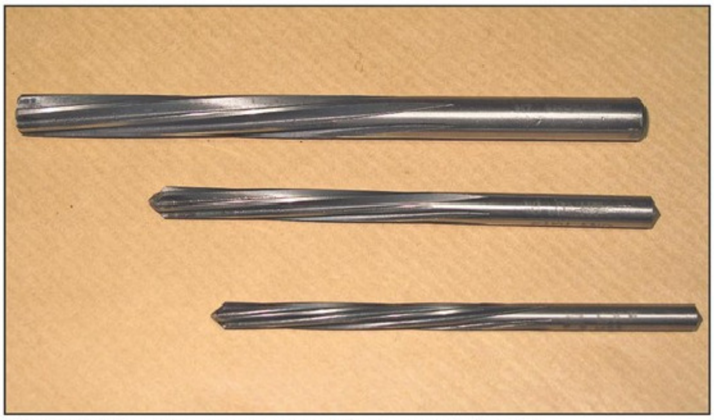


Photo 9. Chucking reamers on size ground shanks

Photo 10. Chucking reamers with relieved shanks.

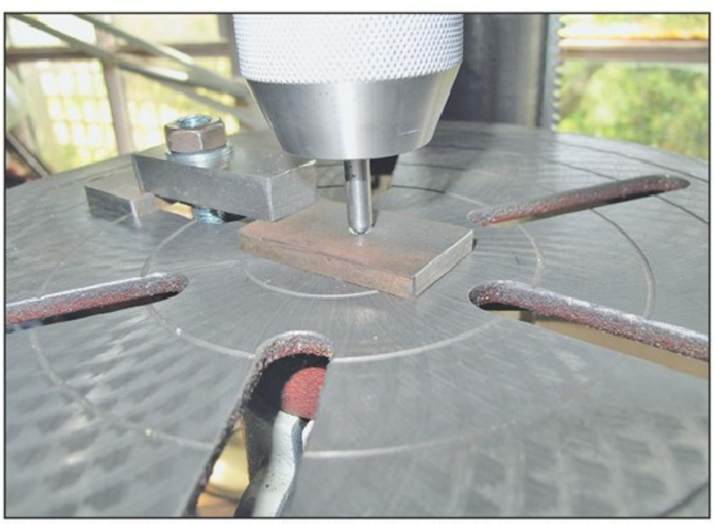


Photo 11. Picking up pre drilled centre with DTI on the mill.

Photo 12. Picking up pre drilled centre on the bench drill.

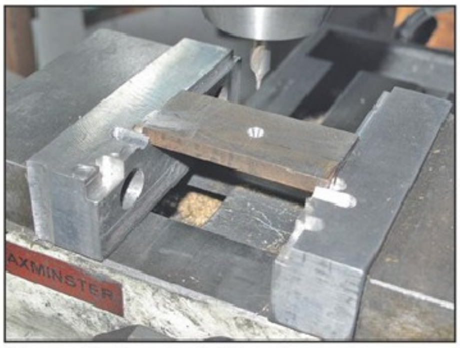


Photo 13. Centre drilling the component.

The reamer being a cutting tool needs to cut to be effective. It is a mistake not to leave enough material in the bore to achieve this as reaming a near size hole will result in the reamer rubbing and becoming blunt.

5/8in. is probably the limit for double drilling as it's not practical to keep a large stock of small increment drills above 1/2in. or 12mm diameter for metric applications. For imperial sizes above 1/2in. carefully drill the reaming hole 1/64th under the required size, for metric 0.5mm. This should result in leaving enough material for finish reaming. It's always prudent to drill a hole in a piece of scrap material first, so the resulting hole can be checked for size and finish, before committing to the work piece.

The first thing to do is centre the hole unless clocking up an existing hole, **photo 13**. Then use a smallish drill to drill a pilot hole, **photo 14**. Drilling speeds depend on two things. One is the cutting speed of the material; the other is the range of speeds available on the mill or bench drill. Those lucky enough to own variable speed machines can minutely adjust the speed to suit the conditions. With the slowest speed on modern machine tools these days around the 120 rpm mark, the rest of us have to make concessions.

A useful and quick formula for calculating the RPM for drilling is:

$$\frac{\text{C S F P M X 12}}{\text{D X 3.142}}$$

Where:
C S F P M = Cutting speed in feet per minute
D = Diameter of the drill

Cutting speeds of the most popular materials (source SKF) in feet per minute are:

- Free cutting steels, aluminium and brass 100-200
- Cast iron and steel 80-100
- Stainless steel 40-60
- Tensile steels 30-50

To determine the appropriate R.P.M. For a half inch drill in cast iron.

$$\frac{80 \text{ X } 12 = 960}{0.500 \text{ X } 3.142 = 1.571} \qquad \text{R.P.M.} = 611$$

My own machines have speed ranges from: 230 / 570 & 1080 / 2730 80 / 330 & 550 / 2180

So the nearest speed to select would be 570 R.P.M. as it's always a good idea to choose lower revs, rather than higher.

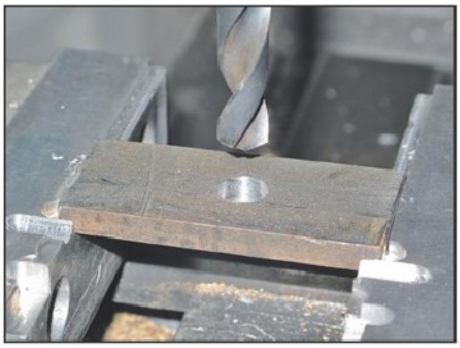


Photo 14. Pilot drilling 3/8in.

The speed for reaming, using Cobalt HSS would be: 406 R.P.M. while HSS would be: 203 R.P.M. You will have to use the closest available speed. On my machines, this would mean speeds of 370 R.P.M and 170 R.P.M. respectively.

With larger diameter drills following a pilot hole, it's quite common for the drill to judder and snatch. This is due to the cutting web of the drill not having any material to bite into, so making the drill unstable. In a production workshop, a core drill, which is multi fluted and very sturdy, would properly be used as a pre-finishing tool to produce the required size of bore. In the home workshop things are slightly different.

One quick method of overcoming this problem is to place a worn doubled over strip of emery cloth, with the abrasive faces turned inwards, over the hole, **photos 15, 16** and **17.** When the hole is drilled, the flutes are filled with the emery cloth so the drill doesn't snatch, resulting in a smooth drilling operation. It should be noted that the drill will cut slightly oversize when this method is employed.

If holes need to be accurately positioned and the diameter is too small for a boring head to be easily used, then a useful alternative is to double drill but use a slot drill to obtain finished size. The slot drill will true up the hole in the same way as a boring tool would. This will insure the bore is generated directly in line with the machine spindle. The slot drill should always be held in an Autolock chuck or similar tool holder, never in a drill chuck.

Photo 18 shows the ream with cutting compound ready to ream the hole. Prior to reaming, it's always good practice to visually check the cutting faces of the flutes. If the cutting faces and lands appear to be the least bit shiny or polished, then it's best to discard the tool and not take the risk. Some machinists try recycling blunt reamers, by grinding off the front section of the tool and then backing off by hand. I have never subscribed to this method. In some cases you might well be lucky and the reamer will cut the required hole. But it's also the case that swarf can weld itself to the rough hand ground relief angles, resulting in a scored bore.

Feeding the reamer through is all a matter of feel. The operator will be aware of any resistance, be it due to too much material removal, or bluntness of the reamer. A reamer cutting in optimum conditions will simply glide through. Power feed is definitely not advised, as by the time the operator realises something is wrong, it's probably too late to retrieve the situation. Depending on the depth of bore being machined, the reamer should be cleared at regular intervals to check for swarf build up and to apply lubrication. Speeds are as mentioned earlier. They are a bit subjective as some machinists may feel uncomfortable running HSS cobalt reamers at high speed. In a production

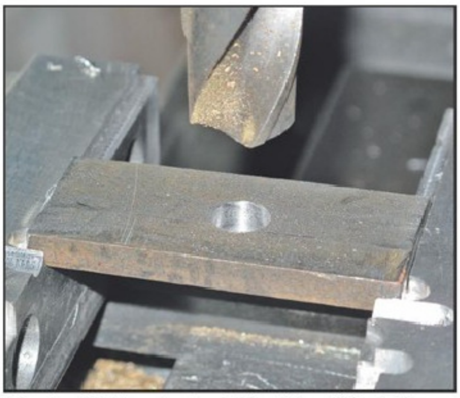


Photo 15. Ready to drill with a 27/32 drill.

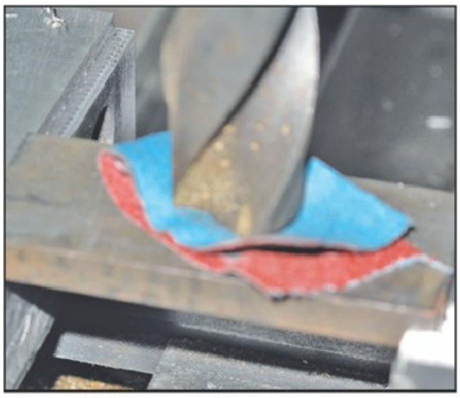


Photo 16. Using a folded strip of worn emery tape to eliminate snatching and chatter.

Photo 17. Emery cloth in the drill flutes.

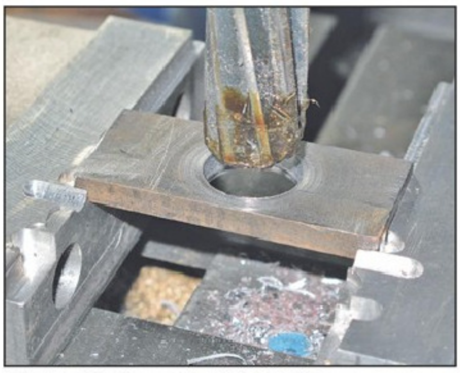


Photo 18. Reamer with cutting paste applied.

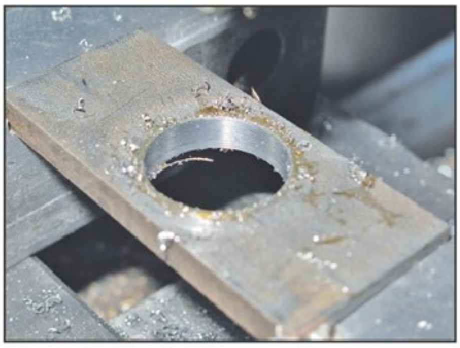


Photo 19. The finish reamed bore.

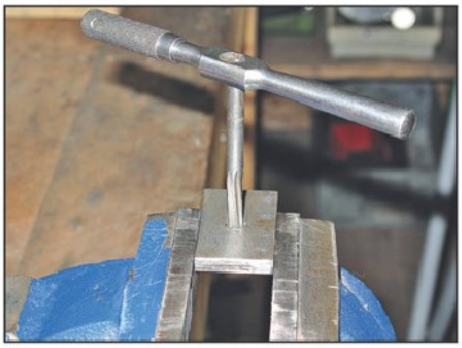


Photo 20. Hand reaming in a bench vice.

environment the reaming speed is judged to be two thirds of the drilling speed for the material. For HSS reamers I have suggested a third of drilling speed. Again, adjustments in speed may have to be made, depending on the size and rigidity of the hobby machine being used. It is as true today as it was in the past, that a slower speed and feed will result in smoother finish bores. **Photo 19** shows the finish reamed hole.

The machinist should always bear in mind that if a large amount of material is left to ream, the more likely the chance of producing an oversize bore. Also, if the reamer is not in reasonable condition, the risk of snatching and jamming is increased, especially in dense materials such as bronze.

This is where the selection of different styles of flutes tends to be more important. The helical fluted reamer provides a shearing cut, which is beneficial in denser materials and is also useful when reaming bores that have a keyway or grooves as the helical flute will bridge the keyway preventing binding or chatter. As most reamed holes tend to be through holes, a spiral fluted reamer will force the swarf chips in front of the cutting faces and out the other side. This style of reamer should not be used on blind holes as the chips will become compacted in the bottom of the hole. A straight fluted reamer, regularly cleared is the best option for blind holes.

Hand reaming

I find hand reaming most useful when line reaming two components, as due to the easy taper on the lead flutes, it will cut the two diameters without deflection, even if they are not presented directly in line. In the same way, hand reaming is a good method of truing up a bore that has become slightly distorted through surface tensions being relieved. They are also an effective way of deburring bores that have been cross drilled.

Care needs to be taken when starting the reamer as it must remain vertical to the hole. A guide block, similar to those used for starting taps vertically can be useful in this situation. The operation can also be started with the reamer held in the chuck of the bench drill and rotated by hand, then finished off by holding in the bench vice, **photo 20**.

A smooth rotating action should always be employed, as a rough, jerking action can result in one of the flutes digging into the hole wall. Once this has occurred it's difficult to rectify. The bore will be marked and in extreme cases become slightly oval. Generally speaking, hand reamers are used in situations where the hole to be reamed is in an awkward position or the workpiece cannot be easily fitted on the machine table. In most cases machine reaming remains the preferred option.

Taper pin reaming

A selection of taper pin reamers are shown in **photo 21**. As taper pins are a method of securing a boss to a shaft, both components must be clamped and machined together. When using a helical fluted taper pin reamer, the pilot hole should be the same diameter as the small end of the taper pin as the bottom of the taper pin will protrude from the boss. After the reamer appears at the bottom of the hole, the pin should be tried for the required fit at regular intervals. To aid the larger diameter straight fluted taper pin hand reamers, the pilot hole should be step drilled with three different diameter drills. There are information charts and data sheets available from manufacturers that suggest the drill sizes and hole depths required to achieve the best results. As it's unlikely the hobbyist would ever have the need to use a large diameter taper pin reamer, this piece of information is included to give balance to the subject.

All the techniques discussed can be equally applied to reaming on the lathe where it's far more straightforward to follow the drilling operation by boring to reaming size.

Cutting compounds & coolants

Where machines do not have their own recycling coolant, which can be directed as a jet or spray onto the work piece, cutting fluid or paste needs to be applied to the hole, or directly to the flutes of the reamer.

The majority of reaming operations will benefit from lubrication, if only soluble oil. Cast iron and cast steel being porous should be machined dry, thus avoiding oil penetrating the material. If this is considered not to be a problem, then a little cutting compound can be applied. For a long time a jet of compressed air was considered the best method of dispersing cast swarf.

If reaming aluminium, the operator should refer to the manufactures recommendations to assess suitability of the product as some chemical compounds have an adverse effect on the surface finish of aluminium.

I tend to use two products (other products are available!) For small diameter holes, up to 8mm I used Tapmatic gold, cutting fluid. Only a couple of drops are required, placed on top of the hole. During the reaming operation the fluid produces a film, which disperses down the bore and cools the surface area between cutter and material due to a chemical reaction. On the face of it this may look like an expensive option, I have a 500ml can, which after several years, is still half full. The other widely used compound is RTD cutting paste. This is applied to the reamer itself. During machining, the heat generated will cause the paste to liquefy and disperse around the reamer. If reaming deep bores several applications may be required to insure efficient cutting.

After use reamers should be cleaned and wherever possible stored in their original packaging, or wrapped in workshop paper wipes, thus avoiding contact and damage to the cutting faces.

A reamer treated with due respect will pay back with longevity. ■

Photo 21. Selection of different size taper pin hand reamers.

QUICK-SET FACE & ANGLE PLATE

Harold Hall machines a Hemingway kit

I had just completed my article on using the faceplate, published in issue 154 and quite by chance came across a new item on the Hemingway Kits web site being a novel design of faceplate, **Ref. 1** having the title "Quick-set Face & Angle Plate". I was though first struck by the similarity of its opening comments regarding using the faceplate which echoed my opening thoughts on the subject. This stated "A faceplate provides the ultimate versatility in accepting irregularly shaped jobs for boring and facing. But oh don't we wince when we know that a component requires this treatment!". With those sentiments being expressed, Hemingway obviously feels that this faceplate will go some way towards easing the task.

The kit seen in **photo 1** includes both the faceplate and the angle plate castings together with some pieces of mild steel, the purpose of which will become apparent through the article, plus some hardware items. Also included are some very detailed drawings and suggestions for a method of manufacture. However, I have chosen to adopt a somewhat different method giving the reader who chooses to obtain the kit the option of two methods. My method includes the use of a milling machine but if you do not own one then Hemingway's approach is to do all the machining using the lathe.

The main feature of the faceplate is that its slots are arranged differently to the normal radial slots of a conventional faceplate as is apparent from the photograph. The plate is 7¾in. diameter and would therefore suit any lathe with a centre height of 4in. or more. Smaller lathes having a gap bed would also accept the faceplate providing the height in the gap was sufficient. It is a substantial casting and appreciably more robust than my standard 6in. faceplate.

Ideally, another faceplate is required for machining the casting though if your lathe is over 4in. centre height you may be able to use the following approach. It will though only be of use to the very small number of readers without a faceplate and who wish to make one. Take a rectangular piece of steel and drill and tap this, arranging the holes so that it can be fixed to the faceplate casting. With that done, grip it in the four jaw chuck and machined both the bore and thread when it can then be removed and fitted to the lathe's mandrel nose for the remainder of the machining. If adopting this method DO ENSURE that the piece of steel is large enough to achieve a secure mount and in any case DO NOT attempt to machine the outer diameter as the inevitable intermittent cut may be more than this holding method can cope with.

Using the lathe faceplate

The majority will of course already have a faceplate and will use this for the initial machining operations. It is at this point that I must confess that I went along with my own method of mounting

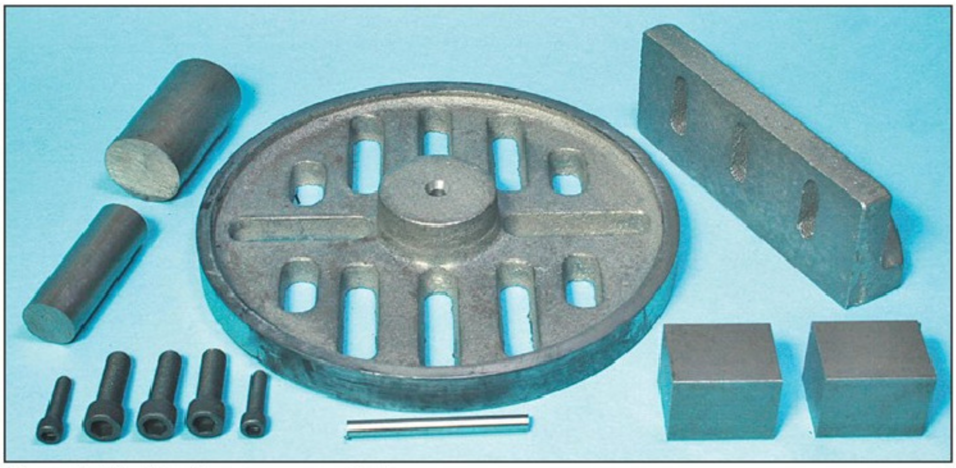


Photo 1. The kit of parts as supplied.

the casting onto the existing faceplate but subsequently when reading the Hemingway literature again realised that their method was superior. Their principle is to use just three fixings and with the casting spaced from the faceplate with extra thick washers allowing both the boring and thread cutting tools to pass completely through the casting. The washers should be at least 5mm thick and material for making these is provided. The method seems so obvious that I ask myself why did I not think of doing it that way. I mounted the casting using thick card to compensate for any irregularities in the casting's surface.

One operation that should preferably be carried out before mounting the casting onto the faceplate is to grind a chamfer of about 1 to 2mm around both sides of the outer diameter and around the boss on the rear. The purpose of which is to reduce the problems with machining away the casting's skin that may possess some hard spots as it permits the machining to approach via the edge of the skin which is much easier than having to break through it.

I initially ground the two sides of the outer diameter using my off hand grinder and whilst not difficult it made a considerably amount of grinding dust around the bench on which the grinder stood but whilst not seen plenty of air born particles also, as was very evident when I ultimately used my handkerchief. I then found that it was not easy or safe to attempt to use the off hand grinder for chamfering the central boss and hit upon the idea of using my angle grinder. I soon realised the advantages of this in that it removed the metal much more quickly but more important the mess made was outside the workshop and the problem of air born dust very much less. I therefore made a very definite mental note always to dress castings outside the workshop in this way in future.

Mounting the faceplate

With the casting now prepared, mount it onto the lathe's faceplate but just lightly gripped and rotate the assembly by hand

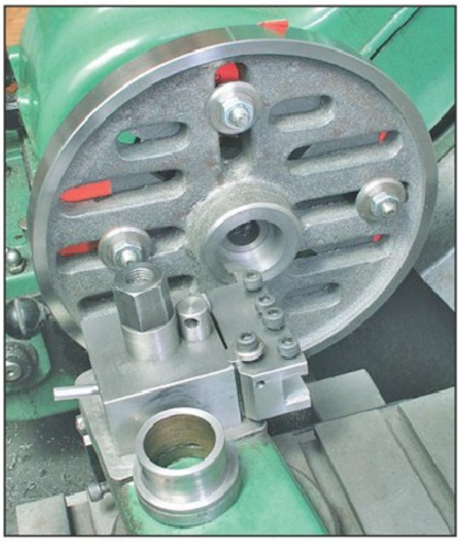


Photo 2. Making the parallel bore.

checking the concentricity of the result. Of course this is a casting and perfection will not be possible. Use a soft hammer and light blows to encourage the casting to run true as best as can be achieved. With that done, tighten the fixings ready for machining to take place.

At this stage machine the outer diameter, the outer rim around the rear of the faceplate and the face of the central boss doing this using a carbide tipped tool as your HSS tools may be very unhappy if you attempt to use them for the task. The central boss will be a straight forward operation being only around 50mm in diameter and only the face needs machining. The outer diameter however will be quite different and will need approaching with much care due to the large diameter and the inevitable intermittent cuts taken. If you have never, like me, machined a casting of this diameter you may find it daunting at first but taken gently and at a low speed (say 150 - 200 RPM) there will be nothing to worry about. After the surfaces have been fully machined then they can be given a final light cut to establish a good surface finish. Also machine a small chamfer, say 0.5mm, on the corner of the outer diameter.

The next stage is to produce the thread and the parallel bore, **photo 2** but as I have produced two articles that need fitting to the lathe's mandrel I have produced this stage as a separate article to avoid duplication. This is published elsewhere in this issue.

Working to dimension

For me, the most valuable commodity in the workshop is time and because of this I am reluctant to spend extra time machining to a given dimension when nothing is achieved by so doing, I am talking about what I would call fresh air surfaces. This is particularly so with castings that have of necessity to be made generously over size. Typically therefore, when the outer diameter was fully machined it was left at this irrespective of the resulting diameter whilst the drawing actually states 7¾in.

I mention this at this point as it is very relevant to the machining that is carried out on the rear of the central boss. For me I just skimmed it until it was fully machined as there is no dimension for the depth or the boss at the rear and then continued with making the bore and the thread.

Ultimately, when the front face was fully surfaced I was surprised just how far this surface was from the end of the lathe's mandrel, especially as the notes said machine to within 1⁄32in. of the mandrel. To do this I needed to remove another 5⁄32in. from its face, no quick job even with powered cross feed available, and if not, then a very tedious task. Therefore, if you wish to conform to the design dimensions then you do need to machine more from the rear boss to avoid so much needing to be removed from the plate's face. I did though eventually make use of this extra thickness as I will explain but on the down side it does reduce the available space within the gap by 5⁄32in.

Machining the face

Having then completed the bore and thread the faceplate can now be removed from the lathe's original faceplate and mounted directly to the lathe's mandrel when the face can then be machined. As cast iron machines easily once the skin has been removed I usually like to finish a surface using a HSS cutter. In this case though the slots in the casting will still be in their cast state and the cutter may still find a hard spot as it passes via each slot. If your lathe has power feed to the cross slide this is definitely a candidate for using this, **photo 3**. If not, then you need to be patient.

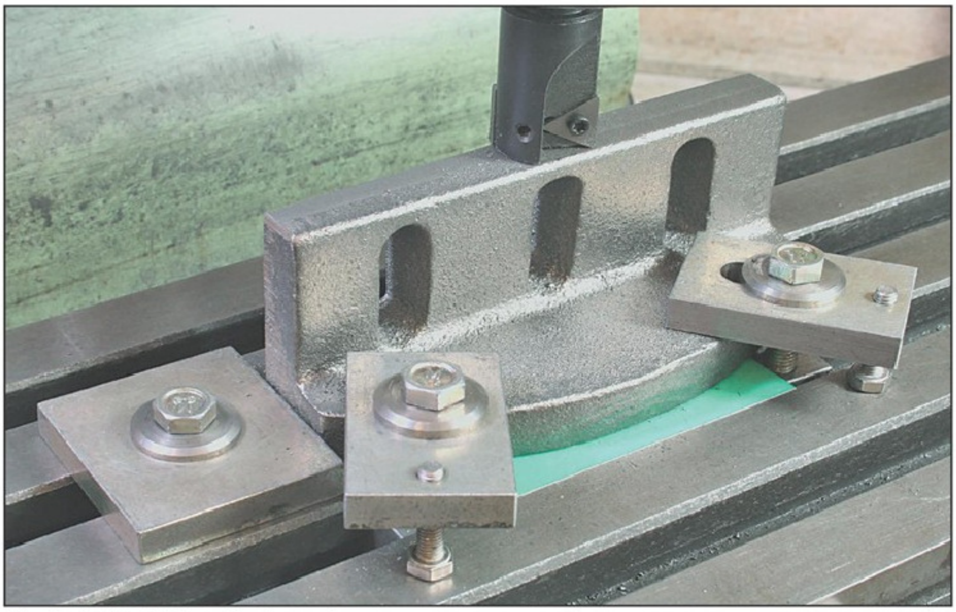


Photo 4. Machining the top edge of the angle plate.

The faceplate is now complete except for a final dressing of the slots and a touch of paint, but delay this until the angle plate is ready for similar treatment.

The angle plate

As I consider it to be easier to machine the angle plate on the milling machine I have decided to adopt this method (saving time again), but for the benefit of the lathe only workshop owner Hemingway describes a method of machining the angle plate on the lathe and using the faceplate itself. Actually, there are similarities with the two methods that I will touch on later.

As was done for the faceplate, produce a chamfer around the appropriate edges to assist with machining. Check the base for high spots and dress as appropriate and fasten to the milling machine table using hard card packing to protect the machine table from damage and to limit distortion of the angle plate due to it not being perfectly flat. With that done, next machine the top edge, **photo 4**.

Whilst the obvious choice will be to use a fully machined angle plate to support the casting for machining I am using a method I adopted for an article I did in a very early issue of the magazine. This is to use a form of "Cylindrical Square". The advantage of this is that it is very accurate and is a viable method for the workshop owner who has yet to obtain an angle plate. Providing the cylinder is turned exactly parallel and the base machined in the same sequence then the cylinder will stand perfectly square to the machine's table and may therefore be more accurate than an existing angle plate that may have aged a little since it was first machined.

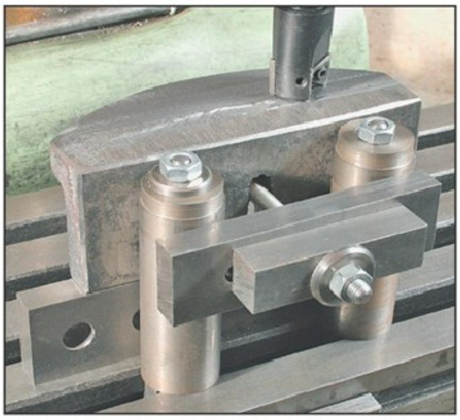


Photo 5. Using "Cylindrical Squares" to support the casting whilst machining the curved face.

Photo 5 shows the first of the two main sides being machined in this way whilst the

Photo 3. Facing the plate's main face.

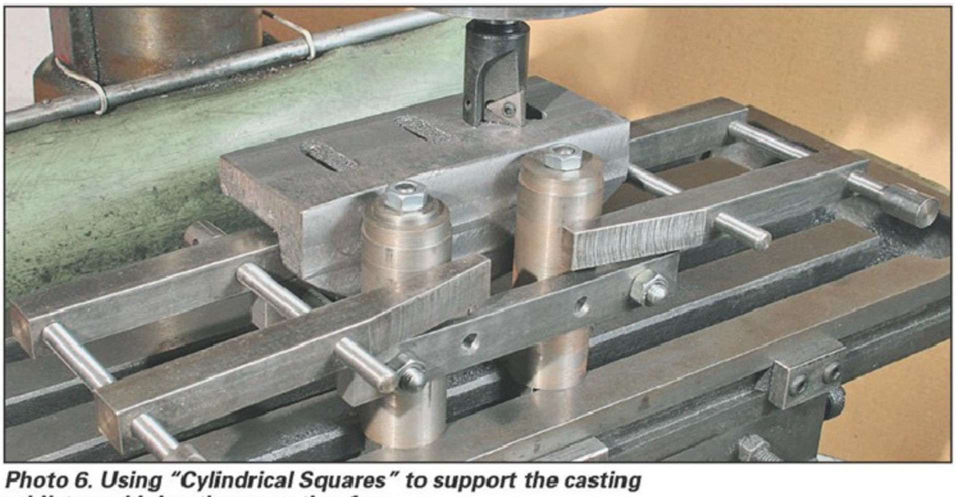


Photo 6. Using "Cylindrical Squares" to support the casting whilst machining the mounting face.

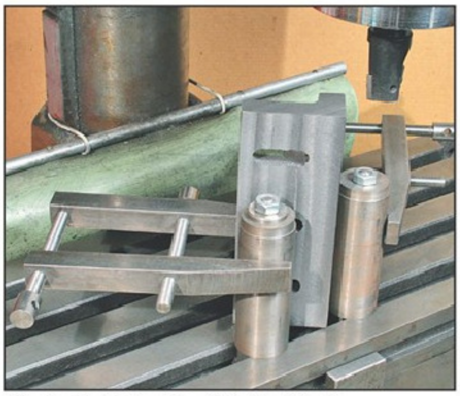


Photo 7. Using the "Cylindrical Squares" ensures that the end face will be accurately at right to both of the main faces.

Photo 8. Drilling the fixing holes in the base of the angle plate.

Photo 9. Whilst not actually machined in this way the photograph illustrates the method suggested by Hemingway for machining the angle plate if the workshop does not posses a milling machine.

second side will be set up in much the same way but the parallel will not be used due to the curved surface. All that will be needed is to set the top face reasonably level to avoid more being machined from one end than the other, **photo 6**. With the two main faces machined the ends can be machined, again using the two cylinders as **photo 7** illustrates. This automatically results in the end being perfectly square to both main faces, something that would be more difficult to achieve if using a single angle plate to mount the casting. The "Cylindrical Squares" were made for a smaller milling machine with smaller T slots and a larger diameter would have been preferable in this case but even so they stood perfectly square to the table's surface when checked with a precision square.

Mark out the base for the five fixing holes and drill and counter bore as per the drawing, **photo 8**. Five fixings would appear excessive but no doubt in use only three fixings would be used, the additional holes just giving some flexibility.

If used as machined so far, then on a Myford Seven the lathe's gap is just insufficient to permit the angle plate to be used fully to the edge of the faceplate and the corners of the main face need some small rebates machined in them, at this stage I have chosen not to do this.

Hemingway's method

The method proposed by Hemingway, whilst a little slower, does have the advantage that it suits the lathe only workshop owner. As I said earlier there are though some similarities with the method I used. Rather than using a "Cylindrical Square" the method uses some square posts to mount the castings, a "Square Square" I suppose. Whilst theoretically not as accurate as the cylinder, providing the jaws of the four jaw chuck used when facing the end are in good condition then the result will be more than adequate. Even though I did not use the method, I have rigged it up on the lathe for the benefit of the reader, **photo 9**.

If you wished to machine the end faces then it will be a case of using the cross or vertical slide, Hemingway do not mention this so appear to accept that the ends are left in the as cast state.

After the angle plate has been fully machined, leave for a week or so and then return and repeat the machining operations by taking a light finishing cut. This will ensure that if the casting moved

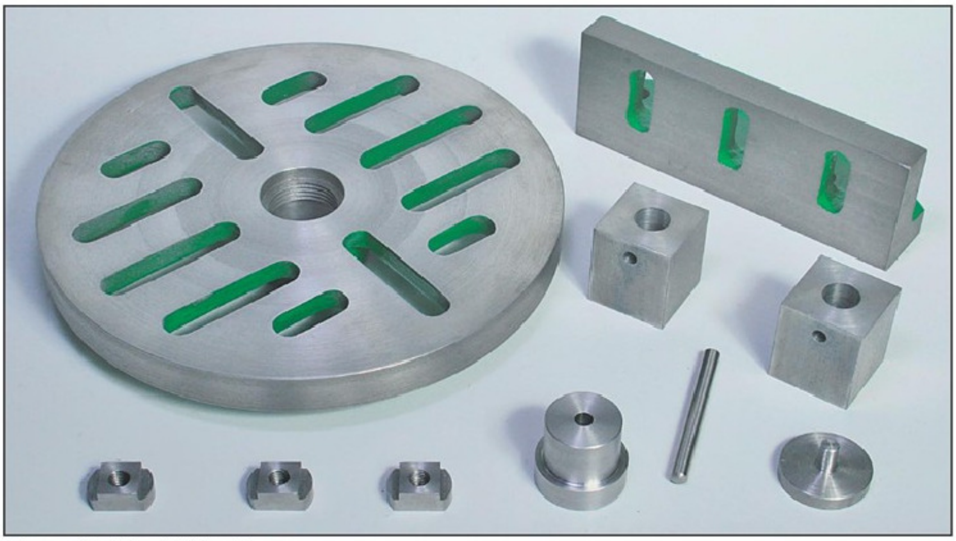


Photo 10. The finished parts.

due to the initial machining that the final result will still be accurate. Ideally though, the time delay should be months rather than weeks but most of the movement will occur in the first few days so it is not that important. A similar operation should be undertaken with the faceplate also.

The accessories

There are four accessories as drawn, with the material being supplied for these. Added to this is one of my own as I will explain later. **Photo 10** shows the accessories together with the finished faceplate and angle plate.

Pillar supports

These (square squares) are an essential item if using the method in **photo 9** but even if the reader uses the milling machine with an existing angle plate they are still worth making as they can often assist in mounting items on the faceplate, angle plate or vertical slide as I have illustrated with similar items in a number of my articles in the past. There is a $\frac{9}{16}$in. counterbore in the end to take the head of the cap screw that secures the pillar but as such a large counterbore is unlikely to be available in the majority of workshops this must be made on the lathe as seen in **photo 11**.

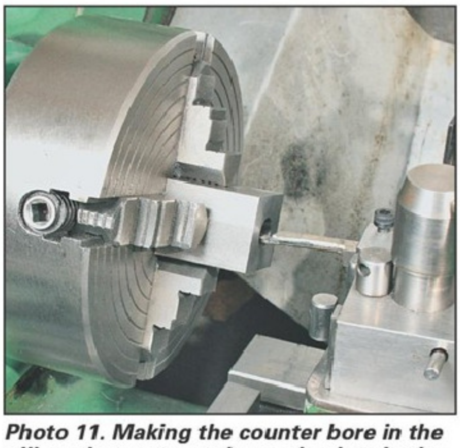


Photo 11. Making the counter bore in the pillars that support the angle plate in the set up in photo 9.

Tee nuts

The Tee nuts are made from round material so, using the lathe, first drill, tap and part off to length. Holding such a small item for milling the rebates can be a problem and holding this across its curved surface between the vice's jaws unaided is definitely a no no. Placing a small V block on its side and holding the disk between this and the moving jaw of the vice as seen in **photo 12** will achieve a much more secure hold as the disk is being held at three points rather than two. With that done the disk can be machined to provide the Tee nut form.

The nut is also machined to reduce its width, a task that may appear unnecessary but as the faceplate has a rim on its rear the extra width will prevent the nut from using the full length of the slots. Of course it is only by a very small amount so you may choose to bypass this operation. If not, then we have a small part that is difficult to position when using the vice and my method is worth considering.

Mount a fence on an angle plate and, using a square, ensure the face is upright then fit a second so that the already machined rebates sit snugly between the two. The T nut can then be securely mounted using a screw from the rear of the angle plate and using the nuts own thread, placing a spacer of some form below the nut will set the height and the first side can be easily machined, **photo 13**. With that done loosen the nut, turn over, and place a 3/16in. piece of packing on top of the spacer and machine the second side, easy!

Setting hub/pin

These are the two items seen to the right of the three Tee nuts in **photo 10**, the purpose of which is to provide a surface from which the distance of the angle plate to the faceplate's centre can be easily set, **photo 14**. In this, the distance from the setting pin mounted in the setting hub is being positioned using a bore gauge set to the required value. The hub is entered into the faceplate from the rear and is a close fit in both the parallel bore and the root diameter of the thread. It is a simple item to make needing only the diameters to be a close fit and these concentric with the hole that takes the pin. Having positioned the angle plate the casting is added for boring as shown in **photo 15**. This photograph is using an already completed workpiece and is just to simulate a typical operation for the purposes of this article.

As I indicated earlier the angle plate will foul the bed of a Myford lathe when it is mounted close to the faceplate's edge. In the photograph the angle plate is about 3/8in. from the edge of the faceplate and there was still about 3/16in. clearance to the bed so this indicates that it will rarely be a problem.

Alternative setting pin

I mentioned earlier that I had ended up with the front face of the faceplate further from the lathe's mandrel than intended by Hemingway and as a result there was visible a length of internal thread that served no purpose. I decided therefore that it would look tidier and be easier to keep clean if I bored the faceplate to remove this and then realised that I could use this shallow bore to take an alternative setting pin. I made the bore 1.250in. diameter to match the size of the parallel portion on the rear and the setting pin seen bottom right of **photo 10**. The reader may consider that this is a worthwhile reason for not machining to the dimensions given.

As both the larger diameter and the pin need to be concentric these would need machining in the same sequence. However, my 1¼in. bar stock was well up to size so I could use this if I could get it running perfectly true. The obvious

Photo 12. Machining the steps of the Tee nuts.

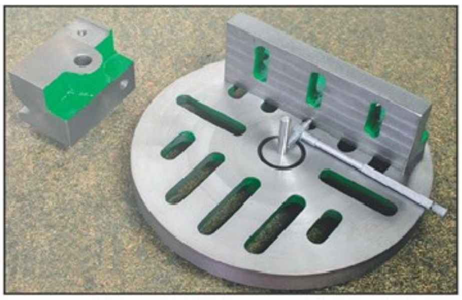


Photo 14. Using a bore diameter gauge to set the distance of the angle plate from the centre of the faceplate.

solution would be to cut a short length and mount this in the four jaw but even with this done, absolute precision would be difficult to achieve and in any case there would be a short length of material left after parting off that may not find a use. I decided therefore to use a method that I often adopt when wanting to avoid ending up with small lengths of material, particularly useful if having to make a number of identical parts, the reader may find the method useful both in this case and in similar situations.

I set up my fixed steady to support the bar which automatically ensured that it was running perfectly true at this point and the pin was then turned and the workpiece parted off. Ideally, the bar should be mounted in the four jaw chuck so that it can be made to run reasonably true at that end also but my three jaw is quite accurate and therefore acceptable when the steady is as far from the chuck as **photo 16** shows.

The Hemingway setting hub has to be used with the faceplate remote from the lathe whereas my alternative can be used whilst on the machine which very occasionally may be beneficial.

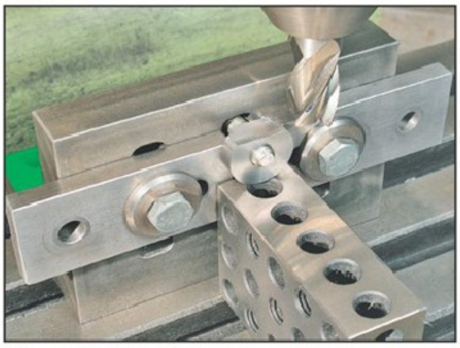


Photo 13. Machining the ends of the Tee nuts.

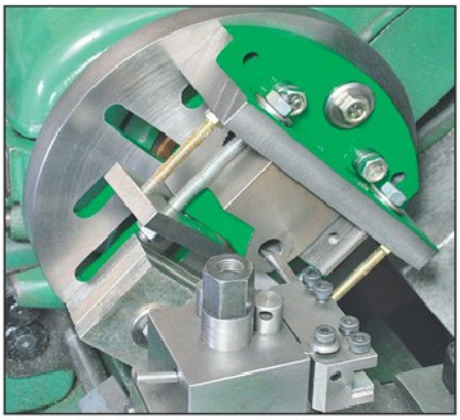


Photo 15. A typical use for the faceplate with angle plate.

A Painting Tip

Screw your thread gauge into the faceplate from its working side and then stand it on the workbench when it will be possible to rotate the faceplate as required for painting the rear side. This will be very much easier and less tiring than attempting to hold the brush in one hand whilst holding the faceplate in the other. You will also end up with two clean hands.

Having completed the faceplate I now have a larger and much more robust plate than my standard item and I am sure that the alternative slot positions will make some tasks appreciably easier. The angle plate will also be useful elsewhere in the workshop. ■

References

Ref 1. Quick-set Face and Angle Plate ref. HK2200. Hemingway Kits, 126 Dunval Road, Bridgenorth, Shropshire, WV16 4LZ. Tel. 01746 767739.
E-mail **info@hemingwaykits.com.**
Website **www.hemingwaykits.com**

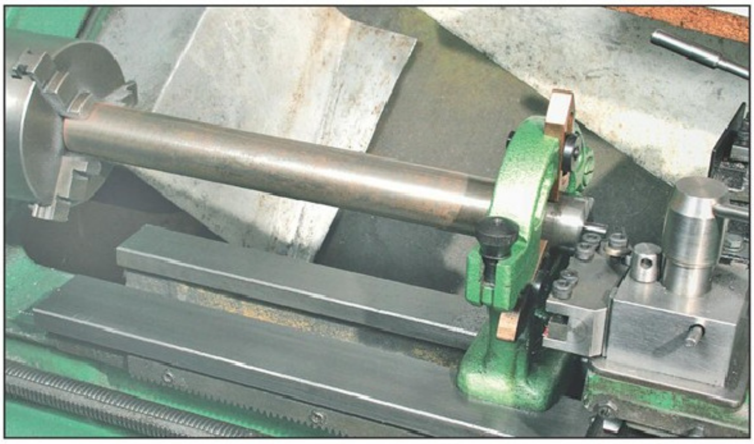


Photo 16. Using the fixed steady as shown enables small parts to be made without there being a small length of bar left in the chuck after parting off that may not find a use.

FIRST STEPS IN 3D DESIGN 4

Introducing trueSpace's mirror, lathe, and macro sweep tools

The mirror tool

Following on from last month, the next demonstration component, a Keats angle plate, will again be constructed with point editing techniques. This example will also introduce the Mirror Tool. This is a handy function which can save a lot of modelling effort. As you may guess from its name, the tool will transform a selected object into a mirror image of itself. By using the tool with a complex but symmetrical object, only half of it need be created, as the object can then be copied, mirrored, and the two halves joined together.

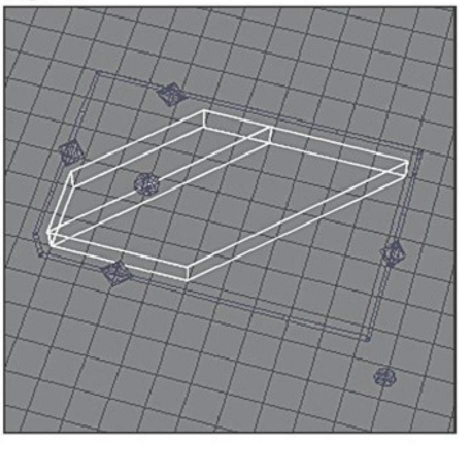
First, to make the mounting flange for the angle plate, start with [**Create New Scene**], [**Reset View**], and [**Wireframe Display**]. Add a new cube, with the following values:

[**XL-2.5/YL-5.0/ZL0.5/XS5.0/YS4.0/ZS1.0**]

Open a subsidiary [**New Perspective View**], and rotate this viewpoint to look at the back of the object. This new window will be used to select the back faces of the component as it is modelled (this is quicker than repeatedly adjusting the main workspace window to switch between front and back views of the object). To avoid confusion, I'll describe the component's front, back, left, and right faces as they appear in the main view.

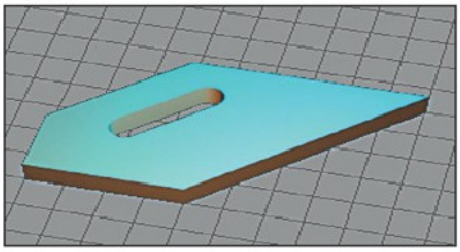
Use [**Point Edit: Faces**], select the back-right face of the cuboid by clicking it in the subsidiary window, then type [**YL0.0**]. Next, select the slanting back-left face, then [**Sweep**]. Type in [**XL-3.5/YL-5.5/XS4.243**] (these values make the extrusion $\sqrt{2}$ grid squares deep - i.e. the diagonal distance between grid square corners, and 3 x$\sqrt{2}$ grid squares wide). Click [**Object Tool**] and you should have this:

Fig. 71



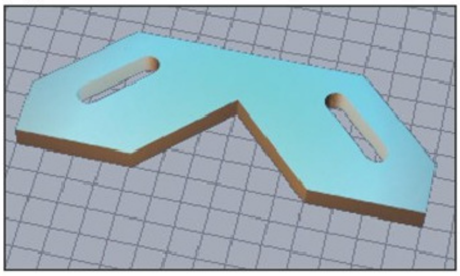
Now to make a mounting bolt slot. Click [**Cylinder**] with LNG:16, and set [**XS0.8/YS0.8**]. Click [**Copy**], and [**XL-2.4**]. Add a [**Cube**], and [**XL-1.2XS2.4/YS0.8**]. Select the first cylinder and [**Object Union**] it with the cube and second cylinder. (The combined object will have the same reference point as the first cylinder, i.e. X=0, Y=0). Type in [**XL-2.0/YL-5.0/ZL45**]. Reselect the previously created object and then subtract the unioned object. Here is the rendered object so far:

Fig. 72



The mirror function is used next to make a reversed copy of the object. The tool works by 'reflecting' an object in a plane that is parallel to the World XZ plane and which also passes through the object's Axis. For the current object, position the plane of reflection with [**Axes**], [**Normalize Location**], [**Axes**]. Click [**Copy**] (we want to keep the original object), [**Mirror**], **Fig B**, then [**Object Union**] the two shapes together.

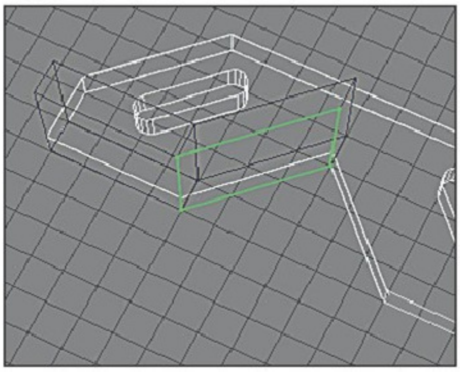
Fig. 73



For the upright part of the angle plate: [**Cube**], and [**XL-0.5/YL-5.0/ZL2.0/XS1.0/YS4.0/ZS4.0**]

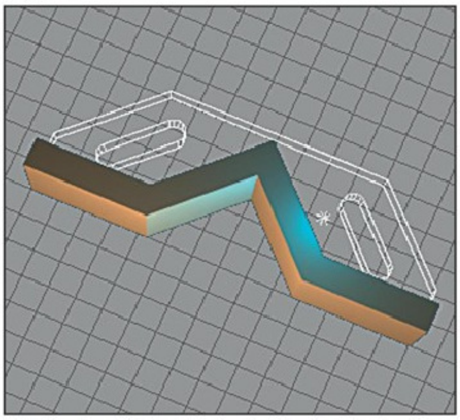
Click [**Point Edit: Faces**], select the right-hand face of the block, [**Sweep**], and [**XL-3.5/YL0.0**]. Click [**Point Edit: Faces**], and select this face:

Fig. 74



Thicken this section by typing [**YL-1.2**]. Next, make a mirrored copy with [Axes], [**Normalize Location**], [**Axes**], [**Copy**], and [**Mirror**]. Select the first upright shape and [**Object Union**] it with the second.

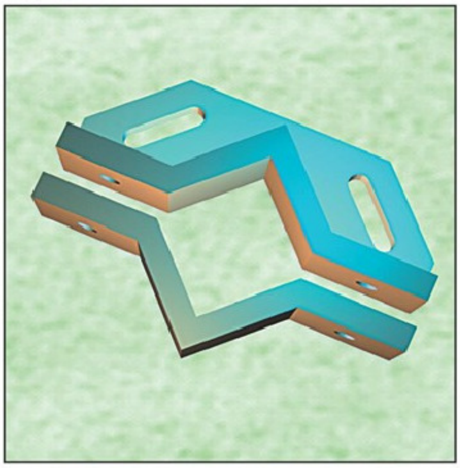
Fig. 75



Create a rotated copy of this object with [**Copy**], [**ZR180**]. Now, select the flange, and [**Object Union**] it with the first upright shape.

For clamping bolt holes, Click [**Cylinder**], and [**YL-5.0/ZL2.0/YR90/XS0.8/YS0.8**] [**Copy**], then [**YL5.0**]. Subtract the cylinders from the two separate parts of the angle plate; this will need to be done twice for each cylinder, so use keep drill, then delete the cylinders afterwards.

Fig. 76



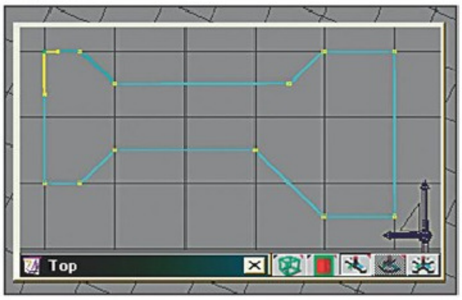
The angle plate is now finished, but you may like to add clamping nuts, washers, and bolts.

2D into 3D: the lathe tool

In last month's article, three of trueSpace's sweep tools (Sweep, Bevel, and Tip) were used to make extrusions from 2D shapes and polyhedron faces. A fourth sweep function, the Lathe Tool, creates 3D shapes by revolving flat faces around an axis. These extrusions can be over a full 360deg. or partial circular arcs. The lathe tool makes it easy to construct components like spindles, and in addition, the tool can generate helical extrusions to make objects such as springs and screw threads. To introduce this function, here is an alternative method of constructing a **flywheel**. This component is similar to the one made for the engine model in part one.

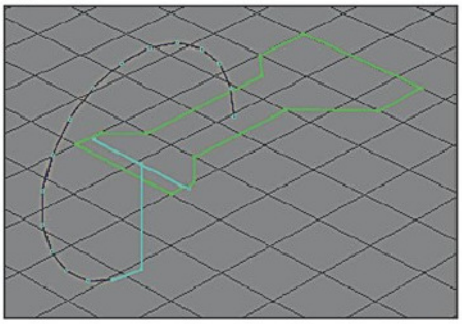
Clear the workspace, [**Reset View**], and click and drag the second icon from the left in the subsidiary Perspective View window to select [**Top Small View**]. Turn on [**Toggle Grid Mode**], set the **Grid Panel** values to 0.5, then click [**Add Polyline**] and draw the following shape in the Top View.

Fig. 77



Now, click the [**Lathe**] tool, **Fig B**. The 2D shape you drew will turn green, and some light-blue and dark-blue guide lines will appear (I've hidden the Object Navigation Control in this next image).

Fig. 78

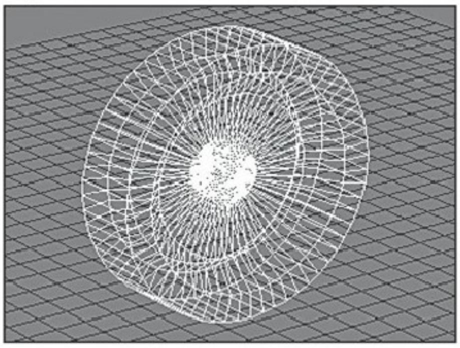


The guide lines give a visual representation of the current lathe tool settings, and if the [**Lathe**] tool is clicked a second time (don't do it yet), the 2D shape will be revolved according to these settings, creating a 3D object. There are three parts to the guide lines. The first is a light-blue horizontal cross-bar, which represents the revolution axis. Second, a blue vertical bar shows the position that the extrusion end-face will occupy when the tool is used; the bar's length is the revolution radius. The third guide line is a dark-blue circular line made up from several straight line segments (the last segment is light-blue). This circular line is an example of what is called a **Path** in trueSpace, and it shows the position that the 2D shape will be moved through when it is extruded. The points between the segments of the path show the location of the intermediate stages of the lathe extrusion.

All the lathe tool settings can be changed interactively by clicking and dragging with the mouse on various parts of the guidelines, but with precision models you will probably need to set lathe values numerically. This is done by typing values in the **Lathe Property Panel**, which is displayed by right-clicking [**Lathe**]. Try typing in various values, and see the changes they make to the guide lines (keep the Helix value zero for now). You can also click and drag the arrow buttons in the panel to alter the guide lines interactively. One useful feature of interactive editing is that, as you drag the Radius value arrow button to move the lathing axis near an edge on the 2D shape, the axis will 'lock' at the edge position. This is helpful because it is sometimes difficult to know what the radius value should be when lathing a 2D shape.

When you have finished experimenting with the lathe values, set them as follows: **Segments:60**, **Angle:360**, **Rotation:0**, and **Helix:0**. Drag the **Radius arrow button** until the lathe axis locks onto the left-side edge (in the Top View) of the 2D shape. To create the flywheel, click [**Lathe**], then exit the function by clicking [**Object Tool**].

Fig. 79

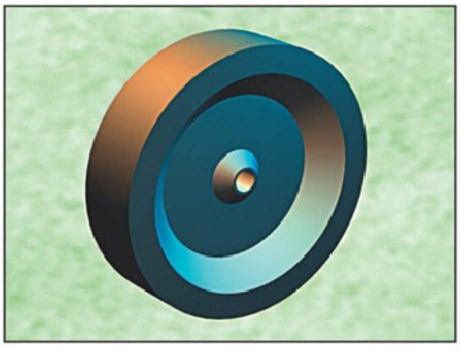


As with all the other sweep tools, the Lathe Panel will close automatically when the operation has been completed. The panel must therefore be reopened each time it is needed (right-click [**Lathe**]); you, like me, may find this mildly irritating when the Sweep tools are used a lot.

One disadvantage of the lathe method of creating the flywheel compared with the method shown in part one (using cylinder polyhedrons), is that the operation generates many additional polygons on the flat sides of lathed objects. This is not really a problem, but there is a trick you can use to clean-up the flywheel. Click [**Cube**], then with [**Object Scale**] and with both mouse buttons down, drag the cube until it completely encloses the flywheel. Select the flywheel, then use [**Object Intersection**] on the cube. The intersection operation creates an object from the overlapping parts of the original objects. In this case, as the cube completely encloses the flywheel, this will leave the flywheel intact, but you will find that redundant polygons on the flat surfaces of the flywheel have been eliminated. This trick can sometimes be useful for simplifying other complex objects you have created.

As the final step in making the flywheel, create a bore by **subtracting** a suitably positioned 8 mm (0.8 grid square) diameter cylinder.

Fig. 80

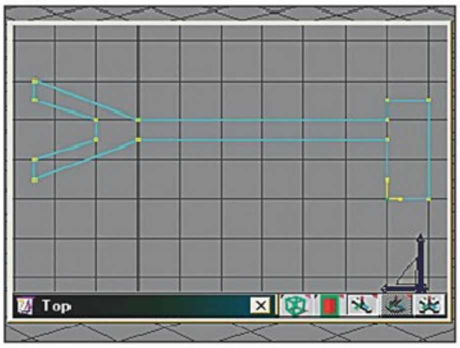


V-belt pulley

This component is made in the same way as the flywheel, but with a more complex 2D starting shape, and this time the object will be formed with an integral bore.

In the Top View, use [**Add Polyline**] with grid snapping on to create a shape like this:

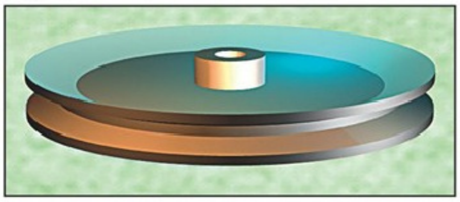
Fig. 81



For simplicity, this cross-section shape does not represent any real pulley, but one could be created by clicking [**Point Edit: Vertices**], selecting individual points, and typing in actual X and Y location values in the Object Info panel.

Click [**Lathe**], and set **Segments:80**, **Angle:360**, and **Rotation:180**. Use the Radius arrow button in the Lathe Panel to move the lathe axis until it snaps to the location of the far right-hand edge (Top View) of the 2D shape. If the lathe tool were to be applied now, the pulley created would have no bore, so look at the Radius value, add 0.8 to it (the bore radius), and type this new Radius value in the panel. Click [**Lathe**], then [**Object Tool**]. As with the flywheel, the pulley will have many polygons on its flat side surfaces, but you can use the clean-up trick described before to remove them if you like. Here is the pulley (shown in a horizontal position):

Fig. 82

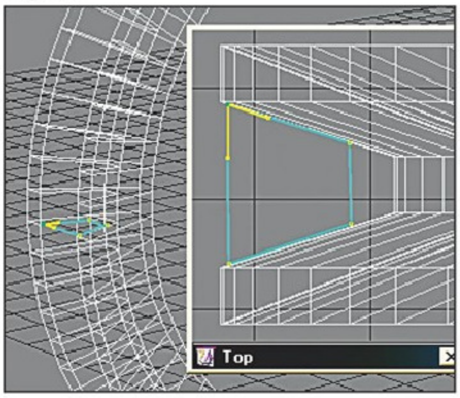


Your rendered pulley won't look quite as well defined as this because of its material settings (in particular, this is due to a parameter called AutoFacet), but there will be more on this in a future article.

V-belt

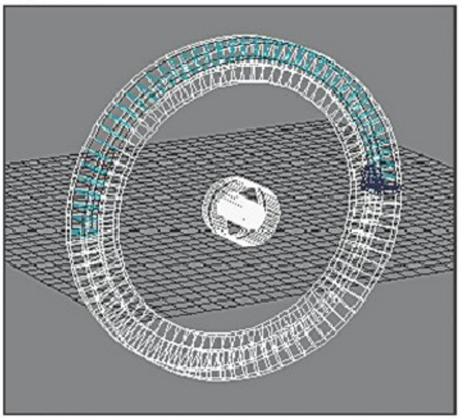
To construct a belt to fit the previous component, first draw a four sided polygon in the 'V' of the pulley with [**Add Polyline**]. No great precision is needed here, so zoom into the Top View and draw it freehand without grid snapping.

Fig. 83



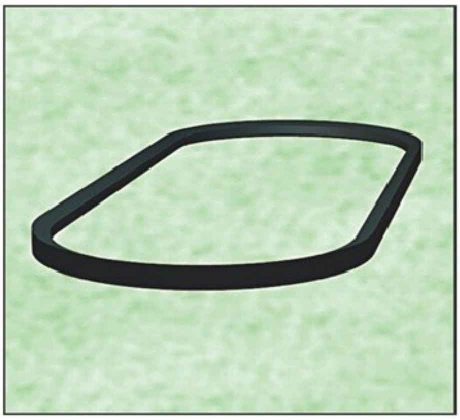
Click [**Lathe**], Set **Segments:40**, **Angle:180** (half a circle rotation only for this section of the belt), **Rotation:180**. Move the viewpoint of the subsidiary Top View to look at the centre of the pulley, and drag the Radius arrow button to move the lathing axis until it coincides with the pulley centre (the position can be judged by eye - the Radius should be about 9.7). Click [**Lathe**] to get:

Fig. 84



Next, extrude the end face of the belt with [**Sweep**], and [**ZL-30.0**]. Click [**Lathe**], **Rotation:180** (do not change the other lathe settings), [**Lathe**], [**Sweep**], [**ZL0.0**], [**Object Tool**]. You should now have a completed V-belt. Here, it is shown rotated and with a dark rubber material:

Fig. 85

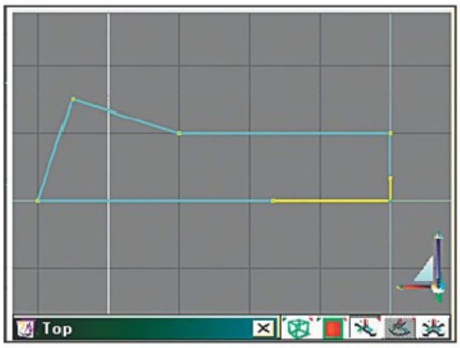


The belt, made to fit around two equally sized pulleys, is not too difficult to construct, but the procedure does get more challenging when there are three or more pulleys, or they have different diameters. I'll show how this can be done in a future part, when some more advanced modelling examples are demonstrated, but you may like to try it for yourself beforehand (hint: although the modelling can be done entirely within trueSpace, it is easier to make a 2D CAD or manual drawing first).

Simple collet

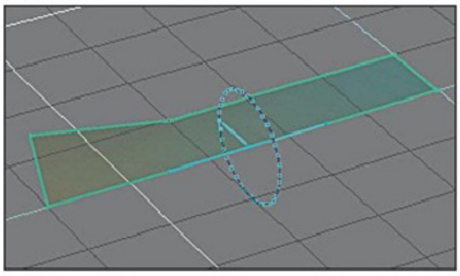
Set both the Main Perspective window and the Small Top View window to [**Direct 3D Solid Render Display**]. This will show the blue X and green Y axes. With grid snapping on, draw the following **Polyline** in the Top View so that its front-right vertex is at the junction of the X and Y axes (i.e. at the World Centre):

Fig. 86



Click [**Lathe**], set **Segments:36**, **Angle:360**, and **Rotation 270**. As an alternative method of adjusting the lathe axis position (and Radius), click and drag the point on the lathe guide-lines where the cross-bar and radius-bar meet. Move the axis near the lowest edge of the polygon, and it will snap to this position.

Fig. 87

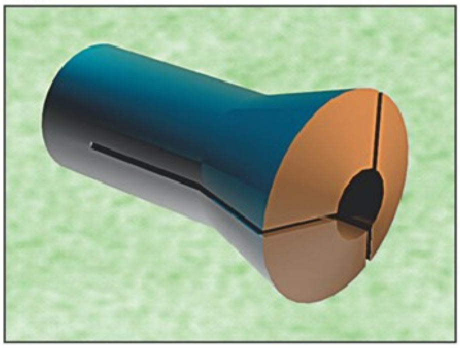


Click [**Lathe**], then [**Object Tool**]. Next, make three slots in the collet with [**Cube**], and [**XL3.0/YL-1.1/ZL0.0/XS4.0/ZS0.1**]

Click [**Axes**], [**Normalize Location**], [**Axes**]. Make two more copies of this subtraction object with [**Copy**], [**XR120.0**], [**Copy**], [**XR-120.0**]. Finally, **Subtract** the three objects from the collet.

Although not yet completed, this would be a good stage to save the object, as several collets can be made from the same shape by subtracting differently sized axial cylinders from the collet. The collet below has a 1 cm inner diameter.

Fig. 88



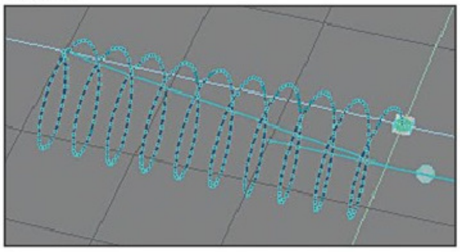
Helical components

The 3D shapes created so far with the lathe tool have been extruded along simple circular paths, but by making the Helix value in the Lathe Property panel non-zero, helically shaped objects can be produced. **Springs** are examples of such components, and one can be made as follows:

Clear the workspace, and [**Reset View**]. This example will start with a 2D circle shape, so click [**Add Regular Polygon**], **Fig**

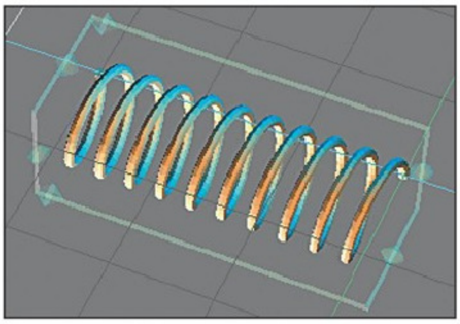
B. In the **Reg.Polygon** panel which is displayed, set the number to 8; this will be the number of sides in the polygon - it's set to a small value as the circle will be small. With grid snapping on, draw a small polygon in the workspace in this way: click and hold the left mouse button down at the World centre (X and Y axes junction), then drag in any direction. On releasing the mouse button, a polygon is created (together with a **DrawPanel**). Type [**XS0.1/YS0.1**]. This value (1 mm) will be the spring wire diameter. Use the [**Lathe**] tool with the following values: **Helix:0.3**, **Segments:360**, **Angle:3600** (ten turns), **Radius:0.5**, and **Rotation:0.0**. The Helix value (3 mm) is the pitch of the spring's coils; It has to be set first because the Angle value is otherwise restricted to 360° when the Helix value is zero.

Fig. 89



Click [**Lathe**] and [**Object Tool**] to finish.

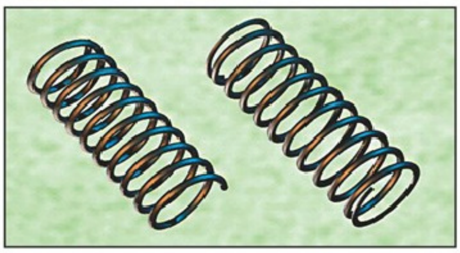
Fig. 90



To make a similar spring, but with closely spaced end coils and flat ground ends, adjust the viewpoint and zoom in close to look at the nearest circular end face of the spring, click [**Point Edit: Faces**], and select this face. Use [**Lathe**] with **Segments:24**, **Angle:240**, **Radius:0.5**, **Rotation:0.0**, and **Helix:0.02**. Click [**Lathe**] again to make the first end coil. Now alter the view to look at the far end face of the spring, click [Point Edit: **Faces**], select the end face, and click the [**Lathe**] tool twice (this uses the previous lathe values). To make the ends flat: [**Cube**] and [**XL0.5/YL-1.5/ZL0.0/YS3.0**]

With the cube selected, use [**Object Intersection**] with the spring. Here are the two forms of the spring:

Fig. 91



Leadscrew

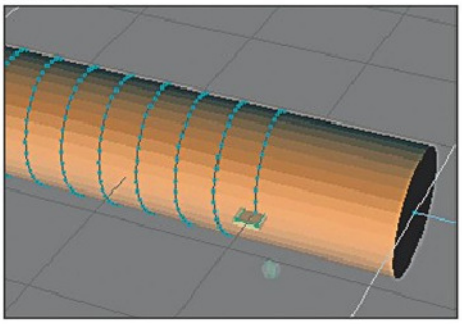
Although this next example demonstrates the creation of a square thread, by starting with other 2D shapes you can also produce other thread forms. The Leadscrew will be 24 cm long, with a 21.3 cm threaded length, and a core diameter of 1 cm. The 1.5 x 1.5 mm thread will have a pitch of 3 mm.

Start with [**Cylinder**] LNG:36 (one face per 10°), and [**ZL0.0/XR90/XS1.0/YS1.0/ZS24.0**].

Next add a [**Plane**], and [**XL0.5/YL11.0/XS0.3/YS0.15**]

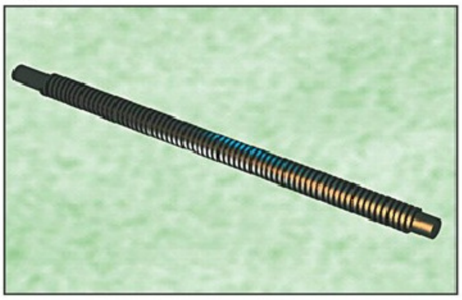
Note that the plane overlaps the core cylinder so that there will be no gaps when the thread is later unioned with the cylinder. Click [**Lathe**] and use the following settings: **Helix:-0.3**, **Segments:2520** (70 turns x 36 segments; 36 is the same value as the core cylinder longitude), **Angle:25200** (70 turns x 360°), **Radius:0.5**, and **Rotation:180**.

Fig. 92



Click [**Lathe**], then [**Object Tool**]. To finish, select the core cylinder, and [Object Union] it with the thread.

Fig. 93



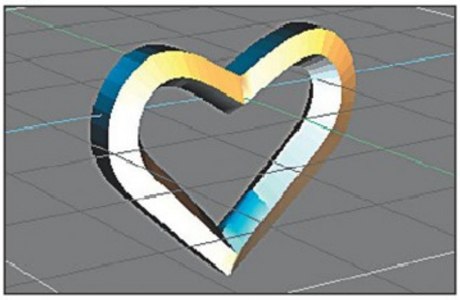
2D into 3D: macro/sweep

This function is yet another Sweep Tool, and is potentially the most powerful of them all. The tool is similar to the lathe tool, but instead of extruding a 2D shape through a circular path, the extrusion path can have any shape. The great value of this tool is that you can define your own paths, save them, and later reuse them on any 2D shape to make other extrusions. In constructing general engineering components, you probably won't have to use the macro sweep function often, but in a few instances it will allow you to build complex objects that would be difficult or impossible to make by other methods. To show the basic macro sweep operation, here is a simple example of using the tool with one of trueSpace's predefined paths:

Start with a simple 2D object by using [**Add Regular Polygon**]. Make the shape about one-quarter grid square in size. Click [**Macro/Sweep**], **Fig B**, and a light-blue path will appear, extending perpendicularly upwards from the centre of the polygon (the actual path shape will depend on what previous operations you have done in trueSpace). To use a predefined path, click the [**Path Library**] icon. This is the second icon down in the Library Toolbar, **Fig A**.

In the panel, select the path named 'Heart', then click [**Macro/Sweep**]. This second click of this icon will extrude the polygon over the selected heart shaped path. Click [Object Tool], type [**XR-90**], and you should have something like this:

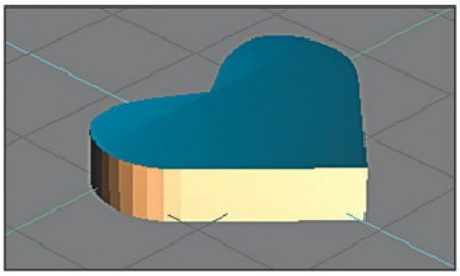
Fig. 94



Try experimenting with the other paths in the library on various 2D shapes, and you should see the possibilities that the macro sweep tool can give you.

Incidentally, some of the shapes in the paths library can also be used as 2D shapes in their own right. As an example, first make sure you are in object selection mode (click [**Object Tool**]), Select the 'Heart' path, then [**Sweep**], [**Object Tool**], and you will have an extruded heart-shaped object.

Fig. 95

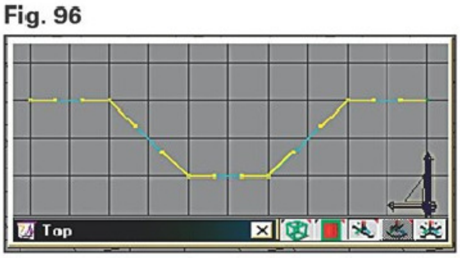


Your own paths

There are three types of path that you can create and then use with the macro/sweep function - **Spline Polygons**, **Macro Sweeps**, and **Animation Paths.** Here is an example of making an object using a simple spline polygon path:

This demonstration is an alternative way of creating the crankshaft component that was shown last month. Turn on grid snapping, and set the X and Y grid values to 0.5. Click [**Add Polyline**], and in the subsidiary Top View, draw this line:

Fig. 96



This object (and all polylines you have drawn before) is actually a curved line with sharp corners and straight edges! As the word 'curve' is ambiguous in this context, such lines are called **Splines** in 3D work. Splines can be straight or curved, have sharp or rounded corners, or be closed (their ends joined together) or open.

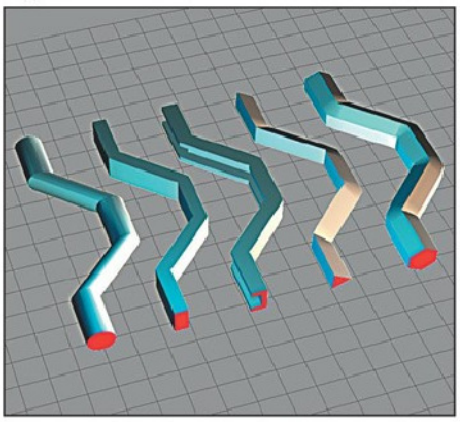
At this stage the spline you have drawn has not been closed with a right mouse click, and it can therefore be saved as an **open spline path**. With the Path Library panel open, right-click the panel and select 'New'. Right-click the panel again, select 'Rename', and type a name such as 'F Steps Paths'. Right-click the panel once more, and select 'Insert'. This will save the current open spline object in the path library.

Now to make the crankshaft. Clear the workspace, click [**Add Regular Polygon**], type 16 in the Reg.Polygon panel , and draw a one grid square diameter circle. Click [**Macro/Sweep**], select the path you have just created from the Path Library panel, then [**Macro/Sweep**] again. You should have an identical shape to last month's crankshaft, except that its orientation is different and it is made up from many more polygons.

While the object is still in editing mode, there is one significant change you can make to the crankshaft. Currently, the swept stages of the extruded object are parallel to the starting 2D shape, producing some flattening of the extrusion in places as it follows the path (complete flattening is possible with some paths). To counteract this, there is a way to rotate the stages to make them perpendicular to the path direction; this produces an object with a more uniform thickness. To do this, right-click the [**Macro/Sweep**] tool, then click the '**Bend**' button. Adjust the viewpoint around the crankshaft, and turn Bend on and off to see the difference. Whether you use this function or not will depend on the type of object you are creating. For the crankshaft, it is not needed, so deselect the Bend button, then click [**Object Tool**] to finish. You could, if you like, reduce the number of polygons in the crankshaft by using the clean-up trick used with the flywheel.

The time needed to make the crankshaft is roughly the same for both construction methods, but the macro sweep method has the advantage that you can reuse the path that you created to build other components. Here are some examples, using various starting 2D shapes made with the [**Add Regular Polygon**] and [**Add Polyline**] tools, and with the saved spline path:

Fig. 97



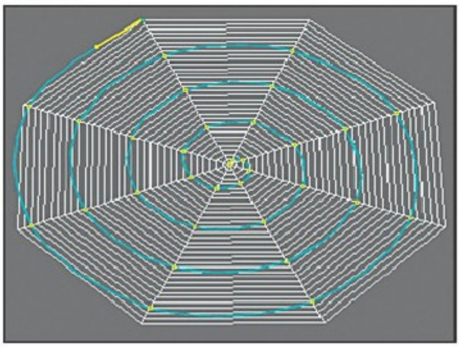
Spiral objects

The value of using the macro sweep function is demonstrated with components such as spiral springs and self-centering chuck scrolls. These are more complex than any of the objects covered so far in this series, but are still relatively easy to build by starting with a spline path. Here is an example of how this may be done:

First, a spiral spline path will be drawn freehand with the [**Add Curve**] tool. Doing this task by eye would be very difficult, but with the aid of a suitable guide object, the spiral can be made moderately (or very) precise for most purposes. To make the guide object: Turn grid snapping on, and use [**Cone**] with **LAT:32**, **LNG:8**. Click [**Axes**], [**Normalize Location**], [**Axes**], and [**XS5.0/YS5.0/ZS0.001**] (this small Z value is needed because trueSpace will not allow a zero size). Change to [**Top View**] and adjust the view so that the guide object fills the screen.

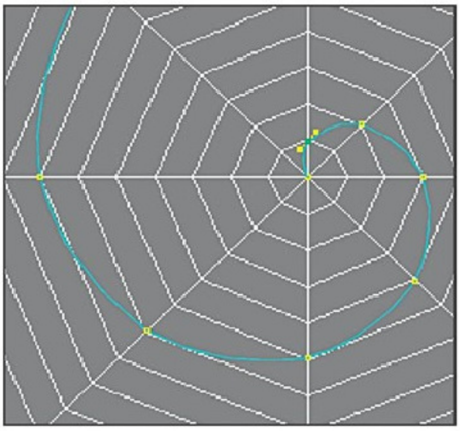
Click [**Add Curve**], **Fig B**, and click the central point of the guide object. Turn off grid snapping and then click on the innermost guide ring at the vertex immediately above the first point. Continue clicking the vertex positions on the guide, each time moving one ring outwards and one position clockwise. Take your time over this - it's easy to miss-position the clicks on the wrong vertex - I know, I did it twice! Try to set the points in the spline close to the relevant vertex positions on the guide, but don't worry if they are a bit out; they can be corrected later. When you reach the outer edge of the guide, you should have a spiral spline path like this (in Perspective View, with the grid hidden):

Fig. 98



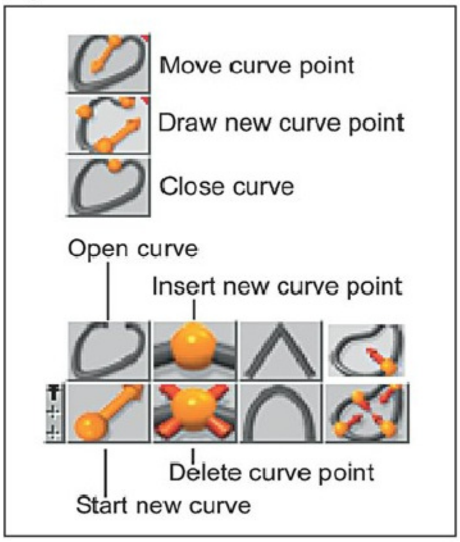
Here is a close-up of the centre of the spline:

Fig. 99



At this stage you can correct mistakes, or just generally improve the precision of the path nodes (the yellow points). Do this by first clicking the [**Move Curve Point**] tool (the top icon in the NURBS Curve Edit Toolbar, shown below), then clicking a node and then dragging the mouse in the workspace. While doing this, you can get a closer view of parts of the spiral by using the View Navigation Control - or zoom in with a wheel mouse if you have one. When you are satisfied with the spiral shape, save ('insert') the spline path in the Path Library panel, and give it a suitable name. Both the spline and the guide object can now be erased.

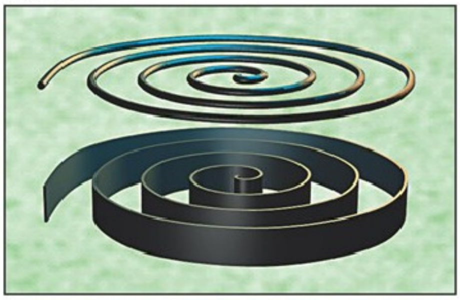
Fig. 100



The **NURBS Curve Edit Toolbar** (above) has several tools for manipulating spline curves. Most of the function names are fairly self-explanatory, and further details are in section 4.3.2 of the Help File. This section also has further information on trueSpace's other 2D drawing tools which you may like to experiment with.

To make a spring, create an eight-sided, 1 mm (0.1 grid square) diameter **Regular Polygon**. Then use the [**Macro/Sweep**] function with the 'Bend' option on, and select the saved spiral path from the Path Library. Click [**Macro/Sweep**] and [**Object Tool**] to finish. Here is the (re-orientated) spring, together with another made with a different 2D shape but with the same spline path:

Fig. 101

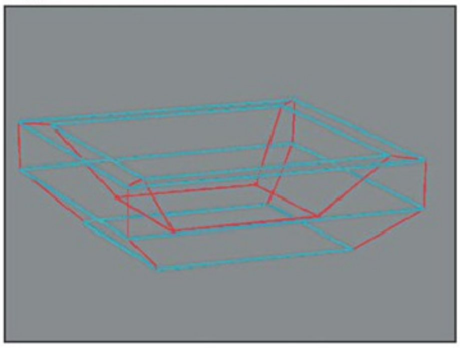


Macro sweep paths

These paths, created by doing a sequence of Sweep operations, are potentially even more powerful than spline paths. The difference between macro sweep paths and spline paths is that in the latter, the cross section of the extrusion remains the same throughout the swept object (i.e. the same as the starting 2D shape). In macro sweep paths, the cross section can be moved, rotated or scaled as it is swept, potentially creating a very complex path indeed. Here is a simple example of creating and using a macro sweep path:

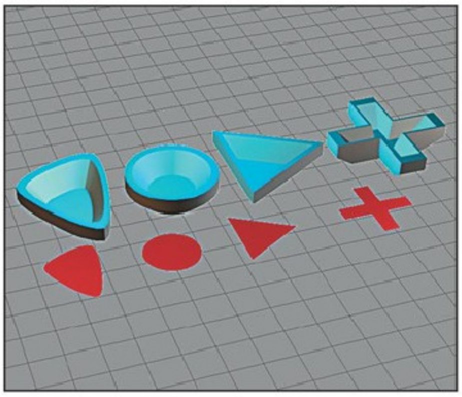
Click [**Plane**], then [**Sweep**], and type [**XS3/YS3**]. Click [**Sweep**] again, and note that trueSpace has remembered the previous sweep transformation (a scaling factor of 1.5) and used it with the current extrusion. Type [**XS3/YS3**], then [**Sweep**], and [**ZL1/XS2.5/YS2.5**]. [**Sweep**] once more, and [**ZL0.3/XS1.5/YS1.5**], and you should have this:

Fig. 102



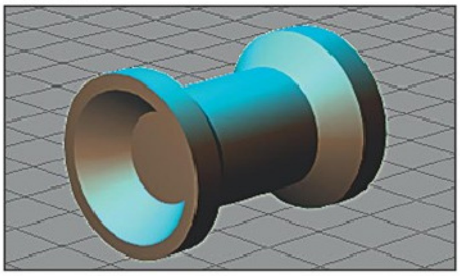
With this sequence of [**Sweep**] operations, behind-the-scenes trueSpace has created a macro sweep path, and this can be saved immediately by right-clicking the Path Library panel, and selecting 'Insert'. To use this stored macro path, create any closed 2D shape with [**Add Regular Polygon**], [**Add Polyline**], or [**Add Curve**], click [**Macro/Sweep**], and select the saved path in the Path Library panel. Click [**Macro/Sweep**] again, and then [Object Tool] to finish. Here are some starting 2D polygons and the shapes built from them with the saved macro sweep path:

Fig. 103



Macro sweep extrusions can just as easily be applied to object faces. Try this: use [**Cylinder**] with **LNG:32**, then [**YR90**]. Click [Point Edit: Faces] and select both end faces of the cylinder (Control Key down to select more than one face), click [Macro/Sweep], then pick your saved path in the Path Library. Click [**Macro/Sweep**] once more, and [**Object Tool**] to finish. This should be the result:

Fig. 104



Next Month: Before this series moves on to some moderately advanced modelling, part five will conclude this initial look at basic 3D object building techniques. Amongst the trueSpace tools examined next month will be **Arrays** for creating multiple regularly spaced copies of objects, and how the **Shell Tool** can simplify the process of constructing thin-walled components such as boilers. To be continued...

HOW I MADE MY LITTLE LATHE

Hubert Elffers makes a 2in. centre lathe

A few years ago, I was seeking a new project, and considered making a model of a lathe. I then decided to have a shot at making a real working lathe, rather than a pretty model. With this in mind, I started planning dimensions. The first constraint was the length of bed I could produce on my milling machine - a maximum of 16in. I am unskilled at mechanical drawing, so I made some rough sketches, and a wooden model. This suggested a 2in. centre height and 8in. between centres. Although this would be a small lathe, I planned a heavy construction, built with as much precision as possible and I wanted to include a screwcutting facility. I decided to use commercially available chucks and changewheels etc, and throughout the design strove to produce a rugged accurate lathe, rather than a superbly-finished show piece, **photo 1**.

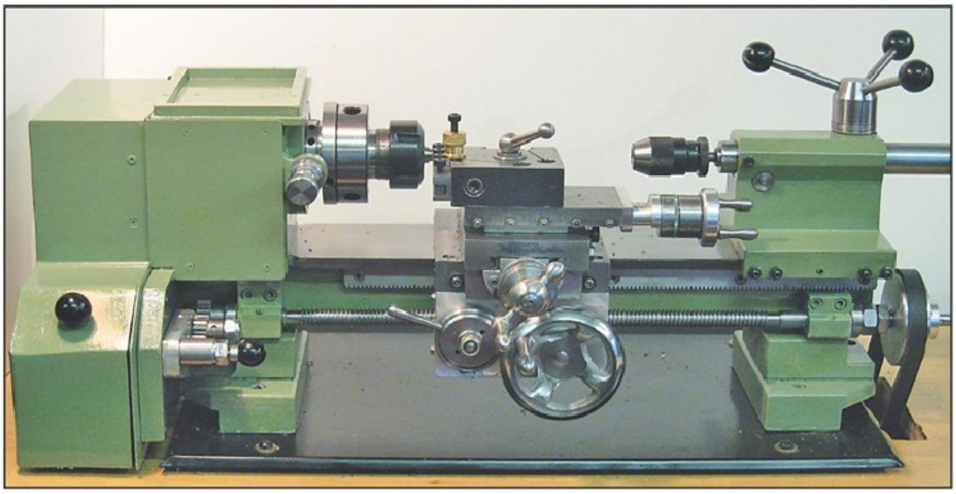


Photo 1. The finished lathe.

For anyone following in my footsteps, I have one warning; making a lathe in this manner is not a cheap option! By the time the lathe was complete and tooled-up, it cost a great deal more than a commercially-supplied new lathe! On the other hand, it has proved to be an interesting, satisfying and rewarding project for an old codger (now 80 years old!). This old dog learned many new tricks! I also spent quite a lot of time and effort re-making parts, until the final result looked right and worked right. The construction breaks down into sub-assemblies, which individually are less intimidating than the complete lathe. I have no working drawings as I only used the drawing board to detail difficult parts. I have, however, given various dimensions and with these and the photographs, it should be possible to visualise the construction. I should be delighted to chat to any prospective builders by email or by telephone.

I thought that my sources of supply might interest others, and I have included these in the text, and summarised them at the end of this article. I include the usual disclaimer that I have no interest in these companies, except as a very satisfied customer.

I greatly valued the advice given to me by these suppliers and by numerous model engineers. Above all, I wish to thank Tony Griffiths for his encyclopedic www.lathes.co.uk website. Many of my design ideas came from studying lathe details on this site. Tony also helped me with sage advice and with a great deal of encouragement.

Another source of encouragement was the late Len Mason. His book 'Building a small lathe' is both lucidly written and profusely

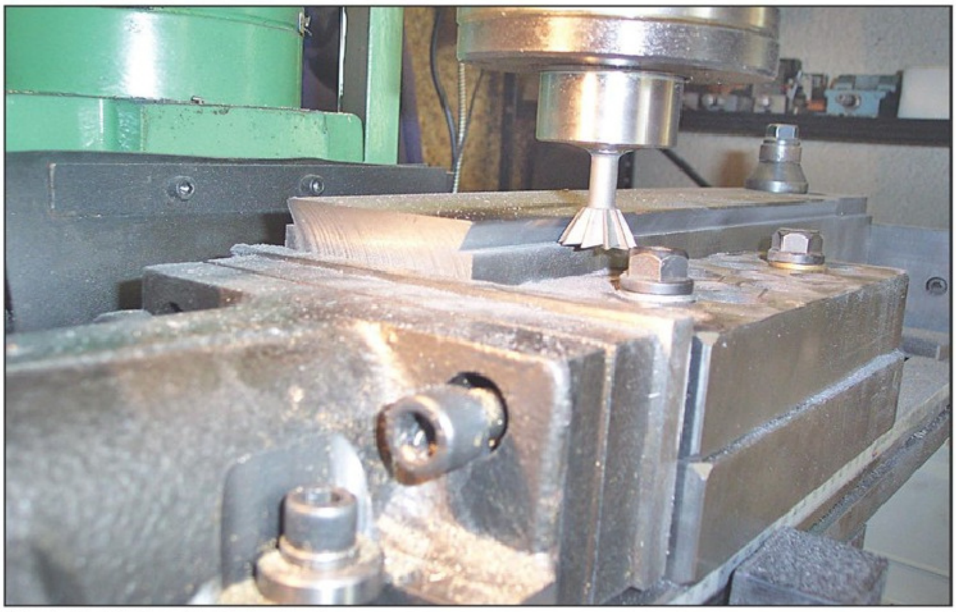


Photo 2. Milling the lathe bed.

illustrated, showed that it was possible for a beginner to make such a machine. Using The Small Lathe is, in my opinion, still one of the very best books for beginners. His was though a very different lathe to mine, but the idea was an inspiration.

My workshop is equipped with an elderly Hardinge HLV-H lathe, a newish Warco VMC milling machine, and an old horizontal milling machine

Lathe bed

Based on the principle that the width of the bed of a precision lathe should be twice the centre height, ideally I would have made the bed 4in. wide. This looked a bit 'over the top' for this little machine, so I settled on a width of 3in. Howard Proffit of College Engineering, supplied me with large lumps of Meehanite cast iron, which machined beautifully. I decided on a simple Vee bed, and machined this on my Warco VMC milling machine, using a dovetail cutter for the Vees, **photo 2**. I then machined away excess material, until the bed 'looked right'. Building out of the solid produces more swarf and the all-pervasive black carbon dust than remains in the actual lathe! I planned a belt drive to a motor directly below the lathe, thus requiring a large hole through the bed, **photos 3** and **4**.

I have never learned to scrape, and I was fortunate in finding a friendly, helpful tool-and-cutter grinder in a nearby village. He kindly ground the bed top and ways and the cross-slide dovetails.

Headstock

I planned to use opposed taper roller bearings from Arc EuroTrade (thanks to Ketan for his helpful advice) for the headstock, and chose a mandrel size of 20mm. This meant an OD of the bearings of 42mm. I milled the headstock into as perfect a cube as possible, this giving me six datum points. I was puzzled how to bore the headstock with a shoulder to restrain the bearings sideways, and finally decided to bore the headstock with a large plain hole, and insert screwed bushes to hold the bearings.
I first machined the headstock, cutting away the middle piece. I find that drilling is the easiest way to remove large amounts of metal, and I used my largest drill (1 1/2in.) in the milling machine for this. I then put the headstock into my ancient heavy power hacksaw, and

Photo 3. Drilling a hole through the bed.

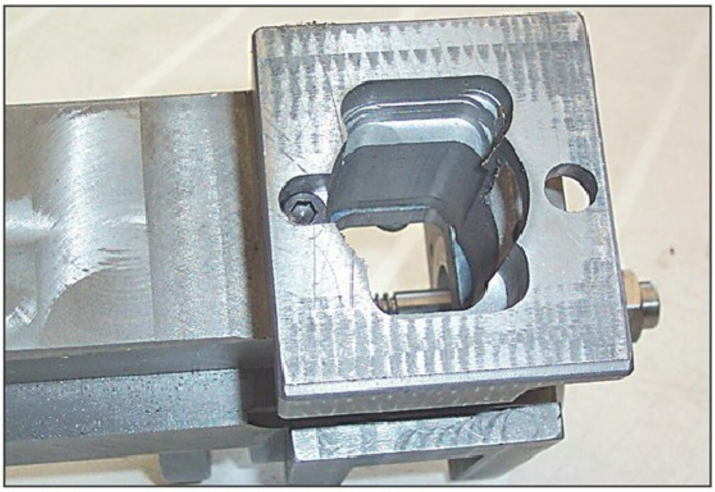


Photo 4. The finished hole through the bed.

Photo 5. Making the headstock blanks.

Photo 6. Boring the headstock.

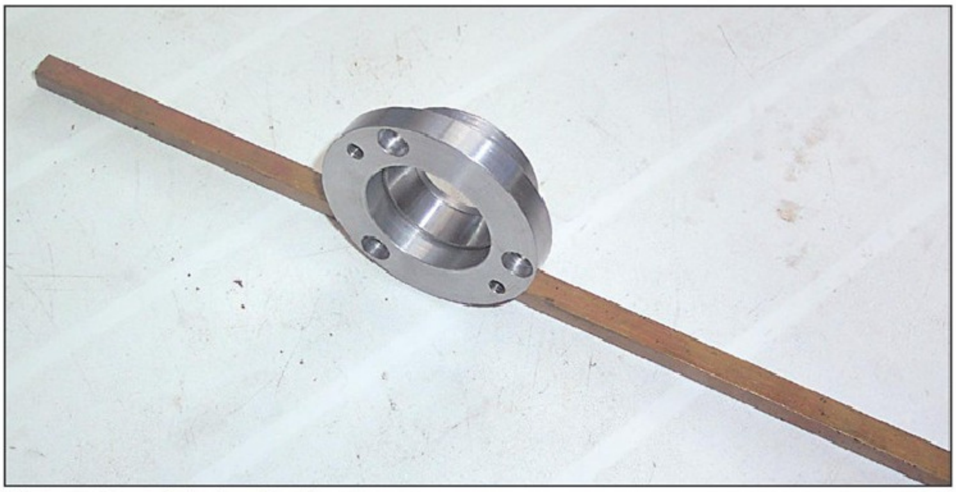


Photo 7. One of the bearing housings.

Photo 8. Bearing housing fitted to headstock.

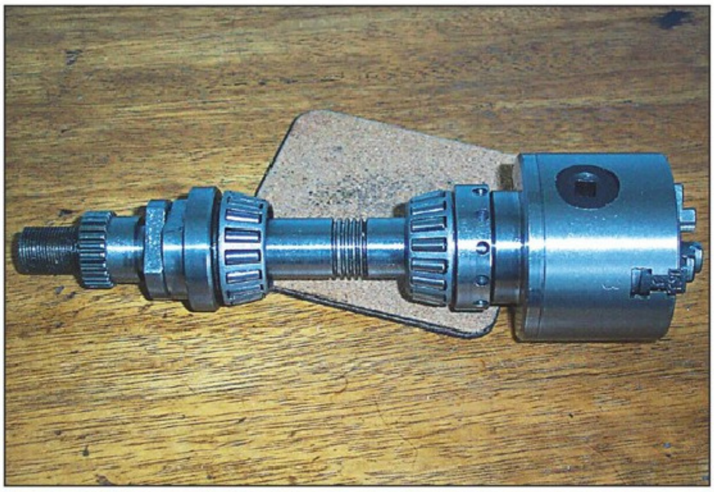


Photo 9. The mandrel and tapered roller bearings.

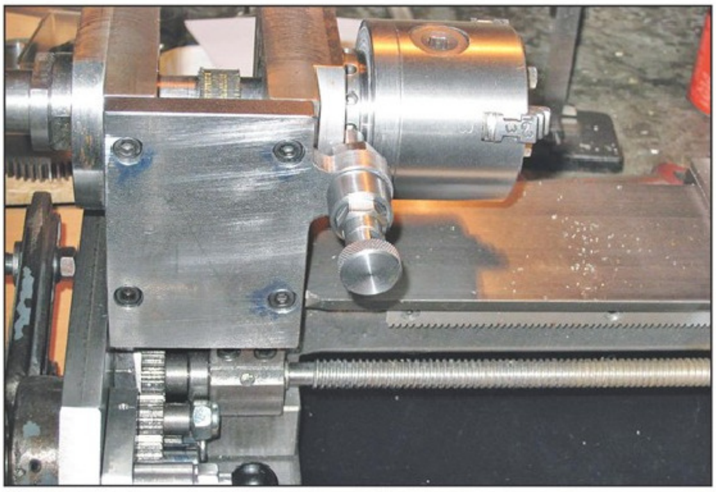


Photo 10. The mandrel showing indexing attachment.

sawed down into the drilling, **photo 5**. After that, I cleaned it up with a large, long end mill.

I made a boring bar with an adjustable cutter to fit into my horizontal milling machine, and bored the headstock straight through. This is a much more rigid method than boring on the lathe, **photo 6**. I then turned and fitted the two bushes to hold the bearings, **photos 7** and **8**.

Mandrel

I turned the mandrel from 1¾in. EN8 carbon steel to provide the front collar against the bearing. (What a lot of swarf!) The mandrel is drilled through 10mm, and has a 1MT taper. I cut the nose thread to match that of the Peatol lathe. I proposed to drive downwards, using a PolyVee belt. I found that the minimum pulley diameter for this belt was 20mm, so I cut the grooves of the 'pulley' directly into the mandrel. I screwcut the left hand end to accommodate two locknuts to provide preload for the bearings and cut a key-slot to hold a change wheel. My tool-and-cutter grinder friend ground the mandrel to the correct diameter for the bearings, **photo 9**.

Main drive

The drive to the mandrel is by the PolyVee belt using a three-phase motor on a shelf directly below the lathe. This motor is controlled by an inverter, thus providing infinitely-variable speeds.

PolyVee belts and pulleys

I bought the PolyVee belts from Alldrives Ltd, who were very helpful with advice, and sent me some product description literature. I chose the J-section belts, and ordered them with 5 ribs. These belts give a very smooth drive, and do not slip, even on the smallest specified pulley of 20mm diameter. To cut the pulleys, it is necessary to have a form tool ground exactly to the correct profile. Not my scene! My tool-and-cutter grinder friend ground me the correct profile and at the same time, ground me a tool to cut the Acme leadscrew thread. Except for the 'pulley' cut into the mandrel, I made the pulleys out of aluminium. The product description supplies the depth of cut and the dimension of the spacing. I cut the pulleys on the Hardinge, measuring the spacing with the micrometer on the top-slide. They work well.

Indexing and detent

The collar on the mandrel just behind the chucks is drilled with 12 holes to provide simple indexing. These holes are locked by a heavy detent, which immobilises the mandrel when mounting and dismounting chucks, **photo 10**.

Chucks

The four-jaw chuck and faceplate came from Peatol Lathes. A dinky little 60mm 'proper' three-jaw chuck and ER 25 collets and chuck came from Arc Euro Trade.

Saddle and slides

These were also milled out of solid cast iron. I considered making taper gibs but the small scale of the lathe made this difficult so I reverted to ordinary gibs with closely-spaced Allen grubscrews and locknuts. This created a problem for the screws for the gibs of the saddle because of the long overhang of the base of the cross slide. Allen grubscrews are not made that long, and my first try of using studding with screwdriver slots, looked horrid! I solved this problem by using countersunk Allen screws (where the hexagon is very small). This enabled me to turn away the countersunk head, and hey presto, long Allen grubscrews!

I carefully milled the ways for the base of the top-slide dead square to the saddle, and then mounted the saddle on the bed, immobilised it, and took the whole caboodle to the tool-and-cutter grinder. He checked the position of the bed with a dial gauge and then ground the cross-slide ways perfectly square to the bed.

The small size of the lathe precludes cutting tee-slots on the cross-slide, but as I do not anticipate milling in the lathe, this is no problem.

Micrometer dials

My Hardinge lathe is Imperial, so I decided to make this little lathe metric. I made lengths of left-hand threaded 'leadscrews' (6mm x 1mm), using a die from the huge selection stocked by Tracy Tools. These

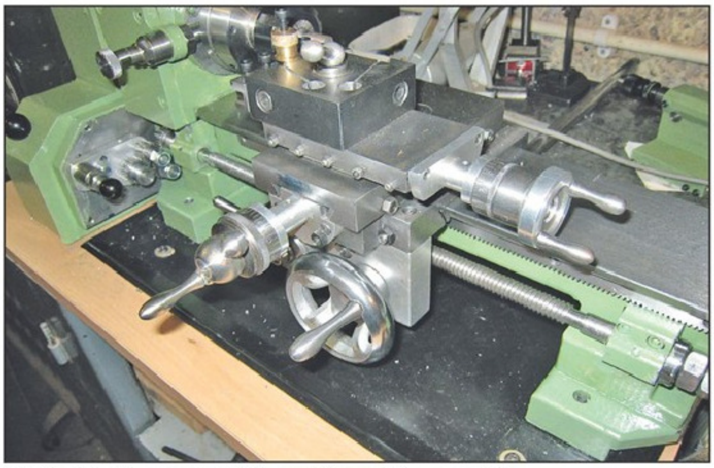


Photo 11. The cross slide and top slide assembly.

Photo 12. The swiveling topslide is similar to the Myford Super 7 mount.

Photo 13. No shortage of tool holders here.

screws were too long to run using a tailstock die holder, so I made a die holder to fit in the tool post and this worked fine. I made two micrometer dials, restrained by a spring pushing onto a ball bearing running in a groove on the screw. This enables zeroing without undoing a setscrew.

Here is a cautionary tale! My cross slide requires a left-hand thread, BUT the top-slide a right-had one! I only found this out after completing the slides. Another job to be done in the future!

I did briefly consider a power drive to the cross-slide, but the available space is too small. I bought two tiny ball thrust bearings from Arc Euro Trade, and these reduce the amount of backlash on the cross slide, **photo 11**.

Swiveling topslide

The design of the compound slide rest was difficult because the small centre height conflicted with my desire to make a strong and rugged little lathe. I eventually adapted the Myford Super Seven design for the swiveling topslide, **photo 12.** The hole in the cross slide was bored on the Hardinge, with the cross slide held in the four-jaw chuck. The base of the topslide was turned out of a round bar, with the slideways subsequently milled square.

I did not engrave a 'protractor' for the angle of the top-slide because of constraints of space and also because these protractors are never very accurate. I have recently bought a digital 'Angelo Angle Finder' (A digital bevel gauge) from Allendale Electronics for a modest price. This reads to .05 degrees (about 3 minutes). This will instantly give an accurate readout for the angle of the top-slide, and has many other workshop uses.

Quick-change toolpost

I altered a toolpost from Chronos, cutting a second tool-holding position, and then indulged in some batch-production of tool holders, **photo 13.**

Apron

The apron is fitted with a three-gear drive from the hand wheel, to the rack. The gears and rack were supplied by HPC Gears.

Screwcutting

The largest diameter leadscrew that will fit between the gears on the apron is 7⁄16in. I plan to use this lathe to cut both metric and imperial threads. Because of constraints of space, there is insufficient room for a conversion gear. I finally decide to cut the leadscrew with a 10tpi Acme thread. 10tpi = 2.54mm. Considering that this little lathe will be used to cut fine and relatively short threads, I believe that the error of .04mm is not relevant. This has been proved by cutting metric threads and checking against a thread gauge. I was fortunate in finding a 10tpi Acme tap at Tracy tools, and I used this to cut the thread in the brass clasp nut.

Cutting this long slender leadscrew with a relatively coarse thread obviously needed some support so I bodged up a travelling steady for the Hardinge supporting the leadscrew in a brass bearing, **photos 14** and **15.** This worked a treat; the only problem was removing the burr before repeating the cut. The leadscrew and clasp nut fitted well.

I milled the clasp nut with Vees and separated the two halves with a thin slitting saw. The clasp nuts run in adjustable dovetail slides, and the actuation by the cam lever is smooth, **photos 16, 17** and **18.** Fitting the mechanism was quite difficult, as there was very little available space.

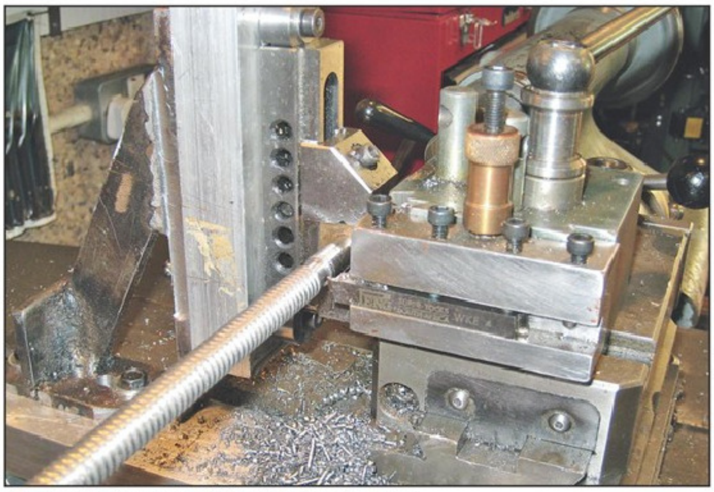


Photo 14. Screwcutting the leadscrew.

Photo 15. The leadscrew is quite a long component.

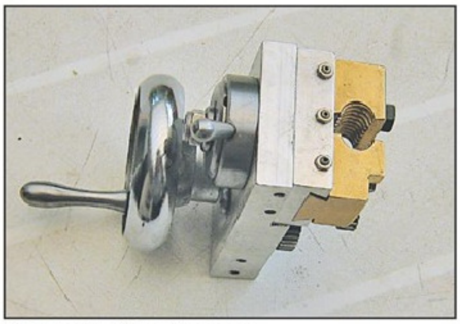


Photo 16. The clasp nut.

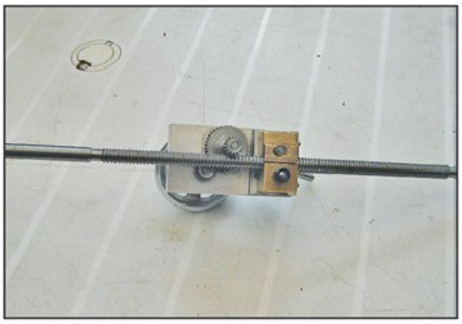


Photo 17. The rear of the apron.

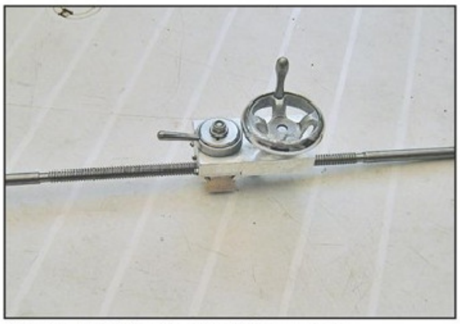


Photo 18. The front of the apron.

Screwcutting gears

Because of the small centre height, there is limited space for changewheels. I have a large selection of Myford gears, which I use on the Hardinge, but these were too big to fit in the available space. I then made the only original design decision on this little lathe - I made a tumbler-gear system placing this on the right-hand side of the 'wall' supporting the changewheels. This made a stub 'leadscrew' below and in front of the leadscrew, and gained a precious few inches, thus enabling me to use the available Myford quadrant and changewheels, **photos 19** and **20**.

Leadscrew variable speed drive

Using the Hardinge had quickly converted me to the joy of being able to vary the sliding speed whilst actually cutting. I rigged up a system at the tailstock end of the lathe, where a car wiper motor mounted on a shelf below the lathe drives a countershaft. This in turn drives a pulley at the left hand end of the leadscrew. The drive is by two PolyVee belts and speed-reducing pulleys. The wiper motor is controlled by a Proxxon variable-speed power supply from Chronos. This arrangement delivers a very fine turned finish, **photo 21**.

Tailstock

I wish to use the tailstock for delicate drilling operations using tiny drills. The conventional screw and hand wheel is too coarse. I think that a lever operated apparatus looks clumsy so I finally decided on a rack and pinion, controlled by a three spoked capstan. I designed a tailstock lock using two clamps curved to fit the barrel - a very secure method, without any barrel distortion.

I started with a 3in. x 3in. x 4in. lump of cast iron. Once again, I milled it to as perfect a cube as possible. I then milled the dovetails to fit the bed, and made the gib and screws. I made a lock, using the idea of a coarse threaded bolt, tapped to accept a stud with a finer thread. This double-threaded idea reduces the travel of the lever.

I then mounted the embryo tailstock on the bed, and spotted the face with a centre drill held in a collet in the headstock. This gave an accurate reference point for drilling the tailstock without any measuring and marking out. Once again, as with the headstock, I mounted it on the horizontal milling machine (so useful for this type of job!) and drilled straight through. I made another smaller boring bar and carefully bored it to size on the milling machine. If you refer to **photo 6** (for boring the headstock), you will get the idea.

Barrel

The 20mm barrel was turned from silver steel, drilled right through 10mm and bored and reamed to No 1 Morse taper. I held the barrel in a vice on the horizontal

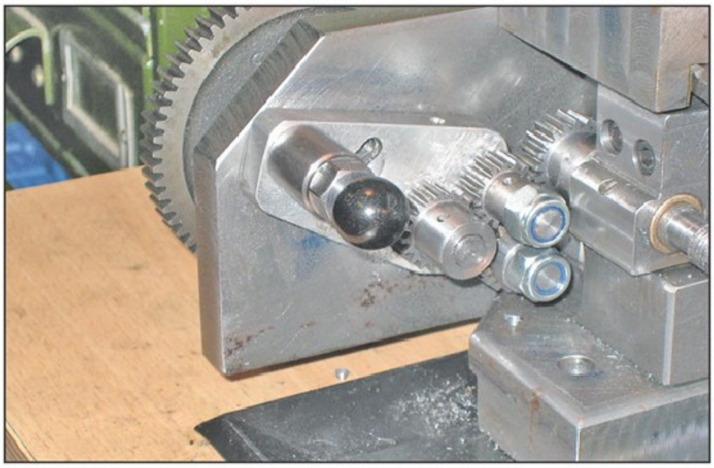


Photo 19. The tumbler gear system.

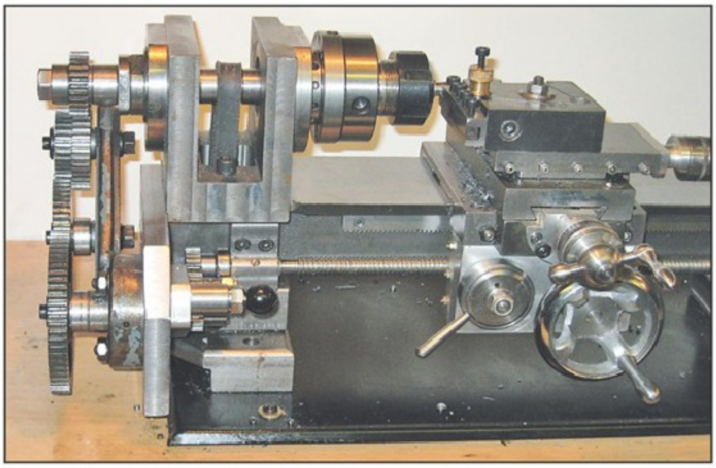


Photo 20. The Myford quadrant in use.

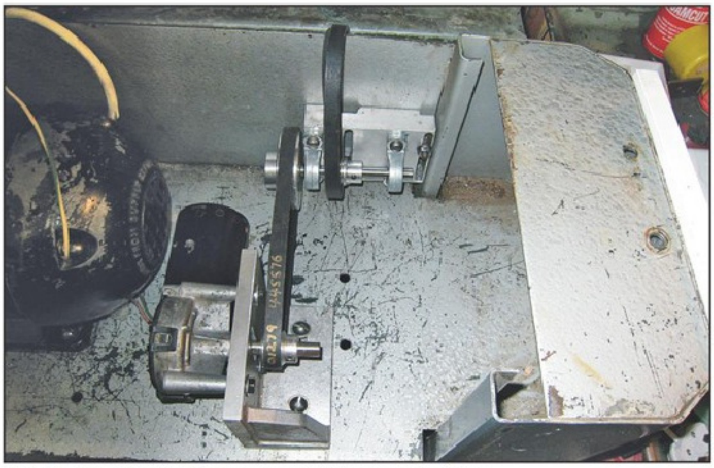


Photo 21. The leadscrew variable speed drive.

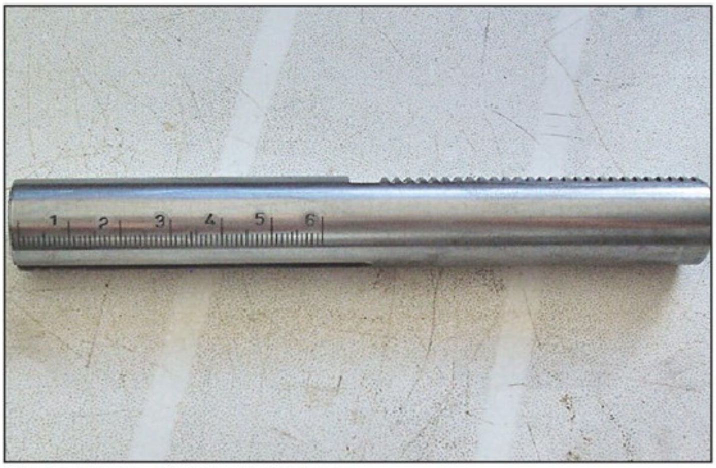


Photo 22. The finished tailstock.

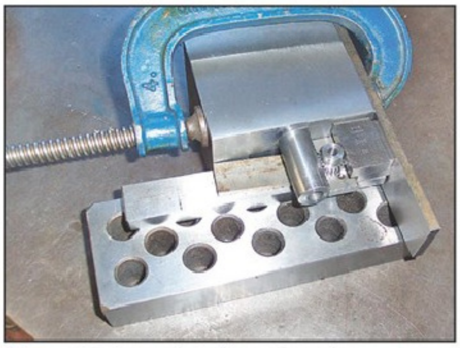


Photo 23. Locating the tailstock pinion position.

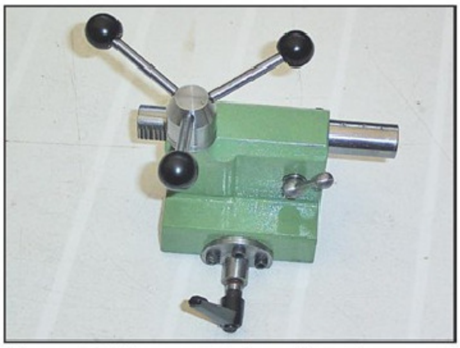


Photo 24. The rear of the tailstock.

Photo 25. The front of the tailstock.

milling machine and cut the rack, moving from tooth to tooth using the Y-axis micrometer. I then used a tiny slitting saw to engrave the millimetre scale. The finished barrel is shown in **photo 22**.

As an aside, my old horizontal milling machine, (not very popular in these days of 'Mill Drills') has proved invaluable. It is easy to do operations which are almost impossible on the vertical machine. I have a homemade vice with moveable jaws bolted directly into the tee-slot nuts, **photo 6** and this creates a quick method of squaring off the ends of bars. I even held the complete little lathe on the bed, between these jaws, to drill the holes on the left-hand end of the lathe, for the bolts to secure the 'wall' holding the changewheel quadrant!

Locating the pinion position

This gave me much food for thought, as if I got it wrong, it would mean scrapping the tailstock. I finally made a lash-up as shown in **photo 23**. I immobilised the barrel and clamped a parallel against the side of the tailstock. I engaged the pinion into the rack and measured the distance to the edge of the tailstock using slip gauges. Once I had this dimension, it was easy to mark it out, using a vernier height gauge. To my great relief, the rack and pinion meshes perfectly, phew! I used a similar method to locate the hole for the barrel lock.

Shaping up the tailstock

Once all of the drilling, reaming etc had been completed, I no longer needed the reference points of the accurate cube and was able to attack the arduous tasks of reducing the lump to the final shape. One design problem was cutting the tailstock away to accommodate the top-slide, without affecting the strength of the whole.

My trusty power hacksaw removed quite a bit of this excess metal, and then it was a case of slowly chewing it to shape, using end mills.

It will be noted that I have made no provision for adjusting the tailstock sideways for taper-cutting, **photos 24** and **25**. The small size made this difficult, and I am not keen on moving the tailstock, once it is dead accurate. During next year, I plan to make a series of attachments for the lathe, including a taper turning device.

Finishing the lathe

I was puzzled how to construct the changewheel cover, and various kind friends suggested a variety of methods. I finally followed the advice of Tony Griffiths, and made a cardboard model of the cover. I am useless at sheet-metal work and so took I my model to a friendly local metal-basher (aka; sheet metal fabricator) who produced an elegant copy of my pattern in sheet steel. This is such a large object, which can make or break the appearance of the lathe. I secured the cover in the closed position, using a cupboard-door magnet, **photo 26**.

Having encased the headstock in sheet metal, the little lathe was complete, except for my most feared operation - painting the beast! I toyed with the idea of having it professionally painted, but finally decided on painting it by hand.

The local Dulux supplier matched the green colour of my VMC milling machine, and supplied me with some metal primer. I bought two top-quality paint brushes, and gritted my teeth and started the operation. I tend to paint everything (including myself), so I spread out copious supplies of newspapers. I degreased everything, and applied the primer. Then, three coats of green enamel. What a transformation!

It certainly is not 'locomotive show' quality, but I think will suffice for a working lathe.

Conclusion

This has been a very satisfying experience during which I learned a lot. I am pleased with the final appearance and delighted with the performance, both of turning and screwcutting. It kept me out of mischief for about three years, and upon completion, presented me with a compact, accurate and unique little lathe.

Back gear

During my trial cuts, I have found that the lathe works perfectly, except when making heavy cuts or cutting coarser threads, when it loses torque at the lowest speeds. This is no great problem as I have the Hardinge for heavier work. I did not design this as a backgeared lathe, partly because of the constraints of space, but mainly because of gears in the drive to the mandrel tend to affect the turning finish.

I have mocked-up a free-standing 'back-gear' in wood, and in due course, I will make this, mounted on the bench behind the lathe. I will use a PolyVee belt to drive from the motor to the reduction gears and the existing PolyVee belt from the reduction gears to the mandrel. This will be a quick change-over and will avoid including gears directly in the drive to the mandrel.

Taper turning attachment

I have milled a tee-slot along the length of the back of the bed to accommodate a future taper-turning attachment. To use this, I will withdraw the cross-slide leadscrew and use the top-slide set at ninety degrees.

Steadies

I bought a fixed steady on 'special offer' from Arc Euro Trade (this is an accessory for their smallest lathe). I will adapt this to fit my lathe and will make a travelling steady.

Saddle stop

I plan to make a micrometer saddle-stop to fit out of the way, permanently under the chuck position.

Filing rest

I plan one of these for use together with the simple indexing arrangement on the mandrel. This will provide a quick method of making such things as one-off hexagon nuts.

No doubt other attachments will suggest themselves during the lifetime of my little lathe. ■

Suppliers

www.lathes.co.uk
www.collegeengineering.co.uk
www.arceurotrade.co.uk
www.warco.co.uk
www.peatol.com
www.alldrives.com
www.machine-dro.co.uk
www.chronos.ltd.uk
www.hpcgears.co.uk
www.tracytools.com

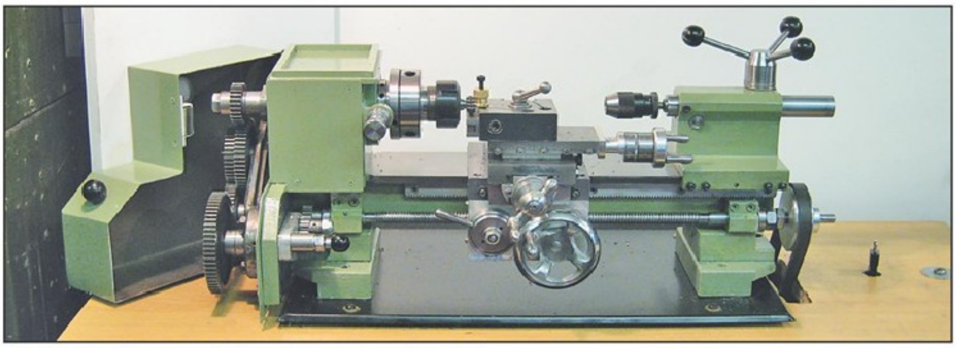


Photo 26. The guard showing magnetic catch.

LIVING WITH THE STENT TOOL AND CUTTER GRINDER 2

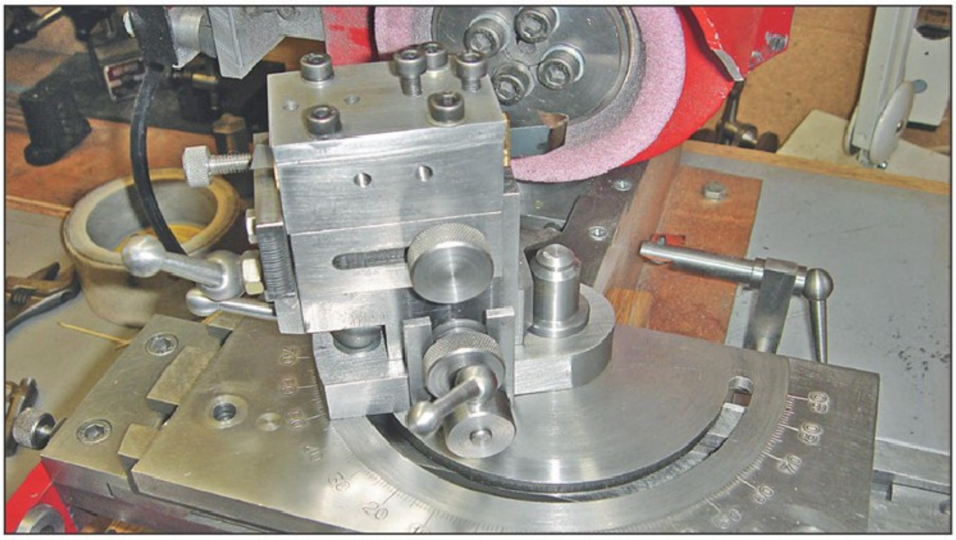


Photo 11. The lathe tool grinding fixture.

Charles Woodward shows us how to use this versatile machine

Since exhibiting the machine I have modified the lathe tool grinding fixture, **photo 11** so that it will grind radii. I will describe this in the next article. I also made a simple adaptor for grinding turning tools which fits into the universal head, **photo 12** and **Fig. 8**.

Another recent addition shown in **photo 13** and **Fig. 9** is an adaptor for grinding along the flutes of small tools. This unit slides in the bore of the universal head.

All the attachments with the exception of the lathe tool grinding fixture are stored in the drawers below the machine, **photo 14**.

Grinding straight shank drills 2mm to 13mm

Before writing this section I had a look in the back issues of MEW. There have been quite a lot of articles on this subject, some more technical than others. The Clarkson tool and cutter grinder manual I have has nothing on grinding drills, (the Stent is based on the Clarkson) however, drills can be ground on the Stent to the four facet format. This format is also covered in Prof Chaddocks book on the Quorn but I don't intend to go over this ground again. The best reference I can find to the discussion of drill grinding is Harold Hall's recent articles in issue 141 and 142 of MEW, so I will give you the method I have been using on the Stent.

To divert slightly before I give the method, and try to answer a question Harold raised in issue 141 about the point angle of drills, the various handbooks I

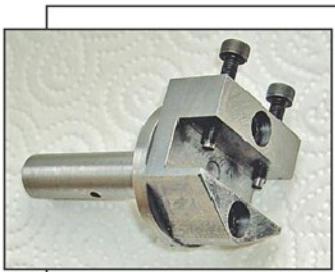


Photo 12. The tool grinding adaptor.

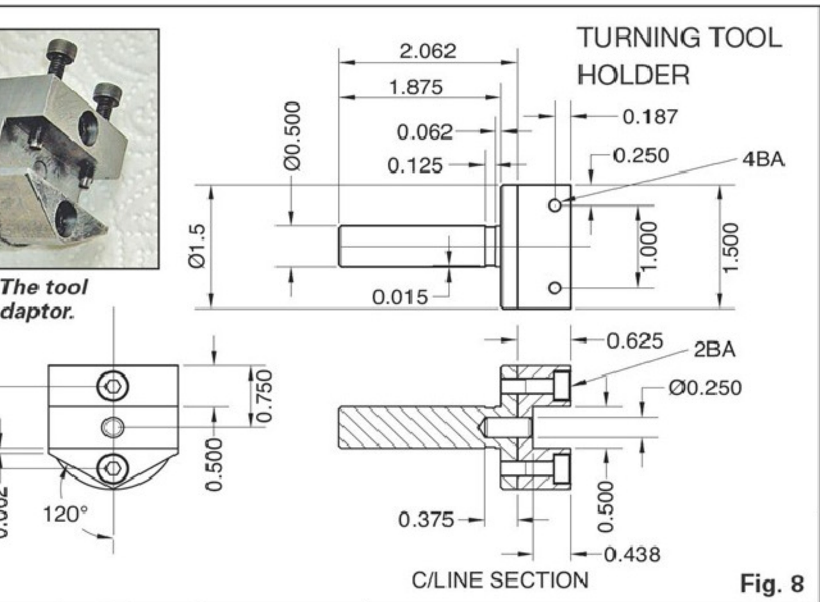


Fig. 8

Photo 13. Flute grinding adaptor.

Photo 14. The storage drawers.

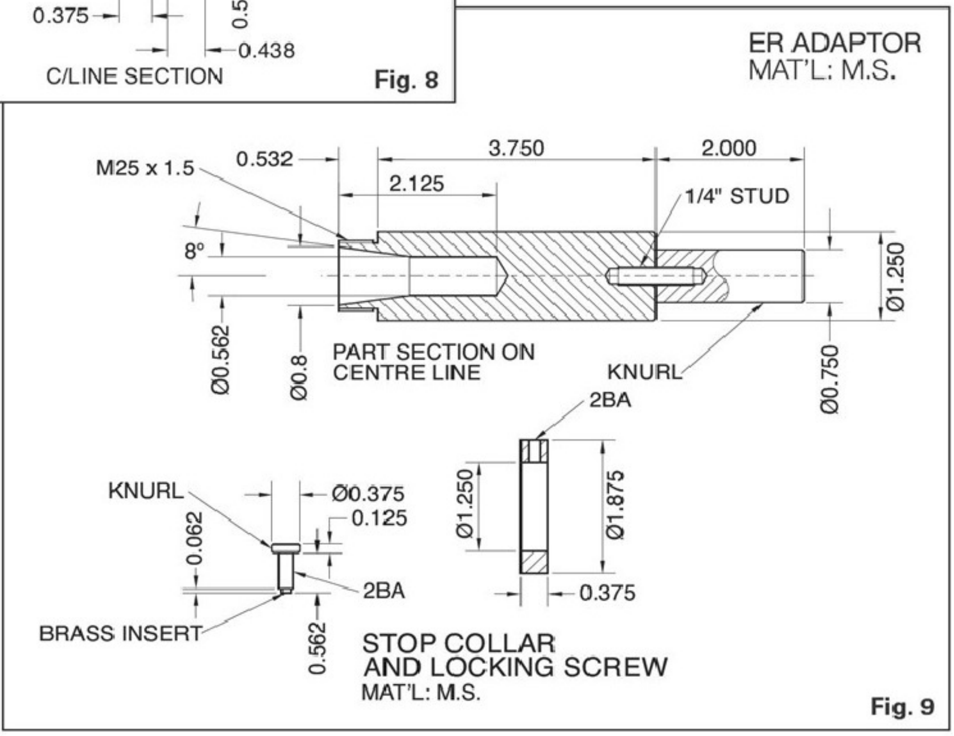
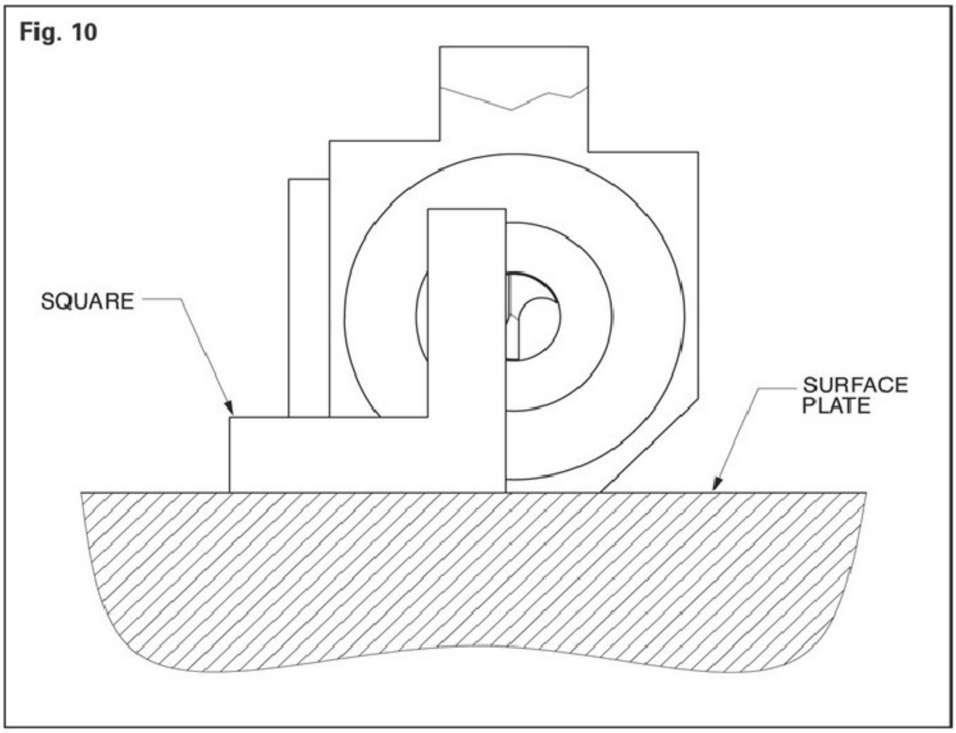


Fig. 9



have from Presto, Dormer and SKF, suggest the following point angle modifications. Acute point angles down to 60deg. are recommended for drilling brittle materials, such as Bakelite (I shouldn't think there is much of this around nowadays) to reduce the tendency to flake away on the underside when breaking through. A flatter point angle up to 140deg. can be an advantage when drilling high tensile and work hardening materials. It also helps when drilling thin materials as it enables the full diameter of the drill to cut before the point breaks through. When I was working at a company that machined a lot of Titanium we used drills with a double point angle. Titanium, as anyone who has machined it is aware, is tough to machine, work hardens very easily, and is difficult to break into chips (the swarf is also highly inflammable and difficult to extinguish). The double point angle gave an obtuse angle to the nose for strength, and to help prevent the drill splitting (the point was thinned). The larger than normal angle on the outside of the drill increased the material in the outer corner of the drill which helped to conduct heat away from the corner of the drill and reduce the chances of it burning out. The double angle also had the effect of breaking the swarf into two streams and reducing the crowding in the flutes.

Back to grinding conventional drills, remove the universal head from its bracket and assemble the appropriate collet and the collet nut into the ER collet holder. Put the drill into the collet and tighten the collet nut. I find the easiest way to do this is to hold the ER holder in the vise in soft jaws. Assemble into the universal head, fit the adaptor nut and screw down the plunger to locate in an indexing hole. Slacken the grub screw in the indexing ring and rotate the adaptor until the cutting edges are straight. One way of doing this is to put the universal head onto a surface plate and set both edges vertically using a set square, **Fig. 10**. This is fairly easy with a large drill but becomes increasingly more difficult with smaller drills. An alternative method is to set a stop for the cutting edge centre height. I fitted a bar onto the side of the universal head bracket, the idea being that the outer edges of drills etc, could be set to the underside of the bar. This worked well enough for slot drills as they are made to cut to centre, but because drills have a core and chisel point a tapering land resulted when set this way. Overall I find it easiest to line the edges of the cutting tools up by eye with the universal head held in the vise (in soft jaws of course). When grinding the end teeth of milling cutters and drills it soon becomes obvious if the cutter is not lined up correctly. When examining the cutter, the ground lands are not parallel. Ensure the locating plunger is in one of the indexing holes slacken the grub screw in the indexing ring, twist the adaptor the appropriate amount and re-tighten.

Set the universal bracket to 59deg. on the Stent table. The bracket casting as supplied has a square base. I thought it too small to machine circular and mark with graduations. I could have put it on a circular plinth, but this would mean raising the height of the universal head but I thought this might lead to problems accessing the wheel (Derek Brookes designed an indexing jig MEW 16 & 17). I was pondering this problem when I was offered 45deg. and 30deg. precision steel set squares. This sparked an idea as if I fitted an adjustable fence to the front of the sub table, I could set the bracket with the squares against the fence. Using them in conjunction with the + /- 10deg. angle setting on the table I could set the universal head from 0deg. to 10deg. directly, 20deg. to 40deg. using the 30deg. angle, and 35deg. to 55deg. using the 45deg. angle, and the same range of angles from 90deg. The only angles I can't get are 10deg. to 20deg. and 80deg. to 70deg. I couldn't think of any rotary tools needing these angles and I could always use a protractor for setting the bracket if necessary.

After setting the bracket to 30deg. and the subtable to 0.5deg. (30- 0.5 = 29.5 x 4 = 118) **photos 15** and **16**, attach the head to the bracket and set to 10deg. Don't forget to index the drill through 90deg. to bring the flutes horizontal if you have set the tool with a set square. Grind the primary clearance, indexing the drill 180deg. between each pass. To grind the secondary clearance index the universal head to 20deg. and the horizontal 10deg. giving a total of 30deg. clearance, **photo**

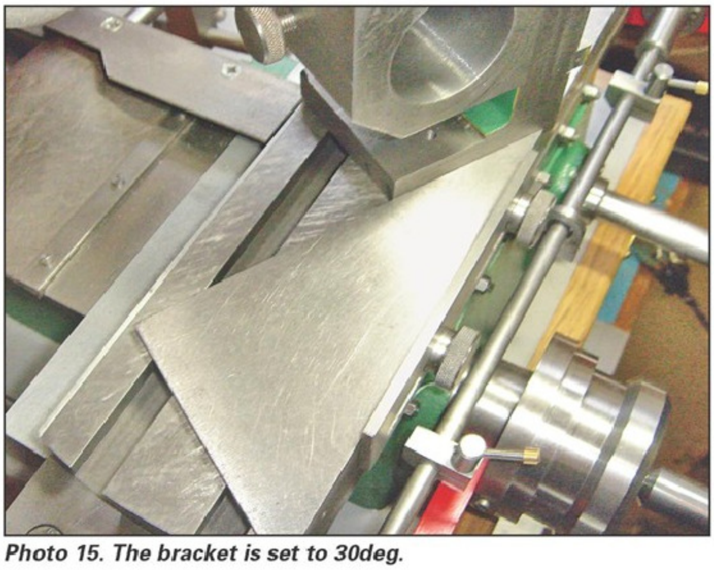


Photo 15. The bracket is set to 30deg.

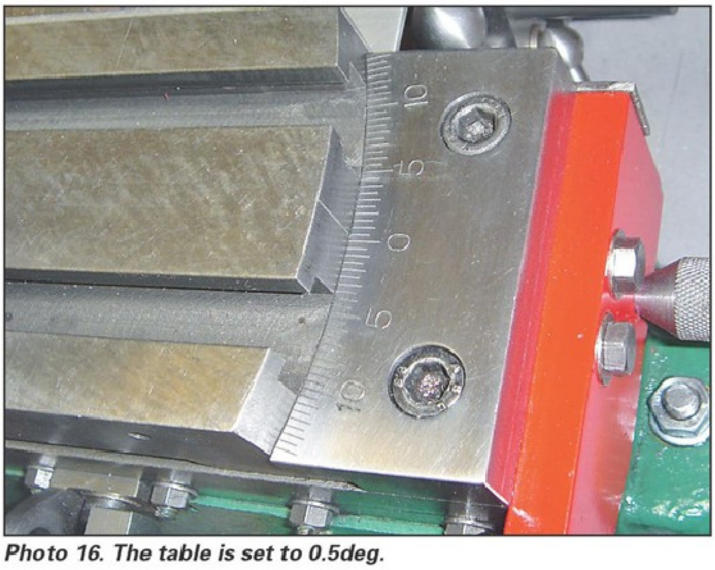


Photo 16. The table is set to 0.5deg.

Photo 17. The setup for drill grinding.

17. I find that this gives better access to the centre of the grinding wheel than indexing the universal head alone.

During recent tests I used the following angle data when drill grinding.

Drill dia	Primary angle	Secondary angle
5/64in. to 1/8in. (2-3mm)	25deg.	None used
9/64in. to 1/4in. (4 - 6mm)	15deg.	30deg.
17/64in. to 1/2in. (7mm - 13mm)	10deg.	25deg.

The above list covers the range of drills I can accommodate in my ER 20 collets (13mm 0.5" maximum) although larger drills can be held in the Morse taper holder. I very rarely use any drill over ½in, I bore anything over this size unless it is a long hole.

Grinding centre drills

Grind to 120 deg. point with 20 deg. clearance set as 15deg. on the universal head and 5deg. on the wheelhead. I don't think its worthwhile grinding the point to 59 deg.

Point thinning

This requires the universal head modifying by drilling a ¼in. dia hole as indicated in **Fig. 11.** If you contemplate making the same modification, drill carefully as the distance between the bore and outside face is 5/16in. I used this hole in conjunction with a long spacer and used a fixing bolt from the tailstock to bolt the universal head directly onto the table at 30deg. (the spiral angle of a standard drill), using my 30deg. set square to set the head. Using a standard 100mm dia taper cup wheel, I lined the edge of the grinding wheel to the centre of the drill and ground along the flutes to thin the point, grinding evenly both sides of the drill, **photos 18** and **19.** There is no hard and fast information on the operation. **Fig. 12** copied from the

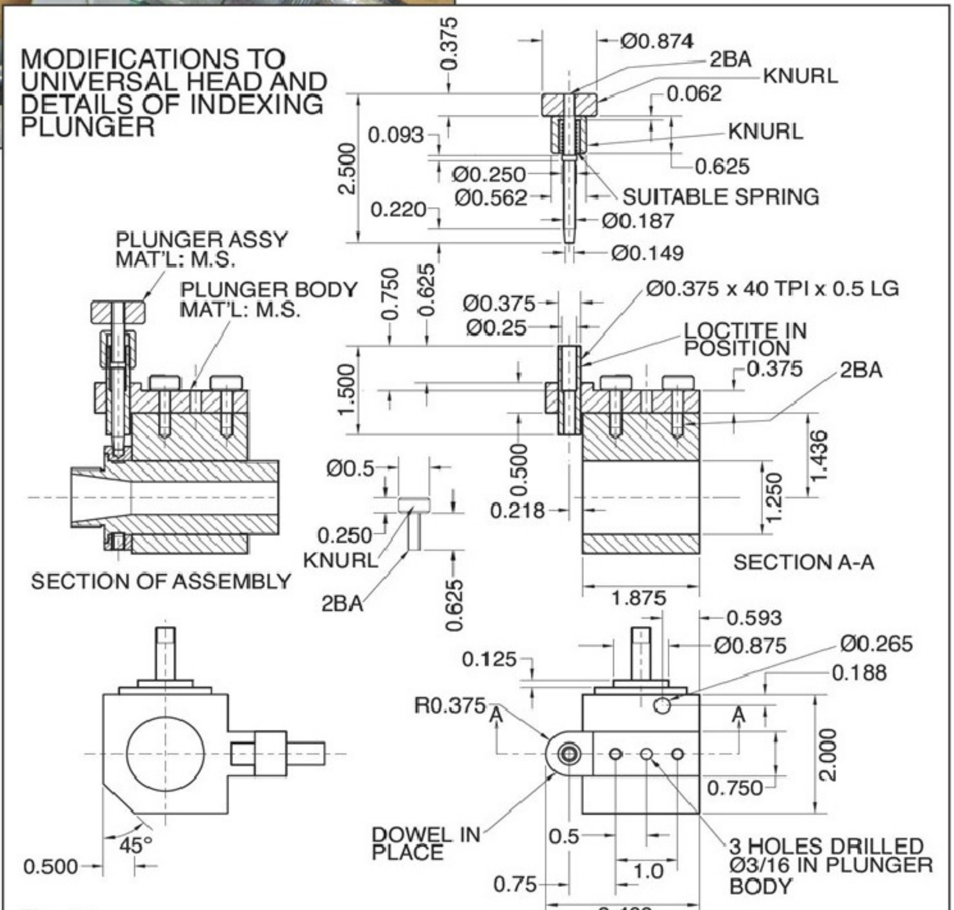


Fig. 11

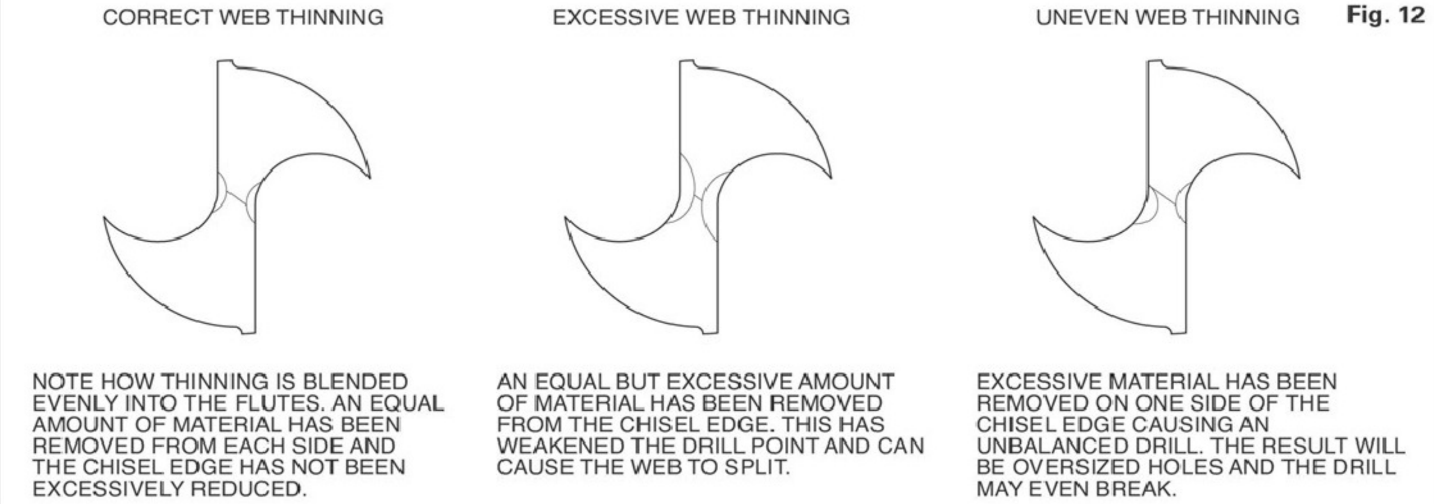


Fig. 12

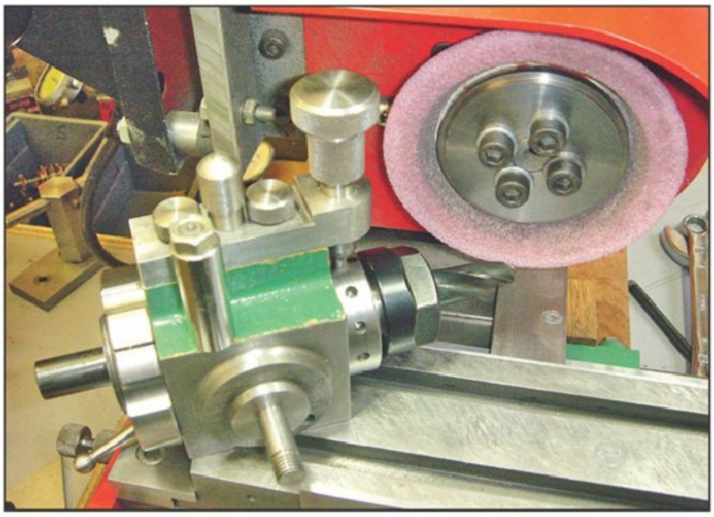


Photo 18. Thinning the drill point.

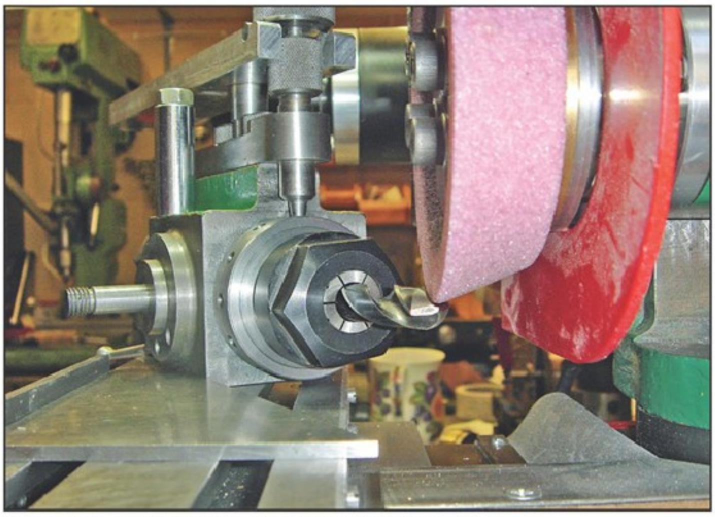


Photo 19. Another view of drill point thinning.

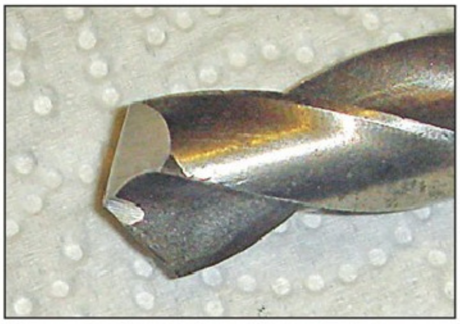


Photo 20. A view of a thinned point.

Dormer catalogue shows the kind of thing required, **photos 20** and **21** shows the result I obtained.

Grinding the end teeth of slot drills and end mills

Set the universal head and bracket on the table to 90deg. with the bore of the head facing toward the cupped grinding wheel. Put the parallel holder into the head with the appropriate bush and set the cutting edges as for the drills. Set the primary clearance on 2 and 3 flute centre cutting slot drills to 8deg. - 11deg. For four flute end mills non centre cutting, the clearance is 5deg. - 8deg. I used a secondary clearance of 15deg. Set the sub table to give 0.5deg. - 1deg. concavity. Note that on two and three flute slot drills one tooth will extend over centre. The adaptor

Photo 21. End view of a thinned point.

normally used for this is the parallel holder and bushes mentioned above. The reason I use the parallel holder and not the ER collets, is because with the locating piece fitted to the adaptor I can easily remove the cutters and accurately replace them if further grinding is required. One of the disadvantages with developing machines "on the hoof", is you make things and then think of better ways of doing it. If I had bought the ER collets first I probably wouldn't have made the parallel adaptors, they can only be used for grinding the end faces; the cutter run out using bushes is too great to enable the cutters to be ground along the flutes. The disadvantage with using the collet holder is the cost of the collets, and the universal head must be removed from the bracket for close inspection of the cutter, although this is not a big job, with only the universal head to be unclamped and reset.

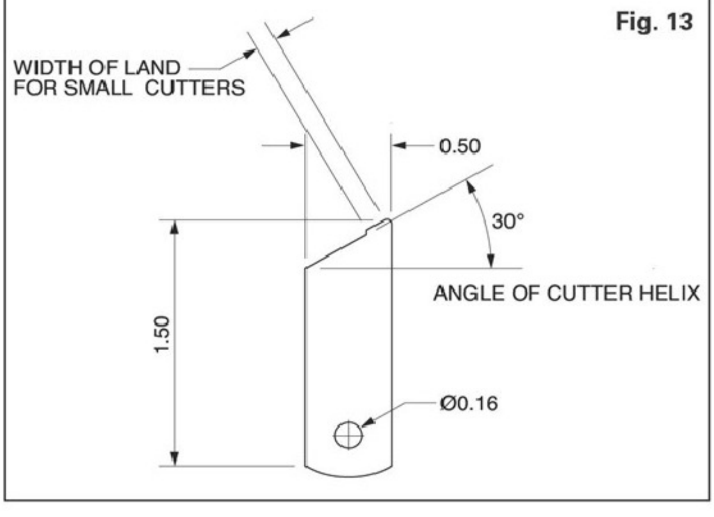
Grinding along the flutes

Grinding the end teeth is relatively easy, grinding along the flutes is somewhat trickier, especially with smaller cutters. Large cutters are easy; I have ground a 100mm diameter slab mill between centres and grinding 12mm end mills and slot drills isn't hard. However, as the cutter gets smaller it becomes more difficult to follow the support finger. Also the grinding wheel must be moved away from the cutter for the return stroke. As I use a dial indicator to indicate the position of the horizontal slide (the grinding wheel infeed), it is easy to zero the indicator for each grinding pass and then back off the wheel for the return stroke. An alternative approach is to use some form of rocking holder. Such a holder is shown in Graham Howes web page. www.homepages.mcb.net/howe/WorkshopTools.htm

Setup

The cutter must be held in the collet adaptor which is free to rotate in the universal head. The support blade should be ground

Fig. 13



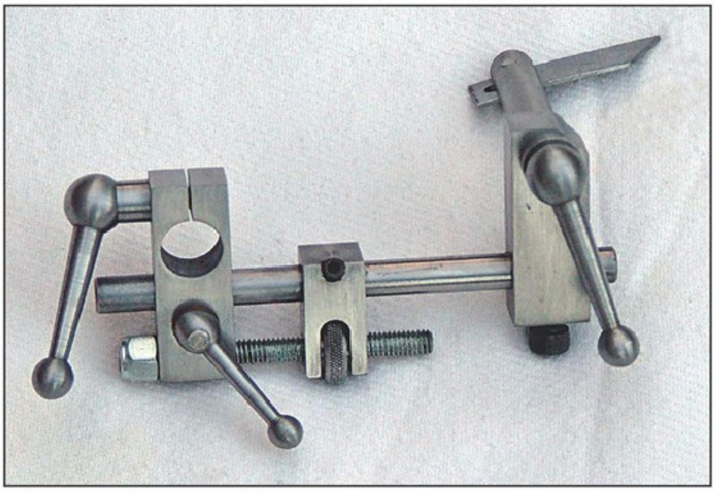


Photo 22. The support finger.

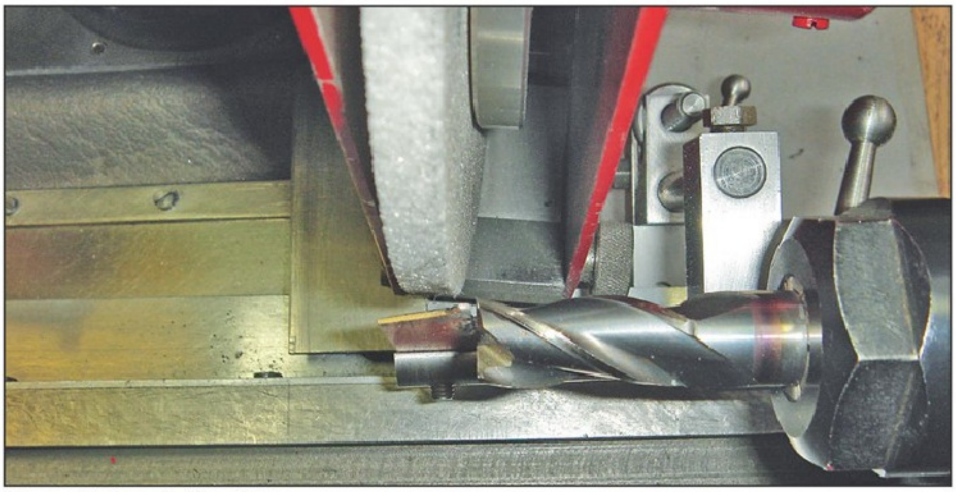


Photo 23. Regrinding flutes.

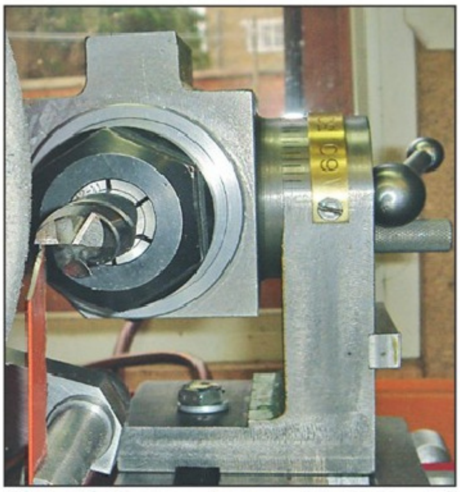


Photo 24. Cutting edges must be horizontal.

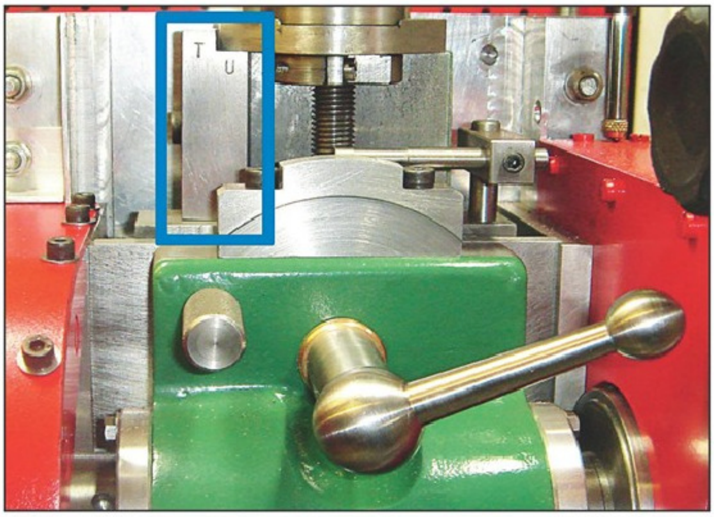


Photo 25. The zero setting line.

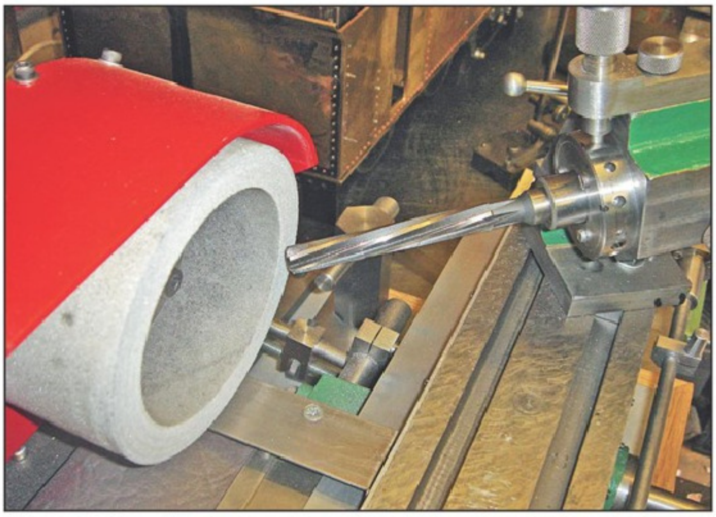


Photo 26.Grinding a ream.

as shown, **Fig. 13** shows the kind of thing required. For large cutters the support can be the full width of the blade, but must be cut down as shown for smaller cutters. The support finger I use is shown in **photo 22**. My previous article showed the support finger in use when grinding a large slab mill. For this operation it is necessary to remove the indexing plunger from the universal head. The ½in. chamfer I machined on the universal head is to provide clearance for the support finger. I use the plain wheel for grinding along the flutes and this should be angled to about 5deg. so that the wheel cuts on the corner, **photo 23**. When setting the support height, it should be set so that the end cutting edges are horizontal when the cutter contacts the wheel, **photo 24**. When using the plain wheel it is necessary to know the height of the wheel above the height of the cutter, to obtain the correct clearance. I use the block shown in **photo 25** to set the wheel to centre; zero the upper dial indicator and use this to set the wheel above centre according to **table 1**, taken from the Clarkson handbook, to obtain the required clearance angle.

For grinding smaller cutters I use the adaptor shown in **photo 13**. The adaptor fits in the universal head and the table is held stationary by bringing the table stops together. The adaptor is slid through the bore of the universal head; it must be a good smooth fit with minimal shake. (A commercial unit for industrial machines is available which uses an air bearing). When using this adaptor I fit the stop collar to give the length of grind and start grinding at the highest point of the cutting edge (nearest the shank), and draw the cutter across the wheel against the support, I find this gives a better result with smaller cutters below 8mm than moving the table and trying to rotate the cutter at the same time.

Cutters with chipped corners

Occasionally, the corners of end mills or slot drills are chipped. One way to gain useful extra life from them without grinding too much from the end teeth is to grind a chamfer on the corner to remove the chip or excess wear. When doing this I set the universal head to 45deg. on

RELIEFS AND CLEARANCE FOR SPIRAL FLUTE CUTTERS FOR 150mm DIAMETER GRINDING WHEEL			**Table 1**
Primary Clearance		Secondary Clearance	
Height of wheel centre above centre of cutter	Dia of cutter	Height of wheel centre above centre of cutter	
20.6	3 to 5	41.3	Metric
0.813	0.125 to 0.187	1.625	Imperial
15.9	6 to 12	30.2	Metric
0.625	0.25 to 0.5	1.188	Imperial
12.7	14 to 16	27	Metric
0.5	0.562 to 0.625	1.063	Imperial
11.1	19	23.8	Metric
0.438	0.75	0.938	Imperial
9.5	20 to 25	23.8	Metric
0.375	0.75 to 1.0	0.938	Imperial
7.9	28 to 100	19.1	Metric
0.313	1.0 to 4.0	0.75	Imperial

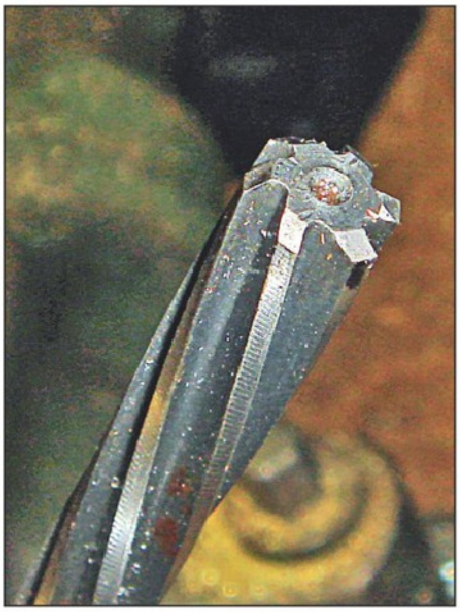


Photo 27. The ground end of a ream.

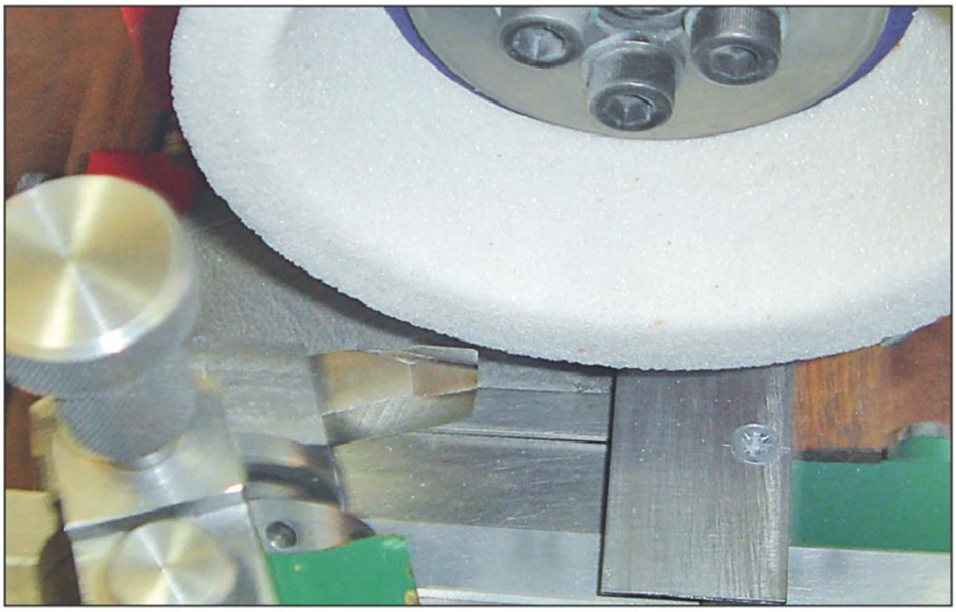


Photo 28. Grinding a turning tool chip breaker.

the table, grind the primary clearance to 10deg. and secondary clearance to 20deg. setting 15deg. on the universal head and 5deg. on the wheelhead.

Grinding reamers

Taper shank reamers can be ground in the Morse taper adaptor, **photo 6** (MEW issue 154). The universal bracket is set to 45deg. on the table and the universal head set to decline 10deg. -15deg. **photo 26**. Engage the plunger in a hole on the indexing ring and release the grub screw. Set the reamer cutting edges horizontal and tighten the grub screw. The ground reamer is shown in **photo 27**. The rings I made all have 12 holes. Looking through my collection of reamers, those up the ½in. diameter have 6 flutes, reamers 5/8in. diameter and above have 8 flutes. When these are to be ground, a new indexing ring will be required, or alternatively, a stop for the flutes rigged up on the table.

Note that machine reamers are only ground on the lead angle, I have very few hand reamers and so have not attempted to grind these. The largest machine reamer I have is 16mm which could easily be ground in the Morse taper adaptor.

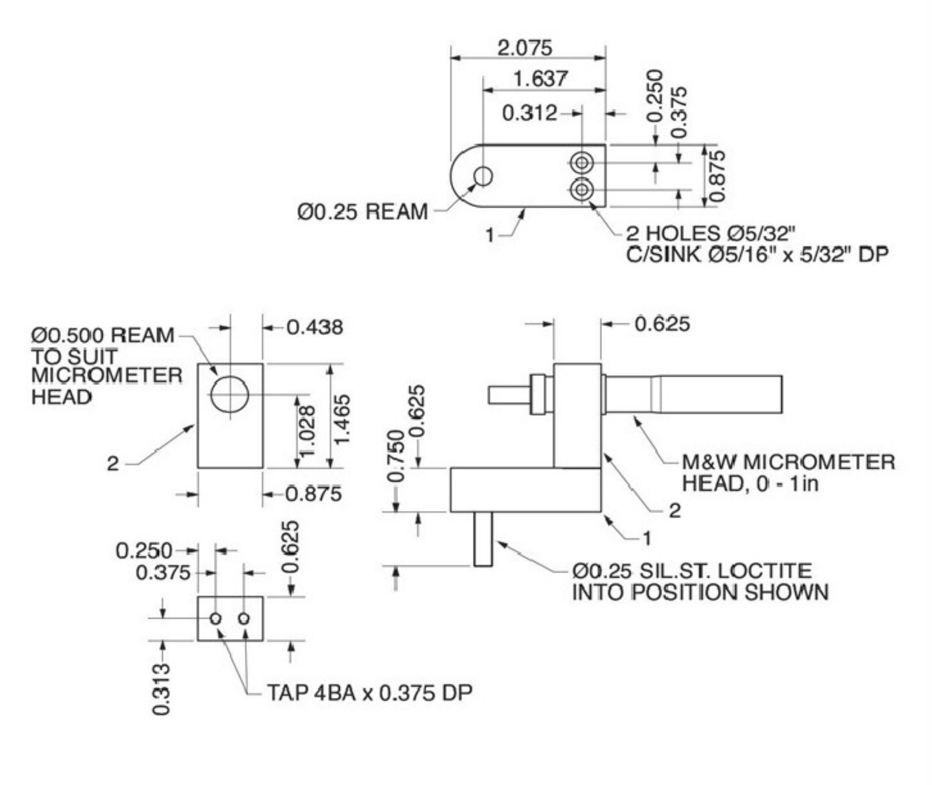
Grinding single point square tools (lathe, shaper, etc)

As I stated earlier, I have modified this fixture in order to grind radii. This modification involved making a new swivel base and support block to create sideways adjustment for the tool blank in order to set the tool to the correct position for forming a radius. I have also added fine sideways adjustment in order to accurately grind a full form radius on the end of a grooving tool. In use the blanking plug is removed from the pivot and a setting rod is positioned in the pivot. The flat on the setting rod indicates the pivot point on the fixture. The tool holder is pulled back against the screw plate, and the tool clamped into the fixture with the nose of the tool against the setting rod and the tool centred using the engraved line. The setting rod is removed, the support block clamped, and the radius set by putting a suitable sized packing piece behind the toolholder (I use drills). When using this method I did not find it accurate enough to centre the radius on an existing radiused grooving tool so I made a setting gauge, **Fig. 14** based on a micrometer head which gave much more satisfactory results. I added a positioning screw to the screwplate in order to obtain accurate adjustment to the setting gauge. I also added the side adjustment for accurate centring. If you are just grinding simple lathe tools, then the setting gauge and adjustment are not required. I made the setting gauge fine adjustment etc. for completeness. I dislike doing a job without covering all bases.

When grinding square tools such as grooving tools the tools are set to 90deg. on the fixture and the clearance angle obtained by setting the sub table to the required angle. Note: if grinding both sides of a grooving tool it will be necessary to grind on the RH and LH side of the cup wheel, it may be necessary to reposition the fixture along the table in order to grind both sides of the tool.

If your requirements are just grinding simple lathe tools then the adaptor shown in **photo 12** is all that is required. This adaptor can also be used to grind chipbreaker grooves in the turning tools, **photo 28**. Note that in this case the universal head is bolted directly onto the table as was the case for point thinning.

Fig. 14



To be continued...

MAKING A PINSTRIPING TOOL

Dave Fenner thinks about lining and pinstriping

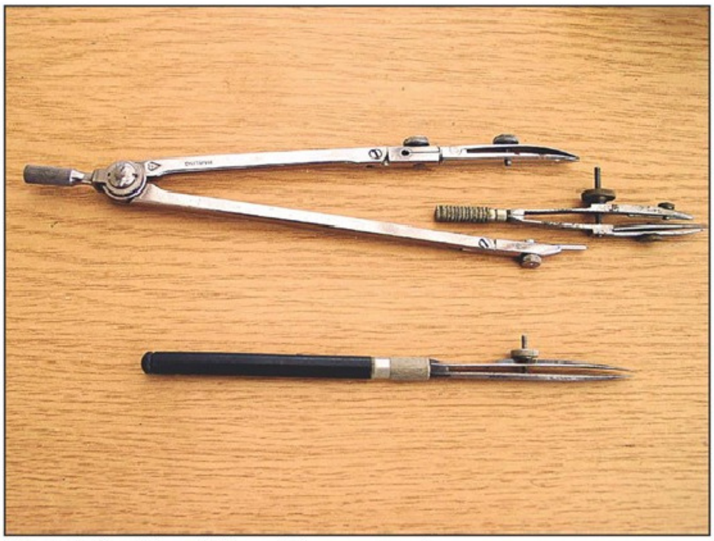


Photo 1. Traditional draughting pen and compasses will handle paint as well as ink.

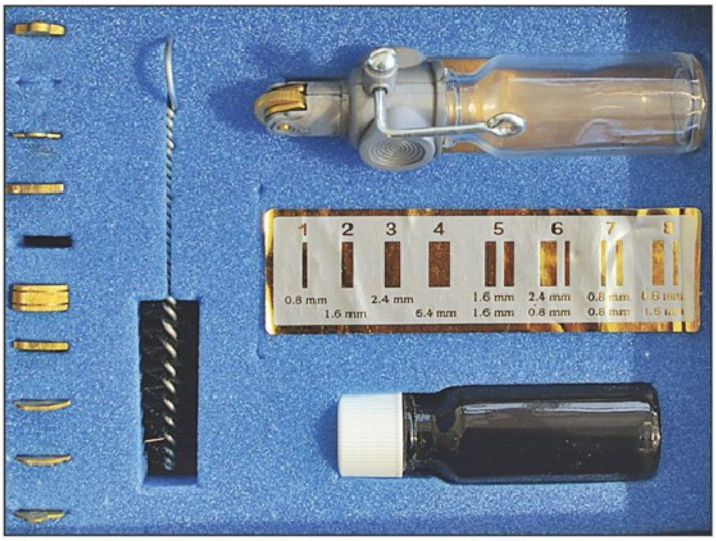


Photo 2. StripeMaster kit includes wheels of different widths.

Photo 3. By no means perfect, but the lines do add to the appearance.

Photo 4. Selection of brushes for pinstriping.

From the outset, it must be stated that I make no claim to skills in these processes which really only come after much research, experiment and most of all practice. Hence the purpose of this article is to acquaint the reader with a number of tools and techniques and offer a design for a home brewed wheel lining tool. Lining is something which I have encountered on a handful of occasions over many years, applied to cars, motorcycles and models. Several techniques have been employed, which, by and large, have yielded acceptable results. If you are after an "exhibition finish", then you either need to spend a good deal of time developing your technique, or bring in an expert. For further reading, I recommend two sources of invaluable advice and guidance on the subject, Chris Vine's excellent book "How (not) to paint a locomotive" **Ref. 1** and the mini bible by Robert Shephard, "The Finishing Touch" **Ref. 2.**

Nowadays, coach lining on cars is usually applied by means of appropriately coloured tapes of the correct width or combination of widths. After respraying an MG midget in 1972 we looked at the car and decided that a gold coach line would improve the appearance. Our makeshift solution was to apply two parallel lines of masking tape spaced about 8mm apart, then brush paint along the gap between them. Not long after that we discovered body lining tape. Also around that time, involvement with a competition Mini, meant bringing in a professional signwriter who was able to give us perfect lettering and graphics using only brushes. I wonder how many of these skilled specialists are around today?

Involvement in model engineering created the need (around 1980) to apply lining to a 7¼ gauge Scot, and my hazy recollection is of various methods, certainly including a draughting pen, **photo 1** and I think, brushing between masks. The pen has also been used on 00 gauge locos. One tool rated highly by Chris Vine is the Bob Moore lining pen, where paint is applied via a hypodermic size tube.

More recently, after repainting the Rickman motorcycle, I wanted to add some lining to the petrol tank. At the model engineering shows I had often seen the Beugler pin striping tool being demonstrated but felt that the cost of one of these was hard to justify for a single project. Other cheaper wheel tools are also on the market, and one of these, the StripeMaster, **photo 2** was purchased. In his book, Chris Vine comments on unsatisfactory experience with a cheap wheel tool, when compared to a Beugler. Not having tried the Beugler, I cannot make a comparison, but with no

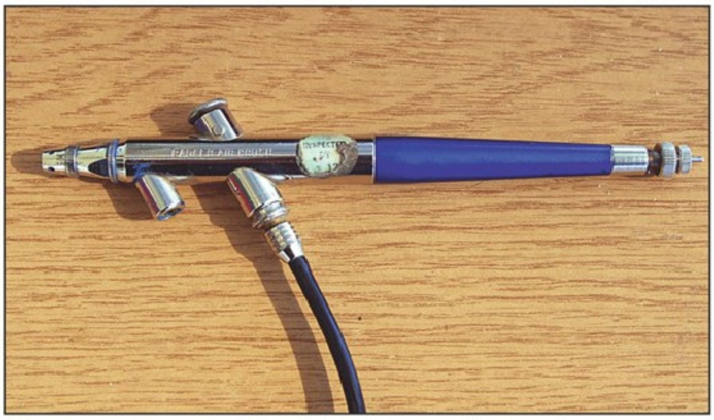


Photo 5. Badger 200 airbrush is a low to mid range device.

Photo 6. Conopois airbrush (no longer made) was considered a high quality item.

Photo 7. DeVilbiss spray gun large enough for vehicle respray work.

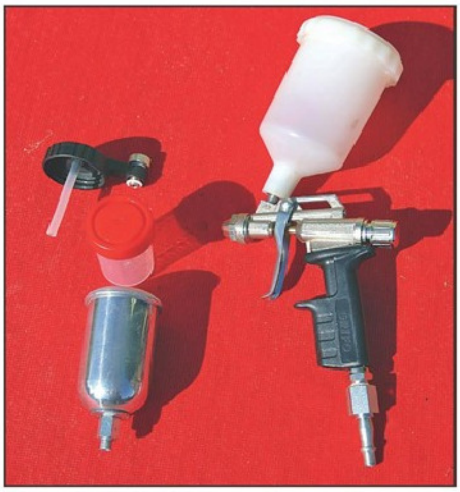


Photo 8. Grifo Minispray has various paint containers and is ideal for models and motorcycles.

significant practice, I did manage to line the tank with reasonable results, **photo 3**.

In the model scenario, we tend to think in terms of "lining" - painting thin lines as a small scale reproduction of what the professional locomotive painters applied to the full size version. In the automotive field, there is not only lining, but also more general customising artwork decoration using techniques such as airbrushing and pinstriping, where an individual artist's talents may come to the fore. Here the intent is not to recreate a replica of a historic design, but to embellish a vehicle with a unique artistic addition. Tools for such activities may be brushes, **photo 4**, airbrushes, **photos 5** and **6** and sprayguns, **photos 7** and **8**.

It is always interesting to discover that acquaintances have talents, hidden so to speak, under the proverbial bushel. One such is Pete Crawford, based just outside Perth, (www.celticcustom.co.uk) who I came to know as an expert on car repair and refinishing. Only when you dig a little deeper do you find that when time permits, Pete's real passion is for more artistic work. **Photos 9** and **10** show the "pop" rivets airbrushed onto the side of his van. Musicians also appreciate customised equipment and Pete was commissioned to apply a Wallace tartan finish to a drum kit for the band "Nazareth". Other commissions include guitars and the more to be expected cars, bikes, and helmets. The brushes shown in **photo 4** are a selection used by Pete for brush pinstriping.

Lining tools

Pens

The draughting pen and associated compasses would have been in regular drawing office use for ink work until the Rotring style of pen became available. The earlier type can equally be used to apply paint and will give a line of consistent width, the width being determined by adjustment of the blades. I found that good old fashioned Humbrol (oil based) could be used straight from the tin. The pen was loaded by stroking a paint filled brush across the inside of a blade, so that the outside blade surfaces remained clean. It is possible that some thinning might be required for very fine lines.

Brushes

Those shown in **photo 4** differ from the typical artists brush in that the handles are relatively short and the bristles long and very fine. The "fluffy" ones are those which have not yet been used. After use and cleaning, these brushes are oiled for storage using neatsfoot oil or similar. Using brushes for lining work really does require a level of skill I do not pretend to have.

Spray guns

These would not be used for striping, but for general background cover; two guns are shown in **photos 7** and **8**. The larger is a professional grade DeVilbiss, suitable for vehicle respray work, while the smaller is a budget product from Anglo Scot Abrasives, which is more suited to motorcycle and model finishing. It can be seen that the pro gun has two adjustments, one to control the amount of paint delivered, while the second varies the shape of the spray fan between a circle and an ellipse. The single adjustment on the Grifo gun controls paint flow. Here the spray pattern is fixed as circular, this being preferred for applications such as motorcycle frames. Currently the entry level Grifo costs just £24-99, and a dual control version is now available for just a few pounds more. Do not be fooled by the low price, these guns can deliver a quality finish.

As can be seen, several sizes of paint container are available for the Grifo, and having a selection can make colour changes easier and reduce paint wastage. It goes without saying that serious spray work requires a fair amount of air, which should be clean and dry. Hence a compressor has to be chosen whose size must be adequate for the spray gun, and the air should be passed through a filter regulator.

Airbrushes

Like the spray guns, the two airbrushes depicted are also representative of two levels of complexity. The Badger 200 is a single action bottom feed, internal mix device, where the elements of the specification indicate:

1) That the trigger action is effectively on or off, paint flow being set by the knurled collars.
2) That the paint is drawn up from below.
3) That the paint and air are mixed inside the airbrush.

In contrast, the older Conopois is dual action, side feed, and internal mix. The principal difference is that as the trigger is pressed further, so the flow of paint increases. Hence a skilled operator can produce a greater variety of effects with this tool. According to the leaflet, lines down to about 1.6mm are possible. For an

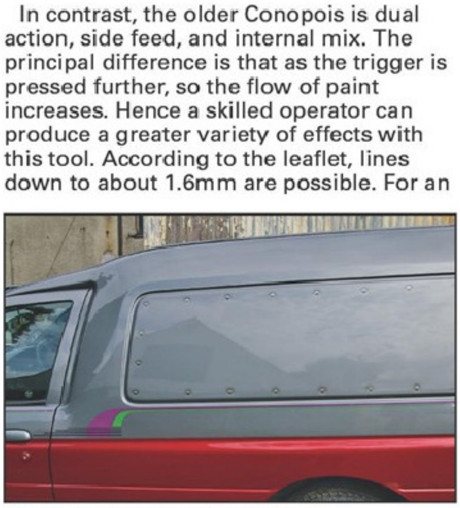


Photo 9. Pete Crawford's van.

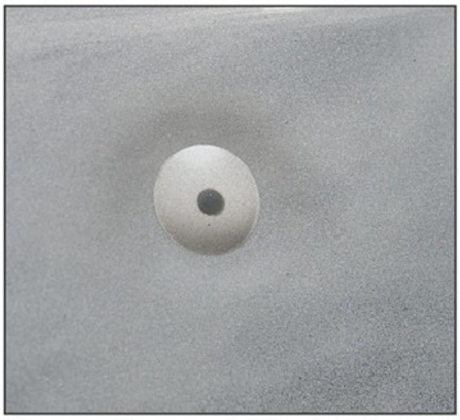


Photo 10. Close up of airbrushed rivet detail shows three dimensional effect.

Photo 11. Small compressor for airbrush.

Photo 12. Better quality compressor has small receiver and pressure cut off switch.

airbrush, the volume of air required is considerably less than for a spray gun, and for small jobs may even be supplied from a pressurised can (available from model and art shops). For the inventive hobbyist, it is possible to use a car spare tyre as a source, but a small compressor is a better option. **Photos 11** and **12** show a couple of types of compressor.

Wheel tools

The essential feature of these tools is a knurled wheel which projects into the paint reservoir. Paint is picked up in the serrations, carried around and then deposited on the work surface. The width of the line is determined by the thickness of the wheel and will normally be slightly wider than it. The Beugler tool has a detachable head and the entire head assembly is specific to the line width.

The StripeMaster shown in **photo 2** scores on price and also because it comes with a variety of wheels and spacers. Setting up the StripeMaster for a given line width involves selecting the wheel and then adding the requisite spacers to ensure that paint does not leak down past the wheel.

The origins of the Beugler striping tool are based very much on automotive applications in 1930's America, where, in Los Angeles, Mr S.B. Beugler had set up Beugler Auto Reconstruction. In 1933 he invented, then a couple of years later, patented the now famous tool which bears his name. Coming back to working on models, it occurred to me that the Beugler tool, while considered the "Rolls-Royce" of its type, was intended from the outset for 12in. to the foot applications, and it might be interesting to explore whether a smaller version might be made in house.

Photo 13. Home brewed wheel lining tool.

The result was the gadget shown in **photo 13** and described below. Being fairly slim, it can be held somewhat more like a pen. The total component count is just seven parts, three in the head and four on the paint reservoir sub-assembly.

Head

The starting point is the wheel and here I chanced upon some reject stainless steel components which featured a tightly toleranced straight knurl of 12mm diameter, which I was able to slice off at about 3mm thickness. I suggest you start with a piece of ½in. (12.7mm) diameter brass or aluminium bar and turn down to about 11.5mm diameter. Then apply a straight knurl and drill 3mm diameter. Face and part off to give the thickness you require. Aim for a knurled diameter of 12mm. The body, **Fig. 1** is a short piece of ⅝in. (16mm) square aluminium, faced to length, in which a ½in. diameter flat bottomed hole is cut with a slot drill. Next the hole for the spindle is drilled through 3mm diameter.

Now comes the tricky part. We aim to cut a slot just wide enough for the wheel and just deep enough so that it can be mounted on the axle and spin freely. My first thought was to use a 3in. (76mm) diameter slitting saw. However, using my standard arbor and cutting to the depth required would have needed a dedicated fixture and this was very much an experiment. Using a 5in. (127mm) cutter allowed me to grip the work in the vice and rotate the job around to the correct angle.

Examining the layout in a CAD drawing and calling up the relative dimensions established that after setting a position by just grazing the cutter against a 3mm drill, **photo 14** the table would be moved 7.07mm to achieve the correct depth. Using the hole as an effective reference position should eliminate problems due to inaccurate positioning. If your knurled wheel does not measure exactly 12mm in diameter, then adjust the slot depth accordingly. My trial wheel measured 0.130in. (3.3mm) in thickness, and as the slitting saw was just 0.0625in thick, it would therefore take three cuts. My first attempt ended in failure due to the order of taking the cuts. If a slitting saw is not "fully loaded" it may cut slightly off square. This resulted in a slot which became slightly

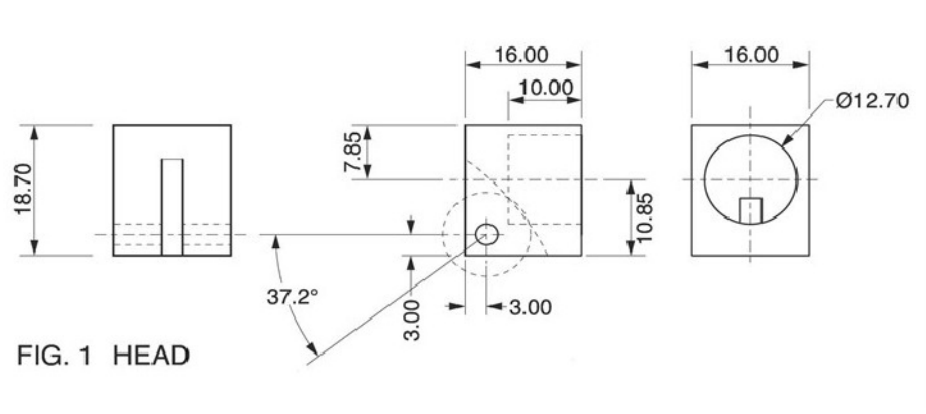


FIG. 1 HEAD

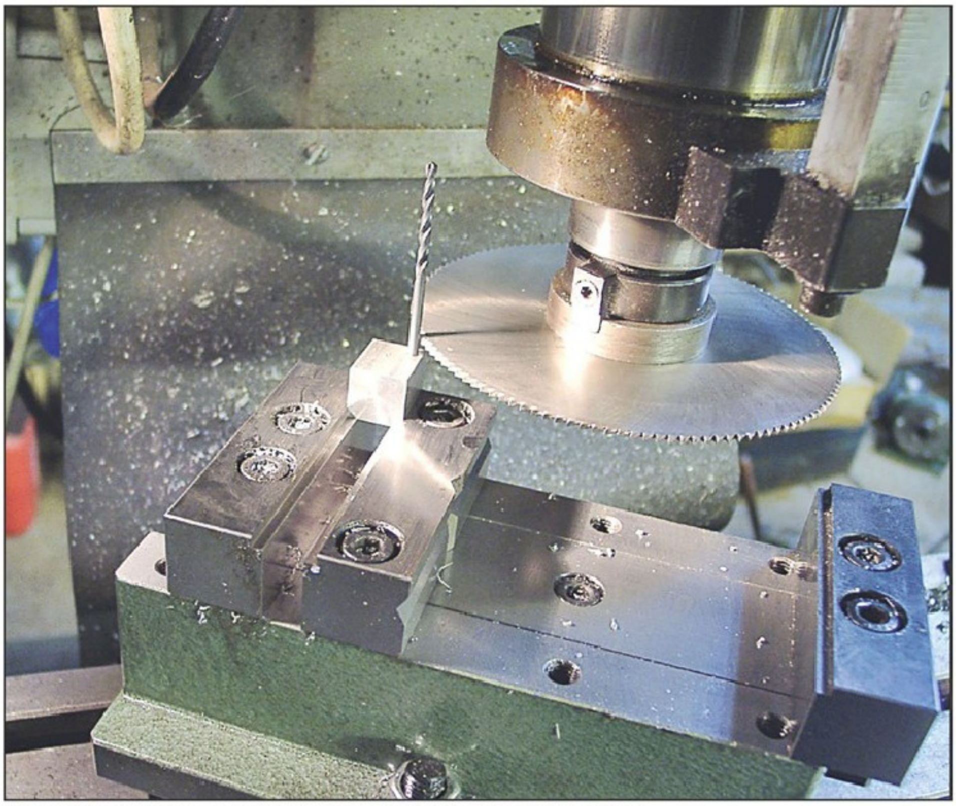


Photo 14. Cutter is rotated backwards by hand and the table advanced so that it just touches the drill.

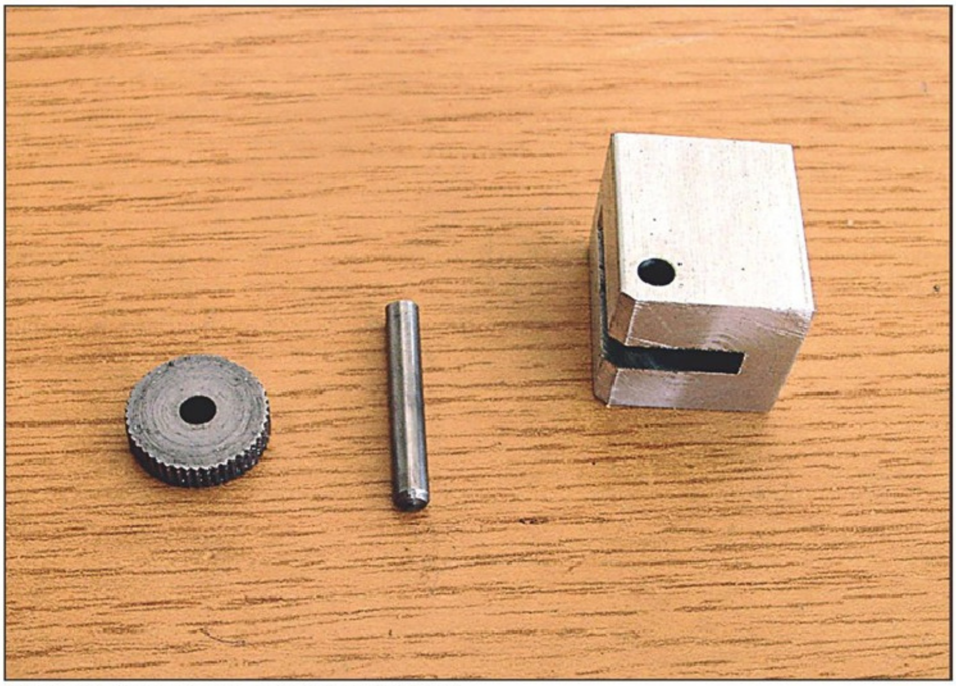


Photo 15. Three parts comprising the head.

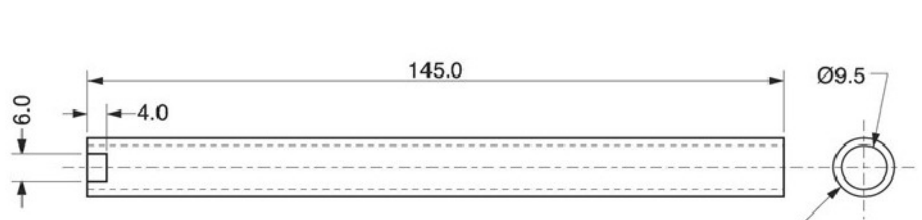


FIG. 2 BODY

narrower towards full depth. The solution was to take the two outer cuts first then remove the waste in the middle.

The remaining component is the spindle, simply a length of 3mm diameter stainless or brass rod lightly knurled at one end so that when pushed in by hand it sticks in place. **Photo 15** shows the head components, and **photo 16** shows how the wheel protrudes through and picks up paint.

Paint reservoir

The reservoir body, **Fig. 2** is nothing more than a 145mm length of aluminium tube ½in. OD by 16 gauge, (12.7mm by 1.6mm wall). It is faced to length, deburred and then given a slot at one end so that when fitted into the head, the slot clears the wheel, allowing free rotation. I cut the slot quickly with a junior hacksaw and then filed to clean up. No doubt a neater job could be done on the mill. Ideally we would have a very light interference fit between the body and the head. My simple and perhaps slightly agricultural solution to this was to squeeze the tube lightly in the vice making the end a few thou elliptical. This then gave the desired push fit.

The rod is made from more of the 3mm rod used earlier, each end being threaded M3 then touched lightly with a file to remove burrs raised by the die at the end of the threads. Two parts, the cap and the knob, **Fig. 3** are made from ½in. (12.7mm) diameter aluminium bar. Both are simple turning jobs. Nylon rod was used for the piston, **Fig. 4** turned to fit the inside diameter of the body. I have not machined nylon sufficiently often to become an expert, but do offer the following in this context. The 8mm hole was drilled first and then the OD reduced to size. Due to the flexibility of the material, the solid diameter was turned to a diameter somewhat less than that around the hole. Thus it became possible to produce a piston with effectively two diameters at one setting. The thin wall section gave a seal, while the solid gave clearance. The final ops were to drill and tap the M3 thread and part off. **Photo 17** illustrates this group of parts.

Assembly

Apart from Loctiting the cap to the body, it is a simple matter of locating the wheel, fitting the spindle and then screwing the rod to the piston, passing it through the body and screwing on the knob.

Materials

Over recent years there has been a shift to the use of water based paint. Apart from art type acrylics, I have no experience of using

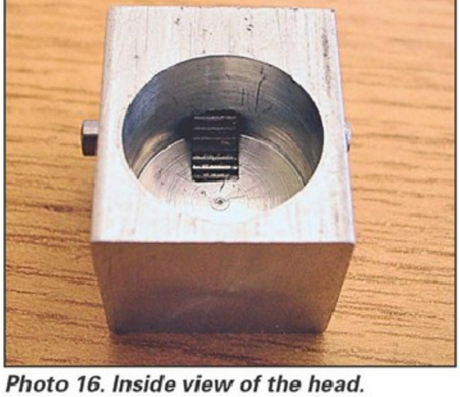


Photo 16. Inside view of the head.

these. The materials selected for making the wheel tool, have been influenced by what was available in the scrap box. My guess is that they will be fine for both oil and water based paints. The obvious alternative material would be brass.

In use

When I purchased the Stripemaster, the paint recommended for use with it was a brand intended specifically for this sort of application (also signwriting, lettering etc.). The same paint was used here for an initial trial. It is relatively thick and therefore does not run through the fine gaps at the wheel. **Photo 18** shows the result of a few freehand swipes using some scrap hardboard. If the wheel is held vertical, then its full width is in contact, and the full width line is the result. If however it is slightly canted then the line becomes narrower. With practice it should be possible to bring lines to near pointed ends.

Areas for improvement

Both the Beugler and the Stripemaster have provision for a guide bar so that the tool can be run along a rail or edge set on the job. Mark two will have a little extra meat at the top of the body to locate such a feature.

This device was concocted with the Beugler concept very much in mind. Thus for a different line width, a new head would be made i.e. three components. When using the Stripemaster, a thinner wheel may be fitted provided that the width is made up using the shaped spacer plates. It is likely that the same idea might be employed here too. My untested thought is that a spacer might be quickly made from plastic, brass or aluminium sheet (say1.0 to 1.5mm thick), to allow the use of a narrower wheel. It should be noted that the spacer must project through the slot beside the wheel thus blocking the path against paint leakage.

Ref. 1 How (Not) To Paint A Locomotive by Chris Vine is available from www.myhobbystore.com
Tel: 0844 4122262.

Ref. 2 Robert Shephard, "The Finishing Touch" is available from Phoenix Precision Paints Ltd. PO BOX 8238, Chelmsford, Essex CM1 7WY United Kingdom
www.phoenix-paints.co.uk
Tel: +44 (0)1268 730549

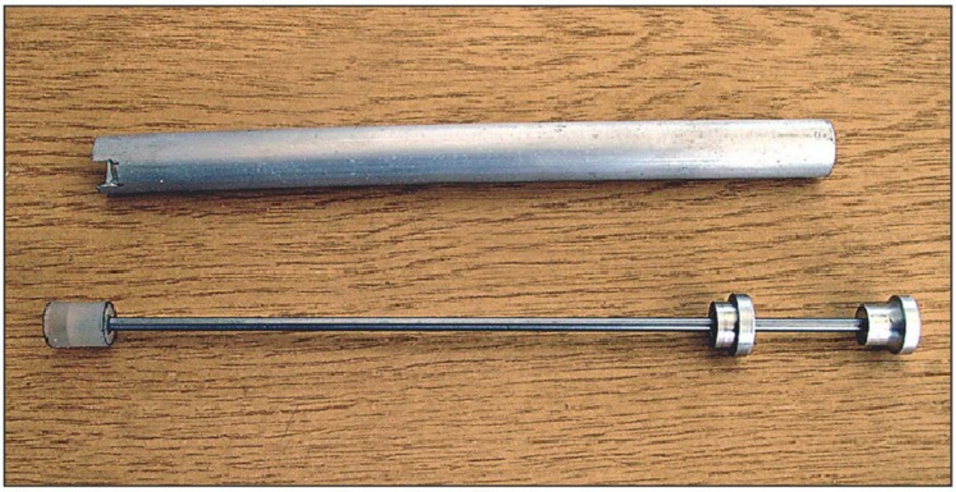


Photo 17. Four components make up the paint reservoir.

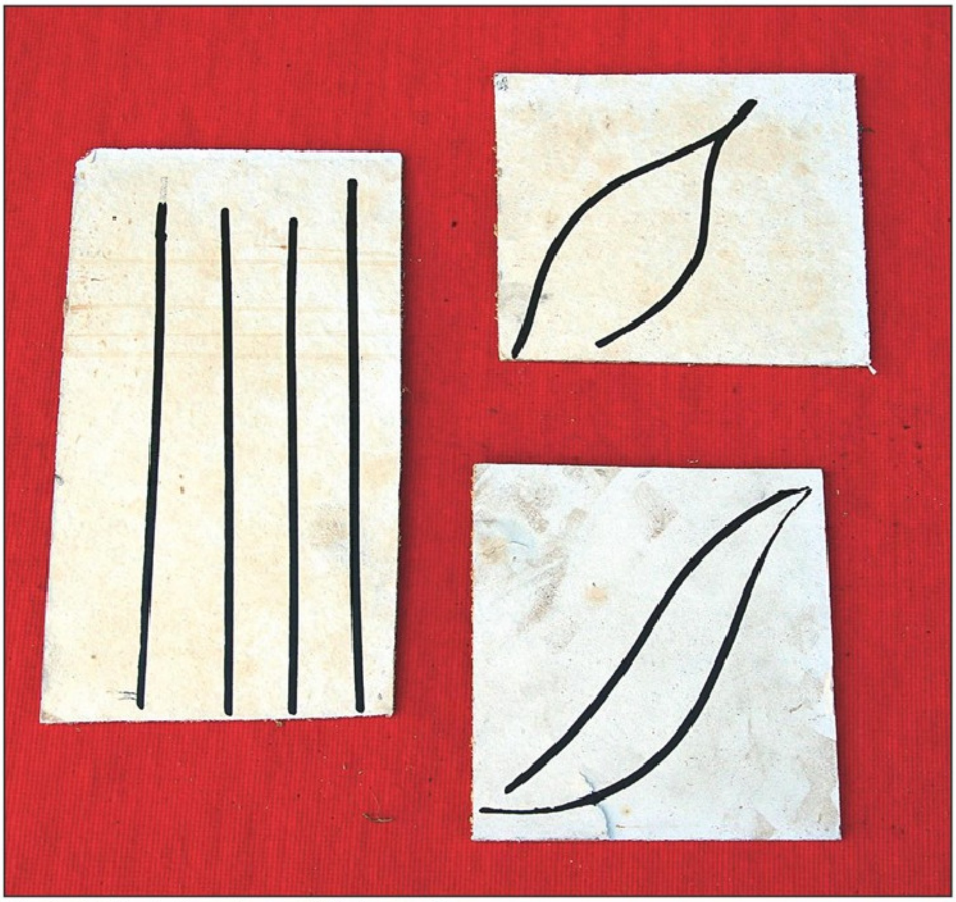
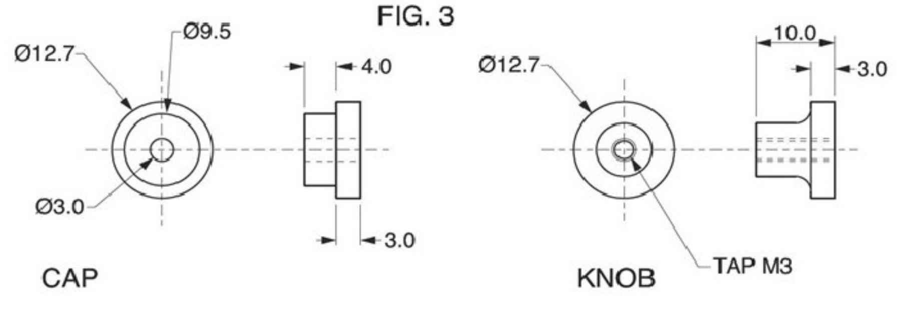


Photo 18. Test pieces by unskilled operator.

FIG. 3



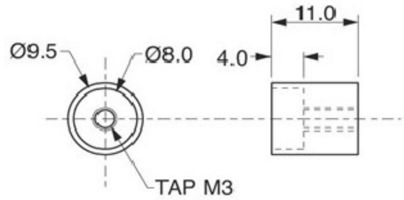


FIG. 4 PISTON (NYLON)

AN INTRODUCTION TO SUPERGLUES AND ENGINEERING ADHESIVES

Mike Haughton takes a look at the basics of polymers used as adhesives in engineering.

I have tried to keep the chemistry in this article at a very basic level, just sufficient to illustrate the principles. Then I will deal with three specific adhesive families, which find uses in our home workshops, **photo 1**.

Photo 1. Engineering adhesives.

Monomers, polymers and initiators

We are all pretty familiar with a whole range of plastics these days. Love them or loath them plastics get just about everywhere. In many applications they have replaced metals because they are lighter, sometimes cheaper and can be readily moulded into very complex shapes when hot (thermoplastic) or become solid when heated in a mould (thermosetting).

A few everyday examples should, I hope, explain the terminology and technology, and then I can move on to specific products that should find a place in your home workshop.

That translucent, waxy white, plastic food cutting board in the kitchen may well be made from Polyethylene, a thermoplastic polymer, and will have the following recycling symbol moulded into it somewhere, **Fig. 1**. LDPE means Low Density Polyethylene. LDPE is inert to most chemicals and softens at about 115deg.C.

LDPE is made by polymerising ethylene, a gas, boiling point -103deg.C, (modern name ethene) like this, **Fig. 2**. Read the equation from left to right. The starting material, a monomer ethene is polymerised by a free radical initiator to form the product, a polymer called polyethene. The actual polymerisation process goes as follows. An initiator is added which thermally decomposes (breaks down) to yield radicals which are highly active fragments of itself. A radical immediately adds to a monomer molecule and several thousand monomer units are then very rapidly added, one after the other, in a chain reaction to make the poly (ethene) chain, with the production of a lot of heat. The polymer contains 2000 to 20,000 monomer units. (Note: HDPE, High Density Polyethene is made by a different polymerisation process which I won't cover here.)

Low density polyethene is not quite the linear molecule indicated by the structural drawing, **Fig. 2** as it has about 30 random branches for each 1000 Carbon atoms of the polymer. Visualise short branches on a tree to get an idea of the structure.

The polymerisation of ethene, our example, is actually very difficult to carry out in practice and requires very high pressures of 1500 to 3000 bar (yes they use massive piston compressors to get these pressures!) and an added initiator that thermally breaks down at the polymerisation temperature of 300deg.C to provide a source of free radicals. The polymerisation isn't very efficient and a lot of un-polymerised ethene monomer has to be recovered at the end and recycled back to the starting point of the process.

The key chemical structural feature (group) of most monomers that polymerise with free radicals is the C=C double bond (alkene). Ethene is the simplest example but if we add more chemical groups to one end of the double bond it makes free

Fig. 1

Fig. 2

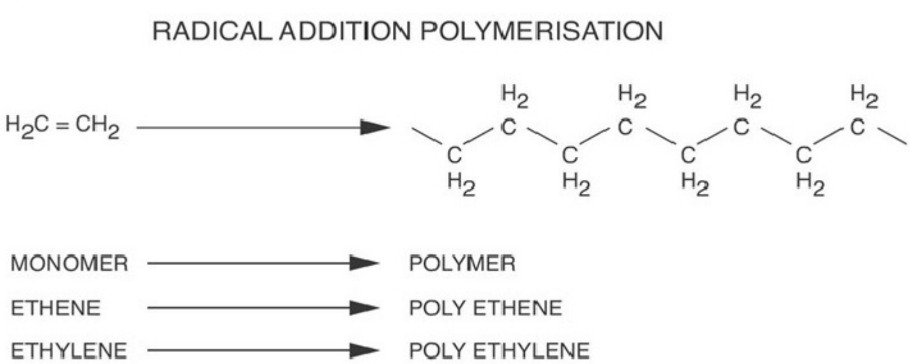
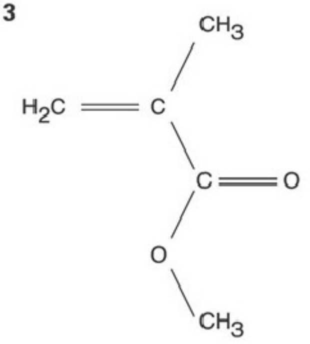


Fig. 3



radical polymerisation much easier to carry out. The monomer methyl methacrylate is shown in **Fig. 3**. This monomer can be virtually 100% polymerised by a free radical catalyst at atmospheric pressure and well below its boiling point.

Poly methyl methacrylate is the chemical name for the well known plastic Perspex® or Lucite®. Methyl methacrylate monomer is a liquid boiling at 100deg.C. Poly methyl methacrylate starts to soften at about 100deg.C and has excellent resistance to Ultra Violet light (UV) and a high refractive index, hence its use in aircraft canopies, lenses and light fittings. Commercial Poly methyl methacrylate can have an average formula weight of well over 1 million, that is >10,000 monomer units in the polymer chain.

Methyl methacrylate belongs to the large family of acrylate monomers which are common components of engineering adhesives. Acrylate monomers are so readily polymerised by free radicals that they are normally supplied with a polymerisation inhibitor deliberately added to improve their shelf life.

Inhibitors

A few parts per million of some inhibitors, when added to an acrylate monomer, will stabilise it against polymerisation by grabbing any free radicals that are around and hence stop short the growth of long polymer chains. The presence of air (oxygen) greatly enhances the efficiency of inhibitors which explains why most engineering adhesives are supplied in bottles that are not full; they normally have an air space at the top. Absence of air is termed anaerobic and this term is often applied to some adhesive systems that polymerise when air is excluded e.g. Loctite® types.

Some inhibitors are highly coloured and can often be seen pink, or green in the formulations.

The use of inhibitors greatly extends the shelf life of adhesive monomer systems. You can also help by storing the adhesives at low temperatures (in the fridge or freezer). Why? At lower temperatures impurities in the monomer are less likely to decompose to yield those radicals which start polymerisation.

Co-polymers

Polymerising a mixture of different monomers to yield a co-polymer is a very common technique applied by development chemists to produce polymers with properties tailored to specific properties for a specific application. This is where the "Black Art" takes over. Formulators will do their best not to disclose the exact compositions they use. One disclosure that may give an insight into the hazardous components in a formulation is to read the Health and Safety Data Sheet for the product. In Europe this is the SDS or in North America the MSDS. As a user you have the right to a copy of the SDS and these can often be found on the manufacturer's website.

Branched and cross-linked polymers

All the polymers described so far are mostly linear chains that get their physical properties from being entangled like a jumbled pile of long pieces of string. When the final polymer is required to be rubbery, tough and low in solubility e.g. a gasket material, formulators will often incorporate monomers that are multifunctional. Multifunctional monomers have more than one polymerisable group. Common systems employ di-methacrylates or urethane methacrylates. The polymers that grow in two or more directions simultaneously can rapidly become very branched or have bridges between polymer chains (cross linked). They have exceptionally high molecular weights. The old name for cross linking when applied to rubber was "Vulcanising" where natural rubber, a linear polymer with double bonds, was heated with sulphur. Think of automotive rubber tyres, rubber hoses etc.

Toughened Adhesives

This term is usually used when very small particles of rubber are blended into the adhesive with the objective of adding resistance to flexing and preventing the propagation of cracks in the set or cured adhesive.

Fillers

Adhesives with added inert solids find use as fillers, e.g. car body repairs or filling defects in castings before painting. It is often called "bondo" in North America. In the model aircraft world hollow micro spheres sometimes called micro balloons are often added to adhesives in order to reduce weight and improve gap filling when working with materials such as structural foams. Micro spheres are usually glass or ceramic.

Adhesives with metal powders added as fillers are often used to repair casting defects or even machined surface damage. Google "Moglice"® for more information.

Aliphatic Adhesives

This term usually indicates that the developers have added a monomer that reduces water solubility, increases oil affinity and increases flexibility.

Health and Safety

Most monomers are toxic, irritant, sensitising and flammable. Please consult the Safety information (SDS or MSDS) that the manufacturer has a duty of care to provide to the user before you use these products. Read the Hazard descriptions and follow the use recommendations.

Most polymers are such large molecules that they pose few human safety issues as they won't penetrate through tissue in the way monomers will. Polymers are often biologically inert. E.g. Aircrew from crashed planes were often found to have dormant Perspex® fragments under their skin and even in their eyes long after the crash.

Heating adhesives

Polymers often have quite poor temperature stability so polymerisation can be reversed by heating and this can be very useful to aid disassembly of components previously "glued" together. Some polymers like Perspex® can be thermally decomposed back to their starting monomer(s), a process used commercially to recover value from poly methyl methacrylate scrap. e.g automotive tail and stop light covers. However, most other polymers thermally decompose to small molecules that are not the original monomers and these decomposition products can be highly toxic and volatile. Beware if you intend to use heat to break a "glued" bond, do it outside and with very good ventilation. See later notes on Superglues.

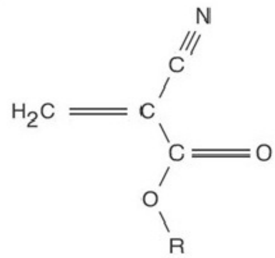
Well, now that you have survived the heavy technical stuff it's time to apply your new knowledge to three real systems that might come within the scope of your home workshop.

Adhesive Class1: Superglues (CA; Cyano; Krazy glue)

Superglue is pretty amazing stuff. Apply a drop of Superglue to the joint area, bring your component parts closely together and within seconds a fairly strong bond is formed at room temperature without the addition of an initiator. Magic! A full strength bond is developed within 2 hours and the bond is waterproof and oil resistant. How does it do that?

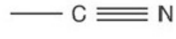
Superglues belong to the Cyano Acrylate (CA) family and the monomers have the following chemical structure, **Fig. 4**.

Fig. 4



You will notice the cyano group, **Fig. 5** which makes the C=C bond we saw earlier so susceptible to polymerisation that even water, actually the hydroxyl ion, in the atmosphere or on the surface of the components becomes the polymerisation initiator. There are no free radicals involved so no initiator is deliberately added. It is a true one pack adhesive and very convenient to use.

Fig. 5



Famously, superglue sticks human tissue to itself and to the superglue tube very fast. We have all done it! Not so bad to deal with on your fingers but serious in the eyes, mouth and other body parts! Lots of jokes here, supply your own! Care is needed.

Fortunately the super glue bond can be broken by adding a solvent for the cyano acrylate polymer. Internet accounts frequently quote acetone (nail varnish

Photo 2. 5Star Cyano Acrylates.

Photo 3. Drill extension with CA.

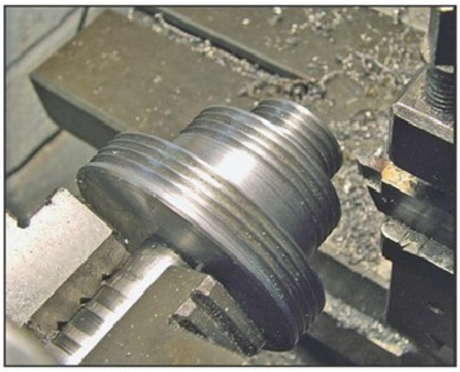


Photo 4. Stub mandrel and pulley.

remover) as a good de-bonder for cyano acrylate. I find that acetone isn't very good on super glue, so for cleaning fingers and breaking bonds it's a good idea to invest in a purpose designed de-bonder for the type of glue you are going to use.

You **MUST NOT USE** Acetone anywhere near the eyes or mouth.

The use of acetone on some plastics is highly undesirable as it may soften the plastic or cause it to fail later due to micro cracking of the surface that acetone has been in contact with.

I have been told that a much safer, but slower de-bonder for superglue on skin is olive oil. (Cooking Oil) I have tried it and it certainly works for cleaning fingers, if a little slow.

Many plastics are difficult to stick together with adhesives and a traditional method of improving adhesion (peel strength) is to flame the plastic surface lightly with a gas torch before applying the adhesive, see **Ref. 1**. A more modern approach is to use an "activator" or "primer".

There are some plastic surfaces that require the use of a primer (usually containing toluidine) before the superglue is applied. Some manufacturers call these primers "activators". The surfaces to be glued are first lightly moistened with the activator, then the superglue applied then the components brought together.

Several Superglues

Most manufacturers offer a range of Superglues. **Photo 2** shows a small part of the range from FiveStar Adhesives, **Ref. 2**. You will notice several viscosities (thin, medium and thick) a de-bonder and an odourless grade in this photograph.

By changing the R group in the cyano acrylate chemical formula, **Fig. 4** it is possible to change the properties of the monomer and the adhesive. In most super glues R is ethyl (C2) but medical superglue is octyl (C8) and the odourless variety is alkoxy alkyl. I find that thin superglue is fine where you want the stuff to penetrate a close fitting joint but the application can be difficult to control. (It rapidly flows everywhere and seems attracted to fingers.) For model making and some engineering applications I find the thick variety is most useful and will stick most metals provided that any oil or cutting fluids have been removed first. I use the thick stuff where I might previously have used tin lead soft solder for temporary assemblies, e.g. **photo 3**, a drill extension and **photo 4**, a three step PolyVee pulley super glued to a stub mandrel for turning. Note the mandrel has slipped during roughing machining in the chuck. The glued joint didn't fail. I always mark the position of chuck jaw 1 on the mandrel so I can return it to its original position should slippage occur.

Breaking these temporary superglue assemblies can sometimes be done by placing in the freezer. When really cold the glue may then become brittle enough to break with a hydraulic press. Alternatively a de-bonder can be used or, most severe of all, and for metal parts only, gentle heat from a gas torch. Superglues (and most other adhesives) loose strength as the temperature rises and taking the joint above 150C will usually soften the adhesive sufficiently to twist or press the parts apart whilst they are still hot. Softening usually occurs long before decomposition of the polymer gets going. One has to be cautious with heating CA adhesives as toxic decomposition products will be formed by any of the cyano acrylate family. Do it outside and stay up wind.

Cyano acrylate monomers are very smelly, unless you have the low odour alkoxy alkyl variety. Methyl (C1) and ethyl (C2) cyano acryates have quite low boiling points and high vapour pressures and your exposure to their vapour is a risk. Once in the nose, throat and lungs the vapour will polymerise on moist tissue. The high vapour pressure of Methyl cyano acrylate is used to advantage by scene of the crime investigators to visualise fingerprints, body fluids etc by exposing them to methyl cyano acrylate vapour.

A small proportion of the population can become sensitised to cyano acrylate adhesives. Read the safety information before you use the product, wear disposable gloves and avoid inhalation etc.

Some of the model plane builders use CA mixed with baking soda (sodium bicarbonate) powder to repair foamed plastic aircraft parts. This definitely works, but please be careful; the reaction of the two materials is very heat producing, exothermic and hence CA vapour producing.

Similarly, if you clear up a spillage of CA with a cotton cloth it can catch fire due to the heat of polymerisation initiated by the cotton. Wool containing cloth does something similar.

A few thoughts on degreasing before gluing

Metal machined surfaces should be regarded as contaminated with oil. None of the adhesive types described here like oil. It slows setting and weakens the adhesive bond to the metal surfaces. It used to be common practice to clean with chlorinated solvents and then dry the joint with paper tissue before drying and assembling with adhesive. Since the availability of chlorinated solvents is now close to zero (ozone depletants), for small components I usually use warm water plus washing up liquid in a small ultrasonic bath, wash with clean water, air dry and finally chemically dry with ethanol or acetone. Larger components can be repeatedly wiped clean with either of these two solvents or a proprietary degreaser designed for the adhesive can be used.

CA Conclusions

If you haven't used CA in your workshop I'm sure there are applications where it can bring benefits. CA adhesives are much cheaper than they used to be and I would advise starting with a small bottle of a medium viscosity grade with a well known brand name, rather than the no name cards of 10x1gm tubes for £1 variety. This CA adhesive will set outside and inside a joint and can produce strong thick bonds. It seems to work on all metals and most plastics and rubbers if you use a primer. It seems to work well for joining elastomer drive belts and making nitrile "O" rings. Model makers use CA extensively to assemble all sorts of materials. They rarely have close fits, e.g. studs, bearings etc to contend with and use the stuff as a convenient "tack it together" adhesive. There are many grades of CA available for specialised applications should you need them. Thoroughly recommended, have a go. See **Refs. 2, 3** and **4** to aid selection.

Adhesive Class2: Anaerobic Engineering Adhesives

Most readers of this magazine will know these materials as Loctite®, a company now owned by the Henkel, **Ref. 3**. As the "anaerobic" name implies, this group of adhesives polymerises when air is excluded. The adhesive formulation is supplied as

Photo 5. Loctite® anaerobic adhesives.

a mixture of monomers (often a mix of methacrylate esters) plus an initiator and an inhibitor, all in one formulation. They are one pack adhesives, **photo 5**. Apologies to Loctite; these grubby bottles are the ones I am using in my workshop and are quite old so the packaging styles and grades may not be current.

Anaerobic engineering adhesive formulations normally contain a peroxy initiator (a hydroperoxide) that is stable in the bottle but when in contact with a metal surface starts to break down catalytically into free radicals and if no air is present these will initiate the polymerisation process as described earlier. Clearly, the metal surface shouldn't be contaminated by oil or the initiator won't "see" the metallic surface and the hydroperoxide won't decompose.

If we were to measure the strength of the metal to metal bond in the assembled parts with time, we would find that there is a delay of several minutes before any bonding starts. This relates to the free radicals being grabbed by the oxygen/ inhibitor system. Once the inhibitor system has been consumed polymerisation commences and can be seen by a gradual increase of the bond strength. Several factors affect the cure speed, which may take up to 72 hours to develop maximum strength.

Temperature: Over the range 5deg.C to 40deg.C the usual chemists' rule of thumb applies, increasing the temperature by 10deg.C doubles the rate of cure.

The metals being bonded

Some metals, e.g. stainless steels, aluminium alloys and passivated metal surfaces are slower to bond because they don't decompose the initiator as efficiently. Consult the manufacturers' literature; there could well be a special grade for the materials you are planning to bond.

The bond gap

Unthreaded components with a joint gap of 0.05mm (0.002in.) will develop maximum strength hours quicker than one of 0.15mm (0.006in.) and possibly days quicker than one of 0.25mm (0.01in.). Also the wider gap joints will never achieve the same strength as the 0.05mm. You will notice that adhesive outside the joint won't set at all and you can wipe the excess away. This is unlike CA, where the entire adhesive sets.

At one time anaerobic adhesives were marketed for engineering applications as if they removed the skill needed to produce accurate fits, especially press fits for bearings, studs, shafts etc. Far from it, anaerobic adhesives need an accurate joint gap, as indicated above, to work well. Some older references describe Loctite joints for "components" attached to shafts with close fitting areas to "centralise the shaft" and less well fitted central areas to hold the anaerobic adhesive. A well designed and accurately made parallel shaft will centralise with the adhesive in the joint gap, provided the gap is of the order of 0.05mm (0.002in.)

Activators

Long cure times and wide joint gaps can be overcome with an activator. Clean the joint, apply the activator then apply the adhesive then assemble. However the use of activators tends to reduce the final bond strength.

Having made a successful bonded joint several factors affect its long term strength.

Temperature

Most anaerobic adhesives will have lost 50% of their strength at 150deg.C. This isn't permanent if the heating is brief and the original strength will return on cooling. Try visualising toffee that melts when hot and sets again on cooling. Most adhesive joints heated to 250deg.C can be disassembled quite readily so we shouldn't plan to secure boiler fittings with these adhesives!

Anaerobics tend to have better thermal strength than CA, but as always there are high temperature CA grades available if you look for them, **Ref. 2**.

Heat ageing

Joints held at 120deg.C for a thousand hours will have permanently lost some of their strength when returned to room temperature. The polymer is degrading slowly with time.

Solvents

Once cured, Anaerobics have good resistance to engine oil, brake fluid, petrol, water, ethanol etc. For confirmation search the manufacturers' product information.

Surface preparation

I have previously described the desirability of removing oil and grease from surfaces to be bonded. Another important aspect is surface roughness. Abrading the surfaces to be bonded is usually advantageous. Grit, sand or plastic bead blasting usually work, but if you don't have access to any of these good old fashioned fine wire wool followed by degreasing works well for me in the majority of cases.

A Huge range of products

One has to feel sorry for the suppliers of engineering adhesives to our home workshops. There are now so many manufacturers. Loctite® no longer has a monopoly and most manufacturers supply a bewildering range of products aimed at different applications. Typical applications include stud locking and sealing, bearing fitting and nut retaining. The rear horizontal bar and the vertical column in the Quorn tool and cutter grinder bed castings can be secured with Loctite®; porous castings can sometimes be sealed with a low viscosity wicking anaerobic adhesive. Don't expect your supplier to stock more than one manufacturer's adhesive range, and probably not a full range at that.

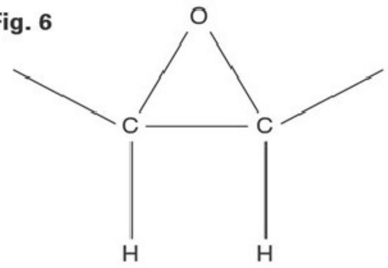
Conclusions

These anaerobic engineering adhesives definitely have a place in the home workshop if you are working with metal components. Make sure you get some degreaser, activator and de-bonder for the metals you are going to bond. For one off temporary assemblies for machining I find CA more convenient.

Adhesive class 3, epoxy

Most will know this class as "Araldite®" **Ref. 5** a trademark now owned by Huntsman, but first commercialised by Ciba®. Epoxy resins and adhesives are two part systems, **Ref. 6.** You have to mix a Resin and Hardener before the addition polymerisation commences. The polymerisation process does not use free radicals so no initiator or inhibitors are involved. The resin component is a pourable low molecular weight polymer containing epoxy groups. An average molecular weight below 700 is common. The epoxy group is drawn as **Fig. 6**.

Fig. 6



The hardener used to be a poly amine but I notice that fast epoxy resins now add a poly thiol as well. A poly amine contains several -N-H groups and a poly thiol several -S-H groups.

Thoroughly mixing the two components, resin and hardener, allows the amine to react with the epoxy rings to form new bonds. The molecular weight of the mix rapidly increases and the large numbers of reactive groups ensure that the resulting polymer is high molecular weight and heavily cross linked. The final cured epoxy resin is very resistant to water, solvents, oils and can be machined if necessary. It will often be possible to drill and tap the cured adhesive and special filled grades are available with a number of metal powders incorporated into the resin.

The UV stability of most epoxy resins isn't great, they tend to darken and become brittle on long exposure to daylight so you might want to consider a two part polyester resin as an alternative system.

Because epoxy systems are two part the user can play tunes with the proportions of resin and hardener. Increasing the hardener proportion (the polyamine which smells like rotting fish, Poly Thiols also smell pretty disgusting) can accelerate the cure time but usually leads to a lower strength resin. To make the product more "goof proof" many DIY rapid epoxy resins are supplied in two parallel connected syringes, **photo 6**. Using the two syringe packs restricts the user's ability to vary the resin to hardener ratio.

Perhaps a better user tactic is to warm the mixed resin to accelerate it's curing. Warming the premixed resin and hardener brings the added benefit of lower viscosity and easier application without loss of strength; it also allows air bubbles to

Photo 6. Epoxy adhesives.

escape from the mixed resin. Warming should be cautious. 10deg.C will double the rate of cure, 20deg.C will accelerate the cure rate x 4. Resins that have been cured at higher temperatures develop higher final cured strengths.

The relatively high viscosity of the uncured mixed epoxy dictates that it isn't going to be a good choice for small clearance assemblies. I regard and use epoxy resins as structural adhesives making them somewhat complimentary to the Anaerobics detailed earlier.

Epoxy as a structural adhesive

The adhesion of epoxy resins to all manner of surfaces is extremely good provided the surfaces are clean, dry and free from oil and grease. Activators or primers are not usually called for, but check the manufacturers application notes if you are attempting to bond something new to you. Please see my earlier comments regarding surface preparation. Abrading (wire wooling) the surface of metals often gives a stronger bond. Epoxy resins have proved useful in bonding aircraft alloy components and many a loco frame and tender have been riveted in place and glued with epoxy to seal the parts permanently. I can remember long ago securing an alloy plate into the base of a Westbury "Centaur" gas engine base casting to form a fuel reservoir with Araldite.

The cured Epoxy resin is tough and long lasting. As with all these families of adhesives, formulators have the ability to change the proportions and compositions of the hardener and resin component to arrive at specific final cured resin properties. Your use may require high bond strength, high peel strength or shock load toughness. I can only suggest that you search for a suitable product, **Ref. 3** being a good starting place.

Temperature stability

My experience has been that "Rapid Epoxy" products, although convenient, don't have as good a bond strength and don't have as good temperature stability when cured compared to slower curing epoxy products. The rapid types seem to have useful temperature ranges of roughly -50deg.C to +60deg.C.

Some epoxy products are available with better long term high temperature stability. 120deg.C with occasional excursions to 150deg.C seem OK for the non rapid types. Silicone epoxy resins are available for those with deep pockets, which can be used up to 300deg.C.

Epoxy putty

Photo 7 shows a couple of Epoxy Putties. At first glance these don't look like two component packs, but in fact they are the hardener and resin extruded into concentric cylinders, like a sausage roll. To get the putty to set you cut off the quantity required for the job and kneed the components together. The metal epoxy contains metal powder and I find it particularly suitable for filling defects in castings. The cured putty can be sanded, drilled, tapped etc.

Potting

Cured epoxy resins have good electrical insulation properties and are frequently used to pot or encapsulate electronic assemblies. The end result is usually anti tamper and anti vibration. Should this type of use interest you, searching one of the electronic suppliers website e.g. **Ref. 7** could provide answers.

Mixing and clean up

Obviously it makes good practical sense to only mix the quantity of epoxy putty or adhesive required for the job in hand. Small disposable plastic pots or sheets of polythene and wooden sticks (lollypop sticks) are ideal for mixing the two part adhesives. Remember you are mixing two quite high viscosity liquids and the two parts will tend to form thin layers rather than actually dissolve in each other. It pays to shear mix the two components between two flat surfaces e.g. a flat surface and a spatula to get good mixing. Similar to mixing paint or printers colours with a doctor blade.

Unhardened resin can usually be removed with methylated spirits (ethanol) from contaminated surfaces and tools. The hardened resins are difficult to dissolve and you will have to resort to a specialised adhesive remover.

Other adhesive classes

I have only covered a small number of the available adhesive classes (chemistries) in this short review. The objective was to explain the basics. I have left out more adhesive classes than I have described but the object wasn't to write a text book. Write to Scribe a Line should you want more information or to add your comments and experiences with using these products. ■

Email **mikehaughton@btinternet.com**

References:

Ref. 1. Workshop Practice Series No 21 ISBN 85486 048 8
Ref. 2. www.starlocadhesives.com/products.htm
Ref. 3. www.henkelna.com/index.htm Search the website for the Adhesives Sourcebook.
Ref. 4. www.loctiteproducts.com/
Ref. 5. http://en.wikipedia.org/wiki/Araldite
Ref. 6. http://en.wikipedia.org/wiki/Epoxy
Ref. 7. www.uk.rs-online.com and search for epoxy

Photo 7. Epoxy Putties.

TRADE COUNTER

Please mention Model Engineers' Workshop when talking to advertisers'.

Dremel model 335 plunge router attachment

This router attachment is designed to be used with Dremel power tools. It includes a fence and a circle cutting guide. The router takes cutting tools with 3.2 (⅛in.) shanks. Dremel supply cutters as accessory items.

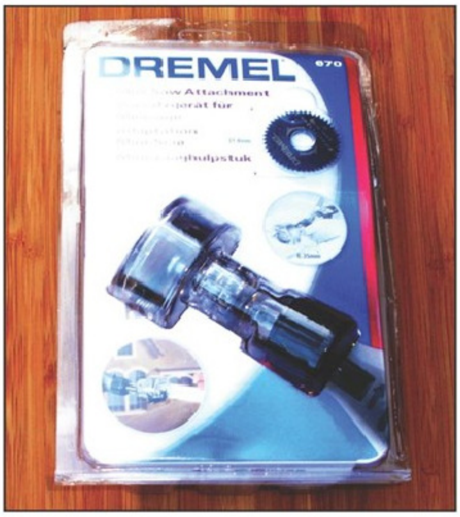
New Dremel stockist

MyHobbyStore Ltd. are now stocking items from the Dremel range. You can find them at http://www.myhobbystore.com/g/32/Specialist-Tools.html

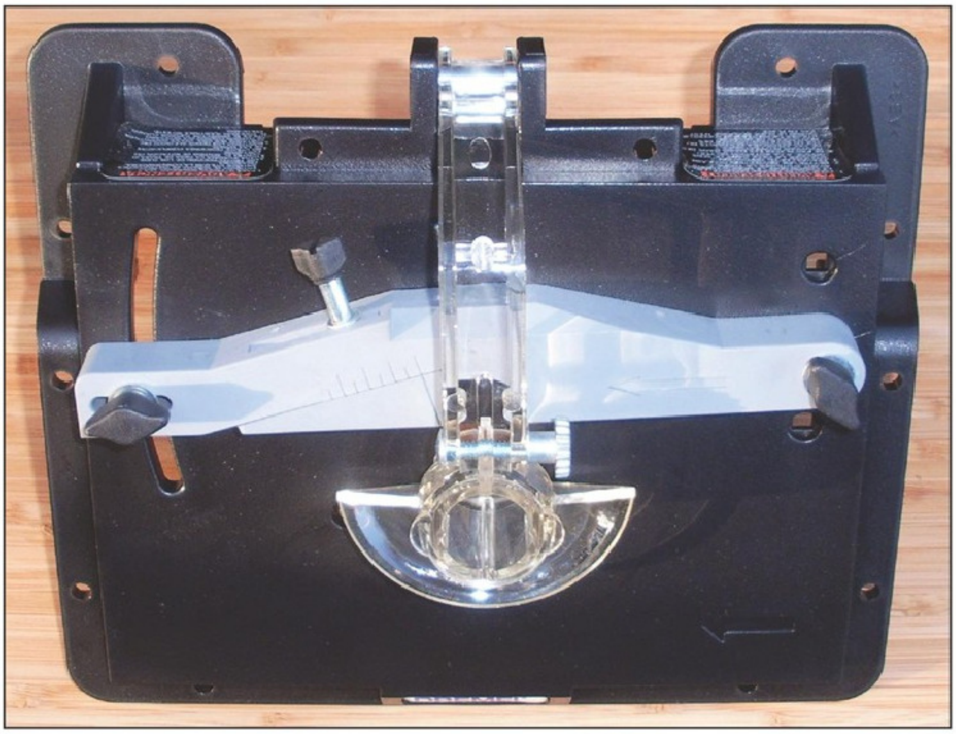
The basic Dremel 300 series in plastic case is only £37.99 +P&P. You can find many more model making tools on the website.

Dremel model 670 Mini Saw attachment

This little saw attachment is designed to be used freehand. The blade is 31.8mm (1¼in.) diameter. It is designed to cut thin sheet using both hands to hold the Dremel. It should only be used so that the saw blade is cutting material on the up stroke only.



Dremel model 231 shaper/router table

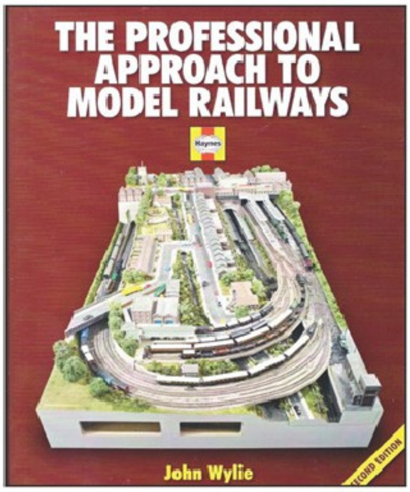


This shaper/router table again takes the Dremel drill and can be used to shape or rout the edges of components. It can also be used as a small drum sander by using the ¼in. and ½in. abrasive drums available as accessories. The table can be extended if required by the use of a homemade wooden false table.

FIRESIDE READING

The Professional Approach To Model Railways
by John Wylie

ISBN Number 978 184425 679 2

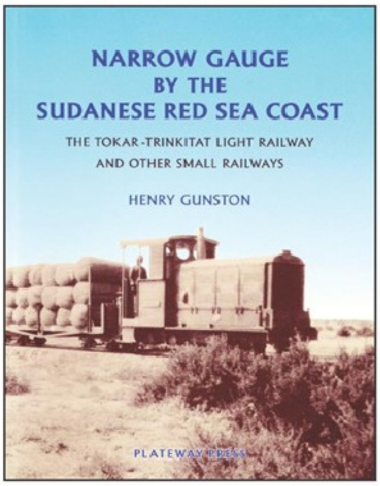


This book is a 220 page manual from Haynes Publishing. At first flick through I put it to one side to review one day. Having picked it up again a few weeks later and looking through it properly, it is quite a well presented book with plenty of information inside. Although mainly black and white, there are some colour photos inside. At first it appears to be model railway layout based rather than scale model railways but as I looked through, I found the architectural model section, the wiring section and kit building sections very interesting. So, beginner or more advanced, this book is well worth a read if you are into model railways in any way.

Order through your local bookseller or online at www.amazon.co.uk

Narrow Gauge By The Sudanese Red Sea Coast
by Henry Gunston

ISBN Number 1 871980 46 **1**



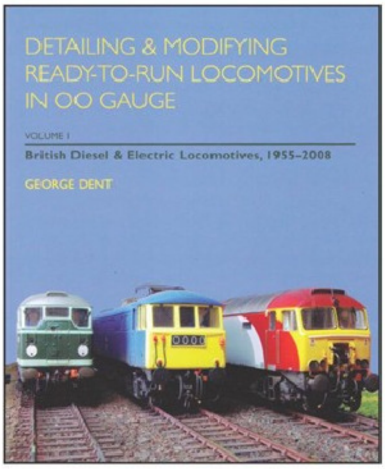
This book is slightly larger than A5 and comprises 70 black and white pages of narrow gauge railway photos and text. This book is probably more suited to the narrow gauge devotee than the casual interest of the narrow gauge enthusiast.

Plateway publish a range of railway and industrial transport history books.

Published by **Plateway press,** Taverner House, Harling Road, East Harling, Norfolk, NR16 2QR
Tel: 01953 717498
www.plateway.co.uk

Detailing & Modifying Ready-To-Run locomotives In 00Gauge Volume 1
by George Dent

ISBN Number 978 1 84797 093 0

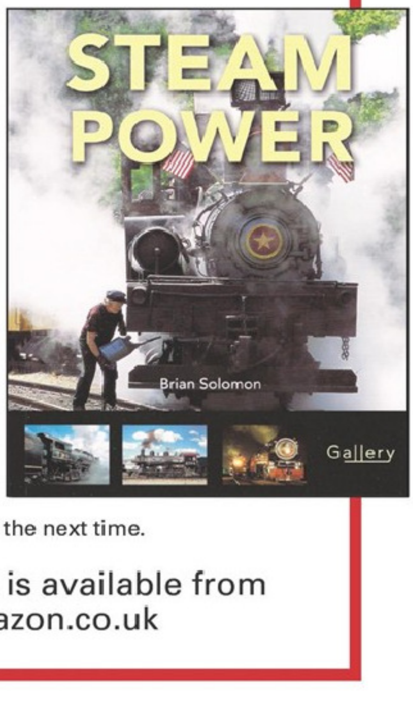


This book is written by George Dent who is the resident Model Maker at Model Rail magazine. He has been working with scale models for over 20 years. This is volume one and deals with improving ready to run locomotives of diesel and electric prototypes. Volume 2 due out later this year will cover steam locomotives. However, back to Volume 1. The book has 192 pages and is in full colour. The first chapter is about reference material and then there is the usual opening chapter on tools and materials. The book covers repainting, adding different name and number plates and making detailed cab interiors. There is also a chapter on cosmetic surgery and another section deals with changing the wheels. This is an interesting book for the so called modern image modeller but as diesel and electric motive power has been around, in bulk, for at least 60 years, I think perhaps the term modern image is now irrelevant.

This book is available from **The Crowood Press,** The Stable Block, Crowood Lane, Ramsbury, Wiltshire SN8 2HR www.crowood.com

Steam Power
by Brian Solomon

ISBN Number 978-0-7603-3336-5



This book is slightly wider than A5 and has 192 full cover pages. It includes more than 200 photos of preserved steam locomotives from North America and Europe. It is basically a coffee table book that you can pick up, look at a few photos and then put back down for the next time.

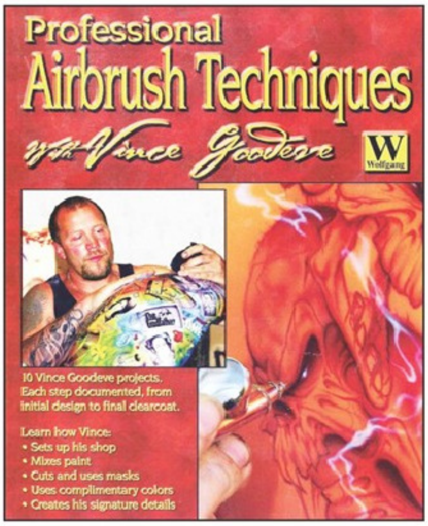
The book is available from www.amazon.co.uk

Professional Airbrush Techniques
by Vince Goodeve

ISBN Number 1-929133-28-6

Available from Grantham book services

This is a 144 page full colour book of around A4 size. It is all about airbrushing designs onto metals (a motorbike). It gives details of 10 designs with each step fully documented from the initial design through to the final clearcoat. Vince shows how to set up shop, mix paint and cut and use masks. If you ever wanted to paint monsters or skulls, this book will show you how to do it.



How To Master Airbrush Painting Techniques
by JoAnn Bortles

ISBN Number 13: 978-0-7603-2399-1

Available from Grantham book services

This book is totally different from the previous one in that it uses a lot more in the way of masks and templates. It also goes into selecting and using a vinyl plotter to make templates. It starts off with a chapter about selecting basic tools, airbrushes, compressors and materials then goes on to show you how to do different designs on the usual motorcycle petrol tank. I found it an interesting book although I will almost certainly never paint or embellish a motorcycle.

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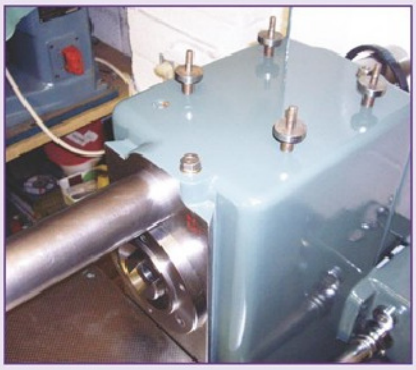
IN OUR NEXT ISSUE

Coming up in issue 156, on sale 2 October 2009



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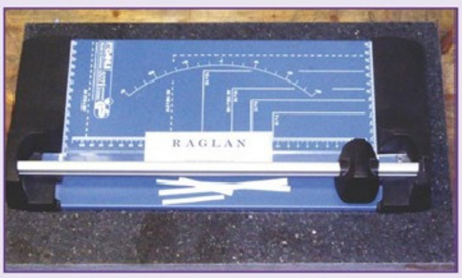

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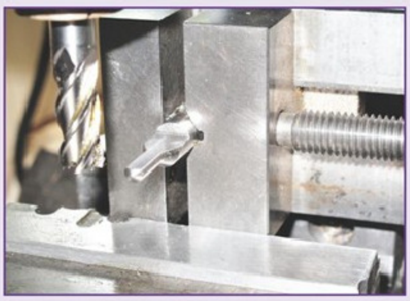

(Contents may be subject to change)

DON'T MISS THIS GREAT ISSUE – see page 10 and subscribe today

SCRIBE A LINE

Evening classes

Scarborough and district Model Engineering Group who meet at Yorkshire Coast College on Tuesday evening 7 - 9 are short of members for the autumn session. For further details please 01723 362537 or email g4egb@yahoo.com.

Please do not contact the College direct.

Ted Fletcher Scarborough.

Knurling - a reply

I note that once again the 'Pontiff of Geneva' has come out from the East in a blaze of glory to educate us mere mortals and dangle the fabulous baubles of the exalted before our eyes. I have done a quick and dirty search through the ME & MEW indices for his work and I find that apart from a surprising number of letters of criticism and pontification there does not seem to be any great opus of the sort of work - 'Duke of Edinburgh Award' standard - that I would expect from such a superior being clearly possessing equipment beyond the dreams of avarice.

I draw your attention to the comments of sundry well known people who held critics in the distain they richly deserve: Brendan Behan - playwright suggested that they were like Eunuchs in a harem and added a few further pithy remarks that don't belong in a family magazine. Several philosophers and yet other playwrights have commented that "those who can do, those who can't - criticise". At least one literary gent said that they were "Lice in the Locks of Literature".

I await with interest for a concerted effort by this being to fill the pages of this magazine with articles imparting the knowledge that we all clearly are in desperate need of. Perhaps an in depth article on all aspects of Knurling so that we are all raised in our standards, however it is first necessary that he update his info as the detail and photos that appear in the letter are possibly rather out of date.

Peter King, New Zealand

In the interests of free speech and non censorship, I have printed this letter in its entirety. Ed.

Harrison M300 and a dynamic converter

I note with interest the article by Ken Wilson on converting this lathe to run from a 240v AC Inverter power source. I too recently purchased the same model of lathe from RK International Machine Tools of Erith (an excellent company too). Like Mr. Wilson's it was an ex-college machine, ten years old and in very good condition, bar some worn paint and slight marks on the front of the chuck jaws. It had been supplied by RKI to East Surrey college in 1999, and still had all the original documentation.

When buying my M300 I too pondered on the best way to power it. Initially, I thought an inverter drive would be best as I already had converted our Myford Super 7 to inverter drive (by Newton Tesla) and found it to be superb.

However, on getting the M300 I changed my mind. Despite being an electronics engineer with some 40 years experience, one look at the wiring in the electrical compartment in the left hand pedestal convinced me that a dynamic converter would be easiest and quickest.

As Ken Wilson describes, it's a bit more than just changing the motor taps from 415v to 240v. The electrical cabinet is not highly accessible in order to get at the wiring. Also, the various contactors in my M300 were for 415v only, and could not be adapted to 240v, as was the transformer for the low voltage lighting (which I note is missing from the pictures of the M300 in the article). This transformer can be seen in the top left of photo 4 on page 22 issue No 154.

As I didn't want to spend a great deal of time re-wiring the lathe, after all I bought it so that I can build a 10¼in. gauge Terrier tank loco, I opted to go down the converter route.

Of the two types of single to 3-phase converter, the static type are cheaper, but will eventually blow the motor windings through over voltage at start up, so I decided to use a dynamic converter (supplied by Transwave), despite it being more expensive. It does make a bit of noise, but I've mounted it on resilient mountings and once the lathe is running it cannot be heard at all.

The biggest problem I had was finding some 25 Amp mains cable and a suitable isolator switch and mini-circuit breaker. How I remember the latter as an apprentice and what they're like now was two different things! The solution was eventually found from an isolator switch and MCB from the Farnell Electronics catalogue and duly wired in. The MCB was a type D which is rated for motor use. The Transwave converter is on a purpose built trolley, so that it can be moved

The purpose built trolley.

The Transwave converter.

The Harrison M300 lathe.

around if need be. At 70Kg the converter is a bit too awkward to manhandle! One photo shows the trolley before putting the converter on it, and another with it in place behind the lathe. Also a picture of the M300; you can just see one wheel of the trolley behind the lathe. Cables from the converter to the lathe are protected by shaped cable covers where they cross a walkway.

Brian Jones by email

Remagnetising

I recently acquired a magnetic chuck which appears to have lost its pulling power. Does any reader have experience of or know how to remagnetize the 23 internal magnets which each measure 40x22x8mm. All responses to **g4egb@yahoo.com** or telephone 01723 362537.

Ted Fletcher, Scarborough.

Painting aluminium

The first thing that's essential is to degrease the aluminium. You can do this with solvents - I often use acetone as a degreaser as I buy it in bulk for cleaning up before glass-fibre layups - often that's handy for a small part. However, it's just as good to use detergent (although anecdotal evidence suggests some brands are better than others).

Wash in dishwashing detergent and rinse thoroughly. Wear gloves to ensure no fingerprints are left on the part. After washing, the part must support an unbroken film of water. Areas that the water film will not cover indicate grease. The part must be washed and rinsed again until the water "sheets" evenly and completely over the surface.

Before painting

I have used zinc chromate primer from LAS Aerospace for some of the aluminium parts in my Europa homebuilt aircraft project, but it doesn't seem to get quite as good a grip on the metal as etch-primer. I have not used either the single-pack or the 2-pack etch primers supplied by LAS Aerospace. Instead I found a local independent car spares shop which stocked a single-pack Teroson Etch Primer aerosol, 500ml for £13. The code is 15492P and it's made by: Henkel Loctite Adhesives Ltd, Watchmead, Welwyn Garden City, Hertfordshire AL7 1JB
Tel: 01707 358800
www.loctite.com

Rowland Carson, by email.

Lathe clutter

In the articles by Jayne Reeve, which I am enjoying, mention is made of clutter on the top of the lathe. This prompts me to offer a cheap solution. The use of a domestic baking tray placed on the top of the lathe will hold all the bits and pieces that are placed there and should it be necessary to change the belts, the tray can be lifted off as one. The trays come in all shapes and sizes and they are also useful as drip trays and cleaning baths. They can be picked up from car boots and similar, but be careful if you remove one from the kitchen! Another source of useful bits is the stainless springs and balls from the tops of domestic cleaning trigger bottles. A few minutes with a mini hacksaw will soon release the required item.

Ian Varty, by email.

Overalls

I wear dust coats when in the workshop and bits of swarf get into the pockets, so before leaving the workshop at the end of the day, I have a small but powerful magnet in a plastic bag, which I run around inside the pockets, its quite amazing the amount of small particles which I fish out that would otherwise finish up in the washing machine. I place the magnet and plastic bag over the waste box, take out the magnet from the bag and the swarf falls away into the box. I clean up the bench and workshop floor from time to time the same way but with a larger magnet and plastic bag. Of course the idea is only applicable to ferrous metal.

Ted Fletcher, Scarborough.

Gear hobbing

I first got interested in gear hobbing for my telescopes when I came across a copy of "Complete Metalworking" by R.H.Cooley. I built a hobbing machine from reworked parts of an old shaper. The hobs I made I relieved with a lathe attachment similar to that presented by Giles Parkes MEW No 57, April 99.

The hobs produce good results but have a tendency to impact as they cut largely on one segment.

On page 102 of Gears and Gear Cutting by Ivan Law he mentions the advantages of spiral gashing the hob. This is a comment made in other publications as well and as this would mean more hob teeth in contact with the work at a time it should result in smoother cutting and a better finish. My problem is how to relieve a spirally gashed hob. If a reader could point me in the right direction I would be much obliged.

I have been receiving MEW for a number of years and when it arrives I never fail to find something to learn or admire.

Trevor Webster, by email.

Trevor Webster's telescope.

Bandsaw problem

Some time ago I purchased a small bandsaw mainly for cutting sheet material including wood, plastic and metal. Overall results have been very satisfactory and I am well pleased with it.

However, on attempting to cut straight across a workpiece the cut tends to veer off at about 15 degrees from the desired line. I assumed that something was out of alignment, but on reading a few books on the subject it appears that this is a well known phenomenon of bandsaws. One book even suggested measuring the offset and making a template to compensate for this.

My questions are, firstly, what causes this bias; the saw band is a closed loop but it is well supported by ball races above and below the cutting area. Secondly, if the above is correct, is the offset constant regardless of the material being cut, the band speed and the feed rate? If not, the template mentioned above is of limited value!

Dr John Nelson, Leeds.

WRITE TO US!

We would love to hear your comments & questions and also feeback about MEW

Write to the Editor, David Clark, Model Engineers' Workshop, MyHobbyStore Ltd., Berwick House, 8-10 Knoll Rise, Orpington, Kent BR6 0EL. Alternatively email: david.clark@myhobbystore.com

THE STAR LETTER OF THE MONTH WINS A WORKSHOP PRACTICE BOOK

SCRIBE A LINE

Jowitt Poppet Valve engine

I read with interest your comments in the editors bench MEW, No154 re materials for pistons and liners. My Branch of the Hobby is Stirling engines and I have little experience of Steam engines (which is what I presume your Jowitt poppet valve engine is?). However I suspect the temperature at which the working cylinder lives in is not much different.

I would personally not expect any problem with Bronze in aluminium; I have done this several times but usually the other way round (to lighten the Piston). I have also used steel and cast iron liners successfully but preferably the other way round again e.g. a very much thinned down steel or cast iron piston in an aluminium bore.

What is also very successful is an anodised aluminium piston in an aluminium bore. I have not tried this so far but have seen the results from colleagues who have.

Again personally I would not consider PTFE unless it is a loaded PTFE material as the temp coefficient of standard PTFE is dreadful, Rulon is better and also makes excellent piston rings and seals. For my engines I still think the old fashioned leather cup seals take some beating being very easy to make and they only dry up if short of lubricating oil. They are probably not suitable for steam, I just don't know.

On a different subject may I say that the articles by Jayne Reeve are absolutely excellent to my mind? They may not be projects we would all care to make but are full of very useful information.

Geoff Bartlett,
Stirling engine Society, Birmingham

Readout spares

As a subscriber of MEW I am hoping that you could ask the readers for help in repairing/replacing my faulty DRO screen? I have a jig boring machine with Newall Spherosyn scales on the X and Y axes to provide a Digital Readout. These are connected to a Newall Digipac 5 reader. The machine is approximately 20 years old and I assume the DRO is of a similar age. The scales/readout worked well at first but have not been used for about 18 months. After this period the digital readout provided very erratic readings. I have been told by Newall that the fault code seems to point to an error on the key pad. However, they no longer supply spares for this unit.

I would like to know if anyone has a Digipac 5, or similar, for sale, that is compatible with the Spherosyn scales. This need not be in working order as it may only be the keypad that is required to restore my own unit to working order. Any help would be appreciated.

Stephen McCordick, by email.

Using the faceplate

Regarding the excellent articles by Harold Hall on the use of the faceplate, I believe there is one very important point that he has missed. When using the faceplate for the first time it is advisable to take a light skim across it as they are rarely if ever true. Similar treatment is also advisable at two or three year intervals, depending to some extent on the amount of use it gets. Cast iron, which is the material from which most faceplates are made is notoriously unstable and will quickly warp a little. Having said that, nobody should be frightened of using a faceplate, following Harold's advice it is quite easy to set one up and if this is done properly the work will be far more stable than it will be in a chuck. It is also possible to apply soft material to the clamping devices and so prevent marking the work, something that is not always so easy in a four jaw chuck. I bought my Myford, which I am still using, brand new for £38-10s-0d. It came without chucks, which I could not afford and so the first two years that I had it I only used a faceplate for work holding. In that time I built a 3½in. gauge locomotive, which should give some idea of how useful a faceplate really can be.

Stan Bray, Lincolnshire.

Unknown surface grinder

I have been an avid reader of your mag since its inception and follow keenly some of the projects. I read your recent request for more input on the "Scribe a Line page" and wondered if you or my fellow readers could put a name or date (or both) to my latest acquisition, namely, a hand operated surface-grinder of uncertain vintage, kindly given to me by my good friend Roy, who himself owns one of these unusual tools. Mine came as a basket case minus main shaft and rack & pinion, but these I have since manufactured in my very compact workshop at home, generating much pleasure and experience I might add. Both machines have war dept brass number plates, the originals being taken off. I am sending you two photos in the hope that someone can put a name or date to them.

Jeff Vines, by email.

Some more tips

A) For those who are plagued by rust, another tip from the woodworkers (apart from grease and heavy oil), is to use Camellia Oil (Axminster Power Tool Cat 510018), water thin and it does not transfer to the workpiece (wood). It is suitable for all fine tools and metal surfaces.

B) Harold Hall mentions using two part adhesives but dislikes the heat necessary to remove it. Use Araldite Rapid with too much hardener [+50%]. Clean the metals with meths, apply adhesive and allow to set for an hour or so when you have machined the part, using light cuts, apply a hard knock along the glue line using a soft impact material (hardwood etc). The part should detach and the surplus adhesive will clean off by light mechanical means.

C) On a Mini Lathe or any other machine with a non taper gib, an improvement is to add a dowel in a reamed hole to prevent the gib from moving along its length, if it moves it will ride up the screws and ball ends and actually stiffen the movement which you do not want.

Ken Willson, by email.

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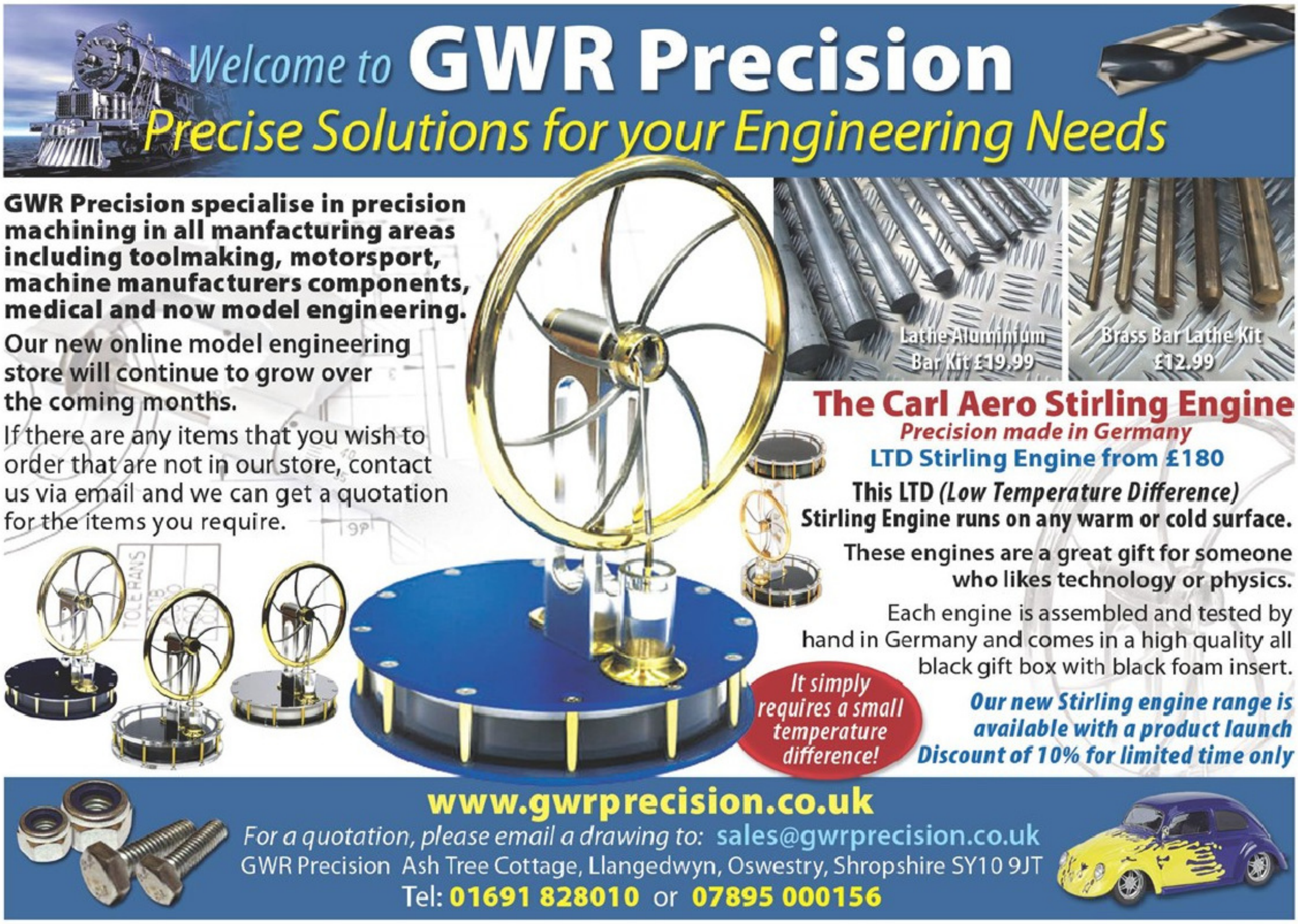

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