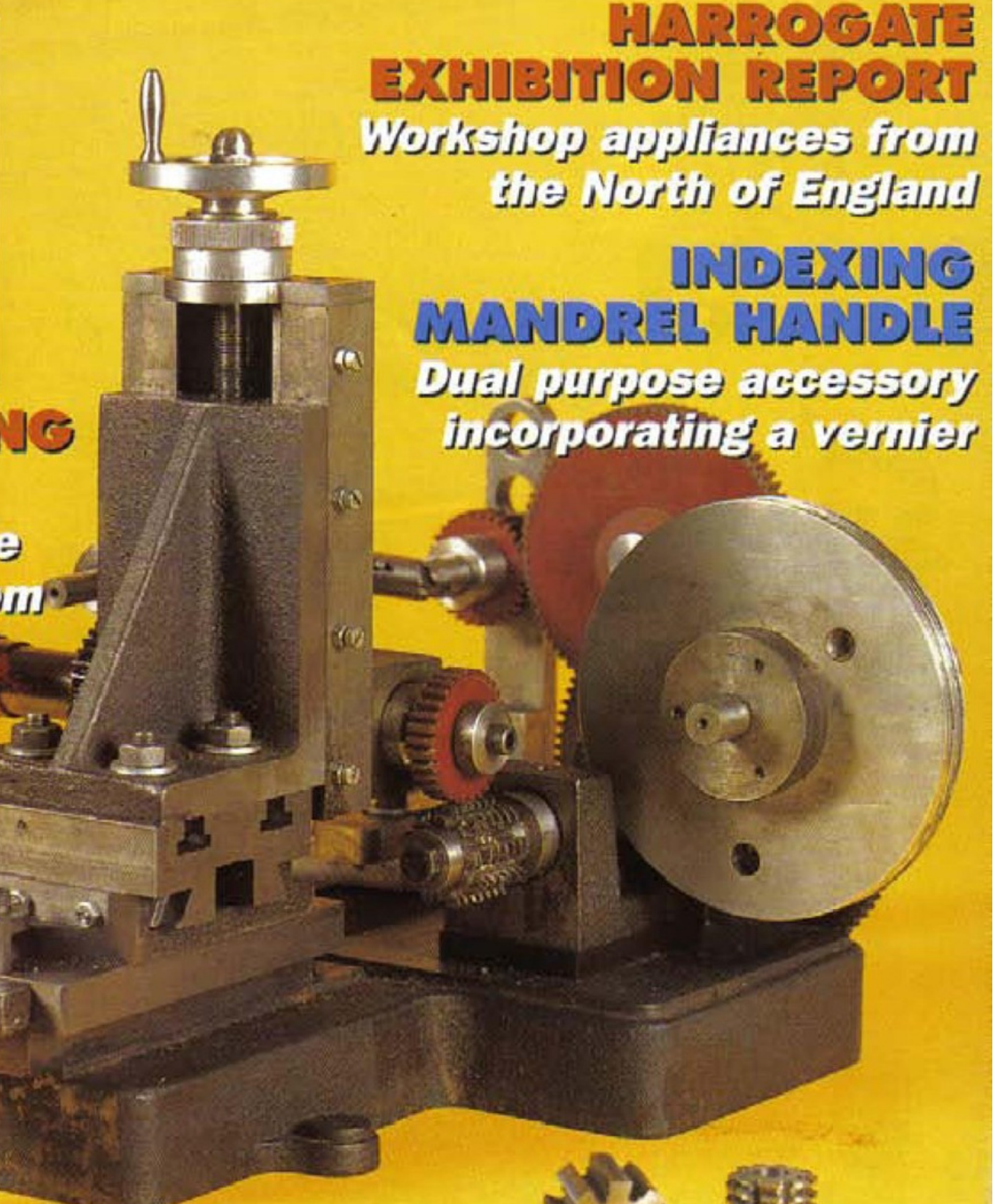
No.58

MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE



HARROGATE EXHIBITION REPORT

Workshop appliances from the North of England

INDEXING MANDREL HANDLE

Dual purpose accessory incorporating a vernier

GEAR HOBBING MACHINE

A special purpose machine built from castings

PROTECTIVE COATINGS

Corrosion protection for a variety of metals

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NEXUS
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Issue No. 58

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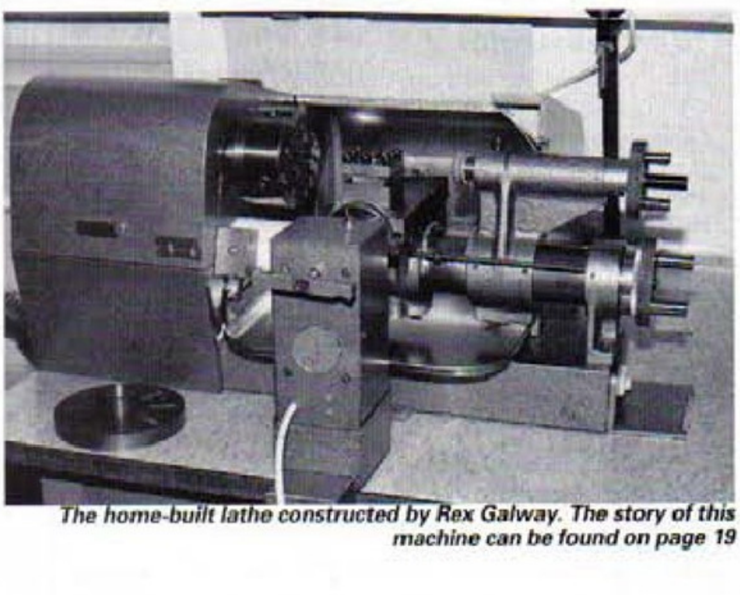
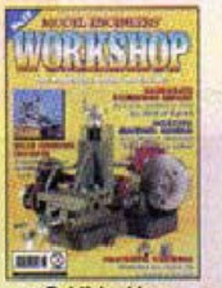
Nexus Special Interests, Nexus House, Azalea Drive, Swanley, Kent BR8 8HY tel. 01322 660070 fax. 01322 667633

On the cover

Our main picture shows the CES version of the Jacobs Gear Hobbing Machine, the description of which starts on page 33 while the inset depicts the original fabricated version (Photos. Jon Jolliffe)



The home-built lathe constructed by Rex Galway. The story of this machine can be found on page 19



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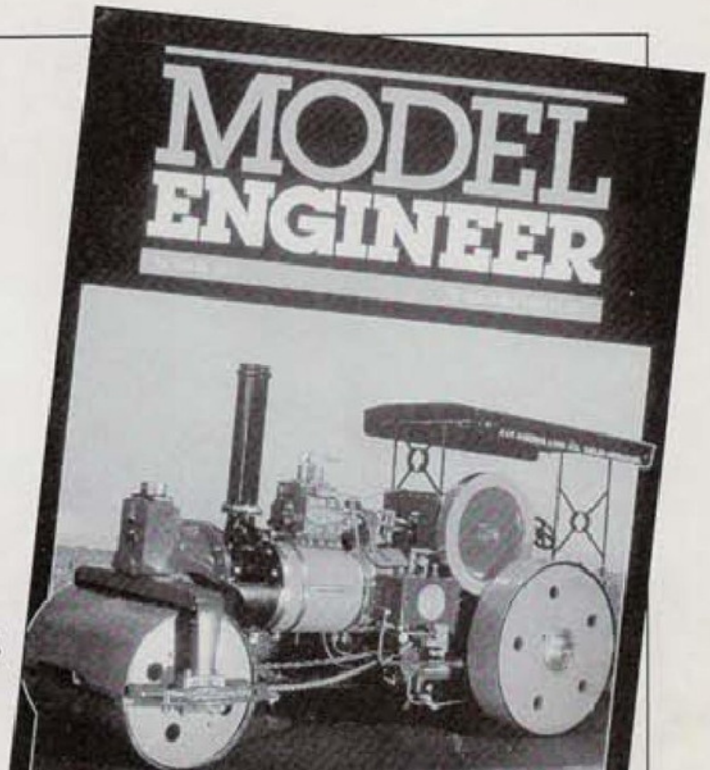
NEXUS

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

Ted Jolliffe retires

Sharp eyed readers may have noticed the absence of a familiar name from the list of credits shown on page 3. At the end of April, Ted Jolliffe retired from the posts of Editor of 'Model Engineer' and Group Editor of the Nexus Special Interests Engineering sector titles. Ted had been Editor of 'M. E.' for fifteen years, his period of tenure being therefore second only to that of the founder, Percival Marshall, who occupied the chair from 1898 until his death in the late 1940s.

With the launch of M.E.W. in 1990, Ted became Consulting Editor and continued in that role until he became Group Editor the middle of 1996. Ted was thus my main contact in the old Hemel Hempstead office when I became involved early in 1995, and I have to thank him for introducing me to the world of publishing and guiding me along the way. As I have always worked from home, Ted was a vital link in the chain, making sure that all the material for the magazine was fed into the production system and channelled back to me as necessary.

Closure of the Hemel Office and the move to Swanley meant that we were then both working from home, transmitting information directly to our design studio. There was thus no longer a need for Ted to be directly involved, but we have since remained in close contact, meeting as frequently as possible, usually over a convivial lunch, to discuss matters of mutual interest and to try to make sure that the content of the two magazines remained in harmony. The third 'conspirator' at these gatherings was, of course, Mike Chrisp, then Technical Editor of 'M. E.', but now the Editor as he has succeeded Ted in the post.

Ted joined the magazine on his retirement from the Metropolitan Police, having had a long interest in model engineering, being a keen member of the Chingford DMEC. As a committee member of the Southern Federation of Model Engineering Societies, Editorship of their Newsletter gave him the opportunity to demonstrate his talents as a journalist.

Ted's particular love has always been the small locomotive, as is evident from his enthusiasm for the IMLEC and LBSC Memorial Bowl competitions. With retirement on the horizon, he made a start on another project, the makings of LBSC's 'Virginia' having come to hand. I understand that good progress is being made.

Ted has also always been keen to nurture the club movement, attending meetings, rallies and exhibitions throughout the length and breadth of the UK, making sure that significant events were recognised and reported. He has said that he often felt that he was not so much a professional editor as the secretary of the biggest model engineering club in the world, able to put people in touch with each other when particular problems and difficulties arose. He has always been well in evidence at the Model Engineer Exhibition, working tirelessly to make sure that the engineering exhibits were displayed to the best advantage and that visitors were welcomed. For some years he also organised the collection service, driving many miles, often in adverse weather conditions, to ensure that models were delivered safely to the exhibition and then returned to their owners at the close.

I am quite sure that we are far from having seen the last of Ted on the model engineering scene. Freed from the continuous pressure of the deadlines associated with the production of a two-weekly magazine, I hope that he will be able to take a much more relaxed attitude, get some of those outstanding projects completed and perhaps play a different role. I know that you will all join me in sending best wishes to Ted and his wife Mary.

Welcome Anthony Watson

Ted's departure has created a vacancy for an Assistant Editor. Anthony Watson was scheduled to have joined us towards the end of May and will soon take up residence at our Swanley headquarters.

Anthony was apprenticed as a professional model maker with the world-renowned concern of Clarkson's of York. He then joined British Rail, working mainly on the Plant and Machinery side, becoming an Incorporated Engineer as a Member of the Institution of Mechanical Incorporated Engineers. In recent years he returned to professional model making in a self-employed capacity, having retained a personal interest in model engineering as a member of the Ryedale Society. His hobby projects include a Stuart Turner No. 9 stationary engine and one of the Austen Walton designed 'Twin Sisters' locomotives. He therefore brings a wealth of experience which I am sure he will soon put to good use.

Anthony will work mainly on 'Model Engineer', helping Mike to meet the demanding two-weekly schedule, but he will also be part of the 'M. E. W.' team, looking after my interests at Swanley and dealing with queries emanating from the production departments. He will also be sharing the load 'out and about', so you may have the opportunity to meet him in the near future.

The Health & Safety Executive draft paper 'Model Engineering: Guidance on safe operation of miniature railways and traction engines'

On pages 60 and 61 of this issue we reproduce the 'Draft for Consultation' of the above paper. We are aware that many of our readers have little interest in these aspects of the hobby, but we also know that some of those who do may take 'M. E.' or 'M. E. W.' but not both. As the Executive is keen to seek opinion from as wide an audience as possible, we have agreed to publish the draft in both magazines.

The need for such a paper arose from a series of misunderstandings. For want of any other suitable place to put it, the HSE gave responsibility for overseeing miniature railways which offer rides to the public with their Entertainment Section. This Section also covers commercial fairgrounds, and the publication of an updated version of 'Fairgrounds and Amusement Parks: Guidance on safe practice' prompted some within our hobby to assume that the requirements contained in that document were to apply to the type of miniature railway operated by many of our clubs and societies. This was never the intention, so it was decided that the best way to eliminate the confusion would be to generate a document specifically to meet our needs.

Consequently, after seminars held in Wigan and Southampton, the HSE co-opted a 'Liaison Group' of willing individuals from a wide spectrum of the hobby to help draft something suitable. Representatives of the model engineering press were invited to join, both to make a contribution and to advise on communication with those likely to be affected. Ted Jolliffe and I have been attending meetings and commenting on a succession of initial drafts. It is now felt that a document exists in a form suitable to be offered for wider consultation.

Many will question the need for such a paper, but it should be remembered that the Health and Safety at Work etc. Act 1974 applies **and has always applied**, as soon as we come into contact with the public. The absence of specific guidance could result in those charged with enforcing the Act (such as Local Authority Inspectors) who have no experience of our operations, applying excessively onerous criteria. Getting relevant and acceptable guidance published by the HSE will to be to our advantage. The address to which to send your comments is included on page 61.

A FABRICATED ADAPTER FOR A SQUARE SHANK DRILL

Norman Hurst devises a way of using larger drills which can often be acquired relatively cheaply

Back in 1992, several issues of MEW discussed details of tapered square shank drills in Scribe a Line. An Australian reader - Cliff Dubois - gave a very good description and sketch of the method used with the drills (MEW No 13). Generally speaking, this system was only used for drills from about ½in. diameter; any smaller than this size could be handled by the machines then in use. As far as I know, these drills went out of fashion from about the late 40's when heavy duty electric and pneumatic portable drilling equipment became available.

These comparatively large square shank drills sometimes turn up at boot sales and auctions, and they could be modified to suit our equipment, albeit for the heavier lathes or drilling machines in the home workshop. I have noticed that, for old second-hand drills, they often have a relatively long length, possibly because they didn't have a lot of use during their 'working life'. They certainly weren't used on production work or run at high speeds and consequently they would have been be sharpened less often. They could therefore be a cheap method of drilling large deep holes. A couple of these drills is shown in **Photo. 1**.

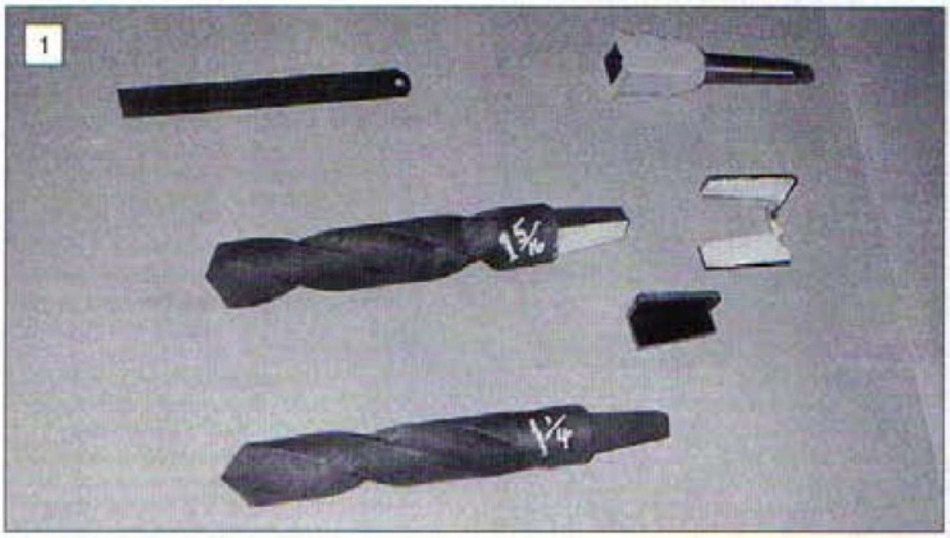
I recently purchased a job lot of drills at an industrial auction and that lot included several square shank drills. In the past, I have used these on the lathe (as well as 3MT shank drills) by fitting the centre drilled hole of the drill into the fixed centre of the tailstock and clamping a lathe carrier to the drill body. Drilling is then carried out by applying pressure via the tailstock, whilst the drill itself is stopped from turning by restricting the carrier. A pilot hole and/or a bored start is required in the work piece. This system has its drawbacks however, and I wondered how to use a more satisfactory method of drilling. I decided that I could either modify the drills or use an adapter and the following methods were considered.

1) Cutting off the tapered square section and welding on a length of steel which would then be machined back to a Morse taper.

2) Turning down the tapered section to give a straight shank.

3) Using a 'square shank to Morse taper' adapter.

1



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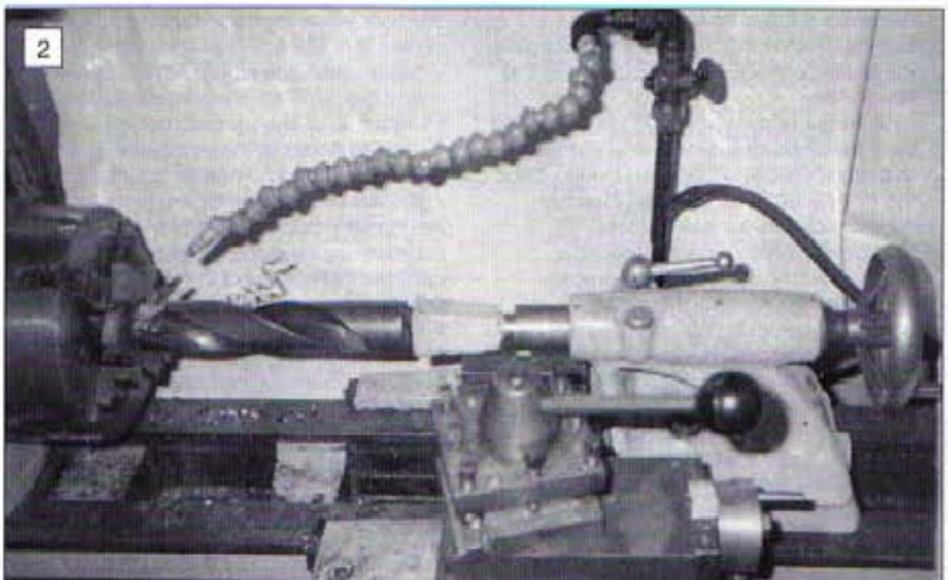


I decided on the last option as it could be used on different sized drills of this type. I have never seen such an adapter or even seen an advertisement for one, so it was obvious that buying one would be difficult, to say the least. I decided to make one with a No 2MT to suit my tailstock. The main reason for going ahead with this idea was that it would be quite a challenging project. At first glance it may appear to be difficult to make a tapered square hole, but I felt that I could do this by using a method that I used some years ago when making windlass handles. The 'business end' of the handles were made by welding the flanges of angle section steel (commonly called angle iron) together, to make a hollow square. Some windlasses have a slightly tapered spindle end, and these would have the corresponding handle welded up with the two pieces of angle iron slightly angled away from each other to give a tapered hole.

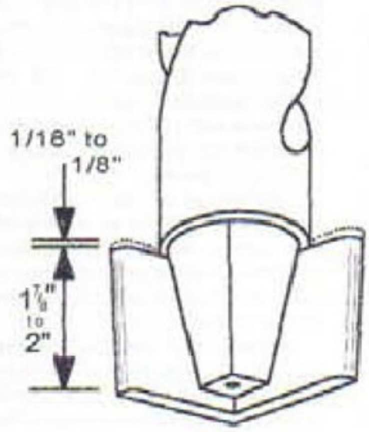


Fig 1a

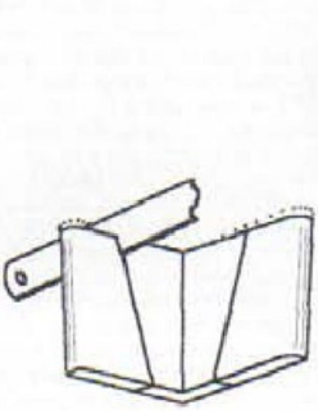


Fig 1b


Fig 1c

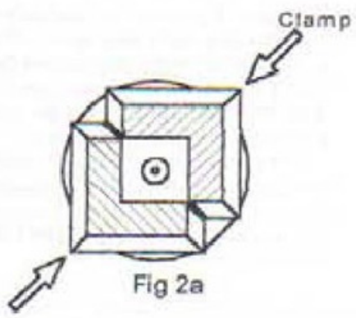


Fig 2a

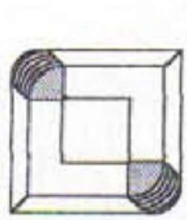


Fig 2b

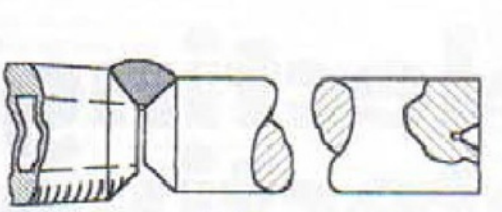


Fig 3a

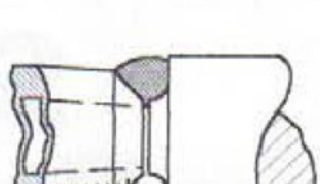


Fig 3b

These old drills are nearly always in Imperial sizes and I have therefore followed suit, with my adapter dimensions also being in Imperial. I believe that there was a smaller size taper system, but the one that is most common, and the one that I am dealing with here, has a small end of 1/2in. square, a large end of 3/4in. square, and a length of 1 3/4in. I noticed that the tapers on all of my drills were a bit hammered, but all were good enough to be cleaned up with a file.

Fabricating the adapter

I used arc welding to fabricate the adapter, but MIG would be quite suitable. I feel however, that gas welding would not be satisfactory; a lot of heat would be required with subsequently a greater chance of distortion. Using a large drill requires a high torque and the adapter's tapered section should be at least 6mm thick, this being the present-day angle section standard. Mine was made from an old piece of 1/4in. angle, which has proved to be satisfactory. I also consider that thicker material (being short and stiff) will have less tendency to distort. An angle iron section with parallel flange sides and with a sharp internal corner is the required material. Fortunately, this is available in the smaller sizes, larger sizes having tapered flanges with rounded internal corners. This latter type is not satisfactory, unless you decide to machine away the inside corner to give parallel sides.

Select a length of angle iron at least 3/4in. x 3/4in. x 6mm. Cut off two pieces, each up to about 2in. long, and saw or grind the flange ends as shown by the dotted lines in Figs. 1a and 1b. Depending on the size of the flanges, this tapering will be about 1/16 to 1/8in. - the dimension is not critical. The idea of this tapering off is to give a closer fit at the large end of the shank.

Hold or clamp each piece of angle against the drill shank (as shown in **Fig 1a**) and mark along the corners where the shank touches. I used white spray primer to leave a silhouette but a scriber would do just as well. Continue the marked lines to the edges and saw down the lines **(Fig. 1b and Photo. 1)** to give two tapered corner pieces **(Fig. 1c and Photo. 1)**. Fit the two pieces back on to the taper, keeping them as close to the large end as possible; that was the reason for tapering the edges - but more of this later. Make sure that the two halves aren't butting and that there is a gap of about 1/32in. between them on each side. With my white spray method, the taper corners show up clearly between the segments. Lightly clamp the assembly together **(Fig. 2a)** and tack weld at each end and each side. Be careful with the large end tacks (you don't want to weld on to the drill), but because the small end is clear of the drill, heavier tacks can be made. Release the clamp, remove the drill and reinforce the tacks if necessary. This part can now be welded up and will form a tapered hollow tube **(Fig. 2b)**. There will probably be some weld penetration in the inside corners which can be removed by using a small diamond point chisel and/or a file. Being a tube, it allows the file to pass right through and it can be worked on from both ends, making the job a lot easier. Test the drill shank in its new holder, turning the drill around to try all four positions. It should fit, but if it had been necessary to do a lot of cleaning up on the drill shank with the file, you may find that it is a bit wobbly in one position. In this case, stamp or otherwise mark the good matching faces of both the adapter and the drill in order to remind yourself which is the best fitting position. You will find that the drill taper does not enter into the adapter as far as it did before welding. This is because the welding has pulled the two sections together and why it was recommended to keep them right up to the large end. This also means that the small end of the adapter protrudes further from the drill. If this dimension is about 3/16in. or 1/4in., that will be satisfactory. If it is more than this, grind it back to about these dimensions, keeping the end square.

The shank

The next step is preparing the adapter shank. For a straight shank or 2MT use a mild steel bar 7/8in. diameter x 3 3/4in. long, or 1 1/4in. dia. x 4 1/2in long for 3MT. The bar should have a weld preparation (commonly known as a 'weld prep') machined or ground at one end, and I would suggest a chamfer for the smaller size - as shown in **Fig. 3a** - or a 'J' shape for the 3MT size (**Fig. 3b**). Do not drill a centre hole at this stage.

Grind, saw or file another weld prep on to the small end of the square tube (**Figs. 3a & 3b**), and align this with the adapter shank for welding, using magnets or your preferred method. This alignment need not be too precise as metal is going to be machined off after welding. Tack the two sections together and weld all the way around. This time however, if there is any weld penetration inside the end of the tube, it won't matter - there should be enough clearance to accommodate it, but check for any weld spatter which may have got inside.

You now have a complete adapter with a rough, unmachined adapter shank. If you intend to have a Morse taper shank, set up your lathe to cut one, using your usual method. I haven't got a taper turning attachment and I machine Morse tapers by setting over the top slide. The finish is not perfect using this method, but it is adequate for my purposes

In order to cut the taper, put the square shank of the drill into the adapter - fitting the corresponding faces if necessary. Give it a tap on the end to make sure that it is well and truly home, as if you were going to use it right away for drilling. Now grip the flutes of the drill in the lathe chuck and set it up to run true. A split bush would be ideal for this part of the job; not only would it be true in an (accurate) three jaw chuck, but it would protect the jaws and the drill. I set mine up with a strip of 1/8in. aluminium bent around the drill and gripped in a four jaw chuck - not the best way. You will probably find it necessary (depends on the size of chuck and length of drill), to support the straight section of the drill in a fixed steady. The drill will now be running true, but the shank of the adapter will be swinging backwards and forwards; this won't matter as there will be enough metal to machine it true. If the shank end is rough or uneven, now is the time to true it up, prior to using your centre drill. The next step is to drill the centre hole and fit a centre (dead or revolving) into the tailstock.

With the centre in position, the support of a steady should not be necessary, so remove it to give yourself more working space. The taper can now be cut - it's as simple as that! However, if you wanted a special end (e.g. threaded for a draw bolt), now would be the time to do it, while the job is set up and running true.

Remove the assembly from the lathe and take out the drill. This shouldn't be a problem, just hold the drill and tap the large end of the adapter, that's how it would have been removed in the past. Now fit the adapter into the Morse taper of the headstock spindle, - the correct way round this time, of course, and then machine the face of the adapter's large end, just cleaning it up.

The length or end details of the Morse taper can be made to your preference. I filed a tang on the end, but kept the length of the taper to a minimum. This suits my machines, but it is below the standard length.

As shown in **Fig. 2b**, the adapter has two sharp corners and two rounded corners. Here again, you can finish it as you wish. I ran another weld bead along the two corners to build them up, and then filed back to make the job more symmetrical. As mine is a working tool, I have not been too fussy about it.

The adapter in use

Photo. 2 shows the first test cut on mild steel, which was with a 1.312in. drill. A 1/4in. pilot hole was drilled first, this being to clear the centre web of the large drill. The hole was cut at 60 rpm and no problems were experienced.

This was a good project with a satisfactory conclusion. It is well worth making if you have any of these drills. Incidentally, I have several to dispose of; anyone interested?

Selecting Protective Coatings

Philip Amos discusses the forms of corrosion which can affect a variety of metals and suggests some processes which can provide effective protection

Because my home is only 150 metres from the sea, the salt laden moist air causes rapid rusting of cast iron and steel items in my workshop - hence my interest in minimising this action. Rust and other forms of corrosion are the bane of things mechanical, and over a very long period a variety of means of combating these scourges have been developed with greater or lesser degrees of success. Different problems confront different materials, so these are addressed below under the following headings:

Iron and Steel.

Copper, Brass and Bronze.

Aluminium.

Silver.

This article examines the questions as to what coatings are available and how to apply them.

Safety

The chemicals used in the plating and blacking processes described below deserve respect. Thus eye protection and the use of rubber/plastic gloves is essential. In particular, care must be taken with caustic soda, sulphuric and nitric acids, as these are all highly corrosive.

1. Zinc plating is a form of protection commonly used on fasteners

2. Hot dip galvanising is more appropriate for items for external use

Iron and Steel - General.

Except for the various varieties of stainless steel, almost all other ferrous products will rust in the presence of air and moisture. Rust is a complex mixture of oxides and carbonates which can be prevented from forming by impermeable coatings or by sacrificial coatings. Thus, if covered with a coating of tin, steel is protected, but if the coating is damaged, the steel will rust at an increased rate due to electrochemical action.

However, if coated with zinc, either by hot dip galvanising or by electroplating, steel will still be protected, even if the zinc coating is damaged, as in this case the electrochemical action causes the zinc to corrode sacrificially and leave the steel unrusted.

A tightly adhering oxide film on the steel can provide some lesser protection against rusting. This occurs with the mill scale on black steel sections and with the blueing or blacking treatment that has been traditionally used with firearms. In more recent times 'blacking' solutions have become available commercially for home workshop use.

Finally, the use of paint systems has long been used to protect steel (and before that iron) structures with reasonably satisfactory results, provided the paintwork has been adequately maintained to prevent direct access for air and moisture to the steel.

Iron and Steel - Applications

If there is likely to be a rusting problem, the selection of stainless steel for a component at the outset is perhaps the simplest solution, as no further protective treatment is required. The machining of stainless steel is not much more difficult than for mild steel; and it is freely available in the trade, although it is more expensive than mild steel.

If mild steel or tool steel must be used then selecting its protection requires consideration of several factors:

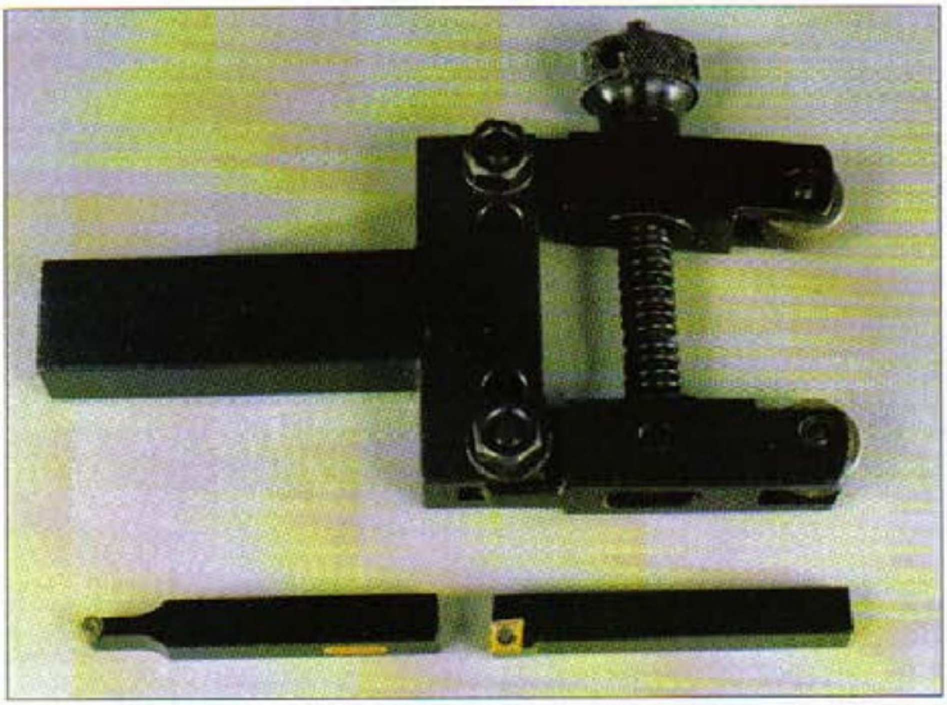
1. If the surface is only in contact with air, then a paint system should suffice.

2. If the surface is in contact with air but will be handled - e.g. operating levers and the like - then zinc plating will probably be the answer. Nuts, bolts, washers and other hardware also are usually treated in this manner.

3. If the surfaces are part of an outdoor structure exposed to the elements then hot dip galvanising with or without subsequent painting is the preferred approach.

4. If the surfaces are in contact with each other, as in bearings, slides etc., then blacking is useful as it offers some protection but leaves the component dimensions virtually unchanged - a condition not achieved in the systems 1, 2 or 3 above.

5. In some special applications such as the piston rods in hydraulic cylinders, the commercial approach is to have them hard chrome plated and then ground to size. This technique is probably beyond the capabilities of the home workshop.



3. Metal blacking processes are particularly suitable for workshop equipment

4. Blacking and electroless nickel plating materials are available in kit form and are suitable for use in the home workshop

Iron and Steel - Systems

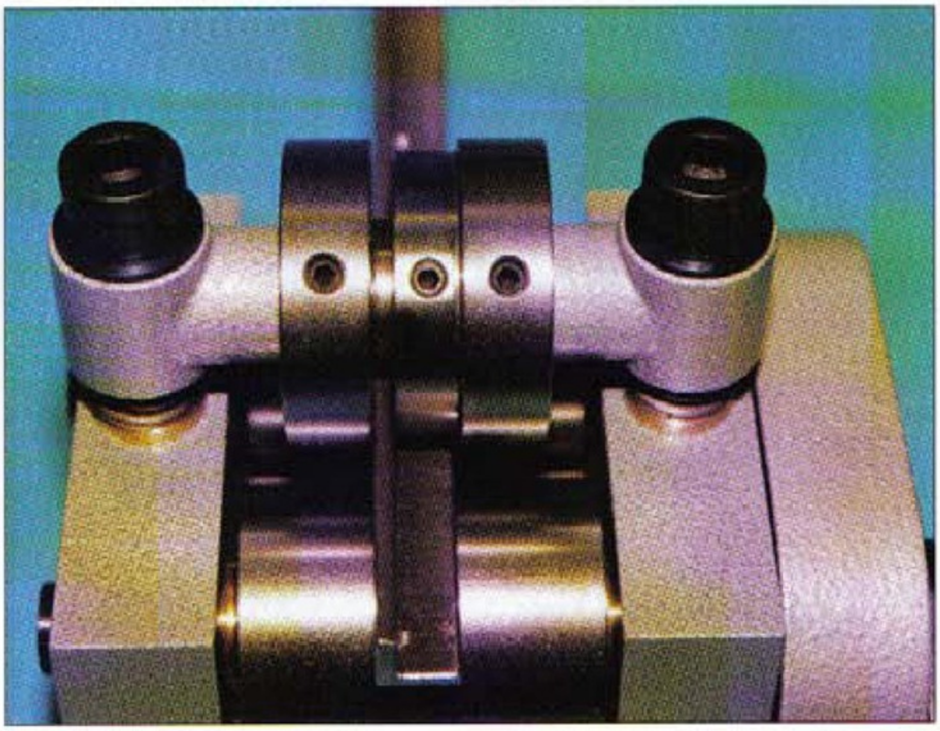
1. Paint

(a) Surface Preparation

For best adhesion, the surface to be painted must be clean, dry and free of oil and rust. Cleaning and de-oiling can be done with a proprietary petroleum cleaning fluid (or less desirably with petrol or kerosene) followed by an alkaline aqueous solution degreaser. Loose rust and scale can be chipped off, wire brushed or abraded with grinding wheels, sanding disks or belts, or blasted with such substances as sand, shot or glass beads.

Sometimes it is difficult to remove all vestiges of rust or scale and in such cases the use of a rust converter product is helpful. Formerly these mainly comprised mixtures of phosphoric acid which converted the iron oxides into iron phosphates. Modern proprietary converters state they do not contain phosphoric acid, but instead use an unnamed organic acid with vinyl copolymer - it seems to work as required however.

For commercial use on large scale painting e.g. automotive body panels,



5. Powder coatings are available in a variety of colours and textures, but are best applied by specialist metal finishers

6. This tarnished E.P.N.S. item will be familiar to many

phosphoric acid treatments were very popular in the middle of this century and are still used in many places. These went under the trade names of Parkerising, Bonderising and Granodising. They resulted in a tightly adhering inert iron phosphate coating on the steel which reduced its propensity to rust. These systems are probably not appropriate for the home workshop.

(b) Primer

After cleaning, the work should then be given a coat of primer, various types of which are freely available. The three main primers used are red lead, red iron oxide and zinc chromate. In Australia, red lead has been banned for about 20 years for health reasons. It was however an excellent primer, particularly for items later subjected to a lot of moisture. Red iron oxide is the stalwart with a long history of good service. Zinc chromate came into use during World War II, but does not seem popular now for use on steel, although favoured on aluminium. From my own experience in industry and in my workshop, steel parts primed with zinc chromate but not finish coat painted can show signs of rust after a couple of months in store, whereas parts prime coated with red iron oxide and not finish coated can be stored for years without rusting.

Zinc chromate primers often included an etching component to give tighter adhesion to the material surface.

(c) Finishing

In former times it was common to use an undercoat followed by one or more finish coats of paint. Contemporary practice is usually to adopt just two finish coats. These can be applied by brush, roller or spray. Some formulations involve two parts (resin and hardener); others require baking, but neither of these would be in common use in the home workshop. Likewise, many commercial articles are painted by the powder coating process which yields a harder, more resilient and thicker coating, but again this process is not for the home workshop.

While water based acrylic paints are very popular DIY materials for house painting, their use on steel or cast iron will yield disappointment as the paint film is porous and air and moisture can access the steel and cause rusting under the paint. Thus oil based enamels are to be preferred.

(d) Special Cases

In conditions where oil will be present, such as the insides of gearboxes and engine crankcases, special 'crankcase' enamels are available which seem to adhere better to the primed steel and which resist any action by the oil and its in-built detergents. These crankcase enamels were traditionally red, but in more recent times white has been used to enhance visibility within the crankcase.

If hot dip galvanised parts are to be painted, they should be allowed to weather for about six months before priming and painting. This allows the surface of the zinc to become roughened, which provides a better key for the primer to adhere to the surface. If this time is not available, then there are available specially formulated (usually water based) primers for galvanised parts which seem to achieve much the same result.

Parts which are liable to get hot, such as exhaust pipes and manifolds, are often painted with aluminium filled paint such as 'Silvafros' which seems to transmit the heat without the paint blistering or peeling off.

Zinc rich paint containing a heavy proportion of metallic zinc dust in an enamel binder can be used as a 'poor man's galvanising' on outdoor steelwork. It is applied directly on the bare steel, and seems to protect the surface better than conventional paint systems. I have had good results with it on steel railings.

Fish oil based paints are marketed for use in rust prone conditions, but in my limited experience their performance is no better than normal paint systems.

Parts which will be in contact with moisture, as in soil, are often painted with bituminous paint as a means of waterproofing, and this can have some success in the short term. However, even heavy varnish can produce a reasonable performance, as witnessed by steel star picket fence posts used on farms, which seem to last 40 or 50 years at least. Bituminous paint is of course widely used for the treatment of roofing felt. In hot sunny countries it is often given an aluminium powder filling, as the resultant coating is then silver rather than black coloured and does not heat up as much due to incident solar radiation, thereby lessening adverse effects on the roofing felt (bulging and cracking).

2. Zinc Coating

There are a variety of ways in which metallic zinc can be applied to steel to provide protection against corrosion; these are discussed below.

(a) Zinc Plating

This process can readily be carried out in the home workshop. Reference 1 describes in considerable detail how to go about it using simple acid solutions rather than the more dangerous cyanide solutions used commercially. The electrical supply described in Reference 1 is adequate, but I have used a more ancient approach as described in Reference 2, which was published 11 years earlier. It yields greater flexibility in providing the appropriate currents for a wide variety of workpieces. Reference 2 also describes an electrically driven agitator for the solution, which seems a useful addition.

While it is possible to predetermine the average thickness of metal deposited in the electroplating process, this deposit is not uniform. In commercial practice it can be made more uniform with a variety of techniques, but it is still difficult to get it sufficiently so to allow shaft/hole clearances to be achieved for particular close fits for bearing and sliding components.

In the case of cast iron it is extremely difficult to successfully zinc plate. The alkali cleaner tends to penetrate between the iron crystal boundaries, and this emerges during the acid electroplating, with the result that a sort of sludge forms on the surface rather than a coherent coating of zinc metal. Some improvement can be achieved by cleaning the parts beforehand by shot blasting with iron shot or glass beads. This tends to close up the surface of the cast iron as well as achieving the cleaning action. The electroplating is effected straight after the blasting, taking care not to handle the parts with bare fingers or greasy gloves. Nevertheless, poor results usually eventuate.

Even commercial electroplaters using cyanide solutions will give no guarantees on zinc plating cast iron. They say that "eventually" the acid in the crystal boundaries will emerge and react with the zinc to cause corrosion and rusting so, if the favoured design selection was cast iron with zinc plating, it might be better to use instead uncoated bronze.

There is a problem with electroplating steel springs called 'hydrogen embrittlement'; here hydrogen ions from the electrolyte get into the crystal boundaries of the steel and weaken it. As the most highly stressed parts of a spring are at its surfaces, this leads to failure. so springs are best treated with paint (or varnish) or else made from stainless steel or phosphor bronze.

A further degree of protection can be provided by 'passivating' the zinc coating. The activity of the zinc is reduced by coating it with a layer of chromium (or molybdenum) ions, which prolongs the life of the zinc deposit and so effectively enhances its anti-corrosive properties. The various passivating treatments cause the zinc coating to become coloured - black, brown, blue or yellowy iridescent. Passivation is frequently found on commercial fasteners e.g. black on hi fi audio, TV and computer components. The procedures for effecting this treatment are detailed in Reference 1.

(b) Hot Dip Galvanising

Those home workshops which include a backyard foundry may be able to provide a bath of molten zinc for this process, but for most of us it will be necessary to send our components to a specialist processor. The treatment often causes distortion of the components, particularly long thin ones. However this can be overcome to some extent by the skill and experience of the operator. Reputable processors normally undertake straightening operations on the components before returning them to the customer.

It is an important requirement that vent holes be provided in closed components to allow escape of during the immersion in the molten zinc, lest explosive blow-outs occur.

Galvanising is undoubtedly the best possible protection available for steel, but its dimensional irregularities must be allowed for in the design and application of the components so treated.

(c) Metal Spraying (Schoop Process)

Special equipment is required in which a wire or powder of the material to be sprayed (in this case zinc) is fed into an oxy-acetylene flame and thus transferred to the workpiece. Probably not for the home workshop.

(d) Sherrardising

The components to be coated are placed in a revolving drum with zinc powder and the whole is heated to about 260 deg. to 315 deg. C. This process was used commercially for small fasteners, but seems to have been largely superseded by zinc plating these days.

3. Blacking or Blueing

These processes produce a tightly adhering coating of black iron oxide on the steel or cast iron which has some corrosion preventative properties. Some of the coatings will absorb minor amounts of oil which also contributes to the anti rusting effect.

The most widely known use of these processes is in the finish on firearms, where such a finish became an art form on hunting rifles and shotguns, being produced by secret procedures by the gunsmiths. In modern times, small arms factories routinely use various chemical baths to achieve much the same result.

Several advertisers in ME and MEW offer systems to effect such treatment, generally comprising three stages - alkaline cleaner, blacking solution and dewatering oil. The whole task takes about 25 minutes to complete. My experience with such products has been entirely satisfactory, both in ease of application and in subsequent protective performance. However, it is important that the surface to be treated be absolutely clean and oil and rust free to start with, otherwise a blotchy appearance will result, which also will probably not perform its 'anti-rust' duty as well as it should. It may be worthwhile giving the workpiece a preliminary degrease with a petroleum based cleaner and then following the manufacturer's normal sequence.

These UK systems are not expensive, but freighting them to the Antipodes is, and it becomes quite a bother to obtain supplies. To this end it may be preferred by readers in far away places to use other approaches. For example, G. Lautard in References 3 and 4 discusses a variety of procedures particularly directed towards gunsmiths, but of interest to home workshop operators also. These processes are generally not as simple or convenient as the UK systems referred to above. They are summarised in Appendix 1, where there are also listed various old time processes taken from Reference 5. These may be helpful to those people who cannot easily obtain the UK materials.

Copper, Brass and Bronze

These materials do not face corrosion problems of the severity of rusting steel, but do tarnish and may be considered aesthetically unsatisfactory as a result. However, the brownish patina which develops on bronze is much favoured in artistic circles, particularly on bronze statues and the like. Copper weathers to a light green colour - largely copper carbonates - which is also highly regarded.

Treatments

(a) Clear Lacquer

While the workpiece is in its pristine polished state, one or more coatings of clear lacquer sprayed on will materially slow down the rate of tarnishing. Brush application is not favoured as it yields a less uniform coating, but as spray packs of clear lacquer are readily obtainable, the spray application is easy to achieve. The only problem is that in some years time, when tarnishing does eventually occur, it becomes a bit of a pain to get the lacquer off again so that the object can be repolished.

(b) Accelerated Tarnish

If desired, it is possible to achieve rapid tarnish by producing a copper sulphide layer on the surface. Sodium sulphide is soluble in water, so by using a solution of say 50g in a litre of water, this result may be achieved. It is largely a matter of trial and error as to the colour obtained, depending on the exact composition of the article and the time it is immersed. However, about five minutes is a good starting point. It is possible to arrive at brown to golden colours for brass, making it look more like bronze using this process. 'Florentine' bronze, which looks rather like mahogany in colour, was originally produced by smoking the bronze articles over a fire of greasy rags and straw - seems a bit inconvenient. Acetic or sulphuric acid will yield a colour 'Vert Antique', similar to the verdigris produced naturally over lengthy times.

(c) Bright Dipping

This process produces a brilliant and clear surface of the natural colour of the metal. It is described in detail in Reference 1. However, its effect does not prevent subsequent tarnishing.

(d) Nickel Plating

This process is usually only for appearance, but may be helpful on knobs and handles (which can cause fingers to get smelly if the parts are of brass) and similar applications. The procedure is detailed in Reference 1.

(e) Chemical Nickel Plating

The electric fields created around the workpiece in an electroplating bath do not allow plating to occur inside holes and other deep depressions. In such cases, a better result can be obtained by using chemical action alone, without any electrical activity at all. Here, the plating will deposit anywhere the solution can reach, so a fairly uniform coating can be obtained inside and outside the object. Once more details are in Reference 1.

Aluminium

This metal is very resistant to corrosion as it forms a closely adhering oxide surface layer which prevents further erosion. Any damage to this layer is self repairing with atmospheric oxygen.

Aluminium alloys are not so resistant to corrosion, and for this reason materials such as Alclad were devised. This is a sandwich of a Duralumin core with thin facings either side of pure aluminium. This was widely used in the sheeting of aircraft.

Aluminium and its alloys can have their corrosion resistance enhanced by thickening up the oxide layer on the surface. This is done with an electrical process called anodising, which is like electroplating, but has the workpiece as its anode, unlike the deposition of metals which takes place at the cathode. Again, the details of the process are to be found in Reference 1.

It is possible to colour the anodised layer with dyes. This was very widely used for domestic articles straight after World War II. The appearance was rather garish and not overly popular. It doesn't seem to be much used nowadays, although black still finds favour.

It is also possible to nickel plate aluminium chemically, using the same approach as mentioned above for copper alloys.

Silver

Not usually found in the home workshop. However I wanted to record two blacking processes used by my father in the manufacture of silver jewellery as a hobby. The item is blackened in the solution and then the higher parts polished, leaving the lower parts blackened thus providing a pleasing contrast. Details of the processes are given in Appendix 2.

Conclusion

Hopefully, this article will allow appropriate decisions to be made as to whether a component should be given a protective coating and, if so, which coating to choose.

References

1. Electroplating - J.Poyner Workshop Practice Series No. 11, 1987.

2. Electroplating for the Amateur - L. Warburton, 1976.

3. Machinists Bedside Reader - G. Lautard, 1986.

4. Machinists Third Bedside Reader - G. Lautard 1993.

5. Chemical Formulary, 1910.

Appendix 1

Blacking and Blueing Steel and Cast Iron.- Summary.

1. Degreasing Treatments

(a) Solvent degreaser, usually petroleum based, and sold for use in the automotive and industrial trades - plus one of the following:-

(b) Boiling solution of 2.5% caustic soda (sodium hydroxide) for 5 minutes - reference 5

(c) Hot (80 deg. C) solution of:-

Sodium Hydroxide	40 g/1
Sodium Carbonate	25 g/1
Sodium Trisilicate	25 g/1

in a black steel tank for 2 to 10 minutes - Reference 1

(d) Proprietary mild alkaline degreaser blacking kits in the UK blacking kits at room temperature for 10 minutes.

2. Blacking/ Blueing Recipes

Those from G.Lautard are from (a) to (f) from References 3 and 4.

(a) Brownell Dicropan T4, liquid or cream, recommended for touching up scratches and wear areas on guns.

(b) Brownell Oxpho Blue, liquid or cream, recommended for occasional use for ease of application (piece of damp flannel) direct on surface. Goes through oil, removes thin rust and blues the underlying steel.

(c) Hot oil dip blue. Heat steel to a dull red then dip into engine oil, cutting oil or similar.

(d) Slow rust blueing. After degreasing allow steel to rust, then boil in water to convert red/brown ferrous oxide to blue/black ferric oxide.

(e) Acid fume blueing. Expose steel **in a closed container** to the fumes of concentrated sulphuric and nitric acids (one drop of each separately on a piece of glass in the container) for 5 to 6 hours. Then boil in water as in (d) above.

(f) Swedish process. Immerse parts in a black steel tank in a solution of

Sodium Hydroxide	1100 g/1
Sodium Nitrate	550 g/1
Sodium Nitrite	550 g/1

at 140 deg.C for 5 to 10 minutes. The temperature is critical. If not correct, a red coating may result instead of black.

Those below, (g) to (k) come from Reference 5.

(g) High temperature fusion process. Melt

Potassium Permanganate	1 part
Sodium Nitrate	2 parts
Potassium Nitrate	2 parts

and boil just above the melting temperature. Immerse object for 5 minutes, remove and wash with water.

(h) High temperature manganese process. Melt

Manganese Dioxide	1 part
Sodium Nitrate	9 parts

Immerse object for 5 minutes and wash with water.

(i) Blue/black hot process. Prepare solution of

Mercury Bichloride	30g
Potassium Chloride	30g
Potassium Nitrate	30g
Nitric Acid	45g

in 500 ml of distilled water.

Dip parts in boiling water for 5 minutes, then immerse in the solution at 60 deg. C for 5 minutes, then wash with water.

(j) Blue/black cold process. Prepare solution of

Iron Chloride	100g
Antimony Chloride	100g
Nitric Acid	50g

in 200 ml of distilled water.

Apply with a sponge, then dry and polish. Repeat until desired colour is obtained.

(k) Blazing off.

Dissolve 20g of Agricultural Sulphur in 500 ml of Mineral Turpentine. Dip parts in this then hold over a methylated spirit flame so that it does not ignite, but gradually fuses into and blackens the steel. Repeat until an even black.

3. Oil Treatment.

For all of the above, subsequently immerse the parts in dewatering oil such as WD 40 or similar commercial product, for 10 minutes for steel or 20 minutes for cast iron. Allow to air dry. After initial draining - say 30 minutes - it may be helpful to pat the part with a paper towel to mop up excess oil. It will probably take a week or more for the oil to dry.

4. Assessment.

It is evident from consideration of the processes 2(a) to (k) above that none is as convenient as the proprietary UK blacking solutions, which are therefore preferred. Of the others process (i) may be preferred for home manufacture or process (b) for a commercially purchased material.

Appendix 2

Blackening Silver

(a) Immerse parts in a solution of

Ammonium Chloride	50g
Copper Sulphate	50g
in dilute Acetic Acid	1 Litre

(Vinegar is satisfactory in lieu) for about 30 minutes. This gives a black finish.

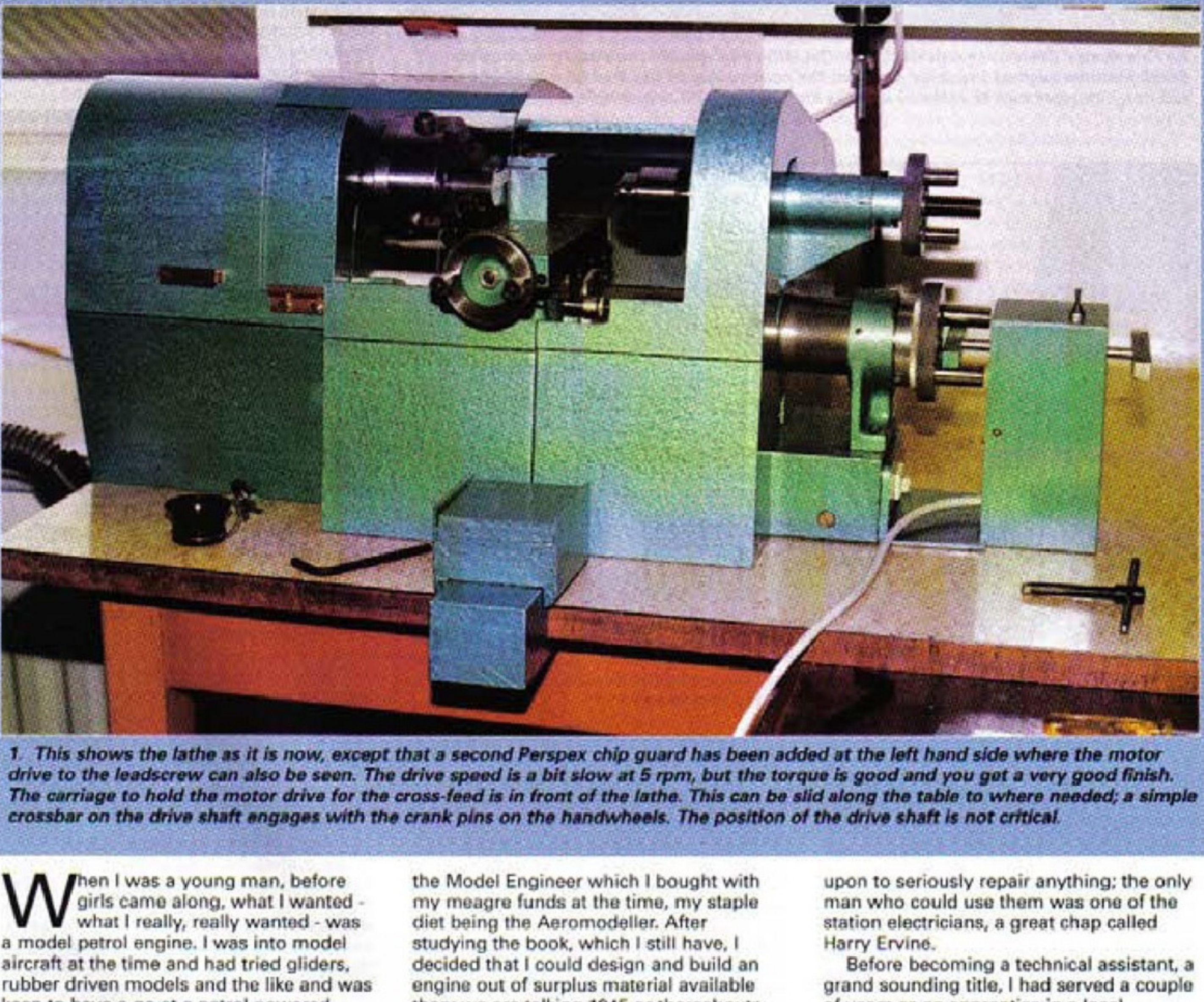
(b) Immerse parts in a solution of

Sodium Sulphide	50g/1

in water for about 30 minutes. This gives a browny black finish.

THE LATHE THAT TOOK FIFTY YEARS TO COMPLETE

In this two part article, Rex Galway of County Down describes how, over a long period, he built his own lathe and also gained many skills along the way

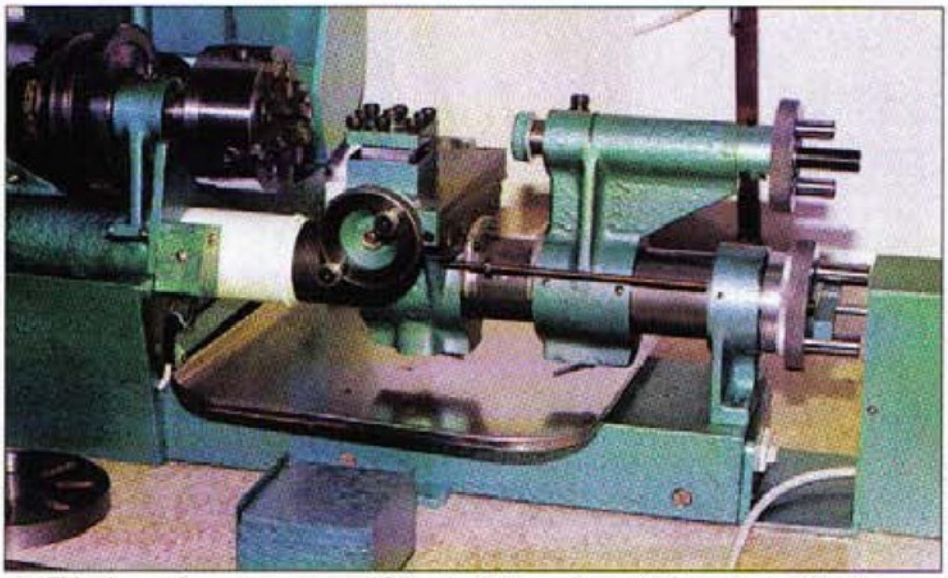


1. This shows the lathe as it is now, except that a second Perspex chip guard has been added at the left hand side where the motor drive to the leadscrew can also be seen. The drive speed is a bit slow at 5 rpm, but the torque is good and you get a very good finish. The carriage to hold the motor drive for the cross-feed is in front of the lathe. This can be slid along the table to where needed; a simple crossbar on the drive shaft engages with the crank pins on the handwheels. The position of the drive shaft is not critical.

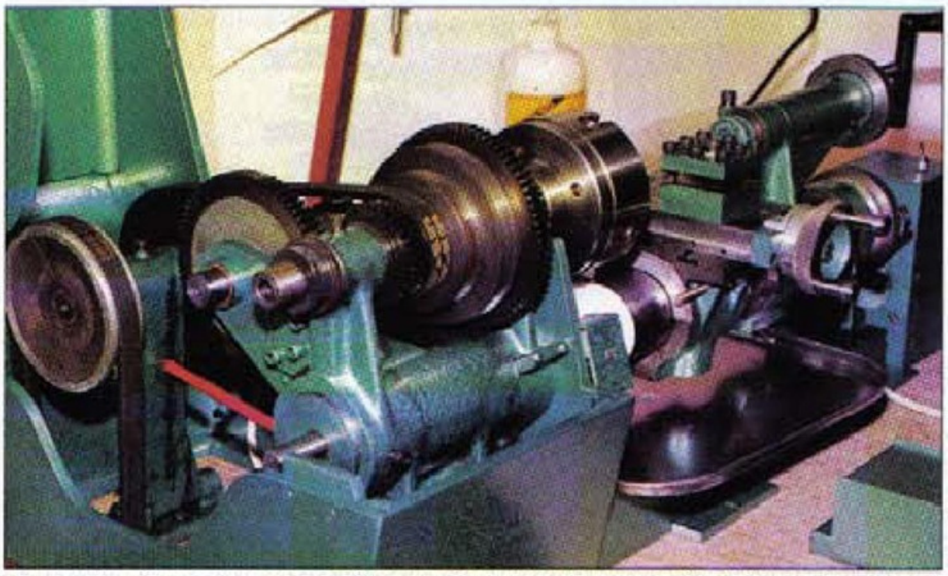
When I was a young man, before girls came along, what I wanted - what I really, really wanted - was a model petrol engine. I was into model aircraft at the time and had tried gliders, rubber driven models and the like and was keen to have a go at a petrol powered model, but the nearest I came to it at was the loan of an engine by a good friend. It was called a 'Spitfire' by him but it was without an ignition system; I was never able to trace the design afterwards, but I had great pleasure just handling it, flicking the propeller over and listening to the very satisfactory noise as it went over top dead centre. After a while I bought Edgar Westbury's Model Petrol Engines book, noticed probably in the occasional copy of the Model Engineer which I bought with my meagre funds at the time, my staple diet being the Aeromodeller. After studying the book, which I still have, I decided that I could design and build an engine out of surplus material available then; we are talking 1945 or thereabouts now.

I was working as a technical assistant for a major broadcasting company (there was only one then) at one of their transmitting stations which was well equipped having a workshop to tackle any war-time emergency; the main equipment in it was a lathe, a vertical drill and a bench grinder. Now nobody on the technical staff had much idea of how to use these items, never having been called upon to seriously repair anything; the only man who could use them was one of the station electricians, a great chap called Harry Ervine.

Before becoming a technical assistant, a grand sounding title, I had served a couple of years as an apprentice in a local electrical installation firm specialising in the fitting and repair of electric motors of all sizes. As luck would have it I was on the 'Outside Squad' whose job it was to fit electrical equipment in workshops, factories and mills. I had therefore seen much machining, inside and out of our own firm, including an enormous lathe turning the steel driving wheel tyres for locomotives on the Belfast and County Down Railway. Many other wonderful



2. This shows the covers removed from the lathe and reveals the structural details. Small features such as the drive pin from the cone pulley to the backgear gearwheel (the red dot, a quarter turn to release) and the limit switch and actuating rod are also seen.



3. Another view of the works. Of interest is the simple means of speed changing; the red dowel is just pulled away and the pulley strut can be folded forward, slackening the 'V' belt sufficiently to allowing it to be moved to the required position. Put the dowel back and off you go.

places were opened to me; iron foundries, brass foundries, coppersmiths who shaped massive piping runs for ships built locally, textile mills and textile machine manufacturing workshops were also visited in the course of work, but I digress.

So, with the confidence of youth, the advice given freely by Harry Ervine and the availability of a workshop, I decided to build a petrol engine.

I was encouraged by my technical superiors to become conversant with the use of the lathe. In those days, the transmitter was shut down before midnight and was not started up again until six-thirty in the morning, so apart from a short period of maintenance work on the transmitting equipment each nightshift I was on duty, I could have about five hours in the workshop. My other shift mates either got their heads down or played snooker; I told you it was well equipped didn't I?

Anyway, I produced an engine design on one sheet of paper and started to cut metal; the cylinder was to be a finned Duralumin tube with a steel liner with the transfer ports and passages machined between both. I managed to turn the Dural outer cylinder, but it became obvious to my mentor Harry, and eventually to me, that the lathe I was using was really bigger than required for my task - it probably had an eight inch chuck since some of the items it was intended for were quite large.

A change of direction

"What you need is a smaller lathe like a Drummond" advised Harry. Well, for all my vast couple of years experience of machine shops at that time, I had never come across a Drummond, though I had seen smaller lathes, probably early Myfords. My question "What's a Drummond?" prompted a very full explanation of the round bed lathe from my good friend. It would not have been an 'in' phrase at the time but it was a case of 'Back to the Drawing Board', this time to draw a round bed lathe. If the lathe I had available to me was too large to make a small petrol engine, it probably would be about the right size to make a small lathe that could make the much desired engine.

This time the drawings were done with greater care and the final version was produced on blue linen tracing cloth, unfortunately since lost, but equally fortunately I had some dyeline prints produced which have survived.

Like many designs, particularly amateur ones, size is controlled not only by the machines available to manufacture it, but by the materials available at the time; in my case the most suitable material for the round bed was an unlikely piece of scaffolding tubing which came from who knows where. I cannot recall what determined the overall length of the bed, perhaps that was all the length of tube I had or perhaps the tracing linen just happened to be that width; however it looked about right on the drawing and although now I occasionally wish for an inch or two more (who hasn't) for most work it has been adequate. The exact diameter of the bed was controlled by how much had to be skimmed off the scaffold tube to leave a clean smooth cylinder This operation was carried out between centres, the ends having been closed off with half inch thick disks recessed into it. Looking back, I cannot recall how I machined the recesses since I did not have a fixed steady available. Perhaps the spindle bore on the big lathe could accommodate the diameter of the embryo lathe bed (1.85in.). Whatever method was used, the same end plates are in the little machine to this day, duly bushed to carry the leadscrew and retained by four Whitworth countersunk screws at each end.

I do remember, during the skimming process, having to experiment with the cutting tool shape and the lubrication to achieve a satisfactory finish on what was probably not meant to be a machineable mild steel. A reasonable finish was achieved as can be seen from the photographs; fortunately without reducing the wall thickness of the bed beyond an acceptable limit.

Patterns and castings

Having reached this stage, critical to the whole project, I could now proceed to get some castings made. As mentioned earlier, my foreshortened apprenticeship had acquainted me with the casting process and indeed pattern making, but it was Harry who knew about pattern makers rulers and how they allowed for the casting to shrink on cooling from the pattern size to the required size for the job in hand, taking into account the metal being cast. Armed with this new knowledge as well as a little about cores and coring as well as draught angles (essential to let the pattern to withdrawn from the sand mould without disturbing the sand), I made wooden patterns for the headstock, the tailstock and the end support for the tail end of the bed. Later, further patterns were made, one for a three step cone pulley, one for a faceplate, doubling for chuck backplates, and ones for a pulley strut and hinge plate (to allow belt changing by moving the rear pulley backwards and forwards when changing the spindle speed). The finished articles can be clearly seen in Photos. **2 & 3**. All of the wood turning was done using metal turning techniques rather than wood turning chisels; the speed range available would have been too low for these - to say nothing of my lack of skill. My aero modelling skills were brought into play in making and finishing those pieces that could not be machined; sufficient to say that my efforts were not derided when I presented my patterns to a local iron founder.

At the end of the war and indeed for some time afterwards, it was very easy to get castings made and I was fortunate to have a small foundry directly on my way home from work. Fortunate indeed because the foundry master turned out to be a great character who became very interested in my project and most helpful when caught in the right mood. However, the foundry was adjacent to a local hostelry, visited more often than wisely by my new friend, and on a bad day the moulders and foundrymen could get the very rough side of his tongue, although I must say I never suffered that fate. Perhaps being a ready cash customer helped.

Machining cast iron

Having got castings to hand it was time to a learn a few lessons about turning cast iron, taught by you-know-who, using both the four jaw chuck and the faceplate and more different shaped cutting tools. My first cuts in cast iron made cleaning up the steps on the cone pulleys using the lathe in back geared mode; very straightforward until it came to cutting the grooves to suit Mr. Fenner's new 'V' belts. Well, relatively new at that time. For example, the little workshop that I was using was powered by a single electric motor driving an overhead layshaft with drive and idling pulleys for each machine, the drive being by flat belts.

My first serious disaster came when trying to cut a straight sided starter groove with too wide a cutter, ground like the parting tool used to cut the fins on my Dural engine cylinder. I still have the scrapped pulley, now used as a counter-weight on a power drill vertical stand. A narrower tool and lighter cuts proved to be a cure and by angle setting the cross-slide, two nice 'V' cone pulleys were produced; the holes for the shafts were drilled from the tailstock. I had my baptism by fire and no further disasters occurred.

Boring and facing the headstock came next. I was advised by my Guru to use the faceplate to mount the casting on the lathe, first cleaning up one face by file to give a reasonably flat and true mounting surface. Packing pieces to allow the boring tool to clear the casting without hitting the faceplate were required as were various bolts and clamps to hold everything firm. All was checked and double checked to see if the best possible alignment had been achieved, using chalk on the casting and a scriber clamped to the cross-slide - eventually satisfaction was achieved and I was ready to start boring. A stout boring tool had been made just long enough to clear the casting using a toolsteel tip from Eclipse, another novelty in those years.

Dire warnings had been issued on the necessity of getting through the skin of the casting and taking due account of this, work proceeded well; this was the first time I had used automatic feed on the lathe, all earlier work having been done with hand feed. I am still amazed at how good a sliding fit I got using a small set of Moore and Wright simple inside and outside calipers, but I suppose I knew how many chances you get at getting it right and I carefully took all one of them. The tailstock and the end support share the same diameter bore and were all machined on the faceplate in the same manner as the headstock.

Boring the lathe spindle holes and that for the tailstock barrel were also carried out on the faceplate; a spigot, the same diameter as the bed was made and mounted offset by the distance required to give the desired centre height. The two castings were mounted on the plate in turn and after careful alignment and firm clamping drilling was carried out from the tailstock chuck. The bore of the tailstock was reamed to size before being taken off the machine. I had obtained a number of reamers from surplus outlets, there being plenty of war surplus tools available then (if only I had had the money), and some of these determined what size some holes would be rather than pure choice. We shall see shortly why it was most important to have the tailstock bore very precise. The headstock bores were left as drilled for the time being. The headstock had slits cut in its wall, fore and aft, to allow it to be clamped to the cylindrical bed; holes were drilled and tapped, Whitworth threads again, to house the clamping screws. Two large holes were drilled in the positions of the oilers in the front and rear mandrel bearings. The tailstock, which of course had to slide readily on the round bed, had one hole drilled and tapped in the bottom to allow a quick release clamping screw to be used; the barrel hole was split and another clamping screw was provided to allow the barrel to be clamped in any longitudinal position.

A Morse taper tailstock barrel

The time had come to move back to machining steel again; I had obtained some short lengths of suitable diameter stock which proved to be quite machineable, producing a tolerable finish in my inexpert hands. From this I first required a tailstock barrel, drilled throughout its length and with a female number one Morse taper at the front end. Harry had warned me of the snares and pitfalls of a three jaw self-centring chuck, preferring a four jaw independent, a feeling I now have myself. He said if you must use a self-centring chuck, do all your machining at one chucking if you require concentricity of all your diameters. Since the only test indicator I had, and still have, was a little Unique, good enough in its own way, but I did not think it would be good enough to set up an independent four jaw, so I started with oversized material in the three jaw self-centring and did all the critical machining in one set up. The barrel diameter, with a good finish, was obtained; again I was surprised at the nice sliding fit that I got. The through hole and Morse taper were simply achieved, the latter with a small boring tool, offsetting the cross-slide by approximately the required amount and following up with a new No. 1 Morse taper reamer, bought at huge expense to me. It has proved to have been money well spent, since it has been used to this day to clean up damaged tapers caused by slipping drill chucks and taper shanked tools. I have come to the conclusion that I am a 'miserable old git' since I tend to buy things at 'bargain prices', only to be let down in the long run. Not so with my No. 1 Morse taper reamer.

Casting white metal bearings

I now had to hand a machined headstock, a tailstock, an end support, a partially machined tailstock barrel and two completed pulleys. Time to think about the spindle and spindle bearings. White metal bearings were common at that time and bearing metal was easily obtained and easily cast. I had read in an American magazine (was it 'Mechanix'?), about a chap, or was it a guy, who had cast lathe bearings in situ on a home-made lathe and I decided to do the same.

The method was to turn up a dummy spindle with the diameters for the main and tail bearings a few thou. less than the intended running spindle; this dummy spindle was extended beyond the main bearing and a No. 1 Morse taper turned on this extension. All this was done between centres, another new experience, and the Morse taper had to be checked against the female taper in the tailstock barrel, correctly finished with the commercial reamer. Harry showed me how to use 'Engineer's Blue' to indicate whether I was making good contact throughout the taper; a very useful lesson learnt on a very difficult object, a small taper. The two bearing diameters of the dummy spindle were given a slight taper towards the rear of the headstock by setting over the centre on the turning lathe with a piece of a cigarette pack, there being no fine adjustment available.

To pour the white metal bearings, the little lathe was assembled into what approximated to its final configuration. The tailstock and barrel were adjusted so that the dummy spindle Morse taper was held firmly, with the two approximate bearing diameters located where required to give two annular holes at the tail and main bearing positions on the headstock. Thin tinplate retaining washers had been cut to close off the ends of the annuli, these being held in place with circlips made out of piano wire. When the alignment had been checked (for the umpteenth time), nothing remained but to melt the white metal and pour it into the annular cavities through the large holes where the bearing lubricators would be positioned. After all had cooled down, the dummy spindle was released from the barrel taper with a few light taps, allowing the tailstock to be removed. A further series of more severe blows removed the dummy spindle out of the headstock once the gentle tapers at the bearings had released. After the sprue and external surfaces had been cleaned up, the holes for the oilers were drilled and tapped in the white metal. Finally, the bearings were reamed to size, removing the few thou of excess metal and the slight taper.

This process of bearing production was the key to the ultimate success of the project; it worked first time, giving alignment between headstock and tailstock better than I could have achieved by machining with my limited resources and experience at that time. Above all, the bearings are still running to this day.

The spindle

I was, of course, still a good way off having a usable machine tool, but having got the feel of turning the steel available to me on the parts already made, the working spindle was turned with some confidence. First, the spindle blank was mounted in the three jaw chuck and drilled throughout its length and a female No. 1 Morse taper machined and reamed at the chuck end as in the tailstock barrel. I had decided to have a taper seating for the faceplate and the chuck backplates as it seemed easier to me to machine a simple taper than very precise internal diameters. Since it was my intention to take the final cuts on the critical mounting faces in situ; any error in the taper fit, which would be repeated at each mating, would be eliminated. Over the years this has proved to be the case and there has been no jamming. of the tapers when removing the chucks or faceplate. **Photo. 4** shows this detail and the retaining screw thread which was machined whilst still mounted in the three jaw. Screw cutting on the lathe was again a new technique to me, and again I owe my success to my tutor Harry Ervine. On completion of the critical nose area, the embryo spindle was mounted between centres to finish the tail bearing area; this was done slightly differently than before, using a No. 1 Morse taper hard centre in the new spindle and located in a hole made by a Slocombe centre drill in a brass block attached to the faceplate. This ensured that the spindle nose was running true. The tail end relied on the accuracy of the through hole drilling which was luckily not too bad, and it was easy to correct the small error with a small scraper using the Unique test indicator.

The spindle diameter was reduced to within a few thou. of its final value and a fine pitched screw thread cut at the end to provide a means to adjust the spindle end play and a possible method of retaining change wheels; such ambitions for a small home made lathe!

I am trying to remember when I got my first Moore and Wright micrometer and I think it must have been about this time because the reduction to the final diameters on the running surfaces, with a good finish, would have been very difficult without one. I do not recall polishing these surfaces, but I must have, having found the hardened remains of a red coloured abrasive compound in my old 'bits and pieces' box which would have had no other purpose.

A trial fitting of the spindle showed that the tail bearing was a good running fit, but the main bearing was very tight; at this stage the slitting of the main bearing, to allow for wear, had not been carried out. When this was done and the bearing sprung open a little with a thin sliver of Tufnol plastic laminate, the spindle turned reasonably freely. Need I say that that piece of plastic is still in place and the spindle, now well run in, runs very freely with no discernible side play as shown on a dial gauge, even with a considerable side load applied to the nose.

The motorised drive

I mentioned earlier that the pattern for the face plate doubled for the chuck backplate. I should have said trebled, because it was also used to cast the blanks for the large gear wheels for the back gearing train. Anxious to see the final assembly up and running, I turned up the back gear blank, reamed it and one of the cone pulleys to be free running on the spindle shaft, and assembled the complete spindle in the headstock. Thrust ball races were sandwiched between the back gear blank and the pulley and on either side of the tail bearing pillar, all end play being taken out by a lockable nut on the tail thread of the spindle **(see Photo. 3)**. A pity I forgot to put the 'V' belt on between the two bearing pillars before I started; a good trial assembly anyway and, after a few choice words, the belt was soon in place One advantage of this false start was that the position of the grub screw that was to initially fasten the gear blank was marked and, before re-assembly, a flat was filed on the spindle, improving the clamping. Later, a Woodruffe key would be fitted as well, to take the heavier loads when the back gears are in action.

The second cone pulley was mounted on its swinging strut, which had been drilled and reamed to take a short shaft, on the other end of which was fitted a Fenner pulley. A 'V' belt drive was taken to an electric motor mail ordered from Gamages. Initially, all of this was mounted, best engineering fashion, on a sturdy angle iron frame which was got on the surplus market, having previously housed some naval electronic equipment. The whole assembly looked ship-shape and was rounded off by a very professional stop-start button switch, also from surplus sources. On top of this frame, a stout piece of plywood provided the initial mount for the lathe proper, but later it became obvious that something stiffer would be advantageous.

On the lathe, the drive from the cone pulley, free to rotate on the spindle, to the gear blank was by a hardened steel pin which, with an arrangement of tapers, notches and a circlip, could be held firmly in the drive position or ejected by simply giving it a quarter turn by a screwdriver slot in its end face. This can be seen in **Photo. 2** which shows the machine in its present state with the back gearing complete. It is the little red dot on the gear wheel. Now that frequent use has been made of the back gears, I can report that this rather simple system has worked perfectly, never failing under drive or refusing to release when required.

So the big switch-on day arrived. With all bearings lubricated, the belts were set for slow speed, held in tension by a simple wooden dowel between the head casting and the pulley strut. This method, still in use, gives the quickest possible belt position change and has yet to fail. When the switch button was pressed and everything was running happily, the main bearing got slightly warm, but not seriously so. After a little while the speed was increased, and soon the bearing was running cool at the maximum speed of about 1400 rpm. Running in was an accepted part of life in those days as far as white metal bearings were concerned; if you were lucky to have a new car, or more likely, one with a reconditioned engine, woe betide you if you exceeded thirty mph or let the engine labour until it had done at least 500 miles.

4. Here the tapered seating for the chucks and faceplate can be seen, along with the threaded nose of the spindle; there has never been a jam on the taper, even after a period of heavy intermittent cuts which would tend to hammer the tapered surfaces together.

1. Bar held in vice ready to be end-milled to a 'T' slot width (note paper between jaws and bar)

MODIFICATION TO A MILLING MACHINE VICE

Fitting tenons to tooling which is to be bolted to the milling machine table can be a time saving move. Pat Twist demonstrates that it is a simple task

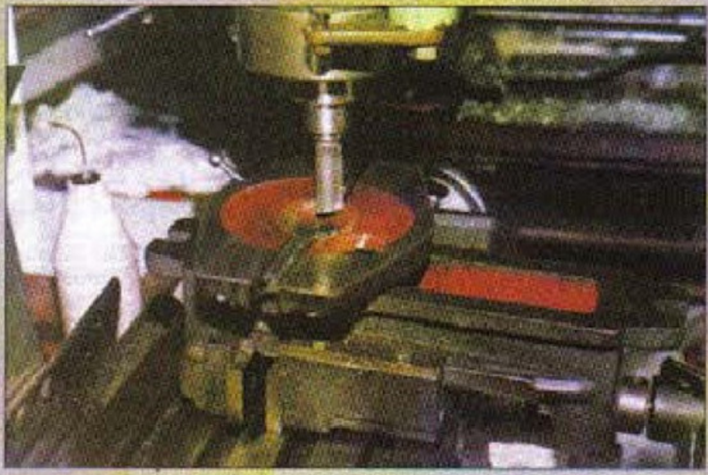
For a long time I had set my vice square on the milling machine table using a D.T.I. against a parallel in the vice jaws. Now, I can just place the vice on the table, bolt it down, and it is absolutely correct every time. I cannot think how it was that it took me so long to get round to doing it, so if you would like to have the same facility, just follow the instructions.

Firstly, measure the distance between the ends of the bolting down slots of the vice and cut off the same length of a piece of square mild steel a little larger than the 'T'- slot width. In my case it was 7in. x $^5/_8$in. x $^5/_8$in. Holding this bar horizontally in the vice, machine the thickness until it is a close fit in a 'T'- slot. To get my bar a really close fit it was end milled to within a thou or two and then draw-filed, checking with a micrometer. Now grip the bar turned through 90 deg. horizontally in the jaws again, but leave half of the thickness of the bar in the jaws and half above. Tighten the vice securely and turn it upside down, fitting the bar into a 'T' slot, and bolt the vice to the table with clamps.

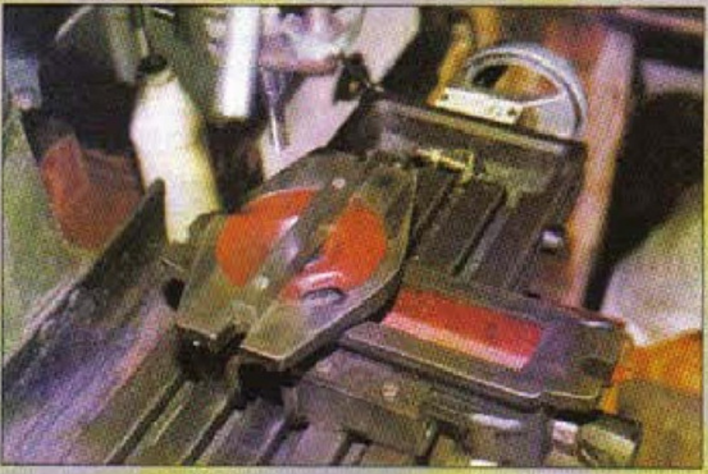
With an end mill centrally over the bolting down slots, cut a $^1/_8$in. deep slot in the base of the vice using an end mill smaller than the 'T' slot width, progressively widening the slot a little each side, keeping the slot central until it is a 'T' slot width.

You are now practically there. Unclamp the vice from the table, remove the bar from the jaws and fit it in the slot that you have cut in the base. Fasten the bar with two counterbored screws (or you could use Loctite), and if you have made the bar a good close fit in a 'T' slot and also in the base of the vice, when you check the accuracy with a 'clock', you should be absolutely spot-on.

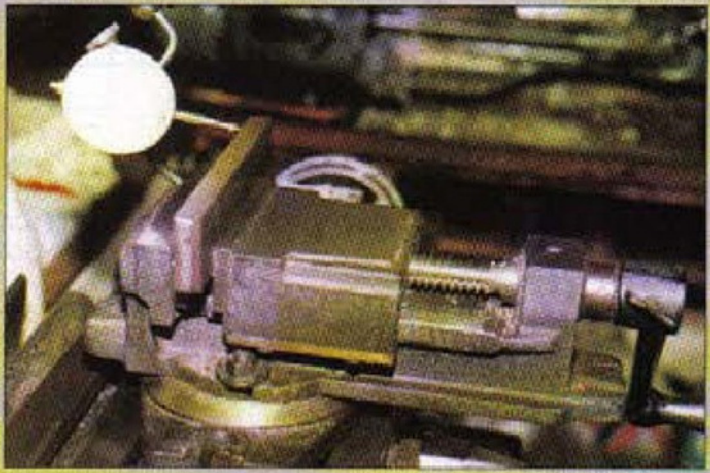
2. Draw-filing the bar to get a good tight fit in a 'T' slot



3. Cutting the $^1/_8$in. deep slot in the base of the vice



4. Bar screwed in place, taking care not to let the tapping drill break through into the protractor markings



5. Testing the accuracy with a D.T.I.

SPARK EROSION MACHINE

Peter Rawlinson continues his description of this interesting machine with details of the main power supply unit and goes on to provide a test schedule for the PCB. There are, however, some amendments to the information given in Issue 57

Amendments and corrections

Before describing the next part of the circuitry, I must bring to the attention of readers some changes to the information given in the previous issue. Reader Hugh Castellan has pointed out a number of errors and inconsistencies and I must thank him for his help and advice.

Output transistors (Q1, Q2, Q3 and Q4)

The output transistors originally specified by Robert Langlois were 2N6387. These were not available in the UK, but I was able to get hold of some 2N6388 which were used on my original board. I was assured that the TIP140 was a plug-in equivalent, but it now transpires that this is not so, the legs needing to be closed in as they are spread too far apart to suit the PCB. This should not cause too much of a problem, but if you have not already acquired the components, I suggest that you use the 2N6388 standard which will fit correctly. There is a company willing to import the 2N6387 from the USA, but I think that the price may be prohibitive.

Control Circuit corrections

When discussing the output transistors, it was pointed out that I have shown the arrows denoting the emitter pointing in the wrong direction (I told you that I was more comfortable with valves than with transistors, didn't I?). The corrected diagram is shown in **Fig. 1c**, and the same goes for Q5 **(see Fig. 1d)**. The numbers were also missed off IC6c, so I have also shown them in **Fig. 1d**.

When looking at IC6, I also realise that there is an earth connection missing from IC6b, so this is shown in **Fig. 1e**. The last amendment to the circuit diagram **(Fig. 1f)** is the addition of numbers to the connections of IC5. Incidentally, the horizontal line above the word 'LIMIT' is spurious and should be ignored.

None of the above omissions make a lot of difference in practice, as the connections are taken care of on the PCB. There are, however, a few changes which need to be made to the board layout, previously shown as **Fig. 3**.

PCB changes

When the PCB diagram was re-traced in order to get the essential dimensions correct, a number of the very small links (five in total) were omitted. Apologies to anyone who has been inconvenienced by this. It would be easy to add them to the original **Figure 3**, but to avoid causing confusion to anyone starting from scratch, a revised **Fig. 3** is included here.

Clarification of component layout

It may be helpful, when referring to **Fig. 5**, the Component Layout, to have additional information regarding the orientation of some of the components. For instance, when locating the output transistors (Q1 to Q4), the positions of the Emitter (E), Collector (C) and Base (B) are as shown in **Fig. 5b**. When fitted, they are placed as shown in **Fig. 5c**, Q4 being shown as typical. Similarly, Q5 **(Fig. 5d)** and IC7 **(Fig 5e)** should be located as illustrated. These orientations correspond to the notes given in the grey panel on page 54 of Issue 57, the 'top' edge of the board being that on which the terminal sockets are located.

Main Power Supply

The five power circuits are detailed on **Figure 6** and a list of components is given at the end of this article. Some suggestions on the manufacture of a suitable case, component layout and wiring are also given, but if builders are keen to press ahead, it is suggested that just the 12V and 6V AC circuits which power the stepper motors and the PCB could be assembled as 'breadboard' units for now. The essential thing is to ensure that the components are well protected to ensure that there is no possibility of hands (or any other part of the anatomy for that matter!) coming into contact with live terminals. **REMEMBER 230 volts can be LETHAL.**

Testing the control circuit

We now come to the testing of the board which is carried out in stages. As a safety precaution **ALWAYS** turn off the power at the mains (not between the power pack and the board) between each set of checks or operations. I know that the voltages in use do no harm to humans, but they do damage transistors.

Check 1

This is a check of the voltages seen at the pins of the bases of the ICs, before the ICs are fitted.

1.1 Attach the 6V AC power supply and switch on. The red LED should light.

1.2 With a suitable meter, check the output voltage which should be 4.5 to 5.1V

1.3 With the negative lead of the meter connected to 'PCB Chassis', check the following voltages:-

IC No.	Pin No.	Voltage
1	1	0
	4	5
	7	5
	8	5

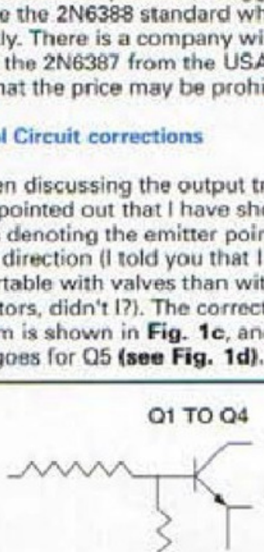


FIG. 1c OUTPUT TRANSISTOR CONNECTIONS

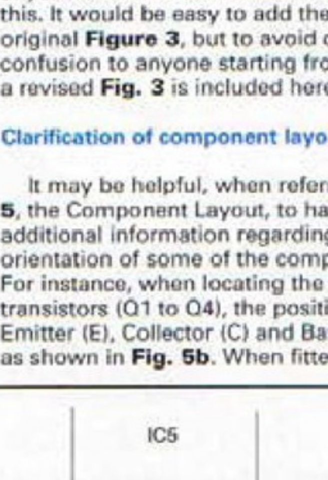
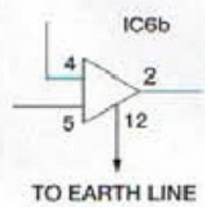


FIG. 1f CLARIFICATION OF IC5 CONNECTION



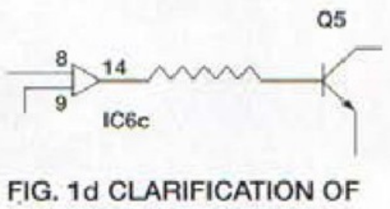


FIG. 1d CLARIFICATION OF IC6 CONNECTIONS

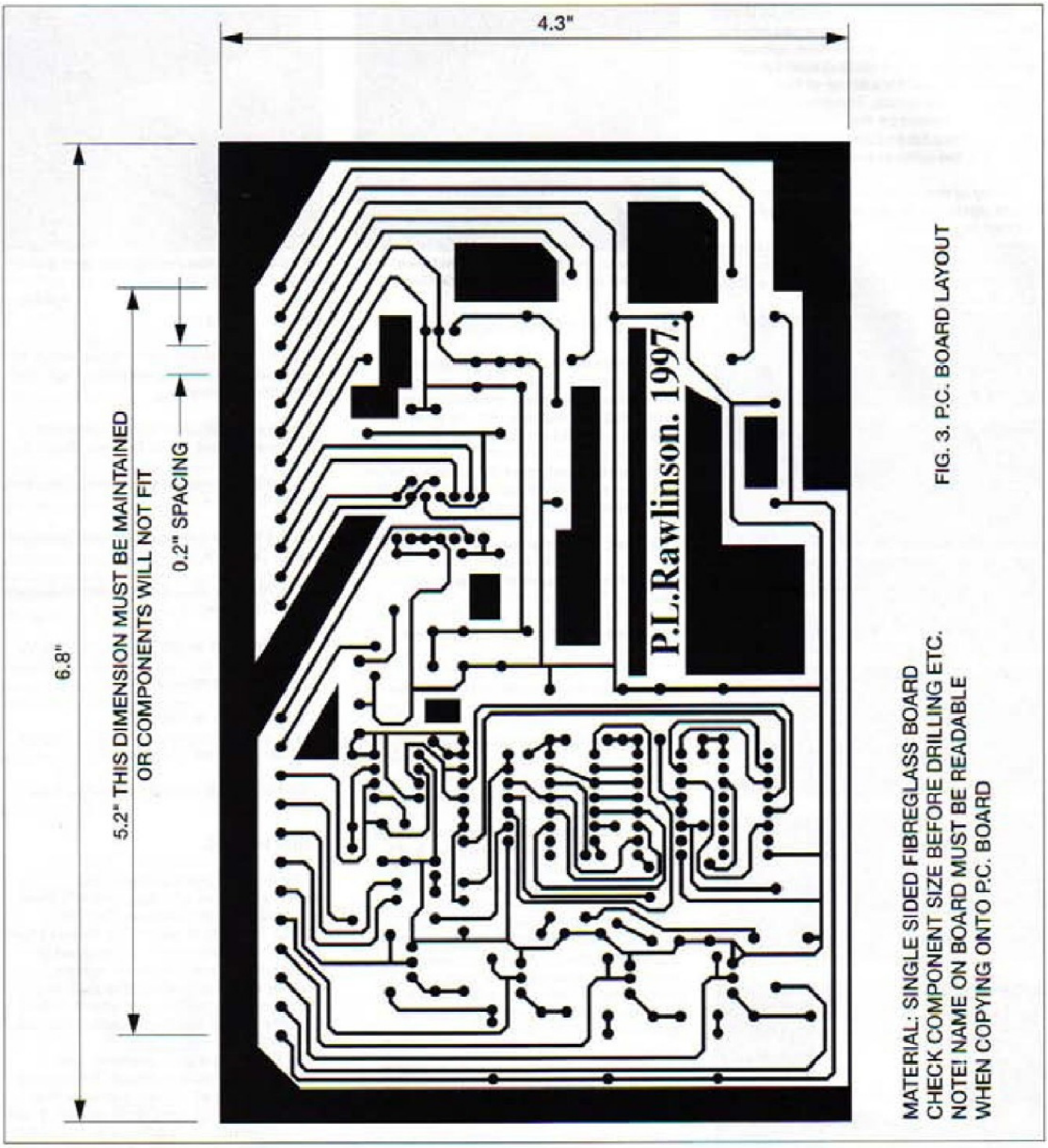


FIG. 3. P.C. BOARD LAYOUT

FIG. 5b OUTPUT TRANSISTOR CONNECTIONS

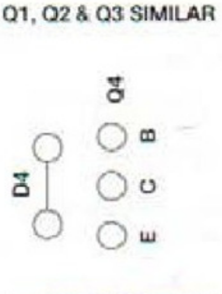


FIG. 5c ORIENTATION OF OUTPUT TRANSISTORS

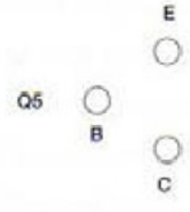


FIG.5d ORIENTATION OF Q5

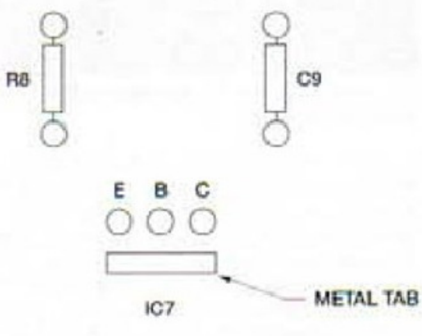


FIG. 5e ORIENTATION OF IC7

Check all the other pins as well as those listed above. None should give the full 5 volt reading, but some will have voltage readings of up to 2.5 volts due to there being connections via some of the resistors in the circuit. The actual voltage will be dependent on the meter resistance, as the current taken by the meter will influence the voltage drop in the resistor in circuit.

If any of the above are incorrect then check again for shorts or breaks, and correct as necessary.

1.4 Check all the other IC bases in a similar manner, the required values being as follows:-

IC No.	Pin No.	Voltage
2	6	0
	7	0
	14	5

IC No.	Pin No.	Voltage
3	6	0
	7	0
	8	0
	12	0
	14	5

IC No.	Pin No.	Voltage
4	8	0
	14	0
	16	5

IC No.	Pin No.	Voltage
5	4	0
	5	0
	6	5
	8	0
	16	5

IC No.	Pin No.	Voltage
6	1	5
	2	5
	3	5
	11	0
	12	0
	13	0

13. Checking the AC voltage to the stepper rectifier

1.5 Now also switch on the power for the stepper motors. A reading of some 17 volts DC should be seen between SMV+ and earth. If this is correct, then I suggest that with both the 5 volt and 12 volt supplies switched on, the same check should be carried out to confirm that the higher voltage is not where it should not be and, by following the circuit, where it should be **(Photo. 13)**.

14. The potentiometers and switches mounted on a slave board to facilitate testing

Stepper Motor Wiring

The next action is to fit the external wiring, which includes that to the stepper motor. If you purchase the unit mentioned at the end of the article, then the wiring sequence should be as follows:-

1. Connect both the RED wires together and connect to SMV+ with four ends of 0.1µf capacitors.

2. Next, miss one terminal.

3 Yellow to next terminal, plus one capacitor.

4. Brown to next terminal, plus one capacitor.

5. Orange to next terminal, plus one capacitor.

6. Black to next terminal, plus one capacitor.

Switch and potentiometer wiring

Next the switches and potentiometers, which can be seen in **Photos 14 & 15**. The switches select 'Auto/Manual' and 'Up/Down' while the 'pots' control 'Speed' and the 'High' and 'Low' Reference voltages. I suggest that a small slave mounting board be made up similar to the one seen in the photos then, when all is working, the switches and 'pots' can be transferred to their permanent site. It will be found easier to work in this way, as everything is out in the open.

Wire the switches as shown in **Figure 1a** and the photos. I used the following colour wires for clarity:-

Red to Terminal No. 7 on Terminal Block 1

White to Terminal No. 8 (Block 1)

Green to Terminal No. 13 (Block 2)

Blue to Terminal No 14 (Block 2)

Black to Terminal No. 18 (Block 2)

Grey to Terminal No. 22 (Block 2)

Next, wire the Speed 'pot' **(Figure 1 and Photo. 15)** as follows:-

Yellow to Terminal No. 9 (Block 1)

Mauve to Terminal No. 10 (Block 1)

15. Details of the switch and Speed pot wiring

Set-up resistors

Now to fit the set-up resistors which will eventually be replaced with the 'High' and 'Low' potentiometers

Wire a 10,000 ohm resistor between Terminals 15 and 18 on Terminal Block 2

A 1,000 ohm resistor between Terminals 15 and 19 (Block 2)

A 4,700 ohm resistor between Terminals 16 and 18 (Block 2)

A 4,700 ohm resistor between Terminals 16 and 19 (Block 2)

Also fit loose wires to:-

SMV+, Terminal 1 (Block 1)

5V, Terminal 18 (Block 2)

VCap, Terminal 17 (Block 2)

Seal the ends of these wires for now.

Logic testing

We now require a piece of test equipment called a " Logic Probe " These are available from Maplins, Part No. FY73Q. These cost about £25, so this could be another good reason for working in groups. If, like me, you are a relative newcomer to electronics, you may not have come across this instrument before, so a few simple words of explanation may be in order.

The probe is a 'self powered' low voltage optical voltage meter, set to show specific ranges of voltage and sensitive enough to pick up very short pulses. It has a very high input impedance so that it will not interfere with the correct working of the circuit under test.

The probe is shown in the accompanying photographs and consists of a hand held device which draws its power from the circuit being tested. It is fitted with Positive and Negative leads which are attached at convenient positions on the board (the correct way round of course!).

The probe is fitted with three Light Emitting Diodes:-

Red = HI-Logic (High Voltage)

Green = LO-Logic (Low Voltage)

Yellow = Pulse

16. The logic probe is used to test the circuit at the ICs. A 'Green - LO' indication is evident

17. Note the different indication

It is also fitted with two switches:-

1. 'TTL' or 'CMOS' is set according to the type of ICs being used

2. 'Pulse' or 'MEM' - 'Pulse' will show the continuous line of pulses being detected, but if these are too short to see, switching to 'MEM' will latch them into a steady indication.

On initial connection, the Yellow LED will pulse once, but if it continues to do so, the ripple in the power supply should be checked (this could be due to a bad capacitor or a faulty rectifier).

With the types of circuits that we are creating we are dealing with pulses of power, i. e. the switching of 0 - 5 volts, the indications are as follows:-

Green (Logic LO) - (less than)0.8V (plus or minus)0.2V

Red (Logic HI) - (greater than)2.3V (plus or minus)0.2V

No indication - 0.8V - 2.3V

Yellow - Pulses in the circuit under test

For a short demo of the workings of the Logic Probe we can now go to the first stage of the test procedure detailed below. IC6 is plugged in then the probe leads connected, the switch settings being 'TTL' and 'Pulse'.

With the 5V DC supply switched on, the tip of the probe is placed very carefully on to Pin No. 1. A 'Green' indication should now be evident **(Photo. 16)**. By connecting momentarily between the 5V line and Pin 7, the indication on Pin 1 should change from 'Green' to 'Red' (Logic LO to Logic HI), showing that the transistor has changed its routing or switched. A similar test with the probe tip on Pin 2 should change the indication from 'Red' to 'Green'.

A demonstration of the Yellow 'Pulse' indication will be seen when testing IC2 **(Photo 17)**, this being the correct indications from Pins 11, 12 and 13. This will be in addition to the 'Red' and 'Green' indications appearing as the voltage pulses between the two. This can be seen especially on Pin 6 of IC2 if the 'Speed' control is turned right down.

The full test procedure is as follows (don't forget to switch off between each set of operations):-

1. Set the switches as follows:-
   Auto/Manual to Manual
   Up/Down either way

2. Plug in IC6 and switch on

Pin No.	Indication
1	Green (LO)
2	Red (HI)
3	Red (HI)
4	Green (LO)
5	0.5V (use voltmeter)
6	2.5V (use voltmeter)
7	Green (LO)
8	---
9	---
10	---
11	---
12	Green (LO)
13	---
14	---

2.1 Connect momentarily from 5V to Pin 7

Pin 1 should change from Green to Red (LO to HI)
Pin 2 should change from Red to Green (HI to LO)

2.2 Connect momentarily from Vcap to SMV+
Pin 1 unchanged at Logic LO
Pin 2 should change from Red to Green (HI to LO)

Switch off

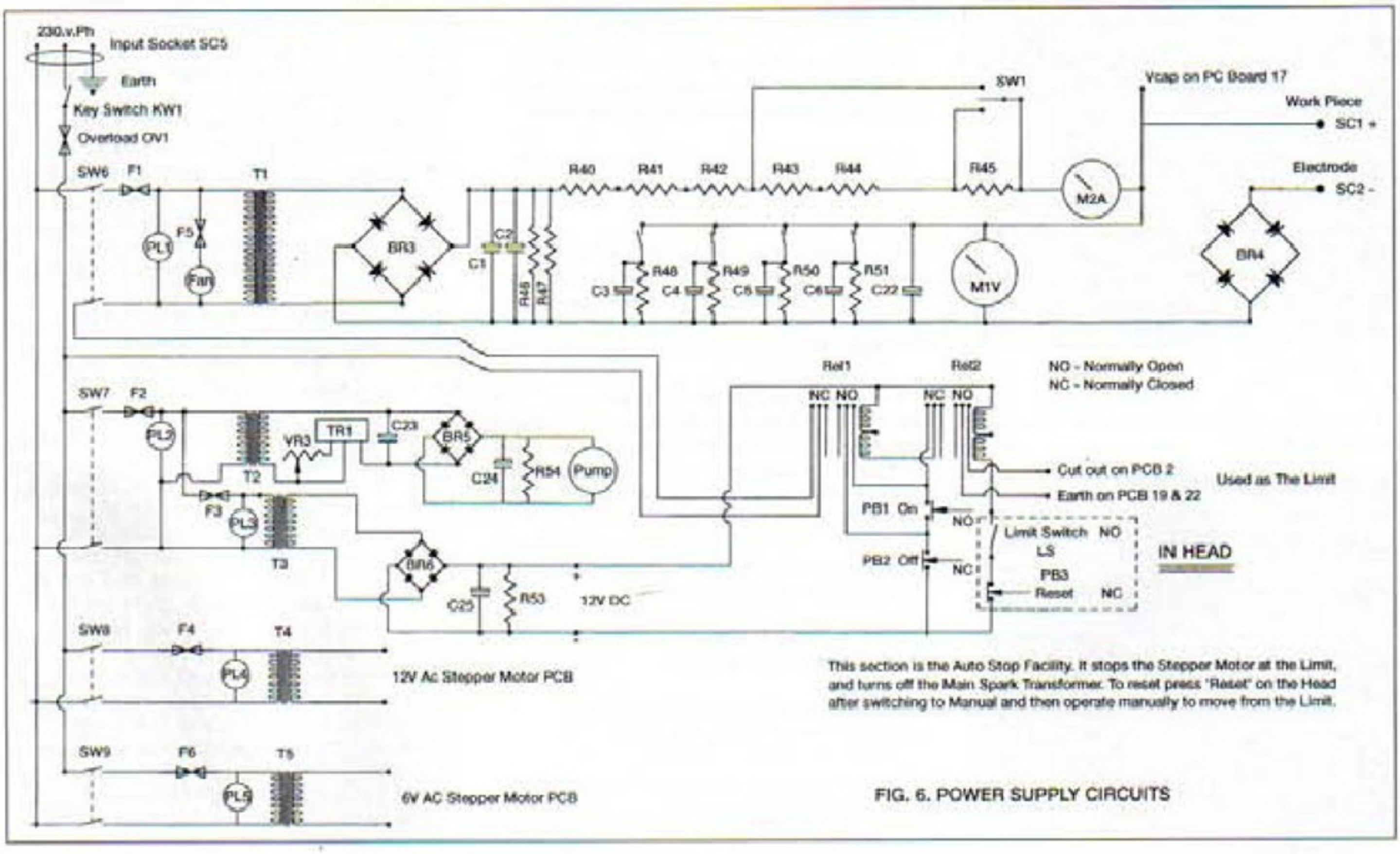


FIG. 6. POWER SUPPLY CIRCUITS

3. Plug in IC1

Pin 3 - 'Pulse' which varies with 'Speed' control	

4. Plug in IC2

Pin No.	Indication
1	Red (HI)
2	Red (HI)
3	Yellow (Pulse)
4	Yellow (Pulse)
5	Yellow (Pulse)
6	Yellow (Pulse)
7	Green (LO)
8	Red (HI)
9	Green (LO)
10	Green (LO)
11	Yellow (Pulse)
12	Yellow (Pulse)
13	Yellow (Pulse)
14	Red (HI)

5. Plug in IC4

Pin No.	Indication
1	---
2	Yellow (Pulse - Medium)
3	Yellow (Pulse - Fast)
4	Red (HI)
5	Yellow (Pulse - Fast)
6	Yellow (Pulse - Slow)
7	Yellow (Pulse)
8	Green (LO)
9	---
10	---
11	---
12	Yellow (Pulse)
13	Red (HI)
14	Green (LO)
15	---
16	Red (HI)

6. Plug in IC5

Pin No.	Indication
1	Yellow (Pulse - Fast)
2	Yellow (Pulse - Medium)
3	Yellow (Pulse - Slow)
4	Green (LO)
5	Green (LO)
6	Red (HI)
7	Yellow (Pulse)
8	Green (LO)
9	Yellow (Pulse)
10	Yellow (Pulse)
11	Yellow (Pulse)
12	Yellow (Pulse)
13	Yellow (Pulse)
14	Yellow (Pulse)
15	Yellow (Pulse)
16	Red (HI)

7. Plug in IC3

The stepper motor should now be rotating smoothly

Pin No.	Indication
1	Green (LO)
2	Green (LO)
3	Green (LO)
4	Green (LO)
5	Green (LO)
6	Yellow (Pulse - Slow)
7	Green (LO)
8	Yellow (Pulse - Slow)
9	Yellow (Pulse)
10	Yellow (Pulse)
11	Yellow (Pulse)
12	Yellow (Pulse - Slow)
13	Yellow (Pulse)
14	Red (HI)

8. Check IC2

Pin 6 - Indication Yellow (Pulse - Slow)

9. Momentarily connect Vcap to SMV+ - Motor should stop

10. Momentarily connect SMV+ to IC6

Pin 7 - Motor direction should reverse

Now that all the ICs are in position, it is advisable to check a few more voltages (all measured between the pin and earth):-

IC1	Pins 2 and 6 - 5V Pins 3 and 5 - 0V
IC2	Pins 1, 2, 9 and 10 - 5V Pins 3, 4, 5, 8, 11, 12 and 13 - 0V
IC3	Pins 1 to 5, 9 to 11 and 13 - 0V
IC4	Pins 1 to 7, 9 to 13 and 15 - 0V
IC5	Pins 1 to 3, 7, 9, and 10 to 15 - 0V
IC6	Pins 4, 7, 9 and 10 - 0V Pin 5 - 0.6V Pin 6 - 2.5V Pin 8 - 4V Pin 14 - 3V

If you do not get the expected indications you will have to trace the fault and correct before going any further. Of course, all should work perfectly from square one!

Permanent Wiring of Potentiometers

Remove the fixed resistors from Terminal Block 2 and replace them with the wires from the High and Low Reference Potentiometers as shown in **Figure 1a**.

PCB availability

Arrangements have been made with Wren Engineering to supply printed circuit boards and components at various levels:-

i. A film positive of the PCB tracking for those who would like to have a go at etching their own board.

ii. An etched and drilled board.

iii. A fully populated and tested board.

Stepper Motors

A suitable stepper motor is available from Model Motors Direct (as is a suitable motor for the rocking table used when etching). This stepper motor has eight wire connections and should be wired as follows:-

All red and black wires joined together to SMV+ (Terminal 1 on Block 1)

In pairs, Grey to SMa (Terminal 3), Yellow to SMb (Terminal 5)

In pairs, Grey to SMd (Terminal 6), Yellow to SMc (Terminal 4)

Other motors (e. g. ex-equipment) may need variations to this wiring pattern.

18. The front panel of the case, showing the external leads

19. View of front and inside of case

Much good advice was given in Richard Bartlett's articles on his 'Compucut' system, so readers are referred to Issues 41 to 45 and 47 of M.E.W.

The case

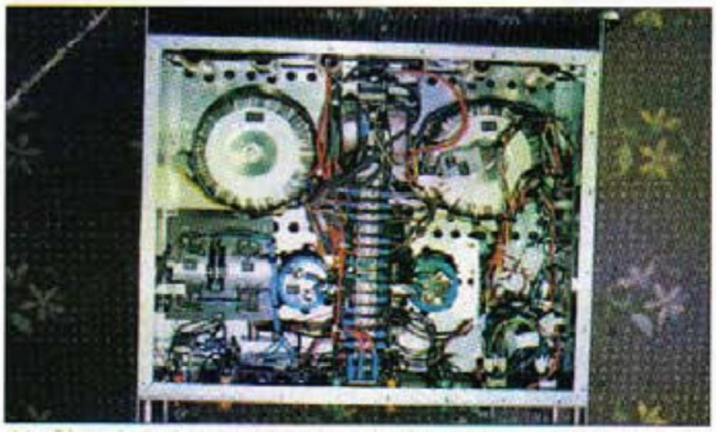
Readers who may have read my article on the Band Saw Blade Welder in Issues 41 & 42 will recognize my system of construction of the case. It is one that originates back in my days of building radio receivers and transmitters for the amateur bands, but do feel free to build in your own manner, as one builder's way does not always suit the tooling available to another. For example, I now have the facility to punch louvre slots, but before it became available, I cut holes of an appropriate size and covered them with perforated zinc, fixed in place on the inside with epoxy glue.

I also now have the use of my own small home-built guillotine, so I can cut sheet material to approximate size with a jig saw and then trim to the required dimension. If this type of facility is not available, then cut as close to the line as possible and then file to achieve size and finish.

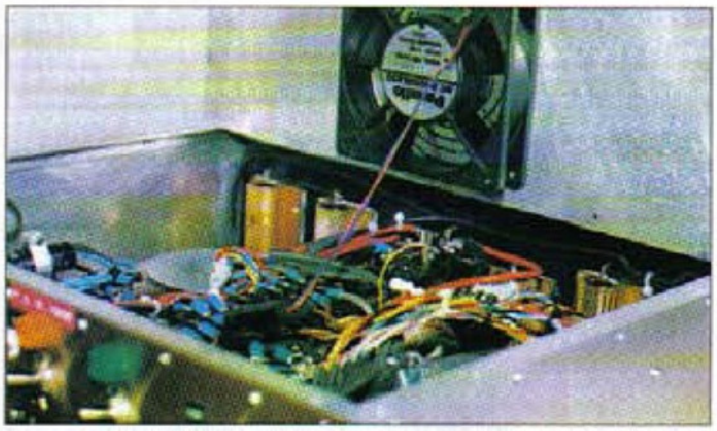
The case sizes given were to suit the sizes of components that I used, but I recommend that the parts are laid out and the overall sizes checked first. Do allow a reasonable oversize allowance, as space always seems to be at a premium on these control panels.

Cut out all the main case parts, including the front panel. If a heavier gauge of material is available, then use it for this panel as a considerable number of holes are required (I used 3mm brass as it was to hand). Glue a piece of paper on to the front panel, using spray photo mount, as when finished, it can be removed with a little WD40. Mark out in pencil, as this will not damage the surface, but again check your components for spacing and hole sizes before any irretrievable mistakes are made. All finishing of the front panel should be carried out before the paper is applied.

The panel can then be mounted on the



20. Plan view showing that there is still a little space left



21. Inside view showing power resistors and cooling fan

22. Inside showing the relays to the left

23. Final view showing how important it is to attach clear labels to the front panel

mill table using a piece of MDF or plywood to ensure that the table is not damaged during the subsequent machining operations. I used a Rotabroach for all the round holes and milled the rectangular ones, finishing off the holes with a file.

I have made up a 'sub-table' which fits on to the mill and has an abundance of tapped holes. It is 300mm x 200mm x 150mm high, made from bright mild steel and is used for any job of this type. It was originally made for the machining of loco main frames.

The handle and feet are quite straightforward and could be omitted, but the feet do help to give better visibility to the control panel.

I next cut the aluminium angle to length + 1mm and machined the mitres on the mill using an old Record picture frame mitring jig that was bought from a boot sale for 10p as its vertical saw guides were broken off. It was subsequently modified by bolting a block on the underside to allow it to be held in the vice and the saw guide machined out to take an 8mm end mill. This has proved handy for many other operations.

When finally machining the angles, ensure that they are all finished 1mm under size as otherwise you may have difficulty in making them fit.

The case is assembled using 8mm round head self tapping screws which require a tapping drill of 2.3mm. The plates are first marked out and I use drafting tape and a pencil for the reasons mentioned. The front, back and bottom are fixed together using the appropriate aluminium angles by first drilling the outer plates tapping size then drilling through the clamped components before opening up the outer holes. Don't forget to de-burr before finally screwing together. The vertical angles are then fixed to the front and back panels, remembering that the rear panel is made up of two heat sink panels. The angles should all be fitted so that they are slightly below the edge of the panel. The side panels should now be fitted, ensuring that the case is not twisted when the panels are secured or the twist will be locked in. It is necessary at this stage to fit the strap which spans from back to front of the case, as this supports the back and front when the top, and sides are removed to carry out the wiring. Next, fit the top and the handles.

When making my case, I then stripped it apart and drilled, punched or machined all the remaining holes that were required, and I also punched the louvres at this time.

The front, back and base can now be put back together and the strap re-fitted, so that the major components can be located, including the transformers and the parts which are bolted to the strap, such as the small transformers and the terminal strips. Mount the components on the front panel, making sure that all nuts are tight. It may be necessary, in some cases, to make special spanners, as some switches are awkward to tighten.

Finally, mount the capacitors. These may not be of the same sizes as the ones which I used, so the system will have to be modified to suit.

NOTE:- The mounting bolt which goes through the centre of each torroidal transformer must be earthed to the chassis at one end only.

Wiring

The next process to carry out is the wiring, and it is best to start on the front panel. This is best done by removing it from the case and laying it down or holding it in a vice. Which ever you do, make sure that it is immobilised, as there is nothing more frustrating than chasing it around the top of the bench during the soldering operations. Set it in a comfortable position and arrange that it can be moved and reclamped for ease of access. Due to the large amount of wiring in the box, I fit over-long wires to the front panel components, most of which will go to the terminal blocks. These are shortened at a later stage, a technique which I know is wasteful, but which I find to be the easiest. Wires from the other components in the case are also treated in a similar way, allowing the terminal blocks to be the interfaces. It is suggested that all wiring is carried out using multi-coloured wires, thus helping to avoid confusion and mistakes

Next, wire in the transformers. It is best to complete all the mains side first, including the relays and fuses. Do not forget to earth all components where applicable and to check the continuity of these earth connections even before the power is switched on. Remember that 230 volts can be lethal and should be respected at all times The supply should be turned off at all times when work is being undertaken and, when it does need to be switched on (e. g. when testing), manipulate the test probe using only one hand, keeping the other in a pocket. Always check in stages as the work proceeds and do not forget to **TURN OFF** and **UNPLUG** between tests. As I have said before, if you are not totally confident, then work in groups of mixed talents.

With regard to the rectifiers (BR3, BR5 & BR6), these must be wired with the correct pins to the relevant the transformer and to the DC side. The rectifier BR4 only uses two connections, the positive terminal being connected to the negative terminal of BR1, while the negative goes to the terminal post.

The only other slight complication is the Triac. This unit is basically a transistor which switches itself on/off at the mains frequency of 50Hz, and by varying the amount of 'on' to 'off' a 'voltage variation' is seen by the rectifier, thus creating a variable DC supply which then varies the speed of the motor for the dielectric pump. The specified Triac is vastly oversize, as I understand that they do not like inductive loads and have therefore played safe.

Plugs and sockets could be used for the connections between the control box and the head or, alternatively they could be permanently wired. In the former case I would not recommend the use of DIN plugs and sockets due to possible temperature limitations. Better to use Bulgin or XLR types, but check the number of connections required.

As always, I am happy to be contacted if help is needed, but by telephone only please, on 01233 712158

Model Motors Direct, Hillside House, Baltonsborough, nr Glastonbury, Somerset BA6 8QJ Tel. 01458 850061

Wren Engineering, 58 Kingswood Avenue, Belvedere, Kent DA17 5HG Tel. 0181 3120413 Fax. 0181 3120414 Email wreneng@aol.com

Parts List

Transformers				
T1	Primary 230V	Secondary 70V 10A		Model Motors Direct
T2	"	Secondary 12V 2A		"
T3	"	Secondary 9V 2A		"
T4	"	Secondary 12V 5A		"
T5	"	Secondary 6V 2A		"
Triac				
TR1	600V 10A		234-679	Farnell
Bridge Rectifiers				
BR3, BR4	400V 25A		371-865	Farnell
BR5, BR6	100V 6A		706-929	"
Relays				
Rel. 1, Rel. 2	DPCO	Coil 12V DC	JG58N	Maplin
Relay Bases (for above)			JG54J	
Resistors				
R40	4.7 ohms 200 watt		272-700	
R41, R42	2.2 ohms 200 watt		272-693 (2 off)	
R43	3.3 ohms 100 watt		652-489	
R44	4.7 ohms 100 watt		652-490	
R45	15 ohms 100 watt		652-520	
R46 to R53	100k 0.5 watt		477-230 (8 off)	
Potentiometer				
VR1	100k		161-587	Farnell
Capacitors				
C1 & C2	1000µF 200V		536-090 (2 off)	
C3	420µF 385V		536-271	
C4	220µF 385V		490-489	
C5 & C23	100µF 385V		490-477 (2 off)	
C6 & C22	68µF 385V		490-465 (2 off)	
C24	Suppressor		238-463	
C25	4200µF 63V		490-404	
Switches				
SW1	SPCO Toggle	On-Off-On	147-744	
SW2 - SW5	SPST	On-Off	(4 off)	
SW6 - SW9	DPST	On-Off	140-600 (4 off)	
KW1	Key Switch			
PB1	Push Button	Normally Open	FH59P	
PB2	Push Button	Normally Closed	FH60Q	
LS1	SPCO Min. with roller	Normally Open	FP43W	
RS1	Push Button	Normally Closed		
Overload Trip				
OV1	10 amp		333-265	Farnell
Meters				
M1	Volt meter	0-300	106-455	Farnell
M2	Ammeter	0-10	106-445	
Fuses				
F1	5 amp	5mm x 20mm		
F2 - F6	1 amp	5mm x 20mm	5 off	
Fuse Holders		5mm x 20mm	418-619 (6 off)	RS
Pilot Lamps				
PL1 - PL5	Holder for MES Bulb		140-253 (5 off)	
	Neon bulb with resistor		140-278 (5 off)	
Connectors				
SC1	Post Socket Red		148-250	
SC2	Post Socket Black		148-251	
SC6	Input Socket	10 amp EURO	313-749	
Terminal Strip	12 way		965-790 (2 off)	Farnell
Pump	12V			Model Motors Direct
Fan (with guard)	180mm	230V (Computer type)		Model Motors Direct

A SIMPLE AID TO ACCURATE DRILL GRINDING

It is often said that the simplest ideas are the best. C. Heyes of Solihull spotted this item on the wall of a workshop, above a pedestal grinder.

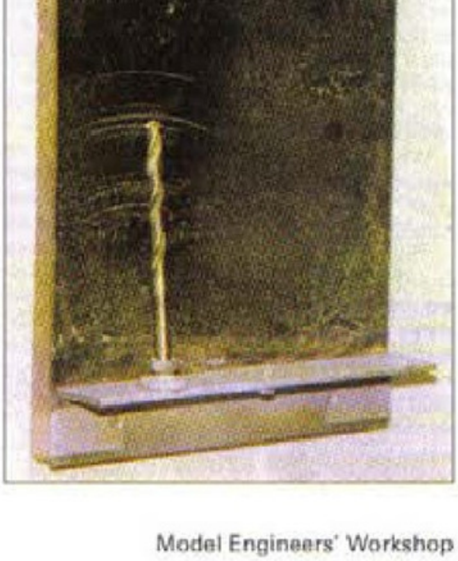
The piece of equipment that is the subject of the following article was first shown to me about two years after retirement. After spending all my working life in various tool rooms, I realised how useful it would be to anyone wishing to regrind their drills.

Referring to the article in Issue No. 50, page 44, on drills and sharpening thereof, Philip Amos stressed the importance of equal cutting angles.

The piece of equipment that I am going to describe will eradicate all the guesswork relating to the length of the cutting angles (see Drawing 17 of the above article).

The attached photograph shows the principle of the device quite clearly. I apologise for the condition of the item as I had to make it in a hurry out of material found in the scrap box. The back plate is plywood faced with a sheet of Duralumin, the size being chosen to suit the length of the longest drill that is used. It is advantageous to spray the back plate with a matt black paint. The shelf is a piece of Dural angle with a selection of pivots or pockets to suit. Straight shank drills need a tapered pocket with half round bottoms, perhaps two or three of different diameters may be required. For tapered shank drills a small peg with a suitable sized ball should be fitted.

To use the device - after re-grinding the drill place the shank of the drill in a suitable pocket, twist the drill until the cutting corner is touching the back plate then scribe a short section of an arc on the back plate. Turn the drill through 180 deg. and repeat the scribing. Comparing the two sections of the arc will show which side of the drill needs grinding. If the lines coincide and the angles are the same, the drill is accurately ground.



THE JACOBS GEAR HOBBING MACHINE

The latest instalment in our series on Gear Hobbing in the Home Workshop is a description of a special purpose gear hobbing machine, the first part of which starts on page 33.
This machine has an interesting background and history, and it is felt that it would be useful for potential builders to know how the machine came to be designed and built and to understand some of its capabilities and operating principles.

The original fabricated machine in its present condition. The motorising unit was a modification which replaced the belt drive from an overhead

Origins

The originator of the machine was T. D. (Tom) Jacobs who had become interested in gear cutting when attached, as an apprentice to a gear cutting shop. On retirement, he moved to the West Highlands of Scotland, and after re-establishing his workshop, decided to further explore the gear cutting process. Inspired by the writings of Martin Cleeve, he set about designing and making a suitable machine of which he gave a brief description in 'Model Engineer' in July 1974. A subsequent interchange of correspondence with G. H. Thomas through the 'Postbag' columns (a list of some of the published material is given at the end of this article) brought forth further details, and a full constructional series was published during 1976.

The original machine was of fabricated construction and I have heard that the piece of rolled section steel used for the base was found at the side of the road! On the death of Tom Jacobs, this machine passed into the care of the Society of Model and Experimental Engineers, of which he was a member, and it now resides in their headquarters, Marshall House. They were kind enough to bring it to the last Olympia exhibition, where we had the chance to take some of the photographs included here.

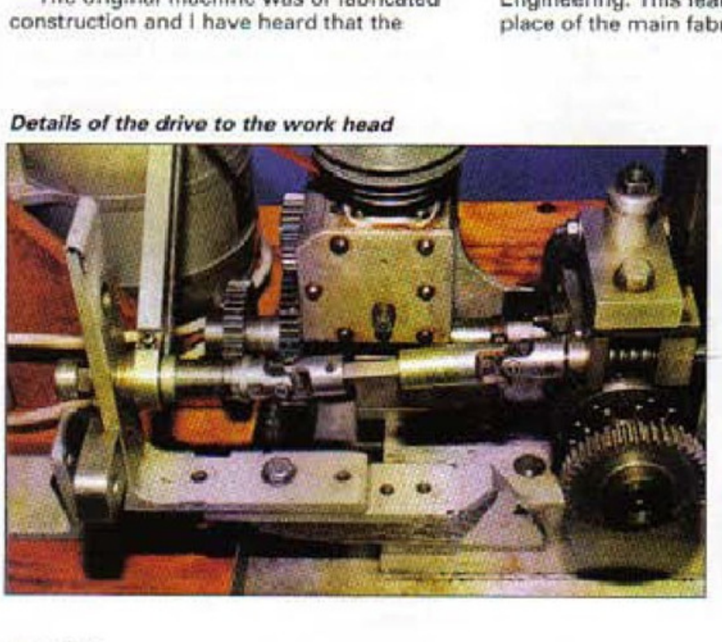
Evolution

Some time after the publication of the original articles, a revised version was produced by John Buckley of Helix Engineering. This featured castings in place of the main fabricated structures, and was marketed under the 'Helix' name. The rights to this design have now been acquired by College Engineering Supply who are marketing castings and part machined components under the 'CES' banner. It is this version which is the subject of Harold Hall's articles.

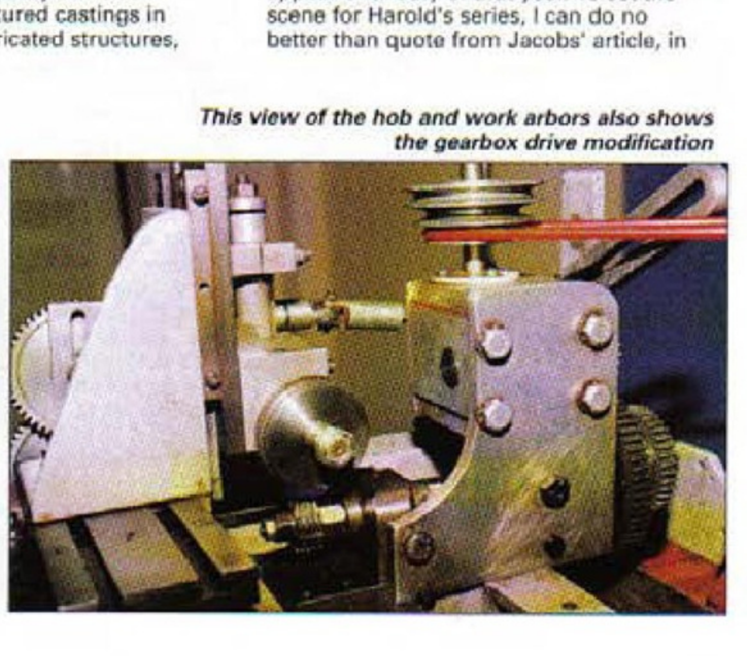
Design specification

Tom Jacobs' original constructional series ran over five instalments published in successive issues of 'Model Engineer' from January to March 1976 but, strangely, the article which gave a basic description of the machine and its capabilities did not appear until July of that year. To set the scene for Harold's series, I can do no better than quote from Jacobs' article, in

Details of the drive to the work head



This view of the hob and work arbors also shows the gearbox drive modification



A superb example of a 'Helix' version built by J. Bentham and exhibited at a previous Harrogate exhibition

A selection of hobs and arbors, also by J. Bentham

which he stated that a machine capable of hobbing gear teeth in spur gear blanks needed to be able to meet the following requirements:-

a. Provide a means of rotating the hob at a suitable speed and with sufficient torque to cut the blank.

b. Provide an arbor or spindle on which to rotate the blank with its axis angularly adjustable in relation to the axis of the hob. The angle for straight spur gears will approximate to a right angle, adjusted to allow for the helix angle of the hob.

c. Provide a means to give a relative feed motion between hob and blank in a direction parallel to the axis of the blank arbor.

d. Provide a means to ensure a positive ratio between the rotation of the hob and blank, which ratio must be variable to suit the number of teeth to be cut in the blank.

e. Provide a means to adjust the distance between the hob and blank in a direction at right angles to both hob and blank axis. This is so that various blank diameters can be cut and the tooth depth controlled.

Features

He went on to say that his machine comprises the following:-

BASE with angle extensions and integral fixed member of the longitudinal slide.

CUTTER HEAD secured by screws to the base in one of two positions, viz. parallel to the longitudinal slide or at right angles to it. The first position is used for hobbing spur gears. This meets requirement a.

LONGITUDINAL SLIDE - this is not strictly necessary for hobbing spur gears but provides a convenient adjustment for this operation. It is necessary for some other functions of the machine.

Secured to the top of the longitudinal slide and angularly adjustable is the CROSS SLIDE which has a tee slotted top and meets requirement c. and contributes to requirement a.

Bolted to the top of the cross slide is the VERTICAL SLIDE.

This meets requirement e. and contributes to requirement b.

On the face of the vertical slide is bolted the WORK HEAD. This carries the rotatable work arbor and therefore contributes primarily to requirement c. One end of the work arbor carries the gear blank, the other the index or dividing wheel. Attached to the work head is a bracket carrying in bearings the index or dividing worm meshed with the wheel, thus providing a contribution to requirement d.

Attached to the raised angle extension of the base by screws is the angle standard of the INDEX WORM DRIVE which carries a banjo plate on which is set up a train of change wheels between a gear on the cutter head mandrel and a gear on the driving end of the universal jointed shaft. The driven end of this shaft is attached to and drives the index or dividing worm. Thus is provided the main contribution to requirement d. The universal joints are necessary both because of the movement of the driven end by the feed, and because the two ends will hardly ever be in alignment.

Finally, a power feed is supplied through a train of wheels between the work arbor and the cross slide screw.

That article goes on to describe the procedure for cutting a 20 DP changewheel.

A study of the general arrangement of the CES machine, a simplified version of which is reproduced in our centre pages, will confirm that these basic features have been carried through to the cast version. Readers who decide to build the machine are recommended to seek out the original articles which contain many useful hints on its construction and operation. Interestingly, the general arrangement drawing shown in the first article of the series was drawn by Professor Dennis Chaddock, who must have worked from the component drawings because, at that time, he had not seen the machine.

Capabilities

Jacobs describes the machine as being suitable for cutting spur gears, either by hobbing or one tooth at a time and, by re-arrangement and using additional components, able to cut straight tooth bevels, spiral bevels and spiral or helical gears. It can also thread mill worms and cut teeth on milling cutters, taps and reamers.

Drive was originally by means of 5/16in. round plastic belt from an overhead, but an integral motor was added at a later stage. By the third part of the series, the construction of the basic machine had been completed and some of the additional components mentioned above were being described, as were some of the procedures. The promised article on fluting taps, reamers and milling cutters appeared a few months later.

Harold Hall's first articles cover the machining of the components of the basic machine and add some information on its use. We are aware that a number of the machines have been and are being built and hope that, as they gain experience, users will send us more information on set-ups and operating techniques. We know that information is already being circulated in an informal manner among a sort of 'owners club' to the benefit of all. Who knows? before long they may have their own Web site!

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10. 'M. E.' Vol. 142 No. 3541 16 July 1976 pp.697, 696 Article 'Gear Hobbing' by T. D. Jacobs (this is the introductory article)

11. 'M. E.' Vol. 142 No. 3542 6 Aug. 1976 pp.757-759 Article 'Fluting Taps and Reamers' by T. D. Jacobs

12. 'M. E.' Vol. 142 No. 3544 3 Sept. 1976 p.876 Letter 'Gear Cutting' from F. Butler

13. 'M. E.' Vol. 142 No. 3551 17 Dec. 1976 pp1295, 1296 Letter 'Gear-cutting' from T. D. Jacobs'

GEAR HOBBING IN THE HOME WORKSHOP

Part 3 - BUILDING THE CES HOBBING MACHINE (1)

Harold Hall describes how he machined some of the major structural castings

Whilst I have, in the past, made items of workshop equipment from other peoples' designs, these have been small items such as vices and angle plates. The more complex items have been to my own design and I am therefore aware of the purpose of each part, so that when making each one, I fully understand whether it is necessary to follow the design explicitly and the degree of precision required.

The drawings

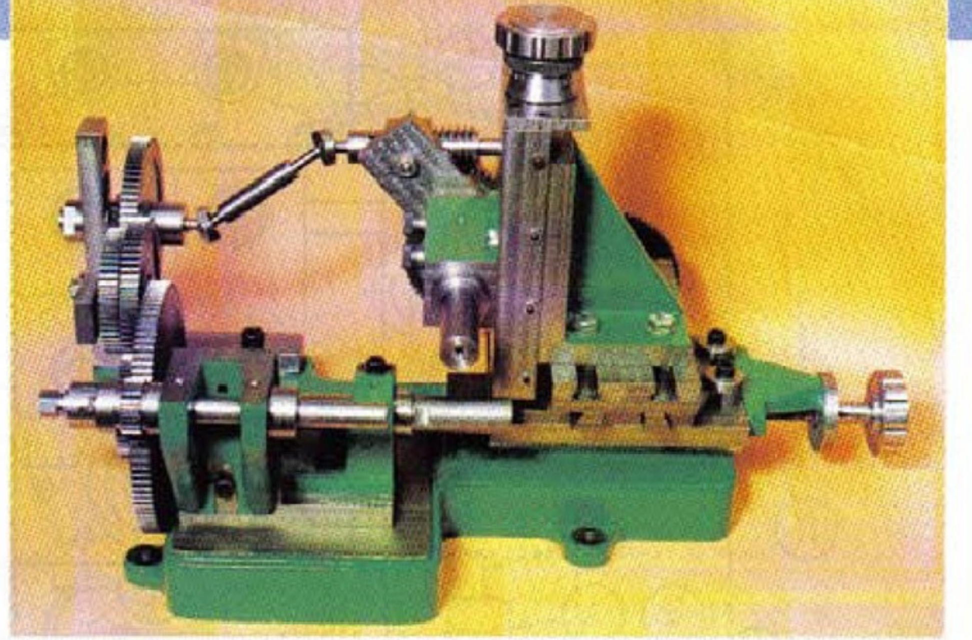
The first task on this project was therefore to study the drawings closely, especially the assembly drawing which is very detailed and, of necessity, complex. It does also contain a few details which would perhaps be better included on the part drawings. For these reasons it was necessary to examine the assembly drawing in considerable depth before commencing manufacture.

Except for the main base which is drawn half size, the drawings are shown full size, and are as a result easy to read. Sheet size is A1 for the detail parts and A0 for the assembly, making them large for the average workshop. A somewhat simplified version of the assembly drawing is shown in the centre spread of this issue. **Photos. 1 and 2** show the complete machine.

A full set of drawings is supplied with each set of castings, so publishing a full set in this article can hardly be justified. Only the drawings of the major items are included, so that the article makes sense to those reading it. Photographs of the smaller parts will be shown later to give some idea of what is involved.

Around 16 parts are not drawn. Why this is I am not sure, as some simpler parts are drawn and some more complex parts are not, but the missing ones can be scaled off the assembly drawing with ease.

Readers making the machine should always work to the drawings provided with the castings, as any subsequent changes made by the supplier may make the drawings published with this article inaccurate for the purpose.



1. The complete machine seen from the working side. The hob arbor is seen running left to right and the gear arbor at right angles to this, the one with the centred end.

2. The machine from the reverse side. The gears on the left set the ratio for the number of teeth on the gear being cut, and those on the right provide the automatic cross feed.

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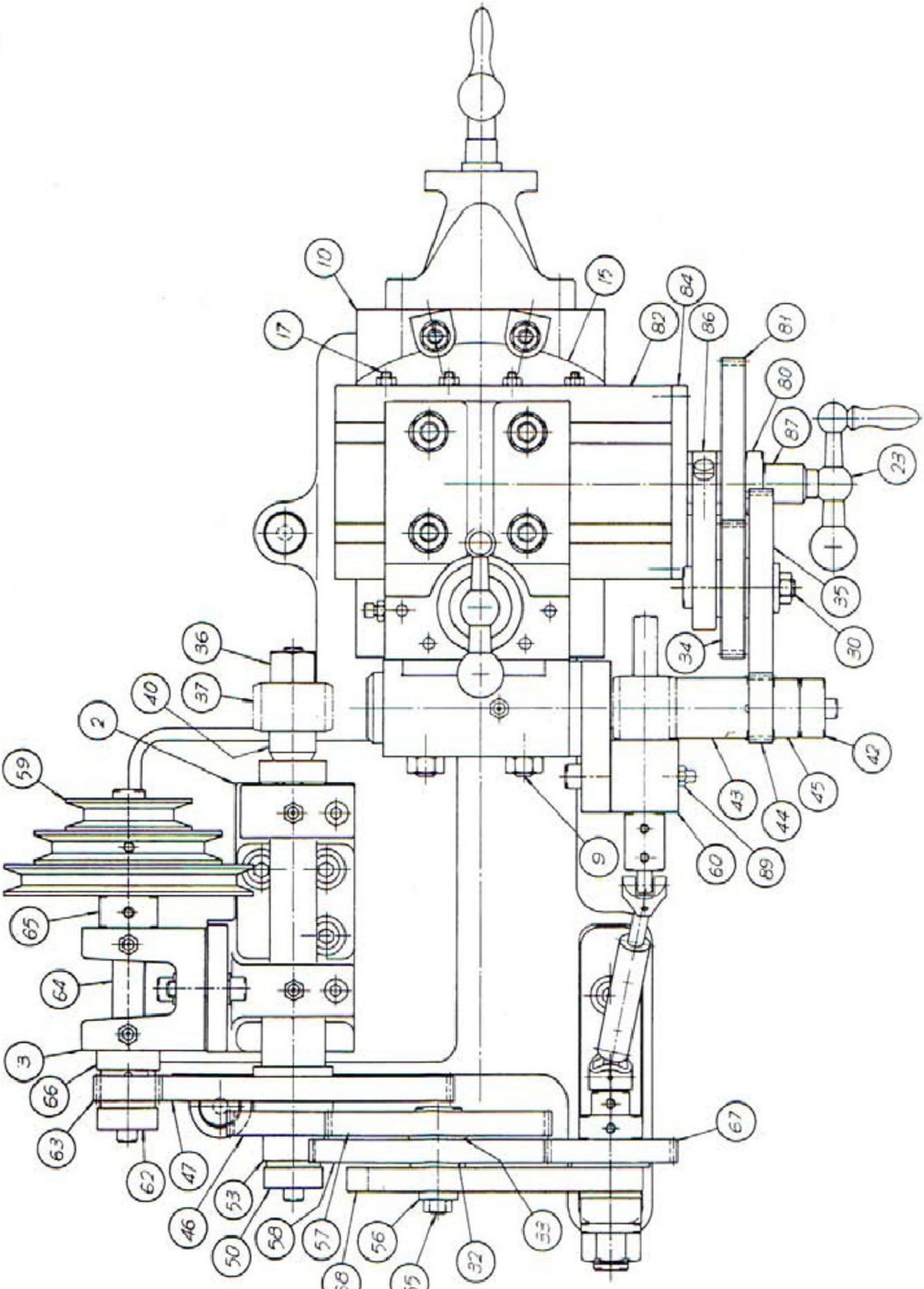

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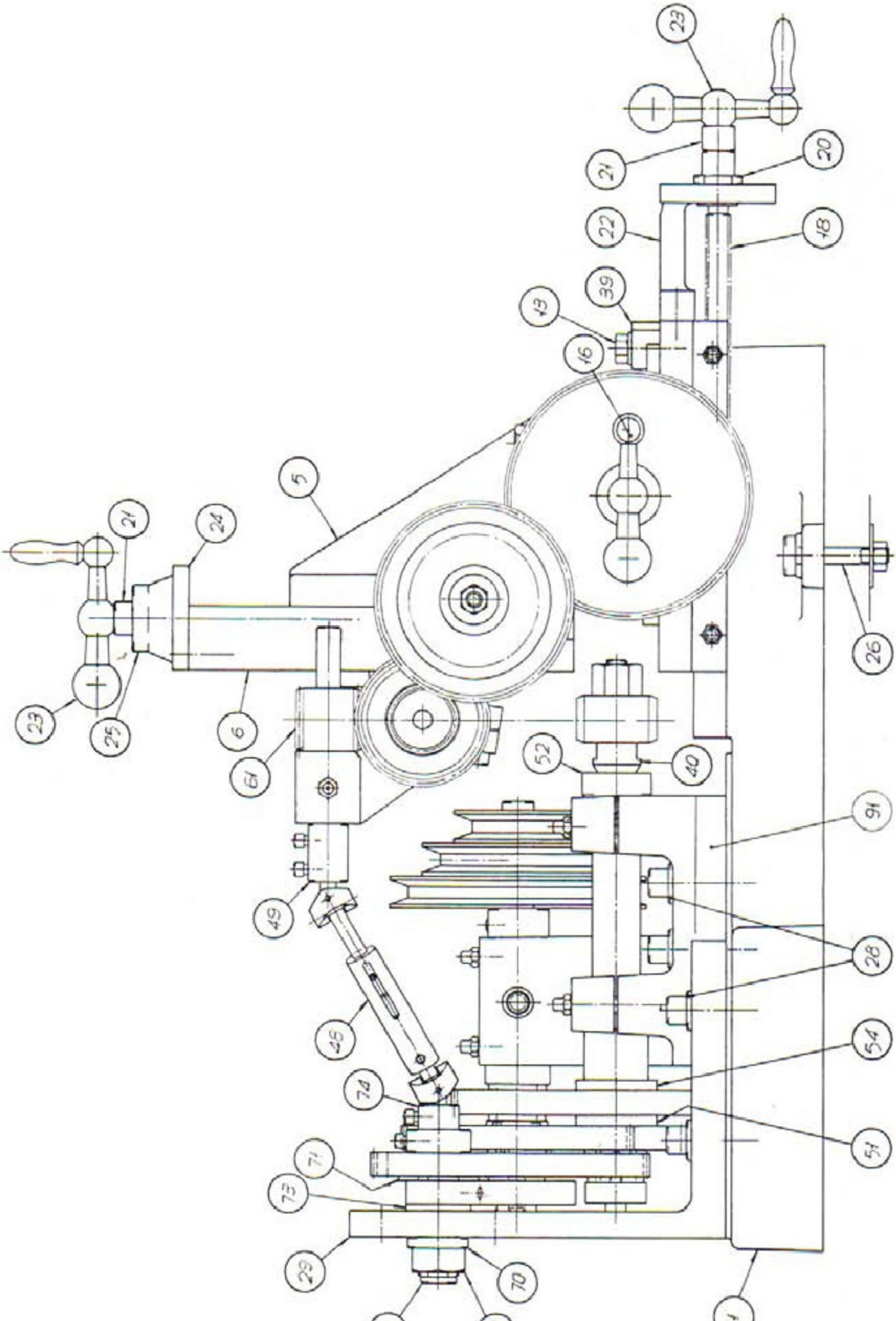
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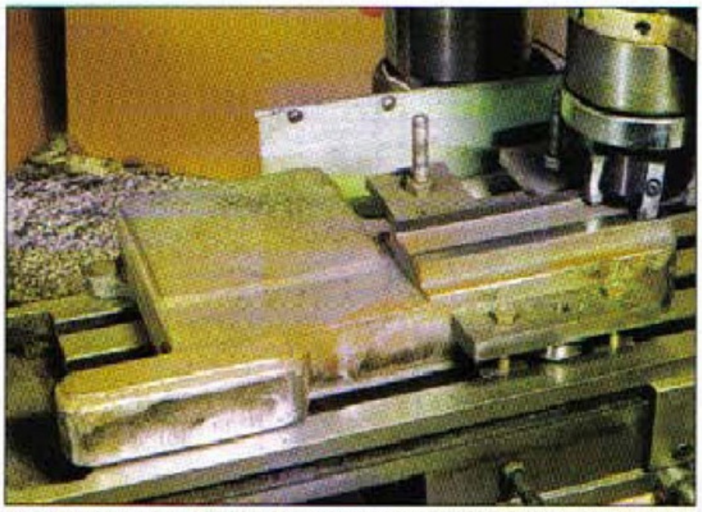
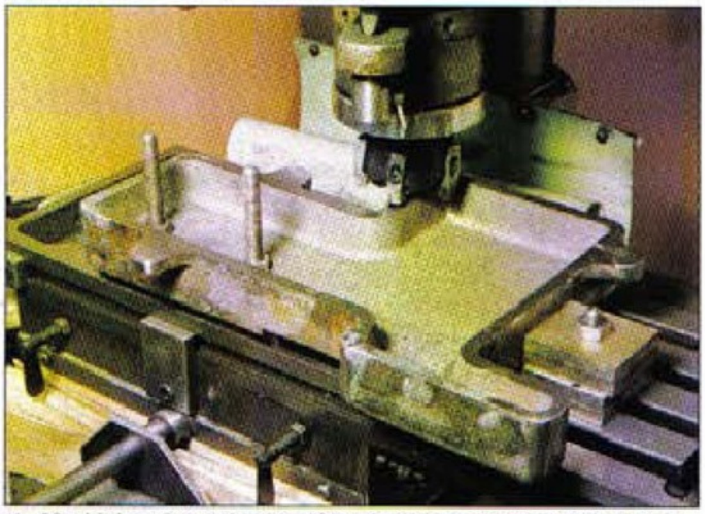


3. Preparing a surface on the top of the bedplate so that it can be turned over and mounted on the machine table for machining the underside.



4. Machining the underside of the bedplate. The bedplate had to be moved three times to complete this operation.

The Design

Not having had previous experience of gear hobbing machines makes it impossible to judge the design from a comparative view point but, as a piece of machinery, I do consider it to be well designed. In such a complex project it is however highly likely that ones' own design preferences may differ from those of the person who originates the drawings, perhaps to suit workshop facilities or available materials. I have made a few changes, so will give details of these at the appropriate point in the article.

Prior to commencing manufacture I was fortunate to have discussions with Giles Parkes who had his machine up and running and Geoff Walker whose machine was well under way. Together they suggested that draw bars to secure the hob and gear mounting arbors would be preferable to the method detailed. This, plus other minor changes associated with the mounting of the arbors is the only change I feel is a must for consideration.

Both arbors mount into a matching taper, like a Morse taper but with a much greater internal angle. The end of the taper has an external thread which mates with a tapped hole in the base of the internal taper. The external taper has therefore to be turned within the internal taper when being secured. The tapers may tend to grip, making it difficult to rotate the thread sufficiently to secure the arbor. If the arbor rotates under load and vibration, so tightening it further, a change in the hob to gear position will result and a sub-standard gear will be produced.

The revised design is not entirely free of risk as, if the draw bar is insufficiently tightened, it will also permit the arbors to rotate under load, and to a greater extent. With the original design, the load will cause the arbor to tighten to a point where it will not move further, but the arbor with a draw bar could continue rotating. In either case the gear being made may be ruined, but I still consider the draw bar to be the better option, providing care is taken to tighten it adequately. My design includes a pin in the spindle bore and a slot in the arbor, together eliminating the possibility of rotation. This safeguard could not be added to the original design.

5. Machining the surface on the bedplate on to which the hob spindle housing (Item 2) mounts.

The taper on the original arbor has a maximum diameter of $\frac{3}{4}$in., but the mating internal taper is only $\frac{9}{16}$in, making the mounting not as rigid as it could be. To improve this, the internal taper was made to the same diameter as that of the arbor. Rather than boring it deeper at the original length, the spindle was extended in length to achieve the larger taper. Even if the draw bar option is not adopted, I feel that this modification is a must, especially as it creates no additional work.

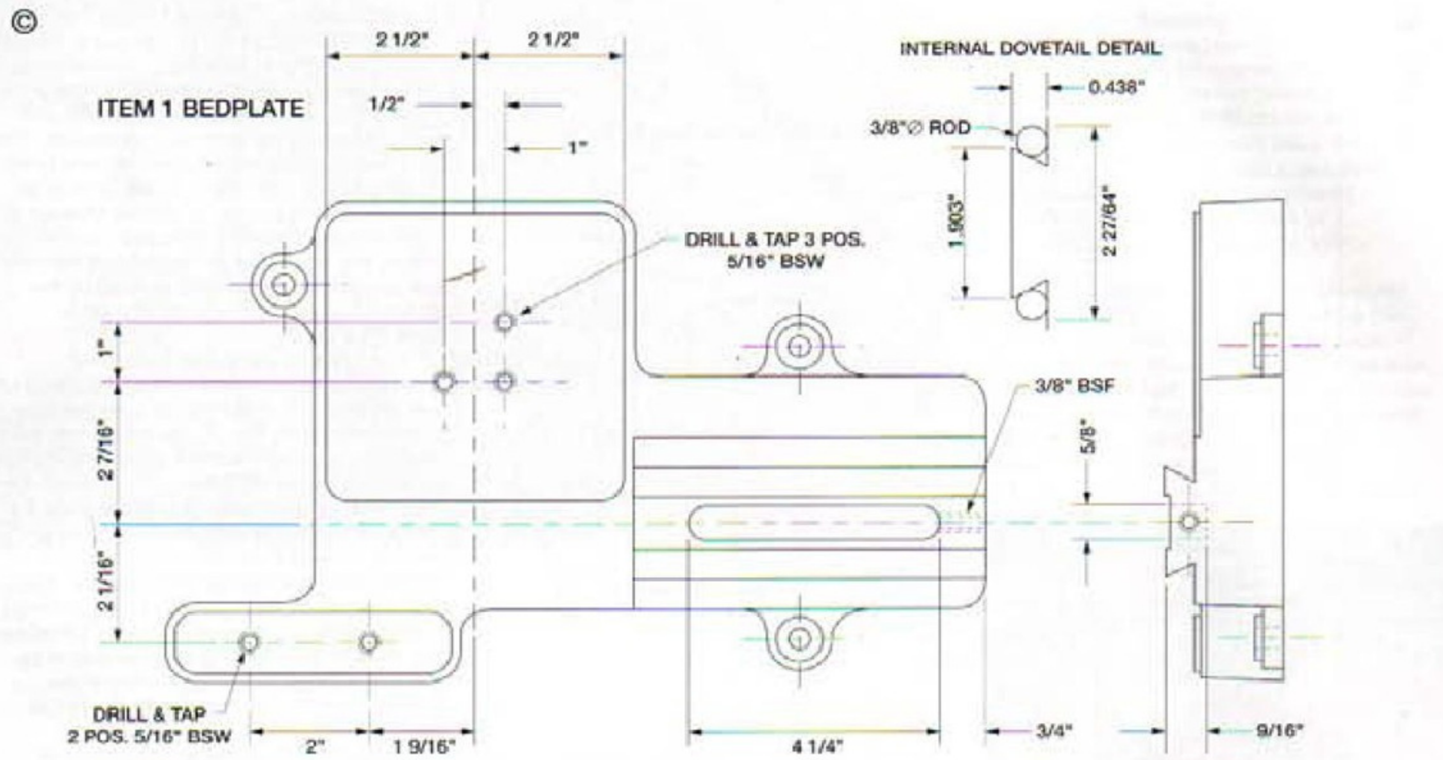
As it is almost impossible to anticipate the bore sizes of the gears eventually to be made and similarly to know the sizes of the hobs which will be used, I made several blank arbors in advance. Whilst the design principle of both of the original arbors is the same, there are small dimensional differences in their mounting arrangements, making it necessary to make two forms of blank. To avoid this the mounting was standardised, so that the blanks would suit either application. An arbor made for one position could even be modified to suit the other, should this be necessary.

Another change I made was to use metric screws rather than the Whitworth and BA screws detailed. Where spanner flats are called for, these were also made to suit metric spanners. Other minor changes made will be commented on through the article.

The kit

The parts supplied consist of the drawings (6 sheets) and 10 castings. These are of good quality as has always been my experience with castings from The College Engineering Supply. The other raw materials required are mostly small and likely to be found in most home workshops, as are the various cap head screws.

The remaining major item is a set of gears, 20 DP 14.5 deg. pressure angle, the



size that Myford use. If you own such a lathe all will be plain sailing, except that a few sizes larger than those in the standard set are required. Gears need not be cast iron or steel, aluminium being quoted on the drawings, but I do feel that if the machine is to be used frequently, aluminium may be inappropriate for the initial gear train to the hob which runs at a high speed and maximum power.

How does one make the gears without the machine being fully equipped with these self same gears? This I will explain later in the article.

Manufacture

For any major, project it is worth giving thought to the manufacturing sequence, as by so doing, tasks such as unnecessary tool changes can be avoided. This may lead to one part being started, then put to one side whilst the set-up is used to make progress on another. Writing the article in this way would make it difficult to follow, so I will mostly deal with a part at a time. One aspect of this approach I will describe is that I did carry out the machining of the castings in two main stages, three where dovetails are concerned. I first removed the skin from all the machined surfaces of all castings prior to returning to them to finish machine to dimension.

Most readers will know the problems associated with machining iron castings, but for those who are not so familiar I will comment briefly. Machining breaks down into two stages, first the mildly difficult, then the very easy but dirty.

The difficulty in the first stage is due to the hard skin that can be present, so hard that it can destroy the edges of ones' valuable HSS tools. Because of this the tungsten tipped face cutters often supplied with Mill/Drills is a good tool for the initial machining. If not available, or where such a cutter is not appropriate, do reserve one or two well used endmills for the task or use a fly cutter. Do not risk your new end mills with razor sharp edges as these edges can so easily be destroyed.

As the hard surface is usually only a few thou deep, its effect can be reduced by making the initial cut sufficiently deep to get below it. A cut of 0.20in. will usually be adequate. Care must be taken though to ensure that this depth is maintained, as due to the taper often present on castings, a cut that starts deep enough can easily become too shallow. Do keep a close watch on the cutting depth and, if necessary, increase it before this situation arises.

Once the hard surface has been removed, machining cast iron becomes very easy, but unfortunately very dirty. Much of the swarf produced is in the form of a very fine black dust which contaminates the workshop, ones clothes and skin. The effects become very noticeable when working on a project as sizeable as this one.

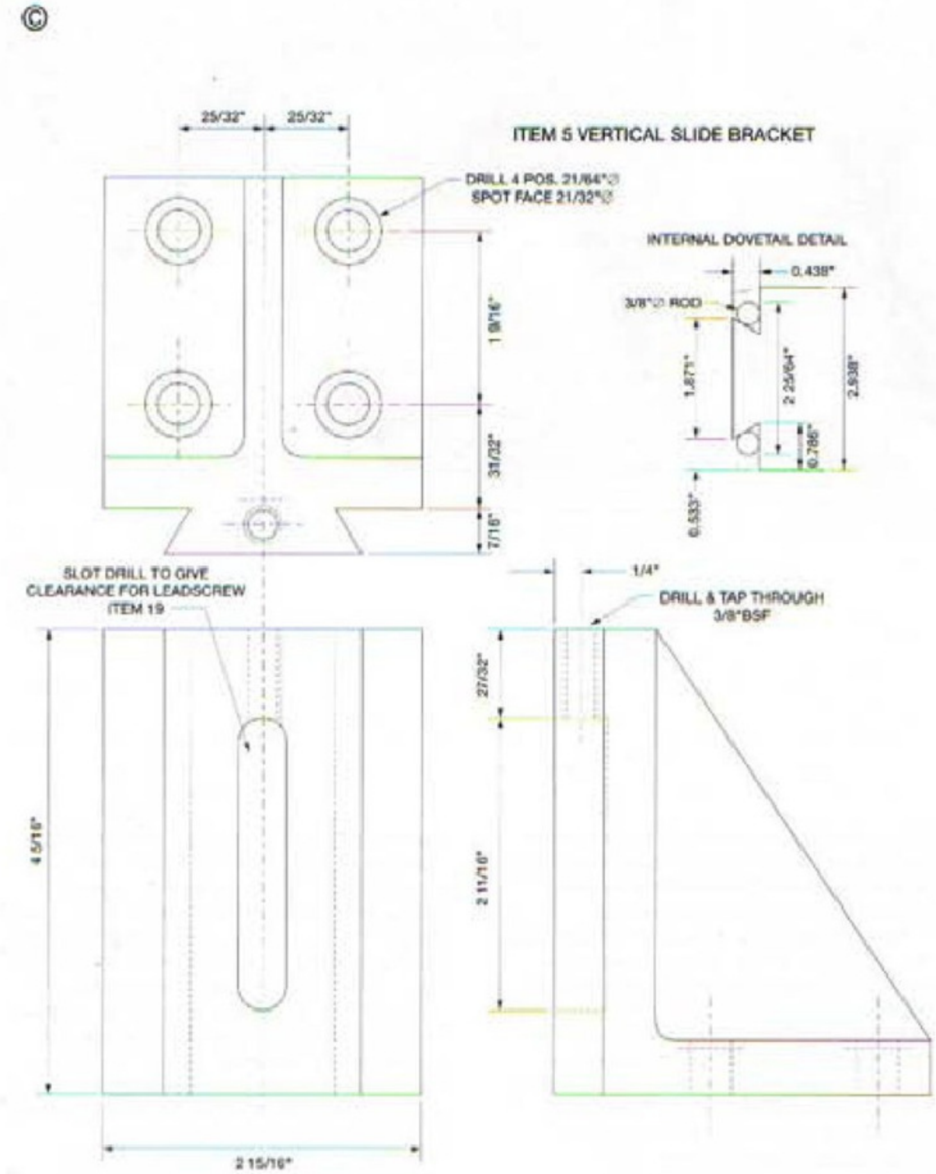
Many of the photographs of castings being machined show the initial skin being removed. Unless specifically mentioned, machining to size was carried out with a similar set-up.

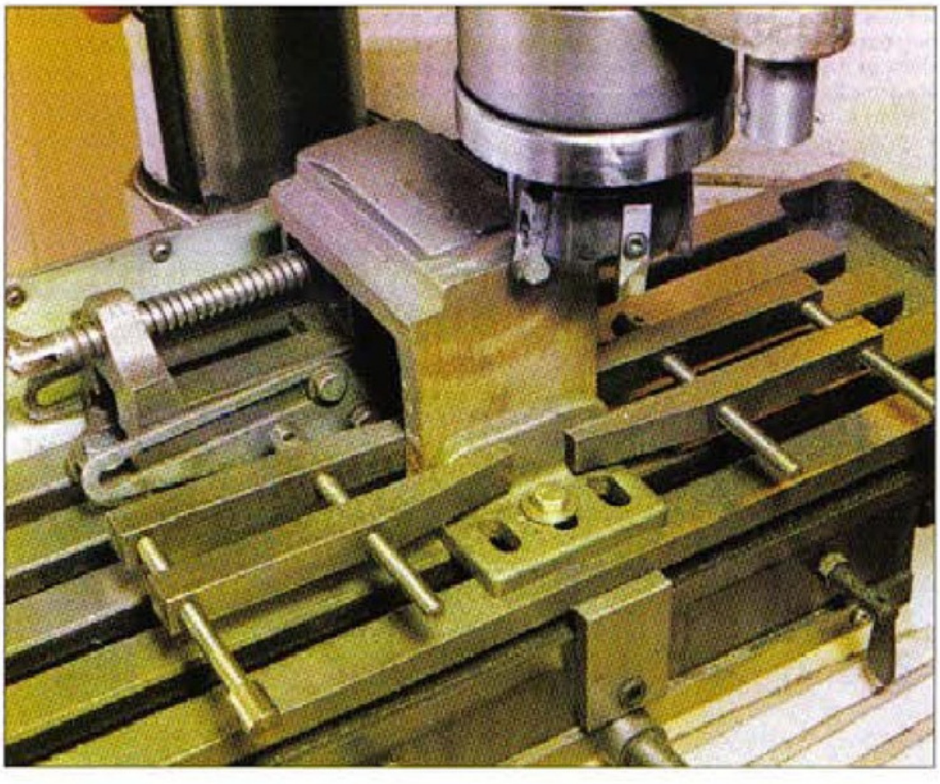
The Bedplate (Item 1)

The bedplate is the only casting to present a problem because of its size. The areas requiring machining are quite small and these are easy operations to perform. There is a problem though with the underside which needs to be flat to enable it to be mounted on the machine table without distortion. This is important as if it distorts when bolted to the table, it may not be true when the part is removed after machining. This would be a particular problem when machining the dovetail slides.

Being a casting, it was not surprising that it rocked when placed on a flat surface, and it was too big to machine the underside all at one go. If removed and replaced on the machine table, maintaining the same plane would be impossible due to the nature of the casting. I tried to level the underside with a file, but this was a non starter as it was taking a very long time. Some means of machining the underside had to be found, so the top surface of the dovetails was machined first **(Photo. 3)**, care being taken to clamp the bedplate only locally to obviate any distortion. Two holes were then drilled for the sole purpose of clamping the bedplate to the machine table. Using the two holes, the bedplate was mounted and machined as shown in **Photo. 4**, with blocks resting against the casting also helping to retain the bedplate in position. It had to be moved three times to allow the surface to be completely machined, but when completed it sat firmly on the table and could be moved to permit the machining of the three areas of the top surface. During this sequence the cutter height adjustment was locked.

Photo. 5 shows the initial cut being taken from the larger flat surface, the two holes also having provided a useful clamping aid for this operation. Work on the small surface and preliminary work on the dovetails was also performed at this stage, all the dovetails being finished to size and form later. This preliminary machining consisted of removing the skin and bringing the tenon square. The drawings as supplied only quote a distance across two rods mounted within the finished dovetails, there being no dimensions to assist this initial machining process. I have therefore included the results of my own calculations for this stage of the process and added them to the drawings shown here. It should also be noted that I have standardised the dovetail heights, so my additional drawings incorporate these changes.





Vertical Slide Bracket (Item 5)

Whilst not as large as the bedplate, this is the most complex casting to machine. Its shape, and the need to machine it over most of its surfaces, makes it a problem when it comes to securing the casting. The rear has a stiffening web which was used to secure the item using a machine vice. This alone though could not be trusted to hold the angle for the arduous duty of taking the initial cut, so for added security a small angle plate was clamped to the shorter leg and to the machine table **(see Photo. 6)**.

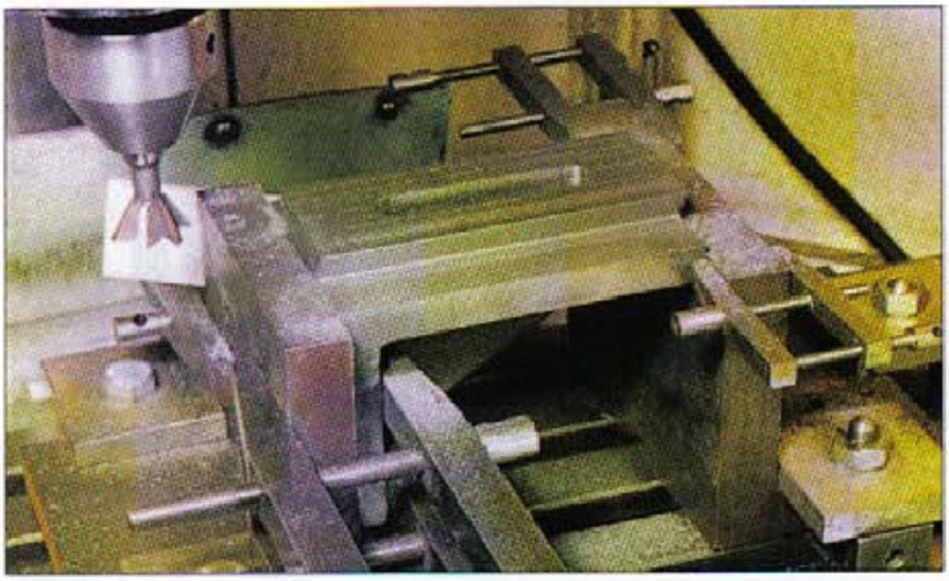
The sides of the angle were next machined, and for this an angle plate was set up and the previously machined face clamped to this. The lower edges were kept clear of the machine table so that they in no way prevented the casting and angle plate mating precisely. It was necessary to set up the casting so that the long edge was nominally parallel to the machine table. After machining the first side, the part was reversed, the side just machined being seated on a parallel which rested on the machine table. The second side was then machined to bring the two sides parallel and at right angles to the initial face.

There remained the underside to be machined to be at right angles to both the first face and the sides. To achieve this, two angle plates were mounted on the machine table and the part clamped to them **(Photo. 7)**. Not often described or demonstrated, the use of two angle plates in this way is often a good idea.

One angle plate was then removed and the larger face clamped to it whilst the underside was clamped to the machine table, and the top edge machined. Next the larger face was mounted on the machine table and the short edge machined. All six machined faces were now either parallel or at 90 deg. to each other.

Apart from the actual dovetails, there remained the need to carry out other preliminary machining in this area using an end mill, including making the slot which takes the leadscrew. The set-up for carrying out these operations is the same as that used later when making the dovetails, so it is shown here **(Photo. 8)**. The angle plate on which the part is mounted must be at right angles to the traverse of the table to ensure that the slideways are truly vertical. A parallel was placed on the machine table and against the angle plate, the lower edge of the bracket being rested on this, thus ensuring

6 and 7. Machining the vertical slide bracket (Item 5)



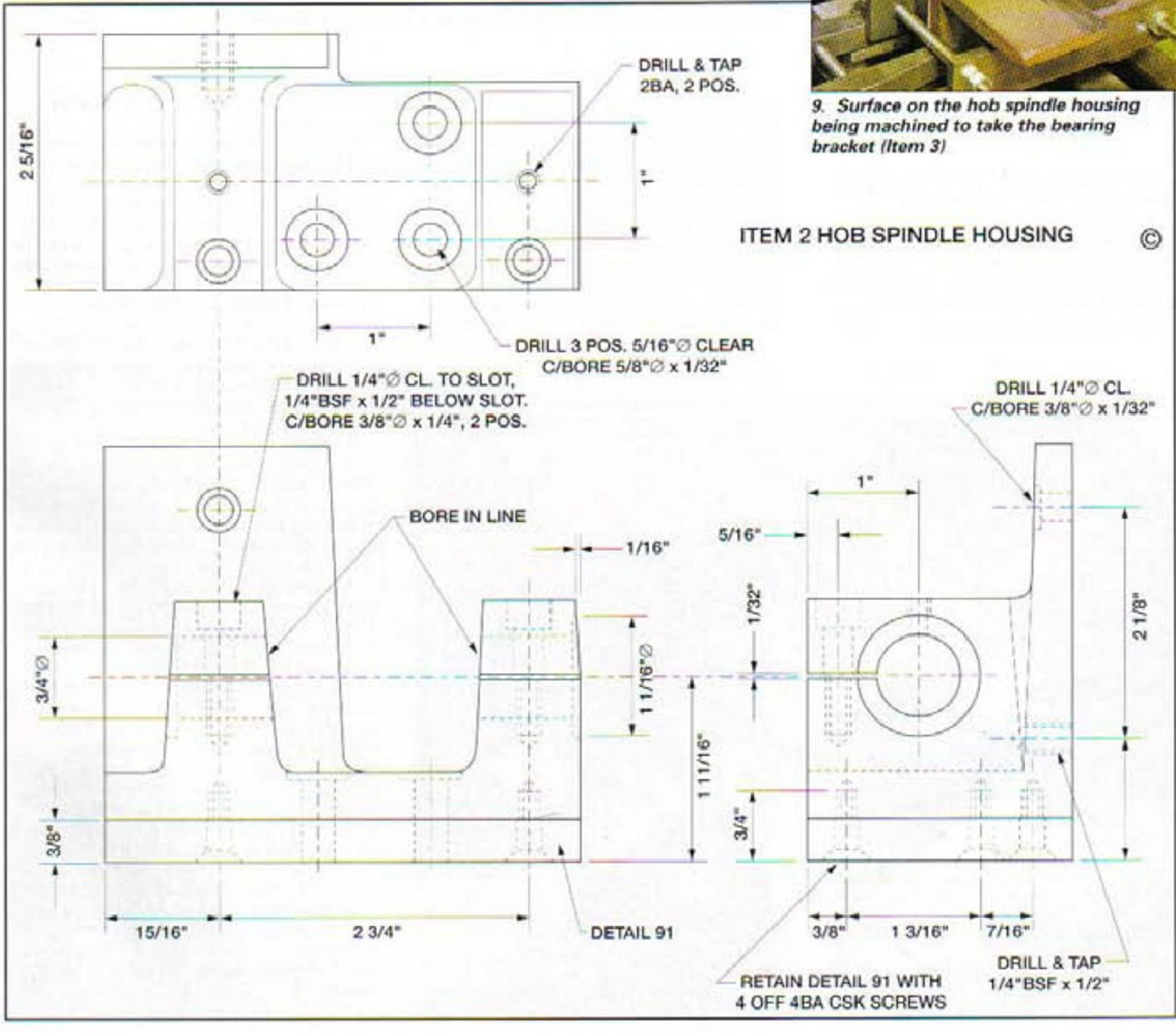
8. The same set-up is used for both the initial and final machining of the dovetail slide

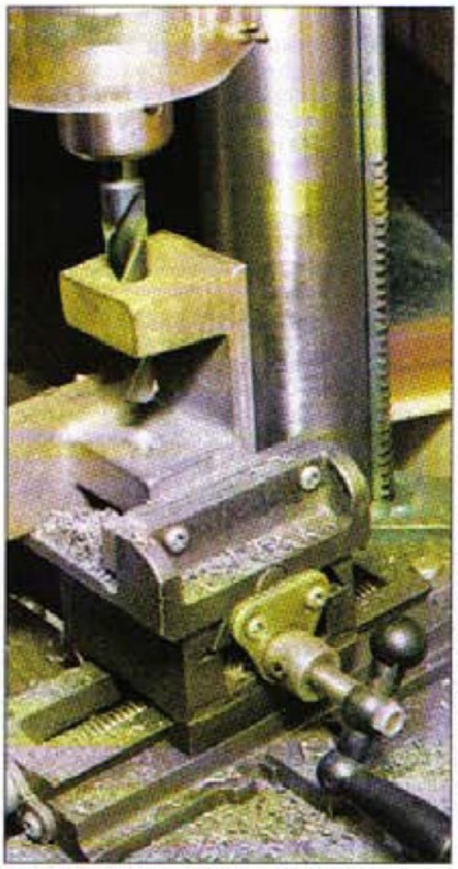
Hob spindle housing (Item 2)

This is an interesting part to machine, requiring a variety of operations. First the upright face on which the bearing bracket **(Item 3)** mounts was machined as shown **in Photo. 9**. The base had been dressed with a file so that it sat firmly, but even so, two pieces of card had to be placed between it and the angle plate to compensate for any remaining minor error.

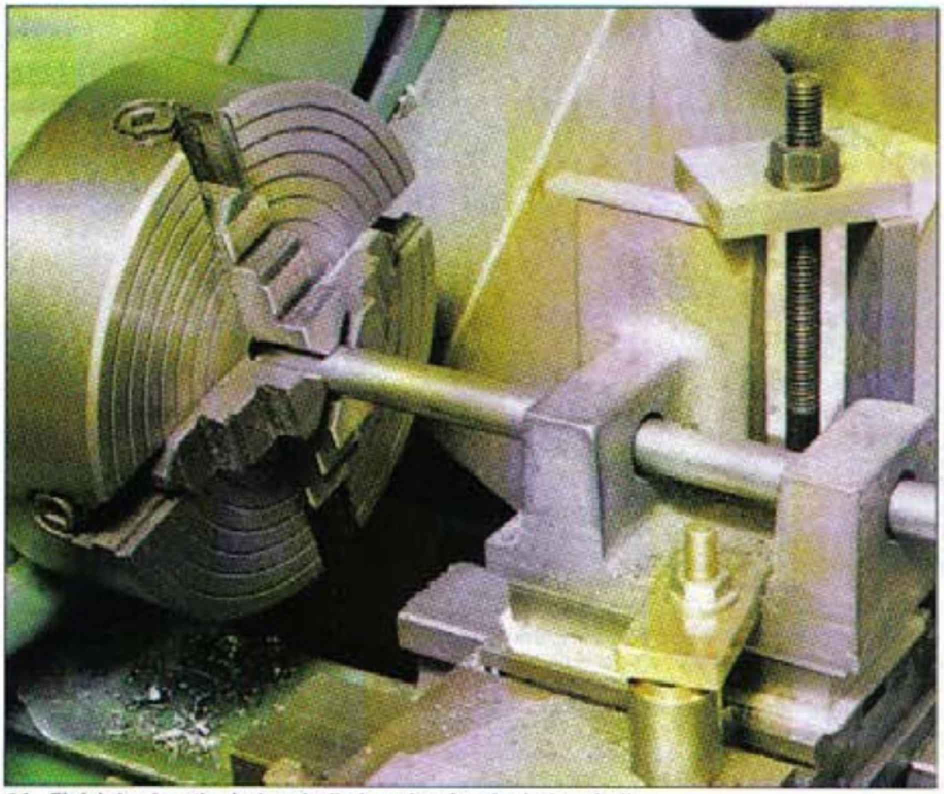
With the machined face now clamped against the angle plate and ensuring that the base was nominally level, the base was machined. The left hand end face was fully machined but, due to the taper on the casting, the front and right hand end were machined for a height of about 1/2in. Whilst there is no long term need to machine these areas, it did help to ensure that the machined faces were also true across the width of the part. However, the bottom face of the dovetail would also be lightly skimmed with the dovetail cutter, so an allowance for this was made in the amount machined off.

9. Surface on the hob spindle housing being machined to take the bearing bracket (Item 3)





10. Pre drilling the hob spindle housing for the hob spindle.



11. Finish boring the hob spindle housing for the hob spindle.

secure mounting during later operations, such as that shown in **Photo. 10**.

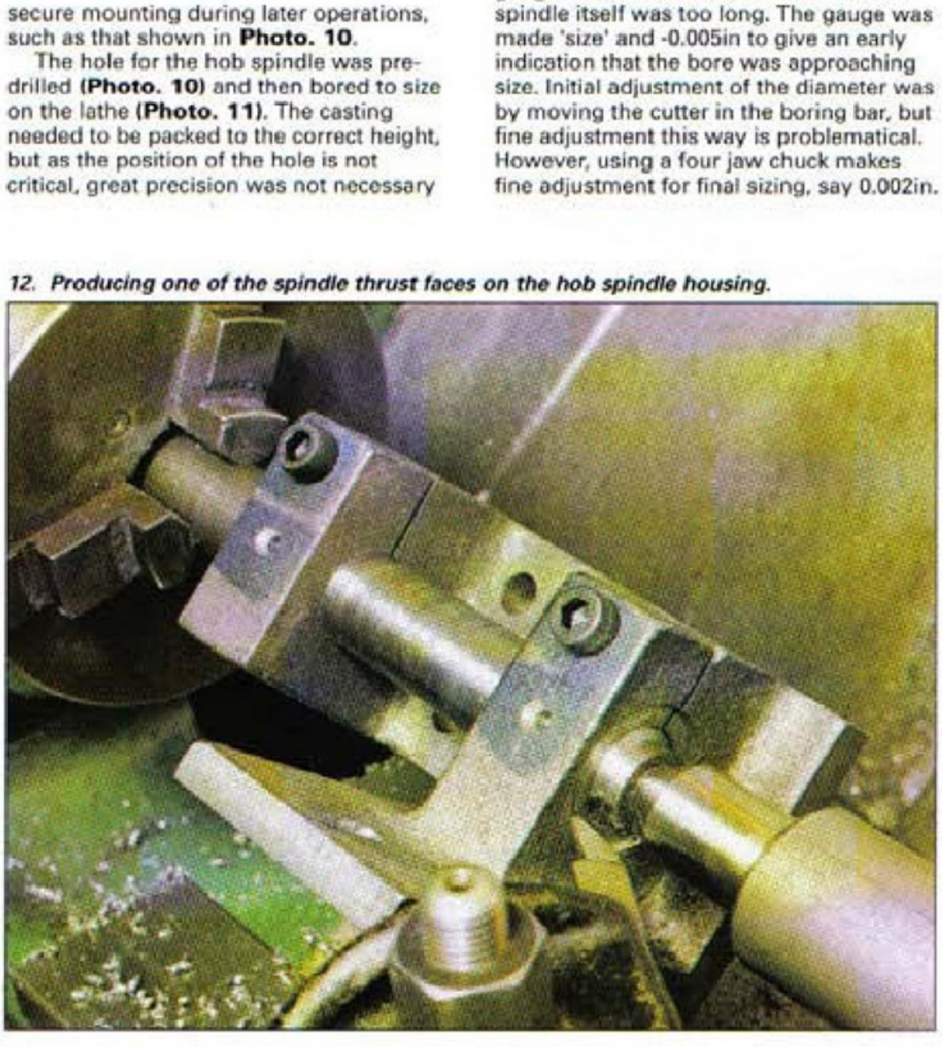
The hole for the hob spindle was pre-drilled (**Photo. 10**) and then bored to size on the lathe (**Photo. 11**). The casting needed to be packed to the correct height, but as the position of the hole is not critical, great precision was not necessary in the choice of packing. Whilst not yet described, the hob spindle had already been made and its diameter known. A plug gauge was made to test the bore as the spindle itself was too long. The gauge was made 'size' and -0.005in to give an early indication that the bore was approaching size. Initial adjustment of the diameter was by moving the cutter in the boring bar, but fine adjustment this way is problematical. However, using a four jaw chuck makes fine adjustment for final sizing, say 0.002in. and less, an easy operation by moving opposing jaws.

Next all holes were drilled and tapped and the blocks slotted. There remained the outer ends of the bearings to be counterbored to act as thrust faces for the hob spindle. The method used was to mount the casting on a mandrel turned in situ and the bearing adjuster screws used to ensure a firm hold. This operation is shown in **Photo. 12**. There is no dimension given for the position of this face relative to other features of the part, I therefore machined to a depth sufficient to create the bearing surface. Its position does though affect the alignment of the gears, as discussed later.

It was found that the bearings had closed a little after slotting so that the spindle would no longer fit. Some may choose to slot the bearing after the initial drilling operation, but this would result in an intermittent cut when boring, not ideal when creating a bearing surface.

Another factor is that, if the bearing needed very little adjustment, the closing screw would require to be tightened only lightly and may then tend to become loose due to vibration. The use of a stud firmly tightened home in the tapped hole plus two lock nuts to adjust the bearing would overcome this. However, it was too late for me to adopt this approach and the method I finally employed is probably as good if not better and it certainly looks tidy. Two M4 holes, one either side of the closing screw, were tapped in the top half of the bearing and socket grub screws fitted. These were used to jack open the bearing sufficiently to permit the spindle to rotate freely but without shake, and the closing screw tightened. This ensured that the screws were tight and would not work loose in operation.

12. Producing one of the spindle thrust faces on the hob spindle housing.



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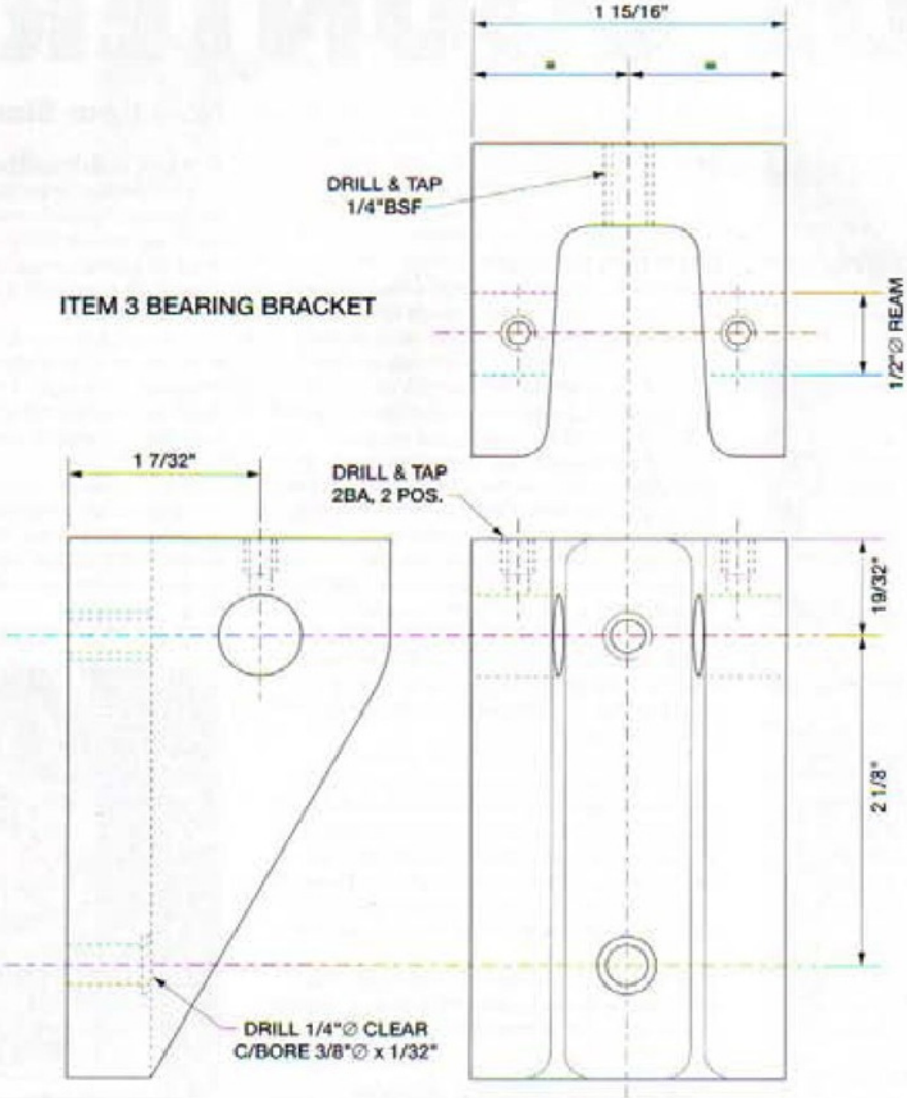
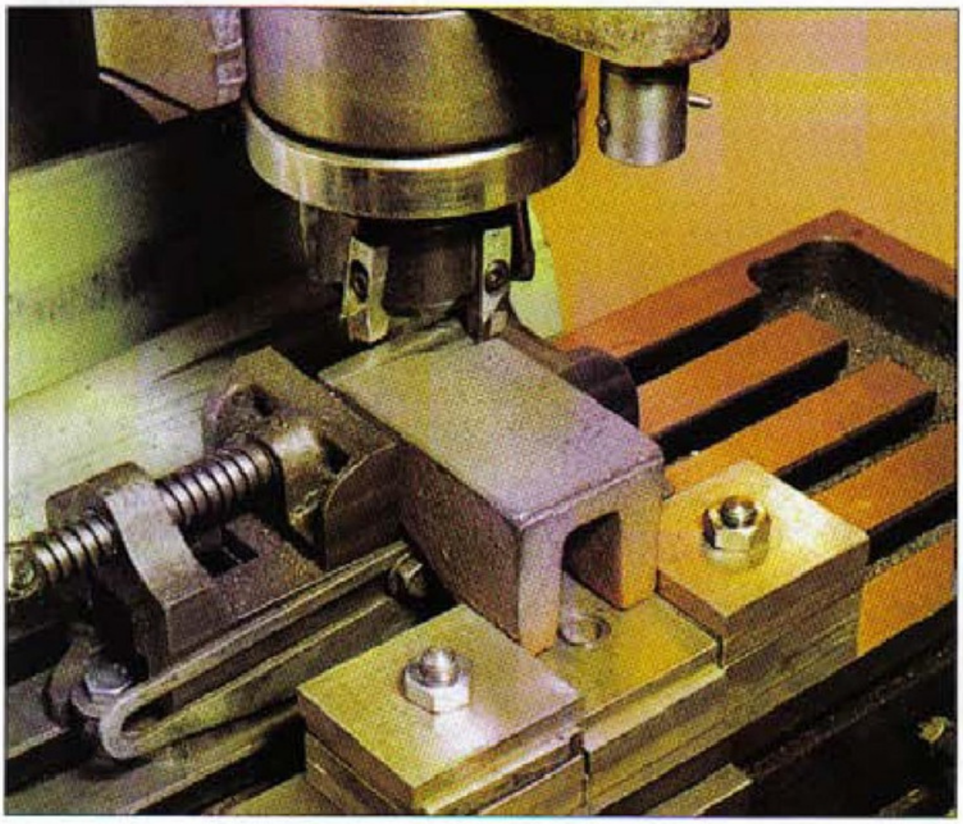


13. Set up for machining the bearing bracket (Item 3)



Bearing Bracket (Item 3)

Photo. 13 shows the main face of this being machined. Note the method of clamping used to prevent the vice attempting to close the gap between the two sides. The blocks on the machine table gave added support for the heavy duty initial cut. After machining the side faces, the bearing holes were bored whilst the part was mounted on the faceplate of the lathe. The top face was also machined, but for appearance purposes only.

Next the fixing holes were drilled and tapped. However, shims are specified to be fitted between this part and the hob spindle housing **(Item 2)** in order to provide adjustment when meshing the 20 and 100 tooth gears. I preferred to do without these items, so the clearance holes, one in each part, were made slotted, allowing the shaft to be raised and lowered to provide adjustment - much easier than varying the shim thickness.

Supplier of the hobbing machine kit. The College Engineering Supply, 2 Sandy Lane, Codsall, Wolverhampton, WV8 1EJ. Tel/Fax 01902 842284.

Harold Hall's description will be continued in our next issue.

TRADE COUNTER

Please note that, unless otherwise stated, Trade Counter items have not necessarily been tested. We give news of products and services which have been brought to our attention and which we consider may be of interest to our readers

A Re-fillable aerosol paint spray can

Phoenix Precision Paints Co. have recently introduced an aerosol paint spray can which can be charged with paint then pressurised with a propellant gas. After use, the can may be emptied and cleaned and is then ready for use with another colour or type of paint. The standard gas which is suitable for use with most types of paint is readily available in the form of cigarette lighter fuel gas, although this is not suitable for use with cellulose paints or etch primer. For these applications, a special gas will become available in the near future.

The 'Superspray' can is priced at £9.95 including VAT.

Phoenix Precision Paints Co., P.O. Box 359, Cheltenham, Glos. GL52 3YN

Hobbymat machines again available in the UK

A number of contributors to M.E.W. are users of the Hobbymat range of lathes and milling machines, as is evident from photographs used to illustrate articles. These machines have not been available for some while due to a break in manufacture. We reported in a recent issue that the range had been re-launched by a new manufacturer and it now gives us pleasure to bring the news that Essel Engineering of Billericay, Essex are importing and marketing a selection of these machines.

The SD 300 lathe is a 65mm centre height machine which will accept 300mm between centres. A 1/3 hp motor drives the headstock spindle which runs in tapered roller bearings, the speeds being 250, 500, 1000 and 2000 rpm. Fifteen Imperial screwcutting ranges are available (11 to 56 tpi) as are eighteen metric threads (0.2 to 3.0mm). Two automatic longitudinal feed rates are provided. The lathe comes equipped with 3 jaw chuck, drill chuck, chuck guard, change wheels, 4-way toolpost and dead centre. A wide range of accessories and attachments is listed.

The addition of the BF 400 milling head converts the lathe into a combination machining centre, but the head may also be used in conjunction with the KT 450 co-ordinate table in the form of a free standing milling machine. The 2MT spindle is driven by a 1/4 hp motor, providing speeds of 365, 560, 1120 and 1800 rpm. The head may be swivelled through 360 deg. The table is 450 x 160mm and has a longitudinal travel of 290mm and a cross travel of 140mm.

The SD 300 lathe costs £895 including VAT with carriage extra at cost while the milling head is priced at £795 and the co-ordinate table at £650.50.

Essel Engineering, 23 Cavell Road, Billericay, Essex CM11 2HR, Tel./Fax 01277 659774

Lead-free pewter

A pewter guaranteed to be free of lead has been introduced by alloys specialist Mining and Chemical Products. Intended mainly for use in ornamental ware, the high-grade material is thought to be the first to comply with European specification pr EN611-1:1991 for non-lead content.

MCP believes it will appeal to manufacturers, jewellers and craftspeople anxious to eliminate traces of lead in their production and in their products. The company says that the demanding standards of the specification are met by producing the pewter in the modern Wellingborough refining centre under controlled conditions to quality-assurance standard IS09002. Only quality-tested constituents are employed, without any unrefined scrap.

Melting at 245 deg. C, the pewter provides the same decorative benefits as traditional pewters. It flows freely when molten, and allows detail to be produced accurately with a classic 'pewter' finish. Priced competitively, it is available in ingot or stick form ex-stock from MCP in quantities from a few kilograms upwards.

Mining and Chemical Products Ltd, The Mill House, Laverstoke, Whitchurch, Hants RG28 7NS Tel: 01256 895255

New from Shesto

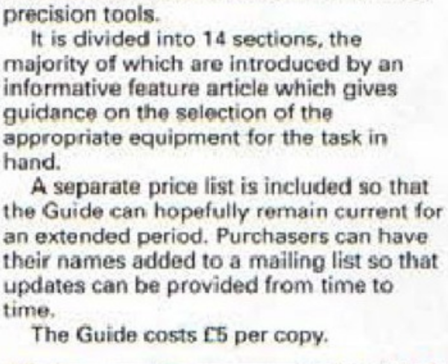
A new publication

The Shesto Essential Tool and Reference Guide is much more than another tool catalogue. It is a 114 page manual containing a wealth of useful information as well a details of over 2000 precision tools.

It is divided into 14 sections, the majority of which are introduced by an informative feature article which gives guidance on the selection of the appropriate equipment for the task in hand.

A separate price list is included so that the Guide can hopefully remain current for an extended period. Purchasers can have their names added to a mailing list so that updates can be provided from time to time.

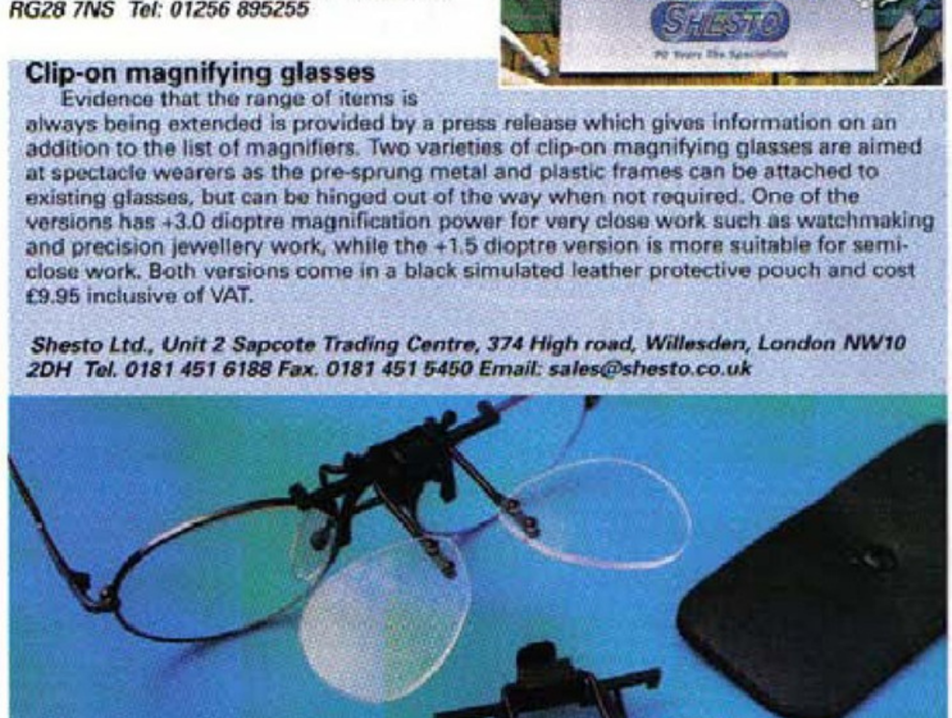
The Guide costs £5 per copy.



Clip-on magnifying glasses

Evidence that the range of items is always being extended is provided by a press release which gives information on an addition to the list of magnifiers. Two varieties of clip-on magnifying glasses are aimed at spectacle wearers as the pre-sprung metal and plastic frames can be attached to existing glasses, but can be hinged out of the way when not required. One of the versions has +3.0 dioptre magnification power for very close work such as watchmaking and precision jewellery work, while the +1.5 dioptre version is more suitable for semi-close work. Both versions come in a black simulated leather protective pouch and cost £9.95 inclusive of VAT.

Shesto Ltd., Unit 2 Sapcote Trading Centre, 374 High road, Willesden, London NW10 2DH Tel. 0181 451 6188 Fax. 0181 451 5450 Email: sales@shesto.co.uk



Moore & Wright return to the model engineering market

There can be few owners of home workshops who do not have at least one piece of equipment bearing the respected name of Moore & Wright. It is therefore with pleasure that we have noted the return of this company to the model engineering field, having been present (sharing stand space with Shesto) at a number of recent exhibitions.

A new periodic six page publication, 'Measurement and Workshop' gives details of a selection of items which are likely to be of interest to readers of M.E.W. Catching the eye in Issue 2 is a range of graduated squares which could eliminate some of the juggling necessary when using both rule and square. Available in both Imperial (3in. to 9in.) and metric (75mm to 225mm) these are based on the Sheffield made 400 Series engineers squares and are made to British Standards. Prices range from £30.89 to £59.04 (excluding VAT).

An interesting item is the Mini Mag which consists of a small magnifier attached to a magnetic base. The prototype is said to have been constructed for his own use by one of the M&W toolmakers and proved to be so useful that it has been added to the catalogue range. It can be placed on rule, vernier or micrometer and will remain in place while the scale is read. Economically priced at £8.50 plus VAT it could prove to be one of the most useful items in your tool kit.

Full details of Moore & Wright products are given in their publication '92 Years of Precision'.

Moore & Wright, Atlas Way, Atlas North, Sheffield S4 7QQ Tel. 0114 225 0400 Fax 0144 225 0410

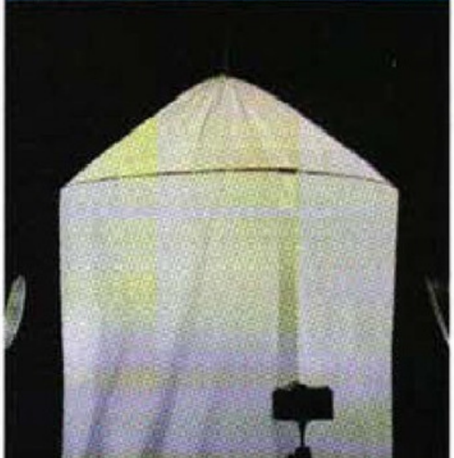
A photographic aid

Recent articles on workshop photography by Bob Loader and Ivan Trobe have prompted Procameras of Wolverhampton to send us details of their cylindrical light tent. Made of white nylon, it has two flexible hoops which maintain the cylindrical shape while a draw string cord allows it to be suspended from some suitable supporting structure. The overall dimensions are 3ft. diameter x 3ft. high.

Placed around the object to be photographed, it can be used with a variety of light sources which are arranged around the outside to provide a diffused light pattern. The camera lens is inserted via a vertical slit in the fabric, the width of the aperture being varied as necessary by moving the nylon on the hoops.

Being suspended, it can be arranged to be lifted clear while the object to be photographed is positioned, then lowered into place. The Light Tent costs £59 plus £4 p & p.

Procameras, P.O. Box 461, Wolverhampton WV10 7YX Tel. 01902 791511 Fax 01902 791585



fohrmann-WERKZEUGE offer 25th Anniversary discounts

German tooling and modelling equipment supplier fohrmann-WERKZEUGE are celebrating their 25th business anniversary in September 1999. To mark the occasion, certain items ordered between 1. 9. 1999 and 14. 9. 1999 will qualify for a 5% discount while the remaining articles in their main catalogue will be subject to a 10% discount. The order date will be taken as that of the postmark and it is emphasised that late orders will not qualify, so send for a copy of their catalogue and place your order in time.

They will also be attending the Hamburger Modellbautage (17 - 19 September 1999) and will be pleased to receive advance orders for collection at the Hamburg Messe.

fohrmann-WERKZEUGE, D-45731 Waltrop, Sydowstrasse 7c-d, Germany Tel. 02309-2962 Fax 02309-73538

Machine Manuals from L. A. Services

We receive many requests for information on how to obtain operating and service manuals for older machine tools. We include many of these in our 'Link Up' feature, but increasingly we direct enquirers to Adrian Grimmett of L. A. Services. His 'Engineer's Emporium' stocks not only a wide selection of machines, spares and tooling, but also a large number of books, drawings and manuals. If you are seeking information, give him a call. He is also always looking for additions to the list, so if you have original manuals surplus to requirements or examples which are suitable for copying, he may well be interested.

L. A. Services Ltd., Bramcote Fields Farm, Warwickshire CV11 6QL Tel. 01455 220340

IN OUR NEXT ISSUE

Coming up in Issue No. 59 will be

SHARP TOOLS FOR BEGINNERS
Bob Margolis suggests some improvements to a cheap bench grinder which will make it suitable for tool sharpening

A CIRCULAR SAW
Dyson Watkins' latest project is a substantial woodworking machine

A TASTE OF THE TAIG CNC MILL
Small CNC milling machines suitable for use in the home workshop are now becoming commercially available. Tony Jeffree recounts some experiences of using a unit which is marketed under the Peatol label in the UK

Issue on sale 9th July 1999

(Contents may be changed)

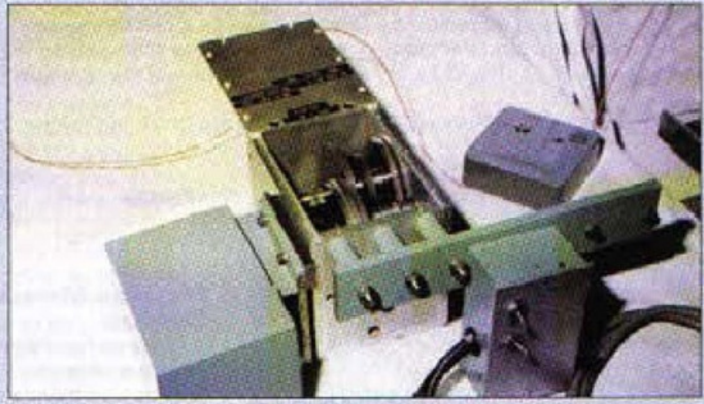
TOOLS AND EQUIPMENT AT HARROGATE

Some of the items of interest seen at The 1999 National Model Engineering & Modelling Exhibition

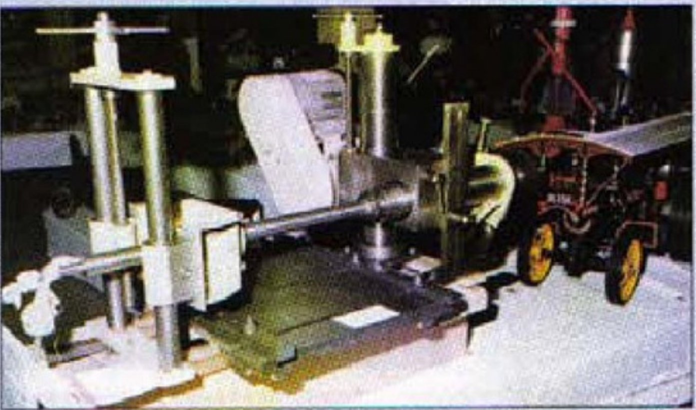
It is always a pleasure to visit the Harrogate Exhibition, the welcome from organisers, exhibitors and visitors making the long journey well worth while. This year, the number of items of workshop equipment being shown was significantly greater than we have seen on some occasions and the standard of workmanship was very high. The one regret is that the majority of these were on the Club and Society stands, when many of them would have made a real impact in the competition section.

Our old friend Barry Jordan provided a magnificent display of his small machine tools, and took the top award in the section with his Archdale radial drill. As we have featured this machine in a recent issue, and will be looking at his latest creation (a 1/5th. scale power hacksaw) in the near future, we have concentrated on some of the other items in this report.

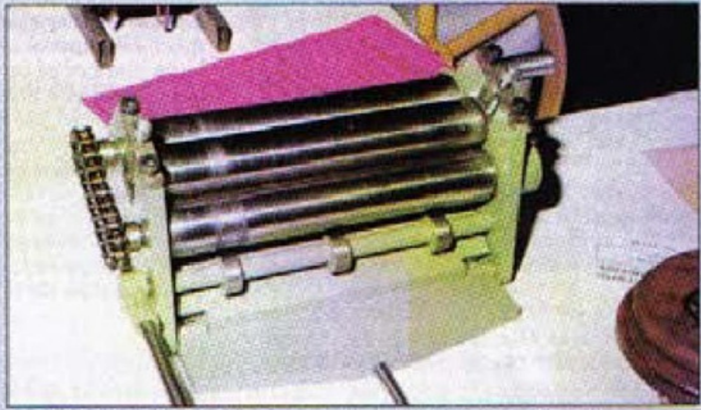
Paul Bowler was awarded a Commended certificate for his neat dividing head. His other entry, a 'Poor Man's Jig Borer' can be seen to the right



Alan Hopwood's milling table drive gearbox is a sturdy piece of workmanship



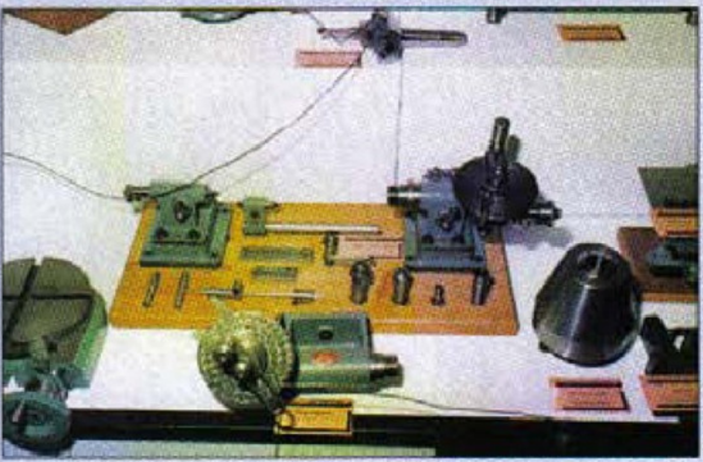
Designed and built by Richard Randell, this versatile boring and milling attachment fits a Harrison M400 long bed lathe. Richard is a member of the White Rose Model Road Vehicle Society, and also exhibited a 4in. scale Burrell Scenic engine.



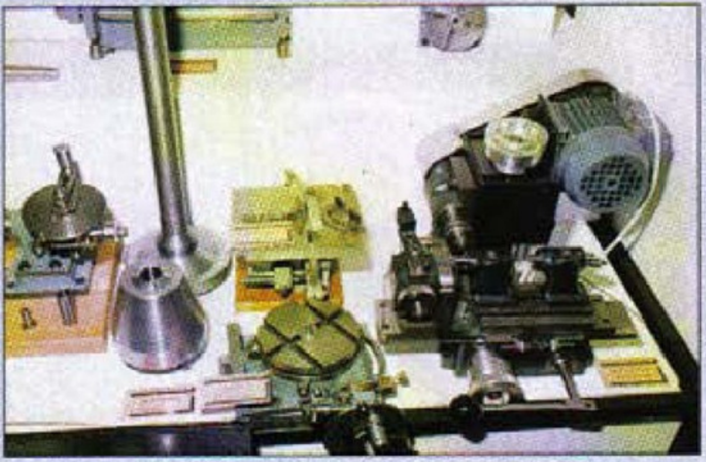
Also from the White Rose Society, T. Halliday exhibited a substantially built set of bending rolls

The imaginative York City and District Society stand was judged to be the best in the exhibition. Alan Hopwood arranged a display of items to George Thomas's designs. The boring head in the foreground is by Don Bowerman

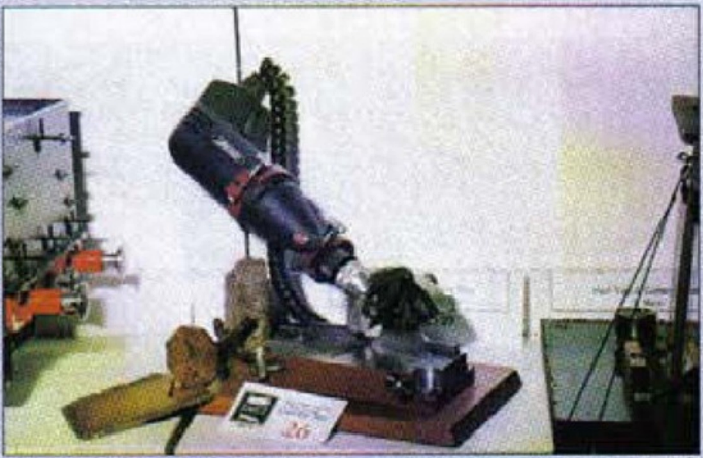
Peter Smallwood's Stent tool and cutter grinder and Pat Inwood's rotary table are seen in this view



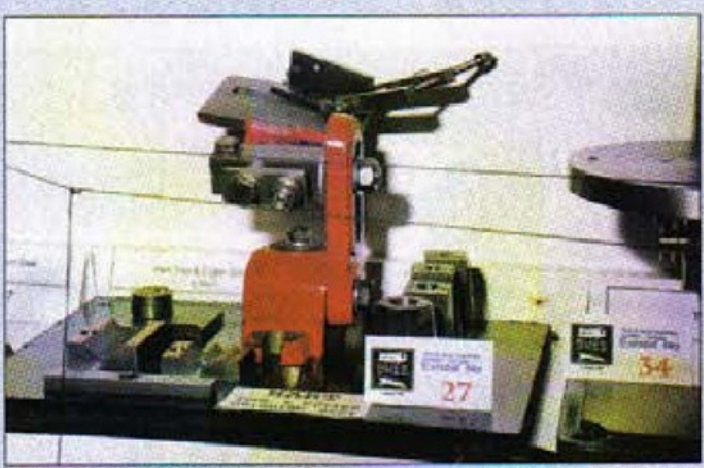
More from Alan Hopwood and Peter Smallwood in the shape of dividing heads to the George Thomas and Alan Timmins designs respectively



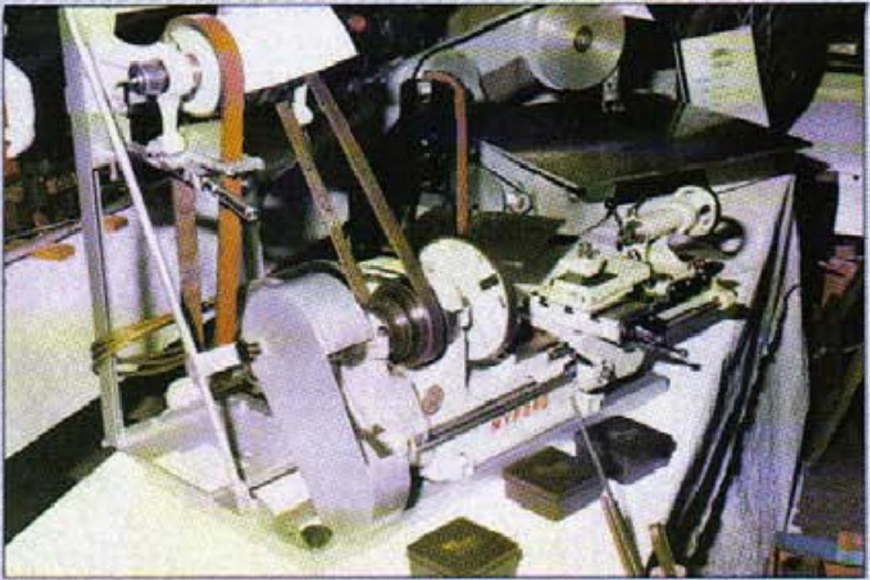
The very impressive collet chuck and drawbar are the work of Jim Winrow, the neat saw table by Ted Hearfield and the second Stent by John Ellison. This rotary table is from the prolific Alan Hopwood.



The Bradford M. E. S. stand featured this interesting miniature combination saw by David Watts. A number of the small items produced with the tool were also displayed

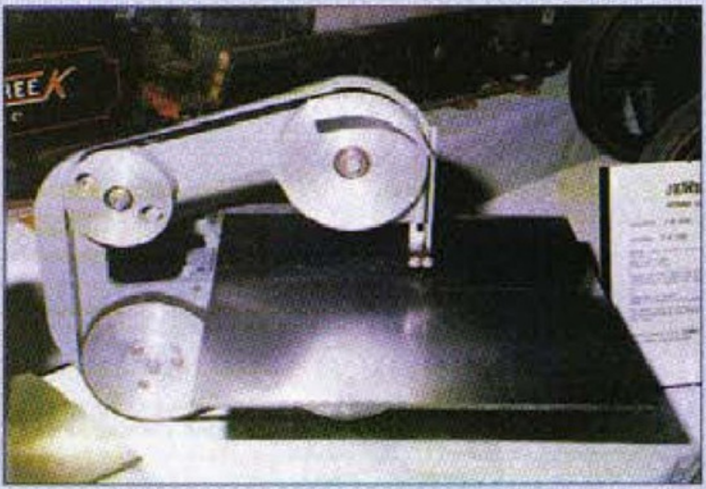


The Hart grinding rest was by Ewan Mann, also of Bradford

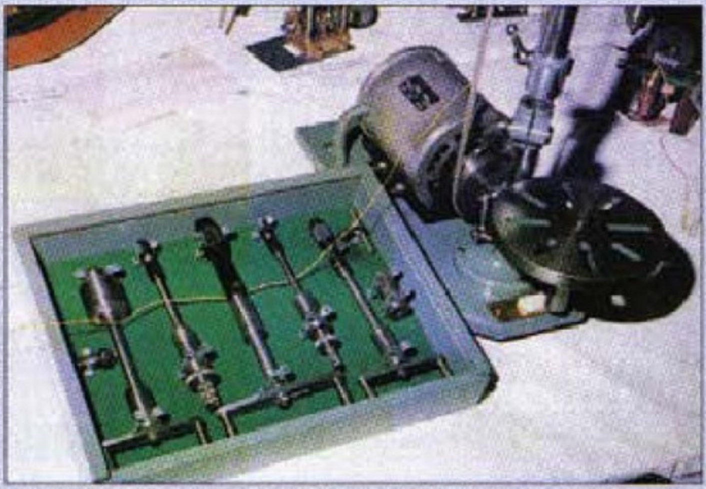


Barry Keal of Lincoln & District M. E. S. exhibited a neatly restored early Myford lathe, complete with a flat belt drive assembly.

LEFT: This adaptation of a double ended bench grinder into a 'swing' surface grinder appeared to be based on the Alan Jeeves design which we featured in these pages some time ago. This example was built by Peter Newby of Tyneside SMEE. In the background is a well finished sensitive drill by Frank Romvari.

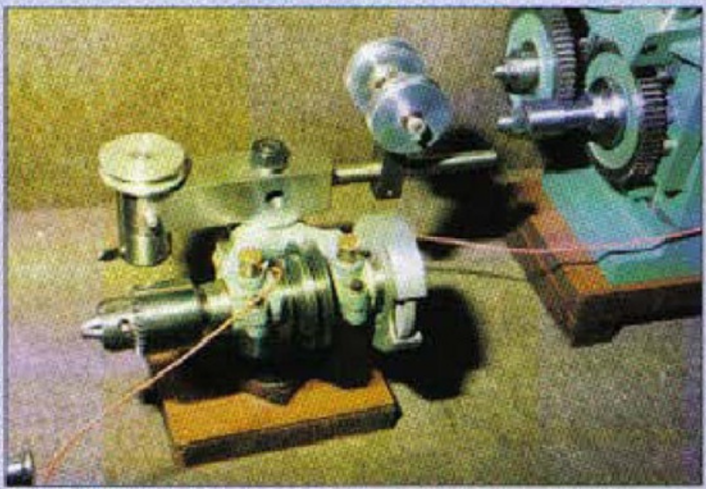


On the same stand was Alan Thompson's band saw, displayed with the guards removed to show the four pulley system. Drive is provided by a sealed motor from a petrol pump.

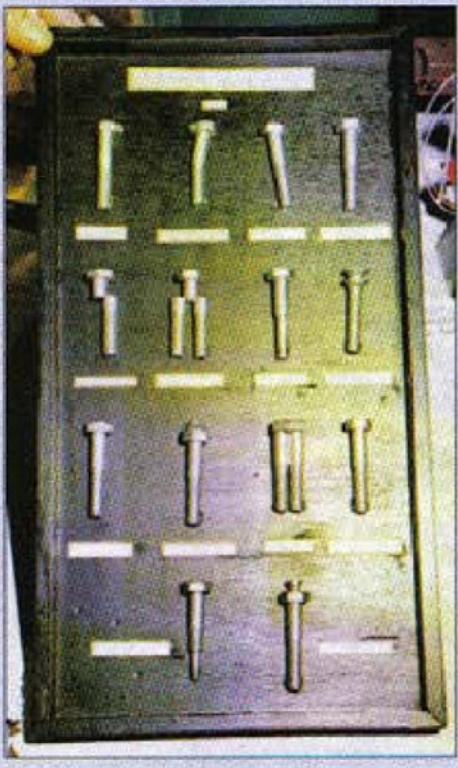


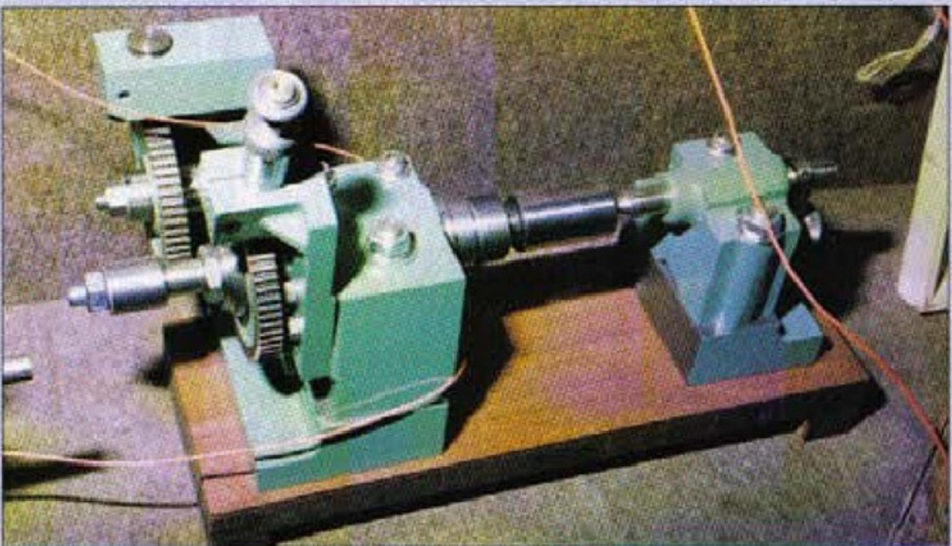
A number of well made versions of the George Thomas pillar tool were to be found on the club stands. This one, by Scunthorpe Society member George Aisthorpe was distinctive because it was accompanied by a well displayed set of interchangeable mandrels

George Aisthorpe also exhibited a number of other useful tools, all to a high standard of workmanship and finish



Jim Batchelor of the Leeds Society is well known for his outstanding workshop equipment. On this occasion he exhibited this intriguing combination attachment which incorporated a cutter frame





A sturdy dividing head was also Jim Batchelor's work. Easily converted from direct to indirect gear wheel indexing, the unit would satisfy the majority of dividing requirements

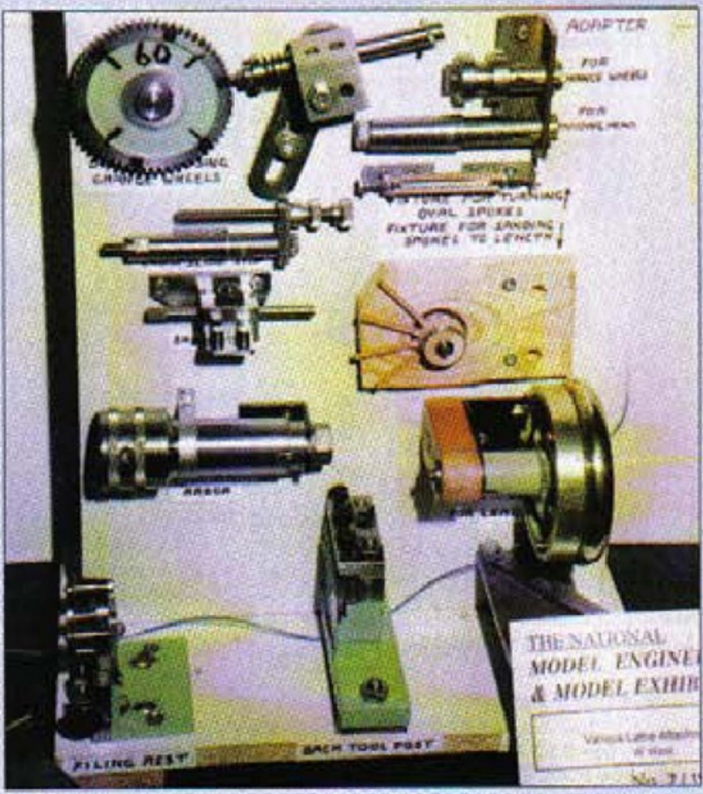
LEFT: Many readers will have seen the cartoon of the set of 'very special purpose' bolts. Here they were brought to life by Tony Sanders of Scunthorpe

The City of Sunderland Model Engineering Society can always be relied upon to provide a varied display of interesting items. Nick Stothard provided a number of items including this capstan attachment and embryo multi position table. In the background is Tommy Husbands' dividing head and worm cutting drive system which we saw at Olympia in January

All Nick Stothard's exhibits were based on well produced castings. The secret was in his simple but high quality patterns which were also on display

The Society of Model and Experimental Engineers is thought by many to be a London club, but it has members based all over the U. K. and in many other countries. Their stand was a gathering point for members resident 'north of Watford' and provided an opportunity to see work not normally taken to Marshall House. A nicely made 'Potts' spindle was the work of Sheffield based member John Slater

A substantial taper turning attachment was also the work of Nick Stothard



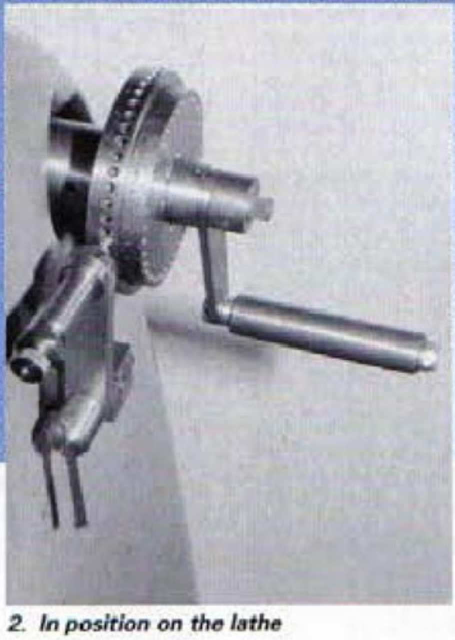
Workshop equipment builders are beginning to master the art of displaying the smaller items to advantage. Bill Wood of Spenborough Model Engineers brought these attachments for a Myford lathe

George Thomas provided us with designs for many useful attachments. His modified leadscrew systems for cross slide and top slide are deservedly popular, these examples also being by John Slater

A HANDLE ON MANDREL INDEXING

Robert Newman devised what he thought was a new form of mandrel indexing device, only to discover that the principle wasn't new after all. Despite this, this accessory is a versatile addition to the lathe

1. The handle in 50 indexing mode

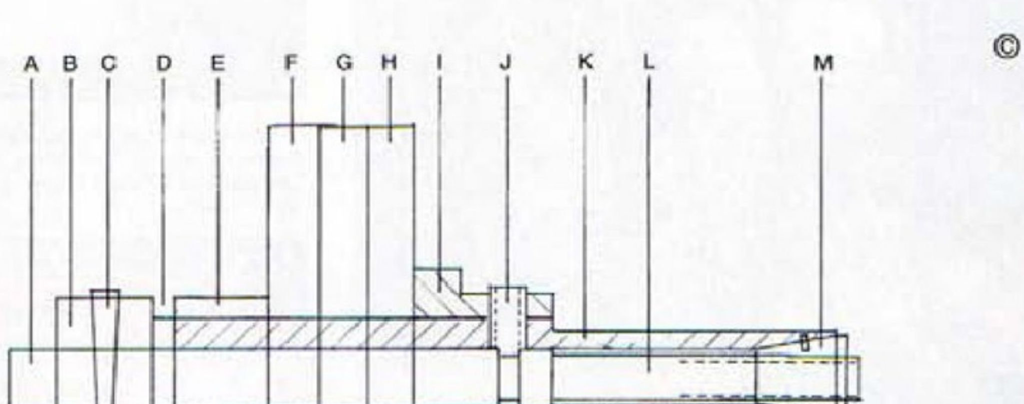


2. In position on the lathe

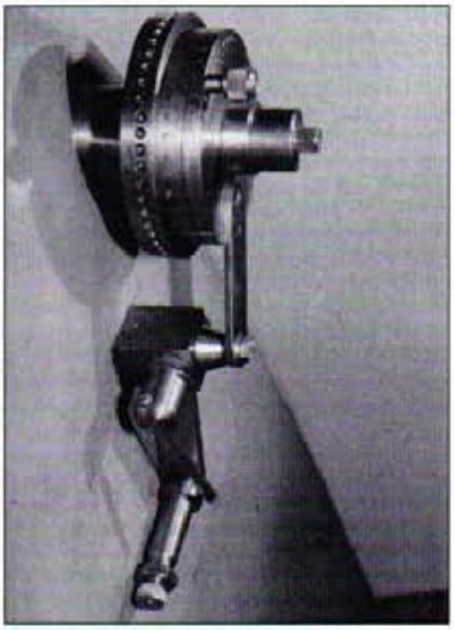
3. Re-arranged to 360 deg. indexing mode

FIG. 1. GENERAL ARRANGEMENT

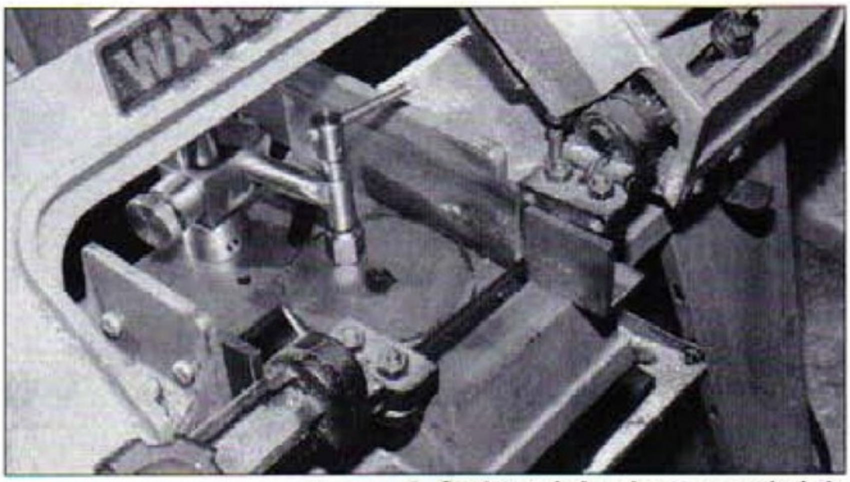
A. DRAW BAR OPERATING HEXAGON
B. STOP COLLAR
C. TAPER PIN
D. HANDLE POS.
E. SPACER
F. VERNIER DISC
G. 36 DISC
H. 50 DISC
I. BUTTRESS
J. DOG SCREW
K. QUILL
L. DRAW BAR
M. DRAW CONE



COMPONENT DIMENSIONS WILL VARY ACCORDING TO THE LATHE TO WHICH THE UNIT IS TO BE FITTED - SEE TEXT FOR DETAILS



4. *On the lathe in 360 deg. indexing mode*



6. Cutting an index plate to a rough circle

5. The sizing tool

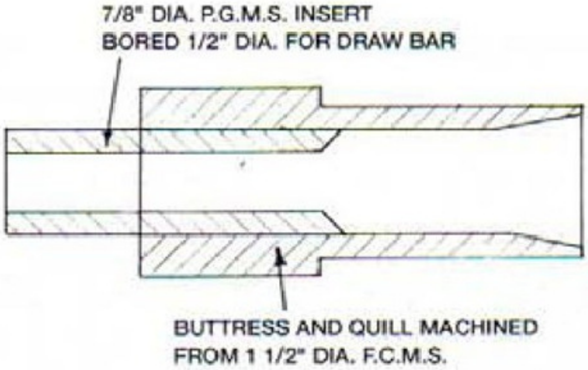


FIG. 2. CONSTRUCTION DIFFERENCES FOR MANDREL BORES 7/8" AND ABOVE

On the acquisition of my present lathe I decided that the first accessory to be made should be a mandrel handle. While measuring up and making construction sketches, I realised that with slight design changes it could be made to double as an indexer through the lathe mandrel. So was born my Mandrel Handle Indexer or MHI as it is now known.

The tool was fitted with two 4in. discs containing 48 and 50 holes respectively. As the tool was required to be instantly ready at all times, either to index or to act as a handle, the discs were drilled and numbered on their edges. Drilling the face would have required only one disc and would have been easier to make. The handle, however, would have got in the way when indexing, necessitating its removal and defeating the object of instant use.

To cope with divisions not divisible into 48 or 50, a 5in. index plate was made so that it could be drilled as required. About two years ago, a major change was made to the M.H.I., brought about by my need to make a 360 deg. by 1 deg. disc for a small rotary table. Engraving such a disc on the lathe would be simple, but I did not possess the means of dividing by 360 using this method. What I did possess was a very old, very big, very heavy, but very accurate rotary table that would only fit on my pillar drill. Dreaming up a means to engrave on this was a bit daunting. Thinking time was indicated.

Eventually I came up with the idea of a vernier to fit the M.H.I. My 'friend in hobby' engraved the plates for me. It worked, but I was never happy with it; too fiddly, easy to make errors. Further, if my friend and I are any example, reading and setting verniers is a very subjective exercise, we never agree!

The idea of using holes and pins for the vernier came to me when setting my workshop heater timer. Mock-ups showed that the idea should work and could be used on the M.H.I. The system dreamed up consisted of two discs on a common seat on the tool. The front disc, called the Vernier from now on, was held in close proximity to the 36 disk, (ditto) but secured against rotation by being attached to the lathe. The 36 was secured to the mandrel handle and rotated with it. The first set of discs did not work as desired. In one 90 deg. sector, the pin would not pass into the 36 disc or if it did, it did so with difficulty. The fault proved to be the disc seat; a tolerance of 0.001in. in the machining of the disc seat and its hole in the disc was overly generous.

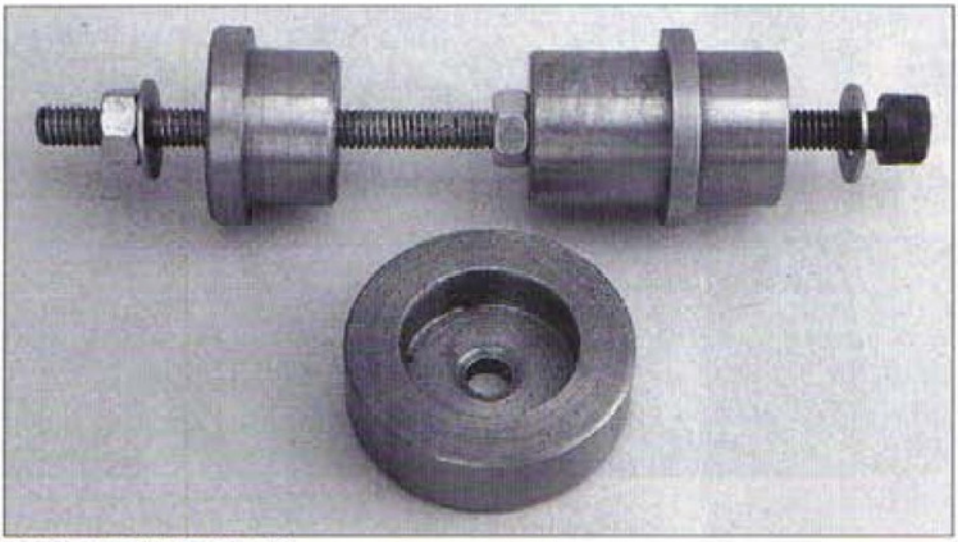
A new M.H.I. was made with new Vernier and 36 discs, the 50 and index discs from the Mk 1 being incorporated into the tool. Precision Ground Mild Steel (PGMS) was used for the disc seat to remove one possible source of error, the discs needing to be a very accurate fit on this; 0.0005in. would be fine.

Making the discs

The 50 disc is fitted because some of the scales I wish to divide are not achievable using the 36. Omit if not required. If you wish to include it with edge indexing, the disc will have to be 4in. in diameter to accommodate the 50 holes. You will also need a means of indexing and drilling the edge. If you have this, fine. If not, it will be discussed when the tool has been made. For the moment, make a blank 50 plus a 5in. index plate. You can, if you wish, front index the 50. In this case the your disc need only be 4 $\frac{1}{2}$in. diameter.

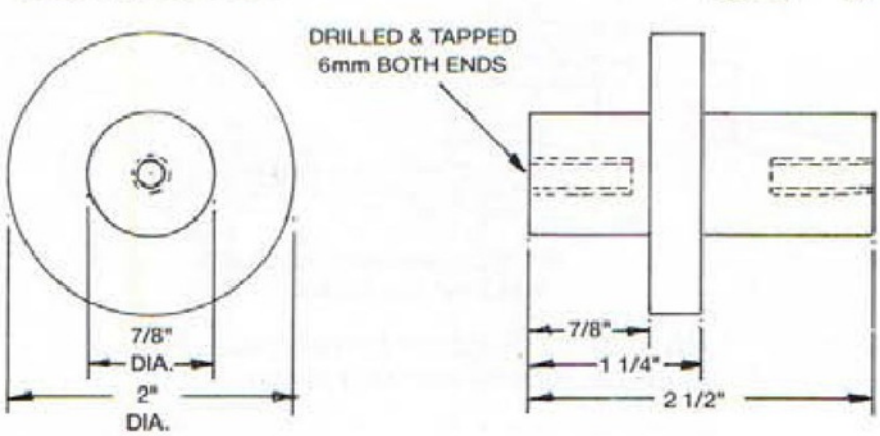
The tool in the photographs has Vernier and 36 discs of 3 $\frac{1}{2}$in. diameter simply because I ran out of 4in. material and was to impatient to wait. They worked, so I let well alone. Equal sized discs look neater. The 50 and 36 discs are made of $\frac{3}{8}$in. steel plate and the Vernier from $\frac{5}{16}$in., but there is no reason why they should not all be $\frac{3}{8}$in. Front indexing 50 and index plates are $\frac{1}{4}$in. thick.

My metal cutting bandsaw made short work of roughly cutting discs to size. **Photo. 6** shows a 5in. index plate being worked on. Centre pop all discs. The Vernier and 36 discs must be identical in size, especially the centre hole, therefore fasten them together by some means. I chose to spot weld them at the spare



7. Rotary table centring jig

FIG. 3. SIZING TOOL



metal on the disc edges. Install the lathe face plate, centre and fasten thereon the two discs. Obtain a length of 7/8in. PGMS and lightly chamfer one end. It is permitted, in fact advised, to very, very lightly polish an inch or so of this end, but do not reduce the diameter. The idea is to remove any surface roughness.

By the best means at your disposal, bore a hole through both discs so that it will accept the PGMS on a tightish push fit. There is no reason why 1in. PGMS cannot be used, just remember to make the necessary alterations to measurements. Bore the remaining discs.

Sizing the discs

To assist in this task, I suggest you make the sizing tool shown in **Fig. 3** and **Photo. 5**. The shaft is made of 7/8 PGMS in the interest of accuracy. The backing disc of FCMS is secured to shaft by either gluing, pinning or shrink fitting then faced on both sides. The securing cap is bored to an easy fit on the shaft.

Mount the discs, still fastened together, with paper between tool and disc then machine to size, taking light cuts. The discs should always remain in this relationship, the front discs being the Vernier, so mark them so that the face side is known and which disk is which. Size the other discs.

Drilling the discs

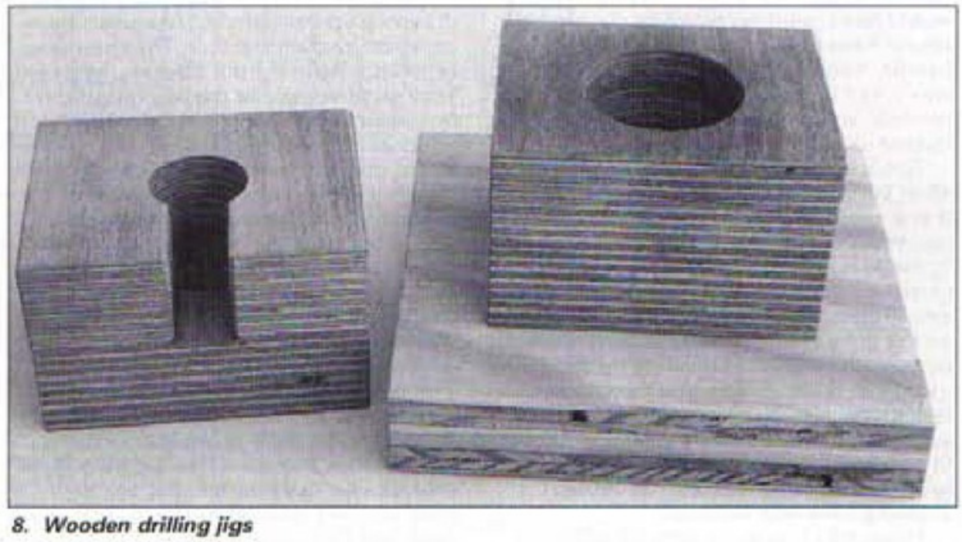
A dividing device with micrometer reading to minutes is mandatory for this operation. Simple rotary tables engraved with degrees acting against a marker are simply not accurate enough. An accurate jig similar to that shown in **Photo. 7** is required to hold the discs central to the rotary table. A securing cap can be borrowed from the sizing tool. Projection above the table surface should be 3/4in., 1/4 in. for plywood backing, 3/8in. for disc plus 1/8in. Prepare a 1/4in. thick, 4 1/2in. dia. ply disc with a 7/8in. central hole. Clamp the Vernier disc, face side up, and the ply to the rotary table using the jig to centre. The drilling is best done on an accurate pillar drill or mill, but could be done on the lathe if your rotary table can be positioned vertically. It cannot be emphasised enough that a very high order of accuracy is required when drilling all discs. The holes in my disks are 1/8in. diameter, a 3mm spotting drill held short in my most accurate chuck being used first. They were later reamed to size. A 3mm stub drill or a Slocombe with a 3mm tip will do the job just as well but, if possible, use brand new drills. If using a Slocombe, through drilling will have to be done off the table. Set the drill depth stop so the plywood is just pierced.

Use plenty of cutting fluid, applying light pressure at first until the drill has created its own start, thus minimising drill wander. The Vernier is drilled with 11 holes at 9 deg. intervals, the 36 disc with 36 holes at 10 deg. intervals. Choose your own radius according to disc size. If face drilling the 50 disc, you will need 50 holes, spacing 7 deg. 12 min. Recommended radius is 2in.

If it is intended to side index the 50 disc, this will have to be done when the tool is finished, you must prepare the index plate for this time by drilling it 50 holes at 7 deg. 12 min spacing, chose your own radius near the edge of the disk.

Having completed periphery drilling, the holes which secure the discs to the tool must be dealt with. Set the table radius at 1 3/16in. and, still using the 3mm drill, drill the 36 disc with three holes located at 0, 140 and 220 deg. Using this disc as a pattern, drill all remaining discs EXCEPT THE VERNIER, opening them out to 4mm.

It is suggested that a copy of the securing hole pattern might save an awful lot of bother in the future, so after drilling the 36 disc 3mm, mount it on the sizing tool and secure in place with a toolmakers clamp. If the centre hole of your drill table is 7/8in. or above, fine. A all you need to do is to place the ply disc in position on the back of the sizer, drop it into the central hole with spacers to keep the clamp clear



8. Wooden drilling jigs

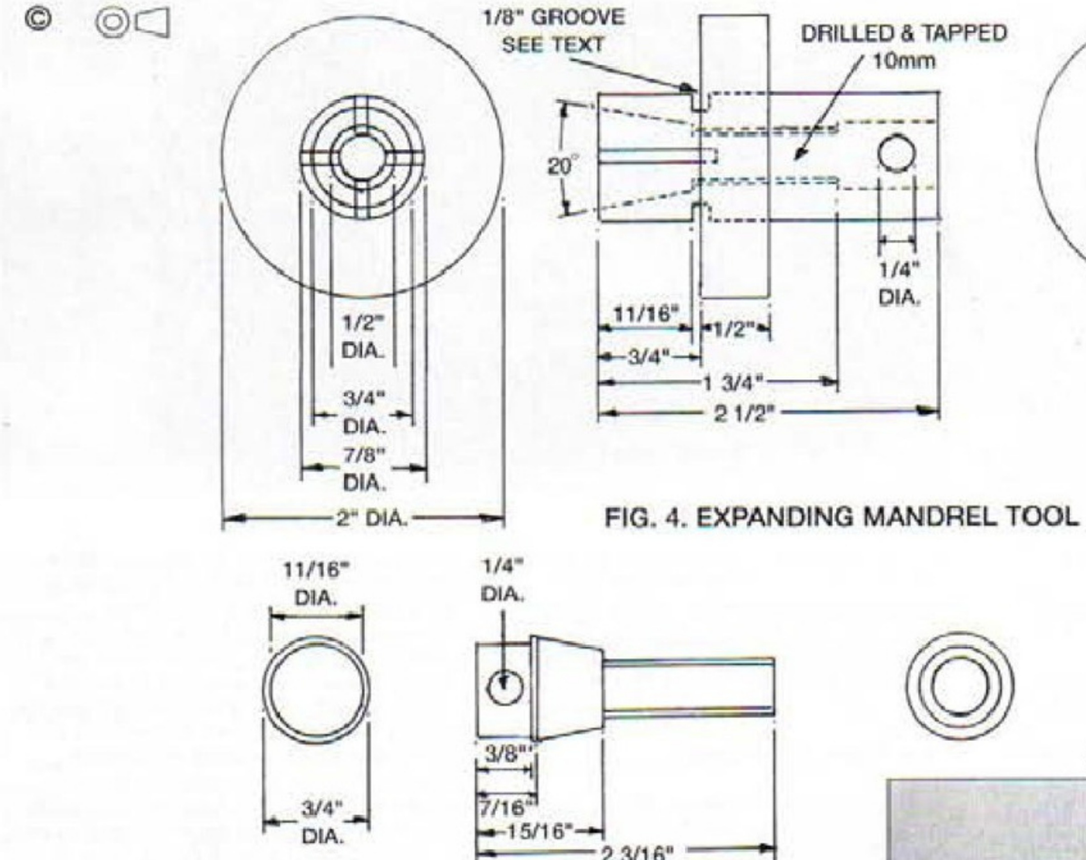


FIG. 4. EXPANDING MANDREL TOOL

of the table and drill the first hole through with the 3mm stub drill. Insert a 3mm pin or drill into the hole, locking the disc to the sizer. Remove the clamp and drill the other two holes. No central hole?. Solution, make the left hand jig shown in **Photo 8**. Multiyply of all sizes gets hoarded in my workshop for just such work. The 3mm holes in the 36 disc can now be opened to 4mm, the holes in the sizer remaining at 3mm.

With drilling of the indexing holes complete, the rotary table is no longer needed. With a sharp $^1/_8$in. hand reamer in the drill chuck and the drill set to its slowest speed, ream all holes except the central securing holes, to size. Take it slowly and carefully, using plenty of cutting lubricant. Using a hand reamer in this fashion breaks the rules, I know, but you get a very good finish. Remember the reamer must go at least two thirds of its length into the hole. I suggest you break another rule:- hand hold the discs, because in this way the reamer automatically self-centres. The numbers of holes I have treated in this manner must run into the hundreds without one single problem. By selecting the appropriate drill size, the amount of metal to be removed is minimal and I always wear an armoured glove.

The discs are retained in position on the M.H.I. by 4mm countersunk screws and it is important that the countersink is drilled with the same accuracy that we have so far used. The 36 disc was placed on the drill table with the countersinking drill in the chuck. The drill table was positioned so that drill was just above the disc but could be removed and replaced without problems. A 2in. length of 4mm silver steel replaced the drill (a 4mm drill would do just as well). The drill chuck was lowered until the end of the silver steel could be located in one of the securing holes then the drill mandrel locked. The 36 disk was now clamped to the table, the silver steel replaced with the countersinking drill and the hole countersunk. The procedure was repeated on all other securing holes - tedious but accurate.

Cosmetics

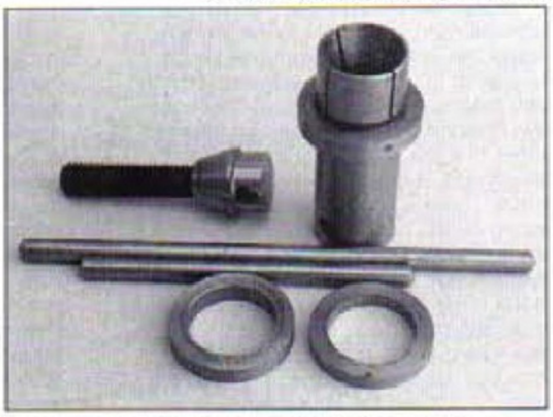
Should you wish to face your discs you should do so at this stage. If for any reason it is not possible to hold the discs in the chuck, the tool shown in **Photo 9** and **Fig. 4** is recommended. The photo shows my original tool which has since been amended as detailed in the drawing. The spacers needed to be increased in diameter to at least 1 $^1/_2$in. The central hole is 0.010in. oversize and the main shaft is, as you might have guessed, $^7/_8$in. PGMS.

The longitudinal slots are $^1/_{16}$in. and intersect the $^1/_8$in. groove. I have now made a number of these expanding mandrels of various sizes, the groove in each case being machined to a depth which allows an expansion of between 8 and 10 thou. In use, the face of the disc should be slightly proud of the end of the mandrel.

The moment of truth

It is pointless going any further if the discs do not work. First we should clean them up. Set the workshop radio to some soothing music, make yourself comfy on the shop stool and lightly chamfer all indexing holes, ensuring that they are also clear of swarf. Pass a short length of $^1/_8$in. silver steel through all the indexing holes in all discs. Now we can test the Vernier and 36 discs. First a reminder that the Vernier is drilled with 11 holes at 9 deg. intervals, so 10 spaces x 9 = 90 deg. The 36 interval is 10 deg., therefore 90 deg. will cover 10 holes, i.e. 11 holes of the vernier must match 10 holes of the 36 disc. You now need two short lengths of $^1/_8$in. silver steel, each with a lightly chamfered end. On to the sizing jig place the 36 disc followed by the Vernier, both face side out. Into the extreme left hand hole in the Vernier insert a pin through into any hole in the 36. In the Vernier right hand hole, insert the other pin. It should pass through into a hole in the 36 disc. Repeat the exercise for the remaining 35 holes on the 36 disc. If the discs pass this test then you will have a very accurate means of indexing 360 deg. providing of course, that you make an accurate disc seat. If one or two holes give trouble and examination reveals no obvious faults, judicious use of the reamer might clear the fault. Tread carefully. Keep the discs locked by one pin while attending to the awkward hole.

If this does not work or you have had trouble with more than two holes and visual inspection shows no obvious misalignment or spacing error, try this. Using the right hand Vernier hole only, pass the pin through into the suspect holes in the 36. Now do the same test using any



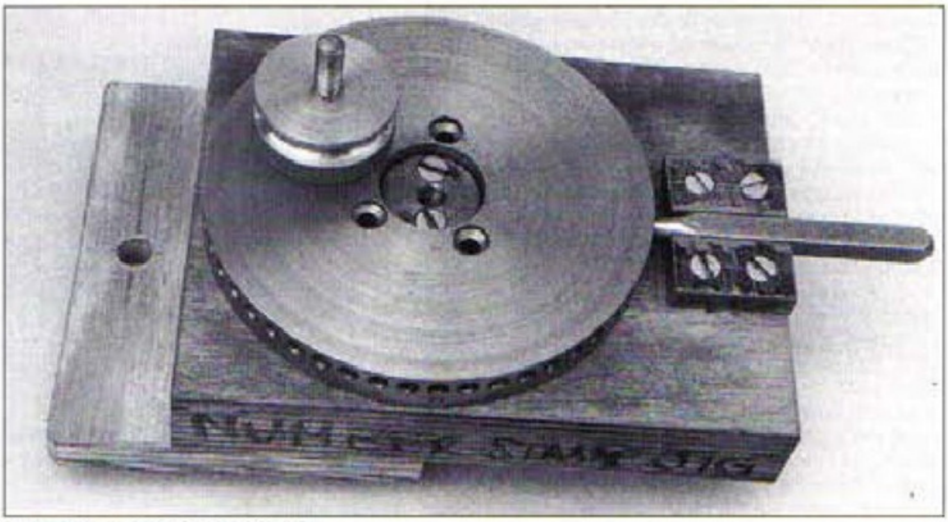
9. The $^7/_8$in. expanding mandrel

two holes of the Vernier. If you can pass this test, the radial alignment is O.K. but the spacing at the faulty holes is probably not. Did you lock the table at each hole before you drilled?. Should the holes not pass this examination then you almost certainly have a radial problem, especially if the faulty holes are grouped together. Probable cause is disc central hole with too great a tolerance or the centring jig of the table didn't. Discs with a couple of holes with angular misalignment that cannot be discerned with the naked eye can be used, I doubt the error will ever be noticed.

Engraving and numbering

Engraving is mainly required for location as the position of the holes in the 36 disc cannot be seen. By the time I came to make the discs for the M.H.I. Mk 2, I had made myself an all singing and dancing engraving tool for the lathe, making engraving at any angle a doddle. Supposing you do not own such a tool! This is how I would go about it (I have tried this with no problems). Place the Vernier on the sizer, face side out and, using double sided tape, stick it to the sizer. Place the 36 disc over the Vernier, insert a $\frac{1}{8}$in. silver steel pin into any hole in the 36 disc and through into the extreme right hand hole in the Vernier. Rotate the lathe chuck until one jaw is horizontal and engage back gear. Use the best means available to level the chosen jaw. Prepare a prop that can be inserted under this jaw to prevent it moving downward. A length of studding inserted into a 'T' piece, resting on the lathe bed would do the necessary. Wind a length of string around the chuck and secure one end to a jaw, attaching a weight of 2 to 3lb to the other end and let it hang. Trying not to disturb the chuck, insert the sizer in the chuck so that the pin in the holes is opposite the centre of the level jaw, then carefully tighten the chuck. Hone your stiffest boring tool to be very sharp, with a 0.002 wide flat on the tip and clamp it securely in the tool holder, upside down (the tip away from you), with the tip at centre height. Place the tool tip to touch the 36 disc opposite the pin, move the tool away from the disc by moving the carriage, then advance the tool 0.003 using the cross-slide. If you can lock the cross-slide, do so. Using the carriage, engrave a line across both discs, this line becoming the zero on the Vernier and 0/36 on the 36 disc It is a good idea to restrain the chuck with a spare hand when engraving. Carefully release the 36 disc by unclamping the sizer cap, remove the pin, rotate the 36 disc until the next hole is opposite zero on the Vernier, reinsert the pin and reclamp. Engrave a line on the 36 disc only, $\frac{3}{16}$in. long. If you have a carriage stop, fix it to this length. Repeat for the remaining 34 holes.

Remove both discs from the sizer, secure the 36 to the tool with double sided tape, fitting the Vernier on top, face side in. Do not clamp. Rotate the sizer in the chuck until any engraved line on the 36 is opposite the engraving tool, then clamp the sizer in the chuck. Rotate the Vernier disc until the hole next to zero is also opposite the tool, insert the pin into both discs, clamping the discs in place



10. The number stamping jig

with the securing cap. Engrave a $\frac{3}{16}$in. long line on the Vernier, remove pin, unclamp discs, rotate the Vernier to next hole, insert pin etc., etc. Engrave all remaining holes on the Vernier except the eleventh, this hole now becoming redundant.

Numbering the discs

The jig shown in **Photo. 10** was made in a hurry when the Mk. 1 M.H.I. was made. It was the intention at the time to make a decent copy, but as the original worked so well, I never did get around to it. There were so many other interesting projects to make. Designed to be held in the vice by the thin ply section, the thick ply transmits the shock to the vice jaws. The central pivot is a 1in. length of PGMS sunk halfway into the wood and bolted in position. Distance from bottom of stamp slide to the centre of pivot is 2 $\frac{3}{8}$in. Stamps are held in position by a High Tech. Thumb. Discs should be numbered anti-clockwise. Do NOT copy me and number them clockwise! The Vernier is numbered 0 to 9, the 36, 1 to 36. If face indexing the 50 disc, stamping must of course be on the front. A piece of 2in. angle with the slides attached and the whole screwed in position on the thick ply will do the job.

When the stamping is complete, mount the sizing jig in the lathe and clamp the Vernier and 36 thereon. Using a fine file, plenty of cutting fluid and high speed, remove the proud metal.

Constructing the body

The description will be for lathes with mandrel bores $\frac{1}{2}$ to $\frac{3}{4}$in., mandrel bores of $\frac{7}{8}$in. and above being dealt with separately. **Figs. 1 and 2** give the general layout and part names.

The quill

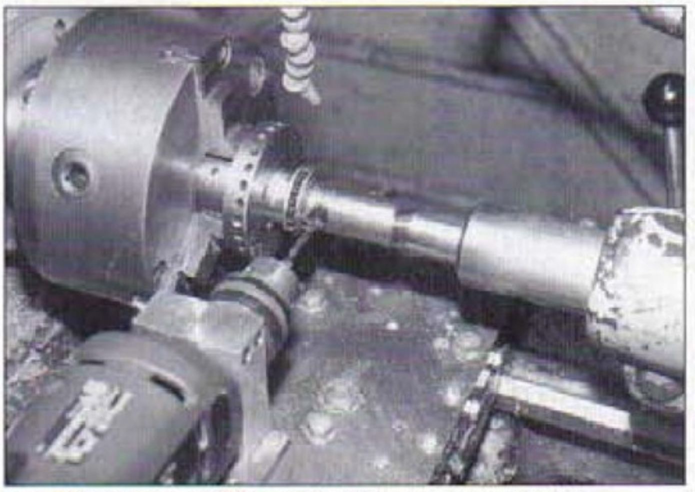
This is fabricated from a length of $\frac{7}{8}$in. PGMS (for disc seat accuracy) and a short length of 1 $\frac{1}{2}$in. dia. FCMS. First, ensure that the last 3in. or so of the mandrel bore is thoroughly clean. Take two measurements of the bore diameter, 90 deg. apart and at least 1in. in from the end. Do not take what your manual gives as the diameter as gospel. From the smaller of the two measurements subtract 0.002in. and machine the PGMS to this diameter for a distance of 2 to 2 $\frac{1}{2}$in. When checked, it should be a nice easy sliding fit in the mandrel, with no slop. From the diameter used for machining, subtract a further 0.250in., this giving the drill size for boring the end of the worked section of the PGMS, depth equal to machined length. The idea is to leave a wall thickness of $\frac{1}{8}$in. Set the compound slide over to 10 deg. and machine a taper in the bored section to leave a rim of $\frac{1}{16}$in. It won't do any harm if it goes down to $\frac{1}{32}$in., but a smooth finish is required.

The draw cone

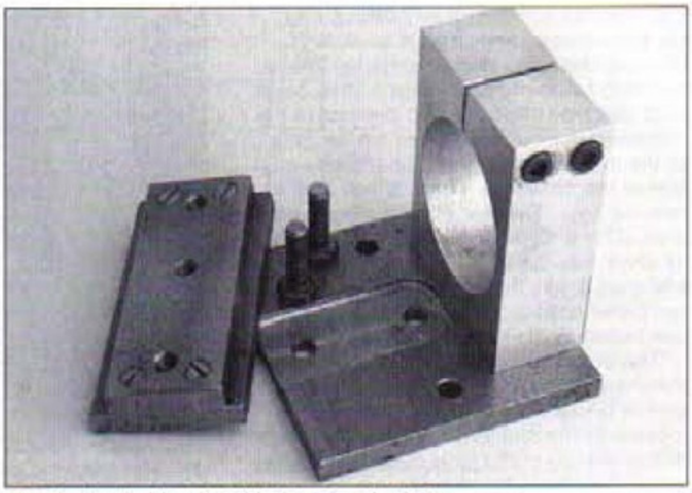
Make from FCMS of a diameter fractionally larger than the mandrel bore, resetting the compound slide to machine a taper in the opposite direction. An end diameter of $\frac{3}{8}$in., again with a very smooth finish is needed, trying the quill on the cone for compatibility. Machine the cone to a diameter equal to that of the mandrel bore less $\frac{1}{16}$in. Again fit the quill to the cone, marking where it finishes on the cone plus $\frac{1}{8}$in. The cone will be parted of at this point, but not yet. Drill and tap for any suitable $\frac{5}{16}$in thread. Glue a $\frac{1}{16}$in. pin in a hole drilled halfway along the cone. Leave $\frac{1}{8}$in. protruding to be trimmed to correct length when the slots have been cut in the quill. The pin must not interfere with the thread. You can now part off, but before doing so, why not machine chamfers on both ends of the cone to pretty things up?

The expansion slots

Four slots, $\frac{1}{16}$in. wide, spaced equidistant around the quill are required. It is suggested that each slot is cut separately, as when attempts to cut two slots at once were made a most unpleasant vibration was set up. No cure was not found and I find that this has happened to others as well as me. The length of the slot is equal to the machined portion of the quill and is best cut with a slitting saw. No means of dividing the diameter? I have never found the trick of folding paper around the metal works accurately enough on smaller diameters, but this does. Measure the diameter, calculate the circumference and divide by



11. The set-up for drilling and reaming for the taper pin



12. A simple pistol drill holder for the lathe

four. Using dividers set from a vernier calliper, transfer this dimension to a length of masking tape four times in sequence. Cut accurately to length, this can be stuck to the quill.

The buttress

Machined from $1\frac{1}{2}$in. dia. FCMS it is the part to which the discs are secured, providing the necessary clearance for the discs to revolve. It also houses the dog screw. The major outside diameter is as near as possible $1\frac{1}{2}$in., length $\frac{3}{8}$in., the minor diameter being equal to the external diameter of the mandrel, minimum length $\frac{3}{8}$in.. It is bored to a close sliding fit on the quill and glued in place with Loctite 601. Bide a while on the gluing as it is best that the buttress is first drilled and tapped for the disc attachment screws. You will need the sizing jig which was previously drilled with the hole pattern, a short length of 3mm silver steel and some means of keeping the jig and buttress upright. The right hand jig in **Photo. 8** will fit the bill, the central hole being the same as the buttress minor diameter, you will also need a 3mm stub drill. Insert the sizing jig into the buttress and drill the first hole, fit the pin to lock the jig to the buttress and you know the drill from now on. Open the holes in the buttress to tapping size and tap 4mm. To check that all is well, slide the quill into the buttress, approximately to the position it will occupy when fixed, slide on the 50 and 36 discs in that order and screw them to the buttress. It should have been mentioned earlier that, if using a side indexing 50 disc, the blank disc must be used for all fitting and measuring.

Assuming that the discs sit nice and snug on the quill and buttress, add the Vernier disc. Insert the quill etc. into the mandrel until the $\frac{7}{8}$in. material is tight up against the mandrel end and, holding the discs, buttress and quill to the mandrel, estimate where a 4in. handle would have to be located on the quill to clear all obstructions. Scribe this point on the quill, add $\frac{1}{8}$in. and part off the quill at this point. It may be that a handle held against the Vernier disc would be clear; this is fine. Scribe the face position of the Vernier plus $\frac{1}{4}$in. on the quill and part off at this point. You can now glue the buttress to the quill, ensuring that the extreme right hand of buttress is level with the shoulder of the quill.

The dog screw

Size 5 or 6mm., length 10 to 15mm. Drill and tap midway of the length and central to the width of the buttress minor diameter. You need to drill to half the depth of the minor diameter.

The driving hexagon

You can, if you have the means, machine this on to the quill, but you will have to remember to leave extra length when parting off. For everyone else, follow me. The method described has been in use on four M.H.Is and has given no problems.

On a length of $\frac{3}{4}$in. AF hexagon machine a $\frac{5}{8}$in. dia. $\frac{3}{4}$in. long. spigot. The recommended handle thickness is $\frac{3}{16}$in., so part off to leave a hex. this long plus 0.002. This measurement must be accurate. Bore the seat end of the quill with a $\frac{5}{8}$in. hole, just over $\frac{3}{4}$in. deep. The hexagon shank should be a nice sliding fit and it should seat flush to the quill end. Remedy if this is not so. Glue the driving hexagon into the quill and leave in a warm place for at least 24 hours to cure. Now drill and ream a $\frac{3}{8}$in. hole in the quill to meet up with the bored hole of the expanding section.

The draw bar

Use either $\frac{3}{8}$in. FCMS (providing it is very near to size) or PGMS. Machine on a suitable length, a diameter of $\frac{5}{16}$in., 2in. long. Thread two thirds of this length with the same thread as used on the draw cone. Try the fit of the two together, engaging two thirds of the cone thread onto the draw bar and slide the whole into the quill, locating the cone pin in one of the slots. You did trim the cone pin, I trust, so that it lies below the quill surface. You are advised to chose one slot and ensure that the pin slides freely in it. Mark and always use the same slot.

The stop collar

Made from FCMS, $1\frac{1}{8}$in. dia., length $\frac{3}{4}$in. bored to a close sliding fit on the draw bar and secured by a taper pin, which should be $\frac{1}{8}$in. to $\frac{3}{16}$in. diameter and at least $1\frac{1}{8}$in. long.

Assemble the draw bar and cone into the quill, seating the cone fully home. Fit the dog screw and, holding the cone tight into its seat but not expanding the quill, tighten the dogscrew on to the draw bar to lock it in place. As this is the first time we have had this assembled, try the fit in the mandrel. With the quill out of the mandrel, fit the stop collar and, with the cone firmly on its seat and the collar against the hexagon, mark where the bar exits the collar. Part off the draw bar to this length.

Drill and ream the stop collar for the taper pin while in situ on the draw bar and pressed tightly against the hexagon. This is easy on the lathe if you have the means. Most of you will own an electric drill with a 43mm collar, so why not make the simple drill holder shown in **Photo 12.** You will find that it compliments the M.H.I. for future use.

If resorting to the pillar drill, you will require some method of keeping the collar tight against the hexagon. I suggest that you tap the collar for a small grub screw. On the lathe, a short length of barrel pressed against the collar by the tailstock will fit the bill. Irrespective of method, ensure that the cone is on its seat and the draw bar locked against movement. The hole is drilled across the diameter, but off centre for length. This saves messing about finding out which end is which. Ream the hole for the taper pin.

Another heresy for you. I used my electric drill with the reamer fitted, the lowest speed engaged and plenty of cutting oil to ream the hole. It gives a very smooth job. Just remember to check the fit of the taper pin frequently. When complete, tap the pin home and trim the draw bar to length where it exits the stop collar.

The draw bar hexagon

Strip the M.H.I. so that the draw bar can be worked on. On a short length of 2BA hexagon material, machine a length of $\frac{3}{8}$in. to $1\frac{1}{32}$in. diameter. Part off to leave a hexagon $\frac{3}{8}$in. long. Bore and ream the draw bar, but you know the drill for inserting the hexagon. There is one small difference in that this insert is glued and pinned using a $\frac{1}{16}$in. rollpin cut to size.

Fitting the dog screw

Assemble the M.H.I. without discs, ensuring that the cone is properly seated etc. The dog screw groove position must be marked accurately if all is to work as desired. Using the dog as a marker I have found to be an iffy procedure. I have dealt with this type of problem in the past in the following manner. I obtained 1in. lengths of the threads I commonly use. Each thread length was carefully drilled and reamed $^1/_8$in.. The end of each piece was slotted for a screwdriver. A 1 $^1/_2$in. length of silver steel had a point ground on one end then it was the hardened and tempered to become a punch. I think its use becomes obvious.

The object of the dog screw is to push the draw cone off its seat. It must play no part in preventing the draw bar trying to move into the tool when rotated clockwise; that is the job of the stop collar. Therefore, when machining the dog groove, give 0.005in. clearance to the right of the dog and 0.020in. to the left. Depth of groove is $^1/_{16}$in. Very lightly chamfer the groove edges.

Reassemble the tool without discs, lubricating the parts as you go. A silicon based lubricant would be best. Seat the dog screw, but not so tight that it binds on the draw bar. We now need to check the tool operation out of the mandrel and, if necessary, adjust the amount of expansion. On the M.H.I. built so far all, irrespective of bore size, finished up with a wall size of $^3/_{32}$in. The best way to achieve this is to measure the quill wall thickness and decide on the amount to be machined off. The metal is best removed from the outside of the expanding section to give a waist effect. The waist should be $^1/_2$in. long and is best machined with a round nose tool. The idea is clearly shown in the photographs.

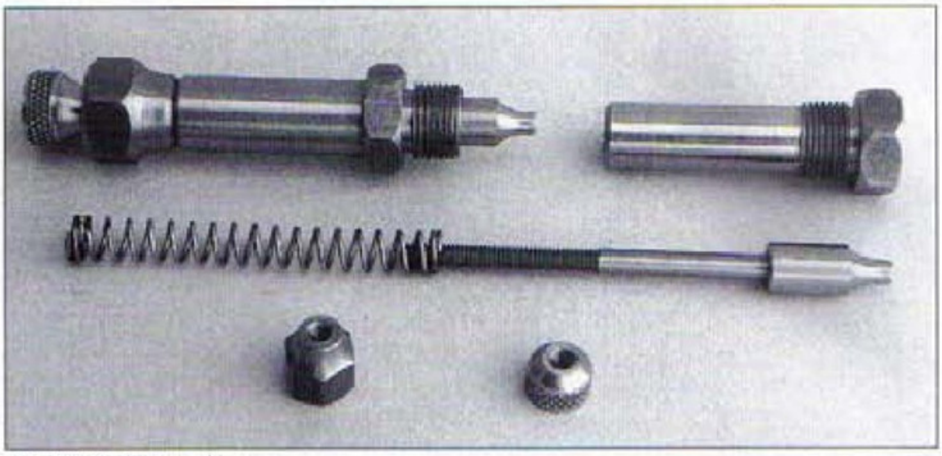
To test the tool action, have a vernier calliper handy. The draw cone should be snug on its seat. Rotate the draw bar, using its hexagon, by one half turn. The movement should be smooth with no roughness. Measure the diameter of the expanding quill section which should be between 9 and 12 thou. greater than the diameter to which you machined it. Adjust the 'waisted' thickness until you have this amount of expansion, but only at 2 thou. at a time. Now rotate the draw bar anti-clockwise by one half turn to release the cone, checking that the cone has released by measuring the diameter. Having assured yourself that the M.H.I. is expanding and contracting to your satisfaction, try the action a couple of times in the mandrel. If you set up the M.H.I. correctly, you should not need more than half a turn of the draw bar to lock it in position or to release.

The handle

Fig. 5 gives the general arrangement and all necessary information. The barrel of the handle is made from 22mm copper water pipe. When complete, try on the tool. With the stop collar fitted, check that the handle is not preventing the collar from bearing against the draw bar hexagon. If it is, rectify by shaving the handle shaft.

The spacers

Remove the handle and fit the 50 and 36 discs, slide the Vernier disc in position and replace the stop collar and taper pin. Fit a clamp to hold the Vernier tight against the 36 disc. Ensure that the cone is firm on its taper and not expanding the quill. Measure carefully the distance between the face of the Vernier and the rear of the stop collar. From any suitable 1 $^1/_8$in. material (brass is nice), machine a length to this size. Bore it an easy $^7/_8$in. fit. Remove the clamp on the discs and fit the spacer, collar and taper pin. Expand the quill by half a turn and you should be able to rotate the Vernier disc without any appreciable movement. If you cannot, the stop collar is bearing against the spacer. Release the cone, trim the spacer by no more than 2 thou and try again. Remember to set up the cone and apply the half turn each time you do this. When satisfied remove the Vernier and replace with the handle. The space between the handle and the 36 looks odd, does it not? Make another spacer, same diameter, to fit snugly in this space. It should support the handle but exert no pressure on it.



13. The indexing plunger

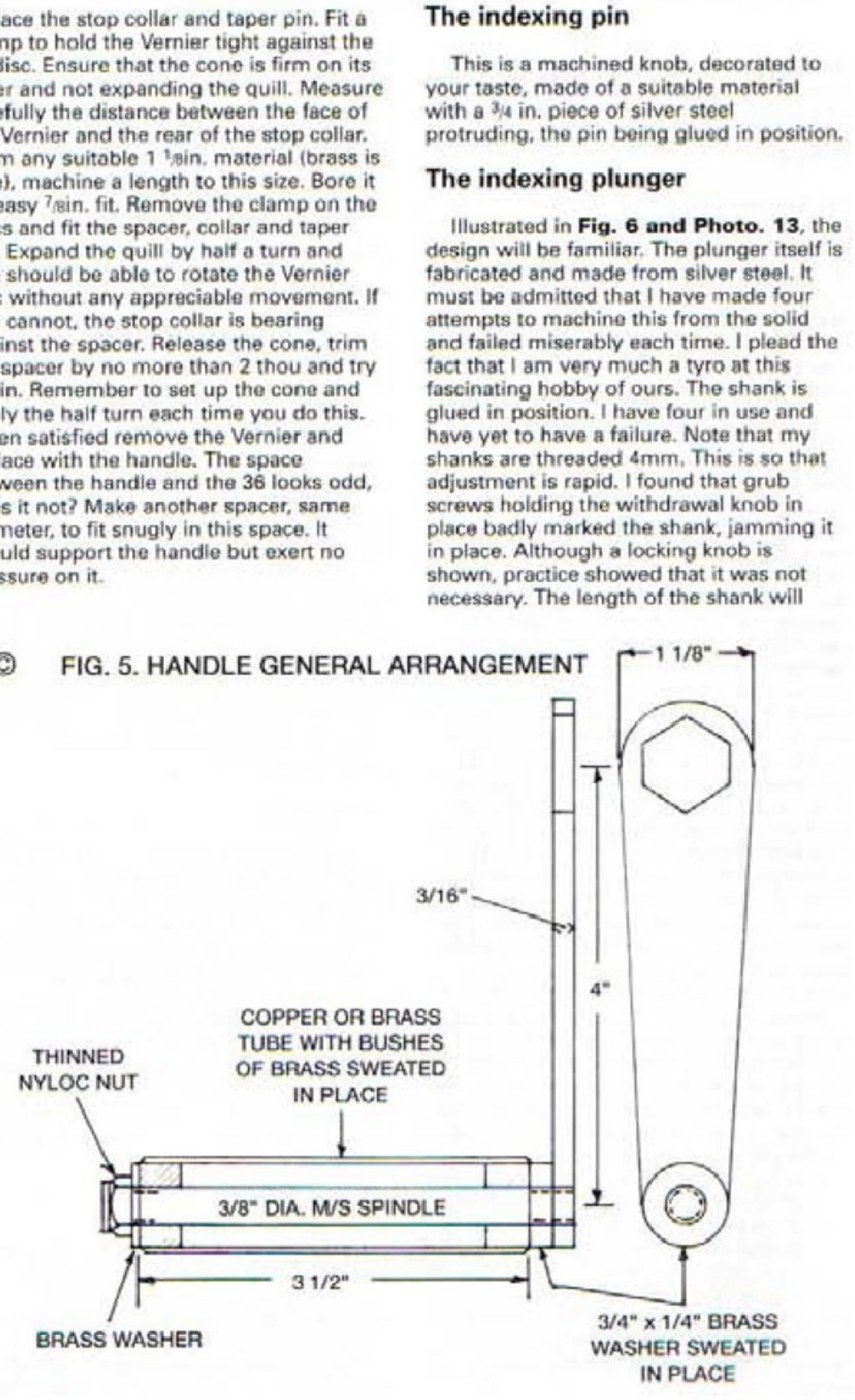
The indexing pin

This is a machined knob, decorated to your taste, made of a suitable material with a $^3/_4$ in. piece of silver steel protruding, the pin being glued in position.

The indexing plunger

Illustrated in **Fig. 6 and Photo. 13**, the design will be familiar. The plunger itself is fabricated and made from silver steel. It must be admitted that I have made four attempts to machine this from the solid and failed miserably each time. I plead the fact that I am very much a tyro at this fascinating hobby of ours. The shank is glued in position. I have four in use and have yet to have a failure. Note that my shanks are threaded 4mm. This is so that adjustment is rapid. I found that grub screws holding the withdrawal knob in place badly marked the shank, jamming it in place. Although a locking knob is shown, practice showed that it was not necessary. The length of the shank will

© FIG. 5. HANDLE GENERAL ARRANGEMENT



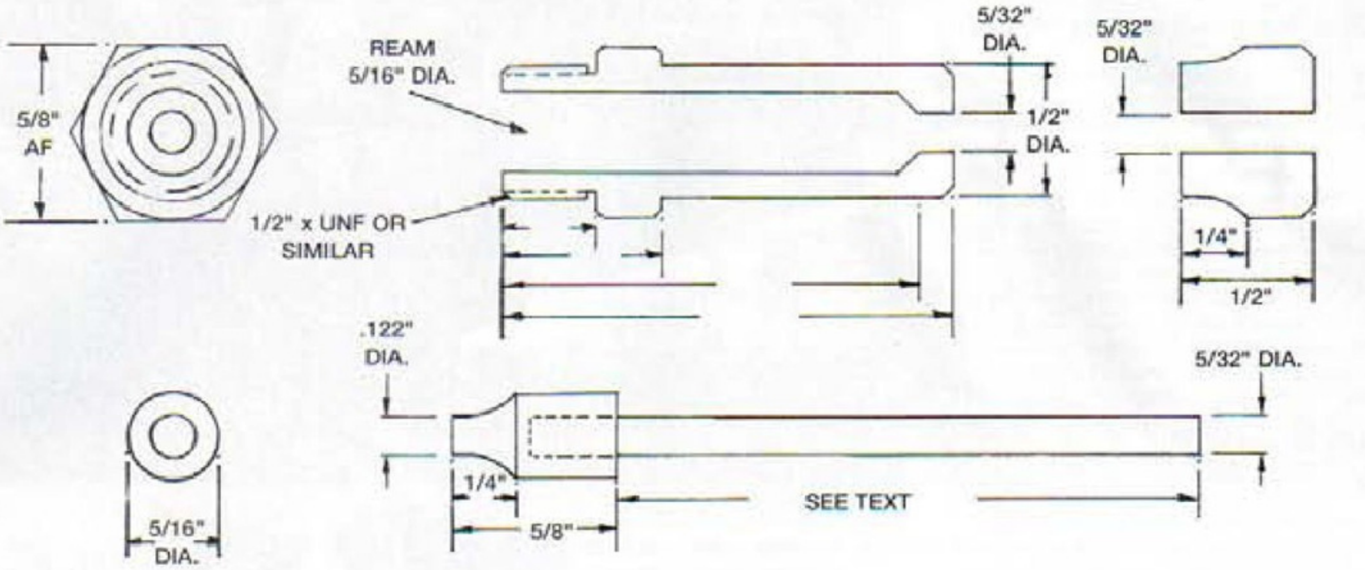


FIG. 6. INDEXING PLUNGER GENERAL ARRANGEMENT

depend on the method you adopt. The body is made from ⁵⁄₈in. hexagon, no milling of spanner flats required. The spring is 20 gauge (0.036), ¼in. dia., 10 coils per inch and 2 ½in. long.

The anchor

The method I adopted for anchoring the Vernier disc and the indexing arm can clearly discerned in the photos. My 'friend in hobby' taught me some new swear words when I suggested that he adopt the same method on his Super 7 (I was only kidding!!).

The anchor shown in **Fig. 7** was devised and served the purpose well. Fabricated to close tolerances, it can be bolted and screwed or welded. The base is permanently bolted to the lathe bench. The post can be mounted or dismounted quickly, but when locked in position by the locking knobs it is very rigid. The knobs serve a double purpose by engaging indents in the base, ensuring that the post always adopts the same position. Locate the post so that indexing arms are as near vertical as possible. The front indexing mechanism of my lathe was not photographed; I forgot to do so. The front indexing plunger and arm are identical to the side indexer in all respects except one, the exception being that the arm is longer. It uses the same anchor point as the Vernier disc, and has to index on two levels, the index plates and the face of the 36 disc It therefore has a spacer which fits on the anchor post, held in its correct orientation by a pin. If you are front indexing the 50 disc, it would be to your advantage to arrange two level indexing so that the 36 disc can be brought into play.

The anchor strut of the Vernier disc is, I think, self explanatory. Two points: make sure the anchoring means at both ends is positive and firm, failure to make this bridge between the disc and anchor rock solid can lead to inaccuracies. Secondly, orient the Vernier so that zero on the disc is at the half past one position when in use.

Mandrel bores above ¾in.

1. The quill and buttress are machined from a single piece of 1 ½in. FCMS.

2. The disc seat is ⅞in. PGMS inserted into the quill assembly and glued in place, this for the sake of accuracy.

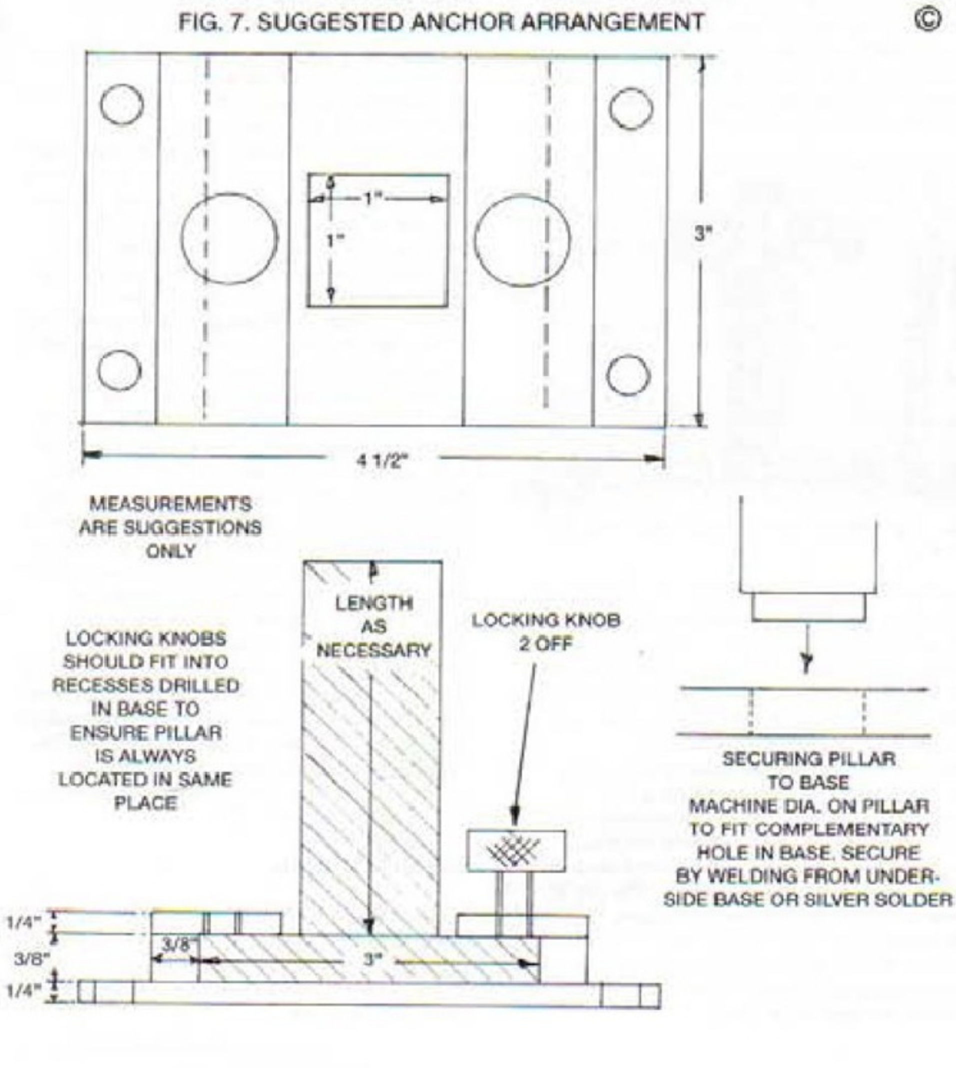
3. The dog screw slot is ³⁄₃₂in. deep.

4. The draw bar is ½in. dia. PGMS or very near to size FCMS, threaded with any ½in. thread.

5. The hexagon on the draw bar is ⅜in. AF.

All else is as detailed for mandrels below ¾in.

FIG. 7. SUGGESTED ANCHOR ARRANGEMENT



Drilling the side indexing 50 disc

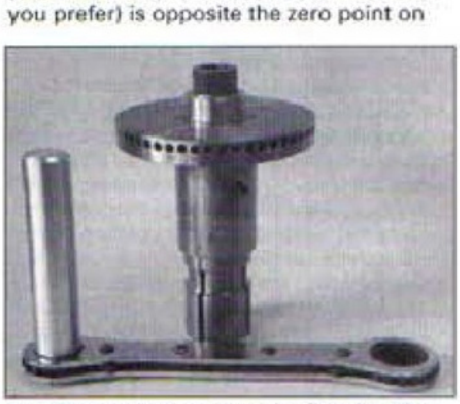
For this, one must assume that you have made or are going to make a drill holder. Remove all discs from the M.H.I. and fit the 50 hole index plate. Fit the blank 50 disc to either the sizer or $^7/_8$in. expanding mandrel and fit the whole in the lathe chuck. Erect your front indexing system and mount the drill, fitted with a $^1/_8$in. stub drill, and drill holder on the lathe. Now drill 50 holes, remembering to leave enough room for numbering. Do not dispose of the index plate as you might find, as I did, that it can become very useful for that oddball dividing task.

Using the M.H.I.

This should have been mentioned before - when fitting the handle hexagon to the quill, before gluing the hexagon in place, fit the 36 disc. Use this as a guide to position the hexagon when gluing so that, with the handle fitted, the shaft would lie midway between 36 and 6. The obvious thing is to use the corners of the hexagon as markers. Remember when making the handle shaft to cut the hexagon with the corner up as in **Fig. 4**. All this so that you can index 1, 2, 3, 4, and 6 while in the handle mode, without having to remove the handle.

It should be noted that when in the handle mode, the Vernier disc is not fitted and, conversely, when set up for dividing 360, the handle is not fitted.

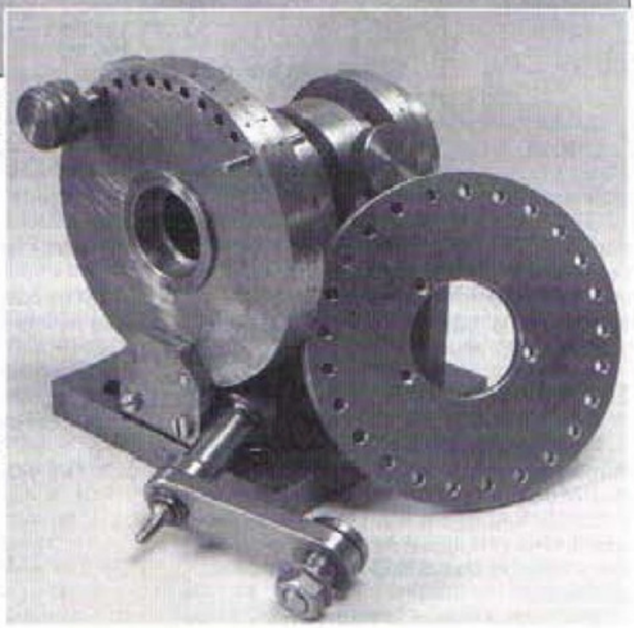
The easiest way to show how too use the system is to give examples. Mount the M.H.I., sans handle, in the lathe. Lock in position, secure Vernier disc to anchor. Say you want to divide 45 positions, which are, of course, 8 deg. apart. Rotate the 36 disc (use the chuck) until 36 (or 360 which ever you prefer) is opposite the zero point on



15. The ratchet ready to be fitted to the M.H.I.

the Vernier. Insert the index pin; that's the first division. Remove the pin, revolve the 36 disc until zero on the Vernier is opposite where you would expect to find 8 on the 36 disc, insert the pin in the 8th hole on the Vernier through into the 36 disc (you might have to move the 36 disc fractionally to achieve this); this is your second position. Let us go on a bit, indexing 144, the 36 disc is rotated until the 140 mark is opposite zero on the Vernier and then eased past until zero is opposite where 144 would be, the pin is inserted into the number 4 hole in the Vernier thence into the 36 disc. It takes far longer to talk about it than do it. The pin automatically locks the mandrel; that's the reason for the thick discs.

14. Ratchet handle components



16. The 360 system fitted to a home-brewed dividing head

The inching handle

The distance from my lathe chuck face to the handle of the M.H.I. is 26in. and, having only normal sized arms and being no Charles Atlas, I have to stand slightly behind the chuck to operate the handle comfortably. Most of the time this does not matter but, every now and again, I need to see exactly what the tool being used is doing. Murphy's Law always decrees that when this occurs, the handle somehow gets in the 6 o'clock position, making it extra difficult to operate. After one especially trying session, steps were taken to rectify the matter. The ratchet handle shown in **Photos. 14 and 15** may be familiar to most of you. I use them for purposes for which they were never intended. The handle hexagon was machined from the M.H.I. Another insert was machined whose length, plus 2 thou., was equal to the maximum thickness of the ratchet ring. The insert was installed on the M.H.I. and the hole for the draw bar was bored and reamed. Two new spacers were made, one for the normal handle and the other for the ratchet. Normally the usual handle is fitted, the ratchet only when required. It's then a case of "however would I get along without it?". It works a treat; the handle can be placed in its most advantageous position and inched around if necessary using the ratchet. The handle proper is solid aluminium with hexagon insert. It is held to the spanner by screw and washer.

General points

To prove the tool, a set of discs was made for my home brewed dividing head using only the M.H.I. for indexing on the lathe. It passed the 11 hole tests easily **(see Photo. 16)**

Before anyone tells me, I am now well aware that the pin vernier has been used before, in, so I am advised, a form of dividing head. My ego received a dent at this piece of information as I had thought that my idea was original! The method can be used to make a super accurate 3 to 4in. rotary table, using easy machining techniques, the table being locked by two pins instead of shaped blocks acting in difficult to machine grooves. I am sure you can think of other uses.

A WARNING

You are advised to devise a system that warns you that the M.H.I. is in use and fitted to the lathe. This is my method, when I THINK about using the M.H.I., I turn off electrical power at the lathe and the mains box for the lathe, a notice warning me that the M.H.I. is fitted is hung on both switches. Only then do I fit the handle. These notices are only removed when the M.H.I. is back in its box. **YOU HAVE BEEN WARNED.**

Supplier details

All metals from G.L.R. Distributors, Unit C1 Geddings Road, Hoddesdon, Herts EN11 0NT

Ratchet Spanners From any good tool merchant. Singletons in ¾ AF from any Draper Distributor.

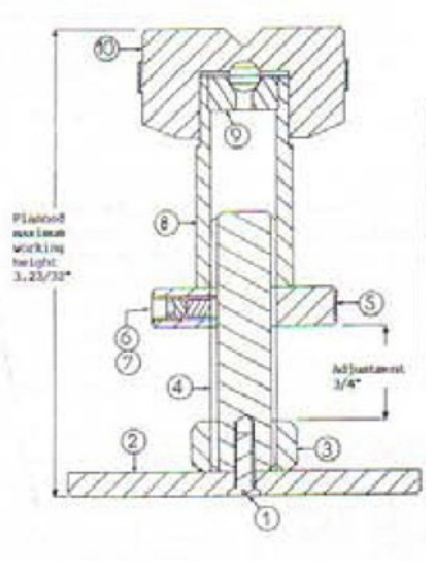
JACK FOR A MILLING MACHINE TABLE

Derek Oxley was unable to recall anyone explaining the basic logic of how to form a 90 deg. 'V' groove in the centre of a disc. The need of a screw jack prompted him to write the following notes

In responding to a "Can you help?" request from a friendly 'old fashioned' ironmonger in a neighbouring village, I found that whilst a particular workpiece could be truly aligned between the dividing head and its tailstock, it could not be adequately supported for the immediate milling and drilling operations, due to the shallowness of a centred hole dictated by subsequent machining operations. So, a jack was required, and improvisation was not an option.

From material stocks on hand I could produce everything required for making a suitable jack, and although I do have the facilities for machining a truly centred .'V' groove in a circular disc, time was saved by utilising the one from a very old Myford drill pad with its 2MT shank removed. **Figure 1** shows the arrangement and the raw materials used - obviously the materials and dimensions can be varied to choice, within reason.

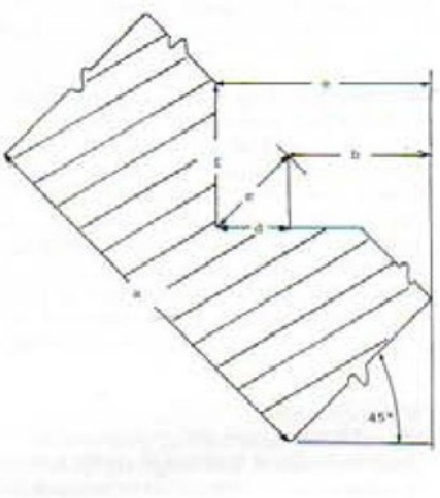
Fig 1. Jack sectional arrangement & materials used



Item	Material
1	Screw. 4BA x 1/2". csk. stainless.
2	Base. Brass. Ø 2.3/8" x 3/16 thick
3	Nut. Brass. 1/2" BSF.
4	Stud. MS. 1/2" BSF x 2.1/16" long
5	Adjusting wheel. Brass. Ø 1.7/16" x 5/16" thick.
6	Pad. Copper. Ø 1/8" x 3/16" long. (3 off)
7	Grubscrew. hex socketed. 2BA x 1/8" (3 off)
8	Sleeve. MS. Ø 3/4" x 1.11/16" long
9	Pad. MS. Ø 13.0mm x 1/4" long.
10	Myford drill pad head and ball

1. The assembled jack

Fig 2. Logic and Notes for setting up



LOGIC

a = Ø of workpiece

b = 0.5a x cos 45°

c = Intended depth of 'V'

d = c x cos 45°

e = b + d

f = 2d (down feed), *or, e/cos 45°*

ACCESSORY

Tilting vice locked at 45°, with fixed jaw parallel to intended line of grooving traverse.

TOOLING

Ø 3" x 3/8" S & F mill

NOTES:

1. In setting the zero position at the periphery of the workpiece prior to traversing to dimension 'e', it is essential that the centre of the S & F mill; the point of one of its teeth, and the centre of the workpiece are truly coincident with the intended line of the positioning traverse.

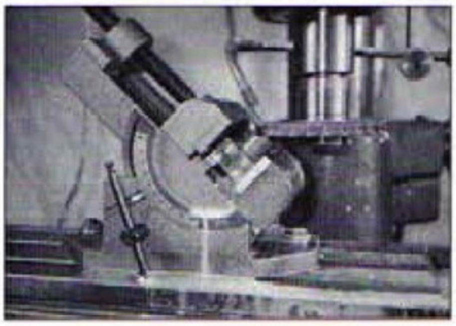
2. After traversing from zero by dimension 'e' the table is locked in that position.

3. With the S & F mill tooth still in the same position, the quill is brought down to just contact the metal, then zero position is set on the quill downfeed.

The 13.0mm dia. pad was prepared in advance, undrilled. After drilling 1/2in. dia. through the 3/4in. bar to form the sleeve, it was opened up for 1/4in. length to received that pad, Loctited into position, then the o.d. was turned down to be a close rotating fit in the Myford part (0.694in. in my case). After the Loctite had cured, the pad was centre drilled BS.4 to full diameter depth to receive the original Myford ball. Only then was the sleeve removed from the chuck, reversed, faced off and deburred.

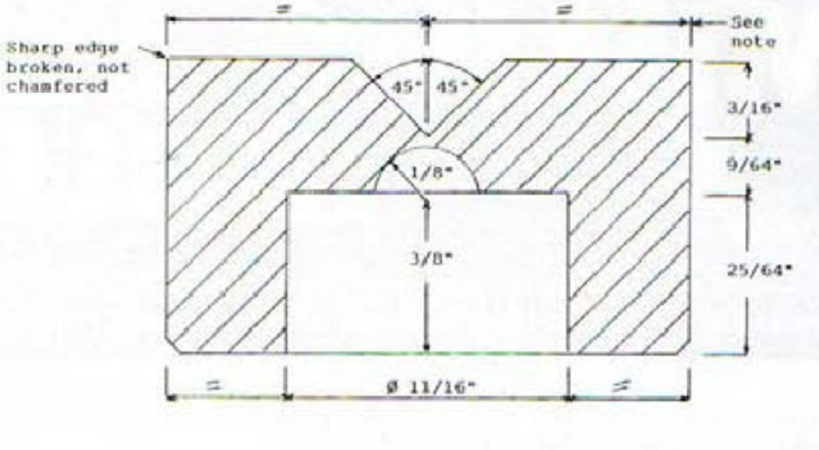
The adjusting wheel is provided with three copper pads and grubscrews, but in use, only the one most conveniently accessible is tightened for locking the pad height. **Photo. 1** shows the completed assembly.

A couple of weeks later I machined a centre grooved pad to the design at **Figure 2** to be donated to a friend who did not have the appropriate facilities. **Figure 3** shows the set-up logic and some relevant notes. Whilst it may be practicable to machine the groove with an end mill of greater diameter than dimension 'f', I believe that a Side & Face mill gives a better finish, and the same logic applies in both cases. **Photo. 2** shows the milling at an advanced stage.



2. Penultimate 0.005in. cut at 110 rpm using a 3in. dia. x 3/8in. Side and Face mill

Fig 3. Typical M.S. centre grooved pad for a Jack



Note: Provided that it is of adequate proportion, the actual finished o.d. of the drum is not critical, but its consistency and precise measurement is. This specimen was made from salvaged material of original Ø 1.5/16" and after removing blemishes and truing measured 1.288".

LINK UP

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- Workshop manual or any other information relating to a hand operated Eagle surface grinder (No.2 or No.3?). To buy or borrow for copying (quick return and expenses reimbursed). Also similar information on an Atlas lathe (VT42).
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George Winspur, one of our Link Up advertisers apologises for including the wrong STD code in his recent advert. A revised version is included here.

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- If any reader has information on refurbishing and operating a Kerry AG2 5 1/2in. lathe would they please contact me. I will, of course reimburse expenses.
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The value of industrial archaeology

From Dr. Bernard W. Langley, Hanley, Staffs

May I write to compliment you on your admirable editorial in the April Issue of Model Engineers' Workshop?

I am an avid reader of both your magazine and of The Model Engineer but I confess to no great feeling for steam locomotives. After a lifetime in chemical research I have returned to Chairmanship of the family engineering companies. These are strictly old world 'metal bashers' specialising in the repair of heavier mechanical and electrical equipment and, as you can imagine, not being within the M25 and not being lawyers, computerers or money men, we are having rather a lean time. Personally I read your magazines because they deal with the sort of engineering we do on a larger scale and they are not, as are most professional engineering periodicals, wholly concerned with computery or HSE.

I was especially taken with your righteous disparagement of the TV critic of Fred Dibnah who would see me and my like buried for ever. You are entirely correct in your view that many folk, especially the young get as much 'inspiration and enjoyment' from elegant machinery as from more formally recognised works of art. I believe also that many of these earlier mechanisms display quite obviously how the end effect was achieved and so encourage youngsters into practical science or engineering. So many modern devices rely so entirely on a grey box that they have no educational value.

I think you are entirely right to emphasise the popularity of what is now called 'industrial archaeology'. I have not been to the Bath/Bristol Mills but last weekend went to our nearby NT Quarry Bank Mill in Styal. This was packed with ingenious but obviously demonstrable pieces of textile machinery. Happily also it was packed with schoolchildren and a few wrinklies like myself.

All power to you and the admirable Nexus magazines. I am sure you do much to sustain interest in engineering at the practical level. I wonder what is the background of most model engineers? So many of your authors speak of their apprenticeships that I presume many must be retired. I also believe that quite a few professional engineers are model makers in their spare time because it is the only time they feel they are in touch with reality and not weighed down by paper, Brussels, HSE and bureaucracy. Possibly a subject for you to speculate on in another leader?

Thank you again.

Electrical safety

From Colin Long, Chigwell, Essex

I was amazed to read in issue number 57 of Model Engineers' Workshop, an article to construct an electrical power transformer. I have been associated for nearly 50 years, as an apprentice trained engineer, with electrical systems ranging from those using kilovolts to integrated circuitry running from small batteries. My experience tells me that the photograph used is of a commercially produced transformer manufactured either before or just after the second world war which would not be allowed to be used today. I cannot ever remember any technical or amateur magazine providing a constructional article for a transformer, although having seen many on their theory and professional construction. The design, construction and testing of such devices must be left to competent manufacturers, the safety testing alone is beyond the capability and competence of any amateur.

I was even more horrified to read on page 54, "Earth yourself (A wire round the wrist to a water pipe is all that is needed)." This could be regarded as an instruction to commit suicide. No competent electrician of sane mind would use an ordinary wire to a water pipe. Firstly is the water pipe metal or plastic? Even with a metal pipe being accessible, it is quite possible that it may be joined to a plastic pipe elsewhere in the system and will not be of earth potential. Also the wire would have to connected to bare metal, not always the case in domestic plumbing systems.

It is necessary whilst fitting electrostatic sensitive devices to earth oneself via a wrist strap and lead with a built in high resistance to dissipate any electrostatic voltage that may develop during assembly. Ordinary wire will not do this. Also great care must be taken to isolate the wrist strap wearer from possible contact with mains powered equipment. Should anybody follow the instruction contained in the article unfortunately make contact with something at mains potential there is a high probability that they will die.

The assembly of any electrical equipment needs to be carried out under safe, controlled conditions. Transformers should certainly not be constructed by amateurs and safety requirements for any electrical work must be fully understood and complied with by the user.

I do not necessarily agree that electrical matters should be the exclusive province of the professionals. Amateurs have been experimenting in the field since the earliest days, illustrated by the fact that the original title, in 1898, of our sister magazine was 'The Model Engineer and Amateur Electrician'.

I do accept, however that safety should be paramount and welcome Mr. Long's advice. Peter Rawlinson is always quick to recommend that anyone not sure of what is required should seek the advice of a competent person. Ed.

Fine feeds for small lathes

From Ian Cook, Aberdeen

On reading Tony Jeffree's excellent article on the fitting of a leadscrew to a small Peatol lathe (issues 56, 57) and the need for such large (and noisy) gearing to give a fine feed, I feel that the method used on a small machine which I recently acquired at a junk sale may be of interest.

The lathe is marked 'FLEXISPEED' and is quite a solidly made machine for its size. 2in. centre height with 12in. between centres it has a three step pulley, back gear, 8 tpi leadscrew etc. as is usual on much larger machines.

The leadscrew is unusual in that instead of a number of gears to carry the drive from the headstock spindle it is achieved by using a double worm unit. The headstock spindle has a double start worm on the end driving an 18 tooth worm wheel which is connected by a short vertical spindle to another double start worm of the same size driving another 18 tooth worm wheel on the end of the leadscrew. This gives an instant 81 to 1 reduction and on the 8 tpi leadscrew gives a feed of approximately 1 ½ thou/rev. (For the purists its actually 0.001543in./rev). This does away with the need of large, clumsy and no doubt expensive gearing.

Whether this unit which replaces the usual gear train 'banjo' was supplied by the maker or made by a previous owner I don't know, but it certainly makes life a lot easier and just a little bit safer and quieter.

I would be grateful if perhaps a reader could supply any information on this make of machine which I think, going by the style of it, had been on the market in the late Forties or early Fifties. (Where are they now?)

Making Printed Circuit Boards

From John M. Clark, Surbiton, Surrey

On page 52 of issue 57, the author remarks on difficulties he has had producing PCB 'negatives' on an inkjet printer. I have found that using NOBO INK JET FILM for Hewlett Packard inkjet printers, (obtained from my local office supplies shop) and then using a hair drier to dry off the wet ink will produce transparencies that will not smudge and will keep for at least three years, maybe longer, only time will tell!

It may be worth experimenting with different printer inks as some do tend to migrate within the surface of the film. I had my best results from a cheap bulk refill ink. This produces good dense transparencies that give me good PCBs with a minimum of hassle.

HEALTH & SAFETY EXECUTIVE DRAFT FOR CONSULTATION

Model Engineering: Guidance on safe operation of miniature railways and model traction engines

INTRODUCTION

Scope

This guidance is intended for those model engineers operating miniature railways and traction engines as a hobby activity, either under the auspices of a club/society or as individuals, where they may give rides to members of the public or be operating in locations where the public may have access. This guidance is inappropriate for any organisation which employs people or operates commercially for financial reward or gain. Such organisations are referred to the Fairgrounds and Amusement Parks: Guidance on safe practice HSG 175 and other relevant legislation made under the Health and Safety at Work etc Act 1974.

About this guidance

The need for this guidance has arisen because the complete application of the fairgrounds guidance to private clubs is inappropriate. However, the fairgrounds guidance does contain much useful information. It is suggested that you should obtain a copy for reference.

This guidance has been prepared after consultation with:

FMEMS
GLG5 Association
Midlands Federation of Model Engineering Societies
Northern Association of Model Engineers
Southern Federation of Model Engineering Societies
The 7¼" Society
The Society of Model and Experimental Engineers

It is specifically aimed at those building and operating miniature railways and traction engines. It describes the legal requirements, managing health and safety, risk assessment, inspection procedures for both pre-service and in service use and the duty of care when buying and selling equipment.

LEGAL REQUIREMENTS

The Health and Safety at Work etc Act 1974 places duties of care in health and safety terms on various dutyholders including employers; self-employed people; those who conduct their undertakings in ways that could affect the health and safety of others; designers; manufacturers; suppliers; operators and inspectors.

MANAGING HEALTH AND SAFETY

You should follow 5 key stages in order to manage health and safety:

1. Setting your policy

Your club or society should prepare a clear health and safety policy statement. Attached to the policy statement should be details of the organisation and arrangements (rules) for the health and safety of members and visitors/members of the public with sufficient detail to identify individual responsibilities.

2. Organising yourself

You should use a system of steps and checks that will ensure the club or society operates in a safe manner. Individual operators need to set up a similar system. A recommended list of steps and checks is set out in **table 1** which, if adopted, will ensure safe working and thereby compliance with legal requirements.

contains all safety documents, documentary proof and records of testing.

You need to keep the following records:

Operating log - recording dates and details of public running.

Maintenance logs.

Records of member and driver competency.

Accident Book - record all incidents and names of witnesses, notify accidents involving general public to HSE or Local Authority.

Insurance details including public liability insurance if appropriate

Table 1: Steps and checks for the management of health and safety

Steps	Checks	Description
Design		Designers are responsible for drawing up safety requirement specification based on risk assessment of safety critical parts of the design.
Manufacture		The production and assembly of a model to design specification.
	Pre-service inspection	To include assessment of the design of safety critical parts; a check that construction matches design specification and that a functional test to verify that safety critical parts of a model or equipment meet the design specification.
Operations Manual		Full instructions for safe operation of equipment including documentary proof of pre-service inspections, recommended in service maintenance inspection and any other records.
Maintenance		Servicing, replacement or repair of components to maintain equipment in safe working order.
	Daily check	Visual and functional check, prior to operating, of all models and equipment to check for any deterioration or malfunction.
Supervision		Management and overseeing of safe operation by appointing club safety officer, person-in-charge of day operation, allocation of duties to attendants and signing-on of drivers and attendants.
	In service inspection	Periodic inspection to determine whether model or equipment can continue to be used based on deterioration as detected and remedied.
Emergency procedures		What to do in case of accident and emergency.

3. Planning and implementation

You should appoint a person-in-charge for each operating session who will ensure that laid down procedures are followed.

You need to ensure that all operators and attendants are competent which means that they have suitable knowledge and expertise for tasks they undertake. Many accidents can be caused by human factors rather than by equipment failures.

You need to ensure that the operations manual includes:

operating instructions for track and ancillary equipment;

maintenance standards;

defines the number of persons who need to be in attendance to ensure safe operation;

outline emergency procedures to be taken in the case of accident, fire, etc;

Individual owners of models need to maintain their own records including a log book giving design details, boiler testing and maintenance records.

4. Measure performance

You need to examine performance at the end of the season or at the annual general meeting. Compare it to the previous year's running or to performance of other similar clubs or societies.

5. Reviewing performance and make changes where appropriate.

You need to carry out a review and consider changes at annual meetings or at other times when operating procedures are under discussion.

RISK ASSESSMENT

You should carry out risk assessment to a degree necessary which is proportional to the risk. A risk assessment is a careful examination how known hazards could occur and cause harm to anyone so that judgements can be made to determine appropriate control measures or precautions which need to be adopted to avoid risk or to reduce risk.

The result of risk assessment is more important than the method used. The findings of any risk assessment, that is the control measures or precautions, need to be fully documented.

You should carry out risk assessment regularly and review it at least every three years or sooner if modifications or new equipment causes changes in the way that you operate.

(See Appendix A for guidance on the ranking of risk and a typical list of topics that might need to be considered).

INSPECTION

One of the ways that you can reduce risk is to avoid the possibility of failure by carrying out regular inspection. Inspection needs to be carried out by a competent person. In this context competency implies that they have the knowledge and expertise relative to the equipment concerned. Inspectors should know their own limitations and not be expected to have an understanding on all matters. Where presented with a particular issue outside their knowledge they should seek the opinion of someone more suitably qualified.

Inspectors need to be seen as being "independent" and have authority so that their views are respected. This is particularly important if they are inspecting their own club's equipment or layout. Inspectors need to ensure that they do not inspect their own work or anything which they have been closely involved as designer, owner or builder. It is recommended that where possible society/club owned equipment (including track and other fixed assets) should be inspected by a competent person from another society or club.

"Individual" operators will need to seek the services of inspectors from other sources. Whilst some organisations within the hobby might be able to provide a pool of competent persons willing to offer their inspection services to individuals, there may be restrictions on insurance cover which would not extend to those who do not wish to become members of clubs or societies. In these cases individuals would have to arrange their own insurance cover or use insurance company inspectors.

Keeping of records

You need to keep all inspection records for at least 10 years, but permanently if possible. This will enable a complete history to be formed and it will help you with future risk assessments.

Pre- service inspection

It is important that all safety critical equipment is designed and constructed to high standards and be fit for purpose. You need to ensure that the design concept of any item of safety critical equipment is sound. All relevant information together with any inspection reports should be kept together. Designs are preferably checked prior to manufacture.

It is recommended that anyone publishing a design checks that the design concept is sound and that the necessary information is published to support these facts.

Anyone creating their own design or deviating from a published design for a model or piece of equipment needs to undertake their own design check and to make the information subsequently available to an inspector.

The safety critical areas which may need to be considered are listed in Appendix B.

On completion of manufacture the maker needs to be able to show to an inspector that the model or piece of equipment conforms with the original design specification in safety critical areas. Any deviation from original design specification also needs to be made known to the inspector together with any details of safety critical modifications. If the inspector considers that a design has been built to the original specification or to an agreed modification he will confirm it in writing.

Initial test

You need to ensure that prior to first use models or equipment are examined and tested. Any steam powered model should undergo and pass the relevant boiler testing procedure before first steaming and then on the first occasion that it is steamed.

In service inspection

You need to regularly inspect all models and equipment and subjected them to re-testing where appropriate. These periodic inspections need to be recorded in the log book relevant to the model/equipment and signed by the inspector.

Daily checks

You should ensure that a competent person makes a daily check of those parts of equipment which could affect safe operation before any member of the public is allowed to use or ride on the equipment.

BUYING AND SELLING

When selling goods the vendor has a duty of care to ensure that the goods are suitable for the purpose intended and provided with sufficient information for safe operation. If a model or piece of equipment is sold the seller should provide the relevant safety documents, logs etc. If the seller has no knowledge of the item it can be sold provided that the buyer is advised that safety improvements may be necessary to bring the item up to modern standards. This advice should be recorded in writing between the two parties concerned.

APPENDIX A RISK RANKING

Use a ranking system such as the formula below to identify which risks need addressing first:

Ranking = Likelihood x Severity

Risk ranking	Action Required
High	Take immediate action to reduce risk.
Medium	Should be avoided - take action if possible to reduce.
Low	Acceptable - but monitor the situation
Negligible	No action required - but don't be complacent

The following list may be used as a prompt for topics that may need consideration when undertaking a risk assessment. It is not intended to be complete and additional topics may need to be added to suit your circumstances.

Access; Animals; Barriers; Brakes; Bystanders; Cinders; Competency of drivers, guards, station personnel etc; Couplings, Derailments; Electricity; Explosion, Exits; Fencing; Fire; First Aid; Gardening equipment; Gauge glasses; Guards (Entrapment of fingers in models); Ground conditions; Handling; Hot Surfaces; Locomotives; Maintenance; Obstacles; Passengers; Passenger carriages; Paving; Refuelling; Security; Signalling; Sparks; Speed limits; Stations; Steam; Testing; Tracks (permanent and portable); Traction Engines; Tools; Turntables; Vegetation; Vehicles; Walkways; Warning signs; Weather; Workshop equipment.

APPENDIX B SAFETY CRITICAL AREAS

Safety critical areas are those involving the following items:

- Track gauge
- Flangeway clearances
- Wheelset dimensions
- Suspension systems and bogie mountings
- Buffing/coupling systems
- Braking systems
- Boilers
- Safety valves
- Injector and feed water pumps
- Emergency systems
- Audible warning device
- Cylinder drain valves

FURTHER READING

- Fairgrounds and amusement parks: Guidance on safe practice HSG175 HSE Books 1997 ISBN 0 7176 1174 4

- The management of health and safety at work regulations 1992 - Updated to include changes affecting young people and new and expectant mothers. HSE Books MISC079

- An introduction to health and safety, free leaflet from HSE Books INDG259

- Five steps to risk assessment, free leaflet from HSE Books INDG163 (rev)

- Managing health and safety, Five steps to success, free leaflet from HSE Books INDG275

HSE Books, PO Box 1999, Sudbury, Suffolk CO10 6FS. Tel: 01787881165 or Fax: 01787 313995.

The Health & Safety Executive welcomes comment on the above draft and suggestions as to how it may be improved. All communications should be sent to Dr. Terry Williams, HM Principal Inspector of Health and Safety, Entertainment Section, HSE, 375 West George Street, Glasgow G2 4LW Tel. 0141 275 3000 Fax 0141 275 3015.