

No. 111

DECEMBER 2005/JANUARY 2006

MODEL ENGINEERS' WORKSHOP

THE PRACTICAL HOBBY MAGAZINE

SHUMATECH DRO

A self build system

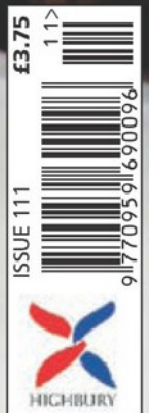
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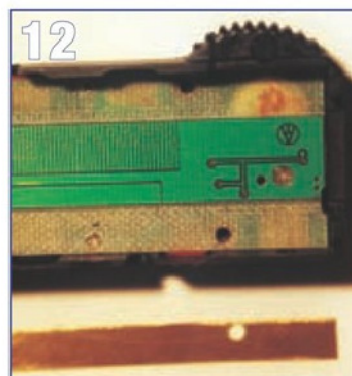
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Scribe a Line

Reader to reader.



On the Cover

Over the years, several designs have emerged for power hacksaws. This one is by Richard Wightman and his description starts on page 42.



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18. SLOT DRILL SET (THREADED SHANK) [$\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$] or (m/m) 3, 4, 5, 6, 7, 8, 10, 12 m/m
19. ENDMILL SET, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{1}{2}$ DIA. WITH $\frac{1}{8}$ THREADED SHANK TO FIT COLLET CHUCK
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21. REAMER SET (STRAIGHT SHANK) [$\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$] or (m/m) 2, 3, 4, 5, 6, 7, 8, 10, 12 m/m
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Soldering, Brazing & Welding - a Manual of Techniques • Pritchard • £16.94

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Hand Forging and Wrought-Iron Ornamental Work • Googerty • £ 8.60

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Secrets of Green Sand Casting • 1903 • £10.05

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How to Build a Wind Turbine • Piggott • £11.35

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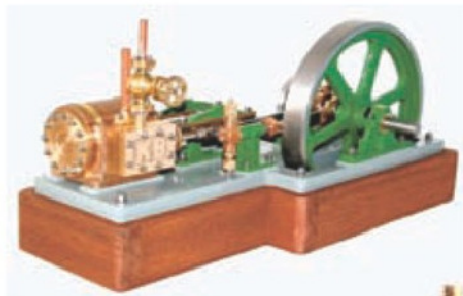
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0"G	Princess Coronation	4-6-2
0"G	Morris de Cowley	4-6-2
0"G	Hertford Hall	4-6-0
0"G	Royal Scot	4-6-0
0"G	Josie	4-6-4
0"G	Bat	4-4-0



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2.1/2"G	Austere Ada	2-8-0
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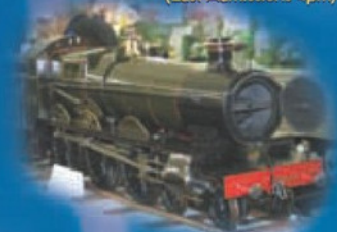
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GZ12	12MM	£29.95 £17.95
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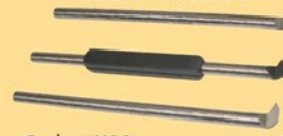


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L5 Taper Turning Attachment	£ 350.00
L5/L15 Micrometer Carriage Stop	£ 50.00
L15 4 Position Indexing Carriage Stop	£ 75.00
L5/L6 Traveling Steady, Complete	£ 30.00

Harrison Cast Iron Tailstock or Fixed Steady Clamping Plate	£ 3.00
Harrison 140 Tailstock	£ 125.00
Harrison 140 Topslide	£ 100.00

Harrison L5 Manual	£ 15.00
Harrison L5 ABC/3 Speed Screwcutting Gearbox	£ 125.00
Harrison L5 Travelling Steady	£ 95.00
Harrison L5 Fixed Steady	£ 65.00

Harrison L5 Thread Dial Indicator	£ 35.00
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L5A Topslide Assembly	£ 75.00
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Harrison M250 Manual	£ 15.00
Harrison M250 Change Gear Cover/Guard, Unused	£ 60.00

Harrison M250 Topslide, Metric, Complete, Unused	£ 225.00
Harrison M400 Capstan Attachment, Unused	£ 500.00
Harrison M400 Saddle Drilling Attachment, Unused	£ 150.00
Harrison M300 Manual	£ 15.00
Harrison Mill Power Feed Gears	£ POA
Harrison L5 T-Slotted Boring Table, NEW, Cast Iron	£ 150.00



24" x 24" Cast Iron Surface Plate
on Stand,
£125.00 plus vat



Moore & Wright Vernier
Protractor with Case, VGC.
£85.00 plus vat.



Alexander Single Lip Tool &
Cutter Grinder, Collets, Bench
Mounting, 3ph
£750.00 plus vat.



Colchester Bantam 5" x 20"
Lathe, Tooling, 3ph,
£975.00 plus vat.



Denford Starturn PC CNC Bench
Lathe, Chuck, OCTP, Tailstock,
1ph, £1100.00 plus vat.



Harrison L5 9" Swing Gap Bed
Lathe, Chucks, Steadies,
Toolpost, Bed Stop, 3ph,
£975.00 plus vat.



Smiths
Tachometer/
Rev Counter &
Accessories
With Case,
£65.00 plus vat.



Optima Bench Drill Point
Grinder, 3ph, £450.00 plus vat.



Roland Camm
PNC 3000
Bench CNC
Engraver/ Light
Mill, 1ph,
£750.00 plus vat.



Watchmakers Bench Lathe &
Accessories in Wooden Case,
£375.00 plus vat.

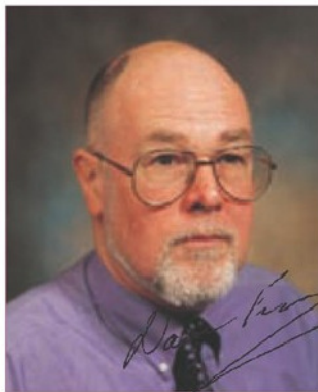


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In the workshop

The Stuart Triple Expansion engine had been gathering dust in the workshop since completion some months ago. As autumn approached the possibility of rust deterioration looked imminent. It would therefore have to be accommodated in the warmth of the house. For this to be allowed, domestic management required an easily dusted case, hence a brief diversion into woodwork with Perspex overtones. I have commented previously that my metal scrap box is pretty capacious; the workshop also houses much surplus material left over from the reconstruction of the house. So the "design procedure" became one of those iterative processes involving successive examinations of what was needed versus what material was in the junk pile.

The engine was already mounted on a pair of bearers, thus a simple flat plinth would clear the flywheel. To form the plinth, a rectangle of oak veneered chipboard was framed within four mitred strips, the subassembly being glued and varnished. Five rectangles of Perspex (two ends, two sides, one top) were then cut to form the case. Here care was taken with the sizes to ensure overlapping joints for gluing. The assembly / gluing was conducted in stages with parts taped, weighted and supported by vee blocks to ensure squareness. Eight lengths of angle moulding were then cut, mitred, and glued in place along the various edges to hide the glue lines and add strength. Finally four corner blocks were attached to the base to give positional location as the cover is lowered. After a further application of varnish, permission was obtained to occupy a display position in the dining room.

New from Alan Munday

Alan sent me a copy of his latest work, a computer program to take much of the number crunching drudgery out of a variety of tasks. Partly based on the Model Engineers' Data Book, section headings are Nearest drill size; Sine bar - Gauge blocks; Sheet metal bending; Length/volume/area; Gears and cutters; Endless belts. This last part now includes toothed belts, a topic covered recently by Dick Stephen. Dick's reaction, like mine was that this is an excellent piece of work from Alan, which loads quickly and does what it claims. Perhaps the best news is that like his

ON THE EDITOR'S BENCH

earlier CNC oriented work Alan will be making this available at no charge via Colin Usher's web site

Index

Up to now, the MEW index available on disk from Barry Chamberlain (who took over its preparation from Harold Hall) is a DOS based version, which runs happily under Windows apart from the disadvantage that some editing functions do not operate. Barry is currently working on a revised fully Windows based program, which will overcome this, and make the software fully compatible with latest Windows systems. Barry can be contacted on 01295 255 744.

Ready Made Board

Ted Fletcher rang after reading Peter Rawlinson's article on the powered tailstock to advise that R.S. Components supply a purpose made p.c.b. to take a 555 timer chip. The stock code is 434-071, and price in the region of fifty pence.

Apologies

- To those readers and contributors who had planned to meet up with me at the Midlands Model Engineering Exhibition, Leamington Spa. For various reasons I didn't make it, but from all accounts it was a great success and thoroughly enjoyed by many visitors. Tony Jeffree kindly volunteered to prepare some notes, and his article appears later in this issue. I will try not to be side tracked next year.

75th Model Engineer Exhibition

The prestigious Sandown Park Exhibition Centre, Esher, Surrey, will once again play host to the Model Engineer Exhibition from 29th to 31st December. Opening hours for this, the 75th in the series will be 10-00am to 5-00pm on the 29th and 30th, and 10-00am to 3-00pm on the 31st. The final day will close with the prize giving ceremony, at which certificates, medals, and many prestigious trophies will be awarded.

The show layout will bear similarities to those of previous years with the ground floor being largely occupied by trade exhibitors, and the majority of club exhibits, competition and loan entries being located in the first floor private function suites, however this year, additional space has been allocated on both levels.

Over the years, this show has gained an enviable reputation for the high quality of work to be seen, something that Mike Chrisp

(former editor of Model Engineer) likened to a "Gold Standard" for model engineering. Sponsored by Model Engineer, Model Engineers' Workshop and Model Boats, the variety of exhibits will interest not only aficionados of these general areas, but also encompass examples of aeromodelling expertise. In terms of historical extent, models will range from horse drawn vehicles, through 19th and 20th century steam power, to the latest advances in miniature gas turbine technology.

Many of our respected trade suppliers will be attending, no doubt some with tempting special show offers. Myford will be displaying some new accessories, including miniature chucks with a variety of attachments to suit machines from their own range as well as from other manufacturers. Warco will have on show their new CNC milling machine.

As I have noted in this column on previous occasions, I would encourage readers to consider exhibiting their work, particularly as regards workshop equipment. My own leanings are towards items of machinery or tooling, particularly displaying original thinking, which are designed for a task, and patently successful in achieving the desired outcome, finish being of secondary importance. An entry form appears later in this issue, and entries may be designated either Competition or Loan. The latter is not judged, and may include unfinished work, which can be particularly interesting for some visitors.

Attending some popular venues can be made problematic due to parking restrictions. Fortunately, Sandown is not one of these. The on site parking is free of charge and extends to around 3000 spaces.

I shall be on hand for the duration of the Model Exhibition at Sandown Park and look forward to meeting readers and contributors.

Dates for the Diary

The London Model Engineering Exhibition will take place on January 20th to 22nd at Alexandra Palace. For more detailed information, see the Meridienne Exhibitions advertisement elsewhere in this issue.

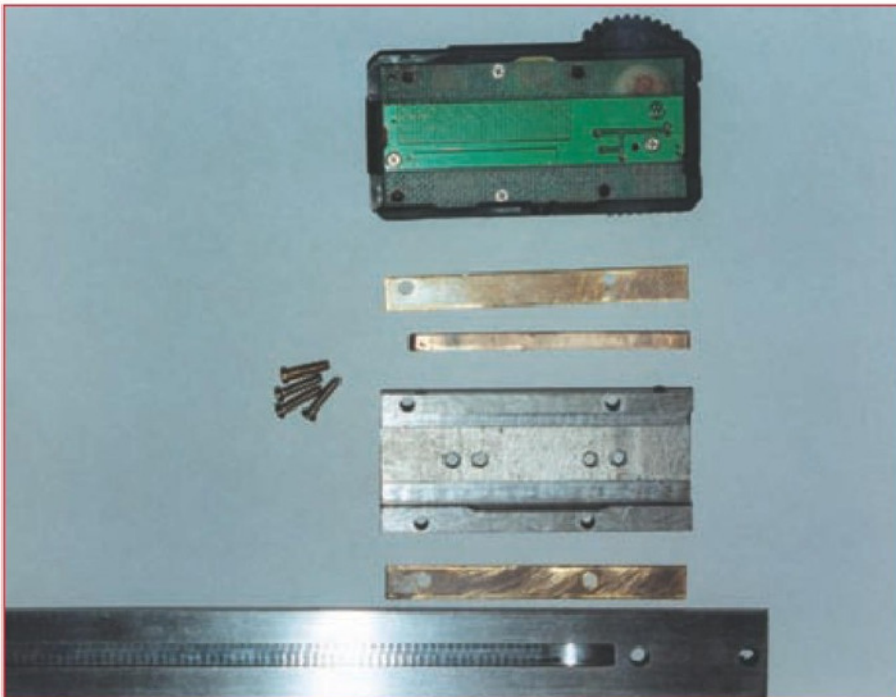
Correction

Eagle eyed readers may have noted a couple of errors which crept into John McIntosh's note on beam deflection Issue 109 page 49, apologies to John.

$E = \text{Young's Modulus} = 210 \times 10^9 \text{ N/mm}^2$ for mild steel.

$I = \text{Section Modulus of Inertia} = (BD^3)/12$ for a rectangular section.

A SELF-BUILD DRO FOR CHINESE SCALES 1



1. Scale dismantled showing gib strips

Summary

There can't be many readers of MEW who don't have at least one 6in. digital caliper in their workshops. They are great for reasonably accurate measurements and brilliant at quickly converting dimensions from imperial to metric and back. More recently digital readout bars, scales, which operate on the same measurement principle, have appeared in both horizontal and vertical formats. Some imported

machine tools are appearing with digital scales built-in and digital conversion kits for Seig lathes are available.

This self-build DRO design is available on the Internet from Scott Schumate, and several hundred DRO's have already been successfully completed worldwide.

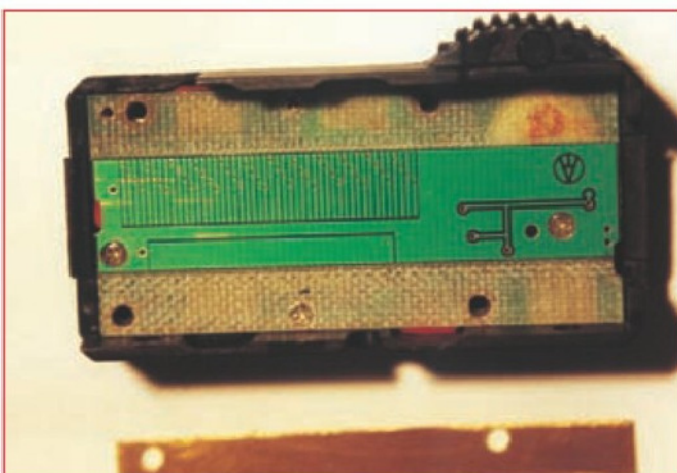
Note that this ShumaTech DRO design does not work with Mitutoyo and any other makers who may use the Digimatic data protocol.

Mike Houghton talks us through the construction and fitting of a DRO system using budget scales and a kit built readout.

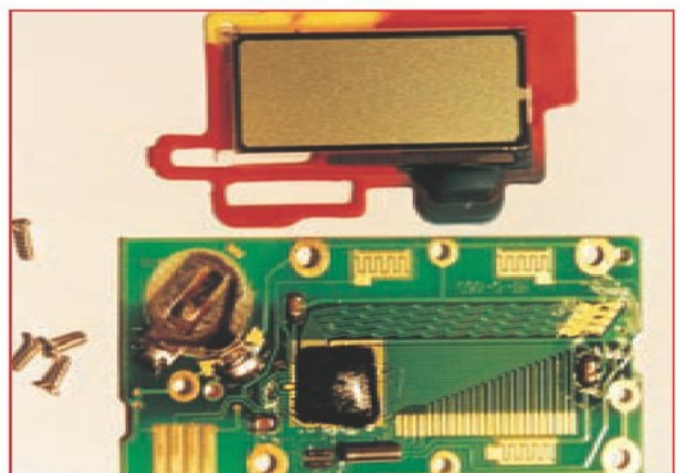
Digital calipers and scales

Just to underline the point, in this article I am describing a DRO for inexpensive Chinese measuring instruments, not those made by Sylvac, Mitutoyo or Tesa. I'm sure you will be familiar with digital calipers, their advantages and shortcomings.

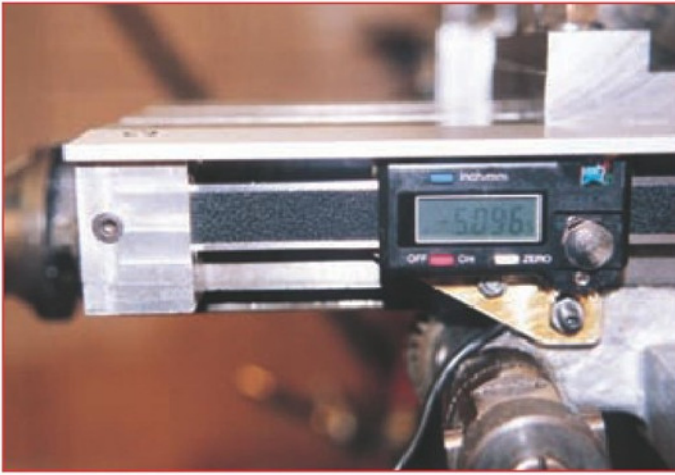
On the plus side they are great for inch to metric conversion, fast, moderately accurate and reasonably reproducible. "Moderately" and "reasonably" depend on the manufacturer and how much you are prepared to pay. On the negative side I have found that Chinese digital calipers and digital readout bars (scales) really don't like contact with liquids (oil or water based cutting oils), swarf, magnets and low working temperatures. In my experience the battery life of the single 1.3v silver /silver oxide cell (LR44, AG13 and SR44 seem common) is only a few months and reduces if you use them in a cold workshop. My guess is that a small current is being drawn even when the display is off; after all, most of them remember the last reading even when they are "off". Taking the cell out and storing it in a warmer place greatly extends its life, but you lose the last measured zero position.



2. Close up of the sensor pcb. Note horizontal scratches due to swarf.



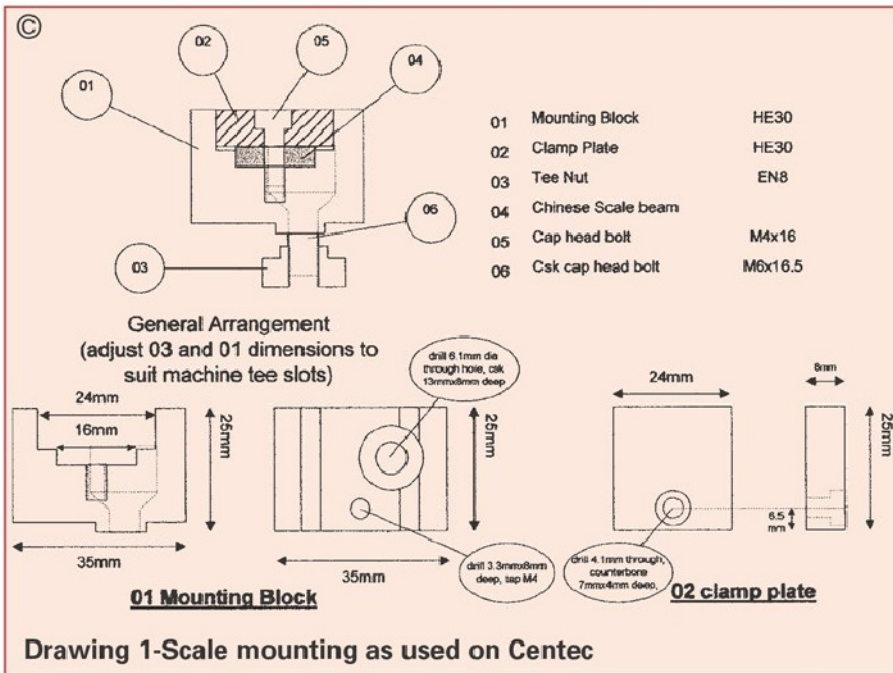
3. Detail of the pcb, component side.



4. Original X axis mounting; better protection was required.



5. Yes two heads on one beam does work.



do not need to do this, I was just curious. Well it was damaged, and yes, it did work again afterwards. Obviously, any guarantee it once had, is now void. Close inspection of **photo 1** shows that in this particular model there are 3 brass or bronze gib strips employed, two thinner ones to adjust the distance between the bottom of the circuit board and the decal and a thicker one to adjust the width across the scale beam. **Photo 2** shows a close up of the bottom of the PCB. The array of transmitters and receivers can be seen printed as copper tracks on the board. You may also be able to see some damage inflicted by a foreign body (swarf) that has been scraped through the gap between the measuring head and the decal. There were two small black rubber wipers attached to the black plastic case to clean the decal, but in my case these were not very effective. If you do dismantle a measuring head these tiny rubber wipers are easily lost and can be secured in their slots with a small dab of superglue. If water gets into the space between the scale body and the decal it dramatically changes the measured capacitance.

Photo 3 shows the other side of the PCB after it had been removed from its case. The black resin blob covers the microprocessor, which is surface mounted. The LCD has been lifted clear with great care. It appears not to have any contacts, but they are there on one edge and it has to be relocated exactly over the contacts on the PCB when you replace it. You can also see the crystal oscillator- a small silver can, responsible for event timing, the four data out contacts and the battery holder. I shall return later to modifications to this PCB. Caution, don't over tighten the very tiny screws holding the assembly together, the plastic or metal holes are very easily stripped.

A Centec 2A Horizontal Mill

I have described the refurbishment of this mill in an earlier article. (No 101, page 32). Older, well used, machine tools exhibit wear to lead screws and nuts. In the case of the screws this can be uneven and very difficult to eliminate, unless you replace both the screw and nut. Long table movements involve counting handle turns and a bit of mental arithmetic to set a new

The cost of replacing the battery in these devices can be quite considerable, especially if you own a few of them. Battery prices seem to be determined by their use in some watches, remote controls and hearing aids. I was fortunate in a car boot purchase of two cards of 30 assorted cells each, for £1 a card. 18 fitted my calipers / scales, all I need now are 2 hearing aids and a few watches to use up the rest.

New cells seem to measure about 1.58volts, but this falls with use to around 1.25volts at which point most scales have stopped working. As low voltage approaches the scale display flashes, but my experience indicates that some accuracy has already been lost before this point. See later.

Capacitance

These calipers and scales are always described, in the literature, as "capacitance scales", but it took me ages to find a description of how they actually work. Searching the Internet with Google located several Chinese manufacturers Refs. 1, but they are all silent on the mode of operation. Incidentally, the various manufacturers' quoted production

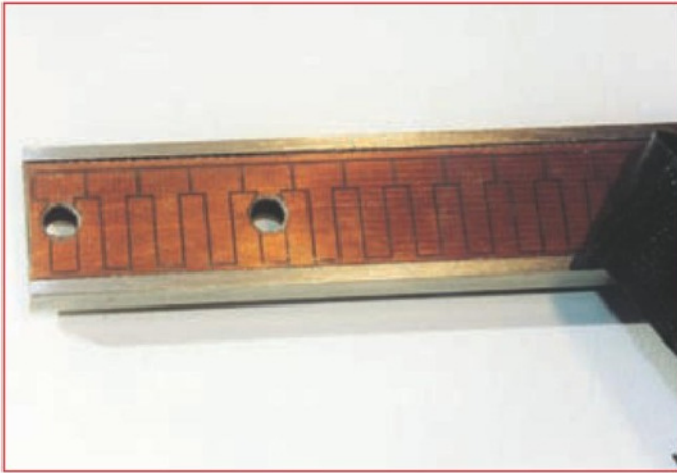
capacities are impressive (millions of units per year) and probably explain why prices have fallen so low of late.

Through the US Mitutoyo website Ref. 2, I found US Patents 4,420,754 (1983) and US 4,879,508 (1989) which explain, in complex patent speak, how capacitance scales work. US patents can be viewed on line for free. Ref. 3. Or, better still, type "US Pat 4,420,754" into the Google search engine and let www.freepatentsonline.com display the patent details.

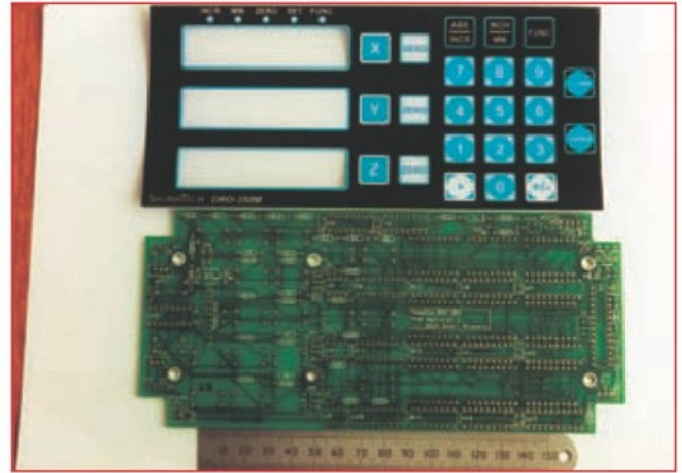
It appears that the Chinese chipmakers have reverse-engineered some of the early Swedish, Swiss and German patent ideas, Ref 4. Basically, the measuring head (the part with the buttons and display) contains a number of transmitters and receivers that react to the position of a printed circuit scale that is hidden under the plastic decal that runs the length of the stainless scale. A microprocessor calculates the result and drives the LCD display.

Inside a typical Chinese scale

Photos 1, 2 and 3 show the guts of one of my Chinese Scales, as I dismantled it. You



6. Showing the etched pattern under the beam decal.



7. The overlay panel and printed circuit board.

position. Placing bolt holes on a circle requires even more mental agility perhaps helped by an Excel spreadsheet. For these reasons, adding a scale to each axis of this mill seemed like a good idea, as it would actually indicate the movement of the table, not the handle dial reading plus or minus the backlash.

My first use of digital scales was to fit one to the X-axis of this Centec Mill. **Photo 4** shows one end of my original X-axis scale mounting. The mounting blocks were milled in matched pairs from 1in. square HE30, 6082 aluminium alloy from M.C.M. (ref.8) Drawing 1. This alloy really machines and taps nicely and is ideal for this type of work. Only one end of the scale is rigidly clamped and the plate transmitting the table movement to the measuring head is made flexible in one plane to allow for any slight mis-alignment as the head moves along the bar. **Photo 12** shows the brass mounting plate and my method of cable clamping (most important). My scales had 3mm tapped holes in their backs. The M3 screws used have integral oversized washers and are a type used to secure hard disks and optical drives into computer cases.

Fitting scales to this or any other mill (or lathe) presents several problems, rigid mounting yet no strain on the scale as it moves, protection of the scales from contamination and being able to read the LCD displays. After a few weeks use my X-axis scale developed erratic readings due

to contamination by swarf and possibly cutting fluids. Better scale protection than that shown in **photo 4** was obviously required. Another downside of mounting the three scales on my mill meant that the displays were located all over the place and no way could I see more than one LCD at a time. A remote, bright, DRO bringing all 3 displays to one eye level location is very desirable and also makes the mounting of the scales easier since guards can be more comprehensive and hiding the LCD displays on the scales is not a problem. With a remote DRO it's no longer necessary to read the scale's LCD displays directly, and you don't have to access the buttons on the scales either.

Scale modifications

Cutting the stainless scale beam with a small abrasive wheel e.g. a "Dremel" can be used to shorten scales. I opened up one of the mounting holes to 4.0mm with a normal HSS drill and cut a short length of the scale from one end to avoid overhang from my alloy mounting blocks. These modifications don't seem to compromise the operation of the scale.

Other scales of mine have proved much tougher to drill, so be prepared to use a solid carbide drill if yours are the hardened stainless variety. Scale measuring heads can be transferred to another scale beam of the same make, even if the length of scale is different. Useful if you damage the

measuring head on a long, expensive, scale as one from a shorter, cheaper scale can probably replace it and work OK. It's worth a try. Care is needed, though, as some longer scales, over 18in. can also be fatter. At one time scales were more expensive than calipers and several users have successfully cut down, i.e. removed the jaws, of old calipers using a "Dremel" to use them as scales. For some reason, vertical scales are still more expensive than their horizontal brothers.

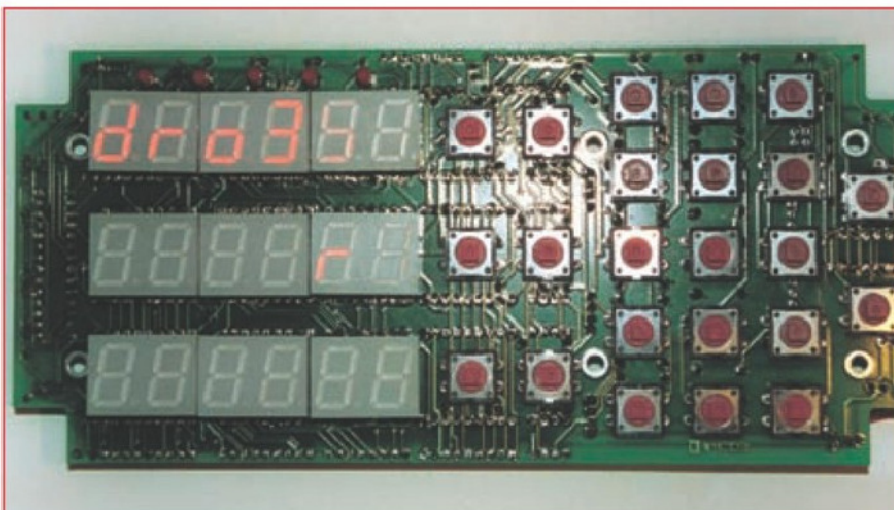
There seems to be nothing to stop you placing two measuring heads on one scale, see **photo 5**. Applications where this might be useful are on a lathe cross slide where one scale might indicate the position of the front tool post tool and the other a rear tool post tool. When I experimented with two heads mounted on one scale their displays did not seem to be quite as stable, when located close together, in the last one and a half digits, even with the second head turned off. Perhaps this is a sign of interaction between the two units.

It is essential to buy Chinese scales with a four contact data output hidden under a small slip-off cover. Ready made data cables are available as are stand alone one, two or even three axis DRO display modules. These displays are usually liquid crystal and are little bigger or easier to read than the scales themselves, especially in a poorly lit workshop. These "inexpensive" DRO's are dumb i.e. they do not carry out any calculations and simply duplicate the LCD display on the scale. Although some expensive callipers are now offered with a wireless connection; i.e. no data cable, I have not seen these offered on the cheaper Chinese units, so check for the presence of a data port before you buy.

If you carefully peel back the decal covering the groove machined in the scale beam you will see it contains a PCB (Printed Circuit Board) with etched copper pattern. I assume this interacts with the scale head transmitter/receiver array. Should you cut off a piece of the beam you will find that this PCB is in fact double sided, see **photo 6**.

ShumaTech DRO 350

I had already bought and fitted three



8. Initial test of the read out board.



9. Drilling the case.



10. Moulded plugs and leads.

scales for this project from Arc Euro Trade, ref. 4, when I became aware, through my membership of some of the Yahoo Internet Discussion Groups, of a new self-build DRO design by Scott Shumate in Texas. Scott has designed a three axis intelligent DRO for a mill or lathe which takes data from these Chinese scales, performs calculations and displays the results on bright light emitting diode displays, LED's, in a remote, mains powered, unit. Thus this is a self contained unit which gives similar attributes to the system designed by John Curtis and now available from Compucut for output to a PC monitor.

Scott Shumate has a very detailed website, ref 6, where you can read full descriptions of his design, circuit diagrams, step by step building instructions and a user's guide. Scott only sells the printed circuit board (PCB) for the project and screen-printed Lexan overlays (Mill or Lathe) for the front of the case. Because Scott was not selling outside N. America when I first became interested in this project, I got a friend living in the US to buy the PCB and a front panel overlay for the mill version and mail it over. **Photo 7** shows the panel overlay built into a completed box. There is an active Yahoo Group with 1600 members, as I write, for builders of these DRO's. Ref. 7. Scott has been very active helping self-builders, answering questions from this group and listening to suggestions for product improvement. Joining this Yahoo group costs nothing, other than providing a minimal amount of information about yourself to keep out spammers.

The Shumate DRO design has very comprehensive calculation features that place it in a different league to the dumb LCD displays mentioned above. Only one version of the DRO-350 PCB exists, it is user configured during set up to 2-axis plus tachometer for lathe use or 3-axis for a mill. You don't have to implement all 3 axes.

One of the really clever parts of Scott's design is the use of a "flash" programmable PIC to run all the functions of the DRO. Once "flashed" the PIC will remember its programme, even with the power removed. The PIC is a one-chip microprocessor (16F876A) made by Arizona Microchip. It has on-chip memory that can be programmed or re-programmed in-situ by a PC connected by a RS-232 serial port. This is an important

point. Should new features be added to the software through the activities of Scott and the User Group, the DRO could be "flash upgraded". As I write this, the software is in version 3, but my DRO is running version 1. Version 1 has both Mill and Lathe functions in the programme. Later versions are either programmed for lathe or mill, but not both.

Assembling the DRO-350

The ShumaTech PCB was found to be an excellent quality, two-sided design with plated through holes and screen-printed component positions on one side. As a concession to the home assembler, no surface mounted chips are used, but the copper tracks are pretty fine so very good eyesight or a magnifier and a fine soldering iron are absolutely essential.

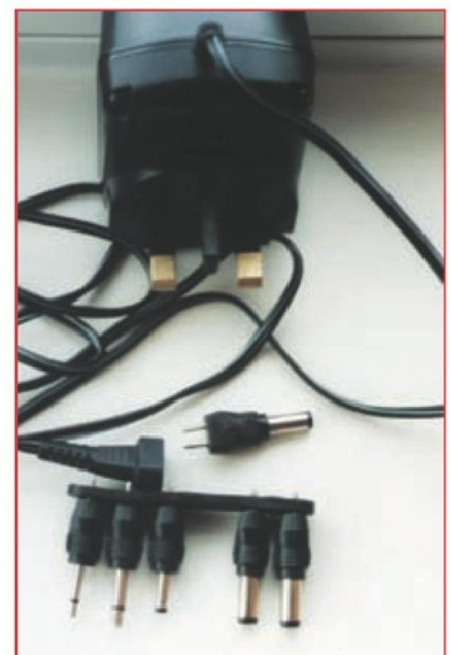
The Shumatech website maintains lists of components and links to US based suppliers of components. There is nothing very unusual in the components list but the Canadian made ABS case looked like a real headache for me, based in the UK. Very fortunately, for non-North American builders, Lester Caine ref.8, has produced an almost complete list of UK sources for the electronic components and the case, so I bought a set of components and a case that included a pre programmed PIC from Lester. As a concession to those not up to speed with the identification of modern components, all the bits and bobs were supplied taped to a printed list of component names and numbers.

Soldering of the components into the PCB took me several hours with a 15watt iron, side cutters and a magnifying glass. I have to admit to soldering a 16pin IC in the wrong way around and struggling with a solder pump (useless) and de-soldering braid to remove the solder from the plated holes, extract the chip and replace it with the correct orientation. Powering up from a 9v wall wart the test display came up correctly, Phew! **Photo 8.** Just shows how robust modern components and circuit boards are. However, later I found that one digit of the Y-axis didn't light up and the Z-axis was completely blank. See "Testing the DRO", below. Please read the warnings about electrostatic damage and the use of low leakage soldering irons on the website before commencing construction.

The case

Lester has sourced the identical Canadian ABS case from Farnell (ref. 9) so there were no problems in fitting the circuit board into the case. Scott provides cutting instructions on his website (ref. 7) for the front and rear in a format that would be ideal if one had a CNC mill, I don't, so I compromised by printing out the panel full size and sticking the paper print on to the case with Power Pritt. You may need a graphics package like Paint Shop Pro to get the print out scale exactly 1:1. The remains of the paper print can be soaked off with hot water when you have completed the case drilling and milling.

ABS is pretty soft and the case no more than about 2.5mm thick. I drilled all the holes with brad pointed wood drills (**photo 9**). As some of the holes are bigger than my biggest available brad pointed drill, 10mm, I used a tapered hand reamer to open up the holes. You can see the reamer in **photo 9**. These tapered reamers are OK for aluminium chassis work, but tend to leave reamed holes with flats on them. No problem in this case as the overlay covers a multitude of ills. The slots for the



11. Power unit is a "wall wart" from Maplin, which comes with a selection of connectors.

displays were milled with a $\frac{3}{8}$ in. disposable FC3 (JL3) end mill in my Dore Westbury Mill. I found it difficult to keep the box clamped in position on the table unless feed rates were very small. The cutter speed on this mill is not fast enough for a soft plastic like ABS. A fast helix milling bit designed for plastics would have made a better job of the case, if I had one available at the time.

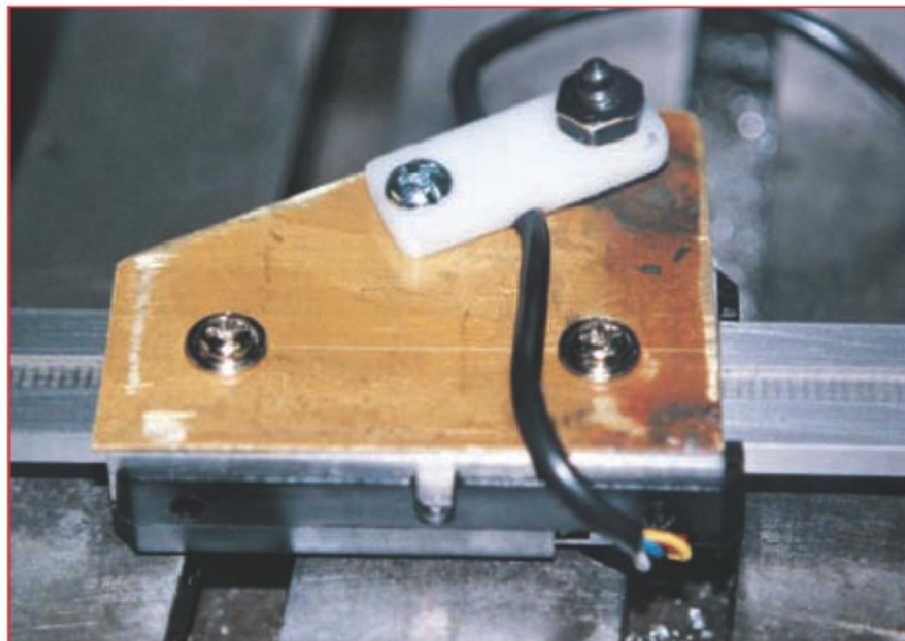
When mounting the completed PCB in the case, I deviated from the instructions and used slender self tapping screws directly into the ABS pillars projecting from the back of the case front. Lester supplies metric pillars that mount on the back panel. Scott, of course, uses UNF sizes and these are not readily available in a metric world. The only critical dimension is the final position of the tops of the 23 click switch caps. They must just protrude beyond the case front surface so they are operable by the flexible membrane overlay. The switch caps must also be an easy sliding fit in the case front holes. A few red fibre washers, (steam) and a spot of superglue were used to get the PCB exactly into position. I attached the Lexan overlay to the front of the case with a few dabs of cyano-acrylate super glue and some moist breath to set it off.

Cables, plugs and sockets

Scott recommends soldering the scale leads directly to the four data contacts on the PCB that is inside the scale measuring head. At first I thought this was a bit extreme so I bought leads for my scales from Arc Euro Trade as they have a plug moulded on one end. See **photo 10**. I mounted four pin DIN sockets (Maplin, ref.12) on the back of the DRO case and used cable and plugs from a trashed video recorder to connect the back panel mounted sockets to the PCB headers. I decided not to provide a D socket on the back of the case for reprogramming the PIC. Reprogramming is something I don't expect to do very often and I can always take the back off the case to access the five pin header on the PCB.

Compatibility of moulded plugs and sockets seems to be somewhat variable and is a common problem with Chinese scales. Mine too, were less than perfect in this respect and I later converted to soldering the leads directly to the measuring head PCB contacts. As an alternative, maybe gluing the plugs in will secure them from moving side to side? Remember, we are dealing with a dirty environment with lots of vibration. If you do decide to glue the plugs in place, use a glue that does not produce acetic acid (smells of vinegar) when it cures (many silicones do). Acetic acid is very corrosive to electronic components, so avoid use of silicone bath and shower sealant.

Other users have soldered a four pin miniature socket directly to the scale pcb. On reflection, soldering directly to the scale pcb is the best solution, but needs a steady hand, speed and a small soldering iron. The quality of the Chinese scale pcb's may not be to defence standards, so excessive heating should be avoided or there may be a risk of the copper track coming away from the board.



12. Cable clamp is an essential feature for strain relief at the joint.

The power supply

The DRO-350 requires an unregulated DC power supply of around 9volts. The power requirements are quite modest, but rise if you install super bright L.E.D. displays, a modification I decided not to go along with. Another possible modification is to change the L.E.D. colour.

I used a Maplin 300mA AC-DC Adaptor that plugs right into a UK mains socket. A "Wall Wart" in US parlance! The ShumaTech board has no protection against incorrect polarity and will be damaged if you get it wrong. These Maplin adaptors have multiplugs attached, see **photo 11** so the polarity can be switched by plugging the two pin plug in different ways and different sized plugs added to suit the equipment to be powered. To avoid any confusion I cut off the supplied socket and wired the adaptor directly to the PCB header. The PCB is well marked Power JP6 + , but the polarity marking is obscured when the two pin header is soldered to the PCB. Constructors beware!

between the DRO and the scale. This can be very confusing at first. The scale and the DRO have different zero points, unless you zero them at the same point; in addition, one can be operating in inches and the other in metric. The DRO will also continue to read the scale even when the scale display is off!

I found the best test procedure was to get the X-axis and scale to operate correctly, then plug the working scale into the Y-axis, test that and then plug the same scale into Z-axis and get that working. One LED segment on the Y-axis didn't light up and the Z-axis was completely dead. These problems were all down to my soldering technique. It's very important to check both sides of the board for potential badly soldered joints and run the DRO out of its case to check all works well. Check that all the buttons work as any binding on the case cut-outs can cause some bizarre effects.

In the next issue, I will look at mounting and guarding the scales, and also comment on accuracy.



Testing the DRO and individual scales

I found my four pin DIN plugs and sockets on the back of the DRO a nightmare to solder up. The plugs and sockets just have solid pins to solder to. A type with solder buckets would have been easier to use and less possibility of solder bridges. How many ways can you solder eight wires incorrectly? I suggest getting one axis working correctly and then copy the successful wiring onto the other axes.

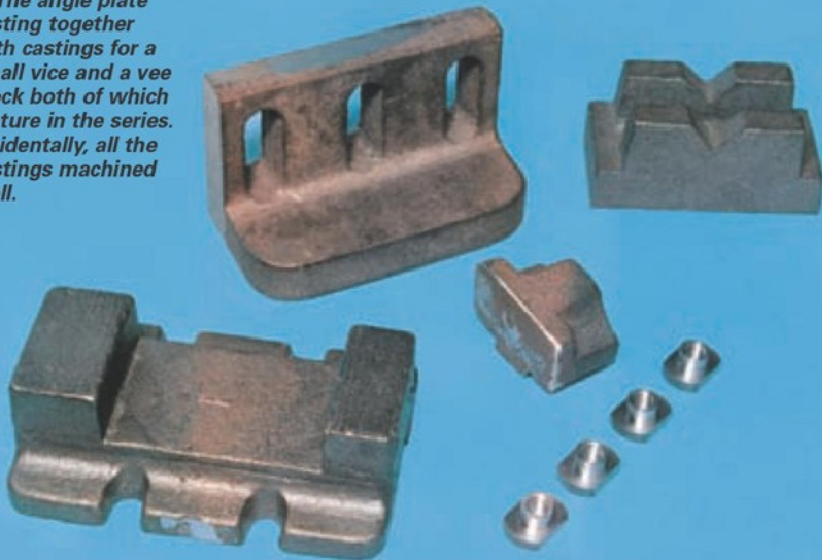
After power up the DRO sets the scales into fast mode, updating the measurement 50 times a second instead of the normal 3 to 5 times a second. (Fast mode is actually a real boon and makes it much easier to arrive quickly at a desired coordinate.) You should see the DRO display flicker once or twice during power up. The start up screen has to be cleared before a measurement will be displayed. The displayed measurement will probably be different

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L.S.Caine Electronic services. Tel: (uk) 01386 842 909. www.lscs.co.uk or see links in Ref 7
M.C.M. Hulme Street, Salford M5 4PZ, UK. 0161 736 2498
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THE LATHE ONLY WORKSHOP 4

1. The angle plate casting together with castings for a small vice and a vee block both of which feature in the series. Incidentally, all the castings machined well.



In this episode, Harold Hall describes the construction of a Small Angle Plate

Angle plate alternative

Before setting the lathe up for milling you will need to make two posts as per Sk. 1. These are used to support the angle plate in some of the machining operations. They will also find uses for other projects. Cut two pieces of $1\frac{1}{2}$ in. square steel, $1\frac{1}{2}$ in. long, the dimensions are not crucial but do not use anything smaller than 1in. square. Fit in the four jaw, checking two adjacent faces with a small square off the chuck face to see that they are true. Face the end and drill through to suit the size of tee nuts and bolts you use. Remove, turn over, again checking with a square, and face this end also. These will be used as an alternative to an angle plate and also from time to time for other tasks. If obtaining square material causes a problem, then you might as a second option turn up a matching pair of cylindrical squares, in which case, use bar of at least one inch diameter. If using round material, then a clamping bar having a thicker section than that shown in several of the photographs, may be advisable due to the higher bending loads generated.

Casting

Generally, clean up the casting in particular taking care to remove any high spots. Check the slotted face against a flat surface to see that it does not rock excessively, perfection will not of course

Following the modification of a drilling vice in the last issue the subject this time is another work holding device, an angle plate. This is an excellent size for using on a vertical slide and is made from a casting available from Woking Precision Models (ref. 1). No drawing is provided with the casting but in any case there is no real reason to work to any particular dimensions, just machine until you have a clean angle plate. Its nominal dimensions are length $3\frac{1}{2}$ in, wide face with three cast slots $2\frac{1}{2}$ in. and narrow face without slots $1\frac{1}{2}$ in. **Photo 1** shows the raw casting together with the castings for a vee block and a small vice that will

be the subjects for two further articles. Also in the photograph are four tee nuts largely made using the lathes turning facility, see **Photo 1** in the introduction to the series, issue 108 page 12. As can be seen from the photos taken during manufacture of the angle plate, I have happily used the three jaw chuck to hold the milling cutters throughout. I am aware that some readers will frown upon this practice and insist on a purpose made milling cutter chuck. Suffice to say, that for the relatively light milling work undertaken in the lathe on this project, it worked for me, and does permit the use of tipped cutters, having shanks outwith the capacity of my milling chuck.

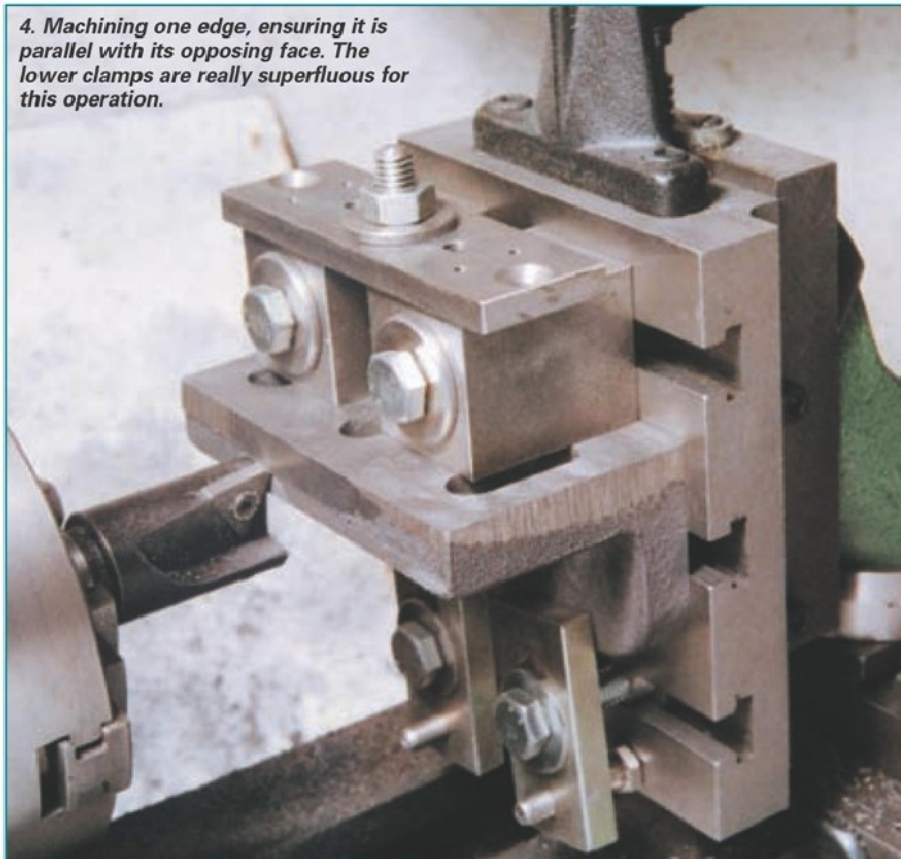
2. Machining the first face.



3. Machining the second face.



4. Machining one edge, ensuring it is parallel with its opposing face. The lower clamps are really superfluous for this operation.



be likely at this stage. Mount the two posts on the vertical slide together with the angle plate and machine the non slotted face as in **Photo 2**. Placing a piece of soft copper between the posts and the angle plate can be a useful technique to help compensate for any irregularities in the casting's surface, though the photograph shows that I did not need to do this. Also for added support, ensure that the top edge of the casting is

against the vertical slide face. However, having made that recommendation, do check that you will not be machining more off the face at one end than the other as you will end up with the thickness of the angle plate being tapered.

I should add at this stage that you must set the slide parallel to the cross slide traverse using a dial test indicator and upright using an engineers square off the

lathe's bed. This should always be the normal procedure when adding the vertical slide to the lathe no matter what degree of accuracy is required for the project in hand.

Next basically repeat the above, machining the second face, **Photo 3**. However, you will not be able to butt the edge of the casting fully against the vertical slide's face as the casting edge is slightly curved. This makes it especially important to check that you will not be machining more off at one end than the other.

Now with the two main faces machined, clamp the slotted one to the two posts and machine the top edge of the casting making this parallel to the base, **Photo 4**. The photograph shows that I used clamps on the non slotted face also. This, in retrospect, appears unnecessary, just ensure the faces are clean and in contact when you tighten the fixings holding the angle plate to the posts.

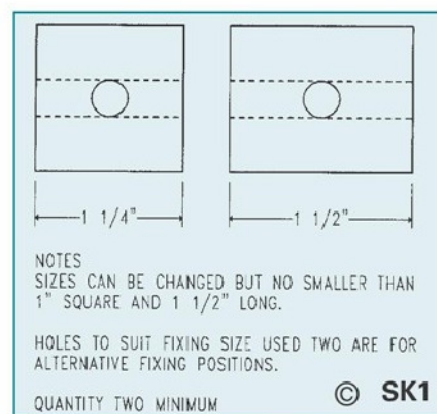
Next machine both edges at both ends of the angle plate as shown in **Photos 5 and 6**. To do this set the vertical slide round so that its face is parallel to the lathe's axis, checking this with a DTI whilst traversing the saddle. This though will only get the ends square to one face. For the other face check also that the undersides of the two posts are also in line and parallel to the lathe's axis. To do this, clamp the angle plate to the two posts and check the top face of the angle plate with a DTI whilst traversing the saddle. If not parallel, loosen the two posts from the vertical slide, keeping them clamped to the angle plate, and adjust the assembly until the top surface of the angle plate is correct. With this done the ends will be square to both faces.



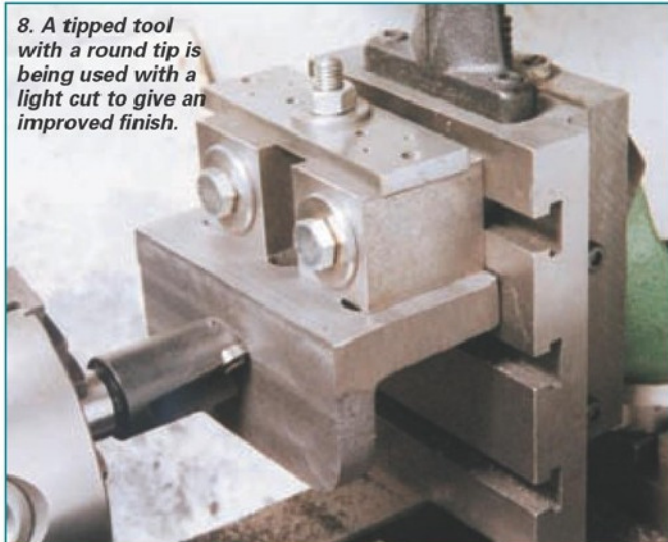
5. Machining the ends. Note the vertical slide has been set parallel to the lathe's axis. This set up is not unlike a mini horizontal mill. However, available traverse of the vertical slide is somewhat limited.



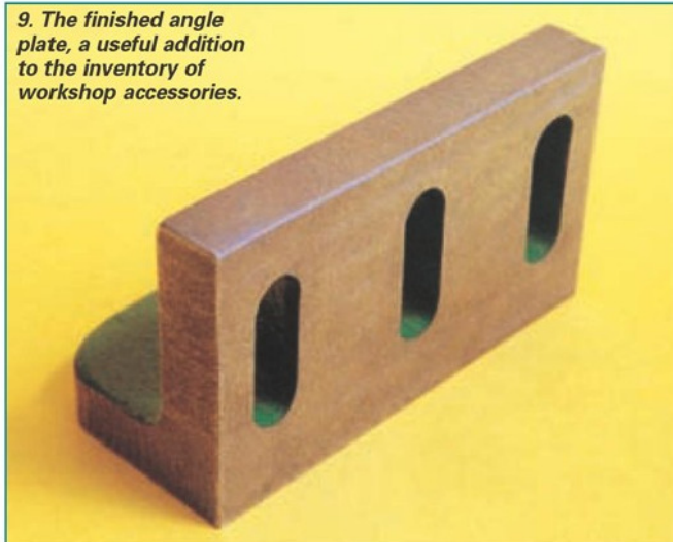
6. Machining the second end. Note the cover to prevent swarf entering saddle slideways.



7. Machining the final edge.



8. A tipped tool with a round tip is being used with a light cut to give an improved finish.



9. The finished angle plate, a useful addition to the inventory of workshop accessories.

Finish machining

Finally, for the milling operations, straighten the curved edge, **Photo 7**. I say finally, but actually I repeated all of the above operations carrying out a light finishing cut to eliminate any movement in the castings due to the machining operations. Also with little to take off I was able to concentrate on a better finish and used a tipped tool with a round tip as seen in the **Photo 8**, though this photograph was taken prior to machining the ends. At this stage also check that the two main faces are square to each other. If there is a significant error, investigate why, if only very small then a very thin shim between

plate and post, positioned appropriately, would be worth trying.

With the second face of the angle plate having no cast in provisions for fixing you can choose to machine what is best for you. I just drilled two holes at a pitch equal to the pitch of two adjacent tee slots on the slide, this enables me to mount the angle plate horizontally or vertically. You may do this or you may choose to mill some more slots.

Remove the as cast surface on the two curved corners using a file, generously chamfer edges, clean out slots with a round file, and give the non machined surfaces a coat of paint. You have then acquired a very useful angle plate, **Photo 9**.



References

Woking Precision Models.
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Web Site
www.wokingprecisionmodels.co.uk
(The web site gives details of the
product range which includes tools
materials, castings and kits for
workshop equipment and i.c. engines,
also accessories such as spark plugs
and ignition systems.)

IN OUR NEXT ISSUE

Coming up in Issue No. 112 will be



Woking Precision Vice

In this instalment of the Lathe only Workshop series, Harold Hall builds a small vice from castings sourced from Woking Precision Models.

Friction Handwheels for the Unimat

Maurice Rhodes describes a modification to aid accurate working.



Multi Facet Drill Sharpening For Larger Drills

Les Riley offers a simple jig for four and six facets.



Webcams in the Workshop

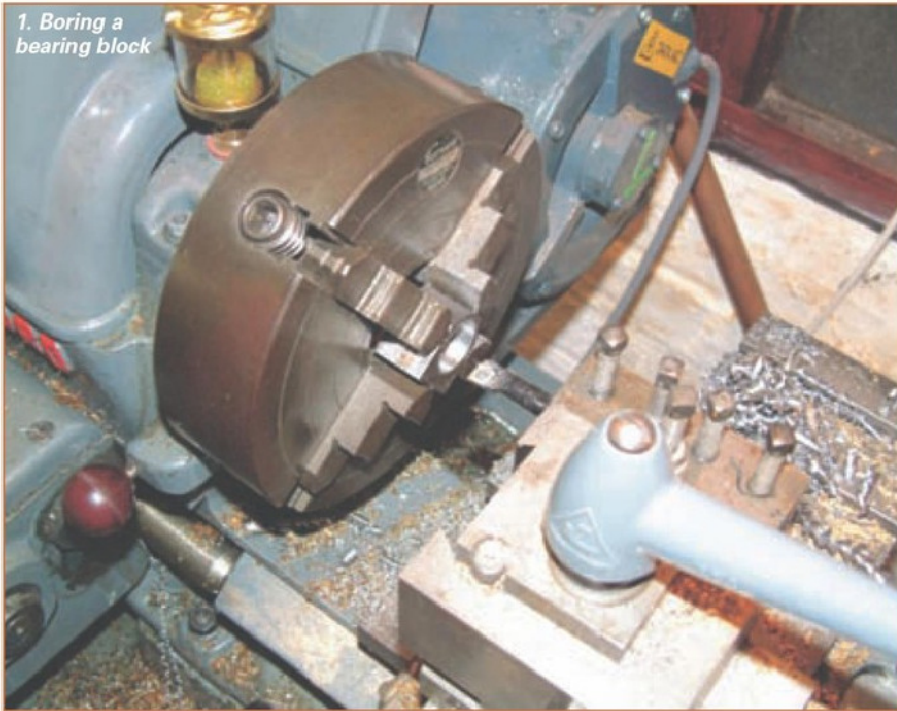
Machine vision systems are no longer the preserve of high end industry. Tony Jeffree and Dick Stephen explore the use of budget equipment in the home shop with particular reference to centering.

Issue on sale 3rd February 2006

(Contents may be subject to change)

A CNC HEADSTOCK ATTACHMENT

1. Boring a bearing block



A good many people have built ML7 and Super 7 headstock dividing attachments over the years, using the designs originally devised by Peter Radford, and later described by G.H. Thomas in his book "Dividing and Graduating" (no longer in print), later re-published as part of "Workshop Techniques" (Ref.1). As I own an ML7, I have planned for some while to build one of these attachments, but to convert it for CNC use in conjunction with the DivisionMaster (Ref.2) automatic indexer. The primary motivation was firstly to demonstrate that "it could be done", and secondly to be able to feed back the right information to various people that have asked me for advice on how to adapt

their dividing attachments in this way.

As George Thomas points out, the ML7 is not ideally suited to performing division operations, as its bull-wheel has 65 teeth, which is far from ideal as you need a large number of non-standard hole-circles in your dividing plates to get all of the useful divisions. George Thomas' solution was to use his micro-indexing attachment in order to generate unusual hole circles; however, for those that find using a conventional dividing head to be problematic, keeping track of movements on the indexing arm and the micrometer thimble at the same time would be something of a nightmare. Of course, replacing the manual dividing components with a stepper motor and an automatic indexing device such as the

Tony Jeffree adapts a classic accessory for modern technology.

DivisionMaster controller makes all of these problems go away; the boring, and all too often, error-prone, job of keeping track of the angle to be moved can be given to the controller, while the operator concentrates on the machining.

The general plan, then, was to build one of these dividing attachments from the excellent Hemingway kit, (Ref.3), discarding any bits that related to manual indexing, and replacing the indexing arm/dividing plates with a suitable stepper motor. So, I bought the kit for the ML7 version of the attachment (there is a different kit for the Super 7 and its variants, as the pitch of the bull-wheel is different on these two machines), and proceeded to allow it to gather dust, in the traditional manner, for three or four years,

in a quiet corner of the workshop. As an aside, I'm convinced that there is a process of "maturation" associated with any new project – possibly somewhat related to the process of "ageing" and "weathering" that improves the quality of iron castings – anyhow, it is clear that this particular kit needed to gather a considerable layer of dust before it was properly matured (at least mentally) and ready to be built. Finding myself with some unaccustomed spare time after the New Year celebrations had died down, I decided to excavate the corner of the workbench where the kit had been "maturing", and think through the modifications that would be necessary to CNC-ize it.

This article concentrates on the changes that need to be made to the basic design of the dividing attachment to convert it to stepper drive, and doesn't give a blow-by-blow account of constructing the parts of

2. Dividing accessory fitted with stepper motor and Oldham coupling.



3. Device fitted to lathe, "D" removed. Homebuilt tachometer is also visible.



OCK DIVIDING FOR THE ML7

the attachment (such as the mounting bracket that fits on the countershaft bracket of the lathe) that are unaffected by the change to motor drive. For details of those aspects of the construction, I refer the reader to the excellent material in George Thomas's book and to the instructions provided with the Hemingway kit.

The approach taken here is appropriate for those that are building the dividing attachment from scratch and have no intention of ever using it in conjunction with the manual dividing attachments described by G.H. Thomas; if you wish to modify an existing dividing attachment, retaining the ability to use the manual option, then you will have to adopt a different approach, maybe devising a way of mounting a stepper motor in place of the division plate/indexing arm, but this shouldn't be terribly hard to do. Similarly, the approach adopted here could be adapted to build bull-wheel dividing attachments for use with other lathes.

In writing up this project, I have made some changes to the dimensions that I used in the prototype, in the light of experience during its construction; hence, the eagle-eyed amongst you will notice

that the photos differ from the drawings in a number of minor respects. Hopefully, the version that appears in the drawings will be an improvement over the prototype!

The modifications

The component parts of the kit consisted of several lengths of round and rectangular bar stock of assorted dimensions, three iron castings for the bearing blocks, and a partially machined worm of the right pitch to properly engage the teeth of the bull wheel. After studying the drawings and associated description for some while, I dug out my copy of "Dividing and Graduating" for further illumination. The drawings supplied with the kit seemed to show only the major differences between the ML7 design and the Super 7 design, so the full text in George Thomas' "Workshop Techniques" was extremely helpful in understanding how it was all supposed to fit together.

The original dividing attachment uses plain bearings. There are two identical bearing blocks either side of the worm, and a further bearing block at the operator end of the worm shaft that serves a couple

of purposes; it forms the end thrust bearing that prevents axial movement of the worm shaft, and is also used to mount the various dividing components (dividing plate, micrometer attachment, and so on). This latter bearing block didn't really serve any purpose in my CNC version, so I discarded it, and decided to control end float by other means.

Plain bearings are a source of relatively high friction, which is undesirable in a stepper motor driven device, so I decided that I would use ball races either end of the worm shaft instead. I had a few of $\frac{1}{4}$ in. OD, $\frac{1}{4}$ in. ID ball races to hand that looked like they would fit in reasonably well size wise; obviously, close Metric equivalents – for example 19mm OD, 7mm ID – could be substituted with suitable dimensional changes to the bearing blocks and worm shaft. You could go up to 22mm OD without too much difficulty.

The remaining two cast bearing blocks looked to me to be potentially a pain to machine; it has always seemed to me that using cast components can be a false economy (in terms of machining time) unless the shape is complex – with simple shapes like these, you spend more time

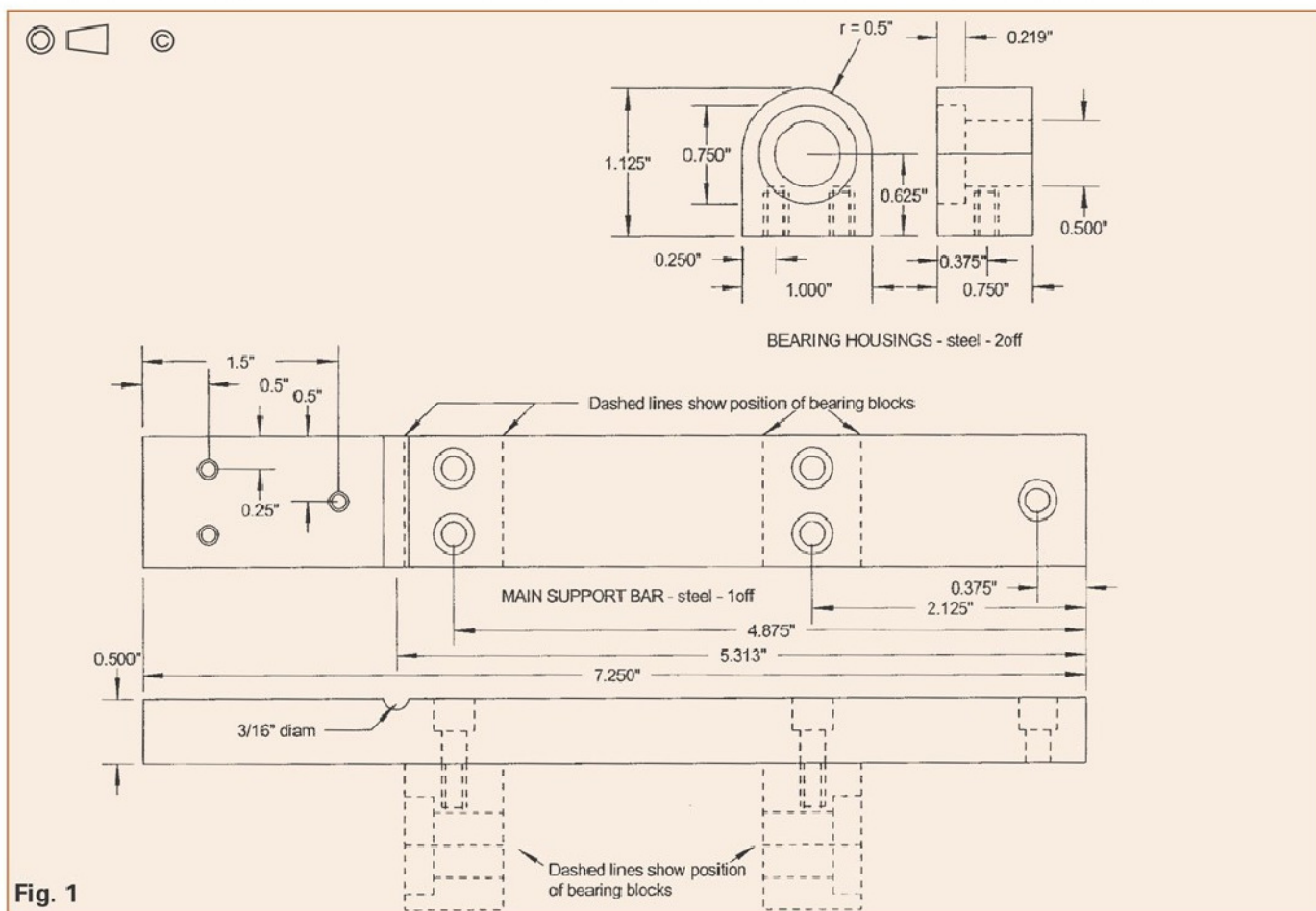


Fig. 1

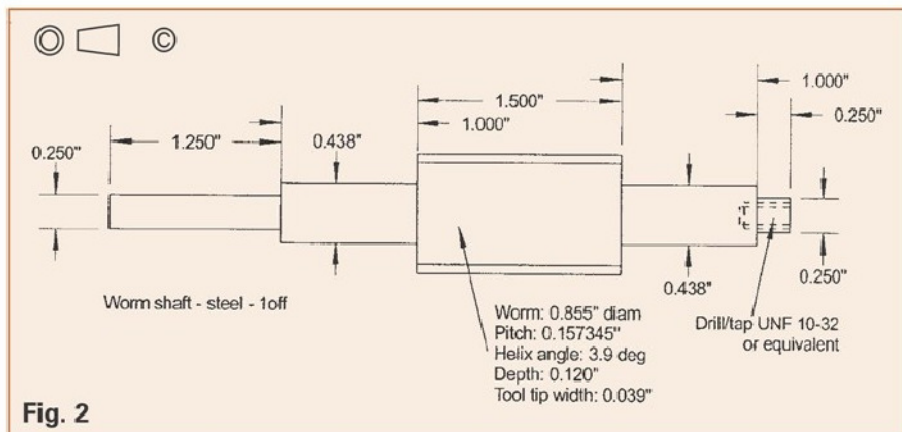


Fig. 2

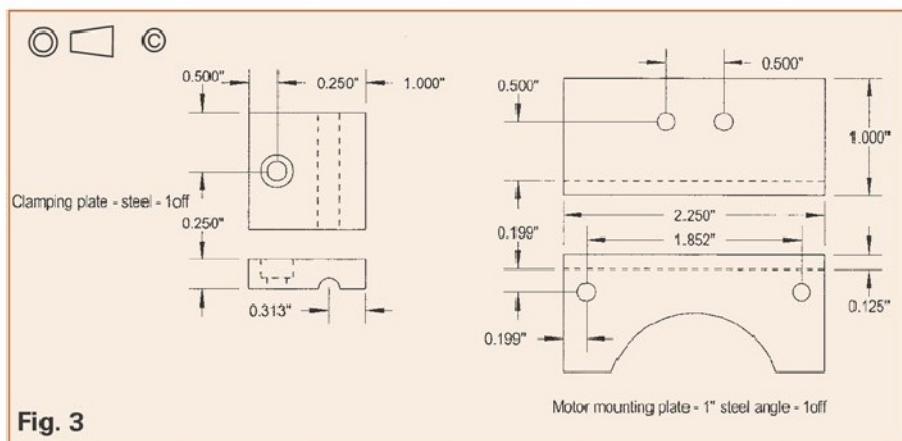


Fig. 3

“truing up” the sides of the casting, and deciding how to get a firm hold of its sloping sides while you do it, than you would have done making the part from bar stock to start with, especially if (like me) you have a metal cutting band saw to hand. So, these two cast components joined the other one in the scrap box, to be replaced by bearing blocks cut from $\frac{1}{4}$ in. x 1in. bar stock.

Bearing blocks

The design of the bearing blocks can be seen in Fig. 1. These are simple to construct; the blocks are cut to finished size (1.125in. long), and bored in the 4-jaw chuck so that the $\frac{1}{4}$ in. through hole is exactly $\frac{1}{4}$ in. from one end and central in the 1in. width of the block (see Photo 1). The counterbore that forms the seat for the ball race is then machined; the objective here is for a close, but not press, fit. There are two tapped holes in the base of each bearing block to mount the blocks on the main bearing bar of the dividing attachment; in my case, I used UNF 10-32 screws as these were in plentiful supply in my screw box, but substitution of any appropriately similar size (2BA, M5, $\frac{3}{16}$ BSF...whatever) is clearly an option.

Once the housings have been fully machined and finished, the bearings can be permanently fitted in their seats with the help of a drop of your favourite bearing retainer (Superglue works just fine for this), taking care not to use so much that the bearing itself gets a wetting, as there is no alternative at that point but to chuck the bearing in the bin and use another one (just don't ask how I know, OK?).

Main bearing bar

The bearing blocks are mounted on the main bearing bar of the dividing attachment, a length of 1in. x $\frac{1}{4}$ in. steel bar stock; see Fig. 1 for dimensions. The counterbored holes for mounting the bearing blocks, and the single counterbored hole that attaches the far end of the main bearing bar to the square section cross-member, are machined to suit the socket head screws that are to be used. I had the advantage of being able to use my CNC mill to spot the positions of these holes (and also the matching holes in the bearing blocks), thus ensuring an accurate fit. Once the main bearing bar has been attached to the cross-member, at 93.9 degrees to allow for the helix angle of the worm, the end of the bar can be filed or ground off to make the end flush with the cross-member.

Worm shaft

The next job is to machine the worm shaft. The dimensions are shown in Fig. 3; this is a fairly simple operation, but should be performed with due attention to maintaining concentricity between the worm and the machined portions of the shaft. One end of the part-machined shaft had a centre machined in it; I used a fixed steady and a 4-jaw chuck to drill an accurate centre in the other end, and then machined the shaft between centres to the dimensions shown. The objective is for the extreme ends of the shaft to be a close fit in the ID of the bearings chosen for the job. The short end of the shaft (the right hand end as seen in Fig. 2) is drilled and tapped to take a cap head screw; this, along with a $\frac{1}{4}$ in. diameter setscrew collar (this can be machined to suit from a scrap of $\frac{1}{4}$ in. round

bar) at the other end of the shaft, will provide the means of adjusting the preload on the bearings and thus eliminating any end-float in the worm shaft.

At this point, a trial assembly of the worm shaft and bearing blocks will allow the overall arrangement to be checked. The set screw collar should be positioned so that the short end of the shaft doesn't quite protrude through the far end bearing, allowing a cap head UNF 10-32 (or equivalent) screw and washer to be screwed into the far end of the shaft to adjust the preload. On final assembly, this screw will be retained with your favourite thread-locking compound, but best to leave it dry at this stage.

Motor mount

Next, machine the motor mounting plate shown in Fig. 3. Mine was made from a piece of $\frac{1}{4}$ in. x 1in. aluminium angle, but pretty much anything (brass, steel, whatever) will work for this. The mount is designed to accept a NEMA 23 frame size stepper motor; to do a reasonable job of driving the Myford headstock, this motor should be rated for a holding torque of 140 oz-in (approx. 1 Newton-Metre) or more. The motor is coupled to the end of the worm shaft by means of an Oldham coupling, as can be seen in Photo 2. These can be obtained from Electromail/RS Components (Ref.4); two hubs are required, part number 748-055, and the plastic torque disc is part number 319-590, for a coupling that will take $\frac{1}{4}$ in. shafts. Other hubs are available with different bore sizes if necessary. Unfortunately, the torque discs are only sold in multiples of 10. Alternatively, DivisionMaster Ltd can supply these couplers in single units.

The motor has a circular register, 1.5in. in diameter, which matches the corresponding cut-out in the motor mounting plate. The final position of the two holes for mounting the motor, and the two holes for attaching the motor mounting plate to the main bearing bar, should be determined by trial assembly – the motor shaft and the worm shaft should be as close as possible to being on the same axis. The Oldham coupling will tolerate a considerable degree of misalignment, but the more misalignment there is, the higher the frictional load on the motor, and the less torque is available to drive the lathe spindle. There should also be sufficient space between the ends of the two shafts to accommodate the torque disc of the coupling without its free movement being restricted by contact with the ends of the shafts.

Swinging latch and clamping plate

The swinging latch that holds the worm in engagement with the bull wheel is constructed pretty much as described in George Thomas's original design, and is pivoted at the same distance from the far end of the main bearing bar as in the original design. The square clamping plate, cut from $\frac{1}{4}$ in. x 1in. steel bar, is positioned slightly differently; however, the positioning/clamping of this plate is far from critical, as its purpose is simply to locate the swinging latch at the right

position along the main bearing bar. Having marked this pivot position, I clamped the clamping plate in position, and drilled both the clamping plate and the main bearing bar for the clamping screw hole using the appropriate tapping drill, then opened up the clamping plate hole and counter-bored it to clear the screw and its head (M4 cap head screw in this case). With the clamping plate in position, the pivot hole can be drilled across the width of the assembly.

The only deviation from the original design as far as the latch itself was concerned was that I chose to tap the thread M8 and used a wing nut that I had to hand, rather than machining up a special nut for the purpose. I found that, as I have a gearbox fitted to the lathe, I had to shorten the latch arm somewhat to make it fit properly, and also had to locate the latching post rather higher on the headstock casting than specified – around the centre of the raised “D” of “Myford”. In order to get a flat surface, I ground away the raised letter “D”, so I am now the owner of a “Myfor” lathe, see **Photo 3**.

Assembly and adjustment

The final assembly involves careful adjustment of the setscrew collar and the screw in the far end of the worm shaft to minimize any end-float in the shaft, while at the same time, not applying so much pre-load that the bearings no longer run smoothly. A trial run is advisable before applying a drop of your favourite thread locking compound and adjusting the screw to its final setting.

One of the Oldham hubs is slid into place on the end of the worm shaft, and one on to the motor shaft, before mounting the motor in position; it should be possible to insert the torque disc between the two hubs, and then slide the hubs back to engage with the disc, before tightening the clamping screws on the hubs. The hubs I used were of the split clamp variety; others are available that use a pair of set screws at 90 degrees to each other, but the split clamp hubs are easier to use and avoid marring the shafts and thereby generating disassembly problems.

The device is attached to the lathe in the same way as the original design – two conical pivots engage with the cross member attached to the end of the main bearing bar (see **Photo 4**), and the screws on the swinging latch are adjusted to minimize backlash between the worm and the bull wheel. I found that there was a minimal amount of backlash that simply could not be adjusted out – this I put down to the worm having been cut with a slightly too wide form tool, or possibly, it may be a reflection of wear in the bull wheel itself. It might have been useful to adjust the angle of the worm relative to the gear to remove this play altogether, but in practice, I doubt that this will be a big issue. If need be, a loop of cord round the chuck and a weight on the end will ensure that the backlash is always taken up in the same direction.

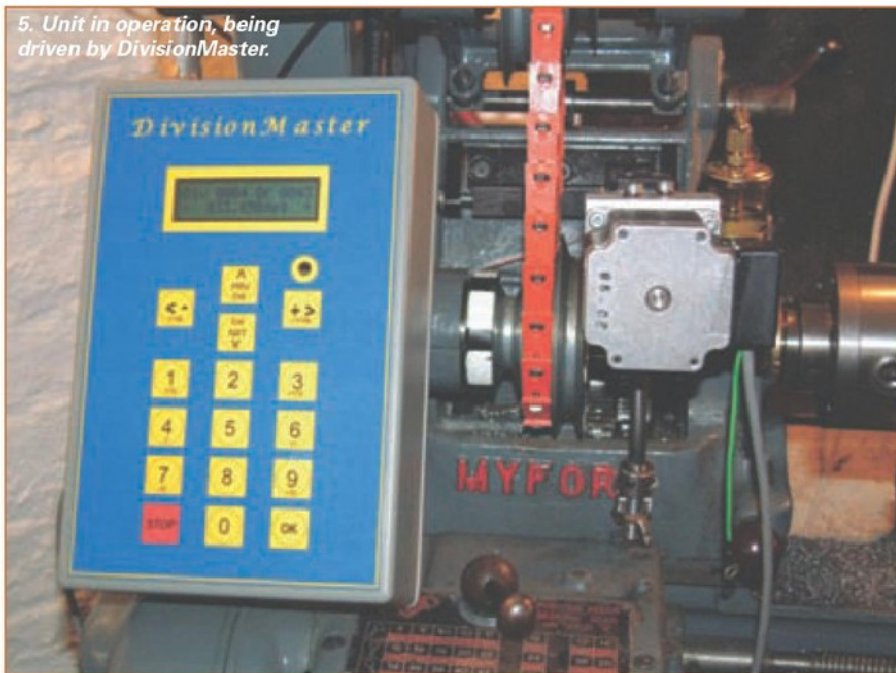
Final words

The final shot in **Photo 5** shows the motor connected to a DivisionMaster controller,

4. View from tailstock end shows attachment details and worm engagement.



5. Unit in operation, being driven by DivisionMaster.



set for 43 divisions, not the easiest division to set up on a conventional dividing head, let alone a dividing head that has a 65:1 worm drive! The ease of fitting/removing this dividing attachment, coupled with the convenience of being able to dial in appropriate angles or numbers of divisions on the DivisionMaster controller, make this approach to dividing operations in the lathe extremely convenient.

A 140 oz-in motor seems to give ample torque to drive this setup on my lathe; however, as the torque needed will depend on how “free” the headstock bearings are, it may be necessary to vary the motor torque accordingly. Needless to say, when the dividing attachment is fitted, the lathe drive belts should not be tensioned, otherwise the dividing attachment will be attempting to drive the lathe’s countershaft and spindle motor as well as the headstock spindle.



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3. **Hemingway Kits**, 126 Dunval Road, Bridgnorth, Shropshire, WV16 4LZ, UK. Tel: 01746 767739. Website: <http://www.hemingwaykits.com/index.html>
4. **Electromail/RS Components**. Tel: 01536 201201 Website: <http://rswwww.com/>

TAPER TURNING ATTACHMENT



1. View of TTA mounted on exhibition stand.

Malcolm Leafe describes his award winning device, designed for a Smart & Brown lathe

There did remain the, as yet, unconsidered trifle of detaching the cross-slide feed screw from its proper place to allow control of the slide to pass to the taper turning attachment (TTA). It did cross my mind also that, it would be neat if the device could be modified to fit non-S&B lathes like my treasured 5in. Drummond which, certainly does not have any of the S&B conveniences mentioned below.

Cursory inspection of commercial attachments, well, hurried passing glances really, showed some alarmingly sophisticated devices with very clever attachment methods which fell into the category of "Who'd have thought of doing that?" Some manufacturers' devices would have needed production facilities not available to me, some would have been difficult to apply to my lathe and some, on brief acquaintance were a bit baffling, the latter usually turned out to belong to the "Oh now I see!" classification.

A session of fiddling about armed with spanners, calipers and other sundry measuring devices showed that my decision to buy S&B had been wonderfully appropriate, as I had known all along, of course. Stretching along the back of the bed was a wide, flat, vertical ground surface with a central tee slot, how convenient for item (1) above. The handbook, when I later thought to consult it, confirmed the use of this surface. My attention was also drawn to the, previously unsuspected, quickly detachable (QD) nature of the cross-slide screw and the dual use of the QD nut, which, after removal from its prime duty of retaining

Taper turning devices seem come in many sizes and sorts, from unexpected looking devices on capstan lathes through to offset centres via swivelled top slides, not forgetting CNC devices whose use I fail to comprehend and the traditional use of the offset tailstock - with ball-ended centres of course! I had tried the usual methods on a centre lathe and, it belatedly struck me, taper turning devices obviously have their uses. Most of my work with tapers seemed to involve either, very short tapers, chamfers really I suppose, - cut with a straight edge tool set at the appropriate angle, sometimes accompanied by a deal of chatter, or fairly long and shallow-ish tapers. Taper turning attachments seemed to me to be the sine qua non for trouble free shallow taper turning, avoiding the expenditure of valuable swarf-making time on re-aligning the tailstock -yes, I know it is supposed to be a snip, but!

Naturally I did have a specific lathe in mind (an old 4 $\frac{1}{2}$ in. S&B Model A) but application to other lathes was considered as I also have a more ancient 5in. Drummond which is a very user-friendly machine.

Design

Design, in this amateur's vocabulary translates as, "Let's see what other people have done, make an informed choice and mix in my own ideas". Three major design features required the attention of the design team,

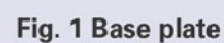
1. Attachment of any device to the lathe bed
2. Connection of the device to the cross slide, and
3. The guiding bits and the angular adjustment of said bits.



2. TTA set up on lathe.



3. TTA in use.

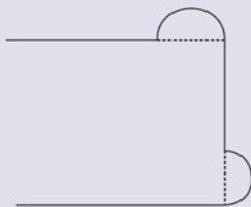


1 off each hand (Rh shown)



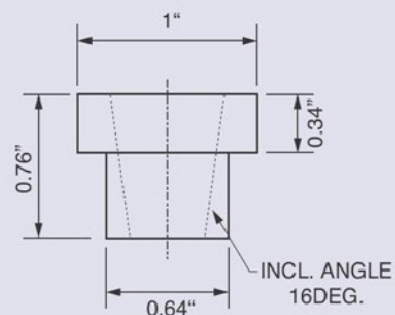
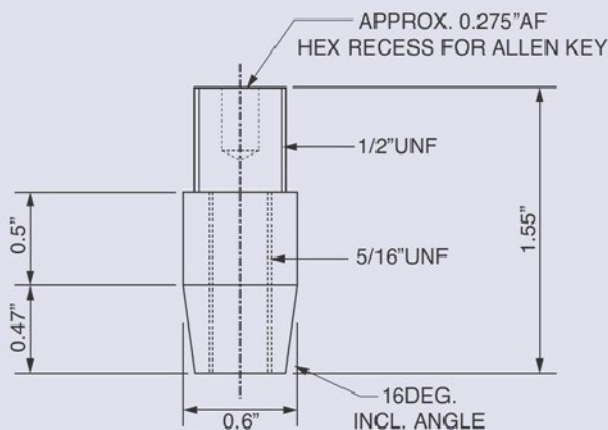
CORNER DETAIL

RECESSES FOR RAISING BLOCKS/CLAMPING SLOTS ETC.
TO ALLOW FOR A CLOSE FIT WITH SQUARE CORNERED
PARTS, SHAPE INTERNAL RECESS CORNERS AS
BELOW. ALLOW CUTTER TO TRAVEL A FULL RADIUS
BEYOND THE TARGET SIZE

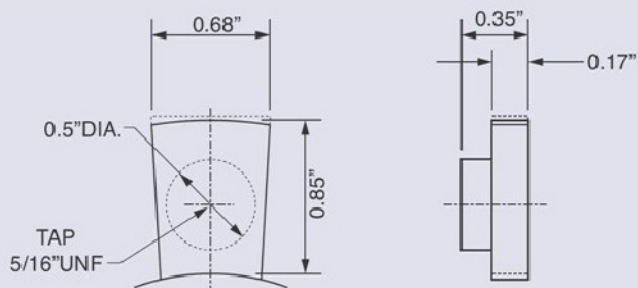


the cross slide feed screw, served to connect the (optional) TTA to the cross-slide. Two of the three items had already been carefully thought-out on my behalf – just as it should be. Taking into consideration my “knife and fork” construction methods it seemed likely that the “thing” could later be altered to fit other lathes. It seemed that only the mounting brackets and the cross slide attachment method would need to be altered. The physical size of the device could be easily changed to suit the subject lathe. **Photo 1** shows the completed device on a wooden stand showing the turner’s view; the side facing you in the photo is the side, which fastens to the back of the lathe bed. I have also included **photos 2 and 3**, which show the thing doing its intended duty.

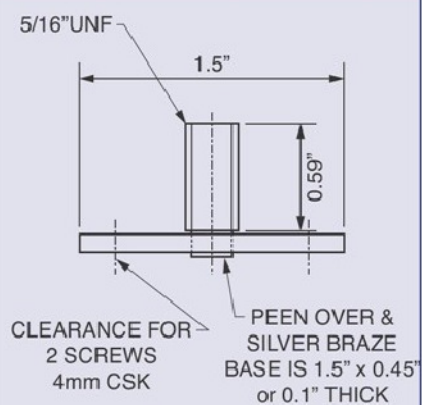
TTA ATTACHMENT QD NUT (S & B PART, RETAINS CROSS SLIDE SCREW) MAT'L: HARDENED STEEL



SLIDE CENTRE PIECE
ACCEPTS ATTACHMENT NUT



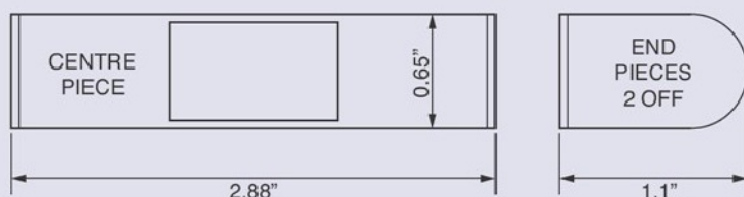
TEE NUTS FOR GUIDE BAR CLAMPING
MAT'L: MILD STEEL



SLIDE CENTRE PIECE STUD

Fig. 3 Detail items

ADJUSTMENT SCREW SHUTTER MAT'L: 0.15" SPRING STEEL



A 0.35" LIP IS TURNED UP AT EACH END
OF THE CENTRE PIECE & DOWN AT THE
INNER ENDS OF THE END PIECES

SLIDE IS CURVED UPWARDS ACROSS
ITS WIDTH TO ADD STIFFNESS

Construction

The drawings, which serve to illustrate the components, are dimensioned in imperial units with occasional glimpses of metric measurements, mainly where milling cutters and fasteners are concerned. My workshop is mostly imperial but I possess parallel sets of measuring tackle and I find no problems at all with the mix and match approach. After all, many metric materials are in sold in sizes, which are in effect translations of imperial units. Are suppliers trying to kid us that 6.35 mm is a metric size? Leaping aboard my hobby horse which was conveniently parked again the workshop door I would cite centilitres and centimetres which are in common use –neither of which is an SI unit. Is it really sensible to measure lengths using units of kilometres or millimetres? Not much choice there!

Base plate

The essentials were to make some sort of slide which would guide the lathe cross-slide which could be swivelled to different angles, thus I would need a plate on which to fasten the swivelling bits. The first component to be tackled was the base plate (Fig 1). The usual rummage through the materials stores (scrap pile) yielded a fair size length of "left-over" mild steel strip 4in x 1/2in section. 17in. was decided on as the exact length required –it was fortunate that the piece of plate was 17in. long. At that time I was able to borrow a surface grinder and the plate was thus surfaced. Incidentally the dimensions on the

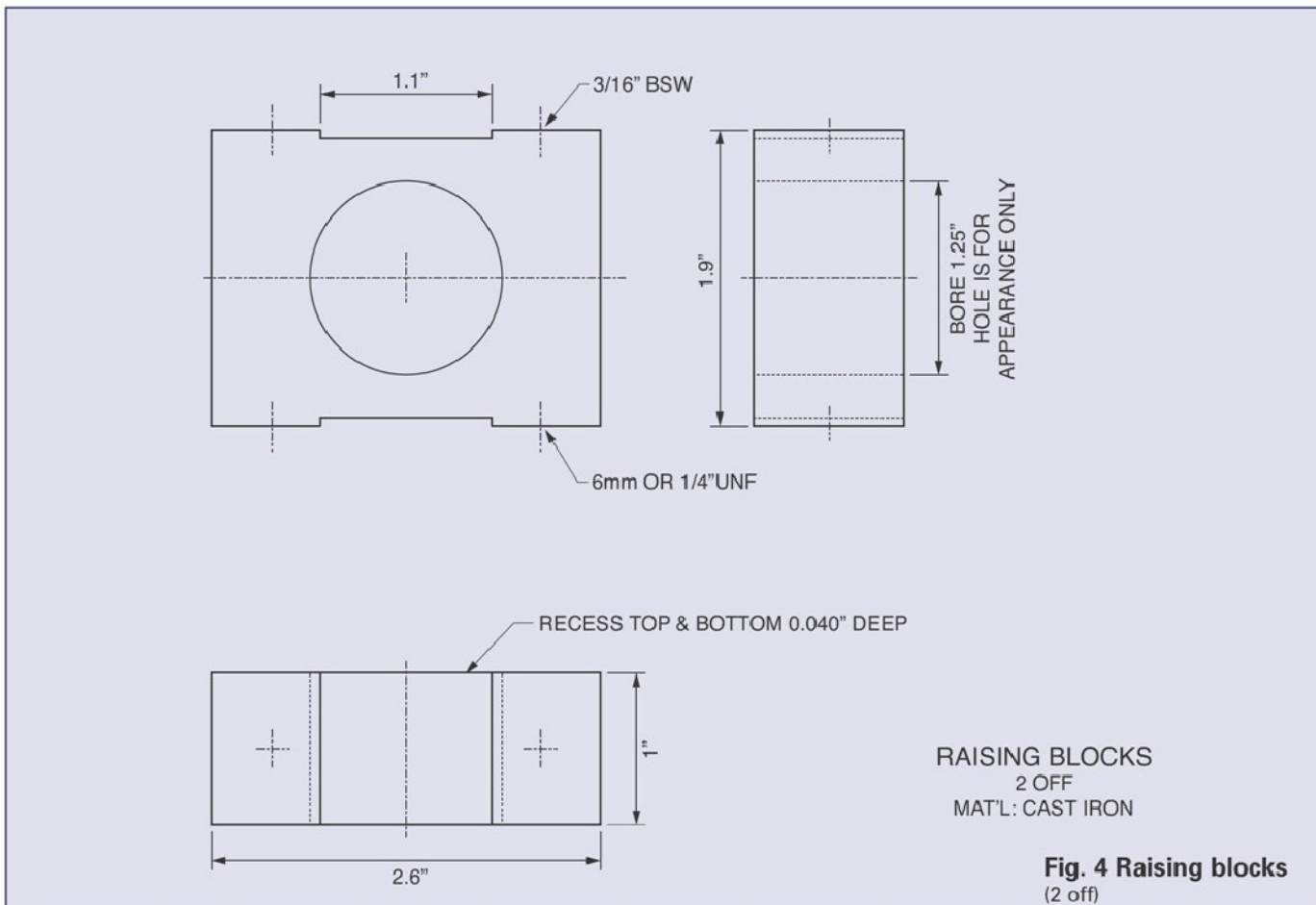


6. Attachment brackets – underneath view.

drawings reflect re-measuring my dismantled TTA for the purposes of doing the drawings and should be altered to fit your needs/ circumstances/ desires. The centre pivot hole was drilled and reamed –the component (a piece of plate with a hole in it) was then left and no other work was done on this until the mounting brackets had been made. Photos 4 and 5 show the base plate at a more advanced stage of construction together with the bracketry. There are a number of surplus holes in the base plate, where visible in the finished device they were welded up, others were left on the grounds that they didn't disturb my aesthetic sensibilities.

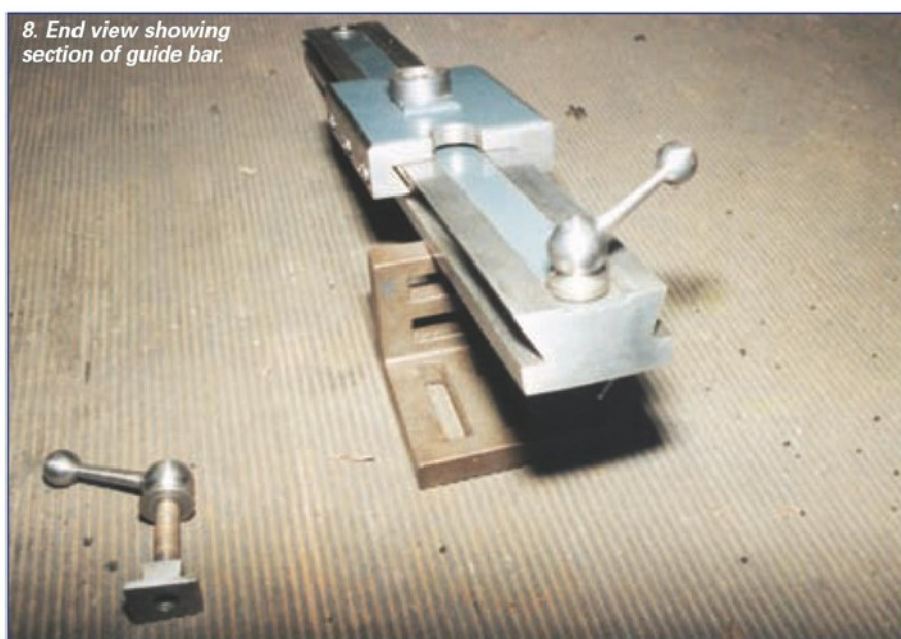
Attachment to the lathe bed

The deft use of blocks of wood, paint cans etc allowed me to balance the embryo base plate in the back of the chip tray (a lot of space available here as this was a Harrison chip tray adapted from a larger lathe) to size-up the situation. After recovery from back injury due to bending over the lathe whilst holding heavy chunks of metal at arms length I generated a few scribbled sketches of brackets for fixing the device to the lathe. The brackets are shown in Fig. 2. They can be seen in Photo 6 with one bracket attached to the base plate and one just idling around. A long





7. Assembly of support brackets and raising blocks.



8. End view showing section of guide bar.

piece of structural steel angle was used for the two handed brackets, the handing is for appearance; they can be plain straight brackets. As you will know structural angle is not of constant thickness through the section and so, after removing two 3in. wide sections with a saw, strips across their inside faces were machined flat on a small shaper to give a datum for mounting on the miller. The brackets at 5½in. x 4in. x 3in. are awkward to hold and I think (it was a few years ago) that I bolted them to a box angle plate which was in-turn bolted to the mill. They are faced all over the bolting surfaces and the tenon recesses were milled to match the width of the tee slot on the back of the lathe. The photographs show that my brackets have two tenon recesses as I had planned to use with a profile turning conversion, which has yet to come to pass. The position of the tenon slots should be identical on the two brackets in relation to the top face. The 40 thou rectangular recesses on the top face also need to be identically positioned as they are used to locate the base plate. These recesses need to have square corners, which is difficult, and so I cleaned out the corners by running the cutter exactly one radius beyond the target size—a sketch in Fig. 3 shows what I mean.

As I did not use castings or welding, the brackets/supports for the base plate are made in two pieces. The 40 thou deep recesses in the bracket tops accommodate the raising blocks, which are shown in Fig. 4. Simple blocks but they need to be square and a matched pair. Shallow reliefs are machined between the bolting faces and the centre hole is simply for appearance (I don't think that reducing the weight really matters in this case). I had some convenient cast iron stock, but MS etc is obviously OK. When complete, check their location and fit into the bracket recesses and drill/tap the fixing holes. I used 6mm x 25 mm button head Allen screws.

To complete this group knock out the location tenons to be a nice fit in the rear bed tee slot and make the tee nuts likewise. Match drill the parts—mine use ¼in. UNF bolts and each one also has two ¼in. dia. spring dowels (Roll pins).

The brackets/raising blocks can now be attached to the lathe rear face—probably after clearing the bed tee slot free from the debris of ages, unless you keep your lathe immaculate...I had perforce to resort to scraper, old hacksaw blade, brush etc. The assembly of the brackets and raising pieces is shown in Photo 7.

A magnetic base and a d.t.i. can be slapped on the back of the cross slide (a lovely flat area, I bet that all sorts of things

could be fastened there) and the brackets can be "clocked". The tops of the raising blocks ought to be level in the horizontal plane otherwise any tapers which you turn will be subject to the sort of errors caused by not having a tool at centre height when using an offset tailstock or top slide swivel set-up. Any such diametral errors will be small but there is another consideration in that misalignment may introduce complications with binding of the dovetails when traversing the TTA. The fore and aft location (i.e. lateral distance from the lathe bed) is preferably identical for the two brackets but it is not of too much concern but, it may lead to some fitting work and awkwardness when fitting the base plate to the raising blocks.

Other makes of lathe

At this point in the metal mangling, if your lathe is not of the S&B variety it is worth squeezing in between the machine and the wall—if your is located as mine is then the accent is very much on squeeze—armed with a mirror, paper/pencil and rule to visualise the necessary fittings. If you are loath to drill holes in the lathe bed then do as some manufacturers do and clamp the TTA to the bedways. Perhaps brackets like mine but reversed so that they stick up and not down plus a couple on neat clamps to fit the bedways?—t'would not be difficult.

Once more to the base plate

The lengthwise distance between the raising blocks/brackets is to choice but it will be best if you avoid the areas of the base plate which will be occupied by the clamping slots and the adjustment screw. The two recesses shown in Fig. 1 need to be machined in square-cornered fashion and exactly in line to just fit the tops of the raising blocks—this locates the base plate without using dowels. Note that the closed side of the recesses face towards the lathe bed. Suitable holes are match drilled for fixing screws—mine are ⅝ BSW Allen screws (if you've got 'em, use 'em), they need to be countersunk into the upper surface of the base plate. Alternatively, the plate could be clamped to the raising blocks and, after careful checking, the two may be doweled and screwed together thus avoiding a milling operation.

The complete assembly of brackets/raising blocks and base plate should clamp neatly to the reverse face of the bed without any "pulling down" when the bolts are tightened. Should you be as lucky as I was, you will be able to slacken the Tee nut bolts and slide the TTA to reposition it along the back of the lathe—but it is a bit of a stretch. If you undo the Tee nut clamp bolts too far then you will also discover that (a) the TTA is heavy, mine weighs in at 28 lbs and, that (b) you are holding it at nearly arms length.

Guide bar

If you like milling, it must be your birthday. The guide bar (i.e. mine) is made from a length of 2in. x 1in. mild steel bar, 16in. or so will do. I suggest that you

roughly mark out the clamping and adjustment slots on the base plate with a felt tip pen and then arrive at the length for your application. Plonk the embryo guide bar on top of the baseplate in position at the back of the lathe and scrutinise thoroughly then decide how long it is to be. Bright mild steel was my "choice" – the piece of bar was a gift is my excuse. However, its use did require a tad of extra work but as a bonus it provided some amusement to fellow ME's. I suggest that a modicum of stress relieving or whatever is desirable to reduce the "tad" of extra work and the amusement factor. Black bar may be better all round, or cast iron.

My favourite technique of procrastination was called upon in making this component. The dovetails were machined on the miller with the bar fastened to the table using two clamps on the longitudinal centre line, the clamps were shifted and the upper face relief was completed. After turning it over, the bottom face was cleaned up and the centre $\frac{1}{2}$ in. hole for the pivot drilled and reamed. I then used up a lot of procrastination – and left it for 5 years whilst I built a steam engine. The stress relief period of 5 years was judged to be a nicety, the shape was such that Robin Hood could have fitted a bowstring, nocked his favourite arrow and terrorised Nottingham with it. The result was unexpected, especially as the machining was almost symmetrically disposed about the bar. A "tad" of extra work was called for.

However, after re-machining the bottom, top, relief, sides and the dovetails all was nearly well, it only took a further week of evenings with scraper, oil stone, surface plate and straightedge to finish it – but the guide bar did look good! Procrastination does pay. A similar period was spent removing "hi-spot blue" from my person, it gets everywhere. It ill behoves me to assign base motives to the giver of the gift of 2in. x 1in. bar – but my tale of woe did cause some amusement – everything has its purpose. The guide bar is shown in **Photos 8 and 9**.

An alternative guide bar

Before starting "design" I had pondered on the need for the guide bar to be of dovetail section. Dovetails provide lateral guidance, and vertical control and permit a measure of adjustment for sloppiness (whether due to wear or whatever) when provided with gibs or, as on some boring heads, they are split and provided with clamp screws. A taper turning attachment needs lateral guidance; that is the whole point of its existence, but vertical control? If using a dovetail, then, when the TTA is assembled on the lathe, the cross slide/lathe bed had better be parallel with the slide and guide bar of the TTA or there may well be a certain degree of binding due to unintentional vertical displacement of one relative to the other. So, why not use a rectangular guide bar? A plain piece of $\frac{1}{2}$ in. x 1in. MS bar would serve. Make the slide as before but forget the dovetails and mill it out with a plain cutter, fit a gib piece and retaining strips rather as, I believe Myford use on their lathes. This will save a lot of bother and you could



9. Underneath view of guide bar.

perhaps use the piece of bar "as received" – this really is a time saver. But, no apologies, I like dovetails and there may be some reason for their use, which I have overlooked and there are a lot of them about, dovetails that is.

Yet again – the base plate

At this stage we have the base plate with just a centre hole and the raising block mounting points and the guide bar with dovetails and a centre hole. The next stage requires a miller with a bigish rotary table or perhaps a device such as is used to mill the slots in valve gear links in conjunction with a vertical slide. The base plate is removed from its mounts, located on a 2in. high $\frac{1}{2}$ in. dia. stub centre arbor in the rotary table and clamped securely along its edges leaving the centre free. The guide bar is then plonked on top, also on the stub centre arbor to locate it, centred neatly along the base plate and clamped down. The job will be on the miller for some time.

The first job is to drill one of the $\frac{1}{2}$ in. clamping holes in the end of the guide bar and to continue it through the base plate; a jack may be useful if there is a lot of overhang. A quill feed will save winding the table up and down and is more sensitive. Pop a centre drill in whatever chuck you use and follow it up with a full-size drill – do not bother reaming, they are only clamp holes. I have a few $\frac{1}{2}$ in. and $\frac{3}{8}$ in. dia. stubs screwed 20 t.p.i. to fit a Clarkson chuck which are bored to take centre drills and stub drills retained with a grub screw, very useful for this sort of job. After drilling through, unlock the rotary table clamp, disengage the worm, turn the table through 180degrees and drill again. Remove the guide bar from the rotary table, do not move the miller table and leave the base plate clamped down. Swap the drill for an end mill and mill the arcuate slots through both ends of the base plate, using the $\frac{1}{2}$ in. hole through the base plate as the entry point for the cutter. Thus the guide bar clamp holes and the clamp slots at both ends are all in alignment without any fiddling with measurements.

If the base plate has been clamped to the rotary table upside down i.e. with the

face which will be the underside of the finished job upwards, then the next step is to machine the tee nut recesses around each arcuate clamping slot. I used a $\frac{3}{8}$ in. cutter for this, as it permitted less material removal when overrunning the intended size to give square ends to the recesses – this allows the tee nuts to move right up to the ends of the curved slots. The recesses were cut 0.160in. deep and 0.870in. total width. If you don't mind the Tee nuts protruding below the base plate then, this can be neglected, just make the usual style of tee nuts.

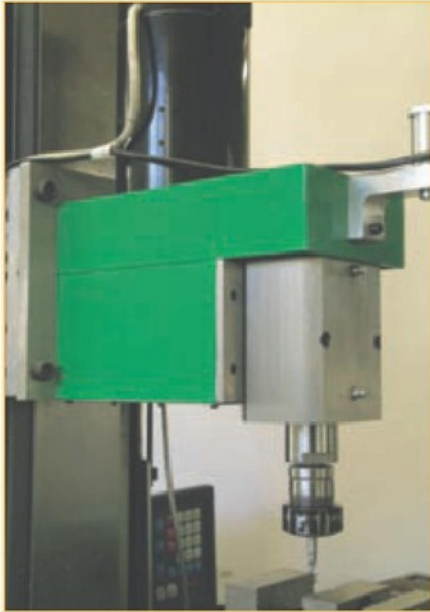
The base plate was then removed and replaced by the guide bar using the same set up. The miller head was tilted to 30degrees from the vertical, the miller table was run away from the cutter and, without changing the cutter, the decorative sloping ends of the guide bar were machined, they form a neat surface for the fiducial mark which is to be engraved or scratched thereupon. Again the guide bar and base plate were swapped (location is automatic using the centre plug) with the guide bar aligned with the centre of the base plate (base plate correct way up) and clamped in position. The purely decorative ends of the base plate were then machined using the same angled cutter set up as used for the ends of the guide bar, again, a jack may be useful if there is much overhang.

Graduating the base plate

The assembly of guide/ base was then clocked parallel to the miller table and adjusted so that the centre of the rotary table aligned with the machine spindle. The milling machine head was restored to the vertical and the spindle brake applied via a luggage elastic/ bungee rubber between it and a convenient tool rack on the wall. The milling cutter was replaced with a short $\frac{3}{8}$ in. dia. HSS tool (broken end mill) ground like a parting tool and both ends of the base plate were graduated at 1degree intervals. The cut is put on by raising the miller table, cutting towards the centre of the base plate. Division was, of course plain sailing using the rotary table. The graduations may, of course be omitted as it is traditional to set the device with a clock gauge and a sample taper.



A PLAIN SPINDLE HEAD FOR THE X3



1. New head and motor fitted to X3

In a previous article I described fitting an HTD belt drive to the head of the X3 mill. The reason for doing this was to reduce the amount of vibration of the tool and to consequently improve the surface finish of the clock parts profile with CNC. The HTD belt did improve the finish I obtained, never the less I decided to see if I could improve the finish even more by replacing the head and the spline drive spindle. (Mills with a quill feed have a sliding spline arrangement, which in order to slide freely, must have slight backlash, which in turn can cause vibration.) I decided to make a head with a plain ball race spindle driven with an HTD belt by a variable speed DC motor. For ease of construction the spindle would be bolted on to the front of the head. To ensure the spindle was set precisely vertical the front and back surfaces of the head were carefully machined parallel and the body of the spindle set between two clocked guide rails. **Photo 1** shows the finished and fitted head and spindle. The two ground guide rails can be seen on either side of the spindle body. After some further thought, I realised that this spindle design and construction of the head offered some distinct advantages. The oil nipples in the body of the spindle allow the ball races, in which the spindle runs, to be regularly lubricated. Regular lubrication of the spindles of most mill drills is difficult and in some cases impossible. A further advantage of the design is that it allows other devices such as a high speed spindle, to be easily attached to the head. The downside is of course, that the versatility of a manual quill feed is no longer available, but as my work is so

Dick Stephen continues his quest for perfection

predominantly CNC, this is of no consequence. When I do require manual Z axis control, the electronic handwheel device described in an earlier article makes it easy and convenient.

I also decided to replace the motor and speed controller that came with the mill. The DC motor supplied runs perfectly well but does get quite warm if it is run at full speed for any length of time. Most of the heat arises as the result of eddy current losses generated within the motor. I replaced the DC motor with a ½ hp DC motor made by Bodine Electric in the USA and the speed controller with one made by KB Electronics also in the USA. The speed controller uses, what is referred to by KB, as "Whisper Technology". This involves driving the DC motor with 15 KHz square waves. The effect of doing this is to reduce eddy current losses to almost nothing as well as suppressing arcing at the brushes. The Bodine motor has no fan cooling and with the motor fully exposed (see **Photo 1**) it barely gets warm even after several hours running at full speed and more importantly is almost silent and totally vibration free.

Readers may at this stage be wondering if the expense in terms of materials and time to replace the head, is really worth it. The same thoughts went through my mind as I set about doing it. All I can say now is that for the kind of work I undertake, I am very glad I did. The finish I get with CNC is immaculate provided I set the job up correctly and use a really sharp cutter.

Making the head

The dimensions of the replacement head are shown in **Fig 1**. I had my head made as an iron casting, essentially a rectangular box, open on the underside. The main reason for using cast iron (and the same philosophy applies if you fabricate the head out of mild steel plate), was to make the head reasonably heavy. The weight of the head does affect the quality of the finish you will achieve with CNC since the sheer inertia of the head has the effect of damping any residual vibration that is generated during cutting.

Having the head cast

If you intend to have the head cast you will have to make a pattern of the head first out of wood. In order for the pattern to be easily removed from the green sand used to make the mould, the pattern must have adequate draw. A 1.5 degree taper on the sides of the pattern should be sufficient. The internal corners of the four sides of

the pattern need to be filleted, again to allow the pattern to be easily removed from the sand mould. Make the external dimensions of the pattern at least 3mm greater than the dimensions of the head to allow for enough material to machine out any irregularities in the casting. It is important that the finished front and back faces of the head are absolutely parallel and flat. The top face of the casting needs to be flat and square to the front and back. I was very lucky to have access to a large mill and a surface grinder and a good friend who did a superb job finishing the head for me. The dimensions of the back plate that attaches the head to the vertical column are shown in **Fig 2**. The back plate is made out of 15 mm bright mild steel plate. Details for fitting the plate will be given later. This plate will have to be machined front and back, again to ensure that these faces are precisely parallel. If you can have them ground, all the better.

Fabricating the head out of mild steel plate

If you don't have access to a large mill and a good friend then I suggest that you fabricate the head out of 15 mm thick bright mild steel plate. The fabricated head is built up from four additional plates (two sides 190 x 85mm, top 190 x 130mm, and front 100 x 85mm), which attach to each other and the backplate in a similar manner as the casting to backplate. Make sure that the supplier of the pieces of plate is prepared to cut the five pieces close to size for you. The plate as supplied will not be flat enough or the edges precisely square to ensure that the sections will assemble squarely. You will have to mill both the front and back of each section flat and all four edges of each plate square.

The head can now be assembled. Begin by drilling all the holes for the countersunk M4 Allen screws and the holes for the 3mm dowel pins indicated in **Fig 3** in the two side sections and the top section. Begin by joining one side section to the front. Clamp the two sections together and check that the front and the side are at exactly 90 degrees to each other. Using the two previously drilled dowel holes as a guide drill the holes in the edge of the front plate for the two dowels. Fit the two dowels into the side of the front plate using Loctite 326 adhesive. Clean off any excess Loctite. Fit the side plate in position and check that the two plates are still correctly positioned. Following the same procedure fit the second side plate and the top again only using dowels. Assemble all

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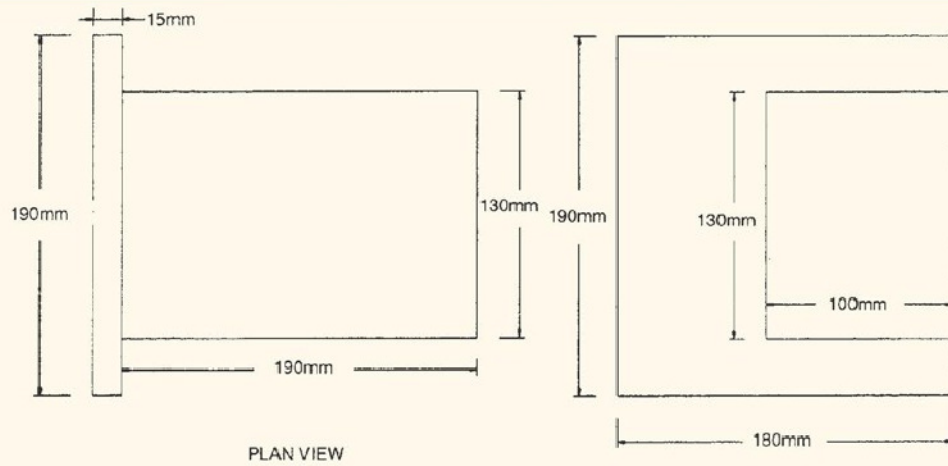


Fig. 1 Cast head and back plate

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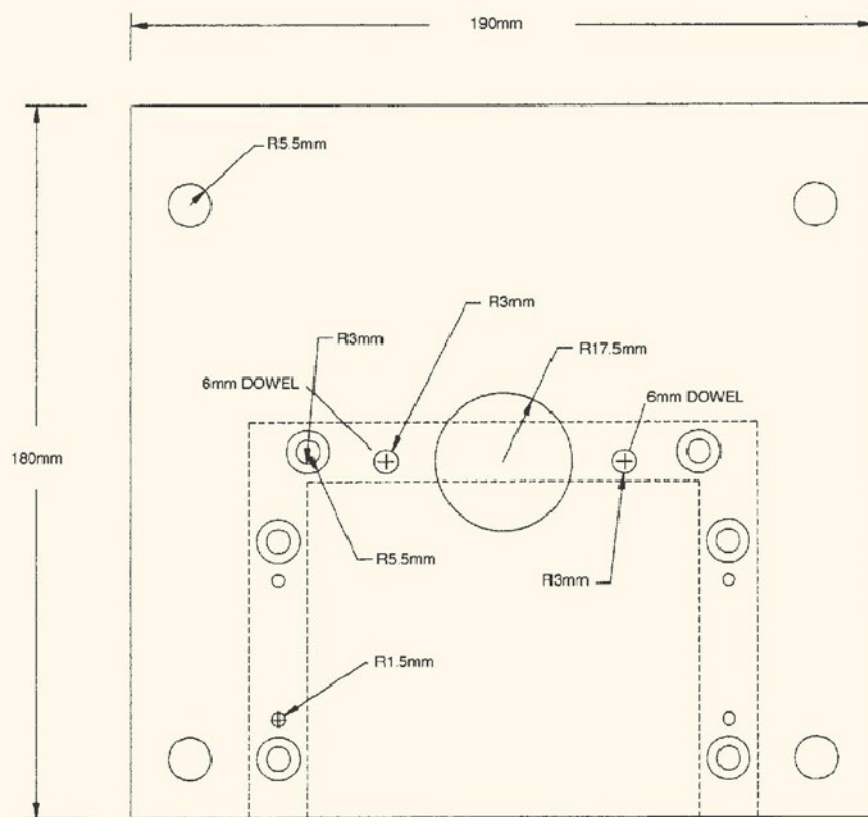
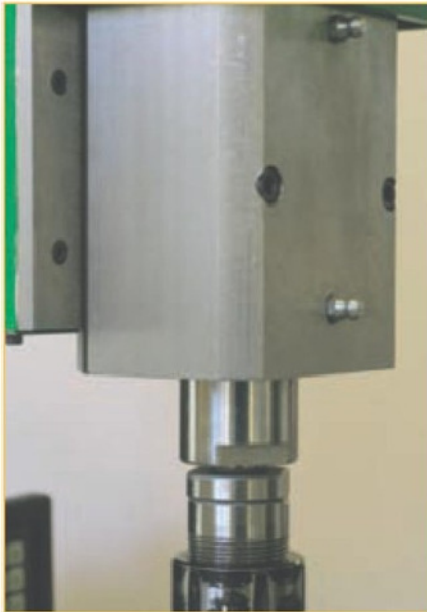
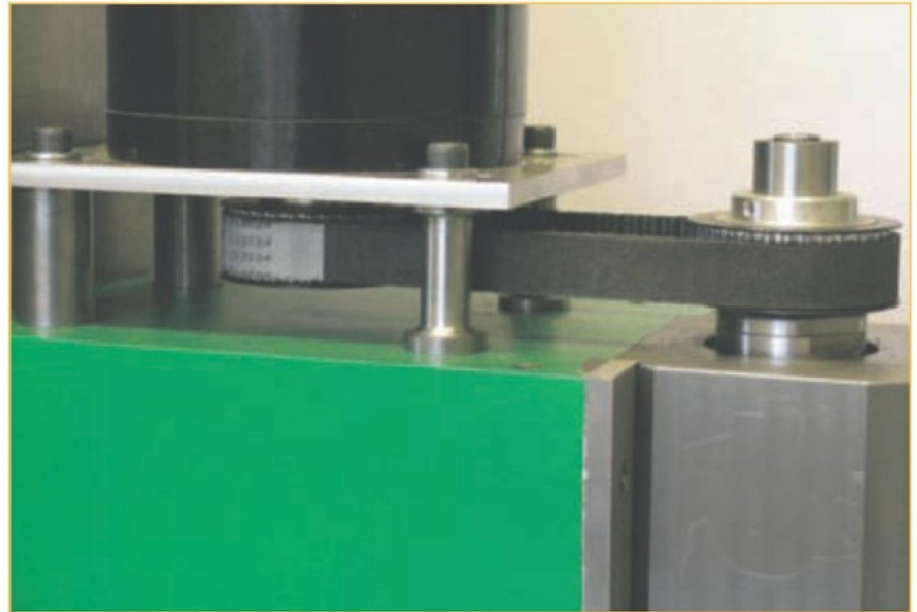


Fig. 2 Backplate

MAT'L: 15mm STEEL PLATE



2. Spindle housing fitted to head.



3. Detail view of motor mounting.

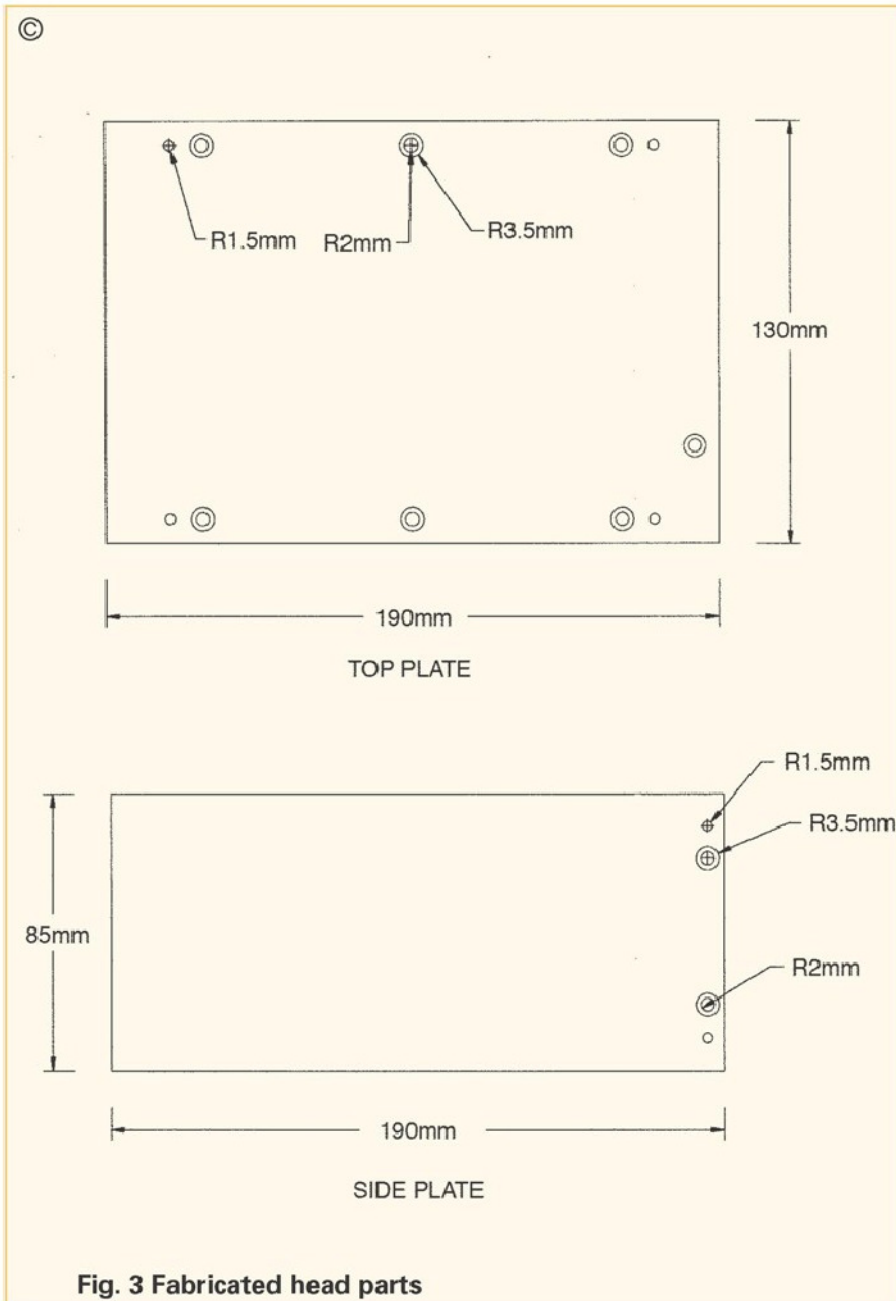


Fig. 3 Fabricated head parts

four plates checking that that all four are correctly positioned at 90 degrees to each other. Now drill and tap all the holes for the 4 mm hex head screws. Reassemble the four plates and secure with the 4 mm hex heads. Disassemble and then reassemble applying Loctite 326 at each joint. Do not apply the Loctite directly from the bottle to the steel surfaces. Squeeze the amount of Loctite you intend to use onto a piece of glass or Perspex and then transfer the adhesive to the work using a toothpick. Loctite 326 is so reactive that if you apply the adhesive directly from the bottle to the work there is a good chance that contact with the steel will cause the contents of the bottle to set. I have had this problem with Loctite 603 and given the expense of 326 I now take no chances.

Drill all the holes in the back plate shown in Fig 2. Before drilling the holes for the 10 mm hex head bolts that attach the head to the column check that the position of the holes given in Fig 2 match those on your machine. Fit the back plate to the column securing it with a couple of parallel clamps. The sides of the plate need to be positioned at precisely 90 degrees to the table of the mill. This is easiest done by lowering the plate using the Z-axis and clocking one side of the plate. When the plate is correctly positioned drill and ream the two 6 mm dowel holes. These holes are initially drilled 5.8mm in the plate and then used as guide holes to drill into the column. The holes are then drilled to 5.9mm and finally reamed 6mm in situ. 6 mm hardened steel parallel dowels will later be set in the back plate with Loctite 326. The back plate can now be attached to the rest of the head. Make sure that the sides of the head are precisely parallel to the sides of the back plate before you drill the holes for the dowels. Re-assemble and check the alignment before drilling and tapping the holes for the hex head screws. Finally re-assemble applying Loctite 326 to all the joints.

With the head fully assembled you need to check that the front and back of the head are parallel. Clamp the head onto the mill table and with a dial gauge in the spindle check the front of the head. If it is not exactly parallel with the back you will need to skim the front until it is.

If you have used a cast head follow the procedure outlined above to fit the back plate to the casting. The positions of the two 6 mm dowels and the 4 bolts to attach the plate to the casting are shown in **Fig 2**. When you have drilled the two 5.8mm holes for the dowels in the column remove the plate and fit it in position on the casting. Now drill two 5.8mm holes in the casting for the dowels to position the plate on the casting. Replace the plate on the column using two lengths of 5.8mm mild steel to accurately re-position the plate. Clamp and drill and ream the dowel holes. Remove the plate and reposition the plate on the casting and ream the holes in the casting to 6mm. Fit the two 6mm dowels in the plate. The dowels in this case should extend on BOTH sides of the plate. Bolt the plate securely to the casting.

Belt and head cover

The cover that protects the belt and the top of the head can be made next. Again this can be made as a casting in aluminium or it can be fabricated out of 6mm aluminium plate. I had mine cast; however in retrospect it would have been a lot easier to have fabricated it. The problem I had was holding the casting to clean it up and then mill out the hole for the motor and access to the top of the spindle. The dimensions of the cover are given in **Fig 4**. The way I would fabricate it would be first to mill the two side panels and the front panel to size. At the same time I would make a plywood back the same size as the front panel. I would then glue the front panel to the two sides using Loctite 326 using the ply panel to keep the sides square with the front. To reinforce the glue joint, drill and peg the joint, setting the pegs in place again with Loctite 326. Using the front and sides as a pattern mark out the top and then, mill it to size. The cover can now be put to one side until the spindle is made and the motor you intend to use has been fitted to the head.

Making the spindle housing

For this you will need a piece of mild steel bar 110mm diameter and 110mm finished length. If you can get EN1A mild get it. I used round stock, as I could not get a piece of rectangular stock of the appropriate dimensions. In some ways round stock is easier to work. My lathe was just not large enough to hold and turn pieces of steel of this dimension safely. A Myford ML7 certainly would not be adequate for this job but I was fortunate to have access to a lathe with an accurate 10inch 3-jaw chuck.

The finished dimensions of the housing are shown in **Fig 5**. If you are in any doubt about the accuracy of your 3-jaw chuck I advise using a 4-jaw. Begin by facing off one end of the bar and turning the outside true. Reverse the bar and using a dial gauge, check that it is running true. Face the end and turn the remainder of the outside true. Now drill and bore a hole right through the length to exactly 42mm for the 25mm i.d. ball races. The finished size of the hole should allow the ball race to just slide in without applying any force. The sides of the housing should now be

milled to the dimensions given. Take care to ensure that the bore of the housing and the back surface that bolts against the front of the head are exactly parallel. Finally drill and countersink the two holes for the 6mm hex head bolts that attach the spindle housing to the head.

The ball races (Ref. No.6905ZZ) are separated by an 82mm length of steel tube glued in the 42mm hole bored in the spindle housing with Loctite. The separator is best made from a length of 3mm wall steel tubing 44.4mm diameter (1.75 inch). I found a piece at my local farm machine repair shop. If you cannot find a suitable piece one other option is to turn a piece out of solid bar. The tube should be an easy sliding fit. The tube is glued in to the tube 9mm from the bottom of the housing and 19mm from the top.

I chose to fit a separate spacer tube. It would of course be equally valid to machine individual locations for each bearing, leaving the spacer material integral with the housing. It was felt that for me, the given arrangement was more convenient, as the bore could be taken straight through at one setting, rather than re-chuck and re-centre for the second location, with a potential for loss of accuracy.

The two oil nipples are fitted into the housing next. The nipples I used were threaded 6mm. Drill 2mm holes through the housing in the centre of the housing 6mm from the top and 12 mm from the bottom. Drill and tap each hole 6mm for a depth of 5mm for the oil nipples.

Making the spindle

The success of the entire project depends on the accuracy of the spindle, so although no tolerances are quoted, you need to aim for the best you can achieve. My spindle is fitted with a No.2 Morse taper, because the ER 20 collet holder I use for milling cutters has a No.2 Morse taper, as do all my other items of tooling. All the Morse tapers are threaded for a $\frac{1}{8}$ in. Whitworth draw bar.

I made my spindle out of a 200 mm length of 40 mm diameter EN1A mild steel bar. Again I chose EN1A because it machines so well and gives an excellent finish. There is no need for the spindle to



4. High speed milling attachment.

be hardened as it is running in ball races. You do however need to be careful to keep the Morse taper clean and free of swarf so as not to damage it.

The dimensions of the spindle are shown in **Fig 6**. Before starting to turn the spindle you will need to have a 100 mm length of silver steel bar. If the draw bar you intend to use has a $\frac{3}{8}$ Whitworth thread the silver steel bar needs to be 10.5mm. If the draw bar has a 10mm Metric thread, the bar might be increased to 11mm in diameter. Face off both ends of the bar and drill centre hole in one end. The length of bar for the spindle is too long to be safely turned without using a fixed steady. Grip one end in a 3-jaw chuck and support the free end in the steady. Using a clock adjust the steady until the bar is runs true. Face off the end of the bar. Now drill and ream a hole 110mm deep in the end of the bar, to suit your chosen draw bar. Remove the fixed steady and carefully clean all swarf from the hole. Insert the length of silver steel bar to a depth of about 75mm applying a small amount of Loctite 603 to about the last 20 mm of the rod as you insert it. Allow the Loctite to cure for a few minutes. With the spindle blank supported now by a live



5. Arrangement for cutting an internal gear.

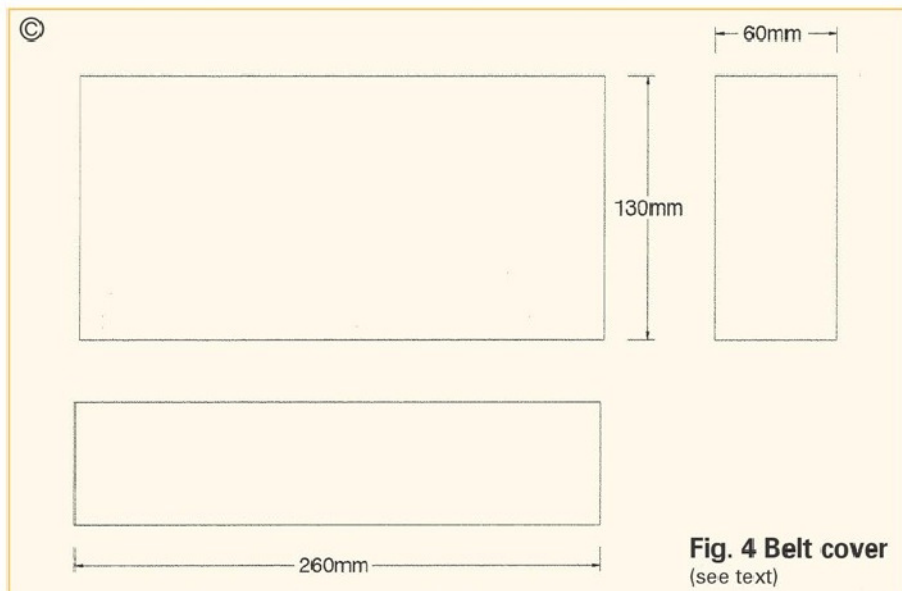


Fig. 4 Belt cover
(see text)

centre turn the shaft of the spindle to size. The ball races should be a sliding (not loose) fit on the spindle shaft. Finish the shaft with wet and dry paper ending with 1200 grade.

The No.2 Morse taper is turned next. For this you will need a No.2 Morse taper reamer to finish the taper. If you haven't

got a reamer it is worth getting one if you have Morse tapers on other machines in your workshop. The reamer is only suitable for the very final finishing of the taper so you will have to turn the taper initially with a boring bar. Before starting, the top slide should be set at the angle of the taper. The easiest way to do this is to use an existing

Morse taper as a guide. Support a Morse taper centre between centres and adjust the angle of the top slide until it moves parallel to the surface of the taper.

Grip the spindle by the 20mm diameter section in a 3-jaw chuck. You may wish to use a strip of aluminium to avoid marking the work. Support the end of the spindle with the fixed steady applied to the shaft in the 24mm recess. Drill and bore a hole 90mm deep 13.5mm in diameter. This is just a shade under the diameter of the end of a '2 Morse taper. Don't worry if the hole is very slightly out of true. This hole should break through into the hole drilled from the other end. Remove the spindle from the 3-jaw chuck. Grip the 10.5mm bar in a collet if you have one or else hold it in a 4-jaw chuck. Support the other end with the fixed steady. Clock both ends of the spindle shaft to ensure it is running perfectly true. The Loctite holding the 10.5mm bar in the spindle is strong enough to allow light cuts. Using a suitable boring bar turn the taper in the end of the spindle. Periodically check the depth a Morse taper will insert. Stop when the Morse taper inserts about 10mm short of the required depth. The taper can now be finished with the reamer. Support the reamer with a tailstock centre to ensure that the taper remains true. Use plenty of cutting fluid and clean the swarf off the reamer frequently. Continue checking the depth to which a Morse taper will insert.

Remove the spindle from the 4 jaw chuck. Heat the end of the 10.5mm bar sufficiently to break the Loctite joint and remove the bar. Reverse the spindle and hold the taper end in the 3-jaw chuck. Support the other end with the fixed steady. Clock the end of the spindle shaft to ensure it is running perfectly true. The end of the spindle is now threaded with a 1mm pitch for the two spindle locking rings. The 10.5mm bore can then be tapped with a 12mm x 1mm metric thread for a depth of 25mm. This thread will accommodate the upper end of the draw bar shown in Fig 7.

The above is the way I made my spindle. The spindle is accurate to a bit better than 0.01mm, certainly precise enough for all CNC applications. It would probably be quite feasible to adopt an entirely different order of operations, and perhaps complete the internal features first, and follow by using a Morse taper insert steadied by a female centre in the tailstock.

The dimensions of the two spindle locking rings are illustrated in Fig 8. These are made from a length of 30mm diameter mild steel bar threaded with a 1mm pitch. Mill a flat on either side, as illustrated, for a spanner to tighten up the rings.

Insert the bearings into the housing and fit the spindle in position. Retain the spindle with the two locking rings. These need to be tightened up just enough to take up any end float in the bearings. The bearings can be left loose or held in place with a couple of dabs of Loctite bearing fit. Fit the bottom bearing first and use the spindle to line up the upper one until the Loctite cures.

Making the draw bar

The draw bar I made for the spindle was a differential thread one. The details are

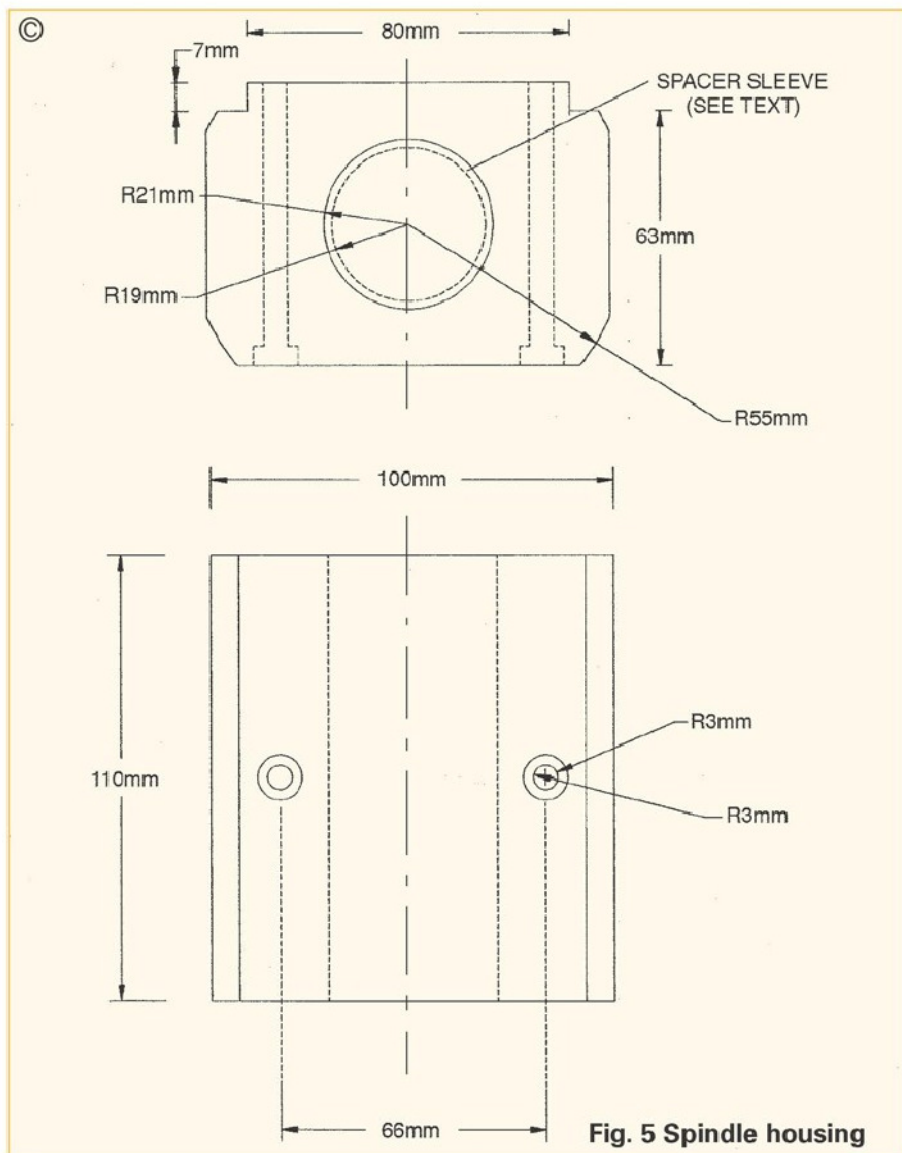


Fig. 5 Spindle housing

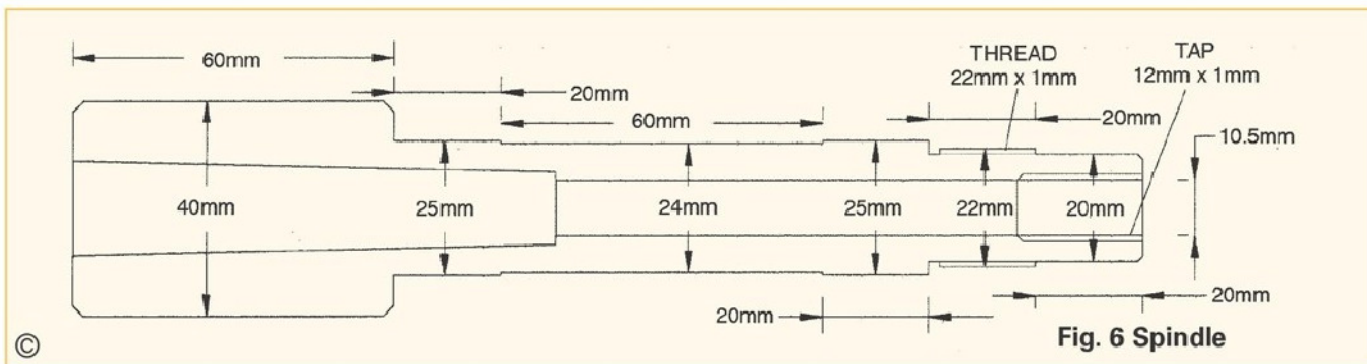


Fig. 6 Spindle

illustrated in Fig 7. The end that screws into the tool holder is threaded with a relatively coarse thread ($\frac{1}{8}$ in. Whitworth in my case), the other end that screws into the spindle has a finer thread, 1mm pitch. When the draw bar is tightened up one turn of the fine thread draws the tool into the spindle by the difference in the two pitches. Unscrewing the draw bar causes the reverse to happen which ejects the tool out of the taper.

The draw bar is made in three parts. For the $\frac{1}{8}$ in. Whitworth thread I used a 50mm length of studding with one end turned down to 6mm. For the threaded top end I used a 10mm hex head bolt 40mm long. I turned down the threaded portion to 6mm and the head to 12mm and cut a 1mm pitch thread in the head of the bolt. The two were then glued with Loctite 326 into a 100 length of 10mm bar drilled 6mm at both ends. A 10mm Allen key is used to tighten up the draw bar.

Attaching the spindle housing to the head

Photo 2 illustrates the attachment of the housing to the head. The two guide rails on either side of the housing line the spindle up vertically. I used 100mm lengths of 6mm gauge plate for the rails. Drill the holes for the two 3mm dowels initially 2.9mm and the two 5mm hex head bolts. At this stage, drill the holes for the 5mm bolts 4.3mm this being the tapping size for 5mm. Clamp one of the guide rails to the front of the head. Using a clock set the inside edge of the rail vertical by raising and lowering the head. Using the upper bolt hole as guide, drill and tap just this one hole in the head. Expand the hole in the rail to 5mm and drill the countersink. Bolt the rail to the head and clock the inside edge again to set it vertical. Clamp the rail and tighten up the bolt to secure the rail in place. Now drill and ream the holes for the two dowels. Insert the two dowels. Finally drill and tap the hole for the second hex head again using the initial hole as a guide. Clamp the spindle to the head lining it up against the guide rail. Following the same procedure outlined above attach the second rail. With the rails in place the two holes for the 6mm hex head bolts that attach the spindle housing can now be drilled and tapped.

Fitting the motor

I replaced the original DC motor as well as the speed controller. I have to say I did

have mixed feelings about replacing the motor, however having done so I am very pleased that I did. The motor and spindle are fitted with 30 tooth 5mm pitch 15mm wide HTD pulleys with a 400 mm long belt. **Photo 3** illustrates the motor mounting. The two front pillars that support the motor mounting have been scalloped to give extra clearance for a larger pulley and belt to drive a high speed milling spindle (see **Photo 4**). I have not provided dimensions for a motor mounting, as the mounting will depend on the motor selected. Any reader wishing to use the Bodine Electric motor I used

(model 4033 see www.bodine-electric.com) is welcome to contact me for details. Details of the KB Whisper Technology speed controllers can be found on the KB web site (www.kbelectronics.com).

As mentioned earlier the advantage of the bolt on spindle is the ability to easily remove it and attach other devices to the head. **Photo 4** illustrates a high speed spindle running at about 8,000 rpm bolted to the head. **Photo 5** shows an internal cutter drive attached to the head being used with CNC to cut an epicyclic gear.

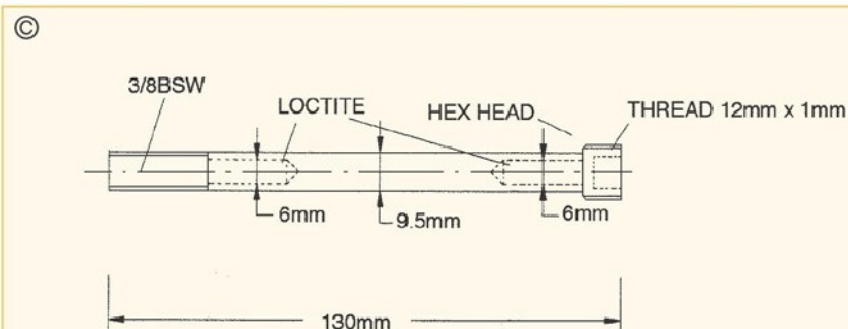


Fig. 7 Draw bar

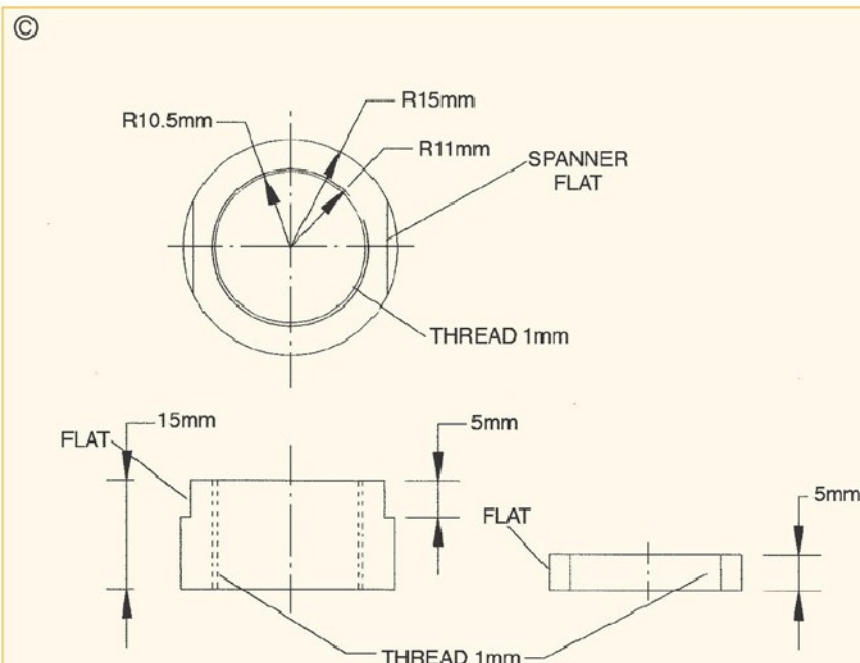


Fig. 8 Locking rings

AN INTRODUCTION AND ITS



7. The furnace hearth following the explosion caused by using excess water in the mix.

Small scale liquid metal hazards

There is always the potential risk of a fire when metal melting and casting is carried out, usually as a result of a liquid metal splash or accidental spillage. For just this reason, it is advisable to have the following random list of items available in your melting area, always ready to use:

- i. A fire extinguisher, containing water if gas firing is being used, or if electric melting is taking place, then the cylinder supplier's recommended alternative;
- ii. A bucket of dry sand, for spreading to limit the extent of any liquid metal run outs;
- iii. At least one fire blanket, preferably larger than those sold for domestic cooker fire prevention. These are useful in preventing the spread of fires, also for body protection;
- iv. A spare gas cylinder key, kept in a 'Break the Glass' emergency box near the cylinder;
- v. A first aid box, containing an eye bath and items for treating burns also a container of clean water for cooling skin burns, if no tap and hose is available very close at hand;

The reasons for including each of the above items are self explanatory, but there may be others you would wish to add to your own list.

Refractory installation preparations

The refractory castables chosen for our furnace come from a group of alumino-silicate products that can withstand hot face temperatures of 1200deg.C or more. Thermal conductivity data for a suitable castable and board insulation was given in part 1 of this article as **Table 1**; (technical data for both from Ref.7). These refractories retain considerable heat within the lining, whilst at the same time allowing controlled loss via the cold (steel) face. They possess sufficient hot strength for the required task, always provided that no attack harsher than that arising from flame passage or heat erosion is involved.

The steps for pattern setting, refractory preparation and casting are now described. All patterns whether of wood or metal, must be well coated with grease before installation, so as to allow easy removal to take place without damage to the 'green' refractory. If no lifting equipment is available in the workshop it is recommended that before refractory installation commences, the empty steel shell is placed in the proposed operating position and set upon two substantial pieces of 25mm angle iron, long enough to safely support the base as shown in Sketch 1 given previously; this allows controlled base heat loss to take place without causing damage to the workshop floor.

Alan Furness discusses furnace construction and associated equipment.

Furnace base

The first job is to install the 15mm thick insulation board or alternative castable, then it is simply a matter of mixing the selected refractory according to the makers instructions and installing it, in a level plane to the required thickness of 130mm. (15 + 115mm)

Furnace body

A wooden burner pattern 115mm dia, tapering slightly over its 170mm length, must be firmly secured at its 115mm dia. end to the burner support frame, so it maintains a horizontal pattern position during refractory casting. Suitable infill material must be packed around the wooden pattern, to prevent refractory spillage around the hole space in the shell.

The 10mm thick insulating board must be cut to size and installed, by using wire loops passing through periodic moisture drainage holes to retain it in close proximity to the inner steel surface; the wire can be removed once casting and drying out has been completed. In the event that an insulating castable is used in place of fibre board, a suitably sized metal or ply former needs to be greased and installed, to ensure that the required castable thickness will be achieved.

The next step is to install the 2-3deg. tapered central pattern with a top diameter of 410mm, in the correct central position. One or more items of sufficient weight to prevent the pattern moving should be placed inside it whilst tamping of the refractory castable around it takes place.

Refractory installation

Before any refractory installation commences, it is essential that one can conduct the full cycle of mixing and installation for each of the three furnace components non stop and without any interruption, (or compulsory shopping trips). Otherwise, oxidation of an unfinished surface may prevent structural homogeneity and allow premature failure at these interfaces to occur. It is quite a different matter at the joint between side walls and base, because a small amount of differential expansion and contraction must be able to take place at this interface.

ON TO ALUMINIUM ALLOYS 2

Furnace base

Once mixing with the refractory manufacturers recommended amount of water, (and no more), has taken place, (despite the strong feeling it's not wet enough), also any makers recommended time lapses have expired, the base casting operations should be completed and covered with damp cloth to prevent premature dry out. The cast base must be allowed to set completely for a day or two before casting the body lining commences.

Furnace body

Small additions of refractory should be made around the circumference of the centre pattern and without damaging the outer insulating board, tamped down using a knobbed rod shaped like a small sized ball pein hammer head. Further uniform amounts of refractory must be added and tamping continued until filling is complete and the top surface is level. The pattern should be left in place and a damp sack cover again used to prevent premature drying out.

Furnace lid

It may be advisable to cast this small quantity of refractory at the same time as the base. Alternatively, a fresh refractory mix must be prepared, after the centre, or three quadrant patterns have been secured in appropriate positions. Filling and tamping as per the furnace body should be carried out until the finished surface is level; it too must be covered and left to set.

Surplus refractory

'Left overs' must not be "re vitalised" with water and used for the furnace but need not be wasted. A workable surplus can be tamped into a prepared trough mould with sloping sides and ends and after proper drying and firing it can be used as a (preheated) ingot mould for surplus liquid metal, which if left in the crucible to solidify, may well cause it damage.

Refractory drying and heatup procedure

The explosive events that can accompany turning inherent refractory moisture into steam, have already been emphasised, but **Photos 7 and 8** serve to confirm such a happening. Those carrying out a new installation in an aluminium plant (in Portugal), seriously exceeded the recommended water content so that they

could bucket pour it instead of tamping it in place. Thus, shortly after low gas preheat had started and no metal had yet been charged, the retained moisture rapidly turned to steam and 10 tonnes of refractory castable blew up, completely taking off the two part roof with integral electric heaters, also distributing debris over a 50 metre square area of the factory.

As we wish to avoid such dangerous activities, the following procedures are recommended and if at all possible, the steps from 3-5, should be carried out without any break in the sequence:

1. Obtain a suitable temperature measuring instrument; more details on this item later;
2. Leave the furnace refractories to set in a cool frost free atmosphere, for several days;
3. Place a quantity of kindling wood in the crucible cavity and light it. Keep a slow wood fire going for up to a 12 hour period if possible; place the lid on to retain the heat;
4. Insert a small gas torch in burner aperture and slowly raise temperature to 150deg.C. with the lid on. Maintain at 150deg.C by periodically taking refractory surface temperature and adjusting the low flame heat input. Hold for a minimum of 12 hours. NOTE: After about 6 hours steam will start to seep out of the vent holes, which shows satisfactory progress. If possible,

drying out should continue until the steam output ceases.

5. The main burner should be installed in place of the gas torch and heat input increased to achieve a constant temperature of 200deg.C. This should remain steady for 12 hours, followed by further 100deg.C increases and holds for 12 hours, until 600deg.C is reached, by which time the complete heat up cycle has been completed.

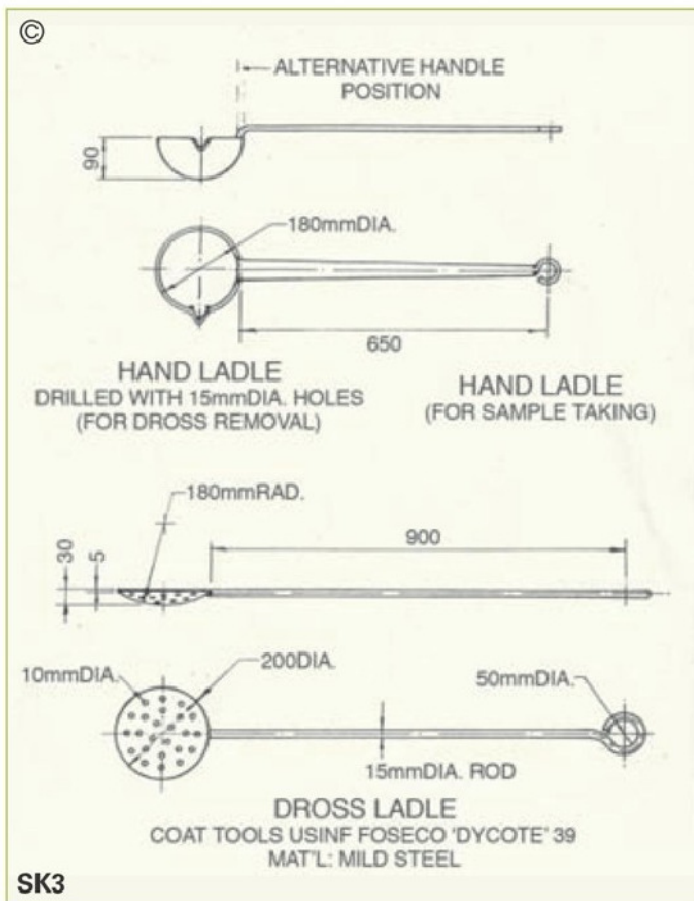
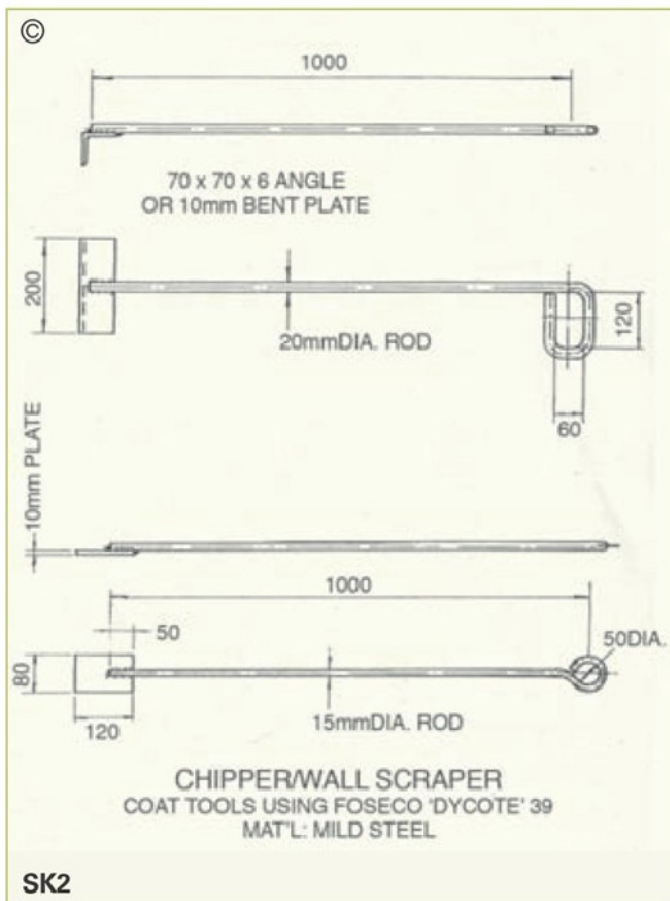
It is fully accepted that the industrial shift pattern dry out/heat up programme recommended above, consists of a series of heating and holding cycles that are not very conducive to normal domestic harmony, even for those who are retired, but much less so for those still at work.

Thus, if a compromise schedule must be arrived at to avoid a lengthy period in the domestic 'doghouse', I recommend a slow rise to 150deg.C, followed by an 8 hour hold at temperature, then an increase to 200deg.C, with a further 8 hour soak at temperature. This is absolutely essential to complete the necessary moisture removal and avoid a "minor Portuguese happening".

At this point an interruption in the cycle is less damaging, but in the interim the vessel should be covered with some kind of suitable insulation to retain heat. Provided it is not frosty or damp, further cycles may be delayed for a week, then re-commenced after a steady 5-6 hour reheat up to 200deg.C. This must be followed by rises to 400 and 500deg.C respectively, with reduced holding



8. The two part roof and integral electric heating system were completely blown off the furnace by the force of the steam explosion.



periods at each of about 4- 6 hours. The cycle can then be completed by an increase to 600deg.C with a crucible in place, at which point the first melting programme can be initiated.

For reasons of safety, once the burner is lit the furnace ought not to be left unattended, so that in the event of flame failure the propane supply can be immediately turned off. If the possibility of extended melting programmes is envisaged, it may be reasonable to install a more expensive burner and flame failure system, which then frees one from full time observation of all melting or fired holding operations. After the initial melting cycle has been completed, no specific cooling down steps are required. But wherever possible, the EMPTY hot crucible should be returned to the furnace and the lid fitted, as this will retain residual heat and allow temperature loss to slowly occur, thereby reducing the possibility of stress damage to both the crucible and furnace refractories.

When charging cold metal into a crucible, or adding preheated metal to complete a charge during melting, great care must be taken to avoid it becoming wedged tight to the sides, or slipping to form a wedge during melting. This is because on heating, solid aluminium expands much faster than the crucible material and what we term as 'bridging', takes place, where the metal expands and initiates a crack in the crucible walls, whereupon an A80 crucible, costing £100 can easily be lost. **NOTE:** Used crucibles are only slightly less susceptible to cracking than are new ones.

Ancillary equipment Requirements

Temperature Measurement

If one is seriously considering melting aluminium, or for that matter any other metal, acquisition of suitable temperature measuring equipment is absolutely essential. As mentioned earlier, when subjected to excessive temperatures, aluminium is the most easily degraded non ferrous metal. Therefore, during melting operations or when holding it in the molten condition, the temperature must be kept below 745deg C to achieve the best cast quality results; details of suitable temperature indicators and thermocouples are given in Ref.8.

Liquid metal working tools

As it is necessary to periodically remove oxide from the liquid metal surface, suitable hand drossing spoons and skimmers are required, together with sampling or casting ladles, stirrers and bell plungers. Of simple design, these are constructed from mild steel, with head or blades attached by welding. **Sketches 2 & 3**, show a typical skimmer, scraper, drossing spoon and ladle, but the precise sizes of each are best tailored to ones individual requirements.

The stirrer is a 25-30mm dia. carbon or graphite rod, purchased from crucible suppliers, which is secured by a jubilee clip within the cruciformly split end of a

200-400mm x 25mm i.d steel tube handle. The bell plunger is a dome about 100mm dia. x 50mm deep, perforated with numerous 5mm dia. holes, welded to a 300-400mm long handle. Its purpose is to push down to the bottom any of the chemical tablet treatments discussed later. These two tools are not illustrated.

Because liquid aluminium will very readily attack and erode any kind of mild steel in a relatively short space of time, it is customary for foundrymen to coat their tools with a protective wash. This also helps to prevent the liquid melt picking up iron, which if it occurs, may cause the alloy to go out of chemical specification and lose properties. Prepared coatings, suitable for painting or spraying on the surfaces of preheated tools are available from consumables suppliers (Ref.9).

Handling tools

It is wise to have several of pairs of tongs available at all times. These can be homemade or obtained from local blacksmiths, also like bell plungers, they are usually available from foundry consumables suppliers. Tongs ends should also be given a protective wash to prevent any molten metal attack. Some types I have regularly used are to be seen in **Sketch 4**. If it is intended to produce larger castings that require removal of the crucible to pour the full quantity of liquid metal, then a pair of scissor lifting tongs and pouring shanks are essential. As will be a "willing helper" to assist in operating the tongs and holding one end of the pouring shanks. **Sketch 4** depicts these items, but not the design for a "willing helper".

Workshop ventilation and fume removal

One can only speculate regarding the various types of building that might be utilised for DIY melting, also the atmospheric air change frequency that is likely occur during melting operations. All too often the workshop (garage) doors may have to be open, allowing minor gales to blow in and whilst this does provide frequent fresh air changes, it will cost the operator a fortune in gas to get the metal melted. Alternatively, if the doors remain shut, the chances are that working conditions will deteriorate and an odd open window will be insufficient to handle heat and fume removal, particularly if the workshop is on the small side.

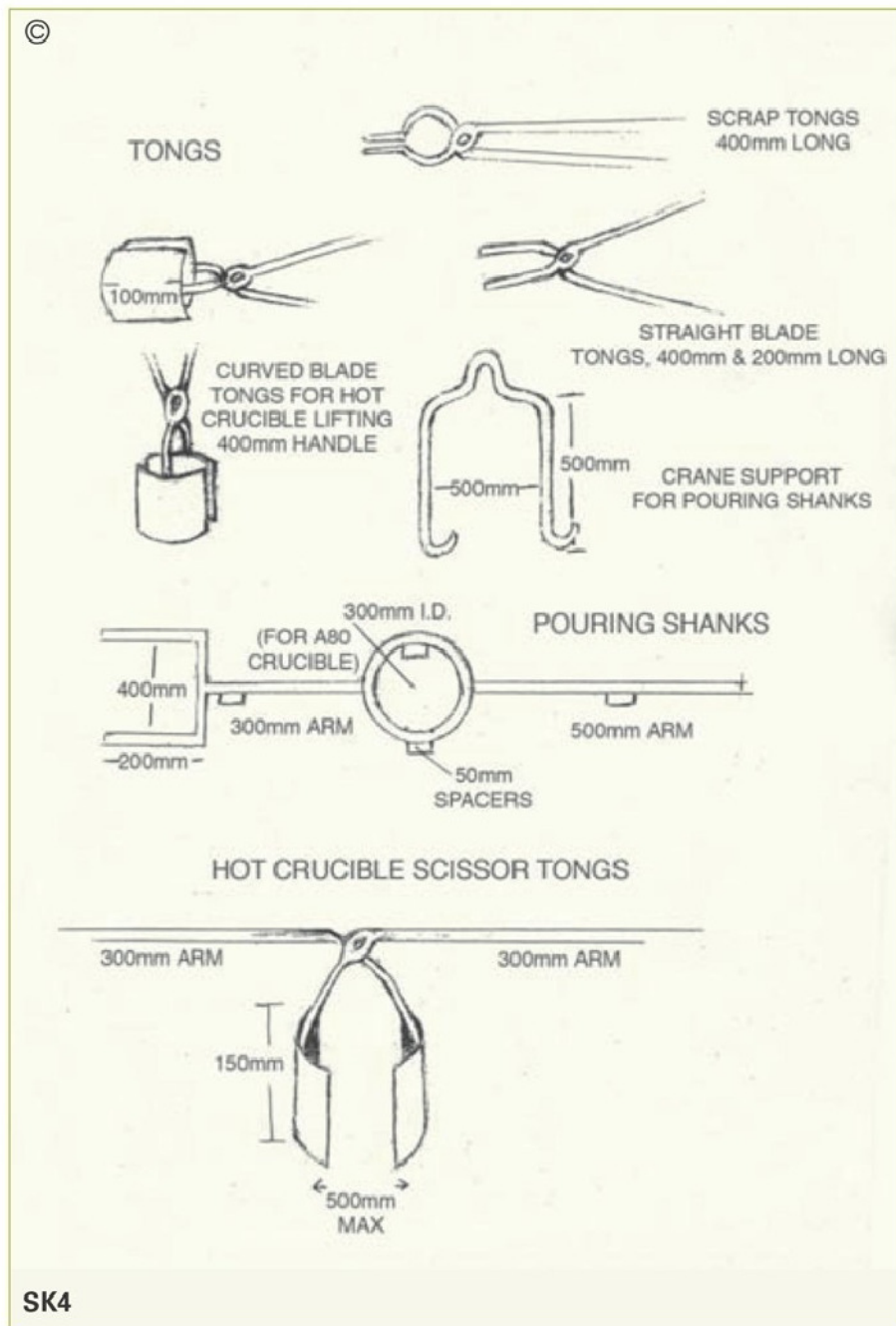
To overcome the heat and melting fume problem in my small (ex garage) workshop referred to earlier, I found that one of the large capacity Expelair fans fitted in the wall, with a shutter which could be closed when not in action, was in the first instance adequate for my purposes. This meant that I could operate both electric and gas fired furnaces without the 'garage' door being open, which greatly benefited my working conditions and improved my fuel consumption by a significant amount.

I later built a sheet metal hood and fixed it one metre above the gas fired melter. This significantly assisted the fan in removing any fume generated, particularly when liquid metal treatment was in progress. In the late 1980's we could still use hexachlorethane tablets for hydrogen removal (since banned by guess who). These effectively purged the melt of hydrogen, but resulted in the emission of dark smoky fumes from my extraction fan. On one occasion this discharge caused a passing neighbour to accuse me of making smoke signals "like those used to announce selection of a new Pope". From then on I utilised several small doses in place of one larger dose!

The installation of an extraction hood has other benefits, in that under it, extra heat sources needed to dry or preheat dropping spoons, ladles etc. can function during operations. Also, when scrap or ingot is being pre heated to 170deg.C, any fume produced from oil or paint on its surface will easily be removed by the extraction hood. It was the lack of a fume removal chimney that lead to my earlier criticism of a pit furnace design which first appeared in MEW 91.

Personal protection

Having had the misfortune (or carelessness) to be burned by numerous hot or liquid metals, from soft solder upwards, I can truthfully say that burns from molten aluminium have been the most painful. It sticks to the skin far more tenaciously than lead or copper and penetrates much deeper than iron. For this reason it is imperative that personal safety equipment is top of the purchasing agenda when one is preparing to carry out the DIY melting of any metal. The head in general and eyes in particular, are exceedingly vulnerable to small splashes, as well as



SK4

larger quantities of molten aluminium or any other liquid metal. Protection is best achieved by wearing a helmet with a permanently attached hinged liquid metal proof visor for preference, or helmet and liquid metal proof goggles as an alternative choice. Details of Kite branded special metal resistant eye protection items can be obtained from a foundry supplies stockist.

The main reason for wearing helmets is that when liquid aluminium "pops" or moisture initiated explosion problems occur, liquid metal always seems to go skywards and when it descends, any head without a helmet is in danger; I still have a scar to prove it. Like motorcycle crash helmets, I was initially opposed to wearing headgear just for effect, until accidents with my bike and molten aluminium, taught me differently. I then took up wearing helmets, and continue so to do.

Other vulnerable body parts needing serious protection are hands and feet. Liquid metal resistant gloves are

available and ought to be worn in preference to thick gardening gloves. Selection of the right size is essential, so that tools can be held safely whilst wearing them. Gauntlets should be avoided, on account of a tendency for liquid metal to be funnelled inside and burn the wrists; for similar reasons it is preferable that loose fitting jacket sleeves cover over the wrist of the gloves.

To avoid the wound known as "foundry foot", the wearing of lace up boots or shoes must be abandoned in favour of quickly removable slip ons. Many years of wearer experience showed that laces easily burn and metal lace holes can become welded together by metal splashes, thereby preventing rapid removal of footwear that is increasingly heating up. Our laboratory experiments carried out to study adhesion of molten aluminium to clothes, indicated that adhesive contact on leather shoes resulted in them burning, but it failed to adhere to and ran off suede finish surfaces.

Like most other aspects of our lives today, the Safety at Work act contains an excessive amount of "overkill". Doubtless, this has been instituted to avoid the worst excesses of the "blame and claim" culture now seriously afflicting us all. Thus it seems possible that "Safety at Hobbies" legislation may also appear and a sketch in one publication, which depicts an apron clad foundryman without helmet but wearing glasses and holding a crucible with gloved hands but bare arms, will be sufficient to cause serious palpitations within the HSE.

Currently, it is believed to be an industrial requirement that all persons involved with molten metal should wear heavy aluminised full length coats and spats or leggings plus aprons. It is not appropriate for me to make any comment either for or against these recommendations, except to say that they are very expensive to buy, have a limited life and are hot and difficult to work in. For most of my 35 year active liquid metal handling career, I wore loose fitting full length, heavy cotton, button up lab coats, which could be very speedily torn off following liquid metal contact. Happily, I sustained no serious burns whilst wearing these garments, plus protective footwear and visored helmet. However, I strongly advise that under no circumstances should boiler suits be worn during melting or casting, because of serious difficulties in their emergency removal.

Large scale liquid metal hazards

Once one has been involved with the melting and or casting of liquid aluminium, its high fluidity and ability to flow very rapidly on many types of surface becomes evident. This fluidity and its relatively low melting point, provide all the evidence necessary to answer questions as to why the alleged aluminium "burning" problems were reported to have occurred in the superstructure of warships damaged by missiles during the Falklands war.

Of course, more than adequate technical evidence was then and still is, available to prove that aluminium does not burn. When the tremendous heat generated by a missile strike occurs, it is more than sufficiently above 660deg.C, to rapidly 'flash' melt all aluminium in the strike area. Thus, both the fast flowing molten aluminium streams and highly fluid amounts discharged through the air, can immediately adhere to and ignite the predominately plastic, wood, or other combustible material components that comprise modern warship structures, thereby causing a fire storm.

Liquid metal treatment prior to casting

Flux treatment

The fact that good metal is lost to unrecoverable oxidation during untutored aluminium melting operations has already received much emphasis. Surface oxide generation can however be usefully

minimised by the regular application of controlled amounts of a substance usually referred to as 'salt flux'. This is not a cue for the DIY founder to dash indoors and avail himself of the "Management's" stock of cooking salt, as that required for our melts is more costly and has considerably different properties to ordinary sodium chloride. The type of Coverall flux and quantity required to reduce oxidation and improve liquid metal quality is referred to in Ref.9.

Degassing

As there is little engineering merit in producing castings that have the strength and internal structure of a bar of Aero chocolate, it is sensible to remove the hydrogen gas causing these defects from the liquid metal before casting it. Liquid aluminium degassing is best carried out by introducing a large quantity of many small and finely divided high purity nitrogen gas bubbles throughout the crucible of liquid metal for several minutes before casting. Unfortunately, only "white spot" nitrogen is suitable for aluminium degassing and it is difficult to obtain, in spite of contrary claims by the gas suppliers. White spot nitrogen, is guaranteed to contain considerably less moisture than either standard or even medical quality nitrogen. Both of these contain sufficient moisture to significantly increase the hydrogen, rather than removing what is already in the liquid metal. Thus, in view of the problems that exist with white spot availability, it is wise to use an alternative like Nital tablets. These are plunged into the crucible shortly before casting and react to release entrapped hydrogen; see ref.9.

Other treatments

At the completion of casting, it is sometimes disappointing to find that the mould has not properly filled despite use of correct temperatures, good liquid metal husbandry and a well prepared mould. Also examinations may reveal that the properties of the casting are poor, even though good quality metal was used. These are just two of a number of instances which tend to indicate that the metal being used is no longer properly grain refined. The refining of aluminium grain structure is brought about by a controlled addition of titanium and boron when the metal is initially alloyed. But as a result of too many remelts, or the absence of a correct amount in the first place, fluidity can be adversely affected and or the solidified structure becomes coarse. To overcome this condition, chemical Ti/B additives in tablet form can be plunged into the liquid metal prior to degassing and casting, to re refine it. Further treatment will not be required unless the same batch is remelted on too many occasions; see ref.9.

Conclusions

A study of previously published information, prompted me to prepare an informed article, which would also contain additional metallurgical data of use to MEW readers. As well as providing some elementary data on aluminium and its alloys, the basic reasons why it differs from most other ferrous and non ferrous

metals has been explained herein.

Additionally, the necessary essentials to be understood and practised, if safe melting and treatment of liquid aluminium is to be carried out in a DIY workshop, have been emphasised in the text.

The author has endeavoured to offer accurate and useful advice regarding the design, building and operation of a simple gas fired melting furnace, based on many years personal experience. Information on refractories for furnace construction that help limit energy consumption has been discussed. Also advice on where to obtain the important equipment, consumables and safety requirements has been referenced.

Purchasing notes

For those not able to build their own furnaces, but still wishing to melt aluminium and produce castings, budget prices for new vessels have been obtained from two manufacturers; as follows:

1. An A70 size gas fired crucible melter, costs around £5,000; a similar sized electrically fired version costs around £7,000, (ref.11)
2. An A80 size gas fired crucible melter from an alternative supplier is on offer at a budget price of around £4,000, (ref.12).
3. A complete 'T' assembly burner with an output of 300,000 BTU/hr, will cost in the region of £617 plus VAT, from Aerogen Co Ltd, Phone: 01420 83744, Mr E. Grant.
4. The refractories needed to complete a furnace lining recommended in items 2 & 4 of Table 1, plus the lid would be: 15 X 25 kg bags @ £14 per bag and 5 sheets of insulation board @ £35 per sheet., available from Jays Refractory Specialists Ltd.



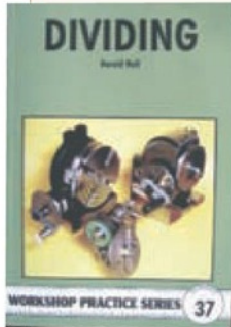
References

- Ref 8. Northern Instruments (Leeds).**
72 Armley Lodge Road, Leeds LS1 2 2AT. Phone: 0113 2791054.
Email info@northern-instruments.com
- Ref 9. Foseco IFS) Ltd,** Fazeley, Tamworth, Staffordshire. B78 3TL. Phone: 01827 289999. Contact: Richard.Cruickshanks@Foseco.com for the various information leaflets.
- Ref 10. 'Foundry Work' & 'The Backyard Foundry',** by B.T Aspin. Special Interest Model Books.
- Ref 11. Ramsell - Naber Ltd,** Furnace Builders and Engineers. Phone:01 922 455521.
- Ref 12. Stinchcombes Furnaces Ltd,** Furnace Builders and Engineers. Phone: 0 1902 870350.
- Ref 13. Alternative burner manufacturers: Eclipse Combustion Ltd.** (Mr G. Acton) Phone:01 905 795900.
- Ref 14. Alternative refractory supplier: Resco Products (UK) Ltd.** (Mr R.M Ingram) Phone: 01530 222694.

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.

Dividing by Harold Hall



Within the ambit of model engineering authors, I believe Harold Hall has demonstrated a special talent for writing in a way that encourages the beginner and also offers much for the more experienced. This book is very much in that vein, and introduces the equipment, methods, and mathematics associated with workshop dividing. There can be few workshop projects that do not require at least elementary dividing, whether this be for spanner flats, cylinder cover bolts, or gear cutting.

Eleven chapters are entitled: An introduction to Dividing; The Machinery; The Methods; The Mathematics; Holes on a Pitch Circle Diameter; Shop Made Simple Dividing Devices; Shop Made Basic Dividing Head; Shop Made Full Function Dividing Head; Shop Made Lining Tool; Prime Numbers; Tables. As the chapter headings indicate, after covering principles and theory, details are given for a variety of dividing devices of varying complexity, and in each case, both the fully dimensioned drawings and the accompanying photographs give very clear illustration of components and assemblies.

Dividing is published by Special Interest Model Books (ISBN 1-85486-238-3) as Number 37 in the Workshop practice Series, and is available from good booksellers.

Arc Euro Trade

Ketan Swali has asked me to pass on his apologies to customers beating a path to his door for gear cutting hobs. Unexpected delays occurred with these, but the samples have now been inspected and approved, and stock quantities should now arrive early in 2006.

Amongst the new products, which have arrived are sets of quality B.A. taps and dies made in high speed steel.

Machine-DRO.co.uk

- is a supplier of toolroom quality DRO equipment at prices to interest the discerning amateur

Machine-DRO.co.uk can offer three versions of display console, 2 and 3 axis types for milling and another dedicated to lathe operation. Milling units include facilities for p.c.d. oblique line of holes and arc milling; for lathe work, features such as radius/diameter, and taper measure are included.

All three consoles have metric and imperial display making for easy conversion. There are two ranges of linear scales available, the standard GS300 and the slim GS500. While the GS300 is suitable for most installations, the GS500 is ideal for installation in limited space, when working with smaller milling machines and lathe cross slides. Both ranges use a precision etched glass scale, mounted in a ridged aluminium extrusion, the type of equipment that has been giving accurate reliable service in toolrooms for over twenty years. More details can be found on their website www.machine-dro.co.uk or by telephoning 01992 450780 or email to: Sales@machine-dro.co.uk

Chronos New Products

Samples of two new items, which many may consider adding to their Xmas lists, were received for examination. First an item of tooling, a tap holding chuck with a range from M5 to M12. At a cursory glance this looks just like any other tailstock chuck. Closer inspection though, reveals two sets of jaws, three at the front, as in any drill chuck, to centre the tap, then two rear jaws to engage with the square end of the tap, ensuring that slippage does not occur. This is the same feature, which typically appears in professional grade tapping chucks and tapping heads. The chuck comes fitted with a MT2 arbor, ideal for tailstock work. If high torque is needed, provision is made for a tommy bar. Chronos stock code for the chuck is MX2000 and it is priced at £29.95 including VAT and mainland UK carriage.

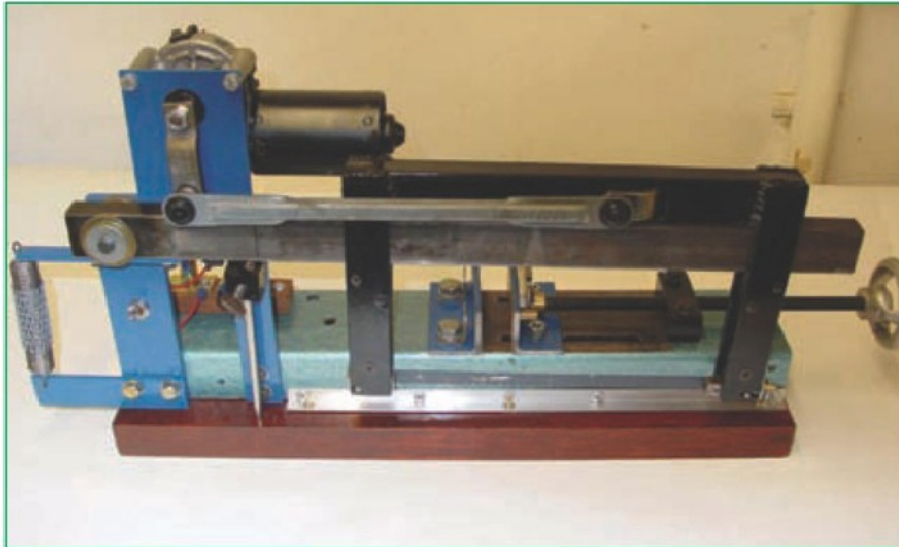
Second, a "how to" DVD. There is of course no substitute for hands on training, and this point is emphasised in this video. However as the opportunities for basic training in machining seem to be forever diminishing, productions such as this, do offer an alternative for preliminary study before venturing forth to the workshop. This one majors on edge finding and location, and is in three main sections. Introduction and safety - is as expected, common sense advice. The tools - introduces the wiggler with its various attachments, and the edge finder, then demonstrates the techniques to arrive at a required position. Laying out the work - introduces marking fluid and gives tips on applying CAD drawings as a direct overlay for marking out. Total running time is about three quarters of an hour. The stock code for this DVD is SWF2X, and as an Xmas special offer it is priced at £17.55 including VAT and UK mainland postage. As will be seen from their advert, this is just one of a growing series of training aids aimed at beginners.



Motors Direct

-have moved location. Alastair Graham who also runs Model Motors Direct has moved to Keepers Cottage, Home Farm, Iwerne Minster, Blandford Forum, Dorset, DT11 8LB. Motors Direct handles larger motors suitable for small machine tool application, where the range includes a quarter horsepower d.c. motor and variable speed controller package which runs on mains voltage, while MMD concentrates on smaller electric motors typically applicable to model boats and model aircraft. However with the growth in interest in small scale CNC, brushless motors developed for model aircraft use, also offer an attractive option for miniature spindle power, particularly where the need is for high speed but low torque. While these are intended to be linked to a radio control package, they may be powered at 12 volts d.c. via a PWM speed controller. Alastair Graham may be contacted by post at the above address or by phone 01747 812 440

LOW VOLTAGE POWER HACKSAW 1



1. Completed saw

As every model engineer knows it's often necessary to cut off a lump of metal, steel or brass etc, to a size that will fit in one of the machines. To me a hobby is something you do for pleasure. Coming home after a hard day at work and standing at the bench vice hack sawing through inch thick steel bars is not a pleasure. One option is to take the bar to work and let Ben, the lad, cut it for me but this isn't always convenient, (and makes Ben curse a lot) because I usually need the bit at night or the weekend. What I needed was to keep Ben under the bench and bring him out when needed or get a machine to do it for me. Of course there are metal cutting saws on the market and much as I would love to pick up one of the many mail order catalogues and order one of everything, a shortage in the cash department prevents this. So it was that I put my mind to solving the problem of how to make one.

Most metalworkers I'm sure have made their own tools of some sort, jigs and clamps etc. but this project would make the leap from making a hand tool to making a power tool. I quickly discounted the idea of a band saw, it would be far too complicated, and so decided that a powered hack saw was the answer. Over the next few weeks many scribbles and jottings started to clutter the bench but I still had the problem of what to power it with. The answer came to me one day at work, while working on a car; I'm in the motor trade. The wipers were gracefully sweeping to and fro when it hit me. As I watched the movement everything seemed to fall into place. 12 volt. Why not. Much safer than playing about with mains powered motors and anyway many cordless power tools nowadays run on low voltage. Now I'm not suggesting you should rush out and grab hold of the wipers on the old Mondeo but take it from

Richard Wightman of Leicester describes a space saving design using wiper motor power.

me they are quite powerful. The motors work on a worm and gear arrangement and are very reliable, we very rarely have to fit new ones, and if you think about it they are capable of running for long periods of time. They very conveniently rotate at about the right speed, (Imagine cutting a piece of metal by hand while keeping in time with the wipers on your car) come fitted with a crank and have all the necessary links and bits and pieces etc that you will need.

As I mentioned earlier I'm in the motor trade so quickly had the parts stripped out of cars that were being scrapped. **Photo 2** show the complete mechanism from a 1993 Ford Escort (this is how the mechanism comes out of the car, as a complete unit). Many vehicles use very similar units, and although there are differences, they all work on pretty much the same principle. I chose to use the one from the Ford Escort purely because it has the greater crank sweep of the three examined at 106mm which will give a saw stroke of the same amount. This compared to a Vauxhall Astra at 78mm and the Rover 214 at 80mm, although it wouldn't be too difficult to extend the crank by cutting in half and welding/riveting/ bolting a longer piece in. I haven't investigated other makes and models of car wiper motors in depth but apart from the crank sweep as mentioned before they are all pretty much the same. The Escort and Astra units are fairly easy to remove, all done from under the bonnet. Other makes and models can be more difficult. If you don't know of anybody scrapping a car where you can



2. Ex Ford wiper assembly

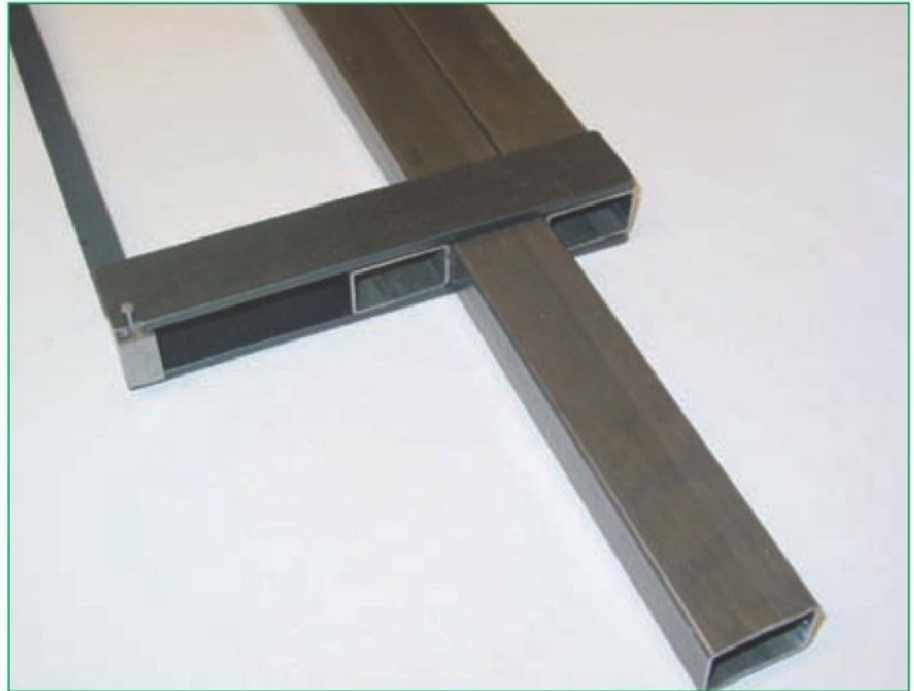


3. Parts of frame showing slots for blade holder.

get the bits for free and have to go to a car breakers you shouldn't have to pay much more than a tenner. One other thing, get the plug by chopping 6-8 inches or so off the end of the wiring loom, it's not absolutely necessary but will make the wiring up easier and neater. Back home in the workshop a couple of quick experiments on power supplies was carried out. It will of course run off a car battery, it will also run quite happily off a 6-amp battery charger or a transformer. Having satisfied myself that the motor would power the saw it was time to empty out the boxes full of bits that will come in handy one day. At this point I think I ought to emphasise that although I wanted a power saw this project was purely experimental so I make no excuses for mixing imperial and metric and using whatever came to hand. As far as possible I will give measurements in mm. Hindsight being a wonderful thing, if I was making it again I would do things differently, but on the basis 'if it works leave it alone' I probably won't. Wherever I can I will throw in suggestions of alternative methods or ideas and afterthoughts. I suggest therefore that you take a good look at the finished tool and use the measurements and drawings as a guide and adapt them accordingly. It's highly unlikely that there are two of us with the same box full of bits and pieces. As I have already said this was an experimental piece so engineering excellence it isn't but that said care was taken to keep things as square as possible where it mattered. Although I have used the lathe and milling machine on some parts this is probably not necessary. It is likely that the whole thing could be made with basic tools, a pillar drill being advantageous. So let us begin.

Concept

The idea I came up with is to have a saw frame slide to and fro on an arm that is pivoted at one end. The arm pivots up to take differing thicknesses of work and keeps pressure on the work via its own weight. The motor mounts directly on to the arm and drives the saw via one link thus doing away with the need for any complicated mechanisms. Keeping things as simple as possible is always the best policy when carrying out experimental work I have always found. A piece of steel channel will form the base on to which will be bolted a vertical post to mount the swinging arm to. A simple vice will be needed to hold the work. On the electrical side I will need an on/off switch and a switch that will cut the power as the saw reaches the end of the cut. With a few rough sketches and measurements I set about making it. This is thus one of those projects where the drawings have in part followed on after the execution. As such, while most dimensions are given, some are not and are determined on the job. Much of the flat steel and the box section steel I bought from B & Q. My nearest branch has a good selection of brass, steel and alloy in a variety of flat, angle, round, square, tube and box sections. I started with the saw frame. This I decided should have a 140mm depth of cut so as to be able to accommodate larger tube sections as well as smaller solid parts. The frame is designed to take 10 inch blades purely



4. Trial assembly of frame parts.



5. Frame welded, spacers in place.

because I had 20 or so in stock. Although not as common as the 12 inch blade they are still available. The saw has a stroke of 106mm and therefore will not use the entire blade anyway. It will of course keep the finished machine 2 inches shorter and the shorter frame will be more rigid. I can see no major problems with using 12 inch blades just remember to make the frame and the swinging arm 2 inches longer.

Frame

I started with the saw frame, the components for which are shown in Fig 1. Cut a piece of 35mm x 20mm x 1.5mm oblong steel box section to 305mm in length and 4 pieces of 30mm x 4mm flat steel to 180mm in length. Clamp the steel flats together in pairs. Drill a 5mm hole

through each pair to take the spacer and countersink the holes then cut/file/mill the 4mm slots that take the blade mounting blocks. One arm from the wiper mechanism must be removed. File or grind off the part of the wiper spindle that has been riveted over and lever off the arm. A square hole must now be cut in the side of the oblong steel section just big enough for the arm to slip in. (The position of this hole must be worked out. The type of motor used, crank sweep, the length of the connecting rod etc. will all have an effect on its position). Clamp the arm in place and drill 2 x 2mm holes through the box section and arm.

Remove the arm and drill the 2 holes out to 5mm and tap 6mm. Drill out the two holes in the box section to 6mm. Make up two spacers to 20mm, (the same width as



6. Guides are retained by pop rivets.

the oblong box section) I made mine on the lathe from 12mm hex steel bar, drilled and tapped 5mm that will take a 5mm x 12mm countersunk machine screw from each side. You could use a piece of tube as a spacer with a nut and bolt right through. Fit the spacers to the steel flats and then clamp to the oblong box section with mole grips and check with a square. To speed

the job up a little I took the frame to work and welded the parts together. If possible do the same as welding makes a good solid frame. (Speak nicely to the guy at your local car welders). Alternatively use bolts/screws/rivets to fix the frame together. Using triangular plates at the corners will considerably strengthen the joint.

Cut two 30mm lengths of the oblong box section to form the lower guides. Slide the frame on to a length of the box section; (the piece that will become the swinging arm) slip the two short guides of box section into the frame and push them up to the top trapping the swinging arm in place. Secure the two guides with mole grips or clamps and check that the frame slides freely along the arm with the minimal amount of free play, adjust as necessary. Drill eight 1/8 inch holes through the sides of the frame and secure the short pieces in place with 1/8 pop rivets.

Blade mountings

Cut two blocks of steel 35mm x 20mm x 12mm to make the blade mountings. Cut out or mill off one corner. On one piece drill and tap 4mm for the blade mounting screw and drill through 4mm to take a 32mm length of 4mm rod. Very lightly peen the rod in its centre and press into the block so that it is central. On the other block drill and tap the same for mounting of the blade. Next drill 5mm to a depth of 10mm and tap 6mm to take the adjusting stud. Screw in a 25mm long bolt then drill through to take the 4mm bar, this will go through adjusting stud and hold it securely in place, lightly peen the rod and press through. Note that the 4mm rod is in a different position on each blade mounting block. Cut the head off the bolt, clean up the thread and fit a large washer and wing nut. When the blocks are fitted in their respective slots in the frame they are held rigidly and will not allow the blade to twist.

Swinging arm

The swinging arm is a 545mm length of the oblong box section, shown in Fig 2 with the top spring bracket. Drill through one end to take a 24mm length of 12mm tube with a 10mm bore. I brazed the tube in place but soft solder would do just as well. Cut a 120mm length of 14mm x 5mm steel and a 70mm length of 14mm x 5mm steel. These two pieces will make up the bracket for attaching the spring counter balance. Clamp the shorter piece to one end of the longer piece and drill through the two pieces with a 2mm drill at 50mm centres. Clamp the long piece to the bottom of the swinging arm and drill through with the 2mm drill. Drill out the holes in the long piece and the swinging arm to 6mm and drill the out the holes in the short piece to 5mm and tap 6mm. Drill a 4mm hole in the other end of the long piece to which the spring will be attached. With the short piece pushed inside the

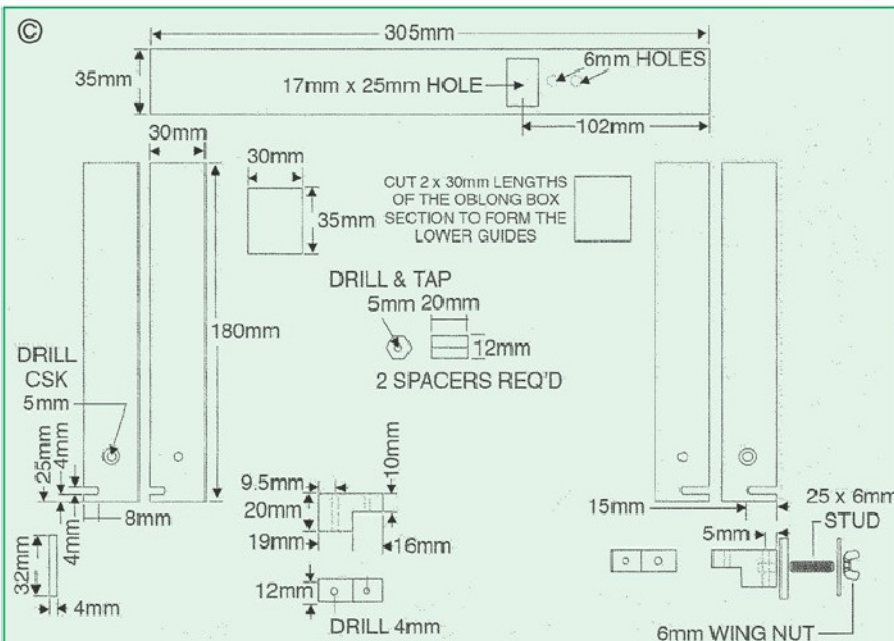


Fig. 1 Frame parts

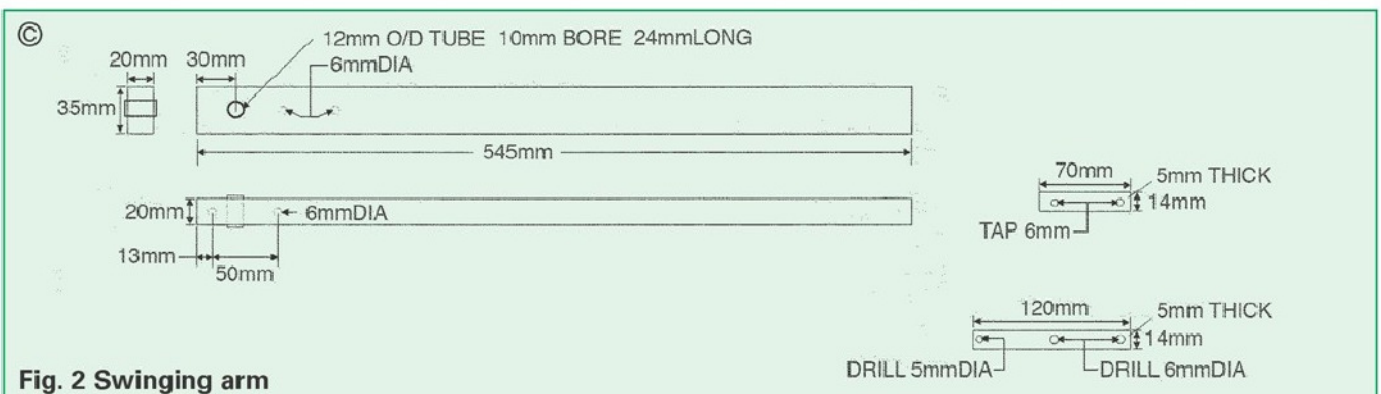


Fig. 2 Swinging arm

swinging arm the long piece can now be bolted on from the outside with two 15mm long 6mm bolts.

Motor mounting

The motor mounts onto the swinging arm via a 3.2mm thick 130mm x 80mm steel plate (Fig 3). Cut an 80mm length of 25mm x 6mm steel and clamp to the bottom of the motor mounting plate. Drill two 2mm holes at 40mm centres through both pieces. Clamp the motor mounting plate to the swinging arm and drill through the two 2mm holes. The motor mounting plate and the swinging arm can now be drilled out to 6mm. Countersink the motor mounting plate. Drill out the piece of 80mm x 25mm steel to 5mm and tap out to 6mm. A 25mm hole must be made in the plate for the motor spindle to go through by drilling and filing. Three further holes must be drilled for the motor mountings. (The position of these to be taken from the motor you are using). By slipping the drilled and tapped plate inside the swinging arm the motor mounting plate can be fitted with two 6mm countersunk machine screws. It's a bit fiddly lining up the holes but once bolted up its nice and

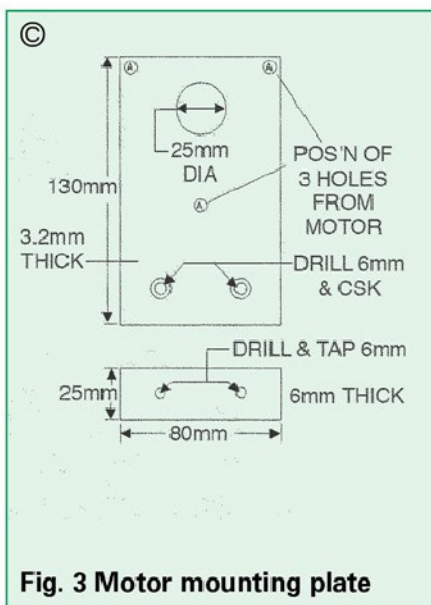
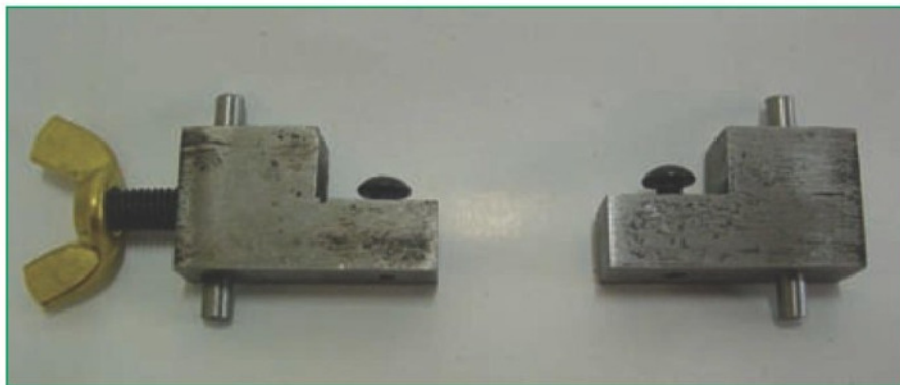


Fig. 3 Motor mounting plate



9. Motor mounting plate part drilled.



7. Completed blade mountings.

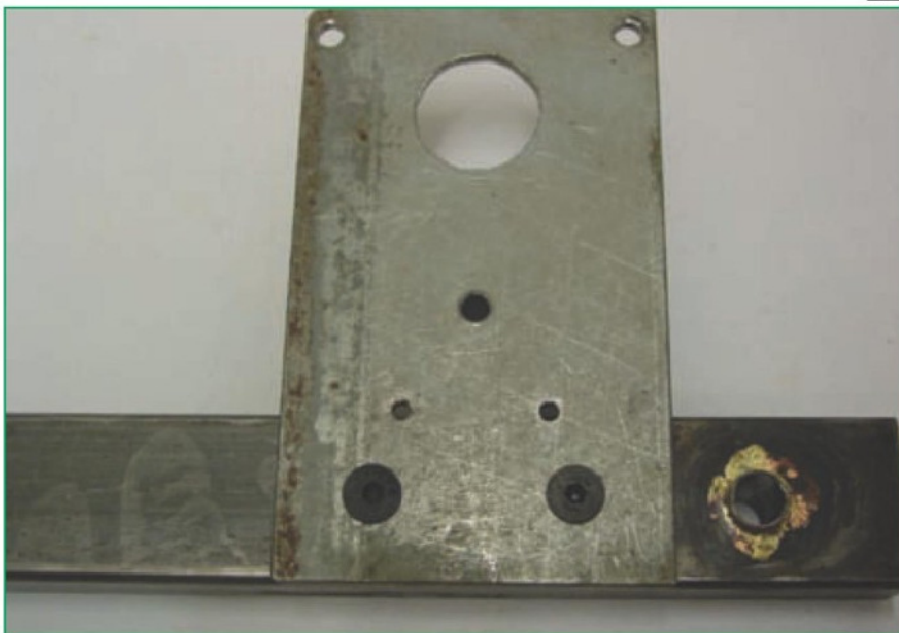


8. Blade mounting fitted to frame.

solid. That's about it for the frame and swinging arm but it's worth having a test run now to check that all runs sweetly. Fit the motor to its mounting plate. Clamp the swinging arm in a vice and slip on the saw frame using a little light oil (3 in 1). Press on the connecting rod. Connect the motor earth lead to the 12 volt power supply earth and touch the other wire onto the positive power supply. It's fairly safe doing

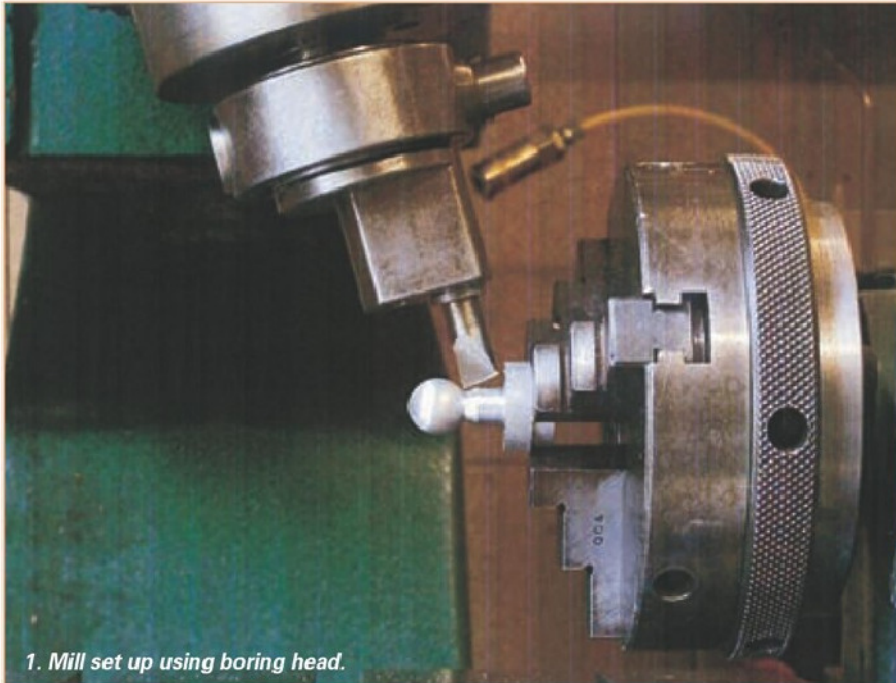
this as we are only playing with 12 volts but be aware that it can kick out a decent spark. If all's well then the frame should move back and forth with no strain. I have to admit it's very satisfying to see it move for the first time.

In the next issue, the second part of the article will deal with the remaining parts, wiring up, and offer some afterthoughts based on experience.



10. Plate completed and fitted to swing arm.

MACHINING BALL GENERATING



Charles Woodward adopts an alternative approach to “ball turning”.

rotating the dividing head (Photo 1 and Sketch 2).

Boring head adjustment

Both my milling head and lathe tailstock have a No 2 Morse taper, so I chucked a piece of steel in the lathe and turned it to leave it a few thou larger than the chord diameter (12.26). I then put the boring head into the tailstock with a boring tool fitted and turned the blank using the tailstock handle as a feed, adjusting the boring head until I had obtained 12.26 diameter. (Apologies to all those who work exclusively in imperial, my equipment is a mixture of metric and imperial. Over the years I have got used to working in both, and nowadays tend to do all my drawing in metric but then use imperial and metric measuring equipment when actually making the parts).

Removing the boring head from the lathe and putting it into the milling machine I locked the table height adjustment and lined the milling head up with the centre of the dividing head. I then brought the boring tool to the centre of the face of the blank. Retracting the boring head I moved the table 0.5mm into the cut (moving the machine table towards the boring tool in order to clean up the front of the ball) and started the milling machine. I fed the boring head into the blank until I thought I had a reasonable cut, locked the milling head and revolved the dividing head through 360 degrees using the worm and wheel manual feed. I then repeated this procedure until I got the correct diameter and the pip on the face of the blank disappeared. And that's it; the ball had been generated using only standard workshop equipment. To satisfy my desire to produce ball handles I made a couple of handles for the Quorn tool and cutter grinder I will one day make one of which is

Background

I have read a number of articles on machining ball handles; every one involves either manufacturing an accessory to turn the ball in the lathe or making a radius form tool with all the problems that brings (making the tool, chatter, etc). An alternative simpler method would be to generate the ball in a milling machine; this method uses standard workshop equipment and does not require any special fixtures or tooling. The inspiration for this idea came from a catalogue I saw some years ago illustrating large ball valves being manufactured on a special purpose machine by using a hollow milling cutter and revolving the component in a chuck, this machine generated the spherical part of the valve by milling. At the time this struck me as being a good way of generating a ball, and although in the intervening years I've had no use for the application in my professional life, (I was a production engineer) the idea stuck.

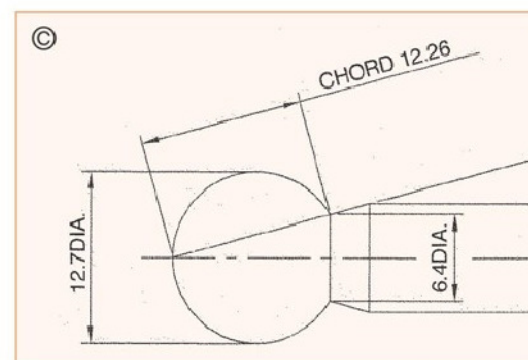
What do I mean by generating a ball? I will give a couple of instances. If a flat surface is milled on a milling machine by fly cutting, then that surface is generated. Also a cylindrical surface is generated on a lathe when turning a shaft. The dictionary definition of generate gives “to trace or form by moving a point, line, or plane in a specific way: circular motion of a line generates a cylinder” (Collins English Dictionary). In other words the cylinder in the lathe is generated by the circular motion of the lathe spindle and the straight motion of the tool slide.

Setting out and setting up

It was while I was reading my copy of the *Model Engineers Workshop*, No 99, which contained an article on machining ball handles that I thought I really would have to put my thoughts into practice and have a go. I first made a sketch of what I wanted to end up with; this was dictated by a likely piece of bar end I had from a previous job. I do all my drawing in AutoCAD, so it was a simple task to measure the chord from the drawing as shown in **Sketch 1**, which shows my chosen approach. It would probably be feasible to use an

increased angle (above 15.13 degrees) in which case a larger cut diameter would be required, (to a maximum of the ball diameter).

As can be seen from the sketch, to obtain a ball of 12.7 dia. with a 6.4 dia. at the chucked end would require my boring head to be set to cut a diameter of 12.26 (the chord dimension) My plan was to hold the 8 dia. in a chuck on a dividing head equipped with a worm and wheel rotary feed (a rotary table will do just as well), mounted on the milling machine table. This would then be locked into place and the ball generated by feeding the boring head into the work at a 15.13 degree angle to give a reasonable depth of cut, and then



ALL HANDLES BY ON THE MILL

shown in **photo 2**. **Sketch 3** is the drawing I prepared to make it. The dotted lines indicate the turned shape prior to milling.

Depending on the care taken during the set up it should be possible to make accurate balls using this method, you will either require CAD software or be capable of calculating the chord to produce the ball.

Sketch 4 shows the dimensions for a 12.7dia. ball, and the calculation is shown below

$$h = r - 0.5 \sqrt{4r^2 - c^2}$$

where r = radius of ball
 $h = 6.35 - 0.5 \sqrt{4 \times 6.35^2 - 6.4^2}$
 $h = 0.8652$

$$\tan \alpha = 0.5c/x$$

$$\tan \alpha = 3.2/11.8348$$

$$\alpha = 15.13 \text{deg.}$$

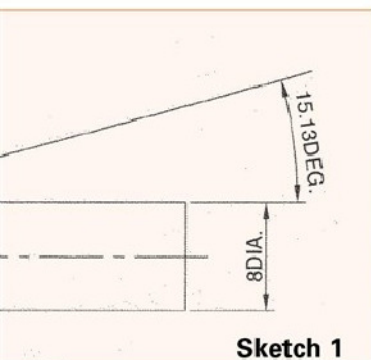
$$\text{chord} = 0.5c / \sin \alpha =$$

$$3.2 / \sin 15.13 \text{deg.} = 12.26$$

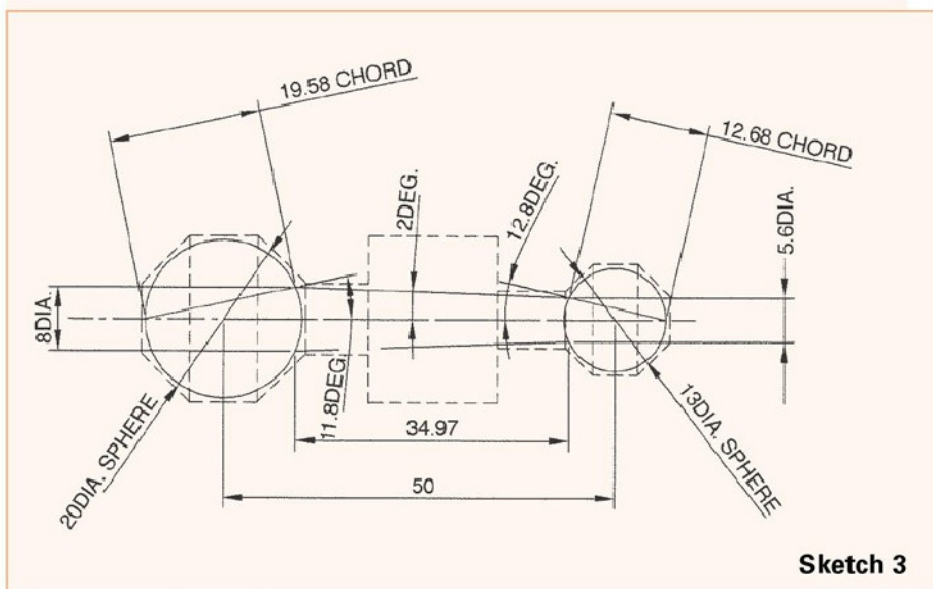
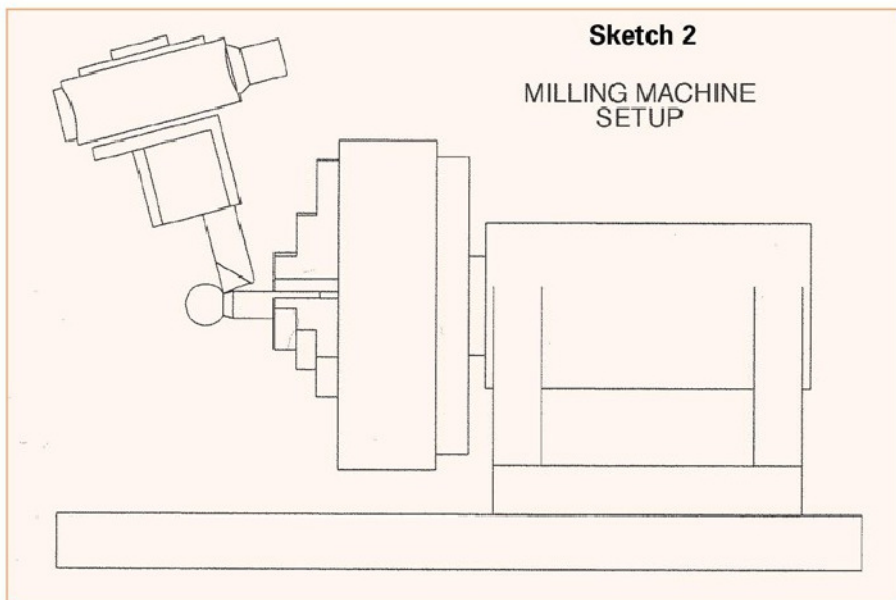
Some may not care for the spiral pattern produced by this method, preferring a normal turned or formed pattern instead. But for those who want to produce balls without making further equipment then this method should fit the bill.

Further thoughts and other applications

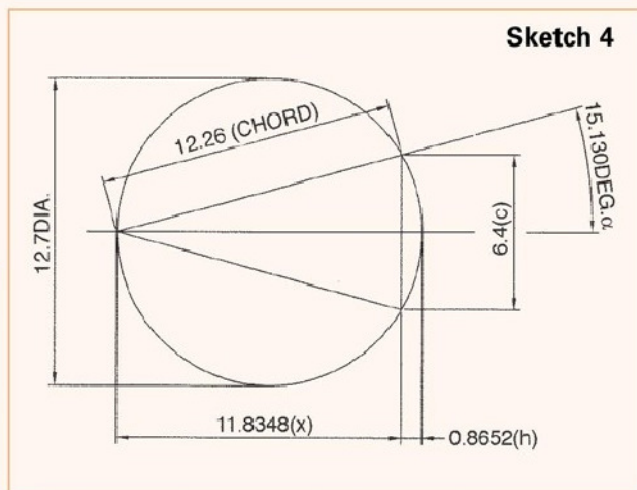
My own interest in this technique was prompted by thoughts of ball handles. However the geometrical principle can be extended, in particular where it is required to machine just a small part of a large radius sphere, such as may be found on locomotive buffers or smokebox doors. Here, the cutter radius would be chosen to be sensibly larger than the component radius (not the spherical radius) and the other parameters calculated to suit. As an afterthought, for generating a nominal half inch ball, it might also be satisfactory to work with a hollow mill of half inch I.D. and use a larger set over the angle, so that the cutter finishes at an equatorial position.



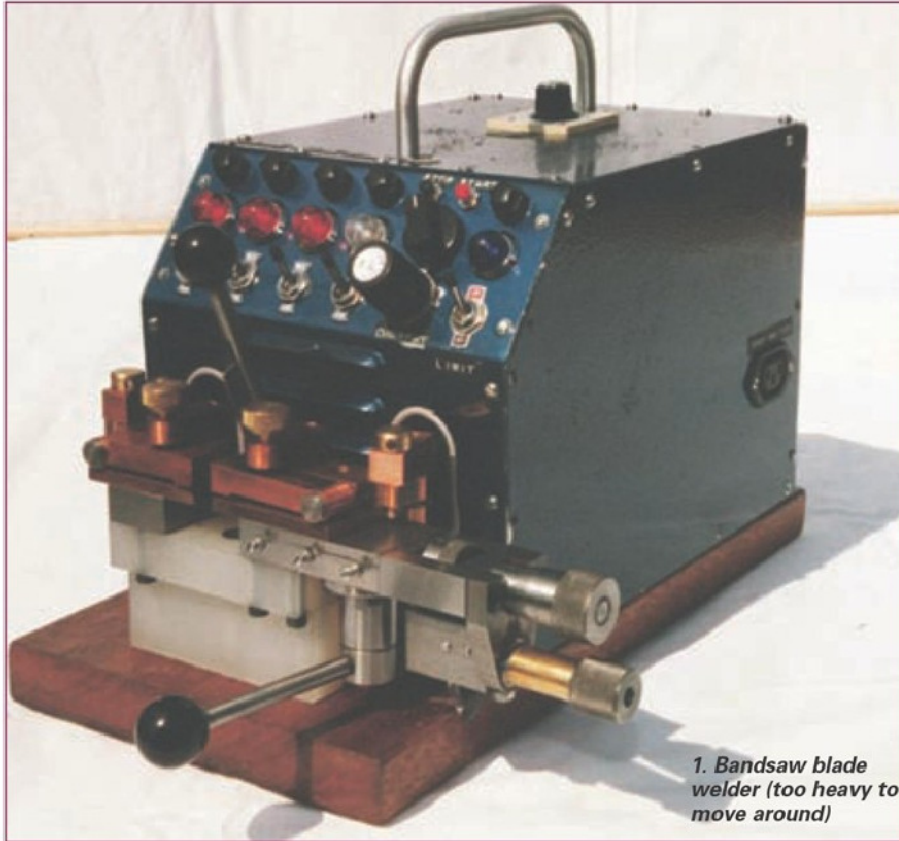
2. Handle with two spheres generated.



©



RESISTANCE SOFT SOLDERING



1. Bandsaw blade welder (too heavy to move around)

The mental prompt

This came about because I was clicking through the television channels one evening and came across a programme on building miniature steam locomotives in brass sheet. Whilst I was watching this, the programme covered something new to me, which prompted some head scratching and subsequent experiment.

In order to soft solder the steam dome on to a 00 gauge loco, a method was employed which utilised a resistance soldering technique being carried out on what appeared to be proprietary commercial equipment. The process bore

some similarities to spot welding. I presume that these types of soldering aid are available commercially, but have no direct knowledge of them. If other readers know more then they might care to write via Scribe a Line.

I decided to have a go on a self build basis, and see what might be required.

Equipment to hand

My first thoughts were to build a power supply specially for the application, but as it is not the type of equipment that I would use regularly, I therefore started looking at equipment that was already to hand and that could be modified to suit this particular duty.

Measurements and experiments conducted by Peter Rawlinson

First thoughts

I have a number of pieces of equipment that will give off low voltage and high current, and the first of these is the "Band saw blade welder". Now this will give off a maximum of 1500 Amperes at about 2.5 Volts but is fully adjustable down to very low currents. However as it is rather heavy to move about, this idea was quickly put to one side.

My next thoughts centred around a 140 Watt instant heat soldering iron made by "Weller Electric Ltd". This comprises a mains powered coil which is wound around a "U" shaped brass rod of 9.5 mm dia. The soldering tip is then attached to this by two hollow screws. I decided to check and find out the output voltage and current that it was capable of delivering. To this end an analogue meter was attached, set at a very low voltage and to my surprise no reading was shown. I then decided to check the current, now this is more complex, but I have a "Clamp Meter". This is not an amateur piece of equipment but was purchased many moons ago in Saudi Arabia to fault find some heavy electrical circuits that were giving trouble. This meter will measure the current flow in a single cable and is capable of (in my case) of measuring up to 900 amps. Using test prods, it will also measure voltage up to 750 volts and also ohms.

To be able to use these meters it is necessary to fit the clamp around a single conductor, so I bent the solder tip into something approaching a circle to accommodate the clamp. The meter was then set to its highest current level and the iron switched on. After a few adjustments it was found that the current draw for the tip was 220 amps. This of course did not equate with the no volt measurement that was taken earlier, as using ohms law the voltage reading calculates as 0.636 volts.



2. Carbon rod used as electrode



3. Clamp meter



4. Ribbon cutter



5. Ribbon cutter power supply

Second thoughts

Some 18 years ago I came up with a safety device for automatic shot guns. This worked well and approximately 3000 were sold, I even had a visit from a Lieutenant Colonel in NATO and I started to have visions of the Rolls Royce parked outside the mansion. But alas, this was not to be.

Anyway this device incorporated a one inch wide ribbon which was an acrylic type material which if cut by scissors frayed at the ends and kept fraying. I found that it was necessary to cut this hot. This then sealed the ends during the cutting process. A company was found that imported a cutter of this type and one was purchased. This comprises a power unit which is controlled by a trigger switch on the cutter, then the remainder is similar to the "Weller" except that instead of having a soldering tip, it has a cutting blade. I then modified this to be able to measure the current by separating the cables. This then allowed me to use the clamp meter applied to a single cable and take the measurements as before.

The power rating was found to be very much higher. The current was shown as being 450 amps and the voltage measurement as 0.6 volts giving an output of 270 watts. I therefore decided to try this.

Modifications

Minimal changes were needed as the basics were already in the control box. The first add-on was a foot switch (already used on the bench drill), and as this was already fitted with a plug, the only additional requirement was a socket and a toggle switch. The other modification was to have the power cables interchangeable so the device could be used in either guise. The only real problem was the banana plugs, which are not available above 32 amp rating, so they were fitted in pairs. This of course is still vastly over rated but they will be conducting for only a few seconds at a time and probably used no more than two or three times in an hour. Any way the proof of the pudding is in the eating and I have used it much harder in my trials than would ever be encountered in real life and no over-heating or problems have been experienced.

First use

This was carried out by holding the cable end on the top of the screw but subsequently a carbon rod was used.



6. Successful soldering

These are available from Machine Mart, who supply them for use in twin carbon brazing torches.

Operation is simplicity itself. One lead is fitted to the job. The second lead has a small holder which is fitted with a carbon electrode. On the television programme, the demonstrator used solder paste but I did not have this so my experiments were carried out using standard multi core. A small amount of flux was put on the plate, the screw put on this and the electrode pressed on to the top of the screw, the foot switched depressed and after a few seconds the solder applied, and that was it. I did have some failures where the screwed shank of the bolt became red hot, and I think it would in some cases pay to partially machine away the contact surface of the head away to give a smaller area which would act as a spot connection. This would then be similar to the method used for stud welding (sizes around M6 for sheet metalwork, and rather larger for structural work on bridges).

Home build

To make the power source is simple if a suitable transformer is available. This should have a primary coil power rating of say 200- 300 watts. The difficulty is the secondary as this requires to be typically a single turn of cable having a cross section of some 25 square mm. Some transformers may have sufficient space to wind this over the existing secondary. If not then the secondary will have to be removed. This is easier said than done.

The next and the best idea is to find a small transformer manufacturing company who would be willing to wind the primary and to supply the laminations. This can then be assembled and the secondary added.

Control

Bear in mind that a small relay will be required for the foot control (or as a last resort, hand switch) as both hands will be wanted for the manipulation of the holder and part. This will require its own power supply which would be dependent on its own particular coil requirement, and therefore a second small transformer will be required.

Safety

This must be borne in mind and the unit fused or fitted with an overload trip.

The above will I hope give food for thought, and I know our editor David has carried out some trials of his own, which I



7. Automotive spot welder

understand will be added to this article. If I can be of help I am happy to do so but phone only please and I will not ring back for obvious reasons.

Peter Rawlinson, Charing, Kent.
01233 712158

Dave Fenner adds:

After talking to Peter about this procedure, I started to wonder about equipment that I had in the workshop, which might be applied to give a similar result. Like Peter I have one of these "instant" soldering irons, but something giving rather more in terms of power is a hand held automotive spot welder. A quick look at the rating plate indicated that peak current could be 8000amps.

This has one or two advantages in that on mine, power control is set by two dials, the first for level, the second for number of pulses. These for spot welding give the range of control needed to join a variety of gauges of material. In addition, switching on takes place automatically as the contacts are closed on the job. Power is then delivered at the level and for the number of pulses previously set. A further adjustment sets the amount of compressive pressure applied to the work during welding.

I did have a small pot of soft solder paste (something that has been on the shelf for around thirty years) but comes in handy every now and again. For a quick trial I cut some strips of 20 gauge brass and applied a little solder paste. The first attempt used too much pressure and too much heat, causing indentation of the brass. Reducing power to almost the minimum with just one pulse, and the pressure to a lighter setting resulted in quite a tidy joint, with melted solder visible at the edges of the contacting surfaces.

As yet, I have not needed to use this new-found technique, which for "stud welding" situations would require careful jiggling but it may well be that a variation on the theme might prove useful in the construction of brass loco tenders in a variety of gauges, perhaps for the initial attachment of half round strip etc.



8. Soldered brass strips with only minor marking to the surface.

A DAY OUT AT LEAMINGTON SPA

Tony Jeffree visits The Fosse



Many of us who heard last year that Donington was unlikely to be the venue for future Midlands Model Engineering exhibitions, and that they were to move to extended exhibition space at "The Fosse" – Tee Publishing/Meridienne Exhibitions' home base near Leamington Spa - greeted this news with interested speculation as to what the new venue would be like, whether there would be enough room, and exactly how many tractors would be on hand to pull the cars out of the mud. So it was with great interest that I set off from Manchester last Friday at dark o'clock in the morning in order to get there before the stampeding hordes.

Location

The Fosse is a good bit further than Donington if you come from the north, so even though I thought I had left plenty of time, it was about 9AM when I arrived after a very pleasant drive through the Warwickshire countryside for the last half hour or so. The location is certainly streets

ahead from the scenic point of view – very rural, with the sound of the occasional cow pleasantly replacing the sound of tortured engines and rubber on tarmac that we were familiar with from the Donington track.

Inside, the exhibition space is split across two types of accommodation – the original exhibition hall, and a large area of additional exhibition space covered by a "temporary structure" – a very sophisticated marquee built on a substantial looking galvanised steel structure that looked to my eye to be anything but temporary, covered in a heavy duty plastic tent material with inset "window" panels in the roof sections. The "windows", plus the naturally translucent covering material, meant that these areas were pleasantly light and airy – definitely an improvement over the rather gloomy hangar feel of the Donington hall. The canteen arrangements were also a pleasant improvement over Donington, but with the notable omission of a bar – the cafe did have a stock of canned beer though.

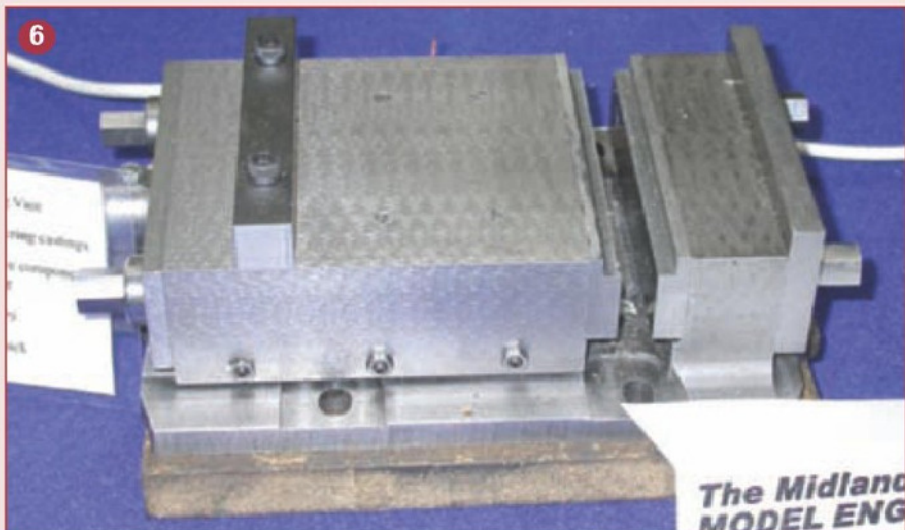
Workshop equipment on show

The SMEE had their usual live demonstration going in one corner – a rather smaller affair than at previous shows. Giles Parkes was there demonstrating hobbing, and there was a particularly shiny example of a Quorn at one corner of the stand (photo 1).

Photo 2 shows an interesting 4-jaw chuck by Keith Harrison in the competition entries – this was constructed by hacking a 5in. Chinese 4-jaw chuck into 4 pieces and attaching each of them to the end of substantial extension arms, in turn attached to a lathe faceplate. The notes suggested a max capacity of 18in. diameter over the gap of a Warco GH1330 lathe.

Photo 3 shows a very nice example of a "freelance" back-geared screwcutting lathe by Philip Arnold. I have nothing but admiration for people that can produce tools to this kind of quality, but I have to say there is always the sneaking question, "Why?", in the back of my mind, given what can be bought at





budget prices from the tool suppliers these days.

Photo 4 shows a very interesting work-holding "chuck" by Keith Harrison. The idea is that you install a variety of posts of different sizes in the pattern of holes, so as best to support oddly shaped workpieces. Some of the posts have screws fitted to lock the part against the others. A useful idea that most of us could have done with in our workshops at some time or another.

Photo 5 shows a "Clark tool chest" by Dave Piddington, containing a 5in. rotary table of his own design, a George Thomas headstock dividing attachment (see page 20 for an article on my CNC version of this device), a George Thomas dividing head, and a tailstock to match. All made to a high standard, and beautifully fitted into the tool chest.

Photo 6 shows a milling vice made from castings from College Engineering by Peter Spick. The information card indicated that it had been "modified to improve component holding", which sounds like a laudable goal for a vice. It was not immediately obvious to me what the modifications were, but these may have been along the lines suggested by Harold Hall.

Photo 7 shows a part-finished cross slide and top slide by Philip Arnold. Maybe we will see the finished article next year?

Photo 8 shows another excellent Quorn, this time by Martin Gregory, nicely painted to almost blend in with the tablecloth.

Again, I am amazed at the sheer hard work and dedication that goes into producing tools to this kind of standard.

There was also an exhibit based on the contents of George Thomas's workshop, which was fascinating to see – all of the old favourites in one place; however, as this was all enclosed within a glass case, I couldn't get any decent photos of it as the flash produced reflections in the glass and obscured the contents.

Whilst I had heard that Warco are now selling a CNC mill, unfortunately it was not on show this time, possibly due to pressure on stand space. However I believe the mill it is based on is the one shown in **Photo 9**.

Engineers Toolroom had a live demonstration of a CNC mill, shown in **photo 10**, based on the X3, using motor mounts made from aluminium castings, size 34 stepper motors, a stepper controller system based around Gecko stepper drives, and Mach 2 software for the control.

Last but not least, I can't resist putting in a plug for my own product – the DivisionMaster automatic indexer, shown in **Photo 11**, set up on the bed of one of Arc Eurotrade's X1 mills. Arc have kindly agreed to act as distributor for the product, which meant that for the first time for a few years I could actually look round the show at my leisure; a very pleasant experience, and at the end of the day, no tractor needed for the exit!



Scribe a Line

Bill Morris writes:

I am sure many readers will want to make Dick Stephen's centring microscope (Issue 106). It can be used not only as a centring microscope but, with suitable illumination on a milling machine, as a poor man's toolroom microscope when forming small but complex shapes. Those who buy the Hemingway kit will no doubt get all the correct optics, but those who attempt to buy the items separately for themselves may make expensive purchasing errors.

Starting at the sharp end, a new 40 mm focal length microscope object may be not only hard to find but also very expensive. In this application, any achromatic lens of 40 mm focal length will do.

To turn the light rays through 90 degrees a prism silvered on its hypotenuse is specified. This is a relatively expensive solution and a piece of front surface mirror about 10 by 16 by 3 mm thick would do just as well. A front surface mirror is silvered on the front and you can tell which is the front by touching it with a finger nail, when the nail and its reflected image will touch without a thickness of glass between them. Next least expensive is a plain prism which will need to be rotated through 180 degrees to that shown in the GA drawing, so that the light enters through one 90 degree face, is internally reflected off the hypotenuse face and leaves through the other 90 degree face.

Perhaps more important than either of these two is the choice of eyepiece. If you ask for a microscope eyepiece you will almost certainly get a Huygens eyepiece and these are quite unsuitable as their focus lies internally between the field and the eye lenses; and you will not be able to get an image of the graticule. You could mount the graticule internally, at the focus of the eye lens but at the cost of chromatic and other aberrations affecting your view of the graticule. You should specify a Ramsden type eye piece, or one of its achromatic derivatives such as a Kellner. These have their focus just in front of the field lens. A good source of a cheap eyepiece is an inexpensive plastic/rubber 8 x 20 telescope, such as is found on many a market stall for a few pounds, but you will have to take it apart and remount the lenses in the same orientation and distance apart as you found them.

For attaching glass to metal, Dick has specified beeswax. This works, but a 50:50 mixture of beeswax and rosin gives a firmer hold which can be used as a permanent fixative. You melt the mixture together and cast it into little sticks. The parts to be joined are gently heated until a touch with a stick just melts the mixture, when the parts are placed together and allowed to cool.

An excellent source of surplus optical parts is www.SurplusShed.com. Their lens, part number L2057 would do for the

objective. They have suitable prisms, part numbers L3124 and L3154, though for a quarter of the price (\$US1.50) you could get a piece of front surface mirror 25 x 20 mm, part number L3206.

John Buckley Golder of Lichfield writes:

I refer to *MEW* 104 page 18, Harold Hall's article on threading, in which he states that you need to have the Coventry die head tail stock mounted. This need not be the case. I regularly use mine mounted in the spare single toolpost holder that came with my Colchester 2000. The tool post was bored in situ and reamed to suit the tail end of the die holder. Now I just square the face of the die head to the chuck face, line it up using the tail stock, so now when I am cutting threads I use the apron hand wheel to assist traverse and apply slight hand pressure to stop the forward travel on completion of the thread, this opens the die head and allows me to back off ready for the finishing cut. I have cut 18in. of $\frac{1}{2}$ in Whit using this method, which would not be possible if the die head was tailstock mounted. I read the article with interest and found it very instructive.

I bought my die heads for £25 each and went to a factory sale and bought more boxed sets of cutters than I could carry for £30. I did learn one lesson at the sale when you have bought anything, if its small don't turn your back for it will not be there when you look again.

Mr N.R. Martin of Ipswich writes:

I write to thank Mr Ian Dawson (*Scribe a Line* Issue 108) for solving a mystery for me, (being a fan of the late Martin Cleeve) why the EW lathe articles stopped in 1960. I am aware that Martin and Edgar "crossed pens" more than once, on castings or fabrication etc.

I must mention that I am a very slow worker, so have just started to construct a top slide to the Cleeve design. Some time lag! My workshop does not include a Myford or E.W. lathe (wish it did), but I have made a number of the Martin Cleeve accessories, including saddle stop, long steel tee slotted cross slide, etc. and started a rack feed tailstock. These are all for my very old lathe which is possibly part Drummond and part home made by a previous owner.

One unusual feature is that the cross slide gib is adjusted by screws set vertically in the saddle. The headstock design is identical in all respects to that shown in Percival Marshall's book "*The Beginner's Guide to the Lathe*" page 13.

Peter Shepherd of Victoria, Australia writes:

I am planning to make a compensating pendulum of the grid type for a Vienna regulator wall clock using steel and aluminium rods in its construction, aluminium having approximately twice the thermal linear expansion rate of mild steel.

However I would prefer to use stainless steel rather than mild or silver steel, but none of my references relate to the thermal properties of stainless. Consequently, I would appreciate it very much if any of your contributors or readers could advise if there is any significant difference in the rates of expansion of normal and stainless steels.

Dave Fenner comments:

I looked first at my old copy of Machinery's Handbook and found no relevant comparative data. Next stop was Tubal Cain's "Model Engineer's Handbook which does give figures for both mild steel (0.0065) and stainless steel (0.0059). In each case this is thous per inch (or microns per millimetre) per degree Fahrenheit rise. No detail is given concerning the specific grade of stainless. If other readers can offer more detailed information please let us know.

Mr John Rutter writes:

I bought a copy of your magazine this morning as I was interested in the article on DIY CNC milling. It certainly provided food for thought as I greatly miss the use of the CNC milling machine I introduced to the school I work at when not ill.

This particular machine is a STEP 4 (Austrian - <http://www.step-four.at/>) which, at around £2,000, is a bargain in terms of CNC in general, especially as it has a cutting area of 1,000 x 430mm but is a little expensive for the home workshop. One problem we had with it was the noise of the 240v router we used as the cutting tool. This was eventually replaced with a much quieter £15.00 Dremel clone that was accurate enough for the schoolboy projects undertaken but not until we'd experimented with almost silent brushless motors mentioned in Chris Fouweather's article.

We tried out a MEGA 22/20/3 (22mm diameter rotor, 20 mm long with 3 turns of wire) brushless motor with adaptor to enable it to fit the CNC machine (yellow acrylic - well it was handy!) and a simple aluminium adaptor to go from the 5mm motor shaft to the 3mm shaft of the tools we were using. It worked very well indeed but there were limitations with power supplies (brushless controllers don't like

power supplies, only batteries according to their instructions), lead length (generally over 300 mm can cause controller problems again) and overall cost of the system within the school budget (about £100 at the time but things are cheaper now) so that its use never passed the experimental stage.

As positioning speed on this sort of stepper motor machine is very slow, I'd be very interested in a system using faster servo motors (model aircraft types are powerful and cheap) if any readers know of any such device.

Ian Moignard of Jersey writes:

I found Bill Morris's article "Moving Workshops" (MEW Issue 109) most interesting and it prompted the thoughts that follow.

An option not mentioned by Mr. Morris would be to hire a self-drive box van or a small lorry, equipped with a hydraulic tail lift, allowing those of us who have to move our workshops to do so without the undesirable and time-consuming task of dismantling and re-assembling our machines into hernia-inducing pieces. All the equipment described in the article could be moved in a single journey for the cost of a day's hire. Self-drive would keep the cost down and a box van would keep the machinery dry. A manual hydraulic pallet mover (pallet truck) could be hired and would be suitable for moving the machines pictured to and from the van provided that those with a high centre of gravity are strapped to the pallet truck's forks to reduce the risk of toppling.

The slats on many pallets are not sufficiently strong to support the concentrated load presented by machinery and some pallets have only cubes of timber between the top and bottom slats (to enable fork entry from any side) which would be unlikely to line up with even two of a machine's bolt holes. In preference to using pallets, the machines could be prepared in advance by bolting two lengths of, say, 4in. x 4in. timber across their holding down bolt holes, having raised them sufficiently with a crowbar, to enable access for the pallet truck. Coach screws could be used to easily secure the machine to the timbers; otherwise the bolt heads or nuts on the underside of the timbers should be recessed to prevent slipping on the floor of the van. If the machines can be adequately secured within the van, there may be no need to secure them to their supporting lengths of timber, though I thoroughly agree with Mr. Morris's warnings about adequately securing cargo against movement. A sack truck is very handy for smaller items and would avoid the struggle of dragging heavy boxes along the ground.

If we are determined to use our car trailers (and I wouldn't wish to be without mine) then strengthening the trailer floor by laying a sheet of 3/4 inch ply on it is strongly advisable – this also serves to reduce the likelihood of sliding associated with metal-to-metal contact as seen in Mr. Morris's photo 7, though I think in his photo 2 he has wisely used ply under his milling machine pedestal.

I'm not keen on all the manual lifting and struggling mentioned, nor do I like the idea

of slinging lifting tackle from the roof trusses in his new workshop, which I'm sure would inflict apoplexy on the truss designer, even if one were to take the precaution of spreading the load across several trusses with a wooden beam. A steel beam could be installed to span the walls of the new workshop, but why not build a portable lifting gantry? Construction would take less time than the dismantling and re-assembly of all the machines, and the gantry would be available for future use. It should be wider than the trailer so that the trailer can be reversed under it for loading and unloading. If the A-frames are bolted to the beam, not welded to it, the gantry can be disassembled to be shuttled between loading and unloading sites. A de-luxe version would have castors. I would recommend a lever hoist in preference to a chain block because keeping the gipsy chain from damaging the load is a chore and, should the need arise, a lever hoist can be used horizontally more easily than a chain block.

Colin Long of Chigwell writes:

I have read with interest the "Moving Workshops" article in this month's issue of MEW and congratulate Bill Morris on undertaking such a task. However, he does not mention anything about the electrical side of the new workshop and it looks as though everything is brand new.

Unfortunately for many of us who feel quite capable of covering the electrical installation of a new workshop, the European Parliament bureaucrats say that we are not and since the 1st of January, 2005, any electrical installation from the provision of a wall mounted power point upwards must now either be performed or inspected by a "competent person".

This competent person must hold a current qualification obtained through study of an approved course and the successful passing of an examination at the end of the course. The qualification needs to be renewed annually. If you undertake any installation yourself and are not qualified, then you must provide details to your local authority who will then send a competent person to inspect and either pass or fail your work.

This is law, and any deviation could result in criminal charges being brought let alone your insurance company refusing to process any claim raised against such an illegal installation.

Don't curse me, blame the bureaucrats!

Mr Tom Smith of Stockport writes:

Following publication of my letter in a recent issue, giving details of the powered cross and topslide arrangements, I have been able to track down the earlier letter which prompted me to build the half nut release arrangement which I also described. It came from Mr J.A. Lewis of Birmingham, and appeared in issue 99. Again my thanks to Mr Lewis for an excellent device.

Chris Strawford writes

It is often said that the test of good

service is not when things go right but when problems arise. For me, Boost Energy Systems, and David Sharman particularly, passed this test with flying colours. I bought a Boost phase converter after reading an excellent article in MEW, and after some months it 'went sick'. I rang David and received nothing but helpfulness - no blame the customer; no 'we've never had this happen before'. In fact, no quibbles at all. The converter was sorted in double quick time and back into service.

Congratulations on the magazine, it maintains the information and interest balance between beginners and the experienced extremely well.

Mr K. A. Willson writes:

Re MEW 109, Myford Seven Shear Scraping

I must comment upon John McIntosh's assertion that "It was assumed that the shear gap could be taken as a datum in terms of straightness as well as dimension"

Not true I am afraid with a well-used machine. With the ML 7 and early Super 7's (I have both as well as a late Super7) it is the back shear rear face that is both unused and a good reference. The tailstock will wear the inside faces of the shears at the tailstock end and the saddle wears both the front shear front face and the front shear rear face towards the headstock end. The front face of the rear shear determines the headstock alignment, or at least that part under the headstock so ensure that visible rear shear remains at a constant width.

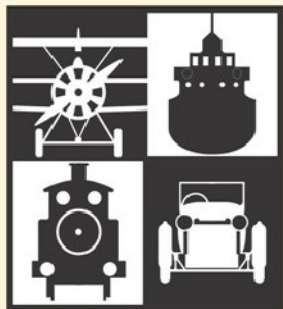
The guide under the saddle itself wears at each end dependant upon how you set up the saddle front gib strip as well as the loads imposed on the guide and gib during traversing. This guide can be far from straight and will need attention. Measurement over the back face of the back shear rear to front face of the front shear will show the wear occurs largely at the headstock end. From this you correct the front face, and then you correct the width of the front shear.

You will also need to take note that any correction may affect the relationship of the clasp nut to the lead screw in the front to back plane and if you need to correct the tops of the shears, in the vertical plane as well. The clearance around the cap head screws is such that minor corrections, front to back, can be made without problems.

Remember the old adage, measure at least twice before you cut, you cannot put it back on again once removed!

John McIntosh replies:

The dimensional survey showed that the shear gap was constant at 1.385in. over the length of the lathe bed, and the gap surfaces showed no signs of wear. On this basis it was pragmatic to use the gap surfaces as datum. If the dimensional survey had shown variation in the gap, then the method suggested by Ken Willson would be appropriate.



THE MODEL ENGINEER EXHIBITION

Please return completed form to:
Model Engineer Competition, The Leys,
Church St., Twyford, Bucks. MK18 4EU

ENTRY NO.

OFFICE USE ONLY

CLASS	ENTRY NO.

ENTRY FORM - COMPETITION & LOAN MODELS

PERSONAL DETAILS (Please print)

Surname Forename(s) Age

Address

.....

.....

Post Code Home Tel: Daytime Tel:

Model Club or Association

Have you entered before? (Y/N)

Do you purchase or subscribe to a Highbury House Communications plc magazine? (Y/N)

How many years have you been a modeller?

Mail Order Protection - please tick this box if you would prefer not to receive mail from other companies which may be of interest to you ☐

MODEL DETAILS - PLEASE TICK BOX IF MODEL IS FOR LOAN ☐

Entry Class (competition entries only)

Model Title (to be used for catalogue and display card)

.....

Model Description

.....

.....

Model Scale Length Width Height Weight

Type of construction

.....

Parts not made by you and commercial items.....

.....

Have you supplied a photograph? (Y/N)

Are you supplying Judges Notes? (Y/N)

Value of model (Highbury House Communications plc will not insure the model unless a value is entered) £.....

Name and address of local newspaper

.....

TO HELP YOU GET THE BEST FROM THE MODEL ENGINEER EXHIBITION

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

If the item is offered as a Loan exhibit please indicate this by writing Loan on the form in the box identifying the Class. Loan models are not judged but carry all other privileges associated with competition entries. Part built models are particularly welcome in the Loan Section; visitors like to see work in progress, and entry does not preclude the item being entered in competition when completed. The classes listed below are those associated with mainstream model engineering.

Club exhibits

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

Additional forms

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

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

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

COMPETITION CLASSES

Engineering Section

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

Railway Section

- B1 Working steam locomotives 1in scale and over.
- B2 Working steam locomotives under 1in scale.
- B3 Locomotives of any scale, experimental, freelance or based on any published design and not necessarily replicas of full size prototypes, intended for track duties.
- B4 Scratchbuilt model locomotives of any scale, not covered by classes B1, B2, B3, including working models of non-steam, electrically or clockwork powered

steam prototypes.

- B5 Scratchbuilt model locomotives gauge 1 (10mm scale) and under.
- B6 Kitbuilt model locomotives gauge 1 (10mm scale) and under.
- B7 Scratchbuilt rolling stock, gauge 1 (10mm scale) and under.
- B8 Kitbuilt rolling stock, gauge 1 (10mm scale) and under.
- B9 Passenger or goods rolling stock, above 1in scale.
- B10 Passenger or goods rolling stock, under 1in scale.
- B11 Railway buildings and lineside accessories to any recognised model railway scale.
- B12 Tramway vehicles.

Marine Models

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

Scale Aircraft Section

- D1 Scale radio control flying models
- D2 Scale flying control-line and free flight
- D3 Scale non-flying models, including kit and scratch-built
- D4 Scale flying radio controlled helicopters

Model Horse Drawn Vehicle Section

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

Junior Section

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

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

Model Vehicle Section

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

DUKE OF EDINBURGH CHALLENGE TROPHY

Rules and Particulars

1. The Duke of Edinburgh Challenge Trophy is awarded to the winner of the Championship Award at the Model Engineer Exhibition.
2. The trophy remains at all times the property of Highbury House Communications PLC.
3. The name of the winner and the date of the year in which the award is made will be engraved on the trophy, which may remain, at the discretion of Highbury House Communications PLC in his/her possession until required for renovation and display at the following Model Engineer Exhibition.
4. Any piece of model engineering work will be eligible for this Championship Award after it has been awarded, at The Model Engineer Exhibition, a Gold or Silver medal by Highbury House Communications PLC.
5. No model may be entered more than once.
6. Entry shall be free. Competitors must state on the entry form:
 - (a) That exhibits are their own bona-fide work.
 - (b) Any parts or kits that were purchased or were not the outcome of their own work.
 - (c) That the model has not been structurally altered since winning the qualifying award.
7. Highbury House Communications PLC may at their sole discretion vary the conditions of entry without notice.

COMPETITION RULES

1. Each entry shall be made separately on the official form and every question must be answered.

2. Competition Application Forms must be received by the stated closing date. LATE ENTRIES WILL ONLY BE ACCEPTED AT THE DISCRETION OF THE ORGANISERS.
3. Competitors must state on their form the following:
 - (a) Insured value of their model.
 - (b) The exhibit is their own work and property.
 - (c) Parts or kits purchased.
 - (d) Parts not the outcome of their own work.
 - (e) The origin of the design, in the case of a model that has been made by more than one person.

NOTE: Entry in the competition can only be made by one of the parties and only their work will be eligible for judging.

4. Models will be insured for the period during which they are in the custody of Highbury House Communications PLC
5. A junior shall mean a person under 18 years of age on December 31st in the year of entry.
6. Past Gold and Silver medal award winners at any of the exhibitions promoted by Highbury House Communications PLC are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy.'

Past winners at any of the exhibitions

promoted by Highbury House Communications PLC, will not be eligible for re-entry into the competition unless it has been substantially altered in any way.

7. Highbury House Communications PLC reserve the right to:
 - (a) Transfer an entry to a more appropriate class.
 - (b) Describe and photograph any models entered for competition or display and to make use of any such photographs or descriptions in any way they may think fit.
 - (c) Refuse any entry or model on arrival at the exhibition and shall not be required to furnish a reason for doing so.
8. Entry into the competition sections is not permitted by:
 - (a) Professional model makers.
 - (b) Anyone who has a financial interest in the direct supply of materials and designs to the public.

NOTE: If unsure, please contact the Competition organisers, prior to the show.

9. The judges' decision is final. All awards are at the discretion of the judges and no correspondence regarding the awards will be entered into.
10. Exhibitors must present their model receipt for all models collected at the end of the exhibition and sign as retrieved.
11. The signed release for each model must be presented to security staff when leaving the exhibition complex with display model(s) after the close of the exhibition.

IMPORTANT NOTE PLEASE MAKE COPIES, INCLUDING PHOTOGRAPHS, OF ALL INFORMATION RELATING TO YOUR MODEL, AS Highbury House Communications PLC WILL NOT ACCEPT LIABILITY FOR ANY LOSS.

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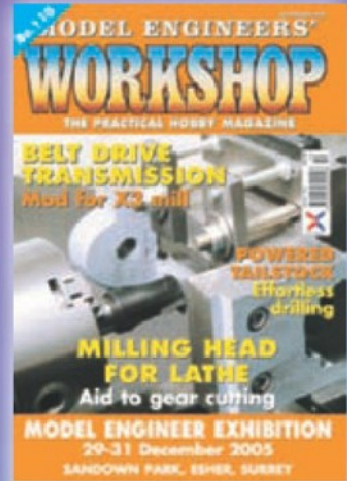
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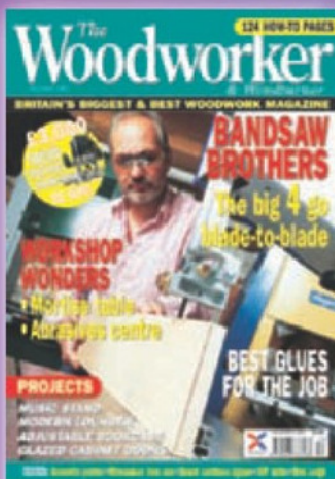
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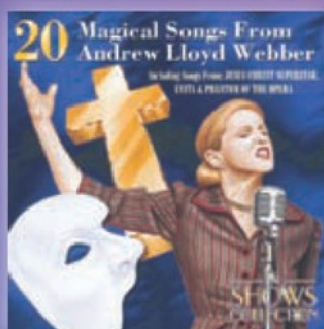
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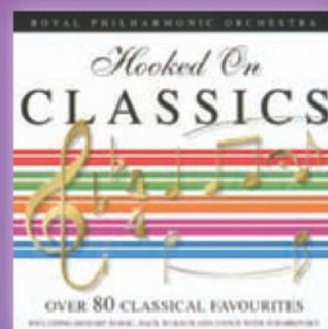
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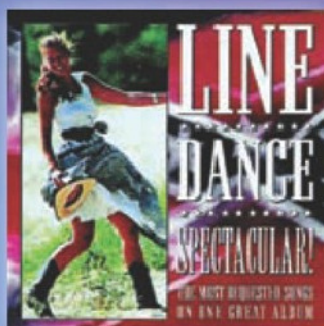
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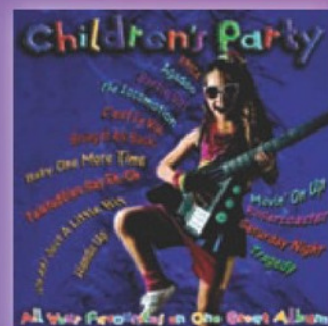
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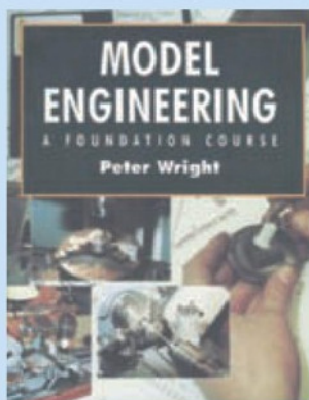
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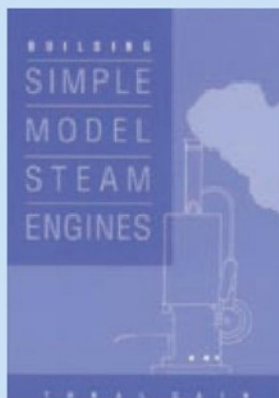
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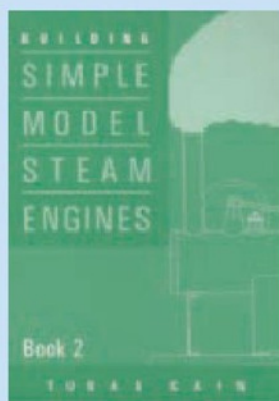
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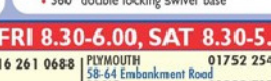
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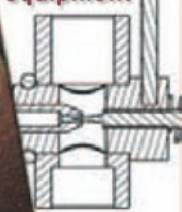
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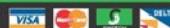
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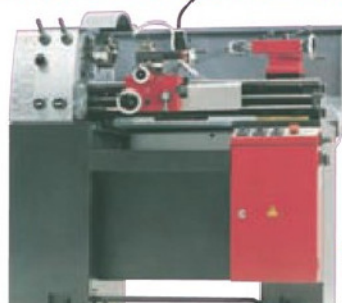


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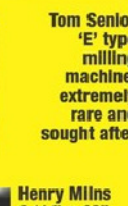
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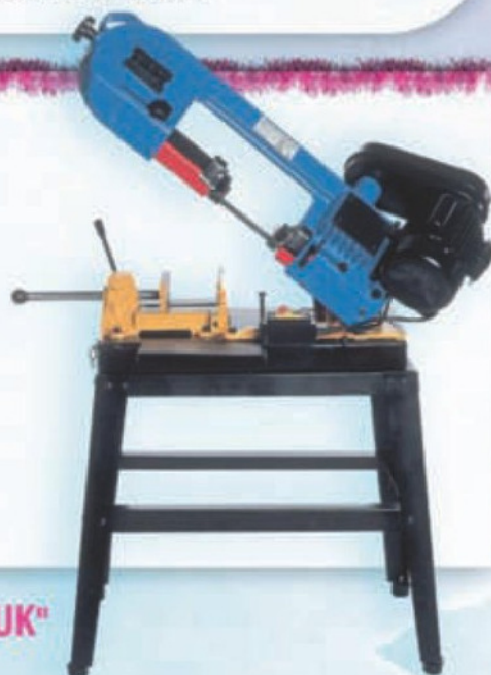
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