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JULY/AUGUST 2001
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MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

PERMANENT MECHANICAL FASTENINGS

Surveying available methods

UPDATING AN ADEPT HAND SHAPER

Adding automatic cross feed

MODELLING IN YORKSHIRE

Events at Harrogate and Primrose Valley

GEAR HOBBING

Electronic synchronisation of hob and blank

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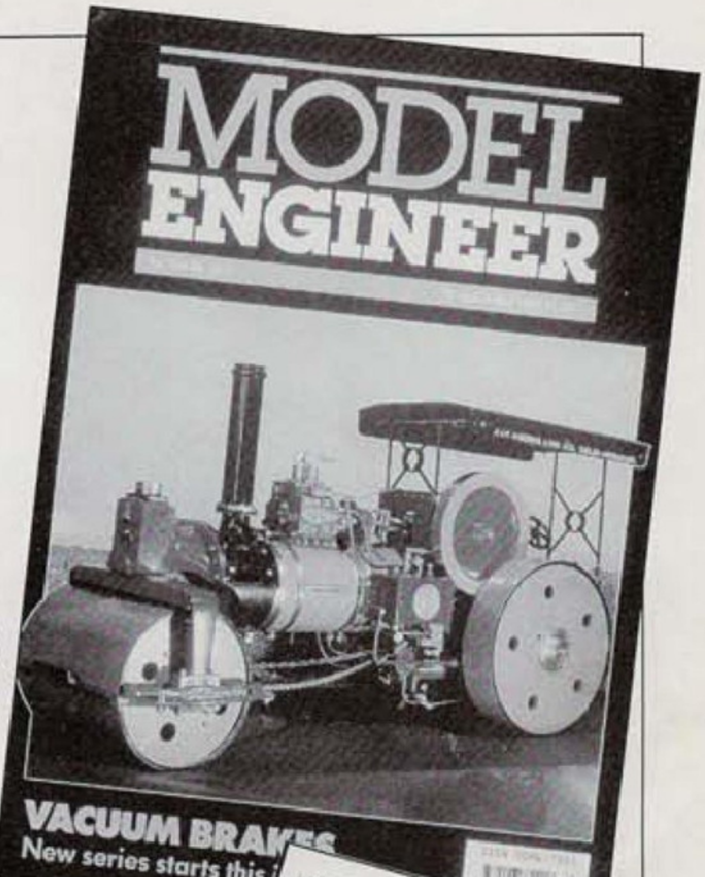

MODEL ENGINEER
VACUUM BRAKES
New series starts this

BORING & FACING HEAD
POSITIVE WHEEL QUARTERING
GREEN ARROW

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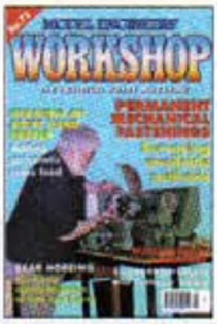
July/August 2001



Front Cover

'Model Engineer' Editor Mike Chrisp made good use of the Warco 918 lathe loaned for use in the workshop at the Primrose Valley holiday. Further details of this lathe can be seen on page 47

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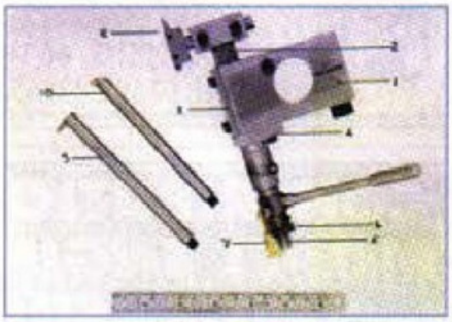

Inside

The toolpost attachment described on page 48 allows rapid withdrawal of the tool when screwcutting (Photo. John Chambers)

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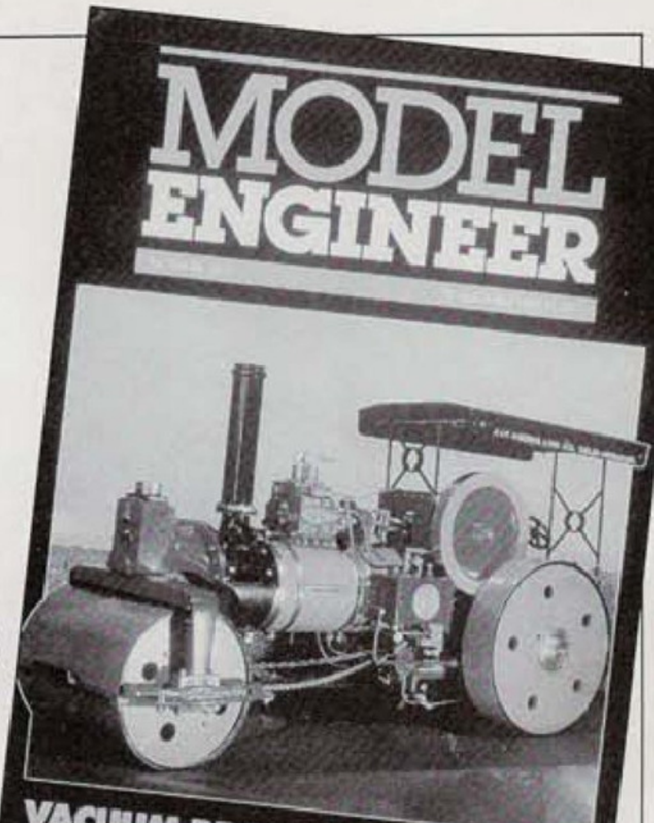
SOMETHING TO LOOK FORWARD TO...

...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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ON THE EDITOR'S BENCH

On this page readers will find an advertisement for two positions with the Nexus organisation, one of them being for an editor for this magazine. I have decided, for a variety of reasons, that the time has come to relinquish the position and to hand over to someone else. When I accepted the invitation to take over the editorial chair from Harold Hall it was my intention to be involved for, perhaps, three years at the most. I now realise that it is almost seven years since I received that initial telephone call, so I feel that it is time to change direction and perhaps complete some of those outstanding projects which I intended to tackle when I retired from the engineering industry.

It is unlikely that I shall lose contact completely with the Nexus organisation because it has been suggested that there are still tasks to be carried out, but these are likely to require a far smaller commitment of time and energy. I shall, of course, be available to give advice and support to my successor in the initial stages. This is not necessarily a full-time post, being particularly suited to someone who would prefer flexible working arrangements

The other post is that of Technical Editor to join the team on our sister publication 'Model Engineer', providing back-up to my colleague Mike Chrisp. If you are interested in either of the jobs, please don't hesitate to give us a call.

Modellers' Insurance

For some months now we have been receiving enquiries about the Modellers Accident Protection insurance policies, particularly in respect of the requirement for full Road Traffic Act cover for miniature road vehicles attending rallies. I have been asked to draw readers attention to the following announcement:-

"Following legislation changes we are delighted to announce that Nexus Special Interests Ltd has located a specialist Modelling Insurance group to cater for all readers' modelling needs.

"With immediate effect, only authorised registered members of the General Insurance Standards Council are able to provide or issue insurance services and this has meant that Nexus is unable to continue to offer Modellers' Protection Insurance. All current policies in place will continue to run to expiry through current brokers HCF - Tel. 020 8731 5155.

"New Policies

For all new policies or renewals we are able to recommend specialist broker Walker Midgley Insurance Brokers Ltd to our readers. Walker Midgley have years of expert experience in providing Select Insurance Cover for Individual Modellers & Model Engineers as well as Model Road Steam Insurance involving full Road Traffic Act cover.

"In addition to their excellent menu of cover, readers will be delighted to hear that the business is actually owned by Tony Wood, an active modeller himself and leading figurehead with the Northern Association of Model Engineers.

"For further information please contact Tony Wood, Walker Midgley Insurance Brokers Ltd., Montague House, 294 Cemetery Road, Sheffield S11 8FT Tel. 0871 871 3080"

Winson Model Technology

The following statement was issued by GCI London on 17 May 2001:-

"ADMINISTRATORS APPOINTED TO WINSON MODEL TECHNOLOGY

"John Kelly and Gurpal Johal, Partners at the Birmingham office of Kroll Buchler Phillips, the UK's leading independent specialists in corporate restructuring, were today appointed by the High Court of Justice as Joint Administrators of Winson Model Technology Ltd, a manufacturer of model steam locomotives.

"Winson Model Technology, based in Daventry in Northamptonshire produces and sells self-assembly kits of miniature-gauge steam locomotives and employs 41 staff. It operates a niche business and has an excellent reputation as a market leader.

"Kroll Buchler Phillips has already opened discussions with a number of interested parties with a view to a sale of the business and its assets. Whilst it is likely that all jobs will initially be lost, it is hoped that any buyer will seek to re-employ many of the employees due to the high level of skills required.

"John Kelly commented: "Winson Model Technology, in essence, make a good and valued product and we are hopeful that we will achieve a speedy sale of the business and that many of the jobs lost will only be temporary until a new buyer is found."

Kroll Buchler Phillips can be contacted on 0121 212 4999

A model engineering class and funding

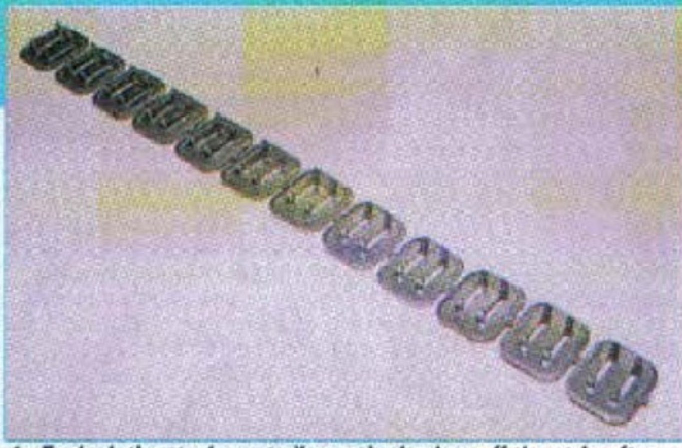
Reader Michael Dyer has telephoned with information regarding a model engineering class which takes place at Maidenhead College, East Berkshire. He gives the contacts as Norman Eatwell and Peter Phillips on 01753 793455 and the cost as £90 per term.

He has also drawn our attention to the Individual Learning Account system, through which UK readers can obtain discounts on the fees of a variety of courses. Reductions of 20% are available on a wide range of courses, while as much as 80% discount can be obtained on some. Additionally, the first million people to open an Individual Learning Account will get a contribution of up to £150 discount off the cost of learning if they put in £25 of their own money.

More information on this initiative, which is sponsored by the Department for Education and Employment, by calling 0800 100 900.

PERMANENT MECHANICAL FASTENINGS

Philip Amos takes a wide-ranging look at the available methods of forming joints in a variety of materials by mechanical means



1. Each cloth attachment clip can be broken off the strip after being hammered into the timber. Styles are available with two, three or four 'prongs'

2. Gang nail plate, suitable for either power pressing or manual hammering into place

The nature of mechanical devices requires that parts be joined together - either permanently or temporarily (in the latter case so that they can be dismantled again if necessary). Threaded fasteners, tapers, keys, circlips and pins cover most of the temporary connection methods. Permanent fastenings can be by adhesives, thermally (forging, hammer welding, shrinking, soldering, brazing or gas/electric welding) or mechanical - and this article addresses this latter category.

Although most home workshop and club activity is concerned with metal, timber still finds uses in workshop building frames, doors, windows, benches, cupboards, shelves, bridges, trestles and boxes, and also for boats of various sizes. Mechanical fastenings are commonly used in these timber constructions.

Introduction

Permanent mechanical fastening requires some distortion of the material. The main joining methods are:-

- Wedges or dowels in timber joints
- Nails, spikes and the like
- Staples
- Force fits
- Riveting in all its guises
- Tabs and slots
- Staking and spin riveting
- Spinning
- Swaging
- Crimping
- Clinching
- Welch plugs
- Interleaved edges

These are all discussed below.

Timber Joints

The most common joints in timber utilise screws, nails or adhesives in combination with various timber shapes to comprise the joint. However there are two types which employ only the timber itself to form permanent fastenings; both are variations of the mortise and tenon joint utilising wedges or cross dowels respectively. Either can also employ adhesives, but if carefully made can be quite satisfactory and long lasting without addition.

a. Wedges

Drawing 1(a) shows the simplest mortise and tenon arrangement, where two wedges are driven in on opposite sides of the tenon thus jamming it tight in the mortise aperture. In a more elaborate arrangement there are two sawcuts in the tenon (each terminating in a drilled cross hole to reduce the chances of splitting) and into which the wedges are driven.

Drawing 1(b) shows a foxtail wedged joint in which the tenon and wedges are not visible after the joint is assembled. (This is also referred to as a stub mortise and tenon joint).

b. Cross dowel

Drawing 1(c) shows a cross dowel locking the tenon in place in the mortise. By drilling the hole in the tenon slightly closer to the shoulder than directly corresponding in position to the hole across the mortise, a tapered end dowel driven in will draw the joint tightly together. This arrangement seems to work very well for large doors.

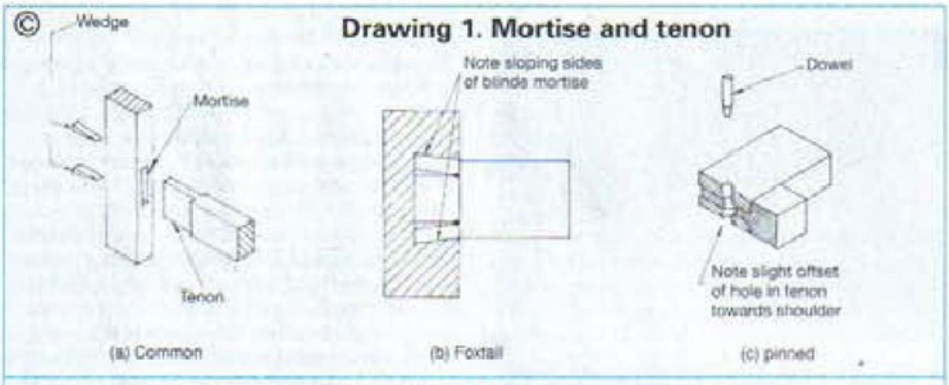
Nails, spikes and the like

a. Types of nails

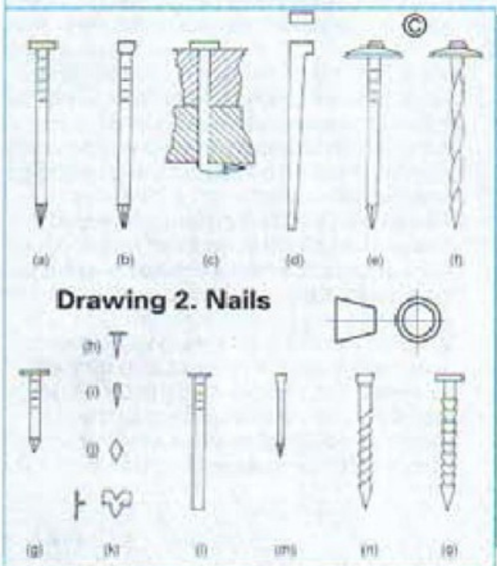
Probably the oldest and simplest of all mechanical fasteners, nails come in a wide variety of styles and sizes to cater for particular requirements; and what a profusion of types there is! Hopefully what follows will provide a bit of a map of the pathways through the puzzle of the correct selection for their use. The size ranges refer to the Australian market place, but other countries are probably similar.

Drawings 2 and 3 show a number of these types, the uses of which are discussed below. Most nails are made of steel, and may be galvanised or zinc plated for protection against corrosion. However for marine use they are also made in copper, monel and silicon bronze.

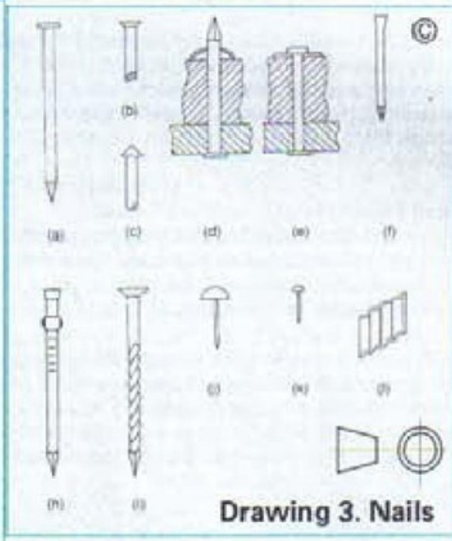
2(a). The Common / Box / Flathead nail range of sizes runs from 1.6mm diameter 20mm long to 5.6mm x 150mm. Used in



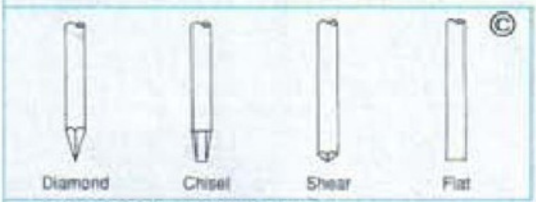
Drawing 1. Mortise and tenon



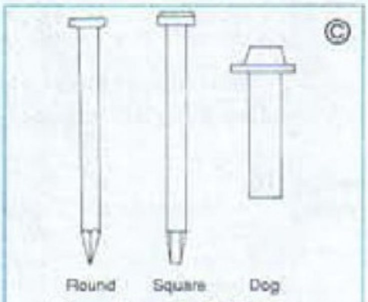
Drawing 2. Nails



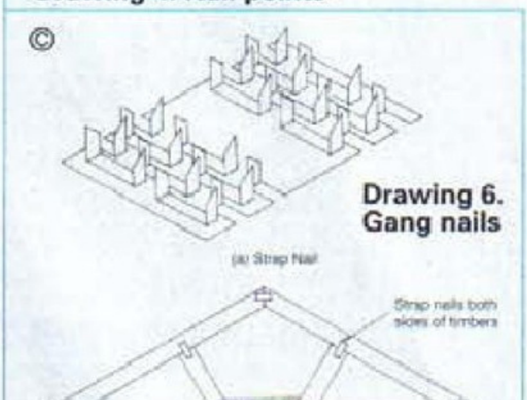
Drawing 3. Nails



Drawing 4. Nail points



Drawing 5. Spikes



Drawing 6. Gang nails

softwoods (particularly sheets) and for packing cases.

2(b). Bullet Head / Jolt Head / Round Head / Finishing nail is the general purpose nail of carpentry, where the head is driven below the surface. The size range is from 1.0mm x 12mm to 5.6mm x 150 mm. It is used for construction work, flooring and wall linings. Wire brads are similar, but smaller, and are used mainly to attach mouldings and panelling.

2(c). Clinching over the far side of flat or jolt head nails greatly assists in preventing their working loose.

2(d). Cut floor brads in lengths from 15 to 150mm are sometimes used to fix floorboards. They provide a good grip and are unlikely to split the timber.

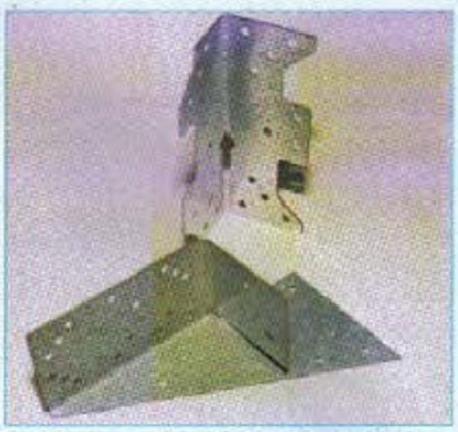
2(e) & 2(f). Roofing/Springhead nails are mainly used to secure corrugated galvanised sheet to roof purlins. They may have either a plain round (2e) or a twisted square (2f) shank and are usually galvanised. The spring head provides a watertight self seal on the corrugated steel, but as time passes and the roof "works" with hot and cold weather cycles this seal may become less effective. Thus some of the nails are now sold with neoprene washers under the head to improve the sealing characteristics long term. The twisted square shank variety seems to resist loosening better than the plain shank ones.

2(g). Clouts are flat headed nails used to attach fibrous plaster or gypsum sheets for walls and ceilings. Usually galvanised and available in range from 2mm x 12mm to 3.75mm x 50mm.

2(h). Cut tacks seem mainly to be used for securing fabrics or leather to furniture, floors or shoes. They range from 1.6mm x 10mm to 2.0mm x 25mm and are mostly blacked steel.

2(i). Headless tacks called sprigs in sizes 12 to 18mm long are used to fix heavy linoleum to floorboards, and glass in frames before puttying.

2(j). Glazing points are diamond shaped pieces of 26 BG galvanised steel, used for



3. Two types of a variety of connector plates. The plain angle one can have its lower legs bent forward or backward as required

4. Desk stapler opened for loading of staples. Collated staples shown in foreground

5. Workshop staple gun to fire staples into hard material such as timber. Collated staples seen at left

6. Crimping tool for the attachment of terminals to electric wires. Two examples in the foreground

7. Close-up of the actual crimps in the terminal barrels - one insulated and one not

a similar purpose to sprigs to hold glass in frames before puttying.

2(k). Push points of 26 BG galvanised steel are for a similar purpose but are much easier to use. They seem to find wide application nowadays.

2(1). Fibre Cement nails are similar to clouts but with a smaller diameter head and a flat end which punches through rather than splitting the sheet. Size range is from 2mm x 25mm to 2.5mm x 50mm.

2(m). Panel Pins are similar to smaller bullet head nails or wire brads, but the underside of the head is conical to allow easy entry to the timber. Widely used for attaching timber sheets to walls. Sizes range from 1.0mm x 12mm to 1.6mm x 40mm.

8. Netting clips, together with the special pliers used to clinch them in place

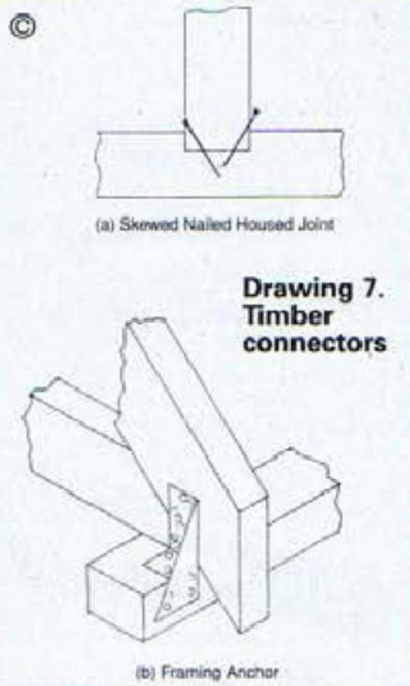
2(n). Particle Board nails are helically threaded due to the low holding power of plain shank nails in this material. They are also useful in hardwood. Range is from 2mm x 25mm to 3.15mm x 50mm.

2(o). Annular nails have a series of annular rings down the shank and are very good for holding in softwood. They are much used in boats where they are usually made of copper, bronze or monel. For steel, sizes range from 1.6mm x 12mm to 3.15mm x 75mm and in copper from 1mm x 12mm to 5.6mm x 150mm.

3(a,b,c). Copper boat nails (other than annular) are either round or square shank. The latter are said to better resist 'popping' when the structure is twisted. Flat, countersunk or conical heads are available as shown in 3(a,b,c). Round flathead nails are usually fitted with 'roves' (tight fitting domed copper washers). A dolly is placed over the end of the nail to allow the rove to be driven hard down; the end of the nail is cut down and the remaining protrusion is riveted over as shown in 3(d) & 3(e).

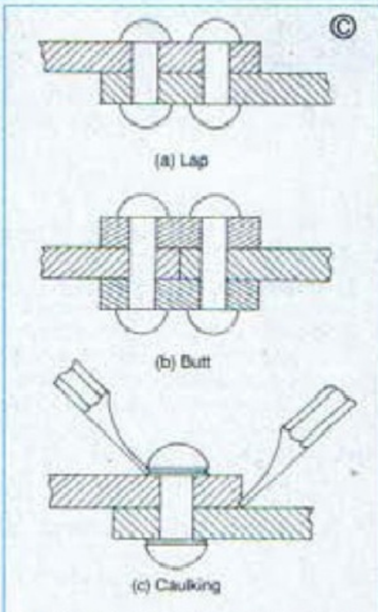
3(f) & 3(g). Hardboard nails are similar to panel pins but made of hard steel. They are used to attach various types of composition boards to interior walls. Usually zinc plated to avoid staining, they range in size from 1.4mm x 20mm to 1.6mm x 30mm. Some have a flattened double diamond shaped head (called a deep drive nail) which becomes hidden in the board - 3(g).

3(h). Formwork/Double Headed Shutter nails have a double head so that they can be driven into contact with the formwork, but later, easily withdrawn using the second head. They range in size from 2.8mm x 50mm to 4.5mm x 100mm.



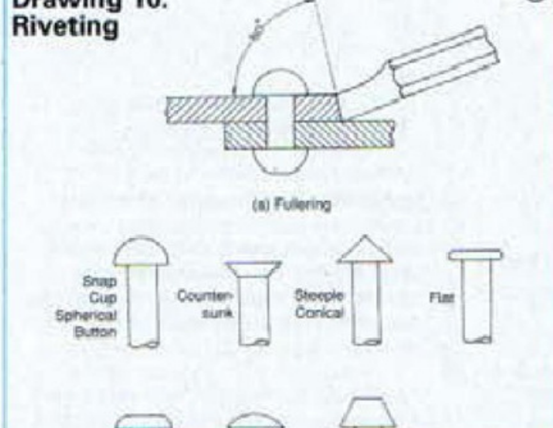
Drawing 7. Timber connectors

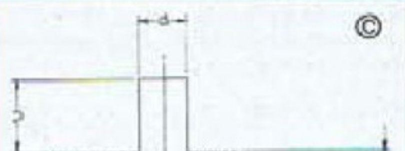
Drawing 8. Various



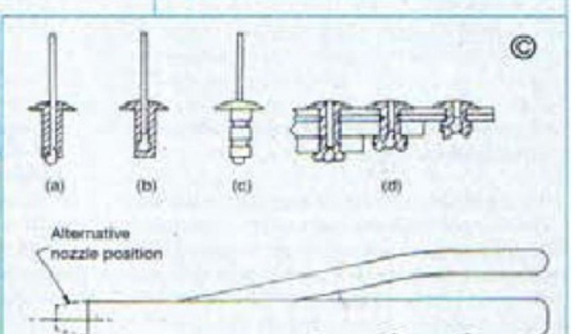
Drawing 9. Riveted joints

Drawing 10. Riveting

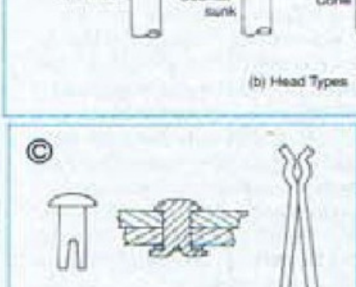




Drawing 11. Rivet sizing



Drawing 12. Pop rivets



Drawing 13. Bifurcated rivets

3(i). Drive Screws are used for roof and deck applications where great holding power is needed. They are usually galvanised and can be obtained with round, raised flat, countersunk or pan heads in sizes from 3.15mm x 25mm to 4.5mm x 65mm.

3(j). Upholstery/Chair nails are rather like a drawing pin with a domed hollow head. They usually are nickel plated, blackened or brass finished and seem to mainly come in one size - 10.5mm diameter head, 1.4mm diameter pin penetrating 13mm (although catalogues show head diameters 3 to 12mm).

3(k). Escutcheon pins are short brass nails with rounded heads. They are used to attach brass nameplates and similar applications. Usual size is 1.6mm x 20mm.

3(1). Corrugated/ Wiggle nails are a cheap means of joining boards together sideways, much used in small packing cases. They range in length from 11 to 19mm with four, five or six corrugations.

b. Nail Points

Four types are shown in **Drawing 4**. Most nails have diamond points.

c. Selecting nail size

i. Length

To resist the separation of two pieces of wood joined together, the nail penetration into the member receiving the point should be at least half the nail length for medium to high density timbers, and at least two thirds for low density ones.

ii. Diameter

To reduce splitting, the smallest diameter which can be driven without bending should be used **or** pre-drill the hole say 10% less in diameter than the nail before driving.

d. Driving

The conventional hand hammer continues to be used for most nail driving activity, but where large numbers of nails are to be driven pneumatic or electric nail guns tend to be used. Thus wall framing, floorboards, wallboards and fence palings are mostly installed by this means nowadays.

The nails are supplied in clips or paper belts (collated) and are automatically fed and driven at each press of the trigger. These machines are very effective, but have a tendency to split hardwood if nails are driven near the edges or ends of the timber. Nevertheless, with attention to these restrictions, they are a fast and labour-saving aid to construction.

e. Spikes

i. Anything larger than 5.6mm diameter or 150mm long is usually called a spike - sometimes Deck Spikes as their main use was once fixing the planks on wooden bridges. They are either round shank with a sort of flattened round head and a diamond point, or square shank with square head and chisel point. Usually 9mm diameter and 150 to 250mm long, either plain or galvanised **(see Drawing 5)**.

ii. Dog Spikes are relatively short fat steel spikes with a round shank and a square head merging into a skirt-like washer - see **Drawing 5**. These have been used for at least a century to hold flat-bottom steel rails on wooden sleepers. The NSW pattern is 108mm long and either 19 or 22mm diameter. These were hammered into pre-drilled undersize holes. Nowadays these have been replaced by special spring clips, but there are still countless thousands out there on branch lines and sidings.

f. Gang Nails

Drawing 6(a) shows a plate of 18 BG galvanised steel with multiple teeth punched out. Such items are called 'gang nails'(or 'strap nails'), and are used in the factory production of timber roof trusses, where they are pressed into the surface of the timbers across a joint, between the platens of a hydraulic or pneumatic press - **Drawing 6(b)**.

Photo. 1 shows a similar concept on smaller scale, which is used to hold insect screening or shade cloth to timber frames - each 4-pin segment is broken off and whacked into the timber through the cloth with a single hammer blow. **Photo. 2** shows another form of gang nail plate. This can be power-pressed into the timber face, but can also be hammered in if need be.

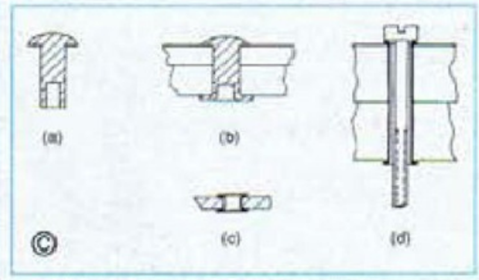
g. Timber Connectors

To join members at right angles, the traditional approach is to skew nail, as shown in **Drawing 7(a)**. It is quite easily done in soft timber with either a hand hammer or a nail gun. It is quite a strong joint if one timber member is 'housed' in a groove in the other. However, a much stronger joint with plain butting members can be obtained using galvanised steel connector plates (framing anchors) as depicted in **Drawing 7(b)** and **Photo. 3**. Multiple special nails closely fitting the holes in the plates are driven perpendicular to the timber.

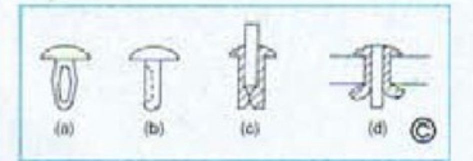
h. Masonry Nails

Sometimes called Concrete Nails these are made from hardened steel and have either a plain or knurled shank and are zinc plated. They have a size range from 2.4mm x 20mm to 4.2 mm x 75 mm. They are rather hazardous to use - eye protection is essential. If not struck squarely with the hammer they may fly in any direction. Even if correctly struck they may be deflected by encountering hard aggregate in the concrete. Some are fitted with a washer near the point which tends to hold them square to the surface which the nail is driven through.

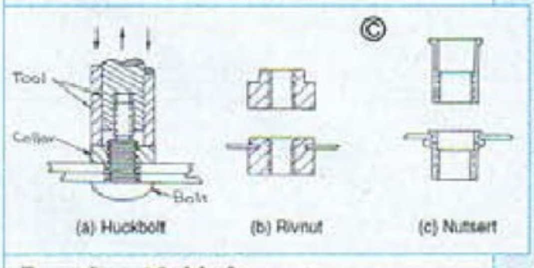
Sometimes these nails are driven with a gun using a cordite cartridge, which can be even more hazardous, and all the operating instructions must be strictly observed if accidents are to be avoided.



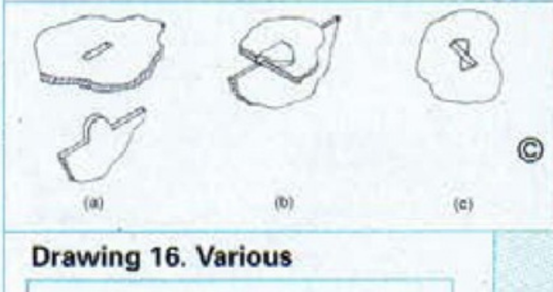
Drawing 14. Tubular rivets



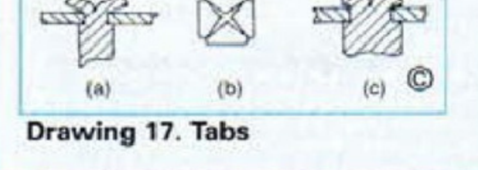
Drawing 15. Plastic rivets



Drawing 16. Various



Drawing 16. Various

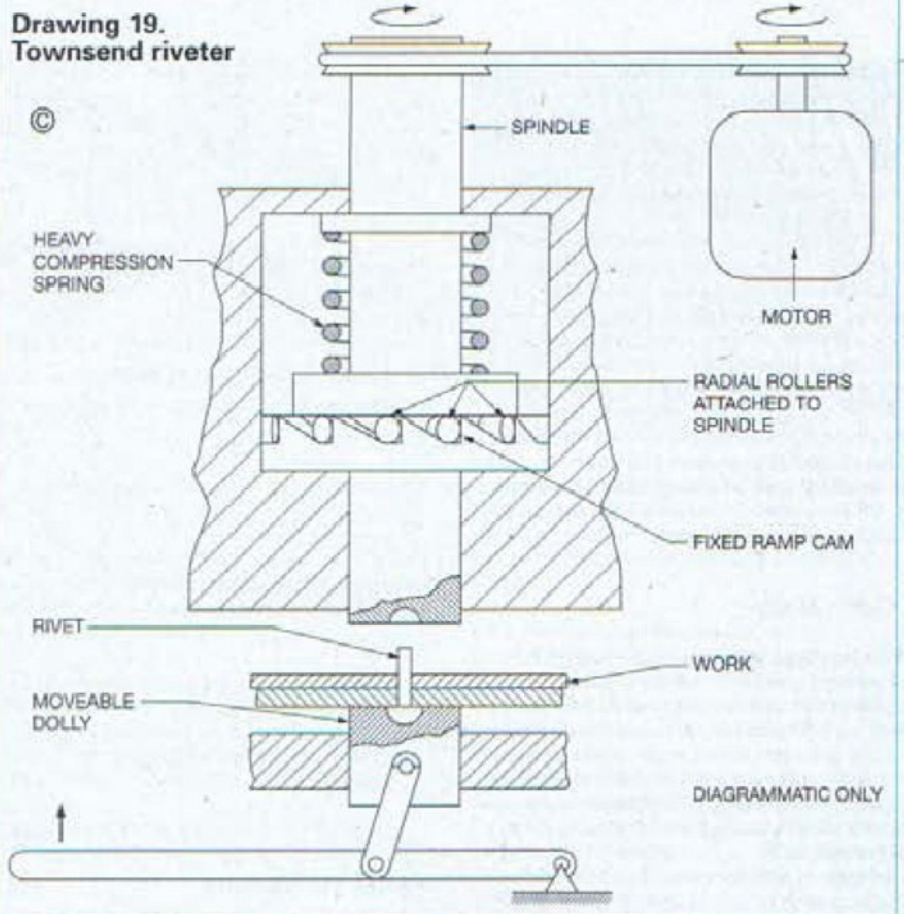


Drawing 17. Tabs

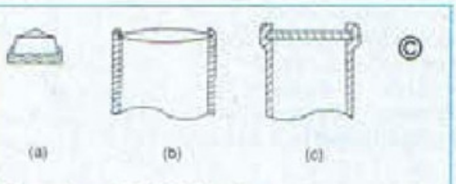
Staples

a). Fencing staples are shown in **Drawing 8(a)** and range in size from 2mm x 12mm to 4mm x 50mm. They are always galvanised and are used to secure fencing wires to supporting wooden posts.

b). Office staples are used to hold papers together and come in a wide variety of sizes, with all sorts of machines to insert them. The machines can also be used to staple paper notices to plywood with varying success. Most office staplers are provided with two position anvils which either clinch or spread the staple legs after they pass through the assembled sheets of paper. Spread staples are easier to remove but not as reliable for holding pages together. **Photo. 4** shows a typical office stapler opened for loading. The alternative



Drawing 19.
Townsend riveter



Drawing 20. Spinning

forming grooves in the anvil are just visible.

c). Manual staple guns fire the staples into whatever material they are placed against and firmly attach fabric, leather, paper and cardboard to timber or wallboard. Usually these staples are 12mm between the legs, the length of which can be 6, 10 or 12mm **(see Photo. 5)**. Pneumatic staple guns achieve the same action with virtually no effort by the operator. Carpet layers make significant use of these machines.

d). Both office and workshop staples are usually collated for easy loading - samples are seen in Photos. 4 and 5.

Drivescrews -Type U

These are hardened steel pins with domed heads and helical grooves in the shank, as depicted in **Drawing 8(b)**. They can be hammer driven into pre-drilled holes in metal or plastics and find considerable application in the permanent attachment of name and operating plates. They are usually zinc plated and provided in a range of seven diameters for holes from 1.3 to 4.0mm diameter and lengths from 3 to 16mm.

Force fits

A shaft having a slight taper on its end may be forced into a marginally smaller hole by means of a hydraulic press. The force required depends on the difference in diameters, the length of the engaged portion, and the coefficient of friction. Typical differences in diameter are 0.0002 to 0.0014 inches per inch of diameter. Typical force required for a 1in. diameter steel shaft pressed into a corresponding hole in a 2in. diameter cast iron boss is about 2.7 tons per inch of axial engagement.

Even with very careful manufacture and control of dimensions it is often difficult to achieve a satisfactory result. For example a steel shaft may split a cast iron hub. Despite getting a satisfactory assembly, there may still be long term problems with the torsional holding ability of such a combination, so keys or splines may necessary as well as the force fit. In some cases, the required size of hydraulic press may be unavailable, and recourse must be made to a shrink fit, where the hub is enlarged by heating or the shaft is contracted by cooling, to produce the required fit, on resuming normal temperature - this however is outside the scope of this article. Reference 1 gives information on dimensions to use and the hydraulic press force needed for the mechanical type of force fit.

Riveting

a. Conventional Rivets

The use of rivets to connect metal parts together goes back into the mists of time. The practice reached its peak in the shipbuilding, boiler and structural engineering industries about 1900, after which time it was gradually replaced by welding.

Closing large rivets in these industries was usually done with them red hot using sledge hammers, or pneumatic hammers, but hydraulic means was also sometimes used. In the home workshop, the rivets are much smaller and may be closed cold with a hand hammer or a special screw press - see Reference 2.

While the easier forming of the head is the main advantage of using red-hot rivets, these also contract axially on cooling leading to a tighter joint.

The riveting process had a new lease of life as the aircraft industry expanded in the 1920's with widespread use of aluminium alloys, and when similar alloys started to be used for boats, the practice moved into that field also.

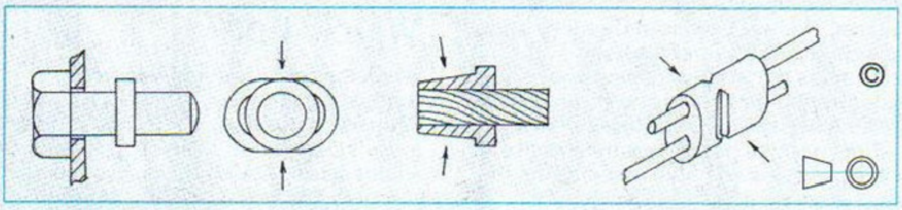
Riveted joints are usually lapped as shown in **Drawing 9(a)** or butt with one or preferably two cover straps, as shown in **Drawing 9(b)**. Where necessary for gas or liquid tightness, the edges are 'caulked' by using a chisel to turn down the edge of the plate and rivet heads, as shown in **Drawing 9(c)**. This is a process requiring considerable skill, as if done badly may make matters worse rather than better. A similar process called 'fullering' may be used instead which is less difficult to effect, but requires the plate edge to be prepared - bevelled to about 80 deg. - see **Drawing 10(a)**. Here the chisel edge thickness is equal to the plate thickness.

The design of riveted joints is beyond the scope of this article, but those interested may find the mathematical treatment in Reference 3, and design guidance in References 1, 4, 5, 6, 7 8, 9 and 10 (the latter being comprehensive). Detailed instruction in the technique of setting and closing (heading) rivets is given in References 9, 10, 11 and 12.

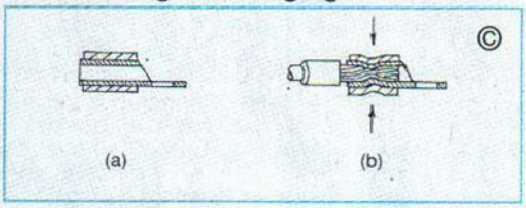
The sizes of rivets have long been standardised and details can be found in Reference 5, but finding sources of supply for a particular size or material may often be a bit of a challenge these days. Rivet materials most common are wrought iron and copper but others are made from soft steel, brass, bronze, monel, aluminium and Inconel.

Head shapes are depicted in **Drawing 10(b)** with a variety of names for each. Of these the Snap / Button / Cup and the Countersunk heads are the most commonly used, but Flat head (Tinman's) rivets have been much used in sheet metal work.

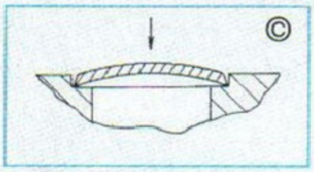
The main selection criteria for dimensions are diameter and 'upstand', the latter being the length projecting beyond the plates being joined, and from which the closing head is to be formed. The diameter is usually chosen from the nearest available standard size between the limits of 1.2 to 1.4 times the square root of the thickness of each plate (Unwin's formula in References 5 and 10), but see



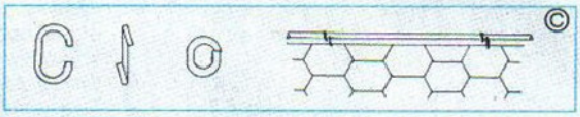
Drawing 21. Swaging



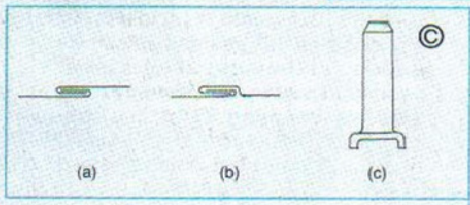
Drawing 22. Crimping



Drawing 24. Welch plug



Drawing 23. Clinching



Drawing 25. Interleaved edges

also Reference 9 **(Drawing 11 refers)**.

The upstand depends on the shape of the head it is desired to form. Essentially, the volume of the upstand must equal the volume of the head chosen. Rules of thumb found in many texts are for Snap Heads - 1.5 x rivet shank diameter and for Countersunk Heads - 1.0 x rivet shank diameter. However, other texts (e.g. Reference 9), show 1.6 to 1.7 x rivet shank diameter for Snap Heads. If you do the sums, the actual equal volume basis gives 1.46 for Snap Head and 0.67 for Countersunk Head. Probably better to err a bit on the generous side and, in the case of the Countersunk Head, file off the excess afterwards.

b. Pop rivets

Where access is only available from one side of the work, the pop rivet is a convenient and rapid means of fastening. It is not as strong as a conventional rivet, but is quite adequate for many purposes. As depicted in **Drawing 12(a)** the rivet shell has a mushroom shaped head - but other shapes are available e.g. Large - diameter and countersunk types. Through the rivet passes a headed mandrel or stem. A special insertion tool presses down on the rivet head while pulling the mandrel through the rivet, causing the far side to expand on the far side of the work. At a predetermined load the mandrel head breaks off, remaining in the rivet, while the mandrel itself is withdrawn and is discarded.

Pop rivets come in diameters 3.2 to 6.4mm and in grip lengths 3.2 to 22.2mm. Various combinations of materials are available for different purposes, thus:-

Shell	Stem
Aluminium	Steel
Aluminium	Aluminium
Steel	Steel
Stainless Steel	Steel
Stainless Steel	Stainless Steel
Monel	Steel
Copper	Steel

The effort needed to close a pop rivet depends on both the material and the diameter. At the smaller end of the scale, hand plier type tools can be used; but at the larger end, lazy tongs or lever action tools are needed, or pneumatic tools.

Usually the plier type are equipped with interchangeable 'nozzles' or bushes to accommodate the mandrels for 1/8, 5/32 and 3/16in. diameter rivets. Most only work at right angles to the pliers, but some can also work in prolongation, as shown in **Drawing 12(e)** - these being much more versatile for use in awkward places.

For liquid or gas tightness, sealed rivets are available - see **Drawing 12(b)**. Material combinations are:-

Shell	Stem
Aluminium	Steel
Copper	Steel
Stainless Steel	Stainless Steel

There are also available multi-set rivets which can be used with a wide range of work thicknesses - i.e. a range of grip lengths available from the one rivet. e.g. for a 3.2mm diameter, a grip range from 1.6 to 4.8mm. These are aluminium shell with steel stem - see **Drawing 12(c)**. The action is shown in **Drawing 12(d)**.

c. Bifurcated rivets

Shaped as shown in **Drawing 13(a)**, these rivets come in a variety of metals, finishes, diameters and lengths. They are used extensively in the connection of soft materials like fabrics, leather, plastics and rubber to similar or harder materials. The rivet is usually passed through a flat washer on the far side of the materials being joined, as shown in **Drawing 13(b)**. The most common size seems to be 4mm diameter with a head diameter of 7.5mm. They come in lengths 6, 10, 13 and 16mm and in materials copper or nickel plated brass. However, others are made with 2.2mm diameter shanks, 5mm long, and 2.7mm shanks, 13 or 16mm long. In former times (say 50 years ago), tins of assortments were available, but nowadays bifurcated rivets are quite difficult to find retail. These assortment tins used to contain a holding aid of springy copper, shaped as in **Drawing 13(c)**.

d. Tubular rivets

Usually made of aluminium (alloy) as depicted in **Drawing 14 (a)** these come in a wide variety of diameters and lengths. They find application in aircraft, vehicle, boat, home appliance and other industries. They are intended for cold closing with a special tool which expands the tube part to form a second head on the rivet - see **Drawing 14(b)**, but they are not likely to find much use in the home workshop. If necessary, the closing operation can be effected by opening out the tubular end with a large centre punch, and then flattening with a ball pein / engineer's hammer.

e. Eyelets

Originally used to reinforce holes in leather, as for example in shoes for laces, they are usually made of soft brass of general shape as in **Drawing 14(c)**. However, they are now often made from long thin brass tubes, with ends expanded by flanging, and are used to hold small plastic boxes together (e.g. the cases of switches and the like). Their advantage is that the same space can be used for mounting screws which pass down through the hollow tube, as in **Drawing 14(d)**.

f. Plastic rivets

As depicted in **Drawing 15**, these are much used in domestic appliances to plug holes and sometimes to attach thin plates of plastic or brackets to larger plastic components e.g. refrigerator liners. There are two main types, as shown in the drawing. At (a) and (b) is one having a bulged stem containing a groove which allows the bulge to be temporarily reduced as the rivet is hammered into place, and then to recover to hold the rivet in position. The type shown at (c) and (d) is split four ways at the bottom, with internal projecting lugs. A captive solid rod, when hammered flush, forces the legs apart to hold the rivet in position.

g. Huckbolts, Rivnuts, Nutserts & Rootnuts

A huckbolt is rather like a nut and bolt, except that it has annular serrations instead of threads, so once in place it cannot be vibrated loose. Huckbolts come in a wide variety of styles and sizes, but the form depicted in **Drawing 16(a)** will give the idea. Part of the shank breaks away after the huckbolt is fixed into place. In this regard it is somewhat like a pop rivet on a much larger scale. These devices find much application in heavy sheet metal construction such as electrical switchboards and the like.

Rivnuts (or Rootnuts) shown in **Drawing 16(b)** allow full thread holes in sheet metal structures. The projecting boss is forced over the sheet metal to permanently retain the nut. These are usually zinc plated and can be obtained with Metric, BSW or BA threads, from about 3 to 10mm diameter.

Nutserts, shown in **Drawing 16(c)**, can similarly be used for sheet metal down to 0.5mm thickness. They are available in BSW, BA, BSF, UNF, UNC and Metric Coarse threads from about 3 to 8mm diameter.

Tabs and slots

Up until World War II many toys (e.g. Hornby Trains) and kitchenware items were constructed from painted (or unpainted) tinplate. One of the commonest means of joining parts was the use of tabs on one part passing through slots in another part. These tabs were bent down at right angles and formed a tight joint - see **Drawings 17 (a) and (b)**. This bending down process was usually done in a press, which required some form of support or bolster on the underside to allow proper completion of the bending operation. Where access for such a bolster was not available the tabs were twisted - see **Drawing 17(c)** instead of folding. These designs are not used as much these days as most of the articles seem to be now moulded in plastic.

Staking

For somewhat heavier construction - say up to 3mm thickness parts - tabs passing through slots can be used, but instead of bending or twisting, the end of the tab is split by staking, as in **Drawing 18(a)**. If the tab is arranged with a square cross-section, then cross staking, as in **Drawing 18(b) and (c)** makes a more solid joint. These processes are to be found in some small appliances and cheap mechanical clocks.

Spin riveting

In the early 1900's, the Townsend company introduced its spin riveter. This machine rotated the rivet head forming punch as well as providing multiple axial blows - see **Drawing 19**.

When the spindle is rotated by belt drive from the motor, the attached radial rollers climb the ramps of the fixed cam, raising the spindle against the pressure of the spring. The rollers pass over the ends of the ramps and the spring drives the spindle rapidly down; the process then repeats. The work is raised by a lever and dolly so that the end of the rivet encounters the rapidly rotating and reciprocating tool in the end of the spindle, which forms the head to close the rivet.

This machine produces very effective results and is used in the manufacture of small accurate items such as circuit breakers. It is very noisy; at the company where I worked, the Townsends were almost wholly enclosed in noise-deadening insulation and the operators wore ear muffs.

It occurred to me that the action is similar to that of a portable masonry drill, so I made up suitable punches and dollies to experiment. I regret to report failure - the axial blows are insufficiently powerful to form the rivet head, even in copper. It "sort of" works with aluminium.

Spinning

If the object is circularly symmetrical, certain fastening operations can be effected by spinning. This is often used to fix gems in place in jewellery **(Drawing 20(a))** and to hold lenses in optical instruments **(Drawing 20(b))**. The spinning process can also be used to turn the end of a cylinder over a disc to make a liquid- or gas-tight joint - see **Drawing 20(c)**. Alternatively, the disc could be spun over a flange on the end of the cylinder. This process can be very useful in some special circumstances where adhesives or soldering are not usable e.g. because of heat damage resulting.

Swaging

This is a process of mechanically flowing the metal of one part over another to form a permanent connection. For example, distorting a collar on to a screw thread to render the latter part captive in a hole - see **Drawing 21(a)**. The process is widely used to attach end fittings to steel wire ropes, particularly in aircraft work, but also on rigging for yachts and other vessels - see **Drawings 21(b) and (c)**.

Crimping

A similar process to swaging, much used in the attachment of terminals to electric wires - see **Drawing 22**. At (a) is shown a cross-section of the terminal lug and at (b) with the wire crimped in place. Often the terminals come already fitted with insulating sleeves and the crimping is done through the sleeve. It distorts the plastic but usually does not cut it. Most times one crimp is sufficient, but for greater security sometimes two are used, side by side. **Photo. 6** shows a hand crimping tool and examples of insulated and non-insulated terminals attached to wires. **Photo. 7** is a close-up of the crimps.

Clinching

The turning-over of the end of a nail, as shown in Drawing 2(a) is one example. **Photo. 8** shows netting clips and their special pliers with recessed face jaws for clinching them closed. They are much used to attach wire netting to supporting fence wires, as shown in **Drawing 23**.

Welch Plugs

When the cores are removed from complicated castings, there are a number of access holes remaining. If the casting is to be liquid tight (e.g. a. water-cooled engine block), the access holes must be plugged. The welch plug is a shallow dome-shaped piece of steel used for this purpose - see **Drawing 24**. It is placed in position and fixed by a sharp hammer-blow at the centre of its dome. Although successful fitting requires some skill, the technique is easily mastered.

Interleaved edges

Sometimes called "welting", this process involves turning a small width at the edge of a sheet back on itself by 180 deg. and engaging this with a similar turnback on the adjacent sheet - see **Drawing 25(a)**. The interleaved sheets are then pressed, rolled or hammered flat (closed). This is called a "folded" seam. If a seam set - depicted in **Drawing 25(c)** is used, a "folded and grooved" seam results, as shown in **Drawing 25(b)**, in which the sheets are flat on one side. Reference 12 discusses these joints in some detail.

Conclusion

From all of the above it is clear that there is a myriad of ways to permanently mechanically join parts together. Which way to go will be determined in each case by the result required, the nature of the materials and the available tools and fasteners, but at least a more informed choice can be made if all the possibilities are known at the outset.

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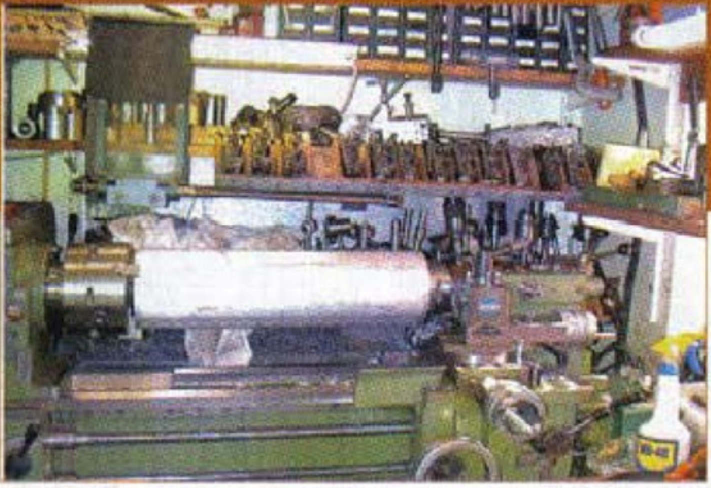
AN AID TO TURNING LARGE TUBES

Although many lathes can accommodate large workpieces, providing adequate support is often difficult. Peter Rawlinson tells how he solved the problem



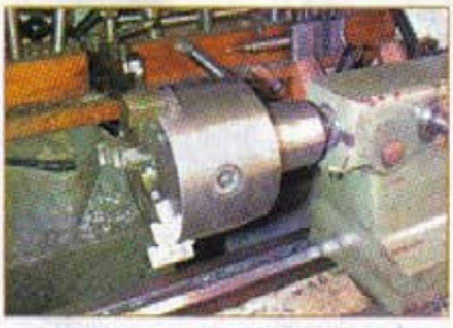
1. The large tube mounted in the lathe

2. The chuck with the new backplate fitted and the No. 3MT mandrel. The spacers and nut are required when the mandrel is used for its original purpose - the mounting of side and face cutters

My son's hobby is scuba diving and he belongs to a local club in Folkestone. One of his friends, a fellow club member, has decided to build a ROV (or to the uninitiated like me, a Remotely Operated Vehicle).

I was asked if I would help by machining some of the parts, something which I was happy to do. The required items consisted of a number of tubes, to which end caps, sealed with 'O'-rings, were to be fitted. I found that the tubes would just fit into the length of the lathe, but the diameters, 80mm and 150mm respectively caused problems as, obviously the fixed steady was required to support the outer end. The only steady available was too small, but this was simply overcome in the case of the smaller diameter because it proved possible to fit new shorter bronze rubbing pads.

The real problem was the machining of the larger tube. Making a large size steady was not considered feasible due to the amount of work involved, and the tube could not just be supported by inserting a simple wooden block as some 10mm of the inside had to be left clear to permit facing and the creation of an internal chamfer which would allow the 'O'-rings easy access.



3. The assembly mounted in the tailstock

There are, of course, commercially available units which will do just this, but the costs would make the acquisition of such a tool out of the question, so I decided to make up my own version using available items. The lathe that I was using for the job is fitted with a 6in. 3-jaw Griptrue chuck, so the headstock end presented no problem. The tailstock end was, however, a different matter.

As it happened, I had retained a 4in. 3-jaw Myford screwed body chuck when I sold the smaller lathe. Although the body was threaded, it still had three holes in the rear face which would allow it to be bolted to a back plate, so I decided to machine a special back plate that would fit on a mandrel which could be mounted in the tailstock.

Luckily I had a No. 3 Morse taper mandrel which I used for mounting Side and Face cutters, and this incorporated an accurate 1in. diameter ground shaft which would be ideal. I was able to fit an Oilite bush of the flanged variety to the new back plate, so this flange would press against the shoulder of the mandrel, providing end restraint.

The back plate was machined from a piece of 4in. dia. mild steel, with the bush a press fit. One difficulty was that this type of chuck does not have the usual locating recess for the spigot of the back plate. This means that the chuck has to be trued up if ever it is removed from the plate then refitted. This is, however, simply carried out using a dial gauge, rotating the chuck by hand on its mandrel.

In use, the assembly is fitted to the tailstock and the chuck inserted into the tube by the required amount, the jaws then being opened up until the tube is gripped. The position of the lathe tool must be checked to make sure there is clearance to the jaws, but other than that it is a straightforward machining job.

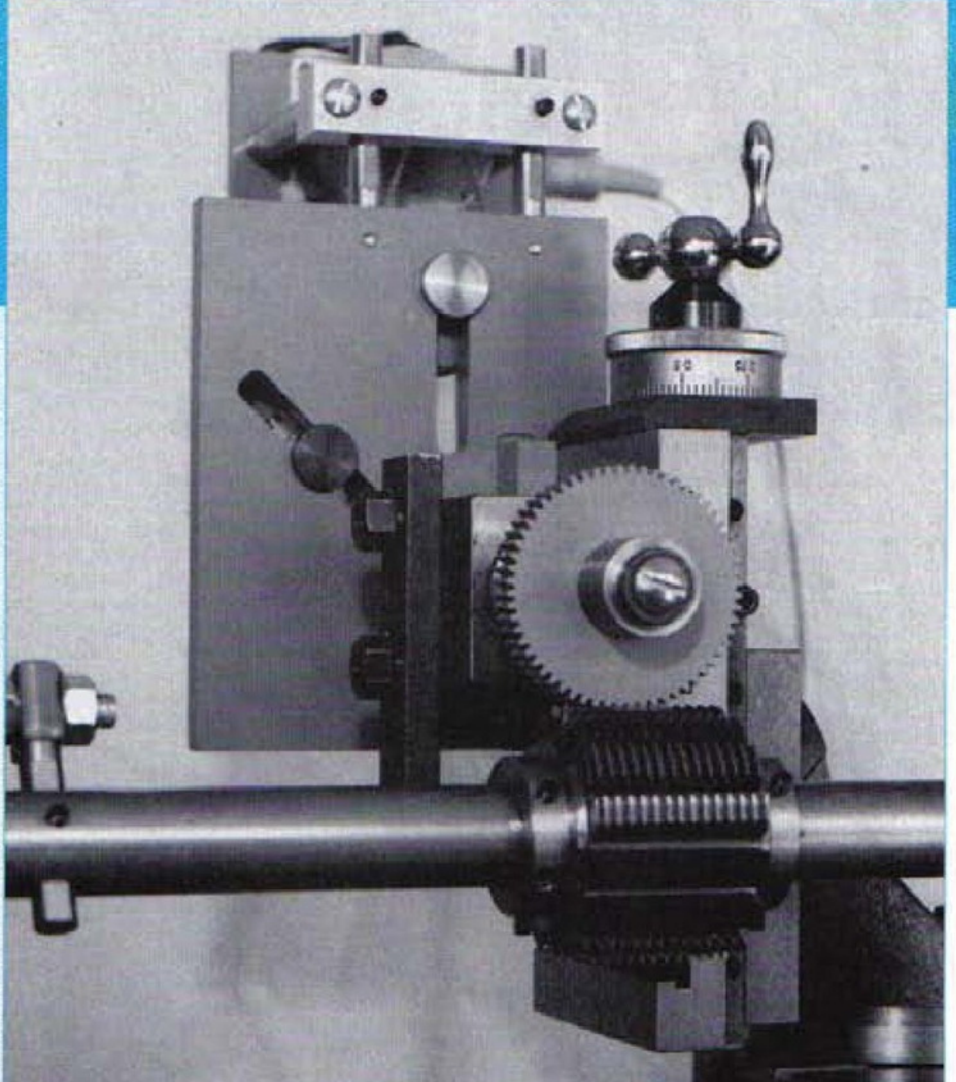
There also turned out to be another benefit. As anyone who has used a fixed steady will know, the setting up of the tube or shaft to run parallel can be a time-consuming operation. For the 80mm diameter tubes I kept the tailstock chuck in position temporarily, setting the tube inside the jaws and then setting the fixed steady to the tube. This worked very well.

The work entailed in making the special back plate was well worth while, just for the simplicity of the alignment of the smaller tubes. I shall certainly use this system when a similar situation arises in future.

As I have mentioned in previous articles, I am happy to answer any queries, but by phone only please (01233 712158).

4. A close-up of the tube end being machined. Care must be taken to check that no part of the chuck fouls the lathe tool

GEAR HOBBING ON THE LATHE - AN EASY WAY



1. *Front view showing the hob between centres and the gear blank on a spindle attached to the vertical slide*

The ready availability of versatile electronic components has transformed the way in which many complex problems can be solved. Eric R Rumbo of Queensland, Australia has applied the technique to gear manufacture

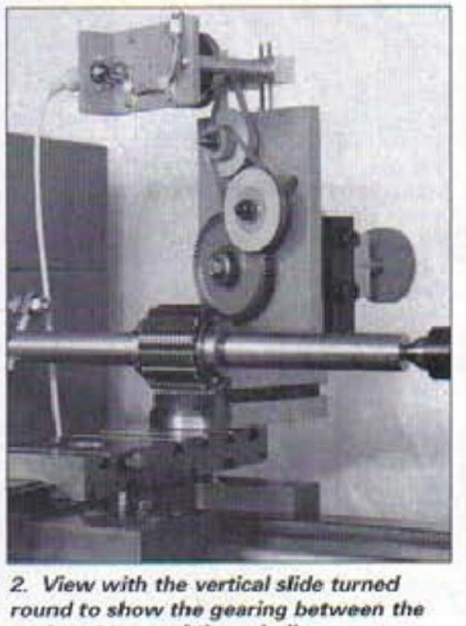
Recent issues of Model Engineers' Workshop (Ref. 1) have described gear-hobbing in quite some detail and serialised the construction of a dedicated hobbing machine (Ref. 2). For the average amateur, who may only need to cut a few gears a year, building a complete machine unfortunately represents a considerable investment in constructional time and hardware costs. Wouldn't it be much easier if the operation could be carried out on the lathe? At first glance the amateur's lathe appears well suited to gear hobbing. With the hobbing cutter turning between centres and the gear blank on a spindle fitted to the vertical slide, all the movements required for gear cutting are available. The only problem (some would describe it as more in the nature of a nightmare) is how to synchronize the gear blank with the cutter whilst maintaining the ability to move the gear blank with respect to the cutter in two planes during the cutting operations. Previous solutions to this problem have involved mechanical linkages using universal joints, but this is not at all easy to arrange on a lathe and what works with one brand of lathe may be close to impossible with another.

Whilst we maintain that the answer to synchronizing the cutter and the blank is a mechanical linkage between the two, there is probably no solution to this problem, but there is really no reason for this link to be purely mechanical. Why not use some of the electro-mechanical trickery available out there? Thus, if a *digital encoder* is used to digitise the revolutions of the hob and the signal it generates drives a *stepping motor*, then synchrony is easily achieved without a mechanical link.

The essential components

The devices mentioned above may not be familiar to all model engineers so what are they: a *digital encoder* and a *stepping (or stepper) motor*? Most would be familiar with the latter. It is a motor which when driven by suitable switches, usually transistors, moves in small steps in response to voltage pulses. They are found in many common pieces of equipment such as printers and copiers and are readily available quite cheaply as second-hand items since, being quite robust, they easily outlast their parent equipment. The most common motors appear to be those with 200 steps to complete one revolution or, as they are often used in what is known as half-stepping mode, 400 steps. Excellent tutorials on these motors and their operation may be found in books, magazines and the World Wide Web (Ref. 3).

Digital encoders are less well known but are also found in many pieces of electro-mechanical equipment. Essentially they consist of a transparent disc with equally spaced stripes around the periphery (alternatively a perforated metal disc) that is mounted on the shaft of interest. A light emitting diode (LED) on one side of the



2. View with the vertical slide turned round to show the gearing between the motor at top and the spindle

disc is paired with a phototransistor on the other. As the disc rotates the opaque strips interrupt the light and generate an on-off electrical signal via the phototransistor. Thus, if a 400 strip encoder is paired via suitable electronics to a 400 step motor, the shafts connected to each will be synchronized just as effectively as if they were locked together mechanically.

Using this arrangement a gear-hobbing attachment can be built for a lathe, which does away with the mechanical linkage and allows for completely independent movements of the gear blank with respect to the cutter, without in any way disturbing the synchrony of their rotations. Since most amateurs will already have a vertical slide, and also possibly a spindle to carry the gear blanks, the actual constructional work involved is not high. What follows describes the author's arrangement, but a number of alternatives are mentioned, and versatility in the implementation of the general scheme should be the order of the day. A view of the arrangement from the front of the author's lathe, a Myford 254s, is shown in **Photo. 1**.

One of the first decisions to be made is where to place the encoder. Since the hob turns between centres, one possibility is to mount the encoder disc on the bar carrying the hob, or else fit it to the lathe headstock shaft. There is some advantage however in bringing the gearbox of the lathe into play and thus maximising the ratios available for cutting the gears (remember the gear blank will need to be turned at $1/n$ times the rate of the cutter, where n is the number of teeth). It was therefore decided to connect the encoder via the gearbox and mount it, at the tailstock end of the lathe, to the screw-cutting drive shaft. On the Myford there is provision for a handwheel to be attached, which makes the connection easy. The location has the advantage of easy removal and it also distances the encoder from the lathe motor which can generate electrical noise that might interfere with the electronics. One disadvantage is that the automatic cross-feed, available on some lathes including the Myford 254s, can no longer be used because it is no longer possible to choose the speed of traverse. The cutter has to be traversed across the thickness of the gear blank manually.

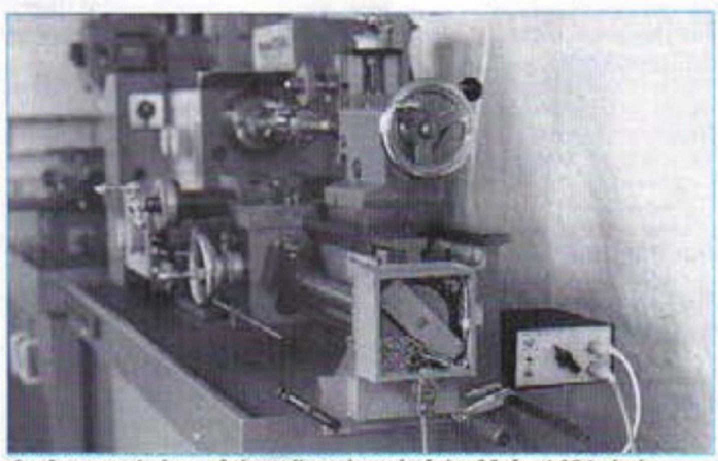
Having decided on location, the next problem is how to obtain the necessary encoder. There were two possibilities, buy one or make one. It was decided to have a go at the latter. The only difficulty expected was how to produce the encoder disc. A disc of 100mm diameter maximum was decided upon. The CAD program on the author's PC has the ability to produce a circular array of any predrawn pattern. Thus the 400 stripes disc can be drawn by rotating a straight line of suitable thickness around a circle and printing on transparency film. As it turned out, 400 lines around a 100mm diameter disc proved beyond the author's inkjet printer (a higher resolution laser printer would probably be up to the job). However, 300 lines were perfectly satisfactory. It would also be possible to print 400 lines over a larger circle and then have them photo-reduced, but at this point the decision to mount the encoder on the screw-cutting shaft proved fortuitous. It allowed the use of the gear-box to speed up the disc by the required 4:3 ratio and thus obtain the required 400 steps per revolution of the hob from the 300 stripe disc. On a Saturday afternoon and impatient to test the system, this alternative was very attractive and in any case the disc could be replaced at a later date with a 400 stripe version. Consistent with human nature the 300 stripe disc, having fulfilled its duties perfectly so far, is still in use!

Other possibilities for producing the encoder disc are drawing the stripes with a pen using an indexing head or even using the stepper motor itself as the indexing device. An alternative is for the stepping motor to rotate a slit and LED combination that is pulsed to record a dark stripe on a photographic negative at each indexed position. This would need a camera of larger than 35mm format, a twin-lens reflex would be ideal. Model engineers will probably come up with a dozen other equally feasible schemes. For those unwilling to make their own, it should be possible to buy an encoder. The well-known Radiospares firm have a number of encoders in their catalogue, but none with 400 steps. Remember, other numbers are possible provided they match the motor to be used. The US firm, US Digital (Ref. 4), well-known to amateur astronomers who use their products on their telescopes, available through suppliers catering for those interests, do have 400 step discs in their catalogue, but they may have to be specially ordered. Commercial encoders are rather expensive and most of them carry provision for detection of the rotation sense of the disc that is of no interest to us in this application. They are however a lot smaller than the 100mm described above (Advice: be a true model engineer, make your own).

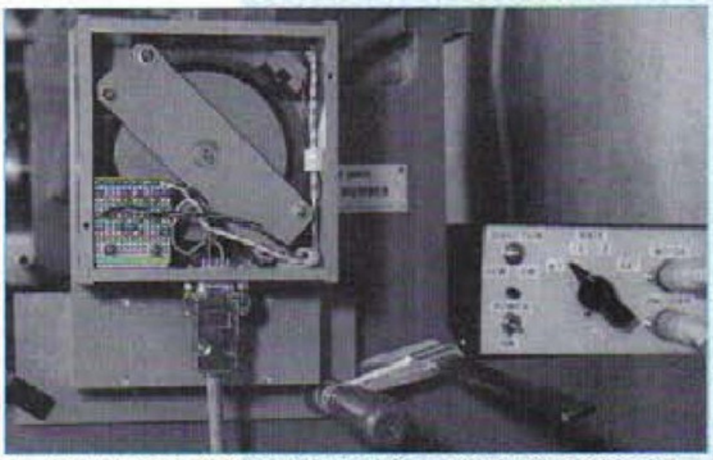
The LED/photo-transistor combination was obtained from the scrap-box. It probably came from an old printer and consists of a U-shaped device with the LED on one arm and the transistor on the other and was placed so that the striped disc rotates between them. These combined devices or individual LEDs and phototransistors are readily available from electronic suppliers. It was found that the aperture on the photo-transistor was too wide for the stripes on the disc so a narrow slit, approximately one quarter the width of a stripe, was cut from thin card and glued on top of the photo-transistor.

The controlling electronics

The electronics to produce the on-off pulses needed for the motor are shown in **Fig. 1**, the circuit being built on a piece of veroboard. The 555 integrated circuit, usually connected as an oscillator or timer, functions here as a Schmidt-trigger to produce pulses with sharp on-off



3. A general view of the tailstock end of the Myford 254s lathe showing the encoder and the box containing the electronics temporarily clamped to the lathe stand. A more permanent bracket may be preferred



4. A closer view of the encoder, cover removed, attached to the screw-cutting shaft of the lathe and the control panel for the electronics

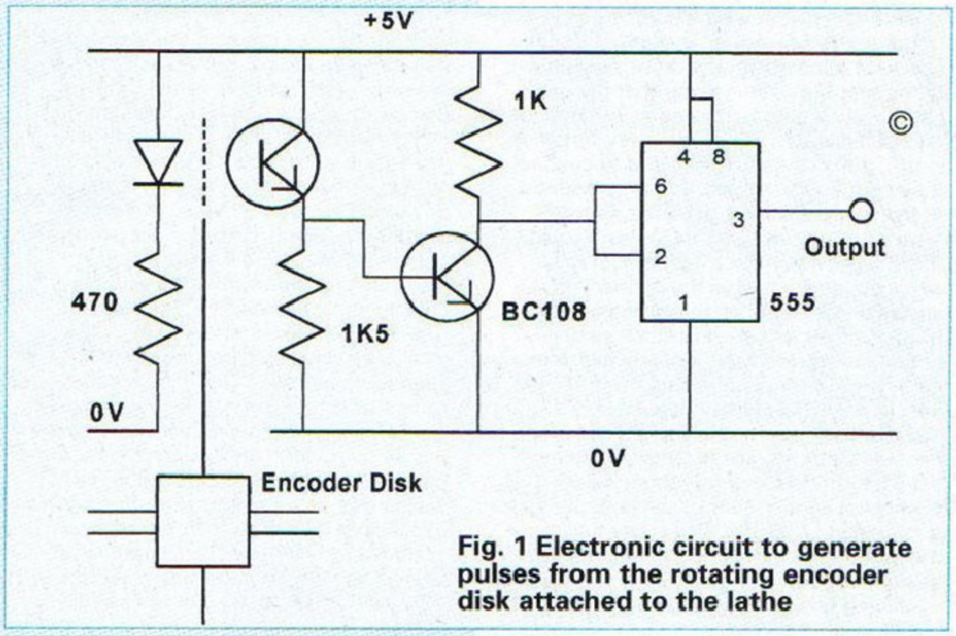


Fig. 1 Electronic circuit to generate pulses from the rotating encoder disk attached to the lathe

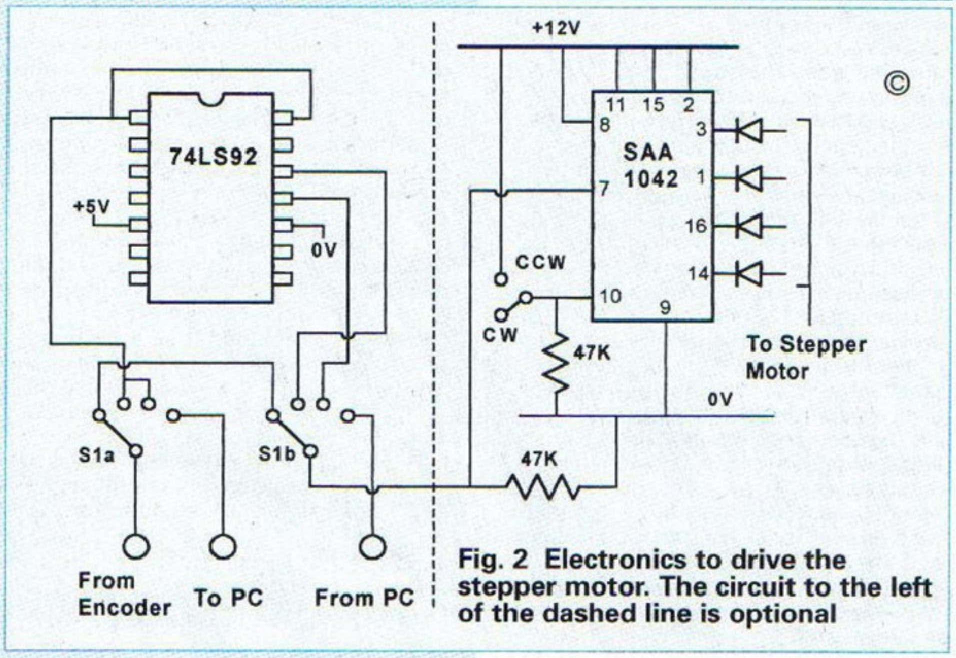


Fig. 2 Electronics to drive the stepper motor. The circuit to the left of the dashed line is optional

transitions. This is advisable to prevent spurious pulses being produced from electrical noise during the transitions, thus upsetting the synchronisation. The encoder, with the cover removed, is shown in **Photo. 2** clamped to the lathe cabinet. Constructors willing to drill two holes in their cabinet can achieve a more visually pleasing result.

The electronic circuit that translates the pulses from the encoder into the voltages required by the stepper motor is shown in **Fig. 2**. The part of the circuit to the left of the dashed line is not essential. It was added to allow division by 2 or 3 (CW positions 2 and 3 of switch S1) to be done electronically rather than using gears, and so allow for larger divisions. There is also provision for processing the pulses through a PC (S1 position 4), with a view to a future expansion, allowing for greater flexibility in the system (virtual hobbing?). Constructors can ignore it and build only the circuit on the right, in which case the output from the encoder should be connected to pin 7 of the SAA1042 chip. This part of the circuit consists of a single chip specially designed to drive stepper motors and widely available. It should also be possible to buy kits with all necessary components to drive a stepper motor using 5V TTL pulses from the many electronic suppliers catering for hobbyists in most countries. A power supply to generate the voltages for the motor and the rest of the circuitry is also required. In the author's case the motor was a 12V version so a 9V transformer and diode rectifier bridge were chosen to generate this voltage without regulation. The 5V required by the rest of the components was produced using a standard 7805 voltage regulator chip. Once again the circuit was built using veroboard and installed inside a box, see **Photo. 3**.

Although relatively simple, constructors without electronics experience should perhaps get some help in assembling the circuit.

The mechanical components

An Arrand milling spindle, lying dormant since a milling machine was purchased, was pressed into service to rotate the gear blanks. The belt pulleys were removed and replaced by a keyed sleeve to accept Myford lathe changewheels. It is clamped to the Myford vertical slide that also carries a plate with two slits, vertical and at 45 degrees, to which the shafts used to carry lathe changewheels can be attached. This allows three gear reduction steps between the stepper motor located at the top and the gear spindle. It was soon realised that the set of change-wheels available would be insufficient to achieve some of the ratios required. It was therefore decided to introduce two toothed belts into the system rather than rely entirely on Myford change gears. The 'gears' for toothed belts are easy to cut from aluminium or PVC using a milling machine and an indexing head. A set of these was produced with varying numbers of teeth from which selections could be made for a wide range of teeth numbers for the gear to be cut. The last two gears in the train are lathe change-wheels **(see Photo. 3)**.

The speed at which the encoder rotates is important. If it rotates too fast the electrical pulses produced will be reduced in amplitude and not properly rotate the motor. The motor is also limited by the speed at which it can rotate. This means that some testing will be required to make sure that neither of these two effects cause synchrony to be lost between encoder and motor. In the author's set-up this means selecting back gear on the lathe and either one of the two lowest speeds available. Having established these parameters everything is now ready to start cutting gear wheels. The blank is turned to the correct diameter (see previous articles in MEW - Ref. 1) and the gear train from the motor to the spindle carrying the gear blank set up to produce the correct number of teeth. The vertical slide is adjusted so that the blank just touches the cutter and the reading noted. The blank is then moved back and lowered the appropriate distance for the depth of tooth required. The lathe is turned on and the blank moved slowly past the cutter until the teeth are cut. When the blank is made of fairly hard material, say steel, it is best to lower it in stages (three appear to be about right) and cut only a portion of the teeth at each pass. Liquid coolant should also be applied to prolong the life of the expensive hob.

The arrangement described has proved quite foolproof although it is realized that there is one possible disaster that can overtake the system. Should the mains power fail, the gear being cut will probably be ruined unless very quick action is taken by the operator. Luckily this has never happened to the author.

References

1. Model Engineers' Workshop, Nos 56 & 57
2. Model Engineers' Workshop, Nos 58, 59 & 60
3. Control of Stepping Motors, a Tutorial by D.W.Jones, www.cs.uiowa.edu/Jones/Step/
4. US Digital, 11100 NE 34th Circle, Vancouver, WA 98682, USA.

AN AUTOCOLLIMATOR FROM THE SCRAP BOX

Bill Morris continues his description of this precision instrument by completing the manufacturing instructions for the component parts

Micrometer calculations

Before we can proceed with the filar micrometer sub-assembly, we need to do some sums, and this is best done by using mine as an example. Returning to the optical principles for a moment, recall that displacement d of the cross hairs image is equal to twice the focal length of the lens f multiplied by the tangent of the angle through which the mirror is displaced a, or:

$$d = 2 f \tan a$$

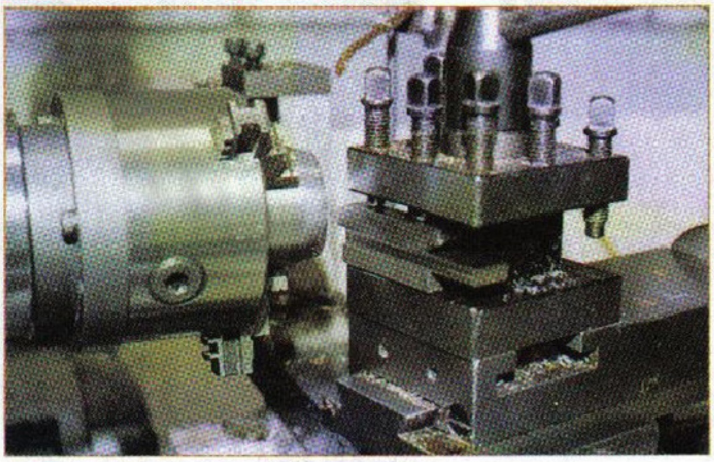
Assume for a moment that the mirror is displaced through an angle of one minute or one sixtieth of a degree. The tangent of one minute is 0.000291. For a focal length of 200mm, therefore, the displacement d will be 2 x 200 x 0.000291 = 0.1164mm. If our micrometer screw were to have a pitch of 0.1164mm, then one full turn would move the micrometer cross hairs this distance and we could of course measure fractions of a minute displacement by dividing the micrometer thimble appropriately. Now it is, for practical purposes, impossible to cut a thread of that pitch, and even if we could, it would be uselessly delicate. However, if we multiply our 0.1164 by 1, 2, 3, and so on, we will eventually get to a pitch that we *can* usefully cut, or at least, to a pitch that is close enough, for example, 0.1164 x 6 = 0.6984 or very nearly 0.7, with a negligible error of only 0.23 percent. If we chose 7, the result is not quite so good, at 0.8148, an error of 1.85 percent from 0.8; and in any case, circular dividing into seven is problematical.

My lathe will easily cut a thread of 0.7mm pitch, so that one turn of the micrometer screw detects a displacement of six minutes and on a fifty millimetres diameter thimble, each minute is subdivided into thirty divisions of two seconds each, a total of 180 divisions. At the moment, two seconds is a smaller displacement than my eyepiece can easily detect, but when I eventually acquire a higher power eyepiece or a lens of longer focal length, detecting angular displacements of this order should be feasible. The pitch you chose will of course depend on the focal length of your lens, the threads that your lathe can cut and what facilities you have for circular dividing. If you took 36 tpi as an approximation for 0.7mm pitch, the error would be about 0.8 percent, quite acceptable for this type of instrument.

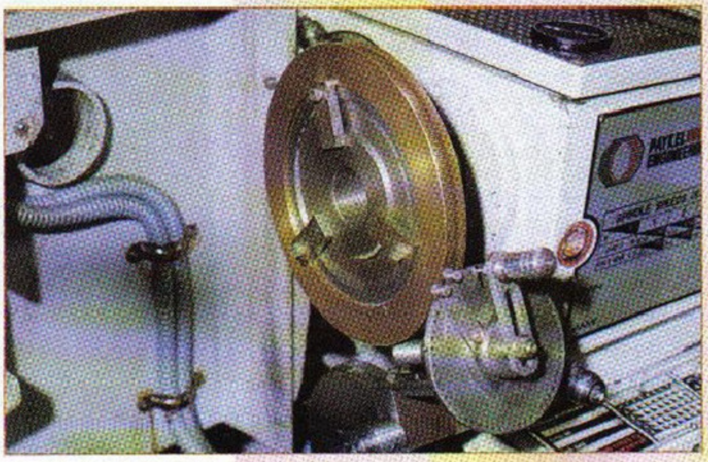
Another approach might be to adapt a differential screw micrometer to the task or to use a relatively coarse thread and subdivide using an optical micrometer. The former was covered in M.E.W. November/December 1993, pp 40 - 45, but the latter is decidedly advanced optical work rather than engineering, and if you know how to make one, you are not likely to be reading this article!

Micrometer Thimble (6)

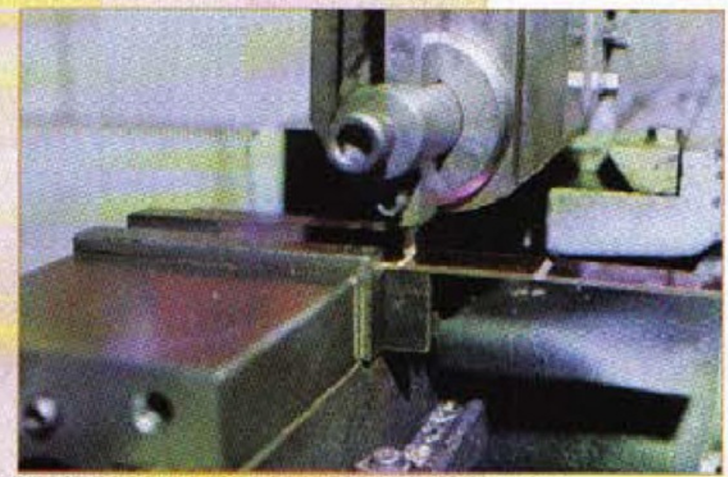
The micrometer thimble is straightforward to make. The 5mm hole can be drilled, but all the other internal dimensions should be bored without removing the workpiece from the chuck. While still at this setting, the tapered part should be turned to a fine finish by setting over the top slide, taking



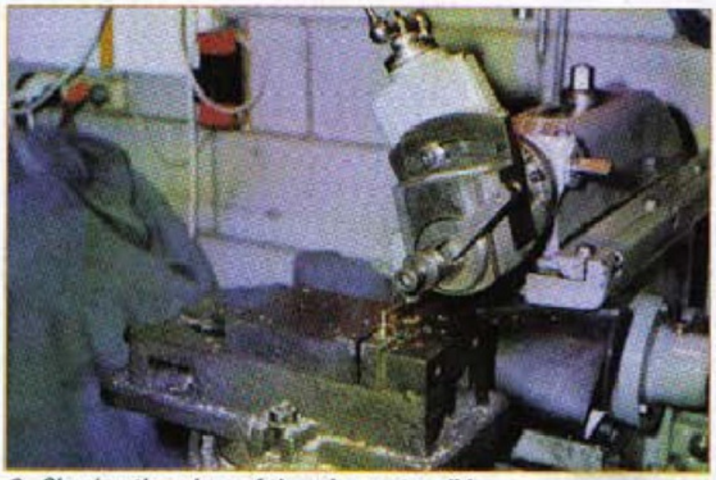
5. The dividing thimble being graduated



6. My headstock dividing device



7. Making mitred joints using the shaping machine



8. Shaping the edges of the micrometer slide

care to avoid producing a sharp edge on the end. Finish turning of the rest of the outside will be done later by mounting the thimble on its spindle, but the thimble has to be divided first. With the top slide left set over, an external threading tool, set on its side at centre height, serves very well to cut the graduations to whatever depth that your eyesight requires (**Photo. 5**). Some sort of headstock dividing device is extremely useful for this type of work and **Photo. 6** shows what I use. The heart of the device is a large bronze worm wheel mounted on a cast iron hub that screws on to the outside of the lathe spindle rear end. The worm wheel was produced by gashing the periphery into 360 with a slitting saw and then finishing the teeth by free-wheeling hobbing, using a spirally-fluted tap to ensure continuous engagement of the tap. The worm is simply a thread cut to the same form and pitch as the tap, in this case 5/8in. BSF I think. The rest of the device was thrown together one afternoon to accommodate parts from a George Thomas dividing head and like so many of these things, the temporary has become permanent! To save time, I drew the numerals on the thimble with a fine pen and coated them with clear varnish. This is perhaps another temporary expedient which will become permanent...

Micrometer Spindle (7)

Though this would ideally be made from hardened and stabilised steel with the plain and threaded parts ground, free cutting mild steel will wear very well for our purposes and makes cutting of fine threads very easy. The part should be produced by turning and screw-cutting between centres with the centre holes being drilled out later for the fixing screw and hardened insert. The strange outside dimensions were chosen so that a piece of 12mm steel could form the starting point. My smallest internal threading tool dictated that nothing smaller than 10mm core diameter would be possible for the thread. The depth of a 0.7mm thread is 0.43mm, so an outside diameter of 10.8mm allows the crest of the thread to be flat to ensure that the thread bears only on its flanks. The radius of the insert is only approximate and is produced by facing the end of a piece of 5mm silver steel, filing it to shape with a fine file followed by an oil stone and parting off. It is then hardened and tempered to a pale straw colour before polishing and gluing into the spindle.

The spindle can then be held in a chuck, the micrometer thimble secured with a 5mm screw and its outside finish-turned using very light cuts to avoid chatter or disasters.

Micrometer Fiducial (8)

I am sure there is a better term for this, but I can't think what it is. The outside diameter is turned so that it just fits without interference inside the micrometer thimble and the central hole drilled and bored at the same setting. To make the graduations, start by making marks with a felt tipped pen on the chuck back plate at approximately 10, 20 and 30 degrees clockwise and anti-clockwise from a zero datum. Fix some sort of pointer to the headstock and also set the top slide parallel to the lathe axis. A threading tool can then be used to make the graduations. For the graduations illustrated in Drawing 8, you would wind the tool into the work with the chuck set at the anticlockwise 20 deg. mark, rotate to the clockwise 20 deg. mark and wind the tool out. You would then move the top slide along 0.7mm, set the chuck to 0 deg., wind the tool in and rotate the chuck to the clockwise 10 deg. mark and wind out again. This latter manoeuvre would be repeated another four times and then a longer graduation made again. In this way, you build up the graduations and finish by scribing the horizontal line with the tool set on its side at centre height.

Part off, clean up each face and finish by drilling and tapping the M4 hole for the grub screw.

Integral Spindle Bearing and Nut (9)

The bearing and nut are made in two parts, so that a reamer can be run through the bearing part, and it also makes the machining of the nut a little easier. Soft soldering is quite strong enough for the purpose. The easy bit is making the mounting base which involves simply sawing, filing and drilling a piece of 2mm brass sheet. The bearing starts as a piece of brass rod about 18mm in diameter turned down to 17mm, drilled 10.5mm and parted off. It can then be held by its outer diameter and a reamer passed through. The nut can be made from a short length of the same rod drilled 9.5mm, bored out to 10mm and screw cut to your chosen pitch until the micrometer screw fits with just a little shake. If it feels tight, it may well be bearing on the crest of the thread rather than on the flanks. Take a fine facing cut to clean up before parting off. The faced end will be married to the bearing face.

Put a very thin smear of oil on the spindle thread and run it through the nut to leave a thin smear on the internal thread to discourage solder from sticking there. The next step is to slowly warm up the nut and the end of the bearing just enough to allow some resin cored solder to spread over the faces. The bearing is then stood upright in a vice and the spindle screwed into the nut and slid into the bearing, so that the weight of the spindle holds the soldered faces together while you heat the assembly until a shiny bead of solder appears at the joint. Once the assembly has cooled you can remove the spindle and clean up the outside of the nut before tapping the assembly down on to a parallel in a vice and machining the flat for the base. Replace the upright in a vice as before, with the spindle in place, and sweat

9. Using a piercing saw requires concentration.......and lots of vision!

the base on to the flat to complete the bearing-nut combination.

Micrometer Box (10)

The base and rear of the box are straightforward sawing, filing/milling/shaping and drilling, though the placement of the tapped holes is best left until the components that they secure are made so that the holes can be spotted through from them. The other three sides of the box can of course be made from separate pieces butt or mitre-jointed with soft solder, but a much neater and stronger job can be done by using the method I alluded to in making the cross hair carrier. Using a shaping machine makes a quicker and usually (in my hands at least!) neater job. You start with a strip of brass in length equal to the total outside length of the three walls and mark out the position of the corners. Then, with a 90 deg. tool set vertically, use the shaping machine to produce a groove at each corner that only just fails to go right through **(Photo 7)**. The three sides can then be folded around the base, filing the latter to get a snug fit, with all the angles right ones. Clamp or wire the four sides and base together, run a little solder into the angles and you have the strong, rigid little box that you need. The little corner pieces that secure the lid can be soldered on at a later stage and the holes spotted through from the lid.

Gibs (11a & 11b)

These can be produced entirely by hand using a little 30 deg. template and careful marking out, but you are likely to get a better job by using a shaping machine, the machine *par excellence* for producing small slide ways, or vertical milling machine with the part held in an angle vice. It would be pointless to machine the oval holes in the adjustable gib as it is so much quicker to use a round file to elongate them.

Micrometer Slide (12)

This too can be produced using entirely hand methods, but it is vital that the edges are parallel to each other and of uniform angle so, on the whole, it is better to machine them if you can **(Photo. 8)**. Attempts to drill a 16mm diameter hole in a small piece of 2mm brass are doomed to failure. Mark out the whole part on a large piece of brass and cut out the oval hole by hand, using a piercing saw. For those who are not familiar with this exceedingly useful hand tool, it is somewhat like a small fret saw (the frame of mine *is* a cut-down fret saw), though the blades are much finer and narrower so that they can cut around small radii and, with suitable pitch of teeth, through thin sheet. To cut a large hole, you drill a small hole, pass the blade through and secure to the frame and form the hole by moving the work piece and by redirecting the direction of cut. This requires strong hands, so I usually clamp the part to an auxiliary bench held in a bench vice as I find two hands on the saw gives better control. The saw is moved up and down and the cut is made on the down stroke, as shown in **Photo. 9**. Expect blades to break fairly frequently and replace them when you can feel them getting blunt. They are cheap enough.

An assortment of V-shaped notches in

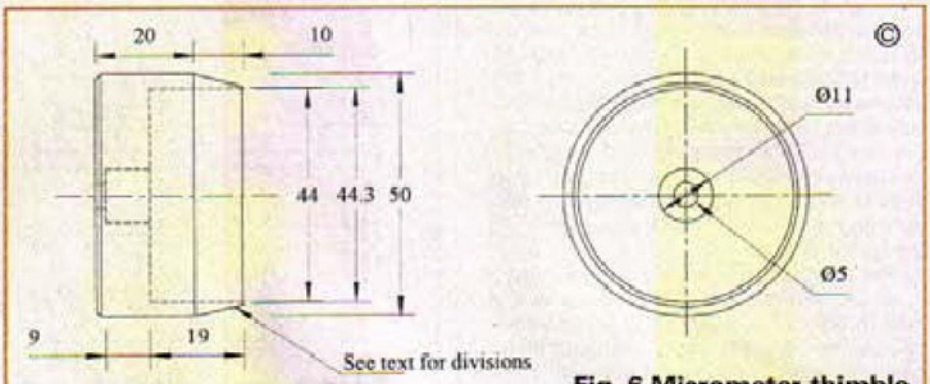


Fig. 6 Micrometer thimble
light alloy or stainless steel

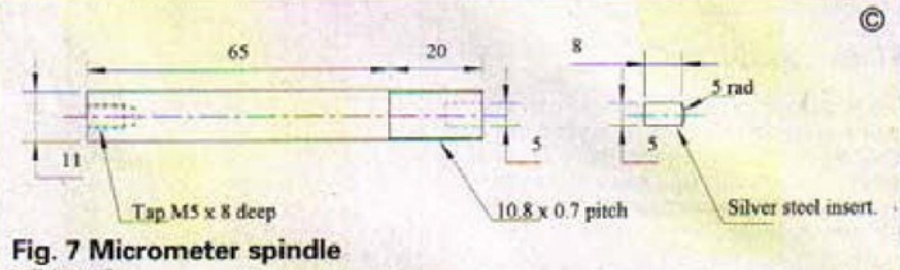


Fig. 7 Micrometer spindle
mild steel

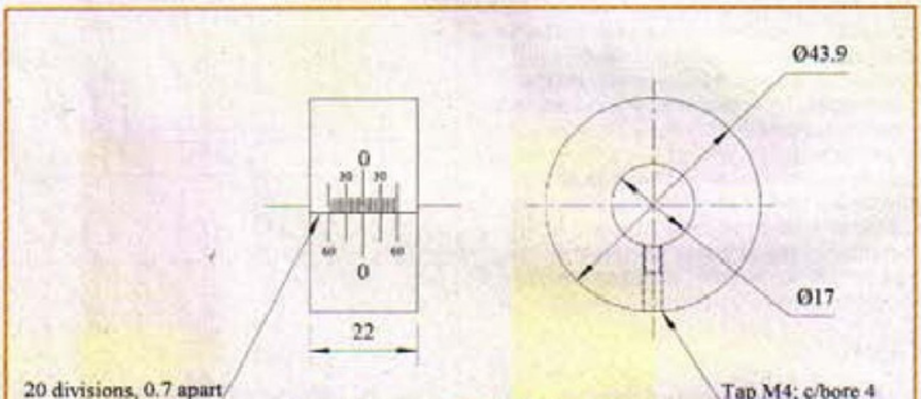


Fig. 8 Micrometer fiducial
light alloy or stainless steel

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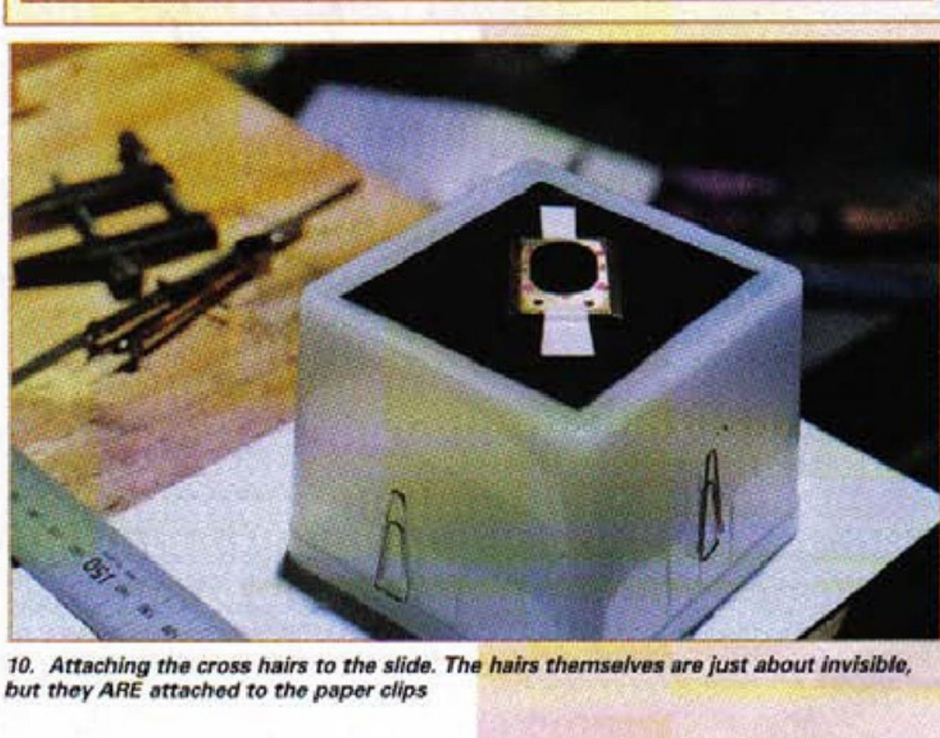

10. Attaching the cross hairs to the slide. The hairs themselves are just about invisible, but they ARE attached to the paper clips the edge of the bench helps when sawing awkward shapes and it helps to be able to sit down while sawing, so that you can get close to the work. You will saw much more accurately and thus have less filing to do if you direct light from two directions on to the part and wear magnifying spectacles, as shown in the photograph (though if you already wear glasses you may have to put up with the greeting "Hello, six-eyes!" from your children).

The two tapped holes are best spotted through from the next part to be made and then the cross hairs can be glued on with nail varnish. Don't forget to mark out their positions when marking out the rest of the dimensions. **Photo. 10** shows how to hold the hairs while the varnish dries. The paper clips that are without visible means of support are of course secured to the hairs to put them under tension.

Slide Elbow (13)

This is a perfectly straightforward part that can be made from a piece of brass angle or fabricated with a mitre joint. Pre-load spiral springs are attached to it and it transmits the thrust of the micrometer screw to the micrometer slide.

Micrometer Box Lid (14)

This again is a straightforward brass fabrication. The dimensions of the tube for the eyepiece will depend on the dimensions of your eyepiece and on its focal length. The eyepiece can be secured either by tapping a hole for a securing screw through the wall of the tube or by making two longitudinal saw cuts about 3mm apart part of the way down the tube and bending the resulting strip in a little to bear against the side of the eyepiece. The tube can be soldered or glued to the lid. Soldering gives a better job.

Pillar (15)

The form that this takes will depend on the contents of your scrap box. Mine took the size, shape and position it did simply because the top plate (16), scrapped from a home-made seismograph, was already vaguely triangular and happened to have a 50mm hole in it just where I wanted to attach the autocollimator tube.

Top and Bottom Plates (16 & 17)

As these are identical in size and shape, they can be cut out and clamped together for marking off and finishing the edges. The holes can be spotted through, one from the other with the exception of the 50mm hole which isn't really needed anyway if you make the pillar 6mm shorter. I made the tapped holes for the foot screws 5/16 x 40 tpi because that was the finest tap of any size that I had. Any fine thread will do.

Feet (18)

These are turned from 10mm silver steel and pressed or glued into the 8mm holes in the bottom plate. The top should be finished as finely as you can. The 8mm radius is not critical as to size and could with advantage be made larger. If the radius is small, the feet might sit in small local depressions of any reference surface the instrument might be placed on. I simply filed the end to an approximate radius and finished off with a fine oil stone. The feet can be hardened and let down to a pale straw colour.

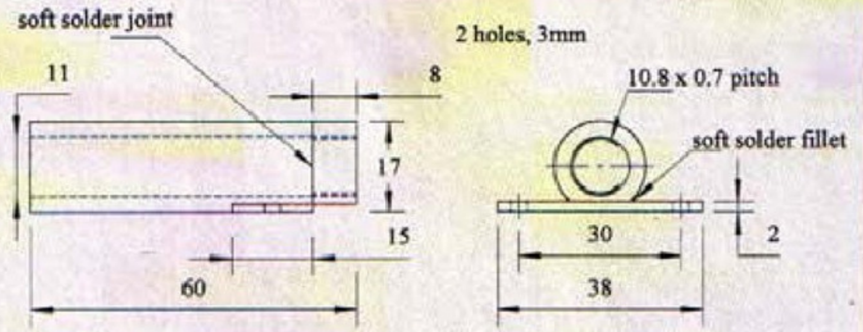

Fig. 9 Integral spindle bearing and nut
brass

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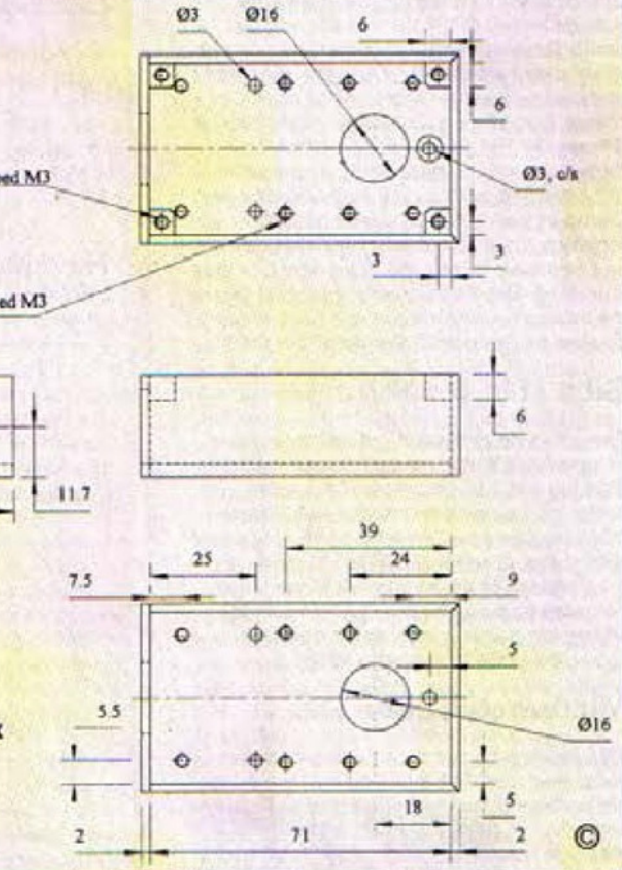

Fig. 10 Micrometer box
walls 2mm brass;
floor 3mm brass

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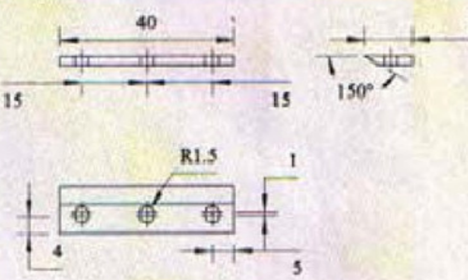


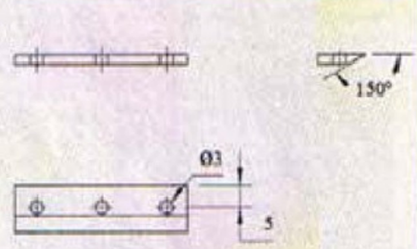


Fig. 11 Moveable gib
2mm brass

©

Fig. 11a Fixed gib
2mm brass

Foot Screws (19)

These are fabricated from mild and silver steel. I started by knurling the outside of a piece of free cutting 32mm diameter mild steel, drilling through and tapping 5/16 x 40

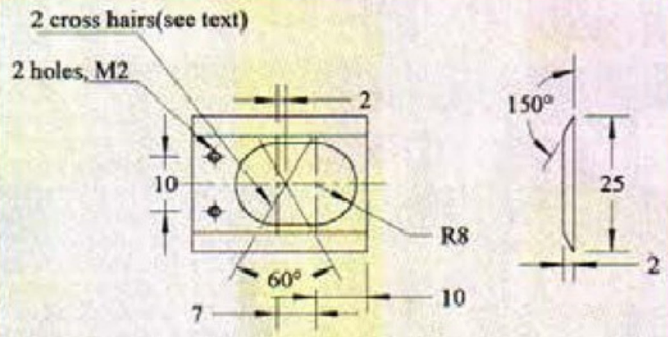


Fig. 12 Micrometer slide
2mm brass

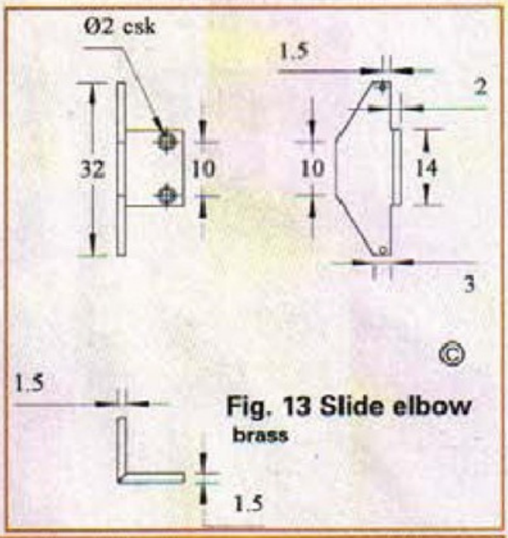


Fig. 13 Slide elbow
brass

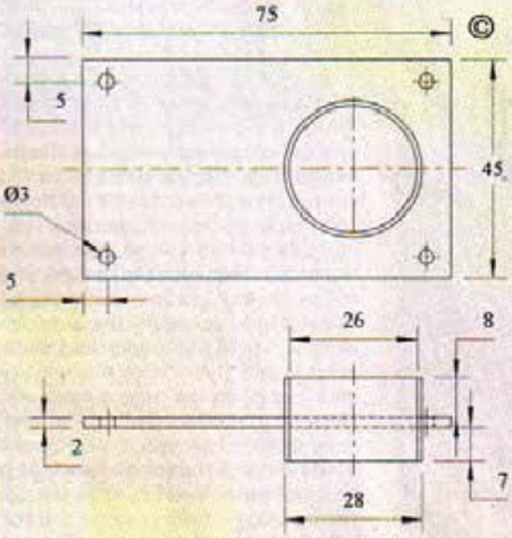


Fig. 14 Micrometer box lid
brass fabrication

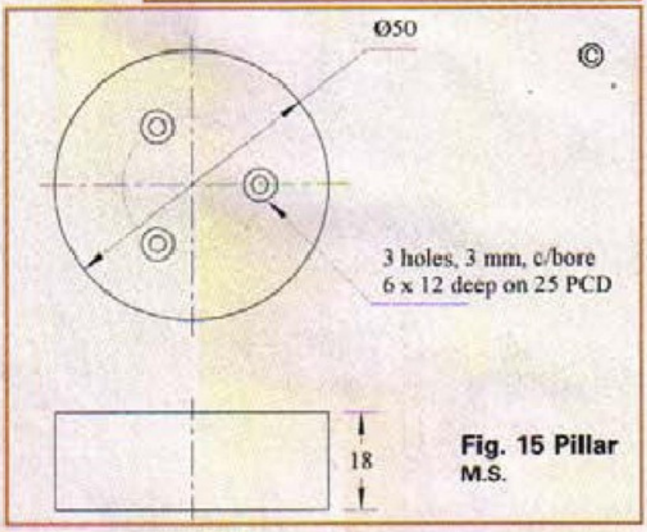


Fig. 15 Pillar
M.S.

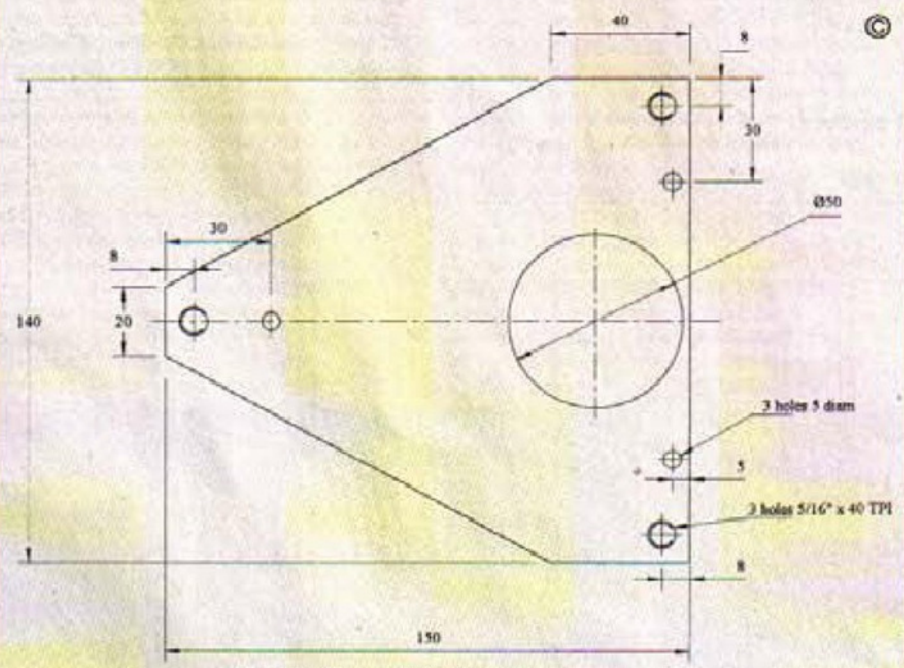


Fig. 16 Top plate 1:1.25
6mm mild steel plate

tpi and then parting off three 5mm discs. If you have a die to match the tap, this can be used to cut the external thread on 5/16in. silver steel, but I had to cut the thread in the lathe. Again, the exact radius at the lower end is unimportant. The two parts are then glued together with Loctite 262 or similar.

Mirror Base (20A & B)

There is only one critical dimension for this: the distance apart of the two pads along one side. The centres of the two pads are 34.4mm apart, so that if one pad is 0.01mm higher than the other, the base will be tilted along this side $\sin^{-1}(0.01/34.4)$, or 1 minute, and of course, vice versa. This means that measured tilt of a mirror mounted on the base can be converted directly into difference in height of the two feet, as will be explained in more detail later. I milled out the pads and finished the undersides with a few strokes on a lap to get a smooth finish. It would be possible to countersink three ball bearings into the under side of a block of steel to avoid the necessity for machining, and indeed one very learned text on advanced optical techniques suggests this. However, there is always the danger that a ball may sit in a local depression and give a false impression about a surface as a whole, so small flat pads are preferable.

If you wish to use the autocollimator as a comparator, you will also need to make another base with just two 2mm wide pads going the whole width with centre lines 34.4mm apart. Since in this case it is vital that the surfaces of the two pads be in the same plane, produce them first by milling or shaping, remove burrs and spot grind the top; and then reverse to spot grind the two pads.

Mirror Holder (21)

This starts as a length of 12mm square steel or brass which is sawed and machined into shape. It could all be done by sawing, filing and drilling except for the cylindrical 8mm plug which has to be turned to fit the hole in the base. The width of the slot at the lower end can be adjusted by means of a screw in order to bring the mirror square to the base. The mirror may be glued to the carrier with contact adhesive and the carrier to the base with Loctite or similar, taking care that the mirror is at right angles to the base edge with the two pads. However, if you have made two bases as above, it is as well to secure the mirror carrier with a grub screw instead.

For some purposes, a piece cut from a mirror tile will serve as a mirror, but as a 'ghost' image is reflected from the front, unsilvered surface as well as the main image from the rear, silvered surface, confusion and degradation of the image can result. For some purposes, too, it is important that the front and rear surfaces of the mirror are precisely parallel and this is not possible if the rear surface is covered with paint as is usually the case. For this reason, it is better to use 'first surface' mirrors which are 'silvered', usually with aluminium, on the front surface so that there is no problem with ghost images. The front surface is however very easily scratched and the mirror needs to be handled carefully. A suitable one 22 x 35mm x 3mm thick may be had for about US$ 7.30.

Supplier:- A reader who is constructing the Autocollimator has written to say that Tilgear are currently stocking 30 x 8 monoculars at £9.50 + VAT each.
Bridge House, 69 Station Road, Cuffley, Herts EN6 4TG Tel. 01707 876008

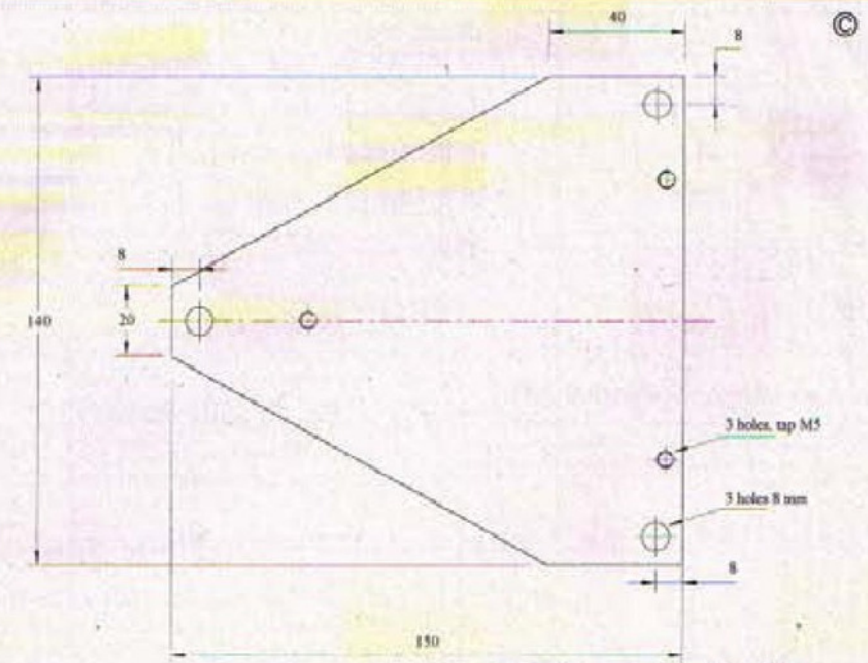


Fig. 17 bottom plate 1:1.25
6mm mild steel plate

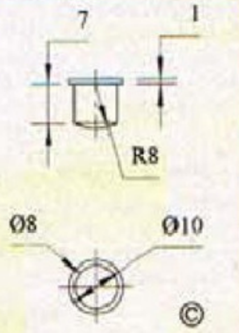


Fig. 18 Foot
3 off
hardened silver steel

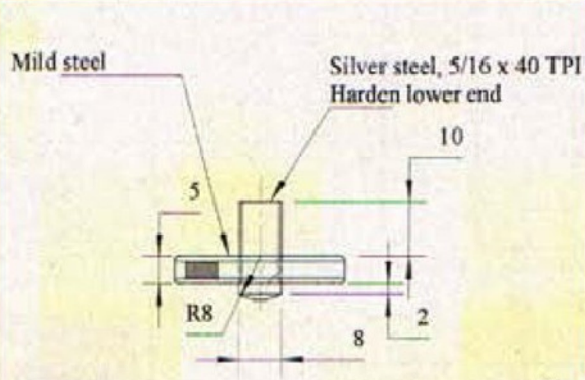


Fig. 19 Foot screws
3 off
silver and mild steel

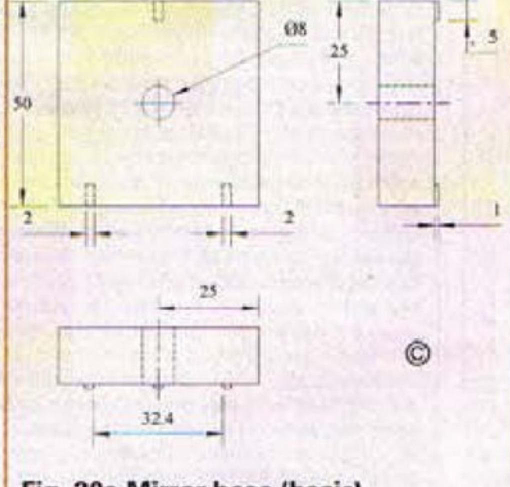


Fig. 20a Mirror base (basic)
mild steel

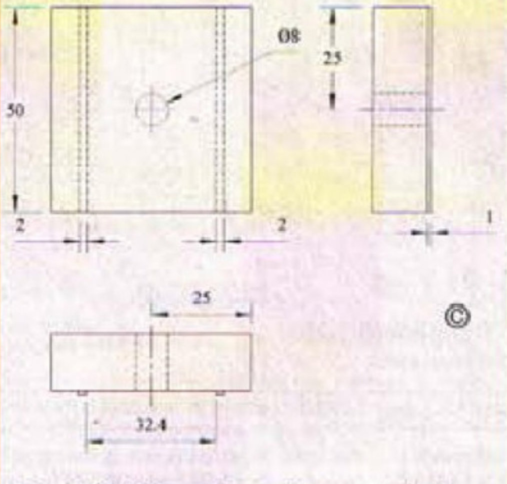


Fig. 20b Mirror base (comparator)
mild steel

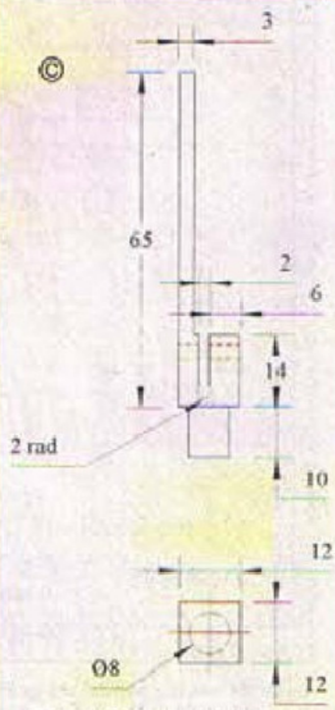


Fig. 21 Mirror holder
mild steel or brass

LATHE PROJECTS FOR BEGINNERS (9)
Precision tapers

Harold Hall describes the completion of the tailstock die holders, which involves the machining of a Morse taper shank

In the last issue, the method of manufacture for the smaller die holder was detailed. Whilst the larger version **(Fig. 2a)** is identical, other than in size, for experience, an alternative method is suggested in this instalment. Please note that photograph, sketch and reference numbers run in sequence from those used in that issue.

Method two

One advantage of this second method over that described for the smaller holder is that it starts with a piece of material only just long enough for making the part, there being no short stub left which may not find a use. Cut a piece of material 40mm diameter by 53mm long and mount this in the chuck; use of the reverse jaws will be necessary. Unless the outer end is running way out of true, you can proceed as follows, otherwise, true up using the method shown in Issue 68 page 39 photo 4. Centre drill the end and support with the tailstock centre and, using a right-hand knife tool, create the spigot **(Photo. 7)**. Make it just over 28mm long and over-size at 14.5mm diameter. Face the end of the head to a final finish then remove the tailstock centre and, with care, face the end of the spigot, resulting in a length of 28mm. Remove from the chuck and re-fit the normal jaws.

Replace the holder in the chuck, this time holding it on the spigot, and face the end, making the length of the larger diameter 24.3mm. Follow this by boring the 1in. diameter and finally finishing the outer face to produce the 24mm length before centre drilling and through drilling the 10.5mm diameter bore. I have not gone into great detail as this is essentially a repeat of the smaller one, but do make certain that the base of the bore is faced level.

The next stage is to reduce the spigot to 14mm, at the same time ensuring that this portion is axially in line with the die housing. To make a parallel stub mandrel, place a piece of 30mm diameter steel, around 40 mm long, in the chuck, concentricity not at all important. Face the outer end and turn a 1in. diameter portion 12mm long. The 1in. diameter must be a close fit in the bore of the holder and the end must sit cleanly on its base. Drill and tap the centre of the mandrel M6.

Fit the holder onto the mandrel, holding it in position with an M6 screw, to reduce the spigot to 14mm +0.0/-0.02mm, as seen in **Photo. 8**, followed by chamfering the end. With the mandrel having remained in the chuck since it was made, the spigot you have just turned will be accurately in line with the die holding bore. Whilst still on the mandrel, the 40mm diameter can be skimmed over for appearance sake, and the two ends chamfered. Remove and drill and tap the holes as for the smaller holder.

8. The larger holder shank being finished turned whilst held on a mandrel after boring

9. Turning the test piece for setting the top slide to the correct angle for machining a Morse taper

Keep a store of used mandrels

Whilst the mandrel will not return to the chuck with the same degree of concentricity, even when using a 4-jaw chuck, it should be kept for possible future use. It may acceptable at 1in. in a less critical application, but more likely it will be turned down for using at a smaller diameter. At least the tapped hole will be ready prepared.

Tommy Bar

Make the ends of the tommy bar a close but easy fit in the holes in the holders, thus ensuring that they do not slide out of the holes when in use. There remain only the screws, which will be dealt with later.

The holder mounting taper

Making precision tapers is an essential feature of two projects in this series, and will continue to be if you become involved in making workshop equipment. I therefore make no apology for repeating my method for making these (Ref. 2). I will, though, limit the description, so refer to the earlier article if you seek more background. Its essential feature is the ability to measure two diameters of the taper at two points located a very specific distance apart, determining from these that the angle is set accurately. A test piece is made having two flanges **(Sk. 5)**, the distance between their two trailing edges being such that the difference in their diameters must be 0.040in. **(Photo. 9)**. If the taper is to be turned with the smaller end adjacent to the chuck the distance is between the two leading edges. Having made the test piece, it can be retained and re-used until the flanges have been turned away, because the outer diameter will require turning each time.

Though I am providing this series essentially in metric dimensions, I do anticipate that the majority of the readers will be working on Imperial machines. As the system relies on an easily-read difference of 0.040in., it would make no sense to convert this to a metric value that would be difficult to read. I will therefore explain the system using Imperial dimensions. However, for the benefit of readers with metric machines, I am including a table giving distance between edges for a 1mm. difference in diameter. Do though note that these are **not** conversions of the Imperial values.

The Imperial table gives the dimensions of the test piece based on the difference between the smaller and larger diameters being 0.040in. With the top slide set to give this difference, a taper can be turned using the normal outside diameter turning methods. Even with this method, I found that setting the top slide can still be on the difficult side, due to the need to make very small adjustments to the angle, but at least it avoids the turn, remove, test, replace, turn, remove, test, sequence of events. I have though adopted an approach that minimises the problem, making the task considerably easier.

Having taken a trial cut leave, the tool in contact with the larger diameter and measure the two diameters. Even with the tool still in place, there should be plenty of room to take the measurements. For an example, let us assume the larger diameter is only 0.039in. larger than the smaller, thus needing the angle to increase. Loosen the top slide and swing it away from the test piece, move the cross-slide forward by 0.001in. and then rotate the top slide until the tool once again touches the test piece and re-clamp the slide in place. This will have made a small and controlled increase to the angle.

You may ask why, if the error was 0.001in. on diameter, was the adjustment not only 0.0005in.? The reason being, of course, because the change of angle will also have an effect on the smaller diameter.

If the error in the difference was larger than required, again leave the tip of the tool in contact with the larger diameter having made the test cut, but this time, after loosening the top slide, wind out the cross-slide and then wind it back in, but stopping 0.001in. short of its previous reading. The top slide, then being rotated so, as the tool again touches the test piece, it will this time be set to a shallower angle. Skim over the test piece once more and again measure; repeat the process until the desired result is achieved.

Having set the top slide at the required angle, the process consists of straightforward outside diameter turning. Rough the taper **(Fig. 2b)** using a right-hand knife tool and then use the finishing tool, as is seen in **Photo. 10**. One aspect of turning longer tapers is that the travel of the top slide may not be sufficient to finish the taper in one pass. This will be no problem at the roughing-out stage, but can cause a small step in the taper when finishing off. To minimise the effect, use the following process. First, finish the smaller end, leaving the larger end unfinished over a length that the slide will just cover at one pass. This ensures that if there is a step, it is furthest from the working end of the taper, though the following will virtually eliminate the possibility.

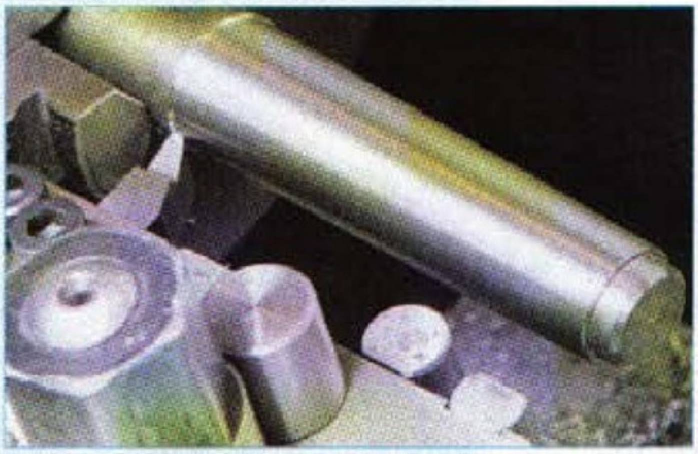
Having finished the smaller end, apply a very thin layer of marking blue to it, adjacent to the unfinished portion. Then, with the lathe running, advance the finishing tool, using the cross-slide, very slowly towards the blue area, until there are just signs of the tool touching the taper, then feed the top slide to finish the larger end. This should give a virtually step-free transition between the two areas. With the taper finished, remove it from the chuck and the chuck from the lathe, and fit the part into the headstock taper, assuming, of course that the headstock taper is the same as that in the tailstock.

Face the end, centre drill and drill with the biggest drill you have, up to 13.5mm diameter and then bore to 14mm diameter **(Photo. 11)**. Use the 14 mm hole gauge, the making of which was described in Issue 72 (page 28) to size the hole. You may ask why not use the spigot on the rear of the die holder, but as this does not have the reduced diameter portion, there will be no early warning that the hole is approaching size. Skim the outer diameter for appearance sake, face the end and chamfer, and the taper shank is complete.

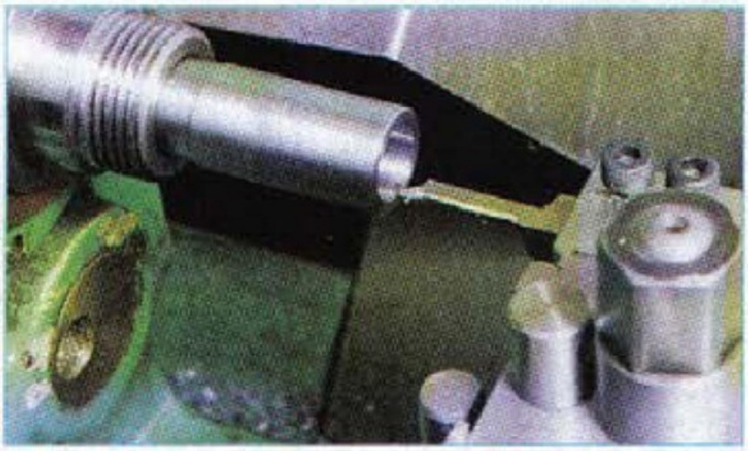
If your tailstock taper differs from that in the headstock, the situation will be much more complex and, unfortunately, space does not permit the process to be detailed at this stage. However, a later project in the series, for a milling cutter chuck, needs to get round the problem and the method will be fully detailed then. Apologies that you will have to wait so long for an explanation, but at this stage you could substitute two short rods, turned to 7mm and 10.5mm diameter, to fit in the internal bores of the holders, gripping these in the tailstock drill chuck.

Using the holders

The die holders are now ready for use as, seen in **Photo. 12**. Normally I am operating with a rear tool post in position,



10. The Morse taper being machined



11. Boring the end of the Morse taper to take the die holder shanks

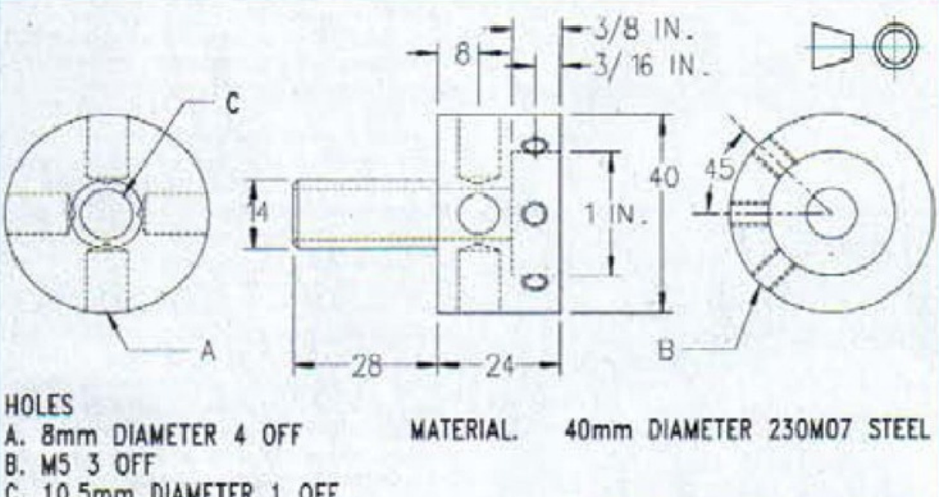


Fig. 2a 1 inch die holder

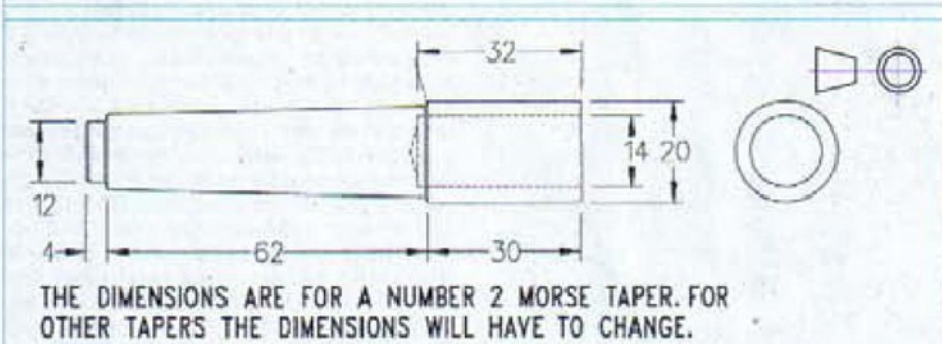


Fig. 2b Tailstock die holder support

but even with this removed, as in the photograph, the tommy bar proved to be a definite asset.

Having obtained your dies and die holders, how are they used? The first question is, with the lathe under power or turning the die by hand? For the beginner, the latter is definitely the approach. In fact I feel that this is almost always the method to use, personally very seldom using threading dies with the lathe turning. Even for the experienced, I would suggest this is only a possibility if using best quality dies with very free-cutting materials, and for smaller sizes only, say M5 and below. It would then have to be done at the lathe's slowest speed.

Preparation of the part to be threaded is minimal. Turn the outer diameter to the thread diameter, or very slightly over, say +0.02mm. to +0.04mm, depending on the size of the thread. This gives the die just a little to take off at the crest of the thread, rather than just rubbing. It will also stop there being a flat on the thread if it wanders a little. A chamfer at the end of the prepared part will aid the die in getting off to an acceptable start, but even with this done, the first thread or two can be below standard, especially with economy dies. If possible therefore, make the part a little on the long side and reduce to length after threading, thus eliminating any poor threads. The use of a good threading compound is also advised.

Split dies can be opened up a little by means of a pointed screw which locates in the split or closed slightly using the two small grub screws. This means that the die will not automatically cut the correct size when it is first run down the workpiece. Ideally it should be tried and set on a test piece before being put to work on the part being made. This can be a chore and one that most would prefer to avoid, so making a holder for each die and keeping it set is often put forward as the approach to take. As I have already found these holders easier to use than my double ended version, I am very much of a mind to make sufficient holders for all my more frequently used thread sizes, why don't you? It will be good experience. If this seems extravagant then, compare this with the multitude of quick change tool holders many readers own and use.

Adjuster screws

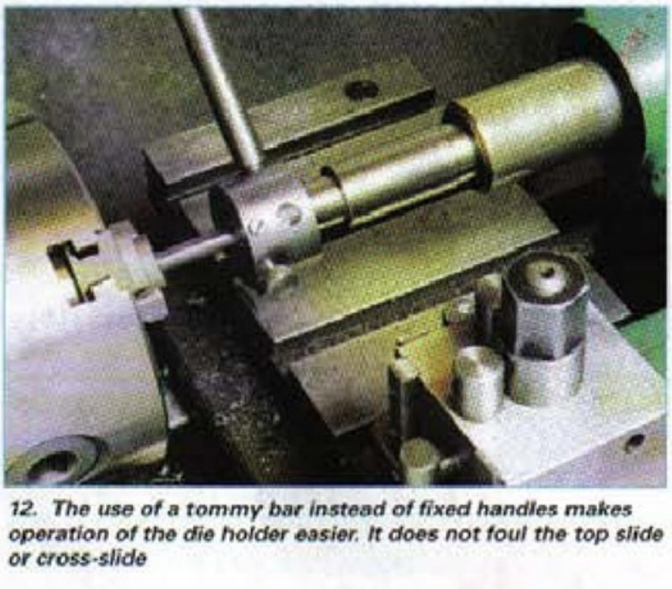
To make the adjuster screws for both holders **(Fig. 2b)**, the latter will need to be fitted with ordinary screws as a temporary measure. With the experience gained so far, the final screws should present no problem, other than the need for them to be knurled, a process which is to be covered in a later part of the series. I would suggest therefore that you stay with temporary screws, replacing them with the knurled versions as detailed in the drawings once knurling has been explained.

This still leaves the grub screws, which traditionally have been slotted types. If you wish to use socket screws, I see no reason why this should not be. However, if you wish to stay with tradition, the following gives some guidance on their manufacture.

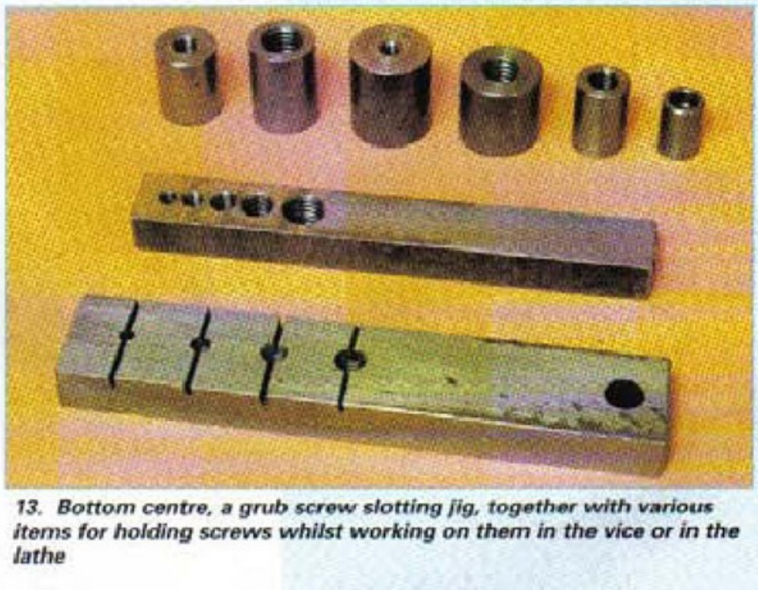
Working with screws

When working with screws in the home workshop, the requirement will invariably be to modify an existing screw to arrive at a variation that fits the requirement of the project in hand. This is likely to consist of:-

1. Reducing the length.
2. Changing the head size.
3. Changing the head type.



12. The use of a tommy bar instead of fixed handles makes operation of the die holder easier. It does not foul the top slide or cross-slide



13. Bottom centre, a grub screw slotting jig, together with various items for holding screws whilst working on them in the vice or in the lathe

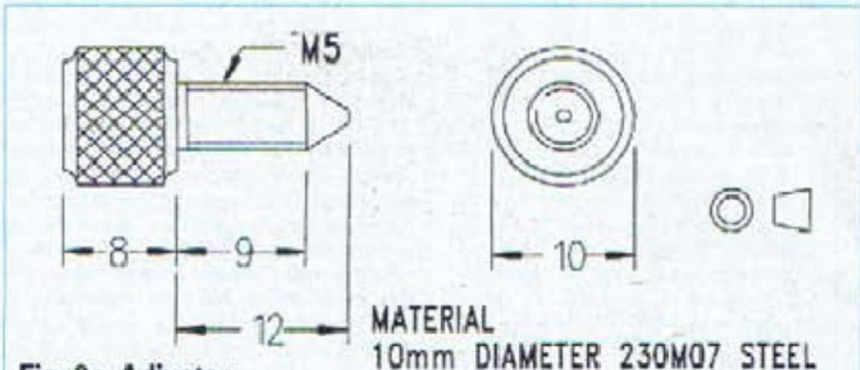
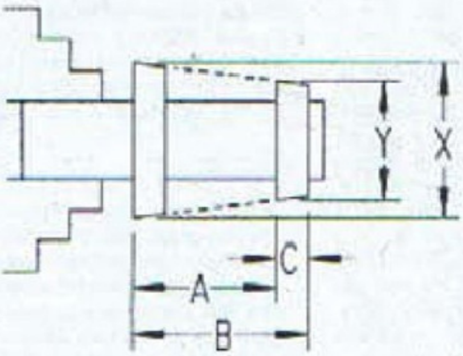


Fig. 2c Adjuster screw, 1in. holder

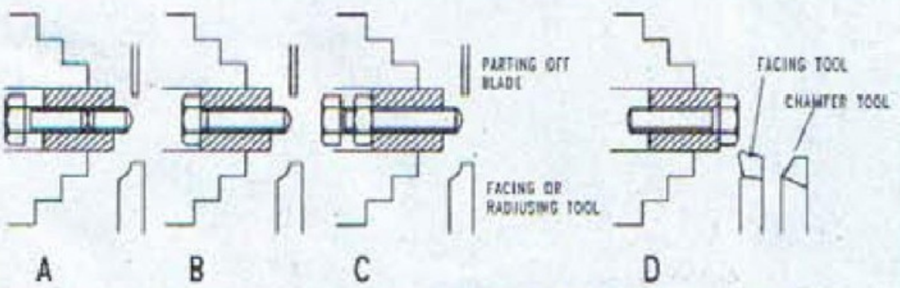


AS DIMENSION "A" WILL BE DIFFICULT TO MEASURE ACCURATELY MEASURE DIMENSIONS "B" AND "C"AND TAKE "C" FROM "B" TO ARRIVE AT "A"

IF MEASURING EQUIPMENT IS AVAILABLE TO DOUBLE DIMENSION "A" THE DIFFERENCE (X–Y) CAN BE DOUBLED MAKING AN EVEN MORE ACCURATE RESULT ACHIEVABLE.

MORSE NO.	TAPER / FOOT ON DIAMETER	DIMENSION "A" FOR X–Y=0.040"	X–Y=1.00mm
1	0.59858"	0.8019"	20.047mm
2	0.59941"	0.8008"	20.020mm
3	0.60235"	0.7969"	19.922mm
4	0.62326"	0.7701"	19.254mm

Fig. SK5 Morse taper - test piece dimensions



THESE SKETCHES ILLUSTRATE HOW TO WORK ON SCREWS USING A THREADED COLLAR TO HOLD THEM, "A" A GRUB SCREW "B" A HEADED SCREW, "C" A LONGER HEADED SCREW AND "D" MACHINING THE HEAD OF A SCREW.

Fig. SK6 Working with screws

4. Changing the form of the end, pointed, radiused, etc.
5. Taking a short length from an existing screw then slotting the end to make a slotted grub screw.

There are two approaches to these tasks, - a purely manual one (hacksaw and file), or a machine-assisted one, parting off and radiusing the end, etc.

Let us take requirement 5 first, as this task is necessary for our die adjusting screws. For this a slotting jig, as seen at the bottom of **Photo. 13** is required to be made. It is suggested that, unless a large number of slotted grub screws is required, when they should be slotted with a slitting saw on the milling machine, this simple jig will give very good results. The purpose of the jig is to ensure that the slot is made centrally on the end of the screw, as any small error will become visually very apparent.

Take a length of steel, typically 16 x 8mm cross-section, and make a number of saw cuts across it, to a depth of about 3mm, as seen in the photo, one slot for each size of screw to be catered for. Use a normal junior hacksaw blade, as this will be a suitable width for most sizes, say M4 to M8. If you are into very small work, then a junior hacksaw blade could be thinned over a short length, using the off-hand grinder. This could then be used, with a little extra care, on say M2.5 and M3.

With the length of steel slotted, take a large centre punch and locate it in the centre of each slot, then make a substantial centre punch mark. Drill through with a small drill (in the order of 1mm diameter) then turn the jig over and open out with tapping drill sizes for the screw threads you intend to use. Tap the holes as required and the jig is complete.

To make the grub screw, take a screw of suitable length and place a nut on it, thread the screw into the jig from the non-slotted side and, when flush on the other, lock in position using the nut for the purpose. It is then a simple process to slot the end of the screw, using the jig to guide the saw, resulting in the slot being accurately placed on the end of the screw. Following this, chuck a length of steel in the 3-jaw, about 15mm long and 10mm diameter, face both ends and drill and tap to the thread size being worked on. This can then be used to hold the screw for working on, parting off, shaping the end, etc. Rather than going into lengthy descriptions, **Sk. 5** shows how this simple device can be put to use. For more information on the subject, a detailed article written by Philip Amos is well worth reading (Ref. 3).

As already mentioned, knurling will be one of the topics to come later in the series, but do not go out and purchase the equipment in readiness, as making suitable tooling will also be the subject of part of the article.

The next part of the series will cover, in two issues, both machining cast iron and cutting screw threads on the lathe, the item being made being a screw jack. This will then be followed by the item on knurling.

References

2. Turning a Morse Taper, M.E.W. Issue 6 page 28
3. Trimming Bolts and Screws, M.E.W. Issue 59 page 35

MORE SPACE AT HARROGATE

The Editor pays a brief visit to the 8th National Model Engineering and Modelling Exhibition

1. Raymond McMahon's 'Raymac' tool and cutter grinder took first place in Section 44 for Workshop Equipment and was awarded the Chester UK Cup.

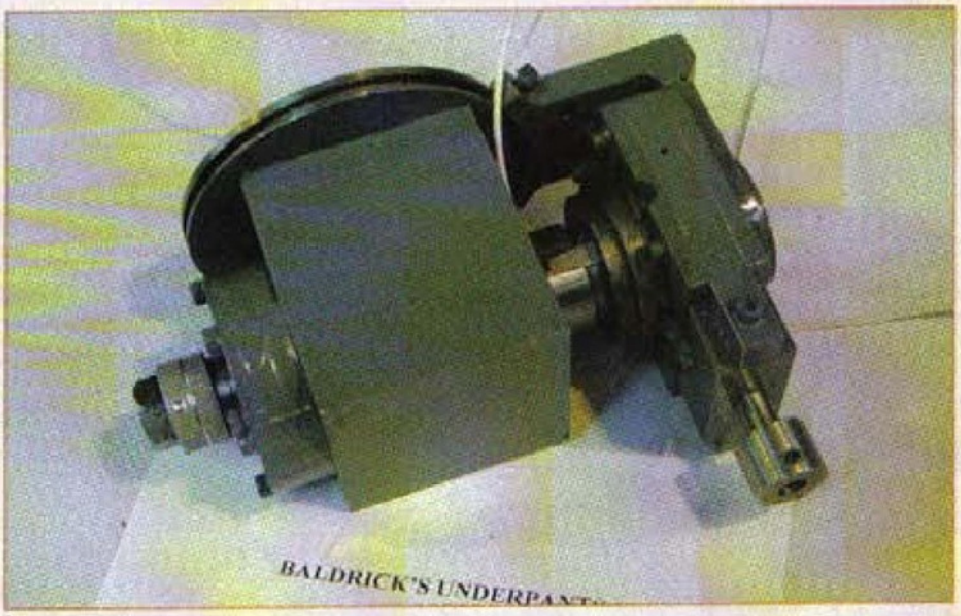
The long-promised extension to the Flower Hall at the Great Yorkshire Showground at Harrogate materialised in time for this year's National Model Engineering and Modelling Exhibition, the eighth in the series. The addition of a complete new hall and a significant expansion of the catering area greatly enhanced the venue and allowed the organisers to dispense with the tents which had been necessary to accommodate the boating exhibits and some of the trade stands. The majority of the traders could now be located in the new Hall 1, with all the model exhibits and club stands in the original hall, now Hall 2. This arrangement allowed improved security arrangements to be put in place.

One problem encountered this year was a clash of dates with other events held at the Showground, resulting in the event having to be staged on the Friday, Saturday and Sunday immediately prior to the May Day Bank Holiday. This resulted in some of the clubs which regularly attend having to withdraw because of prior commitments such as track running days. However, all have stressed to the organisers that they would wish to be invited again next year if the schedule allows. The change of dates also curtailed the time which both the editor and colleague Mike Chrisp of *'Model Engineer'* could spend at the event because we were both due at the Modeller's Holiday at Primrose Valley, Filey early on the Friday evening. However, we were both able to call in at Harrogate en route, but it was, for both of us, very much a whistle-stop tour. We usually try to attend for the duration of the event because it takes the whole of the time available to view all the exhibits thoroughly and take the necessary photographs, as well as meet the many friends from the northern regions we seldom see elsewhere. Naturally, the latter activity tended to take precedence, so our coverage of the exhibits is somewhat limited.

That said, our overall impression was of an exhibition of excellent quality, well laid out with plenty of room to circulate and to view the exhibits in comfort. Unfortunately, the number of competitive entries was slightly down on previous years, but this was counterbalanced by the Loan entries and the number and quality of the items to be seen on the club stands. Last year I happened to meet Harrogate Chief Judge Jim Burlingham at an exhibition in another part of the country, where we bemoaned the fact that there are many high-quality models included in the club displays which, to the best of our knowledge have never been seen in competition. Many of these are potential

2. An impressive vertical milling machine built by E. Norfolk

3. A recruit to the ranks of miniature machine tool builders is J. M. Clennel who entered this $^{1}/_{20}$ scale version of a centre lathe, seen here with a small four-throw crankshaft mounted between centres.



4. *A useful slotting attachment for a home-made milling machine carries an intriguing title!*

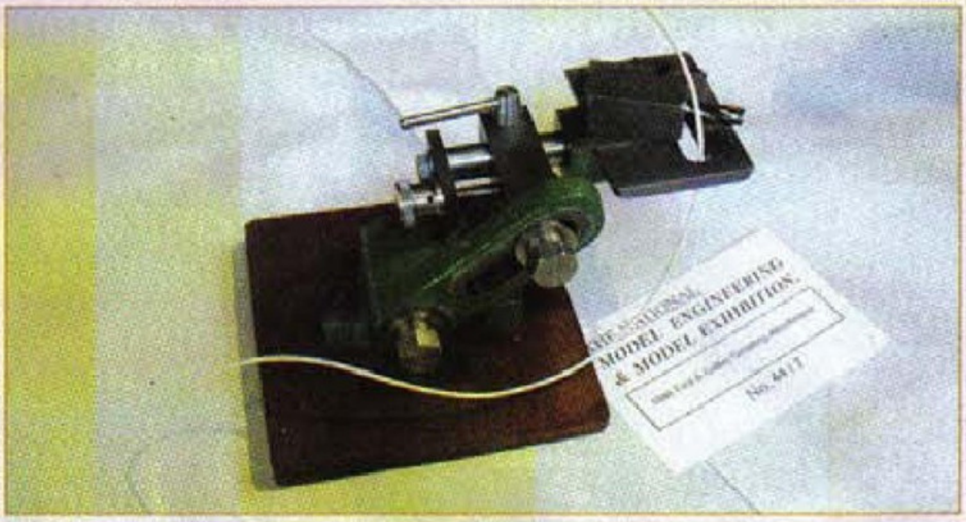
award winners and deserve to be seen, at least once, displayed in the improved viewing environment which is normally made available for the competition entries. We would encourage the builders of these models to overcome their reticence and bring them forward for us all to admire.

As mentioned, our coverage of the event is somewhat limited, so we would apologise to all those whose entries we are unable to show in this brief report, but we have been promised further details from those who were able to spend more time there. We look forward to next year's event and the opportunity to fully appreciate the enhanced facilities.

5. *D. W. Clennel's hand planing machine was made by toolmaker Arthur Firth at the Atlas Works, Cleckheaton over 90 years ago.*

6. *An interesting collection of micrometers has been assembled by J. M. Clennel.*

7. The Hart Tool and Cutter Grinding Attachment has proved popular with those who do not have access to a purpose-built machine. This example was shown by J. Harding.

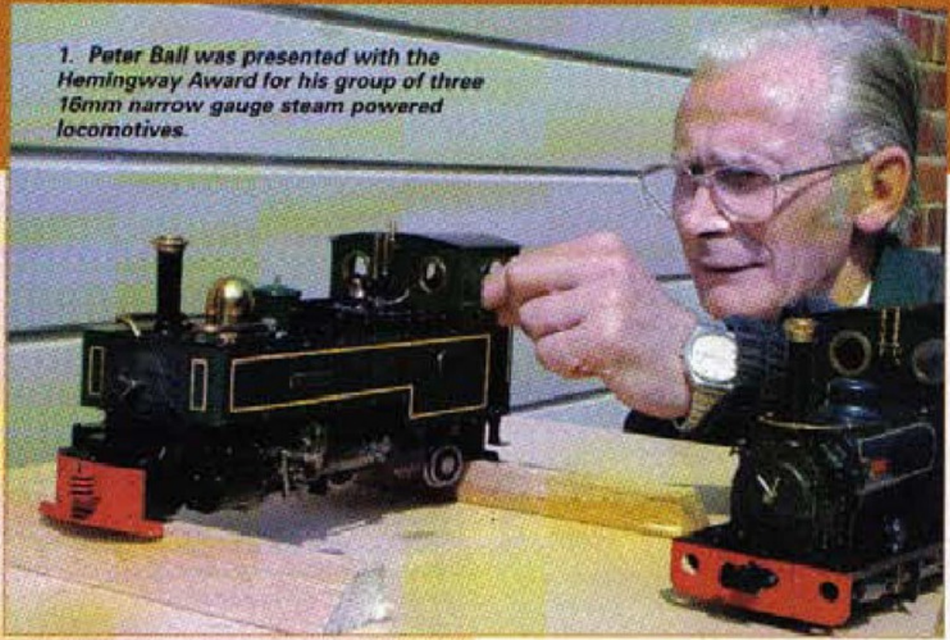


8. Neville Wilkinson has added to his stable of hydraulically powered models with this 1/12 scale excavator simulator. The young lady under instruction soon got the hang of the controls and was shifting dried peas with aplomb!

9. A photo call for Exhibition Manager Louis Rex and his wife Margaret with just some of the Harrogate Live Steamers.

SUN, SEA AND STEAM

Perfect weather added to the enjoyment of this year's Modellers' Holiday at Primrose Valley, North Yorkshire



1. Peter Ball was presented with the Hemingway Award for his group of three 16mm narrow gauge steam powered locomotives.

2. Simon Wass rebuilds his gas turbine engine after a bearing failure. Simon's engine is entirely home-built, basically to the Schreckling design, but incorporating a number of modifications, including an aluminium compressor rotor.

The Editors of *'Model Engineer'* and *'Model Engineers' Workshop'* once again took a significant proportion of their workshop equipment with them when they went on holiday to Filey on the North Yorkshire coast. The Modellers' Holiday held annually at the Primrose Valley holiday village is a gathering point for enthusiasts of many modelling disciplines, providing an opportunity for us to see what the others have been up to in their workshops over the winter months.

The engineering workshop is primarily set up to provide a repair and maintenance service for all who are taking part, and a wide variety of damaged model boats, aircraft and cars pass through our hands, more often than not restored to working order if not to as-new condition. It's not often that we have to admit defeat, causing one humourist to suggest that our motto should be "If we cannot fix it, it's not broken"!

Additionally, the workshop acts as the focal point for the model engineers present, being the base for the owners of the steam powered road vehicles, who take advantage of the extensive system of private roads which traverse the site. When we are not engrossed in the repair of some defective item, we try to demonstrate some aspect of workshop procedure, often as the result of a request from visitors. One example this year was a demonstration of basic silver soldering, put on at the specific request of a number of aircraft and boat modellers.

Each year we are supported by our friends in the model engineering trade, and this time we were grateful to Roger Warren of Warren Machine Tools (Warco) and John Corlyon of Hemingway. The former offered the loan of a new Warco 918 lathe for use in the workshop, while the latter donated a Hemingway kit of materials for a spherical turning tool, which formed the major prize for the engineering section of the exhibition which traditionally starts the week, bringing everyone together on the Sunday afternoon. This time, the Hemingway Award went to Peter Ball of London who had brought three of his steam powered 16mm narrow gauge locomotives to delight everyone present.

At the other end of the technology scale, two modellers had brought home-built gas turbines, Simon Wass of Chesterfield running his Schreckling-based design, while John Benson of Leeds demonstrated his aircraft-mounted JAB Wren engine, which is a modified version of the Wren MW54 design. Simon's father, Peter had brought some of the components of a Bentley BR2 rotary engine which he is building, and promises to be an outstanding piece of work.

3. John Benson explains the finer points of his JAB Wren engine before giving a demonstration of its running characteristics.

4. John Bushell prepares his recently restored Clayton Wagon for a run around the roads of the holiday village.

5. Primrose Valley stalwart John Bamforth with his 2in. scale 'Minnie', which has covered many miles around the site.

WHEN IN DOUBT - FABRICATE

Bob Loader suggests that it is worth looking at alternative ways of making a component

1. The pressure pad is seen on the right of the photo.

Some jobs are of a shape or complexity which makes them awkward to make, all part of the attraction of the hobby. Some examples are quite simple, some more complicated. Two of the simpler sort are shown in Figures 1 and 2.

Pressure pad

The pressure pad **(Fig. 1)**, also shown on the right-hand side of **Photo. 1** is part of a set of tailstock attachments which fit into a sort of running centre device. The face of the pad must be flat and true with the shank and it could, of course, be machined from a length of 20mm mild steel. An easier and quicker way is to make the shank to the finished diameter, but a little longer, with a spigot on the end. The pad is made separately and drilled or reamed to be an interference fit on the spigot.

Interference fit

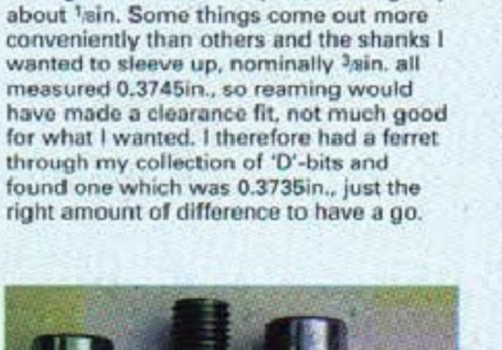
An interference fit is made when the spigot is **very slightly** larger than the diameter of the hole it is intended to fit. For work the size of the pressure pad, 0.0005in. or just over 0.01mm would be about right. It is best to machine the hole first and make the spigot to fit. The spigot should be slightly longer than needed and can have a slight taper, for 1mm or so, to give it a start. The fit is made by pressing in a vice, with soft material protecting the ends. An extra press with a short length of tube positioned over the spigot will drive it fully home. The bit of spigot sticking out can be faced off **(Photo. 2)**, with the shank held in a split bush to avoid damage, thus ensuring that it is true with the shank.

2. Facing the surface of the pressure pad flat and true

Increasing a diameter

This is another very simple fabrication, shown in **Fig. 2**, almost an example of 'putting on' tooling. The problem was to make some cutters with 3/8in. shanks fit into a cutter holder with a 1/2in. bore. There had to be a slot for a locking grub screw. It was easy to adapt the two cutters shown on the outside of **Photo. 3** by grinding a suitable slot, the one in the middle was a different story and needed the fabrication, to give a good interference fit. It had to be right, not able to move even under severe cutting pressure.

As the cutter was an Imperial one, I used Imperial units and decided that an interference of between 0.0005in. and 0.001in. would be right. The easiest way would be to use a hand reamer and take it through the sleeve till it poked through by about 1/8in. Some things come out more conveniently than others and the shanks I wanted to sleeve up, nominally 3/8in. all measured 0.3745in., so reaming would have made a clearance fit, not much good for what I wanted. I therefore had a ferret through my collection of 'D'-bits and found one which was 0.3735in., just the right amount of difference to have a go.



3. The sleeved-up cutter is the threaded one in the middle

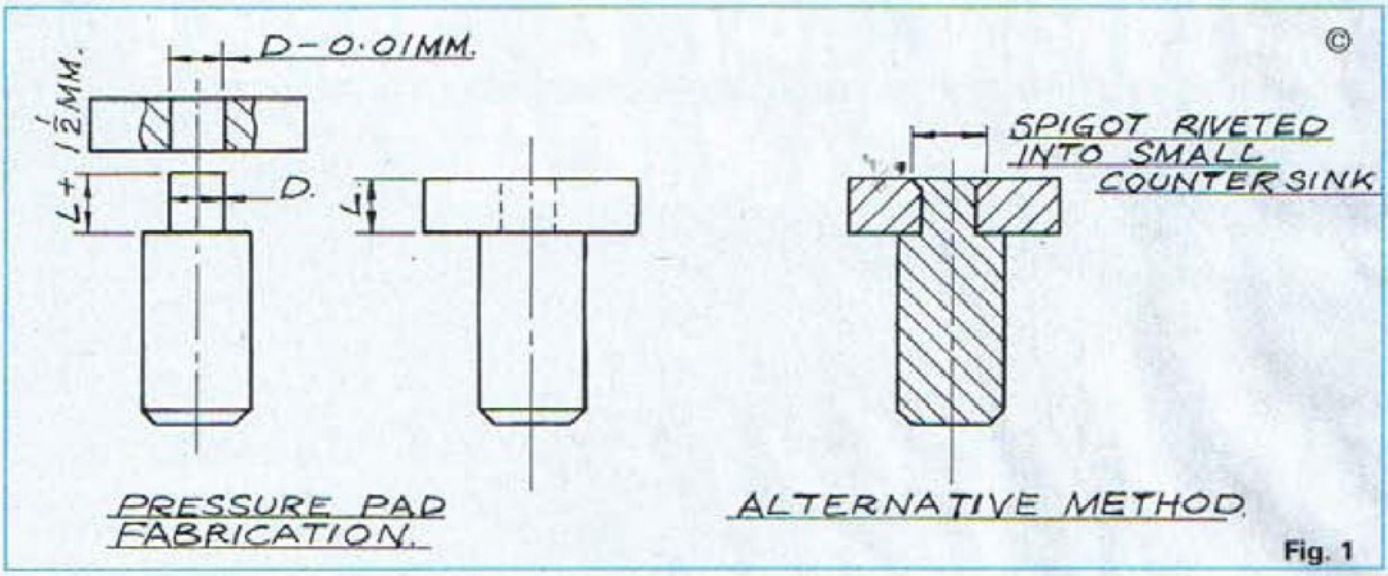


Fig. 1

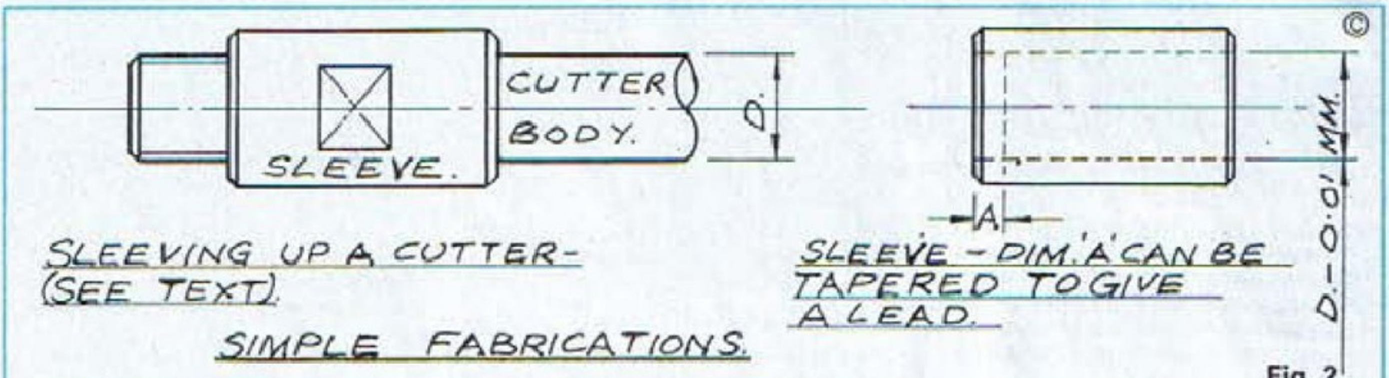


Fig. 2

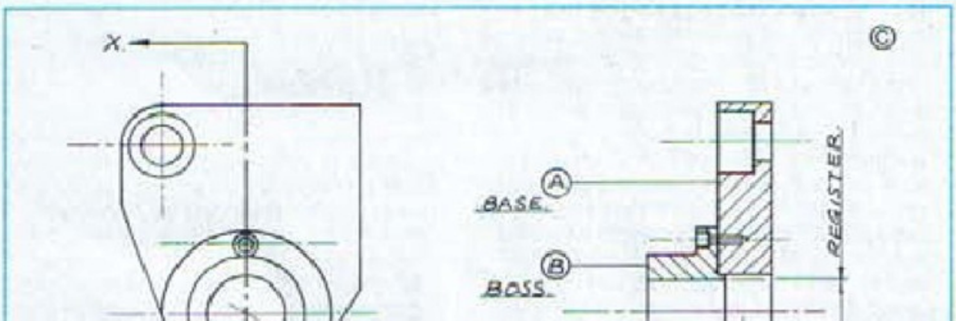


Fig. 3

Use a good vice

I made some sleeves using the 'D'-bit and pressed them on using my 3in. bench vice. A larger vice would have been better, but I used what I had. Don't try it with one of those pathetic vices sold in shops which deal in cheap car maintenance tools, it would probably break in half. My good English-made one took the extra leverage from a short length of tube slipped over the handle, extending it from 5in. to 12in. I scraped out the first 1/8in. or so with a three-square scraper to give it a start. A smear of grease - I use Vaseline - helps and it is vital to begin the pressing operation squarely. The ends of the cutter were protected with pieces of aluminium.

Photo. 4 shows the shank being turned to size, using the centre holes in the cutter. The slot for the grub screw took just a few minutes filing. Had the cutter been a slot drill with no centre in the cutting end, the turning could be done by setting true in a 4-jawed chuck.

Another method

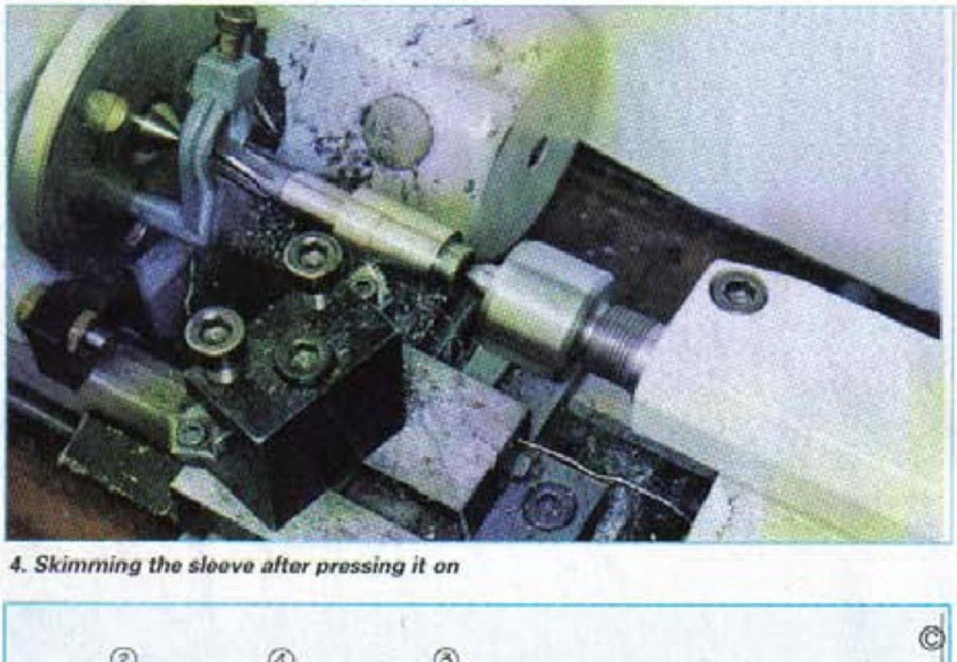
Sleeves could be silver soldered to the shanks. As long as the cutters were made from high speed steel, it is very unlikely that the hardness would be affected because the melting temperature for silver solder is way below that for softening high speed steel. If it makes you feel better, you could bury the toothed length in damp sand, but it isn't necessary.

The two examples quoted are very simple ones, but they show the principles and the usefulness. I made a slightly more complex one for a part I used when making a screw cutting attachment for the Unimat.

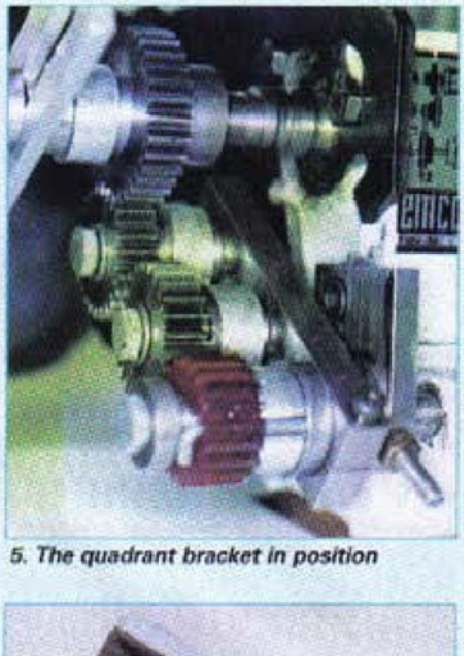
Quadrant bracket

Photo. 5 shows the bracket in position and **Photo. 6** what it looks like before fitting. Making the bracket from one piece of steel would be a 4-jawed chuck or face plate job, taking quite a while and putting a small lathe like the Unimat under a lot of strain. The interrupted cutting action would do it no good at all. Even if some of the waste was cut away with that superb roughing tool, the hacksaw, there would still be a lot of machining left.

A better method is to use a two-piece fabrication, the flat base and the boss, made separately. The two parts can be seen clearly in **Photo. 7**, where the assembly is being offered up to make sure



4. Skimming the sleeve after pressing it on



5. The quadrant bracket in position

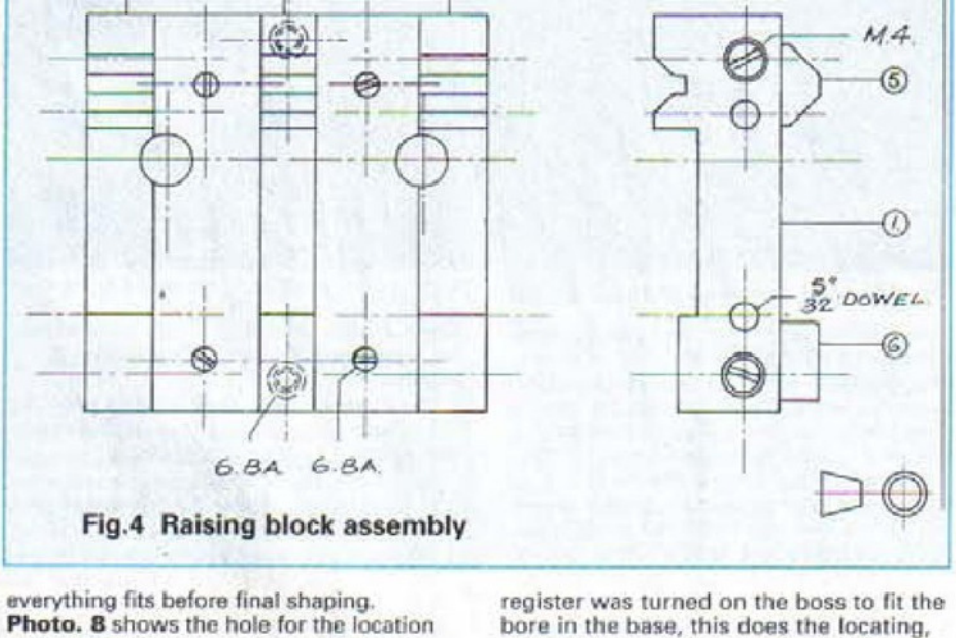


Fig.4 Raising block assembly

6. The finished quadrant bracket

everything fits before final shaping. **Photo. 8** shows the hole for the location stud being drilled.

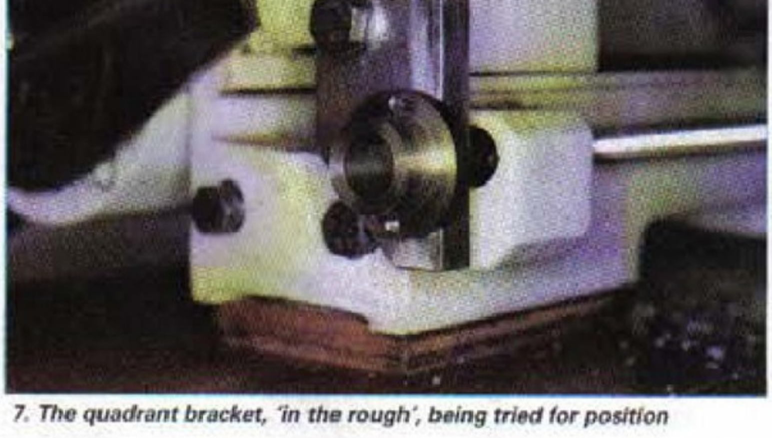
Locating and locking

To make sure that the boss and base fit as if they were one piece, a small register was turned on the boss to fit the bore in the base, this does the locating, the two small screws do the locking. All the details are in **Fig. 3**. As long as the spindle from the gears will pass through and connect with the lead screw, all will be well.

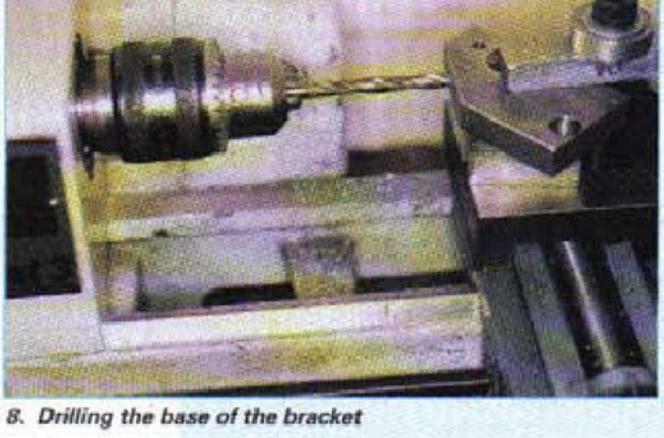
Fabricating for convenience

Sometimes I have fabricated because it has been simpler and taken less time, as well as making things easier when things like 'T'-slots are needed. An example is the face plate I made for the Unimat, **Photo. 9** shows it in action.

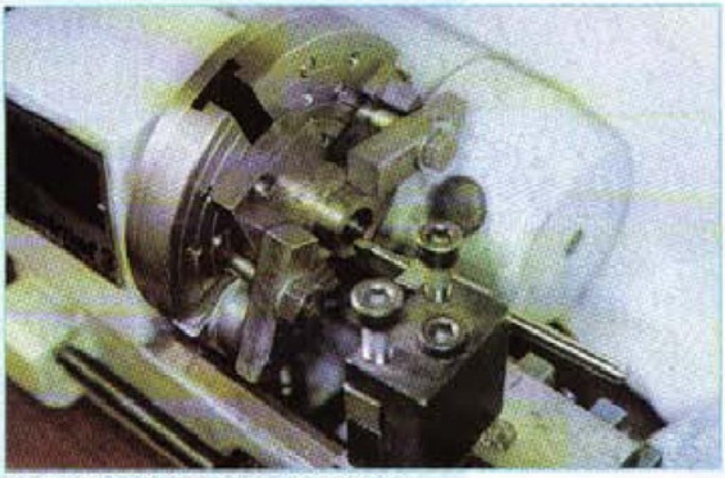
Machining a large solid lump of a size from which to make a face plate from is quite a stressful job for a small lathe and there is the problem of the 'T'-slots. Cutting a slot with a slot drill or end mill is no trouble, but turning it into a 'T'-slot is something else and 'T'-slot cutters are not cheap.



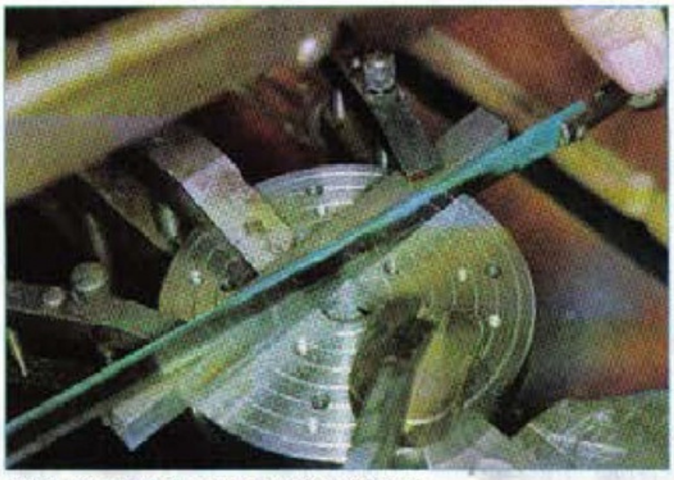
7. The quadrant bracket, 'in the rough', being tried for position



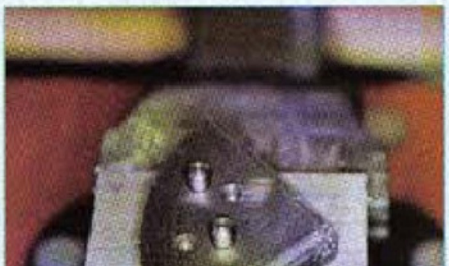
8. Drilling the base of the bracket



9. The face plate made for the Unimat



10. Cutting the face plate into quadrants



11. A finished quadrant

I decided that a reasonable way of minimising the difficulties was to make the face plate in six pieces, a back plate which fastens to the lathe spindle, a base plate which is the foundation, fastening and locating the back plate and four shaped quadrants which solve the troublesome business of the 'T'-slots. The key to the construction is the way that the main parts are held together with screws and dowels, dowels for locating and screws to do the locking. Fitted bolts could replace the screws and dowels if available.

Some filing

Using this method means a lot of filing instead of milling, a lengthy but easier proposition for small lathe users. It must be accurate, especially when filing the steps in the quadrants. The assembly is cut into four pieces after all the holes have been drilled, tapped, reamed and doweled. **Photo. 10** shows the beginning of the process, accuracy taken care of by cutting against a fence. For this part of the job, the base plate is taken off. Similar methods are used to file the steps in the quadrants, one of which is shown in **Photo. 11**. Because of the way the face plate is made, the flat back allows, when required, clamping with a toolmakers' clamp, as was shown in the article on drilling in the last issue. The photos in that article also show how the screws and dowels finish under flush. Another way of using it is the more usual clamping with bridge clamps, using 'T'-nuts in the slots, as seen in Photo. 9. Having four 'T'-slots also helps, the face plate supplied with the Unimat only has three. For the size of 'T'-slots I decided on, an 8mm bolt with the head skimmed to about 3mm fits nicely.

12. First stage in making the raising block

So much for easy examples, as one thing leads to another, I have used similar ways and means for other jobs.

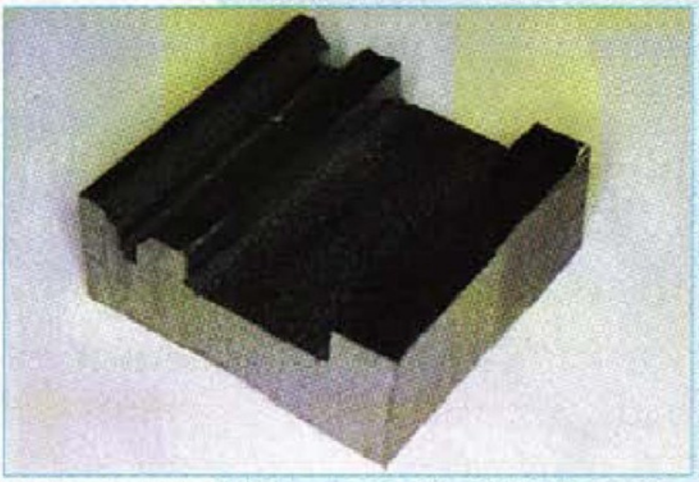
A raising block for the Unimat

This is probably the most ambitious project I have made for the Unimat, its construction being described in detail back in Issue 32. I started optimistically, thinking I could make it from a solid piece of cast iron which I hacked off a spare piece of what I think was a large vice jaw. It was

13. Some heavy filing

14. Cutting some slots to break up the surface

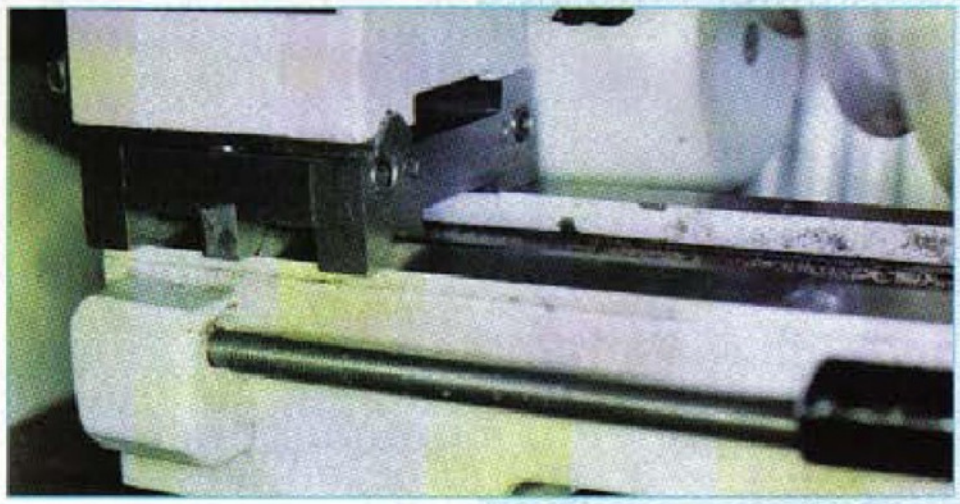
15. *Chiselling off the excess*



16. *Time to think of a better way of making the block*

17. *The re-designed block*

hard work, as **Photos. 12 and 13** show. I made things easier for some parts of the job by cutting lots of slots with a hacksaw and chiselling off the bits in between, (**Photos. 14 and 15**), but it was still hard work.



18. *The raising block in position*

A drastic re-design

When the rough-hewn object in **Photo. 16** had progressed as far as I could in more hours than I liked to think about, plus a lot of sweat, I designed a fabricated version, **Photo. 17**, which is shown in position in **Photo. 18**. The bare bones of it were two end blocks, joined to a solid base with another profiled plate in the middle, **see Fig. 4**. Item 1 is the base, 2 and 3 the end blocks, 4 the middle profiled plate and 5 and 6 the pieces to fit the V and flat of the lathe bed.

My reasons for the change were not because I was too idle to carry on filing. What I wanted was an accessory which anyone could make, without my sometimes masochistic liking for 'a bit of filing'. The new version made more sense and was a quicker and better way to make it, so that anyone who had a small lathe could have a go. It also avoided a lot of the heavy machining which small lathes don't like.

Dowels again

Like the other fabrications, dowels are the key to accurate location. I used a similar construction method when I made the 4-jawed chuck seen in **Photo. 19**. It has been fairly successful and I have used it a lot. The jaws spread a bit under pressure, but it does everything a 4-jaw has to do.

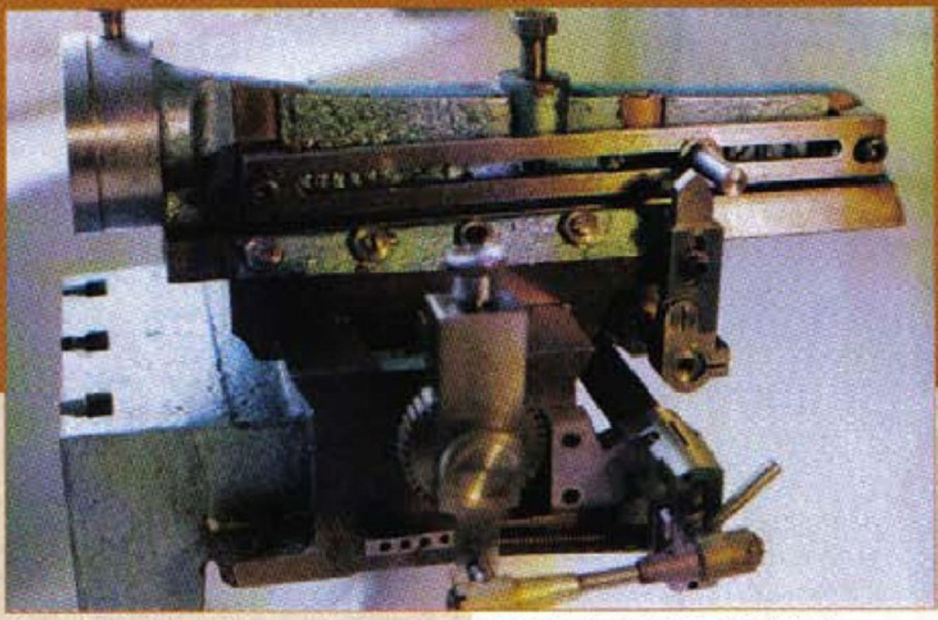
Some idea of the machining involved can be seen in **Photo. 20**, where the slots for the jaws are being cut, the holes for the screws and dowels having already been done.

I began using fabrications so that I could make bits and pieces for the Unimat without putting it under too much pressure. It seemed to be the best way of making complicated things simple enough to make with basic equipment. Without using such methods, I would have no face plate, no 4-jawed chuck, no raising block and be without several other useful attachments and accessories. I recommend it for convenience and ease of manufacture.

19. *The home-made 4-jawed chuck*

20. *One of the milling operations in making the 4-jawed chuck*

A SELF ACT CROSS FEED FOR AN ADEPT HAND SHAPER



1. *The 'Adept' hand shaper with the new cross feed self-act components fitted*

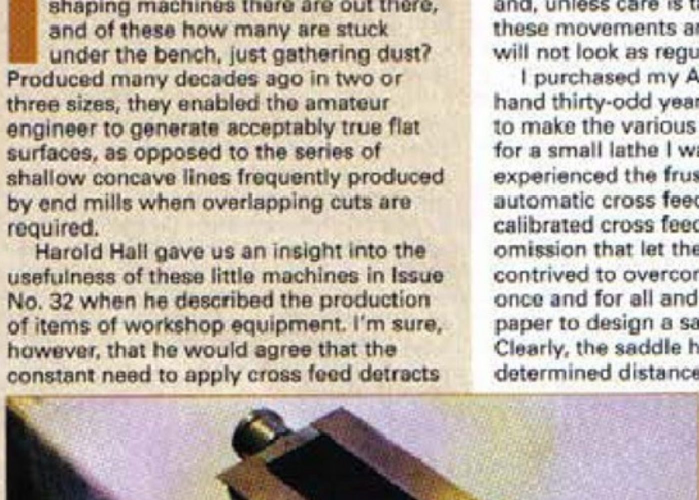
The hand shaper was once a familiar item in home workshops and there are many who still find it a preferred tool in some circumstances. John Crammond suggests a method of upgrading one of the simpler versions

I wonder how many 'Adept' hand shaping machines there are out there, and of these how many are stuck under the bench, just gathering dust? Produced many decades ago in two or three sizes, they enabled the amateur engineer to generate acceptably true flat surfaces, as opposed to the series of shallow concave lines frequently produced by end mills when overlapping cuts are required.

Harold Hall gave us an insight into the usefulness of these little machines in Issue No. 32 when he described the production of items of workshop equipment. I'm sure, however, that he would agree that the constant need to apply cross feed detracts from the pleasure of using the machine and, unless care is taken to ensure that these movements are even, surface finish will not look as regular as it could.

I purchased my Adept No. 2 second-hand thirty-odd years ago when I wanted to make the various dovetail slides needed for a small lathe I was making. I soon experienced the frustrations of not having automatic cross feed, and the lack of a calibrated cross feed dial was a further omission that let the little machine down. I contrived to overcome these problems once and for all and set to with pen and paper to design a satisfactory system. Clearly, the saddle had to be moved a pre-determined distance with each stroke, and a connection between ram and feed screw was obvious. I decided to extend the feed screw through the far side of the base casting, as the mechanism would be less intrusive in this position. With the modifications complete, it may initially appear that the operating lever can now only be mounted on the left of the machine, looking at it from the front. In fact this is no bad thing, as one then tends to stand behind, out of the way of those hot curls of metal that ping off the workpiece and always seem to make a bee line for face or hands. However, if a raising block or pillar is screwed to the saddle protrusion which locates one end of the swinging link, this link can be attached to the top of this, and the operating lever fitted to the top of the ram, rather than through the aperture provided in the ram. This will move the lever above and out of the way of the striker pin and slotted plate. Although added stresses may be placed on the pivot bolt passing through the centre of the ram, I have not experienced any problems over many years of use.

The system I eventually settled on involved making a 20 tooth pinion long



2. *The base, machined to accept the bearing plates for the long pinion and fitted with the new feed screw bearings*

3. *A small area on the flat section at the rear of the saddle has to be machined flat to accept the housing for the smaller gear*

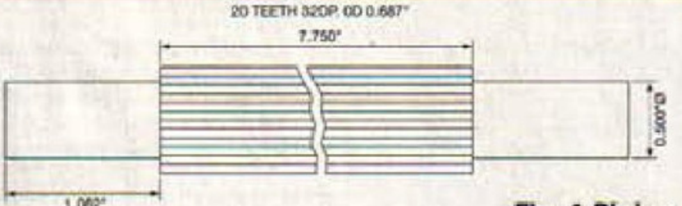


Fig. 1 Pinion

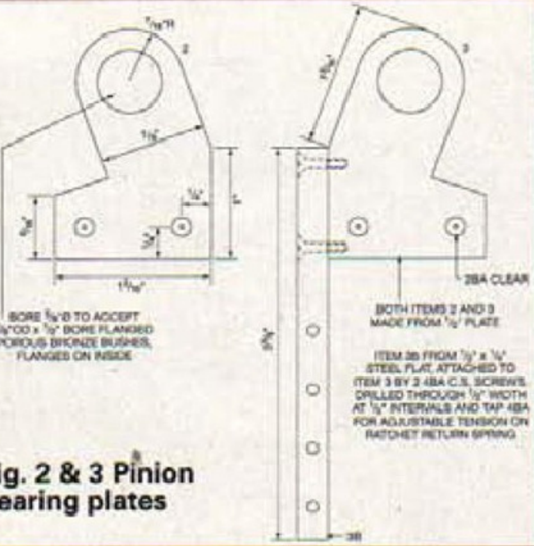


Fig. 2 & 3 Pinion bearing plates

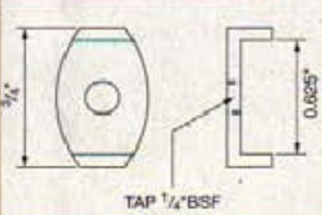


Fig. 6 Nut

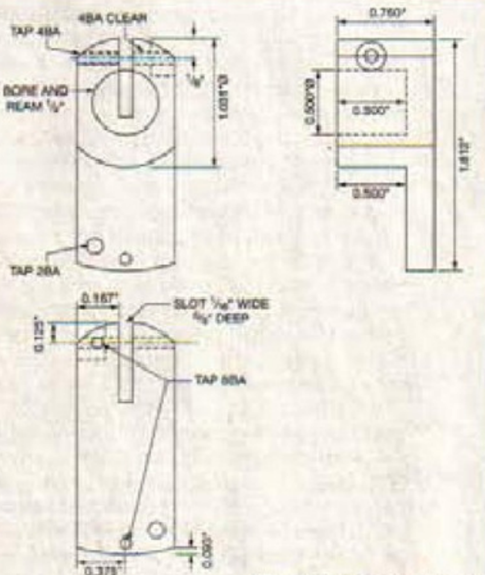


Fig. 4 Stroke lever

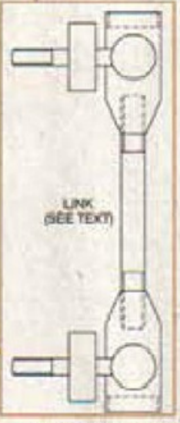


Fig. 7 Link

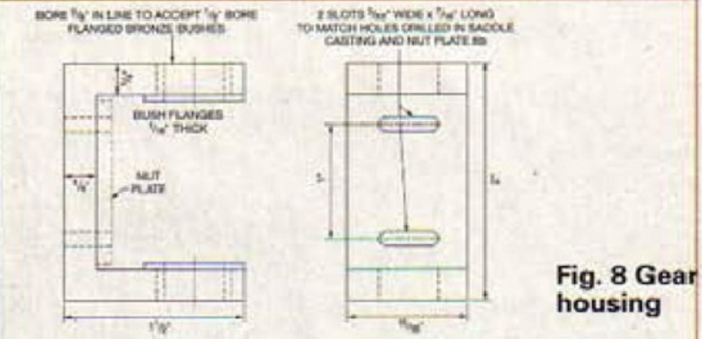


Fig. 8 Gear housing

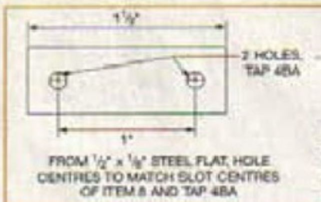


Fig. 8b Nut plate

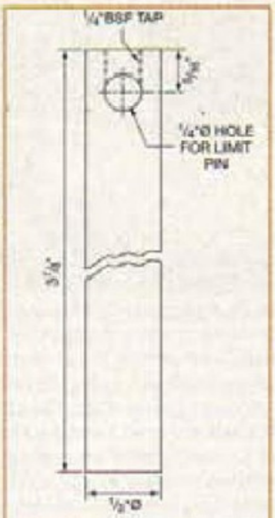


Fig. 9 Gear spindle

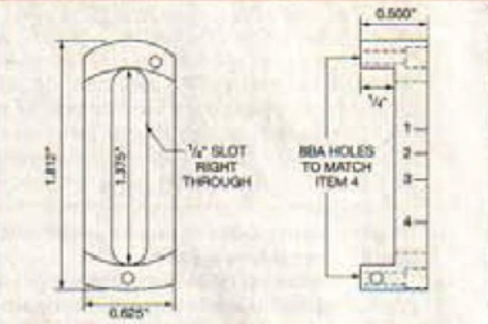


Fig. 5 Stroke adjustment plate

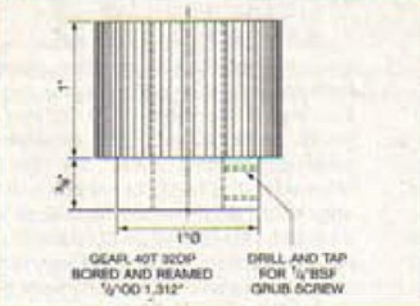


Fig. 10 Gear

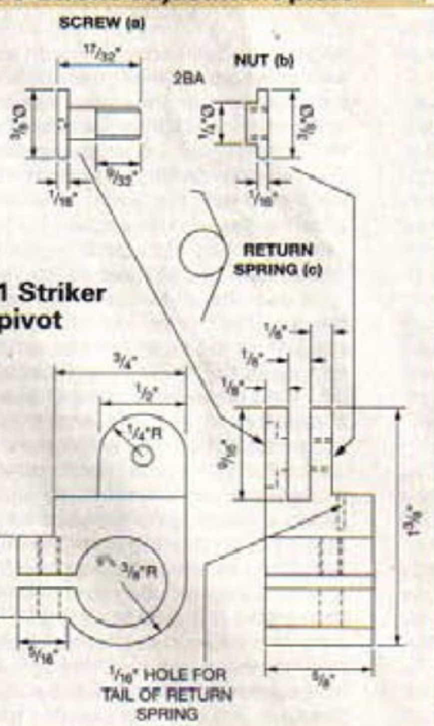


Fig. 11 Striker lever pivot

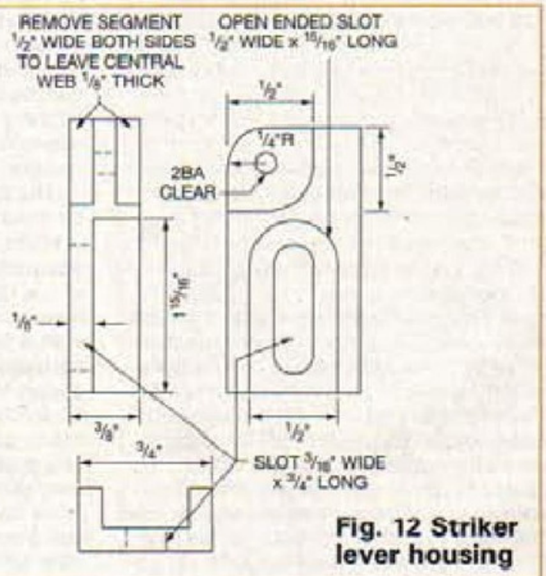


Fig. 12 Striker lever housing

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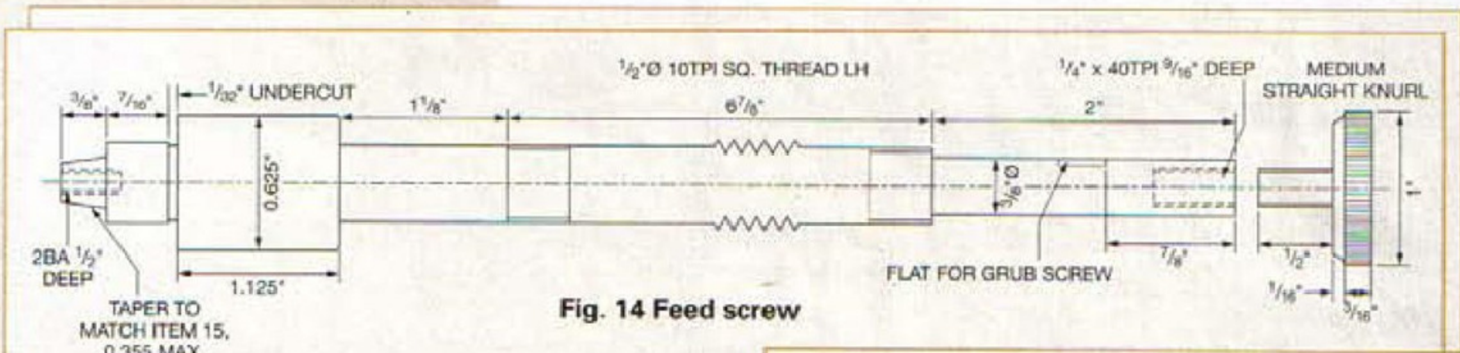

Fig. 14 Feed screw

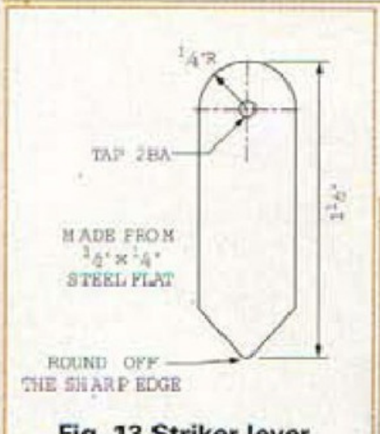

Fig. 13 Striker lever

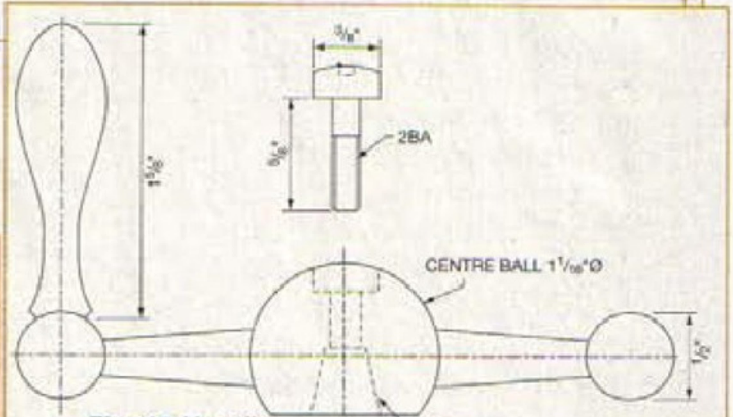

Fig. 15 Handle

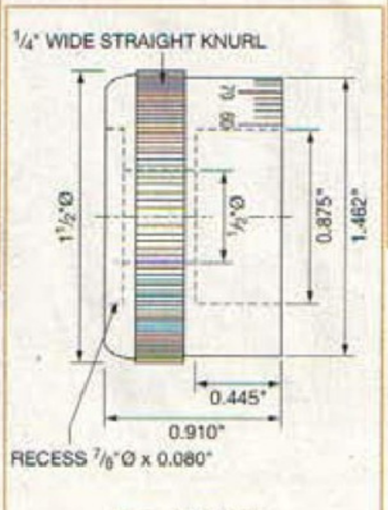

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Fig. 16 Dial

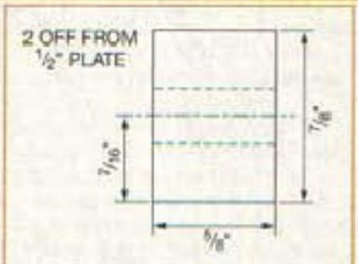


Fig. 17 Blocks

enough to span the whole width of the base, to which is meshed a second gear travelling with the saddle. This gear is revolved through a few degrees by an attached lever being struck by pin protruding from the ram on its back stroke. A further lever, fastened to the long pinion, is consequently moved through an arc and, with the aid of a short link to a ratchet assembly attached to the extended end of the feed screw, revolves this by a pre-determined amount. The accompanying photos will clarify matters.

Modifications to castings

The modifications do involve straightforward machining operations on the castings, but these are few in number and not of an onerous nature, easily carried out on the lathe or vertical mill if one is available.

So to proceed. Completely dismantle the machine - not difficult as there are not that many parts. Start work on the base which needs both sides to be machined flat and at a true right angle to the front machined face and also to the bottom of the casting. If you prefer not to machine the whole width, a 2in. portion at the rear of the machine will do. This provides a true and flat surface to which can be bolted the two pinion bearing plates, one each side.

The second job on the base consists of opening out the present 1/2in. feed screw hole to 3/4in. to accommodate the new bearing. A second hole, 0.562in. now needs to be placed in the far side of the casting, truly in line with the first hole, otherwise the feed screw nut will not be in alignment and the saddle will not traverse as it should. Use your very best endeavours to get these holes in line and press in the two flanged bronze bearings (Items 22 and 23). The use of nuts, bolts and washers ensure that no strain is placed on the casting. Some may prefer to use Loctite instead. The only remaining task on the base is to attach the pinion bearing plates (Items 2 & 3), but as this cannot be attended to at this stage, place the base on one side.

The saddle only requires a flat area to be machined on the underside at the rear, a 1 1/4in. length over the full width being adequate. Two areas at the rear and front of the ram, on the side opposite the feed screw handle, need to be lightly machined with a 5/8in. end mill. These provide flat surfaces to which are to be bolted the spacer blocks and long slotted bar (Items 17 & 19). 1/4in. Whit. holes in the ram and 1 1/4in. socket head cap screws (or bolts if you prefer) make a firm job; no great precision is required here. This completes work on the castings for the time being, and they can benefit from a little love and affection in the form of a strip, fill and respray if yours, like mine, have got a little scruffy over the years.

I hope that you will see from the photographs how all the parts fit together

The new components

All parts to be made from mild steel except where different materials are specified on the drawings or text. Most are straightforward to produce, but one or two of them may require some explanation. The long pinion (Item 1) needs to be machined with the aid of a dividing head of some description and support at the outer end. Before committing cutter to metal, run a dial indicator over the length to ensure that the blank is set parallel to the travel of the milling table. De-burr the end where the teeth run out, otherwise the flanges of the bronze bearings pressed into their plates will suffer. I have specified a length of 7 3/4in., but please check on your machine as this will depend on the amount of metal you had to remove from the sides to get a satisfactory surface; adjust if necessary. Do not be tempted to fit the pinion bearing plates to the base at this stage as you will need the shorter gear and its housing bolted to the underside of the saddle, replaced temporarily on the base to effect a satisfactory meshing. At this stage you can spot through the plate holes provided, tap 2BA and screw to the base.

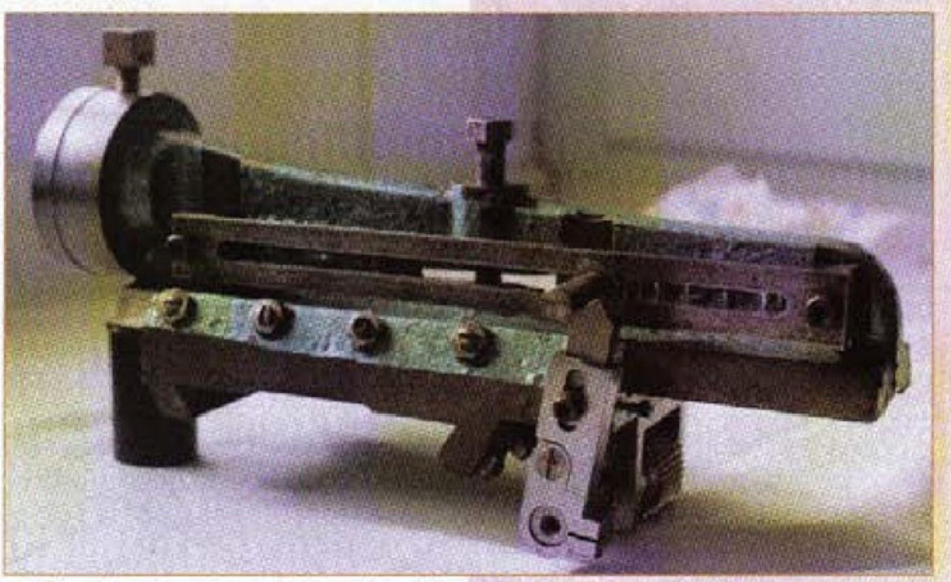
While the dividing head is set up, now is a good time to cut the short gear which is straightforward and requires no comment. There is, however, a good deal of metal to remove in the making of its housing (Item 8) and you may prefer, as I did, to get rid of the bulk of it with saw and drill, leaving only light cuts to clean up the inner surfaces. Alternatively, it would be acceptable to fabricate the component from three pieces of steel, either screwed or welded together. In either way, a sufficiently robust result should be achievable. The two slots allow some movement on the saddle to obtain a nice fit between the two gears. You can now clamp the housing level with the rear face of the saddle, equidistant from both sides, and drill holes half way along the slots, right through, 4BA clearance size. Turn the saddle over and counterbore these holes to accept the heads of the fixing screws, making sure that they will not interfere with the ram at all. The nut plate, Item 8b is fiddly to fit, and you might find it easier if you increase it's width to 1in. instead of the 1/2in. shown on the drawings. In any event, ensure that, when fastened up tight, the screws do not protrude through the nut far enough to hit the pinion. The gear spindle (Item 9) can conveniently be made 1/8in. longer, the 1/4in. hole and adjacent grub screw being there to accommodate a 'limit pin' which prevents overtravel of the mechanism on the return stroke when under spring tension.

The striker lever assembly (Items 11, 12, & 13) is provided with a one-way hinge, allowing the 'striker pin' attached to the ram to freewheel back past it should it, through incorrect adjustment of Item 13, get behind the lever on the back stroke. Screw 11a can be case hardened to minimise wear if you wish, though I personally have not found it necessary.

Moving on, you need at this stage to decide whether you wish to make a new feed screw, friction dial and handle. If you are happy with the existing arrangement you can simply graft a 3/8in. diameter extension onto the end of your existing screw to allow the ratchet housing to be fitted. The handle and dial shown (Items 15 & 16) most certainly enhance the appearance of the machine and enable far more precise movements to be made. The new handle provides additional leverage which is welcome, as the fit of the saddle should always be on the tight side to prevent lift here, which is often mis-diagnosed as slackness in the ram slide. Do not, however, be tempted to increase it's size beyond that shown on the drawings, otherwise it will foul the ram operating lever unless you raise the lever as mentioned earlier.

The ratchet wheel, Item 20, is simply made, the 40 teeth being square cut to a depth of 0.093in. with a 0.062in. slitting saw. The undercut on the 5/8in. side enables a nice close fit against the ratchet body. As the ratchet wheel has 40 teeth, each one, as it is connected to a 10 tpi feed screw, moves the saddle across 0.0025in. The number of teeth the ratchet pawl can cover on each stroke can be varied from 1 to 4 by sliding the nut, (Item 6) closer to or further away from the axis of the long pinion; closer reduces the number of teeth and I chose to calibrate Item 5. A little experiment will reveal where the marks should be placed.

4. The saddle and ram assembly, fitted with the gear in its housing and the operating lever assembly



5. The self-act components. Rotation of the long pinion causes the link to operate the ratchet wheel which is attached to the feed screw

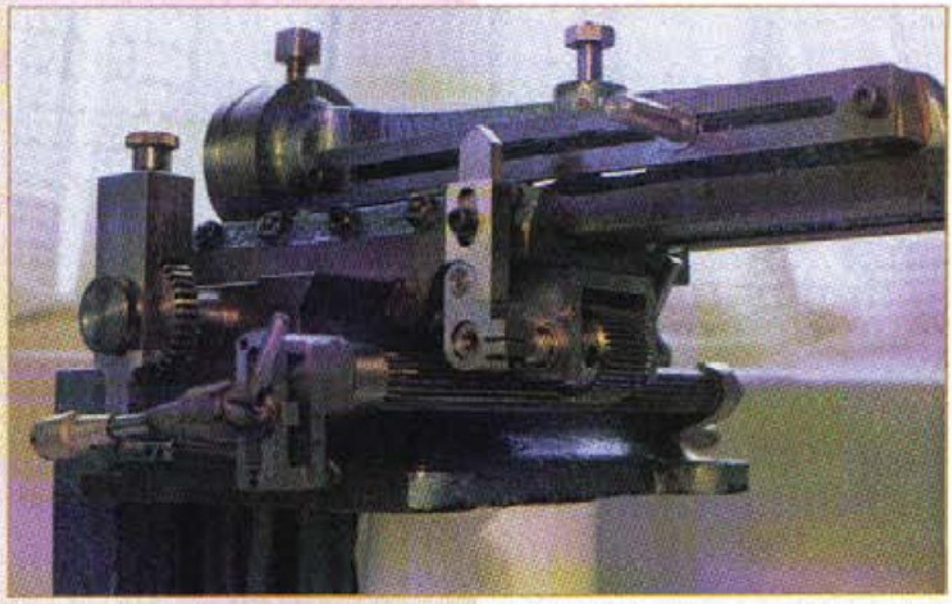
The 0.062in. wide slot in the top of the ratchet pawl housing body (Item 21) accommodates the locating pin 21d and allows the pawl 21b to be reversed, thus reversing the movement of the lead screw. Do please make sure that you drill the hole in the pawl at right angles to the pawl face. When placed across the slot rather than in it, the pin prevents the pawl from engaging with the wheel and enables the feed screw to be freely operated in either direction by means of the handle. The pawl can either be case hardened or made from silver steel, hardened and tempered down to dark straw. No details of the knob 21c are given as dimensions are unimportant; just make it comfortable to hold and in reasonable proportion, as seen in the photos.

The matching tapers on the feed screw and ball handle are not given in degrees. I find the easiest way is to cut the male taper first, and then, without disturbing the top slide setting, cut a similar taper on a short length of silver steel which can then be converted into a 'D'-bit, enabling the female taper to be successfully made without any guess work.

Item 22 is only required in full if the new handle and dial are being fitted, otherwise just press the phosphor bronze section into the original feed screw hole, now enlarged to 3/4in. If you are fitting both parts of Item 22, press them together first before fitting to the casting. The 1/4in. wide steel outer rim should be scribed with a fiducial line, preferably the same width as those made on the dial for appearances sake. Dial making has been described many times and I won't bore you by repeating the procedure here. Suffice it to say that the friction is provided by a silicone 'O'-ring squashed between the dial and handle, the shallow recess in the dial being progressively deepened until the desired amount of friction is achieved.

Assembly

With all the parts made and the sub assemblies working smoothly, final assembly can be carried out. First fit the saddle to the base with the gib strip tightened to provide a fairly stiff degree of movement. The feed screw nut can be fitted, followed by the feed screw itself and the ratchet assembly at the end. Adjust endfloat to a working minimum with the knurled screw (Item 14a) before tightening the ratchet pinion grub screw onto its flat on the feed screw. Fit the long pinion to



6. A view of the new components in their assembled location

the base with its two plates, following which the shorter gear, in its housing, can be loosely bolted to the underside of the rear of the saddle and adjusted with the aid of the two slots to mesh the two gears nicely over their entire width before finally tightening the screws. Fit the two lever assemblies to their respective shafts and connect the stroke lever to the ratchet housing with the link (Item 7). Once again I have not given details of this part as I used a pair of automobile throttle ball joints, obtained from our much-missed friend Whistons, years ago, as one of those 'might come in handy one day' purchases. If, like me, you were a regular customer of this former Alladins Cave, your workshop will bristle with useful bits and pieces, bought without any particular purpose in mind. The problem is that inevitably you forget what is where, and a very pleasant afternoon can be spent re-discovering things you forgot you had! My ball joints have threads on the ball extensions of $^1/_4$in. BSF to match nut 6 and Item 21, the two ends being connected with a length of $^3/_{16}$in. dia. steel, threaded both ends 2BA to provide some adjustment of length. Returning to the assembly, with the limit pin hard against the rear of the saddle, clamp both levers in the vertical position, place the striker pin half way along its slotted bar, and adjust Item 13 so that they will contact each other on the ram back stroke, then watch the feed screw revolve. The spring used to return the mechanism is stretched between Item 4 (using the 2BA hole for a short screw), and Item 3B. It should be strong enough to operate the feed screw in either direction, tension being adjusted by locating the anchor screw in an alternative hole in Item 3B.

This completes the modification. Don't forget to lubricate all moving or rubbing parts. As the steel parts will be bright, or even shiny if you like them that way, keep them in this condition by spraying with 'Duck Oil', produced by the Deb Group, or try the quick tip of silicone furniture polish which a gentleman advocated a few issues ago and which I have found most effective. Although my Adept has now been joined by a bigger brother in the form of an Alba 1a, I use it frequently, as hand operation avoids those heart-in-mouth moments when letting the clutch in on a motorised machine, and hoping that you've remembered to make sure that nothing will hit anything it shouldn't!

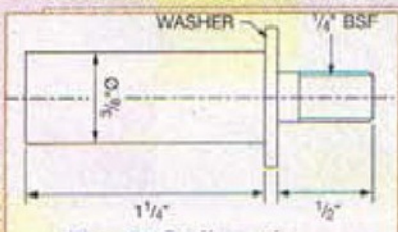


Fig. 18 Striker pin

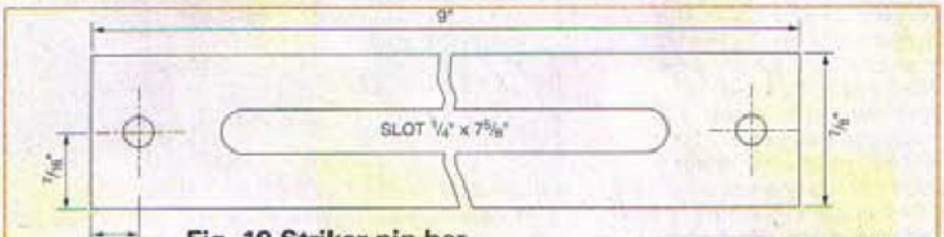


Fig. 19 Striker pin bar

Fig. 21 Ratchet pawl housing, pawl assembly & spring

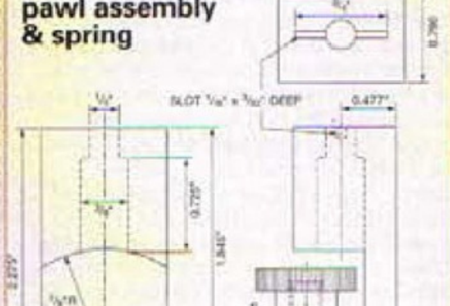
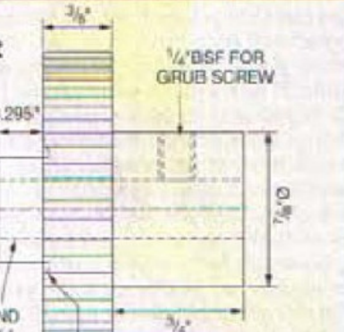


Fig. 20 Ratchet wheel



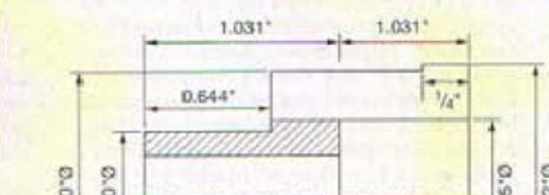


Fig. 22 Bearing

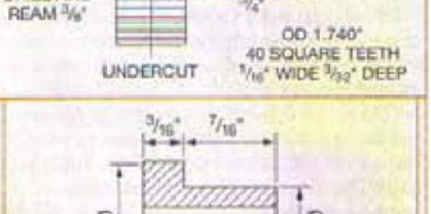


Fig. 23 Bearing

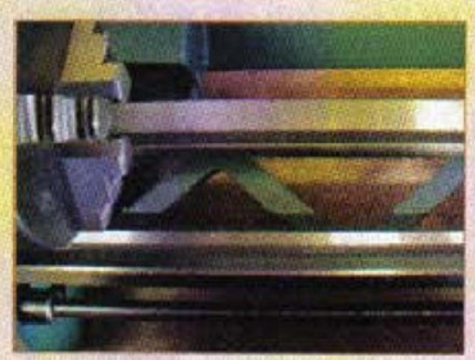
A BRIEF LOOK AT THE WARCO 918 LATHE

Using a lathe in the workshop at Primrose Valley gives visitors an opportunity to see the machine used in anger, although by no means can it be viewed as a comprehensive evaluation. Mike Chrisp was presented with a series of jobs which involved plain turning and boring, some threading from the tailstock and a little milling, the workpiece being held in the toolpost. On these tasks it performed admirably, giving the impression of a workman-like machine, providing excellent value for money. The following photographs illustrate some of the features

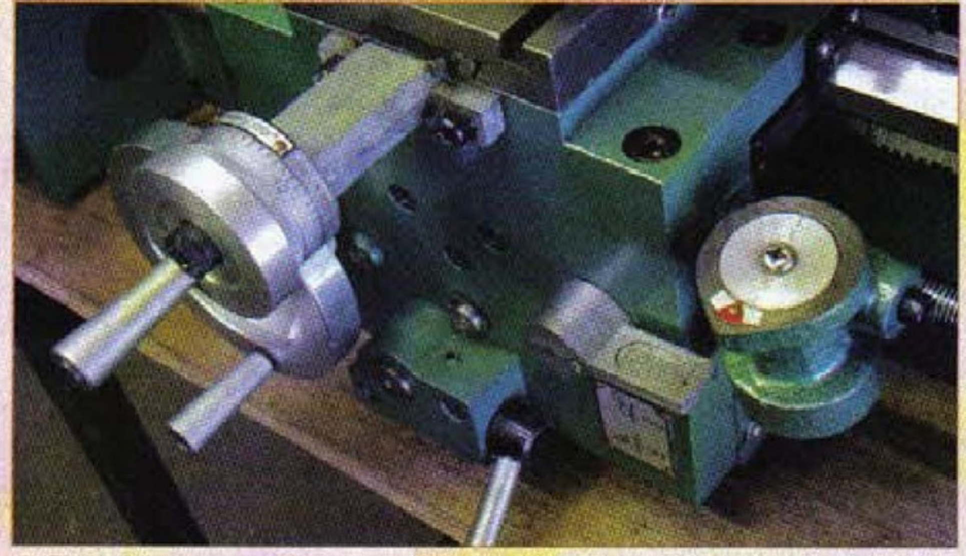
1. The Warco 918 lathe removed from its box and cleaned of its protective coatings stands ready for use.

2. The 918 is supplied with an integral screw-cutting gearbox and a four-tool turret.

3. Headstock spindle drive is either direct from the motor pulley or via the countershaft. The leadscrew gearbox is driven by the train of gears to the right.



4. The bed shears are braced by diagonal webs.



5. The saddle is traversed by means of the handwheel (lower left) and leadscrew drive is engaged by lifting the lever. The threading indicator is fitted as standard.

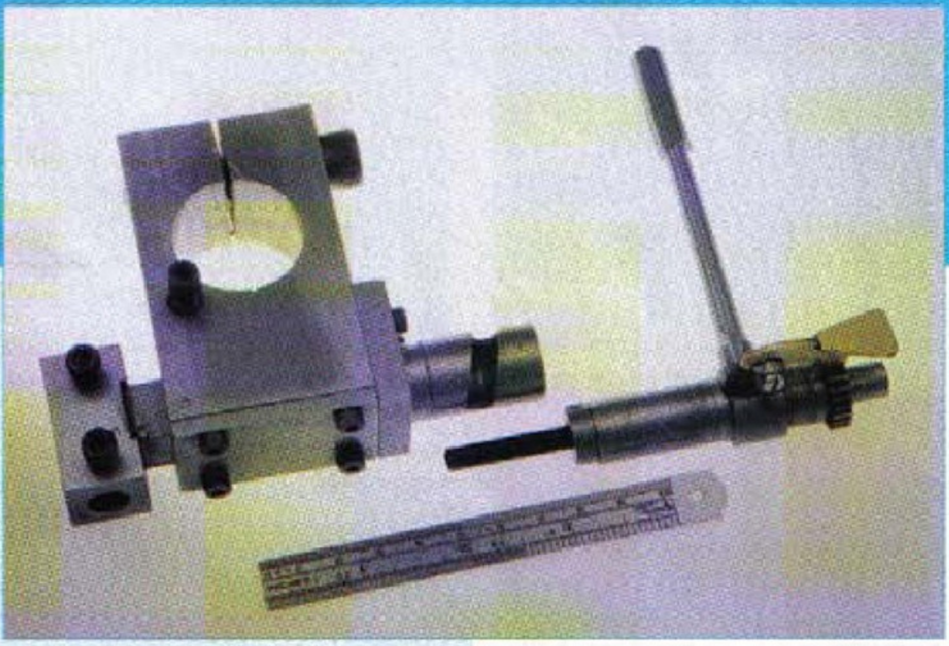
Supplier:- Warco, Fisher Lane, Chiddingfold, Surrey GU8 4TD Tel. 01428 682929 Fax. 01428 685870/686812 E-mail: warco@warco.co.uk Web site: www.warco.co.uk

6. The topslide swivel is graduated clearly.

7. The substantial tailstock is secured to the bed by a central clamping bolt.

8. In addition to the travelling steady, standard equipment includes 3- and 4-jaw chucks, a faceplate and a fixed steady.

A QUICK-CHANGE SCREWCUTTING AND BORING TOOL POST



1. The two main sub-assemblies (2 and 3) of the system

John Chambers describes a lathe tool holding system which incorporates a controlled incremental tool movement device and a rapid retraction feature

The tool post described in this article is an extension to those published in Issue No 65 by John Brittain in his article "Avoiding the use of packing". The General Arrangement Drawing **(Figure 1)** illustrates the relationship of the component parts and, when viewed in conjunction with the photos, should make its function clear.

My workshop equipment consists of machines with either Imperial or metric graduations, so I mentally adjust to which equipment is being worked on. In this case the lathe is Imperial, so the tool holder to be described here is for Imperial increments. By using an alternative screw thread and spur gear combination, metric increments can be achieved, details of which are included at the end of the article. The text refers to the items as numbered in the Parts List, these being shown in bold type.

Materials and fastenings are now more readily available in metric, so stock metric sizes have been used, or sizes which a model engineer would have in the workshop. This, of course, does not preclude other sizes being used - just use what is available and adjust sizes to suit. It is the overall idea that is important.

It should be noted that the material sizes shown on the drawings will require an allowance to be added for machining stock sizes to length

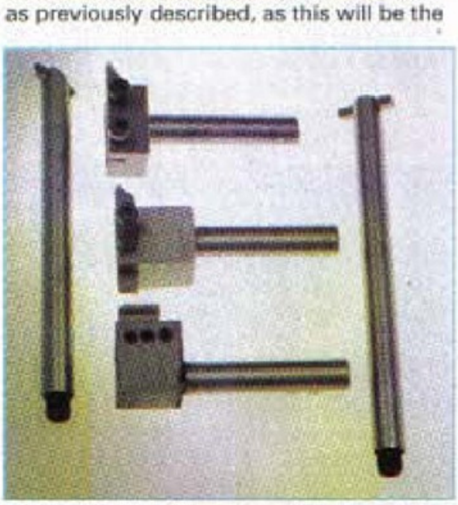
Machining the components

The heart of the tool is the precision fit of the sliding member within the body, hence the first item to be produced is the **Slide Assembly [Item 2]**, the final finish being more important than size. Part C is chucked true in a 4-jaw chuck, faced and centre drilled, then the tapping size (5.60mm) is drilled a minimum of 30mm deep for the 1/4in. x 40 tpi ME thread being used. Tap the hole, guiding the tap in from the tailstock. The other end is chucked true, faced to length, centre drilled, and drilled 7.0mm to break into the tapping hole, leaving 25mm of thread. This will allow the Micrometer Spindle free travel past the end of the thread into the tapped hole and reduce the volume of metal to be heated when silver soldering. An identification mark is stamped at one end to ensure repeatable assembly notation during hand fitting and assembly (The figure '5' can just be seen in the photographs). All four sides are now lapped to remove surface blemishes. This lapping is carried out using 600 grade wet and dry paper, with white spirit as the lubricant, on a piece of plate glass.

Part 'D' is chucked true in a 4-jaw chuck, faced, centre drilled, drilled, and reamed 10mm. The other end is chucked true and faced to length, then the two M5 holes marked out, drilled and tapped. The milled slot is now machined to provide a location when silver soldering the assembly.

Both parts are cleaned, de-greased, and fluxed up, and with health and safety precautions being observed, the soldering operation is carried out. After allowing to cool naturally and removing any flux residue, the tarnishing due to silver soldering should be removed.

Side Plate [Item 13]. Machine the ends square and to size and stamp an identification mark on outside face. Accurately drill the four 4mm holes and de-burr them (a suggested set-up is described later in the article). Lap the unmarked surface to remove blemishes, as previously described, as this will be the



2. Tool holders for external single point tools, chasers and boring bars inner bearing surface. This part will be used later as a drill jig for the corresponding holes to be tapped in the Body.

Body [Item 3]. Square up the ends of the block to size and stamp an identification mark. Line up and clamp the Side Plate [13] to the Body, ensuring that the identification marks line up on both items, then spot through. Drill and tap the four M4 holes from the spots, then mark out for the 16mm square slot. Mill the slot just under size so that, by hand finishing the slot using marking blue, the sliding member is made a precision fit in the Body.

Assemble the Side Plate [13], Slide Assembly [2], and Body [3] using the four M4 Screws [14] and complete the hand finishing with the side plate secured in position. Remove the parts and place to one side, then the other machining operations can be completed with the exception of the two M4 holes for the Cam Bracket [6], which will be spotted from this item later. The boring of the 32mm dia. tool clamping hole can be carried out either in a 4-jaw chuck or as a face plate operation. This hole must suit the lathe tool post location boss. Standard workshop practice would require the face plate set-up to be balanced.

Cam Bracket Assembly [Item 6]. Square up the ends of the material for part 'A' to size, then mark out to allow it to be set up in the 4-jaw chuck, true to the centre of the marked out hole, for drilling and boring the 16mm hole and the 20mm counterbore. Drill the two 4mm holes.

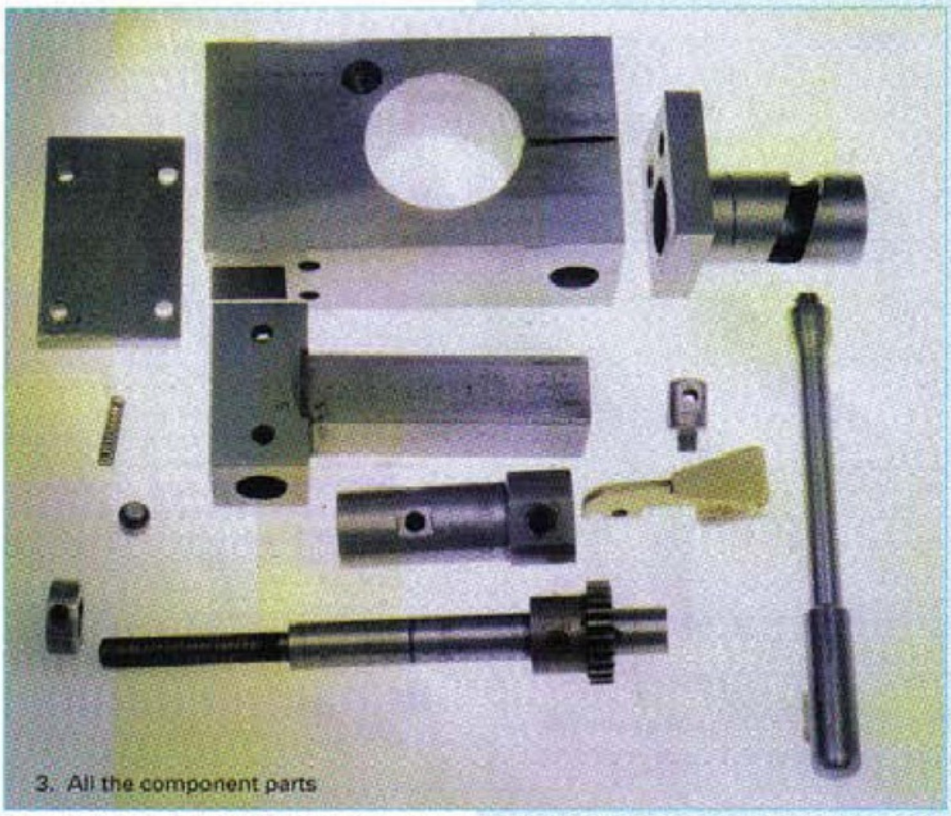
If using 20mm stock material for part 'B', set up accurately in the 4-jaw chuck to bore the 16mm hole to size, then face the ends. Clean and degrease both parts, flux up and silver solder, allow to cool naturally and clean up the joint.

Mark out for the Cam Slot, then drill two 6mm holes at 90 deg., thus determining the ends and throw of the cam. Using hack saw and files, carefully remove the waste material to produce a parallel slot, this being more important than the size as the head of the Cam Screw [7] is turned to suit the slot.

Micrometer Spindle [Item 5]. Face ends to length and chuck to run true (this is very important) in order to reduce a 40mm section to 0.250in. diameter. Using a sliding tail-stock die holder, cut the 40 tpi ME thread using plenty of cutting oil to produce a good quality thread which must run true. When cutting threads of this nature I rotate the head-stock spindle with a hand crank lever, with the power supply turned off. Laborious, but it works for me.

Screwed Bush [Item16]. Chuck in the 3-jaw, face the end and turn the O/D to 15mm, then drill and tap the 1/4in. x 40 tpi ME thread, making sure that it is concentric. Part off to length. Mark out and produce the M3 grub screw hole.

Cam Sleeve [Item 8]. A straightforward turning operation, the 16mm diameter needing to be a good sliding fit in the Cam Bracket assembly [6]. File or machine two flats at 90 Deg. to allow the shoulders of the Pawl Bracket [11] and Handle [19] to



3. All the component parts

seat squarely. A further small flat is also required for the Cam Screw. Mark out the positions for the Handle, Pawl Bracket, Cam Screw [7] and spring pockets, drilling and tapping to complete. Ensure that the hole for the Cam Screw is in line with the Handle hole.

Cam Screw [Item 7]. Turn down the head of a M4 Cap Screw to match the cam slot and reduce the thread length to suit the Cam Sleeve [8] wall thickness.

Handle [Item 19]. Another simple turning job, made to any preferred shape and length, with M5 thread. Some weight is required at the outer end in order to maintain the handle at the end of its slot.

Pawl Bracket [Item 11]. Again a simple job, the slot width being made to suit the Pawl Assembly [12]. See the notes below regarding Imperial or metric increments.

Pawl Assembly [Item 12]. This item consists of two pieces of brass strip, filed to shape and silver soldered together. Make to any preferred shape and drill for the pivot hole. The area which engages in the steel Spur Gear should be filed to fit the tooth profile, with clearance at the bottom of the tooth space. Hence the use of brass - also see note as for Item 11.

Imperial or metric increments?

The Spur Gear is used as an indexing device to advance the tool by a known constant. A 25 tooth gear with a 40 tpi screw thread produces a movement of 0.001in. per tooth. A 40 tooth gear with a 1.0mm pitch screw [M8] produces a movement of 0.02mm. Many other increments are possible by using different combinations of thread pitches and numbers of teeth, the use of other DP or Module gears being quite acceptable. It is well worth the effort of looking around to find a gear which can be adapted to provide an acceptable incremental movement, but the end portion of the Micrometer Spindle may require modification to accept the selected gear. S H Muffett, a well known stockist, can supply any gears required, but they apply a minimum order charge, so it would be worth purchasing gears for any other project requiring them at the same time.

Standard items required

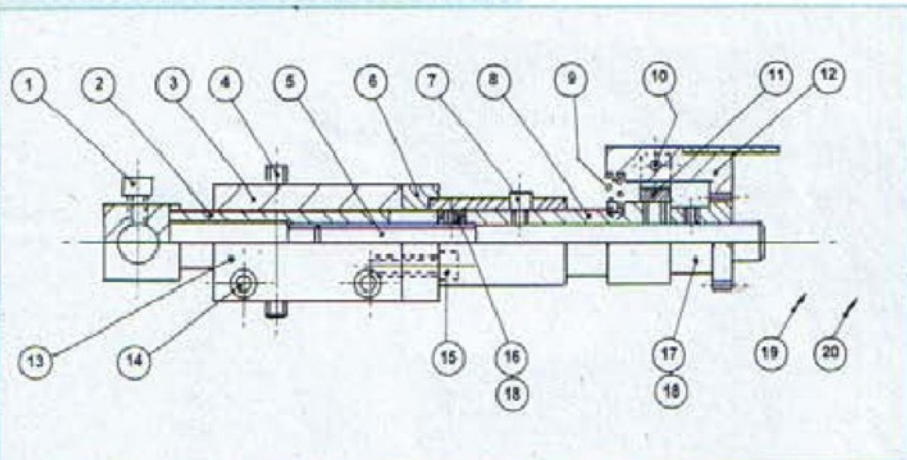
Item [1]	Qty 2	M5 x10 socket cap screws
Item [4]	Qty 2	M8 x 40 socket grub screws
Item [7]	Qty 1	M4 socket cap screw x 6 long
Item [9]	Qty 1	Compression spring
Item [10]	Qty 1	M3 Cheese Head Screw x10 long
Item [14]	Qty 4	M4 socket cap screws x 10 long
Item [15]	Qty 2	M4 socket cap screws x10 long
Item [17]	Qty 1	25 tooth 32 DP spur gear (or alternative)
Item [18]	Qty 2	M3 x 3 long socket grub screws

Final assembly

Prior to final assembly, all parts should be cleaned and lightly lubricated.

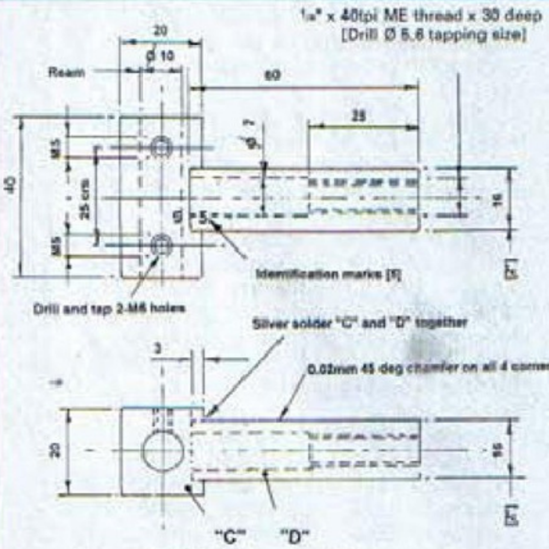
Assembly 1

Thread the Screwed Bush onto the Micrometer Spindle to within about two threads of the shoulder, pass this assembly through the Cam Sleeve and position and secure the Spur Gear onto the other end. Adjust the Screwed Bush to



Item No	Qty	Description	Item No	Qty	Description	Item No	Qty	Description
1	2	Securing Screws [Tools]	8	1	Cam Sleeve	15	2	Securing Screws [Cam Bkt]
2	1	Slide Assembly	9	1	Spring	16	1	Screwed Bush
3	1	Body	10	1	Pawl Pivot	17	1	Spur Gear
4	1	Jacking Screw	11	1	Pivot Bracket	18	2	Grub Screw
5	1	Micrometer Spindle	12	1	Pawl Assembly	19	1	Handle [not shown]
6	1	Cam Bracket Assembly	13	1	Side Plate	20	1	Clamp bolt [not shown]
7	1	Cam Screw	14	4	Securing Screws [Side Plt]			

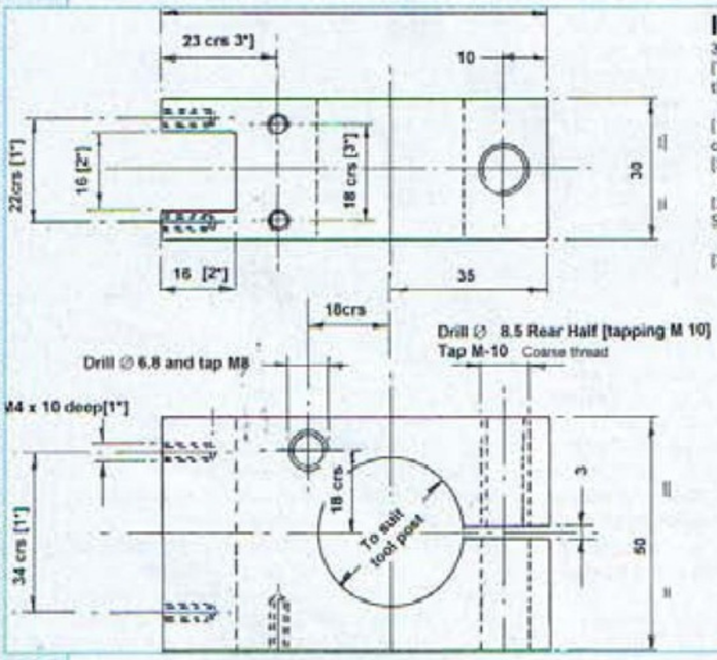
Fig. 1 Section through assembly



Item 2 Slide Assembly

C 20x20x40 BDMS
D 16x16x60 BDMS [2*]
Stamp identification mark
Lap the 4 sides to remove all surface blemishes prior to sliver soldering.
[2*] After lapping this determines the size of he hand finished 16 mm sq. milled slot in Main Body.

All dimensions in mm except thread size.



Item 3 Body Qty 1

30 x 50 x 85 BDMS
[To suit individual lathe. These sizes differ from those in article by J Brittain issue No65]

[1*] Accurate drilling required to ensure that O/D of Cap Hd. Screws lie below top/bottom surfaces. [Spot through from item 10 Side Bearing Member]

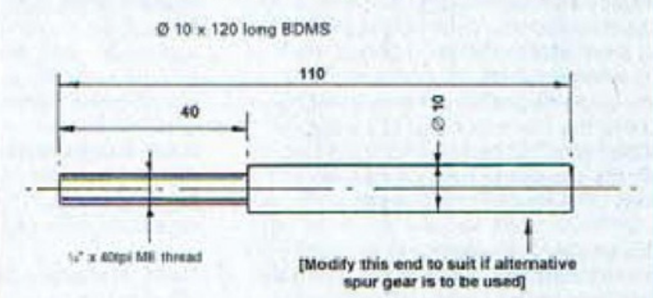
[2*] Hand finish square slot to suit item 2 Main Slide Assy

[3*] Spot through from item 6 Cam Bracket

©

Item 5 Micrometer spindle Qty 1

Ø 10 x 120 long BDMS



give minimum end play and secure this with its Grub Screw, which must be flush or below the outside diameter.

Assembly 2 To Assembly 1

Assemble to the Cam Sleeve, Handle, Pivot Bracket, Pawl, Pawl Pivot and Spring.

Assembly 3

Assemble to the Body, the Side Plate, Cam Bracket, and Slide. Secure with their respective screws. Screw in the Jacking and Clamp Bolt screw.

Assembly 4 to Assembly 3

Slide Assembly 2 into position and screw the Micrometer Screw into the Slide for about 15mm. The Cam Screw can now be fitted through the cam slot and secured. The unit should now be checked for correct operation.

The Micrometer Screw can now be screwed in further, so as to give maximum screw thread engagement and reduce the overhang of the Slide in the Body, whilst still achieving full travel of the Cam Screw within the cam slot.

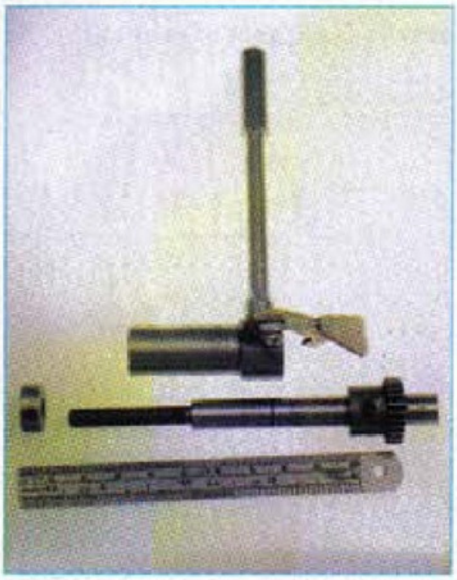
Tool holders

Four are shown as suggestions, but others can be added to the range as required. Interchangeable square HSS tool bits are used for the boring bars and are ground to suit the thread forms to be cut. Old chaser bits from Coventry die heads can be re sharpened and can usually be obtained from tool suppliers attending national and regional model engineering exhibitions.

In order of likely frequency of use, I suggest:-

1. **A single point external tool holder.** These can be fabricated as per the drawing or solid to accept 1/4in. or 3/16in. square tool bits. Two holders would be ideal, one permanently set up for metric and one for Imperial (60 and 55 degree respectively).

2. **Chaser holder.** The rectangular block is machined complete prior to silver soldering. The width of the slot is made to suit the thickness of the chasers you have.



4. The major components of the cam sleeve/mocrometer spindle assembly (Assembly 2)

Check the position of the 10mm dia. shank to ensure that the chaser will cut on centre with the aid of the jacking screw.

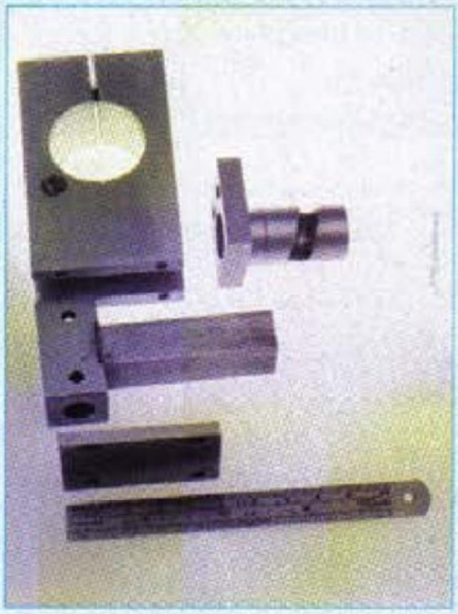
3. Boring/counterboring bar and 4. Internal screw cutting bar. The drawings are self explanatory, using a push bar and screw to secure the tool. Note that only moderate pressure is required to secure the 1/8in. square tool bits.

The above tool holders will require only standard stock screws for securing the tooling

Precision drilling

Figure 2 shows a method I use to achieve rapid and precise location of hole positions. It is quite simple and easy to set up and with care, very accurate and is well worth the time in making the 90 degree location nest, from approximately 3mm thick material. Alternatively, those with milling machines will be familiar with the method of using a centre/edge finder to determine a datum position then, using the table feed screws and graduated dials, centre drilling at the required 'X' and 'Y' positions. The holes may be opened up to the required size in a drilling machine afterwards.

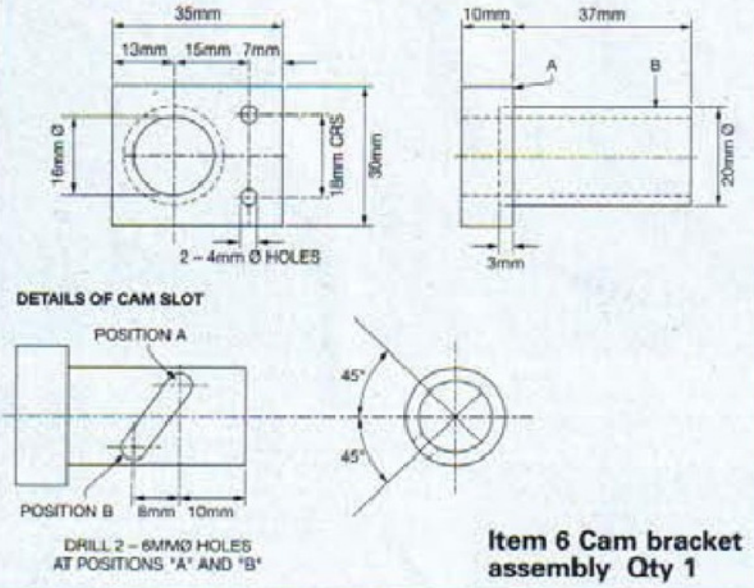
All photographs taken by I.C.A. Chapel Studios Ambergate Derbyshire.



5. The components of the body assembly (Assembly 3)

Supplier:- S. H. Muffett Ltd., 14 - 18 Woodbury Park Road, Tunbridge Wells TN4 9NH Tel. 01892 542111 Fax. 01892 542117 E-mail: sales@muffett.co.uk

A 10mm x 30mm x 35mm BDMS
B 20mm x 37mm BDMS
SILVER SOLDER 'A' AND 'B' TOGETHER
CAM SLOT IS CUT AFTER SILVER SOLDERED ASSEMBLY



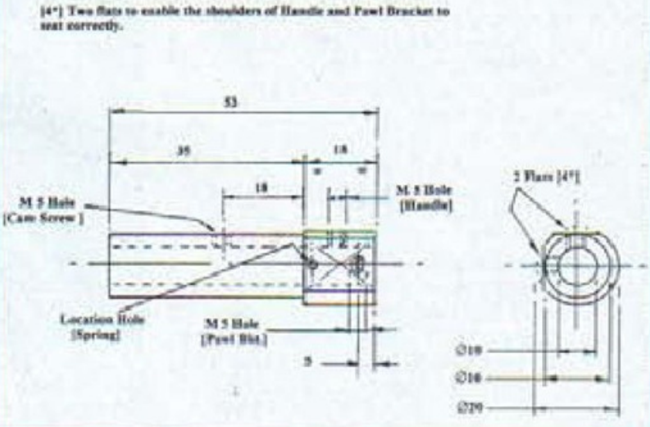
Item 6 Cam bracket assembly Qty 1

Item 8 Cam sleeve Qty 1

Ø 20 x 53 BDMS long

Handle position is shown to the right of Pawl Assy. Could be drilled at 180 Deg. to position shown if left hand is required.

[4°] Two flats to enable the shoulders of Handle and Pawl Bracket to seat correctly.



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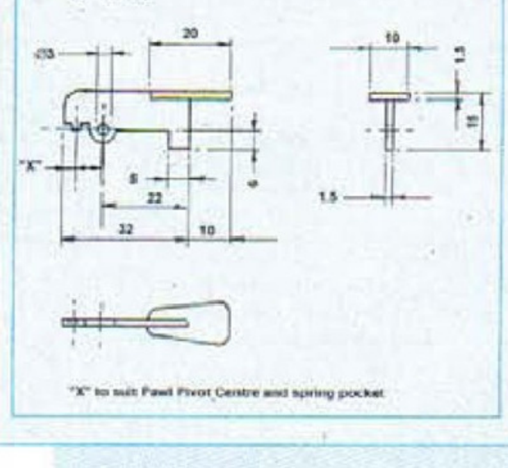
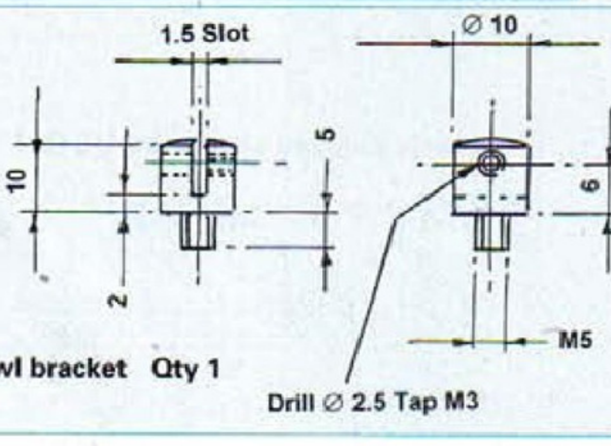
Item 12 Pawl assembly Qty 1

1.5 Brass Strip
A 10 x 20
B 15 x 32



"X" to suit Pawl Pivot Centre and spring pocket



Item 11 Pawl bracket Qty 1

Ø 10 BDMS

Drill Ø 2.5 Tap M3

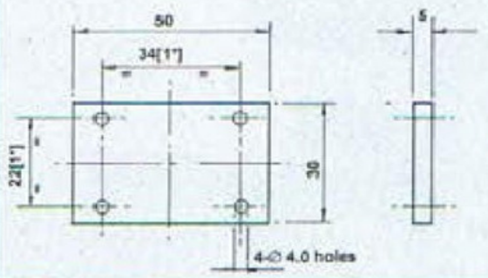
Item 13 Side plate Qty 1

5 x 50 x 30 BDMS

[To suit individual lathe. These sizes differ from those in the article by J Brittain issue No 65.]

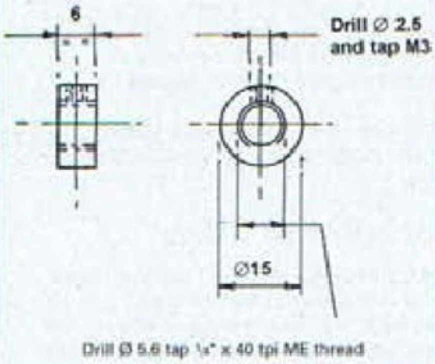
[1"] Accurate drilling required to ensure that O/D of Cap Hd. Screws lie below top/ bottom surfaces.
[Spot through from Side Plate [13]].

All dimensions in mm



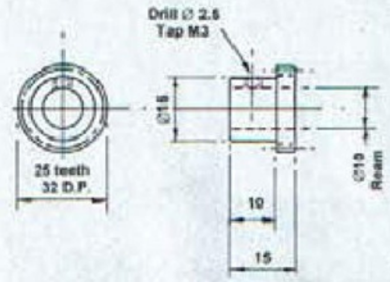
Item 16 Screwed bush Qty 1

Ø 16 BDMS



Item 17 Spur gear Qty 1

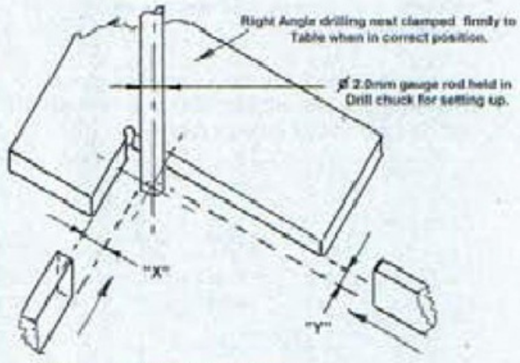
25 Tooth 32 DP Mild Steel.
[See text for alternatives]



©

Fig 2. Set-up for accurate drilling

1 Component to have all edges completely de-burred.
2 Clamp the work piece firmly into the corner of the drill nest.
3 All swarf to be removed from the nest location between each drilling operation.

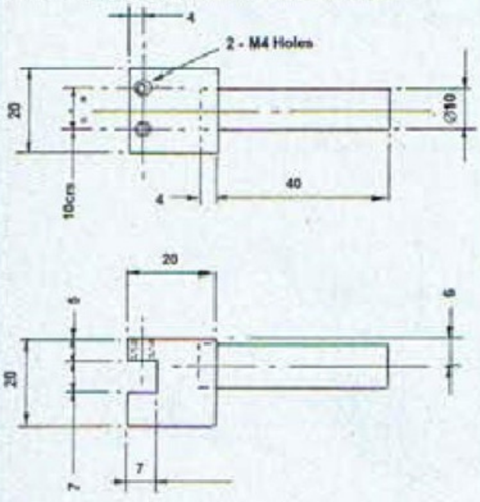


Gauge pieces "X" and "Y" to be 1.0mm less Than the centre distance required.

Single point external tool holder

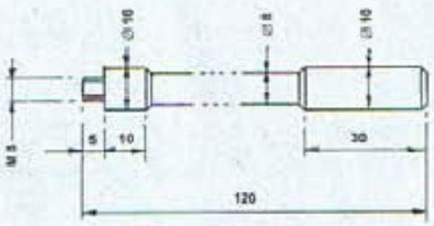
20 x 20 x 20 BDMS 1 off
Ø 10 BDMS x 44 long 1 off
M4 Socket Grub Screws Qty 2
Silver solder parts together

1/8" or 1/4" Sq tool bits ground to suit thread angle



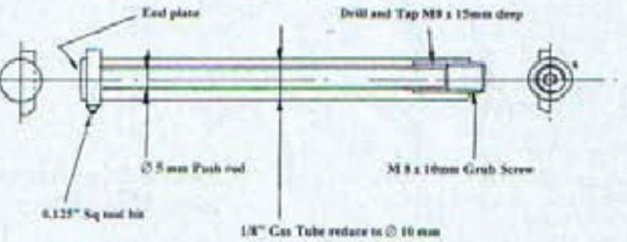
Item 19 Handle Qty 1

Ø 10 x 120 long BDMS



Internal threading tool holder [90 Deg]

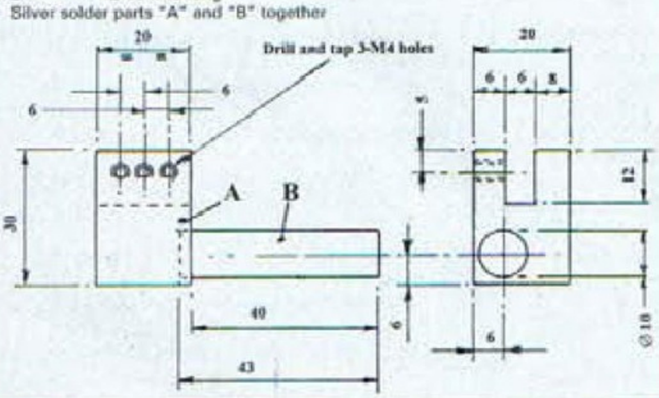
1/8" Dia. Steel Gas Pipe x 100 long
1.0mm Steel Strip to suit
Ø 5mm BDMS x 95 long
M8 x 10 Scoket Grub Screw



[1] Cut 0.125" Square Slot in end of tube prior to Silver Soldering End Plate to Tube.
[2] File End Plate to Shape after Soldering

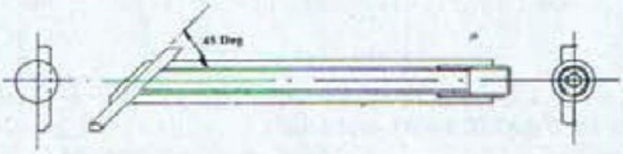
Tool holder for chasers

A 30 x 20 x 20 BDM
B Ø 10 x 43 long
Silver solder parts "A" and "B" together



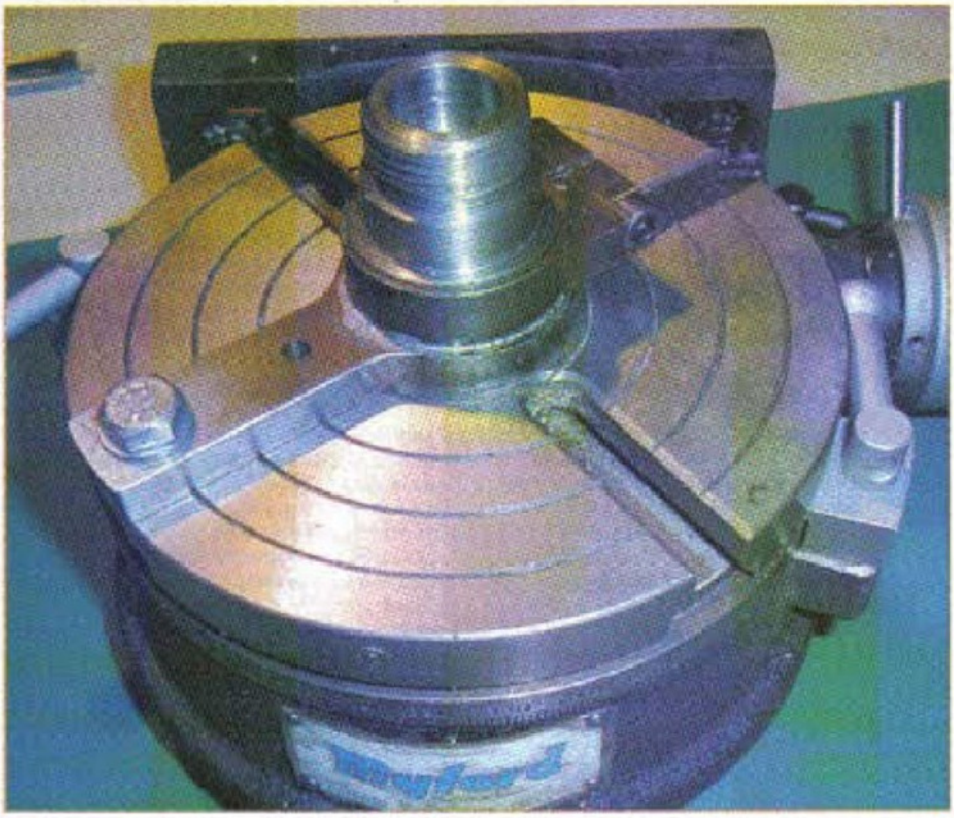
Internal boring and coutner boring tool [45 Deg]

Materials as for Internal Trheading Tool Holder above.
File end of push bar to 45 Deg to suit tool angle slot.



AN ADAPTER FOR THE ROTARY TABLE

John Garnish suggests an alternative solution to the problem addressed by David Oxley in M.E.W. Issue No. 72 (March/April 2001)



My rotary table is Myford-badged but is, in fact, identical to the Vertex unit described by David Oxley. The adapter which I devised can be seen in the three accompanying photos, which are more or less self-explanatory. The key component is an item which many people will already possess, but I made mine from a piece of 2in. bar, bored and Loctited to a No. 2 Morse taper arbor. This was then turned to provide a threaded nose and register, to take the lathe chuck (Myford in my case, but the principle would apply generally). Placing this component into the rotary table ensures that the lathe chuck remains concentric with the axis of the table. The flats milled on the collar are a refinement to assist with extraction of the taper from the sleeve.

The component is prevented from rotating with respect to the table by a split clamp with an extended arm bolted down to a 'T'-nut. Although a second arm might be desirable, I find in practice that this single arm is sufficient - in conjunction with the weight of the chuck - to resist any lifting forces during milling.

This arrangement allows me to transfer the work directly from lathe to rotary table without losing alignment, and also allows the use of a larger 4-jaw chuck or even a face-plate without interfering with any of the table clamps or controls. The absence of a draw bar or hold-down bolt also means that the item can be mounted and dismounted without requiring access to the underside of the rotary table.

To round off by pointing out the blindingly obvious, an adapter like this has many other uses. for example, it can be used to hold a chuck or faceplate in the tailstock or, if the taper is tapped for a draw bar, to hold a boring head on the milling machine.

ELECTRO-MAGNETIC DEVICES - Part 9

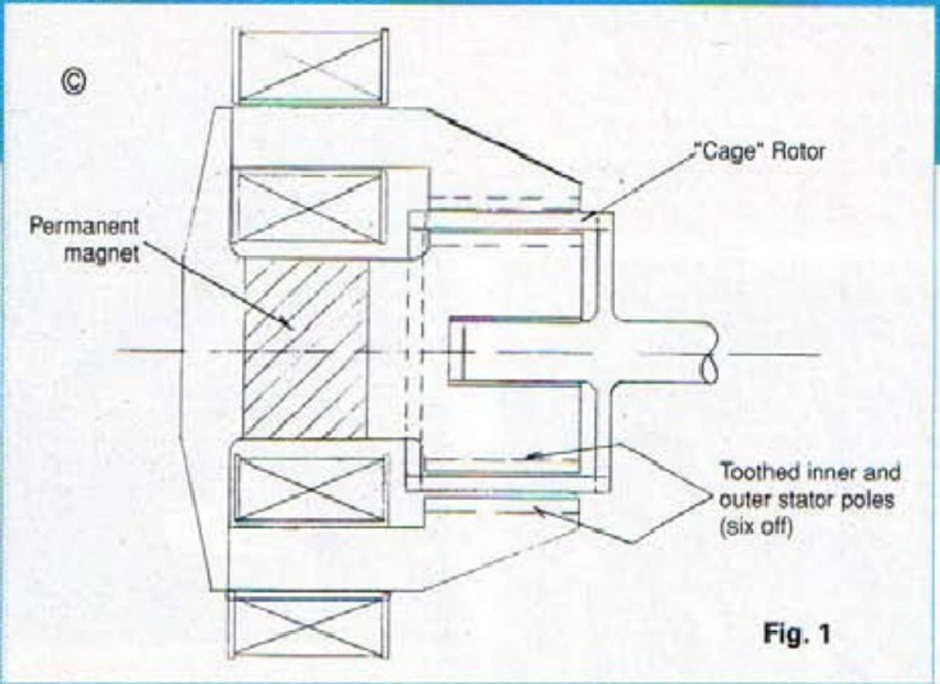


Fig. 1

Tony Claridge now introduces the theory of stepper motors and the like

In the last article we explained the principle of the vernier motor. You will recall that in this kind of machine the rotor revolves so as to keep the low reluctance parts of the field in step with the rotating field generated by the stator windings and the currents in them, but this is achieved with the rotor going round much more slowly than the field produced by the stator. This is the vernier effect which gives the motor its name.

Now you may recall that in an earlier article we learned that by adding some extra magnetic field with a permanent magnet we could make a relay which would respond to very small input signals; this is done by exploiting the fact that the physical force developed by any electromagnet is proportional to the square of the strength of the field, and so a small addition to the total field can produce a large increase in the physical force. This effect can be used to improve the output of vernier motors, and it is widely used in industrial stepper motors, which are really vernier motors designed for specific applications. A common arrangement is to effectively build two vernier motors end to end and insert a permanent magnet (magnetised axially) between the two, with the flux path being completed along the outside of the shared outer iron sleeve.

To analyse the working of this kind of motor is perhaps too ambitious for this series of articles but, coincidentally, a useful review of their design and operation is given in Reference 1, which appeared in print earlier this year and if any reader wants to learn more about them, I suggest that you get a copy via your public library. Despite its appearance in a journal for professional electrical engineers, it is not too difficult to understand, and if you have kept up with these articles then you should have no problems with it.

An unusual vernier motor

The addition of a permanent magnet gives the benefit that the rotor can be made to retain some torque when the windings are switched off so that it will not drift to another angular position. However, for some applications this can be a disadvantage and so we shall now look at a motor which gains the performance advantages of including a permanent magnet, but still has negligible residual torque when it is switched off. So far as I am aware, this machine, which I designed a good many years ago, is the only one of its kind. The requirements were unusual. It had to be low in weight and the rotor was to have a minimal moment of inertia. Further, its power consumption was to be minimised; it operated in a hot environment and so cooling of the windings demanded special attention. This made it important to put the windings on the outside of the machine where there was the most scope for the heat which was generated to be radiated, rather than removed by conduction or convection.

To reduce the residual torque to the lowest possible level, the motor exploited the fact that the sum of three sinusoidal variables such as electric currents is zero,

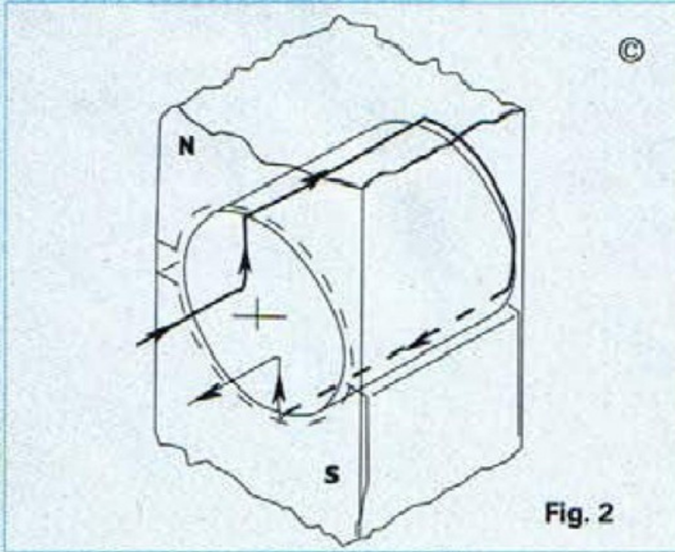
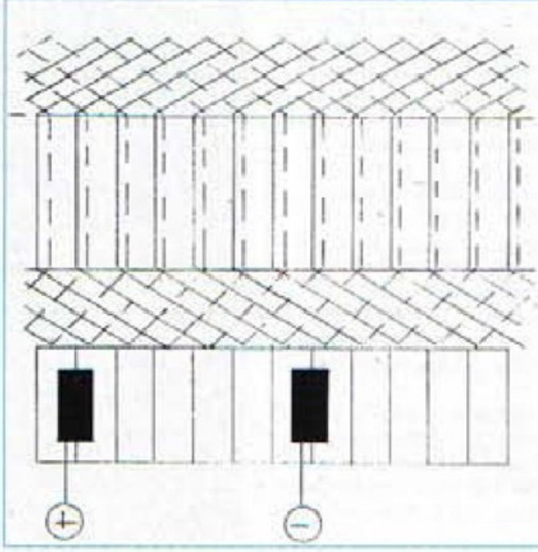


Fig. 2



NOTE: There are two coil sides in each slot. The lower ones (at the bottom of the slot) are shown dotted.
There are two parallel current paths via all the coils, in two circuits, except for the two which are being short-circuited by the brushes while the current is being reversed.

Fig. 3

assuming that the three are equally spaced in phase and have the same value. Expressed mathematically, this is written as:-

$$\sin A + \sin (A + 120^{\circ}) + \sin (A - 120^{\circ}) = 0$$

Now the sets of teeth on each pole of a vernier motor exert a torque when the pole is energised which can be made to vary approximately sinusoidally as the teeth move out of alignment with each other, provided that the two sets of teeth are shaped in a profile which produces this effect. In the motor we are examining, it follows that as the rotor teeth move in and out of alignment on each of the three phases as the rotor moves, the sum of the residual torques due to permanent magnet excitation adds up to something close to zero. Bingo!

The machine's construction is shown in **Figure 1** and to help to understand its features, the following explanation may help. Firstly, the rotor consists of a 'squirrel-cage' of magnetic steel, held together by a welded end ring at one end and a (non-magnetic) disc at the other which serves as an end ring and also attaches to a shaft which runs in a plain bearing in the inner core. There is no winding on the rotor, and clearly this construction has very low inertia. The rotor fits over the stationary core which has teeth on its periphery which mirror those on the outer poles. The vernier action developing torque is thus double sided, the rotor interacting with teeth both inside and outside the rotor cage. The rotor assembly can be described as bell shaped. Not shown is the means by which the rotor assembly is prevented from moving axially. (I've forgotten how it was done!).

Further along the core is an axially magnetised permanent magnet which feeds its MMF and flux to all the toothed sections of the core. At the other end, the magnet abuts a disc which carries the flux outwards to the six wound poles, whose windings are well exposed so that the heat they generate can escape, principally by radiation. Because there is very little structure which does not form an essential part of the magnetic circuit the total weight of the machine is about as low as can be achieved. Even the path length of the magnetic circuit is as short as it can be.

The purpose of describing this unusual machine in so much detail is to show that a radical departure from convention can sometimes be advantageous in the race to "build a better mousetrap". In a more normal application one would never allow the delicate windings to be exposed to possible impact, nor would the expensive machining be justified. This one was for a satellite!

Direct current motors

After this excursion into the oddities of motor construction, we now return to long established DC motor (and generator as well; they are much the same). For many years, DC motors were the only kind which gave a good range of control over speed, and could be started directly on load without danger of blowing the fuses. Of course, a control system was needed to achieve this, but only a very simple one.

We start with a simple description of the principle which underlies the DC motor. **Figure 2** is a diagrammatical representation of a motor. There is a stationary field system, consisting of solid iron poles which form part of a circle in which the rotor is positioned. Each pole has a winding wrapped round it and the magnetic field which is set up when current flows in the pole windings (usually called the 'field coils') can be taken to be proportionate to the current. Figure 2 shows a two-pole machine but the actual number can be up to twenty or more on a large machine. We will come to why a particular number of poles is selected later. For now we use two because this makes it easier to explain how the thing works.

Next we have a rotor (sometimes called the 'armature') on which one coil is shown; the coil can have several turns but we can forget that there can be more than one for our purposes. Because the rotor winding is going to go round we have to have sliding contacts to bring a supply to the rotor coil. Now, going back to something we dealt with early in this series, if we have current in the rotor winding and a magnetic field produced by the field winding, Fleming's Left Hand Rule tells us that the rotor coil, or at least the part which lies on the cylindrical part of the rotor, experiences a force which is tangential. The coil tries to go round. One side pushes to the left, but the other side has both its current and its magnetic field in the opposite direction, so the two sides of the coil both try to go round in the same direction. We have a motor! However, after a quarter of a revolution the coil has moved out of the field and everything comes to a halt.

The answer to this is to wind lots of coils onto the rotor, evenly spaced, and to use the sliding contacts to connect the coils to the supply at the right point in time. Now, since the field poles actually span quite a large part of the rotor periphery, at any instant a sizeable number of them can be connected to the supply at the same time. In fact, only a few are not interacting with the field at any instant; these are in the process of having their connections to the supply reversed. When you think about it, it is obvious that the current in every coil has to be reversed after each half revolution. By this train of logic we have to invent the commutator. This is a synchronous switch which ensures that the current in each coil is reversed at the right point at each half revolution. The construction of the rotor windings is usually something like that shown in **Figure 3**, which is a developed view of the connections and the commutator. There are various ways of configuring the rotor windings, which incidentally are almost always sunk into slots in the rotor; the latter is always laminated to avoid eddy current losses as the field in the iron rotor fluctuates as it goes round. Apart from putting the windings in slots to enable them to be restrained against centrifugal force, the field windings do not have to establish the field across a long air gap.

A small diversion is worth taking here. You will know that well-established rule that nature always offers the most awkward response to man's endeavours? Nature slipped up in this respect when the commutator was devised. To start with, the combination of copper segments and carbon brushes gives good electrical contact, and the oxide which forms on the copper not only has a low coefficient of friction, but is also electrically conductive. What more could we ask?

However, when aeroplanes started to fly at very high altitudes about fifty years ago, it was found that commutator life was sharply reduced. That lovely oxide just disappeared. Experiments with stainless steel and silver in place of copper were not rewarding, and it was eventually found that the near absence of water vapour in the atmosphere was the culprit. So nature was on the side of the engineers until they got above themselves-literally.

Earlier I said that I would explain how the choice of the number of poles is made. On small machines such things as keeping the manufacturing cost down is a big factor. Fewer poles cost less. For larger ones, other things begin to count. For example, the rotor copper has further to go on its way from one pole to the next if the pole number is low, so that the rotor copper loss is greater. The dominant factor though is to do with the current reversal which has to take place as the rotor goes round. Fairly clearly there will be fireworks (literally) if we attempt to do this when there is a lot of current flowing in the coil, and for this reason we try to place the brushes where the reversal can happen peacefully. However, the rotor windings, being coils carrying current, set up their own magnetic field, which tends to drag the main field to one side, so that the ideal brush position is now in the wrong place. Worse, the size of the effect gets bigger as the load current is increased. The problem is so serious that on such as rail traction motors 'interpoles' are installed between the main poles, with windings which are connected in series with the rotor so that they carry the same current and effectively cancel out the field distortion.

There is another problem which has to be dealt with. Do you remember the energy stored in a coil carrying current? It is $\frac{1}{2} \times L \times I$ and each rotor coil is involved. Now, when the current is reversed, the stored energy has to be got rid of and then restored with the current flowing in the opposite direction. The way this happens is that as the, appropriate commutator segments pass across the brushes, current flows from one segment to the next via the brushes, which act as short-circuiting paths. The brushes have a hard life in this respect, but this is better than a damaging flurry of sparks at the commutator. The amount of stored energy which we have to cope with is less if the coils span a smaller area, and so we tend to have lots of poles on big machines.

After all this rather indigestible theory, we will, in the next instalment, go on to deal with the practicalities of using the smaller sizes which we are likely to use ourselves.

Reference

1. J D Wale and C Pollock "Hybrid Stepping Motors and Drives". Institution of Electrical Engineers. Power Engineering Journal Volume 15 No. 1 February 2001. pp 5-12.

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- 68 copies of M.E.W. magazine from Autumn 1990. In good condition. Offered for £34.00.
Tel. S. Price on 020 8444 0998 (East Finchley, London)

- Bound copies of Model Engineer 1948 - 1964 (weekly) 1965 - 1974 (fortnightly) also 1975 - 1978 unbound. Offers.
Tel. 01584 872569 (answerphone) (Ludlow)

- Steel stand / storage unit for miller/driller. £50.00
Tel. 02476 375517 (Warwickshire)

WANTED

- Information sought on a Henry Milnes (Bradford, England) vertical milling machine, 30in. x 8in. table with drill head. Does anyone have a user manual etc.? all help appreciated and costs met.
Tel. John Bridges on 01303 894644 (Kent)

- Small milling machine, Emco or similar, with or without motor. also drawings for Worden cutter grinder, copy or loan.
Tel. George on 01376 511635 (Essex)

- Information/manual for Vernier TV280 lathe. Accessories/parts would be of interest. All reasonable costs covered.
S. Trendall, 15 Waterloo Road, Crowthorne, Berkshire RG45 7PB

IN OUR NEXT ISSUE

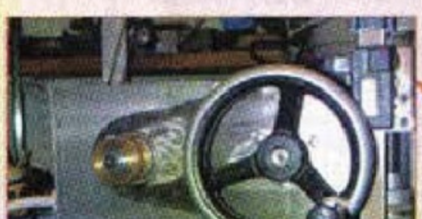
Coming up in Issue No. 76 will be

THE 'RAYMAC' TOOL AND CUTTER GRINDER

An award-winning addition to the workshop from Raymond McMahon

WORKING AND USING EXOTIC MATERIALS

Extend the range of materials which you can incorporate into your projects with advice from Dick Stephen



POWER FEED FOR THE MILLING MACHINE QUILL

Peter Rawlinson adds another enhancement to his milling machine

Issue on sale 3rd August 2001

(Contents may be changed)

Salvaging drill batteries

From Alec Wilson, Winchester, Hants.

I share the dislike of waste which lead to Jim Smith deploring the demise of the batteries of his Bosch hand drill, and taking some action. My unit ceased to respond to re-charging some time ago and, finding the cost of replacement high and the retailer disinterested, had set the unit aside when I read how he had succeeded.

Viewing my battery box with more care, the line of the hot weld was clearly visible and some careful work with a sharp wood chisel opened the unit, showing that the 7.2 volts came from six C size cells. Jim seems to have involved himself in the expense of replacing his cells, but as only two of mine were showing a short circuit, while the other four gave the normal voltage of about 1.2 , my unit has been re-assembled with only two replacements. At between £4 and £5 each cell, this represents quite a saving, but I am still anxious my four re-used cells may let me down.

The Nicad cells used in the past are supposed to suffer from a 'memory effect' and as my use of this drill is very intermittent, I take the trouble to run down the unit to about 0.8 volts per cell before each recharge.

My unit has some form of two stage trigger which enables slow rotation to be used to engage the load, and full voltage is then applied. There is no speed regulation of this second stage, and the prime reason for this contribution is to find out if others have been troubled by this behaviour, and if any reader can suggest a way of avoiding the violent snatch of the second stage?

Lathe clutch replacement

From J. E. Picker, Woodhall Spa, Lincoln

Mr. Howard J. Lister (Scribe a Line, Issue 72) may be interested to know that I have recently fitted a magnetic clutch to my Myford ML7, the clutch of which was suffering from general wear and tear. If I adjusted the clutch to drive a reasonable load, it would continue to drive after the lever was disengaged. to repair the clutch would require access to another lathe in order to bore out and sleeve the large clutch pulley.

I toyed with the idea of using a motor cycle clutch, but then came across a neat magnetic clutch unit off a 'Countax' ride-on mower, where it was used to drive the cutting deck. I would estimate it to be capable of transmitting some 8 - 10 hp. It had almost exactly the same size pulley as the Myford, so all I had to do was to make a new countershaft and a new motor pulley as the belt was a thicker section.

The Countax clutch requires a 12 volt 3 amp supply which I obtained from a battery charger transformer and a bridge rectifier.

12 volt magnetic clutches are also used extensively on tractors and plant as well as vehicle air conditioning compressors and, by the way they load the engine when switched on, I would think capable of transmitting 2 - 3 hp.

A key for the 4-jaw chuck

From William Farr, Swanage, Dorset

When setting work in the 6in. Bernard 4-jaw chuck on the Myford, I find that the key fouls the top pulley support. A much more convenient driver can be made from square bar (the sort which connects door handles in mortise locks is about right) and a 1/4in. square drive socket of 7mm A/F. In my case the bar had two radiused corners and two square corners which could be filed to match. All you have to do is to work out the bits you have to file off the corners to make it fit the socket - a relatively simple calculation of a square inside a hexagon. Loctite the bar into the socket and in less than half an hours work you have a key on which you can use either a tommy bar or the ratchet tool.

A sincere plea from a newcomer to model engineering

From Paul Dudley, Eye, Suffolk

As my heading implies I have a plea to make. I am 52, a gas engineer and very technically orientated. About two years ago I came up with an idea for a mechanical device. The device is very simple in design and fairly easy to build, but here lies the problem. If my design works it has a commercial value so, as previous experience has taught me, I shall be unable to divulge what it's use is, at the moment.

I have decided to build the device myself. About September last year I sat down and worked out what equipment and materials I would need to complete the project. A lathe was first on the hit list, so I surfed the Internet over a period of days and came up with several suppliers of engineering equipment etc. Chronos came to the fore, but on looking at their on-site catalogue, I soon realised that I was walking into a mine field.

I had, in the mean time, purchased a lathe that would be capable of building the individual components I needed. On reflection I should have invested in a better model and make, but you learn by them don't you?

I knew the publication Model Engineer existed, but laying my hands on a copy wasn't easy, but I eventually purchased a copy. My intention was to find out as much as could from Model Engineer, such as suppliers, books, use of lathes and engineering in general, (the last time I used a lathe being at school), also to find out about forthcoming exhibitions, etc. In the meantime I visited my local library to gather information about the use of lathes. To-date I have spent about £150 on books alone and, to be very honest, not one has been useful to me, even though the write-up states it is suitable for the beginner. On reading the first few pages you think this is the one, then they go into extreme technical detail that is not suitable for the beginner.

Late last year I went to the Sandown Park exhibition with a list of tools and equipment that I needed, plus a list of "How to?" questions and wandered around for a couple of hours, admiring the projects people had undertaken and the quality of the workmanship. As all the trade stands were so busy, there seemed no chance of anybody sparing me the time I needed to get my questions answered. As time went on I became more reluctant to ask the questions and the fear of making a fool of myself grew. I eventually purchased a few items from Chronos where a young man managed to give me a bit of advice, but with 2/3 deep around the stand he was needed to serve others. At Sandown I visited the Nexus stall and became acquainted with Model Engineers Workshop, which I immediately, purchased and subscribed to. This publication has helped, but I still am lacking in the basics of lathe work. In the new year, with a little extra knowledge, I went to the Lee Valley exhibition with similar results. It's now six months on and I am almost no further forward.

If I may, I would like to make some suggestions. In my industry, and my wife's (financial) we presume that people not in our industry automatically understand what we are talking about, but in reality they don't. They are not stupid or ignorant - it's just that we talk a different language so we have to say it in a different way so they will understand. This is what I have found in model engineering books and publications. Although certain articles are aimed at the beginner, I/we, the beginner, have immense trouble deciphering what is actually meant! I used to take a magazine called Short Wave Radio and although the articles were quite complex, even the beginner could usually understand because, at the end of each piece, there was a break down and meaning of terms which might be confusing for the beginner.

I am quite involved in radio controlled model airplanes and am lucky to have a mentor to help me in times of crisis, but I live in the wilds of Suffolk and, as yet, I have still to meet anybody in the model engineering fraternity. My point is that I have nobody to answer my questions, but if at the exhibitions there were to be a stand manned by people purely there to answer technical questions and give general advise about the model engineering hobby, what a confidence booster that would be to the beginner.

If I didn't initially have a specific goal, I would have given up a long time ago. How many people attend model engineering exhibitions with the view of starting the hobby, only to be put off by not being able to get basic and relevant information? At the principle model airplane exhibitions the British Model Flying Association (BMFA) is in attendance, their aim, among others, is to answer questions and promote the hobby. This I know is not the responsibility of Nexus, but it could promote the idea amongst its readership.

My final point is about books. With the obvious amount of engineering talent at your disposal and within your readership, surely an up-to-date book for absolute beginners could be written, i.e. The Idiots Guide to Using an Engineering Lathe / Mill / Engineering accessories. This could detail how a lathe and other equipment works, what tools do what and when to use them. Sketches could be used as well as technical drawings. Not sixty pages on how to sharpen tools or what gears to use for thread cutting. Although essential reading, that comes later when we've learnt the basics and understand the terminology. The closest I have come to finding a book that meets the needs of beginners is "Tabletop Machining" by Joe Martin (ISBN 0-9665433-0-0).

Just as footnote, has Nexus ever considered releasing a CD filled with past articles. My reasoning is that for me to gain copies and to store the same is quite a task. Several computer programming magazines that I read offer this service. As you will note, a lot of your articles make reference to previous articles.

Yours truly, a frustrated beginner.

The Editor responds:- In past years, my immediate recommendation would have been to seek a local model engineering evening class, but these now seem to be few and far between. The next step would be to join a local club or society, but those living in more remote areas are obviously likely to find this difficult.

I have recommended the book 'Model Engineering - A Foundation Course' by Peter Wright (ISBN 1-85486-152-2), this being, in my opinion, one of the best books on hobby engineering we have seen in a long while. My favourite book on lathe work was always Len Mason's 'Using the Small Lathe', but this has long been out of print.

With regard to the provision of technical advice at exhibitions, this, for many years, was carried out by the Society of Model and Experimental Engineers (SMEE), but perhaps we have not made this obvious to visitors in recent times.

The provision of a CD ROM containing back numbers of magazines is under discussion, but there are some technical and copyright difficulties to resolve before this can become a reality.

Alternative methods

From John Goodchild, Pencader, Carmarthenshire.

Marvellous! Having just suffered a workshop lockout by the management (medical grounds), I had to cast around for alternative employment. You guessed - preparation of a Drilling and Tapping chart! Pity you and the ME people couldn't give me a prior insight into your thinking. Perhaps I could then have achieved more gainful employ!

Issue 73 of M.E.W. goes into the problem of starting taps off straight as well as an interesting article on the modified Potts spindle. Because of my newcomer status and being of an age that increasingly reminds one that life is finite, I would like to finish what I have started. In consequence, I try to make do with what I've got and if possible prevent being side tracked into expending large amounts of time making jigs and fixtures unless absolutely unavoidable. Both these items are cases in point.

For keeping taps running true, I use one of those cheap oriental pin vices that come in sets of four, with through holes in the handle. A suitable spindle inserted in the vice shank (a drill?) and held in the tailstock or other chuck provides a useful, but not the elegant, solution described by Mr Amos. The larger of the vices only takes taps up to 1/4in. or so, but it is these smaller sizes that cause me most problems. Even with these relatively small sizes, a tommy bar adaptation is required for tapping in steel. The pin vice handle could be shortened if there were space constraints between work piece and drill chuck. I also use the same arrangement for aligning small hand reamers.

My alternative to the Potts spindle was rather convoluted in its development. No, 'development' is too grand a word for the mental processes of that time. I was having a terrible time parting off 8BA studs. The parting tool wasted about 1/8in. every cut, even if it didn't mutilate the thread. The usual hacksaw standby was different, but no better, at which point I must have seen the Dremel advert On TV - the one where it does most things except hammer. Well, after a rootle in the scrap box I knocked up a cradle for the tool so that it could be mounted in the lathe quick-change tool carrier. Now, parting off smaller items is a doddle with minimum waste and an immaculate finish. Larger items can be cut, but is pointless unless the work piece is hardened.

The next use was an attempt to liven up a job lot of end mills/slot drills picked up at a car boot sale. A bit of trial and error, the ability to set the top slide angle and slight height adjustment of the tool post gave me several half-decent milling cutters at minimal cost. Flute sharpening is another matter though! Yes, I do thoroughly cover all lathe parts.

The application, more in tune with the Potts spindle, is to use the Dremel in conjunction with the indexing of the lathe gear train. It is possible to 'spot' or, if size is not a consideration, to drill on a pitch circle. The ability to set the top slide also allows one to drill at an angle. A bit of light milling using the cutters supplied with the Dremel is possible in brass. The minimum speed is perhaps too high for mild steel and could even be frightening if one's feed rate is not kept to the absolute minimum. Electronic speed/torque control is probably the answer but that is for the future.

No, I have not got shares in Dremel. Its first two or three years of life were that of a seldom used Christmas present, that is until I found it these applications. There is no reason why other makes of mini-drill could not be pressed into service pending funds and time to implement a proper engineering solution.

Some issues ago, a reader recommended 'Car Club Maintenance Spray' ex ASDA, I think it was in M.E.W. A while back I ran out of tapping paste, so nothing ventured, I gave it a quick squirt of the Car Club and it worked a treat. In fact the pressurised spray through the extension pipe blasts swarf away and prevents clogging. My opinion, subjective though it is, is that the spray is as good if not better than preparations intended solely for the purpose, especially in the smaller sizes we use.

Another application: small drills have difficulty evacuating the swarf, particularly in steel, and especially when drilling deep. At best you might hear protesting noises but often too late. A broken drill results if you don't resort to 'pecking'. Give it a spray of Car Club - it seems to lengthen the swarf, thus aiding its evacuation. Even when you have to 'peck' as you go deeper still, the spray helps to remove the smaller pieces of swarf. I suppose the lubricating and waxing properties of the substance somehow aids coagulation of the swarf making it easier to expel. To be fair, WD 40 works as well in both applications, but not so economically. Again, I have no connection with either manufacturer or supplier.

On the other hand all this might be so much 'old hat' to you and long-term subscribers so please feel free to ignore it! Thank you and the contributors for an entertaining and informative read.

A design for a muffle furnace sought

From John Morley, Oakville, Canada

I would like to enquire if anyone has any ideas or details on the construction of a small electric resistance heated furnace for the hardening of small items.

The dimensions of 6in. x 6in. x 12in. would approximate to a reasonably sized unit. Tempering could be done with the same unit. Temperature control could be achieved by simple solid state switching from a thermistor sensor or a manual switch, timer and pyrometer, the simpler the better.

We have 220V AC available quite readily here in Canada, compatible with your supply of 240V.