

MODEL ENGINEER

INTERNATIONAL  
MODEL ENGINEER  
AND MODELLING  
**EXHIBITION**  
ALEXANDRA PALACE  
29th DEC 1991-5th JAN 1992

# WORKSHOP

THE NEW, PRACTICAL HOBBY MAGAZINE



**MULTIMETER  
OFFER!**



**THIN PIECE  
WORKHOLDING  
DEEP HOLE  
BORING TOOL**

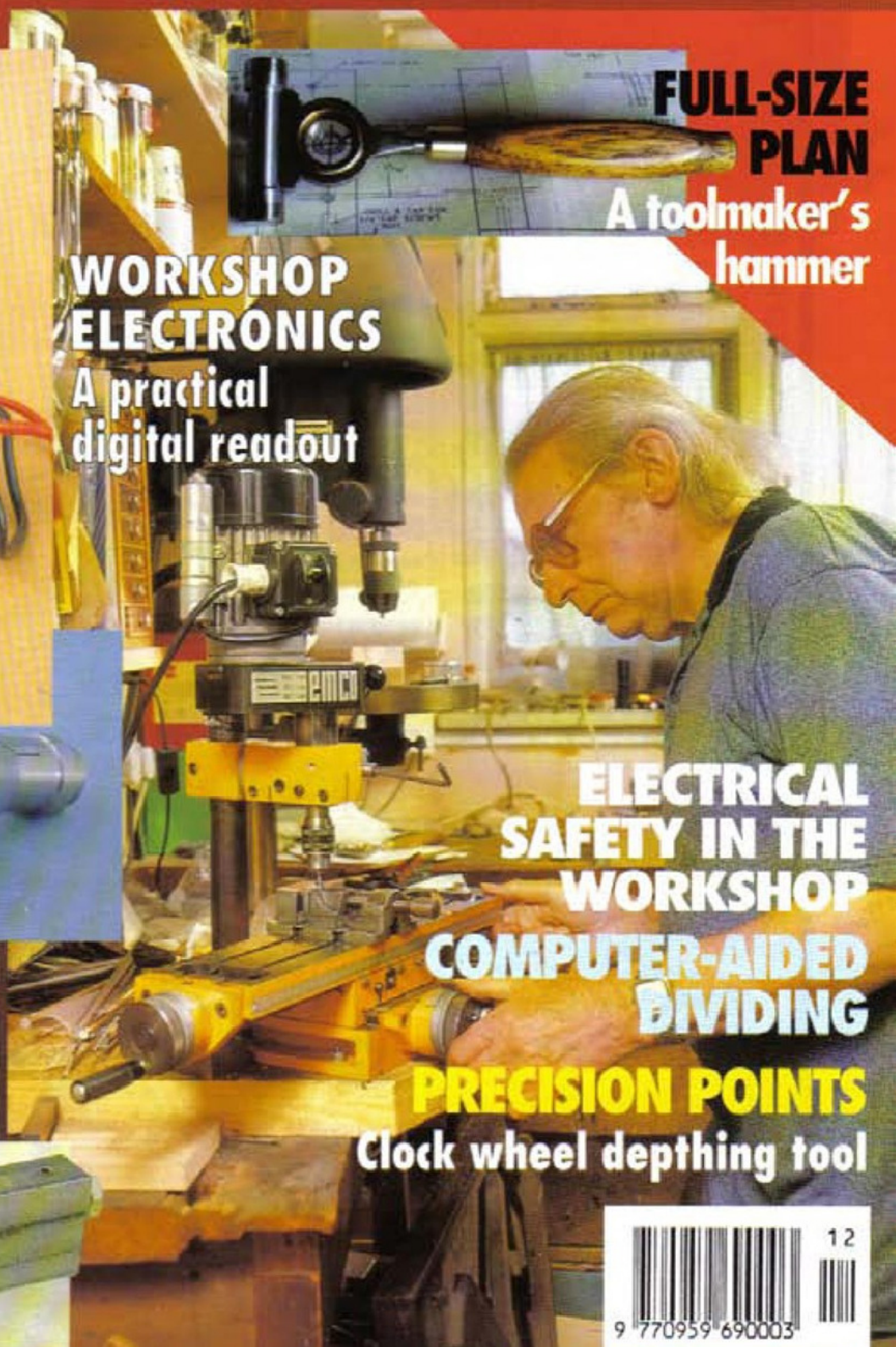


**FULL-SIZE  
PLAN**

**A toolmaker's  
hammer**

**WORKSHOP  
ELECTRONICS**

**A practical  
digital readout**



**ELECTRICAL  
SAFETY IN THE  
WORKSHOP**

**COMPUTER-AIDED  
DIVIDING**

**PRECISION POINTS**

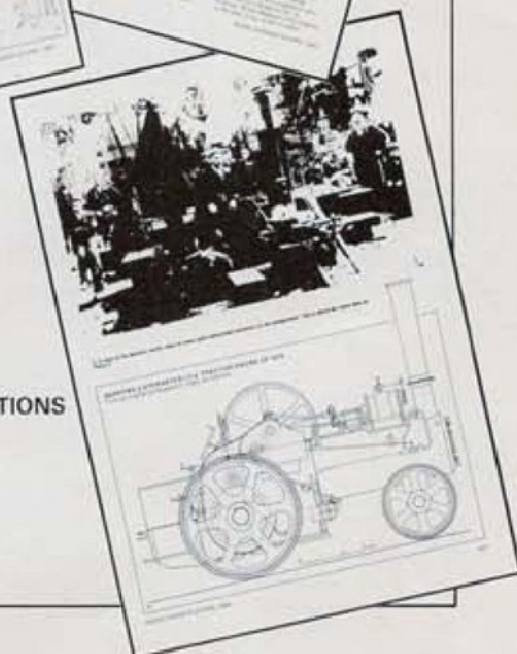
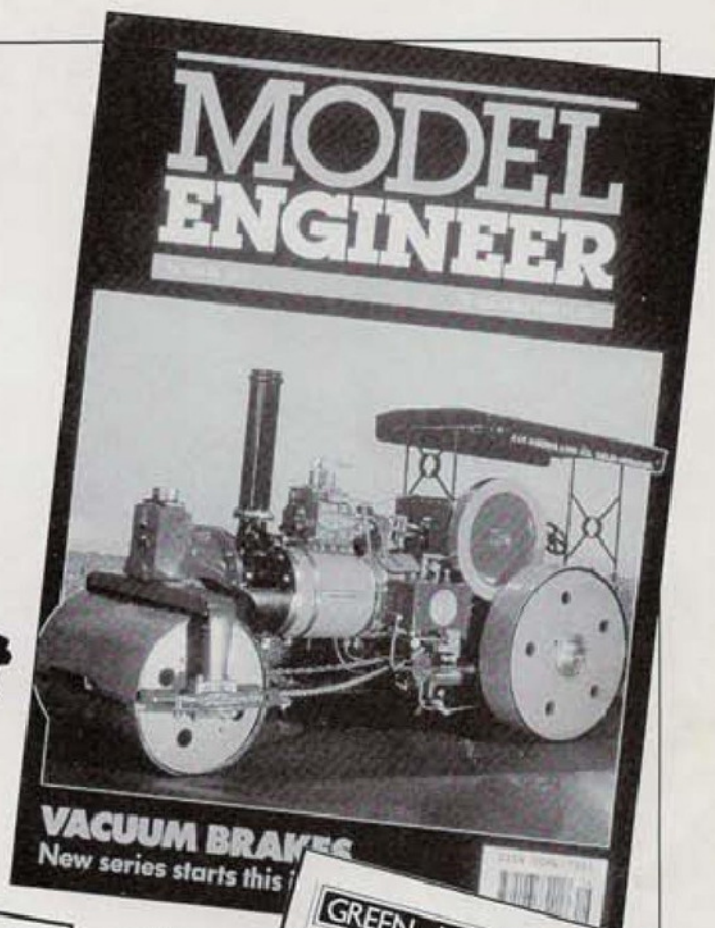
**Clock wheel depthing tool**





# SOMETHING TO LOOK FORWARD TO...

...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription - a mere £33.60 for UK readers (overseas rates and airmail details on request).

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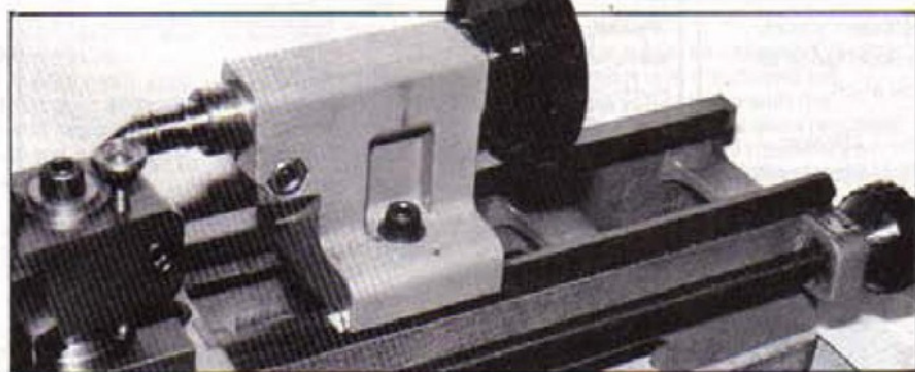
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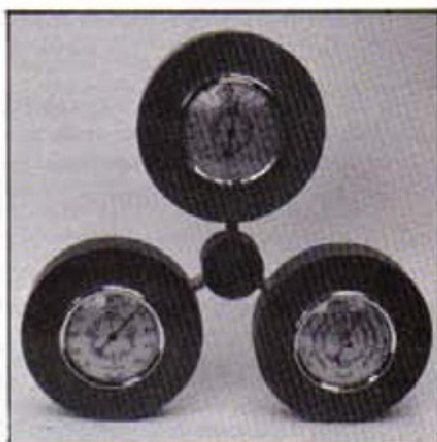
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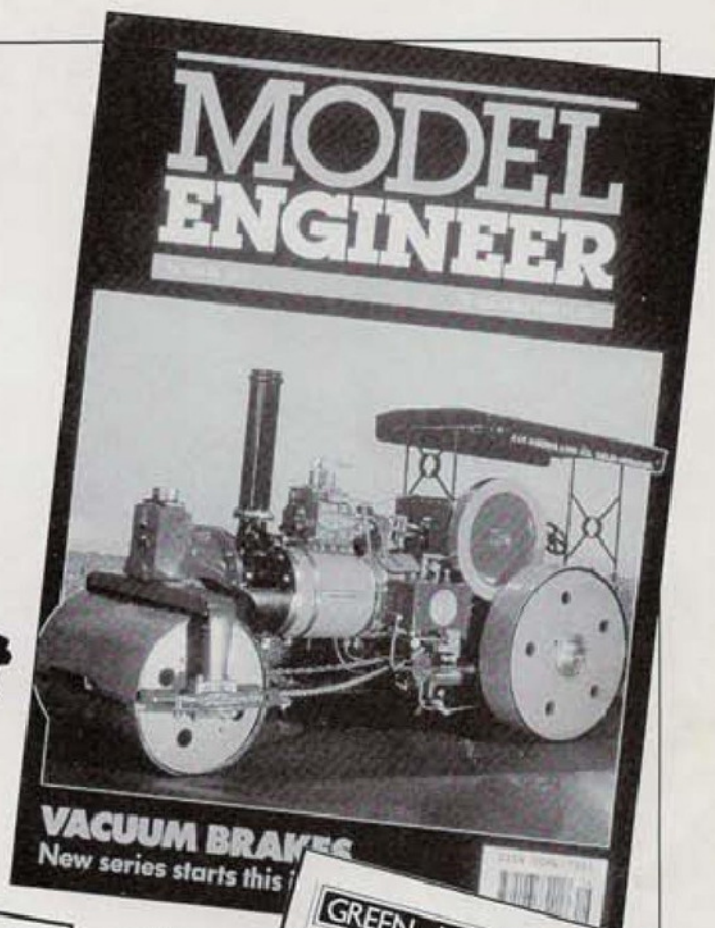
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FORWARD  
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Harold Hall

# ON THE EDITOR'S BENCH

In the Winter '90 issue of *Model Engineers' Workshop* published mid December, Stan Bray the then editor included an article with a Christmas flavour.

One factor of the change from quarterly to two monthly publication, now means that this edition, issued early November, is the last before both Christmas and the International Model Engineer and Modelling Exhibition, to be held at the Alexandra Palace between the 29th December and the 5th January.

I wonder whether, like me, you give out hints for items that you would like as a present at this time? For my part, tools have been the order of the day since the age of ten.

One item that appeared regularly, and caused much amusement to the non-engineering members of my family, was a 1/2 inch Jacobs chuck with a number two Morse taper.

After many years, my wife braved the front door of the local (well, ten miles away) lathe merchant, and my chuck was at last erased from the list. I do hope you will be as fortunate.

But Christmas is a time of giving as well as receiving, so in view of the timespan to Christmas you will find included in this issue, a weather station, an item that will make a nice Christmas present for a friend. I do hope you will consider this once-in-a-while diversion from our normal type of project a good idea.

With regard to the Exhibition, I hope as many of you who can, will attend; if you like to enquire at the organisers' stand, to determine if I am there on that day, I would be delighted to meet some of you, particularly those who have corresponded with me.

In the last issue we have an item regarding edge finders, and a reader has questioned why one of the items in the kit shown did not get a mention. This was intentional, but in view of the query, a very brief explanation with picture is being prepared, hopefully to be included in this issue.

I mention this fact mainly as an introduction to the question of the time between the publication of one issue and the date at which the next issue has to be

completed by me for production to commence. This time is about two weeks, so if you wish to comment on any item in one issue for inclusion in the next, this must be sent within a few days of receiving your copy.

Of course, anything received after this time will be reserved for a later issue if it merits this, so if you are unable to respond rapidly, do not let this put you off writing.

A reader has asked whether we can supply gears for the Myford series seven Quick Change Gearbox described for construction in the Winter 91 issue. The quick answer to this is no!

This has led me to enquire the cost of purchasing a set of gears and, as expected, the cost of a single set would be prohibitive, but if, say, five sets were ordered together, the cost will be around £180 for each set.

Should any reader be interested, please write to me and I will, if sufficient are interested, put you in touch with the manufacturer. If each reader were prepared to provide the blanks ready machined, a cost of around £100 is probable, though this would make organising the facility more difficult.

Following the indication in the Oct/Nov issue of the inclusion this time of an article detailing the construction of a digital readout, I have had much enthusiastic correspondence about the item. This is a demanding electronic project and is therefore covered in greater detail than is normal — I hope that this level of detail will make construction a possibility for a wide range of readers. For those for whom cost is important, the total for parts purchased from the suppliers indicated, will be around £135.

For those readers to whom electronics is a non-starter there are plenty of other interesting items to construct in this issue and it is unlikely that such a complex electronic project will appear again, at least for many issues.

The toolmaker's hammer is a very interesting project and the subject of the centrefold. This is a simpler project than normal for this, but is an attempt to produce an occasional centrefold which is sufficient in itself to complete a project

without the need for additional text or photographs. However, we'll still keep the centrefold predominantly for the more complex projects.

Your workshop is no doubt already wired up with its electrical system. Even so, do please read the article on the legal requirements for such an installation. As a result you may feel some adjustments to your system would be desirable both for the safety of yourself and the workshop itself.

May I also take this opportunity to remind all readers that articles for publication are always being sought. So if you have made any item worthy of being shared with others, please write to me giving some initial details. A fee is paid for all articles published.

I am finding that I receive in your letters many requests for articles on specific, and sometimes specialist subjects. Details of these will be published in the next issue, with a view to encouraging those readers, with specialist knowledge, to share this with us all.

My reason for delaying this, is that your replies to the reader survey, at present being received, are also adding to this list.

In this respect, it has also been suggested that the results of the survey should be published, and this will be done. I must confess that irrespective of its purpose for the magazine, I find it interesting reading, comparing my own equipment and aims, with those of others.

Another request that has appeared a number of times is for an index to be published. I am adding the contents of the magazine to date, into a data base, which will be sorted in numerous ways. This for the benefit of myself, but will also provide the details for an index to be published shortly, and then periodically.

Finally, one would think by printing as part of the geometric chuck article, in the Aug/Sept issue, the actual printout of the computer programs (page 75), that no error could occur! Unfortunately, as two lines (530 & 590) were much longer than the rest, our designer rearranged these to reduce the width, and as a result, left out an asterisk from each.

The concluding part of both these lines should read:

((1 + V1 - (V1\*V2))\*THETA + PHI2))

I would thank Mr Nicholson of Newcastle for pointing this out, and apologise to any reader who has been inconvenienced by this.

With the turn of the year approaching the Model Engineer Exhibition at Alexandra Palace will be a must for most of you to visit. If you are quick you could still possibly get an entry in, workshop appliances and tooling are usually not the best supported section of the show, yet we all need tools in order to build better models. I hope that there will be a bumper entry this year in these sections. Even if you are a long way off getting the equipment to the show is no great problem, A.S.P. run a pick-up service, a phone call to the Exhibition office on 0442 66551 will give full details.

The show is from 29 December — 5 January, full details are elsewhere in this issue, I shall attend several days during the show, and hope to meet and chat with many readers.

Finally this time, may I take the opportunity to wish you all the compliments of the Season, and a happy and peaceful 1992.



# SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in *Model Engineers' Workshop* are always welcome

## SILVER STEEL

In our first letter Mr C. Clarke of Ryde describes his frustration with his supply of Silver Steel, and also requests help for a problem he has with the downfeed on his milling machine which he explains in greater detail in a second letter.

I am entirely a self-taught and probably a poor engineer but absolutely absorbed with your magazine and the problems I encounter. Regarding turning Morse tapers on an amateur's lathe, I wonder if my method may interest your readers.

When you get the top slide and tool set to produce a perfect taper (about 1 in 50 in my case!) immediately turn up another piece of steel about 2" tapers long then place the taper in the headstock and turn another taper on the other end. I defy anyone to forgo turning up a few spare tapers under these circumstances anyway.

The double taper can then be used to set the top slide for any future tapers required. The unique advantage of this is that it discounts a tool which is not exactly at centre height as a feeler gauge passed between the master taper and the tool is all that is necessary to achieve a quick good result. The method of tapping around the top slide seems endless. Also make sure the final finishing cut is removing so little that tool flex is eliminated.

My next tip is written tongue-in-cheek as I am sure no-one will approve. However, it is written in the heat of the moment with oily hands!

Keep your stock of silver steel in three separate boxes:

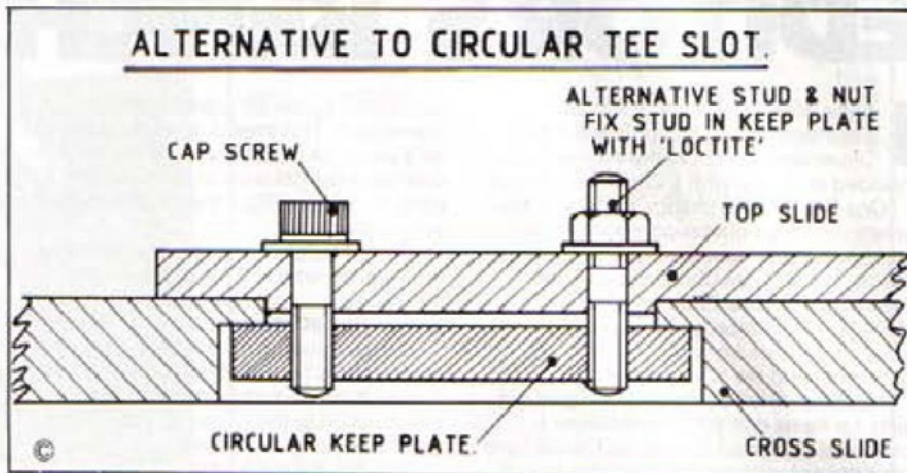
Box one for grandfather's stock and those rods purchased for £d each. These are suitable for machining and dead straight and true.

Box two for rods purchased in the last twenty years. These often have hard ends and need annealing if one isn't going to break expensive tools.

Box three for 1991 stock. This is totally suspect. Throwing the rods in a bonfire, running them all over with a coarse file is no guarantee that dies, cutters, taps, etc., will not shatter on hard spots.

I say, roll on 1992, when I have box four: German and French silver steel. Perhaps Mr Stubbs might like to note my irate views!

Finally, I would welcome help from readers of your excellent magazine to tell



me how to stop my Taiwanese Minor Mill from snatching when trying to set on a very small increase in milling depth.

Mr C. Clarke

PS

Not a word to Mr Stubbs – but what I actually do is to put his steel in a friend's pottery kiln. However, surely Mr Stubbs should have done that for us? Even so, I have one piece that has remained hard 1991!

## SNATCHY MILLING

An extract from Mr Clarke's second letter:

With regard to the milling machine: I lock the quill before machining. If I need to take off a couple of thou more, I unlock the quill with the machine stopped; set on two thou and nothing happens – the bit does not even touch the work! If I set on two thou with the machine running (essential if milling a central hollow) the bit jumps in for the full slack in the quill gear. No doubt this can be got round but I cannot calibrate the amount taken off by the machine index.

The reason I mention this, was because a regular correspondent to *Model Engineer* describing how he designed a slow speed gear (30 RPM I think) in passing said he had snatch, but implied that he got this by a ridiculously simple modification. This has embarrassed me, as I cannot fathom out what he did which makes me look very foolish.

I have a milling chuck which is a sort of Autolock, so something is happening in the quill which moves the index, as the bit cannot move in the chuck. Anyway, it machines perfectly flat so nothing moves once a setting is made and locked. However, when unlocked the index seems to have wandered.

## T SLOTS ALTERNATIVE

There has been much correspondence on the subject of the circular tee slots required in the cross slide published in the June/July issue, and not least the method of machining same.

Mr W. Rose of Rushden, Northants has an alternative, though it would require the spigot on the underside of the top slide to be increased in diameter, but this should not be a problem. In fact, if made as a bush, both a close fit on the spigot and also in the hole in the cross slide, it need not be fixed

to the top slide.

I am not happy with the method shown being used for machining the circular tee slot in the article relating to a tee slotted cross slide recently published, and feel the following which would avoid the requirement for this, a better proposition.

The method I propose is not original as it is used by Harrison on their L5 lathe, far superior to the Colchester which uses the same arrangement as in the article.

The top slide has a larger spigot through which the clamping screws pass, the cross slide is bored to take the larger spigot, and is further counterbored on the underside to take a keep plate tapped to take the clamp screws, by this means the top slide is held and yet is permitted to rotate through a full 360 degrees, the arrangement is best seen in the drawing.

As an alternative to using screws, studs could be fitted being held with Loctite.

W. Rose, Rushden

## FINISHING METALS

Mr. D. Evans of Blackpool has a problem which I am sure readers can solve.

I would be very grateful if any of your readers could supply me with information regarding the finishing of non-ferrous materials?

Your magazine has done many fine articles on similar subjects, but the simplicity of buffing and polishing has



possibly been overlooked. The type of information I am very interested in is the peripheral speeds recommended for brass and aluminium. Also I would like to find a good clear lacquer, and where it can be obtained.

Congratulations on a very excellent publication.

D. Eaves, Blackpool

## PARABOLIC MIRRORS

Mr K. Hamer of Colne sent us this brief letter, in reply to the poser in a previous letter from Chris Dyos.

I was very interested in the letter from Chris Dyos (Scribe a Line Oct/Nov) in which he states that if a cylinder of liquid is spun round on its axis, it will assume a parabolic shape.

This is quite correct, and is in fact put to use in a telescope mirror. (USA I think).

The liquid was mercury and the focal length could be altered by variation of the speed.

The explanation of why it assumes a parabolic shape is probably connected with the vortex which is all about varying speeds and the distance they are from the centre.

The telescope was not a success due to problems with the drive mechanism, but it proved the basic principle was sound.

May I congratulate you on a very good magazine.

K. Hamer

## SUDS PUMPS

Now some thoughts regarding suds pumps from Michael Dover of Truro and with which we close this subject.

The recent letters regarding controls of suds pumps reminds me of a similar problem I had many years ago on a much larger scale.

I was in charge of an open-cast mine where the water collecting in the mine sump was pumped out by two six inch

single stage centrifugal pumps. Usually only one pump was required but due to rain or drought the flow varied but never stopped.

The accepted method was to employ a pump attendant until shortage of labour made this impossible, switchgear that sensed the water level by electrodes dipping in the sump was then installed to stop and restart the pump. This worked well until the electrodes became insulated with a goo of oil, grease, cotton waste and sawdust.

The solution which worked for many years was to fit a butterfly valve in the pump suction below the lowest water level and above the strainer, this was worked by a large ball float as shown in the sketch below.

Centrifugal pumps have an advantage over positive types in that the power falls as the quantity of water is reduced even if this is caused by increased pipe friction or head.

Another trouble was the formulation of

a vortex over the suction allowing air to enter the pump and lose its prime, this was prevented by leaving bits of wood floating in the sump.

M. Dover

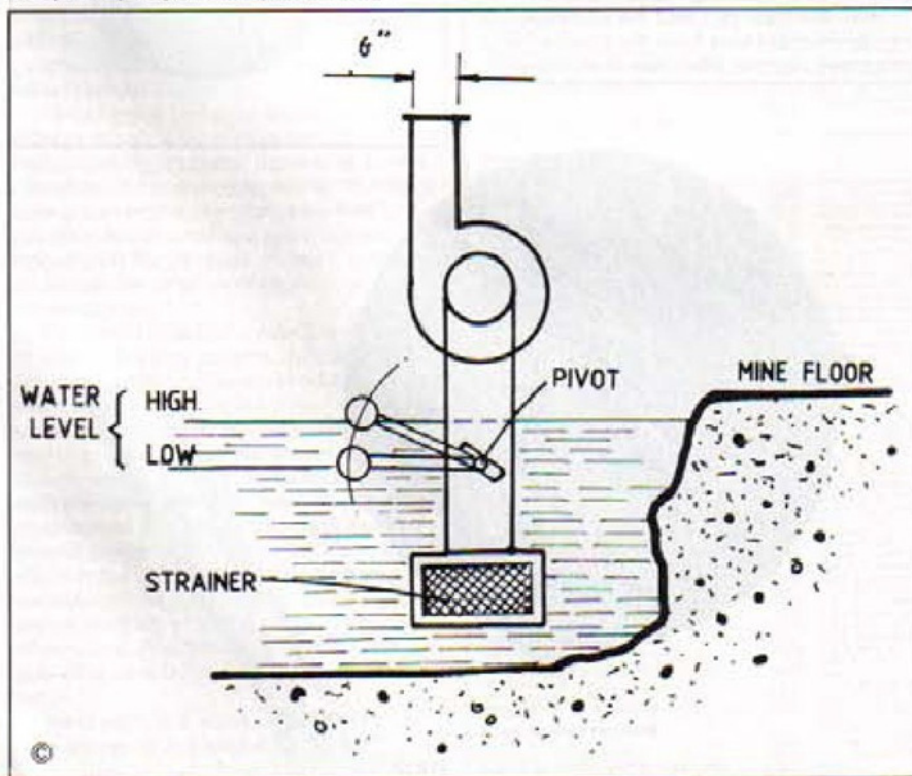
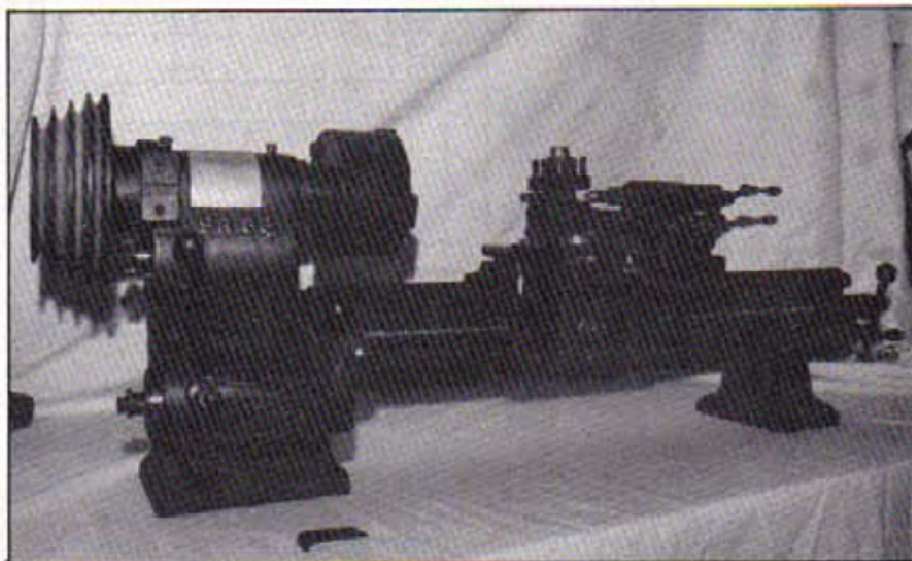
## ODD MYFORD

Can anyone help Mr Holben of Ashbury?

Having recently bought a second-hand Myford ML7 lathe I found it was fitted with a modification using an extra lever to right-hand side of the lead screw in the area of the change wheel cover, and I have not been able to find out what this lever is for and nor have several friends I have asked about this.

Having studied Fig. 10.9 on page 141 of Ian Bradley's Myford series 7 manual, I see this lathe fitted with an identical lever which is arranged to move the change wheel in and out of mesh although there is no mention of this lever in the text.

M.J. Holben



## MYSTERY LATHE

Can anyone help Mr Steve Sinclair of Alnwick identify this lathe?

I would be grateful if you could help me to identify the above Lathe and forward me the manufacturer's address.

The SR-80 was found in a scrapheap in Nigeria a few years ago, after removing several coats of paint I discovered it was practically new but missing a few gears for screwcutting.

If any readers can help me, I would be grateful for manuals etc, all costs will be reimbursed.

Steve Sinclair

## TOOLMAKERS' CLAMPS

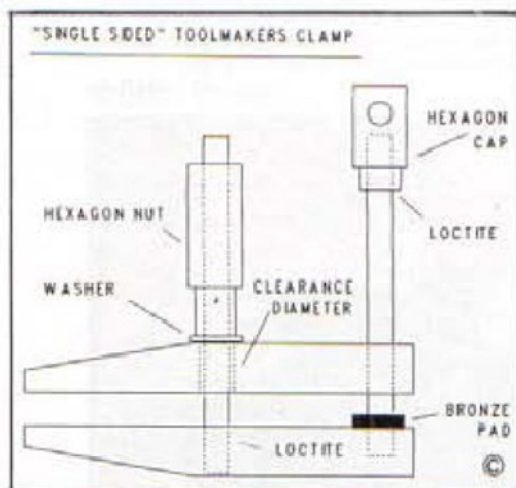
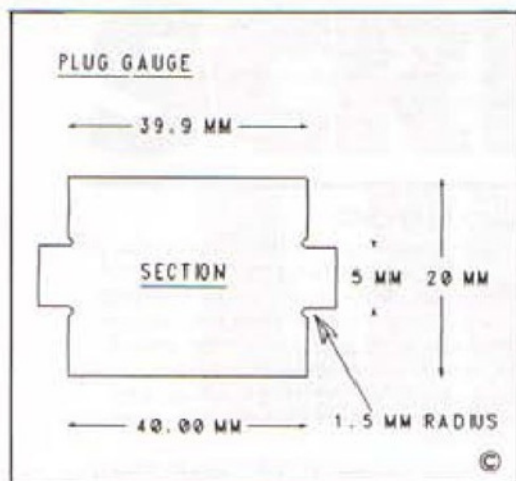
John Jennings of St. Albans comments on two items from the Oct/Nov issue. The variation to the normal toolmaker's clamp design looks a very useful idea.

1. Collet Chuck for Compact 5 (as you saw on your visit)

I made a similar nose adapter to that shown as the FIXTURE (Fig 2) so that my Unimat 3 chucks including the collet chuck could be used on the larger lathe.

For the latter chuck a really good fit was required and I found that it facilitated the job to produce a plug gauge the same size





as the Compact 5 nose - which is of course inaccessible when the lathe is operational. The plug gauge is easy to machine - use free-cutting steel a little larger than the nose diameter. The run off grooves help final turning to size and it doesn't take much longer to produce a double-ended version to give early warning of coming to size. Stone off the sharp edges to ease entry. I can confirm that the finished dimension should be 40.00mm. Using the gauge, the nose adapter mark II fitted better than the Emco Compact 5 collet adapter.

Incidentally, other readers like Gordon Lewis who are (rightly) alarmed at screw-cutting at 200 rpm without a half-nut to disengage might like to construct the slow speed attachment I described in Model Engineer (17-30 June 1983) which gives a 35 rpm minimum. [Photocopies are available - please write for a quote - Ed]

2. For many purposes the "single sided" toolmaker's clamp has advantages over the traditional pattern described, for example clamped objects will often sit happily on the bench using the clamps as feet. The general arrangement is shown in the drawing and apart from the mechanics the same dimensions can be used as in the original article, the optional lift-off device being added if preferred. Toolmaker's clamps, made to either pattern, also benefit if they are made from rectangular material aligned with the large dimension parallel to the operating screws.

John Jennings

## MORE ON CLAMPS

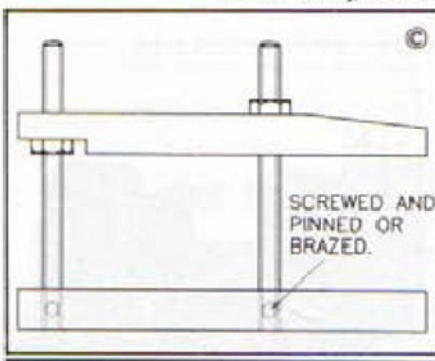
Dave Feasey of Matson Glos. makes a very similar suggestion regarding toolmakers clamps, and also offers some interesting ideas for their use. It is surprising that these type are not available commercially, or are they?

Having read your article "Toolmakers Clamps" I thought other modelmakers might be interested in a different type of toolmakers clamp.

The advantage of this clamp is that the threads are all one way, so they don't get in the way as much as normal clamps.

If you use several made from the same stock the square section can be used as parallels. If you make them from material smaller than the grooves on your milling machine, then you can clamp the job onto the bed, and still keep it clamped together, for removal to another operation or machine.

Dave Feasey, Matson



## TWO JAW CHUCKS

Can anyone help Mr Gunston of Northallerton resolve his problem regarding this unusual chuck, or have any information of its origins?

I wrote to you in July regarding an old chuck I have. You kindly replied and enclosed a copy from Model Engineer's Handbook, [Argus Books, £6.95 plus 70p. p and p - Ed.] regarding Jacobs Tapers.

From the copy you sent me and from measurements I took from my chuck I concluded that the arbor size in my chuck

was JT33. When a friend took my chuck to his local Tool store and got an Arbor 2MT/JT33, he tried the JT33 into the chuck and it only went in slightly with about  $\frac{1}{8}$ " still to go. That seems to indicate that it's not a Jacobs Taper.

As you said, if I was unable to resolve this problem, you'd print my letter in MEW. This time I've enclosed some photos of the chuck which my wife took for me.

The Chuck body is about 2.125 in. dia. The jaws open 0-1 in. There are some very faint markings. "Positive Drive" around the body followed by a Pat No and then what appears like a date of 1903/8 it's very difficult to make out 3 or 8. On the front face is a very faint marking which looks like "BRITSON" followed by a Patent No. There is a  $\frac{1}{2}$  in. hole in the centre of the plate allowing access to the jaws. On the end of drive spindle is a  $\frac{1}{2}$  in. square hole.

There are two jaws which move in and out at 90 deg in to the main centre line through the chuck.

On one of the photographs is what is left of the arbor I removed out of the chuck.

So if you print my story, hopefully someone will recognise my chuck and give me information about the taper in the chuck.

M.J. Gunston





## CIRCLIPS

Mr Salter of Woodend, Staffs offers this suggestion for a possible supply of circlips, requested in an earlier *Scribe A Line* letter.

With ref to Mr Stephensons letter on the subject of obtaining circlips for the Drilling Depth Gauge project by Mr Coe. Many such clips are used on cars i.e. in hydraulic assemblies and no less than eight to hold together the U J joints on the prop shaft.

Therefore a local car spares shop may be able to supply one off, or if not, a word to a car repair garage may prove fruitful, as when new UJs are fitted, the repair kit comes complete with new clips, the old ones are perfectly serviceable for use with this project.

**Mr Salter, Staffs**

## FASTENERS

Brian Taylor offers an alternative solution to the supply of circlips.

Having been faced with a similar problem to that described by Mr Stephenson (Scribe a line, Oct./Nov. issue), I draw on experience and offer a suggestion which worked for us in a wide variety of similar applications. We made our own odd-ball 'circlips' both internal and external, from piano wire which is readily available at model shops. Using the lathe we wound piano wire springs on over-size wooden mandrels (under-size for external types). After cutting single-turn rings we bent the two ends radially inwards (or outwards), so providing convenient lugs for closing by long nose pliers or opening by screwdriver blade.

On one occasion we used the method to make a jumbo version, an internal retainer ring to suit a 10 inch bore; at the opposite end of the scale, we cut lively little devils from the coils of junked springs.

**Brian Taylor**

## COLOURS IN THE WORKSHOP

Mr J. Scott from Lincolnshire wrote in with the following observations and conclusions that he recently arrived at in his workshop.

For a long time I used an old pre-war lathe in my shop. I never got around to really cleaning it up and repainting it, so it remained in the colour typical of its time, dark green which over the years had become discoloured to a rusty brown colour with the passage of swarf, cutting oil and all the other workshop contaminants.

Recently I obtained a new machine, one of the Far Eastern imports, but painted in a light green colour. The old lathe had to go, there wasn't room for the three of us in the shop. Apart from giving the shop a good clean-up before installing the new lathe I did nothing in the way of redecorating, yet with the inclusion of the new machine the shop seems lighter and although the new lathe is bigger there seems to be more room in the working area. I had never considered this point before, but it certainly seems to make a difference to the quality of my work. The family claim that I am spending more time in the shop than ever before.

Have any other readers noticed this in their shops, or am I deluding myself?

## J. Scott

# G & M TOOLS

## USED EQUIPMENT

[illegible]



**Solder sucker, solder wick and heat shunt for clipping onto the leads of delicate components during soldering.**



requirements for this as detailed later, the leads should be left full length and splayed just slightly on the trackwork side. The degree of splay should be sufficient to capture the component, and should, if practical, be in the direction that the track leaves the pad, for if it were to be bent towards an adjacent track or pad, this may encourage the solder to build up in a manner to bridge over, causing a short circuit between tracks.

Some instructions on the method of soldering recommend that the end should be bent flat along the length of the appropriate track and soldered. Whilst this is probably slightly better in terms of a reliable joint, it does have the major disadvantage that components fitted this way become much more difficult to remove.

# ELECTRONIC PRODU

**The early success of any electronic project will depend very largely on the approach to assembling it in the first place. This short article has some useful suggestions and recommends a methodical approach as being one which will avoid too many false starts**

**W**hen building an item of electronic equipment based on a tried and tested design, the areas for problems to occur are limited, being basically as follows:

1. Faulty manufacture.
2. Faulty components.
3. Damage caused due to errors in testing.

By far the most likely cause of a problem will be due to faulty manufacture of the assembly. Whilst components which are faulty when supplied new are possible, this is not that frequent if purchased from a reputable supplier, though electronic components if they are going to fail in use will frequently do so in the first few hours of being on power. With care, damage on test should be an unlikely occurrence.

## Faulty manufacture

Faults in manufacture can be divided as follows:

1. Poor soldering.
2. Wrong component fitted.
3. Component fitted the wrong way round.
4. Component not fitted.
5. Component damaged by heat when soldering.
6. Wire links missing or fitted in the wrong place.
7. Stripboard tracks not cut in correct position.
8. Mechanical damage.

## Poor soldering

Soldering is an acquired skill and easily lost if not used for some time. Even those who have reasonably mastered the process in the past should practise a few joints using spare components and a piece of stripboard before proceeding with the actual assembly. Those with less experience should do likewise but making as many joints as is necessary to fully master the operation.

The first essential is a soldering iron of suitable size. The very smallest irons of about 15 watts and with a tip of say 1-2mm diameter may be necessary for the very

densely packed assemblies with very fine PCB tracks, but these cannot store the required energy in their tip and cool down if applied to a larger joint arrangement, resulting in good joints being difficult to achieve.

A larger iron of about 25 watt rating and with a bit around 3mm will be about right. This will store sufficient heat energy in its bit to enable the joint to be made rapidly, which is preferable as is discussed later. A stand, whilst not essential, is highly desirable on safety grounds, and will probably contain a cleaning sponge, another essential feature.

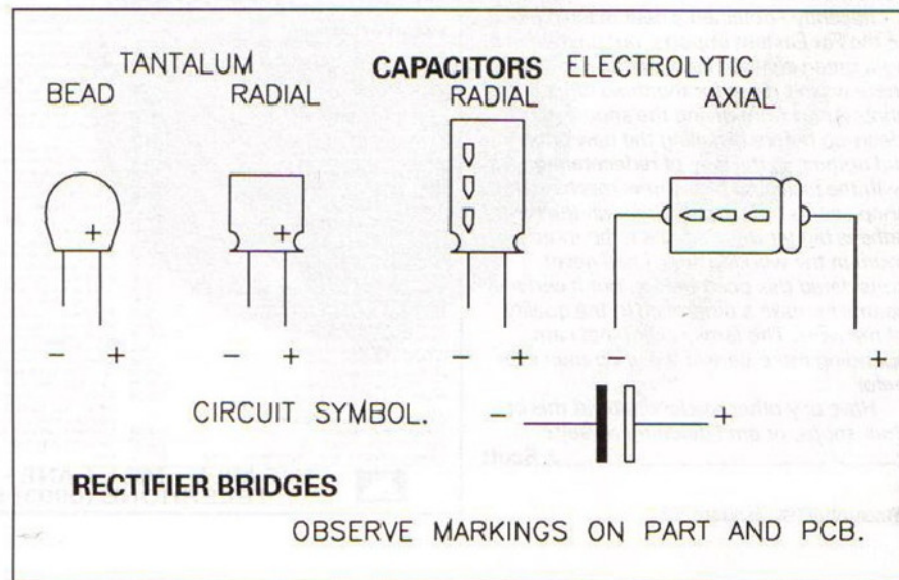
To produce a good joint the condition of the component lead and the PCB track are important factors. With these purchased from reputable suppliers as detailed in the accompanying article this should be no problem, but if in doubt, the component lead can be cleaned with a sharp knife or a clean piece of fine emery paper, and even tinned with solder prior to placing into the PCB. Do use an appropriate solder, 18 swg 60% tin 40% lead Multicore type should be ideal.

Now to make the joint. With the component in place and taking note of the

To make the joint, with the iron hot, first wipe the end of the bit on a damp sponge or cloth to remove any scale that has built up. This should leave the end of the iron looking bright but largely free of excess solder. Now melt a small portion of solder onto the iron; this will give the iron a soft end which will hug both the lead and the PCB pad when the end is applied, and thus assist in the essential rapid transfer of heat from the iron to the component and trackwork. The end should be applied in a manner so as to contact both lead and track, and almost immediately the end of the solder applied into this area, so that additional solder rapidly melts and flows around the complete pad and in contact with the component lead.

From the time the iron is applied until it and the solder is removed should be no more than two seconds and preferably only 1½ seconds. The joint should finish up with a bright appearance with the solder having a feather edge at both the lead and the track. This is a sign that the solder has thoroughly wetted the two parts and a satisfactory joint is made. The component should not be moved during the solidifying stage for, if it does, the joint will take on a frosted appearance and a suspect joint will result. In this case it should then be remelted and left undisturbed to harden again.

The amount of solder left at the joint should be a minimum to give a satisfactory result — additional solder will create a number of potential problems. It will take





longer to cool and make problems from component movement more likely, but a greater problem will be the additional likelihood of the solder bridging across to a neighbouring circuit. Other potential problems will be discussed later.

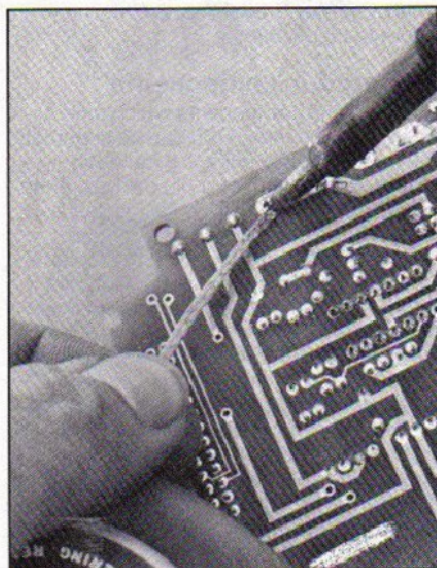
After two seconds, should a satisfactory joint not be achieved, then the iron should be removed and another attempt made after the area has had sufficient time to cool, probably 15 seconds.

This process should be repeated until the necessary ability is achieved — it is foolish to proceed with assembly of an actual project until this skill is mastered.

### Wrong component fitted

The next probable cause of a problem is the use of the wrong component which can

# CTION



**De-soldering a component using the soldering wick.**

be due to a number of reasons. Being able to recognize the component is the first essential requirement of locating the correct component and for the larger components this should present no problem. Most carry the full part number or the value clearly marked; integrated circuits and large capacitors are typical of this.

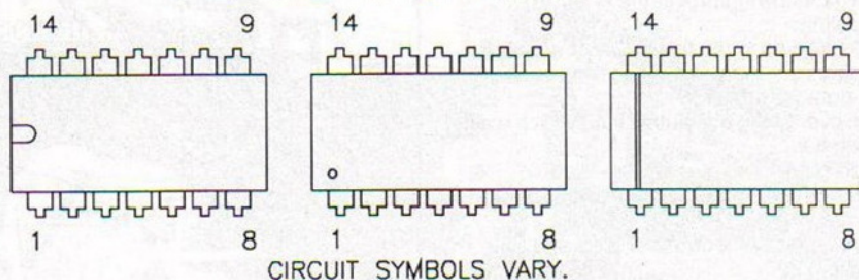
Smaller components are frequently marked using some coding system, such as the colour code scheme used for resistors. Those readers who do not have any reference charts giving details of these coding systems could purchase from Maplin their *Construction Guide* ref XH79L which costs a few tens of pence and also includes some useful constructional information, or similarly the *Modellers Guide to Electronics* from Greenweld Electronic Components (0703 236363) also at a similar price. Greenweld is another useful source of electronic components.

Having established an understanding of component markings then divide the components into groups in accordance with the parts lists for each individual assembly, placing those assemblies not being made at the time to one side. With the components split into groups, choose

## INTEGRATED CIRCUITS

ALTERNATIVE MARKINGS.

OTHER SIZES MARKED SIMILARLY.



CIRCUIT SYMBOLS VARY.

one group to start assembling and make one final check of the components against the parts list. This tidy approach will help to avoid the accidental fitting of a wrong component, and also help to avoid leaving components out.

### Component fitted the wrong way round

Having chosen the correct component, some must be fitted the correct way round; resistors and most capacitors can be fitted any way, but all semiconductors (which includes ICs, diodes, and rectifier bridges, etc., and some capacitors such as electrolytics and tantalum types) must be fitted the correct way. This information is included in the chart with this article showing the mechanical orientation compared with the circuit diagram symbol — again the above-mentioned guides have details of help here.

### Component not fitted

This is another probable area for errors and also includes the omission of wire links which are frequently required. A systematic approach to the assembly should make this situation improbable.

### Component damaged by heat when soldering

Providing the art of soldering has been mastered, this should not be a problem but, even so, some additional precautions must be taken as follows:

Transistors, tantalum capacitors and diodes must be mounted with at least  $\frac{1}{4}$  inch of lead showing on the component side. This helps to avoid the heat of soldering reaching the internal delicate parts of the component. As an additional protection, each lead can have a heat shunt clipped onto it on the component side during soldering — these can be purchased from Maplin (Part No. FR10L) and cost less than a pound.

It should also be understood that the PCB can be damaged by excess heat resulting in the track losing its adhesion and coming away from the insulating material.

We said earlier that if a joint failed to produce the desired result after two seconds it should be abandoned and a further attempt made once the area has cooled down. In a similar manner, if a quantity of joints can be made rapidly in a localized part of the PCB, this is best avoided and the area left to cool after the first joint, before a subsequent joint is attempted.

Integrated circuits are also another problem area, particularly as there are so many very short leads into the same component. It is suggested that these are mounted into sockets; as the IC is not fitted

in the socket whilst it is being soldered the problem is eliminated.

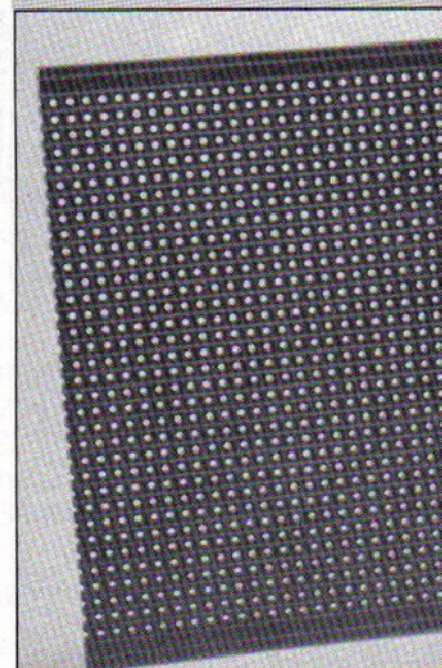
### Stripboard tracks not cut in correct position

For readers not conversant with this material, a piece is shown in the photograph, it consists of an insulating material about  $\frac{1}{16}$  inch thick on one side of which strips of copper are laid in one direction only. These strips are positioned at a pitch of  $\frac{1}{16}$  inch, the present standard for electronic components. Along each strip, also at a pitch of  $\frac{1}{16}$  inch, is a series of holes about 0.04 inch in diameter; this gives a matrix of holes on a pitch of  $\frac{1}{16}$  inch in both axes.

Stripboard is used to replace normal PCBs in one-off type applications. The strips can be cut by the use of a small drill held in the hand. About  $\frac{3}{16}$  diameter is ideal and locating this in the correct hole and on the copper side, a few turns of the drill between thumb and finger will remove the copper and as a result isolates the track on one side of the drill from that on the other. The use of wire links fitted on the other side mostly running in the other axis completes the substitute PCB.

By this approach, and the correct choice of layout of splits in the track, wire link and component positions, an alternative to a purpose-designed PCB can be created.

With this in mind it is obvious that the assembly must be created strictly in accordance with the drawings, for without the aid of a component layout printed onto



**A typical piece of strip board.**



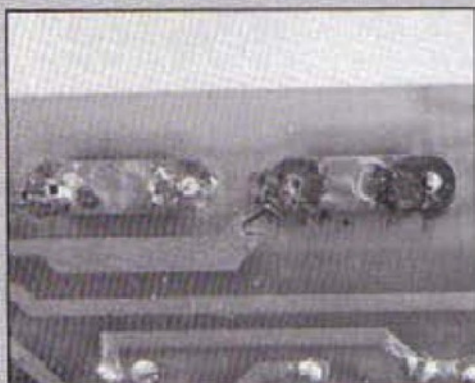
the PCB, errors are more easily made.

The following procedure is worth following:

Make all cuts to the tracks as per drawing.  
Inspect very thoroughly, checking against the drawing.  
Turn over being absolutely sure which way round it is.  
Insert links.  
Inspect very thoroughly, checking against the drawing.  
Place a piece of wood over links and turn over.  
Solder all links.  
Inspect both sides again.  
Add and solder components in most suitable order.  
Final inspection.

## Mechanical damage

Damage to the components can be caused by rough handling, the most likely is when bending the leads of a component to enable it to pass through the PCB at the hole centres to which it has been designed. This can cause a strain on the end of particularly small components and cause the joint inside the component to fail, or become weak and a potential source of



Before (above) and after (below) de-soldering operation.

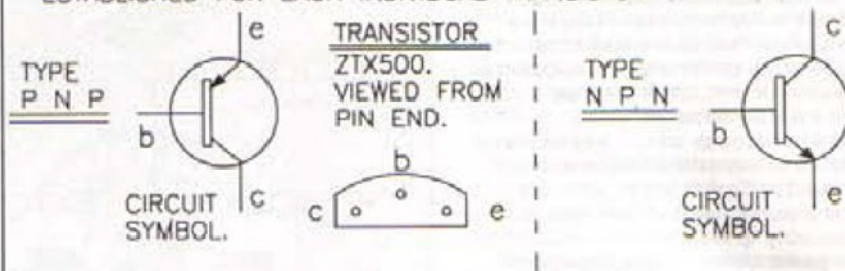


Left hand pair of joints were de-soldered using the wick, right hand pair the sucker.

failure at a later date. Using a pair of very small long-nose pliers, hold the lead close to the component and bend the lead on the other side of the jaws using the fingers; by this method, strain on the components-to-lead joint will be avoided.

One possibility of mechanical damage is when cutting the leads to length after soldering. The method to adopt is this: using a pair of side cutters, cut the lead just clear of the solder joint leaving about  $\frac{1}{16}$  inch of wire showing. This must be done using a sharp pair of cutters — if you use blunt cutters, the temptation will be to rock them

THERE ARE TWO DIFFERENT TYPES AND MANY VARIATIONS OF EACH TYPE OF TRANSISTOR. THE PINOUTS VARY AND HAVE TO BE ESTABLISHED FOR EACH INDIVIDUAL TRANSISTOR VARIATION.



## COMPONENT ORIENTATION

to remove the partially sheared lead and this action can disturb the solder joint and cause it to fail even though it may appear sound. This is termed a 'dry joint', a condition which can also occur at the soldering stage if the joint is not correctly made.

## Faulty components

Checking for faulty components during manufacture is not a practical proposition. They are not very likely at this stage, and those which just may be faulty are those most difficult to test outside the circuit, therefore locating faulty components will have to be carried out during the assembly testing stage.

## Damage through faulty testing procedures

Care must be taken during the testing stage of the manufacture as damage can be done to sensitive components. However, some components are more capable of withstanding abuse than would be anticipated, and many semiconductor circuits have protection against short circuit built in.

A few basic rules are: Ensure the power supply is the correct voltage, is applied to the correct terminals, and that the polarity is correct. Make sure temporary wiring is as per the diagram and adequately made and not likely to short onto other circuits. Do not apply the soldering iron to the assembly to make changes whilst the power supply is still switched on.

## Removing components

One remaining aspect of manufacture is of considerable importance, and that is the ability to remove components without damage to them, or the PCB.

## Integrated circuits in sockets

There are two possible problem areas: the first relates to the removal of integrated circuits from their sockets. If one attempts to remove these with the fingers, particularly if it has say 14 pins or more, then the force required is quite high, and as the pins suddenly release from the socket they can become badly bent. The aim is to keep the IC moving parallel to the socket to avoid this, but is not that easy due to the sudden nature in which the socket finally releases the IC.

Special tools are available for this but they are relatively expensive. The alternative is to apply a small screwdriver between IC and socket, first at one end and then the other, each time levering out the IC by a few thou only, until the IC is free enough to be removed with ease.

Another point worth making here is that many delicate integrated circuits can be damaged by static electricity, particularly when being handled, so do take care when handling ICs in an environment where static is likely to build up, and limit handling them as much as is possible. Do leave them in the packing in which they are supplied until required to be fitted, which should not be until assembly is complete and they are about to be powered.

## Soldered-in components

Removing components which have been soldered into a PCB can be extremely difficult, particularly if it is a multi-pin device — even with two-pin devices, if the component is not on long flexible leads such that one lead can have its solder softened and the lead removed, problems can occur, as the solder on the first lead begins to solidify before the second lead becomes molten. With three leads it is very much a problem, and with four or more it is impossible without the help of additional tools or materials.

Bearing in mind the earlier remarks regarding damage to the PCB and/or components due to excessive heat, removal should only be attempted with additional facilities. Fortunately these are not expensive.

The principle of both systems is the removal of the solder from the joint leaving the lead free to be removed. In the first and cheapest method, a narrow (about 3mm) braid of woven copper is placed over the joint and a hot soldering iron placed over this. As the solder melts, it is taken up by the braid and as the braid is removed, the joint is left largely free of solder. This process should be limited to about 2-3 seconds to avoid overheating the PCB. If some solder remains, a second attempt can be made using a fresh piece of braid. This can be purchased from Maplin as Desoldering Braid order code FR29G at about £1.

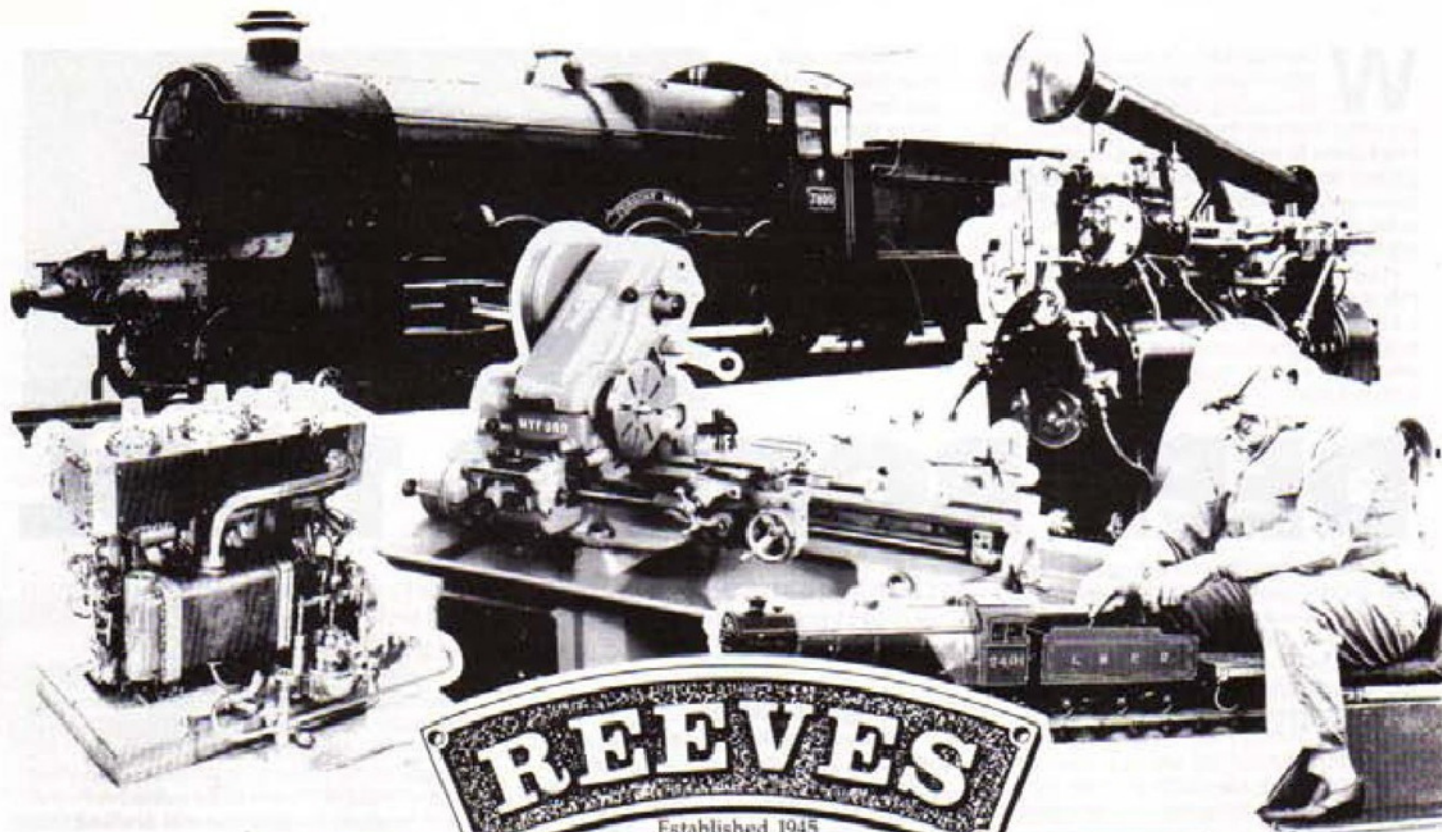
The second method is a form of pump which acts rather like a bicycle pump in reverse: the plunger is spring-loaded and has a catch to hold it in the loaded position. When the catch is released, the plunger flies back rapidly and draws in air which, if applied to the joint where the solder has been melted, will draw in the molten solder with the inrush of air.

## Conclusions

Do approach the manufacturing stage with considerable care; with this carried out properly and using an established design, there is no reason to anticipate any problems at switch on.







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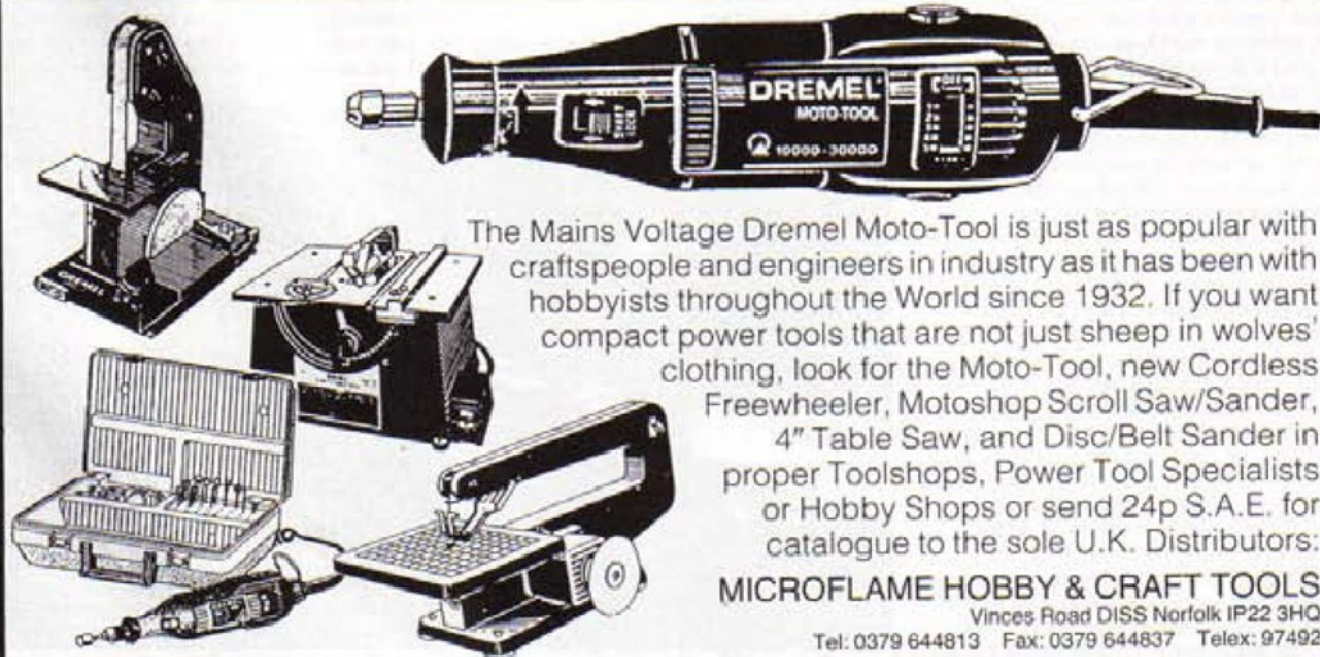
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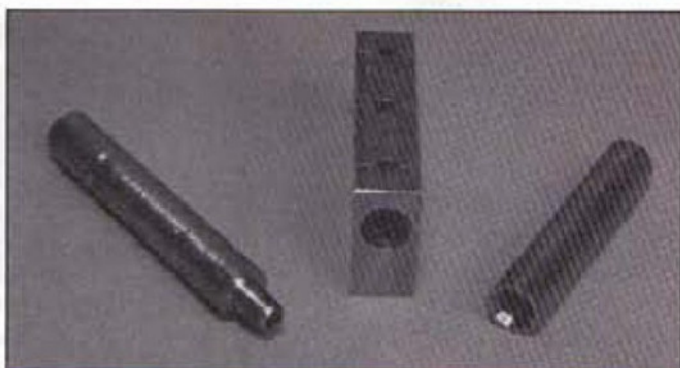
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**W**hen starting my turning activities some years ago I commenced by producing my lathe tools by grinding them all from square toolstock, as I had done in my early turning experience gained on capstan lathes where almost all tools were ground specifically for each part to be made, and retained only for that application.

I soon learnt that, for centre lathe work, this was not the case and tools were created as general-purpose tools, and also not always ground from one piece of tool steel. This was particularly the case for boring tools.

*The holder and two halves of the bar before joining. Note the recess on the female section and the matching chamfer on the male section to ensure as large a contact area as possible.*



# DEEP BORING TOOL

In the recent interesting article by Ivan Law on clamping tool bits into various holders using a ball as a pressure pad (MEW No. 7, Oct/Nov '91) he gave a simple example of a boring tool holder where the tool bit was clamped by means of a ball and rod passing down the centre of the boring bar. Whilst I had made a similar device but without the ball as pressure pad, it resurrected an idea from the past for making a deep boring tool by the method to be described.

**Getting to the bottom of it!** In this article we expand on an idea from our last issue, to achieve a boring tool holder able to reach into deeper holes than would normally be possible

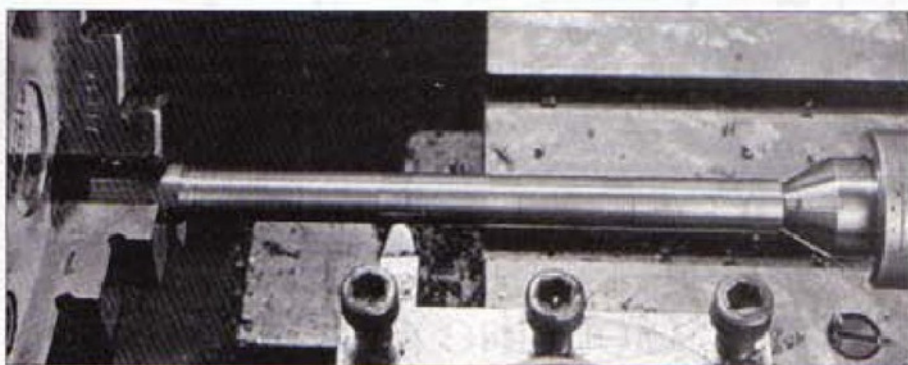
## Joining the halves

After making the two halves, both can be joined using a suitable high strength adhesive and screwed very firmly together. After this all around the join can be lightly tapped with a ball pein hammer to firmly

returned to the three-jaw chuck, and with the outer end supported by the tailstock centre, the bar can be turned along its length to the required diameter. The portion in the chuck will have to be turned with the part reversed to make the end available but, as an alternative, this half could have been made with extra length for chucking so that the whole bar could be turned at one go and then parted off to length.

Whilst still in the lathe the shallow grooves can be made, the purpose of which is to prevent the burrs created by the grub screws capturing the bar in the holder. Four grooves are suggested; this will allow for the bar to be moved within the holder so that less bar projects to give a more rigid bar for the heavier jobs, whilst similarly if greater reach is required the bar could be held by two only grub screws — in this case a longer tool bit clamping screw would be required as is shown in the drawings.

To drill the hole in the end of the screw, make a bush equal in diameter to the across flats dimension of the hexagon screwhead. Placing the screw in this and with a nut tightened to make it firm, the assembly can easily be held in the three-jaw chuck with the jaws holding both the bush and hexagon head and its end to be



*The outer diameter of the bar being finished after joining the two halves.*

## Deep hole boring tool

To make a tool with a long reach by this method requires a suitable long drill, and, whilst these are readily available, the cost of buying one would, in part, defeat the object as further use for an expensive drill would be minimal.

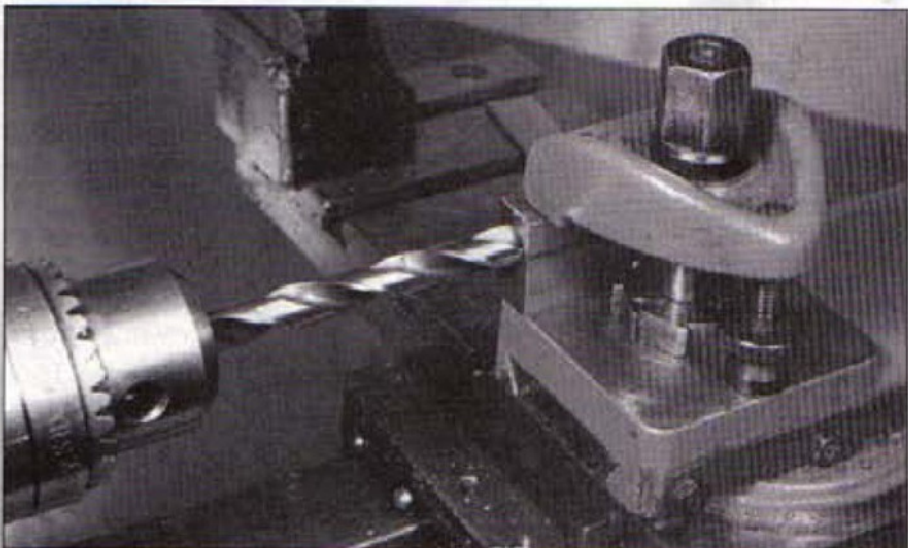
The procedure to overcome this is to make the bar from two (or even three) pieces; this is seen in the drawings but a few points are worth elaborating on.

It can be seen that to achieve the required length the two parts are screwed together; note that one half has a countersink whilst its mating part has a chamfer. This helps to eliminate the weak point that will occur at the joint. Also the through-hole in the part farthest from the tool bit has a larger hole; this is to avoid any problems with alignment if both holes are a close fit on the clamping rod. The outer end of this part is countersunk for eventual supporting on the tailstock centre. Finally, the parts are made oversize to allow for machining after the parts are joined.

There should be no problems in making the two halves which can be exactly as the drawing, or made larger in diameter for a more robust bar and/or made longer if this would suit your requirements better.

close the join which will make sure it is invisible after the bar had been machined on its outer surface.

Leave the bar for the adhesive to arrive at maximum strength when the bar can be



*Method of drilling the holder to achieve hole in correct position.*



drilled when in this position.

No drawing is included for the clamping rod, but one point is worth emphasising: that is to make a small chamfer on both ends when the length has been finalised, this to make sure that any burr created on the end when tightening will not capture the rod in the bar. If it became tight in the screw, this would be less of a problem.

It was at this point that I learnt the error of my ways for I had intended to adopt Ivan Law's idea from the previous issue, of using a steel ball, but when attempting to insert one into the assembly, I found that those I had assumed to be  $\frac{1}{8}$  inch were in fact a few thou over and would not fit! I can only apologize to Ivan for my careless mistake and not being able to put his excellent idea to use. For this application,



*With the bush diameter equal to the A.F. of the hex., the screw can be held in the three jaw chuck for drilling.*

though, where the tool bit will be fitted and left in position, a small flat ground onto the tool bit will ensure a satisfactory result.

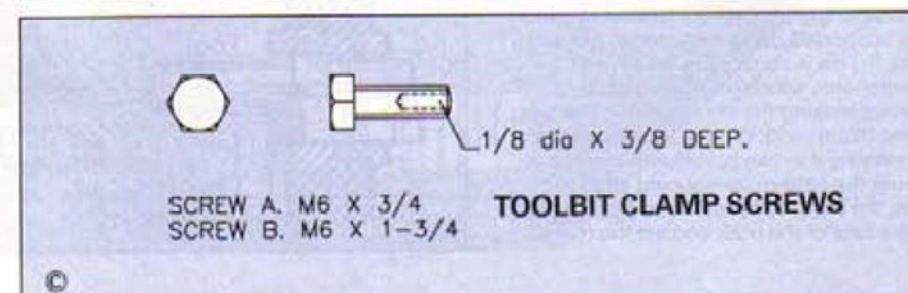
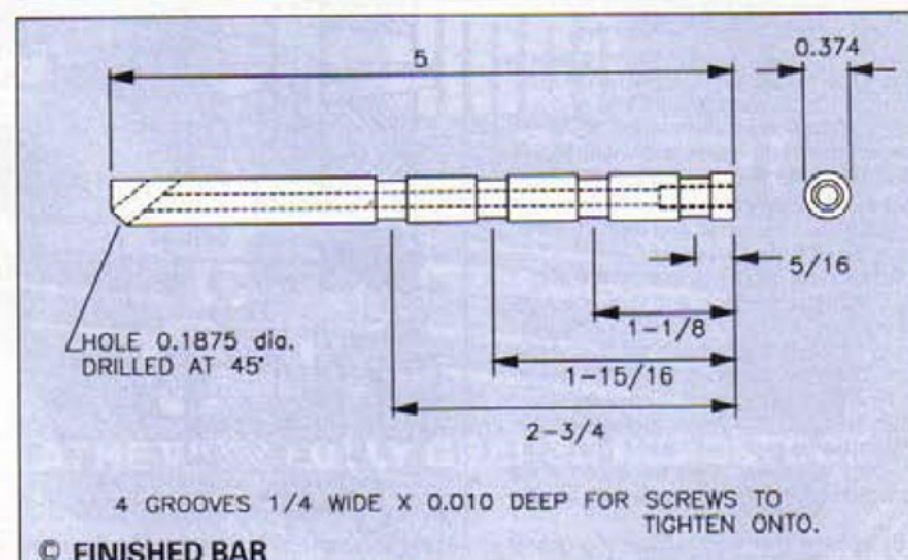
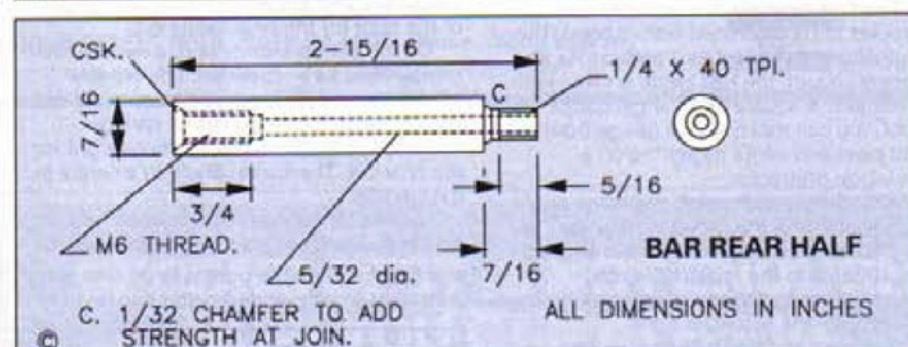
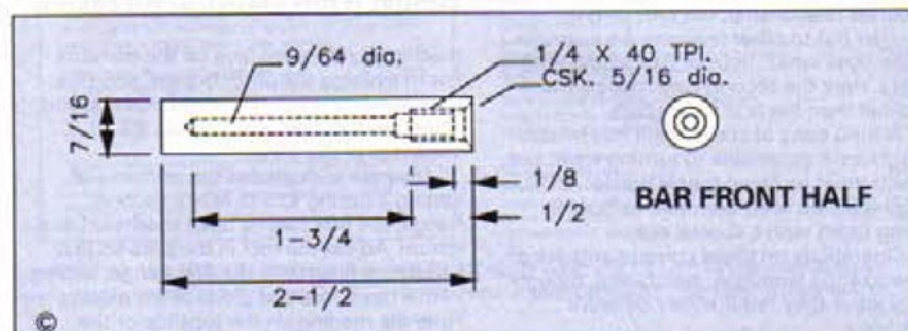
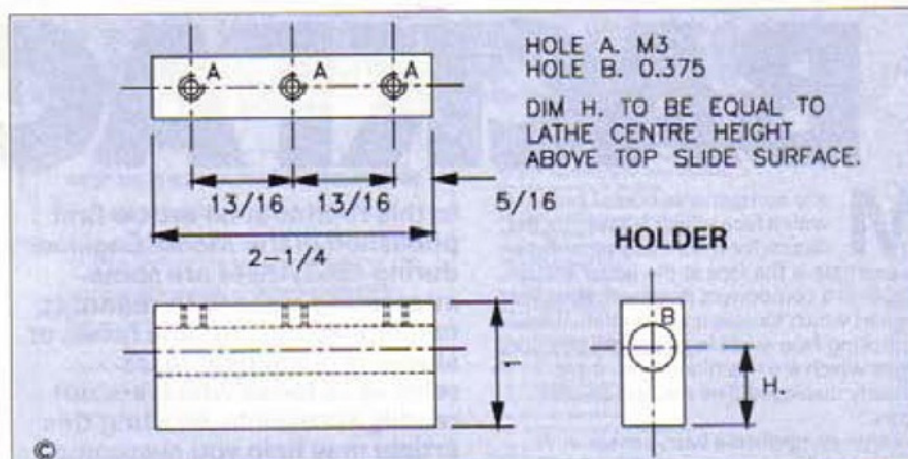
The tool bit can be ground in place and, if made as per that shown in the photograph, the bar will be able to bore to diameters not that much greater than that of the bar itself.



*With the cutter ground as shown, it can be used for hole sizes almost as small as the bar itself.*

## The holder

The holder requires no explanation other than to say that the hole should be at centre height when placed on the top slide, and to achieve this easily it can be drilled with the drill fitted to a chuck in the lathe spindle, and the holder drilled whilst being held with the toolclamp on the top of the slide. One final point: the grub screws must be short enough to make sure they do not project above the top of the holder when tightened, or else they will interfere with the top slide toolclamp.





# BACKFACING

**M**any components have a boss with a face which is taken as the datum for machining other faces. An example is the face at the larger end of a taper in a component (flywheel, sprocket or gear) which locates it on its shaft. If this controlling face is not in its correct position, edges which are machined from it are similarly displaced. The result is several errors.

Other components have bosses with two faces which must be machined in accurate relationship, not only to one another but to other features. An example is the boss which houses flanged bearing liners. Here the second face may be more difficult than the first to machine.

A third class of component has bosses which are inaccessible to turning tools, but which must be faced for clearance. An i.c. engine piston is an example, its bosses being faced with a special cutter.

Operations on these components are all, in workshop language, *backfacing*, though in practice they require very different methods.

The first example is a replacement sprocket to be machined from a blank, the original being to hand as a pattern. As its taper is known, the half angle is taken with a diemaker's square or an angle gauge, as at A1. You can make such a gauge from flat mild steel and verify its setting on a workshop protractor.

With the topslide set to the same angle, a taper gauge is machined in mild steel in the chuck. You may have to make several adjustments to the topslide, testing between cuts by fitting the sprocket on the gauge, until the setting is right.

To get a good finish on the gauge, use a Swiss file or fine emery cloth and run the lathe rather fast. To test the fit of the sprocket, press and twist it on the gauge by hand. If the tapers agree, it will hold firmly. If it does not, correct the tight end of the taper with further touches of the file or emerycloth. Bright marks show which end this is. Finally, to finish the gauge to length, use a parting tool or a grooving tool to neck the stock near the taper, and then turn the face flush with the sprocket.

To machine the blank, first centre and drill it from the tailstock, and then machine its back face with a turning tool, using a boring tool with the topslide set to opposite angle. Open out the bore. When the gauge can be entered about one third of its length, take some fine cuts to see the difference that each one makes. Then you can judge more accurately the depth of the last which will let the gauge in flush as at A2.

By another method, the face of a boss is finished on a mandrel which is run between centres or gripped in the chuck at one end and supported by the tailstock at the other, as at B. This is convenient for several components which have been taper-reamed making the bores slightly oversize at the datum end. You prepare the mandrel by necking it in two places and then you mount the pattern component as shown. With the topslide parallel, you place a block to the face of the boss and set the tool to

**In this reprint of an article first published in the *Model Engineer* during 1963, there are some interesting ideas with regard to machining inaccessible faces, or similarly machining faces relative to those which are not readily accessible. Reading this article may help you overcome similar if not identical problems**

machine a reference face on the mandrel. For machining the other bosses, you pick up a topslide reading from this flange, and move the tool back as much as the thickness of the block.

Diagram C illustrates the principle of setting a boring tool to face a second flange, the first having been machined as a datum. Adjust the tool in the bore so that its edge is flush with the first flange, testing with a block or other piece of flat metal. Note the reading on the topslide or the leadscrew, and advance the tool the length of the bore for the final facing cut.

On the set-up shown at D, a second face is machined as a repetition. The work is held in the chuck. To get the boss to correct length, its bore is fitted with a spring-loaded plug to which the tool is brought for the final cut. The spring abuts to a centre in the spindle.

Cutters for facing piston bosses, and similar inside faces, can be of two types, as at E and F. When the bore is large enough, a straight double-ended cutter can be used

in a mandrel; but for a small bore a multiple-toothed cutter from silver steel must be used. Both can be secured by a grub screw.



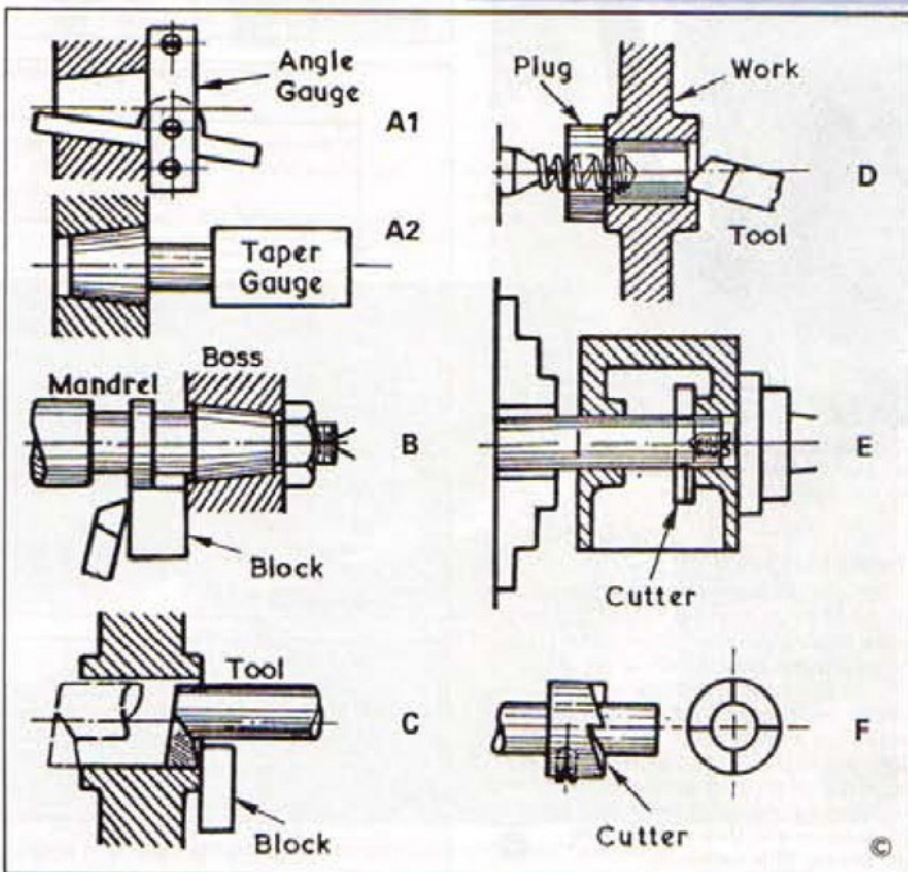
## QUICK TIP

If you traverse the saddle for parallel turning rather than using the top slide, then by setting the top slide at an angle of six degrees in the direction that reduces the diameter as it is moved towards the headstock (when being used for outside turning, or in the reverse direction for internal turning), this can assist in precision turning as follows.

The angle of six degrees gives a one thou change in position, either towards the centre for external turning or away from the centre for internal turning. For a ten thou movement of the top slide, or say when turning to close limits, a change of one tenth thou for a one thou movement.

Rather than leave the top slide in this position it would be preferable to make the adjustment only when requiring to carry out close tolerance turning. Alternatively, the slide can be set at one half of a degree to give a ratio of ten thou to one tenth of a thou.

If the top slide is not calibrated, then the slide can be set to a variation of one quarter of an inch over a length of two and a half inches to give a ratio of one to ten. In a similar manner the slide could be set at an angle of eighty-four degrees to achieve fine adjustments in length.







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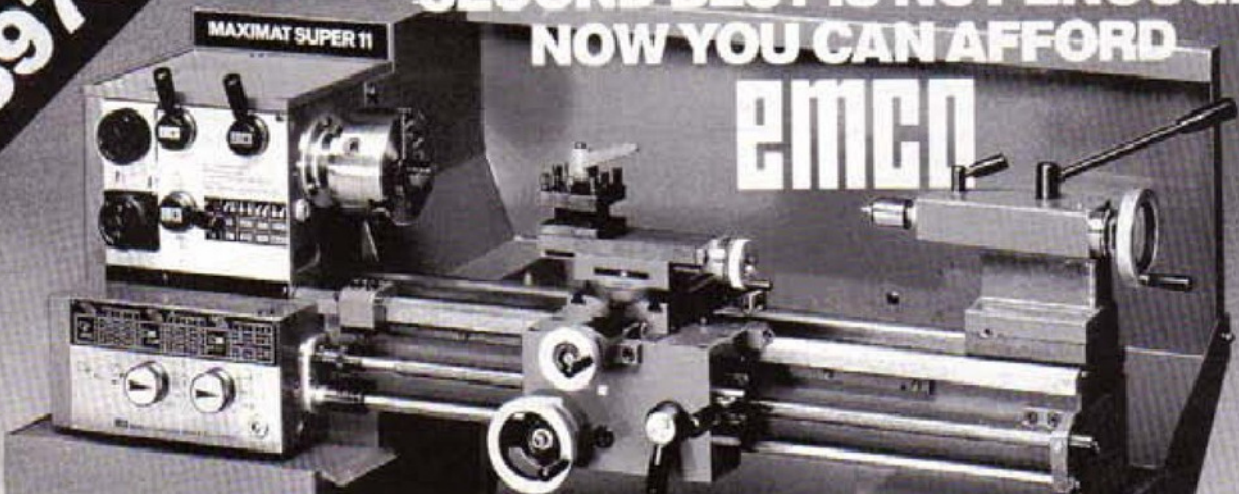
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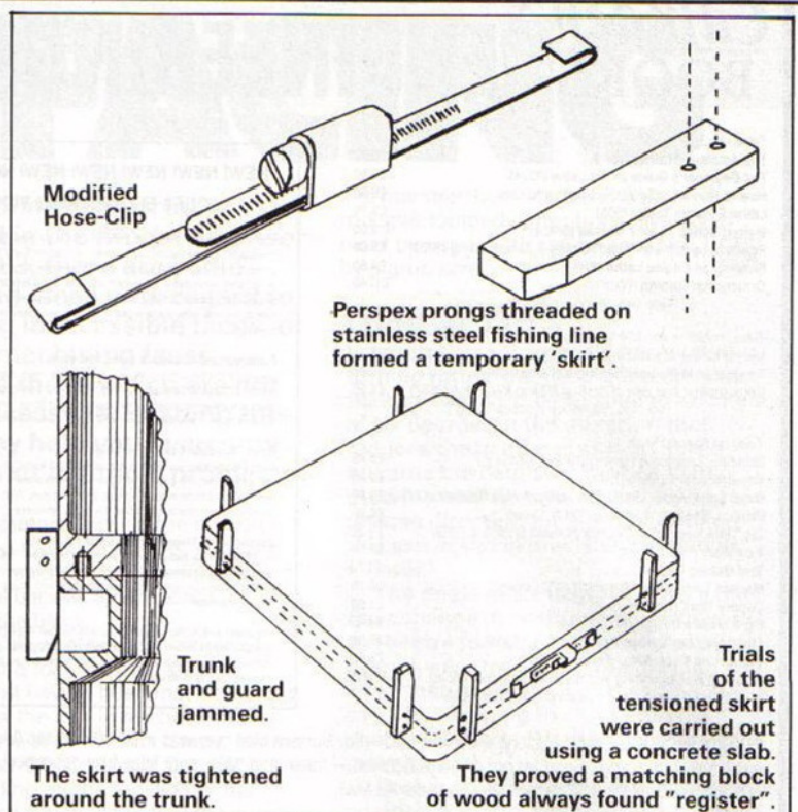
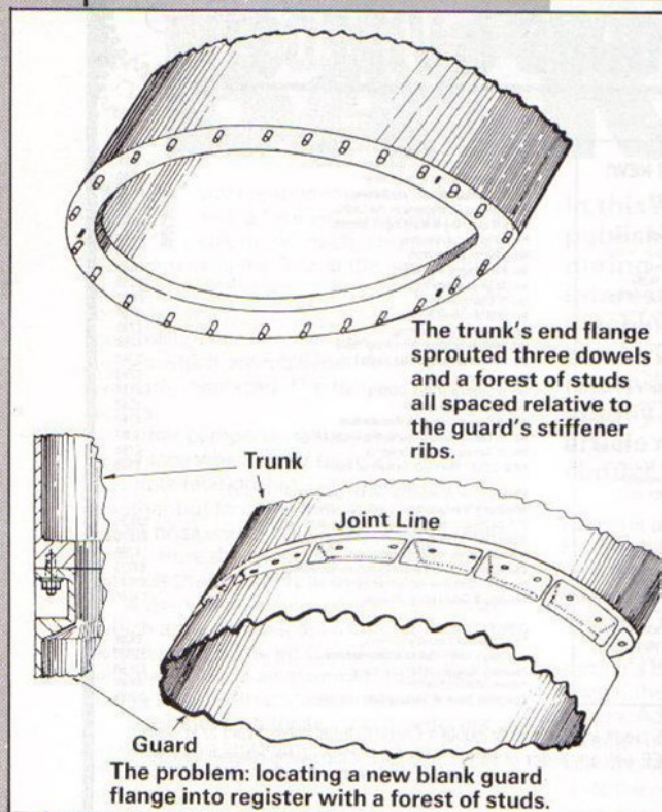
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Brian Taylor will be well known to readers for his amusing articles about his long experience in engineering, which also offer help and advice. This time he explains how hole centres were picked up and suggests the method could be used for fitting a chuck back plate

**O**dds on it's a murky gloom, with no floor for parking components; nowhere to lay tools of the trade. To drop things spells loss, in guzzling mud or ocean depths. As for handy waterproof reference manuals? – like tea-breaks – just wishful thinking.

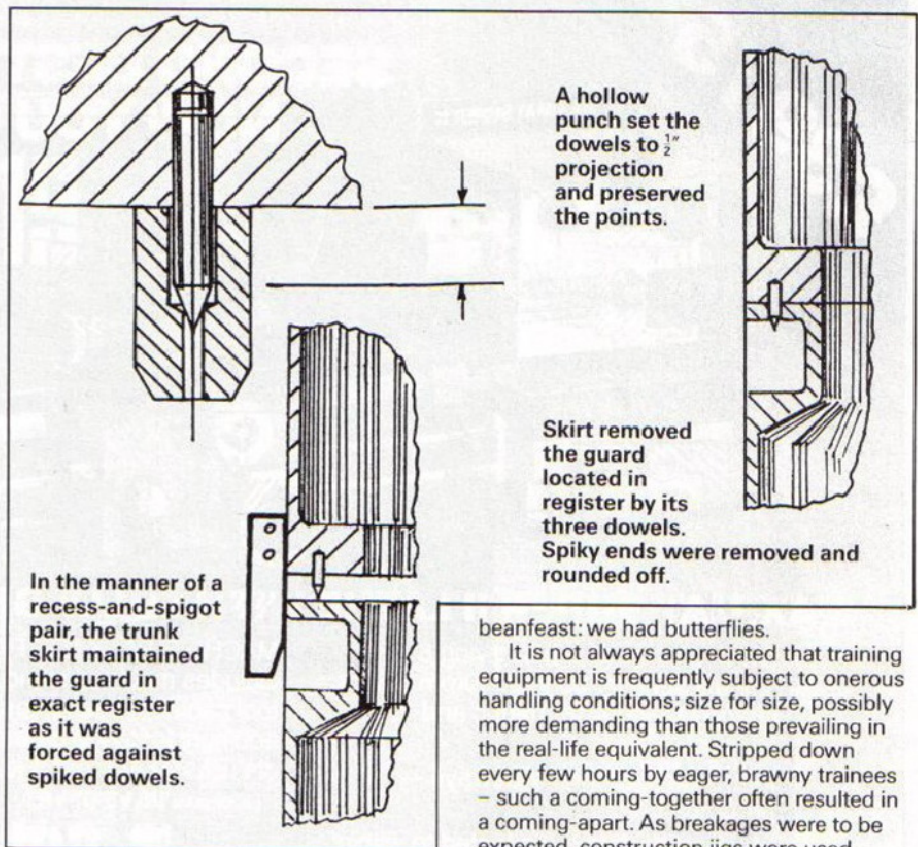
Working under such conditions demands an excellently retentive memory and a highly trained sense of touch. Without hands-on experience, even straightforward run-of-the-mill tasks may develop into bizarre 'now-get-out-of-that' predicaments. Even stashing nuts and bolts, bits and bobs, assumes a vitally important role. In addition to absorbing the technicalities, mundane procedures require to be understood and committed to memory.

Royal Navy instructors demonstrate techniques at lectures, but for obvious reasons, it is not always possible to use full-size equipment. As a result, accurate functional models frequently play a major role during lectures, demonstrations and ability tests.

The company by whom I was employed, supplied many such models. Subject matter dictated scale, quarter full-size being popular, with far greater reductions when full-size equipment was extensive. (Many square miles of seaway were compressed into minesweeper training aids).

Models were constructed from the same detail drawings as their real-life counterparts, non-essential details omitted

# GUIDE DODG



if they didn't contribute to a training function or proved mechanically weak at model size. Occasionally, because it played an essential role, a weak (model) item just had to be included. Our gremlins had a

beanfeast: we had butterflies.

It is not always appreciated that training equipment is frequently subject to onerous handling conditions; size for size, possibly more demanding than those prevailing in the real-life equivalent. Stripped down every few hours by eager, brawny trainees – such a coming-together often resulted in a coming-apart. As breakages were to be expected, construction jigs were used. They ensured Royal Navy stores held interchangeable spares.

Retrofitting of upgraded equipment items presented a variety of problems, not the least being those associated with fitting



items of a new design to existing apparatus of dubious origin.

## Relating to model engineering

The article appearing in the April/May issue of *MEW* entitled: *Fitting a Chuck to a Backplate* revived memories of many retrofitting episodes.

There were no second attempts allowed; no pepperpot perforations, fittings had to match first time round. Blindfold trainees working by sense of touch were not to be led astray.

By way of an example, we were required to supply a model of a revised guard which, in real life, bolted to the bottom face of a submerged vertical trunk. Guard removal was an essential preliminary to routine maintenance of the technical innards, so divers had to be familiar with all its dismantling and reassembly techniques. The model guard had an aluminium joint flange, ovoid in shape and measuring about 3 feet by 2 feet which had to register with the model trunk's identical ovoid joint flange.

Maybe twenty or thirty  $\frac{1}{8}$ in. BSF studs, together with three silver steel  $\frac{1}{4}$ in. diameter dowels projected from the model's flange, spaced to avoid ribs on both the old and new guard's flanges. No doubt their positions were according to plan, but all appeared as if spaced by rack-o'-thee. Like hen's teeth, hints and tips about picking up from blind holes on apparently ad-lib

edges – trim the guard if need be. Once fully matched, the trunk's profile could then – temporarily – have a 'skirt' attached. In that manner, the inside surface of the skirt would coincide with the outside shape of the guard, in which case a slight lead-taper would guide the guard into register when offered up.

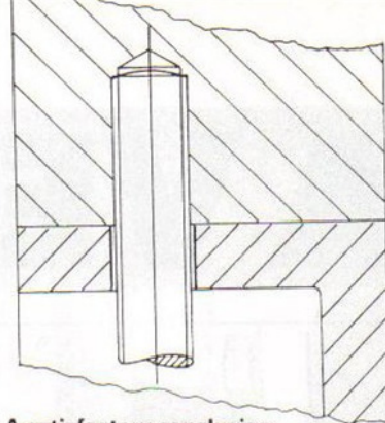
## The method

Eight – 2 in. lengths of  $\frac{1}{2}$ in. Perspex strip, threaded onto stainless steel fishing line formed an experimental 'pronged' skirt. With roughly an inch of each prong projecting above the surface of a concrete slab (ex garden path!), the skirt was tensioned around its edges by means of a 'modded' worm-drive hose clip. (ie. sawn in two at about mid-length, ends bent over and almost flattened to form hooks). The eight 'prongs' guided a matching wooden shape into exact register.

It proved beyond doubt that a temporary skirt's prongs and the guard's flange would together perform as a recess-and-spigot pair when the new guard was offered to a completely bald trunk flange.

## A good start

Although we established the final scheme by numerous workshop experiments, salient stages by which the dowel and stud centres were located are described as they proceeded on site. Once all studs and dowels were extracted and



**A satisfactory conclusion.**  
Trunk and guard in register on three dowel and joint studs concentric with flange drill.

Following an extra tap on the wedges for good luck, the guard was lowered, revealing three accurate spottings.

Dowel holes drilled and reamed, it was again raised, this time with skirt removed. It slid onto its dowels as planned, both flanges in full contact and exact register. So far so good.

Having served their purpose, those spikey sharp dowels were rounded-off, rendering stud hole location less of a b\*\*\*\* problem.

An appropriate number of  $\frac{1}{8}$ in. BSF grub screws had been prepared with end slots as a means of screwing them into stud holes. Each also featured a concentrically drilled hole, through tapped 6 BA, into which a cone pointed 6 BA socket head

# GE FOR THE BLIND

centres were in short supply. We plodded on alone. One way or another, holes in our guard had to match the trunk – and dowels had to maintain register.

To bedevil matters, the new guard had to be fitted on site, so the guard's blank ovoid flange had to be drilled for dowels and studs on delivery – somehow!

The daunting prospect of matching umpteen blind holes on site, without mishap at first attempt, was eased when a practical scheme slowly took shape: remove studs and dowels from the existing flange; raise and wedge the new guard hard against the trunk and compare profile

the trunk's bald flange deburred, the new guard was raised, jammed in place and trimmed with a Surform to match trunk-end profile. While still jammed together, the prong skirt was looped in place. When tensioned to a firm grip on the trunk, it allowed the guard's removal.

New, specially prepared sharp pointed silver steel replacement dowels were carefully driven home with the aid of a purpose-made hollow punch, leaving  $\frac{1}{8}$ in. of parallel dowel protruding as before. Maintained in register by the temporary skirt, the guard was raised and wedged into firm contact with the three dowel points.

grub was screwed until its point stood proud of the slotted end.

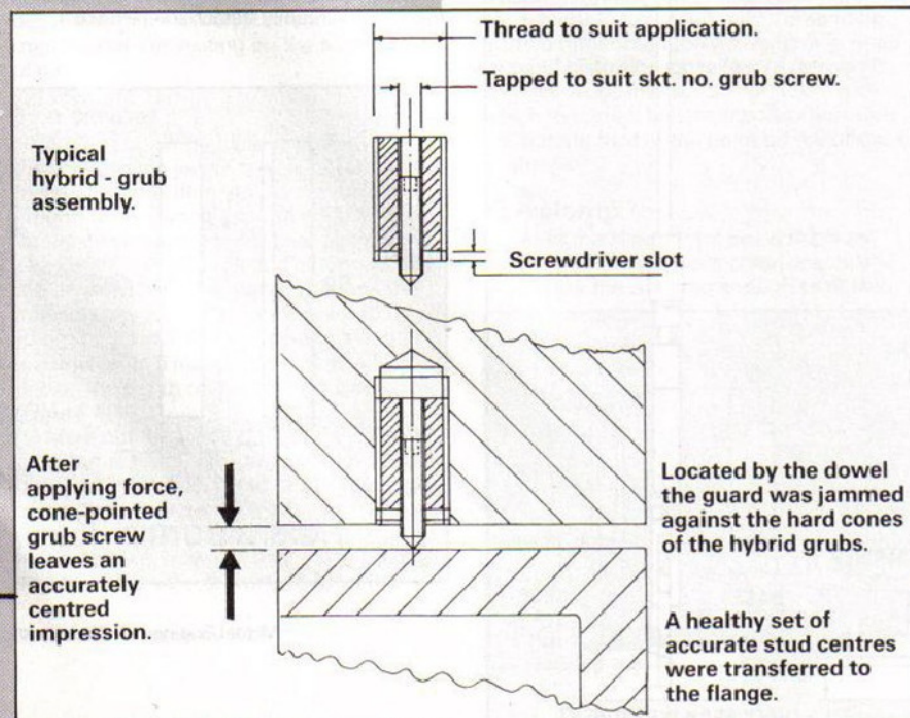
A bifurcated screwdriver eased each  $\frac{1}{8}$ in. BSF hybrid-grub into a stud hole until only its 6 BA coned point stood fractionally proud of the surface. In that manner we obtained a full complement of relatively hard points, each located exactly on stud-centre.

Now located by its dowels, the guard was raised into position, jammed against the multitude of hard cones – then lowered again. High points produced healthy spottings at the first attempt. Those grubs were removed and a second impression made, following which the remaining hybrids were removed.

After running a  $\frac{1}{8}$ in. drill through each pop and refitting studs to trunk, we re-offered the guard. To everyone's relief, all studs slid through, each concentric in its drilling, a satisfying conclusion to a daunting problem.

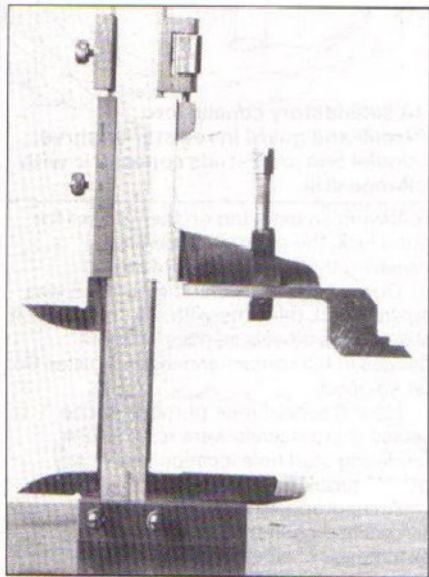
Typical of many dodges primarily evolved for beating a tricky situation, we found the hybrid-grub technique spawned numerous other applications. Matching to blind holes lost its terrors and became a straightforward run-of-the-mill task. A vice or clamps transferred impressions on small items, larger jobs required purposeful taps with a wooden persuader.

Similarly, worm-tensioning, with or without 'prongs' or maybe wire replaced by strap banding – or chain, proved advantageous for holding 'barrel' or 'picture-frame' constructions where a wrap-around grip was required. Its compactness suited locations far too confined for bulky 'Gee' clamps.





# A VERNIER HEIGHT



Vernier caliper fitted with base and scribing blade to form a height gauge.

We have seen in the previous article (MEW No. 7 Oct/Nov '91) how the usefulness of the vernier caliper can be extended by attachment of scribing points; this article stretches the application to include that most useful of marking-out tools, the height gauge.

For those not familiar with the instrument, a height gauge is used in

In this second of two articles by Dave Lammas he now continues his conversion of a vernier caliper to produce a very useful height gauge

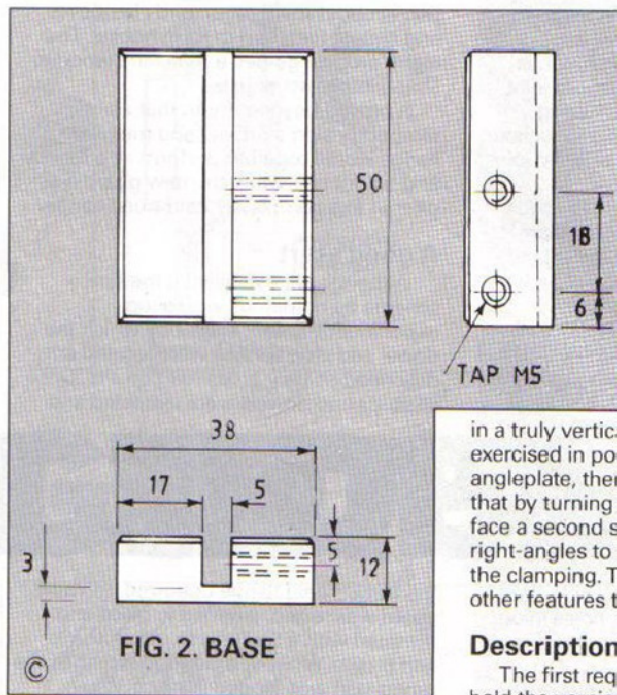


FIG. 2. BASE

similar fashion to the ordinary scribing block though with greatly improved accuracy of measurement. Large heavy workpieces such as castings may be free-standing on the surface plate whilst the height gauge is moved around the work to scribe lines at various heights above the base or at various distances apart vertically. Smaller workpieces are usually clamped to an angleplate to keep them

in a truly vertical position. If care is exercised in positioning the work on the angleplate, there is the added advantage that by turning the angleplate onto its other face a second set of lines may be scribed at right-angles to the first without disturbing the clamping. This enables hole centres or other features to be marked precisely.

## Description of instrument

The first requirement is a base block to hold the vernier caliper in a vertical position, the block is fitted with a pair of grub screws bearing on a gib-strip which avoids damage to the instrument. The end of the caliper is already ground flat to seat in the groove of the base. The second requirement is a shaped scribing blade of cranked form whose depth is chosen to ensure that the height of the scribed line above the surface plate corresponds to the reading on the scale. A clamp similar to that used for the earlier scribing points means the blade is readily detachable, **Photo 1, Figure 1.**

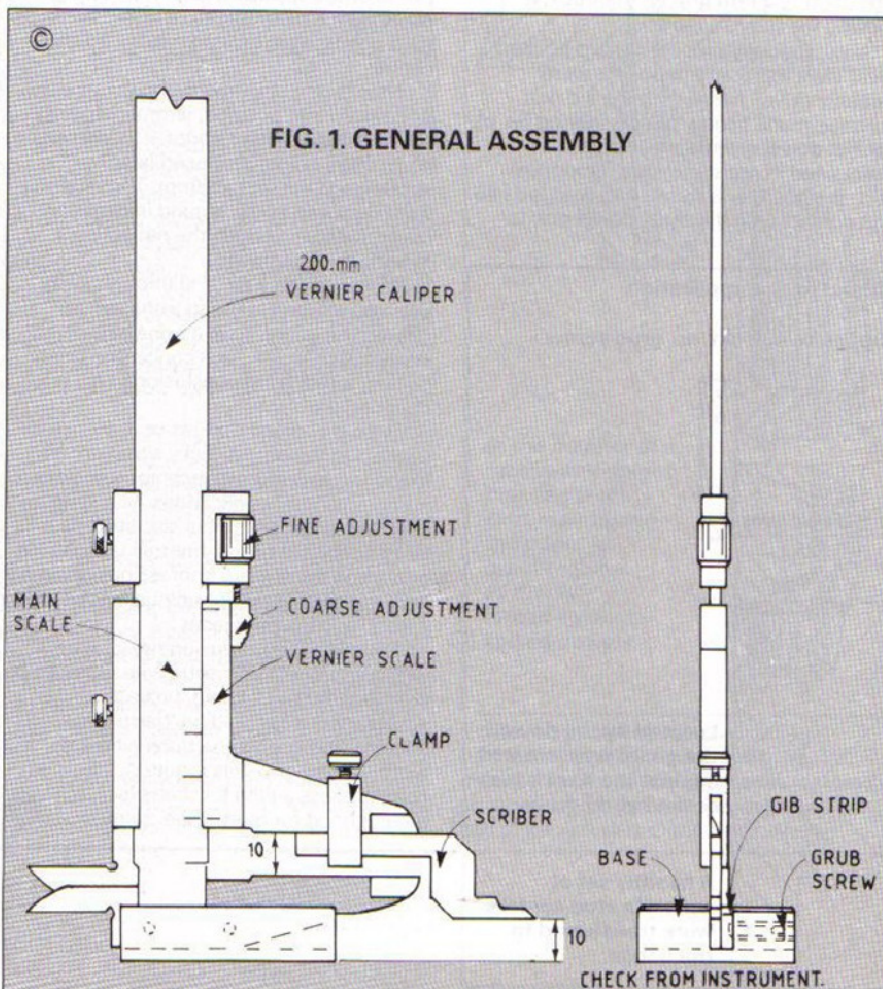


FIG. 1. GENERAL ASSEMBLY

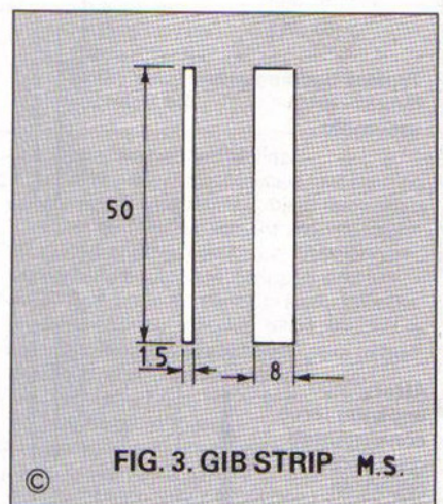


FIG. 3. GIB STRIP M.S.



# HEIGHT GAUGE

## Construction

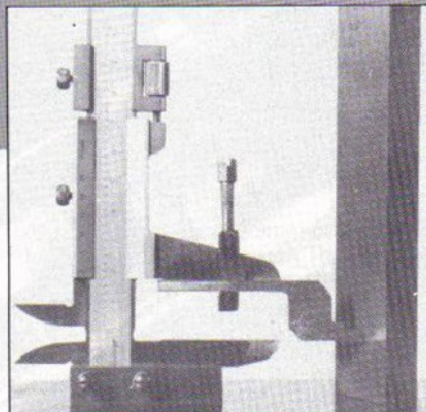
The base may be made from a block of either mild steel or cast iron though the latter might be thought too brittle in view of the thin section at the bottom of the groove, **Figure 2**.

Start by squaring up the sawn block by flycutting in lathe or milling machine or if you prefer, by holding the piece in the four-jaw chuck to face each side in turn.

Width of the slot is not critical so long as it permits the instrument plus a strip of steel about  $\frac{1}{16}$  in. thick to fit easily. The base of the slot must be smooth and true if the caliper is to sit exactly vertical. Although marked with both inch and millimetre scales, my own instrument was made in a 'metric' country so the dimensions of the fittings have been shown in millimetres. Personally I work in either imperial or metric systems as the job dictates since it

clamping arm but leave the right-hand side square. Use a small temporary clamp to fasten the embryo scribe to the jaw.

Now prepare a small block of metal exactly 10mm (or 0.5 in.) high, place it on the surface plate then adjust the caliper until the blade just touches the top of the gauge block; a gentle touch on the vernier screw is necessary for this operation. It should be possible to slide the block in and out from under the blade without interference whilst at the same time ensuring the blade does touch the block. Now read the setting on the caliper scale which should indicate slightly more than the block dimension, the difference between the two tells us how much more to take off the bottom of the blade but when doing so, be careful to keep it exactly parallel to the top of the blade. Use your micrometer (or caliper) to check. The



**Vernier caliper adapted as a height gauge, in use for marking out a piece of metal.**

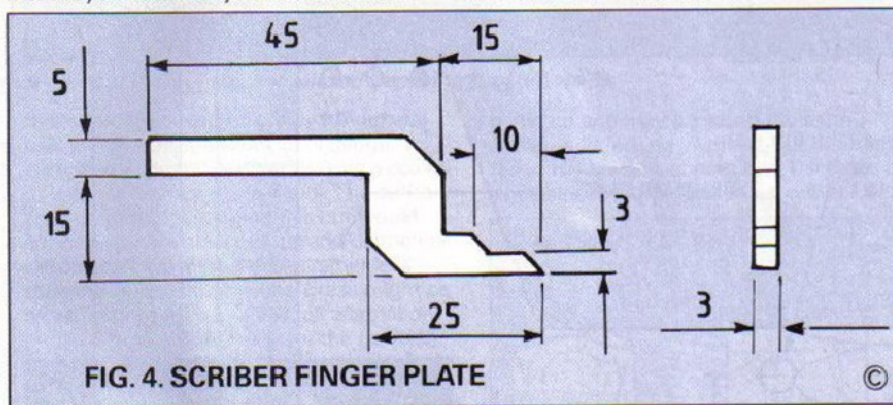
the jaw plus the scribing blade shank. A knurled screw completes the work, (**Figure 5**).

## Using the height gauge

It is recommended when dealing with small components that they should be clamped to an angleplate but where the clamps would obstruct the work and interfere with marking out, a solution is to stick the work to the angleplate using a few spots of 'instant glue'. For this to be successful, first clean both surfaces of oil and dirt by rubbing with a clean rag dipped in meths, 'trike' or other suitable cleaning solvent. Apply the adhesive to the back of the work, carefully position it close to the angleplate then press firmly against it for a few seconds or so. Positioning is facilitated if a 'parallel' or strip of metal some multiple of the main scale divisions is placed beneath the lower edge of the components, this also means that one does not then have to work right 'down on the deck' where it may be difficult to see the lines. Another parallel clamped to the angleplate can be used to set the horizontal position which makes life easier when the angleplate is turned on its side for the second set of lines to be scribed. Instant glue used in this way is quite brittle, making removal relatively simple — just place a strip of mild steel against the edge of the component and tap it sideways, (**Photo 2**).

Besides its usefulness in marking out, another function of the height gauge is to act as a measuring instrument for parts where it is not possible to get both jaws of the caliper itself, or a micrometer, to bear, i.e. where two points are not in the same plane but their vertical distance apart is required. We speak here of vertical distances apart only because that is the manner in which the instrument is employed, in practice it is just as easy to measure distances that are normally horizontal if the piece can be stood on end.

It is true to say that once its use has been mastered the height gauge will find application in all manner of tasks previously handled in less accurate ways or where haphazard methods of doubtful precision had been devised. This version is so simple to make that there is really no excuse for using less satisfactory devices. An added incentive for making it is that a commercial height gauge would currently set you back about £100, and that's only for a 'cheap' one.



**FIG. 4. SCRIBER FINGER PLATE**

matters little whether it is based on the length of a 'barlecorn' or some fraction of the earth's circumference, both are rather arbitrary, (**Figure 3**).

Check your own instrument to see that the grub screws will bear directly above the flat portion when the caliper is fitted into the groove as indicated on the drawing before marking out and tapping the holes. Chamfer all edges and corners as an aid to comfortable handling as well as decreasing the risk of accidental burrs that might upset the seating on the surface plate.

## The scriber

A piece of gauge plate similar in thickness to the jaw of the caliper is the raw material for this item. As purchased it is ground to size, so utilise one edge for the reference surface that will bear against the jaw. Before marking out and cutting, check the distance from the surface plate to the movable jaw when the scale is set to 10mm or 0.5 inch if you intend working in Imperial units. This measurement will decide the depth of the scribing blade, (**Figure 4**).

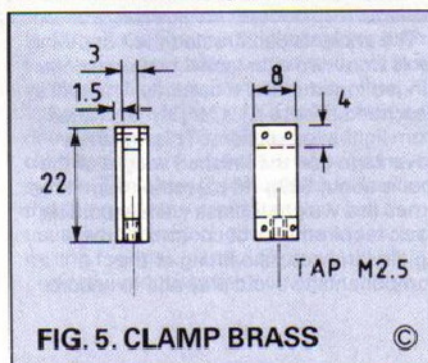
Mark out the blade shape on the gauge plate but at this stage, only saw it out as a plain rectangle. File, flycut or mill the edge opposite to the reference edge so that it is parallel but slightly deeper than your measurement. Now cut only the left-hand side shown on the drawing to form the

reason for taking so much trouble over this is to maintain the accuracy even after the blade has been resharpened many times over the years. Note here that one ONLY sharpens the blade on the sloping face, NEVER on the underside!

Carry on with the remainder of the shaping then harden the end of the blade by heating to redness and quenching immediately in cold water, leave it dead hard without any tempering. Note here that it is advisable to harden only the scribing portion rather than the whole item in order to avoid distortion since few of us model engineers possess surface grinders with which to correct hardening distortion. Rub the sloping face of the point on the oilstone to sharpen.

## The clamp

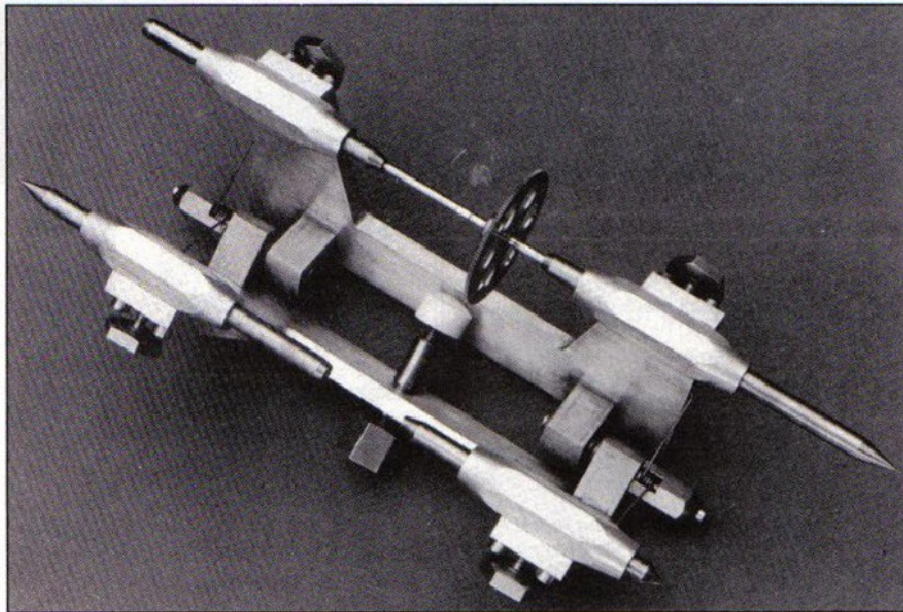
Make the clamp from brass sheet as detailed for the previous ones, only this time make the slot long enough to fit over



**FIG. 5. CLAMP BRASS**



# A CLOC



Tool in open position showing adjustment mechanism and hinge blocks.

## METHOD OF HOLDING BAR IN 4 JAW CHUCK

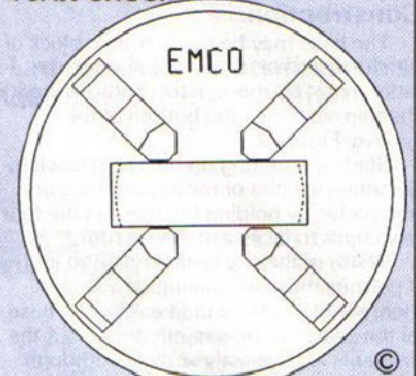
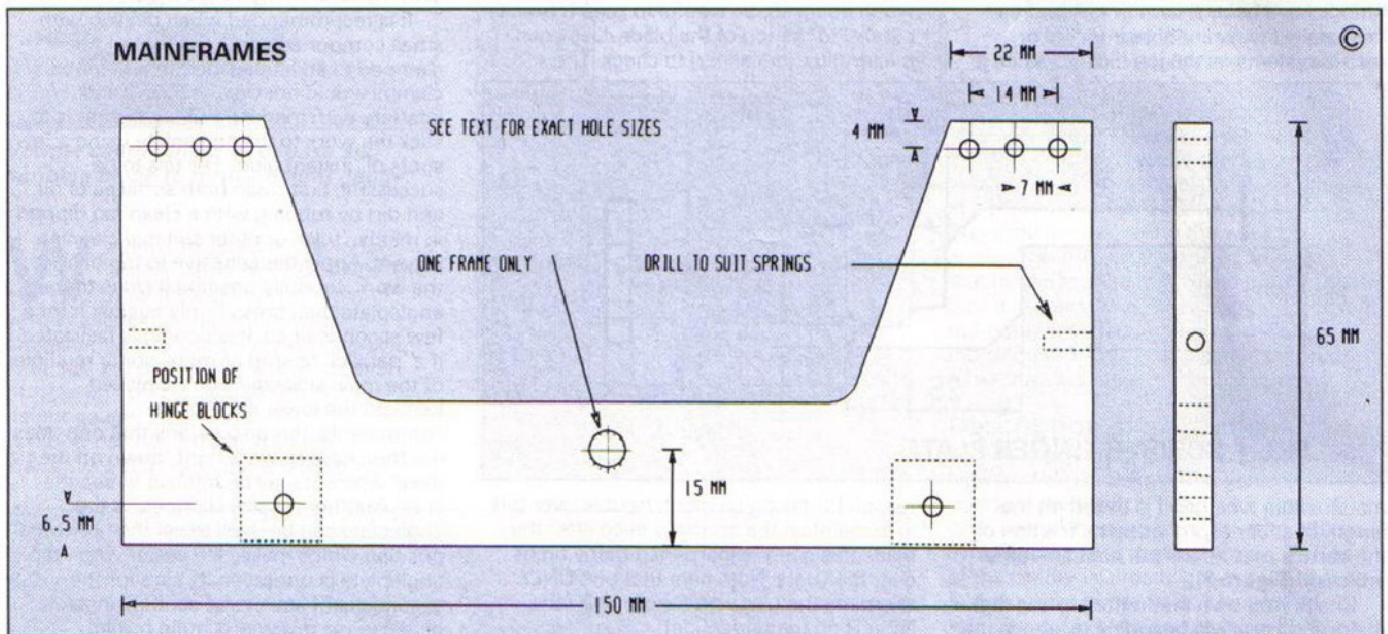


FIG. 3

## MAINFRAMES



A depth tool is a device that enables its user to determine and mark out the precise separation of two spindles on which two meshing gears are mounted. In clockmaking the depth tool reduces the reliance that has to be put on calculated dimensions and gives the lowest friction rolling action that is required in such low-power devices. In making or repairing clocks, the depth tool also facilitates the examination of escapements the pallet/pallet wheel action being much easier to observe without the clock plates obscuring the line of sight. Although historically a clockmaker's device, a depth tool will facilitate the work of any workshop which is involved with the use of small gears and mechanisms.

The traditional pattern of depth tool is still available but, at the time of construction of the prototype, was listed at roughly half the cost of the basic Unimat 3 lathe, which seemed excessive. It was therefore decided to attempt to construct a similar device. All the machining was done using the Unimat 3 lathe and vertical drill-mill attachment which were the author's machine tools at that time.

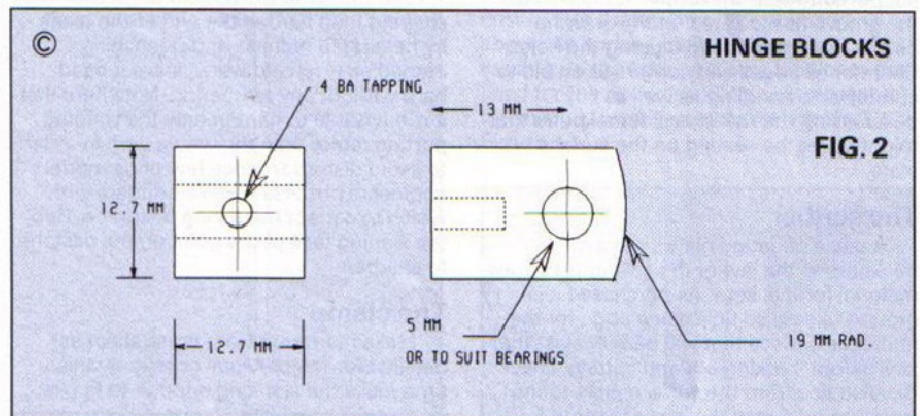


FIG. 2

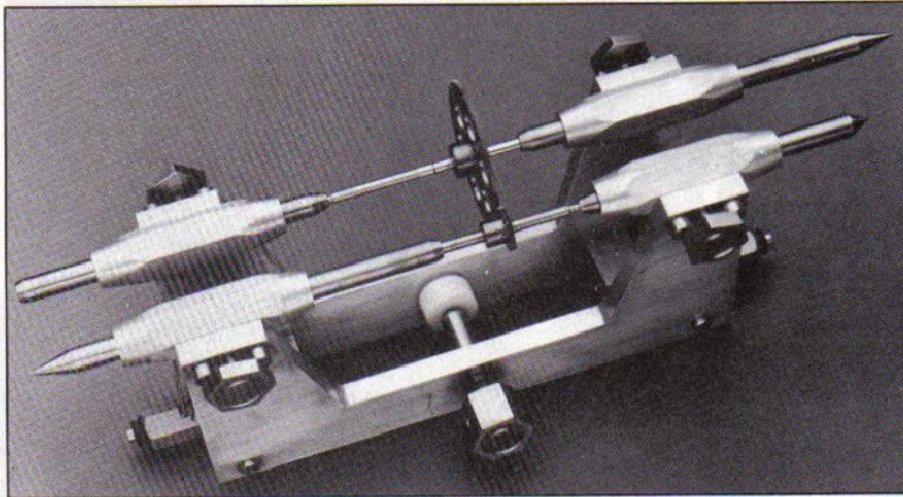
The ancients constructed their depth tools from two substantial brass castings hinged together like a butterfly. The tool described (Photo A) is largely fabricated from light alloy sections. This has the advantage that the finished weight of the tool is about 500g (18 oz) rather than three times this weight if brass were used. The basic requirements of construction are rigidity and accurate fitting of the components to avoid play and to ensure

the parallelism of the two sets of runners and hinge pins. The tool as described is suitable for 'clock work' and allows a maximum size 80mm diameter wheel to be spun and meshed with a 20mm diameter pinion, the smallest diameters that can be handled would together total about 25mm. If a larger capacity is needed, the mainframes can be made taller or to a limited extent slotted in the manner of a gap bed lathe, too large an increase will



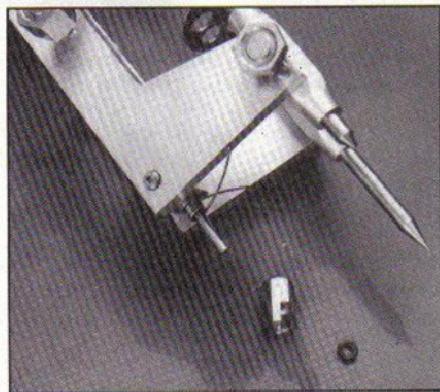
# CLOCK DEPTHING TOOL

John Jennings of St Albans provides us with this clock depting tool. It is not without uses in areas other than clock making and repair, so do read on, as you may find uses for it even if this is not your normal activity



A general view of the completed depting tool (Photo 1).

make the device too unwieldy for general use. Watch, carriage clock or N gauge enthusiasts might consider making a scaled down 'half size' or smaller tool. The author sees no problem in doing this but would suggest that the thicknesses and diameters of materials are scaled down rather less than the overall dimensions. Brass might be more suitable for a really small adaptation — use a hard leaded brass for the frames.



Close-up showing torsion spring and cover.

## Construction

Constructors should feel confident that small changes to accommodate materials that are to hand or readily available should lead to no problems, providing rigidity is not sacrificed. Dimensions are generally metric unless imperial material is used. Drawings are dimensioned in mm.

Construction should begin with the mainframes (Figure 1) which were cut from 1/4 in. thick 65mm wide alloy strip, check that the material is straight along its length and not twisted, propeller fashion, and reselect if necessary. The author's material was slightly but uniformly bowed across the width, no attempt was made to flatten it; but the frames were arranged to bow outwards when assembled. Hard plate material, if you can find a source, is likely to

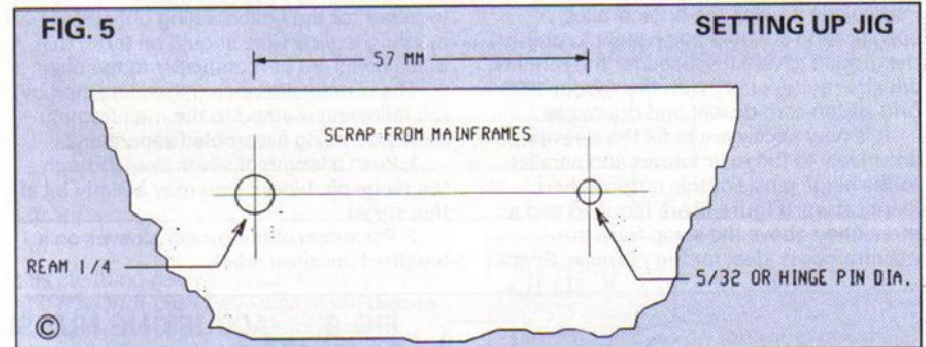
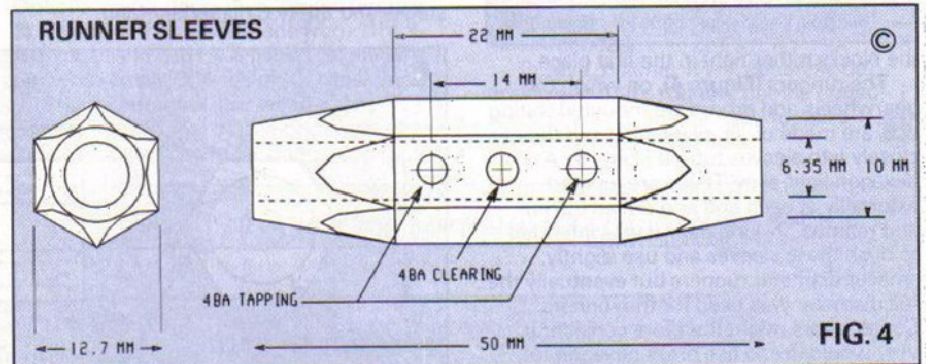
be flatter and may be worth the extra cutting and fettling involved. Cut the frames out with hacksaw, coping saw, bandsaw as available. The large pieces cut out to form

dimensions are involved. If using plate, you will need to ensure that the bottom edges are true enough to act as references for marking out etc.

Mark out and drill, 2.9mm or No. 33, the holes for the runner sleeves. The two outside holes of each group of three will be opened out at a later stage to 4BA clearing size.

The next job is the hinge blocks. Cut two 40mm lengths of 1/4 in. square light alloy, grip symmetrically in the four-jaw chuck with all four jaws in contact with the long sides to leave the ends clear (Figure 3). Pack out from the chuck face if necessary to provide clearance. Skim off the ends to about 19mm radius (or until the sawmarks are removed). The blocks are then cut into equal halves — using a slitting saw gives a good finish with a minimum waste of material.

Measure the rough blocks and then, taking the shortest first, grip each of the four resulting blocks endwise in the four-jaw chuck and turned to length. With a four-jaw independent chuck the easiest method of centring the square bar is to initially centre a short length of 1/4 in. round bar then replacing this with the square bar. All four blocks should be the same length, so either machine all at the same setting or note the slide settings so that you can



the yokes are required for later use and should if possible be removed substantially in one piece. The rough blanks were then finished to size using a small-end mill in the vertical mill attachment, clamping the frames to the milling table as required — use packing underneath to provide clearance for the endmill — plywood will suffice. The Unimat mill coped well with this although the motor ran very hot as usual on protracted jobs. In the absence of milling facilities, careful filing would be perfectly adequate as no critical

replicate the machining process. After facing the end of each block, centre drill and then drill 2.9mm or No. 33, finally tap 4 BA.

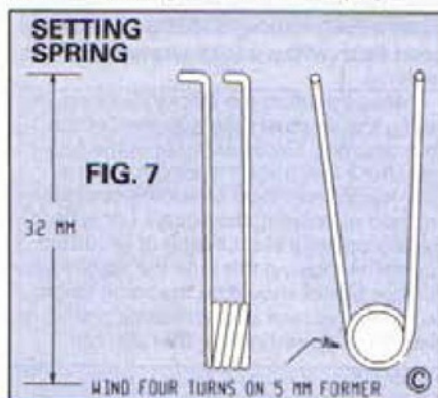
Mark off and crossdrill for the hinge pins. The marking out is most easily done with a small surface gauge and a surface plate (or substitute such as plate glass).

If plain 'bearings' are used, drill through the blocks 5mm or 1/4 in. or a little smaller and ream to size. The author had available some small flanged bronze bushes which were a press fit into 6mm holes. The blocks



were drilled to this dimension, and after fitting the bushes they were reamed through  $\frac{1}{16}$  in. for the hinge pins.

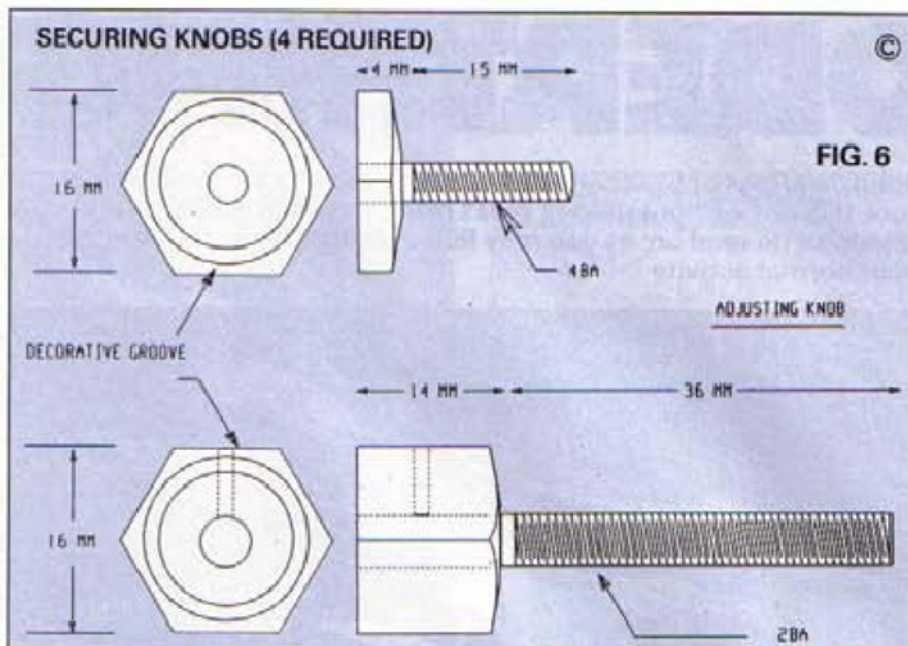
Mark out and drill, 3.6mm or No. 27, the holes to mount the hinge blocks in the front mainframe (these are the outside parts of the hinge). Assemble all four hinge blocks on a length of silver steel of diameter to fit the bore of the hinge block —  $\frac{1}{16}$  in. in the case of the bushed version. Space each pair with a brass or bronze washer if using the plain bearing option. Fasten the two outside blocks to the front mainframe using 10mm x 4BA cap screws. Carefully mark out the positions for the mounting holes in the back frame and drill, you may prefer to do this in two stages. On fastening the second pair of blocks to the back frame, a firm but free moving hinge should be obtained. The endplay can be adjusted by either reducing the spacing washer thickness or bush flanges on one of the hinge blocks or by shimming, the former is preferable, so try to make the endplay of



the blocks rather tight in the first place.

The runners (Figure 4), on which the gearwheels and arbors are mounted during use, are made of  $\frac{1}{16}$  in. silver steel and they fit closely into sleeves turned from  $\frac{1}{16}$  in. A/F hexagon light alloy. These are tapered externally at each end and drilled 6.3mm and reamed  $\frac{1}{16}$  in. Originally it was intended to bush these sleeves and use slightly smaller diameter runners but eventually the full diameter was used for the runners. Constructors might therefore consider if they would like to use brass hexagon to provide a harder bearing surface. Particularly if using the original alloy specification it would be prudent to polish the ground silver steel used for the runners, which is quite rough, with fine (about 1000 grit) silicon carbide wet and dry paper.

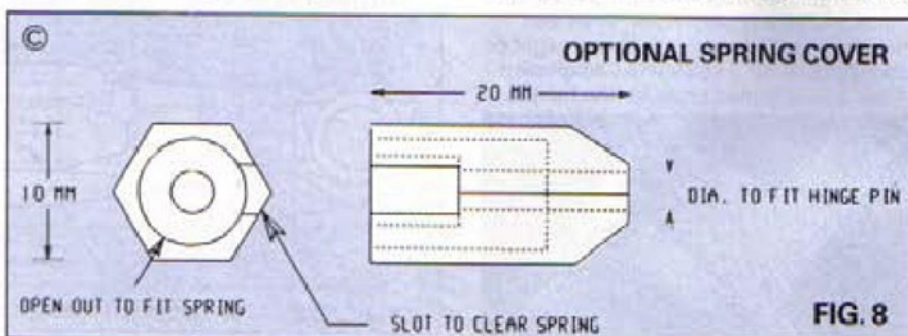
It is now necessary to fix the sleeves accurately to the mainframes and parallel to the hinge pins. For this purpose two identical jigs (Figure 5) are required and as mentioned above the scrap from the mainframes is ideal for the purpose. Scribe



a line down the approximate centre of each piece and mark off and carefully pip two centres 57mm apart. This is the distance between the centre lines of the hinge pins and of the runners. If you have altered any sizes, you will need to check this dimension which should sit the hexagon sleeves neatly at the top of the mainframes. The two plates are then carefully drilled and reamed: one hole  $\frac{1}{16}$  in. (or the hinge pin diameter) the other  $\frac{1}{16}$  in. (or the runner diameter). The drilling should be done in stages and the two plates clamped

3. Thread the two lengths of silver steel through the appropriate holes in the jig plates, one at each end of the main frames. The two lengths of silver steel are now parallel and therefore the bores of the runner sleeves are also parallel.

4. Align the two runner sleeves with the mainframe and clamp them to the mainframe with toolmakers' clamps or miniature G clamps. This will obscure the centre hole of the three but leave the outer holes accessible for drilling through 4BA tapping (2.9mm). Before drilling, check that



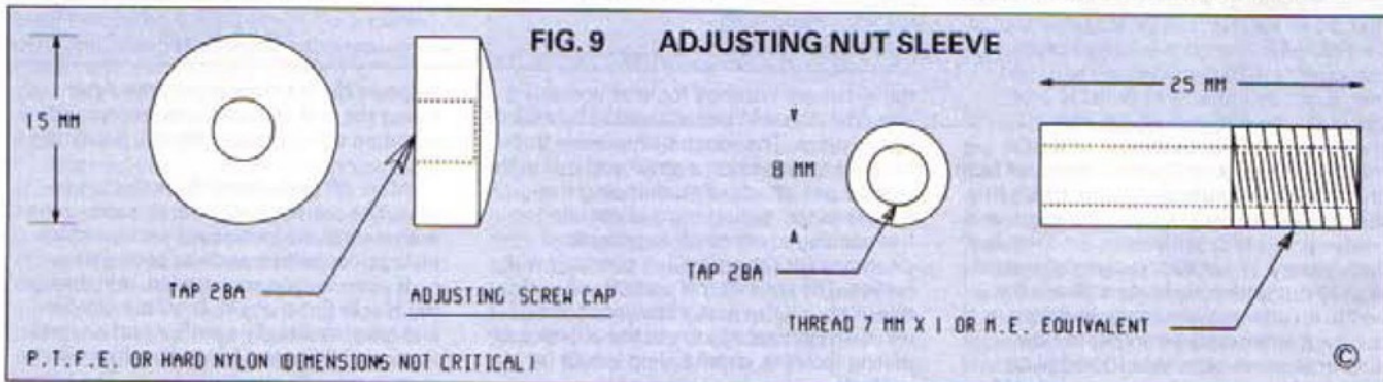
together for the final opening out and reaming to size. Care should be taken that these holes are perpendicular to the plate.

The runner sleeves are then attached by the following method to the mainframes, each side being assembled separately:

1. Push a length of silver steel through the hinge pin blocks (you may already be at this stage).
2. Place two of the runner sleeves on a length of  $\frac{1}{16}$  in. silver steel.

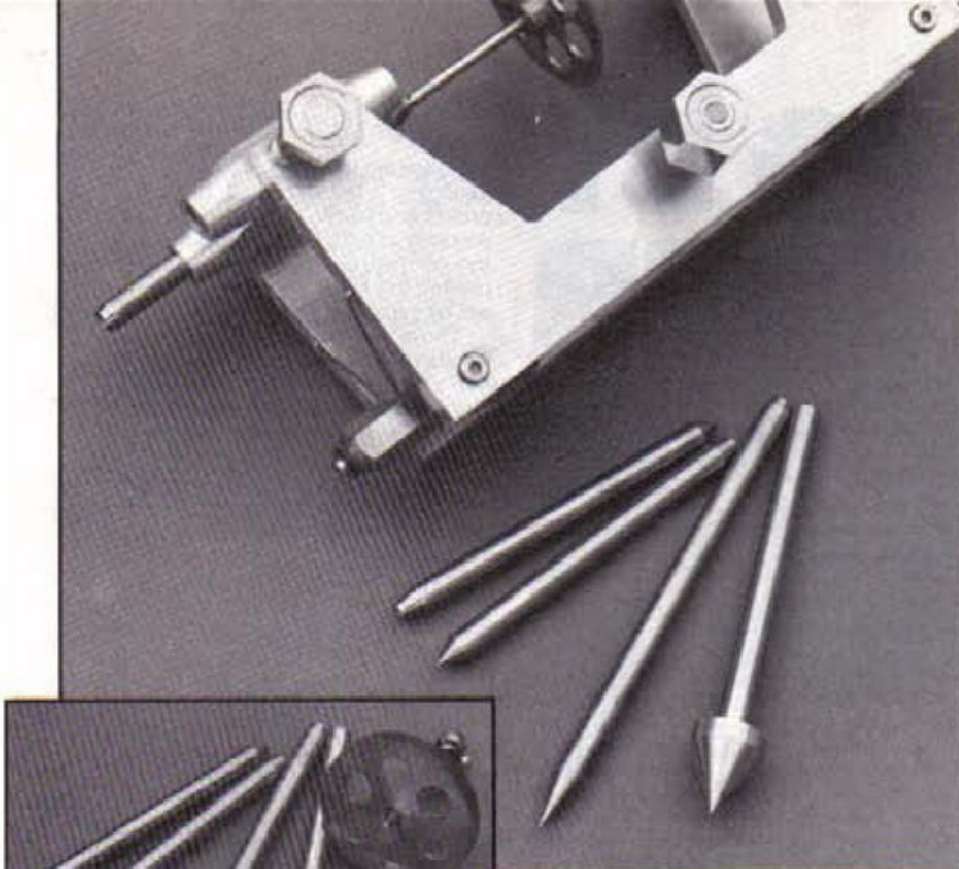
the  $\frac{1}{16}$  in. silver steel is reasonably free, if it has jammed, undo the clamp and rotate the sleeve so that another face of the hexagon abuts the mainframe and try again.

After drilling the tapping holes in the sleeves, dismantle and tap the holes in the frames to 4 BA clearing (3.6mm) and assemble with 4 BA cap head screws instead of clamps. Spot through the centre holes and on dismantling, open out the



P.T.F.E. OR HARD NYLON (DIMENSIONS NOT CRITICAL)





**A selection of runners.**

The springs pivot about the hinge pins and the open ends fit into 2mm holes drilled into the ends of the mainframes. Drill these holes to suit the spring, which are difficult to make exactly to size. Optional, semi-decorative, covers (Figure 8) for the springs were made from 11mm A/F brass and can be retained on the hinge pins with small 'O' rings or 'C' clips.

The mainframes are forced apart, against the springs, by a short length of 2 BA studding (Photo C). Direct tapping for

centre holes in the sleeves to 4 BA clearance and tap the central holes in the frames 4 BA.

Repeat these procedures for the other mainframe and finally reassemble using the jig plates to assist alignment. At this stage the 1/2 in. silver steel should slide smoothly but firmly in the sleeves.

To secure the position of the runners in their sleeves, four thumbscrew (Figure 6) are required. These were made from 5mm slices of 16mm A/F brass hexagon (use what material is available) fitted with brass pins threaded 4 BA. To machine the front and backs of the heads of these thumbscrews a short length of 1/2 in. brass should be turned down and threaded 4 BA to form a simple mandrel and the previously drilled and tapped blanks mounted in turn, the decorative groove was machined using a small round-nosed tool. After fitting the 4 BA spindles, securing them with Loctite or superglue, the external faces and protruding studs can be skimmed and it will be difficult to detect that these items have been fabricated.

The relative position of the two mainframes which determines the separation of the runners is altered by pushing against the action of a spring. Traditionally this is a shaped piece of clock spring, probably because this was a ready source of quality spring steel. In the present design two wishbone springs similar to safety pins are used as shown in Figure 7. They are wound cold from 20g piano wire, personal preference may be for a firmer action and 18g may be tried. As will be seen in Photo B these spring were assembled in a cross arms position that was found to give the best action in use.

than adhesive.

The inner end that pushes against the rear frame is fitted with a plastic cap. PTFE is ideal but any machinable plastic will be OK here.

## Runners

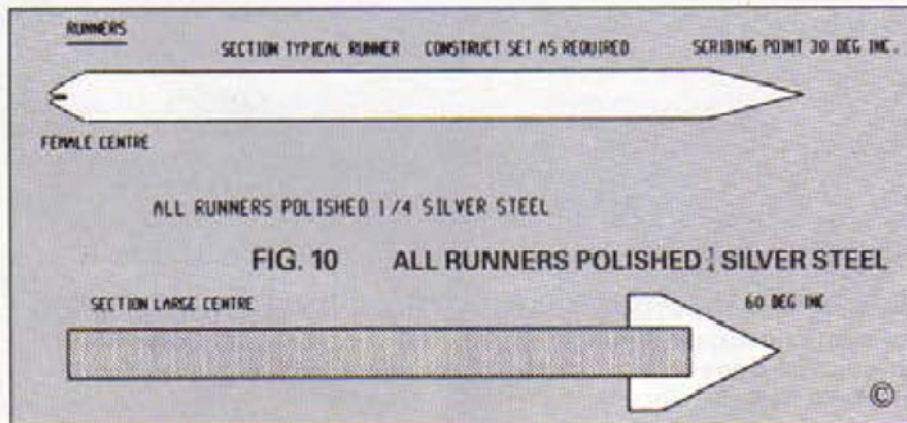
The runners to support the gears for depthing are made of lengths of silver steel, the more modern free machining variety being ideal. Double ended runners (Photo D) should be 80-100mm in length. A selection is shown in the photo. Individuals will have to decide what they require and choose from:

**External cone runners** for unmounted gears or gears mounted on hollow or centre drilled arbors, **Internal cone runners** for gears mounted on plain or coned arbors, **Scribing runners** to transfer the arbor separation determined by the depthing tool to be transferred to a workpiece. A 30 deg. included angle is required. **Centre runners** to use with a scribing runner when there is an existing hole in the workpiece. These runners may be larger in diameter than the runner itself.

To make runners, a collet chuck is ideal or a carefully used independent chuck. For external tapers the tool height needs careful adjustment. For later internal cones, use a suitable centre drill. For small cones, drill a fine hole and then form the cone with a small cone chaped 'D' bit. Large centre runners should be fabricated as shown in Figure 10.

Unless very heavy use is intended, it is probably only necessary to harden the scribing points. As noted above, polishing the ground surface of the silver steel is recommended.

To save material, it will generally be possible to make runners double ended and you will in general need to make pairs of the coned runners.



this studding gave an unsatisfactory action and a short brass sleeve was made (figure 9). This is threaded for a short length externally 7mm x 1mm and drilled and tapped 2 BA internally. Equivalent M.E. fine threads would probably be more suitable for this item. The thread in the mainframe is angled at about 10 degrees downwards which gives a bigger smooth working arc. The easiest way to drill this is to use a three flute end mill (i.e. the type that doesn't leave a centre pip).

The outer end of the studding is provided with a control knob similar to the four runner knobs but some 15mm in length. To allow for dismantling, this is fastened with a 6 BA grub screw rather

## QUICK TIP

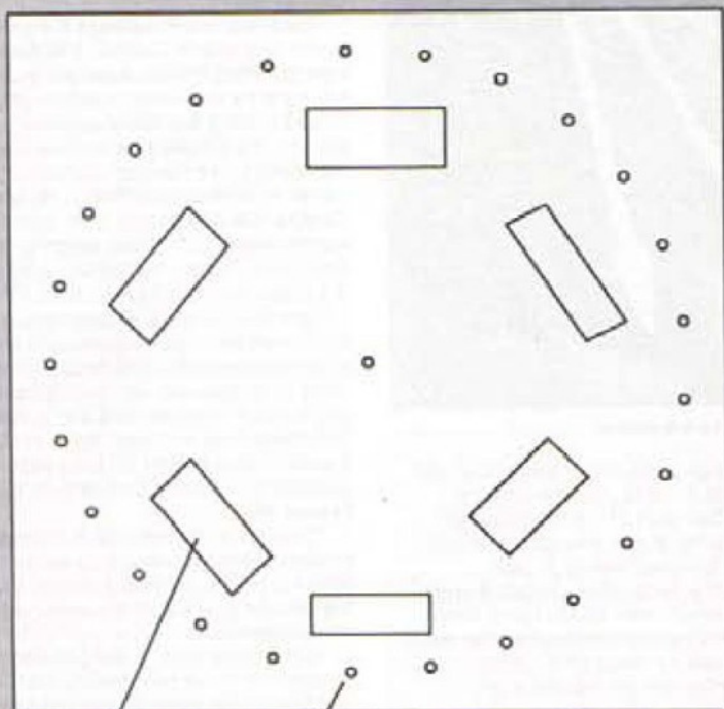
The tilting tables on some economy drilling machines have only an adhesive paper label to calibrate the angle which is not very accurate. To set up the table reasonably accurately in the horizontal position, bend a piece of heavy gauge wire into a 'Z' shape, place one leg in the machine chuck and rotate, then adjust table until the other end is the same distance from the table on both sides of the table. Use a feeler gauge or similar to check the gap.

David Salter



# DIVIDING BY COMPUTER

## TEMPLATE



SLOTS CUT TO ENABLE PLOTTED SHEET TO BE FIXED TO PLATE USING ADHESIVE TAPE.

ARRAY OF SMALL CIRCLES PLOTTED BY COMPUTER.

SHEET OF PAPER

**Dividing plates are not the easiest of items to make, particularly if for some unusual number of divisions. This article suggests how this can be done with a little help from modern technology (and maybe a friend)**

If you have access to a computer-aided drawing system or maybe a friend who has, or even a friend of a friend who has, then you may have the answer to producing dividing plates from two to many hundreds of divisions.

Requiring a division of 125 and not being able to achieve this with a single lathe change wheel, led me to consider a facility available on the CAD system that I was closely associated with.

Knowing that the system was able to repeat an item a number of times on a given pitch circle diameter, I decided to raise the question regarding its capability. What I did not know, and it came as quite a shock was the range that this facility covered, the simplicity and therefore speed

with which it could be instructed, and also the accuracy of the final result.

To produce a dividing plate paper template, all that is required is to create on the computer screen a small circle to represent the centre of the dividing plate, and a further small circle at the correct radius to represent one of the holes of the dividing plate, following this by instructing the system of the number of pitches required by entering the number into the correct entry box, and then returning to the screen to indicate which of the two circles first drawn represents the centre and which represents the hole on the periphery.

The computer will then quickly work out the co-ordinates for all the holes and draw the complete dividing plate image on the

screen, also storing the co-ordinates in the memory.

Following this, the information generated is fed to a plotter or a laser printer, and will be drawn out with an accuracy of within two or three thou though there are some factors which may prevent this being achieved fully and this will be expanded upon later.

Those who may feel uneasy (and rightly so) about having work carried out on a firm's computer and in a firm's time may be surprised to learn that this whole procedure will be completed in less than five minutes, maybe a little more if it is a very slow system or you are requesting, say, 500 divisions. Therefore it's something that can easily be carried out during the lunch break or some other natural break!

For accuracy, the plot is best carried out on drawing film as this is more stable and will not alter with changes in temperature or, more important, changes in humidity. If the holes are far enough apart, this may be satisfactory though if they are, say, only  $\frac{1}{2}$  inch apart, the plastic film can create problems and a plot on paper will be preferable. This will be explained later in this article.

Having explained the computer provision, we now come to the method of producing the dividing plate from this. Take the plotted sheet and cut some holes using a sharp knife inside the ring of circles taking care not to crease the sheet, and by placing adhesive tape over these holes, fix the plot to the plate from which the dividing plate is to be made. As the material — either film or paper — is transparent, the centre mark can be lined up with the centre of the plate if this is already drilled, otherwise this can also be transferred from the paper template.

Now take a centre punch and, taking each circle in turn, centre punch each one lightly. If the distance between each hole is small, it will be possible to view the result to see if any are out of position, in which case the centre punch mark can be encouraged to move by holding the punch at an angle and tapping it again until the result appears satisfactory. If the holes are a greater distance apart, any error will be less evident.

When confident regarding the result, return to each mark in turn and make the centre punch marks more substantial to give the drill the best possible chance of picking up in the correct position. In this respect also, use a small diameter drill that will not be rigid enough to go its own way if it is not lined up perfectly when drilling.

The distance apart also has a bearing on the material used for the plot. Plastic film does not puncture so easily but tends to stretch, as a result if the holes are close, this stretching prevents the material lying flat for the adjacent hole, and this makes it less easy to determine the position for the centre punch. In this case, plots on paper would be preferable.

As a rough guide, dividing plates with holes closer than  $\frac{1}{2}$  inch should be plotted on paper, though of course it is easy to test a small scrap of both materials to establish the best to use, bearing in mind that plastic film is more stable and therefore preferable if it can be worked with.

A number of points should be taken note of to improve the accuracy of the final result. The plot should be created with very small circles no greater than 1mm; this will



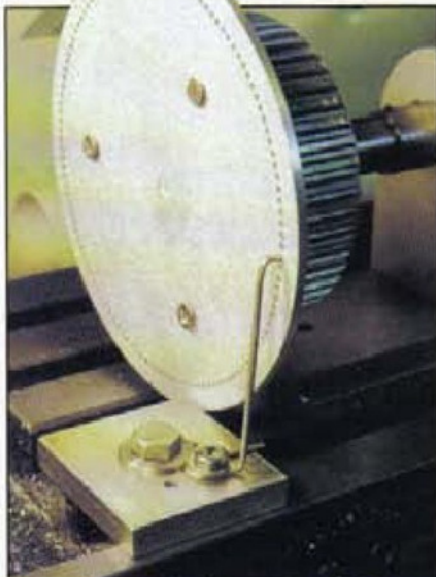
enable the centre of the circle to be located with greater certainty, thus helping to eliminate one cause for error.

Any error created for an individual hole will be an error in co-ordinates and the accuracy that can be achieved will be independent of the size of the dividing plate. Bearing this in mind, take note that, as a result of this, the angular error being the one we are interested in will become progressively less the greater the radius on which the holes are placed. It is therefore preferable to have the holes on as large a radius as possible.

If material is available, it will take only a little longer to drill two plates at the same time, and having done this the two plates can be placed together and one rotated on the other; by this means any rogue hole will soon be located. Placing two close-fitting pins through both plates will assist in inspecting for errors and attempts can then be made to correct any errors found.

The method to do this is to open up the hole to  $\frac{1}{2}$  inch diameter if the pitch of the holes permit this, otherwise as large as can be accommodated. Countersink slightly on each side and rivet in a small plug, make this flush on each side using first a file and then emery paper. Then, using a good section of the second plate, or if a second plate were not made make a segment from a good section of the plate being modified, place close-fitting pins through two holes to locate the second plate onto the first and redrill the hole being corrected.

Two forms of error can exist. The first, and obviously the most important, is an error in the pitch of holes which results in angular errors. These can be corrected as above. Another error which may be found



**The dividing plate in use; note the heavy gauge spring wire plunger, rigid enough to prevent rotation but will allow for any variation in hole position from the centre.**

is an error which exists in the distance between the hole and the centre hole of the dividing plate. In this case, if a rigidly mounted plunger is to be employed, the plunger will not locate in this hole correctly, and errors result. These holes will also require to be corrected as above.

A conventional spring-loaded plunger which will accommodate this error is not that easy to make, but by using a robust

piece of spring wire, and with its end ground to a taper to locate in the divider plate holes, this will accommodate for errors in radius but if mounted at right angles to the radius will not permit any rotational movement. This is best seen in the photograph with this article; if this method is adopted, then errors in radius can be left as they are.

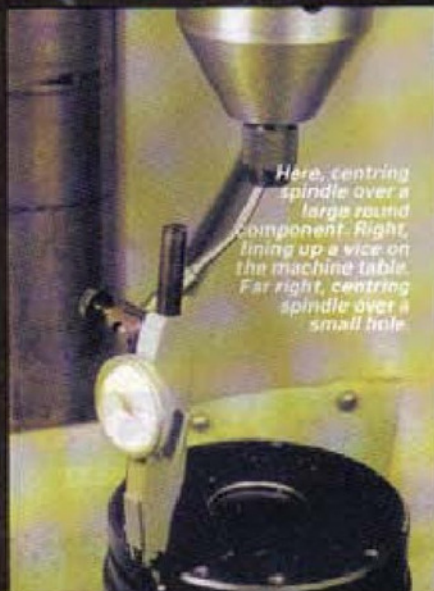
Since carrying out this exercise I have obtained my own bottom-of-the-range PC and a relatively cheap drawing package. I find that I have this facility, even on this, and it is as quick; the only limitation is the accuracy of the dot matrix printer, but even here by making two plots and using the same technique for checking accuracy suggested above, very acceptable results have been possible.

It is also worth considering that if a number of randomly positioned holes need to be accurately placed on a metal plate, then whilst each will have to be positioned separately (and it will therefore be slower to input the information to the computer), this still may be useful in positioning the holes. My cheap drawing package can position to an accuracy of seven significant figures though of course no plotter will match this.

Another computer facility that may also be of use is its ability to automatically position holes in a straight line, no matter how complex the pitch is.

Whilst this method may not suffice for all applications, it is certainly worth considering when a project requires a division which is not readily available by any other means. With care and using the two plate method to spot errors, it should be adequate for all applications other than maybe high-speed gearing.

## DTI CARRIER



Here, centring spindle over a large round component. Right, lining up a vice on the machine table. Far right, centring spindle over a small hole.

### Clarification of an item illustrated in our last issue but not described

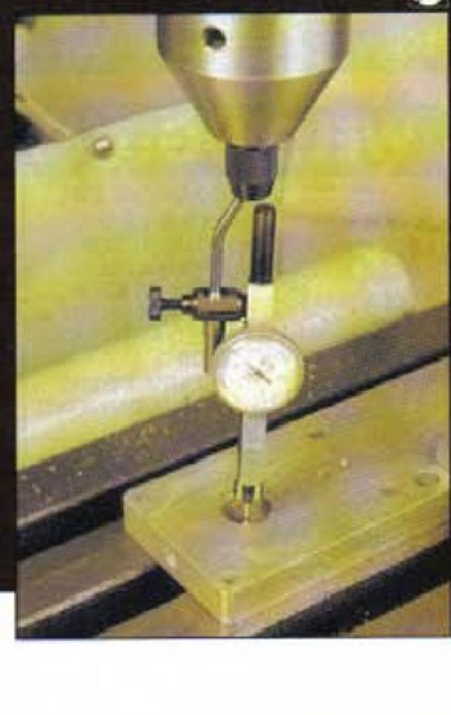
was that it is not actually for edge finding, which was the subject of the article.

In briefest terms, its purpose is as a dial test indicator carrier, the ball joint enabling the indicator to be moved easily into the best position. This is particularly important,

when being used to centre the machine spindle over a hole, or similarly, the outside of a circular component. The ball joint will allow the test to be carried out over a wide range of diameters.

Even where precise adjustment of the dial indicator test position is not a requirement, such as when testing an angle plate or a vice to see that they have been set parallel to the table axis, the device can still be useful just as a means of holding the indicator to enable the tests to be carried out.

No further explanation is required as the photographs with these brief details best indicate the methods of using this dial test indicator carrier.



In the last issue, an article relating to edge finding showed in the photograph a typical wiggler set, a fourth item which was not discussed in the test, the item in question being the bent part shown on the left of the group (page 22).

In view of a query from a reader asking the purpose of this item a brief explanation is given here. The reason for its omission





Upper picture shows finished item in action; lower picture shows base being faced for 90 degree accuracy.

# AN ECONOMIC ANGLE PLATE

After reading the article in *Model Engineers Workshop*, Winter 1990/91 on the Keats angle plate, I wondered if other readers would be interested in my version. As can be seen from the photos, it is fabricated from mild steel, and was originally made, many years ago, to suit my old treadle operated Mines lathe.

In use, the plate is set to run true in the usual way, then the strip of steel seen bolted to the faceplate on the right (photo 1) is pressed close up to the side of the angle plate and tightened. The round post seen beneath is set by using a suitable packing or slip gauge to the required offset.

The angle plate can then be loosened and slid down to the post, and returned to run true, or even removed from the lathe, as many times as is required, with a good degree of accuracy.

## Construction

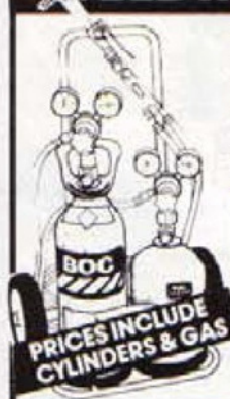
To construct the plate, first get a piece of angle to whatever size suits your needs but slightly longer, then make up the simple U bolt and bridge piece. Next put any old piece of bar (within the capacity of the angle) in the lathe, protruding slightly more than the length of angle, support with the tailstock and take a light skim off the diameter to true up. Clamp the piece of angle onto this mandrel, overhanging the end, using its own U bolt and face the end off. This ensures that the end is square to the inside faces of the V, repeat with the other end. From a suitable piece of mild steel make the backplate. One side and the bottom should be filed or milled straight and preferably square to each other. Drill or slot to faceplate requirements.

The two components can now hold together with a large C clamp and either welded or brazed. To finish off, once again place a piece of bar in the chuck, this time slightly shorter than the length of angle, and skim true on diameter. Clamp the angle plate to it as shown in photo 2 and face off to make sure that any distortion from welding is removed and that the rear bolting face is true to the inside of the V.

In this article we offer an easily fabricated Keats Angle Plate by H.M. Turnbull of Sheffield; the design should prove easily adaptable for any size of lathe



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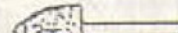
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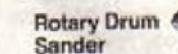
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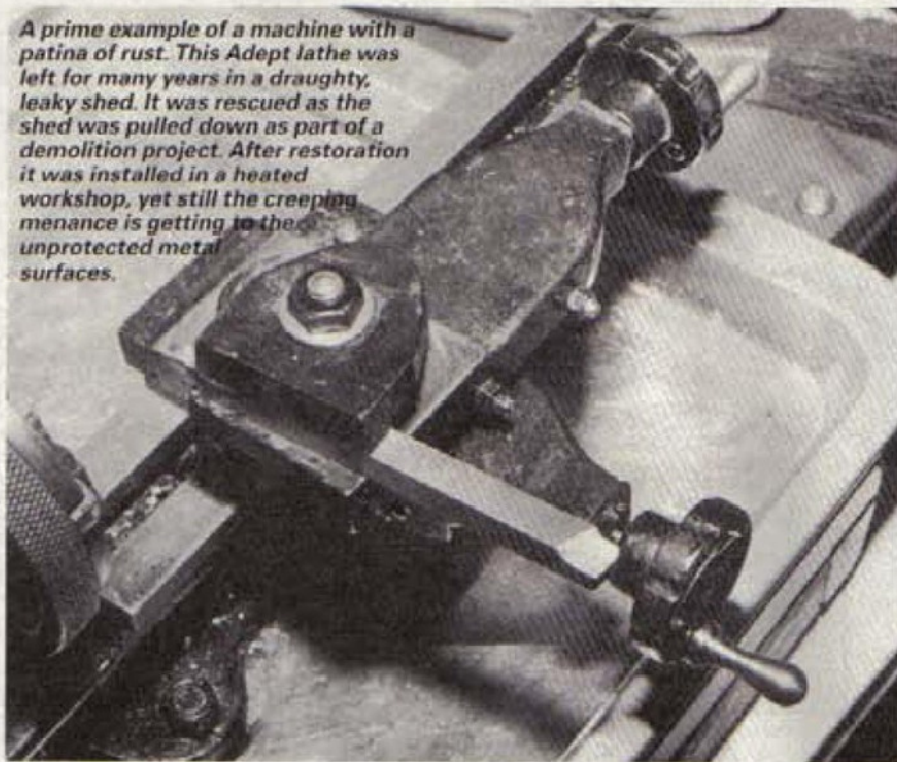


**W**e will all have, at some time or another, been disappointed to find rust developing on one of our more important machine tools, and whilst it is slight no real harm will have been done. In fact, we are told that a very slight dulling of the surface will help to prevent more serious rust at a later date! Despite this fact we are still reluctant to see our new machine surfaces losing that new appearance.

Differing experiences in a number of workshops has led me to investigate the matter more thoroughly, and come up with some conclusions and some answers. We understand that if we leave an article out in the rain it will start to go rusty very quickly, but why in our dry workshop will we leave an item just one weekend only to find it going rusty when we return again the next weekend?

The answer, as we know, is condensation, but where does this moisture come from, and why do some people have more problems than others? The simple answer is that, at some time during our absence, colder metalwork has been in contact with warmer air, extracts the moisture from it and this moisture naturally then rests on the cold surface. Being cold the moisture will remain there

*A prime example of a machine with a patina of rust. This Adept lathe was left for many years in a draughty, leaky shed. It was rescued as the shed was pulled down as part of a demolition project. After restoration it was installed in a heated workshop, yet still the creeping menace is getting to the unprotected metal surfaces.*



# KEEPING RUST AT BAY

until the surface starts to go rusty. For the technically minded we will give a little more detail at the end of the article.

The simple answer to this problem would be to avoid this temperature difference by continually maintaining a constant and reasonably high temperature, say sixty degrees. For most, this temperature would be prohibitively expensive and some compromise must be arrived at.

My experience based on the last three workshops I have had has thrown some light onto the subject.

## Workshop one

From the first, the workshop was unheated and other than taking care to see that metalwork was kept lightly oiled no real problem was experienced.

## Workshop two

I then moved to an area that was known to be very damp – a fact that was evident inside the home. It was at this point that I started to experience severe problems (I should add that all three workshops have been wooden sheds.)

Believing that heating would help to minimize the problem it was decided to insulate the workshop using insulation board, the cavity filled with fibre-glass matting, including the roof area and then to install background heating.

A temperature of about 45 deg. F minimum was maintained and this almost cured the problem totally, being considered a very satisfactory situation.

## Workshop three

On moving to a new area and one which was considered to be a relatively dry situation, I set up my workshop in a similar manner complete with insulation and background heating. It then came as a great

Many of us spend a lot of time protecting our workshop tools and equipment against rust. Here we examine in depth some of the causes of this enemy of the workshop, taking the view that if one knows why a problem is occurring it may be easy to solve it

surprise to me when I began to experience severe condensation and accompanying rust!

This situation did not conform to my simple understanding of the reasons for condensation and caused me to consider the facts in more detail. As I understood it, condensation was caused by a temperature difference between the air temperature and the metal temperature, and also by the amount of moisture being carried in the air.

The area was, without doubt, less damp than the previous site and I was maintaining the same minimum temperature, so why the increase in condensation and then only on some days and without apparent reason?

## CONDENSATION – WHY?

This led me to question why the difference in temperature occurred, which did not seem difficult to explain. As the air temperature in the workshop rises during the earlier part of the day, the temperature of the metalwork will follow but will lag behind. Then, as the air cools during the latter part of the day, the various items will be above air temperature as they attempt to follow the changing air temperature. When the air stabilizes at its lowest value sometime during the night, the machines will continue to drop in temperature until they eventually also arrive at or near this value. All during this time the metalwork has been above air temperature and this explains why no condensation occurs

during the night.

As the air commences to rise in temperature during the day the same process will occur, again with the metalwork lagging behind the value for the air, but this time with the metalwork at a lower temperature than the surrounding air, this being one of the conditions for the creation of condensation.

The amount by which the metalwork lags behind will depend on a number of factors which it was considered (in error at the time) to be those of shape, position and size. By far the most important of these is size; the larger and bulky items will respond more slowly to the changes and as a result have the larger temperature differences.

This explains why the larger items will frequently suffer more than smaller items and to counteract this the machine tools are frequently left with a film of oil and, as a result, have added protection.

In my case I have most trouble with items such as large angle plates which get taken from the machine, wiped clean and returned to the shelf in a clean but largely oil-free state. This highlights a fact that we all take for granted but most, myself included, do not understand the reason for, that is the fact that the condition of the surface also has a marked effect on the production or otherwise of condensation.

Returning now to the question of why the sudden unpredicted increase in condensation when the reverse would have been expected. I seemed no nearer to



understanding the reason for the increase in rust evident in my new workshop.

### The answer!

The answer was found quite unexpectedly one day when I went into the workshop, there finding considerable evidence of condensation, but also an extremely high air temperature. The answer was obvious! Sudden late morning sun, had caused a rapid air temperature rise to which the metalwork could not respond, and a large temperature difference between metalwork and air temperature resulted with the accompanying severe condensation.

The reason for the differences were at last obvious: the current position for my workshop faced into the morning sun whilst my previous position had not.

Following a cold night and then a cloudy morning, leaving the tools still relatively cold, if then the sun quickly broke through, the temperature would rise rapidly, particularly in view of the large window area, and, as the metalwork temperature could not follow this, a large difference would result followed quickly by condensation.

Ideally the workshop should for this reason not be positioned facing the mid-morning sun, though in most cases as in this instance, there is little choice.

The solution to this problem would be either to increase the minimum temperature by raising the setting of the thermostat (this has been done), or alternatively to install a ventilation fan

controlled by a second thermostat set to come on at, say 65 deg., thus limiting the rise in temperature which without this can go as high as 80 deg. even in the winter months. This has not been tried but I am sure it would work providing the fan could move enough air. It would also result in saving money as it would then not be necessary to maintain such a high minimum temperature.

Some slight improvement can be achieved by covering the larger items – lathe, milling machine, etc – with a large cloth, which has the effect of insulating the machine from the changing ambient temperature limiting slightly the drop in machine temperature during the night. But, more important, it also limits the rapid increases that may occur during the day, the machine maintaining a lower temperature under the cover. The benefits from this will be slight but may be worthwhile on the odd occasion.

### Surface treatment

More important will be to keep all tools slightly oiled. Having recently cleaned some small items for photography and then found them showing signs of rust within just a few days confirmed the value of a very slight film of oil.

Most oils will leave the tools with a rather sticky feel and unpleasant to work with, and because of this a special oil for the purpose will be worthwhile investing in.

Contact Duck Oil supplied by DEB Chemicals is an excellent oil for the purpose also having quite good lubricating qualities. At around £15 to £20 for a 5 litre can it will last a long time and can be used for many other purposes, such as on the lawn mower after use to avoid rust and keep it lubricated, or to spray on the car ignition leads to assist starting on a damp morning. For details of where to obtain duck oil locally, contact DEB Group Ltd, Belper, Derbyshire DE5 1JX. Tel: 0773 820051.

A very convenient method of applying Contact Oil is to use a small hand sprayer of the type sold for about a pound at all garden shops or garden centres. The oil has a viscosity not that much heavier than tap water and is very easy to clean off and yet quite long lasting in its effect after it is applied.

To recap, do ensure that the workshop is heated and to maintain a minimum temperature of 45 deg. (though this may need to be increased in areas that are particularly a problem). Insulate the workshop to minimize the cost and, as a result, thus afford a higher minimum value.

Where you have the choice, site the workshop to avoid rapid changes due to sudden bursts of sun, particularly in the earlier part of the day. Keep larger items covered to isolate them from these sudden changes in temperature.

Do keep all surfaces lightly oiled with a special-purpose oil.

### For the technically minded

The published Psychrometric chart with the following brief definitions will be of interest to those with a technically enquiring mind.

#### Dry-bulb temperature

The temperature as measured by a conventional thermometer.

#### Wet-bulb temperature

The temperature as measured by a thermometer with its sensor covered by a damp (distilled water) wick and with air passing over it a minimum of 1000 ft/min. The evaporation results in the thermometer reading a lower temperature, except for the condition where the air is saturated (100% relative humidity). No evaporation can take place and for this condition the wet bulb and dry bulb temperatures are identical.

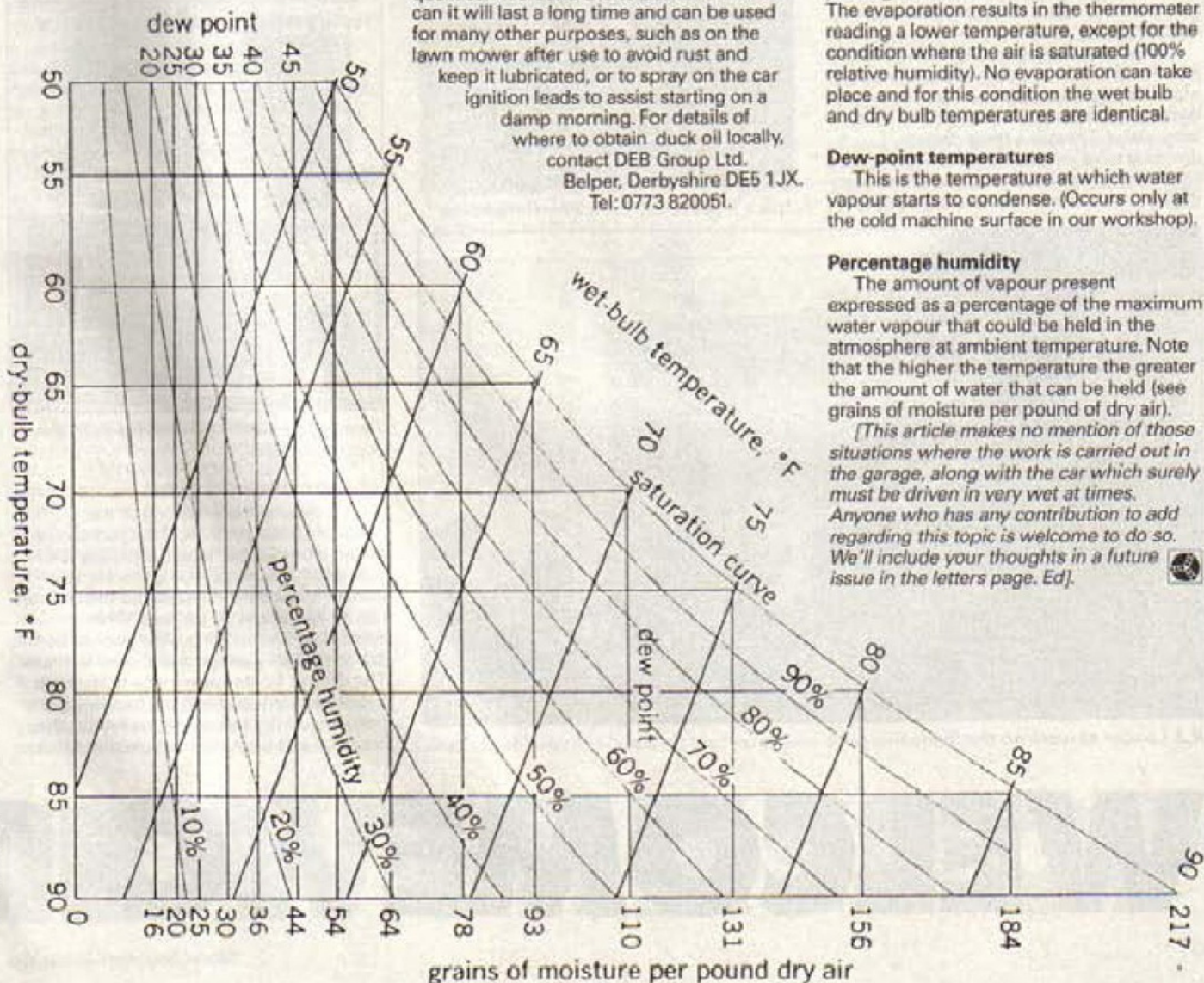
#### Dew-point temperatures

This is the temperature at which water vapour starts to condense. (Occurs only at the cold machine surface in our workshop).

#### Percentage humidity

The amount of vapour present expressed as a percentage of the maximum water vapour that could be held in the atmosphere at ambient temperature. Note that the higher the temperature the greater the amount of water that can be held (see grains of moisture per pound of dry air).

(This article makes no mention of those situations where the work is carried out in the garage, along with the car which surely must be driven in very wet at times. Anyone who has any contribution to add regarding this topic is welcome to do so. We'll include your thoughts in a future issue in the letters page. Ed).





I've only been a model engineer for about 15 years, although my working life has been spent in engineering. Serious model engineering dates from the Model Engineer Exhibition of 1984-85 when my wife bought me a Unimat 3. Since then I have been pleasantly surprised at what can be done with the Unimat and somewhat limited facilities.

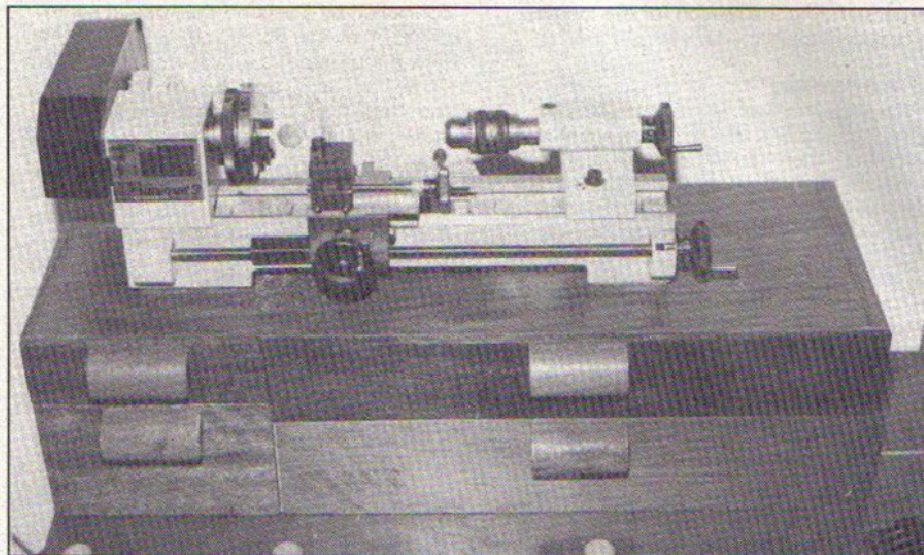
The main problem is space. I have no loft or garage and the shed in the garden is full of all sorts of things, as well as gardening equipment. So I make the best of what I have, which is a working space of about 7ft x 4ft, in a small spare bedroom. I share the room with various odds and ends which have to be stored somewhere, and a tandem.

Some of my larger tools are hung on, or clipped to, pieces of veneered chipboard screwed to the walls. This is an ideal way of storing a lot of things which would be a nuisance in drawers or cupboards, especially if there is a supply of chipboard from redundant room dividers and other examples of modern furniture construction.

### Packing it all in

There are lots of shelves with space for lighter things and my drawing board and instruments and books, some technical, some which have overflowed from the sitting room. There is a cupboard screwed to one of the walls where I can keep things which need somewhere a bit special, like my micrometer, vernier caliper, dial indicator, battery charger and multi-tester, to name a few. There has to be space for my cassette player and the tapes I play most, on one of the shelves where I can reach it easily.

Of the actual equipment which does the job, the Unimate is mounted on a home-made base/cupboard, which stands on a Workmate which is the heavy bench and lathe stand. There is a three drawer dressing table which I have converted into a light bench, a two drawer chest which was the bottom of a wall unit and assorted



*Author's Unimat on its cupboard base.*

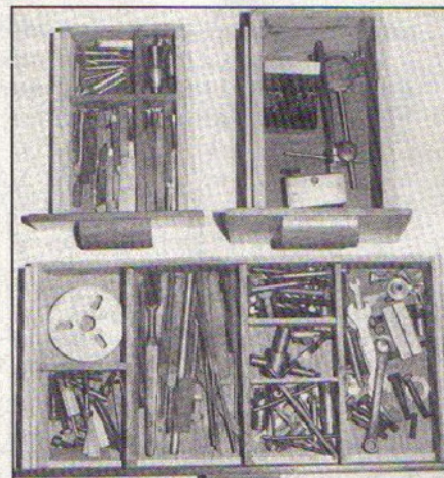
**In this short article by R J Loader he explains how he and his wife cope with an indoor workshop, including also some ideas of general interest to us all**

storage boxes. Among these boxes are a home made toolmaker's chest, two small plastic drawer units and a smaller plastic box designed for fishing tackle or similar small items.

The drawer units are ideal for drills, end mills, reamers, punches, stamps, nuts, bolts, washers, springs and all the other model engineering essentials. Taps and dies and some other special cutters are kept in the fishing tackle box, its variety of compartments make it very convenient for this.

When I used to potter about with the Unimat, all it needed was a thick piece of formica-faced chipboard for a base. When I began to use it in earnest, it needed something more substantial, with storage space if possible. That's when I made the

cupboard/base from plastic veneered chipboard of the standard 15mm thickness. I know that it is only synthetic wood, but it was available and it has several important virtues. It is very stable, easy to cut and join, thick enough to be nice and solid and the plastic finish is quite durable and easy to keep clean.



*Three of the well-filled drawers from the cupboard/base.*

### ...best skimmed over!

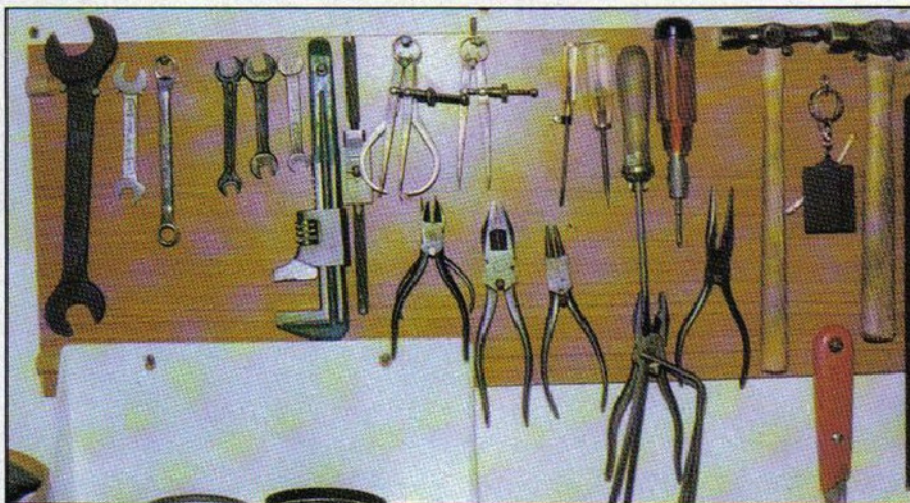
The details of the making of the cupboard/base are best skimmed over; a skilled woodworker would probably turn pale and hurry away. The joints are all butted, screwed and glued and the drawers run on hanging type runners. What I wanted was something which would do the job but which was quick and easy to make. The drawer fronts were made from some better quality wood and the handles came from one of the redundant wall units, they could be just plain wooden pegs or blocks. I



*R.J. Loader at work on the 'bench'.*

# WELCOME TO T





Larger tools hang on the wall in R.J. Loader's mini-workshop.

made a stupid mistake when I made the drawers and made the fronts flush with the frame. I should have made them so that the drawer fronts were *inside* the frame; a constant trickle of swarf into the front sections of the top drawers reminds me!

The photographs show a general view of the cupboard/base and the top drawers and the smaller of the two bottom ones. It gives an idea of what they will hold. The large bottom drawer stores the larger things like the milling/drilling table and vee blocks.

I stood the lathe off the cupboard top by putting 10mm thick pieces of plywood under the headstock, tailstock and the place in the middle where the vee for the pillar is. I did this to give more room to get a cleaning brush in the places where the swarf accumulates. The machine is bolted down by 2½ in. bolts which have their heads sunk into the underside of the base, the counterboring must, of course, be done before the framework is assembled.

When the lathe is on the Workmate it is at the right height for me to operate it sitting down. The only snag is that the 2½ in. vice I use clamped to one end of the Workmate is then too low for heavy filing and sawing. I have to stoop a bit and this goes against all the principles of good filing practice, but you can't win them all. I modify my filing technique to suit. The other problem is vibration which is enough to make objects left on the lathe or the bench vibrate on to the floor.

The most interesting aspect of my situation is that I have to improvise. I haven't any really effective drilling tackle but for a Black and Decker pistol drill and a homemade milling/drilling head for the lathe. The one isn't accurate enough for most things and the other takes up valuable time in the setting up and taking down. I find it more convenient to clamp an angleplate to the cross-slide and drill from the lathe headstock, especially since I made an adaptor to fit a ½ in. capacity chuck to the spindle.

Centre punching and any hammering jobs have to be done on a board on the floor, because even my heavy bench isn't

strong enough to hammer on. The vice is limited too by its size but I can get over that in one way or another; the photograph shows one way. A 3½ in. disc is being worked on by clamping it to a bar held in the vice.

Most of my cutting is done dry and if I do use anything like a smear of oil or grease, I use it sparingly. I have a vacuum cleaner for cleaning up, it is an old one but does a good job.



Improvisation! The job is too big so is clamped to a bar held in the vice 2½ vice.



Some of the storage boxes on the two drawer floor unit.

## Out of sight...

I am very lucky to have a wife who supports and encourages me in my hobby. She knows a fair bit about engineering too and is no mean photographer; she has taken several of the photographs illustrating this article. She is also my proof-reader, illustrations editor and my greatest fan. More than that, she has the endearing trait, among many others, of forgetting that the room I work in exists. This makes life much easier!

There are problems of course, I can get too excited sometimes when doing some heavy filing and have the tandem handlebars nudge me in the back. It is also easy to bang knees, elbows and ankles on things and occasionally I drop something small and have to do a quick Winwoods impression before I can find it. Mostly though, it is a reasonably good set-up for the sort of model engineering I do, which is on the small side or to do with gadgets and things to make life easier for those who, like me, have to work with limited facilities. It is lovely in the winter because there is an efficient radiator but in the summer and better weather, then the whole workshop goes mobile. It is an easy matter to put an extension lead through the window and work outside. There is an area of crazy paving just outside the window and provided that the Workmate is on one of the less crazy bits and doesn't rock about, it is very pleasant to work alfresco. I have made a trolley for taking the lathe and any other heavy stuff so I don't even have to carry anything other than the Workmate.

The moral is: if you have limited room and a small lathe, don't waste time wishing and dreaming for something better. Set to and make the best of what you have. You will be surprised how interesting the challenge is and through the many improvisations which you will have to think of, you will be a better engineer. Anyone can do the job with *all* the tools — it takes someone a bit better to make do with less...



# THE WORKSHOP



It was at a time when I was considering extending my range of hobbies and woodturning was on the list as a possibility, that I came across a catalogue for a company called Craft Supplies. This company specializes in providing a very wide range of machines, tools and materials for the woodturning enthusiast.

This interested me very much and I was surprised to see the range of goodies available for extending the range of items which could be made, beyond what I considered to be the obligatory bowls, plates and tablelamps, and into the area of clocks, thermometers, pens, pencils, table knives and forks, etc.

**Coming up to Christmas we have, in this article, something quite different to our normal workshop equipment items. Included as a possible Christmas present for someone, maybe, it will be specially appreciated as something made by a friend, and this really professional item can be made in a matter of four hours!**

*The complete 'weather station' unit consists of hydrometer, thermometer and barometer.*



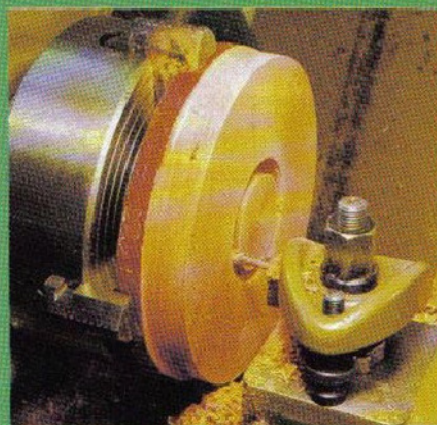
# FAIR WEATHER FR

With this range before me I was very tempted to get started but as there were overriding factors (such as available space) with regard to obtaining a proper woodturning lathe, I decided to at least have a one-off diversion into this activity using my metalwork lathe, and using metal turning methods. At least this wood (sorry) gave me a brief change from my more normal activities!

I decided to go for a weather station containing a thermometer, hygrometer and barometer.

## The design

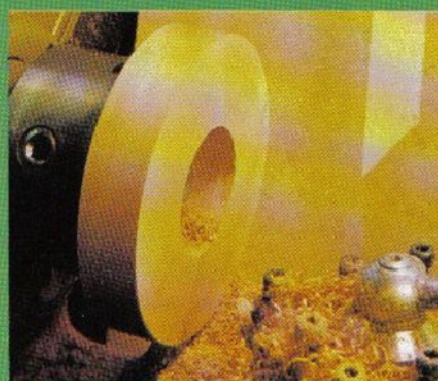
Then came the question of the design. A modern approach was preferred, and as



**Turning a disc, first stage; turn half o.d., face back and cut out centre for centre boss.**

there were three instruments to mount and, since I wished to include some turning, a flat board with some form of trim was out. Also if it were to be one large turned disc then this would be too large to accommodate on my lathe — it would have to be three smaller discs.

With this in mind the possibilities were



**Disc turning with three-jaw chuck gripping inside of bore; counterbore for fixing ring is still to be done.**

explored. There could be three in a line, horizontally or vertically, or in triangular formation. Having already decided that they would be joined together using dowels, the triangular formation was decided upon in what I considered the best way to describe it without drawings as, a dowel between A and B, and dowel between B and C and a dowel between C and A!

## The materials

With this established, the parts were purchased as follows from the following address

|                |                                  |
|----------------|----------------------------------|
| Thermometer    | 70mm dia Cat no. DM702           |
| Hygrometer     | 70mm dia Cat no. DM703           |
| Barometer      | 70mm dia Cat no. DM701           |
| Mahogany discs | 125mm dia<br>Cat no. KT845 3 off |

These are also available 95mm dia when 150mm discs would be required. These instruments are at the cheaper end of the range and many others are available from: Craft Supplies Ltd., The Mill, Millers Dale, Nr Buxton, Derbyshire SK17 8SN (Tel 0298

871636).

Other companies which supply this type of instrument but not the wood and are predominantly suppliers of materials and tools for Horological and Jewellery activities, are: H. S. Walsh and Sons Ltd, Beckingham (081 778 7061) and A. G. Thomas (Bradford) Ltd (0274 497171).

## Manufacture

Some readers may have access to a woodworking lathe and therefore will not be troubled with the discs being contaminated with oil, but for those using a metalworking lathe the first operation will be to remove all traces of oil from the external surfaces. I am sure that there will be some who will be very reluctant to do this, particularly in view of some types of wood being considered to encourage rust.

This reluctance I can understand but as

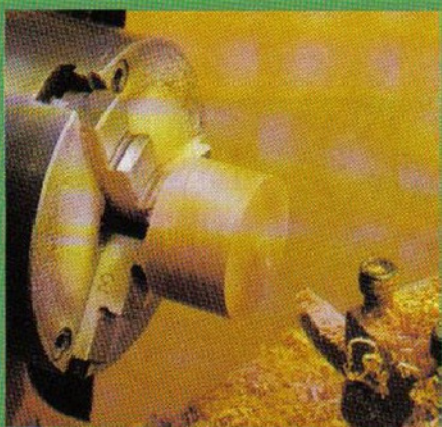


**One ring complete with instrument fixing ring fitted.**

this item can be completed in about three hours, the unit can be made, and the machine thoroughly cleaned and re-oiled at one session, which it should be.

It was whilst boring out the first disc that I realized that a small disc was going to be produced from its centre, and that this could form a centre to produce the





**Turning the boss mounted on a stud.**

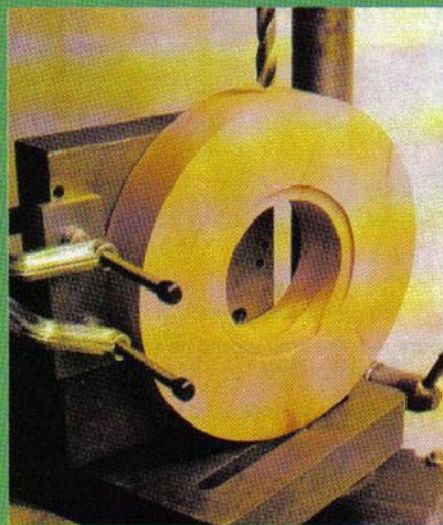
triangular formation with dowels radiating from it and, as a result, the design was changed from that originally chosen. This can be seen in the photograph.

Manufacture followed normal metal-working techniques with a roundnose tool being used for all the turning, except the bore which was done using a boring tool ground from a solid tool bit and with the front cutting edge the widest part, enabling the tool to be fed straight in to produce the bore and the centre disc at the same time. The length of the tool necessitated this to

ensure the part previously turned is running true as this will enable the bore now to be made from the other side to be concentric with the first. With the bore now made right through, open up the bore to its final size.

The disc can now be held, probably with a three-jaw chuck, with the jaws gripping outwards into the bore; this is quite adequate for the operation to follow. Face the second side and also turn the outside to its final diameter. As the discs as supplied are only rough cut, make sure that the two remaining discs will also be able to be finished to the same size. Sand the face and outer edge to a good finish, and also make the counterbore to take the fixing ring.

Woodturners are used to putting their hands close to the rotating work to complete the finishing operations, but then their machines do not normally have odd shaped parts such as chuck jaws rotating, so do be careful.



**About to drill the discs for the dowel; note how the arrangement ensures that all are the same.**

Having completed the first disc, produce the remaining two in the same manner, ensuring that they are all the same size. We now have the three completed discs and the portions which have been removed from the centres; select one of these and return it to the three-jaw chuck, face and sand the outer face.

Choose a short length of threaded rod of about  $\frac{1}{2}$  to  $\frac{3}{4}$  inch diameter or, if not available, a long screw with the head cut off. Drill the piece in the chuck with a hole about  $\frac{1}{2}$  inch deep and sufficiently smaller than the chosen stud to allow it to be firmly screwed into place.

Remove the part from the chuck, reverse and replace holding it with the stud in the chuck — both the outer face and the outside diameter can now be turned and sanded.

## Finishing

The type of finish applied can be varied as best suits the person making the unit. For the original this was wax polished mainly as this was available at the time, and in any case it was considered that the lower level of shine it would give was preferable, as it would not conflict with the highly polished finish on the instrument bezels.

If wax polishing is to be adopted, then this is best done initially with the part *in*

*situ* in the lathe and rotating. Again it is stressed, do take great care with this operation. The small centre portion can be finished whilst still in place, followed by the discs, being returned to the lathe one at a time for finishing.

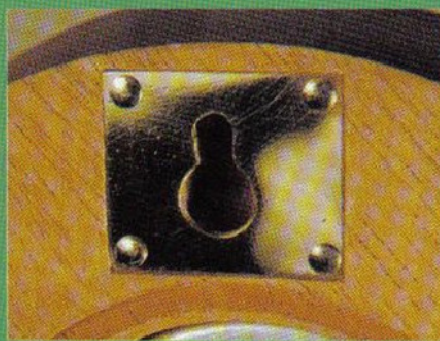
## Assembly

Take a piece of dowel about  $\frac{1}{4}$  inch diameter and cut three pieces 2 inches long. Now drill the centre piece with three suitable size holes. The photograph indicates a good method for doing this which will give some consistency. To get the three holes at reasonably equal divisions, the back can be marked with a pencil after turning the back face, using the three jaws as a reference. These can then be lined up with a mark on the small angle plate when drilling.

A single hole now requires to be drilled into each disc, and again if placed against a larger angle plate will ensure all holes are the same distance from the rear face, and a bar clamped to the angle plate for the disc to locate on its side will make sure the hole is pointing through the disc centre.

Even with one hole only, some consideration should be given to the position on the disc. The holes can be arranged to give the grain running horizontally on each disc or alternatively vertically or, as in the original, random, done without thought (I will be honest enough to own up!)

Using a little glue on each dowel, assemble the unit and lay flat for the glue to set. This will make sure that the finished item will lie flat on the wall when hung. To enable this to be achieved, make a small brass plate with a keyhole slot and fix this



**The arrangement for hanging the unit.**

at the top of the disc chosen for this purpose. Provide a small recess behind the plate to allow for the head of the screw on which the weather station is to be hung — if you wish to achieve a really professional result, recess the plate flush with the rear surface, polish it and fit with brass pins.

The dowels were made from dowelling purchased from the local DIY store and were rammed which being lighter, make a nice contrast with the Mahogany, which incidentally was not stained to give it the more traditional colour for this wood. The dowels were given a finish of wax polish as was the remainder as a final overall polish.

It remains only to fit the instruments using the holding rings supplied; fit these using small nails and insert the instruments in the desired positions. The rings hold the instruments firmly but still permit them to be rotated into position and also to be removed if required.

With the unit complete you will now have a useful Weather Station that will grace any modern home.

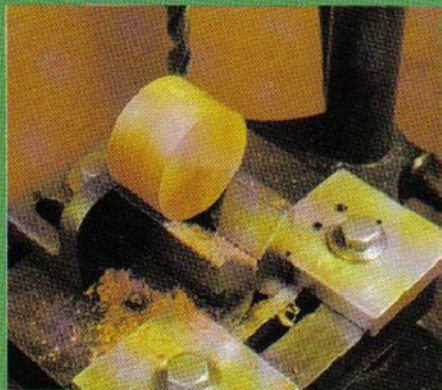


# FRIEND!

be done from both sides of the disc to complete the bore.

No drawings are included with this article as the dimensions are not critical and the essential details required can be gained from the photographs. The method of fitting the instruments is by means of a ring which is included with the instrument.

The method of manufacture described here requires a six inch chuck which could be either three or four jaw; anyone who does not have such a large chuck should be



**Drilling the centre boss.**

able to adapt the procedure to use a faceplate for the initial stage of producing the bore, after which a smaller chuck will be adequate.

First mount the disc in the chuck, face the disc and also turn the outside (which is supplied only approximately round) along its length as far as the jaws will allow. Now bore out the centre a little smaller in diameter than ultimately required and as deep as possible. Glasspaper the face which is to be the rear and therefore not that critical.

Remove from the chuck and reverse, now holding the disc on the part which has been turned. If using a four-jaw chuck,



In this follow-up article to the lathe collets in our Oct/Nov issue, we offer an addition to the system, this time for holding those difficult to grip, thin pieces. It is able also to hold much larger diameters than the normal collets

In the article on collets for the lathe (MEW No. 7, Oct/Nov '91) the question of the merits of the closing ring system over that of the draw bar were discussed and the closing ring method adopted. Even so, in these collets made with the purpose of holding thin items (maybe even washers) and intended to be used as part of that collet system, these do use the draw bar method of closing, as the alternative is not practical.

The very major benefit of adopting this method is the ability to hold much larger diameters. What the limit is, is difficult to estimate but up to 2 inches had been achieved and this is by no means the final limit — had the closing ring method been



Photo 2: The basic collet system.



Photo 3: A finished loose jaw collet gripping a 1 1/2" dia. piece of BMS having a 1/8" wide cut made on it.

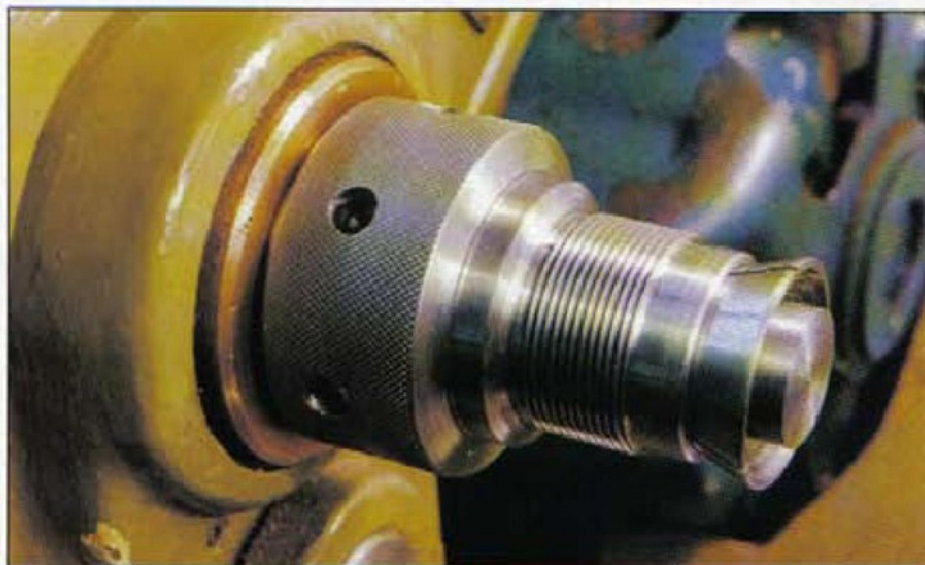


Photo 1: The multi-size collet.

# THIN WORK HOLDING

pursued, the limit would have been as per the normal collets, i.e. 1/2 inch.

## The design

The draw bar arrangement consists simply of a hand wheel at the change wheel end of the lathe spindle, and with a 1/2 inch diameter draw bar screwed into the back end of the collet (Photo 2). This can be done as the collet can have a solid end as no material has to pass through it as is the case for a normal collet. The other end is then screwed into the hand wheel which is then used to draw the collet into its taper.

Two types are suggested, the first being a one-piece construction, and has been made to hold a number of sizes (Photo 1). This has the advantage of limiting the number of collets to be made, but has the disadvantage that the smaller diameters are somewhat obscured by the larger part of the collet.

## An alternative approach

An alternative approach would be to turn a number of collets, say three, and to give these an additional projection of about 1/2 inch (Photo 5) then to turn the internal jaws only as required and with a single diameter to a depth of 1/2 inch. Then, when a conditions arrive that a required size is not available, and choosing the collet least probable to be used again, face the outer end flat and recess to the diameter required.

To enable the jaws to be turned to suit a new diameter after slotting, the collet would require to have inserted a short length of material into the inner bore, and for this reason they should be turned to a precise size and a suitable plug turned with this in mind when the collets are initially made.

## To suit larger sizes

To enable the system to be able to cope with larger sizes, and at the same time avoid the necessity for the collets to be individually made from larger diameter material, a method of removable jaws has been used. A collet is established with a single diameter turned into it, and onto this is screwed a thin addition jaw piece in which is turned a recess to the diameter required. The limit in size with which this arrangement could cope will largely be dependent on the user of the equipment and the amount of care taken in its use.



## Manufacture — the one-piece type

All the turning operations can be done in one operation without the need to remove the item from the three-jaw chuck, with the exception of turning the final internal jaw sizes which will be done *in situ* in the collet assembly, though some may wish to provide some means of holding the

repeating, that any error present should preferably result in the larger rather than the smaller diameter being oversize.

Place a short length of  $\frac{1}{2}$  inch dia. bright mild steel and turn this to 0.625 inch diameter over a length of 1 inch, then turn the first  $\frac{1}{2}$  inch to 0.620 inch dia. and part off to 1 inch length, this to be used as both a gauge for turning the internal bore and also

bored to the required diameter using the gauge made previously. This can be seen in the Photograph.

The inner end of the collet can now be drilled and tapped to suit the draw bar, and the collet finally parted off. Whilst the workpiece is still supported, the end can again be centre drilled and the whole process repeated until sufficient collets have been made. This method of manufacture will limit the number of off-cuts to just one.

For those who wish to obtain a better finish on the parted-off end, a simple stub mandrel could be made a tight fit in the bore and the collet pushed onto this and its end carefully finished. The draw bar presents no problem, though if you do not

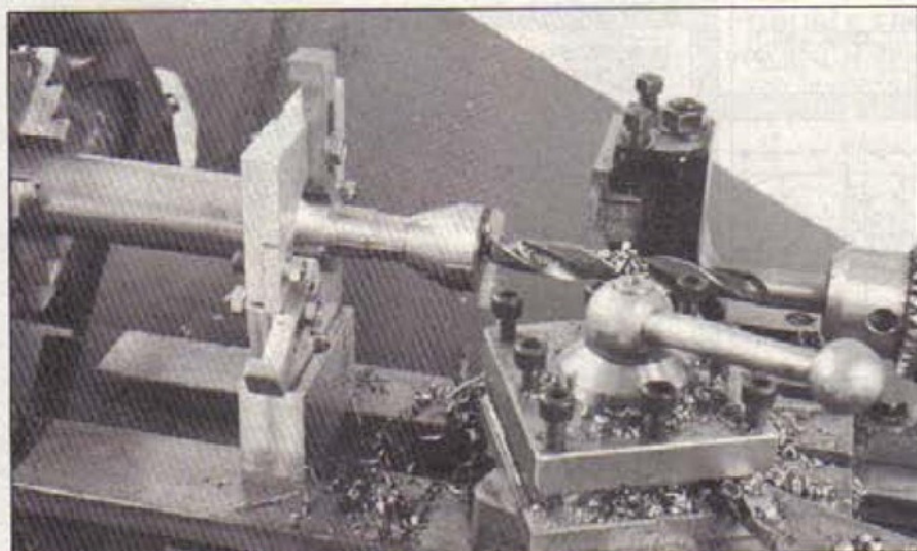


Photo 4: The first of three collets to be made from the same bar.

collet with the back end available for facing after parting off.

It is first necessary to set the top slide to the required angle to match that of the internal bore of the collet assembly body. The taper is eventually to be turned with the largest diameter farthest from the chuck, so the slide must be set with this in mind.

There are a number of ways of setting

as a plug for this bore when turning the jaws after slotting.

Now take a length of  $1\frac{1}{2}$  inch diameter bright mild steel of sufficient length to make the number of collets required plus sufficient to hold in the chuck.

Place in the chuck and support the outer end with a fixed steady and centre drill. To avoid having to continually remove and replace the steady, open up the jaws and move it towards the chuck and fix, but not

## QUICK TIP

A simple way of transferring the position of a blind tapped hole, say from a lathe chuck to a back plate, is to use a junior hack-saw to make a screwdriver slot across the cup point of a socket set screw (grub screw) of the same thread as in the chuck. Insert, socket first, the screw in one of the tapped holes leaving it slightly proud of the back face, assemble back plate and lightly tap with mallet. Mark zero position of chuck to back plate, disassemble and centre punch in the middle of the small circle marked by the screw.

Drill the first clearance hole and repeat twice, using firstly one bolt and then two. The three clearance holes could be marked at one setting by using three screws but this would increase the odds of misalignment as a drill will never accurately follow a

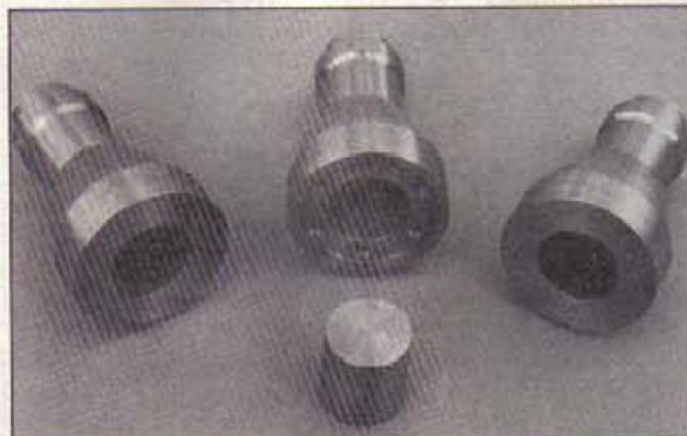


Photo 5: The loose jaw collet (centre) plus two collet blanks, all before slotting. The plug is for use in centre hole when boring to new size after slotting.

the required angle, though the most probable is to fit the body to the lathe then using a dial test indicator to test that the top slide has been set up correctly. The weakness of this method is that unless the test is carried out at exactly centre height the result will not be accurate, so do ensure that the test and the tool used to turn the taper are exactly at centre height.

The alternative is to turn a test piece and try this using engineer's blue, but in view of the orientation of the tapers this is not so easy. It has been said before but is worth

supporting the workpiece. The end can now be supported with the tailstock centre. Now follow this by turning all the outside diameters; this is quite straightforward though it may be a little unusual for the largest diameter to be farthest from the chuck. However, this should present no real problem.

Turn also the large diameter for the second chuck, and support again with the fixed steady at this point. The tailstock centre can now be removed and the end of the collet faced and drilled (Photo 4) and

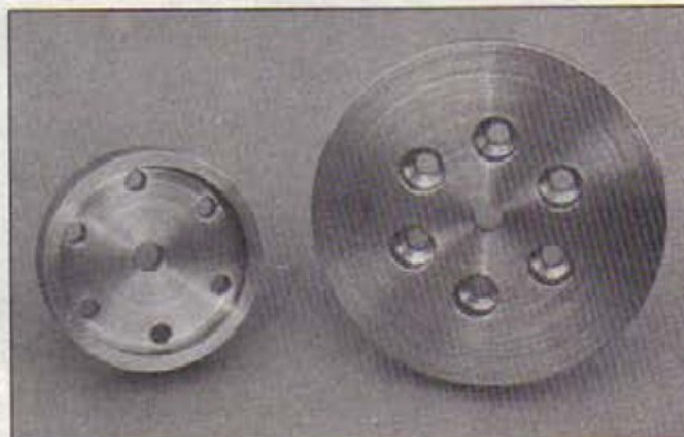


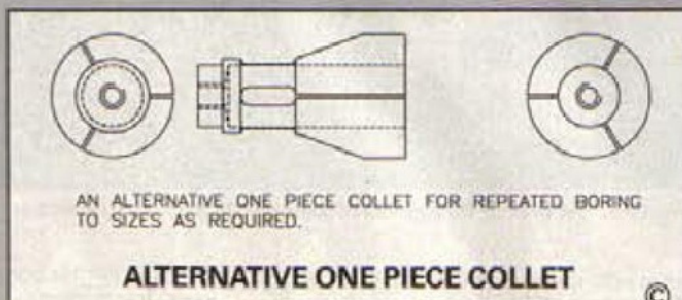
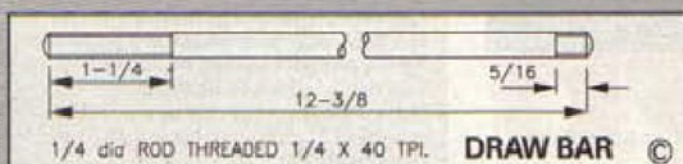
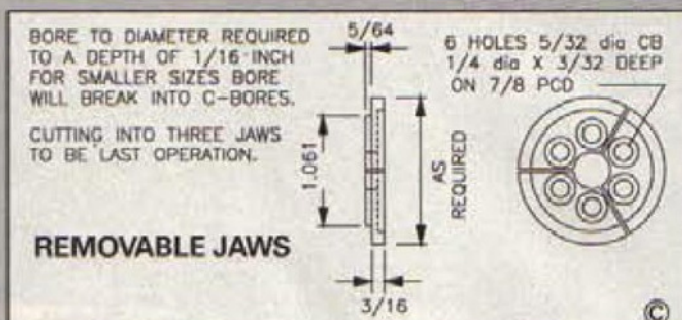
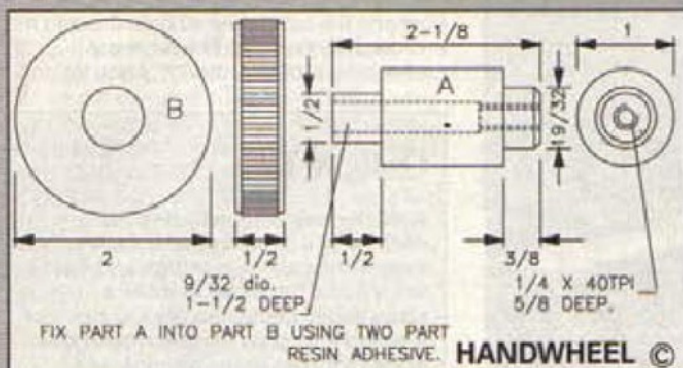
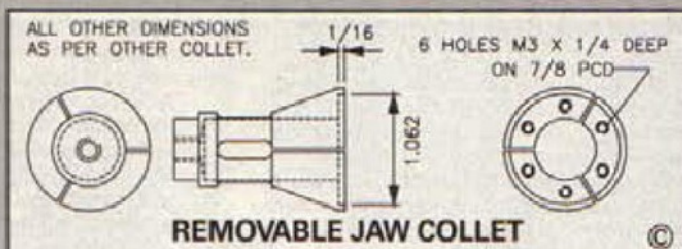
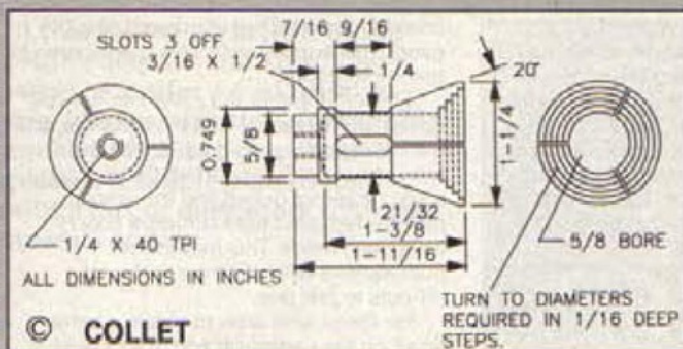
Photo 6: The drilling jig and a loose jaw piece ready for boring and then slotting.

have a 40 TPI tap and die, use the finest thread you have available.

So as to reduce the amount of heavy turning, the handwheel is made from two pieces, and these are joined using resin adhesive. A tommy bar may be considered easier but do not be tempted to adopt this method as, if the bar is made a fixture it could be dangerous, and even if removable, is not without its dangers. Similarly, do not be tempted to use a spoked wheel if one is available.

With the essential elements of the





**Photo 7: Using the drilling jig to drill a loose jaw.**

assembly made, the parts can be assembled in place on the lathe and the chosen diameters turned into the front face. With this done, the collet can now be removed and slotted in a similar method to that adopted for the collets previously made.

### Manufacture — the removable jaw type

To manufacture the removable jaw type, take one of the collet blanks already made and set as previously for boring but this time turn a single recess only, as per the diameter indicated. Remove from the lathe and place to one side. Do not slot it at this



**Photo 8: Drilling the loose jaw collet using first jaw as a jig; holding was overcome by use of the collet assembly body stage.**

With a piece of 2 inch diameter bright mild steel in the lathe, turn the spigot which locates in the collet making certain that this is a close fit. Whilst doing this, make more than one.

Whilst making these discs, make one additional disc but instead of having a projection, turn with a recess equal to that on the collet face, and then in the centre of the recess, produce a dimple about 15 thou deep using a centre drill.

Take this disc and, using a pair of dividers, scribe a circle from the centre mark created. Then, with the divider still set at the same setting, step round six times to

achieve the six divisions required for the M3 holes and centre punch.

Drill the six holes at this stage to the chosen diameter for M3 tapping (Photo 6), then using this disc as a drilling jig, transfer these holes to a jaw disc (Photo 7), and then from the jaw to the collet itself (Photo 8), and tap these M3. The collet can now be slotted. Retain the initial disc as this can be used as a drilling jig for any jaws made subsequently.

Now open up the holes in the jaw disc as indicated. The hole sizes quoted are generous to ensure that final location of the jaws is established by the recess and not the screws. Note the counterbore depth is from the face of the recess which has not been made at this stage, and will therefore be deeper when drilled initially.

Fit the jaw piece to the collet using M3 pan head screws and place the complete collet assembly on the lathe. Face the outer face of the disc and recess to the diameter required. It now remains to cut this disc into three jaws and this can be done adequately in a bench vice using a hacksaw. Before removing the disc from the collet, it may be worth marking both disc and collet to ensure they are always assembled in the same positions.

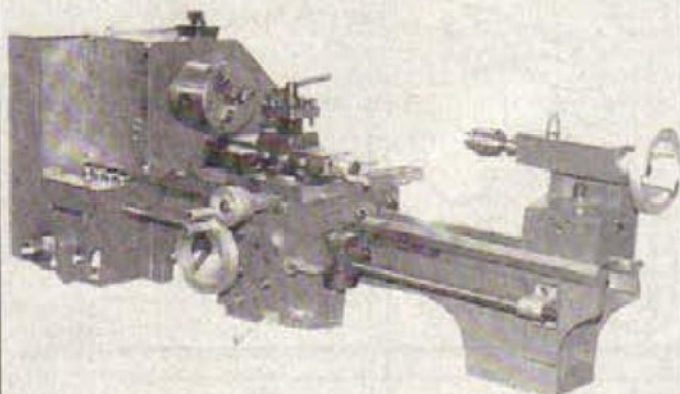
Scribe on the rear of each jaw the diameter for which they are intended as this will not be that easy to determine after they are slotted, particularly if they are not common dimensions.

Whilst not indicated in the drawings these removable jaws could also be made thicker to allow for eventual turning to a new diameter. Also do make some spare jaws, as this will make it so much easier to make use of this system when the need arises.





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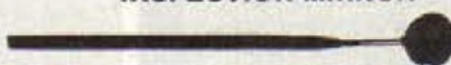
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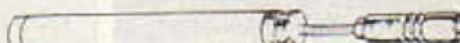
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Electricity is not something to be trifled with but we have probably all done this at some time, to a greater or lesser degree. In this article, Chris Boucher of Wellingborough explains the requirements of the IEE Regs, with which, as installers of electrical systems in our own home workshop, we are obligated to comply

**T**his article is intended for those model engineers who may be slightly in awe of electricity and to show that, provided the right rules are followed, there is no reason why any mechanical engineer should not carry out all the wiring required in his workshop. The majority of readers will already have their workshop set up, and this article will enable them to check that their electrical wiring meets all safety requirements.

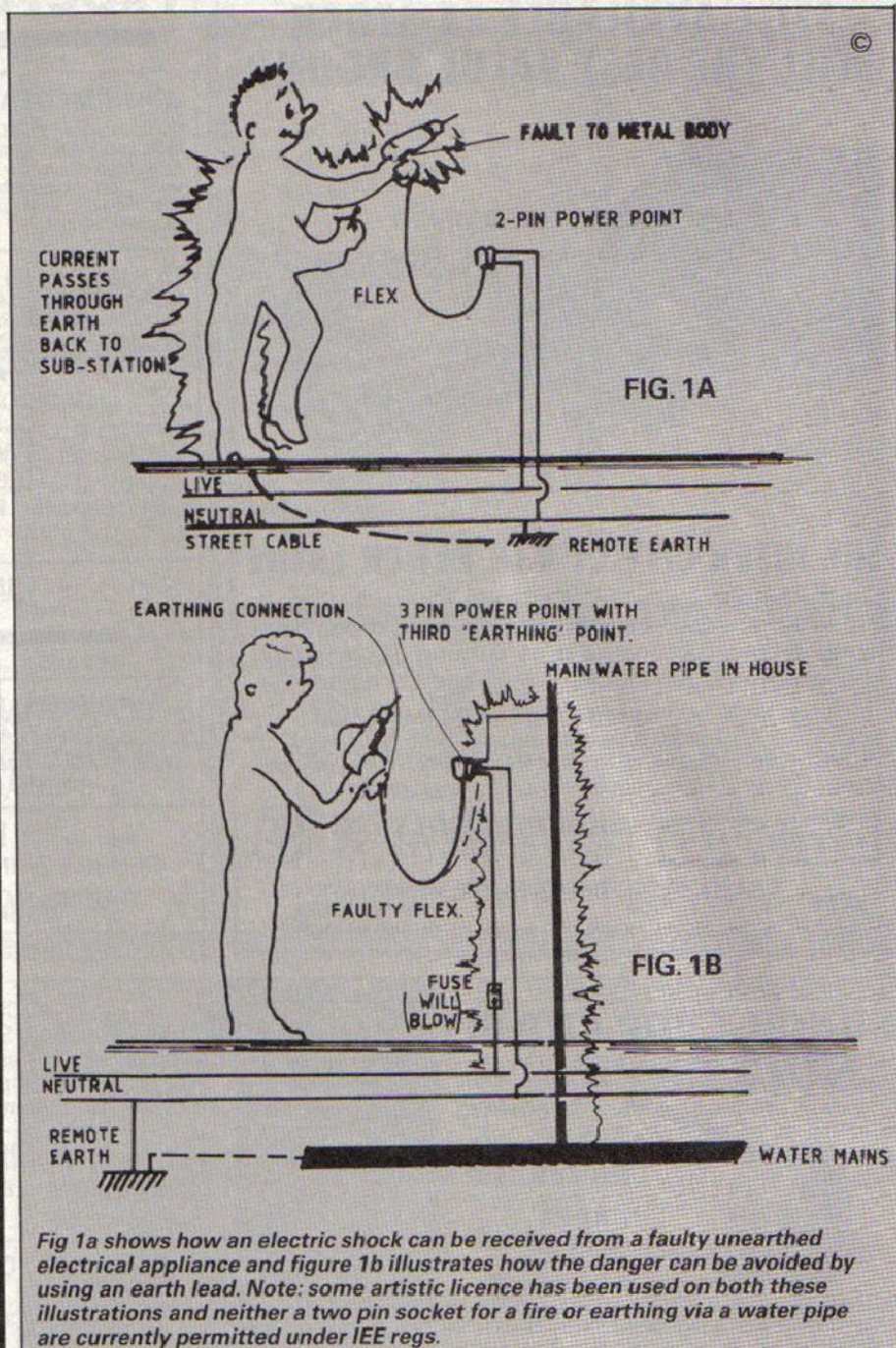
In this country wiring standards are governed by the Regulations For Electrical Installations, issued by the Institution of Electrical Engineers, and known as 'I.E.E. Regs' for short. This is a tome of 250 pages and fortunately not all the requirements affect home workshops. The regulations are aimed at safety in home and work environments, and the two primary hazards caused by electrical faults are fire and electric shock. Electricity is not to be trifled with and, make no mistake, the normal 240 volt mains can kill! Approximately 40 people a year are killed by electric shock in the home and many more are seriously injured by burns.

## Safety Devices

We will first of all look at the various safety devices which are part of any installation and then see how they are combined in a typical workshop.

The first means of protection is the switch or isolator. Every circuit must have a means of isolating it so that wiring in the installation can be worked on safely. In our case this will be a main double pole (live and neutral) switch which is part of the consumer unit (main distribution point) at the entrance to the workshop.

The next safety device to be considered is the humble earth wire. This is the third conductor in any cable which is either bare or covered with a green/yellow striped sleeve. Because all appliances will work without the earth wire being connected, it is often neglected. It is, however, A VITAL SAFETY REQUIREMENT. (See Figure 1a and 1b). I.E.E. Regulations refer to it as a protective conductor which goes a long way to explain its purpose. If any fault occurs in a system, it is important that a very high current flows to ensure that the fuse, which is the deliberate weak link in



the circuit, blows quickly to prevent overheating. The earth connection provides this quick path for the current. If the earth circuit is not complete, then the metal body of the appliance or machine tool is likely to become live and next time you touch it the earth return circuit will be completed via your body with disastrous results!

I.E.E. Regs place great importance on earthing and they also state that all exposed metalwork on the premises must be bonded to the main earthing terminal. In the workshop this means bonding any service pipes, such as water or gas, plus any other metalwork, e.g. non-electric fixed metal tools such as guillotines/benders and even metal window frames to earth.

It must be remembered that, if there is a fault, it is essential that the earth conductor is of large enough diameter to ensure that the fuse blows! The normal two core twin plus earth cable is designed with this fact in mind, but to be safe, use 4mm cable for bonding. Lathes/drills, etc., must of course also be earthed but this is normally achieved via the electrical connection. The only exception to earthing requirements (apart from very special circumstances unlikely to be met in the workshop) is the use of electrical appliances of all-insulated or double insulated construction. These will be fitted with a two core flexible cord (live and neutral) and the label on the appliance will include a double square symbol.

# WORKSHOP W



Mention has already been made of the fuse, another essential safety device. All electrical circuits must be protected against excessive current, and the simplest means of achieving this is via a fuse. The rating (current which the fuse can safely carry) is very important and will vary according to the circuit. For instance, the main workshop isolator could be fused at 45 amps, the circuits feeding the socket outlets at 30 amps and the lighting circuit at 5 amps. Generally, a fuse will blow at approximately double the rating and this has a bearing on cable size selection, which will be discussed later. The rewirable fuse is still a cheap and reliable device but it does suffer from the disadvantage that it is possible to rewire it with the wrong size wire, which could cause serious overheating and even a fire in the event of an excess current flowing.

A better device is the replacement cartridge fuse, which will always have the rating stamped on it. As an alternative to fuses, small automatic circuit breakers are available which can be mounted in the consumer unit in much the same way as fuses. These miniature circuit breakers (MCBs) are, in fact, switches designed to open automatically when the current passing through them exceeds the value for which they are set.

Another device which is well worth paying a little extra for is a Residual current device (RCD). Some readers may know of this as an Earth Leakage circuit-breaker and this older term describes its function better. Briefly, it will interrupt the circuit as soon as current above a specified limit flows between live and earth. This feature is particularly useful if someone touches a live conductor and receives a shock, which could be fatal. RCDs act in milliseconds and sensitive ones with a design operating

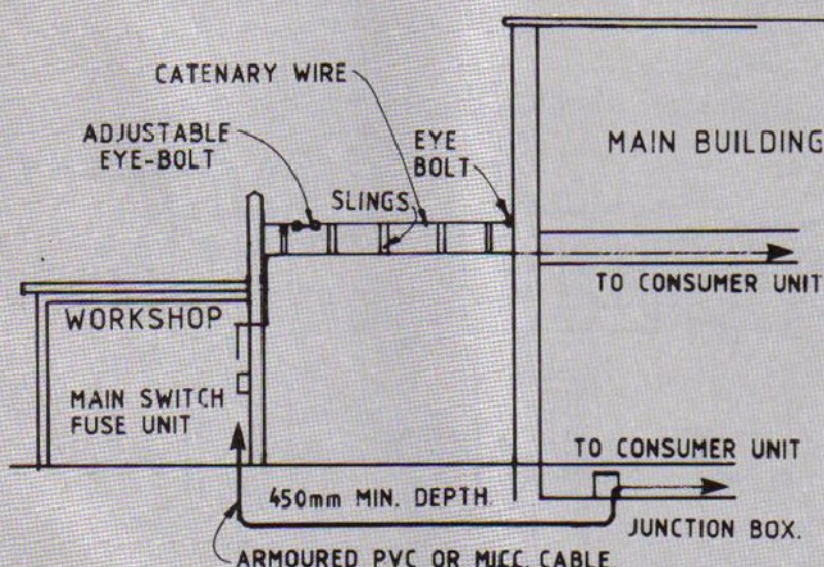
current of 30mA can save lives! Incidentally, it is a *requirement* to have any socket outlet which is likely to supply a portable appliance to be used outdoors, protected by an RCD. A further I.E.E. regulation which affects the home workshop states "Every motor shall be provided with means to prevent automatic restarting after a stoppage due to drop in voltage or failure of supply, where unexpected restarting of the motor might cause danger". This in effect means that a pushbutton starter which will trip on failure of the supply is required for all machine tools.

### Supply cable selection

Having looked at the various safety devices that will feature in the workshop circuit, we can now move on to the actual design and layout. Let us assume for the moment that the workshop is in an outbuilding remote from the house. A cable feeding a detached building may be run overhead, underground or along a wall, but IN NO CIRCUMSTANCES may it be run along a fence. For a short distance between the house and workshop there is much to be said for running the cable overhead, but for long runs an underground cable is usually preferred. If you decide on overhead, ordinary twin core and earth PVC-sheathed cable can be used. If the distance does not exceed three metres, then no additional support is required.

For longer spans, the cable must be supported by a galvanised steel wire or cable (catenary). The electric cable must be at a minimum height of 3.5m above ground level, but this must be increased to 5.2m above a driveway. Clips or slings should be attached to the catenary not more than 225mm apart. Don't forget to bond the catenary to earth as already described, but it must not itself be used as the earth

**FIG. 2 TWO ALTERNATIVE METHODS OF SUPPLYING A WORKSHOP EITHER OVERHEAD OR UNDERGROUND**



**Top:** Workshop consumer unit. Note supply armoured cable terminating at the unit, main isolator incorporating a residual current device (RCD) and three miniature circuit breakers (MCBs) protecting each circuit. N.B. Protective covers have been removed for photographic purposes.

**Centre:** RCD used to provide protection for single portable appliance to be used outside.

**Above:** Possibly an exaggeration, but

# IRING WISDOM





Top: This fused connection unit complete with neon light provides a warning that power is on to the grinder.

Centre: Armoured cable showing the various layers of insulation plus the gland used to secure the cable at the junction box.

Above: An illustration of bonding of water pipes; note the safety label which states: "Safety electrical connection. Do not remove".

continuity conductor. Underground cable must be buried as least 450mm deep. This depth must be increased to 600mm under cultivated land, so stand by for a weekend of concentrated digging! By far the best type of cable to use underground is armoured PVC (two core) with an extruded covering of PVC over the wire armour. The photograph illustrates the various layers of insulation around armoured cable together with the gland used to terminate the ends of the cable. No special tools are required to terminate armoured cable and the use of the gland is very simple.

An alternative to armoured cable is mineral insulated, copper sheathed (m.i.c.c.) two core cable with an extruded covering of PVC which is usually orange in colour. The disadvantage of m.i.c.c. cable is that special tools and waterproof seals are required for the terminations. On the other hand, for a given current-carrying capacity, it is of a much smaller diameter than armoured cable. Providing it is protected by high impact PVC conduit or galvanised metal conduit, PVC two core and earth cable can be run underground. If you decide on armoured cable, it is well worth shopping around the local suppliers. The length of cable required for the average home workshop could be considered as an offcut by an industrial supplier and some useful end of drum bargains can be had!

If clipping the cable to an outside wall forms part of the run, don't forget the I.E.E. requirement to provide adequate protection from mechanical damage. Enclosing in conduit may be necessary in some situations. **Figure 2** summarises the requirements for overhead and underground runs of cable between house and workshop. The next decision to be made is what size cable to use? This depends on the following factors:  
Voltage drop  
Maximum load  
Diversity (how many appliances are likely to

## QUICK TIP

To remove the mill scale from black iron, sprinkle some Harpic on the metal and moisten it with water (Sainsbury's equivalent works just as well). Wash and oil afterwards as rust will quickly form.

P.A. Twist

be run at any one time)

Length of cable run

Whether cable is in air or underground

Type of cable (armoured m.i.c.c. etc)

Type of fusing employed

With all these factors to be considered, only a general guide on cable size can be given (see **Table 1**). If in doubt, the I.E.E. regulations should be consulted. Your cable supplier should have a copy and be prepared to advise. A requirement which is often overlooked is the regulation that the voltage drop on any installation must not exceed 2%. The supply voltage can be taken as 240 volts and it is important that under full load conditions the voltage drop over the cable run does not allow the supply in the workshop to drop below 234 volts.

This point is best illustrated by an example: The table of supply cables shows the most commonly used types of cable in normal environments. Suppose that the run length is 25 metres and the maximum current required is 30 amps. 4mm armoured cable is selected. This has a current-carrying capacity of 38 amps and therefore appears perfectly suitable until the next column giving the voltage drop in millivolts per amp per metre. This is 11, so carrying out a simple calculation, the total voltage drop is  $11 \times 30 \text{ (amps)} \times 25 \text{ (metres)}$  divided by 1000 to bring the total to volts. This equals 8.25 volts which is higher than the 6 volts allowed, so it is necessary to

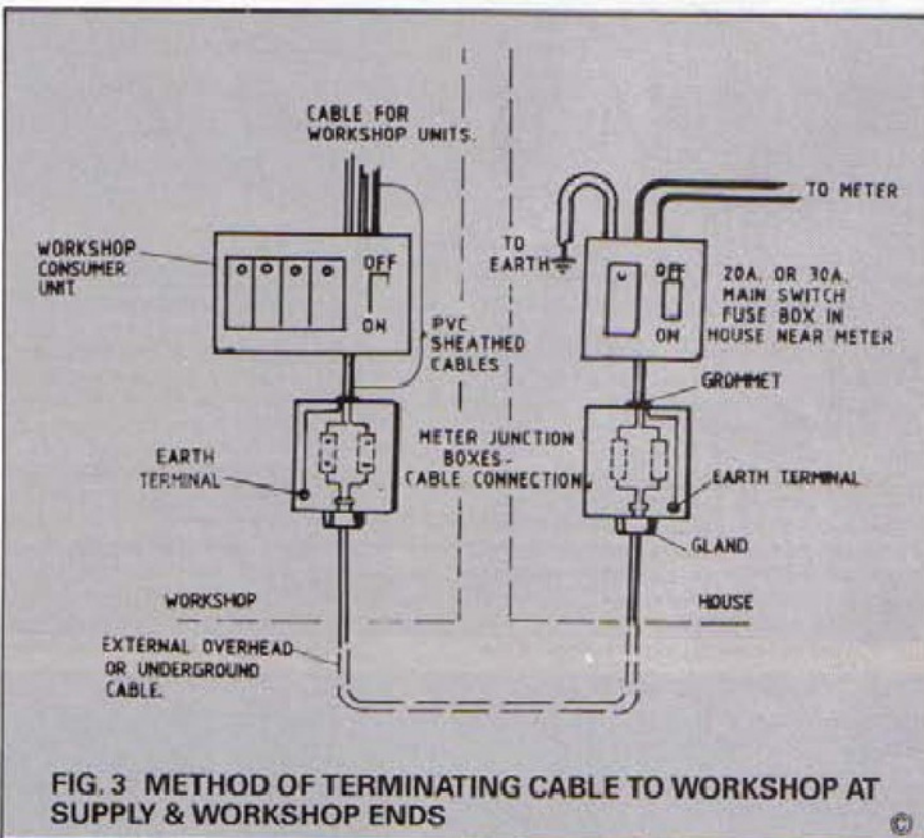


FIG. 3 METHOD OF TERMINATING CABLE TO WORKSHOP AT SUPPLY & WORKSHOP ENDS



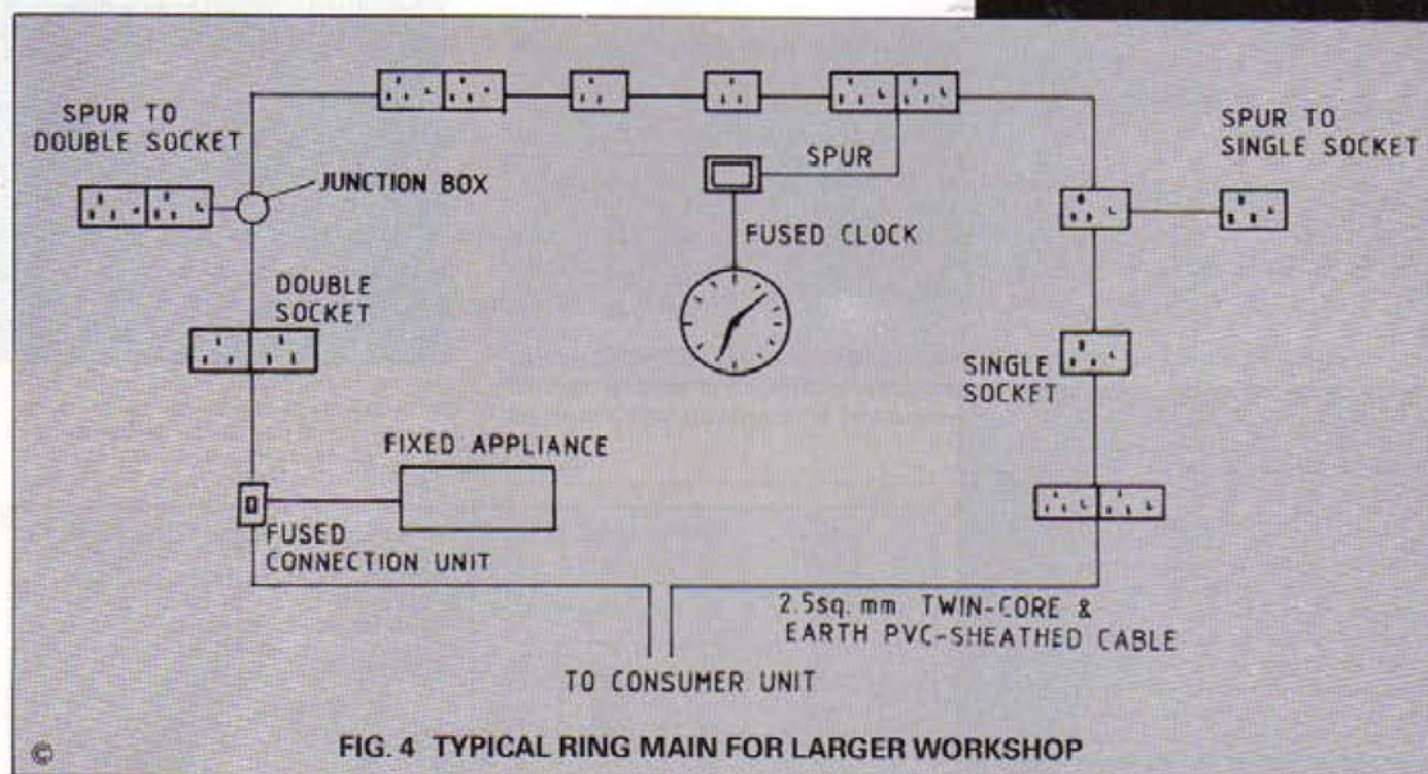


FIG. 4 TYPICAL RING MAIN FOR LARGER WORKSHOP

move to 6mm cable when the calculation becomes  $73 \times 30 \times 25 \div 1000 = 5.48$  volts, which is within the limits required.

Having decided on the cable and the method of run, the terminations must be considered. A main switch should be used in the house near the meter. Connection to the house supply can either be via a spare way on the consumer unit or, if one is not available then "tails" should be left for the Electricity Board who will call and connect these directly into the meter. Incidentally, the term 'tails' is used to describe heavy capacity single core cable used for connections between the Board's and Consumer's installation. If your current requirements are very high, check with your Electricity Board that the cable supplying your house is large enough before proceeding!

If armoured cable is employed, it is usually more convenient to terminate it with a small metal junction box just inside the house and then use normal PVC twin and earth cable (see Figure 3).

### Workshop installation

We can now move on to the workshop itself. The easiest way to terminate the cable is directly into a consumer unit. These are available with any number of fused ways to suit the number of circuits required, and they can be fitted with an RCD as part of the main switch and rewirable or cartridge fuses or MCBs. The photograph shows the author's installation with an RCD and three circuits all protected by MCBs, with room for further circuits as necessary. The actual circuits will of course depend on the workshop layout, but all will have lighting and socket outlets in common.

The lighting circuit will follow the same form as normal house wiring and should be on a separate circuit protected by a 5amp fuse. A convenient form of lighting over the bench is fluorescent since it provides an even lighting effect over the whole area. If you have a bench-mounting

drill, be careful of the stroboscopic effect. These tubes flicker at the mains frequency of 50 cycles. If the drill is rotating at an exact multiple of this speed, it can appear stationary although it is actually revolving. For this reason machine tool lights should be of normal incandescent type. Very often it is more convenient to run these from the ring or radial circuit supplying the machine tool, but the lights should be run from their own spur unit protected by a 3amp fuse.

The socket outlets can be either radial or in the form of a ring circuit (Figures 4 and 5). The names are self-explanatory, but the main point about a ring circuit is that the two ends of the ring are connected to the same fuse in the consumer unit. Radial circuits are probably better for the small workshop, but a ring may be easier and

more economic in a larger one. It can be seen from Figure 4 that spurs are wired to the ring main. This is more convenient when a socket is a long way from the ring. The rules regarding spurs are: "The total number of fused spurs is unlimited but the number of non-fused spurs must not exceed the total number of socket outlets and items of stationary equipment connected directly in the circuit. A non-fused spur must only feed one single or one twin socket outlet or one permanently connected item."

Regardless of whether a ring or radial circuit is used, it should be protected by a 30amp fuse or MCB in the consumer unit. It goes without saying that any fuses in the final circuit must not exceed 13amps and should be considerably less in many

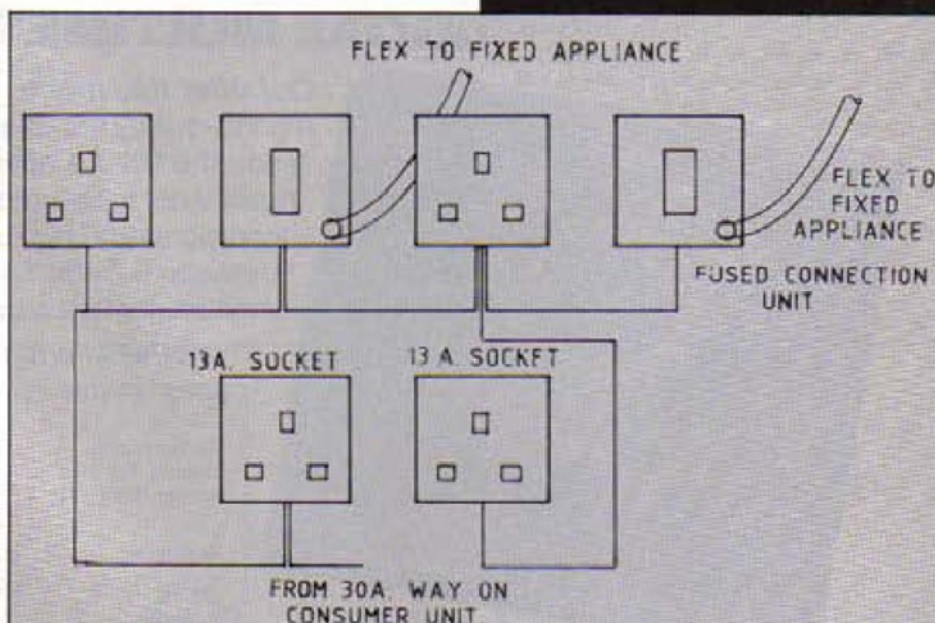


FIG. 5 TYPICAL RADIAL CIRCUIT IN WORKSHOP. FIXED APPLIANCES, DRILLS, LATHES ETC. WITH INTEGRAL SWITCHING



**Table 1.**  
Approximate guide for choosing supply cable size

NOTE: See text for factors which can affect the current-carrying capacity of cables.

| Conductor cross-sectional area mm <sup>2</sup> | Voltage Drop mV/A/m | Current capacity — Amps |          |
|------------------------------------------------|---------------------|-------------------------|----------|
|                                                |                     | PVC insulated           | Armoured |
| 2.5                                            | 18                  | 18.5                    | 28       |
| 4                                              | 11                  | 25                      | 38       |
| 6                                              | 7.3                 | 32                      | 49       |
| 10                                             | 4.4                 | 43                      | 67       |

circumstances. For instance, a mains clock should be fused using a special connector with a 1 amp fuse. Fixed socket outlets with a neon light can be very handy as a warning that power is on to the lathe or other machine tool.

Any appliance consuming a large amount of current should have its own circuit run from the consumer unit. In the author's case, it was considered advisable to feed an electric arc welder from a separate circuit. **Table 2** provides a guide to the size of cables to use within the workshop. Heating is another matter to be decided when planning the workshop wiring. Radiant heaters are more economic for local heating of any area likely to be used only intermittently in the evenings. One or two 1kW heaters can safely be fed from the ring or radial circuit, but once again a separate circuit is desirable if a large number of heaters are contemplated.

Next issue — three phase supply to the workshop.

*To be continued*

## QUICK TIP

If you sometimes use a piece of paper behind the lathe tool so as to more clearly see the distance between the tool and the part being turned, you will have probably, at some time, had to search around the workshop for a suitable piece of paper. If so, look out for a piece of white plastic sheet, maybe from the back of an old catalogue or similar. Cut out a suitably sized piece, make a small hole in the corner and hang it on a hook close by the lathe. It will then always be ready and available for use and, being plastic, can be wiped clean after use each time.

**Table 2.**  
Guide to cable sizes

| Size mm <sup>2</sup> | Current rating amps | Circuit                                                                                     | Circuit fuse amps            |
|----------------------|---------------------|---------------------------------------------------------------------------------------------|------------------------------|
| 1.0                  | 14                  | Single light                                                                                | 5                            |
| 1.5                  | 18                  | Lighting radial                                                                             | 5                            |
| 2.5                  | 24                  | Ring circuits, Radial circuits up to 20m <sup>2</sup> floor area                            | 30<br>20 for radial circuits |
| 4                    | 32                  | Radial circuits up to 50m <sup>2</sup> floor area. Medium machine tools on separate circuit | 30                           |
| 6                    | 40                  | Large machine tools on own circuit                                                          | 45                           |

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In the first Winter Edition of *Model Engineers' Workshop* there was an article on the use of Datums. When doing many jobs in the workshop it is necessary to position a drill or cutter in a precise position over the work surface. One way of doing this is to use an edge or edges of the material as Datum points.

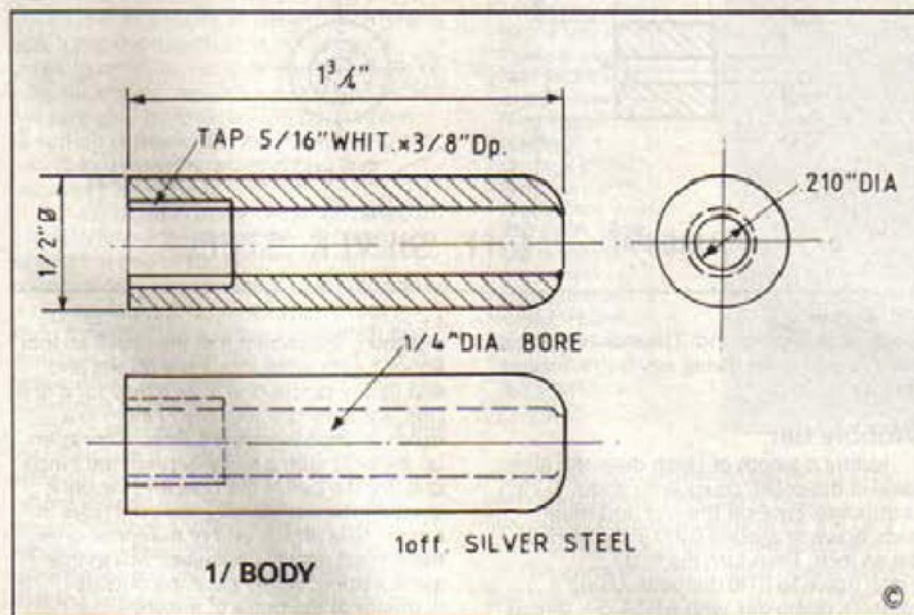
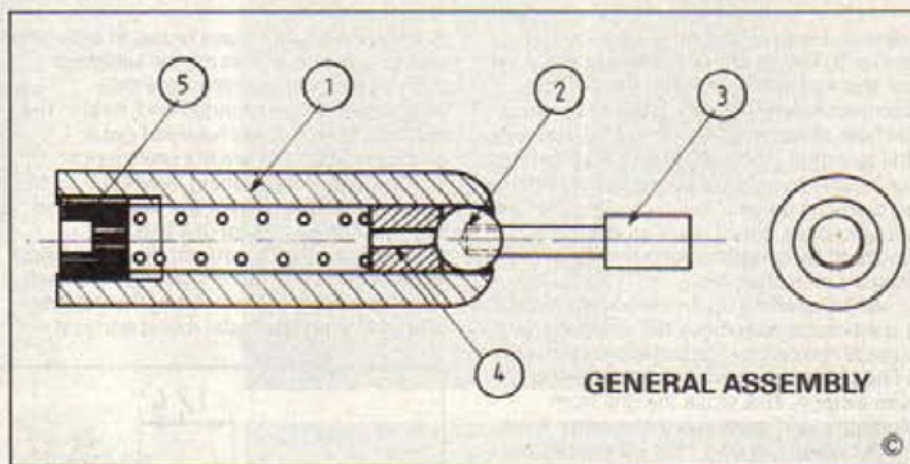
The problem then arises of positioning the cutter or drill exactly over the edge in question, so that the graduated feed screw can be used to position the cutter or drill in exactly the right position. This is where the edge finder (E.F.), described in this article comes in so useful.

It is tempting to try and just touch the edge of the material with the drill or cutter, using engineer's blue, and then winding over the feed half the tool diameter to position the cutter exactly over the edge, but as we all know to our cost this often ends up with an unsightly cutter mark on our latest masterpiece.

Using the edge finder the job becomes child's play. Position the E. F. in the chuck or collet and set the tip of the wobble bar so that it is about  $\frac{1}{4}$  inch below the top surface of the work. Start up the machine and the wobble bar will spin out of true. Using the feed screw, slowly wind the E. F. into the edge of the workpiece. The run out of the wobble bar then gradually decreases as the edge of the material restricts its swing. Continue until the wobble bar is seen to be running dead true; if you go too far, the wobble bar slides along the surface of the work and you must withdraw the E.F. from the work and start again. Once you have the wobble bar running true you have the

# MAKING AN EDGE-FINDER

In the Oct/Nov issue we published an article on using the edge finder; in this article D.J.P. recaps very briefly on this, then proceeds to detail the design and requirements for making one



silver steel so that it will fit your metric collets. And the tip of the wobble bar could easily be 5mm, so that you would have to wind over the lead screw 2.5mm to position your tool over the edge of the workpiece.

Just one final point before I go on to describe the construction. If you haven't got a mill, don't jump to the conclusion that this device is no use to you on your lathe. It works just as effectively in the horizontal plane and can be used very effectively with work set up on the vertical slide.

## Construction

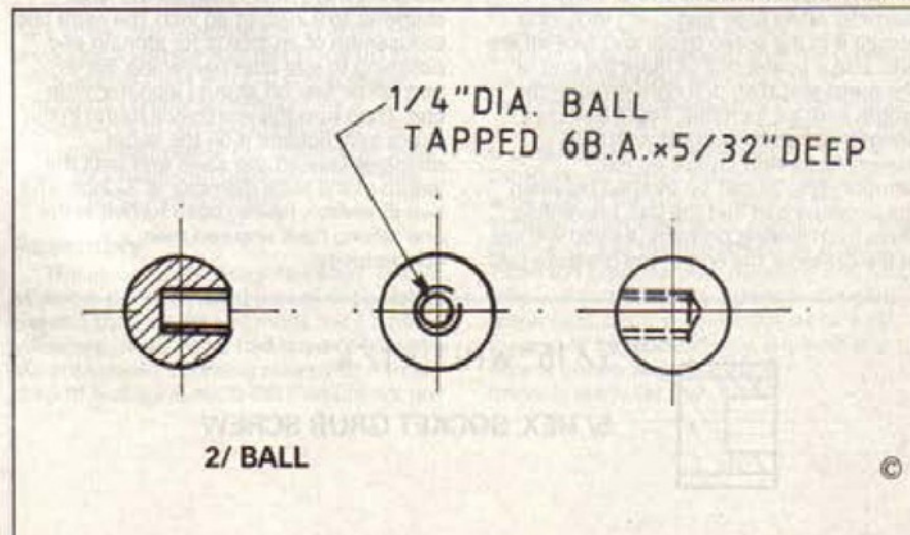
Cut off a piece of  $\frac{1}{2}$  inch diameter silver steel to a length of approximately  $1\frac{1}{4}$  inches and position it in the lathe collet/chuck, so that it protrudes about  $\frac{1}{4}$  inch. Face off the end, and use a centre drill to mark the end of the material. Use any suitable drill, smaller than a No. 4 drill, and drill right through the length of the silver steel. If you are not used to working with silver steel, remember to use a slower spindle speed than for mild steel and use a coolant.

Then turn the steel round in the chuck/

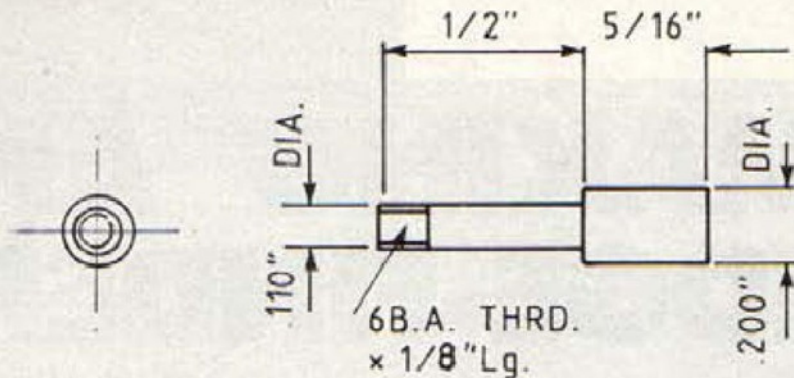
machine spindle exactly 0.300 inch from the edge of the work i.e. half the diameter of the tip of the wobble bar. Replace the E. F. with the cutter or drill that you wish to use and wind the feed to exactly where you wish to cut.

If you have doubts about the accuracy of this simple device, or your ability to see when the wobble bar is spinning dead true, just try it out in the workshop and you will be amazed at how easy it is to get repeat readings on the graduated dial of your feed screw time after time.

Because old habits die hard, I have used Imperial measurements for its construction, but it is just as easily made out of metric







3/ WOBBLE BAR

10ff. SILVER STEEL.

collet and face off the other end. Do not reduce to length at this stage, just clean up the end and lightly chamfer the outside diameter. Now use a  $\frac{1}{8}$  inch drill to open up the hole already through the steel, but only drill to within  $\frac{1}{8}$  inch of the end. As this does not require to be an accurate depth, use the graduations on your tailstock spindle or use a rule to put a pencil mark on the drill. Finish off by countersinking the hole with at least a  $\frac{1}{8}$  inch chamfer.

When opening up an already drilled hole it is advisable to remove the sharp cutting edge of the drill by lightly touching them on a fine grinding wheel and then rubbing with a stone. This stops the drill from digging in and produces a smoother finish, while cutting a tighter hole. Of course you will need to sharpen the drill before using it again for normal drilling.

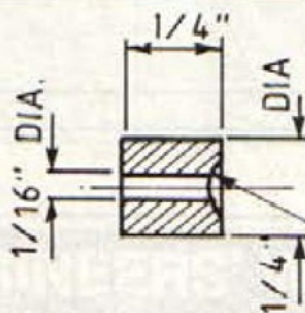
While on this setting, use the tailstock chuck to hold a  $\frac{3}{8}$  inch Whitworth tap to start a thread in the end of the body. Use plenty of cutting compound and repeatedly back off the tap to clear the swarf or you will find that the body starts to turn in the chuck/collet. Tap to a depth of about  $\frac{1}{8}$  inch.

Now again turn the work round in the chuck/collet and open up the smaller diameter with a suitably prepared No. 4 drill. Now you will realise the value of not previously finishing the length, for it is possible to carefully face off the end of the material until the length of the smaller diameter is reduced to only a few thousandths of an inch. This is necessary to leave the maximum amount of material to retain the ball end of the wobble bar in the body, while at the same time allowing the ball to protrude through the hole to allow a good degree of wobble. Finish off by turning a suitable radius on the outside diameter to give a pleasing effect.

### Pressure pad

Cut a piece from a length of  $\frac{1}{8}$  inch diameter silver steel just over  $\frac{1}{2}$  inch long. Mount it in the collet/chuck and face off the end. Use a centre drill to mark the end of the metal and then drill right through the length with a  $\frac{1}{8}$  inch drill. This hole is not obligatory, but does assist with final assembly, as with grease on the components, air can be trapped between the pressure pad and the ball, preventing them from sealing properly. As you will see in the drawing, the end of the pressure pad

is shown with a concave radius to allow the ball to seat into it. This can be achieved with a  $\frac{1}{8}$  inch radius cutter, or a drill sharpened with a rounded end, held in the tailstock chuck. If you have not got a suitable cutter and are not proficient at handheld drill sharpening, it will suffice to lightly indent the end of the pressure pad with a  $\frac{1}{8}$  drill or countersink to a depth whereby the flat face round the indentation is reduced to a width of about  $\frac{1}{8}$  of an inch. After removing any burr from the outside diameter, turn the metal round and just



4/ PRESSURE PAD

10ff. SILVER STEEL.

clean up the other end. The exact length is not critical, so removing any burrs finishes this part.

### Wobble bar

Mount a length of  $\frac{1}{8}$  inch diameter silver steel in the collet/chuck with about  $1\frac{1}{2}$  inch protruding. Face off the end and rough turn, down to around 0.210 inch diameter, for an inch. Then turn the first  $\frac{1}{8}$  inch down to 0.110 diameter. Using a tailstock dieholder, with a 6BA die, thread the first  $\frac{1}{8}$  inch. Now finish off the large diameter to 0.2005 of an inch; the extra half thousandth of an inch is for stoning and polishing to size after hardening. Either part-off or saw off about  $\frac{1}{8}$  inch from the end. Then turn the workpiece round in the chuck and, holding it on the larger diameter, face off the sawn end until the length of the large diameter is  $\frac{5}{16}$  inch. The two diameters having been turned in the one setting have ensured their concentricity.

We now need to prepare the ball, which is going to be the other part of the wobble bar. It is made from a perfectly standard  $\frac{1}{8}$  inch ballbearing, which has to be softened, drilled and tapped, and then rehardened.

To soften the ball it has to be heated to cherry red and then allowed to cool slowly. When I was working as a toolmaker, we used to have a box of powdered chalk into which we put heated components to ensure that they cooled slowly. The average household is not likely to have this facility, but I have found that ordinary dry cement serves the purpose.

I used a length of wire with a small circle bent at one end, into which the ball rested, to hold it in the flame of my propane torch. Once it was cherry red, I dropped it into a tobacco tin containing fresh cement and covered it over. When I later removed it, it was quite soft enough to be drilled and tapped.

### Holding the ball

How exactly does one hold a small ball to be able to drill and tap it? The easiest way is in a collet, with a short piece of  $\frac{1}{8}$  inch bar pushed into the collet first to stop the ball from going in too far. If you don't possess a collet, an alternative method has to be found.

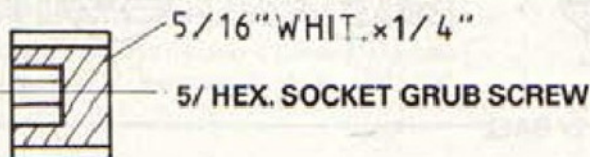
Take a short length of brass, about  $\frac{1}{8}$  inch



SPHERE  $\frac{1}{4}$ " DIA.

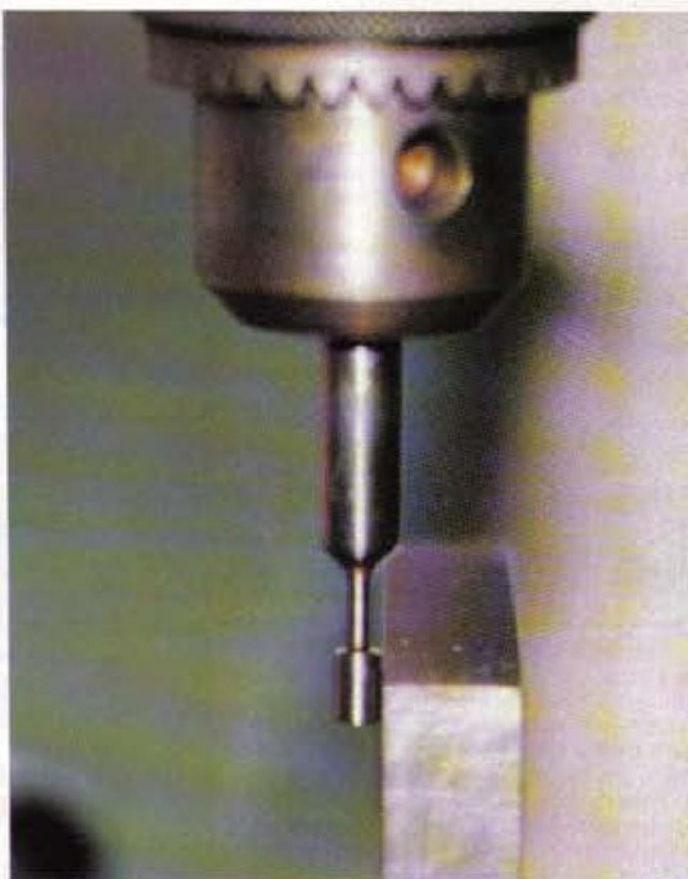
diameter, and mount it in the chuck so that about 1 inch protrudes. Face off the end and lightly centre-drill it, as a lead for a drill. Drill, with any drill less than  $\frac{1}{8}$  inch, to a depth of approximately  $\frac{1}{8}$  inch. Then open up the hole with a suitably prepared  $\frac{1}{8}$  inch drill. Try the ball in the hole and ideally it should protrude about  $\frac{1}{8}$  inch. If it goes in too far, face off the end of the metal until the correct result is obtained. Still in this same setting, lightly skim the outside diameter of the brass to ensure concentricity. Now part or saw off as close to the chuck as is reasonably convenient. Place the piece sawn off into the chuck the other way round and after facing off the end, turn the outside diameter down by about 0.010 inch to within  $\frac{1}{8}$  inch of the end which has been drilled. Remove the metal from the lathe and, using a hacksaw, cut two slots centrally and at 90 degrees to each other longitudinally in the end containing the hole to a depth of about  $\frac{1}{8}$  inch. You will then have a type of split collet which you can place in your chuck. When the chuck is tightened it will close on the end containing the hole and clamp the ball tightly without marking it.

With the ball mounted in either a collet



5/ HEX. SOCKET GRUB SCREW





or your specially made jig, face off a very small flat. This is so you can use a centre drill to mark the end, before drilling with a No. 43 drill to a depth of about  $\frac{1}{8}$  inch. Use a 68A taper tap mounted in the tailstock chuck to carefully tap the hole to a depth of  $\frac{1}{8}$  inch, finishing off with a plug tap. The ball will probably be fairly tough, so use plenty of cutting compound. The rehardening can be left to later, when you do the other necessary hardening.

As will be seen in the drawing, I used a  $\frac{1}{8}$  inch Whitworth grub screw by  $\frac{1}{2}$  inch long to seal the end of the body and put pressure onto the spring. If a suitable screw is not available, it is just as easy to cut a short length off of a  $\frac{1}{8}$  inch Whitworth bolt and, having faced off the sawn end, put in a screw driver slot, either with a slotting cutter or a hacksaw.

Silver steel was used for the parts of this tool, because it is so easy to harden and temper. I hardened the end of the body, where the ball sits, the large diameter of the wobble bar and the pressure pad, and I rehardened the ballbearing. It is necessary to reharden the ball and I certainly think that the large diameter of the wobble bar should be hardened, as in use it receives a lot of rubbing as it makes contact with the surface of metal. However, with the limited use this tool would get in a home workshop the pressure pad and body end could probably be left soft.

The body was heated at the one end to cherry red and quenched into oil. Similarly I did the same with the large end of the wobble bar. The pressure pad was strung on a piece of wire and heated throughout to cherry red before quenching. The ball bearing was heated in the same way as for the annealing, but this time it too was quenched in oil. I used old engine oil discarded from my car for the quenching. (Leave it uncovered for a few hours first so that any dissolved hydrocarbons will

**Top left:** Although the chuck appears stationary due to the use of flash, it was in fact turning. It can be seen how the run-out is decreasing as it nears the workpiece.

**Top right:** Here the wobble bar is now running true. **Right:** The components ready for assembly.



evaporate). This produced perfect results without subjecting the parts to the likelihood of cracking, as is often the case when silver steel is quenched in water.

The parts were then lightly polished, so that the colour produced by heat could clearly be seen. I then heated all the hardened components until they were a dark straw, before re-quenching in oil. This produced a surface that has stood up to many years of use without any apparent detriment. I finally polished all the components to remove the heating colour. The large diameter of the wobble bar was carefully stoned and polished until it was exactly 0.200 inch diameter.

### Assembly

The assembly is straightforward. First of all screw the silver steel part of the wobble bar into the ball. When I made my E.F. many years ago, I had never had any trouble with the components coming apart, but a small drop of Nutlock (Loctite 241), would not go

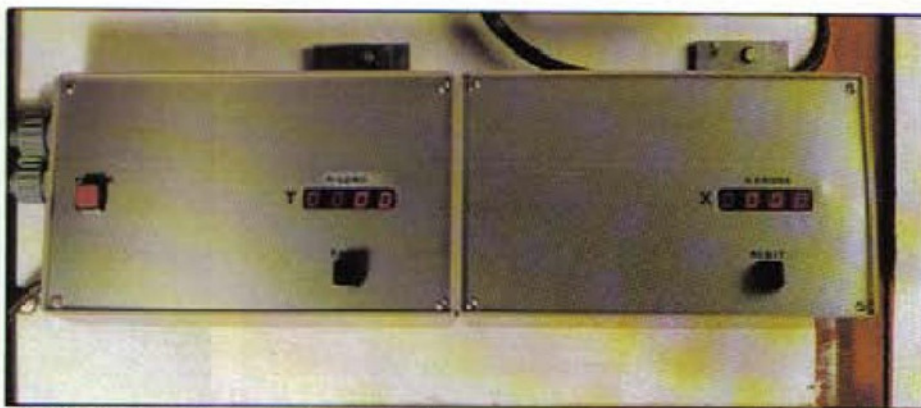
amiss if it is readily available. In fact on reflection, with modern locking components, it would probably be quite satisfactory to just drill the ball and make the small end of the wobble bar a push fit into it. It could then be assembled with Loctite 601, and would probably be quite serviceable.

A light compression spring, of just sufficient length to ensure that the pressure pad makes contact with the ball, is required. Do not use too much pressure or you will find the tool is not as sensitive as it should be. Lightly grease all the components before assembly. Push the large end of the wobble bar into the threaded end of the body and right out the other end until the ball sits on its seating. Insert the pressure pad, recessed end first, followed by the spring. Screw in the grub screw until it is just below the surface of the end of the body. Finally, wipe off any excess grease and your edge finder is ready for use.



**T**rying to operate a far eastern drill/mill with fixed index dials (and, even more infuriating, an 8 pitch lead screw) made me begin to have doubts about my purchase. The fixed dials I had anticipated, had raised the question with the suppliers and been prepared to accept, but the 8 pitch leadscrew was something I just had not contemplated.

Replacing the machine with a more acceptable version was out of the question if for no other reason than the difficulty of removing the machine and replacing it, due to its extreme weight, a factor which presents many with a problem as has been indicated in this magazine on a number of occasions (*Does anyone offer an installation service, at a charge of course? ED*)



*Finished unit; the two axis digital display.*

# DIGITAL READOUT

Not surprisingly, to modify the dials to be a friction fit was the first considered solution and one eventually undertaken in parallel with this exercise, but we would still have the dreaded 125 thou per revolution. Replacing the leadscrews seemed the obvious solution but this did not appeal, though looking back it would not have been all that difficult even though the longer leadscrew would have required to be made from more than one piece.

Another solution would be to fit a gear train between the leadscrew and the hand wheel, this requiring a ratio of 5:4 — not that difficult to achieve, but this did not appeal either, particularly as it would introduce additional backlash.

**For all but the few, a Digital Readout will be but a dream, being prohibitively expensive. In this multi-discipline item we have a demanding project, enabling one to be acquired at a fraction of the purchase price. This is the first part of a two-part article, but the details included will enable a substantial start to be made before publication of the concluding part in the next issue**

basically an electrical/electronic design engineer, one may have thought that this was the obvious answer to the problem, but electronics is a very diverse discipline and, if for no other reason, the thought of producing complex electronic circuits without the aid of purpose-designed

individual) that I came across a printed circuit board being sold to construct a four digit counter with a wide range of facilities — such as, count up and down, count hold, count reset to zero, decimal point and many others. Also available in similar form was a power supply printed circuit board that would be suitable for the five volt DC supply that would be required. The idea was now well and truly resurrected.

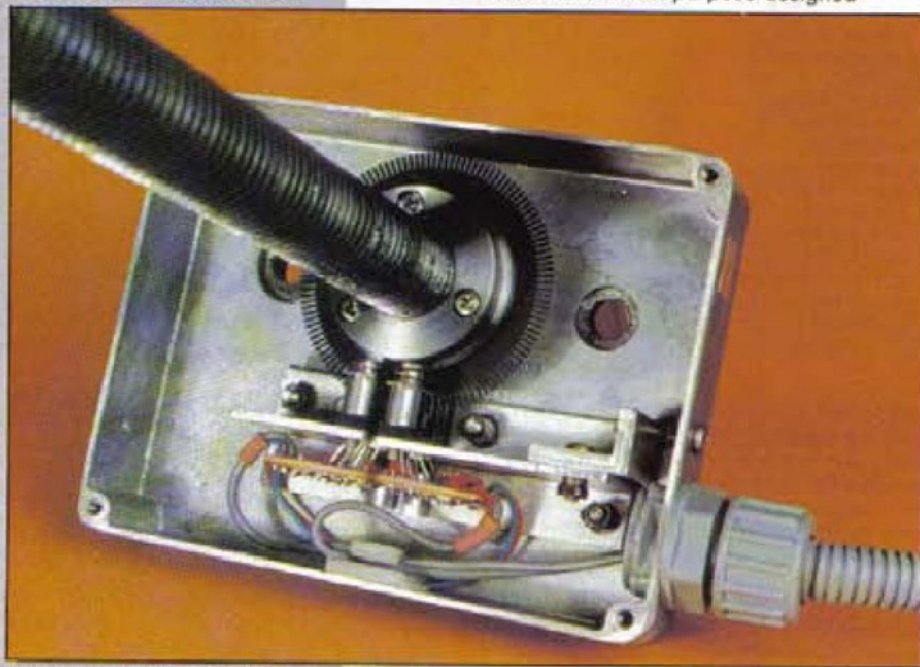
I was subsequently to learn that I would require a special circuit to complete the unit satisfactorily which had to be made from a general purpose board, though this presented no real problem as it was a quite simple addition.

Now being confident that a display could be constructed, one more major hurdle was still left to be overcome, this being that pulses would require to be generated with movement of the slides.

The counter would obviously require to count in one thou steps (or other if metric) and would require, as a result, at least one pulse per thou, though two or four (or more) could be accommodated using a divide by two or a divide by four circuit (not difficult to achieve). With sufficient pulses a conversion circuit could even be established and the display could then be made to read both imperial and metric — a nice idea but the project was still looking complex enough without this added complication!

Two basic possibilities for achieving the pulses are available, each with their own variations. The method which has the real advantages is to mount two linear encoders one on each axis and to take from these the required pulses to drive the counter.

This method has two very definite advantages: first it has no backlash and therefore can display correct readings when travelling in either direction during the same machining operation, and it is independent of any errors in the leadscrew. It is also probably easier to mount.



*The cross feed pulse generator assembly.*

Considering that a more professional solution should be sought, I started to think along the lines of a digital readout. A mechanical version was a possibility and they had appeared on micrometers at one time and maybe other items of equipment as well though I have no knowledge of this. The only practical digital solution would be an electronic version.

Working in a highly electronic design and manufacturing organization and being

printed circuit boards to assemble them onto was not one I relished. So this idea, and also the project as a whole, was shelved.

## The display solution

At some later date it was whilst looking through the catalogue of a well known supplier of electronic components to industry (and now also to the private



With this method in mind and after a few short flights of fantasy which I will not go into fully, considering methods of making them myself, it was very soon realized that, other than to purchase these encoders at a very high price, it was an impracticable solution. I quickly concluded any thoughts of this approach.

It remained therefore only to mount a rotary encoder on the leadscrew but these would also be expensive to purchase and not a viable solution.

However, using a proprietary item was also considered a non-starter as due to its size, about 3 inch diameter by 3 inches long plus drive shaft, they would be very difficult to mount.

the same direction, during any one machining sequence, but as far as the second limitation, the leadscrew was found to be very accurate and was not therefore a problem. In use, it would be equal to using the leadscrew dials, but without the need for constant calculations.

The final design arrived at consisted of two digital four digit counters reading up to a maximum of 9.999 inches. One was used to indicate the movement of the table in one direction and the second display movement in the other, no display being made for the downfeed.

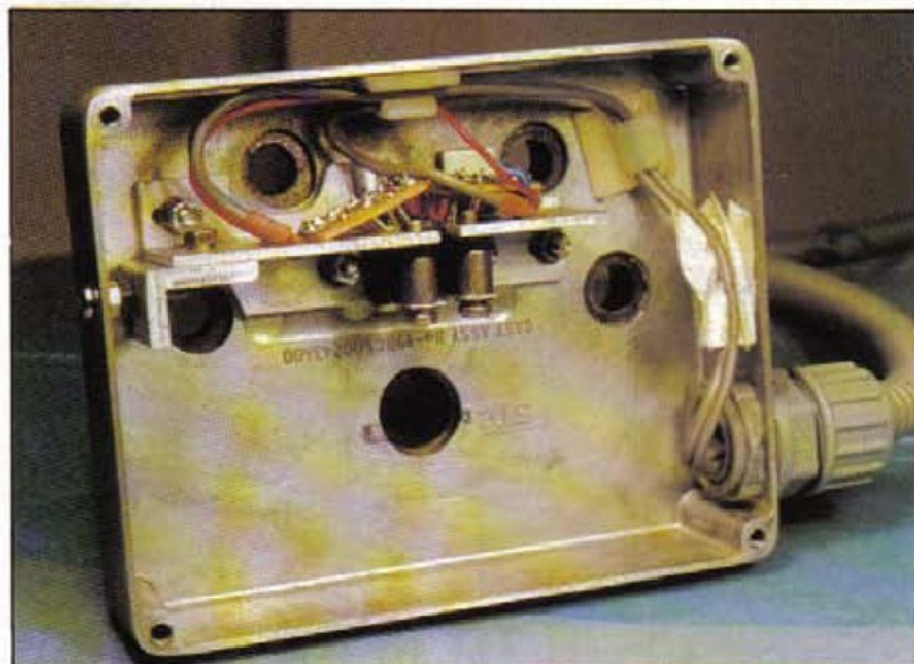
The counter will zero on reaching 10.000 and start counting up again so will still be satisfactory on the rare occasion when the

## General principles

With much electronic equipment, even to the highly qualified electronic engineer, items are considered as building bricks and no attempt is made to understand the working of the internal circuitry. In this respect no attempt is being made to elaborate on the display-cum-counter circuits.

Whilst these are to be made from individual components, if built with care there is no reason to expect any trouble — in any case, having two identical units makes for easier testing as it is unlikely that both will fail, and in the case of a fault the two units can then be compared and critical components such as the integrated circuits can be interchanged. For this reason it is proposed that these are fitted into sockets to permit easy interchange, but much more about this later.

Therefore ignoring the innermost workings of the individual assemblies let us consider the operation of the complete system. This is of particular importance, surprisingly, with the mechanics of the pulse generators, for without this understanding it may be difficult to get the unit working as a system even though tests on the individual sections show them to be working correctly.



*The table feed screw pulse generator assembly; do take care when fitting unit to machine to avoid trapped cable and route latter accordingly.*

## The pulse generator solution

Again observed in the previously mentioned supplier's catalogue a small slotted opto switch comprising infra-red transmitter and receiver complete with Schmitt trigger logic (more about that later) at the cost of around four pounds. Two would be required for each axis, and with this being available it was considered practical to construct one's own encoder directly into the machine.

With all these decisions having been made, and it now being considered practical to proceed with confidence, some purchases of components were made, and whilst it was subsequently found that no major errors of judgment had been made up to this point, some very interesting factors were still to be resolved.

## The final specification

Having now established the basic design it is worth considering its limitations, as these do have some bearing on certain aspects of the results subsequently achieved.

The main limitation in use of this display is that, as the pulses are derived from a device mounted on the leadscrew, it will not be able to compensate for backlash in the system. It will also be subject to any errors in the leadscrew itself.

As a result of the first, all readings will have to be taken with the table moving in

table is used over 10 inches. Each display is mounted in its own box and has its own reset button; this enables the count to be zeroed individually as required.

A single 5 volt supply is mounted in one box and is used to power both displays. A mains voltage transformer is included with the power supply which permits the unit to be powered from the mains; a switch is mounted on the front panel to switch the equipment on and off.

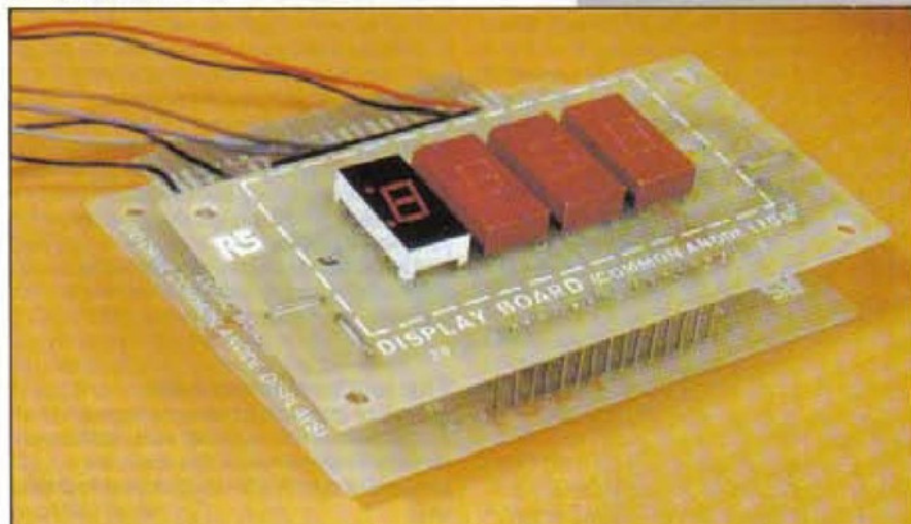
## QUICK TIP

The following are taken from *The Model Engineer and Practical Electrician*, February 12 1931. To Harden and Temper Small Flat Drills up to 1/2 inch, make your drill out of a needle, knitting needle or piece of silver-steel (drill rod) by forging, filing or grinding. Get it bright red in a Bunsen or spirit flame and, at once, plunge it into a raw potato until cold; it will be found beautifully hardened and tempered.

## Scribers

A steel scriber marks well on chalked or whitened metals, but on cast-iron or a black oxide surface a brass scriber leaves a first-class mark without any chalking.

From Calgary Model Engineering Society Newsletter No. 27



*The counter display assembly; there is no significance in the differing colour display.*



## The counter requirements and facilities

The connections to the counter are surprisingly simple being as follows; also detailed is the purpose each connection serves. These can be seen in the display unit wiring diagram, which will be published in the concluding part of this article in the next issue.

### 5V+ and 0V

These are the power input rails to the electronics and also to the seven-segment display devices.

### ZERO SUP

Some counters used to count in whole numbers would not require leading zeros to be displayed, but by connecting this terminal to 0V, leading zeros will be

voltage. More about this later.

### UP/DOWN

This terminal determines whether, as a result of the pulse received as indicated above, the display counts up or down. With the terminal at or near 0V the count will be down, and if the terminal is at or near supply voltage the count will be up.

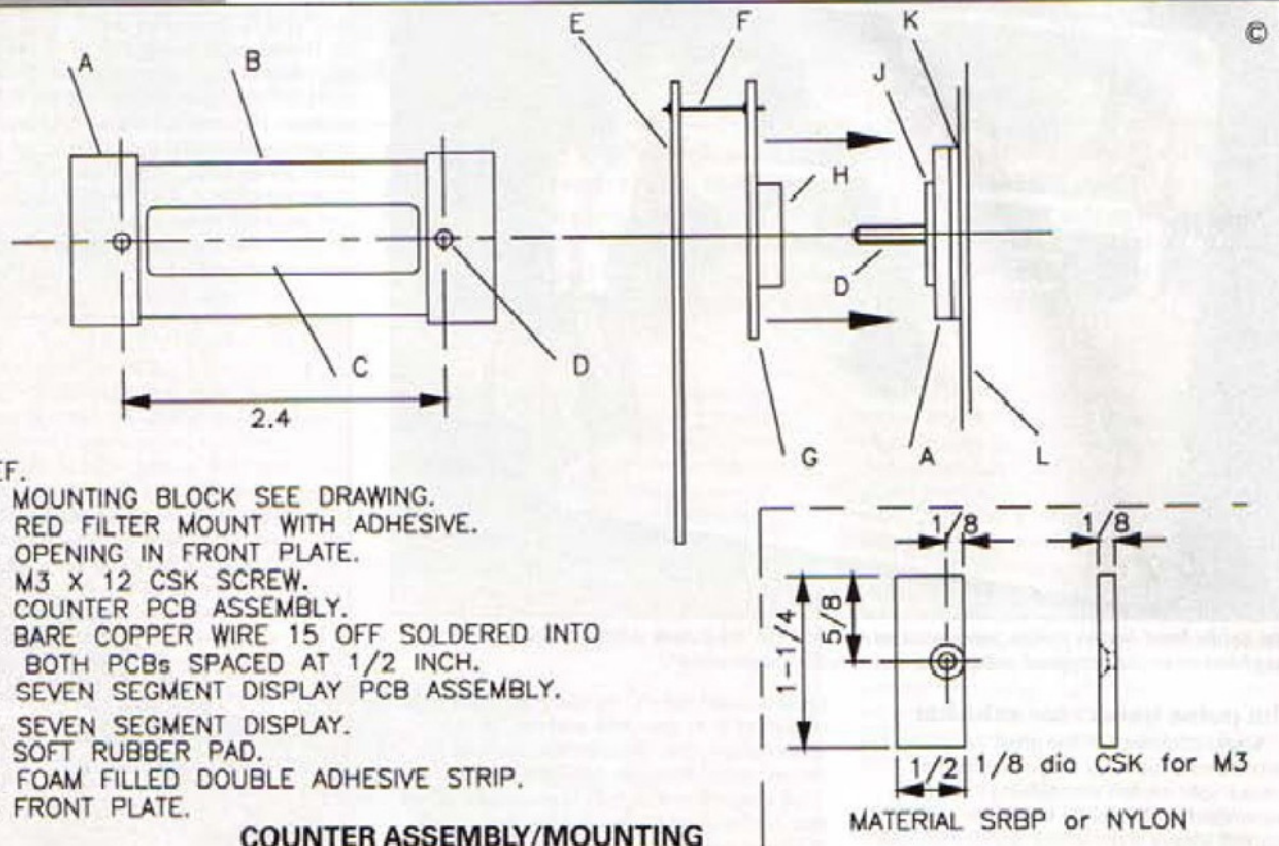
From this it can be seen that, in addition to the expected count pulses, we require a direction signal. This could simply be obtained with a switch, but this would not be practicable as one failure to operate the switch would result in errors in readings which would be difficult to correct. The method for obtaining this signal will be described later.

The counter unit also has many other

determines the pulses will require 100 slots for a 10 pitch leadscrew and 125 for an 8 pitch leadscrew. Each opto switch contains a light source on one side and a detector on the other; both use the same disc.

The detector includes a small integrated circuit which contains on it a Schmitt trigger. This trigger ensures that the signal derived from the detector, due to the rotation of the disc gradually obscuring the beam of light, is converted from a gradually increasing and decreasing voltage (approximately a sine wave), to a sharp edged pulse much more satisfactory for counting purposes.

From the diagram for the pulse unit it can be seen that the device has five terminals and the duty of these are as



COUNTER ASSEMBLY/MOUNTING

displayed as is required for this application.

### Dp 0.000

The counter being used to display decimal quantities, it requires a decimal point. By connecting this terminal to 0V the decimal point will be displayed permanently between the first and second digits.

### RESET

When moving the machine table to a known position it will be preferable — in most instances though not all — to zero the reading and move on to the next position from a zero display, thus avoiding the need for calculations and possible errors as a result, this being a major advantage of this electronic digital display.

To achieve this zero facility, this terminal is connected to 0V via a pushbutton, so that when the button is pressed connecting the terminal to 0V the display is zeroed.

### COUNT I/P

This terminal requires one pulse to cause the display to increment by one; the count actually counts on the leading edge of the pulse, that is when it rises from a near zero voltage to almost power supply

facilities, most of which are not appropriate to this application but there are two that may be of interest to those who like lots of buttons to press. First is a test to see if all segments of the displays are working; with this pressed all segments light up and the unit reads 8888. This would highlight potential for errors, say if the centre segment had failed an eight would read as zero. The second is an input via a push button which would inhibit the count whilst the table was moving and may be of use in some cases but I have not thought of one yet. (Any suggestions?)

These facilities and others are fully detailed in a data sheet free from the supplier.

## The leadscrew encoder

In view of the need for direction sensing as well as pulses for counting, each leadscrew encoder requires two pulse units, the purpose of which will be explained in detail later.

The small units as purchased can be seen in the photographs and the disc which

follows: Two are the power input to the light source which at 5V requires a resistor in series, two are for the power input to the detector and Schmitt trigger, and the fifth is the pulse output.

By including the resistor on a small piece of stripboard with the opto switch the number of leads to the unit can be limited to three, being +5V, 0V and pulse. This can be seen in the circuit diagram.

There is one other unexpected requirement with regard to this unit for which, after much difficulty, the solution was discovered. As it turned out it was also then the obvious answer and was found to be the way professional encoders are arranged.

This condition is best understood if we consider an encoder required to give a large number of pulses, say 1000 pulses per rev, in this case and, as the pulse wheel is likely to be, say, two inches in diameter, the total width of one tooth plus one space will only be about 6 thou. It is obvious that the light beam will be much wider than this, say at least 50 thou, and in this condition 8 segments will always be in the



light beam at any one time. As one segment leaves on one side another will be arriving on the other and, as a result, the receiver portion of the opto switch will see only minute changes in light intensity, and will therefore not function.

The answer to overcome this situation is to include in the lightbeam a stationary grid equal to a small portion of the disc being used. When this is done the light source will vary between 50% obscured when the segments on both the wheel and the stationary grid are in line and 100% obscured when the segment on one line up with the space on the other as the disc rotates.

It is interesting to note at this stage that, as a result of this procedure, the number of pulses per revolution is limited only by the ability to produce that number of segments on a suitable disc, and well over 1000 pulses per rev are easily achieved, the most popular method being to produce these photographically on a glass disc. As this method was not available, the disc was produced by cutting slots but more about that when we discuss the manufacture.

If the number of pulses were small, then the width of a segment will be sufficient to obscure the beam totally on its own and no additional grid will be required. The size of the segment in this assembly is a borderline case (probably the reason why I was so confused, initially, using only handcut linear combs for testing), and a single slot equal to the width of a tooth will suffice.

## Pulse and direction shaping circuits

Above we have indicated the need to generate a direction indicating signal; unfortunately this is not available in the form of a purpose-designed printed circuit board, and requires to be constructed on a piece of general-purpose stripboard. The circuit is not very complex and presents little problem this way.

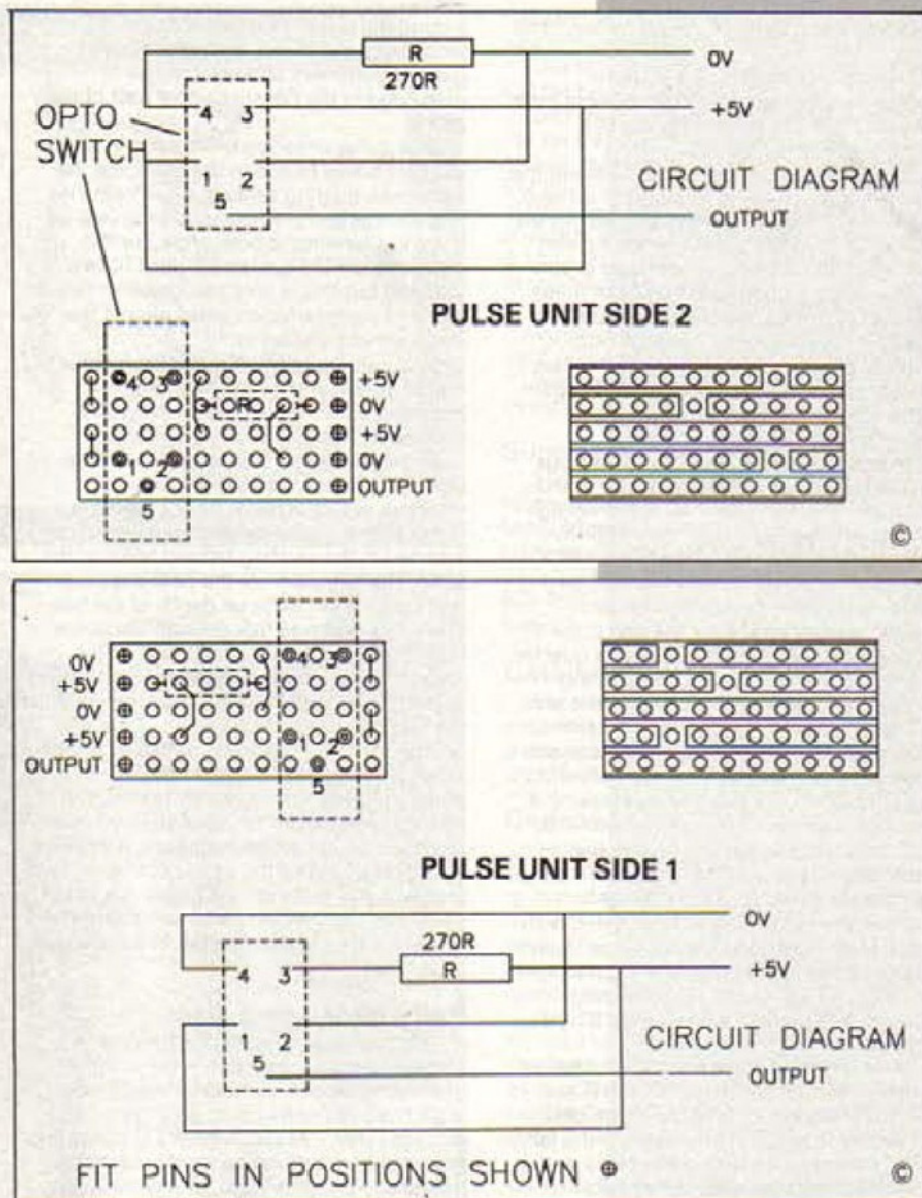
Before proceeding with the actual method employed it is worth discussing one method which could have been used to avoid the additional assembly and to sound a word of warning to anyone considering mechanical switches as an alternative.

## Mechanical pulse switches — a warning

Considering first the question of using mechanical switches to replace the opto switches, be warned that this is not practical. Without going into the method of achieving 125 pulses per revolution which, given the ability of many of our readers would not be a problem, the result would be a failure unless some suitable filter network were designed, so we would be back to the electronics albeit using passive components (resistors/capacitors). The reason for this failure is that mechanical switches tend to bounce on making and what may appear as one pulse would be seen by the much faster electronics as many more. Even using switches to test the counters in the first place is not worthwhile.

## Alternative to pulse shaping circuit

Now to consider a method of eliminating the pulse and shaping circuits that would be totally viable, and of benefit



to those wishing to minimize the electronic content of the system.

The system would still require a pulse wheel complete with an opto switch to create the count pulses which could be fed direct to the counter assembly. The direction signal would be obtained from a second opto switch but this time not looking at the pulse wheel but at a flag. This would be friction fitted to the leadscrew shaft and for its rotation limited to a fraction of a degree by mechanical stops.

Tests on the opto switches when originally supplied were carried out with a single flag, the purpose of which at the time was to determine the ON/OFF differential, to be aware of any possibility that vibration may cause additional pulses. This was considered unlikely but it is better to be warned if this were a possibility.

The tests revealed that this was unlikely but even so the differential was much smaller than anticipated, being between 1/2 and 2 thou. Tested with a single flag, the movement of which was monitored by a dial indicator, the flag was fed in until the output switched and then reversed back until it reverted. This took place within a two thou range.

Therefore it can be seen that the movement of a friction driven flag could be

limited to a very small amount, 5 to 10 thou would have an adequate safety margin and would be more than adequate, this being between 1/600 and 1/1200 of a revolution — more than adequate to indicate direction of rotation.

With this achieved the output would be fed direct to the up/down terminal and, as a result, with the pulse and direction shaping circuits eliminated, the success of this would rest wholly on the reliability of the friction driven flag. This should not really be a problem (if anyone adopts this method I would be pleased to hear from them. ED).

## The method employed

Returning now to the method employed, it is not intended to fully explain the workings of this circuit in detail but if the diagrams are followed with care they should not fail to work. Again there are two identical circuits which will help with fault finding if necessary, but as this is not a proprietary unit the circuit diagram is published with this article.

An extension to this circuit permits pulse multiplication of either by times two or by times four; this was of no practicable use in the prototype with 125 not being divisible by either four or two. For those requiring 100 pulses this additional circuitry



would permit a 25 or 50 segment disc to be used.

The circuit is not published but a stamped addressed envelope will acquire a copy; this will not include details of a suitable stripboard layout.

It is necessary though to understand the results the assembly is required to achieve. The unit will receive the two pulsed signals 'A' and 'B' from the pulse unit on a given leadscrew, there being an identical circuit for the second leadscrew, and from these two sets of pulses to generate a 'count' pulse and the 'up/down' voltage output; this only changes from high to low when the leadscrew reverses and similarly again in the other direction from low to high when the direction changes back.

To make this possible the pulses from the leadscrew have to be precisely timed, and it can be observed from the drawings and the photographs that one of the two opto switches is mounted with a small leadscrew to adjust its position and, as a result, to achieve the timing required.

The requirement is for the one pulse to be displaced from the other by one quarter of one cycle, and is best left for setting during the final commissioning of the unit. This arrangement has one other major advantage, being that of adjusting the one pulse to be in front or behind the other, so changing direction of count and making it possible to achieve the count direction to conform to that as established by the leadscrew dials without the need for interchanging internal connections.

From the pulse diagrams included with this article it can be seen that pulse 'A' will go high when pulse 'B' is low for one direction, whilst for the other direction pulse 'A' will go high when pulse 'B' is also high.

If we return to the requirement detailed earlier in the article for the 'COUNT' and 'UP/DOWN' signals, it would seem only necessary to connect one pulse to the UP/DOWN terminal and the other pulse to the COUNT terminal to achieve the two direction counting required. This unfortunately is not so, as whilst the up/down signal is in the correct state when the count pulse rises (counts on leading edge of pulse), this does not work as the direction signal requires to be a constant low or high and not a pulsed signal (for reasons we will not attempt to describe here.)

Because of this, the additional circuit as mentioned above is required to achieve the signals in the form to suit the counter assembly.

### The power supply

The remaining item of electronic equipment to be considered is the relatively simple power supply; for those who would prefer the unit not to be connected to the mains this could be replaced by batteries. The voltage is not critical but should not start lower than 5V — a 6V battery would be ideal.

The power supply again uses a printed circuit board designed for this purpose and a data sheet is available, but in this case is rather general, and because of this the circuit diagram is published with this article.

### The mechanics

The mechanics present a number of interesting requirements, these being solely

around the pulse generators; the mechanics of the display units require no general comment and will only be discussed in the constructional part of the article.

The pulse units were mounted in small die-cast boxes between the table and the leadscrew bearing casting, there being no real alternative for the longitudinal axis as there is a bearing at both ends. For the other motion the leadscrew does have a free end but this is very inaccessible. See the photographs for an initial idea of the arrangement arrived at.

Without doubt the biggest problem is one of space, and as the bearings are mounted differently on each screw the problem has to be resolved twice!

Firstly the space has to be created to permit the small die-cast box to be inserted, and to achieve this posts were made with a male thread at one end and inserted in the existing tapped holes in the table. The extension of the post should be just longer than the total depth of the box. The outer end was tapped with the same thread and the bearing mounted on the ends of these posts using the same screws as originally used to fit the bearing direct to the table.

The box then has to be drilled to permit these posts to pass through, the result being that they then severely restrict the space inside for the fitting of the two opto switches. Again the photographs will give a good initial idea of the extent of the problem. Not done on the prototype but of benefit maybe, would be to waist some of the posts thus increasing the internal space available.

### Pulse generating discs

It is now time to consider the one remaining major problem — the pulse generating disc. A number of methods were tried but none could give the accuracy that was required. If a single pulse was required then any error would only marginally bring forward, or alternatively delay, the count by a fraction of a thou — but this would rarely be a problem. But in this application as has been indicated earlier in the article, two pulses are required separated by  $\frac{1}{4}$  of a cycle, and as the opto switches have to be mounted some distance apart around the disc any localized error will be seen by one opto switch but not the other, resulting in the fraction of a cycle differential between them varying as the disc rotates. This cannot be tolerated as it can cause the counter to make individual counts in the wrong direction.

Those with access to a computer aided printed circuit design facility may like to produce the disc photographically but take note: the taped method of producing artwork will not be sufficiently accurate even if drawn more than the normal twice full-size.

The disc was eventually produced by cutting slots round an aluminium disc.

### Manufacturing order

I consider that any reader contemplating making this digital readout, particularly those for whom electronics is a borderline activity, would start by making a display unit and test this with an opto switch just resting on the test bench, using a piece of card to break the beam to create the pulses. In this event construction of the machine-

mounted opto switch unit must be established as being possible before purchase of expensive items of electronic equipment is undertaken and much time is spent in construction of the display units.

On this basis the remainder of this article will cover the following, and in the order indicated:

1. Purchase of all materials.
2. Making and testing all the individual electronic assemblies, except the power supply.
3. Packaging the complete display unit, including making the power supply.
4. Extending the leadscrew and making other provisions for fitting the pulse generator units.
5. Making the pulse generator units and testing the whole assembly on the bench.
6. Finally, installation of the pulse generators onto the machine and the display unit to its final location interconnecting these assemblies and final testing.

Items 3 to 6 will be covered in section 2 of this article to be included in the next issue.

### Data sheets

Data sheets are available for some items, and those for the counter/display printed circuit, power supply and opto switch should be considered essential reading for those making this unit. Details of these and where to obtain them can be found with the parts lists. They can be obtained free of charge and in advance of ordering the components if required.

### Materials

The materials lists included indicate the parts that are required and a possible source of supply; almost all the components are generally available, and could be purchased from a wide range of suppliers. The only exception to this is the printed circuits for both the counter/display assembly and the power supply. In the case of the latter this is so simple it could easily be constructed on a piece of stripboard.

Whilst two of the suppliers are predominantly suppliers to industry they will supply to individuals, also accepting phone orders using credit cards. As far as is practicable for a given assembly all major components come from one source; this will make it easier for those wishing to make one assembly at a time and to obtain the parts similarly.

### The parts lists

For ease of understanding, the parts list is broken down into separate lists for individual assemblies as follows:

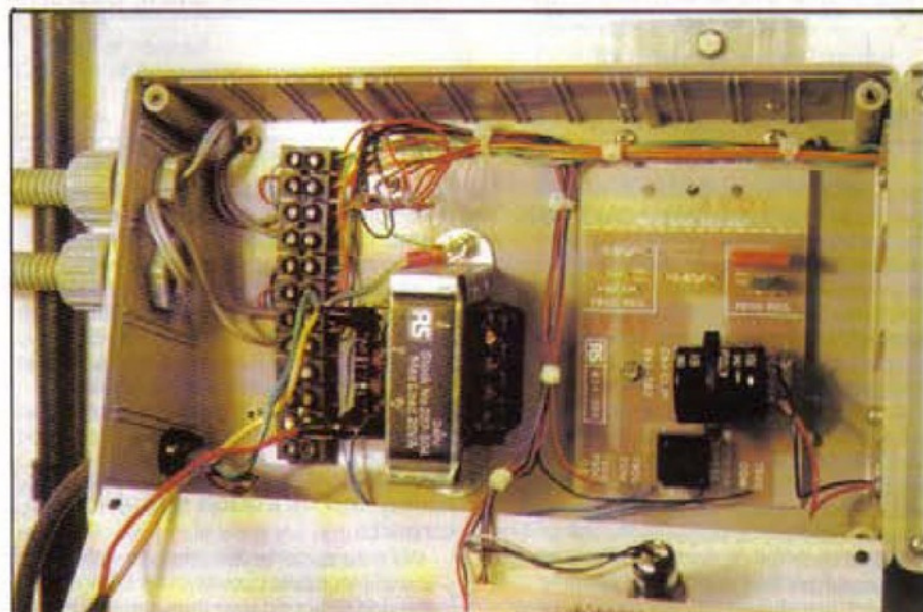
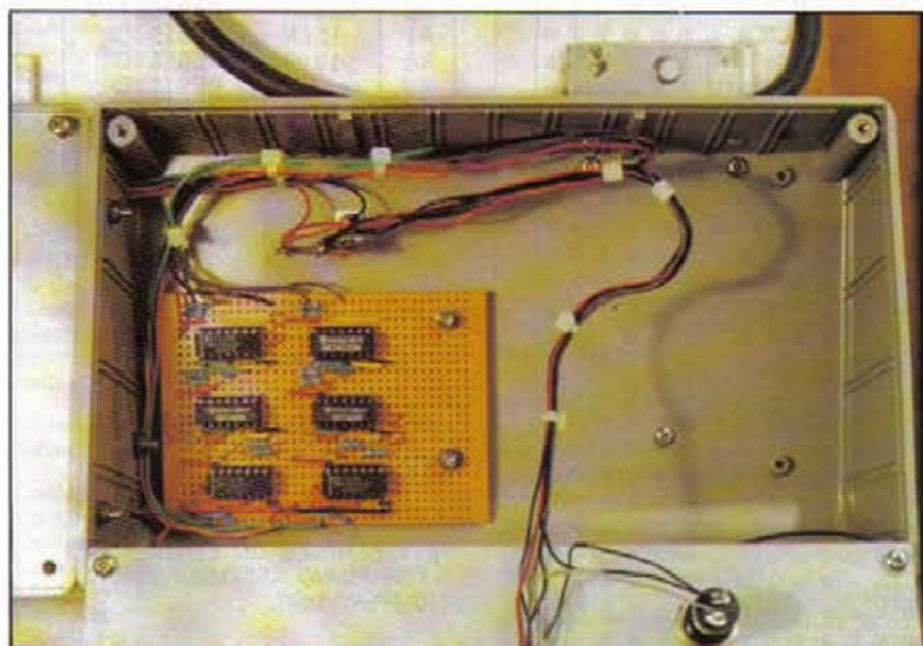
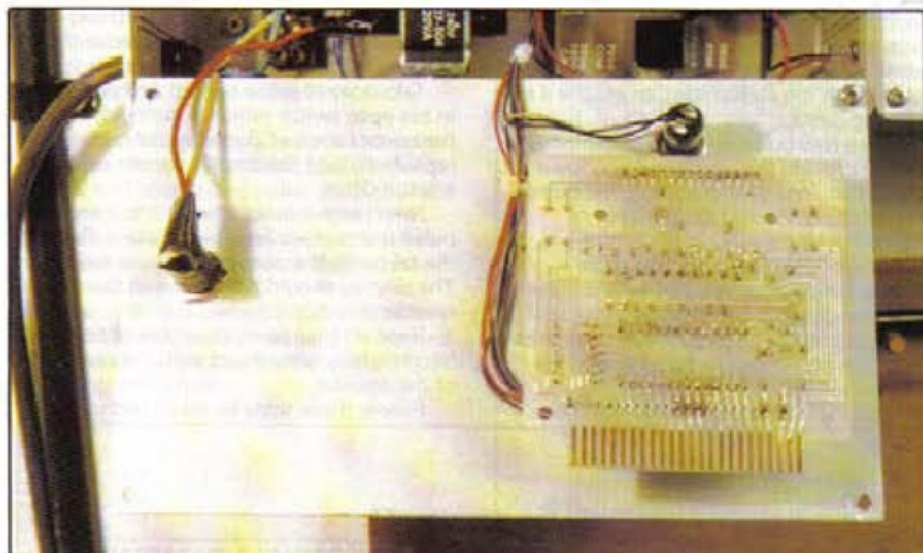
- a. Counter assemblies.
- b. Power Supply assembly.
- c. Pulse and Direction Shaping circuits.
- d. Enclosure, Switching and general Hardware.
- e. Pulse Generator Assembly.
- f. Interconnecting Counters and Pulse Generators.

The following notes relating to the parts lists will ease their understanding and should be read carefully to ensure the correct quantities are ordered.

### Parts list notes

**General:** Where quantity to be purchased is in excess of quantity required this is due to supplier having a minimum quantity for that part. The quantities quoted are total quantity





*Top: The rear view of the front plate; counter/display assembly is on the right hand side.*

*Centre: Inside the right hand box. The strip board arrangement differs slightly from that detailed in the article.*

*Above: Inside the left hand box. This illustration shows the mains transformer and power supply assembly. We'll be providing full theory and construction details on this aspect of the project in the final part of this feature in the next issue.*

- required and do not require doubling where two assemblies are to be made.
1. Data sheet number 2848 is available from EM for this assembly.
  2. Data sheet number 6610 is available from EM for this assembly.
  3. Data sheet number 4276 is available from EM for this part.
  4. Uses parts surplus from the pulse and direction shaping circuits parts lists.
  5. Uses parts surplus from the counter assemblies list.
  6. Order sufficient cable for a total of two runs between the counter assembly and each pulse unit mounted on the machine.
  7. Uses parts surplus from the pulse and direction shaping circuits parts list.

### Suppliers

EM: **Electromail**, PO Box 33, Corby, Northants NN17 9EL. Tel 0536 204555.  
 MAP: **Maplin Electronics**, PO Box 3, Rayleigh, Essex SS6 8LR. Tel 0702 552911  
 STC: **STC Electronics Distribution**, PO Box 555, Harlow, Essex CM20 2RY. Tel 0279 626777

### Catalogues

Catalogues are available from all three suppliers though a charge of about two to three pounds will be made by Electromail and Maplin.

### Construction

Those conversant with electronic production and theory could now proceed to manufacture the complete electronic package, but for the majority I would advise that manufacture is carried out in stages, testing each module as it is completed.

Those who fall in this category would be advised to read the article in this issue relating to electronic components, assembly and testing; this is most certainly not the time to work on the basis of IF ALL ELSE FAILS READ THE INSTRUCTIONS!

### Check and divide components into groups

First check the materials received to see if they are correct as ordered. Having done this, locate a number of small boxes and divide the materials into these in accordance with the parts lists published. Label each box with the name of the module for which it contains the parts; where there is more than one module of the same type, have a box for each individual unit. One exception to this rule would be the integrated circuits and these are best put to one side, as being fitted into sockets they can be installed at the last moment which is preferable due to their susceptibility to static electricity.

These precautions will considerably ease the assembly stages, as modules can be assembled without the need for parts to be sorted at the same time. This will greatly reduce the possibility of parts being incorrectly positioned and/or parts not fitted, and thereby the need for unnecessary fault finding. It cannot be stressed too greatly that the most probable cause for failure to work on completion of assembly will be poor soldering, or incorrectly positioned or missing components.

### Where to start

It may be considered the obvious order of assembly to start with the power supply so that this was available for powering the



remainder of modules as they are completed. This would require to be built into a temporary enclosure in view of the presence of mains voltages, but a greater reason for not starting with the power supply is that interference can be caused with sensitive electronics from simple mains generated power supplies, and testing modules powered by a battery will eliminate this possibility. Modules first tested and proven correct when powered by a battery will highlight the fault as power supply-created if they appear only when fed in this manner.

For this reason, first obtain a 6 volt battery (4 D size batteries in series would suffice.)

the limited space available. This can be observed in the photographs showing that in one case the stripboard is not at right angles with the switch itself to enable it to clear the posts.

These two pulse assemblies can now be used to provide the count and up/down signals required by the counter, the pulse and direction shaping circuits are not required at this stage.

Connect the power supply to the counter assembly and also the two pulse units; the drawing shows each pulse unit having two sets of power supply terminals which are connected together inside the unit and, as a result, the supply only requires to be connected to one of these.

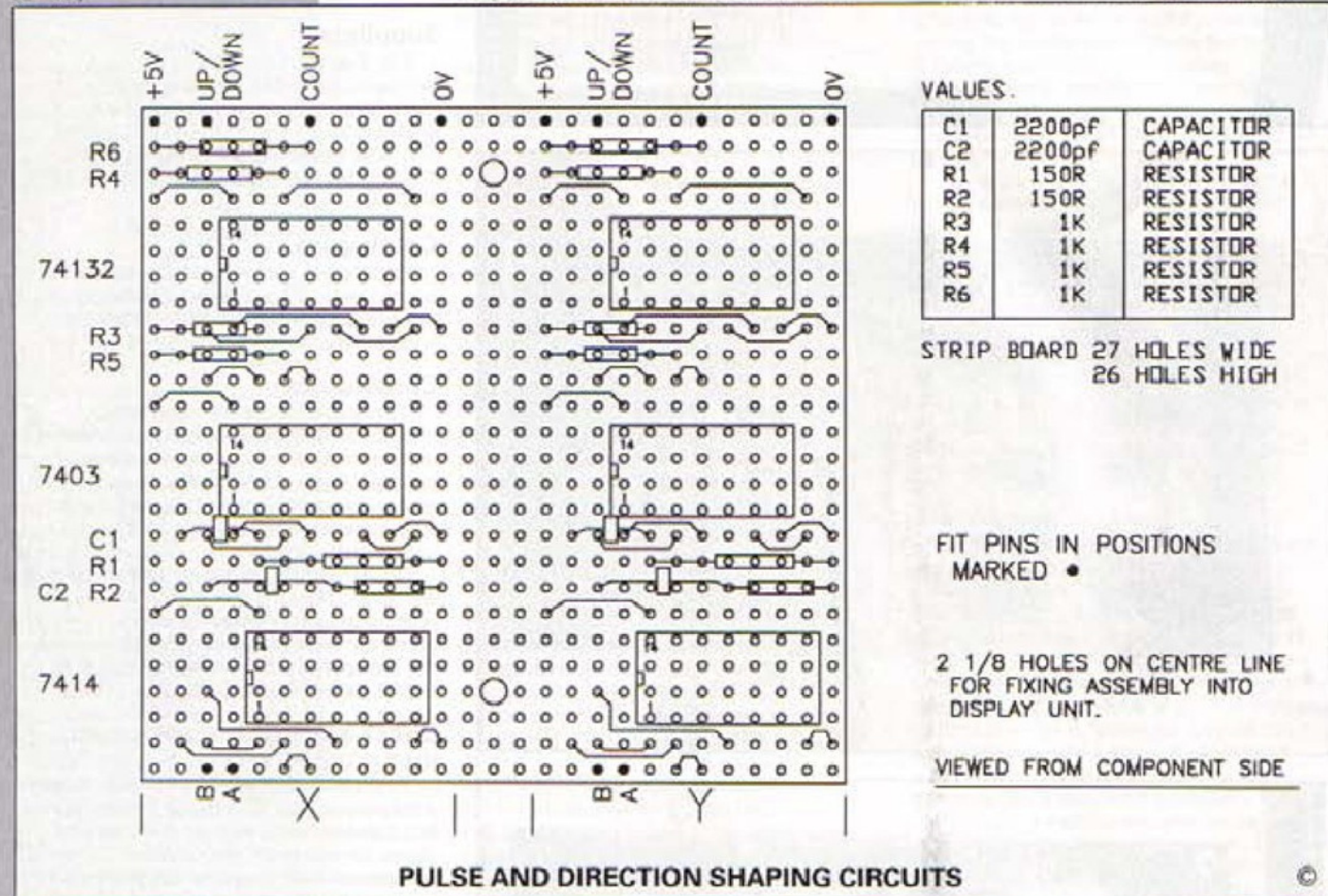
onto the terminal marked LAMP TEST. The display should read 8888 (1). Remove the wire and all lamps should extinguish.

Take a small piece of card and place this in the opto switch which is connected to the count terminal. Remove and replace repeatedly and the display should count as a result (2).

Now place a piece of card into the other pulse unit and leaving it in position. Repeat the test with the card in the count switch. The display should now count in the reverse direction (3).

Repeat these tests a number of times to become fully conversant with the operation of the counter.

Follow these tests by again taking the



## Display and opto switch assemblies

First assemble one counter printed circuit assembly plus one display printed circuit assembly and carry out the visual checks recommended in the accompanying article before connecting these two assemblies together using bare copper wire as indicated in the assembly drawing (and as seen in the photograph.)

It will be found that the display PCB appears to require a 16 pin seven-segment display; this is not so — at least not for this arrangement. The 14 pin package goes in the 14 holes farthest from the interconnecting wires.

Now construct two pulse units, one side one and one side two as shown in the appropriate drawings; again visually inspect before proceeding to test.

Do solder the opto switches into the small portion of stripboard on the extreme end of their leads, as in this case the assembly may require some adjustment on final assembly to enable it to be inserted in

The purpose of the two sets will become obvious on final assembly but TAKE NOTE that the polarity of the power supply terminals are reversed on the side one pulse unit relative to the side two unit.

For convenience and to conserve the batteries, a switch should be connected into the positive battery supply lead for switching the power on and off.

Connect also the output from one pulse unit to the COUNT terminal and the output from the other to the UP/DOWN terminal. The terminals for decimal point, leading zeros and count reset can be left disconnected at this stage.

In this description, for simplicity, each stage assumes that the desired result is achieved, but should this not be so for any test, consult the fault finding chart listed elsewhere in this article; the numbers in brackets cross-refer.

Switch on the power supply and take a length of wire. Remove a short length of insulation from each end, hold one end onto the zero volt terminal and the other

short length of wire and holding one end to the zero volt terminal and the other onto the terminal marked zero sup. All the leading zeros should display (4). Then connect it to the terminal marked DP 0.000 when a decimal point should appear between the first and second digit (5).

With the first display functioning, follow this by assembling the second together with the second set of pulse units and repeating the tests until two satisfactory sets have been established.

## Pulse and direction shaping circuits

We now come to the other complex piece of electronic circuitry, this being the pulse and direction shaping circuits. These are assembled onto general-purpose stripboard and it would be advisable to return to the article on electronic assembly and read again carefully the section on the use of stripboard (often called Vero board after the company which probably first introduced it).



Again there are two identical circuits but this time assembled onto a single piece of stripboard. Even so, it would be preferable to assemble and test one half before the other.

Connect the power rails again using the switch, to the terminals indicated as -5V and 0V and also to two pulse units as in the previous tests. Connect the output from one pulse unit to terminal A and the other pulse unit output to terminal marked B and switch on.

Now, with two pieces of card, simulate the signals which will eventually be created by the pulse wheel by observing the following sequence:

Card in A  
Card in B  
Card out of A  
Card out of B  
Card in A  
Card in B  
Card out of A  
Card out of B  
Card in A  
Card in B  
Card out of A  
Card out of B: continue repeating this as is required to observe the operation of the shaping circuit.

The COUNT output should give one pulse for each complete cycle whilst the UP/DOWN output should remain constant (6). Do use a digital meter to observe these output conditions (the reason for using a digital meter is explained in the accompanying article dealing with fault finding.)

Follow this by simulating a reversal as follows:

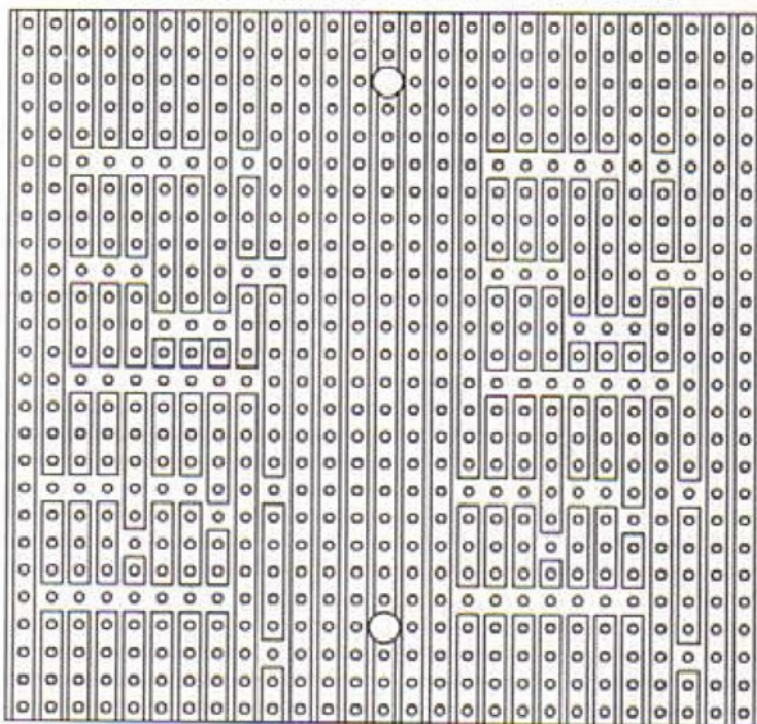
Card in A  
Card in B  
Card out of A  
Card out of B  
Card in A  
Card in B  
Card out of A  
Card out of B  
Card in A  
Point of reversal  
Card out of A  
Card in B  
Card in A  
Card out of B  
Card out of A  
Card in B and so on.

During this test, the UP/DOWN signal should be seen to change either from low to high, or from high to low depending on the simulated direction (7). These conditions can easily be seen by referring to the pulse diagrams shown.

Should these tests be required to be carried out a number of times due to problems requiring solving, it would be a good idea to construct a simple pulse wheel assembly, say with 6 segments to a disc, and running this on a spindle between two V blocks, positioning the opto switches approximately to achieve the required 1/2 cycle difference. In any case, this is so simple to carry out that it is a nice thing to do as it will ease testing, and will be beneficial when next testing complete with the display units.

Having completed the first circuit satisfactorily, proceed to assemble and test the second onto the same piece of stripboard.

## PULSE AND DIRECTION SHAPING CIRCUITS



VIEWED ON TRACKWORK SIDE.

CUT TRACK IN POSITIONS SHOWN USING SMALL HAND HELD DRILL BIT AS EXPLAINED IN TEXT.

### Testing the complete set of units made

The output from the count terminal on the shaping board can now be connected to count input terminal on one of the display units and similarly the up/down terminal on the shaping board to the up/down terminal on the display unit. With the power rails also connected, a complete system can now be tested, proving that it will now count up and down.

There remains just one facility to test, this, being the reset to zero feature. To do this, operate the opto switches to ensure a number is being displayed and, again with a piece of wire connected to the zero volt rail, hold the other on the reset terminal and the display should reset to zero.

These tests can then be carried out on the second set of equipment.

### Fault finding the assemblies

It would be very space consuming in this magazine to attempt to be fully detailed with regard to fault finding on this project, but it is intended to give initial approaches in locating the reason for a situation where the equipment fails to work in the manner expected.

These fault finding procedures are given in the same order as that proposed for testing, and cross-referenced with the numbers indicated in the manufacturing section of this article.

But before dealing with the actual fault finding specifically relating to the assemblies in this project, a few general ground rules are to be established.

### Equipment

The only item of test equipment required is a multimeter to measure Volts, resistance and, less frequently, current. The long-established analog meter of the type with a needle to be read against a scale is not ideal, and a digital type should be used

if at all possible.

The reason for this preference is that a meter draws power from the circuit under test to enable it to determine the value at the point being measured and this can have the effect with modern sensitive electronics of creating an abnormal situation which in itself may cause a temporary fault where one otherwise would not exist, thereby confusing the situation.

This condition is far less probable if tests are carried out using of a digital meter as these draw far less power from the circuit under test, probably in the ratio of at least 50:1, thus the possibility of creating problems rather than locating them is very considerably reduced.

With modern electronics and production methods, digital meters can now be purchased as cheaply as analog meters, and a suitable item should only cost around £20.

You'll also need some test leads complete with clips for fixing onto resistor leads and similar — old-fashioned crocodile clips are not that suitable.

### Fault finding general

Fault finding divides into two categories of which we are interested in the second.

1. The development engineer will be testing his piece of original design with the thought in his mind that there may be an error in his design as well as possible faults with manufacture or components used in his prototype.

2. With tried and tested circuitry (as in this case) we are only concerned with testing for faults in manufacture or components used and, as a result, fault finding is much simpler.

Having established this point, it should now be understood that fault finding will consist of testing in localized parts of the circuit to determine whether or not that part, frequently only one component, is working correctly, without consideration to







output is switching as a result of the card being inserted and removed. IF NOT: Check that the power supply is available at the opto switch assembly, and of the correct polarity, *take note the polarity differs between side one and side two assemblies*. Check resistor value fitted to opto switch assembly.

Inspect opto switch assembly for faults in cutting track on stripboard, and soldering. Try with second opto switch assembly, take note of change in supply polarity. Remove connection from count input terminal, if switch now functions, fault is on counter pcb assembly.

Test to establish pulse arrives at the count input terminal, and then at pin 22 on the ZN1040E IC.

Carefully change the ZN1040E IC with the other one.

(3) *The display fails to count in reverse:* Repeat all tests as in (2) but to the up/down terminal and pin 21.

Also check that the 1K resistor between +5v and pin 21 is fitted and the correct value.

(4) *Leading zeros fail to illuminate:*

Check that the 1K resistor between 5V and pin 3 on the ZN1040E IC is fitted and the correct value.

Test to establish that pin 3 changes from 5V with the wire not connected, to 0V with the wire connected.

Carefully change the ZN1040E IC with the other one.

(5) *Decimal point fails to illuminate:*

Check that the 270R resistor to terminal DP0.000 is fitted and the correct value.

Check appropriate wire link between the two pcbs.

Replace the second seven-segment display.

## The pulse and direction shaping circuits

This section of the equipment uses digital logic and a basic understanding of this is required. The procedure of starting to test at the input end is very much the procedure to adopt for digital logic, but because of the presence of the resistor/capacitor networks which convert pulses (no matter how long) to very brief pulses, the results will not be easy to observe with the simple digital meter. If all else fails, the capacitor could be replaced with a wire link and the resistor removed. Then, to check that the remainder follows the simple logic rules, before reinserting these components.

Analog circuitry deals with continuously varying voltages and is, in many ways, more difficult to fault find; this being digital we are only concerned with low voltages and high voltages being nominally supply voltage and zero voltage. In practice this means any voltage below 1 volt is considered low and a voltage within 1 volt of supply voltage is considered high — any voltage between is probably a fault.

Two conventions are used when referring to logic conditions, one which we have already used being high and low, and the other where they are termed 1 and 0, 1 being high and 0 being low, this article will use the high and low terms.

Whilst it would be good to fully explain the working of all the basic logic elements, this assembly uses only two and detailed explanation is limited to these. Whilst three different ICs are used the 7403 and 74132 are basically identical, being NAND gates.

An AND gate is a device which will give a high output when input one AND input two are both high, hence the term AND; for all other input conditions the output is low and the term NAND gate refers to an AND

gate but where the output is inverted therefore, with input one high AND input two high the output will be low and for all other input conditions the output will be high.

Without explaining in detail there are also OR gates and NOR gates; the working of these should be obvious.

The remaining IC is a form of buffer, i.e. a device which, for a high input gives a high output, and as the input and output are the same it could be considered unnecessary, but some circuits benefit by the isolation this gives between the two parts of the circuit; in this case though the 7414 is an inverting buffer, that is, a high input gives a low output and vice versa.

(6) *The circuit fails to give pulse output at the count terminal:*

Check the assembly thoroughly against the manufacturing drawings.

Check power supply is present on pins 7 and 14 of each IC.

Make sure all ICs are in the correct position and the correct way round.

Monitor the output voltages of each IC to ensure they are working in accordance with the logic statements above. Note that each IC has more than one buffer or gate in them, each is independent of the others. Replace each IC in turn with the other one for the second circuit.

If still unable to get the circuit working, make second unit, carefully working to the drawings and not copying the first. Test and compare.

(7) *The circuit fails to reverse output on UP/DOWN terminal:*

Repeat generally as in (6)

## The complete system

Fault finding for the complete system will be covered in the next issue.

### DIGITAL READOUT COUNTER ASSEMBLIES PARTS LIST

| DESCRIPTION          | TYPE/VALUE      | Pt. No. | REQ | PURCH | FROM |
|----------------------|-----------------|---------|-----|-------|------|
| Capacitor Ceramic    | 0.1µF 50V       | 124-178 | 2   | 10    | EM   |
| Capacitor Ceramic    | 0.001µF 100V    | 125-676 | 2   | 5     | EM   |
| Capacitor Tantalum   | 47µF 16V        | 102-724 | 2   | 5     | EM   |
| Double Adhesive      | 12mm foam strip | 567-907 | 1   | 1     | EM   |
| Dual In Line Socket  | 28 pin          | 404-806 | 2   | 5     | EM   |
| Integrated Circuit   | ZN1040E         | 306-285 | 2   | 2     | EM   |
| Numerical Display    | 7 segment 0.3"  | 587-894 | 8   | 8     | EM   |
| Printed Circuit (1)  |                 | 434-239 | 2   | 2     | EM   |
| Resistor             | 270R 0.25W      | 131-182 | 16  | 20    | EM   |
| Resistor             | 100R 0.25W      | 131-132 | 14  | 20    | EM   |
| Resistor             | 1K 0.25W        | 131-255 | 14  | 20    | EM   |
| Single Ended Pin 1mm | Type 2145       | FL24B   | 14  | (7)   | MAP  |
| Transistor           | ZTX500          | 294-463 | 8   | 10    | EM   |

### DIGITAL READOUT PULSE & DIRECTION SHAPING CRTS PARTS LIST

| DESCRIPTION          | TYPE/VALUE      | Pt. No. | REQ | PURCH | FROM |
|----------------------|-----------------|---------|-----|-------|------|
| Capacitor Ceramic    | 2200pf 100V     | RA40T   | 4   | 4     | MAP  |
| Dual In Line Socket  | 14 pin          | BL18U   | 6   | 6     | MAP  |
| Integrated Circuit   | 7403            | QX74R   | 2   | 2     | MAP  |
| Integrated Circuit   | 7414            | QX46A   | 2   | 2     | MAP  |
| Integrated Circuit   | 74132           | WH03D   | 2   | 2     | MAP  |
| Printed Circuit      | Stripboard 2958 | JP48C   | 1   | 1     | MAP  |
| Resistor             | 150R 0.6W       | A150R   | 4   | 1pkt  | MAP  |
| Resistor             | 1K 0.6W         | A1K     | 8   | 1pkt  | MAP  |
| Single Ended Pin 1mm | Type 2145       | FL24B   | 12  | 1pkt  | MAP  |

### DIGITAL READOUT PULSE UNITS PARTS LIST

| DESCRIPTION          | TYPE/VALUE      | Pt. No. | REQ | PURCH | FROM |
|----------------------|-----------------|---------|-----|-------|------|
| Box                  | Die Cast        | 0733998 | 2   | 2     | STC  |
| Double Adhesive      | 12mm Foam strip | 567-907 | —   | (5)   | EM   |
| Printed Circuit      | Stripboard 2958 | JP48C   | —   | (4)   | —    |
| Pulse Generator (3)  | Opto Switch     | 304-560 | 4   | 4     | EM   |
| Resistor             | 270R 0.25W      | 131-182 | 4   | (5)   | —    |
| Single Ended Pin 1mm | Type 2145       | FL24B   | 16  | (7)   | MAP  |

### DIGITAL READOUT POWER SUPPLY ASSEMBLY PARTS LIST

| DESCRIPTION            | TYPE/VALUE      | Pt. No. | REQ | PURCH | FROM |
|------------------------|-----------------|---------|-----|-------|------|
| Capacitor Ceramic      | 0.1µF 63V       | 126-556 | 1   | 5     | EM   |
| Capacitor Electrolytic | 4700µF 16V      | 106-158 | 1   | 1     | EM   |
| Capacitor Metal Film   | 0.47µF 100V     | 115-590 | 2   | 5     | EM   |
| Printed Circuit (2)    |                 | 434-289 | 1   | 1     | EM   |
| Rectifier Bridge       | 2A 200V         | 261-592 | 1   | 1     | EM   |
| Regulator 5V +         | LM7805CT        | 648-422 | 1   | 1     | EM   |
| Resistor               | 4.7K 0.25W      | 131-334 | 1   | 10    | EM   |
| Single Ended Pins 1mm  | Type 2145       | FL24B   | 4   | (7)   | MAP  |
| Transformer            | P 240V S 6V20VA | 207-504 | 1   | 1     | EM   |

### DIGITAL READOUT ENCLOSURE, GENERAL HARDWARE PARTS LIST

| DESCRIPTION            | TYPE/VALUE      | Pt. No. | REQ | PURCH | FROM |
|------------------------|-----------------|---------|-----|-------|------|
| Cable                  | Blue 7/0.2      | BL01B   | 1   | 1     | MAP  |
| Cable                  | Black 7/0.2     | BL00A   | 1   | 1     | MAP  |
| Cable                  | Green 7/0.2     | BL03D   | 1   | 1     | MAP  |
| Cable                  | Orange 7/0.2    | BL05F   | 1   | 1     | MAP  |
| Cable                  | Red 7/0.2       | BL07H   | 1   | 1     | MAP  |
| Cable                  | White 7/0.2     | BL09K   | 1   | 1     | MAP  |
| Cable                  | Yellow 7/0.2    | BL10L   | 1   | 1     | MAP  |
| Capacitor Electrolytic | 10,000µF 25V    | JL45V   | 1   | 1     | MAP  |
| Enclosure              | Sloped Panel    | 508-475 | 2   | 2     | EM   |
| Light Filter           | Filter Red      | FR34M   | 1   | 1     | MAP  |
| Strain Relief          | 6R1             | JH23A   | 1   | 1     | MAP  |
| Switch "Power on"      | Red Latching    | 336-624 | 1   | 1     | EM   |
| Switch "Reset"         | Black Momentary | 336-602 | 2   | 2     | EM   |
| Terminal Block         | 12 Way 6A       | 423-166 | 1   | 5     | EM   |

### DIGITAL READOUT INTERCONNECTING PARTS LIST

| DESCRIPTION      | TYPE/VALUE   | Pt. No. | REQ | PURCH | FROM |
|------------------|--------------|---------|-----|-------|------|
| Adaptor          | 12mm         | 039822C | 4   | 4     | STC  |
| Cable Screened   | 4 Core 7/0.1 | XR23A   | (6) | (6)   | MAP  |
| Flexible Conduit | 12mm 5m Long | 039820G | 1   | 1     | STC  |
| Lock Nut         | 12mm         | 039824X | 4   | 4     | STC  |



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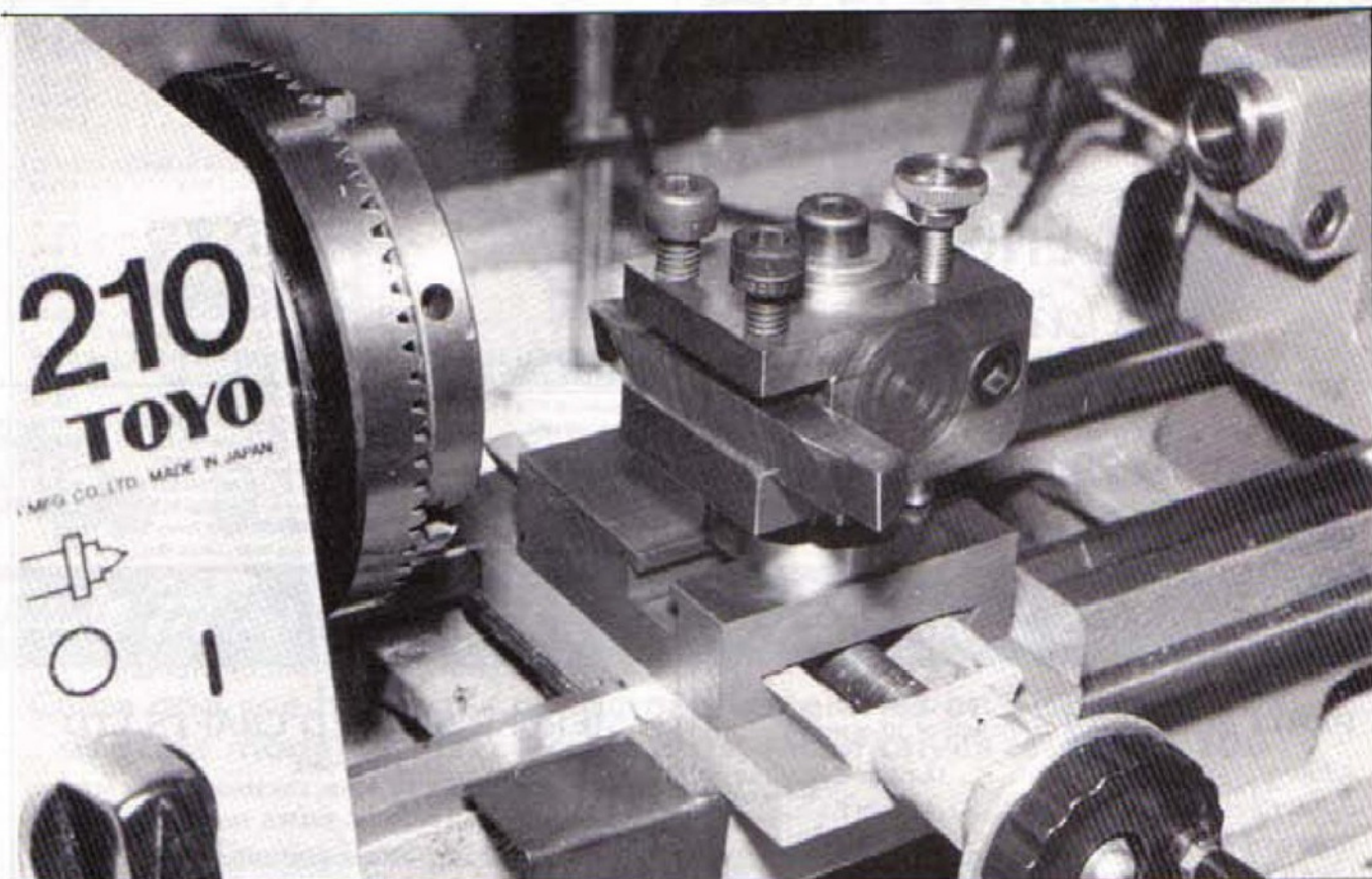
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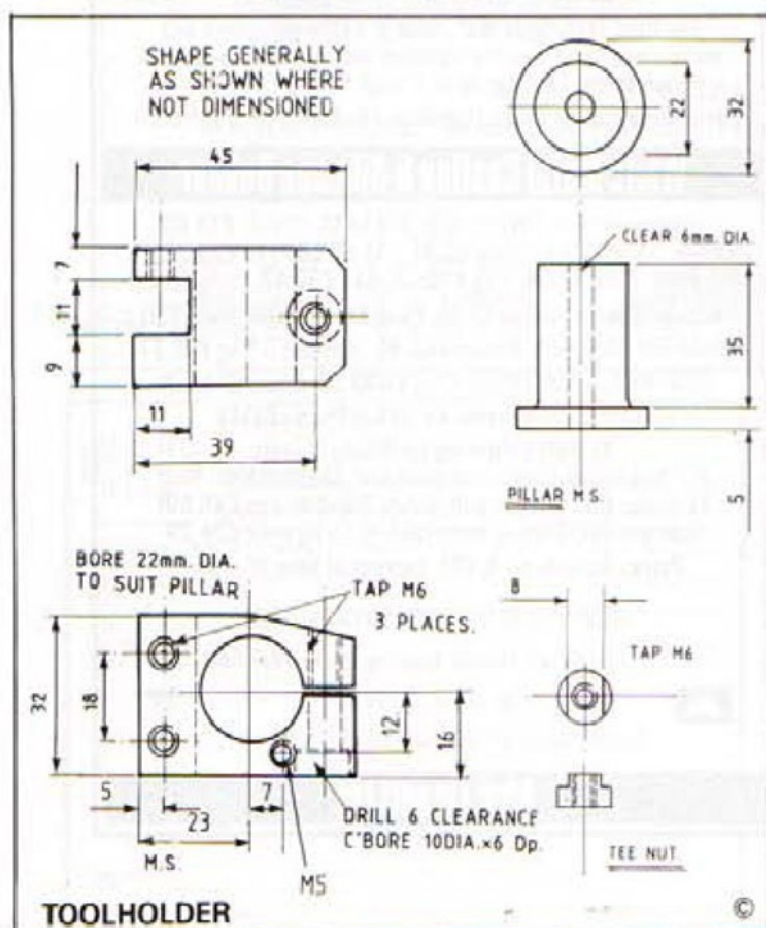
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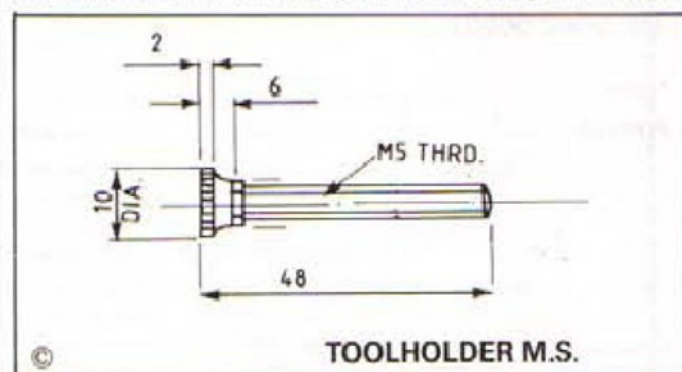


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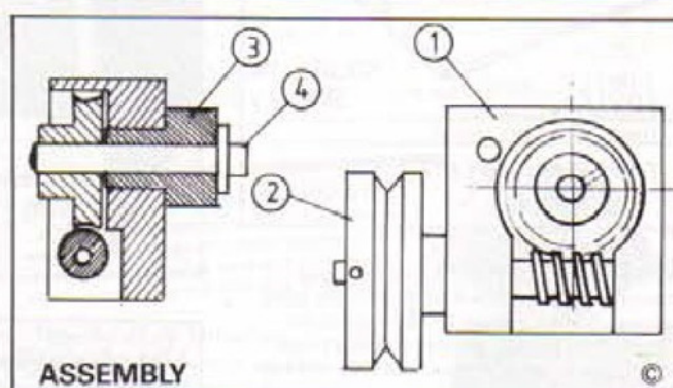
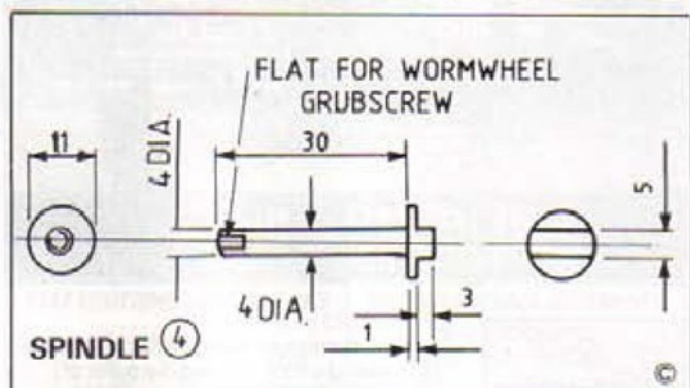
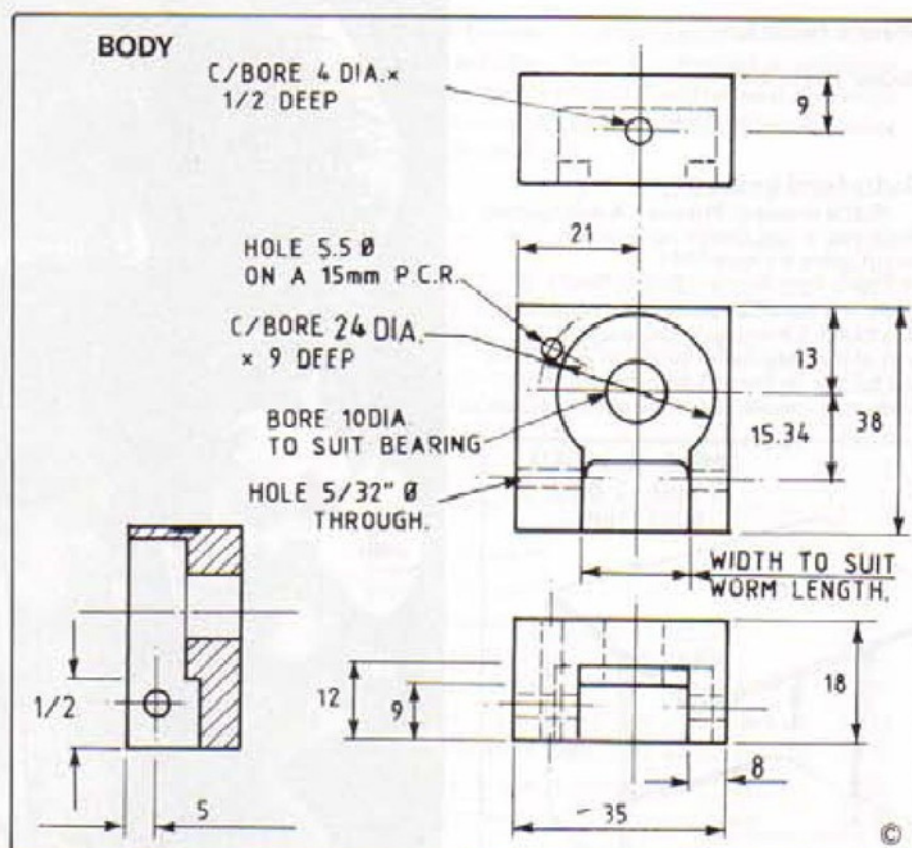
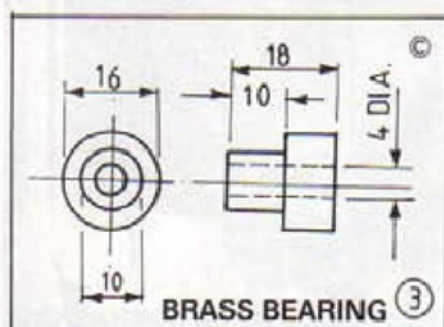
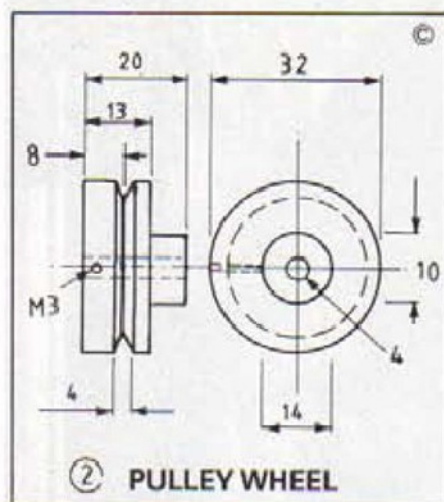


In our last issue, Derek Winks gave us an excellent taper turning attachment for the Toyo 210; in this article, intended to be the first of the series, he describes a toolpost and an auto-feed feed gearbox plus some other smaller items. There will be more ideas and articles for attachments and improvements designed for this popular small lathe.

**S**ome time ago I purchased a Toyo 210 lathe to supplement the rather ancient 5 in. Atlas which has formed the basis of my workshop for many years. I soon found it to be most useful and convenient for making the smaller components. However, there is a limit to what can be done with a basic lathe, and







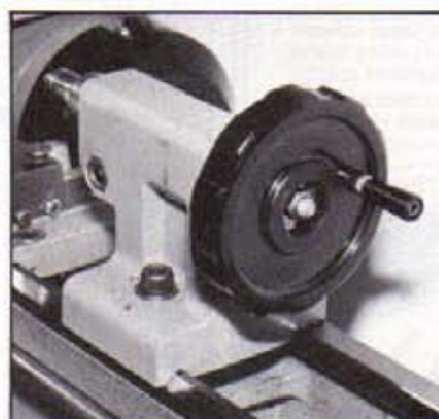
many of the extras, where available from the manufacturer, are decidedly on the pricey side. The accessories to be described in this article can all be made at low cost in the home workshop, but access to a larger lathe (and preferably also a milling machine) is required for some of them.

The first job was a new tailstock handwheel seen in **Photo 1**, as the one supplied is too small for comfortable use when drilling. I used a commercial plastic handwheel 2.5 in. diameter. This was bored out  $\frac{1}{2}$  in. and a brass bush cemented in with Araldite. The bush was tapped 5mm to fit the original spindle, and the finger-grip removed from the old wheel and refitted to the larger one. Removal of the old wheel requires a thin-walled box spanner to release the acorn nut which locks it to the spindle; this was made by turning down the end of an ordinary tubular spanner as thin as possible with a carbide-tipped tool. The bigger wheel gives a much improved feel when drilling from the tailstock. Sometime I will make a lever-feed barrel, but have not got around to it yet.

### Toolpost

The toolpost supplied with the lathe is a

conventional type — adequate but time consuming in use as tool-changing requires fiddling about with bits of packing to get the height right. Replacing it with a quick-adjustment type was an early priority. **Photo 2** shows the design used. There is nothing new about this; something similar was used on the old Drummond



Above: **Photo 1**.

Top of opposite page: **Photo 2**.

3 in. lathe, but without the adjusting screw. For some reason I don't understand it has never become popular with lathe manufacturers" which is a pity because it is quick and easy to use.

The construction is clear from **Photo 2**. The pillar is about 22mm diameter with a flange 32mm diameter at the base to provide a large area to bear on the cross-slide; the upper surface of the flange acts as a bearing for the 2BA adjusting screw. The toolholder block is 32 x 45mm & 27mm deep. As I did not have a suitable chunk of steel, the block was fabricated from three pieces of  $\frac{1}{2}$  in. flat stock silver-soldered together. The clamping pressure tends to force the joints apart so it is obviously important to make sure the silver-solder flows completely through the joint; any weakness here will soon result in failure.

After silver-soldering, the block was machined all over to clean it up, then bored through a good sliding fit on the pillar. It remains only to open out the tool slot to 11mm width with an end-mill, drill and tap the holes 6mm for the clamping screws and 2BA for the adjusting screw and to cut the slit which enables the block to be clamped to the pillar.

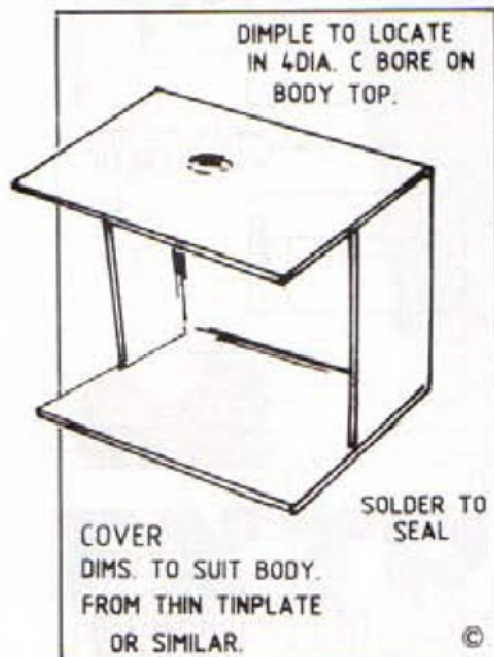


At right: Photo 3.

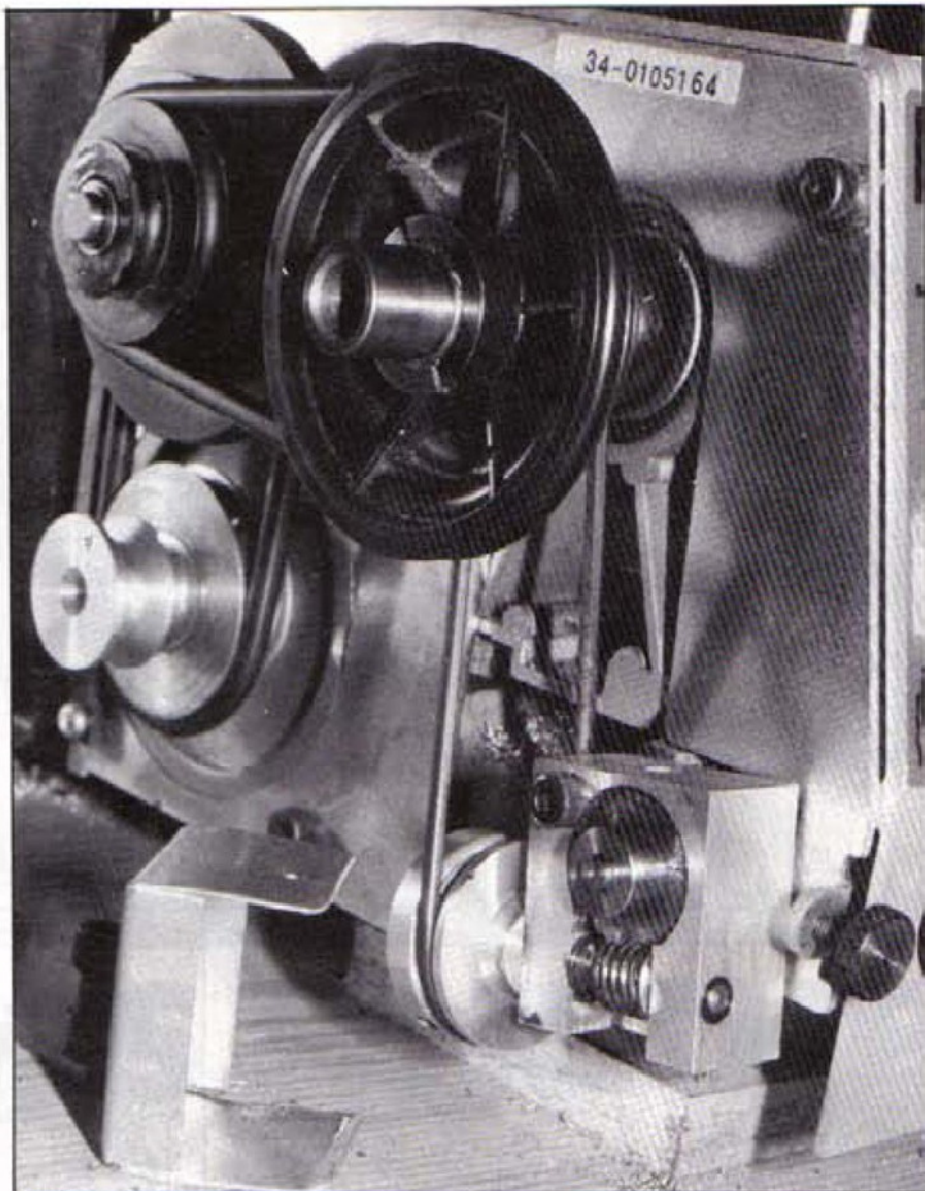
Below: Photo 4.

### Auto-feed gearbox

This is shown in Photos 3 & 4. It follows the maker's own design fairly closely. The worm gears are type C140, 18:1 ratio from Bonds o'Euston Road Ltd. (Note — a list of suppliers is appended.) A dog-clutch for engaging the leadscrew is part of the basic lathe, so all that is required is a tongue on the end of the wormwheel shaft to fit into the slot in the moving clutch



element. The body of the gearbox was machined from a block of aluminium alloy approx. 35mm x 38mm x 18mm, but the dimensions are not critical. A brass boss 16mm diameter with a central hole reamed  $\frac{1}{16}$  in. forms the wormwheel shaft bearing; it was cemented in with Araldite. It projects 8mm from the back of the block, fitting into a hole in the headstock when the block is bolted on with a single 5mm Allen screw. The correct centre distance for the gears is 15.34mm. I made a mistake, putting them  $\frac{1}{16}$  in. apart, hence the eccentric bronze bushes for the worm shaft which can be seen in the photo. Get it right first time, and



### List of suppliers

Note — The author has no connection with any firm mentioned here.

Bond's o'Euston Rd. Ltd.  
Arundel House, Rumbolds Hill, Midhurst,  
Sussex GU29 9NE. Worm gears.

Shesto, Unit 2, Sapcote Ind. Estate, 374  
High Rd., Willesden, London  
NW10 2DH, Plastic belting.

these could be omitted!

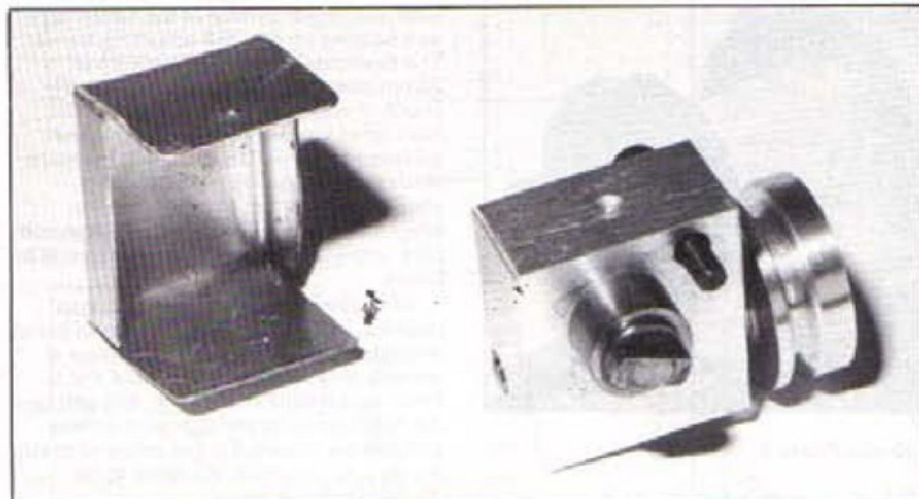
The aluminium pulley is 32mm outside diameter giving a running diameter of about 28mm in the V-groove which is about right for a fine feed. I also made a smaller pulley for a coarser feed, but this does not get much use. The belt is made from 3mm plastic belting, which can be joined by heating the ends and pressing them together. This can be done by holding the ends against the side of an electric soldering iron until melted. The belting is obtainable from Shesto.

The feed may be in either direction, according to which way the belt is crossed. A simple clip-on cover of 18g aluminium sheet was made to keep swarf out of the gears.

### QUICK TIP

A simple reamer can be made by filing or machining a flat at 15 degrees to the axis across the complete end of the appropriate size of silver steel, hardened and tempered to a light straw colour and then stoned to a good finish. Obviously, this method cannot be equated with commercial reamers but has proved satisfactory when used with care on through holes.

E.R. Whiffin





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# TRADE COUNTER

## Digital Multimeter

**Q**uiller Ltd have introduced a new range of good quality digital and analogue multimeters of which the Q19001 reviewed here is the lowest cost item from the range and also one of the lowest priced digital meters available.

The Q19001 offers AC/DC voltage, DC current and resistance measurements. A diode test facility is also included. The unit is rugged and achieves accuracy ratings of between 0.7 and 1.5% depending on range being used. Five DC voltage ranges are included, the lowest being 0-200mV and the highest 0-1000V. Six DC current ranges cover 0-200 microamp to 0-10A. Resistance measurement ranges cover 0-200 Ohm to 0-2 Megohm in five ranges. AC voltage ranges are 0-200V and 0-750V.

The meter display has what is termed 3½ digits; this indicates that the leftmost digit can display only a blank or a one, therefore a range stated as 0-200 will in fact be a range of 0 to 199.9. From this it can be seen that the resolution (minimum increment) is 0.05%.

The meter is complete with leads and comes in a very robust bubble pack. The bubble pack is obviously primarily intended as a display pack, but includes a slide-off rear cardboard back and, with care, could act as a storage case for the instrument for many years.

**A brief look at new products for the home machinist; this time an economical multimeter, further Emco developments and a new specialist store**

For those more used to analogue meters, this package also has another benefit. As the meter has a battery to power it, it is necessary to switch off before storing the meter away — easily overlooked if you are not used to this being a



*Above, the new Q19001 large display analogue multimeter from Quiller. Left, others in the range. MEW has a special readers' offer on the handy Q19001 — see elsewhere in this issue for detail.*

requirement. The pack has, formed into its shape, a groove for the switch knob to locate into, this making it almost impossible to forget to switch off.

The meter would make an ideal companion to the digital readout project in this issue, and whilst most will see this as a meter for the electronic enthusiast, it is equally at home on the car, or for mains voltage work, or other more basic requirements.

The meter is available as a readers' special offer elsewhere in this issue, but should any reader be interested in the other meters in the range, the address is: Quiller



**With the optional vertical attachment, Emco's Compact 5 lathe can be used for milling and drilling work.**



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### Compact Turning Machine

Design of the Compact 5 lathe ensures that it appeals to both the modelmaking sector and the educational market. For this sturdily constructed benchtop turning machine combines precision performance with long life and ease of use. While the addition of a new vertical milling/drilling attachment transforms the lathe into a machining centre.

Produced in Austria by Emco Maier, the Compact 5 lathe is a well-engineered machine tool. The bed of the lathe is manufactured of high grade, vibration-absorbing grey cast iron and features high cheeks and sturdy ribs to resist twisting and torsional loads imposed during cutting. Both the saddle and the tailstock run in their own ground vee ways for maximum rigidity and accuracy while the large diameter spindle is supported by deep groove ball-bearings for optimum performance.

Basic specification of the lathe includes: 130mm swing over the bed, 65mm centre height, 350mm between centres, 50mm cross slide traverse and a 16mm diameter hole through the work spindle. Automatic longitudinal feed of the saddle is powered by a 12mm diameter leadscrew which provides two feed rates (0.07 and 0.34mm/rev) and five common thread pitches (for screwcutting operations). The 500W main motor drives the spindle (by way of vee-belt transmission) at speeds of up to 2800 rev/min.

With the addition of a new vertical attachment, the Compact 5 lathe becomes a machining centre capable of complex milling and drilling work. And with the optional dividing head, the machine can also be used for gear milling, slotting, co-

ordinate drilling, boring and facing and slot boring. The milling head can be adjusted vertically for height and it can be turned and swivelled through 360° for angular machining.

The milling attachment has its own 200W motor which provides spindle speeds up to 1900 rev/min. This unit has a working radius of 82mm, a quill stroke of 30mm and can handle components measuring up to 200mm high.

There is a wide range of accessories

available for the lathe including: chucks, clamping plates, arbors, toolholders, steadies, change gears, cutting tools and a full series of collets. The machine is supplied with a comprehensive operator instruction manual and detailed educational instruction sheets (where applicable). Basic price of the Compact 5 lathe is £585.00.

For more ambitious users, Emco also produces two computer-controlled versions of this standard lathe — Compact 5 PC and the Compact 5 CNC. The former can be controlled by either IBM compatible PC/XT or Apple IIe hardware and has full graphics simulation. The Compact 5 CNC model has its own built-in two axis micro-based control system. For more information contact: Emco Maier Ltd, 10 Woodshots Meadow, Croxley Centre, Watford, Herts WD1 8YZ. Tel: 0923 50051.

### Machine Mart Superstore Number 24

Branch number 24 in the developing nationwide network of Machine Mart Superstores was official opened on Saturday 14 September at Thornaby-on-Tees, Cleveland.

The new store, located at Mandale Triangle, Thornaby-on-Tees, has 743 square metres of sales space offering a comprehensive selection of tools, garage equipment, woodworking machinery, construction equipment, industrial products, safety wear and a host more to cater for all professional and home user requirements.

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A full-colour catalogue is available by telephoning Machine Mart on 0602 411200.



**The interior of the new Machine Mart store at Thornaby-on-Tees; super new shop opened for business in September. If you don't live near enough to call in, Machine Mart will send you a free catalogue on request.**



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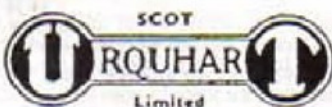


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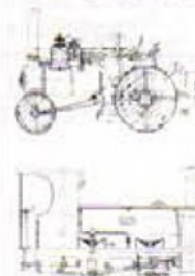
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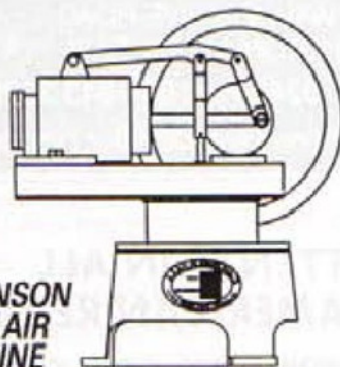
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# 'ECONOMY' MILL TABLE CALIBRATION RINGS

**A**ccording to the manual on my Warco Economy Mill Table, leadscrew dials are in 2 thou calibrations and are: "To be reached when turn a run on wheel lengthwise and crosswise." The part No 157 'Dial' is fixed to the leadscrew No 162 by a spring pin.

### Adjustable dials are a must

The opportunity to rig up a simple method came my way whilst fixing aluminium gutter and down spout. The latter was a full 2 1/2 in. in diameter, 2 in. inside and in cast sections. To make them suit their positions they had to be cut and rewelded and carrying out these alterations left quite a few off-cuts. Being the usual model engineer jackdaw I took these pieces back to my workshop, parking them on my mill bench for several days until I noticed that the inside diameter of the downspout off-cuts was quite close to the overall diameter of the table leadscREW securing bracket.

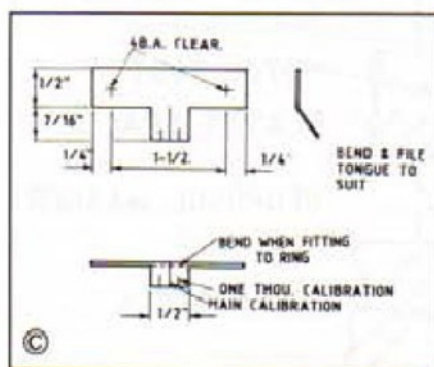
A circular piece of the downspout was machined all over and to  $\frac{1}{16}$  in. wide. In the edge I drilled and tapped three holes  $\frac{1}{16}$  in. BSF, one at nine o'clock, one at 12 and one at 3 o'clock positions on the ring.

To fit these threaded holes three knurled thumbscrews were turned out of  $\frac{1}{8}$  in. diameter alloy; these screws afford adjustment of the ring around the lead-screw bracket.

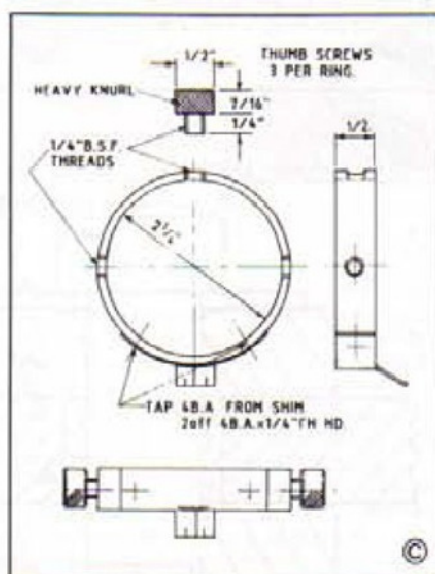
### Positive adjustment

In use, this adjustment is quite positive. At the 6 o'clock position on the ring I bolted (4BA cheesehead) a piece of shim with a projecting piece of tongue on which I scribed a centre line. The small projecting tongue needs to be bent and filed to rest behind the fixed dial. With the aid of a dial test indicator fixed to the table to register a movement of one thou 'lengthwise and crosswise', with the centre line on the

**Roy Clarke bought a Warco Economy Mill/Drill and became dissatisfied with the control dials. He describes how he modified the machine to have adjustable dials, in the hope that others will find the method he adopted useful. This could apply to similar machines from other stables...**



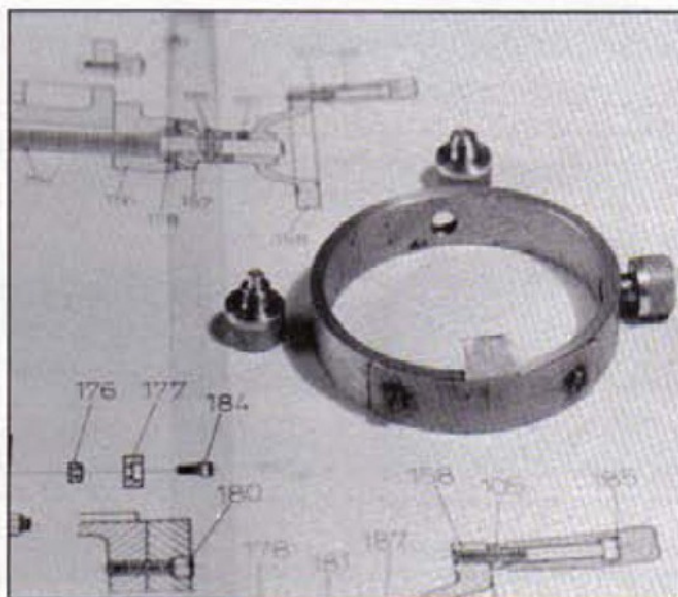
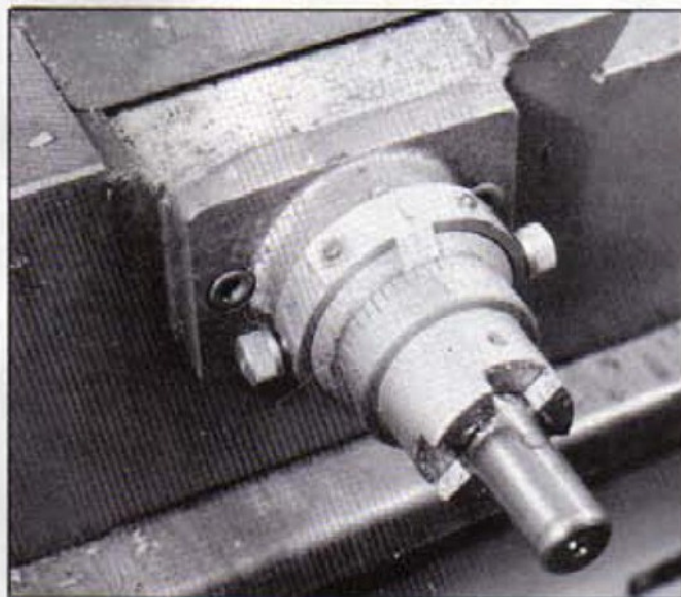
Right, the completed ring with its thumbscrew and projecting shim tongue. Originally the screws were turned with the  $\frac{1}{8}$  in. x  $\frac{1}{8}$  in. dia. turned on their ends but it was found that it was better to file away on two of them. The  $\frac{1}{8}$  in. extension is not required; the author used it to pull in the ring close to the top edge of the dial. Screws as detailed on the drawings are sufficient to secure. Left, the attachment fitted in place.



projecting tongue lined up with one of the numbered divisions on the dial and by taking out much of the screw backlash, I carefully scribed a line on the tongue each side of the centre line (it helps if the table locking screws are slightly pinched up).

This mark gave me a one thou division which I could align with any of the numbered divisions on this fixed dial just by rotating the ring round the handwheel boss and locking into the desired position with the thumbscrews. As a temporary expedient this method works well, BUT, only until such time is available to replace the fixed dials with fully adjustable types correctly graduated according to one's needs.

At the moment, I am busy making the necessary graduating tool to allow me to make the correct dials to read both metric and Imperial measurements.

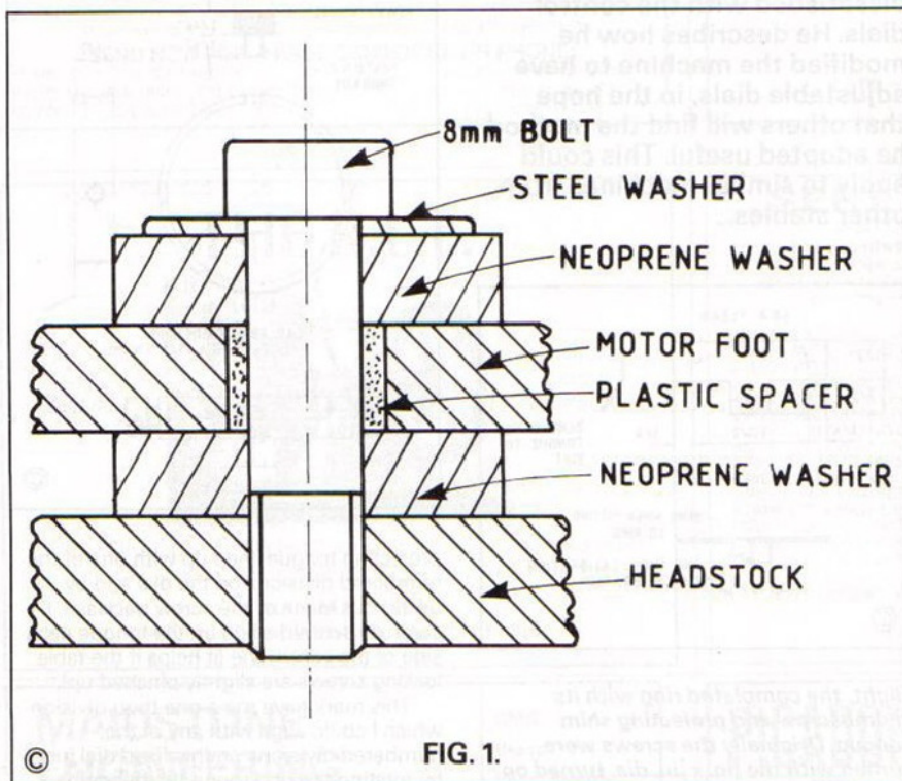




**T**here are several causes for poor finish on work machined in the lathe or vertical milling machine and sometimes the reason is not obvious. Perhaps the commonest reason for poor finish on turned work is a blunt tool or one with an incorrectly shaped tip. A sharply pointed tool, even if sharp and used with a fine feed, will not give a smooth finish and the solution here is to grind a slight radius on the nose, so that it engages the work over a longer length than the feed per revolution.

# CHASING VIBRA

In this short article on setting up a lathe, Bill Morris of New Zealand explains how he cured the effects of vibrations and includes a photograph which clearly indicates the success of his endeavours



A blunt tool used below centre height on a lightly constructed lathe with bearings in poor condition and a poorly supported workpiece is a good recipe for chatter, in which the workpiece and lathe vibrate as the tool digs in, is flexed away and out of the workpiece (or the workpiece is flexed away from the tool) and then springs back in to repeat the process. The finish on the

workpiece is characteristically wavy and the noise unbearable, except for the really insensitive. It is also possible to get chatter on a milling machine for much the same reasons. Fierce chatter may damage not only the workpiece, but also the lathe itself. Fasteners may vibrate loose and as if this weren't bad enough, the spindle bearings may be severely damaged, especially if

they are ballbearings.

## Locating the problem

Attention to the points that I have mentioned will often put matters right and if it doesn't, reduction in cutting speed usually does so, because the forces are reduced and characteristic frequencies of vibration are changed. Sometimes, however, the source of poor finish may be hard to track down. Recently, I was very puzzled by finding that in taking fine finishing cuts on my near-new lathe I was getting a periodic pattern superimposed on the reasonably fine finish. It seemed only to occur with fine finishing cuts and while it didn't seem to make any difference to parts that just had to fit and sit together, I had my doubts about parts that had to run together. There was no question of chatter occurring. The cuttings came off with a satisfying gentle sizzle. Obviously there had to be something making the tool vibrate and indeed I could feel a fine vibration of the toolpost with the lathe running. Since the problem occurred with both auto and hand feed, it wasn't due to some periodic error in the gear train, so it had to be due to motor vibrations transmitted to the tool and workpiece. I reasoned that the vibrations were passing along different routes and drifting in and out of phase to produce the curious pattern at the point of cut.

There are two ways the vibration of the motor can be transmitted to the lathe: through the belt and through the bed. Boxford lathes have motor platforms which are attached separately to the bench and vibrations could pass through the bench and through the tensioning arrangement. When I owned a Boxford, the motor was in a flexible mounting and I never had any

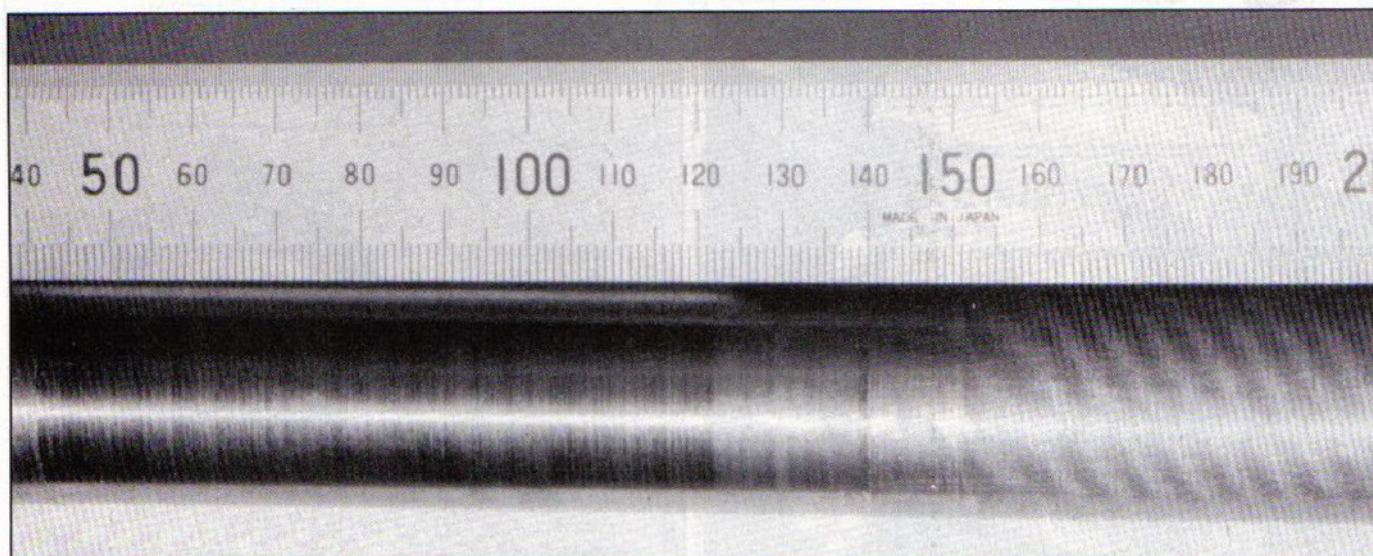


Figure 3. The improvement can be seen easily; section of bar on right was turned before the cure was applied, that on the left after...



# SOLUTIONS!

problems. My newer lathe has a very heavy 2 hp single phase motor bolted directly to the back of the bed. Those with deep pockets would no doubt have first replaced the motor belt with one of the Nu-T-Lock variety which are said to reduce the transmission of vibration via the belt, but I found it altogether too expensive and in any case, I could still feel the toolpost vibrating with the belt detached. Instead I decided to concentrate on a low-tech solution of isolating the motor vibrations from the bed.

## The solution

I visited the local suppliers of rubbery things and they produced four pathetic-looking objects like the devices used to suspend (or, rather, which periodically failed to suspend) the exhaust pipe of my first car. Despite their assurances, I was not confident that they would safely hold the motor's deadweight, never mind when it was transmitting its full power, so decided on my own solution, based around rubber washers, (Figure 1).

Eight millimetre thick neoprene rubber sheet costs NZ\$230 (about £70) a square metre so I bought myself a small bit and wasted some time on thinking how to punch round washers out of thick rubber sheet before realising that washers can be square too and can then be cut out of rubber with a sharp knife, but first the holes have to be made. This is best done by

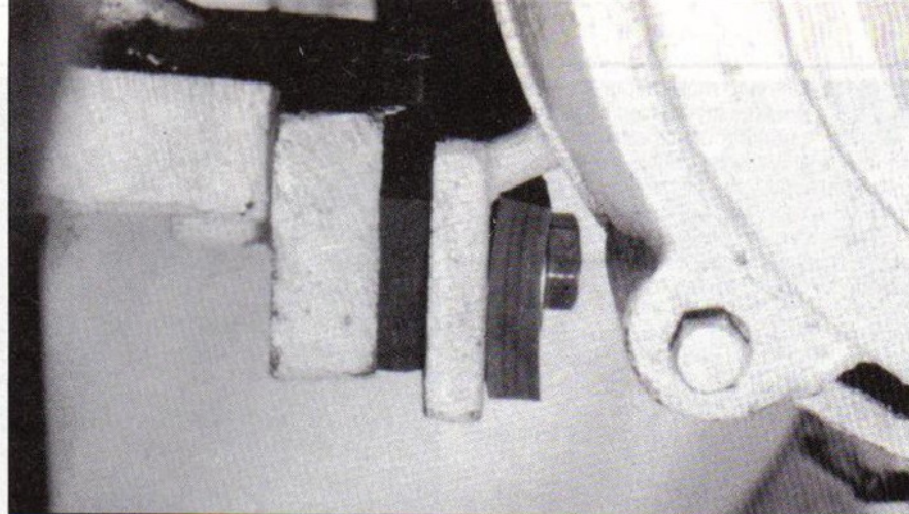


Figure 2. The motor mounting after resilient mounts have been fitted.

nipping the sheet between two parallel sheets of scrap wood with the vice and a G-clamp to keep the sheets parallel. A sharp drill running at high speed then makes short work of the job, though the hole shrinks a little when the pressure comes off. I found that an 8.5mm drill gave a snug fit on an 8mm bolt, while 9mm gave a comfortable clearance. Once the holes are made, the washers can be cut to a suitable size.

It is important of course that the fixing bolts should nowhere come into direct contact with the motor feet so I cast around for a spacer and my eye lighted on a scrap of transparent plastic tubing which was an easy fit on the bolts and had an outside diameter of 12mm. I had to enlarge the

holes in the feet from 9 to 12mm to fit. I had an exhausting struggle demounting the motor so it didn't occur to me to detach the foot casting from the motor to do this in the drilling machine. Instead I "reamed" the hole with drills in  $\frac{1}{8}$ mm steps, holding the drill in a chuck, guiding it with my hand and rotating it with a spanner on the tang. It worked very well and saved more struggle.

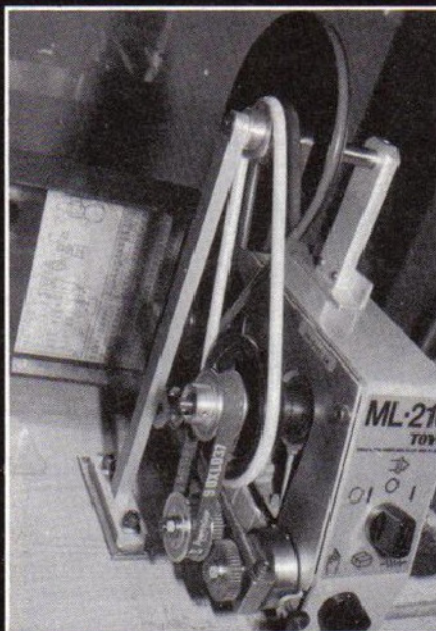
It was then a simple matter to assemble the washers and spacers, (Figure 2). Compressing the washers by about 1mm seemed to feel right and I gave it a try, with the result shown in the photograph, (Figure 3). Both cuts were done with the same new carbide tool at the same speed, feed and cut. I'm going to do my milling machine next!



# IN OUR NEXT ISSUE!

Coming up in the February/March issue will be:

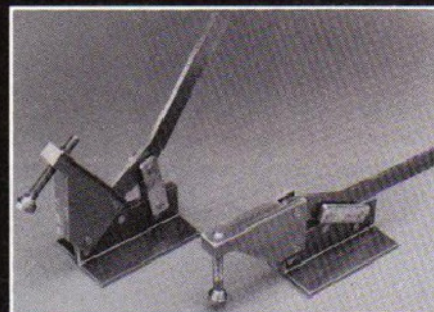
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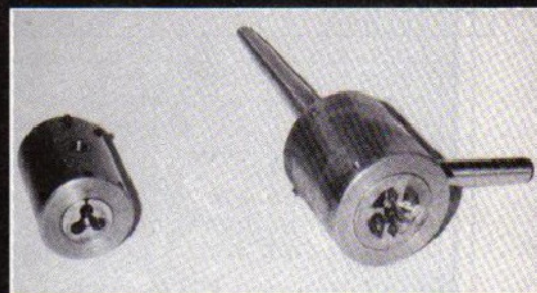
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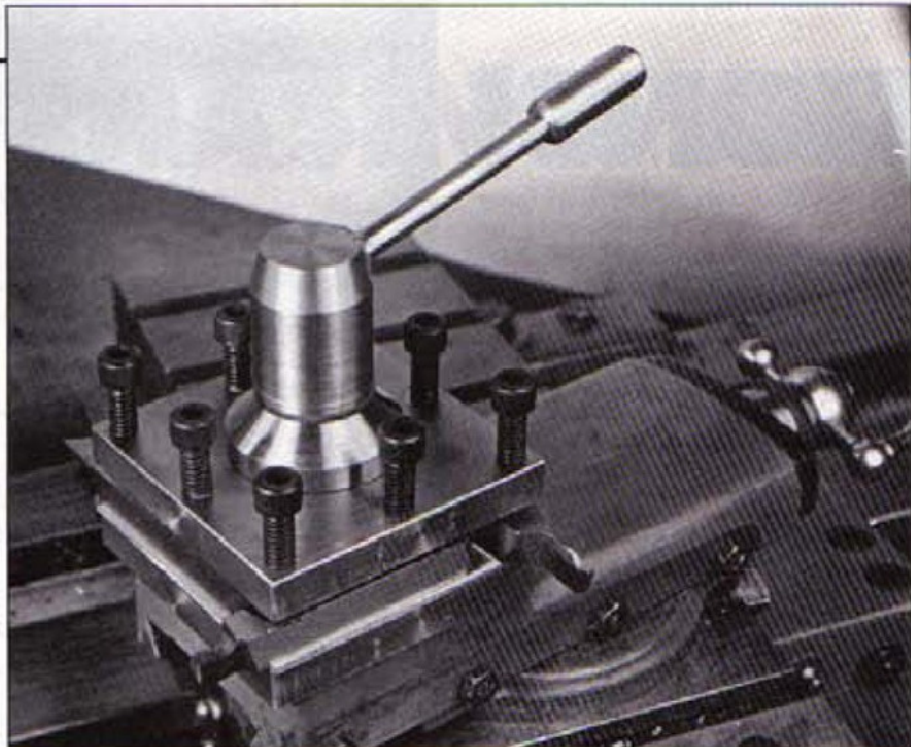
**W**ishing to make a four-way toolpost for my Myford ML7 lathe but without any milling facilities, either using the lathe or by a separate milling machine, the possibility of making it from one piece was not on the cards.

There was, of course, the possibility of obtaining a piece of bright mild steel as near to the required size as possible, and machining this in the lathe using the large four-jaw chuck which I possessed, to achieve the correct size block. This could be followed by sending it to one of the firms which advertise in *Model Engineers' Workshop* as providing machining facilities for items too large or complex for the individual, and to have the slots milled in round the edges. I could then take over and complete the rest.

The idea then occurred to me of fabricating it from three pieces, but how these were to be fixed together had still to be decided. A number of possibilities were considered though some were obviously non-starters, and did not warrant further thought.

Welding was not available but even if it were, it seemed unlikely that a tidy result could be obtained. Modern adhesives, too, are surprisingly good but even if it were possible I was not brave enough to go down this road!

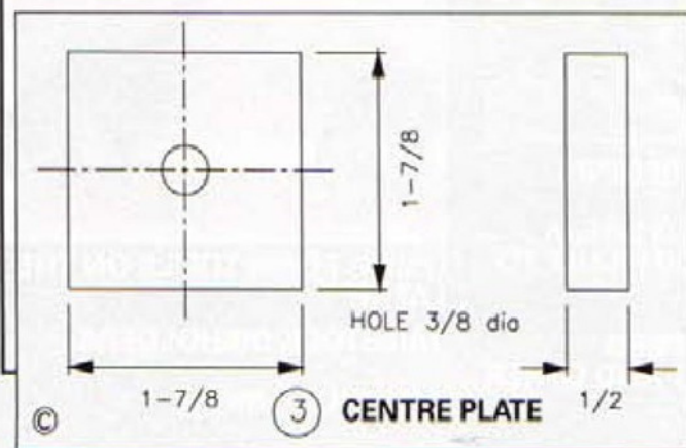
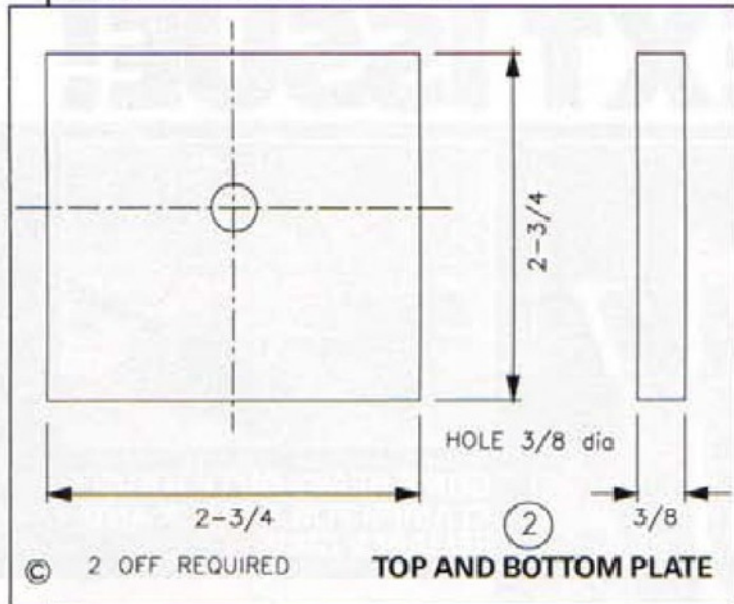
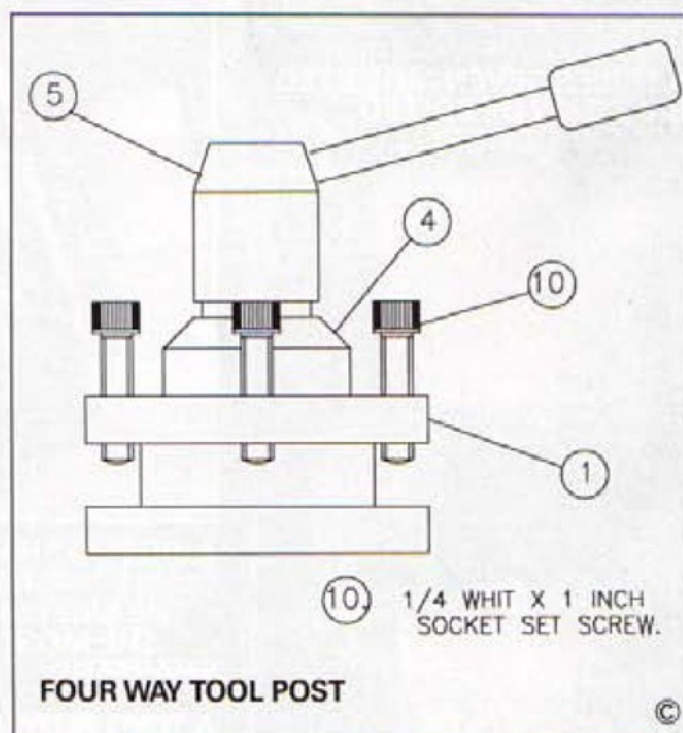
The only solution would be to use screws but then it was realised that, if a ratchet indexing mechanism was to be included, a sizable recess would be required in the base and there would be little space to accommodate these. Four could be fitted, one in each corner but, whilst this would probably be adequate, with eight screws being used to clamp the tool bits, I would be happier with more.



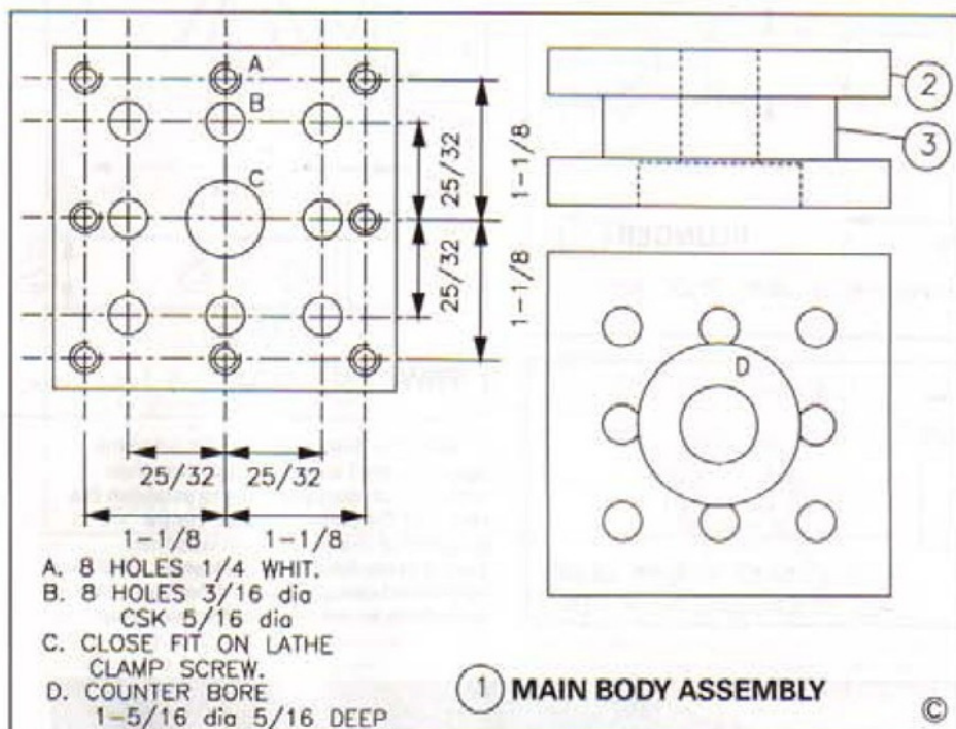
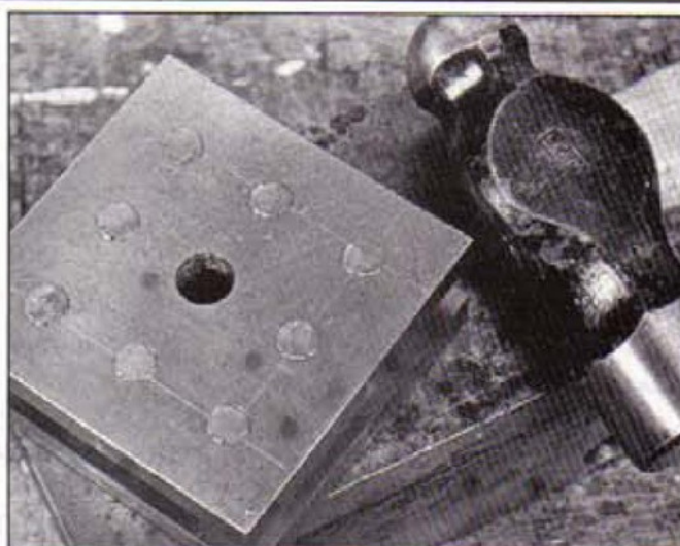
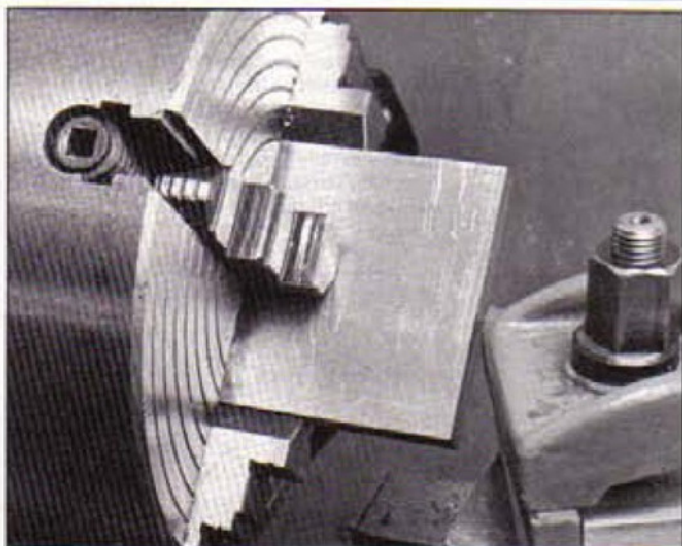
The finished toolpost, ready for use on the Editor's lathe.

# A FOUR-WAY TOOLPOST

Those whose workshop is presently limited to lathe work only, and who have not yet kitted it out for milling, will find this way of arriving at a four-way tool post a useful proposition







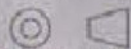
**Left: Machining the top plate to size.** Note that the plate fits in the groove in the chuck body for maximum security in the chuck. **Right: The assembly after riveting — a laborious task but do not economise by reducing the size of the countersink.**

Considering my earlier remarks regarding adhesives, I then gave thought to the possibility of combining this with the four screws, and decided to proceed along these lines. Detailed consideration was given to the material to be used and this then ordered. It was whilst giving it further thought that the ideas of riveting the assembly together came to mind and was immediately decided upon as the way to arrive at a satisfactory conclusion. It was also decided to continue with the idea of using adhesive as this would give added strength and (as was subsequently found) eased the construction.

Unfortunately, material could not be purchased to exactly the size required; this could have been overcome by making the post bigger than the top of the top slide and using 3 inch wide material to give a 3 inch square assembly as opposed to the 2 1/2 inch which seemed correct for the lathe,

#### NOTES:

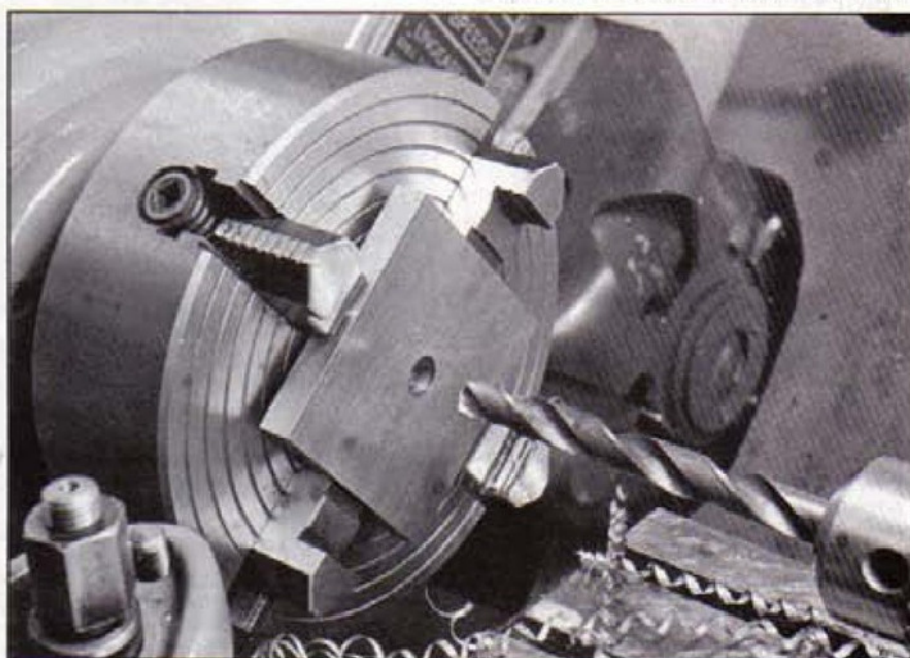
- COUNTERSINK FOR RIVETS USING CSK BIT AND NOT A DRILL TO ENSURE MAX DEPTH OF COUNTERSINK AND ADEQUATE STRENGTH.
- USE ADHESIVE TO FIX THREE PARTS OF CLAMPING HANDLE TOGETHER.
- DRAWN FIRST ANGLE.



- MAKE 1/32 INCH CHAMFER ON FOUR CORNERS AND TOP FOUR EDGES DEBURR REMAINING EDGES.
- ALL DIMENSIONS IN INCHES.

#### MATERIAL LIST LARGER SIZES.

- 3 X 3/8 INCH B.M.S. 6 INCHES. (2)
- 2 X 1/2 INCH B.M.S. 2 INCHES. (3)
- 1-1/2 INCH DIA B.M.S. 2 INCHES. (4) (5)
- 1 INCH DIA B.M.S. 3 INCHES. (5)
- 1/4 WHIT X 1 INCH SOCKET CAP SCREWS 8 OFF REQUIRED.



**Drilling the hole in the top plate.**



- A. 1/8 dia.  
B. 13/64 dia.  
C. 1/4 WHIT.

©

7/32

DRILLING FOR INDEX MECH.

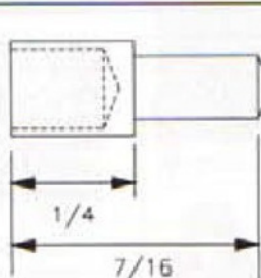
5/8

1/4



3/16

5/32 X 3/16 DEEP.



7/16

PLUNGER (7)

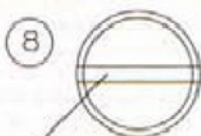
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- © REDUCE LENGTH OF SMALL END GRADUALLY UNTIL TOOL POST FITS OVER PAWL EASILY.

HOLLOW GRUB SCREW

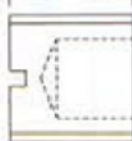
1/4

1/4 WHIT.



©

SCREW DRIVER SLOT.

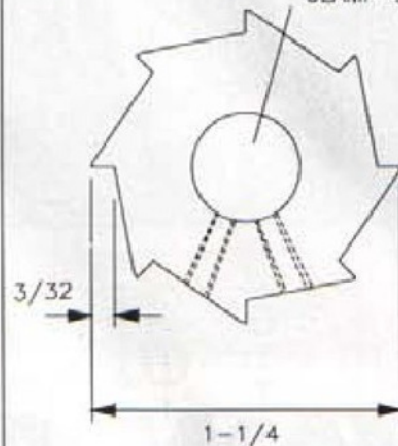


5/32 X 3/16 DEEP.  
ALL DIMENSIONS IN INCHES.

the jaw, it is likely that an insufficient hold on the material would result, and in this case an alternative method should be adopted, such as holding the part on a small angleplate on the faceplate or clamping the part to the cross slide and using a simple flycutter in the chuck. Those fortunate enough to have milling facilities would, of course, not adopt this method anyway.

©

CLOSE FIT ON LATHE CLAMP SCREW.



3/32

1-1/4



9/32

PAWL (6)

2 HOLES M4.

With the three parts machined to the correct overall size, each part was then scribed with diagonal lines to establish the centre of the plate, and then centre punched at this point. Each was then placed in the four-jaw chuck and centralized using the centre punch mark and centre in the tailstock for reference,

©

RIVETS (9)

NOTE. MAKE ONE 3/16 dia X 1-11/32 FIT AND CHECK LENGTH MAKE FURTHER 7 LENGTH TO SUIT

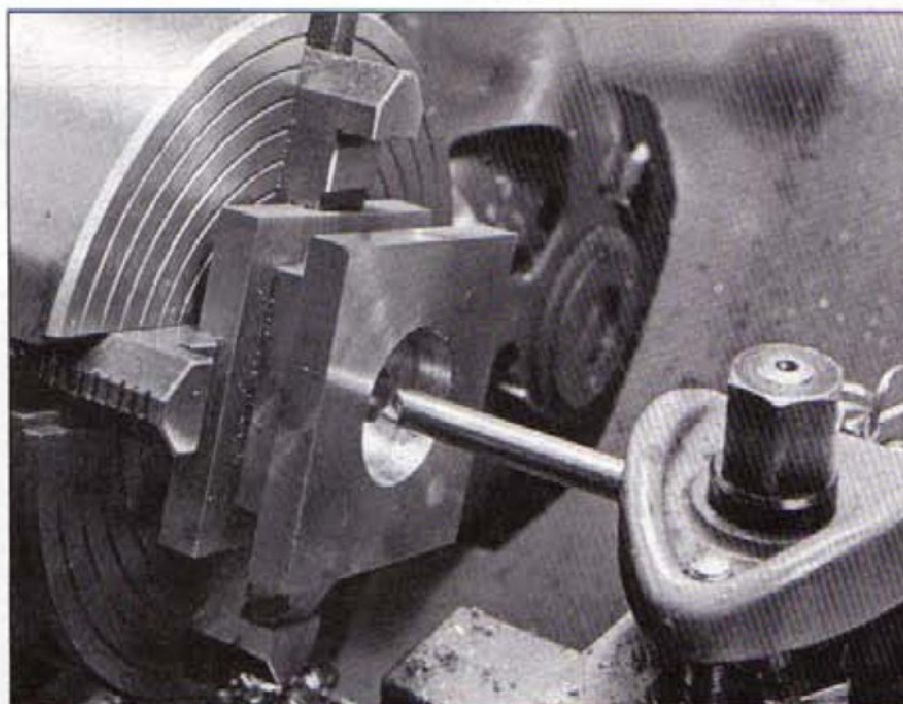
but it was decided against this.

It was therefore decided to purchase 3 inch wide and machine this to 2 1/2 inch for the upper and lower parts, and 2 inch machined to 1 1/4 for the middle.

## Construction

The first stage was to machine the three pieces to the required overall size. Two pieces were cut from the 3 inch material to a length of 2 1/2 inch which were then machined to 2 1/2 inch square. This was done by inserting one piece at a time edgewise into the four-jaw chuck, and facing each edge to get the required 2 1/2 inch square. As can be seen in the photograph, the chuck was large enough to allow the material to pass into the slot for the jaw and therefore achieved a substantial grip on the part being machined.

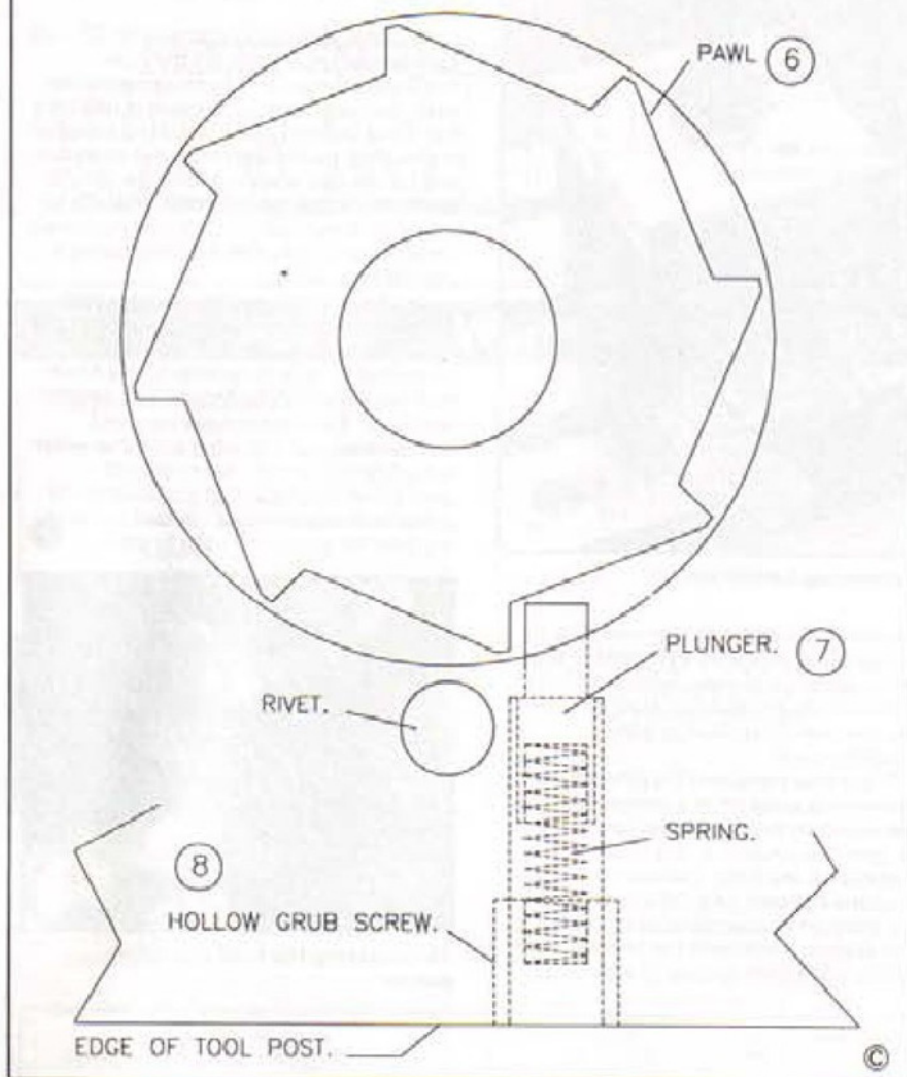
If only a smaller chuck were available, or the material would not go into the slot for



The rivet heads are finished off and the two bores are also finished at this visit to the lathe.



## RATCHET ASSEMBLY



then drilled about  $\frac{1}{16}$  inch smaller than the final size required, this to allow for the centre hole to be finally machined to size when the three parts are assembled.

The parts were then prepared for sticking together using two-part 24 hour resin adhesive. The surfaces were thoroughly degreased and then roughened and then degreased again. A small amount of adhesive was prepared and spread very thinly over the required surfaces; they were then placed together and moved one on the other to help spread the adhesive. The drill initially used was placed in the holes to line them up and the assembly clamped very firmly with four substantial toolmaker's clamps.

The assembly was then placed on the hotwater tank in the airing cupboard for a little extra heat, so as to achieve maximum strength. DO NOT leave the drill in, as some adhesive is bound to be squeezed into the hole and, as a result, the drill will become stuck and very difficult to remove. It was then left for about 18 hours before further work was undertaken.

When the clamps were removed, the assembly had a very solid feel to it and I was tempted to try it without further work to strengthen it. However, the real test would come when the eight screws used for fixing the tool bits were tightened, and not whilst the post was in use, and if the joint failed then, time would have been wasted. It was therefore decided to continue with the idea of fitting rivets.

The benefit of using adhesive in the manufacture of the post now became evident, as all the holes for the rivets could now be drilled without the inconvenience of toolmaker's clamps making it difficult to place the assembly on the drilling machine table.

Eight  $\frac{1}{16}$  inch holes were drilled for the rivets which were then countersunk to a diameter of  $\frac{1}{8}$  inch on both sides. One rivet

$\frac{1}{16}$  inch diameter and  $\frac{1}{32}$  inch longer than the thickness of the toolpost was made; this was then riveted, gradually turning from side to side until it fully filled the countersink and with some projection left for eventual machining flush — quite a lengthy process but do not be tempted to ease the situation by countersinking to less than  $\frac{1}{16}$  inch diameter. From this initial rivet, the length for the remaining seven was established and seven made to this length and riveted in as before. Anyone who has any reservations regarding the strength of this arrangement may like to use some adhesive on the shank of the rivet also.

To enable the post to be returned to the four-jaw chuck for facing its top and bottom and also level off the rivet heads, it was necessary to file off the heads of the four centre rivets on one side to allow the assembly to sit properly on the lower step of its chuck jaws. With this done, first one side and then the other were faced.

After facing the second side the post was left in the chuck and the hole bored out to be a close fit on the top slide tool-clamping screw, if an indexing mechanism is to be included, the counterbore should also be added.

The post was then removed from the chuck and all the edges deburred using a file. The top edges and the four corners were given a generous chamfer (about  $\frac{1}{32}$  inch) to improve appearance. The positions for the toolclamp screws were then marked out, drilled and tapped.

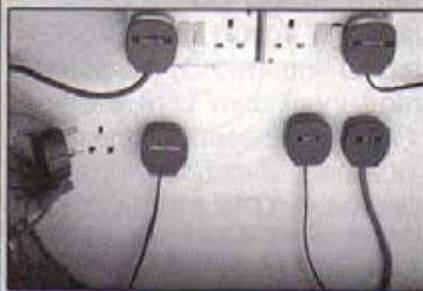
### Testing for strength

Four tool bits were then fitted into the post and the screws tightened to give the assembly a strength test, tightening the screws to a greater extent than would normally be done. The result was a slight indication of strain on the heads of the four corner rivets, though they had only been countersunk to about  $\frac{3}{32}$  inch diameter. From this test it was obvious that the greatest strain was seen by the corner rivets and perhaps some advantage could be gained by making these  $\frac{1}{16}$  inch diameter, there being less room for larger rivets in the middle positions if the indexing arrangement is to be included.

Also it was found when placing a straightedge diagonally across the top that it had bowed slightly, this being the reason

### QUICK TIP

If, like most workshops, yours has a limited number of power sockets for the many items of electrical equipment permanently installed and ready for use, such as the bench grinder, electrical heater, soldering iron, drilling machine, etc., the chances are that you have a number of electrical plugs lying around on the bench.

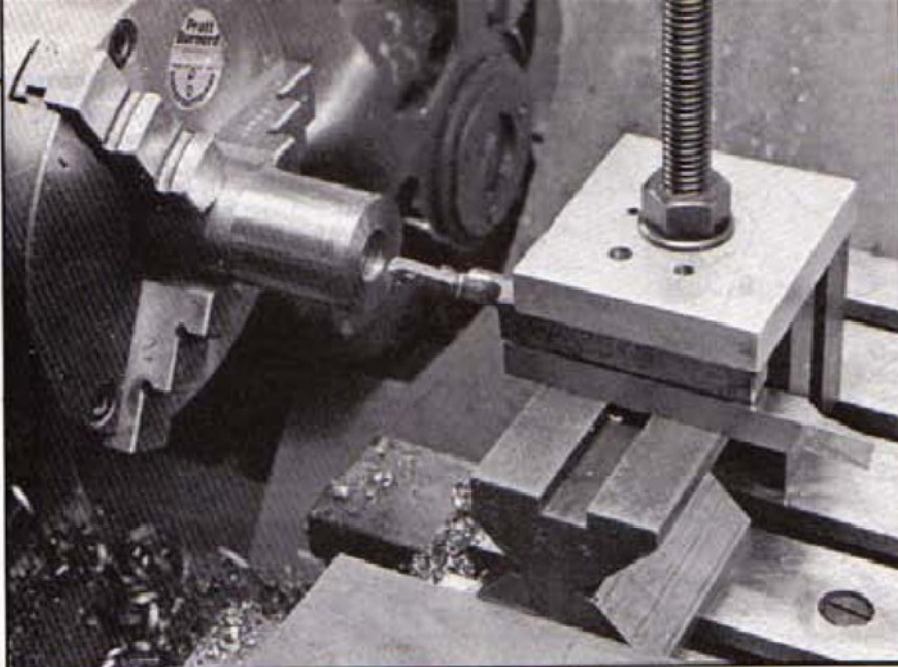


This is not good for the plugs as they may become contaminated which may result in a dangerous situation, also the leads may become damaged and, less serious, they will get in the way of other activities.

If you have a wooden workshop which has been lined with insulation board or similar, drill holes to simulate a row of sockets. If the holes are drilled on the small side, then the plugs can be pushed in, and the holes will take on the shape of the 13amp plug. The plug will then reliably stay in position and be kept tidy and ready for immediate use.

For those who do not have this or a similar lining to their workshop, in this situation fix a small panel of a suitable material and in a convenient position and drill this similarly. To further improve the safety of the installation, label all the plugs with their purpose to avoid the wrong item of equipment being energised.





*This is the special set-up for screw-cutting the clamping handle nut.*

why the four corner rivets were the ones to show signs of stress. A  $\frac{1}{2}$  inch thick top plate could be considered though this would not be practicable for the lower plate as it would raise the tool bits too high — in any case, this is really only of academic interest as the screws were considerably overtightened.

### The index mechanism

A disc was then turned to produce the index pawl. This was then carefully marked out to give the eight divisions and carefully shaped by hand which was considered acceptable as the degree of accuracy required was not that great, though care was taken to make sure the long faces were smooth as it was considered this would ensure the action of the mechanism was satisfactory.

The hole for the indexing plunger was drilled in the base as per the diameters indicated and threaded to a depth of  $\frac{1}{2}$  inch, the small parts made and a  $\frac{1}{2}$  inch diameter compression spring located and cut to a suitable length and the parts assembled. The projection of the pin into the counterbore was measured and the amount by which it had to be shortened established. It was then removed, shortened, and reassembled. The consideration here was that if it were too long, the toolpost would not fit easily over the pawl when being placed on the top slide, and yet if too short would soon wear and not work adequately.

The pawl was then fitted in place and only tightened very slightly, and the post placed in position and rotated clockwise, rotating the pawl with it, until the post was in the correct working position. The toolpost was then removed and the screws in the pawl finally tightened.

### The clamping components

It now remained to make the parts for clamping the post onto the top slide. No tap was available for the topslide clamp screw thread, and it was decided that the only way was to screwcut this on the lathe. The change wheels were set up and the screwcutting tool placed on the top slide — when it was realised that this was not practicable as the top slide screw would be required to test the internal thread being

produced! The only solution would be to remove the slide and fit the screwcutting tool by some temporary method. This can be seen in the photograph. Having done that, the clamp handle was quite straightforward.

There now remained the load-spreading washer. This must be to a thickness which makes certain that the clamp handle tightens to a position that is best for operation of the lathe. This I consider to be about the 4 o'clock position. To achieve this, the post is assembled onto the top slide and the position of the handle noted and the additional amount to which it is

required to be reduced in thickness arrived at.

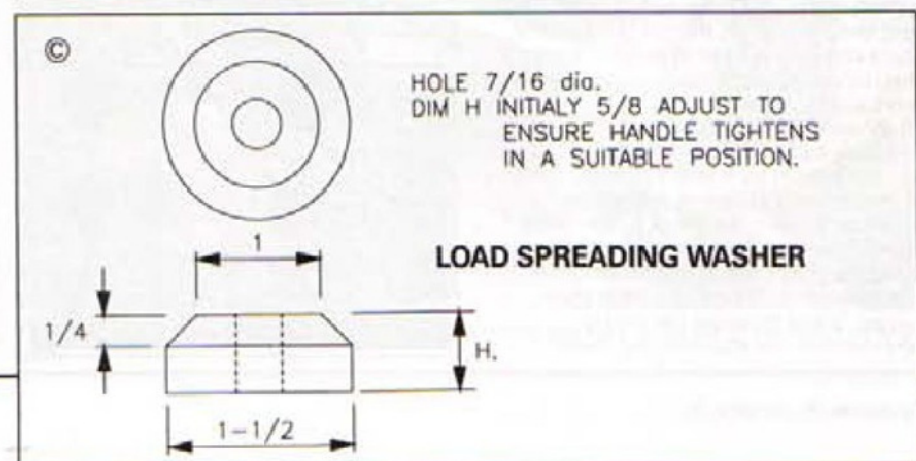
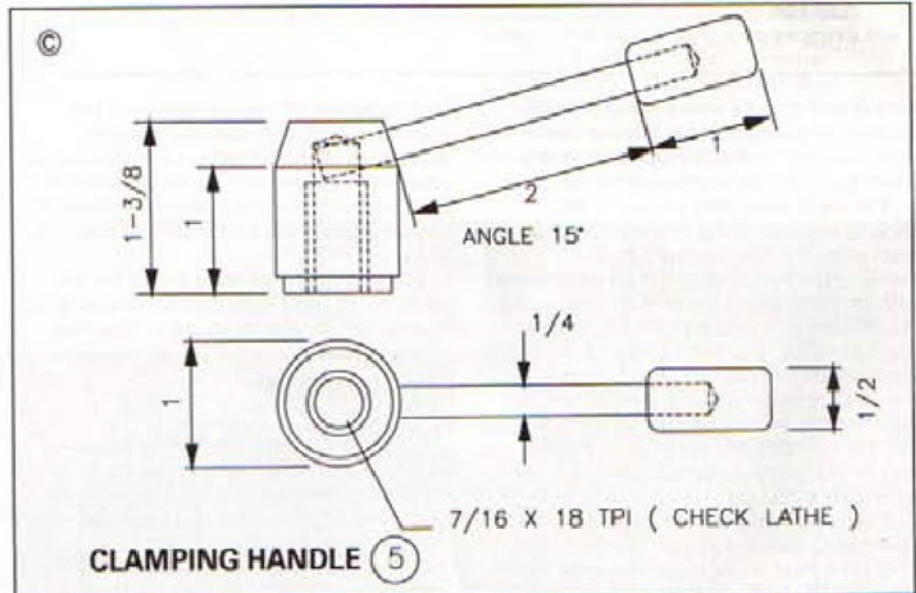
Knowing that the thread was 18 TPI, and therefore approximately 55 thou per revolution, the amount to be removed can easily be calculated. As the part is relatively thin I was worried that it would be possible to place the part in the chuck out of square and for the two sides not to be parallel. To avoid this, a stub mandrel was made to be a tight fit in the hole and the part machined whilst it was tightly fitted to this, taking a little off both sides.

As this process was so simple, a little less than calculated was removed first time to be on the safe side, as it would be preferable to have to remove a little more than having to reduce it by almost another revolution if too much were removed.

The dimensions quoted are those which suit a Myford Series 7 lathe, but the principle is so simple that it should be no problem to adapt the size to that required for any other make of lathe.

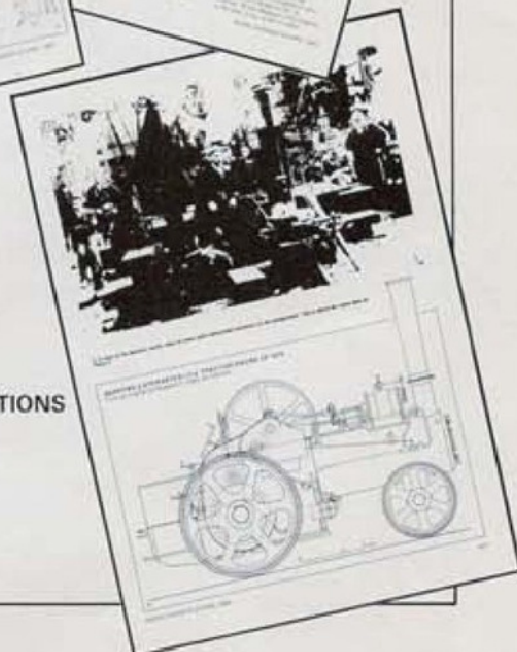
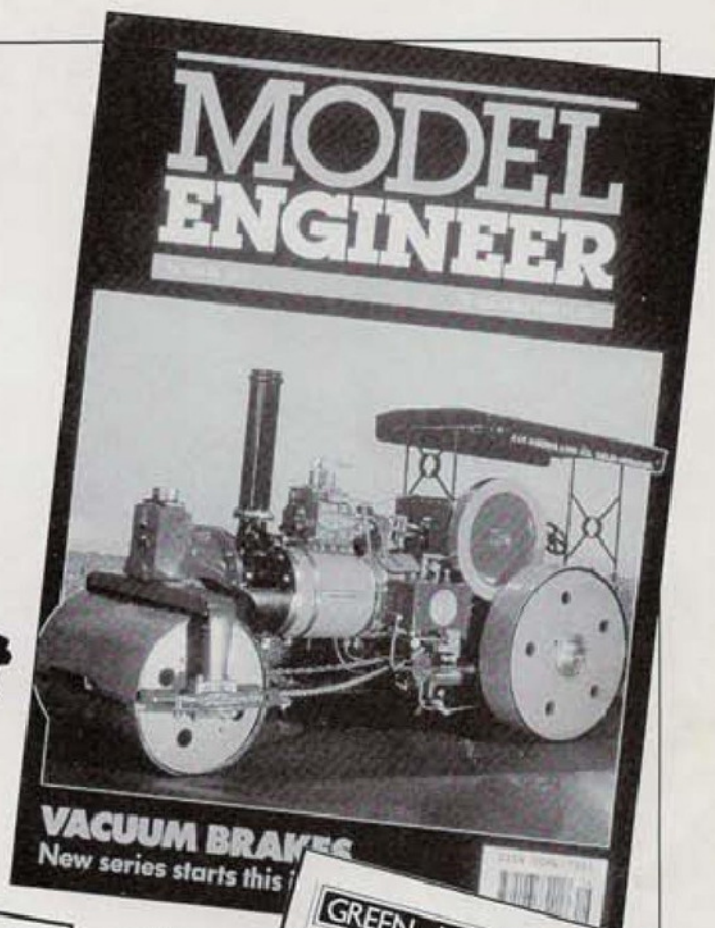


*Thickening the load-spreading washer.*





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