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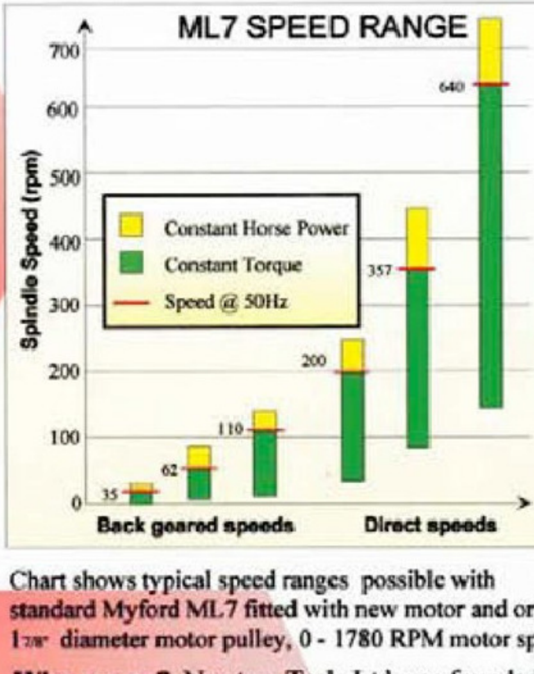

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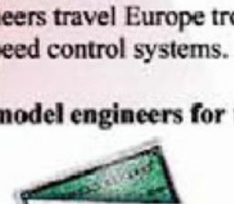

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MODEL ENGINEERS' WORKSHOP

Issue No. 77

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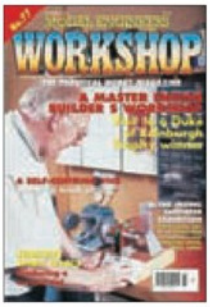
October 2001

The Tools and Workshop Appliances stand at last year's Model Engineer Exhibition



Front Cover

Brian Perkins winds the coil for the magneto of a miniature i.c. engine on his home-built coil winder. A report on our visit to his workshop starts on page 44

Published by
Nexus Special Interests
Nexus House, Azalea Drive,
Swanley, Kent BR8 8HU

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Origination by
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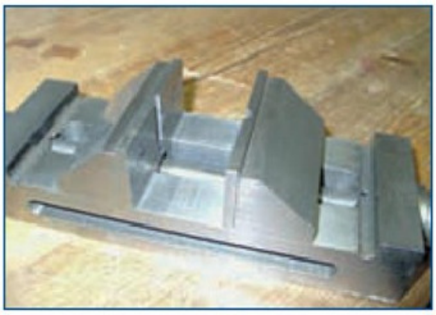

Inside

A self-centring vice permits rapid location of a workpiece for drilling or milling on a centre line. A description of this useful workshop accessory begins on page 47

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8 issues UK £24.00, Europe & Eire £28.88, Sterling Overseas: £31.44 (surface-mail) £34.48 (air-mail), US$ overseas $47(surface-mail) $52 (air-mail) Cheques payable to Nexus Special Interests Ltd.
USA Subscription Agent: Wise Owl WorldwidePublications, 1926 South Pacific Coast Highway, Suite 204, Redondo Beach, CA 90277-6145, USA. For Visa/Mastercard orders in USA telephone (310) 944-5033. Fax (310) 944-9963. Postmaster send address corrections to; Model Engineers' Workshop c/o Mercury Airfreight International Limited 365 Blair Road AVENEL, NJ 07001, USPS 010876

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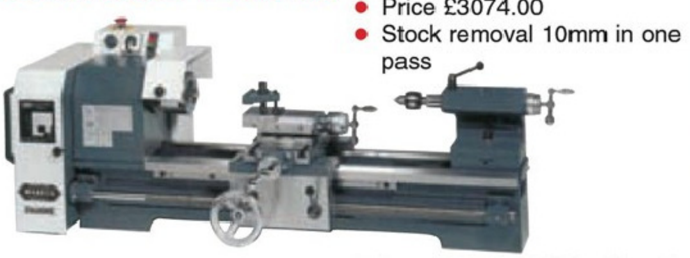

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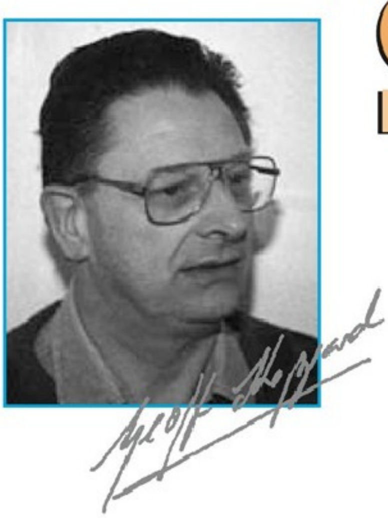


I am pleased to be able to tell readers that my successor as editor has now been appointed. David Fenner has a remarkably similar background to myself, having been apprenticed into the aero-engine industry (albeit at the other end of the country), has followed this with a successful career in the engineering industry and has now decided to seek a change of direction. He has been a practising model engineer for many years and has been actively involved in the affairs of his local model engineering society. He has said that he is currently making slow progress on a Bentley BR2 rotary engine - I have warned him that progress is now likely to be even slower!

David is now organising himself and his computing equipment to pick up some of the articles for the next issue and I foresee that I shall hand over Issue 79 completely to him. This will make a very neat arrangement because Issue 78 will be my fiftieth since I took over from Harold Hall.

Although David will be operating from a base even further from Swanley than mine, I am sure that the wonders of modern communication will not cause disruption to the production of the magazine. That said, readers may notice a few small inconsistencies in this issue. Our draughtsman, Grahame Chambers has moved to his house on one of the Greek islands, and although Paxos is 'fully digital' and communication is excellent, the transport company managed to damage one of his vital pieces of equipment beyond repair. We have therefore had to seek other help at short notice and also to use a few of our author's drawings untraced. We apologise and hope that the variations of style do not cause inconvenience

I must thank all those readers who have sent kind messages since I made it known that I was leaving the magazine, a number having made the comment that they suspect that it will not be retirement, but an opportunity to find yet more things to do. They are right, of course. I have already picked up the editorship of the newsletter of my local Industrial Archaeological Society, though at 12 pages three times a year, I don't feel that this should prove too onerous after M.E.W.! I have been approached by another publisher to write a book on an aspect of hobby engineering, but this I have declined as I don't feel the need for another deadline of that sort. There is, however, one publication for which regular requests have been received from readers and which may prove to make an interesting project. Perhaps more news of this in the near future.

One of the most enjoyable aspects of my time as editor is that it has given me the opportunity to meet many interesting and friendly people - indeed my wife, Gill, and I have made a number of new and lasting friendships which we value greatly. It has also given me the chance to look into some fascinating workshops and to discuss the many and varied approaches to model engineering adopted by their owners. In this issue I show just a few photos of the facilities available to Brian Perkins, a fellow member of the Rolls-Royce Heritage Trust and the builder of some exquisite internal combustion engines. Interestingly, his workshop is remarkably similar to my own, both in space available and the equipment housed therein, with a modest range of equipment of the sort likely to be found in most home workshops. Coincidentally, within a couple of days we were accepting a long-standing invitation to visit an eminent model engineer, the winner of many awards. This workshop was the type of which we all dream, both in terms of space and machinery, all used to maximum efficiency in the creation of some wonderful models. Comparison of these two facilities set me thinking. Clearly, the quality of workmanship coming from both is of the highest order, so this is obviously due to the skill of the operator rather than the facilities available. The difference is probably in the speed with projects can be completed as set-ups do not need to be disturbed if, perhaps, an additional item of tooling is needed and another machine is standing free. In the end, though, it all depends on the dedication of the modeller and the amount of time and effort which can be devoted to one's pursuit of the hobby.

I have just received a call from a reader inviting us to visit a very large, brand new workshop, purpose-built from the ground up and kitted out with no expense spared. I am looking forward to seeing his approach to the task and, even more, to examining the output from such a facility. From what I have heard, there are some interesting larger items to be seen.

All this has set me thinking about my own workshop, now that, hopefully, I am going to be able to spend more time there. Is it what I really need? What should I be looking to add or change? I suppose the first thing is to re-examine what I really want to do when I am there. What do I want to make? Perhaps a good starting point is to look at all those part-finished projects tucked away in cupboards and corners. Do they still interest me? Do I really want to spend hours finishing them?

The next thing will be to look at that fascinating collection of items squirreled away because I am sure they will come in useful one day. Throwing most of them away (No, can't do that - take them to the next club bring & buy sale) would create space for further development, but I guess the majority will have the dust blown off and get carefully stored for another five years. Reorganisation of the storage facilities is probably next on the agenda, trying to get a few more quarts into the pint pot. Previous attempts have usually resulted in it being just more difficult to find things when I really have needed them. As my colleague Mike Chrisp has remarked, if its not possible to find the things you have, you might as well not have them at all. Still, I mustn't get too gloomy, its all going to be a new adventure, so I must travel hopefully.

What do readers think? What would they put on their lists for the items to be put in their ideal workshop, and in what order? After all, for most of us home workshop equipment comes in the 'discretionary spend' category and there is a limit to that which we can justify. Please write and tell us. I'm sure that David would appreciate some letters to publish in future issues.

The Model Engineer Exhibition

Included in this issue is an entry form and the list of competition classes for the forthcoming exhibition. Please let us know in good time if you are planning to enter, so that the organisers can make sure that the necessary arrangements are in place. If you are willing to show a part-completed model or do not wish to have your entry judged, please use the same form, but just mark it clearly as being for the 'Loan' section.

We particularly welcome projects which are in an incomplete state because these are often more informative to visitors than the finished item. If someone is contemplating building a model, it can be very helpful to be able to examine the internal workings, to gain some idea of just what is involved in its construction.

Don't forget that we would like to see lots of workshop items, particularly projects from M.E.W., to encourage other builders. Also remember that, in Class A5 judging is carried out on a slightly different basis to that used for models. What counts is that a piece of workshop equipment should be able to carry out the intended task to the required level of accuracy. The finish on a piece of tooling need only be appropriate for the job.

Calling North Hykeham

Would the contributor to Scribe A Line from North Hykeham, Lincoln who wrote regarding the CES Gear Hobbing Machine please make contact as the letter which we have received is incomplete.

AWKWARD DRILLING

Not all drilling operations are straightforward. Philip Amos suggests ways of getting around some of the problems likely to be encountered

1. A right angle drive unit fitted to a portable drill, locked in angular position, with the drill depth rod engaging a hole in the attachment block

Drilling holes of required size in desired positions is not difficult, using centre drills for accurate positioning and successively larger size drills to reach the size needed. However there are times when accessibility becomes a problem; either there is inadequate space above the hole location to get the drill into position, or there is insufficient room beside a shoulder to accommodate the chuck diameter. This article suggests some ways that these problems can be addressed.

Free Space

It may be found that the overall length of the drill and its bit 'A' exceed the space available to work in 'B' - **see Drawing 1**. There are commercially available drills with a right angle drive which can sometimes overcome this difficulty, but these are expensive items (about twice the price of an ordinary portable drill) and would be hard to justify for the infrequent use they would get in a home workshop.

However, also available are relatively inexpensive right angle gearboxes such as that shown in **Photo. 1** attached to a normal drill. The manufacturer intends that these should be used by removing the chuck from the drill and replacing it with the gearbox; then refitting the chuck on the output side of the gearbox. This process is not altogether convenient, and furthermore if your drill does not happen to have a chuck with the same thread as the gearbox, it is not possible to effect.

My gearbox was sourced from Sears & Roebuck, USA, and its shafts have internal threads $^3/_8$in. x 24 NF together with an adapter as shown in **Photo. 2**. The gearbox has a 2:1 ratio so it is used to step up or step down the drill speed. It has a removable handle on its side to maintain its position relative to the portable drill and to allow pressure to be applied to the drill point more or less vertically above the hole.

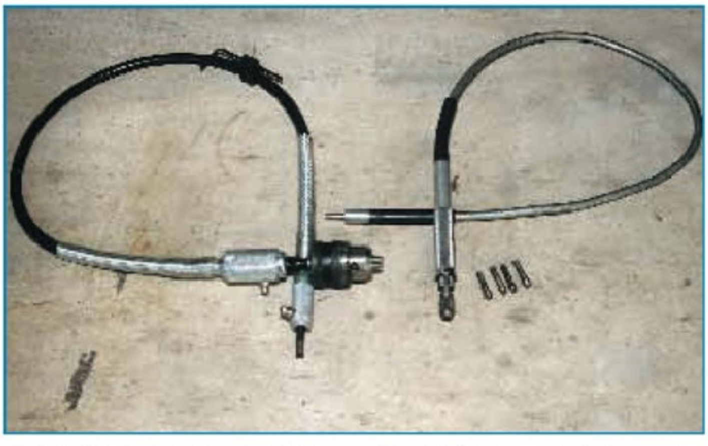
I have made an adapter, as shown in **Drawing 2**, so that the gearbox can be driven directly by the drill chuck and I have a separate spare chuck (shown in the photo) which fits on the output shaft. The attachment block shown in the photo and in **Drawing 3** is to hold the gearbox in a fixed relationship to the portable drill so that the use of the side handle is not required, but it can be fitted using a piece of studding as shown in the photo and the drawing. The drill depth gauge engages a hole in the attachment block to position the gearbox with respect to the portable drill body. The arrangement appears a bit flimsy but it seems to work all right in practice.

With this gearbox fitted the overall length of drill chuck and gearbox is about 150 mm as compared to the lengths for drill and chuck with my other drills as shown in **Drawing 4**.

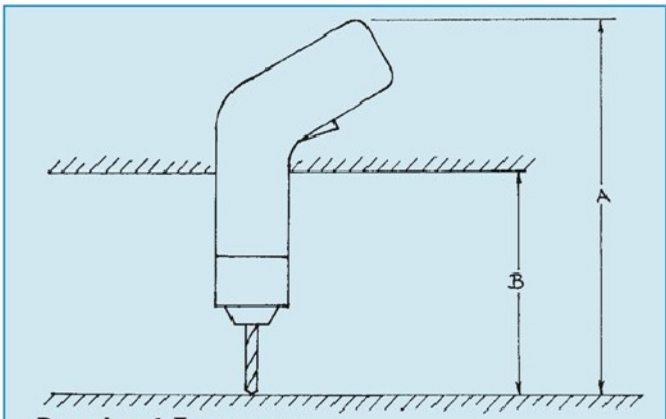
Very Limited Access

Even the arrangement described above may not allow the work to proceed. A flexible drive shaft may then provide the answer. **Photo. 3** shows two such devices, the large one having a conventional drill chuck and grease nipples for lubricating the shaft. Mine is Brand X from the local DIY shop. The

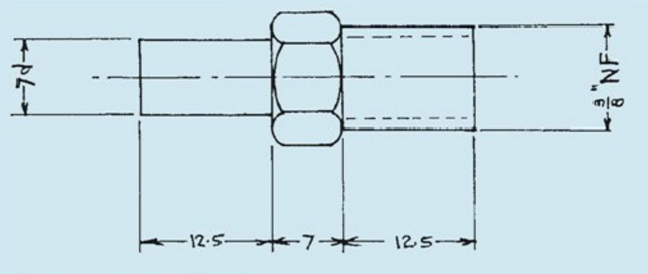
2. A right angle drive unit which had the bolt, handle and double threaded adapter supplied. The chuck, single threaded adapter, attachment block and screw are additions



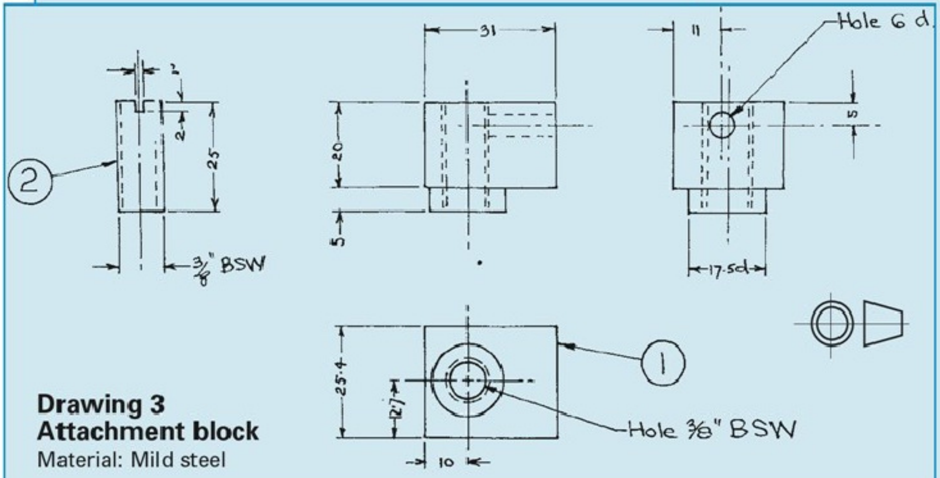
3. Flexible drives. The handpiece on the right has a movable sleeve to keep fingers away from the chuck



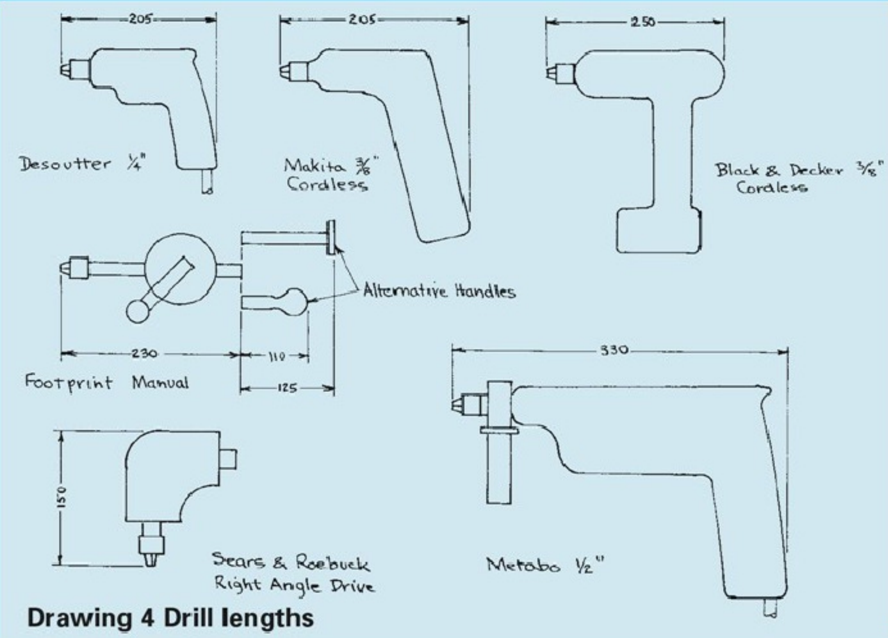
Drawing 1 Free space



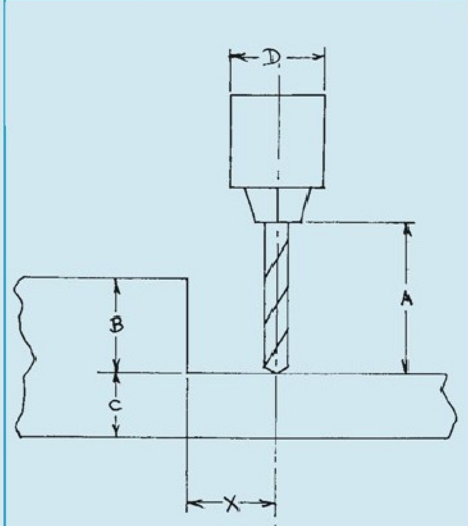
Drawing 2 Adaptor



Drawing 3
Attachment block
Material: Mild steel



Drawing 4 Drill lengths



Drawing 5 Shoulder

©

small one has a handpiece with interchangeable collets, intended more usually for use with grinding points and burrs, but which can be used for some small drills also. Mine is from Foredom Electric USA which I purchased there about 40 years ago but still in their catalogue. It has four collets with capacities as follows: 1/8in./3mm; 3/32in./2.5mm; 1.5mm & 1mm.

These flexible drives operate better when there is an angle greater than 90 deg. between the ends. Furthermore, there can be a problem if the drill catches when it breaks through. That end of the shaft stops dead while the drill continues to wind the opposite end. In such conditions the flexible shaft can tie itself into a knot if the drill power is not switched off immediately, with consequent severe damage to the device. I have destroyed such a device on one occasion because of this happening.

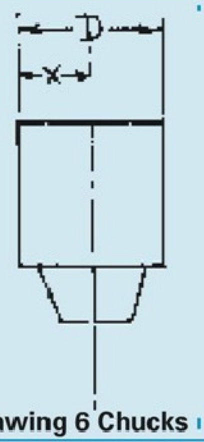
Nevertheless, with care the flexible shaft does allow the drilling of holes in places that are very difficult to get at.

Shoulders

Drilling a hole beside a shoulder on the workpiece is not a problem if the drill bit projection length A is greater than the sum of the height of the shoulder 'B' and the required depth of the hole 'C' - **see Drawing 5**.

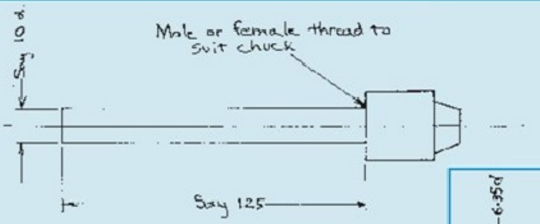
The availability of long series, and extra long series drill bits can sometimes overcome the immediate problem, but it is impractical to completely duplicate one's set of drills with long series or extra long series items. Furthermore, the range available in the catalogue is much more restricted than for jobber's length drills. However, if the drill bit length is insufficient for the Drawing 5 criterion, some problems ensue. Provided the distance from the shoulder to the hole centreline is greater than the radius of the fattest part of the drill chuck we are still in business, so the difficulties only arise if this is not the case.

What can be done? Firstly a smaller diameter chuck can be tried if one is available. The 1/2in. capacity chucks for my lathe, drill/mill and large portable drill have a maximum diameter of 55mm; those for 3/8in. capacity drills a maximum of 38.5mm and for 1/4in. capacity drills 29.5mm. These are tabulated on **Drawing 6**.

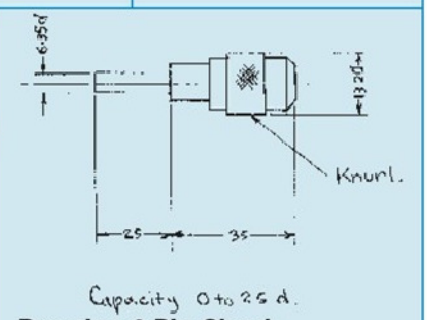


Drawing 6 Chucks

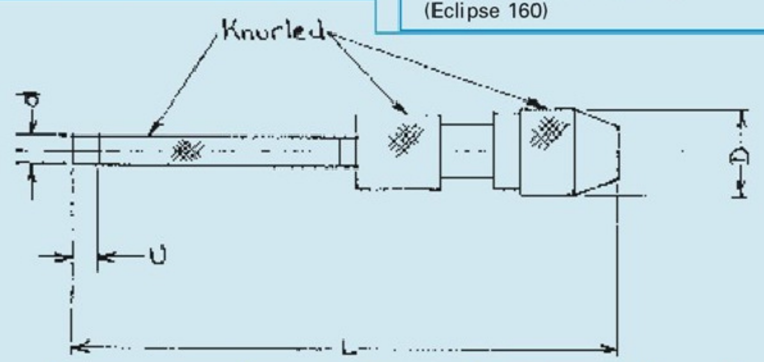
Item	Location/ Description	Capacity	D	Min X
1	Lathe	½″ or 13	53	26.5
2	Drill/Mill	½″ or 13	55	27.5
3	Desoutter	¼″ or 7	29.5	14.8
4	Makita	⅜″ or 10	31.5	15.8
5	Black & Decker	⅜″ or 10	38.5	19.3
6	Metabo	½″ or 13	42.5	21.3
7	Footprint (hand)	⅜″ or 10	33	16.5
8	Quorn	⅜″ or 10	32.5	16.3
9	Flexible Drive	⅜″ or 10	33	16.5
10	Foredom Flex Chuck	⅛″ or 3	11.5	5.8
11	Foredom Flex handpiece		16.5	8.3
12	Drill & Tap Jig - Drill Chuck	½″ or 13	42.5	21.3
13	Drill & Tap Jig - Large Tap Chuck		28.5	14.3
14	Drill & Tap Jig - Small Tap Chuck		22	11



Drawing 7 Extended shaft



Drawing 8 Pin Chuck
(Eclipse 160)



Size	Capacity	D	d	L	U
Large 124	3 to 5	14.5	8.3	104	9
Medium 123	1 to 3	13	6.5	93.5	9
Small 122	0 to 1.5	10.5	6.5	90	5
Xtra small 121	0 to 1	9	5	75	9

Small Chuck

The first approach might be to use a smaller chuck mounted on a short spindle which can be gripped in the main chuck jaws - **see Drawing 7**. The thread on this spindle to mount the chuck must be lathe cut to ensure that it is square to the axis and also concentric.

Pin Chuck

For smaller size drills (0 to 2.5mm diameter) commercially available pin chucks can be used - **see Photo. 4 and Drawing 8**. Mine is Eclipse brand. Their small overall length limits their usefulness for this purpose.

Pin Vices

These are similar to pin chucks but have greater length and greater capacity (0 to 5mm diameter). However, as the outside diameter of the shaft is knurled their centring accuracy is diminished. **See Photo. 5 and Drawing 9**. A light skim over the shaft with the vice held between lathe centres may improve this accuracy.

Drill Bit Extension

By carefully drilling a hole axially in a piece of silver steel rod and Loctiting (680) a drill bit in this, it is possible to overcome almost all the problems. But of course it is a burden to have to do this too often, particularly if it is intended to reclaim the drill bit after the event (e.g. by destroying the Loctite bond with heat).

4. Pin chuck with three collets

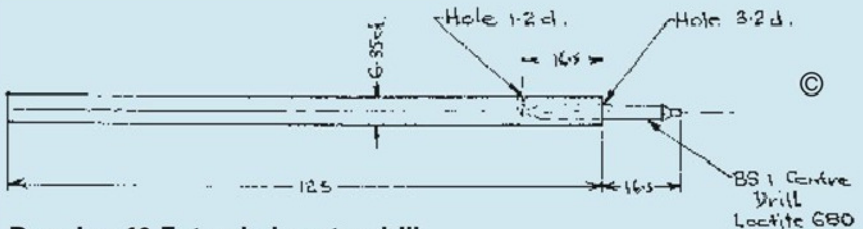
5. A set of four pin vices

6. Jobbers and long series drills (1/8, 3/16, and 1/4in. diameter) shown alongside a 1/2in. diameter jobbers drill to illustrate relative lengths. Also shown are an extended centre drill and an extended countersink.

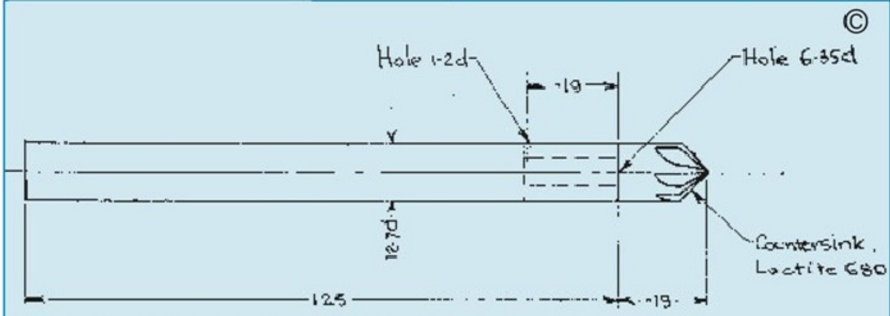
Special Cases

In two cases there would seem to be value in making up permanent extended length pieces. These are (i) a small centre drill and (ii) a countersink. In addition to allowing access beside a shoulder the availability of these devices also means that the head of the drill/mill does not have to be adjusted up and down when changing from centre drill to normal drills, and so these are commended as a worthwhile addition to the equipment of the home workshop - **see Photo. 6 and Drawings 10 and 11**.

The hole shape to accommodate the drill shank should match that of the shank for greatest strength of the Loctite bond. Thus for the centre drill the hole end is finished with the centre drill itself, and that for the countersink with a slot drill to get a flat bottom to the hole. A small transverse hole provides escape for air and excess Loctite.



Drawing 10 Extended centre drill
Material: Silver steel & HSS



Drawing 11 Extended Countersink
Material: Silver steel & HSS

Conclusion

With a bit of thought and preparation it is possible to drill holes in awkward hard-to-get-at places, which may otherwise not seem possible.

MODEL ENGINEERING COURSES

We are pleased to be able to bring the following courses to the attention of readers. Please support them as, without adequate numbers some are likely to be cancelled.

Dudley College, Broadway, Dudley. Wednesdays, 6.30 pm to 9.00 pm. Tel. 01384 455433 or Alan Jones on 01902 89 3557

Coleg Menai, Bangor, North Wales. Model Engineering Course Code GE40B. Wednesdays, 5.30 pm, commencing 29th September. Cost £47 for 10 weeks

Isle College, Ramnoth Road, Wisbech, Cambs PE13 0HY. Model Engineering day class. Friday, 10.00 am to 12.00, commencing 28th September. Cost £54 (£32.40 concessions) for 10 weeks. contact Chris Rabicano on 01945 582561 ext. 250 or e-mail chris.rabicano@isle.ac.uk

Chelmsford College, Moulsham Street, Chelmsford, Essex CM2 0JQ. Engineering Manufacture for Model Engineers - NVQ Level 2 (Course No. 20289C). Mondays, 6.00 pm to 9.00 pm, commencing 17th September for 36 weeks. Contact the Course Information Centre on 01245 265611 or tutor Steve Fewell on 01245 265611 ext. 5468

Reid Kerr College, Renfrew Road, Paisley, Strathclyde PA3 4PR. Model Engineering. Mondays, 6.00 pm to 9.00 pm, commencing September. Contact Eileen Mooney on 0800 052 7343

Falkirk College. Model Engineering. Wednesdays, 6.00 pm to 9.00 pm, commencing 19th September for 12 weeks. Cost £36. Contact Class tutor, Ian Bryce on 01324 403160

The Leys School, Cambridge CB2 2AD. Model Engineering. Wednesdays, 7.00 pm to 9.00 pm, three 10 week terms. Contact Edward George on 01223 508936

Southgate College, The High Street, Southgate, London N14 6BS. Model Engineering. Three courses, Tuesdays, 7.00 pm to 9.30 pm, commencing 2nd October, Wednesdays, 9.30 am to 12 noon, commencing 3rd October and Saturdays, 9.30 am to 12 noon, commencing 6th October. Contact the College on 0208 982 5050

East Yorkshire College, Carnaby Site, Carnaby Industrial BV, Bridlington, East Yorkshire YO16 7JW. Model Engineering. Mondays, 7.00 pm to 9.00 pm, commencing 17th September. Contact Roger Fozzard on 01262 852000, Fax 01262 852001

Gorseinon College, Belgrave Road, Gorseinon, Swansea SA4 6RD. Model Engineers Club. Thursdays, 7.00 pm to 9.00 pm. Welding for Beginners (BTEC Level 1). Wednesdays, 6.00 pm to 9.00 pm. Contact Michael Wildin on 01792 898729 Fax 01792 898729

Somerset College of Arts and Technology, Wellington Road, Taunton, Somerset TA1 5AX. Applied Machining Skills (Course No. L6614). Thursdays, 6.30 pm to 9.00 pm. 20 weeks commencing 20th September. Tel. 01823 366355

Bridgwater College, Bath Road, Bridgwater, Somerset TA6 4PZ. Mechanical Engineering (Practical Tasks) (Course No. TL319). Wednesdays, 7.00 pm to 9.00 pm. 10 weeks commencing 19th September. Tel. 01278 441234

TEMPERATURE MEASUREMENT

1. *A digital hand-held thermometer connected to a thermocouple probe*

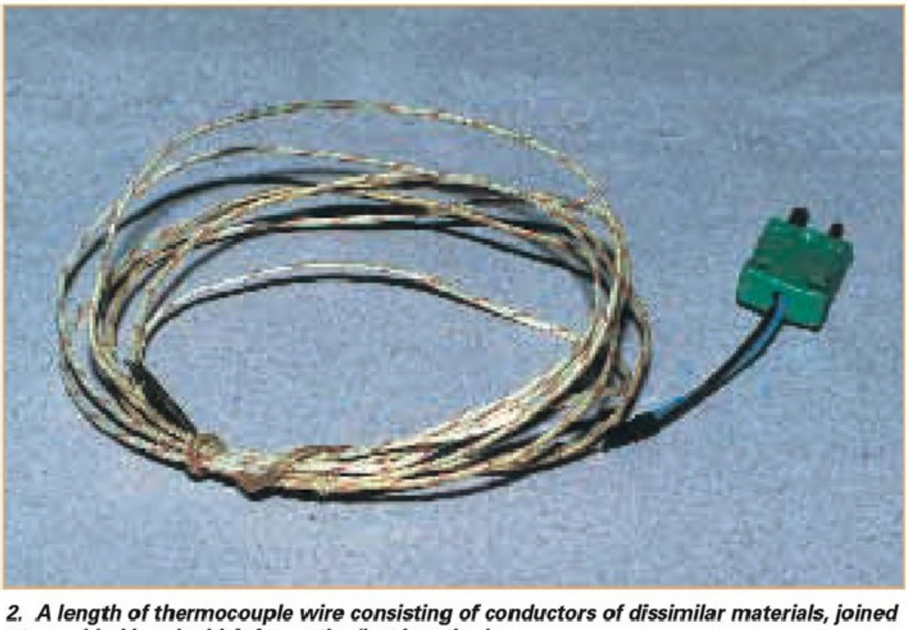
Dyson Watkins surveys a couple of methods of temperature measurement which may find application in the home workshop and briefly describes an example of an industrial system

An engineer often needs to be able to determine the temperature of a piece of equipment or a process, sometimes with a high degree of accuracy but occasionally a guess will suffice. At the lower end of the scale we have the mercury or alcohol glass thermometer. A version of this has without doubt been pushed under the tongue of most of us at some time or other. The purpose of this article is however to look at situations involving temperature measurement at more extreme values. In the case of automated methods, once a process has been adjusted to produce the required result, the repeatability of the equipment will ensure that the temperature attained will always fall into the required tolerance band. Take for example a steel automotive component which needs to be hard wearing but also having a degree of toughness. Ignoring induction heating, the steel (assume it to be a plain carbon steel) needs to be heated to a temperature of about 800 degrees Celsius, then quenched in cold water to achieve full hardness. The steel will now be very hard but also brittle, and in order to toughen it, the hardness needs to be reduced i.e. the steel has to be tempered. We do this by reheating the steel to a temperature at which it takes on a particular colour. Different colours occur at differing temperatures, and the hotter the steel the more the hardness is reduced. Judgement of the temperature will be affected by the amount of light falling on the object, which tends to make this method, a little hit or miss! The foregoing is not intended as an instruction in heat treatment, but simply as an illustration of the need for a means of temperature measurement, for without it, the final metallurgical condition of our workpiece may not be as we intended. It could still be rather brittle, or possibly too soft.

Another instance whereby determination of the temperature is desirable is in the use of a muffle furnace, which can be used for a number of purposes ranging from heat treatment to enamelling. Enough then of the preamble. Let us look at some of the methods available to us for measurement.

Direct reading thermocouple

This is a good choice for the measurement of temperatures up to about 1100 deg. C. The equipment consists of two dissimilar metal wires joined at the 'hot' end, and the other two ends are connected to the terminals of a calibrated instrument to read off the temperature directly **(Photo. 1)**. The instrument can be chosen to read in either Celsius or Fahrenheit. It might have several inputs, which enable the outputting of the difference in temperature between two points of measurement. It could even be a multi-input chart recorder capable of producing a number of temperature graphs plotted against time. Such items of equipment are understandably rather expensive and are generally aimed at the industrial user. It is possible however to construct your own thermocouple, the principle of operation being easy to understand. When the junction of two dissimilar metals is heated, a small voltage is generated across the junction. The higher the temperature, the greater the voltage developed. Strictly, for accuracy, the temperature of the 'hot' junction should be compared with that of a similar 'cold' junction held at zero degrees (perhaps in melting ice), but when elevated temperatures are being measured, the error due to the cold junction being at ambient temperature makes little difference. The cold ends of the wires are, therefore, connected to a DC milliammeter, a suitable range being 0 - 50mA. It should have a scale length of at least 2in. and for accuracy be readable to



2. *A length of thermocouple wire consisting of conductors of dissimilar materials, joined at a welded bead which forms the 'hot junction'*

one milliamp or better. The device as it stands cannot read temperature directly unless it is calibrated, the easiest method being the direct comparison with a commercial instrument. If when the meter needle deflects downwards when the hot junction is heated, simply reverse the connections to the meter. The type of thermocouple chosen will depend on the temperature range on which it is to be used. The most suitable type for an application such as the making of aluminium castings is the type 'K' 'chromel-alumel', as some types might be unable to withstand the temperatures encountered. This type can also be used for the heat treatment of metals and would be ideal for measuring temperatures at various points on, say, a hot air engine, or possibly to monitor the temperature of a bearing during a 'running-in' period. The type 'K' is the commonest thermocouple in use at this time, and is easily obtainable, being relatively cheap. It can be purchased with the hot junction in the form of a welded bead **(Photo. 2)**, which offers the possibility of installation into a small drilled hole of about 1mm diameter. The bead can also be cut away, and the ends can be separately tack welded near each other at the point whose temperature is to be monitored. Surface measuring probes of the type seen in Photo. 1 are also available, and are useful for quickly checking temperatures at various points, but have the disadvantage of being larger in diameter than the bead type and also take a longer time to reach temperature due to greater mass. The smaller the mass, the smaller will be its heat capacity, and the probe will track the temperature being monitored more closely, i.e. with a smaller time lag.

3. Tempilaq paints and crayons which are used to indicate, by melting, when a particular temperature has been reached

Attachment by spot welding

This procedure can be easily carried out where the thermocouple needs to be tacked onto ferrous metals, but it is not as easy to obtain a sound attachment onto some materials. The method involves charging up a fairly large value capacitor using a DC power supply and then discharging the capacitor into the object whilst positioning the thermocouple wire in between **(Figure 1)**. A 30 volt power supply is suitable, and is connected directly across the capacitors, observing polarity. A bank of five or six electrolytic capacitors each of 4700 microFarads with a working voltage of 50 volts connected in parallel will be enough. Electrolytic capacitors must be connected the right way round otherwise they are likely to burst; refer to the circuit diagram if in any doubt. Alternatively, charge the capacitors using batteries. It is a good idea to connect a current limiting resistor in one of the charging leads. This will limit the surge current from the supply and slightly delay the fully charged condition of the capacitors, but its use might be desirable if the supply can only deliver a small current. To calculate a suitable value of resistor, first obtain the rated output current of the power supply. This is usually marked on the rating plate. Let's assume the rated current to be 2 amperes. Then calculate as follows; -

$$\text{Resistance (Ohms)} = \frac{\text{Volts (say 30V)}}{\text{Current (2 Amperes)}}$$

$$= 15 \text{ Ohms}$$

Wattage rating of the resistor = Volts x Amperes

$$30 \times 2 = 60 \text{ Watts}$$

This might appear to be a rather large rating, but at the point of switching on the power supply, the full voltage will appear across the resistor because the capacitor will appear to present a short circuit. As the capacitor charges up so the current flowing through the resistor reduces until

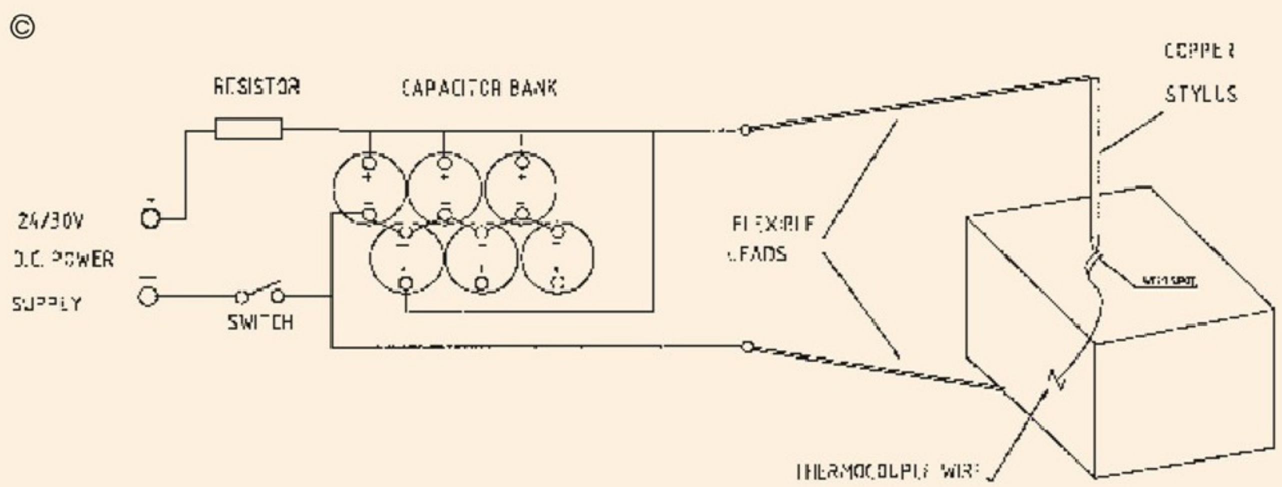
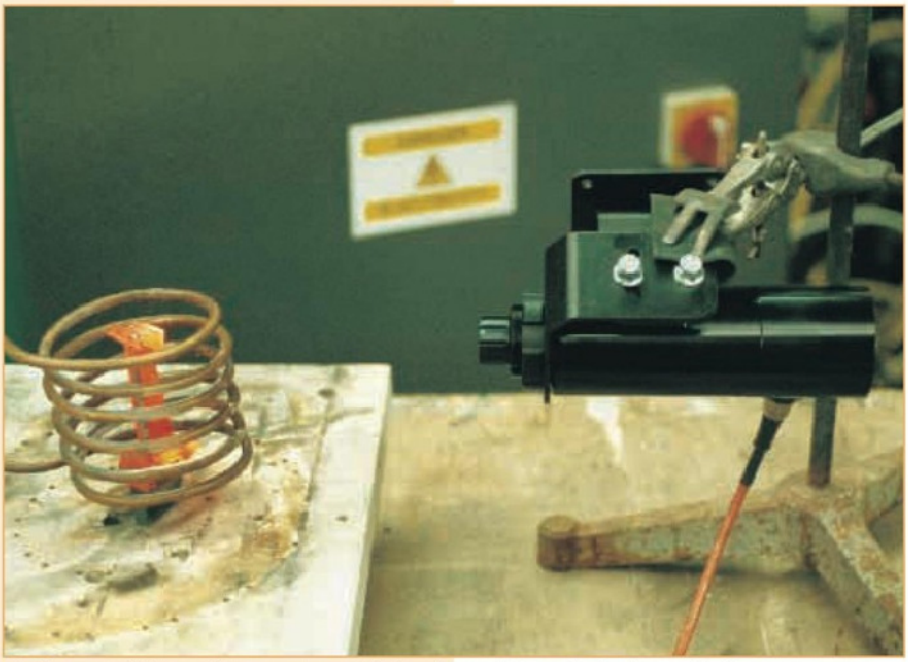


Fig. 1 Spot welding set-up



4. A gas turbine engine component being heated by an induction coil, the temperature being controlled by an optical pyrometer and a closed-loop system

to all intents and purposes, no current flows at all when the capacitor will have a voltage present across itself of 30 Volts. For practical purposes, a resistor having a much lower power rating would be suitable because of the short duration of the high current flow. A 5W resistor would be large enough.

When the capacitor is discharged by a short circuit into the workpiece, a large current will flow which provides the welding current for attaching the thermocouple. A secure attachment can be made in this way to steels and many alloys, but some difficulty is likely when spot welding to aluminium and copper, because their resistivity is low and therefore less heat is developed in attempting to produce the spot weld. Specially made adhesive patches are available from RS whose address is given below.

Tempilaq temperature indicator paints and Tempilstik

At the outset it should be mentioned that use of these indicators will not tell the user what the temperature of the part being monitored actually is, but it will show when a particular temperature has been reached. Both Tempilaq and Tempilstik **(Photo. 3)** are obtainable in over 100 temperature ratings each having an accuracy of +/- 1%. The range covers 38 deg. C to 1371 deg. C in steps which vary from some one or two degrees at the bottom end to 28 degrees at the top.

In use the part being monitored is marked with the required temperature marker. The marker should be applied thinly, as the thicker the application, the longer it takes to melt, even if only a fraction of a second. Colour changes can take place during heating and should be disregarded, the correct temperature being reached at the point when the mark has melted. It may not be possible to obtain Tempilaq for the exact temperature value required because melting points depend on the characteristics of particular compounds, but there is usually a value somewhere near.

A method I find useful is to paint a line of the required value (or the closest to it) on the part, together with lines of paints of above and below this value. This method gives prior warning of when the required temperature is being approached and, in addition, indicates whether or not this temperature has been exceeded by the margin indicated. Because of their accuracy, this method of temperature monitoring is particularly useful in the heat treatment of metals where the observation of oxide colours is unreliable i.e. the range of oxide colour temperatures for carbon steel is somewhat different from those for stainless, and in the case of non ferrous metals such as aluminium or brass, no well defined oxide colours occur to give a guide. Who hasn't accidentally melted a piece of aluminium during annealing? Silver soldering brass can also be a little tricky as the silver solder melts at a temperature not very far below that of the brass itself.

It is worth mentioning that these paints tend to thicken with the gradual evaporation of the liquid within each bottle, and should thinning be required it is imperative that the correct thinner be used according to the colour of the label on the bottle. Red label thinner for 93 deg. C to 1391 deg. C., Blue label thinner for 45 deg . C to 90 deg. C, and Green label thinner for 38 deg. C to 43 deg. C (this is simply tap water).

Tempil pellets are simply Tempilstik supplied in tablet form. The tablets are available in two sizes, the larger being 7/16in. dia and 1/8in. thick. The smaller tablet measures 1/8in. diameter x 1/8in.. Pellets are useful in providing temperature indication when using an oven, the indicated temperature being attained at the first sign of melting.

Infra red pyrometer

These instruments are rather expensive, and come in a number of varying styles with different facilities being provided depending on the particular manufacturer. The simplest versions are just temperature indicators tracking the actual temperature, whereas the more sophisticated instruments offer facilities such as closed loop control, laser sighting, pre-set temperature profiling etc. This method of temperature measurement is quite sophisticated compared with the others, and is more complicated to set up. The emissivity of the material being monitored needs to be known. For instance, the indicated temperature of a heated carbon block would be somewhat different compared to a heated block of stainless steel, although their actual temperatures might be the same. Compensation for the differing infra red emission from the various materials must therefore be made. Another problem which manifests itself, is the development of surface scale due to oxidation, which takes place during the heating process thus creating changes in the emissivity. A special coating is available which exhibits a constant emissivity throughout the temperature range, which has a value in the region of 0.9. The greatest advantage however is that this is a non contact method of measurement, which does not rely upon the attachment of a thermocouple. **Photo. 4** shows a component being held at a temperature of 950 deg. C using the infra red camera on the right of the picture and using a feedback loop via a fibre optic cable coupled to an induction heater via control gear.

Such a system does not lend itself to use in the home workshop environment on grounds of complexity as well as prohibitive cost, but has been mentioned to illustrate one of the techniques currently being employed in industry

The other methods described are, however, quite simple and one should be able to select something suitable for the problem in hand.

It should be noted that the foregoing article is not intended to be in any way exhaustive and is merely a brief look at some of the methods available.

Suppliers

Tempilaq

Walters & Walters, Orchard Road, Royston Herts SG8 5HA Tel 01763 245445

Instruments

A.T.P. Instrumentation Ltd, Ashby-De-La-Zouch, Leicestershire LE65 2YG

Maplin Electronics, Rayleigh, Essex SS6 SLU

RS Technical Help Line 01536 402888
National Order Line. 01536 201201

TAMING SPRAYDRIFT

Derek Brown suggests some simple methods of preventing ones' precious possessions ending up the same colour as the latest workshop project

Spray painting using either a spray-gun, aerosol can or airbrush gives rise to considerable quantities of spraydrift. Especially if the workshop is small or unventilated this can be a great embarrassment as I know only too well to my cost.

Several years ago I used a Badger airbrush to finish my Hunslet "Tony Priest" which many readers will know from its efforts on various tracks. The premises I used was a room about 10ft square at the back of the garage which housed two nice clean white motor cars. The room had once upon a time been my workshop. Spraying went well and I had a simple extractor fan which quite frankly was completely inadequate for the purpose. I kept the outside door almost shut to reduce the risk of dust ingress and I donned a 'romper suit' and correct face mask. Coat after coat of Midland Red enamel went on and the depth of colour built up to a pleasing finish. Then it was time to go and get some food - my wife had dug her heels in and it was my turn to go to the supermarket.... Strange: the bonnet of the car looks pink, even in the rain!.....So does the other one, and its roof and its boot, in fact all the horizontal surfaces.

I ended up washing both cars with thinners and then polishing them to restore long term protection; not a procedure to be repeated in a hurry. On examination it turned out that the connecting door with the garage had been cracked open and that is where the spray drift had gone. Lesson learned.

For my latest major painting project I wanted to use my workshop, which is attached to the house and to experiment with drift suppression measures, which turned out to be very successful, as I shall now report.

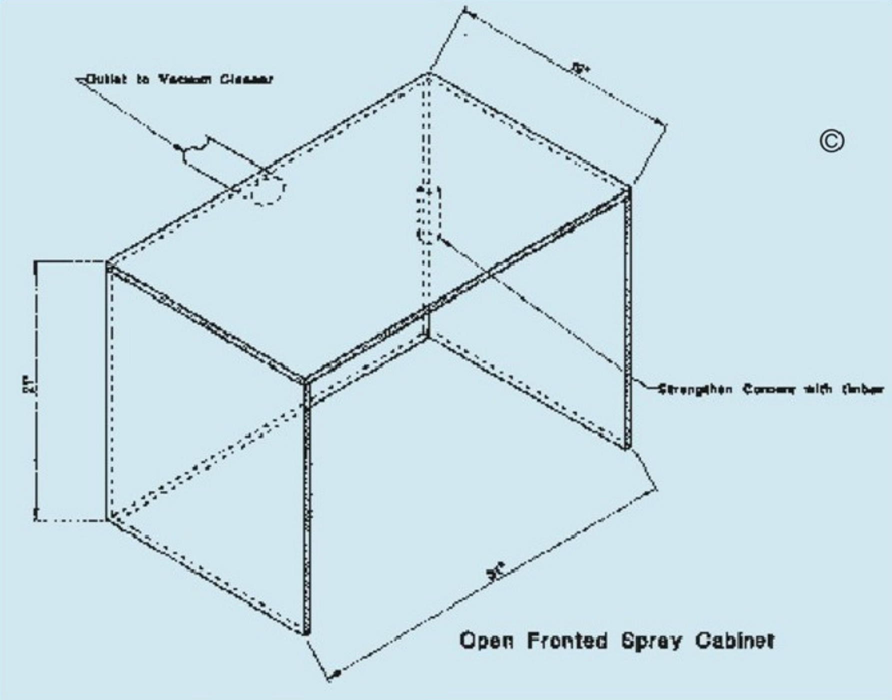
Our Church recently had a new notice board and as I helped put it up I was able to reclaim the original one, dated 1967. This was basically a sheet of fibreboard with its face painted to take the pins and clips of the notices. This was cut into four pieces to form respectively the back, top and two sides of an open-fronted spray cabinet which sits on the workshop bench.

Near the top of the centre of the back panel a 2in. dia hole was cut to take the hose of a vacuum cleaner. Now here I should say that I had available an old Electrolux which had seen service throughout about 35 years, so it did not owe me anything and had by now been relegated to workshop duties. It proved to be ideal for the purpose, a cylinder machine with plenty of 'suck'. Such old models are readily available second-hand and are much better for our purpose than the upright model of Hoover.

The hose used to connect from spray cabinet to vacuum cleaner was a length of flexible black rubber, purchased from the vacuum cleaner stand at our local street market. It is more flexible than the original maker's component, but plugs into the inlet side of the machine just the same. I found that by removing the dust 'clean-up' filter from the outlet side of the machine, the suction was considerably better. The original apprehension was how long a standard paper dust bag would last without

1. A general view of the cabinet. The vacuum cleaner is on the window sill while in the cabinet are the cake turntable, liberally covered with the Financial times, air brush to the right and face mask on the left

2. Looking up inside the cabinet, shewing the crude construction and vestiges of emulsion paint from its former existence. The red splodge is from a previous test run of paint, while the bluing around the vacuum outlet is obvious



Open Fronted Spray Cabinet

3. After a long session of Garter Blue spraying the vacuum cleaner inlet is well encrusted with colour but it goes no further than the bag

blinding. I reckoned that the paint pigment would give a good idea of how things were going. So, to start off, the vacuum cleaner discharge was led out of the window by means of the original flexible hose (that had been replaced by the cheap rubber one). In the event whatever I did, there was no trace of paint pigment anywhere downstream of the machine dust bag, but the delivery hose was found to cause a significant pressure drop and thereby restrict air flow; so it was discarded and the outlet end of the vacuum cleaner merely pointed at the window opening to aid the paint solvent on its way into the garden. A few handfuls of coarse sawdust were used to line the dust bag and this caught whatever spraydrift got into the vacuum cleaner.

4. This plastic syringe has dispensed several dozen doses of colour followed by corresponding amounts of matting agent and the thinners. The syringe is almost clean although the plastic tube retains some blue pigmentation

So long as the items being sprayed fitted inside the spray cabinet, the airflow was such that virtually all the spraydrift was removed down the flexible tube to the vacuum cleaner. Obviously a large item such as a pair of main frames requires dimensions greater than those shewn in the drawing. The immediate surrounds of the hole in the back panel were encrusted with dried paint as the air laden with paint particles swirled towards it and most of the rest of the contamination precipitated on the wall of the flexible hose. The dried paint in this area soon forms a brittle crust which can be easily removed to keep the airway clear. A small amount of drift finds its way into the bag where the sawdust soon mops it up, leaving the pores of the paper bag quite clear. A sheet of newspaper is ideal for protecting the bench etc.

The overall verdict of this method is that it really works and involves relatively little effort or expense to set up and lends itself to recycling second-hand materials. A cabinet could even be made from stout cardboard of the type used to wrap consumer durables from the factory.

Other Bits and Pieces

Gaining access to all sides of a component being sprayed is almost essential. A cake maker's turntable is a useful accessory for this purpose; it turns freely and is heavy enough not to be easily moved or upset. Such items are available at auctions and car boot sales.

Mixing paint for spraying should be regarded as a precision operation, but measuring the liquids accurately and cleanly is not always easy. Cheap plastic syringes are ideal for the purpose, sizes around 20 to 25ml (or just short of an ounce) are ideal. A syringe is useless if it contains a rubber 'O'-ring, since the paint solvents play havoc with the rubber, so the cheap disposable type is the only answer and this can be obtained from Paul Gammon.

A successful procedure is to measure out first the paint of the desired colour, then a dose of matting agent (if required) and finally the correct quantity of thinners. This ensures that the syringe is washed clean in the process. I have found no problem in sucking paint solutions direct from their tins, but the thinners usually comes in a tin with a small diameter lid; so my solution is to attach a suitable length of plastic hose to the end of the syringe through which the thinners is easily sucked. Here again I should like to pass on a tip for recycling useless household trash which normally goes into the dustbin. Years ago domestic liquids such as window cleaners and hair sprays came in aerosol cans, but environmental pressures have banished such packaging in favour of plastic bottles with hand pumps. When the bottles are empty, take a look at the delivery mechanism: you will find a useful length of plastic tube of varying diameter, one or two stainless springs and a stainless steel ball of excellent quality; the rest, so far as I am concerned, is junk. I now have a collection of stainless balls from $^3/_{32}$in. to $^7/_{32}$in. dia. which are perfect for injectors, non-return valves etc., some springs of dubious usefulness and a whole load of short plastic tubes, some of which fit the end of a plastic syringe perfectly. I would add that I have learned such thrifty tricks from one member of our local Society usually known as "The Bearded Sage"; he not only dispenses with razor blades, but also makes small locomotives completely from scrap components and other people's cast-offs. He warms to this latest idea of reclaiming waste materials!

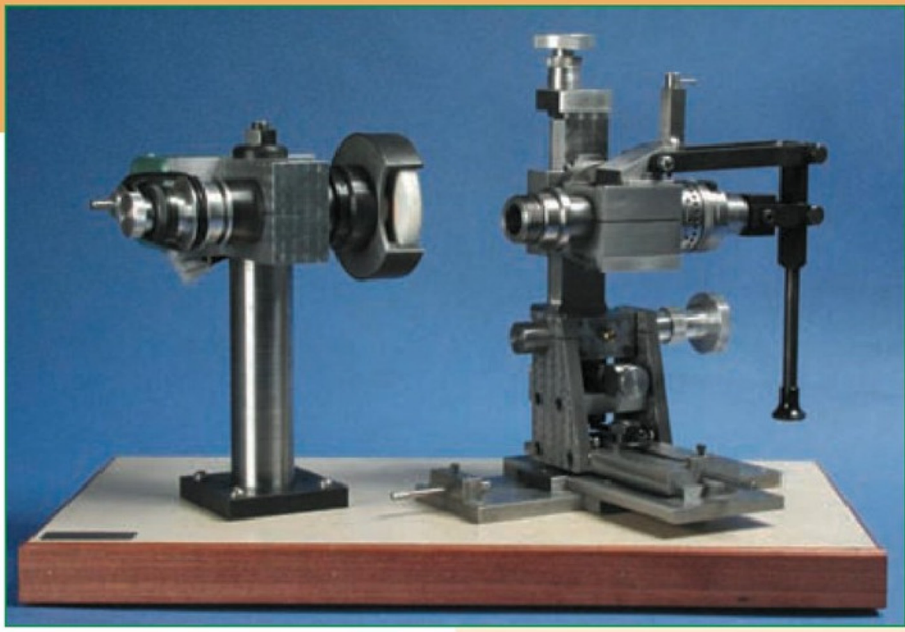
So on that rather light note I can honestly claim that if you adopt these ideas spray painting with an airbrush will become a much less disruptive occupation. As for the vacuum cleaner, mine has so far suffered no ill effects and even the bag is good for further service.

Supplier

Paul Gammon 4 Hurst Road, Epsom, Surrey KT19 8SJ (Tel 01372 729726).

THE RAYMAC CUTTER GRINDER

Raymond McMahon continues his description of his award-winning cutter grinder



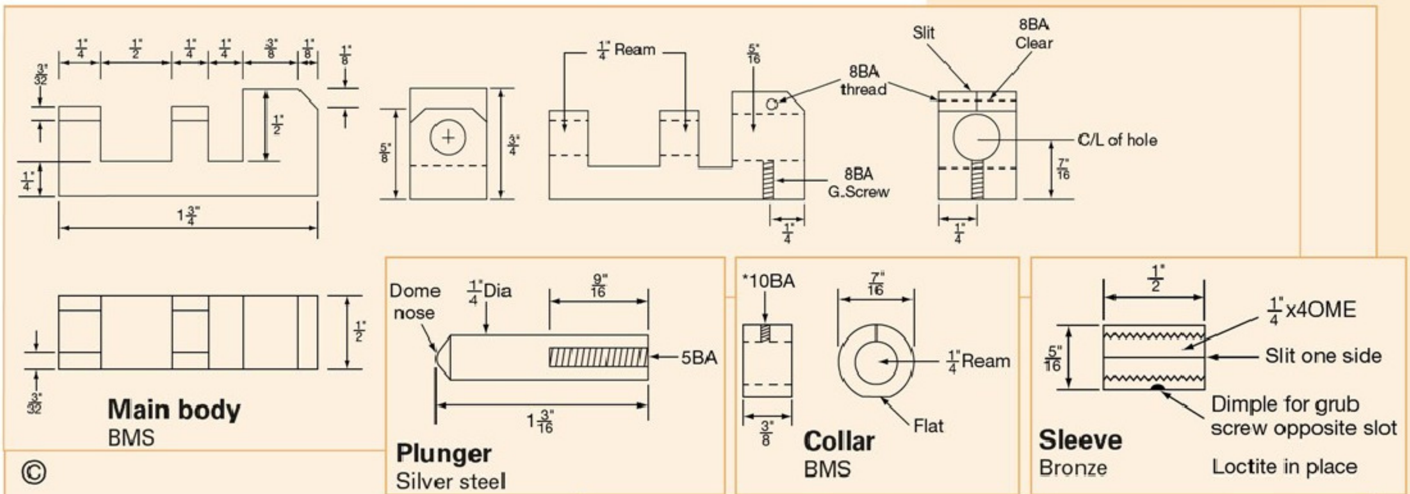
The superfine adjuster

I had originally intended to keep this item up my sleeve until later, hence the out of sequence item numbers. However, as it is attached to the Spacer Plate (Item 16), it is probably more appropriate to describe it now. It is the assembly which controls the angle to which the Pivot Pillar (Item 28) is set on the Pivot Shaft **(see Photo. [29])**.

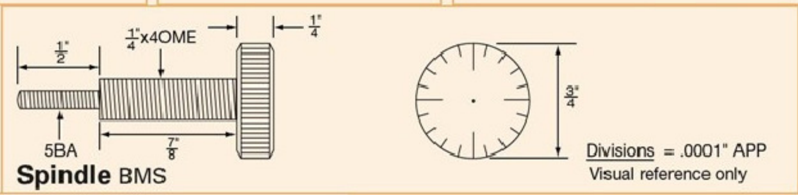
Some years ago I had occasion to design a very fine mechanical adjuster for a piece of scientific equipment that was destined for Antarctica. The unit worked extremely well and was found to be very precise in operation, working on the principle of a differential thread. I will try to explain how it operates:- if we take a threaded spindle that has two threads on it, such as our example 5BA and 1/4 x 40 tpi, we know that if we turn the 40 tpi thread it will advance 0.025in. per revolution. At the same time, if we have a nut on the 5BA thread which is not allowed to rotate, it will retract at the same time by 0.023in. per revolution. Note the difference between the two pitches - 0.002in. per revolution, which means - if you are still with me - that as one thread advances that advance is almost cancelled out by that of the other thread. Because of the difference in pitch, the total movement in a forward direction is just 0.002in. per revolution - EUREKA! If you now add a micrometer head to the spindle which is divided by 25 you end up with an adjustment control which is too fine for me to work out - mathematics was never my strong point!

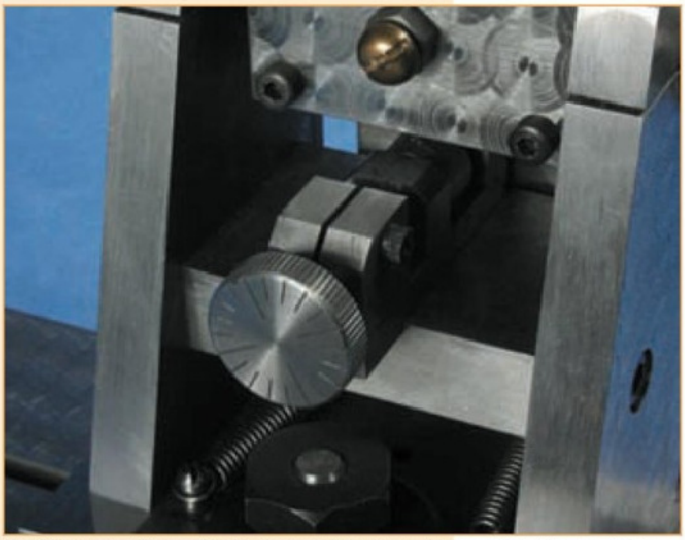
If we now replace the nut with a plunger, we now have our superfine adjuster. It is used for the pivot control stop when grinding the helix angle of end mills where very fine control is highly desirable. As there is only a limited amount of total plunger thread movement in the system, I have made provision for a coarse setting control to the rear of the pivot pillar

The unit is quite simple in its construction but there are a few things to watch for. The movement is contained in a block of steel 1/2in. x 3/4in. (Item 76) and after machining the two slots in the Body you are likely to meet up once more with Mr Stress, the underside probably having arched by a few thou. Skim to correct this and re-skim the top surface again. Set up in the 4-jaw chuck with the 5/16in. bore end of the block facing the tailstock, carefully drill and ream the 1/4in. bore for the Plunger (Item 77), making sure it is a very good fit, then open out the end to 5/16in.

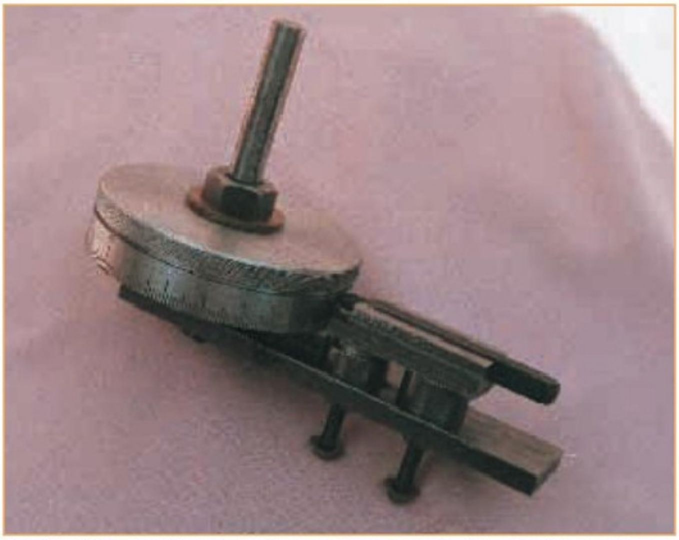


Note:
Plunger must be close fit in main body.
Collar flat clearance only to allow linear movement.
All threads to be close fitting.
* Dimple plunger to take 10 BA thread





1. The superfine adjuster assembly mounted on the Spacer Plate. The two Balance Springs are also visible (Photo. Mike Chrisp)



2. The jig used for stamping numbers on dials and micrometer sleeves

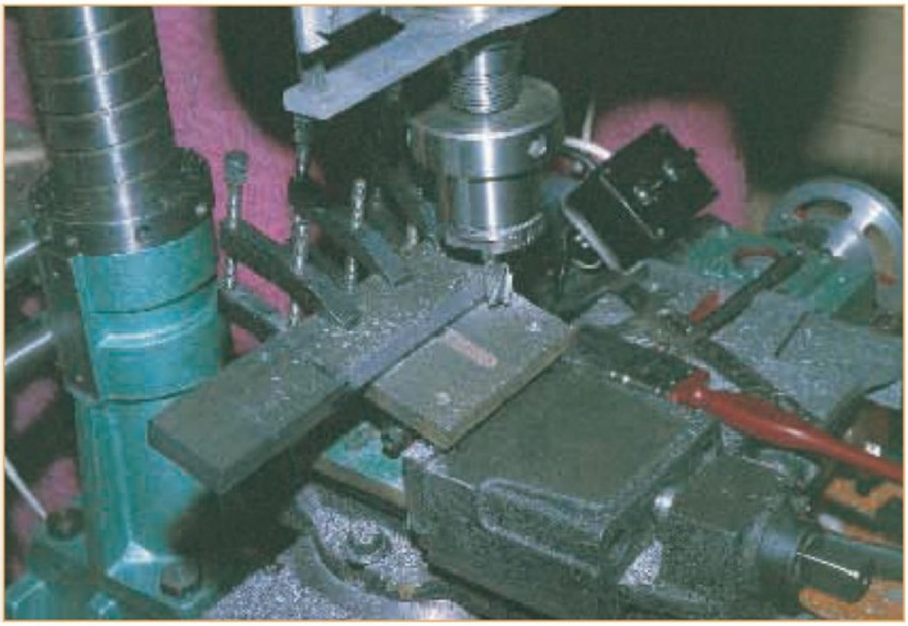
diameter. Remove and carry out the rest of the machining to the block, taking care when cutting the threads to aim for a close fit in respect of the 5BA thread in the Plunger, a split thread being incorporated to take care of adjusting the 40 tpi end. Carefully machine the flat on the plunger Collar (Item 78) - I would suggest that it may be better to part off a few extra collars as it is rather tricky to remove the correct amount of material for the flat at the first attempt. Machine down to within a few thou. and do the final dressing by hand. Clearance at this point should be such that the Collar can advance forward with the Plunger with hardly any radial movement. You will be amazed to see how many turns of the Spindle you will have to make in order to see any significant movement of the Plunger in a forward direction. Remember that you have only approx. 25 thou. total forward movement.

When you have all the parts made, Loctite the split Sleeve (Item 79) in place. Screw in the Spindle (Item 80) until the start of the 40 thread section is just visible at the wall of the slot, slide in the Plunger at the opposite end with the Collar and screw it on to the Spindle until the end of the Collar is again level with the wall of the slot. Assembled correctly you should have a 1/4in. space between the end of the Plunger and the start of the 40 tpi thread. In between you should have only the 5BA thread showing. You can now lock the Collar in place; it should be by now in the middle of the gap. The graduations on the Spindle are there for position reference only.

The unit can now be mounted on the Spacer Plate. You will find that the hex. head attachment screw is easily reached with a 2BA spanner for setting up.

Pivot Block (Item 22)

The Pivot Block is straight forward enough, but it must be pointed out that the 1/2in. hole should be carefully reamed. Note that it is offset to one edge and not in the middle of the block. Care should also be taken to make sure that the slit is positioned on the underside, as in this position there is a certain amount of protection from any grinding dust. The 1/16in. deep location channel for the Pivot Pillar should be a close fit and exactly at right angles. If you have a piece of 1/2in. silver steel to hand, now is the time to pass it through the bearings and pivot block in order to check alignment. Any inaccuracies found at this stage should be investigated and corrected accordingly as the stability and accuracy of the assembly is completely dependant on the close fitting of the block on the Pivot Shaft. In order to obtain a perfect fit, use a piece of scrap silver steel and insert it into the bore, charged with light oil and a drop of Brasso. Rotate and move it up and down the bore at the same time, thus honing and polishing the bore. As you work, close the bore round the shaft using the two pinch screws and very soon you will feel the difference as the bore becomes highly polished. Add oil and decrease the amount of Brasso until you end up using just oil. You will find that, using the screws, you will be able to adjust clearance to a very fine tolerance.



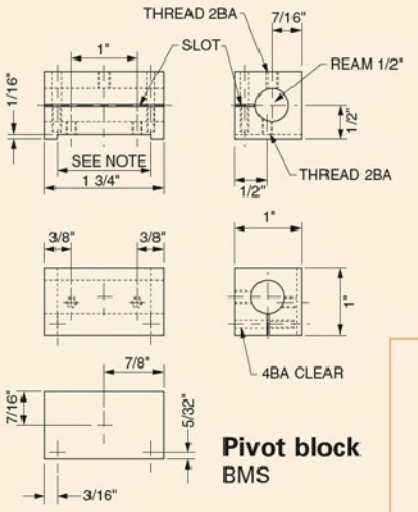
3. Machining the angled edge on the Pivot Pillar

Pivot Shaft (Item 23)

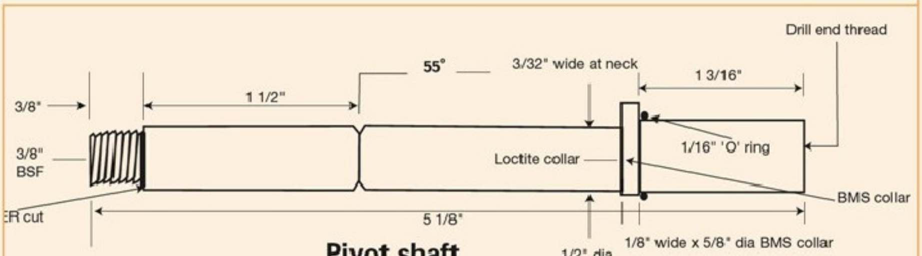
This shaft is machined from silver steel, the nose being threaded 3/8in. BSF. It is recommended that the shaft should be set to run true and the thread screw-cut to start with, to within a few thou. of the finished size, after which it can be chased up with a die in the tailstock die holder. The V groove should be machined, again with the shaft clocked true. The cone-head screw (Item 22A) that locates in the groove is made from brass so that it does not cause damage. In use, this screw should adjusted periodically so that it allows the Pivot Block to rotate without axial movement, this being particularly important when it comes to grinding the nose of endmills.

Knurled Knob (Item 25)

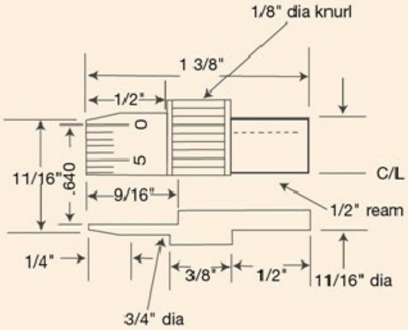
The Knurled Knob was made quite large so that firm control can be achieved when advancing the cutter towards the grinding wheel. It is used in conjunction with the graduated Micrometer Sleeve. A 6BA screw is used to provide positive locking



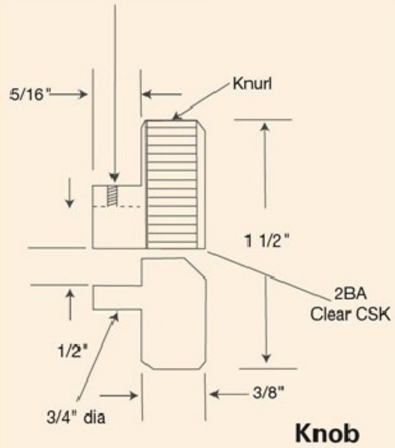
Pivot block
BMS



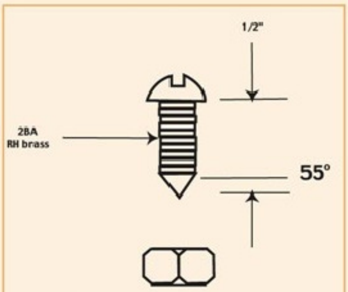
Pivot shaft
½" dia. silver steel



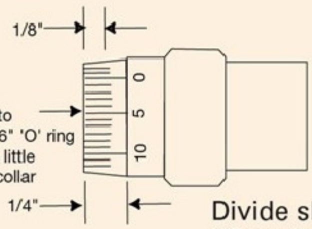
Micrometer sleeve
Alloy



Knob
Alloy



Screw and nut



Note:
Length of collar to be such that 1/16" 'O' ring is compressed a little for friction fit of collar

Divide sleeve 0-50 = .001" div.
1⁄16" number stamp

©

of the Knurled Knob to the Pivot Shaft. The hole should be drilled with the Knob located on the Shaft, drilling on through into the shaft then threading in situ.

Micrometer Sleeve (Item 24)

The periphery of this Sleeve is divided into 50, each division representing one thou. of axial movement. An adjustment of one thou. or less is quite easily achieved. The Sleeve can be set to zero, an '0'-ring (Item 27) being used to provide the necessary friction. The blank should be set up so that drilling, reaming and counterboring is carried out at the one setting. Ideally, after machining the taper and knurling, dividing should be carried out while the component is still in the lathe chuck. If you cannot do this operation directly, you will have to set up a division plate or jig to give 50 divisions. The sleeve can now be reversed and machining completed. Incidentally, if you prefer to use steel for the sleeve there is nothing to prevent you in doing so, but in some ways aluminium alloy is to be preferred as the component will not then rust with handling.

The numbering is carried out with a simple jig, **(see Figure 1)**. It consists of a slotted carrier to which a channel is attached using two steel spacers. At the foot of the channel there is a centre graduation and one to either side. The

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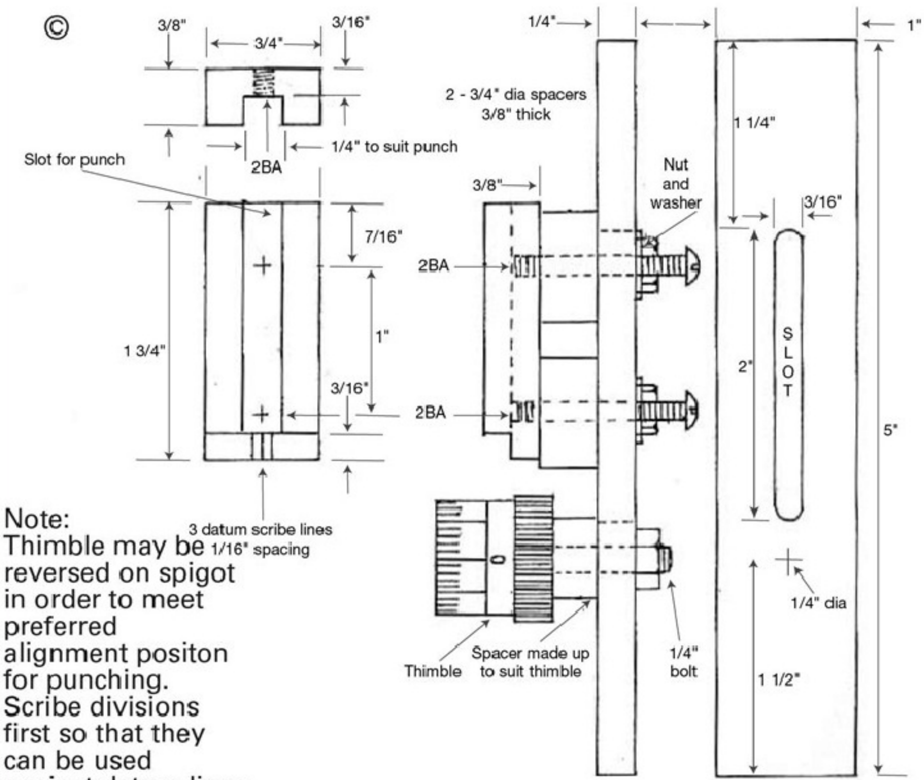
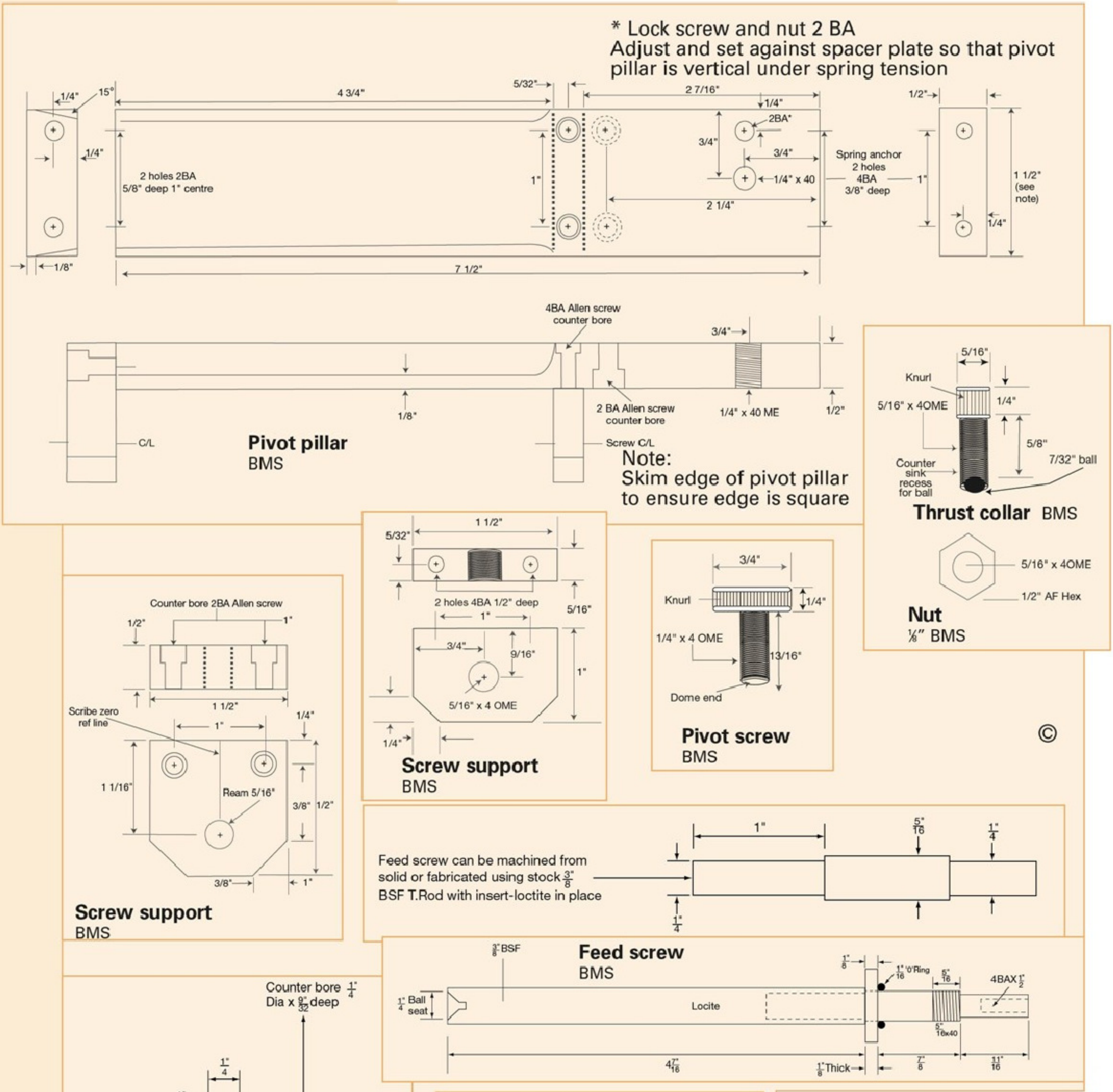
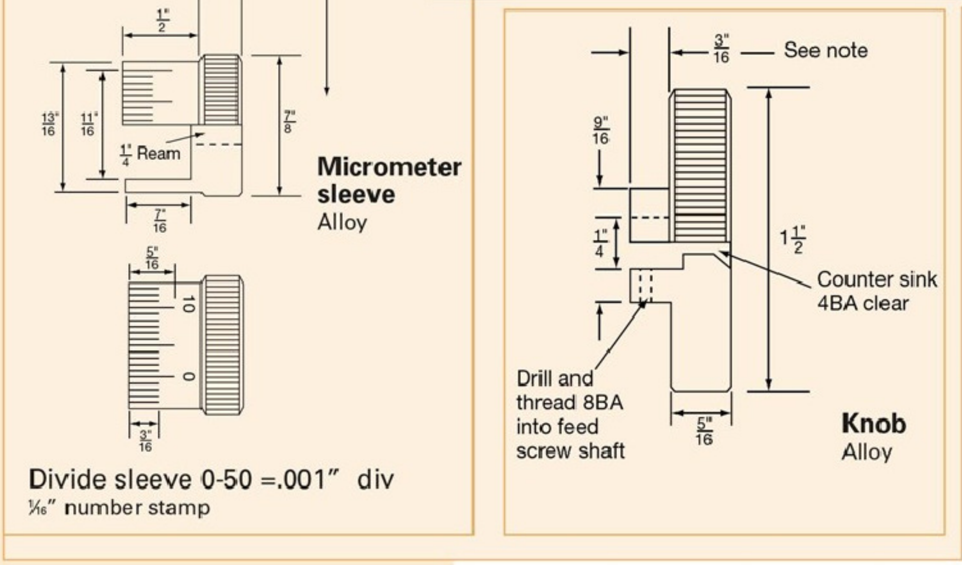


Note:
Thimble may be reversed on spigot in order to meet preferred alignment positon for punching. Scribe divisions first so that they can be used against datum lines on jig.

Fig. 1 Number stamping jig
BMS

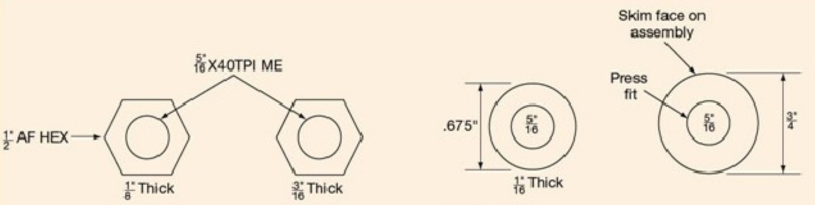




spacers and carrier are slid in to the required position and locked, the thimble is located on the mandrel, and for single figures it is just a matter of aligning the centre line on the channel with the graduation on the thimble, inserting the punch and stamping **(Photo. 2)**. For two figures you line up the graduation to the left or right line on the channel and punch accordingly. The whole assembly is held in the vice for this operation.

Collar (Item 26)

The bore of the Collar should be reamed. The position at which it is Loctited the shaft is important, so the sequence for fitting is as follows:- with the Pivot Block assembled, turn the Shaft clockwise so that the Block

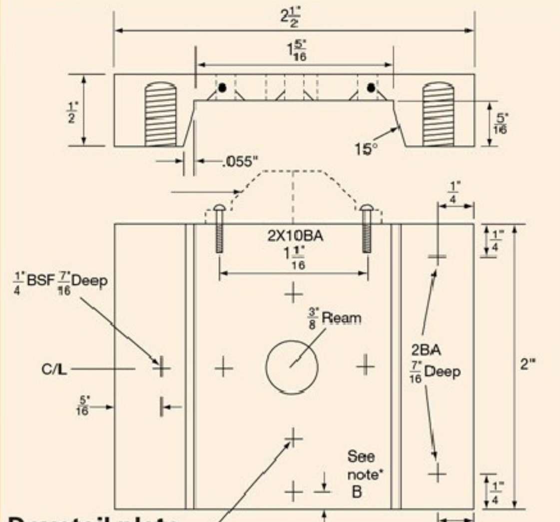


Lock nuts
BMS

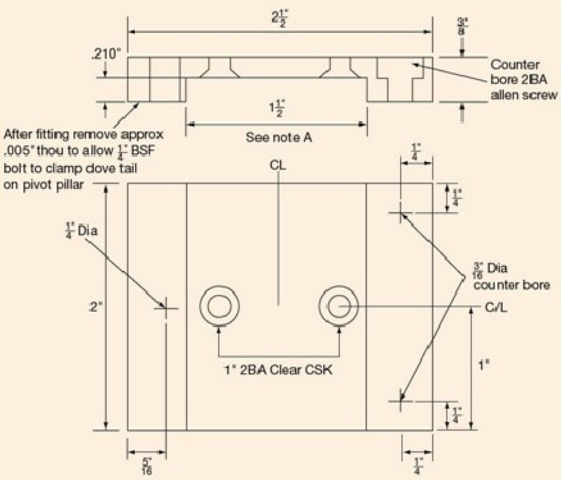
Washer
BMS

Collar
BMS

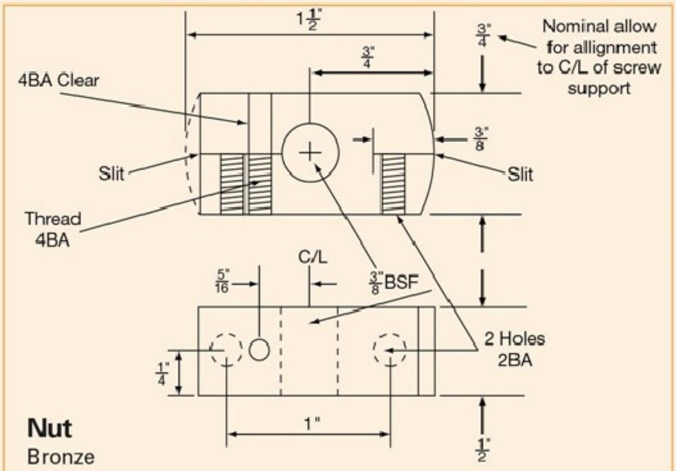
Note:
Length of collar to be such that 1/16" 'O' ring is compressed a little for friction fit of micrometer collar.



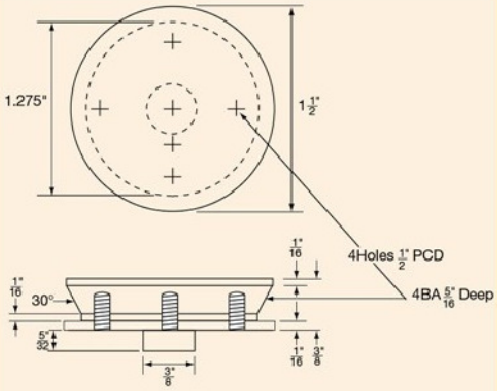
Dovetail plate
BMS



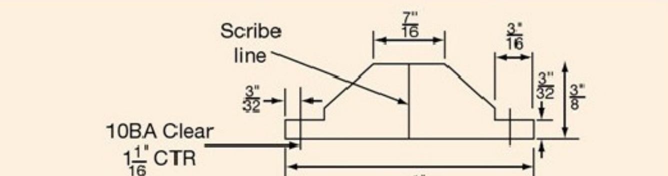
Clamp plate
BMS



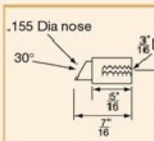
Nut
Bronze



Dovetail
BMS



Datum plate
3/16" BMS



Locking pin 2
Silver steel

arrives at the extreme of its travel - no gap between the end face of the Block and the side of the right hand Side Plate. The Collar should be placed with a 5/16in. gap between it and the end of the bearing. When the Loctite has cured, fit the '0'-ring and assemble the Micrometer Sleeve along with the Knurled Knob. If the Micrometer Sleeve rotates freely without friction, skim a little off the recess inside the Knob. If the Sleeve will not turn or is very tight skim a little off the extreme end of it. Ideally one should have enough pressure applied to the end of the Sleeve via the Knob in order to compress the "0" ring very slightly. It is this little bit of compression that allows the Sleeve to be adjusted to zero when required and to stay in place when set.

Pivot Pillar (Item 28)

The Pivot Pillar which, up to now, has had only the edges machined square in order to fit the channel in the already machined Pivot Block is next. The Pillar supports the Collet Head which has to be adjustable for height and has to rotate on a central axis. Added to this it has to be located positively and set to a centre line which is comparable to the centre line of the grinding head spindle. This centre line height may vary slightly as the grinding wheel wears, but a simple setting gauge will make allowances for this as required. Only when the centre line has been set can the additional corrected height adjustment be made for grinding the helix edges of the end mill - but more of this later.

I decided to compromise between a dovetail slide and a slide with square edges - you can see it is a bit of both! It is easy to produce and one angular setting will allow all the machining to be carried out without any adjustment, thus ensuring that everything will bed in together. For this operation you can, if your milling machine will allow, set over your spindle to the required angle. Alternatively you can set up an adjustable angle plate and clamp the material in place. As light cuts were being taken, I was able to use tool maker's clamps in this instance **(Photo. 3)**. The line at 1/8in. from the face should be carefully scribed as a reference and you will find that when you get near the line, you will be able to establish if your angle is running parallel to the edge of the material. Initial clamping to the edge of the

4. The Pivot Pillar Assembly, showing the feed screw and its mountings (Photo. Mike Chrisp)

angle plate should be accurate enough in most instances, but if you have any doubts, use your dial gauge. Once machined its just a matter of reversing the material to complete the other side.

Dovetail Plate (Item 43)

The Dovetail Plate which is made from $^1/_2$in. thick steel can be marked out, the narrowest point of the dovetail on the Pivot Pillar being measured for reference. This measurement should then be transferred to the Dovetail Plate blank, after which the channel (with square walls at this stage) can be machined. When the base measurement line is almost met, the blank should be removed from the vice. Stresses which are relieved during the machining will now come into play, and if you examine the back of the blank you are likely to find it curved - admittedly it will only be a few thou., but it is enough to matter. This curvature is easily removed by rubbing the back on a sheet of emery on a flat surface, and the same treatment should be given to the other side. The blank can now be repositioned in the vice and machining continued, the next part of the operation being to angle the walls. As before, it can be clamped to an angle plate or the head set over. When the cutter just touches the top edge of the wall, zero the dial and continue to machine the angle until you have machined away 0.055in. until, at this point, the cutter will have almost met up with the bottom corner base line. Reposition the blank and machine the same amount off the other wall until, with the two angles machined, you are in a position to drop the Pivot Pillar into place. All things being even, the Pillar should lie snugly in place, with a gap between the underside of the Pillar and the inside of the dovetail. This measurement can be between 5 and 15 thou. Polish out any machine marks that are on the walls of the dovetails so that you have a nice sliding action.

There is a small but important item to complete this part, that is the Datum Plate (Item 48), although the fitting of this item cannot be carried out until the Collet Head is completed, two 10BA bolts holding it in place. The scribed line will need to be carefully positioned with relation to the zero line on the Degree Setting Ring (Item 50). Needless to say, the Collet Head must be positioned horizontally and at right angles to the Dovetail Plate.

Dovetail Clamp Plate (Item 44)

The blank for the Dovetail Clamp Plate is similarly machined, the depth of the channel being quite important, but this can be measured from the Pivot Pillar when the Dovetail Plate is in place. As with the latter, before final machining of the channel, correct any distortion which has taken place and continue machining. If you go too deep when machining the channel, the lobes can be adjusted by taking a little skim off them. Toolmaker's clamps can be used to advantage to hold both components together to ascertain the sliding fit. When satisfied, drill the three sets of holes and, with all the bolts in place, you should be able to slide the unit up and down on the Pillar with the minimum of clearance. Unscrew the assembly and, taking the Clamp Plate in hand, carefully file a few thou. off the face of lobe which has the single clamping hole. If all is well, on re-assembly, you should be able to lock the unit in any position by use of the clamping bolt. You may find that you still have a little dressing or a little shimming to do in order to achieve this, but that is acceptable. The assembly can be seen in **Photos. 4 and 5**.

Feed Screw (Item 36)

To keep things simple you could use standard $^3/_8$in. BSF threaded rod for this item. If you want to spice things up a little, you can screwcut it instead and, if you really want a posh job, you could machine an Acme thread of 10 tpi, bearing in mind that the divisions on the Micrometer Sleeve (Item 37) will have to be altered to suit. If using the threaded rod, make sure it is running true - a collet will be most useful here. Circumstances dictated that a sleeve be fitted on to the feed screw because the core of the $^3/_8$in. thread could still be seen when it was machined down to the required $^5/_{16}$in. diameter, but as you can see it was a straightforward operation. Remember to ream the bore for a close fit, after which it can be Loctited in place. You can proceed with the upper lower Screw Supports (Items 29 and 30); careful marking is a must, but the design is such that a little skim off the base of the bronze Nut (Item 45) or the underside of the bracket can be used to achieve any final adjustments. The Thrust Collar (Item 32) at the base is coned in order to support the screw, and may need further adjustment during early use until the Ball (Item 33) finally seats itself in.

Nut (Item 45)

For the Nut I used a slice of round bronze. This item is straightforward enough and should not present any problem, just take care in positioning the bolt holes. The split allows for slight adjustment of the thread should this be necessary.

Micrometer Sleeve (item 37)

The Micrometer Sleeve should be treated like the other one, again being divided into 50, thus equalling one thou. divisions, and as before it uses an 'O'-ring for friction adjustment. Setting the amount of friction is as with the other collar.

Remember that when stamping the numbers on the Sleeve that they run in the opposite direction to normal. If you do happen to drop a clanger there is enough material left for another little skim off and re- stamping - I know!

The Knob (Item 38) will now complete this part of the assembly.

Balance Springs

I have incorporated two balance springs in the design. They counterbalance the mass of steel that is pivoted on the vertical slide and at the same time load the assembly against the coarse and fine feed adjusters.

The springs came out of my spring box, and although I give dimensions, similar springs will suffice. In the event you may have to reposition the two holes in the sub base, in doing so watch that you keep clear of the two holes that are already bored in the side of the plate.

Supplier:- Full kits of materials and accessories for this machine tool are available from Model Engineering Services, Pipworth Farm, Pipworth Lane, Eckington, Sheffield S21 4EY Tel./Fax 01246 4332128

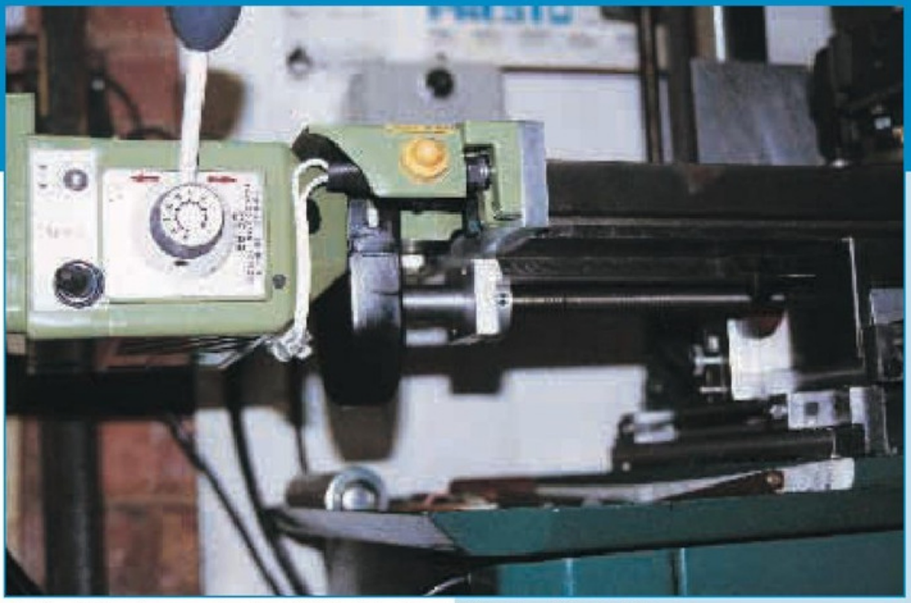
5. Another view of the Pivot Pillar assembly (Photo. Mike Chrisp)

FITTING POWER DRIVE TO A SENIOR 'E' MILLING MACHINE TABLE

Shelley Curtis describes how he fitted a commercially available table power feed unit to his milling machine

I have owned a Tom Senior 'E' milling machine for a number of years and from time to time had given thought to fitting a power feed for the table. One obvious problem is that there is no handwheel on the left of the table - the feed screw ends flush with the end plate - and therefore there is no apparent means of connecting to a power unit. There is, however, some $^{3}/_{8}$in. or so of plain shaft between the back of the endplate and the screw itself. A friend has a Myford VMB fitted with the Taiwanese 'Align' power unit and I was able to examine it closely and have a working demonstration. I could see that, with a new end plate to accommodate the 8in. wide unit, fitting it to the Senior was perfectly feasible. My enthusiasm was rekindled and a new project was born!

Figure 1 shows the arrangement of the components on the end of the machine table and I have appended a few notes on the manufacture of the new items.



1. The 'Align' power feed unit fitted to the milling machine table

Item 1 - End Plate

Square up a piece of aluminium to 8in. x 3.70in. x $^{1}/_{2}$in.. Ensure that both faces are flat - and parallel with each other - by flycutting. Drill - ream and tap where indicated - all holes by co-ordinates **(see Figure 2)**, with the exception of the two 4BA holes. Profile the plate, using a $^{1}/_{4}$in. slot drill. Break all sharp edges. Leave the workpiece clamped to the table for the time being.

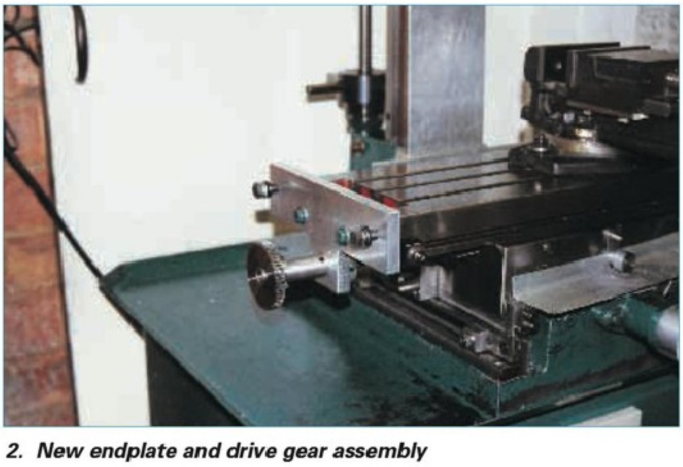
Item 2 - Bearing Housing

Turn from aluminium bar. Drill and ream the $^{1}/_{2}$in. hole and part off to length.

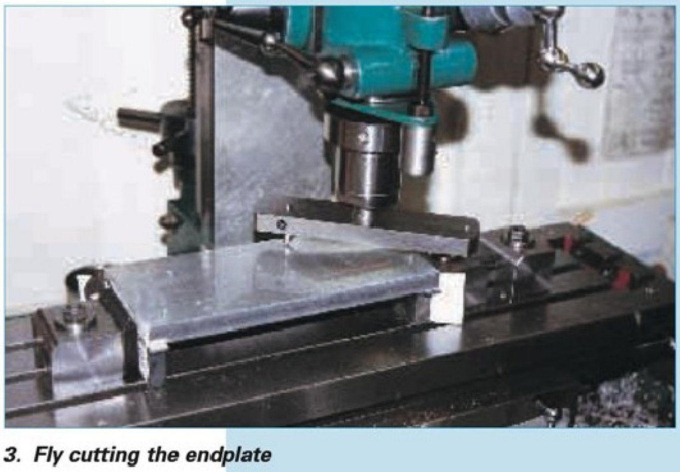
Drill and counterbore the 3.60 mm holes as shown, but do not drill the oilway and oiler seating for now.

Item 3 - Bush

First make a plug gauge of 0.436 diameter. (This is the diameter of the plain portion of the feed screw. Check yours before making the gauge).Turn the bush from cast iron bar then bore the internal diameter and size with this gauge. Turn the outer diameter using the Bearing Housing as a gauge. Insert the Bush into the End Plate, locate the Bearing Housing on it and spot through, drill and tap the two 4BA holes. Secure the Housing to the End Plate with 4BA Socket Capscrews.



2. New endplate and drive gear assembly



3. Fly cutting the endplate

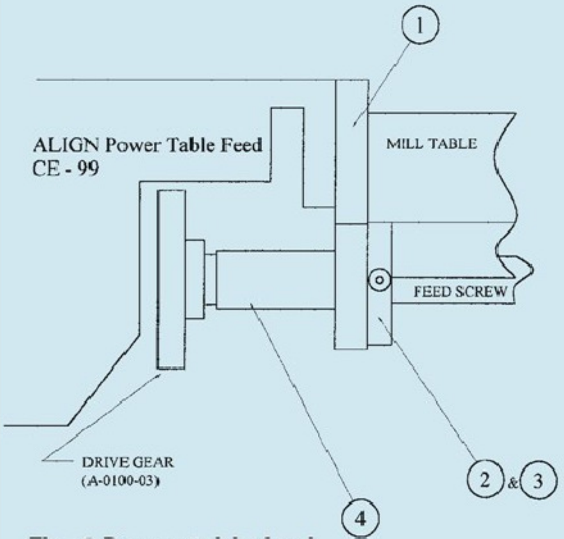


Fig. 1 Power table feed assembly

©

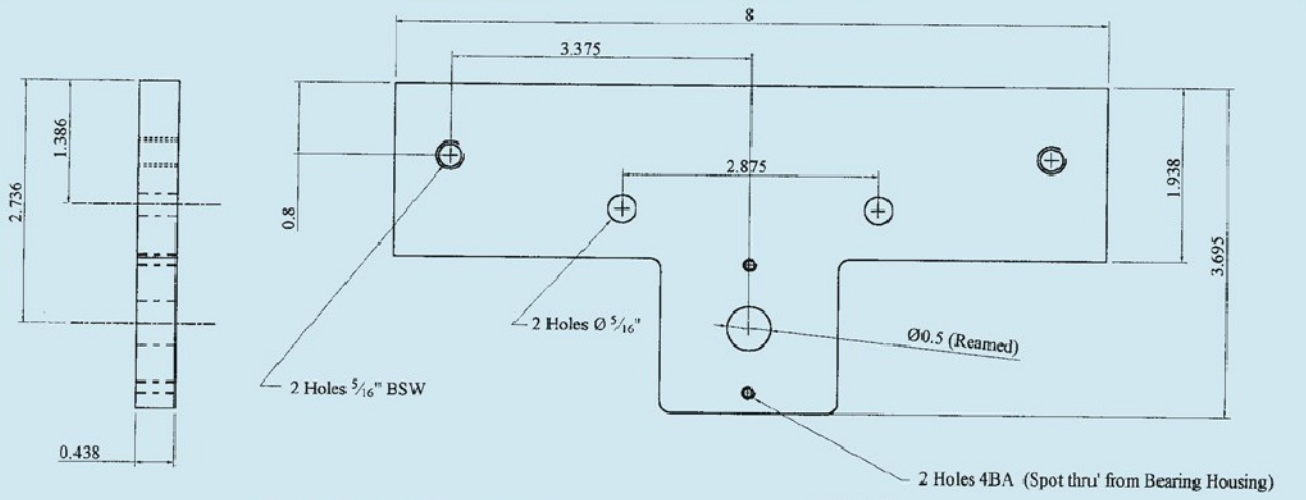
Wind the table fully to the right, remove the original end plate and test fit the new assembly. Traverse the table to confirm smooth operation and return it fully to the right. Remove, disassemble and fix the bush in the bearing housing **only** with Loctite 641, or similar. Drill the 1/8in. diameter oilway, counterbore 1/4in. diameter x 1/4in. deep and press in the Ball Valve Oiler. Re-assemble, but do not refit to the table yet.

Item 4 - Feed Screw Extension

Turn to dimensions shown. Use the Drive Gear as a gauge to obtain a push fit. Bore the socket for the feedscrew. Size with the previously made plug gauge.

Item 5 - Spacers

A simple turning job.



Item 1 End plate Matl. Aluminium

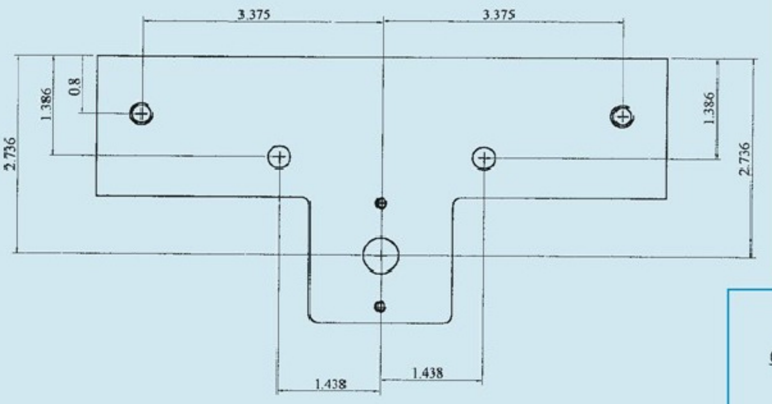
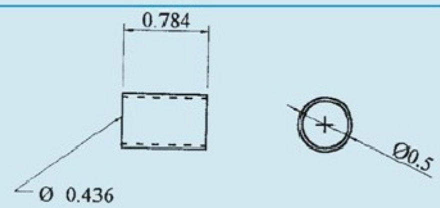
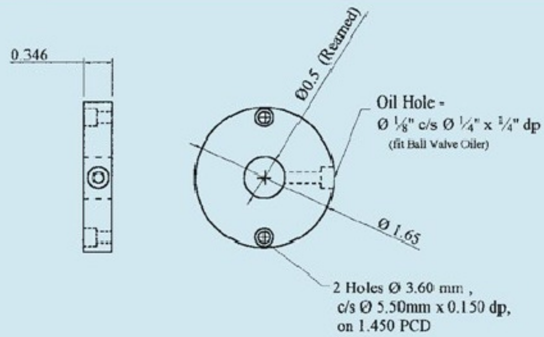


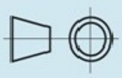
Fig. 2 End plate drilling co-ordinates



Item 3 Bush Matl. Cast Iron



Item 2 Bearing housing Matl. Aluminium



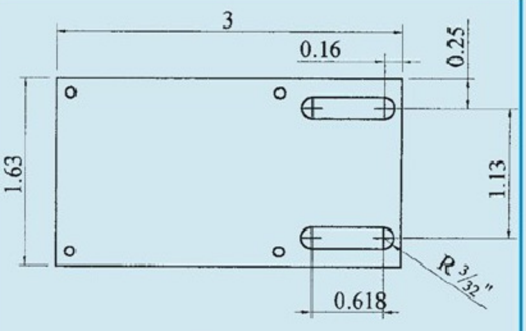
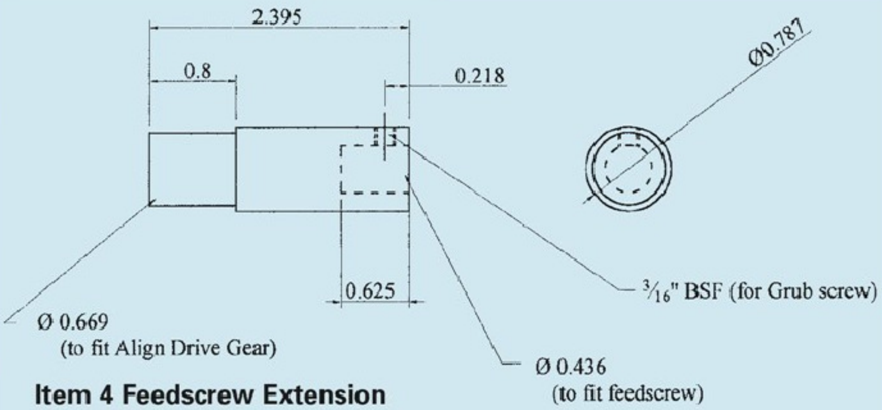


Fig. 3 Modified switch plate



Item 4 Feedscrew Extension
Matl. BMS

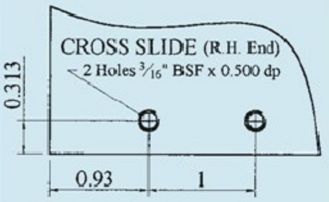


Fig. 4 Switch bracket fixing holes

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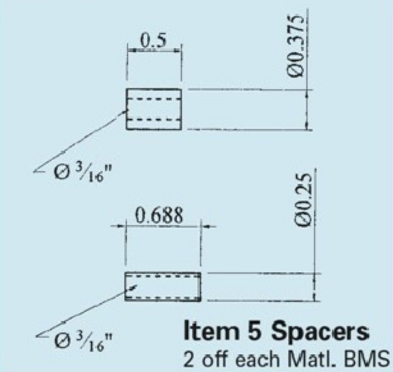


Item 5 Spacers
2 off each Matl. BMS

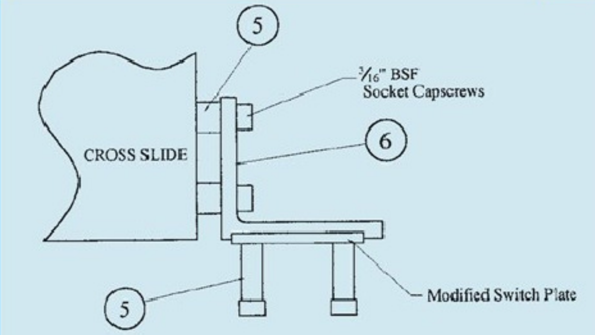
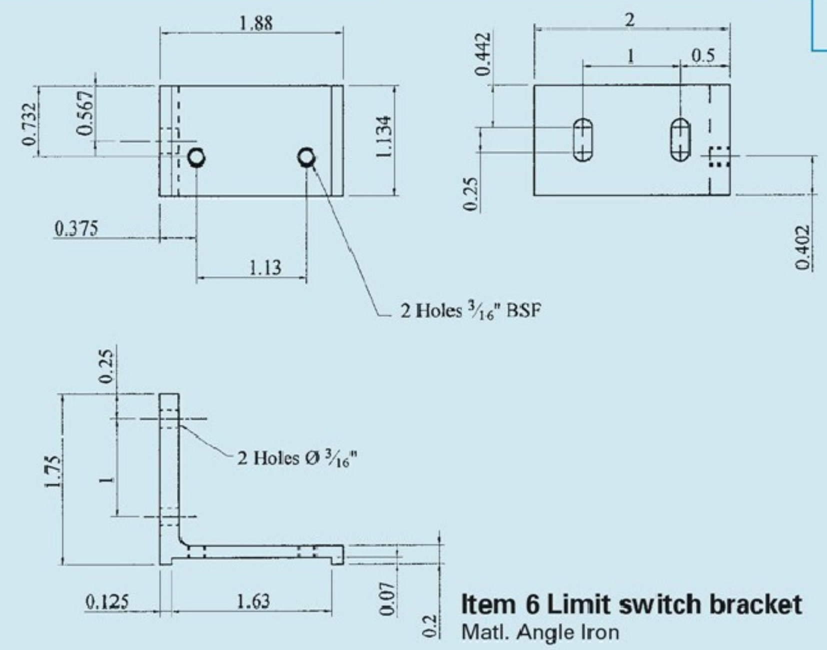


Fig. 5 Limit switch mounting viewed from aboved (limit switch omitted)

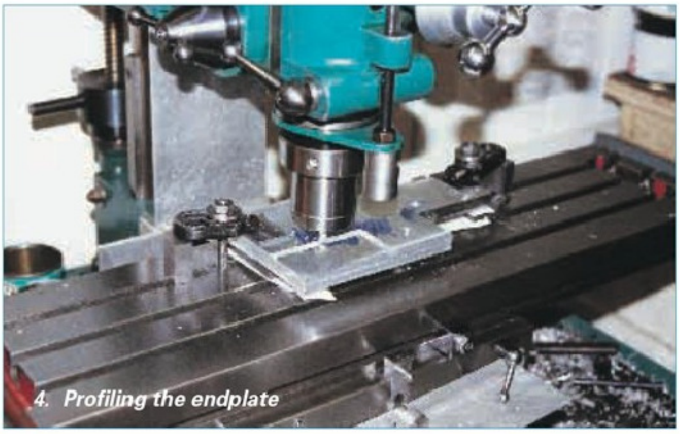


Item 6 Limit switch bracket
Matl. Angle Iron

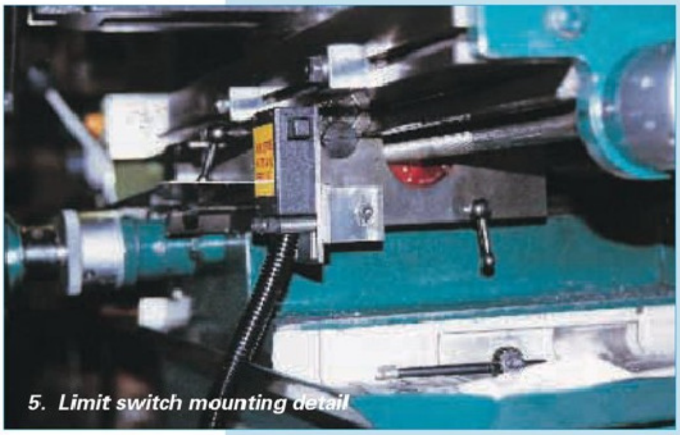
'Align' Power Feed CE-99

(Refer to Installation Instructions)

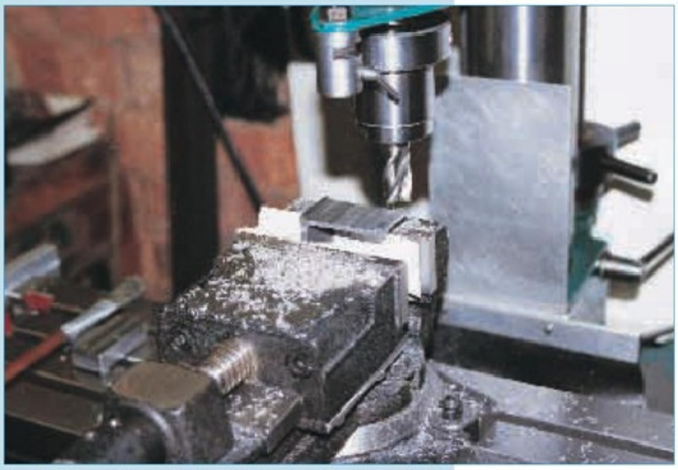
Discard the 'Small Adaptor' - Part No. A-0113-99A. Fit 'Big Adaptor' - Part No. A-0113-99 - to the Power Unit, overhanging the front edge by 5/16inch. This is to provide clearance for the heads of the bolts securing the new endplate to the table. Stand the unit on its end and lightly bolt on the new end plate. Push the drive gear onto the feed screw extension, offer it into position and locate with the shank of an 11.00mm drill through the bearing housing. With the front end of the extension touching the end plate, position the drive gear so that it is in line with unit's pinion and lock it with the grub screw provided. Remove the drill shank, drive gear/extension assembly and end plate. With the mill table still positioned fully to the right, re-attach the end plate. Fit the drive gear/extension assembly to the feed



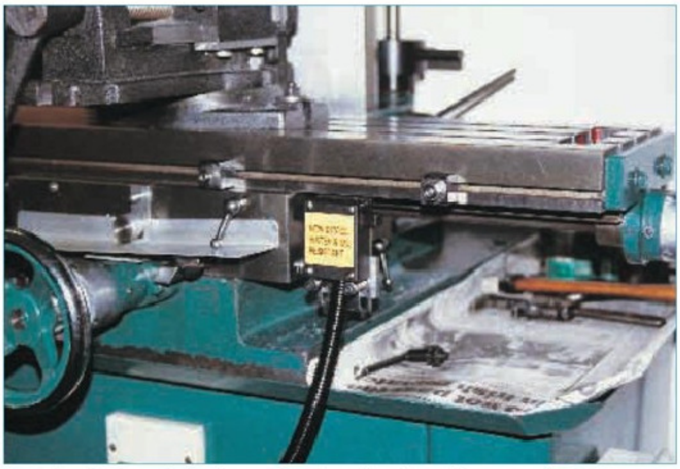
4. Profiling the endplate



5. Limit switch mounting detail



6. Milling the guide slot in the limit switch bracket



7. The limit switch shown in the raised position, ready for powered traversing

screw, securing it with a $^3/_{16}$in. BSF grub screw. (File a small flat on the feed screw to correspond with grub screw). Check running truly.

Now attach the power unit to the end plate, using the two $^5/_{16}$in. BSW bolts provided. Locate it so that the drive gear and pinion mesh with no tight spots and minimum backlash.Finally tighten the holding bolts. Fit the plastic gear cover, Part No. A-0113-991. It is held in place with double sided adhesive pads. (No comment!)

Limit Switch

Remove the mounting plate and modify as shown in **Figure 3**. Reassemble and file any screw protrusions flush with the back of the plate.

Item 6 - Limit Switch Bracket

I used a piece of 2in. x 2in. angle iron for this. Mill to a true right angle and make as shown. Use the modified switch plate as a gauge when milling the guide slot. Drill and tap the two $^3/_{16}$in. BSF fixing holes on the R.H. end of the cross-slide, as per **Figure 4**. Fit the bracket to the cross-slide with $^3/_{16}$in. BSF capscrews and the two x 0.375in. dia. spacers. Fit the limit switch to the bracket with $^3/_{16}$in. BSF capscrews and the two 0.250in. dia. spacers. **(See Figure 5)**.

With the switch in its lowest position relative to the bracket, loosen the capscrews securing the bracket and adjust it so that the top of the switch just clears the underside of the table traverse stops. Check switch is vertical and finally tighten the capscrews. Raising the switch in its guide will engage it with the traverse stops.

Electrical

Mount the transformer in a convenient position and connect its input lead to the output side of the NVR switch on the milling machine (consult an electrician if you are not sure). Switch on and check everything is working properly, especially the limit switch.

Summary

Generally speaking, milling machines with power feed do not have a fixed stop, for obvious reasons! So the rule here must be:-

Manual traverse

Limit switch lowered. Fixed stop raised, if required.

Powered traverse

Limit switch raised. Fixed stop lowered. Traverse stops adjusted to prevent full table movement in either direction, in the event of one being distracted for any reason.

Interestingly, the 1980 Senior brochure and price schedule listed a Power Feed attachment for the Senior 'E', but there was no illustration of it and I have never seen or heard mention of it. One would assume it was a British made unit. Thus I hope that mating a Taiwanese unit to this excellent machine doesn't amount to an insult to the memory of a fine British machine tool manufacturer. The principal benefit of powered traverse is the improvement in surface finish brought about by a constant feed rate. The consequent freedom from the mind numbing tedium of winding a handle slowly could encourage one to get on with another job - or just stand there and daydream! That's one reason why the limit switch is there - USE IT!

Footnote

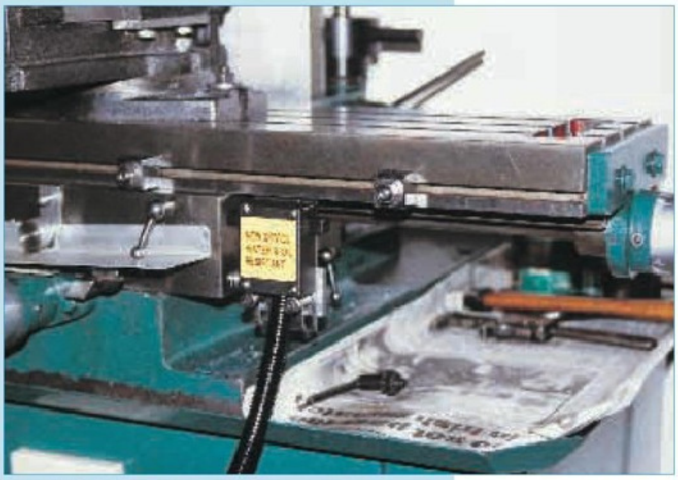
The machine referred to above has a 25in. x 6in. table. Some were produced with a 25in. x $4^1/_2$in. table. From illustrations I have seen they appear to be identical in all other respects.

Suppliers

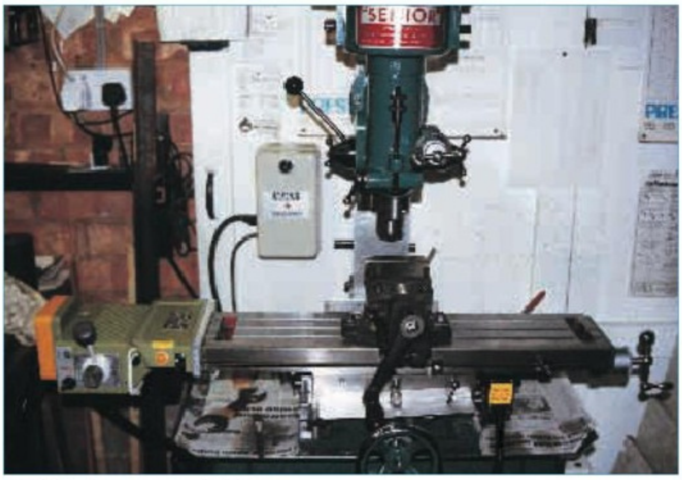
'Align' Power Feed CE-99.
Chester UK Ltd (01244 531631)

Ball Valve Oilers.
Adams LubeTech Ltd,
Coventry. (02476 467941)

(Telephone for details of nearest stockist. They will sell direct, but there is a minimum order value of £5).



8. With the limit switch lowered

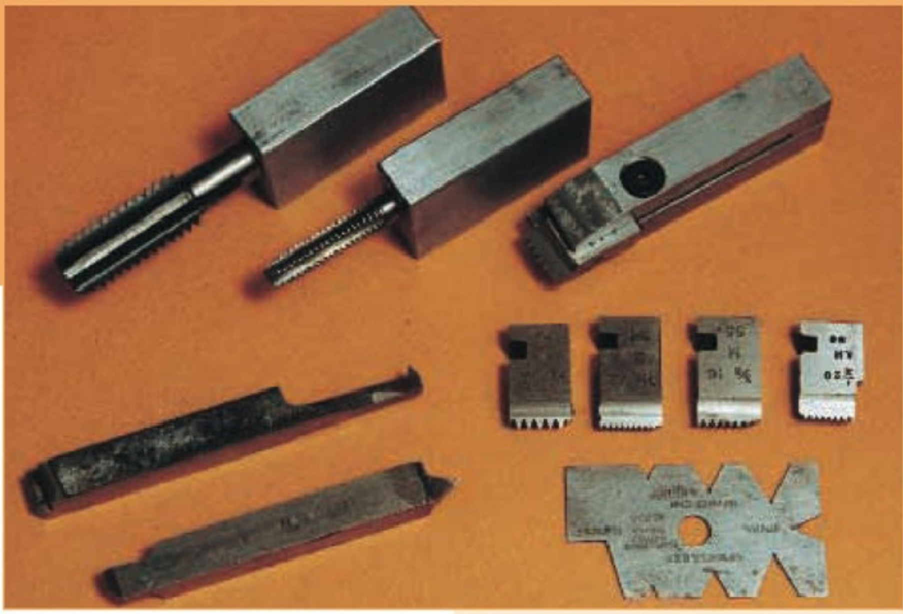


9. Mission accomplished!

LATHE PROJECTS FOR BEGINNERS (11)

Screw cutting

To complete the small screw jack, a couple of threaded items are required. These give Harold Hall the opportunity to introduce the topic of screw cutting in the lathe and to discuss a variation on the usual theme



1. A selection of tools for screw cutting on the lathe including modified taps and individual die head chasers

When it comes to screw cutting I do not consider myself experienced, having cut only a limited number of threads over the years, but having had consistent success with those I have cut (except maybe for a few of my very early efforts), I feel able to share my method with you.

Initially, I considered that I would detail the screw cutting operation only as it applied to the threaded parts contained in this jack. However, my memory was telling me that articles I had read in the past were very much biased towards screw cutting with a single point tool and, as this differed from my approach, I was prompted to glance through my library. This confirmed my impression, 99% of their content being based on this form of tooling. I also searched the content of Model Engineers' Workshop and Model Engineer over the last ten or so years and found only one article on the subject, in Model Engineer. This also centred around the use of single point tooling, in all, leading me to have a change of mind, making me realise that a more detailed explanation of my method was justified.

I am not about to suggest that single point tools for cutting threads on the lathe are totally inappropriate but that other methods are now possible. I use the term "now" as almost all the information on the subject seems to be from many years past, with only one obvious mention of the use of chasers (multi tooth cutters) The advantage of the single tooth cutter is that it can easily be made in the home workshop and to those involved in the hobby in years past was the only way to proceed.

Using the single point tool

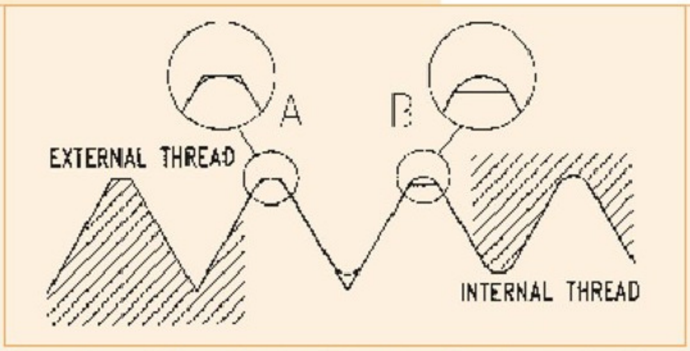
The subject will be discussed in terms of external threads, but much of what will be written will apply equally to internal threads. Cutting internal threads, and the required shape of the tool, will though have similar problems to those discussed relating to boring in Issue 70, to which the reader should refer.

An advantage of the single point tool is that, as the angle is common throughout the size range of a thread system and between many systems, only one tool is required. This assumes that the radius in the root of the thread is ignored and all threads are cut to a point, with only a small radius to strengthen the tip of the tool. This would not affect the thread's ability to mate with its other half, only making the part very marginally weaker which, in the vast majority of cases, would be of no consequence. It will be obvious though that the standard single point tool will be unable to create the radius on the peak of the thread and this would cause problems with mating if the other half was a conventional thread form, such as when making a new part to fit in an existing component, **(see Sk. 1)**. I would only recommend the use of a single point tool for those pitches and thread angles for which I was unable to get a suitable chaser, likely to be some obscure thread from the past, or present day coarse pitches. Special single point tools which incorporate the root and crest radii in their form are available but, of course they will produce only one thread depth, so their use is limited.

Two methods of feeding the tool into the workpiece are employed, one to use the cross-slide, the other, to use the top slide set at an angle of half the internal angle of the thread. A similar effect to the latter can be achieved by setting the top slide at right angles to the cross-slide and advancing the tool along the lathe axis by an appropriate amount for each increment of in-feed. With the first method the tool will cut on both sides whilst in the second it will only cut on the leading edge, **(see Sk. 2)**. With method 'B' top rake can be added, as shown in **Sk. 3**, as it only cuts on the one edge. Setting the top slide angle for method 'B' is not easy, especially on some lathes with limited calibration, so an error is understandable. To overcome this it is normal for the angle to be set just short of half, say by 1 to 2 degrees. This results in the major cut being taken on the leading edge but for the right hand to just shave the side, ensuring a smooth finish. A large top rake will, though, significantly change the angle of the right hand side and so this would defeat the purpose of the top slide being so set. For this reason a compromise has to be made and rather than the normal 15 to 25 deg. rake angles, a rake of about 5 deg. should be employed. This significantly improves the ease of cutting over a tool with zero rake but has minimal effect on the angle of the tool.

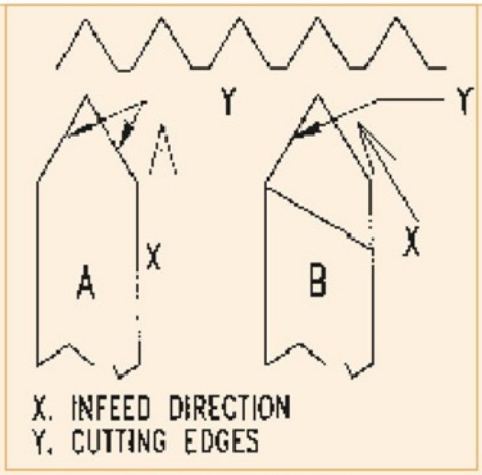
Calculating in-feed

If you are cutting the outside thread first (normally preferred), you will not have a mating thread with which to check it with

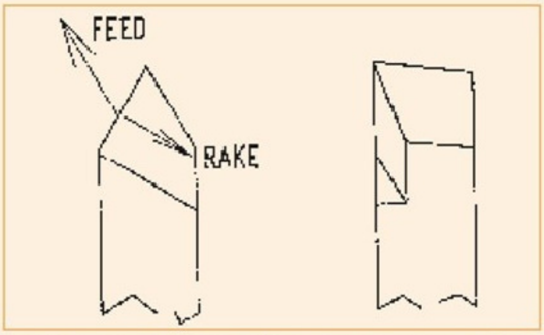


An external thread cut with a single point tool will foul with a genuine form internal thread as shown at "A". To make it fit, the outside diameter should be reduced as shown at "B".

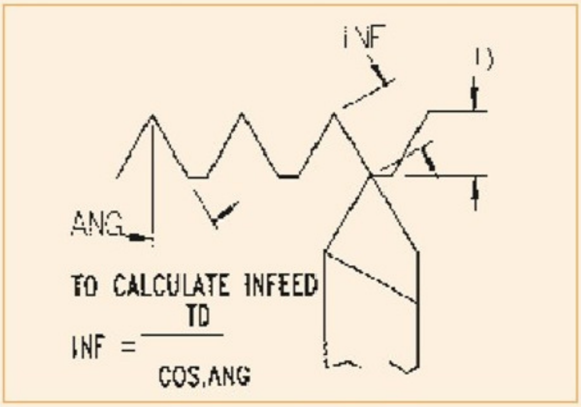
SK1 Single point and full form thread conflicts



SK2 Alternative tool forms



SK3 Feed and rake directions method "B"



Values for "ANG" and "TD" will have to read from charts for the thread form being cut. Note that "TD" is from the peak of the thread but to the point created by the continuation of the thread flanks and not the base of the normal thread form.

SK4 Infeed calculation

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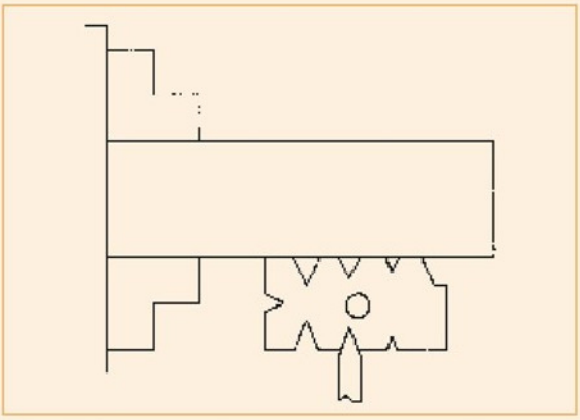


SK5 Using thread gauge to set thread cutting tool

and as the outside diameter does not change with this method, it is not practicable to use this to determine when the thread is at its finished size. For this reason it is necessary to calculate the in-feed required **(Sk. 4)**.

Setting the tool

It is a waste of time working to precise angles if the tool point is not set accurately; to do this a thread gauge (front right **Photo. 1**) is used as shown in **Sk. 5**.

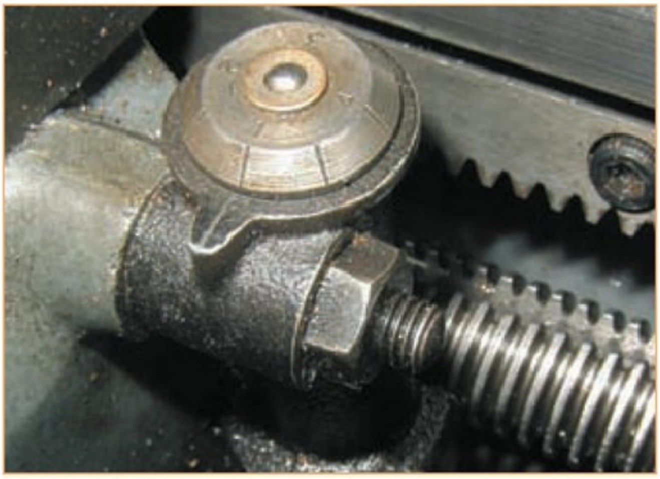
These brief comments on the use of single point tooling give only an insight into the method, if you wish to adopt it then do read the various books on the subject. Even if written some years back they are still totally applicable to using the method in these days.

Using Chasers

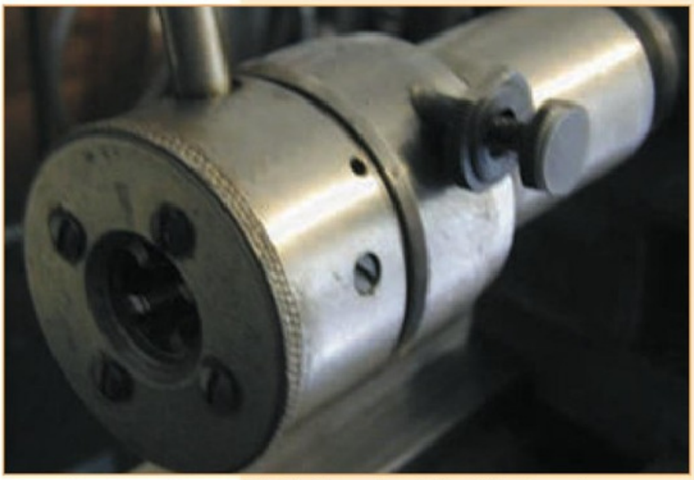
A major factor in the use of single point tooling in the past was surely the expense of purchasing chasers. Chasers were originally associated with the hand forming of threads, being used to correct inaccuracies of pitch and form. Whilst commercial chasers are still expensive, and not offered by most suppliers to the home workshop, there are ways round the problem. Photo. 1 shows the tooling that I use, consisting of internal and external single point tools, external chasers made from individual die head (* see 'Terminology') chasers and internal chasers made from taps. Die head chasers are made is sets of four and if purchased new would be expensive but some suppliers (Ref. 1) do now supply individual chasers, at only a few pounds, from used industrial sets. They are too small to be held on their own but with a holder as seen in the photograph (Ref. 2) they can be held with ease.

Similarly, the taps would be difficult to hold but the simple holder shown makes it easy. Just drill with the drill in a chuck in the lathe spindle and the holder held on the top slide, resulting in a hole at centre height. Then drill and tap four holes from below and fit grub screws to secure the tap. Grinding a flat on the tap to aid fixing may seem a good idea but this would prevent the tap from being rotated to adjust the cutting edge height and angle. Even though the hole is at centre height, some packing may still be required. As is the case with ordinary boring tools, threading tools may also benefit from being a little above centre. It is possible that at smaller diameters the difference in helix angle could cause a problem, I have though not been aware of this.

When using chasers it is not necessary to angle the top slide and infeed is carried out using the cross-slide. One major advantage of this and because the thread form conforms exactly to the standard for the thread being cut, the amount of infeed can easily be read from tables, as typically found in the Model Engineers' Workshop data book. Of



2. A thread dial indicator engaged with the leadscrew, showing the four main markings and the intermediate graduations



3. A Coventry die head in the 'open' position. The four chasers are moved to their screwcutting position by rotation of the front part of the body, using the lever seen at the top. The knurled knob is used to achieve fine adjustment of the depth of cut

course for an external thread the outside diameter can be measured, in this respect I would suggest that the outside diameter of the part prior to cutting the thread should be very marginally oversize, say +0.05mm, to allow for the tips of the threads to be fully machined. When turning an internal thread, measuring the diameter is not practical so determining the required infeed and working to this is the only way to proceed. If no other factor overrides the choice, make the external thread first and use this as a gauge to finally check the size of the internal thread.

Setting the tool is easy; just hold the front of the chaser against the workpiece so that all teeth touch and clamp the tool in place. The tool should only cut on the first few teeth and if there is evidence of the other teeth removing a lot of metal the tool will need resetting.

Taps as chasers

The idea of using taps as chasers was put forward by Alan Jeeves in a previous article (Ref. 3) which I suggest you read. In this he carries out more work on the tap than I am proposing, but ends up with a more professional looking result. At first it may be considered that there will be no need to shape the tap at all and at larger diameters this will be largely the case. A plug tap will, of course, be necessary. Earlier in the series when discussing boring small holes, the importance of the shape of the tool was explained and with chasers for small internal threads the problem is even greater. The reason for this is that the chaser is eventually working at the outside diameter of the thread but the hole in which it is working is still at the smaller core diameter. For this reason grinding away one or more of the unused cutting edges may be necessary, but I would suggest that no more is ground away than is essential to avoid weakening the tap unnecessarily. The remaining cutting edges can also be pressed into service if the original one becomes blunt, but you would need to do a lot of screw cutting before that happens.

Select a good quality tap for the purpose, preferably ground thread, and if you are not inclined to destroy a tap in this way, note that car boot sales and market tool stalls often have cheap taps, some new. Failing that, there are suppliers to the home workshop that supply taps at very reasonable prices.

Unless small holes are being threaded chose the largest diameter tap available at the required pitch - typically for a 20 tpi thread, a 3/8 in. BSF tap would be preferred to a 1/4 in. Whitworth version.

The common factors

Having dealt in detail with the points that are peculiar to the two methods, there are also many common factors.

Having chosen the tool type the first thing to do is to set up the gear chain between the lathe mandrel and the leadscrew. If you are fortunate enough to have a screw-cutting gear box the task is simple. If not then refer to your changewheel chart and set up the gear chain suggested. I use the word suggested because for many thread pitches, there are many combinations that will come up with the same result. With a standard set of gears it is probable that there will be in excess of 10 combinations for any given common pitch. This means that if you are missing a few gears then other suitable combinations of those available can be employed. Unfortunately, space will not permit detailed explanations as to the way of locating these alternatives, but for the simpler threads, observation of the chart and the gears to hand should find a result.

Consider a chart based on a set of gears from 20 teeth to 75 teeth and in increments of 5 teeth. If you look up the combination for 20 tpi with an 8 tpi leadscrew, typically you will find a driver of 20 teeth and a driven wheel of 50 teeth. What can you do if you are missing the 20 tooth wheel? If this were replaced by a 40 tooth wheel this would half the ratio, but if an additional pair of gears with a 2:1 ratio was included, the original ratio would be restored. For this we could have the 40 tooth driver and the 50 tooth driven, adding to this a 30 tooth driver and a 60 tooth driven, restoring the value. If either the 30 or 60 tooth gears were not available gears of 35 and 70 teeth could be used. Here then are three solutions to the same problem and of course there will be others.

The formula for the pitch cut is:-

$$\text{thread} = \text{leadscrew tpi} \times {Dn1}/{Dr1} \times {Dn2}/{Dr2} \times {Dn3}/{Dr3}$$

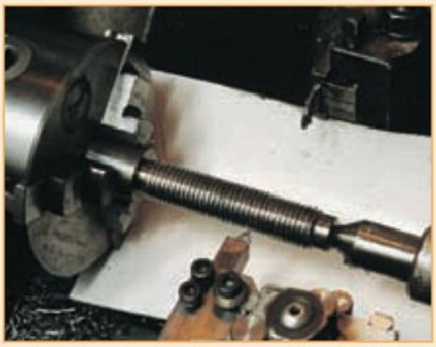
where Dr are drivers and Dn driven gears.

Tumbler reverse

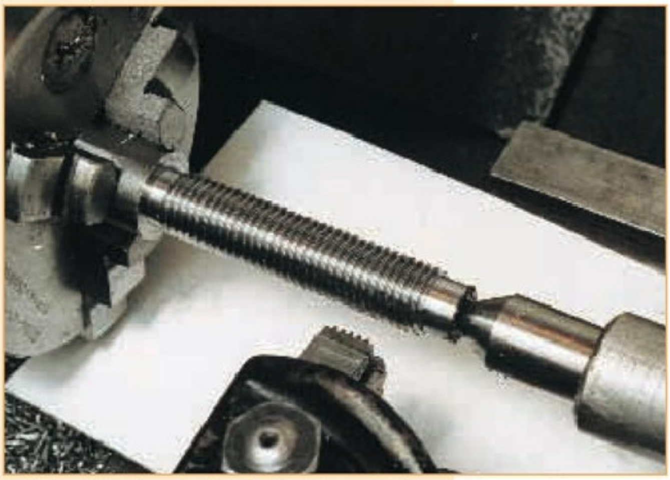
The effect of there being one, two or three pairs of gears is that the output to the leadscrew will reverse depending on the number of pairs of gears, two pairs being reversed from that with either one or three pairs. This could cause the hand of the thread to be different to that required, (left hand instead of right hand) is required. However, this rarely causes a problem as the possibility is overcome by the inclusion a tumbler reverse mechanism between lathe mandrel and the input to the gear chain. This facility is not included on all lathes and achieving the correct hand thread is by the inclusion of an idler gear, that is a single gear between any pair of gears. This in no way affects the ratio of the gear chain and can be any gear that will go in the available space, it does though create the required reversal of output.

Setting up

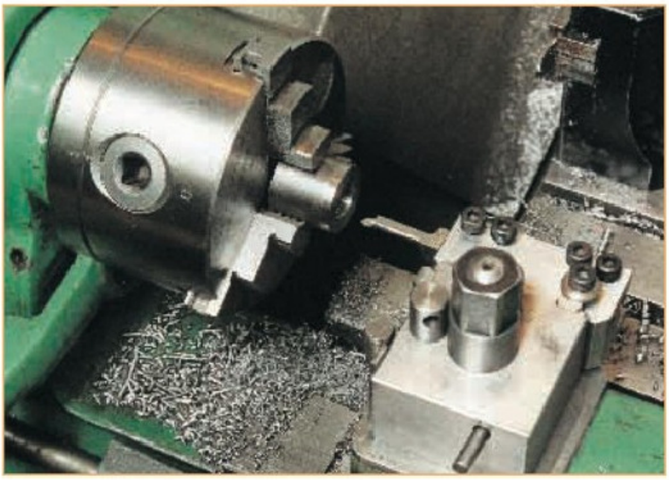
Setting up the gears is not difficult, albeit not the nicest of tasks. One method of simplifying the set-up is to insert, between each mating pair, a piece of very



4. An almost completely cut thread having been produced with a single point tool.



5. The thread now finished, using a die head chaser, shows a much improved thread. The thread could have been cut fully with the chaser as there is no need to use a single point tool to start the thread.



6. A mild steel insert was used for the internal thread rather than threading directly into the casting. This shows the insert being bored.

thin paper, thus establishing an adequate but not over-large clearance. The mandrel can be turned by hand and the pieces of paper removed before running the lathe under power. This also provides an opportunity to check that the direction of saddle movement is correct (i.e. towards the chuck with normal mandrel rotation for a right-hand thread).

Lathe speed

With the change wheels set up, the tool of your choice in place and the workpiece in the chuck, thread cutting can begin. Do be aware though that with the ratio of the changewheel gear chain being small, the leadscrew speed is not that different to that of the workpiece. If, therefore, the lathe were run at the normal speed for the diameter being machined, the saddle would traverse at a rapid rate. There is no way that the lathe could be controlled under these circumstances, so run at a very low speed and I would suggest the lowest available to start with. As you become confident you may find it possible to move up a speed. These comments assume your lathe has a back gear (*see 'Terminology') or some other method of providing speeds of around 50 rpm.

If you own one of the lathes that does not have low speed facilities then it will be a case of turning the lathe by hand, this being achieved by fitting a handle at the non working end of the lathes spindle. Many designs for such a device have appeared in the Model Engineers' Workshop so will not go into detail here (Refs. 4, 5 & 6).

Over-run groove

Only if you turn the lathe by hand will it be possible to stop the lathe very accurately at the same position at the end of each pass of the thread cutting tool. As a means of providing some tolerance to the final stopping position, a run-out or over-run groove is cut in the workpiece at the point where the thread is to end. I would suggest that while you are at the novice stage, this should be made on the wide side, say three thread pitches minimum. It is in the use of this groove that there is a major difference between using a single and multi-tooth tool, but more about that later.

The half nut

A misconception often implied, if not intended, is that the purpose of the half nut engaging the saddle to the lead screw is solely to aid screw cutting. This is not so, its other purpose being to enable the saddle to be rapidly moved along the lathe bed from one position to another, unhindered by the leadscrew. Readers who have lathes without half nuts will know the chore of winding the leadscrew to move the saddle from place to place. In fact, whilst probably slower, cutting threads on a lathe without a half nut would be a simpler task as there would be no possibility of subsequent cuts misaligning with earlier ones. Let us consider the problem.

If a thread of 8 tpi were being cut on a lathe with an 8 tpi leadscrew, then at whichever point the nut was closed, the tool would line up. If the pitch being cut was 16 tpi (i.e. an exact multiple of the leadscrew pitch), when the nut was closed it would line up with every other pitch on the thread being cut - still satisfactory. However, with a thread of 12 tpi only every alternate position of the leadscrew would line up, every other position misaligning, so in this case the half nut can only be closed at certain positions.

Thread dial indicator

To overcome this problem, a thread dial indicator is normally fitted to the saddle **(Photo. 2)** to provide an indication of when the half nut should be closed. A small graduated dial is rotated by means of a gear which engages with the thread of the leadscrew. Typically, for an 8 tpi leadscrew with an indicator fitted with a 16 tooth gear and having four main markings on the dial, the nut can be closed as follows

Pitches which are multiples of 8 (16, 24, etc.) at any position on the leadscrew

Others which are multiples of 4 (12, 20, etc.) at any of the four main markings, and half markings if provided

Other even numbers (14, 18, etc.)
at any of the four main markings

Odd numbers (11, 13, etc.)
at any opposite marking, (1 and 3, or 2 and 4).

Half numbers (9.5, etc.)
at the same position every time

For more complex numbers the nut should not be disengaged.

If you do not have a lathe with an 8 tpi, 16 tooth gear, 4 main markings combination, then see the Model Engineers' Workshop Data Book page C60.

Cutting the thread

Wind the cutter up to the workpiece so that it just touches, move the cutter to the right to clear the workpiece and place on a depth of cut using the cross-slide and make the first cut. Well, I am afraid that is an over-simplification and some preliminary tasks should be carried out before actually making the first cut. I made the comment earlier about there being differences between using a single point tool and a chaser when it came to the purposes of the over-run groove. At the end of the cut there will be two or three ways of stopping it: opening the half nut, stopping the motor and, if available, disengaging the drive clutch.

Opening the half nut will only be a possibility if a single point tool is being used as with a chaser some teeth will still be in contact with the workpiece and if this continues to rotate, grooves straight round the part will be the result. However, if a single point tool is being used then opening the half nut is the method to use. You could, of course, grind away all teeth on the chaser except for the first two and, providing the over-run groove is wide enough, the half nut could be used.

Considering now using a full chaser, in which case the only options available are to leave the half nut engaged and stop the drive or to withdraw the tool at the instant the chaser reaches the end of the thread. This is, in effect what happens when the chaser is used as part of the set in a Coventry die head **(Photo. 3)**. The mechanism of the die head causes all four chasers to be withdrawn from the thread almost instantaneously, allowing the die head to be run back to the starting position with the cutting edges clear of the newly formed thread. Experienced turners develop a coordination of hand and eye which allow them to retract a single point tool in a smooth movement, at the same instant disengaging the half nut. They need only a minimal run-out groove and are quite capable of threading up to a shoulder. For the novice, if a drive clutch is available this is probably the best way, as with the machine running at a very slow speed it will stop almost instantaneously with very little over-run. If stopping the drive motor is the only option then it will be found that due to the speed of the motor its inertia, the machine is likely to run on after the power has been switched off. Fortunately, with the ratio between motor and workpiece being so high, over-run should be minimal, though it must be allowed for when stopping the machine.

It is because of these factors that I suggested delaying making that first cut, but first doing some dummy runs with the tool just clear of the work, so as to become aware of the time intervals involved. This is especially important if the length of thread being cut is short, as the time span will be only a matter of a few seconds, not giving much thinking time. If you do however feel very apprehensive, consider making that handle for manual operation.

Having arrived at that stage, place on a depth of cut and make your first cut, taking note of the thread dial indicator for determining the half nut closing position. The depth of cut will depend on many factors, typically, material being machined, state of the cutting tool and rigidity of the whole system. Initially a depth of 0.1mm should be suitable, gradually reducing this to 0.01mm as the tool becomes more deeply engaged in the thread. Keep repeating the process until the thread arrives at a fully formed profile and has the correct outside diameter. The result will be far superior to that obtained from a single point tool. Start with the outside diameter of the workpiece just greater than the finished thread diameter, so that it is possible to fully machine the thread without a flat remaining, I would suggest +0.05 to +0.1 mm. Whilst final finishing cuts of 0.01mm. will always be the order of the day, you will be able to increase the initial cuts as your confidence grows, thereby reducing the number of passes necessary and the time taken to complete the task.

Internal threads

Cutting internal threads follows exactly the same procedures - use of half nut, method of stopping the cut and the need for a run-out groove, unless of course if it is a through hole. Being unable to fully see what is happening, difficulty with clearance between tool and bore, especially at small diameters, does unfortunately make the process a more daunting one. Practice will increase confidence.

The threaded parts for the jack

With such a detailed explanation given, no more needs to be said regarding the threading operation specific to the parts for the jack. Also, by now, your increased experience of plain turning should mean that very little comment is called for in this respect either. **Photo. 4** shows that, as a test case and to provide a photograph, I started the thread with a single point tool and with the top slide set round, though this is not evident from the photograph. What can be seen is that the almost finished thread is not that good, though I will admit that, with more care, a better result could have been achieved. **Photo. 5** shows the thread having been completed using the chaser and the difference in quality is obvious. A point to note is that if the part is small in diameter and/or long and needs supporting with the tailstock, a short parallel portion will be necessary to give the chaser room to start, as seen in the photograph.

The diameter of the bore in the insert, seen being made in **Photo. 6**, will be equal to the outside diameter minus twice the thread depth, a dimension which can be obtained from suitable thread charts. Also the bore can be increased to the actual thread diameter and to a depth of say 2mm. This will show when the chaser has arrived at the full thread diameter, when the external thread can be used to check if the required fit has been achieved. Finally, **Photo. 7** shows the tap being used for the internal thread. This worked very well after resolving a little problem over shaping the tap for use. It was the first time I had used this tap at such a small diameter and there was not much clearance between it and the core diameter of the thread. After realising that the top cutting edge of the tap would have to be ground away, as can be seen in this photo and also Photo. 1, the task was completed without any further problem. In fact I would go so far as to say it was easy.

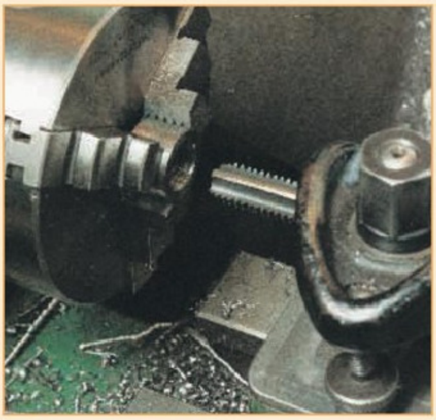
Imperial pitches

Whilst I work now in metric measurements, my main lathe has Imperial calibrations and, of course, an Imperial leadscrew. Because of this it would be foolish to attempt to achieve metric pitches when I am making both the internal and external threads. I therefore find it easier to produce threads with metric diameters but with the nearest Imperial pitch. Readers in the same position may wish to do likewise.

Screw jack assembly

This needs no explanation other than to say that the insert can be made captive with a little adhesive. As the mating hole in the casting provides a shoulder, the adhesive has to do no work other than to hold the insert in place when the jack is not under load.

The appearance of castings, especially the unmachined areas, can be improved if given a coat or two of paint. I use the smallest sized tin of modelling paint, and it is surprising how far one of these tins will go. There is plenty of choice with regard to colours.



7. A modified tap being used to screw cut the thread in the insert.

Faceplate Work

In the next issue we get to grips with using the faceplate, with the project to illustrate this activity being a two-wheel knurling tool.

References

1. ***Supplier:-*** Graham Engineering (Midlands) Ltd. Alpine House, Roebuck Lane, West Bromwich, West Midlands B70 6QP Tel 0121 525 3133 fax 0121 500 6453 E-mail graham-engineering.co.uk
2. Changewheel quadrant (chaser holder) M.E.W. Issue 56 page 38
3. Internal Chasers on the Cheap, M.E.W. Issue 28 page 32
4. Cross Slide Bracket (Hand Drive), M.E.W. Issue 28 page 45
5. Releasable Mandrel Handle, M.E.W. Issue 29 page 68
6. Expanding Mandrel (handle), M.E.W. Issue 34 page 74

Terminology

Back Gear

The gear chain associated with the lathe spindle, which when brought into use reduces each of the normal speeds, typically by a factor of 7 : 1 Used when screw cutting or carrying out heavy or intermittent machining

Die Head

An industrial threading device, rather like a very large threading die but with cutting edges that can be removed for sharpening. The device has fitted four cutting edges, these can be purchased individually (Ref. 1) for use in the home workshop as a chaser to be used on the lathe.

UPDATING THE 'WORDEN' Mk. I

Inspired by a recent constructional article, Giles Parkes decided to modify his 'Worden' Tool and cutter grinder

1. The revised table assembly, showing the new cam arrangement. The table now pivots at the back (i.e. on the side remote from the grinding wheel) rather than the front. Ball lever handles are used instead of knurled knobs, a modification which may be considered desirable by all Worden owners

I visited Neil Hemingway in 1989 soon after I came upon the joys of Model Engineering; I had gone to pick his brains about all sorts of gadgets in his catalogue and I came away with a complete kit to build the Worden. I was doubtful at first about my ability to build the machine but I need not have worried; Neil was exemplary in helping a novice over the phone and the Worden was very soon up and running and I rejoiced in the ability to get tools with correct angles.

There was one slight problem in that the table did not traverse as freely as I would have liked and I came to the conclusion that the table angle clamping device was unsatisfactory. It can't have been all that bad as it has taken me twelve years to do anything about it, but it was when I saw Geoff Sheppard's article on building the Worden that I decided to do something. First I e-mailed Hemingway enquiring about a kit to modify to the cam method of raising and lowering the table, but there is no such kit and no plans for one. I therefore set about taking my Worden to pieces and found that it would be very simple indeed to upgrade it. The only new parts needed were two side plates for the table, one shaft to hold the eccentric cams, three cams and one slider rod to bear on the cams.

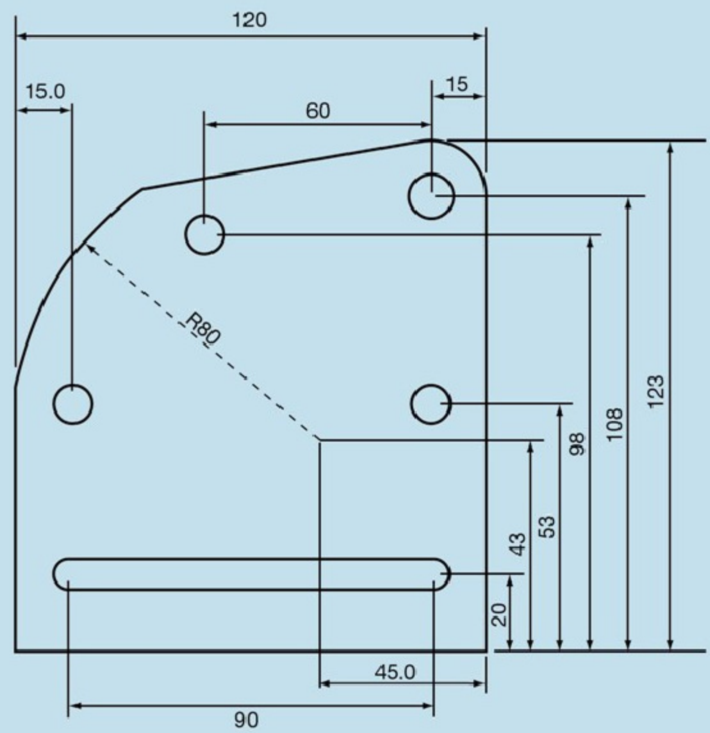
The side plate measurements are the result of trial and error but the finished items fit and work well: the inclination and rounding of the top edge have to be sufficient to allow the slider bar to rest on the cams without fouling the side plates. The brackets which hold the slider bar to

Angle upper edge to meet arc with 10mm gap between edge and hole circumference

Ream holes.
Lower three 10mm
Upper hole 12mm

Slot 8mm

Side plates
two off 3mm or 1/8"
mild steel



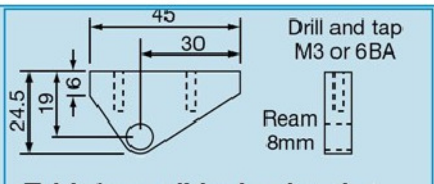
the table are shaped to make for ease of location and fitting. When making them I superglued the two together and made a rectangle 45mm x 25mm; the position of the hole is very important and I drilled and reamed that next. I then drilled the table for the bracket fixing screws and used it as a jig to drill the fixing holes in the separated brackets. It is so much easier to hold and drill into the edge of a rectangular piece rather than the edge of a triangular bracket with a radius on the bottom corner. The brackets were then shaped on the belt sander, the radius on the bottom being brought to size onto a stub of 10mm bar with an 8mm spigot in the hole. It is necessary for the circumference of the 12mm slider bar to stand proud of radius on the bracket so that the bracket cannot foul on the eccentric cam.

Making the eccentrics was described by Geoff Sheppard (M.E.W. Issue No. 71 p41). The bushes and cam spindle call for no comment but I used a ball handle at each end, one to move it and one to fix it: ball handles are so much kinder to the skin than knurls.

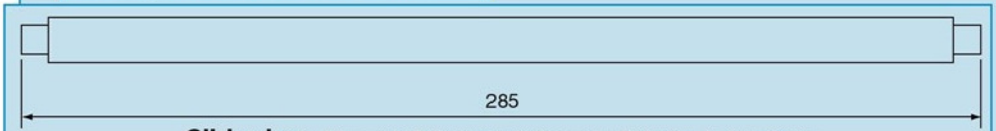
The only other modification is to drill the table for the two table pivots: as the table is hinged from the back instead of the front you either have to do this or cut another circumferential slot!

Use the original stretcher bars and reassemble the whole unit and the modification is complete.

2. ***The bar attached by brackets to the front of the table bears on the cams. It serves the same purpose as the sheet metal angle section spot welded to the table on the later versions***



Table/cam slider bar bracket



Slider bar 12mm MS Spigots 8x8mm to fit holes in brackets

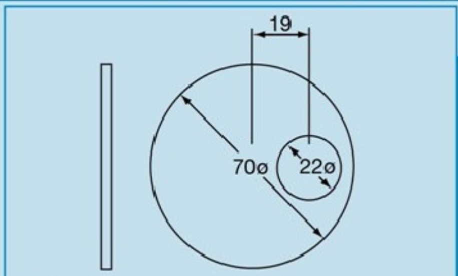
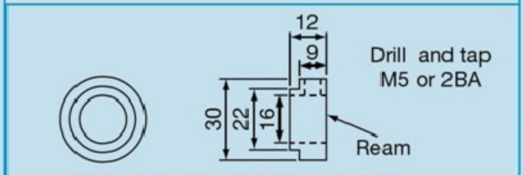
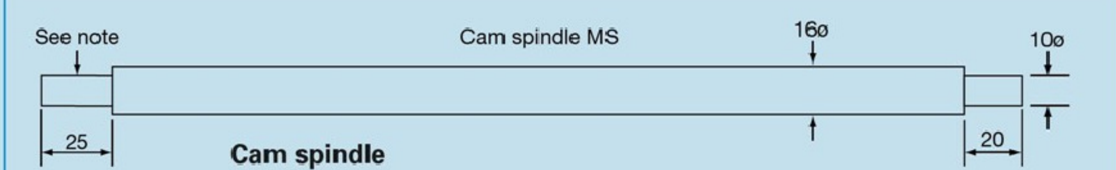


Table lifting cams
Mild steel 3mm



Cam bush shoulder to fit hole in cam



Cam spindle
Mild steel

Spigots 10mm. The longer one to be screwcut M10 to within 4mm of shoulder.
Shoulders approx. 29mm apart to be easy fit between side plates and good fit in 10mm reamed holes.

LINK UP

Would readers wishing to make use of this facility please note that the maximum total value of items accepted for a 'For Sale' entry is £50. To advertise goods of a greater value, please contact our Classified Advertisement Department. Please indicate clearly if an item is intended for Link Up.

WANTED

- Apron, saddle cross-slide and top slide for a Viceroy TDS 1 lathe.
Tel. Barry Robinson on 0121 704 4343 or e-mail at bsjriota@aol.com

- 135 tooth gear for Boxford lathe
Tel. 0208 856 4159 (London)

- Users'Instructions or a manual for a 6in. Bulgarian SOFIA C8M toolroom lathe. I would appreciate a photocopy to assist in restoring and maintaining my lathe. All costs will be reimbursed.
David Dunnet, 20 Roseworthy Cres., FARRER ACT 2607 Australia

- Vertical slotting attachment for a Harrison 600 milling machine. Also has anyone an Acme tap, ½in. x 8 tpi LEFT HAND THREAD that I could buy, borrow or hire. I have just one bronze nut to thread.
Tel. Denis on 01777 704582

- Instruction book or information on the use of a Viceroy (Denford Machine Tools) drillsharpener Model No. TDS 29 Serial No. 001
Tel. Arthur Booth on 0115 9654 958 (Nottingham)

- Information/Manual (or copy) required for my almost complete Taylor Hobson engraver. The only information I have is :- Motor belt 110/596 and Spindle 110/279. All help appreciated and costs met.
Tel. H. Lloyd on 01443 412578 (Mid Glamorgan)

- I recently acquired an old Hilger & Watts centring microscope (TM80-1 177742) on an R8 shank, but the cross-hairs do not coincide with the centre of rotation. Can this be re-adjusted? Any advice would be welcome and a photocopy handbook even more so.
Tony Moss, 43 Windsor Gardens, Bedlington, Northumberland NE22 5SY Tel./Fax 01670 823232 e-mail tony@lindisun.demon.co.uk

ON THE LEVEL

1. *The prototype large lapping jig*

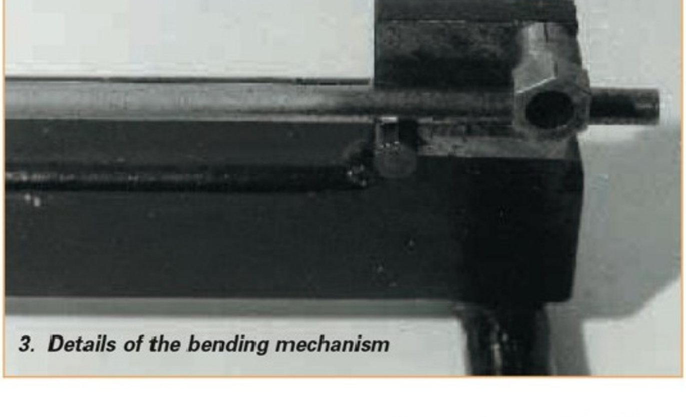
Precision instruments of high sensitivity are usually expensive, so their purchase cannot often be justified for home workshop use. Bill Morris demonstrates that it is possible to construct one such item with relatively little difficulty

Spirit levels have been used in surveying and scientific instruments for at least two hundred and fifty years, though carpenters and joiners probably made do with plumb line and square for much of this time. Every engineering workshop too should have access to a precision level, an instrument which is indispensable for setting up machinery so that surfaces are not only horizontal, but also that each part of a plane surface is in the same plane as every other part. A good example of this is the top of a lathe bed. If a lathe bed is without 'wind' (not twisted) when bolted down, a level placed across each end of the bed will give the same reading. If it is without wear then a level placed on a base with two feet about 30mm apart will give a constant reading as it is stepped along the bed. The level then in effect detects changes in height. In this instance, it is unimportant that the bed is truly horizontal, but on milling and shaping machines, when setting up a work piece, it is very helpful at times to know that the table top is horizontal. For example, on that occasion when you forget to do part of a machining operation and break down the set-up, a previously-machined surface on the work piece can be set level, with the assurance that it will again be parallel to the table top.

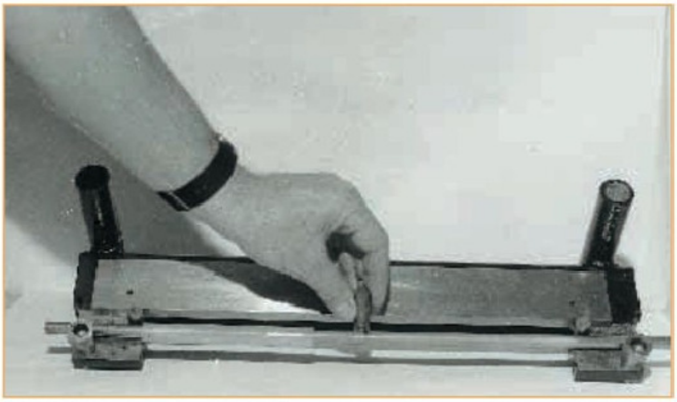
Spirit level vials are also to be found in clinometers. Angles can be set up using various protractors of more or less precision, but sometimes it is all but impossible to set up an angle between a datum on the work piece and the vice base or table top. In these situations, a clinometer really comes into its own. I owned a sine bar clinometer for many years before I was first able to use it. My grandfather bought it after the First World War because he thought it would interest his children, three of whom subsequently became engineers. When I got my hands on it as a twelve year old, the first thing I did was to break the vial accidentally, as I could not resist taking it to bits to find out how it worked. It was years before I could find - and afford - a replacement vial of appropriate sensitivity. In workshops throughout the world, there must be many clinometers and levels that are just so much scrap metal because their vials have been cracked or broken (I found a Moore and Wright level with a broken vial priced at $1 in the local junk shop just before Christmas!). It was with this in mind that I experimented with producing vials and wrote my article *"Playing with Spirits"* in Issue 33 (Jan/Feb 1996) of MEW. The method I described produced useable vials and in the article, I expressed the hope that another reader could enlighten me about the method actually used to produce precision vials. Cheap and insensitive vials are of course simply bits of bent glass tubing and later in 1996, in Issue 36 (July/August 1996) Peter Peters described a method of flexing glass tubing to produce the curve of large radius necessary for a precision level vial. A somewhat similar method was described in *"Home Shop Machinist"* of Jan/Feb 1988, which was in turn based on an article in the same magazine of Nov/ Dec of 1984.

Early in 1999 I mentioned in a letter to Derek Pearce of Shepperton that I had in mind to build a level comparator. This is a device used to compare lengths with a precision of a few micro inches and was devised by A J C Brookes of the National Physical Laboratory towards the end of the First World War. At its heart is a long spirit level vial, the bubble of which moves about 2.5mm per two or three arc seconds change in slope. Derek, who had worked at the NPL for many years, sent me some sketches to illustrate how vials were produced at the NPL in the early fifties and an illustration of the small-angle generator used to calibrate them. I set to work immediately and after many slips and false starts I can now reliably produce vials of about ten seconds sensitivity per 2.5mm division, complete with a calibration chart. Despite years of searching, I have never found any written account of producing ground vials (other than my own, of course), so I thought it would be of benefit to owners of levels, clinometers and divers scientific instruments with broken vials throughout the amateur world if I set down how it's done. Since you can't produce a useful vial without calibrating it, I will also give an account of my version of the *"NPL pattern Small-angle generator."* I will include too a little information on using computer programs to produce vial divisions and calibration charts.

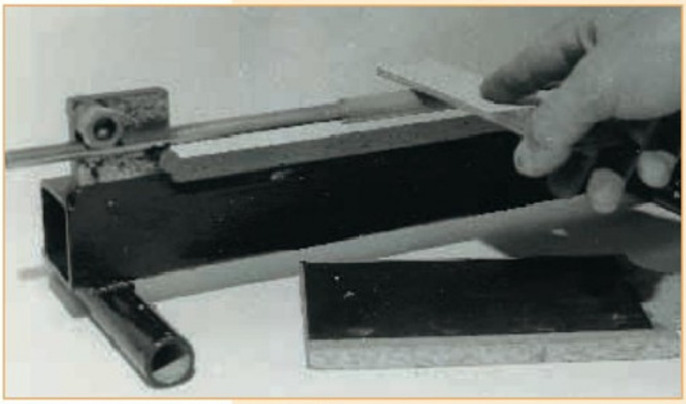
2. *The small lapping jig*



3. *Details of the bending mechanism*



4. Setting curvature with the gauge



5. Carrying out the initial lapping

Primer

Since not everyone will have access to the publications I have noted above, a brief primer of the level may be helpful. One way or another, the inside of a sealed glass tube or *vial* is curved. It is partly filled with a fluid, usually alcohol, but sometimes ether or acetone. Gravity pulls the fluid down, leaving the bubble at the top of the curve. Horizontal is defined by the two ends of the bubble or, what amounts to the same thing and much more usefully, at right angles to the line that passes from the centre of the bubble to the centre of curvature of the vial. If one end of a level of length l is raised through a height h to rotate it through an angle θ, the end of the bubble will move through a distance s **(Figure 1)**. For small angles, the tangent of the angle *expressed in radians* is very nearly the same as the angle itself. Since $h/l = s/r = \tan\theta = \theta$, then s/θ, the ratio of bubble movement to the change in angle, or *sensitivity* is equal to r, the radius of the vial. In other words, the larger the radius of the curve, the more the bubble moves for a given change in angle.

10 arc seconds = $1/360$ or 0.00278 degrees

$$0.00278 \text{ deg} = 0.00278\pi/180$$

$$= 0.0000485 \text{ radians,}$$

so for a bubble movement of 2.5mm the radius is

$$2.5/0.0000485 = 51566\text{mm}$$

$$= 51.566 \text{ metres or } 169 \text{ ft}$$

As the articles I have quoted above show, it is possible to bend glass tubing to a large radius and hold it bent, but in practice, the interior of a precision level vial is lapped to a barrel shape. My original article showed one way of doing this, producing an interior like two segments of cones stuck wide end to wide end, but again in practice this is not the most convenient contour and I only used the method because I could not find out how else to do it. Now if we had a cylindrical lap bent to the correct radius, we could lap the interior of our vial, partially fill it with alcohol, seal the ends and the problem would be solved. But how do we bend the lap to a segment of a circle (rather than, say, of a parabola or other shape) of the correct radius and hold it there? Assuredly not by putting a bar across a knee, pulling the ends and hoping for the best!

How much to bend

If you hold a flexible ruler with your index fingers on top at the ends and press upwards underneath with your thumbs a little way from the ends, the same distance each end, the ruler will bend without shear and is said in this state of symmetrical stress to be in pure bending. As mathematicians are fond of saying, "it can be shown" (but not by me!) that bent in this way the curvature of the ruler is circular. If we can do something similar with a cylindrical lap reproducibly and in a controlled way, we shall have more than half-solved the problem of lapping the vial. But first we need to work out how much to bend our lap.

Let's first assume that the space between our thumbs, as it were, is a manageable 700mm as in my prototype and make this a chord of our circle of radius of 51.566 metres (**Figure 2**, not to scale!). We need to know the distance d between this chord and the circumference.

By Pythgoras's theorem, $r^2 = x^2 + 350^2$

So $x^2 = r^2 - 350^2$

and $x = \sqrt{(r^2 - 350^2)}$..................*(1)*

But $r = x + d$

so $d = r - x$

so $d = r - \sqrt{(r^2 - 350^2)}$...............*(2)*

Substituting in *(2)*

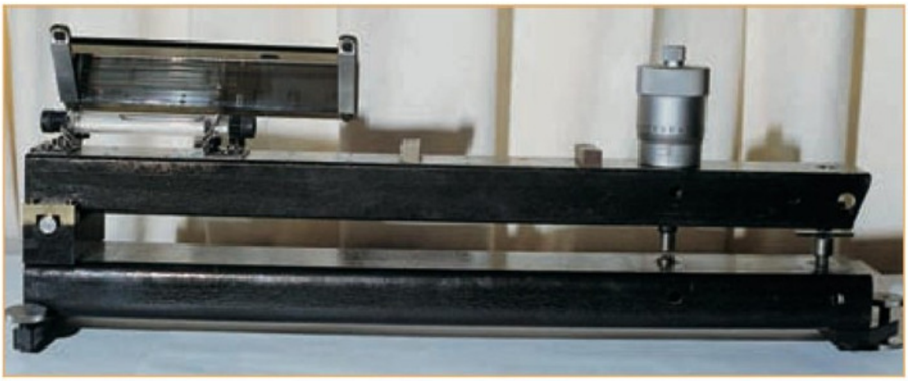
$$d = 51{,}566 - \sqrt{(51{,}566^2 - 350^2)}$$

$$= \underline{1.19\text{mm}}$$

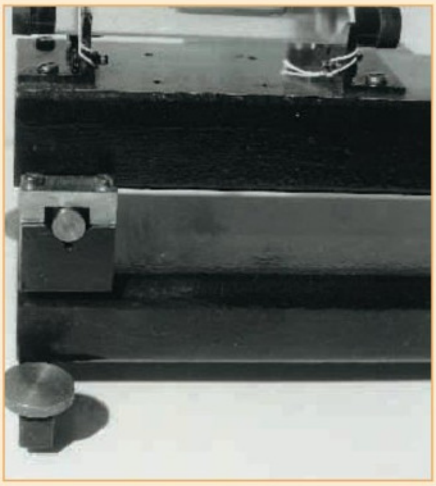
For a given chord length, if you want a tube half as sensitive, the radius halves and d doubles. So for, say, a sensitivity of 20 seconds per 2.5mm division , the radius halves to 25,783mm and d becomes 2.38mm.

Jigs

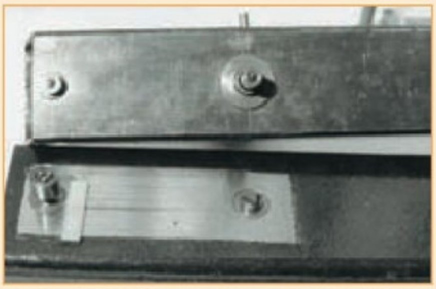
My prototype lapping jig is shown in **Photo. 1.** I needed a level tube about 300mm long and had a large quantity of glass tubing of about 22mm internal diameter that a friend had given me, so I built the jig to be able to bend a 1 metre length of 20mm diameter round mild steel bar. Since I also had a large quantity of scrap rectangular steel tubing, I used this, following the NPL pattern, but passing the bar through the walls of the tubing as shown. Two hardened silver steel pegs form the fulcrums while two



6. The small angle generator



7. Details of the axis



8. A view of the anvils and their bushes

screws bear down on centre holes in the ends of the bar. Another piece of scrap steel tubing, ground flat along the top, forms a datum base for a dial indicator stand. This datum is attached only at its centre, so that the flexing of the jig that occurs as the bar bends is not transferred to the datum. The screws are progressively tightened, keeping the readings of the DTI the same at 350mm from the centre point each way, and adjusting until the desired reading at the centre of the bar is obtained.

I learned a lot about lapping with this jig, but not many people would want such a large level vial, so I also built the smaller and simpler one shown in **Photo. 2** and **Figure 3**. This is suitable for lapping tubing of about 10mm internal diameter. Its origins in the scrap box can be seen. Two pieces of 12mm plate are welded atop a piece of 50mm square tubing and each plate has let into it two hardened 12mm diameter projecting pegs. The two lower pegs are filed into a vee shape on the top, leaving narrow lands 340mm apart to act as lower fulcrums for the lap. The two upper pegs form spindles for case-hardened eccentric round nuts which are rotated to apply a downward force on the ends of the lap which is 10mm in diameter **(Photo. 3)**. The nuts are rotated symmetrically until a plug gauge of the correct calculated size just fits between the underside of the centre point of the lap and the top of a straight edge resting against the underside of the lower plugs **(Photo. 4)**. Again, the datum is independent of any flexing of the bed. The drawings are simply to illustrate the construction of a jig that works and you can of course adjust dimensions to suit the contents of your scrap box.

For a ten second vial, radius of curvature 51,566mm and a lap of half-length 170mm, equation *(2)* above becomes:

$$d = 51{,}566 - \sqrt{(51{,}566^2 - 170^2)}$$

$$= 0.280mm$$

As the fulcrums are 12mm in diameter, the plug gauge needs to be 12.28mm diameter.

First get your tubing

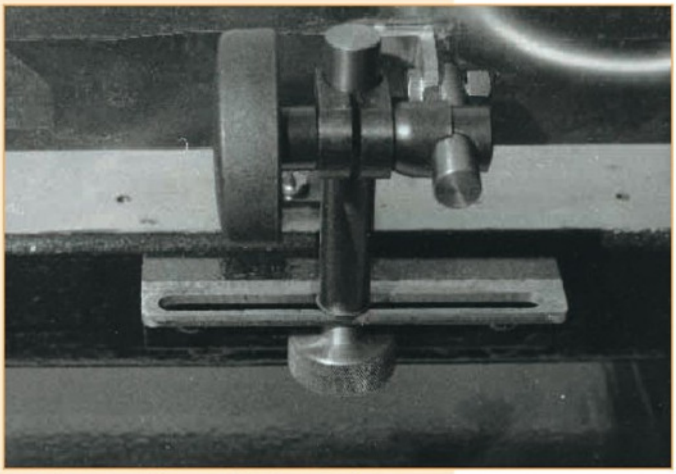
The standard technique for cutting glass tubing is to make a nick in it with a triangular file and then confidently, with the nick facing away from you, snap the tube with your thumbs. This only works for relatively small diameter tubing, is a marginal technique for 10 to 12mm tubing that I will be writing about later and consistently and expensively fails for 22mm diameter tubing, if indeed you succeed in applying enough force to break it at all. For larger diameters, say 12mm or greater, I found the easiest way was to grind a groove all round the circumference of the tubing with a miniature grinding disk in a Dremel-type tool and then heat up the tubing in the region of the groove with a blow torch. It needs a bit of experimentation to determine the right degree of heat, but it is short of red heat. The correct temperature is that which leads to a crack propagating around the groove when it is touched with a drop of cold water on a piece of flattened wire. Once this has happened, the glass breaks with scarcely any force needing to be applied and in my hands, at least, with a better than eighty percent success rate. I also tried, successfully, to speed up the grooving process by holding the tubing wrapped in a piece of rubber sheet in the chuck of the lathe, rotating at about 200 rpm and feeding in a wheel-truing diamond.

Now glass tubing is only approximately cylindrical and the internal diameter is only approximately constant. Since the lapping process is a longish and tedious one, it makes sense to employ machinery to do the hard work whenever possible, to get the interior of the tubing straight and round. To do this, chuck a piece of round bar that is a comfortable fit inside the tubing, centre the outboard end, smear some coarse grinding paste over the bar, thread on the tubing, support the outboard end with the tail centre and set the lathe in motion. Unless you are rich and careless about the well-being of your lathe bed, cover it with plenty of newspaper to protect it from falling grinding paste and grit. Don't use old rags for this purpose as they cannot be relied upon to tear like newspaper if they get caught up in rotating work and take your hand with them. With a piece of board coated with rubber sheet or thin foam plastic, counter rotate the tubing against the rotating mandrel, adding a few drops of fluid - water or kerosene, depending on the type of grinding paste, when resistance seems to be increasing. Remove the tube from time to time and wash it. When it is evenly frosted on the inside, you are ready to move on to lapping the interior to a barrel shape.

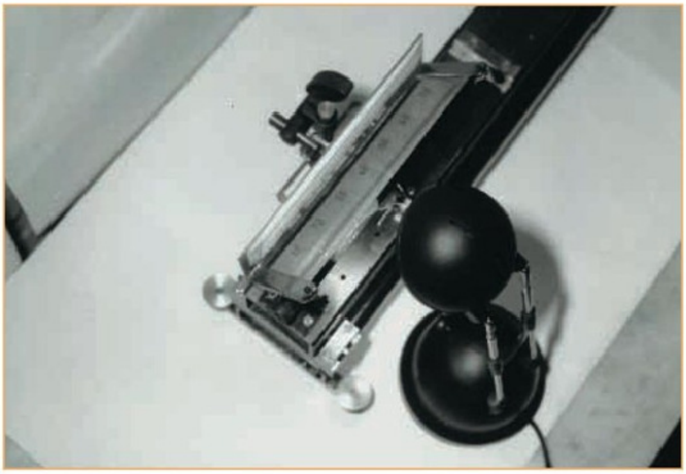
Lapping

Thread the 'tube blank' on to the jig mandrel and rotate the eccentric nuts symmetrically until your gauge of chosen size will just fit between the centre point of the mandrel and a straight edge held against the underside of the lower fulcrums. You are then ready for a trial run. Smear a little medium grinding paste along the top of the mandrel, slide the tube to the middle and with a narrow, rubber faced paddle bearing on top of the middle part of the tube start the lapping process **(Photo. 5)**. Work out your own routine. I use a few back and forth strokes, finishing with the paddle at one end of the stroke and then restart another series at the other end of the stroke so that the tube is ground evenly around its periphery. There is no need to apply any more force than is necessary to make the tube rotate and it is the fine slurry of grinding paste that does the work rather than the grains embedded in the mandrel as in conventional lapping. Try to keep the movements of the paddle in the horizontal plane.

Quite quickly on 100 - 120mm lengths of 12mm OD tube you will see the initial zone of contact in the middle of the tube spread out until it reaches the ends of the tube. Then spend a few minutes using a broader paddle that spans the whole length of the tube. At this stage you can check to see whether the lapping has resulted in the hoped-for radius of curvature, but first



9. The assembly on which the scale is mounted



10. A view of the reflected image of the scale

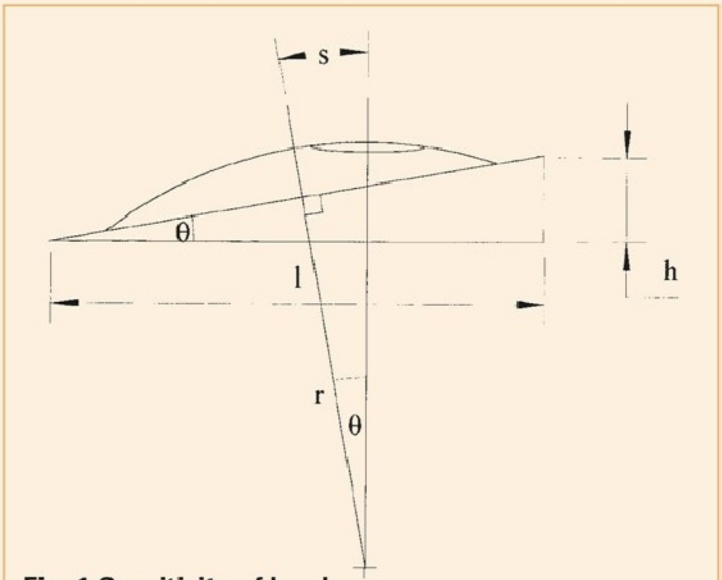


Fig. 1 Sensitivity of level

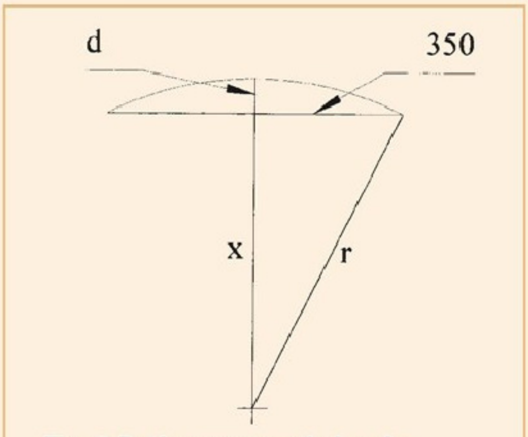


Fig. 2 Pythagoras and chords

mark the nuts with a pencil against a datum, as visible in Photo 3, so that you can return to the same starting point. In practice I have found that the radius is nearly always less than calculated, presumably for two reasons. The first is good old Hooke's law (stated in modern form): that where there is force there is bending, so that the mandrel's curve flattens a little under lapping forces. The second is that there is not line contact precisely along the top of the curve and as contact slips around the sides, the curvature reduces. No doubt machinery could be devised to keep the paddle moving precisely in the horizontal plane and I did toy with the idea of getting my shaping machine to do the work, but it scarcely seemed to be worth the trouble.

Rather than digress at this point with a description of tube calibration I will complete the description of the lapping process. If the tube has come close to the required radius first go, you have only to finish off with a few minutes spent lapping with fine paste. You can then clean up, recheck calibration and seal off the ends. Otherwise, make a small, symmetrical adjustment of the nuts in the appropriate direction and re-lap until you get to the desired curvature. I have found that once this point is reached, it can be reliably reproduced to within one second/division for a 10 second/division vial - but only if you remember to re-mark the nuts!

I use methylated spirit, decoloured with a drop of household bleach as the filling liquid. Isopropyl alcohol from your community chemist would do just as well. Rubber bungs from various sizes of "Vacutainer" blood test tubes come in very handy for temporary closure, as the bubble size can be adjusted by injecting through the bung with a syringe and needle, though you will need to be on good terms with your doctor or local medical laboratory. Experienced glass blowers will be able to close the ends with the alcohol and correct-sized bubble in place. All I have ever succeeded in doing is getting an interesting but rather useless spirit lamp. Instead, for permanent closure I make brass end caps with a 6BA tapped hole in one of them. I glue them on with Araldite which seems to cope quite well with alcohol as long as you let it cure thoroughly, before filling the vial through the hole in the end and closing off with a screw and fibre washer.

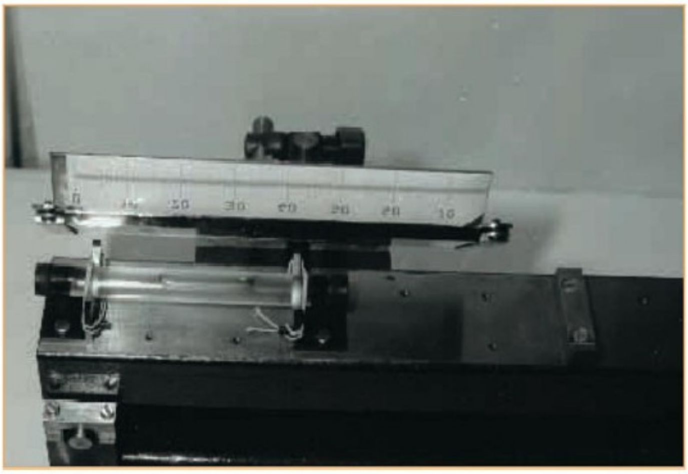
Calibration

If all you want to know is that your vial is of an approximate sensitivity, the vial can be mounted atop a parallel with Blue Tack and a feeler blade used beneath one end of the parallel to get an approximate angle, as described in my original article on vial-making (M.E.W. Issue 36). If you own or can borrow a sine bar with grade A surface plate and slip gauges, you can get a better idea of sensitivity and determine whether your vial is of constant radius. This is especially important if you want to use your vial as part of a measuring device. I did, so I set about making my version of the NPL small-angle generator.

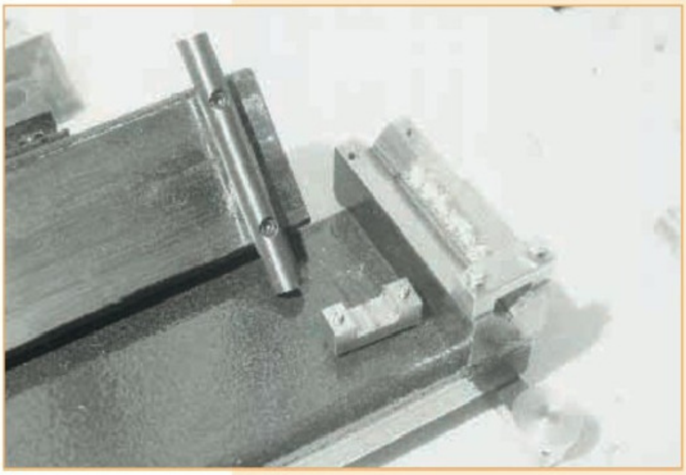
Small angle generator

This is essentially a long sine table. In it, I have incorporated adjustment methods that may be of interest to readers who, though not wishing to make the device, may well find application for them in other fields. I have a fairly large stock of scrap rectangular tubing with 3mm walls, so I decided to use up some of it to give a light but rigid structure **(Photo 6 and Figure 4)**.

The level of the base (1) can be adjusted by three foot-screws (2). Attached to the base at one end is an accurately made vee block (3) and a lapped round bar (4) attached to the top (5) rests in it and is restrained in place by a pair of trunnion caps (6) **(Photo. 7)**. At the other end of the base is an anvil (7), adjustable up and down, made up of three hardened steel balls. At this end of the top is another anvil



11. A direct view of the scale



12. The scraped vee block

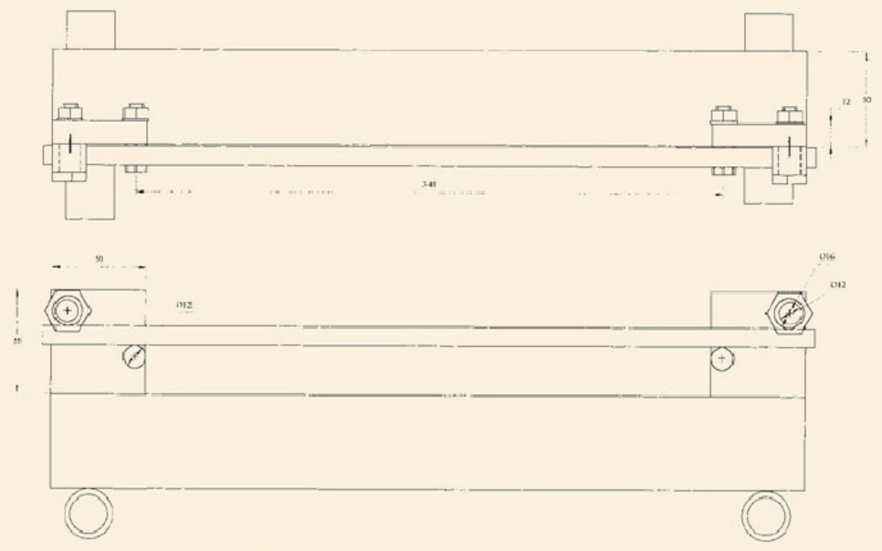


Fig. 3 Vial lapping jig
General arrangement

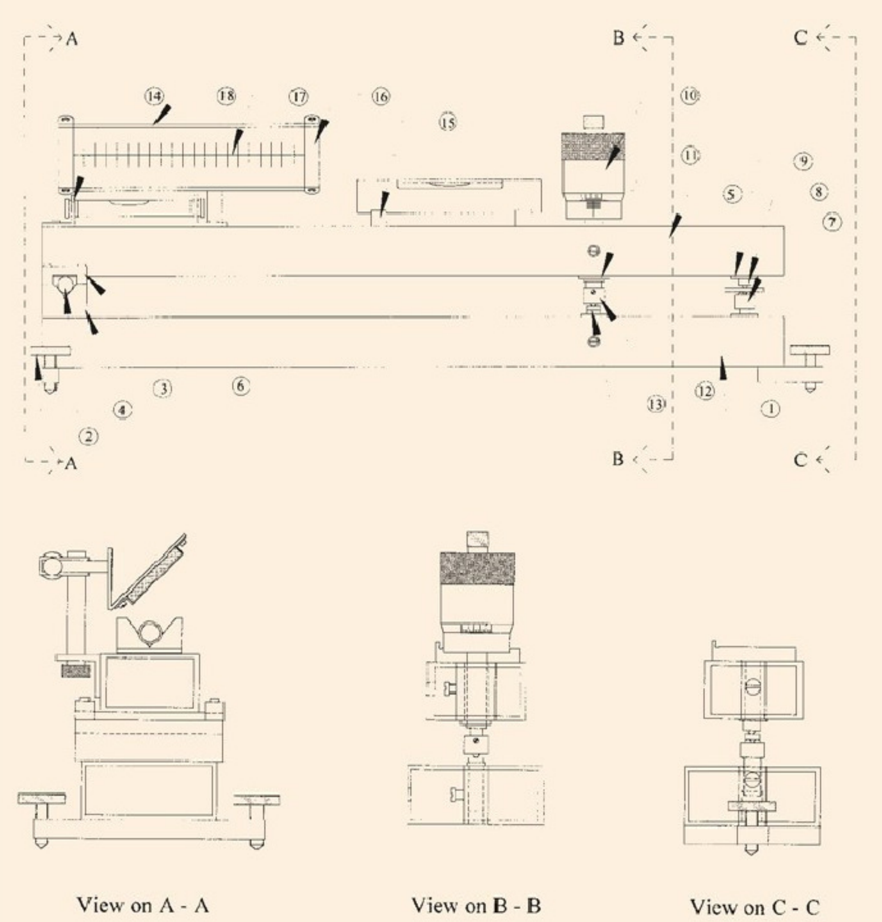


Fig. 4 Small angle generator
General arrangement

(8) consisting of only one ball. The holder for the ball is made of some convenient diameter which is easily measured, while the spigot that mounts it in the bush (9) is made slightly eccentric so that the distance between the axis of the bar and the centre of the ball can be adjusted accurately **(Photo 8)**.

What is this distance? Well, if you have Imperial slip gauges, it is convenient to make a change in height of $^1/_{1000}$in. correspond to a change in angle of 10 arc seconds ($^1/_{360}$ degree), so the separation is $^{0.001}/_{\sin 10\ \mathrm{sec}}$, which comes to 20.627in. (523.93mm). Since you cannot measure from the centre of the bar to the centre of the ball, you measure the distance between the bar and the ball holder. This will be 20.627in. *less* the semi-diameter of the bar and the semi-diameter of the stem of the anvil. This distance cannot be set out using a ruler, because two end measurements are needed. No very great accuracy is required, however, as an error in length of 0.01in. in length causes an error in angle of less than a tenth of a second, so it is not very hard to make an adjustable length bar of an accuracy that will depend on your means of measurement. If you have access to a set of proper length bars or *two* sets of slip gauges, these are ideal, but at a pinch, a ruler dimension will do.

If you have metric slip gauges then it is convenient to make steps of 0.01mm correspond to 5 sec, in which case the distance between centres is 412.53mm (16.24in.). I have only Imperial slip gauges but I have several large metric micrometer heads that I switch between equipment, so I mounted one of these in an eccentric bush (11) at the requisite distance, for illustration and for when smaller degrees of precision are required than are given by slip gauges. The ball end (12) fitted to the micrometer spindle, bears on a flat anvil (13) made from a discarded carbide insert, lapped flat on a diamond lap, though hardened silver steel would probably have done just as well (Photo. 8). The various anvils and micrometer bush are mounted in substantial bushes, visible in Photo. 8, that span both walls of the rectangular tubing that makes up the base and top. These are glued in place.

I surface ground the top surface of the top, but this is not really necessary so long as the top is reasonably smooth and flat. At one end of the top are mounted two skeleton vee blocks (14) made from steel angle so that a level vial can be attached by means of elastic bands. Further along are two blocks (15) with the tops ground and scraped so as to be in the same plane. These provide a seating when calibrating vials already mounted into level bodies. There are tapped holes in the top, to allow vials and levels of various lengths to be accommodated. Mounted on a bracket **(Photo. 9)** attached to the back of the top is a holder (16) for a scale (17) held in the vertical plane with, at 45 degrees to it, a piece of semi-reflective glass (18). The scale and glass can be adjusted up and down. When looking vertically downwards through the glass at a well-illuminated level vial below, the image of the scale can also be seen and can be brought into the same image plane as the ends of the bubble **(Photo. 10)**. The main divisions on the scale are 2.5mm apart, as this is now the standard separation of vial graduations, rather than the former 0.1inch. A little thought will show that the numerals on the scale have to be both upside down and laterally reversed as in a mirror image **(Photo. 11)** for them to appear correctly when looking from above from the front of the instrument.

Construction

Construction of the angle generator is quite straightforward for the most part, though it requires careful marking out. I cannot think that the instrument will be constructed by very many readers, and those who do so are likely to be experienced, so I will let the drawing tell their own story for the most part. The holes in the top and base for the anvil bushes can be drilled and reamed, but the ones for the micrometer is rather large and

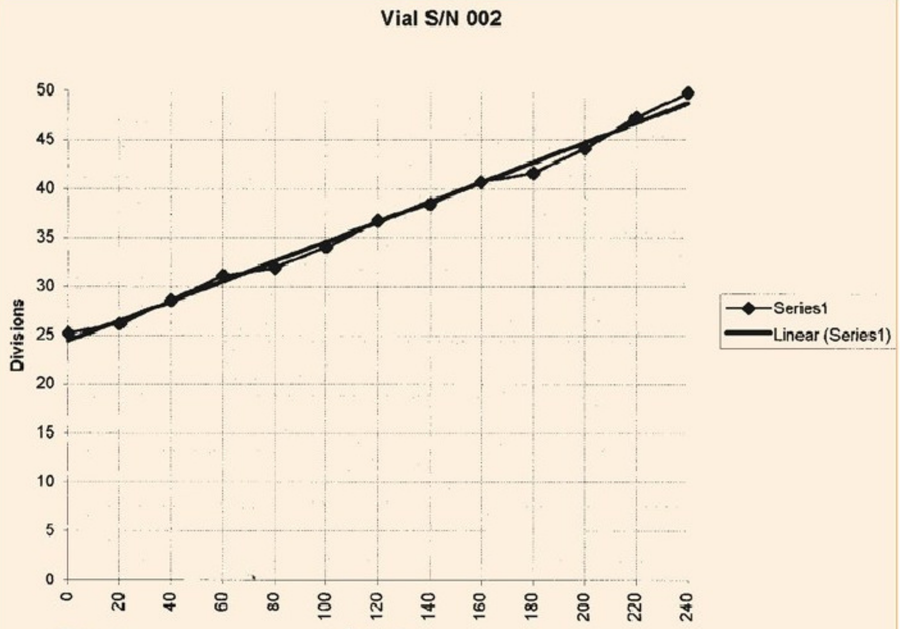


Fig. 5

Vial S/N 002			
Seconds	**Mean**	**Divisions L**	**Divisions R**
0	25.2	18	32.4
20	26.2	19	33.4
40	28.6	21.4	35.8
60	31.1	23.8	38.4
80	31.9	24.6	39.2
100	34	26.7	41.3
120	36.7	29.4	44
140	38.4	31.1	45.7
160	40.7	33.4	48
180	41.6	34.8	48.4
200	44.1	36.8	51.4
220	47.3	40	54.6
240	49.8	42.6	57
Slope 9.8 arcseconds per 2.5mm division			

is best drilled and then bored either mounted on the boring table of a lathe or using a boring head in a vertical milling machine.

The axis of the instrument can be made from a piece of silver steel bar and in amateur hands is unlikely to see much wear, so does not need to be hardened. As such bar is centreless ground it is usually slightly lobed, perhaps not enough to cause much error when only very small angles are involved. Neverthless, I made a ring lap and spent a few minutes removing surface blemishes and perhaps also reducing lobing. Its mating part, the vee block, I made from cast iron in the shaping machine, but it could also be done with an end mill in a vertical milling machine or on the vertical slide of a lathe. However, the finish on the side produced by the side teeth of the milling cutter is not as good as that produced by the end teeth. On the other hand, if there is any slackness in the ram of the shaping machine, the width of the vee will end up greater at one end than the other and the base of the block will then have to be re-finished to bring it parallel to the walls of the vee. I thought it worth while to finish by scraping and I then relieved the central portion of the vee by further scraping **(Photo. 12)**, so that the top of the instrument bears on two small areas and a ball point. I made the trunnion caps out of brass, aiming for a slightly loose fit at first. A perfect fit can then be arrived at by rubbing the surface that mates with the vee block on fine emery paper on a flat surface, until, with the caps screwed up tightly, there is free rotation but without any trace of shake at the anvil end of the top.

It might be thought that if the thread of the three-ball anvil and its bush are not perfectly square with the plane passing through the tops of the balls, serious errors will result. However, the error, L(1 - cos *x*), where L is the thickness of the gauge and *x* the angle of misalignment, is proportional to the length of the gauge, so that the *difference* between two gauges of, say, 0.1 and 0.11 will still be 0.01. To fit three balls snugly into the top of the anvil, make the seat for them 2.15 times the diameter of the balls you have on hand.

For the scale reader I begged a large scrap of 5mm reflective window glass from a local glass merchant. Mount it with its reflective coating uppermost and if you are not confident cutting glass to size talk nicely to the merchant and he may pass on some tips to you or even cut it for you. Most beginners press too hard with the glass cutter and move it hesitantly, so that the resulting scratch is irregular and a clean break a matter of luck. The scale can be laid out by hand, but if you or a friend have a drafting program on your computer, very professional-looking results can be obtained. I used the *Edit/Copy entity/Fit linear* device of TurboCAD Designer 3.0 to give 2.5mm divisions, each subdivided into 5. With a hand lens of about 60mm focal length it is then possible to read easily to the nearest 0.5mm. I couldn't get the program to give me inverted mirror images, so in the end I used an upside-down, back-to-front lettering stencil.

Using the generator

In use, the instrument must of course be on a stable surface that is not likely to move as you shift your weight on the floor. Level vials often break if dropped so I secure mine in the vees with elastic bands as can be seen in **Photo. 11**. With a 0.1in. slip gauge between the anvils, or the micrometer set to some convenient whole number of mm, use the single levelling screw at the anvil end to bring one end of the bubble against a graduation on the scale. Move your head from side to side along the length of the tube and if the graduation stays in contact with the end of the bubble all is well: there is no parallax and the image of the scale is in the same plane as the bubble. If contact is lost, then adjust the scale up or down and try again until there is no apparent parallax. Note the reading at both ends of the bubble, record the mean and replace the slip gauge with one that is 0.001in. larger, again noting the readings at both ends and recording the mean. Continue until the bubble has traversed the whole length of the tube and then come back down again, again recording the means as you go. They should be the same each way to within very close limits. You take the mean of both ends because with very sensitive vials, changes in temperature caused by breath or draughts can lead to significant changes in the size of the bubble.

Once you have all your readings, you can make a pretty graph **(Figure 5)**. If all the points are on the same straight line, then the curvature of your vial is constant, i.e. circular and you can actually rely on its graduations to measure small changes in angle. If you get a straight line graph, then the slope of the graph gives you the sensitivity of the vial. If you have a computer program like Microsoft Excel 7.0, you can use its Graph Wizard to produce the graph, and its Function Wizard to draw in the line of best fit and to tell you what the slope of that line is. Choose *Statistical* under "Function category" and *Slope* under "Function name". Figure 1 shows some actual results in which the angle went up in steps of 20 seconds. Inspection shows that the reading increased by about 20 divisions for a change in angle of 200 seconds, so that the vial is of about 10 seconds per division. The line of best fit is of 9.8 seconds per 2.5mm division, not a bad result for my second attempt!

Graduations

CAD programs have made drawing of graduations much easier. My original article advised drawing graduations directly on to the vial and then protecting them with polyurethane varnish. If you have a CAD program, you can draw the graduations very easily, using the *Copy entities* function. You can then copy several on to one sheet of A4 for your friends to use and take it along to your local copy shop to have it printed on to Mylar film. This can then be wrapped around the vial printed side in prior to mounting to give very clear and professional-looking results, rather more durable than ink protected by varnish.

I look forward to hearing from people who have at last resurrected previously useless clinometers and levels and would be happy to receive enquiries and comments via the Editor or by e-mail at engineer@clear.net.nz.

WE VISIT A MASTER ENGINE BUILDER

1. Brian at work on his latest project, the cylinder head of a 1/4 scale model of a 'Bristol' Hydra 16 cylinder double-octagon radial aero engine

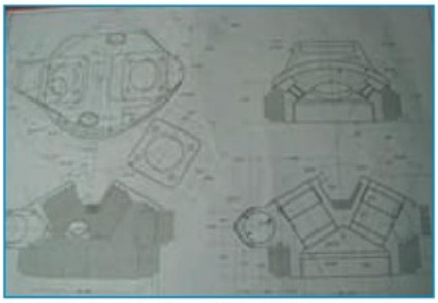
Brian Perkins developed an interest in air-cooled aero engines during his apprenticeship with the Engine Division of the Bristol Aeroplane Company, but was diverted to other subjects when he left to establish his own design and manufacturing business. However, in the 1970s he built his own full size single seater Colibri aircraft, powered by a Volkswagen engine, and later decided to construct a 2/5 scale replica of the aircraft and engine combination. On his retirement from the business he set out to tackle a 1/4 scale working model of one of the smaller 'Bristol' sleeve valve engines, the nine cylinder Aquila, using the example in the Rolls-Royce Heritage Trust collection as the source of data. He actually worked on two sets of parts in parallel, so that we are able to see the completed version and a partially assembled engine which allows us to examine the complex structure and to admire the high quality of workmanship.

Brian's workshop is modestly equipped, housing a Myford S7 lathe, Warco bench-mounted milling machine, drilling machine and bandsaw, demonstrating that it is possible to create sophisticated award-winning models with the machinery available to most model engineers. As would be expected, many special purpose tools, jigs and fixtures are needed, but Brian has shown that these can be simple as well as effective.

2. A test piece for the Hydra cylinder head being used to determine the process for machining the cooling fins. Brian has commented that he is still not certain how the full size heads were produced

3. Another view of the set-up on the 'Warco' milling machine showing the simple base, attached to the rotary table, used to vary the radius of the cutting path

4. Digital read-outs fitted to the milling machine have proved invaluable when machining complex components from the solid



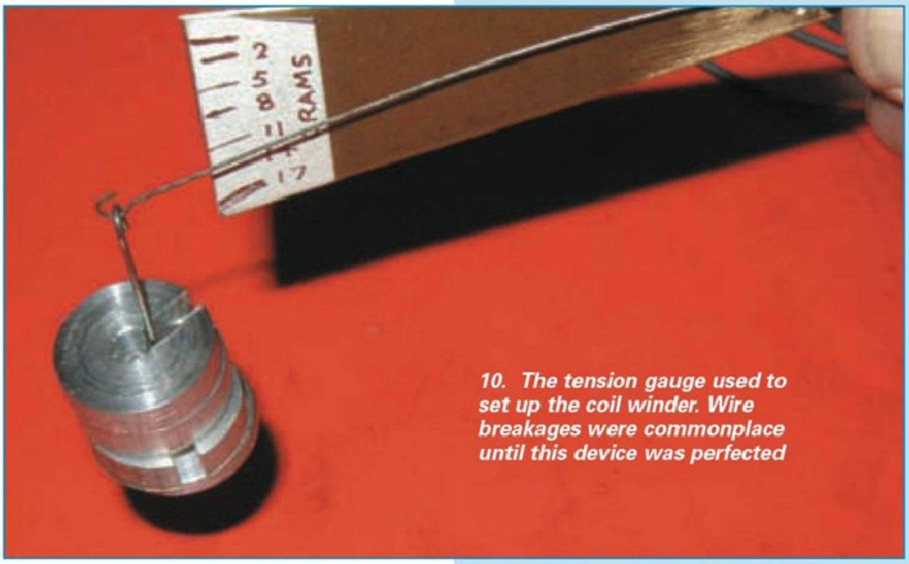
5. Brian's drawing of the Hydra cylinder head. The majority of the drawings for the engine are now complete

6. The 1/4 scale model of the nine cylinder 'Bristol' Aquila sleeve valve radial engine which won the Duke of Edinburgh Trophy at the Model Engineer Exhibition at Sandown Park

7. A second Aquila, built in parallel with the 'D of E' winner

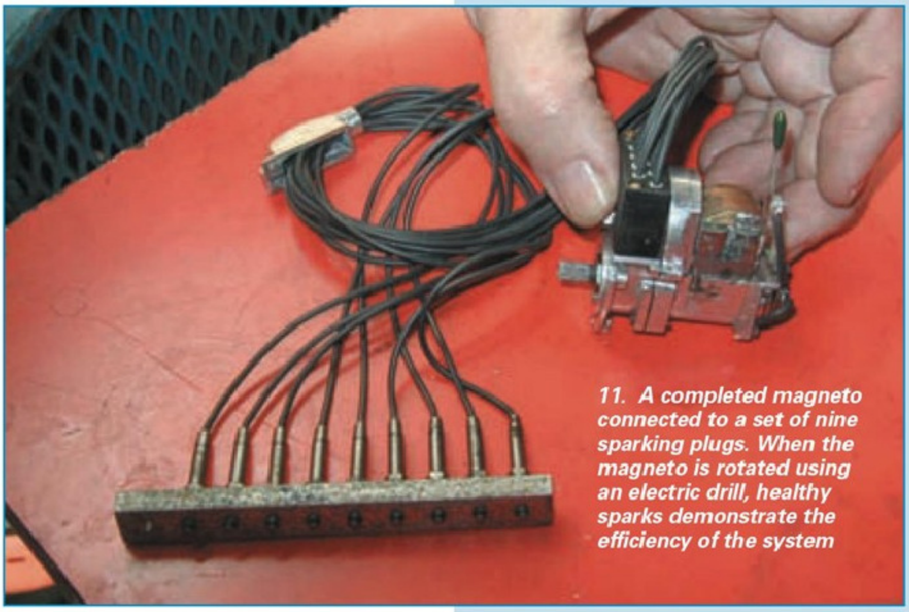
9. The winder constructed to facilitate the winding of the magneto coils. The secondary windings consist of 18000 turns of 0.0011in. dia. wire

8. An Aquila cylinder barrel shown with the eccentric turning mandrel on which it was made and the barrel to crankcase securing stud hole drilling jig



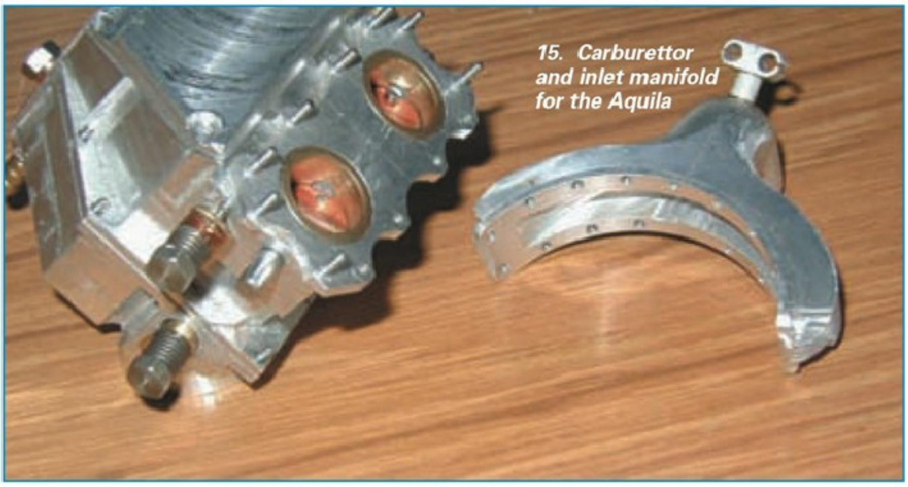
10. The tension gauge used to set up the coil winder. Wire breakages were commonplace until this device was perfected

12. A view of the magneto coil and contact breaker. After winding, the coils are vacuum impregnated with epoxy resin



11. A completed magneto connected to a set of nine sparking plugs. When the magneto is rotated using an electric drill, healthy sparks demonstrate the efficiency of the system

His current project is another 'Bristol' engine, but this time a poppet valve unit, the Hydra, of which a few prototypes were built. We look forward to following its progress.



15. Carburettor and inlet manifold for the Aquila

13. The Aquila ignition harness. Two plugs are fitted to each cylinder, independently energised by the pair of magnetos

14. The Aquila master connecting rod and articulated rod assembly

16. Assembly of the complex units requires miniature versions of the special spanners us ed in full size

IN OUR NEXT ISSUE

Coming up in Issue No. 78 will be

FREE-WHEEL HOBBING

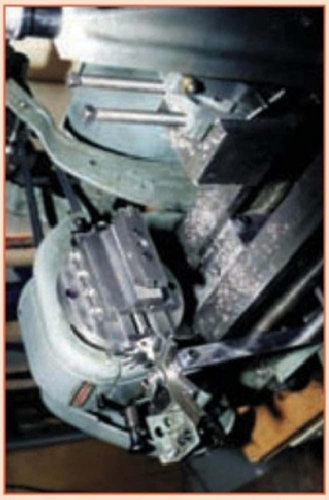
A relatively simple method of producing a worm wheel is described by Bill Morris

RENOVATING A MACHINE VICE

Victor Elseendoorn used two different methods of reclamation

A FACING AND BORING HEAD

Ted Wale updates an old Westbury design

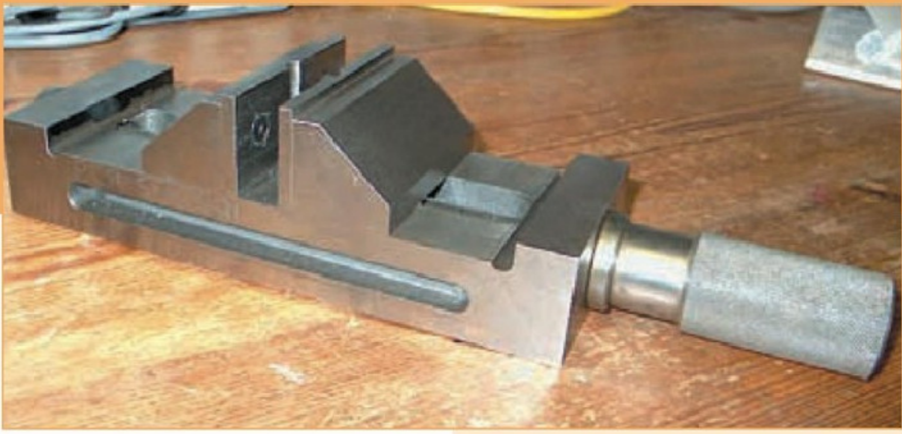


Issue on sale 9th November 2001

(Contents may be changed)

A SELF-CENTRING VICE

Peter Rawlinson describes a simple but useful addition to the range of workholding equipment to be found in the home workshop



1. The vice with a piece of material gripped between the jaws

This vice has been a useful item to build as with it is possible to drill or to mill on the centre line of a piece of material without having to measure to ensure central location, thus reducing the problems of alignment. The procedure used is to fit the drill bit or the milling cutter into the chuck or collet of the machine and to lower it between the jaws of the self-centring vice, lightly clamping it between the jaws. The vice, now positioned on the table, is then firmly clamped into place.

It is now possible for any piece of material of a size within the capacity of the vice to be gripped in the knowledge that the drill or cutter will be on the centre line of the material. Of course, the accuracy with which this can be achieved is going to be dependent upon the quality of manufacture of the components of the vice, something which is within the hand of the builder. Of particular importance is the machining of the left- and right-hand threaded clamping screw which brings the two moving jaws together.

I would suggest that this part is machined between centres, using a travelling steady for support, then to use a die as a chaser to finally shave the thread to size. Using this combination helps to produce the correct pitch of the threads and then to guarantee that the diameter and the angles and radii of the thread form are correct. I personally prefer to use a fine thread and to this end I have used 1/2in. UNF, which is of 20 tpi.

To some this may seem to be cheating, but I do not believe in making unnecessary work for myself and, unlike industry, we do not have facilities to grind the thread which would, of course, be the preferred method of finishing.

The only drawback of the design, if it can be called that is that the clearance from the top edge of the clamp screw to the 'table level' of the vice is only 5mm, so there is the possibility of drilling or machining through the workpiece into the screw, something which must be watched in order to avoid the need to continually have to make new screws.

As far as materials are concerned, cast iron would be ideal for the base and jaws, but mild steel would perform adequately and can be obtained much more easily, avoiding the added work required in the making of patterns. Stock section cast iron is available from some of our suppliers, and one of them may have something suitable.

The clamping screw is supported at each end by deep groove ball bearings of 1/2in. ID x 1 1/8in. OD x 5/16in. wide, which makes for ease of use and a provides a good 'feel'. I must admit that I took the easy way out and located the bearings directly on a threaded portion of the screw - not ideal, I will admit, but providing plain lands on which to locate the bearings would have greatly complicated the screwcutting and probably made it necessary to use a smaller diameter thread for the locking nuts.

The jaws carriers of my vice were made

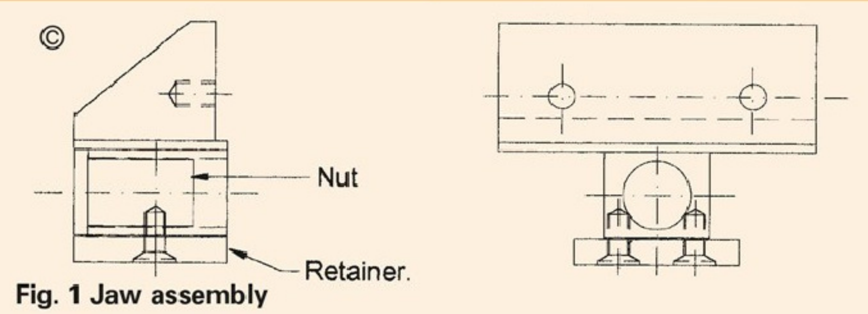
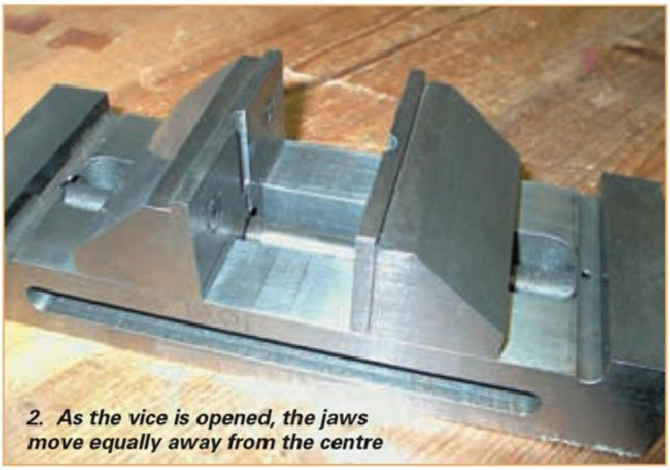
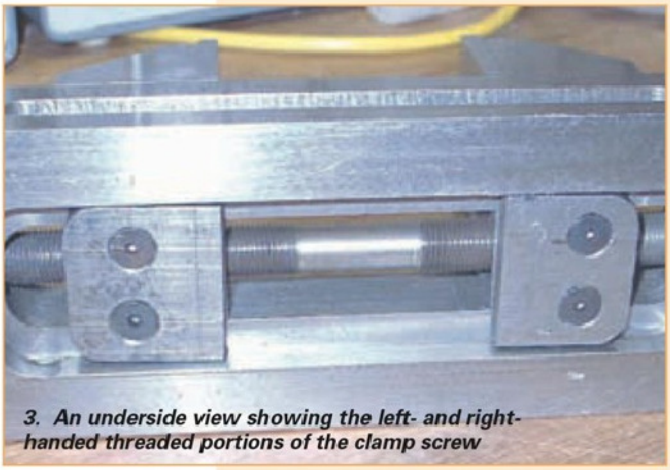


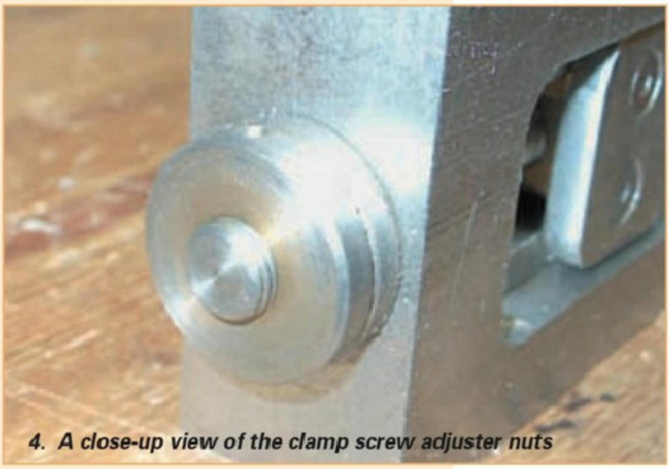
Fig. 1 Jaw assembly



2. As the vice is opened, the jaws move equally away from the centre



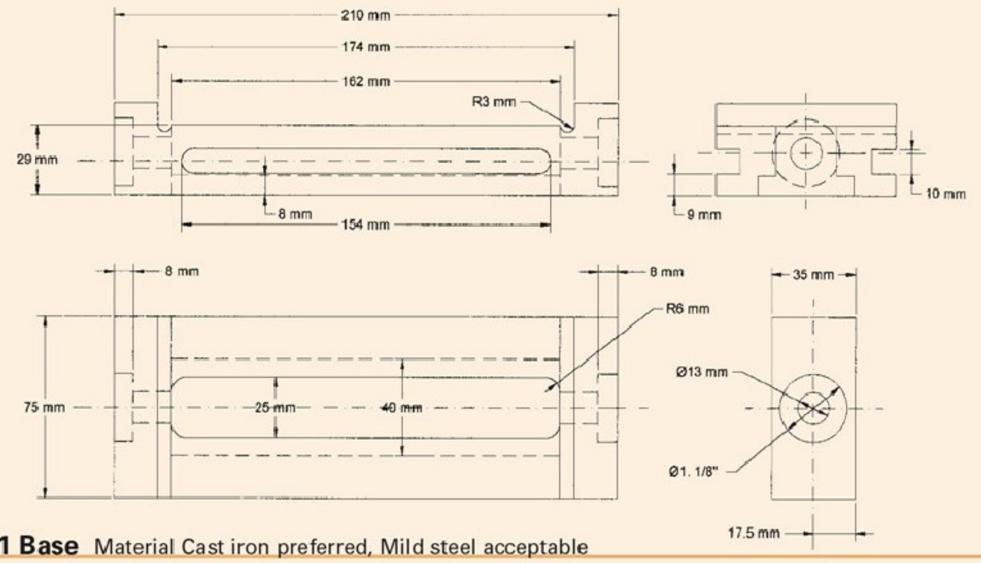
3. An underside view showing the left- and right-handed threaded portions of the clamp screw



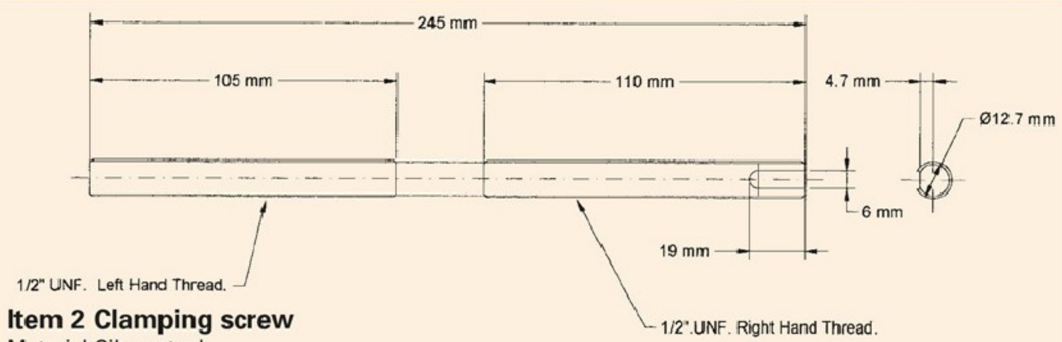
4. *A close-up view of the clamp screw adjuster nuts*

5. *The knurled handle could be drilled through to allow the use of a tommy bar*

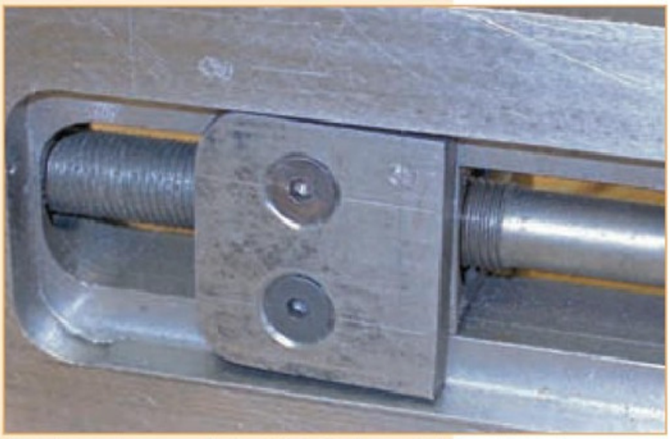
©



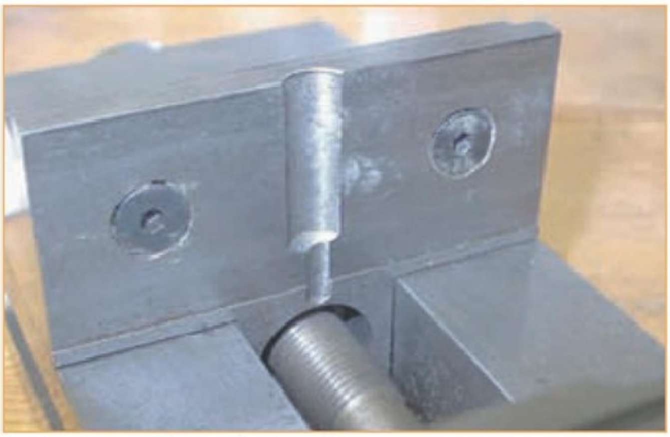
Item 1 Base Material Cast iron preferred, Mild steel acceptable



Item 2 Clamping screw
Material Silver steel



6. *The surfaces against which the jaw retaining plates bear may be scraped to adjust clearances and to provide a smooth action*



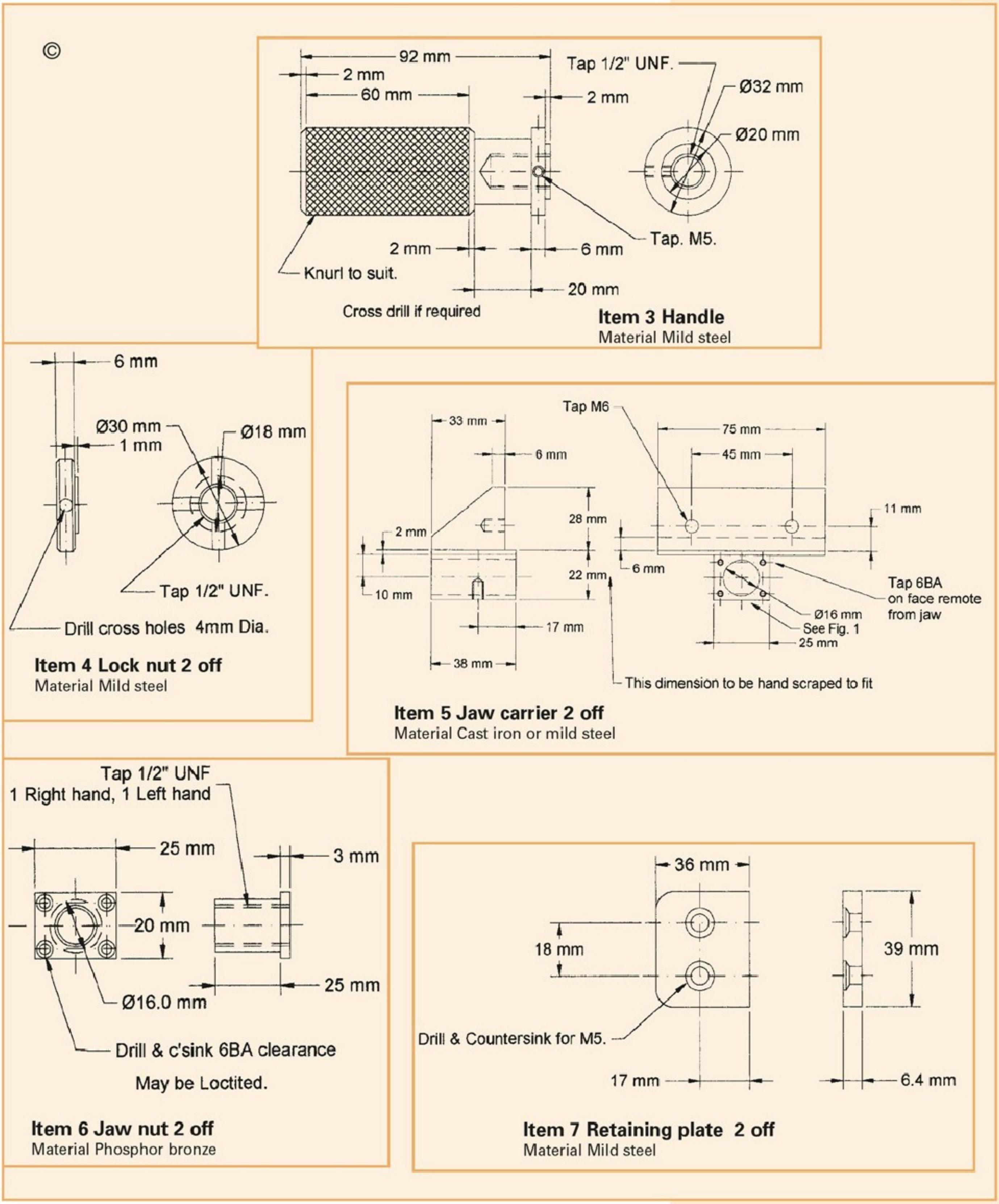
7. *Interchangeable jaw facings allow purpose-made groove patterns to be employed*

as shown on the drawing and the nuts can be retained by 6BA screws as I have shown or could be made either a press fit or Loctited into position. Any of the methods will be quite adequate as the flange of each nut is positioned on the opposite side to the pressure face of each jaw carrier **(see Figure 1)**. The nuts should be made from phosphor bronze, and if a press fit is to be used, ensure that the thread is not squeezed as it will be very difficult to recut the nut with only a few thou. to remove.

My own vice is only equipped with one set of removable jaws, but could be very easily made to accept the types covered in my article in Issue No. 48 (Jan. 1998) of M.E.W. Alternatively a variety of different jaws which simply bolt into place could be made, the faces being grooved or profiled to suit particular jobs. I am in a position to be able to surface grind jaw faces and wear surfaces, but if the machining is carried out using a fine finish cut and then hand finished, this will be adequate for the purpose.

The last and most important fitting operation is that of attaching the jaw retaining plates to the underside. These must be hand fitted such that the jaws slide easily but there is no play such as to allow the jaws to 'birds mouth' when pressure is applied.

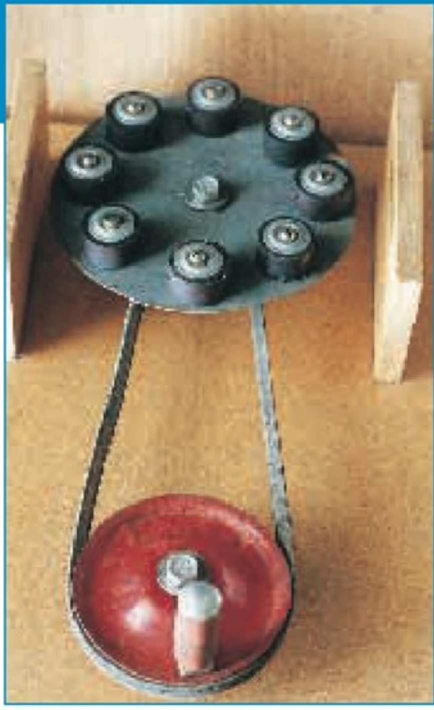
I hope that this project will be of interest and as I have said in previous articles, I am willing to provide advice if I can, but by telephone only please, on 01233 712158 (Charing, Kent).



ELECTRO-MAGNETIC DEVICES - Part 11

Toys for children of all ages

Tony Claridge concludes his series by describing some small constructional projects which will demonstrate some of the principles which have been discussed



A circular linear motor

Over twenty years ago I had the privilege of a private tutorial by the late Professor Eric Laithwaite of Imperial College, dealing with linear induction motors. Among other things, he showed me the action of what he called his "magnet river" which was essentially the stator of a three phase induction motor unrolled into a straight line. This produced a travelling magnetic field on its surface which could be observed through the effect on iron filings sprinkled on a card placed on the face of the motor. I was astounded at what I saw, and the professor confessed that he was not able to explain everything which he showed me that day.

I judged that the construction of a similar contraption was beyond my resources, so instead I built something which provided a cruder but real travelling field in a different way. It is illustrated in **Photo. 1**. It has fascinated many groups of school children when I have given lectures and demonstrations, mainly to promote engineering as a career. Like LBSC's creations it was built without drawings, but its construction is self-evident from the illustrations. You can devise your own version if you would like to make one. My example was made of MDF and the rotor is just a disc of sheet steel about 9in. diameter and 1/16in. thick, but I would have preferred to use a thicker disc to give better rigidity.

The permanent magnets, eight in number because that is what I happened to have, are ferrite and measure 30mm diameter by 15mm long. They are fixed with 4BA brass screws through a central hole in the magnets. The disc turns on a 10mm spindle which started life as a bolt and is fixed to the base board. The handwheel/pulley drive is of about 4:1 ratio, but I suggest that 6:1 would be better. The rotating magnets set up a rotating field which approximates to that of the Professor's magnetic river and to increase the 'frequency' you just turn the handle more quickly!

The MDF walls on each side are there to support the tray of iron filings which, in my case, is a transparent cake box kindly donated by the domestic authority. Iron filings can be obtained from suppliers of chemicals in most towns and will be more consistent than those you sweep up from around your vice. The whole thing needs to be securely fastened down to stop it skating about when you turn the handle.

Eddy Current Brake and Induction Motor Rotor

This item is even easier to make. It consists of little more than a disc of aluminium alloy supported on a bearing. Mine is fastened to a small drum for which I used a wooden cotton reel, and the assembly revolves on yet another 10mm bolt/spindle. **Figure 1** shows the idea. The mounting bracket is a bit of 2 1/2in. angle iron, and in use the thing is clamped to a bench or table top. A length of string is anchored to the drum and about a metre or so is wound on. A small weight of 75g or thereabouts is tied to the other end of the string and when this is released the string unwinds till the weight hits the floor in around a second. Next, a permanent magnet is held close to the disc and the test repeated. This time the weight will take between 3 and 10 seconds to reach the floor. We have built an eddy current brake! To get the most retardation the magnet's field should go through the disc, and the effect is greater when the magnet is close to the outer part of the disc. Now, take the disc and its bearing assembly and hold it with the disc horizontal just above the rotor of the circular linear motor described above. It will begin to revolve when the circular ring of magnets is turned, making what is perhaps the most inefficient induction motor in the history of electrical engineering. But it is a real induction motor! Finally we can make a simple electric generator. If you can find one, an old relay magnet or even part of an old transformer can be used. A better result will be obtained if you make something like that shown in **Figure 2**. By all means use solid steel, though laminated is to be preferred. Any coil will serve, with perhaps 100 turns or more. Experiment with what you can find. Connect a couple of light-emitting diodes in parallel across the ends of the coil with the polarity of each the opposite to the other. LEDs cost only a few pence each and can be obtained in a range of colours. Hold the assembly close to the rotating magnets and the LEDs will flash as each magnet goes past. The light is not very bright so it cannot be seen in sunlight.

Another Electromagnetic Gun

This device is really a toy which can be fun for small children. The construction is self-evident from **Figure 3**. The one I made for my daughters was about 75mm long with a bore of perhaps 6mm, to suit

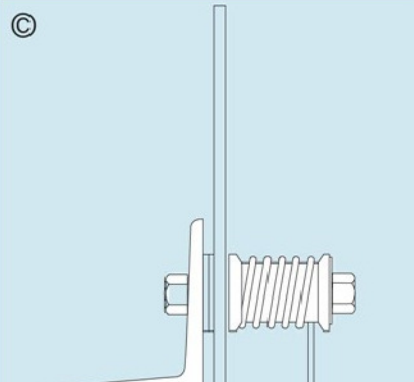
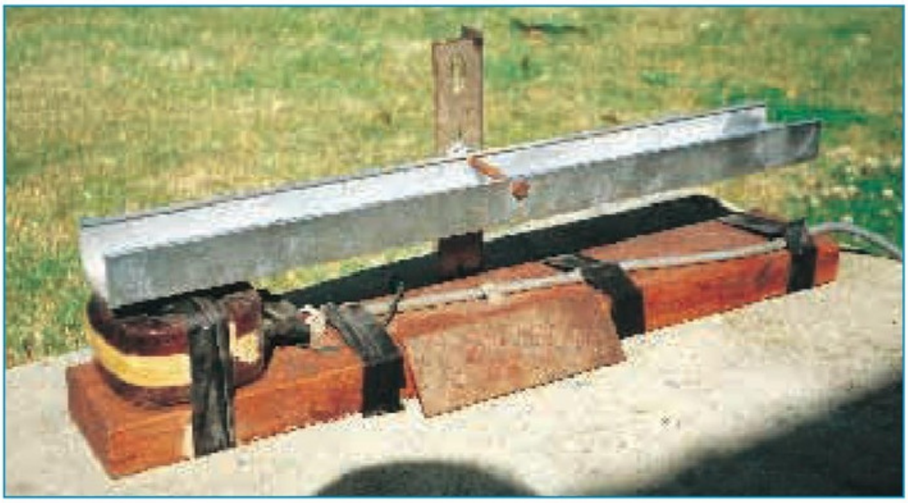


Fig. 1



the 'bullet' of 5mm mild steel. The spool was filled with enamelled wire of about 18 or 20swg (it was a long time ago) and that was it. The idea is that the projectile is attracted towards the middle of the coil when it is connected to a (six volt lantern) battery and if the current is cut off at the right instant, it will shoot out of the end and travel maybe a couple of metres. The forces involved were not great, but if anyone tries making one, for safety it would be best to ensure that no-one is in line with the 'business end' when it is demonstrated. Operation of my example was very erratic, and I was planning to experiment with capacitors charged from the battery and then used to deliver a more consistent current burst to the coil, but as my children grew older, the idea fell through. There's scope for some interesting development though.

An Electromagnetic Balance

Many years ago Professor Laithwaite presented the Royal Institution's Christmas Lectures, which you will perhaps know are aimed mainly at children. I watch them every year! One of his demonstrations was of magnetic levitation, making a copper sphere float above a coil. Two things are essential for this to work. First the coil, which in his demonstration was a reel of cable, has to be quite large, and secondly it is necessary to provide a field which is 'travelling' towards the centre; otherwise the sphere will just fall off. This was done by fitting a substantial shading ring on top of the coil so that roughly half the flux was retarded in time behind the rest, the retarded part being in the centre of course. All this was, like the magnetic river, beyond my resources so instead I built a balance, to enable some of the principles to be shown to children. It is seen in **Photo. 2**.

As you can see, it is a crude construction, but it serves well enough. The baseboard is is about half a metre cut from a length of 4 x 2. (how's that for mixed units?). Pivoted on a horizontal spindle, actually a 10mm bolt, is an aluminium beam. I was fortunate in finding a length of channel section alloy measuring 50mm x 30mm and with a wall thickness of about 1.5mm. The coil is acquired from I don't know where, and measures about 100mm OD, 40mm ID and 50mm long. In order to give it a magnetic core, the hole in the middle is stuffed with pins cut from plastic coated garden wire; being insulated, there is no problem with eddy currents. The electromagnet would be more powerful if one used an old mains transformer with one end of the magnetic core taken away, ie with the 'E' part of the laminations only, and with the open end facing upwards. If your transformer used 'T' and 'C' laminations it would be OK to take a saw to them.

I collected some off-cuts of both steel and aluminium which just fitted into the inside of the channel section beam, and were around 100mm long. In the schools I also borrowed one or two weights.

Now, with current flowing in the coil, AC of course, the field emerging from the inside of the coil acts on the metal above it. Aluminium and any other non-magnetic material is repelled in an endeavour to reduce eddy currents, the strength of the repulsion varying with the distance from the coil and also from the strength of the field. It also depends on the electrical conductivity of the material. By using a weight on the beam which is positioned to exactly match the magnetic repulsion, it is possible to conduct some experiments to find how the repulsion force changes according to the set-up.

When the steel plates are tried, there is a force of attraction, which can similarly be countered by a weight, this time on the other side of the beam. Later, one can experiment with a combination of steel and aluminium plates. If any reader fancies making a balance along these lines, I will be happy to help out with the coil design and anything else as well. No doubt any readers who do pursue the device will build it to a far higher standard of construction than mine.

This brings this series of articles to an end. I hope that you have found them interesting and if you have any queries about the articles or anything to do with magnetic devices, I shall be happy to answer them, or try to at least. Please send letters via the editor. If you have any projects where you think I may be able to help, don't hesitate to get in touch.

The torque reaction poser

In Part 10 (Issue 76) I said that I would reveal the way in which torque reaction occurs in the homopolar motor (the superconducting machine) which was described in the last article. Here is the answer.

Start by assuming that both sides of the power supply enter near the motor shaft. One is then connected via sliding brush contacts to the centre of the disc rotor. The other runs radially outwards via a second (stationary) disc to another sliding contact on the rotor's periphery. Then it is apparent that the stationary disc experiences the same torque as the rotor. Incidentally, if anyone had an application for a motor with outputs at both ends of the shaft, but with opposite direction of rotation, this is one way to do it. There is no torque on the superconducting field system.

The next step in the explanation is to point out that no matter what route the stationary current takes to reach the outer rim of the rotor, it has to cross the whole magnetic field to get there. Consequently the torque reaction always apppears somewhere along the current carrying member.

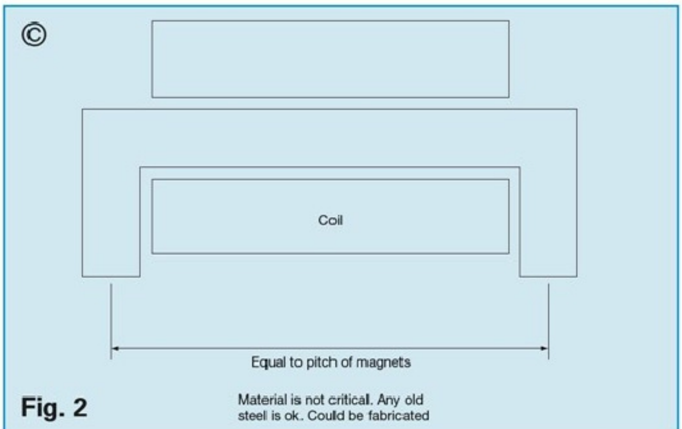


Fig. 2

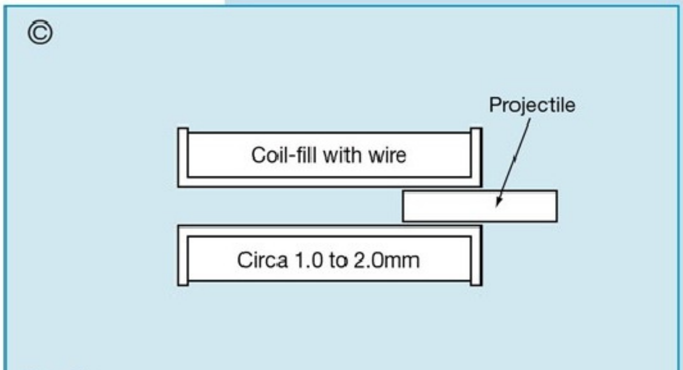


Fig. 3

SCRIBE A LINE

Help for the newcomer

From Gerry Collins, Chairman, The Society of Model and Experimental Engineers, London

I read with interest the letter from Paul Dudley (MEW July/ August 2001). The writer raises a number of issues which need to be addressed if the hobby is to continue to attract newcomers. Firstly, and this has nothing to do with model engineering, is the device that Mr. Dudley has invented. It is true that any inventor has to be careful until a patent is granted. I have on occasions carried out development work on various devices and I have always been happy to sign a confidentiality agreement before I knew any details of the device concerned. A year or two back I was approached to manufacture a prototype device and, having signed an agreement not to divulge any details I looked at the specifications and sketches. I formed an opinion that the device would not work as the inventor envisaged and at this stage he could have walked away with no fees involved. However, he did ask me to make a prototype and it gave me no satisfaction when the device failed to work. I suggested an electrical component instead of a mechanical one but the inventor was not interested and there the matter ended. I could have continued with the revised idea and quite easily developed it outside the scope of the patent, but it would have been morally wrong to do so. One easy way to protect your intellectual copyright is to put copies of all your notes, sketches and details in a sealed envelope and post it to yourself then lodge it with your solicitor or bank. The dated postmark will prove when your intellectual ideas were available if anyone tries to say that they thought of it first.

I would advise all beginners to join their nearest model engineering society, although in some parts of the country this may be a few miles away. Going to an exhibition armed with a list of questions is one way, but with an investment of several thousand pounds to recoup, it is not surprising that most trade stand are unable to spend time answering a list of questions; the next customer is only a few inches away. The Society of Model and Experimental Engineers have attended every Model Engineer Exhibition since the first in 1907 and as long as I can remember have manned a workshop and advice centre. It is a pity that Mr. Dudley did not make his way over to the Society's stand where I am sure we could have helped.

Some societies are very much steam oriented, with a track and facilities to run a public service, but the SMEE is a multi discipline society with members interested in most forms of model engineering. Based in South London, the Society has a large and varied library which is available to all members. If Mr. Dudley had been a member he could have saved his large expenditure on books by consulting the library to find out which book or books fulfilled his requirements before placing an order on the new or second-hand market.

The Society is aware that, with the reduction in the teaching of metalwork in schools, apprenticeships and evening classes, it is difficult for people wanting to take up model engineering to get the basic instruction that previously was widely available. We are not just talking about young people but also the more mature person who has seen their family grow up and possibly taken early retirement and has the time (and money) to take part in what is a fascinating and enjoyable hobby.

We realize that it is up to the hobby (i.e. clubs and societies) to encourage the beginner by instigating basic instruction and advice. If clubs only welcome experienced worker the hobby will decline.

The Society is planning a series of seminars to be held next year at our headquarters, Marshall House. These will be open to all, particularly beginners of all ages and will be free of charge. At present it is envisaged that they will include, Setting Up a Workshop, Basic Lathework, The Amateur Milling Machine, Grinding Lathe and Other Tools, Measurements and Setting Out, and possibly Silver Soldering and Joining Metals. These Seminars would be held on a Saturday, one each month; more details will be available later. For insurance reasons these sessions would not involve "hands on teaching" but would include time for a "question and answer" period where beginners could seek advice from an experienced member.

If you are a model engineer, particularly a beginner and are interested in attending these Seminars, please drop me a line with an SAE c/o Marshall House, 28, Wanless Road, London, SE24 0HW and as soon as further details are to hand you will be notified with a booking form.

What will the Society get out of all this? Firstly the satisfaction of knowing that more people will be encouraged into the world of model engineering, and secondly the participants (and others) will realize that the Society is not just for the elite of the model engineering world but that all who have an interest in engineering can apply for membership to the Oldest Model Engineering Society in the world.

Finally, if Mr. Dudley still has his list of questions that he took to Sandown Park and he likes to send them to me, I will do my best to provide some answers.

After-sales service

From Gary Wooding, Leamington Spa, Warwickshire

Earlier this year I decided to purchase a new lathe from Chester UK Ltd. where I got a good deal on the machine of my choice, which was duly delivered on time. After installation though, it became apparent that there were problems, but a 'phone call received prompt attention and everything seemed OK. This was the lull before the storm however, as later on other problems, some serious, surfaced. Chester rose to each occasion with sympathy, advice and packages of replacement parts until the final problem that necessitated them in sending a highly competent engineer to fix it at my home - a round journey of well over 200 miles. In addition to their excellent after-sales service, they also supplied me with complimentary tooling, of significant value, as compensation for my troubles.

I must admit that it would have been better for all concerned had the problems not been present in the first place, but machine tools are complex items and problems, even with highly reputable British makes, are not entirely unknown. What I consider as important is that Chester UK Ltd went out of their way to ensure that my lathe met their obviously high standards. It is not often that one meets with a company of such integrity, so can I, through your pages, offer a big thank you to Chester UK Ltd. Thank you Chester.

Elevating Head Lathes

From George A Mills, Southampton

In the '50s I worked for an electrical firm in Morden, Surrey. We used many large machines but also an advanced, for those days, elevating head lathe system - the Astoba - from, I think, Switzerland.
This had:

- 1000mm bed length
- 3 & 4-jaw chucks
- full sets of collets, metric from 1mm to 20mm and corresponding Imperial sizes
- elevating head with 300mm travel-two 'fixed' centre heights
- the tailstock mounted on a special base for the greater of the two heights
- 4 speed pulley + 2 speed motor and back-gear with full thread cutting facility
- an attachment which, in conjunction with the 600mm x 230mm cross-slide, made a very acceptable horizontal mill
- the whole head/motor/bed assembly could be turned through 90 deg. and a right-angle cross-slide attachment allowed the machine to be used as a vertical mill we also had a machine vice and a dividing head from the same Astoba set-up.

The whole machine was very well engineered and was extremely accurate. I searched for a similar machine when I retired, but have never seen another - any news or information from other readers?

THE MODEL ENGINEER
Exhibition & Competition

LOAN/COMPETITION ENTRY FORM

A separate form is required for each entry.
Please send to:
Nexus Special Interests, Events Dept.
Nexus House, Azalea Drive,
Swanley, Kent BR8 8HU
Tel: 01322 660070 Fax: 01322 616319

ENTRY NO.

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CLASS	ENTRY NO.

PERSONAL DETAILS (Please print clearly)

Surname ______________________ Forename(s) ______________________

Address ____

______________________________________ Post Code: ____________

Home Tel No:______________Daytime Tel No:____________________Age:__________

Model Club or Association membership ______________________________

Value of Model (Nexus takes no responsibility if the value is not entered) £____________________

N.S.I. plan used? (Y/N) ______How many years have you been a modeller? ______________

Name and address of your local newspaper ______________________________

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My model will reach the exhibition via:
Post ☐
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No. of boxes/crates ☐

Have you filled in your insurance value: (Y/N) ☐
Have you entered before? (Y/N) ☐
Are you supplying notes? (Y/N) ☐
Have you supplied a photograph? (Y/N) ☐

Signature:

Date:

Please tick this box if you would prefer not to receive mail from other companies which may be of interest to you. ☐

Do you subscribe to a Nexus magazine? (Y/N) ☐

MODEL DETAILS

Title of model: ____

Description ____

____

Machinery used: ____

Type of construction: ____

Parts not made by you and commercial items: ______________________________

____

Name and address of your local newspaper ______________________________

Scale: Length: Width: Height: Weight:

N.B. Please make copies including photographs of all information relating to your model as Nexus will not accept liability for any loss.

TO HELP YOU GET THE BEST FROM THE MODEL ENGINEER EXHIBITION

These notes are written purely for guidance. Full information is contained in the Competitors' Information booklet which is sent to every entrant as part of the information package. If you have an item and are unsure as to the Class into which it should be entered, leave that section blank and we will take care of it. The Judges have the right to move any competition exhibit into another class if they feel that by doing so its chances of gaining higher marks or a more appropriate award are improved.

If the item is offered as a Loan exhibit please indicate this by writing Loan on the form in the box identifying the Class. Loan models are not judged but carry all other privileges associated with competition entries.

Part built models are particularly welcome in the Loan Section; visitors like to see work in progress, and entry does not preclude the item being entered in competition when completed.

The classes listed below are those associated with mainstream model engineering.

Club exhibits

Where a club is exhibiting, each model should be entered on a separate entry form and clearly identified as a club exhibit by entering Loan/Club in the class section box. This ensures that we have a full record of all models on display during the show and facilitates matters of administration and insurance.

Additional forms

If you do not wish to deface your copy of the magazine we are happy to receive photocopies of the entry form, one for each model. We will be pleased to send out extra forms if required, so if you know of a modeller who is not a reader of one of our magazines but who you think may wish to participate, please advise them to contact our Exhibitions Office (01322-660070), or simply photocopy the entry form for them.

The success of the show depends largely on the number of models on display. Your work could well be the stimulus which inspires someone else to start in the hobby. There can be no doubt that this event is our showcase on the world of modelling in all its aspects. Every modelling discipline needs more and more participants, and it is by displaying not only the crème-de-la-crème, but also examples of work of a more achievable standard, that people are encouraged to join into the wonderful world of modelling, in whatever aspect.

We look forward to seeing a sample of your work at the show!

Engineering Section

A1 Hot air engines.
A2 General engineering models (including stationary and marine engines).
A3 Internal combustion engines.
A4 Mechanical propelled road vehicles (including tractors).
A5 Tools and workshop appliances.
A6 Horological, scientific and optical apparatus.
A7 General engineering exhibits – not covered by the above

Railway Section

B1 Working steam locomotives 1" scale and over.
B2 Working steam locomotives under 1" scale.
B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered steam prototypes.
B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
B9 Passenger or goods rolling stock, above 1" scale.
B10 Passenger or goods rolling stock, under 1" scale.
B11 Railway buildings and lineside accessories to any recognised model railway scale.
B12 Tramway vehicles.

Note:

Kitbuilt: any model containing a preponderance of commercially produced parts.
Scratchbuilt: wholly made by the entrant except wheels, gears, motor, engraved plates and small turning, etc. not exceeding 5% of the whole.
Rolling Stock: Where a rake is entered, competitors are asked to nominate one vehicle for judging purposes.

Marine Section

C1 Working scale models of powered vessels (from any period). Scale 1:1 to 1:48.
C2 Working scale models of powered vessels (from any period). Scale 1:49 to 1:384. Excl. miniatures as classified in C8.
C3 Non-working scale models of powered vessels (from any period). Scale 1:1 to 1:48
C4 Non-working scale models of powered vessels (from any period). Scale 1:49 to 1:384 excl. miniatures as classified in C8.
C5 Sailing ships and oared vessels of any period – working.
C6 Sailing ships and oared vessels of any period – non-working.
C7 Non-scale powered functional models including hydroplanes.
C8 Miniatures. Length of hull not to exceed, 15in for 1/32 in. to 1ft scale or larger, 12in for 1/25 in. scale, 10in. for 1/16 scale; 9in. for 1/8 scale. No limit for smaller scales.
C9 For any model boat built from a commercial kit. Before acceptance in this competition the kit must have been readily available for at least 3 months prior to the opening date of the exhibition and at least 20 kits must have been sold either by mail order or through the retail trade.
C10 Functional Model Yachts

Supporting documentary evidence of accuracy may be submitted by entrants in large and clearly identified envelopes.

Model Horse Drawn Vehicle Section

G1 Carriages & other sprung vehicles. (Omnibuses, trade vans etc.) Wagons, carts and farm implements. Caravans.

Junior Section

J1 For any type of model, mechanical or engineering work, by an under 14 year old.
J2 For any type of model, mechanical or engineering work, by an under 16 year old.
J3 For any type of model, mechanical or engineering work, by an under 18 year old.

All entries will be judged for standard of craftsmanship, regardless of the modelling discipline, i.e. a boat will not be competing against a military figure. Providing a model attains sufficient marks it will be awarded a gold, silver or bronze medal.

Model Vehicle Section

K1 Non-working cars, including small commercial vehicles (e.g. Ford Transit) all scales down to 1/42.
K2 Non-working trucks, articulated tractor and trailer units, plus other large commercial vehicles based on truck-type chassis, all scales down to 1/42.
K3 Non-working motor bikes, including push bikes, all scales down to 1/42.
K4 Non-working emergency vehicles, fire, police and ambulance, all scales down to 1/42.
K5 Non-working vehicles including small commercial vehicles (e.g. Ford Transit,) scale from 1/43 or smaller.
K6 Any available body shells including Concours, in any scale or material, to be judged on appearance only.
K7 Functional model cars/vehicles which must be able to move under its own power of any type. Can be either free-running, tethered or radio controlled or slot car, but must represent a reasonable full size replica.

Duke of Edinburgh Challenge Trophy

Rules and Particulars

The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.

The trophy remains at all times the property of Nexus Special Interests.

The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of Nexus Special Interests Ltd, in his/her possession until required for renovation and display at the following Model Engineer Exhibition.

Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by Nexus Special Interests Ltd.

No model may be entered more than once.

Entry shall be free. Competitors must state on the entry form:

That exhibits are their own bona-fide work.

Any parts or kits which were purchased or were not the outcome of their own work.

That the model has not been structurally altered since winning the qualifying award.

7. Nexus Special Interests Ltd. may at their sole discretion vary the conditions of entry without notice.

Loan Section

The Loan Section is for anyone wishing to display models on a non-competitive basis. Unfinished models will be eligible providing a good standard of engineering workmanship is displayed. FREE entry by normal competition application.

Self Delivery

If you intend to bring your model to the show personally please take note of and comply with the delivery times and instructions contained in the Competitors' Information pack.

UNDER NO CIRCUMSTANCES CONSIGN YOUR EXHIBIT DIRECT TO SANDOWN PARK EXHIBITION CENTRE. The staff there have no facilities to deal with them, and no insurance cover for such items.

The Early Bird

If you intend to visit the show on your own, with friends or as a member of a party, substantial savings on tickets may be had and queuing avoided by ordering your tickets in advance. A special Hotline is in place: Tel: +44 (0)1858 438897, Fax: +44 (0)1858 461739. The Hotline is open Monday-Friday 8am-9.30pm; Saturday and Sunday 8am-4pm. Call and place your order after 2nd October.

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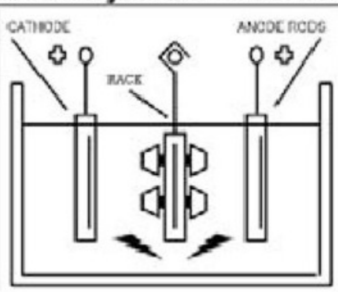

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