

No.120

NOVEMBER 2006

# MODEL ENGINEERS' WORKSHOP

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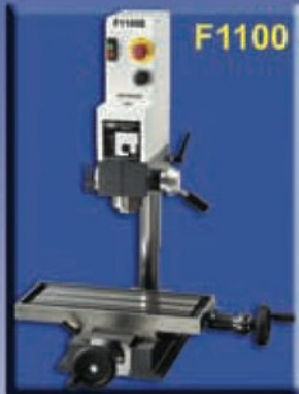


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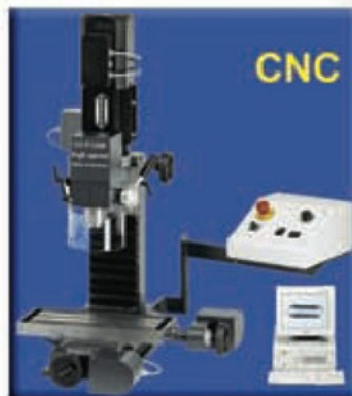
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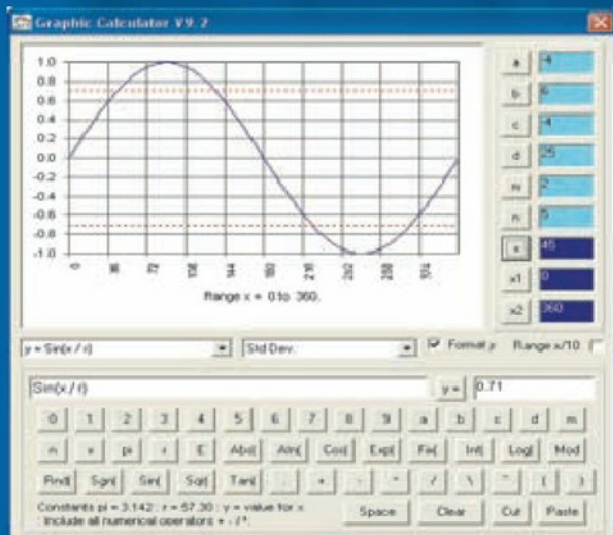
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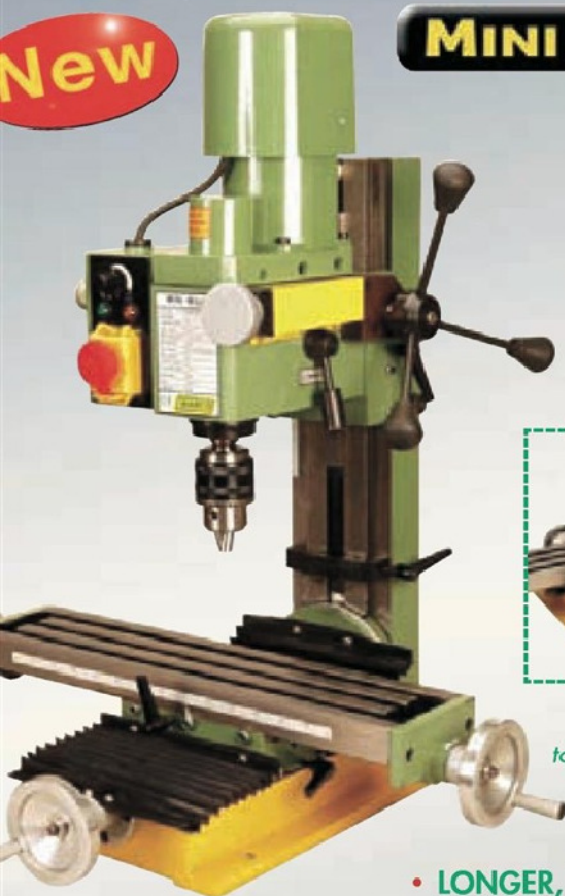
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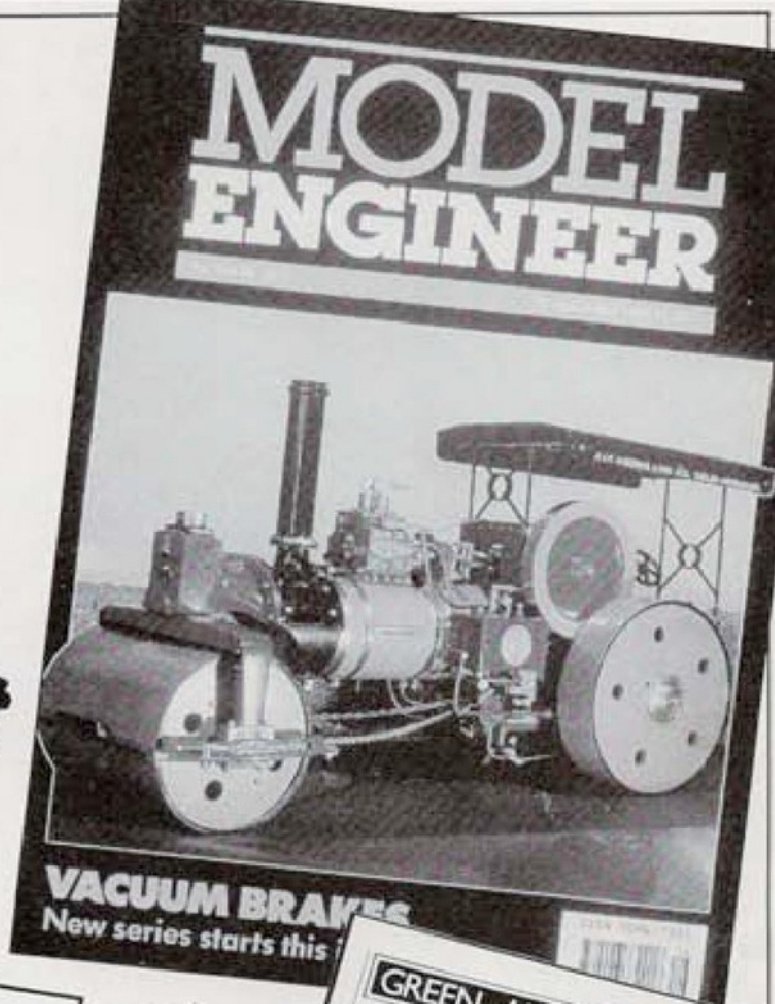


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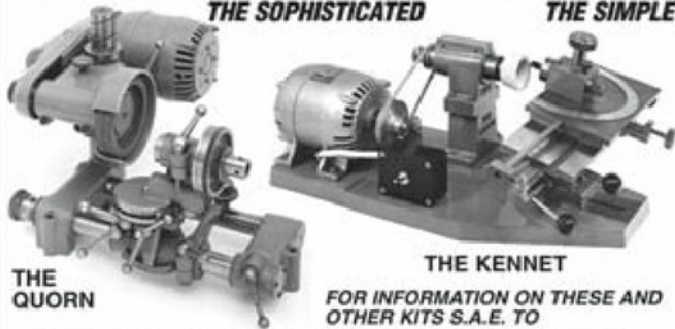




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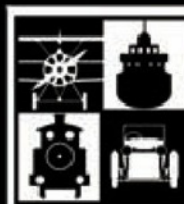
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| Colchester Bantam 1600 Centre Lathe, 5 1/2" x 20", Tooled, 3ph, VGC | £ 2250.00 | Boxford Change Gear Cover                                                               | £ 40.00      | D'Andrea TS3 40 INT Boring & Facing Head                         | £ 550.00                |
| Colchester Bantam 800 5" x 20" Centre Lathe, Tooled, 1ph            | £ 950.00  | Boxford Change Gear Quadrant                                                            | £ 15.00      | Small R8 Boring Head                                             | £ 65.00                 |
| Colchester Bantam 800, 5" x 30" Centre Lathe, Grubby, 1ph           | £ 1650.00 | <b>Boxford Change Gears</b>                                                             |              | Small 30INT Boring Head                                          | £ 65.00                 |
| Colchester Chipmaster 5" x 20" Variable Speed Lathe, 5" x 20", 3ph  | £ 850.00  | These gears will fit all the belt drive Boxford lathes, models, A, B, C, AUD, BUD, CUD. |              | Rawlwyer Boring Head with W20 Shank                              | £ 265.00                |
| Colchester Chipmaster 5" x 20" Variable Speed Lathe, 5" x 20", 3ph  | £ 595.00  | These will also fit the similar size Southbend machines.                                |              | Wohlhaupter UP44 Boring & Facing Head                            | £ 425.00                |
| Colchester Master 2500, 6 1/2" x 40" Gap Bed Lathe, Tooled, 3ph     | £ 3250.00 | 16TE10.00, 18TE11.00, 20TE11.00, 21TE11.00, 22TE11.00, 23TE11.00, 24TE11.00,            |              | Clarkson 3 MT Autolock Milling Chuck & 4 Imperial Collets        | £ 120.00                |
| Denford Startum 4 CNC Bench Lathe, 1ph                              | £ 750.00  | 26TE11.00, 27TE11.00, 28TE11.00, 30TE12.00, 31TE12.00, 32TE12.00, 35TE12.00,            |              | Clarkson 30 INT Autolock Milling Chuck & 4 Collets               | £ 135.00                |
| Emco Maximat V10P Lathe with Milling Head, Rough, 3ph               | £ 650.00  | 36TE12.00, 37TE12.00, 38TE14.00, 40TE14.00, 41TE14.00, 42TE14.00, 44TE14.00,            |              | Clarkson 40 INT Autolock Milling Chuck & 4 Imperial Collets      | £ 100.00                |
| Emco Maximat V10P Lathe, 3ph, Dirty                                 | £ 750.00  | 45TE14.00, 46TE14.00, 48TE14.00, 50TE15.00, 52TE15.00, 53TE15.00, 54TE15.00,            |              | Large Type, 2 Imperial Collets                                   | £ 85.00                 |
| Harrison 9" Gap Bed Centre Lathe, Tooled, 3ph                       | £ 650.00  | 56TE15.00, 59TE15.00, 60TE15.00, 64TE15.00, 71TE18.00, 75TE18.00,                       |              | Clarkson 50 INT Autolock Milling Chuck & 4 Imperial Collets      | £ 65.00                 |
| Hobbymat MD65 Bench Lathe, 1ph                                      | £ 350.00  | 80TE20.00, 88TE22.00, 100TE25.00, 127TE30.00, 100/127T Compound Gear £55.00,            |              | Clarkson 50 INT Autolock Milling Chuck,                          |                         |
| Hobbymat MD65 Bench Lathe with Milling Head, 1ph                    | £ 750.00  | 127/135T Compound Gear£95.00, 54/18T Compound Gear£30.00, 72/18T Compound               |              | Large Type, 2 Imperial Collets                                   | £ 65.00                 |
| Myford ML7 Lathe with Gearbox, 1ph                                  | £ 950.00  | Gear £35.00, 32T Tumbler Reverse Gear £12.00                                            |              | Clarkson R8 Autolock Milling Chuck & 4 Imperial Collets          | £ 100.00                |
| Myford ML7R Lathe with Stand, VGC, Tooled, 1ph                      | £ 1650.00 | <b>Myford Spares &amp; Tooling</b>                                                      |              | 4 Morse Taper Horizontal Arbor                                   | £ 50.00                 |
| Myford Super7B on Stand, Tooled, VGC, 1ph                           | £ 2850.00 | Toolmex Quick Change Toolpost & 4 Toolholders, NEW                                      | £ 115.00     | 4 Osborne Titanic Collet Chucks & Quantity Collets               | £ 150.00                |
| Pultra 1750 Lathe with Capstan Attachment                           | £ 450.00  | New Toolmex Quick Change Toolholders, Each                                              | £ 16.50      | T Slotted Cast Iron Tilting Table, 5" x 7"                       | £ 58.00                 |
| Pultra Capstan Lathe on Cabinet Stand                               | £ 650.00  | L W Staines Milling Attachment for Myford Super 7 or ML7                                | £ 175.00     | 6" x 5" x 4 1/2" Cast Iron Angle Plate                           | £ 25.00                 |
| Pultra Capstan Lathe with Stand                                     | £ 1250.00 | Myford 3" x 11/2" x 2" Angle Plate                                                      | £ 15.00      | Reeves Swivel Angle Plate Casting Set                            | £ 25.00                 |
| Raglan Training Lathe, Currently Dissassembled                      | £ 200.00  | Myford 4 1/2" Catchplate                                                                | £ 15.00      | 3 MT - 2MT Open Ended Ejecting Adaptor                           | £ 15.00                 |
| Schaublin 70 Centre Lathe, 3ph                                      | £ 2250.00 | Myford 4" Chuck Backplates                                                              | £ 18.00      | <b>Magnetic Chucks Etc.</b>                                      |                         |
| Viceroy Plain Lathe, 240 volt                                       | £ 325.00  | Myford 5" Chuck Backplates                                                              | £ 20.00      | Eclipse 10" x 5" Magnetic Chuck                                  | £ 75.00                 |
| <b>Milling Machines</b>                                             |           | Myford 7" Faceplate                                                                     | £ 30.00      | Eclipse 18" x 8" Magnetic Chuck                                  | £ 200.00                |
| AEW Viceroy Horizon Vertical Mill, Swivel head, Power Feed, 30INT   | £ 975.00  | Myford Dividing Head & 2 Division Plates                                                | £ 375.00     | Eclipse A612 Magnetic Adaptor Plate, 10" x 5"                    | £ 85.00                 |
| Deckel LK Jig Borer with Jig Grinding Head and Tooling & DRO        | £ 3500.00 | Myford MA73 V-Block                                                                     | £ 15.00      | Eclipse AP5610 Magnetic Adaptor Plate, 200mm x 120mm             | £ 50.00                 |
| Denford Startum CNC Vertical Bench Milling Machine, 1ph             | £ 1250.00 | Myford Metric Conversion Set                                                            | £ 150.00     | Eclipse No 955 Demagnetiser, VGC                                 | £ 100.00                |
| Dore Westbury Vertical Bench Mill, 1ph, The Best we have had.       | £ 875.00  | Myford Between Centres Boring Bar                                                       | £ 25.00      | Soba 4" x 7" Magnetic Chuck                                      | £ 60.00                 |
| Emco FICNC Vertical Bench Mill, 1ph                                 | £ 2000.00 | Myford Plain Vertical Slide                                                             | £ 120.00     | <b>Workshop Equipment &amp; Spares Etc.</b>                      |                         |
| Emco Unimat 3 Mentor Bench Top Mill/Drill, 1ph                      | £ 250.00  | Myford Swivelling Vertical Slide                                                        | £ 145.00     | Smart & Brown Model A Topslide                                   | £ 75.00                 |
| Gravograph Pantograph Engraving Machine, Type & Laminate, 1ph       | £ 550.00  | Myford Swivelling Vertical Slide, Immaculate                                            | £ 175.00     | Smart & Brown Model A Tailstock                                  | £ 125.00                |
| Greenbank Horizontal Broaching Machine                              | £ 850.00  | Myford Super 7 Saddle Assembly                                                          | £ 150.00     | Smart & Brown 9" Faceplate for Model A                           | £ 75.00                 |
| New SIP Mill/Drill, 3 MT, 1ph                                       | £ 895.00  | <b>Lathe Tooling, General</b>                                                           |              | 2 PCM Colets Holders with 1" Shanks & 17 Schaublin Collets       | £ 100.00                |
| Scripta SA Three Dimensional Engraver/Diesinker                     | £ 675.00  | New 2 Morse Taper Live Centre                                                           | £ 20.00      | 7 Long Series Schaublin Collets, 20mm Shank                      | £ 50.00                 |
| Myford VMC Turret Mill, 3 ph                                        | £ 850.00  | New 3 Morse Taper Live Centre                                                           | £ 20.00      | 9 x 10mm Pultra Collets                                          | £ 100.00                |
| Warco VMC Type X5015 Turret Mill, 1ph, VGC, 2003 Machine            | £ 950.00  | Jones & Shipman No 8144 Knurling Tool                                                   | £ 15.00      | Alexander 2C Engraver Cam Forming Attachment                     | £ 75.00                 |
| Tom Senior MI Milling Machine, 3ph, Choice of 3, 3ph                | £ 600.00  | Jones & Shipman No 8142/001 Knurling Tool                                               | £ 14.00      | Jones & Shipman Internal Grinding Attachment                     | £ 225.00                |
| <b>Drilling Machines</b>                                            |           | Pultra 10mm Collets, Choice of Sizes                                                    | Each £ 15.00 | Jones & Shipman Radius Attachment                                | £ 125.00                |
| Startrite Mercury Bench Drill, 3ph, Old                             | £ 85.00   | Pultra 8mm Collets, 3 for £25.00 or                                                     | Each £ 10.00 | Jones & Shipman Grinding Wheel Balancer                          | £ 350.00                |
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| Elliott Progress Pillar Drill, Needs Quill Lock, 3ph                | £ 75.00   | Miller CNC Quickturn Knurling Tool                                                      | £ 50.00      | Raglan Lathe 2 Point Steady                                      | £ 55.00                 |
| Progress IS Bench Drill, Needs Quill Lock, 3ph                      | £ 75.00   | Dickson Toolholders For Bantam                                                          | Each £ 24.00 | Deckel FP3 Horizontal Overarm Support                            | £ 100.00                |
| Progress IS Pillar Drill, Needs, Quill Lock, Handles & Spring, 3ph  | £ 35.00   | Dickson Quick Change Toolpost & 3 Holders, (2 7/8" Square)                              | £ 100.00     | Deckel FP1 or FP2 Overarm for Vertical Head                      | £ 225.00                |
| Meddings LFI Pillar Drill, 1/2" capacity, 3ph                       | £ 150.00  | Arrand 12" Between Centres Boring Bar                                                   | £ 55.00      | Denford Startum 8 Tailstock                                      | £ 100.00                |
| Progress IS Bench Drill, Needs Spring & Quill Lock, 3ph             | £ 75.00   | Arrand 2 Morse Taper Saw Arbor                                                          | £ 40.00      | Jones & Shipman 12" x 12" Precision Co-ordinate Table            | £ 450.00                |
| Viceroy 20mm Pillar Drill, 3ph                                      | £ 60.00   | Jones & Shipman No 8142/001 Knurling Tool                                               | £ 14.00      | Tom Senior Vertical Milling Head                                 | £ 550.00                |
| Union Pillar Drill, Needs 1 Handle on Starwheel, 3ph                | £ 75.00   | Jones & Shipman Type 8144 Knurling Tool                                                 | £ 30.00      | Viceroy 5" Lathe Tailstock                                       | £ 125.00                |
| <b>Milling Tooling</b>                                              |           | 5 Straight Tail Lathe Carriers                                                          | £ 25.00      | Viceroy Topslide & 4 Way Toolpost                                | £ 350.00                |
| Clarkson R8 Autolock & 4 Metric Collets                             | £ 100.00  | Soba 3 Morse Taper Tailstock Die Holder                                                 | £ 32.00      | Set of Vickers Machine Dials, Dual Metric/Imperial, Unused       | £ 35.00                 |
| Clarkson 3MT Autolock Milling Chuck & 3 Collets                     | £ 120.00  | Soba 2 Morse Taper Tailstock Die Holder                                                 | £ 30.00      | Hare SBS Power Press                                             | £ 350.00                |
| Clarkson 2 MT Autolock Milling Chuck & 4 Imp Collets                | £ 110.00  | 2 Morse Taper Drilling Pad With Plain & V Head                                          | £ 15.00      | Pinko No 1 Bench Arbor Press                                     | £ 40.00                 |
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| Clarkson 40 INT Autolock Milling Chuck & 4 Imp Collets              | £ 100.00  | 5/16" & 3/32" Square 5C Collets                                                         | £ 20.00      | Smart & Brown H3 Toggle Press                                    | £ 185.00                |
| Clarkson 40 INT Autolock Milling Chuck & 4 Imp Large Collets        | £ 100.00  | 14 5C Collets                                                                           | £ 70.00      | Sweeney & Blockside Large Flypress                               | £ 350.00                |
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- 300mm between centres • LH/RH thread screw cutting
- Electronic variable speed • Gear change set
- Self centering 3 jaw chuck & guard • Power feed



ONLY £359.99 EX VAT £422.99 INC VAT



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- 150w motor
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- Variable speed control 100-2000rpm



Kit Includes: Tapered spindle  
Coloured mop for initial cleaning, pure cotton mop for high polish finish  
6" & 8" available

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Complete with bolt mountings & feet anchor holes

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CBG8W features 8" whetstone & 6" drystone.

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- Simple boltless slot & pin locking mechanism
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- Quick assembly unit



Available in red, drak grey & blue from only £35.25 INC VAT £29.98 EX VAT

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## Clarke MEASURING EQUIPMENT



Model Description EX VAT INC VAT

|                |                 |        |        |
|----------------|-----------------|--------|--------|
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- Oil-free diaphragm
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- High quality tungsten steel
- Supplied in metal storage case, except 16pc

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| 24pc UNC/UNF/NPT    | £19.98 | £23.48  |
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†28pc Best Budget Buy, 33pc Recommended: Practical Classics

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Includes: • Gas regulator • Earth clamp • Face mask • Welding torch

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† REDUCED CBB209 was £140.94 INC VAT

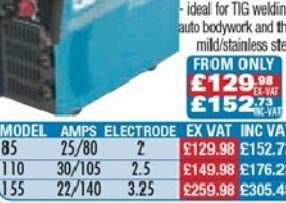
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| MODEL | AMPS   | ELECTRODE | EX VAT  | INC VAT |
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- Blast away paint, surface rust, scale, burrs, carbon & dirt & revitalise aluminium
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| MODEL  | DESC.           | TYPE  | EX VAT  | INC VAT |
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- Instant heat & trigger operated for controlled application
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- Scraper/probe tool • Spare gum tip

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- Ideal for low cost, efficient heating in workshops, warehouses etc.

| MODEL        | OUTPUT BTU/Hr | EX VAT  | INC VAT |
|--------------|---------------|---------|---------|
| LITTLE DEVIL | 35,000        | £69.98  | £82.23  |
| DEVIL 650    | 52,000        | £99.98  | £117.48 |
| DEVIL 850    | 107,000       | £139.98 | £164.48 |
| DEVIL 1250   | 149,000       | £169.98 | £199.73 |
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## Clarke DRILL PRESSES

- Tables tilt 0-45° left and right
- Depth gauge • Chuck guards

| MODEL   | WATTS/ SPEEDS | EX VAT  | INC VAT |
|---------|---------------|---------|---------|
| CDPS00  | 250/5         | £29.98  | £35.23  |
| CDP101B | 245/5         | £49.98  | £58.73  |
| CDP151B | 300/5         | £79.98  | £93.98  |
| CDP108  | 370/12        | £89.98  | £105.73 |
| CDP201B | 370/12        | £99.98  | £117.48 |
| CDP15F  | 370/12        | £109.98 | £129.23 |
| CDP201B | 510/12        | £134.98 | £158.61 |
| CDP351F | 510/12        | £149.98 | £176.23 |
| CDP401B | 510/12        | £159.98 | £187.98 |
| CDP451F | 510/12        | £189.98 | £223.23 |
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B=Bench mounted F=Floor standing

## Clarke 12 SPD MILL/DRILL



FROM ONLY £599.99 EX VAT £703.99 INC VAT

PRECISION engineered with cast iron head, base & column

- Spindle speeds 100-2150rpm
- 1/2 Hp, 230v, 1 Ph motor
- Accessories available
- 63mm milling cutter
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ONLY £239.99 EX VAT £281.99 INC VAT

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- MT2 Spindle Taper
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FROM ONLY £99.98 EX VAT £117.73 INC VAT

- 7cm displacement
- 1.5Hp
- 24ltr

Clarke 8mm air hose (10m long)

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| MODEL          | MOTOR CEM | TANK      | EX VAT  | INC VAT |
|----------------|-----------|-----------|---------|---------|
| 8/45 a/1       | 1.5Hp     | 6.3 24ltr | £84.99  | £99.86  |
| Panther 25 2Hp | 8.2       | 24ltr     | £129.98 | £152.73 |
| Panther 50 2Hp | 8.2       | 50ltr     | £169.98 | £199.73 |
| 10/70†         | 2.0Hp     | 9 50ltr   | £259.98 | £305.48 |
| 15/55          | 3.0Hp     | 14 50ltr  | £259.98 | £305.48 |
| 15/65†         | 3.0Hp     | 14 50ltr  | £359.98 | £422.98 |

## Clarke ANGLE GRINDERS



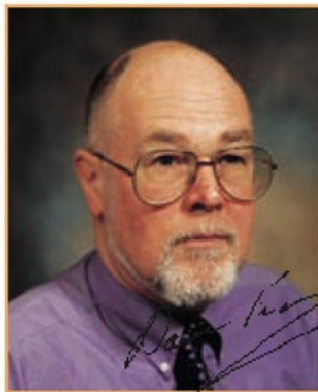
FROM ONLY £12.99 EX VAT £15.99 INC VAT

- Instant heat & trigger operated for controlled application
- Hands free magnifier
- De-solder suction tool to remove excess from joints
- Scraper/probe tool • Spare gum tip

Inc. disc & handle

| MODEL   | DISC | MOTOR | EX VAT | INC VAT |
|---------|------|-------|--------|---------|
| CAG1218 | 115  | 500w  | £12.99 | £15.26  |
| CAG115  | 115  | 500w  | £23.99 | £28.19  |
| CIN115  | 115  | 1010w | £24.99 | £29.36  |
| CAG232  | 230  | 2000w | £25.99 | £30.54  |





# ON THE EDITOR'S BENCH

## A correction

The update for the MEW index was published in Issue 118. The index is compiled by Barry Chamberlain and is available for Issues 1 to 116 on disc from him priced at just £10.00 including UK postage. Unfortunately, his address was incorrectly given. The corrected version is: Barry Chamberlain, 43 Waller Drive, Hardwick, Banbury, Oxon, OX16 9NS.

## Out and about

Several of my "hobby engineering" friends and acquaintances have interests represented at the "vintage do's" such as the recent "Farming Yesteryear" at Scone palace where Gordon Mackie exhibited his Fordson Dexta and Triumph Twenty One. Another vehicle regularly seen at these shows is the immaculately presented 1936 Morgan Super Sports owned by John Macdonald. A view of the front of the car with its distinctive Matchless vee twin engine is shown on the front cover. One surprise for me was a tractor bearing the Porsche name, presumably not their most rapid vehicle.

Workshop equipment was represented in one sense by the numerous trade stands offering a wide variety of tools, and in another by exhibits where stationary engines were coupled up to drive such items as drills, saws, grinders etc.

## Temporary closure

Thanks go to reader Pat Grimes of Aberdour who rang after a fruitless trip to Coatbridge, where he intended to visit the Summerlee Heritage Park. The main exhibition hall, which houses the principal items of machinery on show, is presently closed to allow extensive refurbishment, assisted by cash from the Lottery Heritage Fund, to the tune of some £4.7m. It is expected that the hall will reopen at Easter 2008.

## Editor wanted

Imminent senility brings with it a desire for a reduced workload, so I intend to retire from the editorial chair at the end of this year. We are therefore keen to recruit a replacement. If you think you may be the person for the job then please get in touch. Whoever takes over will enjoy making a great number of new friends amongst staff, contributors and readers. It is also an extremely interesting challenge.

## In the workshop

Earlier this year I decided to dispose of the TVR Tasmin. Now I don't pretend to be in close touch with the classic car market but it certainly appears to be pretty depressed here in Scotland. Numerous adverts and an auction entry produced no concrete results. I therefore decided to investigate the possibility of a trade, and eventually, after an email exchange of photos, struck a deal over the phone with Alan Rohers who runs Lanivet Motors near Bodmin. Its common for businesses to claim they go "The extra mile", well Allan had to go the extra 1100 miles in total round trip. So I now have a '77 Triumph Bonneville 750 to play with, and of course, can't resist taking things apart to check on condition. As this machine will probably be with me for a few years, a fairly extensive rebuild is planned for the winter months.

Having lifted off the head, I reached for my trusty valve spring compressor, only to find that it would not fit around the head casting. After a bit of head scratching, the set up shown in the photo came to mind and worked perfectly. The valve collets were first jarred free by placing a block of wood under each valve head and then tapping the top collar with small hammer and socket to free the tapers. A six inch length of 1.5in. dia bar was faced off and clamped in a vice, which was in turn bolted to the drill table so that the bar lay directly under the spindle. This provided a stable base location for the valve head. The "cage" was made up a number of years ago probably for working on Vauxhall or Rover overhead cam or V8 engines. It proved very easy to compress the spring, lock the drill quill in position, and then have two hands free to manipulate the collets.

I also needed a couple of matching piston ring clamps. Now I have vague recollections of books or magazine articles in the early sixties suggesting the use of Jubilee hose clips and Heinz beans cans. I think I did try it once but with limited success. One pattern that I have produced and used in different sizes over a number of years can be easily made. A strip of 18 or 20gauge sheet steel is cut wide enough to span a little beyond all the rings, and long enough to be bent around the piston leaving a gap of say an eighth of an inch. A Jubilee type clip is cut, partially straightened and welded across and near the top of the joint so that when screwed tight the rings are compressed. One was made by tack welding with MIG, the other using a hand spot welder. Silver soldering would probably work equally well but I cannot claim to have done it this way. You might also use a larger clip (or clips) and wrap right around the steel strip but this gives you more loose parts to manipulate.



Valve springs compressed in drill press.

Home constructed ring clamps



## Model Engineer Exhibition

It is well known that the Harrogate exhibition is one not to be missed by model engineers, and that the organisation of the event is due to the dedication and

determination of Lou. Rex, BEM. Lou has kindly agreed to add to his workload and assume the lead role in organising the 2006 Model Engineer Exhibition which will be staged at Olympia 2 from 29th to 31st December. Given his past success, we all now look forward to a superb show located within the metropolis.



# BASIC ELECTRICAL THEORY 2



The Brennenstuhl PM230 meter

## AC power

In the last issue the question of DC supplies was considered and how various components function when connected into a circuit supplied from a DC source. Now AC supplies will be discussed in a similar manner.

The first question to answer is why are AC power supplies the main method of distribution? The short answer is that it is relatively easy to change its voltage, a process that is near impossible in the case of DC at higher power levels. This enables power to be transmitted from the power station at high voltage/low current and then used locally at a lower voltage/higher current. Transmitting power at a lower current means that there will be less power loss in the cables that will also be smaller and lighter making them much easier to install. DC would have to be generated and distributed at domestic voltages resulting in much higher currents having to pass over long distances. The component to establish the change in voltage is, no surprise I am sure, the transformer. At much lower voltages and current the transformer has also become an essential component in modern equipment.

## Voltage values

I will first deal with the relationship between the peak voltage and the quoted

Harold Hall moves on to consider aspects of AC power circuits.

voltage of a supply. The stated voltage value of an AC supply, say that known for the voltage of the domestic supply, 240V in the UK, is 0.707 times the peak value (which would actually be 339V). This is known as the "effective" or "RMS" voltage (root mean squared), "effective" because it is the voltage that produces the same heating effect in a resistor as would a DC supply of the same value.

In a very few cases the average value is also used. This is arrived at by taking instantaneous voltage values at numerous points on the waveform, summing them and then calculating their average. This results in a value of 0.636 times the peak value. I have included this for completeness just in case you should come across it. However, in all common applications it is the RMS value that is given.

**Sk 1** in the last issue showed how an AC supply voltage varies with time, both in magnitude and polarity. Applying such a voltage to a load will result in a similar current waveform and again its quoted value will be the RMS value, that is 0.707 times its peak value. Unfortunately, at least in terms of it being easy to understand, the current waveform can occur as shown in **Sk 2.1** simultaneously with (A), before (B), or after (C) the voltage. The factor that determines this relationship is the type of load, resistive, capacitive or inductive.

Taking resistive first, being the easiest, here the current waveform will follow faithfully that of the voltage (**Sk 2.1A**), known as being in phase. In this case, calculating the relationship between current, voltage, resistance and power will be the same as for a DC circuit, that is

$$I = \frac{V}{R} \text{ or } V = I \times R \text{ or } R = \frac{V}{I}$$

and

$$\text{Power} = V \times I \text{ watts}$$

Unfortunately, beyond this point the calculations become much more complex. Whilst the formula required will be very similar to those above the term resistance (R) is replaced by impedance (Z), typically.

$$I = \frac{V}{Z}$$

## Impedance

Impedance, Z, is more complex as it is frequently not a value for a single characteristic but a combination of resistance, capacitance and or inductance. This is necessary as they frequently occur together in a single component. Typically,

the windings of a coil will have a resistance and inductance.

As mentioned above, resistance performs identically in both AC and DC circuits. However, unlike capacitance and inductance in a DC circuit where a steady state condition is arrived at some time after being energised, the continually changing voltage of an AC supply means that the charge on a capacitor or the field strength created in a coil is continually changing. This makes arriving at a value for Z more complex, especially as the effects of inductive and capacitive elements in a circuit are frequency dependent.

The term for the characteristic that determines the flow of current through a pure inductor or capacitor is called "reactance" and is known by the letter "X". The value for this can be calculated using the following formula.

$$\text{Inductive reactance } X_L = 2 \pi f L \text{ ohms}$$

Where P equals 3.14

f equals the frequency in Hertz

L equals the inductance in Henries

Similarly Capacitive reactance

$$X_C = \frac{1}{2\pi f C} \text{ ohms}$$

Where C equals the capacitance in Farads

Assuming pure inductance or capacitance the resulting current would be:

$$I = \frac{V}{X_L} \text{ or } I = \frac{V}{X_C}$$

In these cases the current will be out of phase with the supply voltage by 90°, leading in the case of capacitive reactance (**SK 2.1B**) and lagging when inductive (**SK2.1C**). In practice, pure inductance or pure capacitance rarely occur and the effect of a resistive element must be taken into account. As the current due to the resistive element will be in phase, resistance and reactance cannot be added to arrive at a value for the impedance, Z. The formula for an inductive circuit being,

$$Z = \sqrt{R^2 + X_L^2}$$

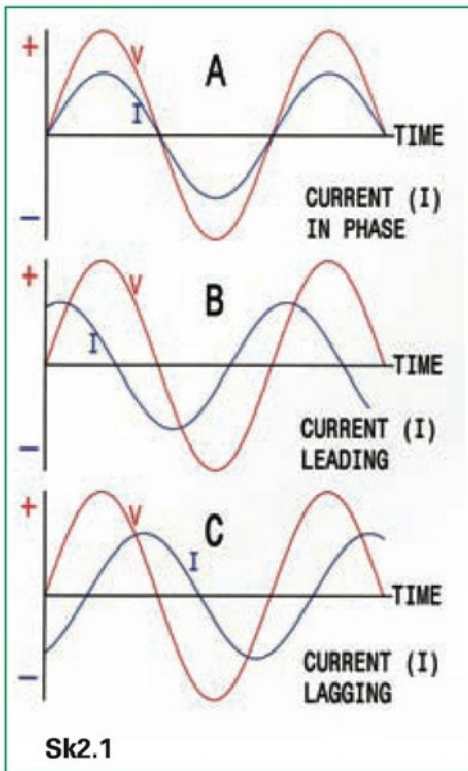
or for a capacitive circuit:

$$Z = \sqrt{R^2 + X_C^2}$$

The mathematically minded reader may have spotted that this uses Pythagoras's theorem as the resistive current will be at 90deg. to the reactive current.

Because the currents due to inductance and capacitance lag and lead by 90deg. that is with 180deg. between them, their





total reactance is not the sum but their difference. The formula therefore becomes for a circuit containing both inductance and capacitance.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Having arrived at a value for Z then the current taken can easily be calculated using the simple formula

$$I = \frac{V}{Z}$$

## Power in an AC circuit

From this one may assume that having arrived at a value for the current (I) the power consumed would just be the product of V and I as is the case in a DC situation. This is not the case and is due to the fact that the voltage and current waveforms are out of phase. The amount is though not fixed as it is dependent on the relative values of the resistive and inductive/capacitive elements.

Sk 2.2 shows how the value of the instantaneous power (V x I) varies throughout the voltage cycle, showing what occurs in three different cases of voltage/current phase relationship. Sk2.2A shows that when the voltage and current are in phase so is the power. However, you may be surprised to see the power waveform for the second half of the cycle is also positive. If you remember your mathematics you will know that a negative times a negative results in a positive, therefore negative voltage times negative current gives positive power.

In the case of Sk2.2B, for a pure capacitive load, the current is leading by 90deg. and you have both positive and negative going power pulses, both being equal. The capacitor will be charged whilst the supply voltage is greater than the charge voltage but will discharge when the charge voltage is greater than the supply voltage. The result is that power is just

shunted back and forth and over the cycle no power is consumed. From this it can be seen that with pure capacitance, and similarly pure inductance, connected to a supply, current will flow but over a complete cycle no power will be being consumed. This, I expect will come as a surprise to some readers.

Another interesting factor evident from Sk2.2B is that the frequency of the power waveform is twice that of the supply frequency. The reason is because the instantaneous value of the power waveform will be zero every time that either voltage or current passes through zero which they do at different times. This situation will occur whenever V and I are out of phase though the two halves of the power cycle will not be equal if the angle of lead or lag is other than 90deg, see Sk2.2C. Here, less is being returned to the power source but the power consumed will still be less than the volts times current product.

I am concerned that this explanation has become more involved than I would like but have been unable to see a way of emphasising the crucial factor, which is, that in an AC circuit, knowing just the voltage and current will not enable you to determine the power being consumed. The essential additional factor is the angle of lag or lead. Knowing that, then calculating the power consumed is calculated with the relatively simple formula

$$\text{Power} = V \times I \times \cos\theta \text{ watts}$$

where  $\theta$  equals the angle of lag or lead, and  $\cos\theta$  is known as the "power factor".

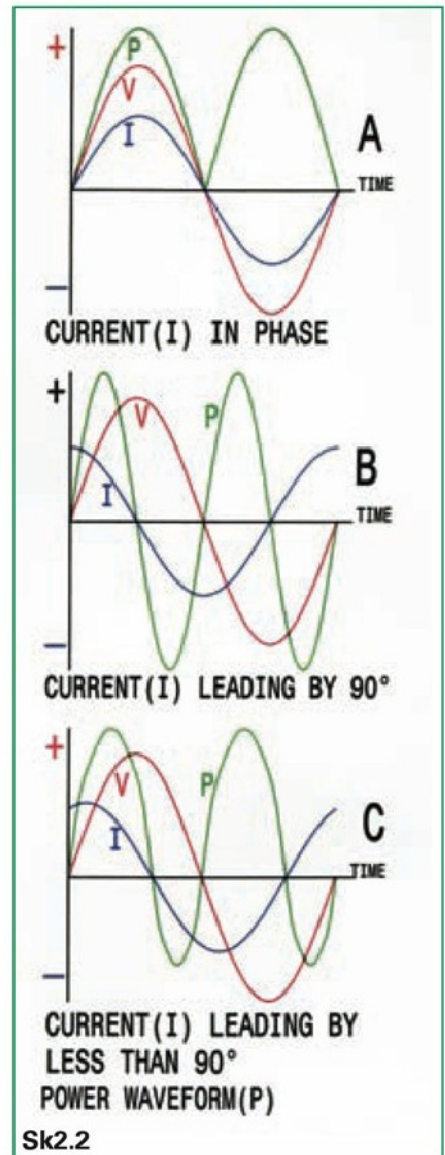
Knowing the values of R and X, and that they are at 90deg. one with the other, the angle  $\theta$  can be calculated using simple trigonometrical principles. However, I must stress that I believe that this level of mathematical involvement with the subject, including the formula above, will be unnecessary for readers of MEW. The inclusion of them in this article is an endeavour to emphasise the situation regarding power in an AC circuit.

Where might this information be of practical importance? I have known workshop owners to place an ammeter in the supply to a machine's AC drive motor so as to establish the mechanical power being demanded. The results from this though, would be largely meaningless without knowing the power factor, enabling the electrical power consumed to be calculated. Even with this information, electric motors are notoriously inefficient if not run near to their rated load and so using this route to determine mechanical power needed is far from precise.

With this point in mind I have taken some readings for the drive motor on my lathe, a Myford super seven. These are for the lathe working in three conditions:

1. Line shaft only running,
2. Clutch closed and lathe spindle running, and
3. Machining a piece of steel 42mm diameter.

The speed was 600 rpm, feed rate 0.06mm and depth of cut 1.5 mm. The supply voltage was 240 V at 50 Hertz.

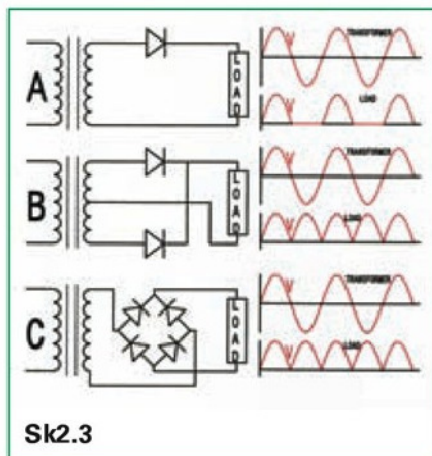


|                 | Amps | Cos $\theta$ | Power Watts |
|-----------------|------|--------------|-------------|
| Line shaft only | 4.28 | 0.35         | 360         |
| Mandrel running | 4.35 | 0.41         | 430         |
| Machining       | 4.60 | 0.60         | 662         |

From these figures it can be seen that taking the current readings as an indication of the electrical power consumed gives a totally false indication as the current increases by only 7% whilst the power consumed increases by 84%. Note how the value for  $\cos\theta$  varies for the three conditions. If the current value gives such an inaccurate indication of electrical power then using it to estimate mechanical load will be even further adrift.

Readers may wonder what methods I used to acquire these values, incidentally all three values are read rather than calculated. Not so many years ago meters to read these parameters would have cost a considerable amount. However, the Brennenstuhl PM230 at under £20 (ref. 1) and seen in Photo 1, is capable of being switched between time, volts, frequency, amps,  $\cos\theta$ , watts, kilowatt hours, and cost of power consumed. It also has some memory features that enable maximum values over a period of time to be read including running time. Amongst other things I have found it interesting to use





this instrument to find out how costly it is to provide continuous back ground heating to both my workshop and my greenhouse.

## Power factor correction

I am including this purely for academic interest, that is unless your workshop is in a very remote location and with the supply cables a little on the meagre side. In practice, especially in industry, loads presented to the supply are invariably inductive with capacitive loads being rare, (except for fluorescent lighting I believe). This means that the supply cables and transformers (see later comments re transformers) have to be larger than the power required would seem to call for.

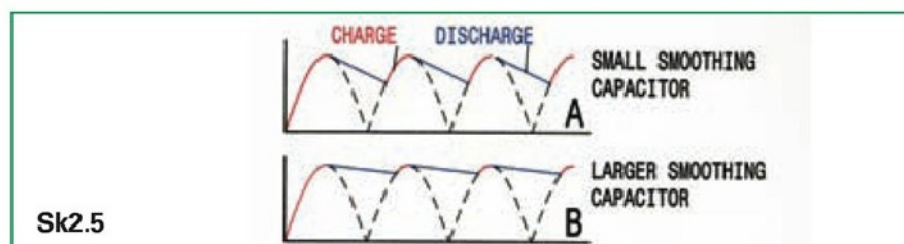
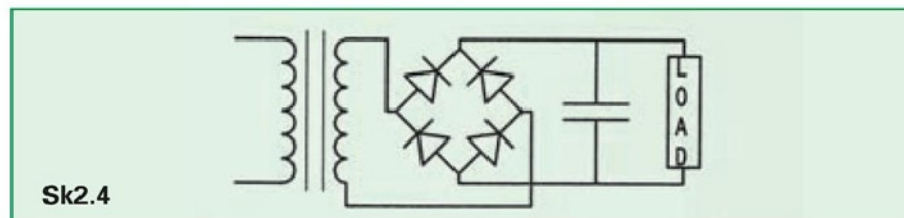
To overcome this, very large capacitors are connected to the supply to balance out the inductive load resulting in the current demanded being reduced, even though the power demand remains essentially the same. The ideal would be to balance the inductive load precisely resulting in a power factor of one, zero lag or lead. This is difficult to achieve but any improvement is worthwhile in a large industrial setup. The improvement in power factor mainly benefits the supply authority, who do as a result adjust their prices to the consumer for having installed the equipment.

## AC to AC conversion

Converting AC at one voltage to another using a transformer is common place and I am sure one that almost all readers will be conversant with. Whilst I would certainly not recommend a reader to make his or her own transformer unless they are fully aware of the pitfalls and the dangers, just a little background information here may not be out of place. The ratio between the primary and secondary voltages is achieved by having the same ratio of turns. That is, for a step down of 2:1 then the primary would need twice the number of turns that the secondary requires.

Transformers are very efficient so the current ratio is very close to the voltage ratio except that it is of course the other way round. In the above example the primary current would be nominally half that of the secondary, but just a very little more to allow for losses.

With regard to capacity, transformers normally have a VA (volts times amps) rating rather than a power rating in watts, the capacity is therefore independent of



power factor. Because of this, if the power factor can be made to approach the ideal, as noted above, then a smaller transformer will suffice.

## AC to DC conversion

Whilst there are numerous ways of converting AC to DC, even at very high power levels, here we are discussing the basic power supply as used in electronic equipment, battery chargers, etc. In its most basic form it will consist of a transformer feeding the load via a single rectifying diode. These are devices that permit current to flow in one direction only and can be had capable of carrying just a few milli amps up to hundreds of amps.

**Sk 2.3(A)** shows how the diode conducts on one half of the cycle and whilst it is unidirectional it is far from pure DC. This arrangement is known as "half wave". An improvement shown in **Sk2.3(B)** uses two diodes and a centre tapped transformer, both the positive and negative halves of the cycle are made available and is known as "full wave". A further improvement would be to use a full wave bridge that uses four diodes, either individually or these can be obtained encapsulated into a single assembly. This arrangement is shown in **Sk2.3(C)**. Whilst it still produces the same waveform it has the advantage of using a simpler transformer. The three arrangements shown would no doubt suffice (especially B and C) for a simple battery charger or motor driven toy maybe, but would though be totally inadequate as a power supply for electronic equipment. In this situation we need to use the charge and discharge characteristics of a capacitor discussed earlier to smooth out the result.

If a capacitor is placed across the diodes output, **Sk 2.4**, it will be charged up to near the peak value of the waveform. However, when the diode's input voltage falls below the capacitor's voltage the diode will cease to conduct and the capacitor will then start to provide the power for the load. During this time its voltage will commence to fall as it discharges until it once again is lower than the diode's input voltage and the cycle is repeated, **Sk 2.5(A)**. For a smoother output a larger capacitor resulting in a longer time constant would provide the result shown in **Sk 2.5(B)**.

The actual value of the capacitor is not critical providing the time constant is long

compared to the half cycle time. Knowing the power supply voltage and the current taken by the load, the load's resistance can easily be calculated using Ohm's law. From this and with a suggested capacitor, the resulting discharge time constant can be calculated.

It is though, also essential that the charge up time constant is short enough to ensure that the charge voltage very closely follows the supply voltage waveform. As there would appear to be no resistance in the charge up path one may assume that the time constant would be very short. However, in practice this is not the case as the transformers winding will have a resistance value that will limit the charge current. Because of this it may be necessary to use a transformer with a higher rating than the load demands just to achieve a rapid charge up rate.

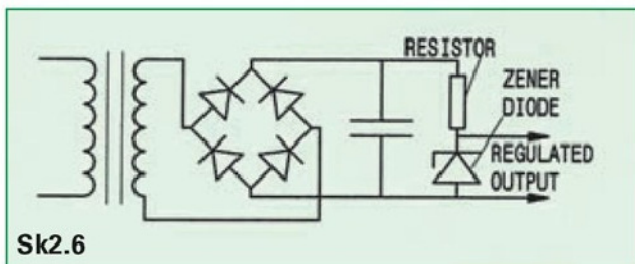
## Resulting voltage

A major question to resolve is what should the transformer output be? Earlier it was explained that the stated voltage of a supply was 0.707 times the peak value, working in reverse therefore the peak value will be 1.414 times the transformers stated output voltage. From the above explanations it should be obvious that with a generous size capacitor the average voltage will approach that of the waveforms peak value.

Unfortunately, if being used to power an electronic system the resulting ripple will often be more than is acceptable, even with a large capacitor being used. Similarly, the resulting voltage will be somewhat dependant on the load current as the greater the current the more the capacitor will discharge. Also, the output voltage from the transformer may require to be a value that is not available as a standard. Another factor in the choice of the transformer's output voltage is that a silicon diode has a forward volt drop of 0.7 volts. Therefore, with one in each arm this amounts to 1.4 volts which also needs to be taken note of, especially for low voltage power supplies.

Where a smooth supply, or the voltage value is crucial, then some additional components will be necessary to smooth and or regulate the output voltage. In some cases, especially at high powers, an inductor in series with the rectifier output and prior to the capacitor will smooth the





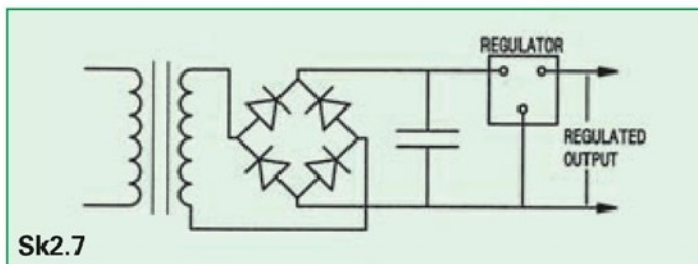
waveform better than a single capacitor. Two simple components are available that will both regulate the voltage and eliminate the ripple and at the power levels demanded by simple electronics are quite cheap. These are either a Zener diode or a voltage regulator, they also have the advantage that the smoothing capacitor, that could be physically large and expensive, can be much smaller.

## Zener diodes

Zener diodes are diodes having a very specific characteristic, that is they attempt to hold the voltage across them constant by increasing the current they pass if the voltage attempts to increase. Putting it in simple terms their resistance reduces if the voltage across them increases beyond their rated voltage value, even very slightly. A very basic circuit for using a Zener is shown in **Sk 2.6**, in this case the resistance  $R$  absorbs the ripple whilst the Zener holds the voltage almost fixed. For this to function the voltage developed across  $C$  would require to be a few volts greater than the required output, the

additional voltage, including the ripple, being dropped across the resistance. If the voltage at the Zener attempts to increase due to an increase in voltage across  $C$  it will increase the current it passes causing the resistor to drop the excess voltage. The voltage at the Zener will therefore rise only marginally.

Looking at it from another perspective the sum of the current through the Zener plus that taken by the load must be almost constant so that the voltage dropped across the resistor is essentially constant. A reduction in load current will therefore be counterbalanced by an increased current through the Zener. As the Zener has to carry a relatively high current the set up is normally only applicable to a very low power requirement. Note the difference in the symbol for a Zener in **Sk 2.6** compared to the symbols used for conventional diode shown in earlier sketches. Zener diodes also find use within circuits as a means of protecting delicate components from voltage surges. However, for a higher current output, say up to a few amps, a regulator as illustrated in **Sk 2.7** is preferable. These regulators can be used back to back to provide



positive and negative power rails as are frequently required in electronic equipment, typically  $\pm 15V/0/-15V$ .

Please note that these comments regarding power supplies are intended to give an insight only and are far from being an exhaustive description of the subject. If you wish to delve more deeply then you will need to seek out more detailed explanations, as you will for other parts of this series. In the next issue we will conclude with some discussions on simple logic functions and also various individual components, typically, transistors, thyristors, LED's, etc.



## Supplier

Brennenstuhl Wattage and Current Meter PM230 order code BRE-06213k, from **J and L Industrial Supply**, 7 Pacific Avenue, Wednesbury, West Midlands, WS10 7WP. phone 0800 663355, fax 0800 580058. E-mail [sales@jindustrial.co.uk](mailto:sales@jindustrial.co.uk) Web site, [www.jindustrial.co.uk](http://www.jindustrial.co.uk)

# IN OUR NEXT ISSUE

Coming up in Issue No. 121 will be

### Centrecam Photo

Mike Trethewey describes a reduced cost approach to dimensioning and centering by web cam



### 9 inch Disc Sander

Originally for woodwork, but equally at home on metal, Richard Wightman presents a budget home constructed machine.

### Basic Electrical Theory

Harold Hall concludes this mini series by considering logic systems, selected electronic components and electric motors.



### Truing up a Drill Press

Laurie Leonard improves the accuracy of a budget offering.

Issue on sale 15th December 2006

(Contents may be subject to change)



# TAIG/PEATOL MILL CNC CONVERSION

# 1

In this first of 3, Tony Jeffree discusses the mechanical modifications



1. Standard Taig motor mounting.

I have a Taig CNC mill that underwent a previous upgrade, documented in an earlier issue of MEW, to replace the Z axis with the current specification "box" slide-way design and to upgrade the stepper motors to the current 200 oz-in torque versions; the however, for a while now I have been wanting to make some more far-reaching changes to the drive system of the mill. These changes affect two major aspects of how the drive system works:

- Improving the way that the motors are coupled to the leadscrew shafts;
- Upgrading the whole of the electronics and the control software to use a modern specification microstepping drive.

Once I had started work on the mechanical side, I realised that there will actually be very little difference between these upgrades and converting a new manual or "CNC-ready" Taig mill to CNC operation. So, while describing the upgrades, I will also include the additional information that would be needed to convert a manual mill to CNC.

This article is part 1 of a series of three that I will write over the next few months as I work on various aspects of the conversion. The second part will deal with

replacing the motors and electronics with a new microstepping drive system. The third part will look at the PC and software elements that will complete the system. As the writing of these articles will necessarily go hand-in-hand with my working on the conversion itself, I cannot offer any guarantees as to exactly when work will be completed, however, part 2 has been prepared and part 3 will follow shortly.

For those readers who have a Taig CNC mill and are happy with the way their PC/software/drive electronics are working, the mechanical changes described in this article offer an easy way to improve the way their system works without getting into the more complex aspects of electronics and software; from beginning to end, the changes described here took me a couple of (short) evenings of workshop time.

Of course, if you ignore the Taig-specific aspects of this series of articles, the rest of the conversion will potentially be applicable to other mills of comparable size – for example, the Seig X1 mill that is available from the various UK machine importers.

## Motor mounts and couplings

The standard Taig motor mounting arrangement can be seen in **Photo 1**. This is basically a length of Aluminium tube that screws onto the threads on the outside of the leadscrew bearing housing

(see **Photo 2** which shows the Z axis housing with the mount removed), with a captive rectangular mounting plate drilled and tapped to match the hole centres on a standard NEMA 23 frame size stepper motor. These mounting tubes can be obtained from Taig in the USA or Peatol in Europe; however, I have also included drawings of the mount components for those who fancy making their own (see **Figure 1**) – the drawings are pretty self-explanatory so I don't plan to go into a blow-by-blow description of how you would make them. The threaded end of the tube is split with a couple of saw cuts, and a setscrew collar is used to clamp it in position once the tube has been screwed onto the housing. On my original mill, the setscrew collar fixing method wasn't used; the tubes were simply thread locked in position, so dismantling the mounts for this exercise involved careful application of a blowtorch to soften the thread locking compound to allow the tube to unscrew.

**Photo 2** shows the leadscrew shaft "half" of the motor coupling and the means of adjusting bearing end float. At the bottom, next to the bearing housing is an adjustable indicator dial, engraved in thou as this is a 20 TPI leadscrew Imperial machine. Not visible in the photo, there is a small circlip on the shaft under the indicator dial (but more of that later). Above that is one half of the motor coupling, which is axially drilled to take the four 1/4in. diameter plastic quills that can be seen in the photo; these locate in matching holes in the motor half of the

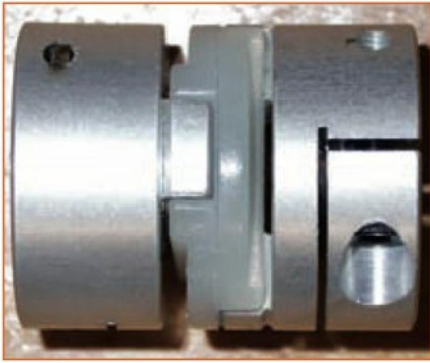


2. Detail of threaded location on Z axis.



3. Four holes can be seen in the end of the coupling.





4. Detail of commercial Oldham coupling which has proved backlash free.

coupling that can be seen attached to the motor shaft in **Photo 3**. The indicator dial and the leadscrew half of the coupling both have a keyway machined into their bore, and share the use of a single Woodruff key that serves to locate them and couple the drive boss to the leadscrew. The UNF  $\frac{1}{8}$  nut on the end of the leadscrew tightens the coupling boss and the fixed central boss of the indicator dial down onto the circlip mentioned earlier; I presume that the purpose of the circlip is therefore to prevent over-tightening affecting the smooth running of the back-to-back ball races that are contained in the bearing housing. On earlier machines, this is a half nut held in place with thread locking compound; on later machines this is a Nyloc nut.

This drive arrangement was the target for the mechanical changes in this project, for the following reasons:

- The quality of the coupling between the motor and the leadscrew, and in particular, control, of backlash in the coupling, depends upon the accuracy and stiffness of the four plastic quills that join the two drive bosses. When new, these work reasonably well, and don't introduce significant backlash; however, at least on my machine, I have found that they wear over time and the backlash noticeably increases.
- As mentioned above, the Woodruff key in the leadscrew shaft serves to couple the drive boss to the leadscrew. Any play between the key slot in the shaft, the key itself, and the keyway in the boss can show up as backlash in the drive to the shaft. Although this can be controlled to some extent by tightening the nut, this is unsatisfactory (at least, it was on my machine!), as on one of my mill axes, applying sufficient torque on the nut to lock up the drive boss can also lock up the ball races. On another of my mill axes, the positioning of this circlip means that although you can tighten it up enough to hold the drive boss in place, it is not possible to adjust the end float/pre-load on the ball races. In either case, the arrangement is unsatisfactory from the backlash point of view.
- The plastic quills can be a pain to line up properly when removing/re-fitting the motors. While this isn't something that you need to do frequently with a properly adjusted machine, it is irritating on those occasions when it is necessary. In the various other CNC activities I have been involved in, I have found that Oldham couplings



5. Before and after remachining the lead screw.

(see **Photo 4**) provide a very satisfactory, and backlash-free, method for coupling shafts together, so the modifications I describe allow Oldham couplings to be substituted for the cruder Taig couplings. In the process, the drive to the leadscrew no longer relies on (or even requires the presence of) the Woodruff key, and end float can be adjusted without involving the drive coupling hardware.

## Leadscrew modifications

The Oldham couplings that I use are 25mm diameter and each of the hubs is 12mm thick, which is near enough the same size as the coupling components supplied by Taig. However, as a plastic torque plate is used to join the coupling bosses together, the nut on the end of the leadscrew needs to be moved to the other side of the coupling boss. If you are starting with a manual Taig mill (as opposed to modifying a Taig CNC mill), then you will find that the crank handles take the place of the coupling boss in **Photo 2**; otherwise the arrangement should be the same as described above.

So, what needs to be done is to machine the ends of the leadscrews down to  $\frac{1}{8}$ in. diameter, for a length of 12mm, to take a  $\frac{1}{8}$ in. bore 25mm diameter Oldham coupling hub, and to cut a  $\frac{1}{8}$ in. UNF thread from the shoulder formed by this machining operation, for a length sufficient that the nut will do its job of tightening down onto the hub of the indicator dial and in turn, adjusting the shaft end float and bearing pre-load.

The first step is obviously to dismantle each of the three leadscrews. In the case of the CNC mill, remove the stepper motors by unscrewing their mounting screws, and unclamp and unscrew the motor mounting tube from the bearing housings. With either a manual or a CNC mill, you now remove the two cap screws holding the bearing plates onto the ends of the axes. The leadscrews can now be unscrewed from their feed nuts and the complete leadscrew/bearing housing assemblies removed from the mill. Undoing the nut on the end of a leadscrew allows the engraved dial, and either the coupling boss or the hand crank lever, to be removed from the end of the shaft; the Woodruff key and the small circlip can also be removed, and the leadscrew will now slide out of the bearings.

The screw is then held in a 3-jaw chuck

with the machined end of the shaft protruding from the jaws. I used some brass shim stock to protect the screw from damage during this operation. I also supported the free end of the shaft with a 3-point steady while machining was in progress.

Once the  $\frac{1}{8}$ in. diameter has been formed, the thread for the nut can be cut; if you don't have a suitable UNF die, a substitute is perfectly acceptable –  $\frac{1}{8}$ in. BSF for example, or maybe even M8 as  $\frac{1}{8}$ in. is 7.9375in. **Photo 5** shows a "Before and After" – the upper shaft in the photo is the original leadscrew end; the lower shaft shows the result of the re-machining.

The leadscrew end is then fed back into the bearing housing, the indicator dial fitted in place (without the Woodruff key), and the nut screwed into place, using a drop of thread locker so that it will stay put if you don't have Nyloc nuts. The nut should be adjusted so that there is no end float in the shaft, but not so tight that the smooth operation of the ball-races is affected. An Oldham coupling hub is then attached to the end of the shaft. The split clamp-type hubs are best for this application; there are versions with paired setscrews, but for these you need to file flats on the shaft. RS stock a wide range of these couplings with different bore diameter hubs. The  $\frac{1}{8}$ in. bore clamp-style hub



6. Part reassembled with half of coupling in place.





**7. The motor mount components.**

is stock number 748-055; two will be needed for each axis (one for the motor, one for the leadscrew). Stock number 748-156 is the matching torque plate; unfortunately the latter only come in packs of 10. If you don't need more than the three needed for this conversion, contact L.S. Caine Electronics who will sell these components in smaller quantities. The standard NEMA 23 motor shaft is  $\frac{1}{8}$ in. diameter; however, some motors these days have different shaft diameters – I have used 6mm, 8mm, and 10mm diameter stepper motors, so best check what diameter the shafts are before ordering the Oldham hubs. The  $\frac{1}{8}$ in. diameter hubs can be bored out for larger shaft diameters; RS also stock them in larger sizes.

## Feed nuts

The standard feed nuts on the manual mills, and on the earlier CNC mills, were

plain brass or bronze nuts with no adjustment for wear; later CNC mills had nuts that allowed adjustment to take up wear (a longitudinal slit along the nut and a clamping screw that allowed the nut diameter to be reduced). These adjustable nuts can be obtained from Taig in the USA or Peatol in the UK if you want to further reduce the leadscrew backlash. If you plan to fit these nuts it is worthwhile to take some time while the mill is disassembled to adjust the clamping screws for minimum backlash on the leadscrews. Obviously, as any wear on the leadscrew is going to be in the middle of the range of travel, this is going to be a compromise between backlash reduction in the middle and freedom of movement at the ends.

## Re-assembling the axes

This is a simple reversal of the disassembly process. The screw is fed back into the feed nut, and the bearing housing mounting plate is re-attached to the end of the axis – see **Photo 6**. The motor mount components (see **Photo 7** and **Figure 1**) can then be fitted, remembering to fit the motor plate over the tube first, then the setscrew collar, before threading the tube onto the bearing housing. You will need to fit the motor half of the Oldham coupling, and the torque plate, to the end of the motor shaft and do a trial fitting of the motor, in order to determine how far the tube needs to be threaded onto the bearing housing. The aim is for there to be no end play at all between the torque plate and the two coupling bosses; however, avoid any axial force on the motor shaft, and the cut-outs in the tubes should end up at the top and bottom, so the dials will be visible and swarf can fall through. If necessary, the Oldham hub



**8. Motor refitted now driving through Oldham coupling.**

positions can be adjusted on their shafts to make this work – their clamp screws should be accessible through the ports in the mounting tubes. It is also worth bearing in mind that although the NEMA 23 standard calls for a standard shaft length, some of the ones I have seen with non-standard shaft diameters also have longer-than-standard shafts. With these, the ultimate adjustment option (application of hacksaw-and-file) may be required. **Photo 8** shows the Y axis fully re-assembled, with the motor attached to the mount.

## Results

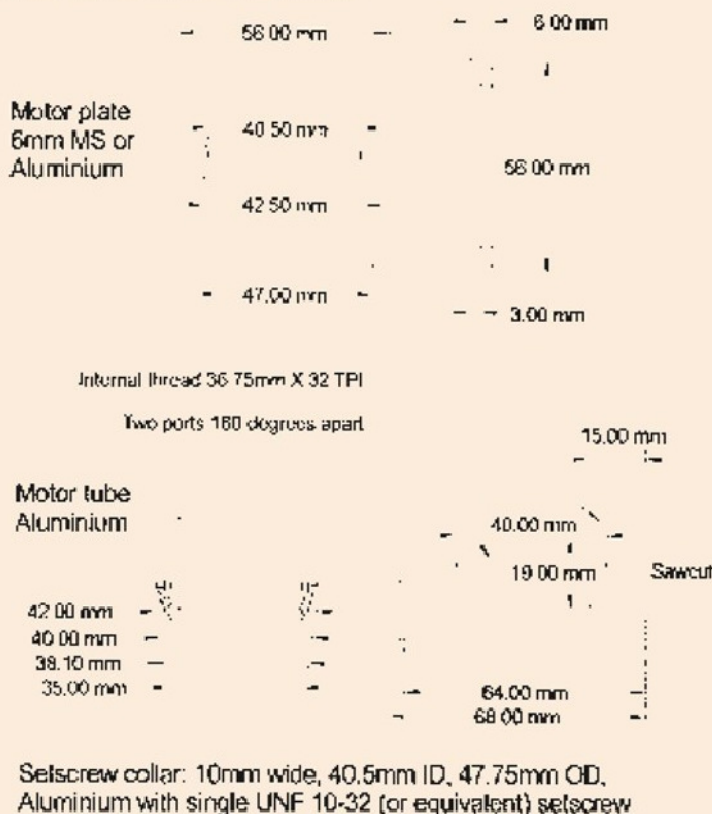
Testing the mechanical improvements out using the original Taig motors and half-stepping drive system (each half-step equating to  $\frac{1}{8}$ th of a thou) shows that the backlash in the axes has improved dramatically – from something in the region of 3-5 thou on each axis before the mechanical re-work, to a situation now where, using a dial indicator to measure movement of the table, I cannot measure any backlash at all. Thus, if there is any there to measure, it is smaller than the mechanical resolution of the drive system (i.e., less than  $\frac{1}{8}$ th of a thou). I think that I can therefore safely say that this was a successful exercise.



## Suppliers and other contact details:

**Peatol Machine Tools**, 19 Knightlow Road, Birmingham, B17 8PS, Tel. 0121 429 1015 website [www.peatol.com](http://www.peatol.com)  
**Taig Tools**, 12419 E. Nightingale Lane, Chandler, AZ 85249 USA website [www.taigtools.com](http://www.taigtools.com)  
**RS Components**. Tel: 01536 201201 Website: <http://rswww.com/>  
**L.S. Caine Electronic Services**, 25 Smallbrook Road, Broadway, Worcs, WR12 7EP. Tel: 01386-852122

**Figure 1: Motor mount components**





# BUYING ENGINEERING STUFF ON EBAY

Mike Houghton ponders the plusses and minuses of on-line buying. *Note that he has no connection with any of the organisations mentioned in this article!*

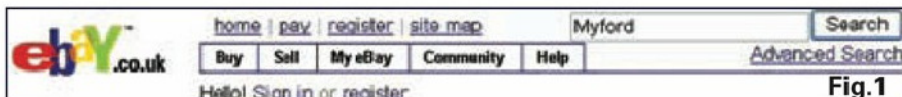


Fig. 1



Fig. 2

## In the beginning...

The on-line auction internet site eBay has been with us since 1995. The original concept was for registered users to offer new or used goods to registered buyers; the highest bidder at the end of the auction time being the winner. Now, just about every country has a national eBay site and the people at eBay keep developing their product way beyond the original auction concept. There are said to be 3.7million potential buyers and over a million items listed at any one time in the UK.

These notes are intended for a new eBay user with engineering and workshop interests.

## How to get started with eBay...

I find you need a Broadband connection to get the best out of eBay, but dial-up can work for simple searching. Log onto the internet and type [www.eBay.co.uk](http://www.eBay.co.uk) into your browser (Internet Explorer) address line and click go or press enter. (Change the country code from .uk to your own, if you are outside the UK)

I strongly recommend that if you are new to eBay, you limit yourself to searching for goods for a few weeks to get the hang of how things work. To search you don't need to register as an eBay member, you don't need an account and it won't cost you anything. (Other than your

internet connection cost) The eBay opening screen, the home page, will have a search box at the top. Ignore the invitation to sign in or register and type Myford in the search box as in Fig 1 and hit the enter key (or click on the Search button).

My search results looked like Fig 2 I have copied the screen with the Windows Print Screen key and pasted the image into Paint. Here is a selected area of that screen image.

As you can see, my search returned 382 results (hits) for the search word Myford. Your search will obviously give different results as time will have rolled on since I wrote this article. The search results are organised by the least time left before the auction closes. However, you can change this results sort, if you wish, by using the sort by dropdown list. Inspection of the first few results shows that only one is actually a Myford Lathe, a ML7. The remainder are goods to which the seller has added the word Myford to the item title to get attention from the search engine. Why?

The seller has to describe his/her goods with searchable keywords and place the goods into a Google category. To the left of the screen displaying the Myford search results you will see the Google Matching Categories (Fig 3) and the Myford search hits in each one. The hits are distributed over many categories, but mostly in the Industrial Tools Category, a sub category of Business, Office & Industrial.

Google does not cater for our specialised interests very well, so be prepared to use cunning to search out what you are looking for. The sellers have also become cunning and often attach well known machine

names to small tools. You will see that some of the hits displayed in your Myford search also manage to include Harrison, Colchester etc. Of my 382 Myford results, only 12 were actually Myford lathes. About 35 entries were for used Myford parts, indicating a fair amount of machine dismantling going on; a pretty useful recycling service. I also noticed some genuine Myford accessories and copy parts for sale.

## Search keywords

Fig. 3

For the beginner, searching with keywords is a good place to start. In general I find that, manufacturers' names work well as search keywords. Try and experiment with Bridgeport, Elliot, Hardinge, Centec, Harrison Lathe, Boxford, Denford, Emco, Atlas, Raglan, Tom Senior, Smart and Brown, Stuart Turner etc etc. More generic searches like "metalworking lathe"; "milling"; "inverter" and "CNC" can work well, if you are prepared to go through long lists of hits. You don't need the quotes "----". Experiment! Type in Myford Lathe and see that your number of hits decreases, compared to Myford alone.

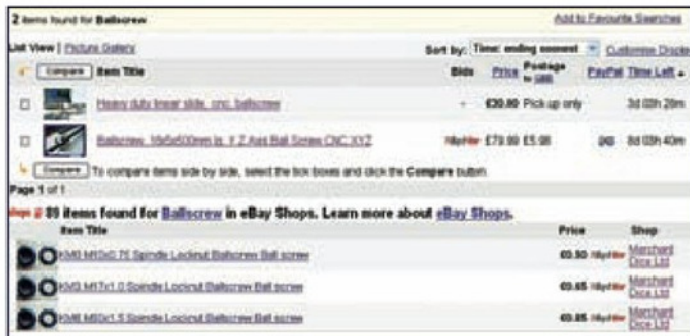
The range of engineering tooling on offer is quite staggering. Search for well known manufacturers names (Guhning, Dormer, Presto, Lyndon, Garryson, Kennametal, Jacobs, Rohm, etc etc.) to find factory clearance items.

## Who is selling?

If you think this all sounds a bit like an Internet Car Boot Sale, you would be right; except the prospective customer numbers







Left: Fig. 4

Above: Fig. 5

are massive, it operates 24/7, you won't get wet and sellers can be traced. Sellers costs (overheads) are even lower than a car boot. More on sellers costs later.

Motives for selling, other than the obvious ones of profit, saving stuff going for recycling, lifestyle and bereavement de-cluttering, have changed. Many of our well known Home Workshop suppliers are now taking advantage of the eBay system to shift their machines and tooling in eBay Shops. To illustrate eBay Shops, I carried out a search for Ballscrew. You might get different hits if you use Ball Screw or Ball-screw!

In Fig 4, you can see a screenshot of my Ballscrew search results. You should be able to see that only 2 Items have been found, but eBay has also found 89 items in eBay Shops and 22 items from international sellers. (Off the bottom of my screen shot) You will also see several *Buy it Now* Prices. These developments; Buy it now and eBay Shops are designed to support sellers who have many of the same item to sell, who don't want to gamble on not covering their costs in an auction and want to sell today, not at the end of an open auction. If I click on the second found item I see the details of the 16mm dia x 5mm pitch x 500mm long ballscrew. Here I have cut out two parts of the screen. In Fig 5 are details of the ballscrew, the price, the post and packing. There are more details further down the page and another button to buy the item. Shown in Fig 6 are details of the seller. Study the seller information very closely. Feedback indicates the posted opinions of customers that have already bought from this seller, a measure of their reliability as sellers. If you click on the Visit the sellers shop, Marchant Dice Ltd you will be taken to their eBay shop or eBay store.

An eBay Store is an eBay seller's online storefront where sellers can showcase all of their eBay listings. eBay Store sellers are trusted and established eBay Sellers because they must have at least 20 positive Feedback or be ID Verified to open a Store. A red tag next to sellers' User IDs indicates they have an eBay Store. By clicking on the red tag, you will link directly to those sellers' Stores, (they may have more than one) where you can access all of their eBay items. Notice that the Sellers' eBay user ID may not be the same as the Store or company name.

## Registering as a Buyer

To make a bid or email the seller for more information on an item for sale it is necessary to register with eBay. See the eBay home page for a link. For a Buyer, registration is a reasonably quick and free process. Be ready with a few buyers'



Fig. 6

names for yourself, as these have to be unique, eBay will reject any that you submit that are already allocated. I recommend that the ID you choose does not indicate who you are and avoid adding any numbers after your ID. These can get confused with your feedback rating.

Registration also brings the benefit of "My eBay", which records bids you have made, things you are watching, and favourite searches and favourite sellers on line shops. Things you are watching will record the final price long after the item has disappeared from the auction listings. My eBay is confidential to you and only visible once you have logged into the eBay system. So remember your user name and password.

## Meet The seller

In my second "Meet the Seller" example (Fig 7) you can see a very active seller, RDG Tools OnLine, part of a family business that is often seen at Model Engineering shows. If you click on the seller's name you will see their trading record and feedback from customers. Having found a reliable seller who offers interesting workshop stuff it's very useful to add them to your eBay favourites list and search them regularly. You can also set up searches that email you when a new item meeting your criteria is listed. E.g. you might want to be alerted if a motor made by Parvalux is listed.

## Auction action

So you have seen an item for sale, the price is currently low; the seller looks OK and quickly answers any questions about the goods. You have to decide whether to bid now (Fig 8) or sit on your hands until



Fig.7



Fig.8



Fig. 9

the last minute and grab a bargain or to place a bid now and reveal your interest. eBay will automatically bid for you up to a limit you set. If there have already been a number of bids enter a slightly higher bid and watch to see if you are quickly outbid, indicating a higher maximum bid has already been placed.

If you watch the bids towards the end of an auction there is frequently a lot of action right up to the final whistle. You really need to watch using Broadband and keep refreshing the screen with the refresh icon (Fig 9). Clicking on the bid history will show you who has been bidding. Experienced bidders stay logged on to eBay during the last few minutes of an auction, hoping to find it stalled at a fairly low bid. They then put in a bid during the final minute. The auction closes before anyone else can respond. Great fun if you have strong nerves. Particularly annoying if you have set your max bid at, say, £50.05 and it goes at £50.55. Oh well, that's life. Have another go later!



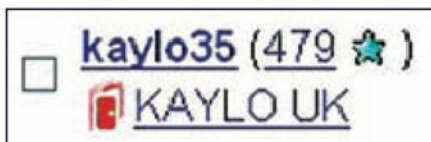


Fig. 10

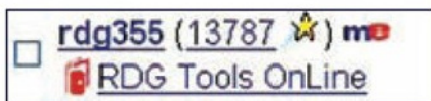


Fig. 13

## PayPal or plastic

So you have won an auction or started a "buy it now" transaction. eBay would like you to use PayPal, well they would, they own the company. (There are alternatives, Nochex, FastPay or Moneybookers but I have not used them) Essentially you sign up with PayPal before bidding and give them access to your Bank or Credit card account so they can move your money to the sellers account once you have won an auction or pressed a buy it now button. Sellers don't see your account details or your real identity, just your eBay ID. All PayPal transactions are encrypted. Check that the lock is displayed on the screen.

There is automatic payment tracking and you have £500 cover through the PayPal Buyer Protection Scheme. Should the transaction go wrong (No goods delivered, goods faulty or miss-described) there are procedures for recovery of your money. There are many more details on the eBay website, please read the details before you jump in. Go to the eBay home page to find details.

Should you intend to purchase stuff from overseas, PayPal is valuable as it also takes care of foreign currency payments and currency conversions. Remember you (UK) can import goods with a value up to £30 without paying import duty but VAT may be applied and will be collected at the point of delivery.

I notice that more and more sellers based in Europe, China, Hong Kong and the Far East are listing goods on the UK eBay. Careful reading of the supplier's details should provide a clue. A credit card also carries with it some buyer protection for on-line transactions, certainly more than a personal cheque or a debit card.

## Registering as an eBay seller

Having registered as a Buyer, if you wish to sell goods, you have to register again as a seller. Ebay will need credit card or bank account details as proof of identity. Please read the appropriate section accessible from the eBay home page. I'm assuming that if you have mastered buying then you are very familiar with the eBay system and will be able to do this without notes from me.

## Charges

As an Ebay buyer using a credit card or PayPal you don't receive any transaction surcharges (except postage). Surcharges

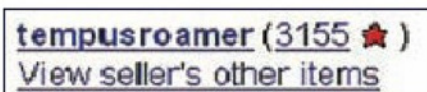


Fig. 11

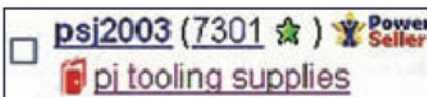


Fig. 14

are all levied on the Seller. Some sellers will however apply a surcharge on the final auction price to recover some of their PayPal costs. Around 3.5% is common. There seems to be nothing illegal about this, but you need to be aware that some sellers claw this back and they should say that they do it.

## Most eBay charges fall on the seller

When a seller lists an item on eBay, you're charged an Insertion Fee according to the tables given. If the item sells, you are also charged a Final Value Fee. The total cost of selling an item is the Insertion Fee plus the Final Value Fee. These are UK fees and can be varied from time to time, so check the current rates. (See Table 1 and Table 2 below).

## Fraud

Many model engineers that I correspond with are satisfactorily buying new and surplus machines and tooling on eBay with little or no problem with fraud. eBay does a lot behind the scenes to create a safe trading environment. Nevertheless, it's a case of buyer beware and friends have told me that they regularly get reminders for bills for goods they have not paid for, nor ever ordered. Ignore them, they are clearly fraudulent. Like the scammers that ask you to confirm your bank or PayPal details. DON'T REPLY.

### Insertion Fees (Table 1)

| Starting or Reserve Price                          | Insertion Fee |
|----------------------------------------------------|---------------|
| £0.01 - £0.99                                      | £0.15         |
| £1.00 - £4.99                                      | £0.20         |
| £5.00 - £14.99                                     | £0.35         |
| £15.00 - £29.99                                    | £0.75         |
| £30.00 - £99.99                                    | £1.50         |
| £100.00 or more                                    | £2.00         |
| For multiple item listings in £100.00 or more tier | £3.00         |

### Final Value Fees (Table 2)

| Closing Price    | Final Value Fee                                                                                                                             |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Item not sold    | No Fee                                                                                                                                      |
| £0.01 - £29.99   | 5.25% for the amount of the high bid (at the listing close for auction-style listings) up to £29.99                                         |
| £30.00 - £599.99 | 5.25% of the initial £29.99 (£1.57), plus 3.25% of the remaining closing value balance                                                      |
| Over £600.00     | 5.25% of the initial £29.99 (£1.57), plus 3.25% of the initial £30.00 - £599.99 (£18.53), plus 1.75% of the remaining closing value balance |

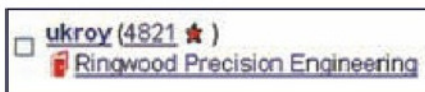


Fig. 12

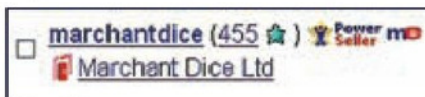


Fig. 15

## Other ways of shopping online?

The goods offered for auction are, after all, sight unseen. For low value items you are not risking much, and that's where most of my purchases have been to date. I might think very hard and long before bidding for a major piece of machinery. I note with interest that some of our traditional suppliers are frequently placing items on eBay and many now have eBay shops, often with links to their regular non eBay on line shops. Search for your favourites by name. There are a host of smallish dealers regularly offering items of interest to us. Figs 10-15 show a few taken from my eBay favourites.

Several of these sellers have more than one eBay shop and also operate an online shop not connected to eBay.

Even if you don't bid, eBay gives you a very good snapshot of current prices for second hand and new machinery. In my opinion the prices in some auctions are a bit over the top.

Some of our UK based suppliers operate very good online shops not connected to eBay and can be cheaper. Look for them and use them.

## Freecycle

Go to [www.freecycle.org](http://www.freecycle.org) and select your country. This organisation encourages the gift of unwanted goods to prevent them going to landfill or recycling. If you want something or have something to dispose of, this is a way of extending the useful life of goods. By its nature this organisation must work at a very local level. Follow the above link and select your country, then the nearest group to you. In joining you are joining a Yahoo group and will receive or make offers by email.

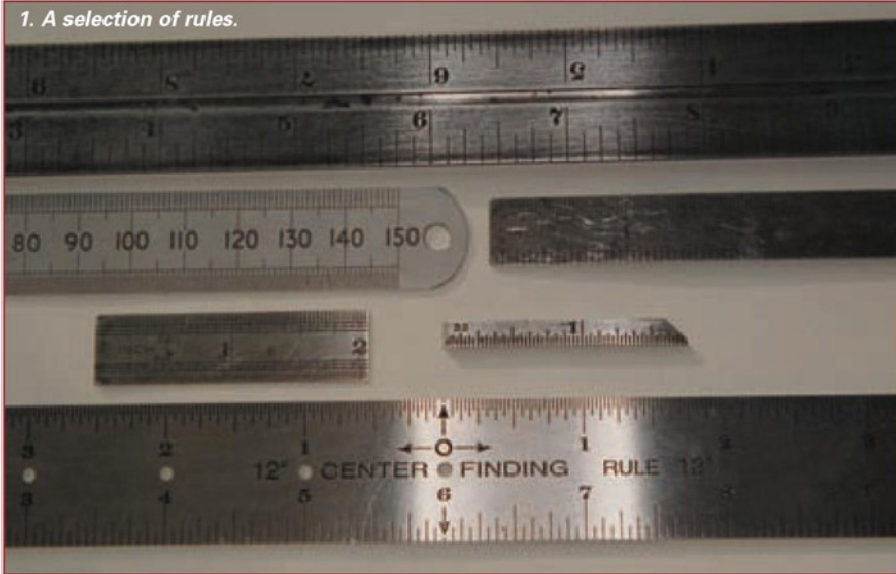
Although a comparatively recent innovation this is clearly taking off in a big way. Have a go and let me know if you collect any useful engineering stuff.

[mikehaughton@btinternet.com](mailto:mikehaughton@btinternet.com)





1. A selection of rules.



# THE BUSINESS OF MEASURING

Bob Loader takes a look at measurement systems, techniques and equipment

**N**ext time you measure something, spare a thought for all those who did the development and thinking which has made the business of measuring things easy and accurate. Go back a few hundred years and some aspects of measurement were a bit dodgy. Once upon a time an inch was the length of three barleycorns placed end to end: imagine the hunt for the longest or shortest ones, depending on which way the advantage was needed! Even some towns had their own ways and means of standardisation.

## Enter the modern standards

Eventually people realised that a standard was needed, to spell out what was what

and stop the quarrelling. Until the 1960's there was an Imperial Standard Yard, a length of specially shaped and stable bronze with a gold plug at each end. Very fine lines were engraved on the plugs exactly a yard apart. An inch was defined as  $\frac{1}{36}$ th of the Imperial Standard Yard.

The French had a different system and used the Prototype Metre which was the length of arc of one minute of longitude on the earth's surface. It was known as the International Prototype Metre and, like the yard was used as the metric working standard till the 1960's.

## Snags and problems

The trouble with mechanical standards, is that they can be subject to minute variations caused by all sorts of things like, humidity, small differences in temperature

etc. One clever clogs even suggested that, in so many hundreds of years they would have shrunk enough to be no longer accurate, we should worry!

## The new standard

Engineers and physicists are always finicky about accuracy and chose light waves for a standard which will not be affected by all the variables which bedevil mechanical standards. So the technical answer is to use the wavelength of part of the spectrum of the light emitted by Krypton 86 in a vacuum. Precisely, one metre is 1,650,763.73 wavelengths of this light.

In plain language this means that a micron (a millionth of a metre or 0.001mm.) is approximately equal 0.000039in. It is a bit of a struggle to imagine all this but luckily we don't have to. For our purposes all we need to know is that there are two sorts of standards, line standards and end standards.

## Line standards

These are the simplest and most useful and are usually different sorts of rules and verniers, more about verniers later. The rule is an indispensable tool and with practice can be surprisingly accurate, in the right hands to within 0.005in. or 0.20mm and if used by skilled toolmakers or instrument makers often less. Hard to believe I know, but I have seen it done.

## Rules

Photo 1 shows a selection of my rules. From the top, the rule out of a combination set, below it two 6in. /150mm. ones, the left hand one is the best because of the satin chrome finish which shows the graduations beautifully. The right hand one is one I have had for many years and it shows the limitations of an ordinary steel one. Below again, a couple of useful fragments, the short narrow one made from a broken depth gauge and the two inch one both useful for getting into confined spaces: the two inch one has an interesting history. The one right on the bottom is a useful one graduated on one edge from the middle, which was sent from America by my daughter and son-in-law. It is stain-less steel and brilliant for finding centres.

The two inch rule was once part of my 12in. semi-flexible rule. I foolishly told a group of apprentices that it would bend a little. One of them put it to the test and I soon had three 4in. rules. In the days of engraved divisions there was always the

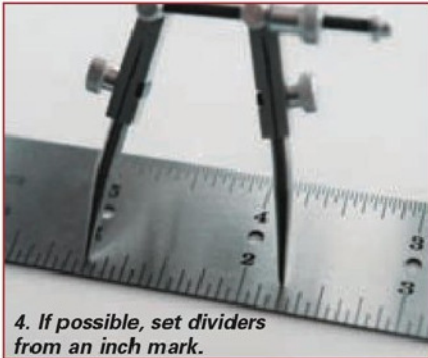
2. A rule which has seen better days.



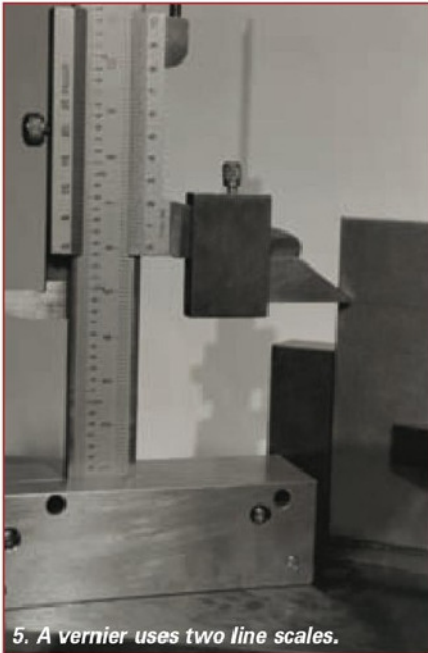
3. Using a block to make sure of accuracy.







4. If possible, set dividers from an inch mark.



5. A vernier uses two line scales.

chance that very thin rules would break at the lines when stressed. I shortened one of the pieces to 2in. for a particular job.

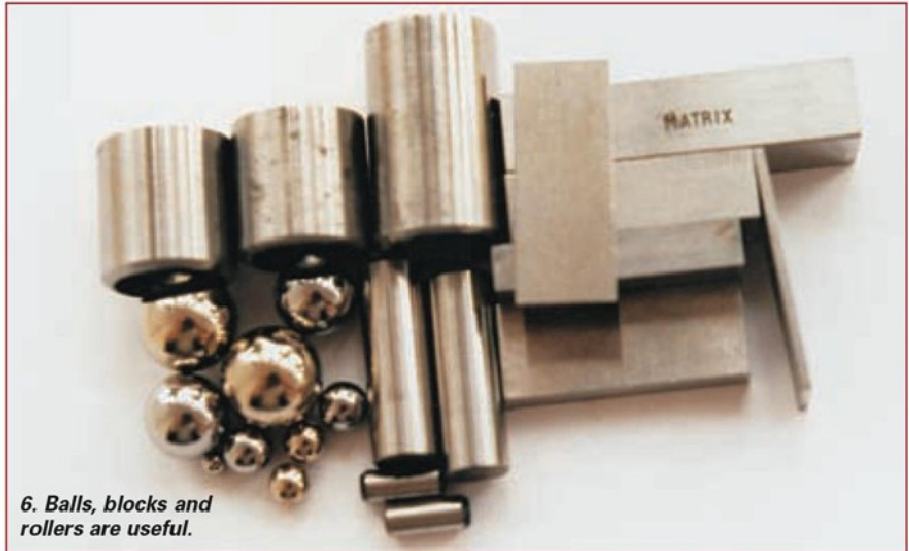
All measuring is comparing an unknown dimension with a known one or a standard. To be ridiculous, you could measure with a piece of string with two knots in it, but you would have to know the precise distance from knot to knot and anything which was not exactly so many knots would complicate things. That's why we need standards.

When using rules for accurate work it pays to take care. The end of a well-used one will be a bit battered and worn like my old 6in. one in **photo 2**, so any measuring from zero is best done by butting, the rule and the part to be measured against a true flat face as in **photo 3**. When setting dividers, start from an inch mark, as in **photo 4** it makes things easier.

Look after rules, do not leave them to clatter about with other things, the edges



7. Using blocks and a feeler gauge to get a dimension right.



6. Balls, blocks and rollers are useful.

get burred easily and you need a clean edge for checking for flatness. Keep them lightly oiled. Bumps and burrs can be gently stoned off. I knew of one rule which was bi-coloured, lovely and shiny from 2½in. to 6in. but the first 2½in. was a pale brown from stirring tea, canteen tea at that. When you are choosing, note that good rules will have "standard at 20deg. C." marked on them.

## The vernier system

We are indebted to the French for the vernier system, which is a super accurate line scale sliding against another slightly shorter one. I won't weary you with the maths or how to read it, there are plenty of references in many books. **Photo 5** shows a vernier caliper which I converted into a height gauge.

The clever chap who developed the vernier and gave it his name, was Pierre Vernier who, in the early 1600's described the principle in a book he wrote about maths. It also included some trigonometry for finding angles of triangles from knowing lengths of sides, a clever chap indeed. A feature of a vernier instrument is that it can be used for substantial lengths. I have used calipers up to six feet and height gauges up to four feet. With such a large caliper, it is a two-handed job, one person to hold the fixed jaw on the surface or edge to be measured from and the other to do the adjustment and get the feel right, more about feel later.

## End standards

An end standard is an accurate method of checking a dimension from one face to another and the ultimate workshop end

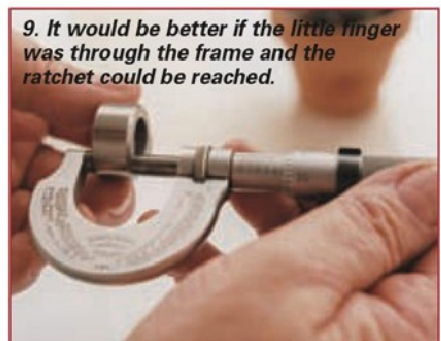
standard is the slip gauge. Sets of slips are made in both imperial and metric sizes. Most of the development was done by the Johanssen company who used them for checking various dimensions in the making of guns, especially the breeches. They have the important property of wringing together when one is slid over the other, as long as they are perfectly clean. Tests have shown that a couple of slips, correctly wrung will stand a pull of up to 200 lbs. without coming apart. They are the ultimate argument solver in disputes about dimensions. When I had access to them I used to check my micrometer over every 0.1 up to 1 in. Imperial sets have 41 or 81 pieces and can be made up into most dimensions to an accuracy of 0.0001 in. Slips are simple looking things, just rectangular metal blocks of various thicknesses but a lot of care and technique goes into the making. They are made from special steel, sized, hardened, ground and lapped till the surface is a super flat and accurate block with a mirror finish.

They are used for checking precision equipment, setting gauges and things like sine bars. With a set of accessories they can be used as inside and outside calipers, height gauges, trammels and many other variations. Although I have used them fairly regularly, I have never owned any, they are very expensive, particularly for amateur use. There are end standards at reasonable prices but typically for checking micrometers, bars of hardened steel with lapped ends and made in inch or metric sizes.

I was lucky enough to acquire a part of a slip gauge accessory set. A student dropped one of the internal measuring jaws on the concrete floor and the tip broke



8. An improvised ball attachment for measuring a curve.

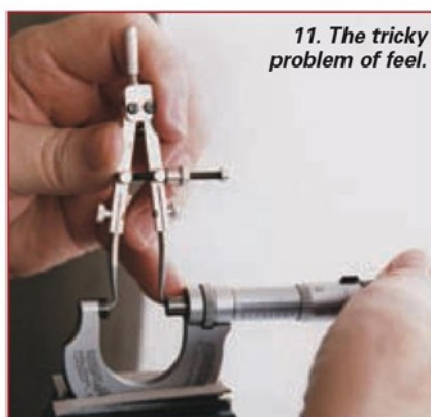


9. It would be better if the little finger was through the frame and the ratchet could be reached.

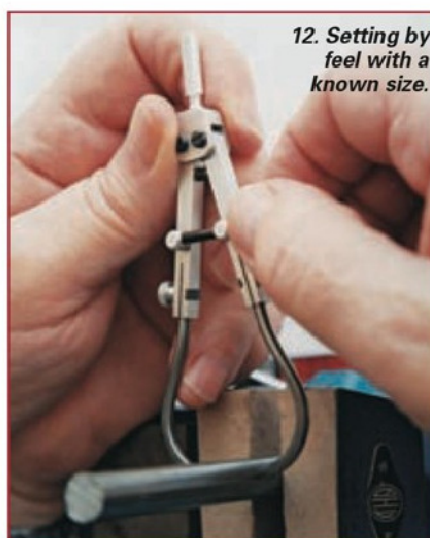




10. A small vice makes a good micrometer stand and the ratchet can be employed.



11. The tricky problem of feel.



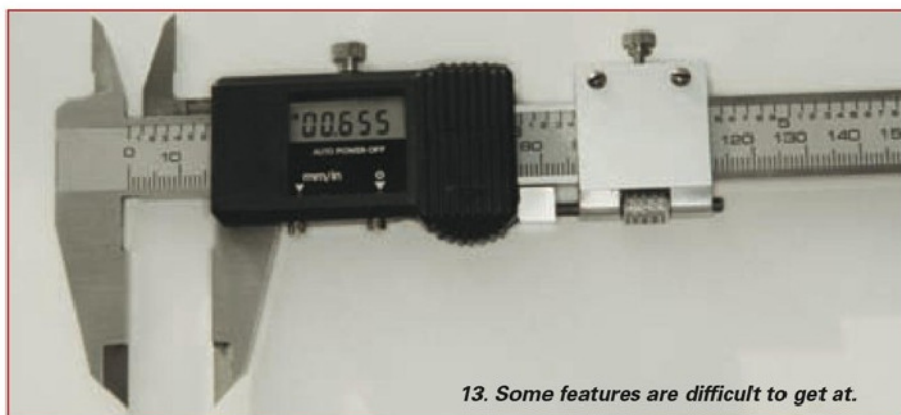
12. Setting by feel with a known size.

off, it is the block in **photo 6**, which has the name 'Matrix' engraved on it. So I have one block which is extremely accurate.

## Balls, Blocks and Rollers

All of these are useful and **photo 6** is a selection. Sources are, broken bearings, lengths of silver steel cut into convenient lengths and in the photo, some pieces of steel which look like slips but aren't, just some bits which were part of a job and rejected for a reason I have forgotten but very good for awkward measuring, like checking gaps and similar features. They can also be combined with feeler gauges

to get things exact, **photo 7**. Another source for steel balls is cycle shops which sell the races for wheels and bottom brackets. Never though, take it that the balls will be exactly the nominal size, always check. There are also lots of hand-held games which can drive you to distraction, where the object is to manoeuvre steel balls into holes or gaps, another source of cheapish steel balls. The three large rollers in the photo are my toolmakers' buttons, the small ones are dowels, both are reliable, being accurately ground to specific sizes.



13. Some features are difficult to get at.

## Micrometers

A 0-1 in. or 0-25 mm. is a must for any engineer. Like the vernier it has a history. The earliest reference I could find was to a man named William Gascoigne who used a sort of micrometer system in the 1600's. What he used it for was not that clear but he was an amateur astronomer, so it may have been a sighting device, adjustable, for finding distances of stars from each other. Whatever it was, poor William was killed at the battle of Marston Moor in 1644, the first Royalist defeat in the civil war. Who knows what his experiments could have led to, had he lived?

Once again, the French had a hand in the development of the modern micrometer and in 1848 Jean Palmer made one which looked something like the one we use today, except that the thread showed and there was no ratchet or locking device. With the principle established, it took very little time for improvements to be made and it was soon adapted for moving and measuring with machine tool slides. For precision, micrometers are normally limited to 1 in. or 25 mm. total movement because small and accurate screw threads are best kept to short lengths.

## Many different Micrometers

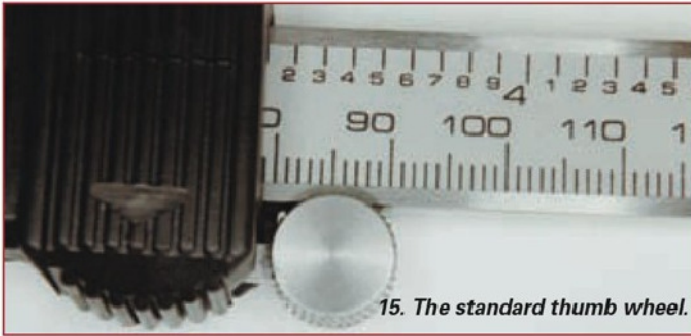
There are many variations. Inside and depth micrometers are both essential in a well equipped workshop. Each will cope with a large range of dimensions. Because of the design of the inside one, it starts at 2in. which is the length of the barrel and thimble. The range is extended by locking in extension bars. Some inside ones will measure from 2in. to 12in. A handle can be screwed into the body of the instrument so that it can be used like an inside caliper, its other name is 'stick micrometer'.

The depth micrometer, like the inside one, has a range, normally from -0 to 4 or 6in. They have a solid base which the barrel fits into, making a datum surface. The thimble screws on to the barrel and the length bars fit into a hole which goes all the way through the barrel. To change the range of measurement, different length bars are used, locked by a screwed cap.

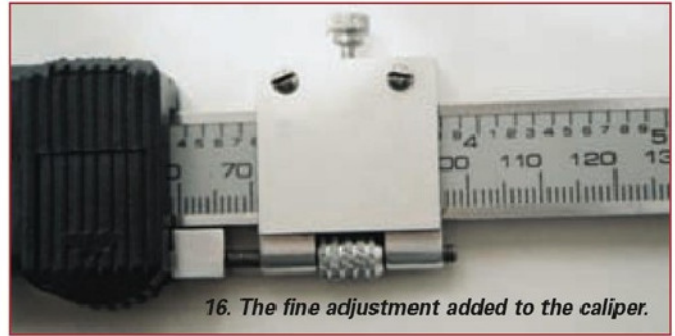


14. My modified digital caliper.





15. The standard thumb wheel.



16. The fine adjustment added to the caliper.

## Special Micrometers

If there is a special requirement, manufacturers will make a special for it and separate micrometer heads are also made for fitting into custom made instruments. In the past machine tools such as Strippit punch presses and Herbert Dialset lathes have been fitted with near standard micrometer thimbles for accurate setting. There are thread micrometers with profiled spindle and anvil to fit standard thread forms, those for soft materials with very large pads on the measuring faces to spread the pressure, tube wall ones which have a ball shaped anvil, and many more. For versatility, some models have a detachable anvil which can be changed for many different shapes and locked with the right one in place.

There are some bits and pieces which can be slipped over the anvil to measure different features; a simple one is an adapter to measure the wall thicknesses of tubes and other concave surfaces. I use an improvisation, the one in **photo 8**. All it needs is a steel ball of a known diameter and some blue tack or plasticene. As long as the ball makes a point contact with the inside of the curve, it is only a simple sum to find the thickness.

**Photo 9** shows a problem which can affect me. I haven't very big hands and cannot always use the ratchet. The ideal solution is to use a micrometer stand for work where two hands can be used. If no stand is available, use a small light duty vice, like I did in **photo 10**, making sure that the micrometer is well padded with some thick cardboard and not too tight.

The micrometer in the photos is mine, still going strong since 1947.

If possible always use the ratchet, it is there to make sure that anyone will have the right degree of tightness. The fun starts when the ratchet cannot be used and this is where feel is important. The best way I can describe correct feel is that when the measuring faces slide off the work, it should feel greasy. This applies to a vernier or a digital caliper too and is really one of those things which you have to practice.

The setting in **photo 11** is an example of setting by feel, another way would be to lock the micrometer at the dimension and take it from there. Where there is no adjustable instrument to use, **photo 12**, some sort of standard will do, in this case a bar of silver steel which is an accurate and reliable item, but always check with a micrometer to be sure. Once set, the caliper can be used to check the awkward feature in **Photo 13**.

## Digital read-outs

Both micrometers and calipers can be bought with digital read-outs. The calipers especially are a boon to model makers and anyone who has to measure precisely, sometimes in imperial and metric units. A touch of a button and they can be changed from inches to millimeters and also zero'd anywhere on the scale. I would advise anyone thinking about buying a measuring instrument to go for a digital caliper. They will measure length, both inside and outside, and depth too. Since Pauline bought me one for a birthday, the one in **photo 14**, I was able to leave my 'old fashioned' vernier set as in **photo 5** set up as a height gauge.

## Getting the feel right

Feel is an awkward thing to describe and quite often an awkward thing to get right.

## A modification

The only complaint I have with a digital caliper is the silly rolling thumb wheel,

which is allegedly the fine adjustment.

**Photo 15** shows it. Perhaps I am too pernickicky but I couldn't get on with it so I had a good look at it and made my own version, based on the fine adjustment of any vernier. **Photo 16** shows a close up of the modification. It is much more sensitive in adjustment, see **photo 17**. One more little bit of nit picking, why do they call it a digital vernier? I haven't seen one yet with a vernier scale!

## Measuring by comparison

There are many ways of checking an unknown dimension by comparing it with a standard or measuring instrument. An example is shown in **photo 18**. A pair of toolmakers' buttons is being used to position centres of holes to be bored accurately in the work piece. The feature being set is the pitch between the buttons. By using the dial test indicator to transfer the dimension from button to height gauge for the top button and the same for the bottom one the pitch can be calculated. There are many ways of using this system, all it needs is some way of holding the dial test indicator and a measuring device of the right accuracy. The height gauge could be replaced by a combination of accurate blocks, if enough could be found.

That is a very brief look at the measuring business and some of the things we use, there are more and I really have only just scratched the surface. In conclusion, can I finish up back where I started. Spare a thought for those who, without any previous knowledge and lacking the equipment we have, worked it all out for us.



**Note:** photos showing both of the author's hands are courtesy of Amanda Loader



17. Using the modified caliper.



18. Measuring by comparison.



# THE BRISTOL MODEL HOBBIES EXH

## Neil Read heads out to the West Country.

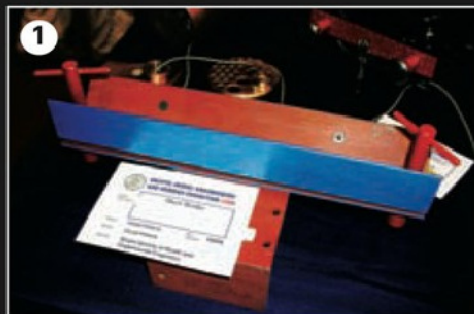
**M**en of learning are sometimes heard to mutter an old adage that goes something like 'it is better to be born lucky than rich'. Well, I am not sure I agree entirely with those sentiments but lucky we certainly were after we arrived at Thornbury on 18 August 2006 for the opening day of the above exhibition organised by the Bristol Society of Model and Experimental Engineers. Why lucky? Well, you see about ten minutes after arriving, the heavens opened and it rained heavily - so much so that we understand

there was some concern about the movement of vehicles on the (free) parking field. We were nice and snug inside the Thornbury Leisure Centre by then and although we did not suffer the effects of the rain we certainly heard it on the roof. Had no problems getting out of the parking area either when the time came to leave so perhaps our luck was still in!

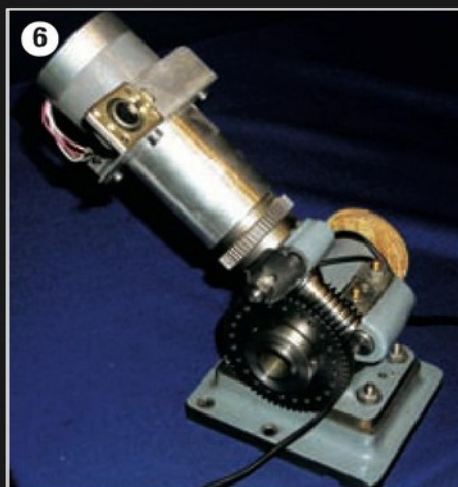
The Bristol Exhibition is now a regular feature of the model engineer's August activities and is well attended by the trade and several clubs and societies complementing a fine display of the work of

the host society. The team from *MEW's* sister magazine, *Model Engineer*, were there in some force and a full report will appear in that journal in due course ably penned by my colleague Malcolm Stride. However, I was asked to keep an eye open for items of interest to readers of *MEW* and hence this brief, essentially pictorial report. The accompanying photos convey a sample of the workshop equipment on display.

Should you consider visiting this popular event? Well, if you enjoy looking at engineering models and tooling, chatting to like-minded individuals and



1. A sturdy sheet metal bender by Gerald Roberts of Bristol SMEE.
2. Also by Gerald Roberts was this rivet crop.
3. A set of bending rolls to the George Thomas design by Don. Cordall of Bristol SMEE.

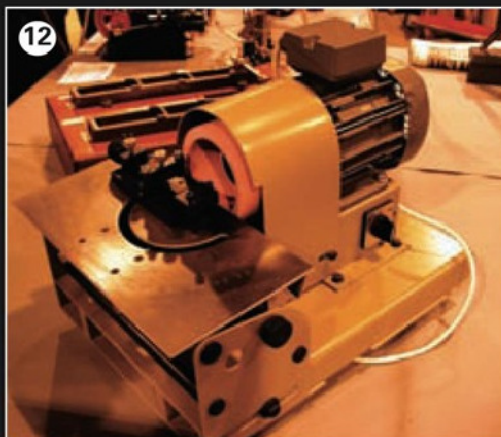
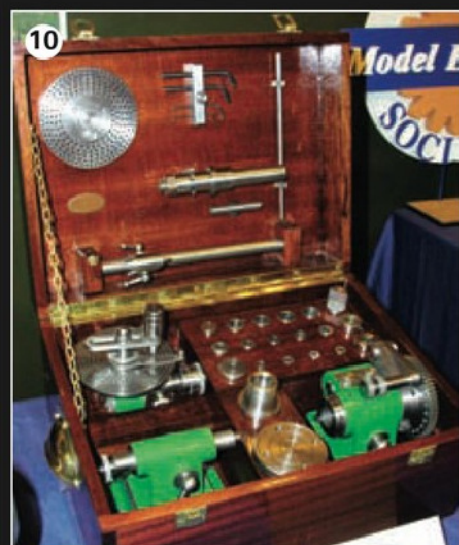
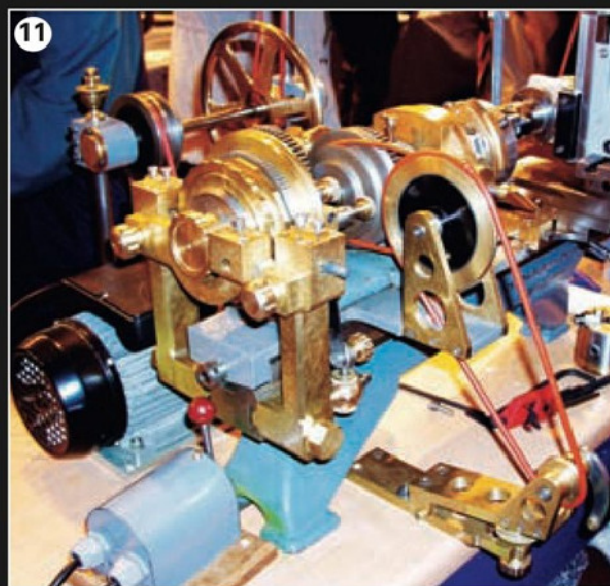
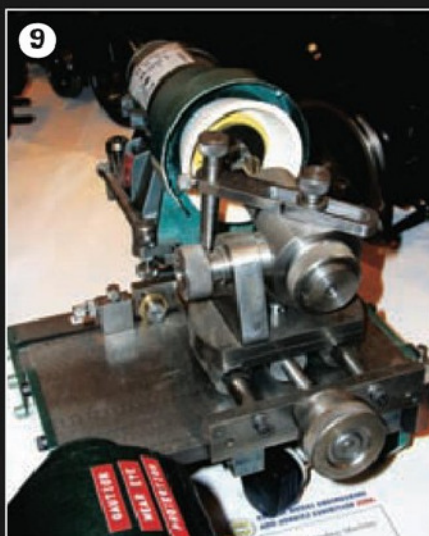
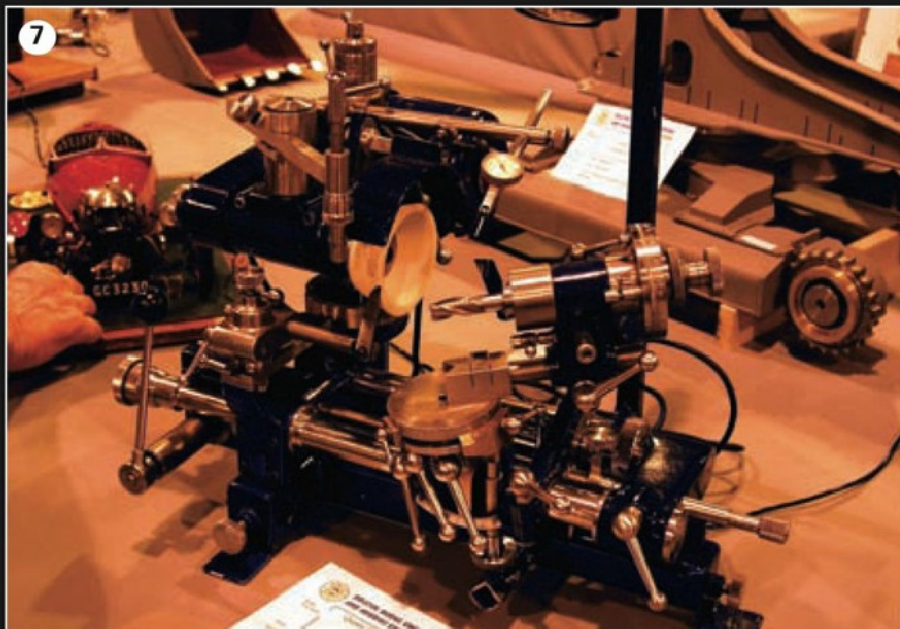




# ENGINEERING AND EXHIBITION 2006

stocking up on items for your workshop then why not give it a try. Bristol is one of the "younger exhibitions on the calendar" but over just five years at Thornbury, has grown to be one of those not to be missed. The venue is easily accessed by road from both the M5 and M4 motorways and I have always found the natives friendly. Thornbury Leisure Centre is a modern, pleasant building and parking in a field behind the main site is free. Food and refreshments are available on the site. Keep an eye open for the announcements next year and give it a try!

4. Also by Don Cordall, a neat example of the George Thomas boring head.
5. A keyway cutter for the lathe built by David Harding of Bristol SMEE from a College Engineering kit.
6. A Versatile Dividing Head fitted with a stepper motor by Geoff Sheppard of Bristol SMEE.
7. Martin Gregory's Quorn tool and cutter grinder. Mr. Gregory assured us that he does use the machine regularly and has to work hard to maintain its immaculate appearance.
8. A Colyer/ Caseley cutter grinder by Peter Richardson of Cardiff MES.
9. A cutter grinding machine by John Tovey of Cardiff MES. Not instantly recognisable as a published design.
10. A boxed Versatile Dividing Head by John Shipton of Stroud SME.
11. A Schaublin precision lathe modified for ornamental turning work and seen on the Society of Ornamental Turners stand.
12. An unlabelled Wordon tool grinder.
13. Also without label, an MES rotary table.





# RENOVATING A MYFORD SUPER 7 LATHE



1. The most notable absentee item is the top slide assembly. The tray is an obvious custom-made item, for which flimsy (0.5 mm) galvanised steel sheet had been used. Also, as the stand was the type designed to take the standard Myford imperial thread chart panel, whereas there is no need for this panel for an imperial gearbox model, this stand obviously couldn't have been originally supplied with the lathe. (The standard metric chart is attached to the inside face of the gear cover)

## Synopsis

This series of articles describes the renovation work carried out on a second hand Myford Super 7 lathe, with gearbox. This lathe was bought at an engineering auction in 1999. Following an introduction, there is list of the "problems" which were identified, and which required to be dealt with in order to get the lathe back into good working condition. It is hoped to encourage those model engineers who would consider such a task to be quite beyond their capabilities that this need not necessarily be the case.

**M**y first "proper" lathe was a Myford ML7 bought new in 1951 direct from Myford's. It had lots of use for many years, mostly on non-model engineering projects. This lathe cost me just over £100 including many accessories. If the Super 7 had been available at the time I would have bought one of those instead. However, I was to be committed to the ML7 for about 33 years. I mention "proper" lathe because my first lathe – bought from Bond's O' Euston Road for about £5 in about 1950, as I vaguely recall – was tiny, with an overhanging tailstock end. I can't remember if I ever set it up and used it. Presumably I must have done because I

## Mike Thurgood, Cape Town, describes the renovation of a 1964 machine, purchased at auction in 1999.

still have the ½ HP single phase motor I bought for it.

I eventually bought a secondhand Super 7 with **cabinet stand** in 1985 with the objective of renovating it as a challenge, basically. The lathe didn't have a screw cutting/fine feed **gearbox** and it was missing its topslide assembly, a four-way tool post having been substituted by the previous owner. I machined a new **top slide assembly** using CI castings I imported from Britain from an advertiser in *Model Engineer* by the name Ward. I also machined a **feedscrew** and **nut** for it (the latter threaded with an Acme tap bought from Tracy Tools Limited), with a handwheel (**ball handle assembly**) and micrometer dial.

The renovations included repainting it in bright colours. Once the Super 7 was in proper working order I sold the ML7. (Let me explain here that, in order to avoid any confusion over the names of parts, I have emphasised in **bold print** the names as given in the Myford listing, but only on the first occasion that they are mentioned in the text).

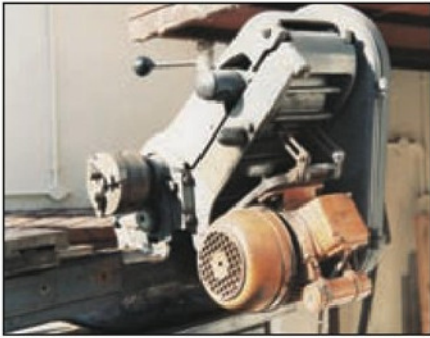
The ML7 had, and my first Super 7 has had, their fair share of work, but the latter lathe, in particular, has been used far less use than it otherwise would have been, since I bought a new Rexon 350m vertical mill/drill in 1987. Before owning this mill/drill I never knew what I had previously missed.

There were no problems with my first Super 7 except that I burnt out the starter windings of the single phase non-capacitor start electric motor twice. It was of Taiwanese manufacture and was supposed to be rated at ¾ HP but I strongly suspect that this rated power was its total electrical consumption, not its true output power. (I was told by a Cape Town firm who



2. The head end of the lathe was fairly clean as can be seen in this photo from the rear, but the lathe and its cabinet had been repainted, probably not so long before I bought it.





3. Two additional short brackets can be seen supporting the motor hanger plate. These brackets were checked on reassembly and I could find no reason to refit them. Note the front end of the latheways, and that there is no lever on the belt tensioning camshaft arm.

specialise in motor rewinds that the Taiwanese tended to do this at one time.) The burning out occurred in winter when starting the lathe from cold in the morning at the penultimate top mandrel speed setting. On both occasions I didn't pay attention quickly enough to the rapid hunting in and out of the starter windings, which was followed by ominous smoke coming from the air circulation holes - the omen indeed of disaster. Needless to say, I now take precautions to start up on a lower mandrel speed in cold weather.

However, as I use standard 20/50 engine oil for the mandrel and countershaft bearings this could have explained the reason for heavy going on cold starting. Why didn't I use a light oil in winter? Because the headstock front tapered phosphor bronze bearing rapidly warms up, initially, until the surrounding bearing housing has also warmed up and expanded, when the bearing cools down. I reckoned that using too thin an oil could accelerate bearing wear.

## Acquisition

At a local auction in September, 1999, I came across a rather mutilated Super 7 on a cabinet stand, but it had a gearbox, and I made a successful proxy bid for it. It was the gearbox which mainly encouraged me



6. This photo shows the most startling view of the damage to the lathe bed - viz ~2in. removed from its headstock end, done in the most appalling way. The four rubber tyres seen on the latheways were from a kiddy's toy and were used as resilient material under the lathe feet! Better than nothing, I suppose.



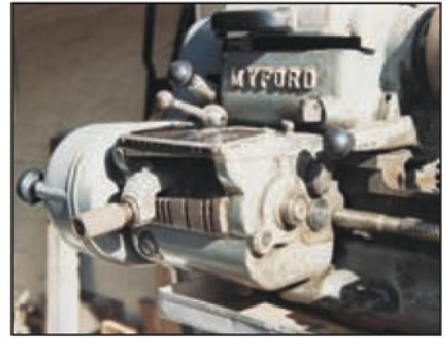
4. A close-up of the lathe carriage. The base of the 4-way tool post can be seen welded to the cross slide. The end plate (or extender bracket) supporting the cross slide handwheel is clearly non-standard. There is no thread dial indicator, and the knob on the carriage handwheel is definitely non-standard. The cross slide looks rusty - it sure was.

to make the bid. I could see that there were going to be some "problems" with the lathe, but not quite as many as I actually found by the time I had completely dismantled it. **Photos 1 to 5** show some views of it in its as-bought state. (When I received the parts leaflet from Myford's I found that my offer in Rands for the lathe was about a third of that just for a new gearbox, let alone requiring the longer **leadscrew** and hinged **changewheel guard**). I enquired about the age of the lathe from Myford's, quoting them the serial number: it was 1964 vintage, the gearbox being original equipment.

There were quite a number of problems to deal with, some difficult and others relatively minor. A list of them is given below. The rest of this series of articles describes the remedial work that I carried out, ending with a Myford Super 7 lathe once again in very good working



7. This view of the underside of the tailstock body shows how the eccentric arbor was pushed through the distorted slot in the eyebolt using a coach bolt. Although, initially, turning the nut to tighten the coach bolt against the arbor and the other side of the tailstock casting didn't move the latter through the slot in the eyebolt, a light tap on the head of the bolt soon shifted it, albeit by a small amount. This procedure was repeated until the arbor was clear of the eyebolt. Doing the job this way avoided having to apply any potentially damaging impact force on the casting. Another, minor, problem was the tight fit of the arbor in the hole through the rear of the tailstock casting - seen on the LHS in this view.



5. This shows the gearbox. Although the paintwork is dirty and badly chipped, the gearbox mechanism was found to be in perfect condition as it had had very little use. But lots of metal swarf had found its way into the works over the years.

condition, and undoubtedly which will see my lifetime out. There are lots of photos with this series of articles. As in the case of other articles of mine, I have provided comprehensive captions to them, with information additional to the text.

## Problems requiring remedial work

1. There were no **raising blocks** - see **Photo 1**.
2. No less than 2in. had been cut off the head end of both lathe ways, see **Photo 6**. I presume that a previous owner had decided that, having a job to do which required a longer gap, it was cheaper to cut 2in. off the bed of this lathe at the head rather than buy a larger one with a bigger gap. The main problem was that, having angled vertically and part-way through horizontally, the pieces of the bed were then messily broken off!
3. A flimsy steel **coolant tray** had been made for the stand at some time using 0.5 mm galvanised steel sheet - see **Photo 1**. It had been damaged, very likely during transit to the auction rooms - the damage to the tray can be seen to the right in **Photo 1**. Since



8. The front end of the tailstock showing the drill chuck No.2 MT arbor actually brazed both to the tailstock barrel and to the drill chuck. If the tightening lever looks slightly bent towards its boss end, in fact it is. One of the half dozen unceremoniously hacksawn graduating marks can be seen on the barrel.





9. This photo shows all the blemishes on the tailstock barrel even more dramatically.

there was no way this tray could ever be transformed into a strong component, it was relegated for use as floor tray under the car

4. Kiddy's toy rubber tyres were used as resilient supports on the standard cabinet stand for the bed – see **Photo 6**. Better than nothing!

5. The lever for the **eccentric and lever assembly** from the tailstock had been bent, and also its arbor wouldn't slide out of its housing in the **tailstock body** because, somehow, the oval hole in the eye bolt had become slightly elongated and it was, as a result, slightly smaller than the diameter of the lever arbor. (For anyone who hasn't seen it removed from the tailstock body, the eccentric arbor has a reduced-diameter section machined off-centre to provide the eccentric clamping action through the eye bolt and **clamp plate** when the arbor is rotated). The arbor can be seen in **Photo 7**, but its offset length is hidden where it is seen being pushed with the coach bolt through the arbor locating hole in the side of the tailstock casting. This method of removing the arbor from the tailstock body avoided the risk of smashing the latter, which could have easily happened if I had used a hammer and brute force to drive it out. Rather strangely, however, the bend in the handle, which is tapered, was near to its larger diameter root, not at its smaller diameter ball end. I wonder if anyone can explain that



10. This photo shows the remodelled feedscrew for the topslide on the LHS, which had yet to be completed at the time this photo was taken. Also shown is the camshaft lever (for releasing the drive belts) with its lever arm missing. A crack can be seen at the tip of the CI end fitting, and also a piece of metal has been broken from the edge of the hole which takes the handle shaft.

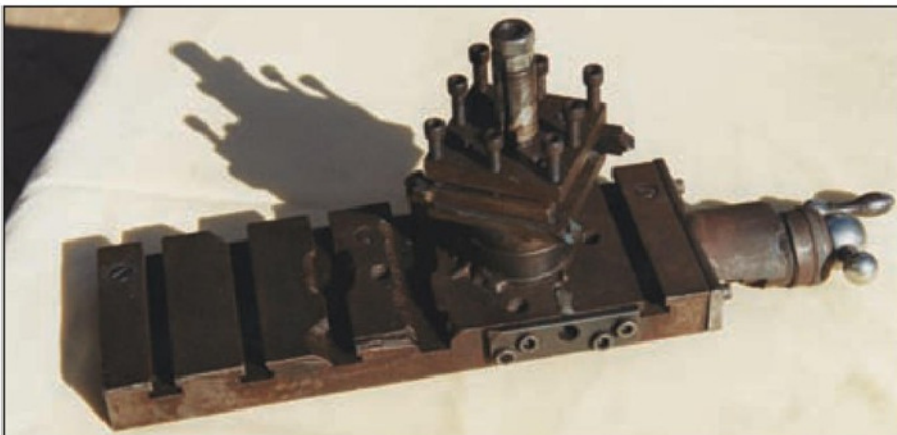
phenomenon – unless it had indeed been partly re-straightened.

6. The tailstock **barrel** was a story in itself. Firstly, the drill chuck arbor was brazed both to the barrel and the drill body! – see **Photo 8**. Then when I removed the **barrel feedscrew** I found that the ball **thrust bearing** had been reassembled not with the ball ring between the two outer hardened races with the grooves facing towards the balls, but both hardened races were assembled together at the front end, relying on the pressure of the shoulder of the adjusting feedscrew against the ball locating plate to provide the thrust action! Incredible? Say it again! Also the barrel had some "additional" graduations very roughly cut on it with a hacksaw. It was a mess, as can be seen in **Photo 9**. The question here is why was it necessary to braze the MT arbor both to the tailstock barrel and the drill chuck? Usually the taper of the arbor in the latter is designed so that the parts will not too readily separate. A possible answer, of course, is that it was done to prevent the drill chuck from being stolen - that's not so improbable in South Africa. Or the No.2 Morse taper had been damaged



11. I have included this photo, and the next three, to show how a vital part of a lathe can be mutilated beyond recovery – viz the cross slide assembly. The cross slide is shown the from its rear end, with a vee undercut at the normal 60 degrees on the RHS, but that on the LHS is machined at a right angle: this the normal Myford procedure. The thick two-piece gib strip is attached to the body of the cross slide with four screws.

7. The motor hadn't been wired up to the rotary switch for reversing, although what appeared to be a standard Santon rotary reversing switch was present, mounted on the large format Myford imperial screw-cutting chart plate – i.e. the one in which the motor reversing switch is mounted in the middle, as is shown in **Photo 1**. (The switch is, of course, hidden behind the panel). Thinking about it, though, the only occasions I recall wanting to reverse the motor has been when reverse-threading a die from a long thread or cleaning a RH thread, and smoothing



12. Another view of the damage and "repair" work, this time showing the top of the cross slide. One of the steel strengthening plates that were bolted across the brazed repair on both sides of the cross slide is clearly visible in this view, as is the damage to the tee slots.



13. This photo shows very clearly the brazing of the base of the 4-way toolpost on to the top of the cross slide; the badly damaged tee-slots; and the brazing across the top on both sides of the toolpost. The two strengthening plates can just be seen on both sides of the cross slide.





14. The underside of the standard Myford Super 7 cross slide is shown in this photo, fitted with the standard thick gib strips in two halves, which are bolted to the slide from the upper surface. The gib strip is in two halves because a single strip this thickness would not be satisfactorily flexible along its whole length to give the right "feel" for the movement of the cross slide over its whole travel - it would, in fact, be impossible to adjust it. Two brazed repair welds can be seen. A total break occurred across the casting at the point where the holes are drilled on either side and tapped for screws that tighten brass locking thrust pads against the topline spigot. Although the feedscrew assembly is complete, the end plate is an amateurishly made replacement. The Acme thread had been damaged at one point, not shown in this photo. Also the graduated end of the micrometer dial had been damaged by grinding.

the surface of a piece of turned wood with sandpaper. (Slivers of grain require the rotation to be reversed to remove them). In contrast, to run in reverse when taking a substantial cut would require the chuck to be positively locked to the mandrel so that it couldn't possibly unscrew - and that definitely does not mean by overtightening it on the mandrel thread. None-the-less, when eventually reassembling I re-established the reversing capability of the motor.

The presence of the un-necessary imperial thread cutting changewheel chart plate (ie when the lathe has an imperial thread cutting gearbox) would indicate either that the lathe hadn't been bought with a cabinet stand, or certainly not the one on which it was now mounted

8. There were a few missing and broken grease nipples. (Myford's refer to these as **oil nipples**, so am I wrong to be using a low melting point grease?)

9. The lever was missing from the cast iron boss on the **cam shaft and lever assembly** which is used for raising and lowering the **swing head assembly** for belt tensioning - see **Photo 3**. Also a small part of the boss round the hole in which the missing lever had been fitted was broken away. There was also a crack in the metal from this hole to the bullet end of the CI boss. Sometime or other the handle must have had a very hard knock, but which surprisingly didn't damage anything else. **Photo 10** shows this lever after its removal from the lathe

10. There was no top slide assembly, only a fourway toolpost mounted on a pedestal which was welded to the cross slide - see **Photos 1 & 4**.

11. The **cross slide** was an original Myford part with the two-part gib strip screwed to it. The slide had been broken into two parts across the large

diameter hole which accommodates the top slide base. The broken parts had been brazed together and the base of a 4-way toolpost had also been brazed on to it - see **Photo 4**. Finally, most of the tee slots were badly damaged - see **Photos 11 to 14**, inclusive. I decided that this cross slide had to be scrapped

12. The lathe **carriage** would only move a short distance along the lathe bed before binding. Obviously over some considerable period of use the carriage had only been moved a short distance along the bed. I would imagine this to be a fairly common problem that arises with a non-hardened bed, particularly if one doesn't rack the carriage right back to the tailstock every time there's a need to move it from the headstock. Very tedious, I know only too well, but it does lead to even wear along the latheways. However, badly adjusted gib strips could also have contributed to the binding

13. The lathe mandrel (**spindle**) had about 1½ mm of free axial movement. Incredible! Luckily - extremely so, in fact - the front phosphor bronze taper bearing (**spindle bearing - front**) hadn't been damaged. The wick oil cup for this bearing had been packed with grease instead of being filled with oil. How could anyone have expected the front bearing to be lubricated? Well, obviously it could happen in South Africa.

14. The **oil cups** for the **countershaft** had also been greased instead of being filled with oil. The oilways were, therefore, completely blocked. (The lathe must have been awfully stiff to start in cold weather, until the bearing faces had warmed up). One of the oil cups was missing, but I found it hidden in thick greasy dirt in the swing head casting

15. Luckily the gearbox was in perfect condition internally, and it obviously



15. The 60T bullwheel showing the repair fillet machined to the wheel profile. But the two 5/16in. diameter holes should be noted - what are they for if not to fit a short bar with two pins...

had had very little use. But a feature I particularly noted and had, in fact, wondered about for a long time, was that, over many years, lots of swarf had found its way into the bottom of the gearbox casting. This would indicate that when the gearbox is not in use - probably 95%, or even more, of the time the lathe was used - some form of movable guard is required to prevent the ingress of swarf through the gap through which the change lever is moved - see **Photo 5**. The range selector knob on the top of the gearbox casing - see **Photo 5** - had worked itself loose basically because there wasn't a flat on the **pivot pin** to which it was attached to positively prevent the locking grub screw from moving round if excessive force was applied to the lever.

16. Although the gearbox top cover is readily removed from the body to give access to the gear mechanism, the gears inside leave little access for cleaning the bottom of the casting, unless perhaps petrol is used to flush out the swarf through the oil drain



16. ...for engaging with the protrusion seen in this view inside the headstock casting just in front of the RHS mounting hole in the base when loosening a tight chuck? This would presumably save a high force being applied to the Woodruff key in the vee cone pulley when releasing a tight chuck, or would it smash the gearwheel against its key to the lathe mandrel? Maybe the wooden wedge idea is the best of all for avoiding tooth damage, but it still wouldn't help the Woodruff key for the gearwheel.





**17. Headstock belt guard showing the clearance cut-out for the swing arm casting on the RHS from the front, which has been very roughly increased in size.**



**18. The cut-out on the LHS of the headstock belt guard showing the same rough treatment.**

hole. Removing the gear trains in normal use in order to remove the swarf would be a rather tedious and extreme measure, to say the least. However, in order to properly clean out the swarf and to allow the inside of the box to be painted white, the whole gear train assembly was dismantled.

17. There was one broken tooth on the **60T backgear assembly** (often referred to as the "bullwheel"), and likewise on the 17 tooth pinion on the matching **17/53T backgear cluster**. Presumably the breakage occurred through using excessive force at some time with locked backgear to loosen a tight chuck instead of locking the mandrel with the pulley **locking pin** or, better still, using a wooden wedge, as is indeed recommended by Myford's. But one needs to be very careful when using that locking peg, though, because resistance to rotation is given by the Woodruff keys in the aluminium pulley wheel on the mandrel and the bullwheel. The more one thinks about it, that wooden wedge is the safest way to ensure the least damage when loosening a really tight chuck.

18. The arbor of the **hand traverse pinion** on the lathe carriage was very loose due to wear of the unbrushed hole through the cast iron **apron** – a common problem. Using the handwheel for this pinion arbor applies a lot of sideways force and, in particular, a substantial downwards force, on to the bearing face in the apron due to the position of the former relative to the position of the operator's hand. These combined forces result in accelerated wear of the hole, even though it is 30 mm long through the wall of the apron casting. However, the pinion arbor was also badly worn down in diameter where it passes through this hole, as also were the gear teeth, no doubt by being pushed hard up against the **rack pinion gear** due to the looseness of the arbor. This wear was probably compounded by lack of lubrication. This arbor is, in fact, supported only where it goes through the hole in the apron wall unlike the immediately adjoining arbor for the rack pinion which is supported at its other end by a larger diameter phosphor bronze

bush located in the alloy die cast **gear cover assembly**.

The hand traverse pinion was replaced with a new one, and the original hole, now oval, was rebored and a phosphor bronze bush fitted, as will be described later. Myford's gave me the centre distance between the two arbors.

19. The knob on the carriage **handwheel assembly** had presumably come unscrewed and had been lost at some stage, and had been replaced with a rather odd-looking substitute made from a length of MS hex bar – see **Photo 4**.
20. The leadscrew nut (half nuts) were so full of swarf that they hardly engaged with the leadscrew at all. Apart from this there was very little wear on the half nut threads or on the leadscrew itself, for that matter. But there was another problem with the two halves which, somehow, had been badly distorted, with their stems being twisted. This distortion must have prevented their proper engagement with the leadscrew for years. I will return to this later.
21. The **headstock belt guard** was badly fitting for some reason - I didn't investigate this until some time later because I thought it was merely a matter of adjustment. The large gap where it should bear down on to the headstock can be seen in **Photos 1 & 5** and a part of the cut-outs in it which provide clearance for the **swing head assembly** had been very roughly extended, presumably to increase clearance for the swing arm when the belt tension is released. **Photos 17 & 18** show the extra cut outs on the right and left hand sides of the guard, respectively (as seen from the front of the lathe). Initially I thought that it wasn't going to be easy to make an effective repair to these cutouts but I changed my mind after I had given the problem more thought. I will deal with the remedy later. Prior to repainting the aluminium castings I removed the existing paint with a normal commercial paint stripper. They were coated with a lightish grey-white undercoat, which was also very likely some form of self-etch primer, not the more common yellow chrome etch. Interestingly, it was very difficult to remove, so much

so that I didn't even bother to remove it right down to bare metal everywhere. What remained – see **Photos 17 & 18** for typical examples – was very tenaciously adhering to the aluminium, and which wasn't lifted when I subsequently painted with Hammerite paint

22. One flange on the countershaft **CI cone pulley** had two chips broken from its edge.
23. The aluminium **motor pulley** was badly damaged, with a large section of the smaller pulley flange having been broken off. The repair work will be discussed later.
24. The spring-loaded **roller and plunger assembly** for keeping the headstock belt guard in the open position was seized almost solid.
25. Finally, all parts of the lathe which had the original painted surfaces were badly chipped and everything required to be stripped and repainted, including the cabinet stand

With all these problems there was obviously going to be a great deal of work involved in properly renovating the lathe, and three major components either required replacements to be purchased from Myford's, or to make them myself, viz the cross slide, top slide assembly and the tailstock barrel.

Because repainting is relatively routine I don't intend to discuss this in any detail except to mention that, having stripped off most of the paint with a paint stripper - not by sand blasting - I used appropriate self-etching paints as primers for the aluminium and cast iron parts. However, where the original primer was found to be well adhering to the metal, whether CI or aluminium, it wasn't removed. The parts were then finish-painted with various colours of Hammerite paint, using both plain and hammered finishes.

I will proceed to discuss the various parts of the lathe which needed attention, and exactly what I did to renovate them where this was considered to be feasible. Although I didn't deliberately work out an order to progress with the renovation, I decided that the best policy was generally to work from the bottom up, i.e. from the cabinet to the lathe bed; then the headstock, gearbox and leadscrew; next the lathe carriage; and finally the tailstock.

The work on the cabinet stand included making a new drip tray because the tray which came with the lathe was far too flimsy. (A drip tray is absolutely essential, of course, even if it is only used to catch swarf. But in my case it invariably becomes the repository for a vast range of bits and pieces, lathe tools and swarf! Also, when moving the lathe about it is the tray which one grabs a hold of).

Therefore this tray, together with lathe bed raising blocks, were made at a necessarily early stage. I decided to make the drip tray, rather than buy one, firstly because it was part of the challenge of the renovation work that whatever could be made would be. And secondly, limiting the cost of bought out items had to be considered very seriously.





# A LEVER LOCKING TOPSLIDE 2

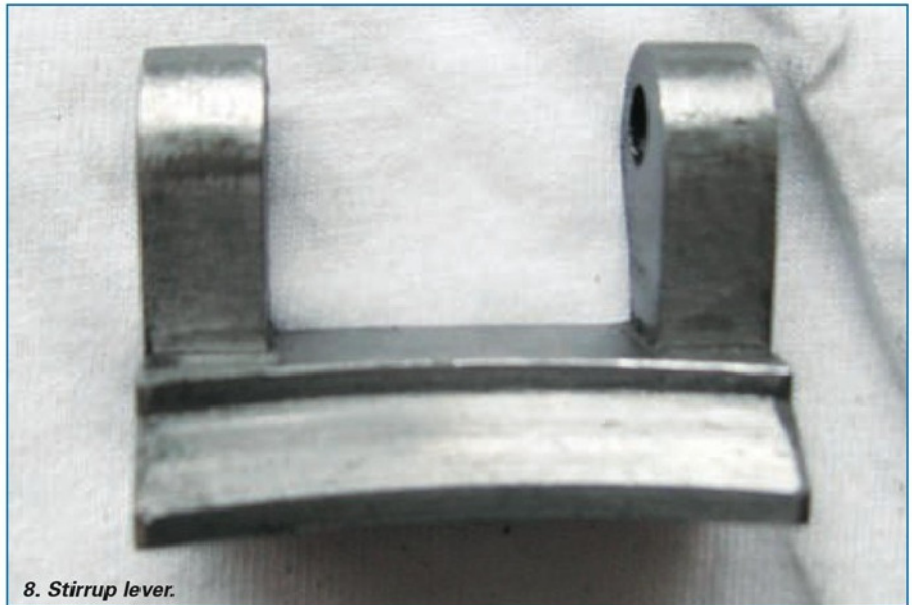
Alan Jackson continues his description of this ingenious accessory shown at the Model Engineer Exhibition

Part 1 of this article, published in Issue 119, dealt with the general description, rationale and *modus operandi* for the device. Cross slide requirements were discussed and general arrangement drawings also given. Consideration is now given to the top slide, retract mechanism, and toolpost. Initial comments are made concerning manufacture.

## Top slide arrangement

The drawing, **Figure 4**, which appeared with part 1 of this article, incorporates improvements I can now see over my first attempt. In **photo 5** (also part 1) you will see that the annulus protrudes on each side of the top slide. Swarf guards have been fitted to both sides of the protrusions. This is not entirely necessary. For a long time I only had one swarf guard on the operator side and did not have any trouble with swarf affecting the locking arrangement. The design I built is symmetrical with the annulus in the centre of the top slide base. If it is offset slightly towards the operator the annulus can be enclosed on the side opposite the operator (Lathe mandrel side). This will provide better protection from swarf ingress and also increase the top slide base stiffness. However I am acutely aware that when you make things asymmetrical, you create the potential for problems; it is so easy to make it the wrong way round.

The cutting tool should be as well supported as possible, so I have arranged for the support beneath the tool to go directly down to the lathe bed with no overhang, apart from when the top slide is moved forward on its own slide. As we are all aware, the upper slide cantilever should be kept to a minimum. The overall length of the upper slide is 6.5in. (165mm) for the one I made. This allows a movement of about 90mm, which is adequate. I can see no reason why this should not be increased to 200mm, which will give much longer travel up to about 5in. (125mm), which will always be useful. I have also simplified the feed screw nut and made it adjustable for backlash. The long nut, for low wear, has two slits in the centre portion and can be squashed to reduce (eliminate?) backlash via the two retaining hex socket cap screws. The feed screw is now located in a long bore rather than an open groove. This gives better protection for the feed screw and makes the lower slide stiffer but the downside is that the



8. Stirrup lever.

stirrup lever pivot pins cannot be removed if they are plain pins. The new location of the nut also gets in the way. To solve this I have threaded the outer part of the pivot pins to enable their removal.

The width of the top slide adjacent to the tailstock has been reduced as much as possible. Not to the extent of some good previous "L" shaped designs, but everything helps. There are no locknuts on the gib screws just because it allows a clean design, and I have not found the

adjustment to change in use. There are grub screws with Nyloc inserts available, I believe, which could be used. I have not provided a vee slide locking screw either. These things are personal preferences and can be incorporated as desired.

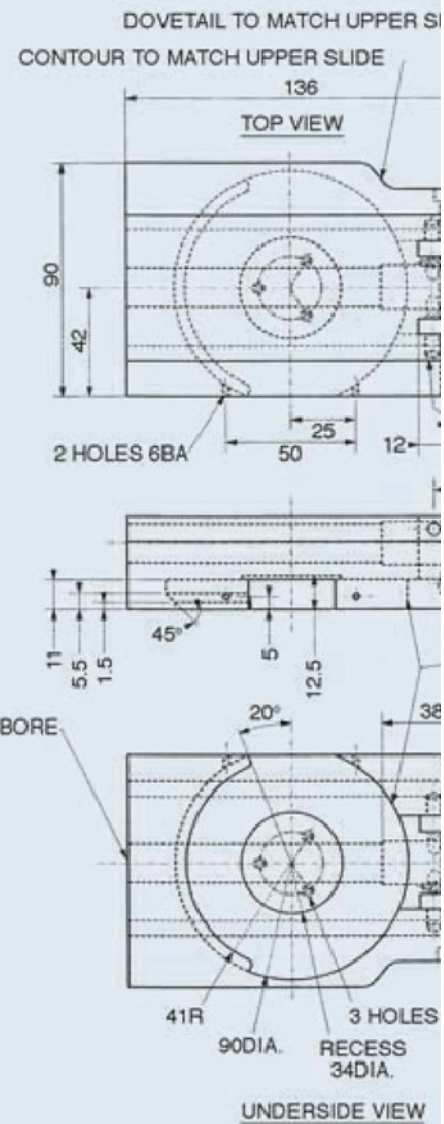
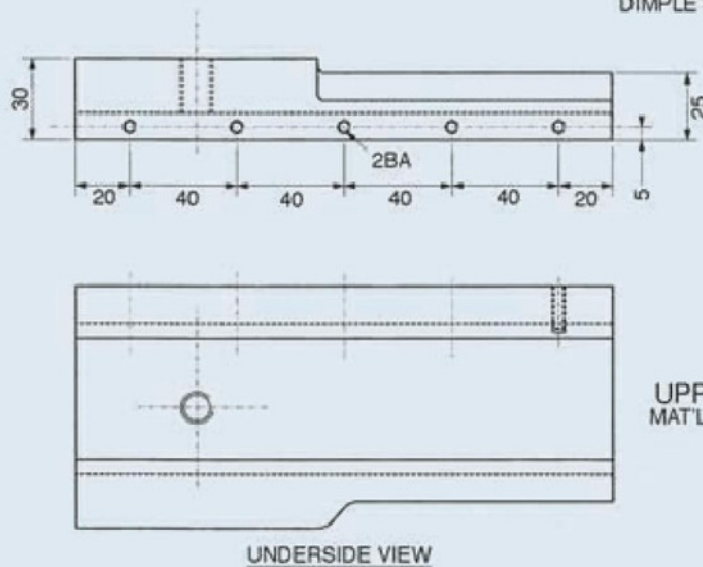
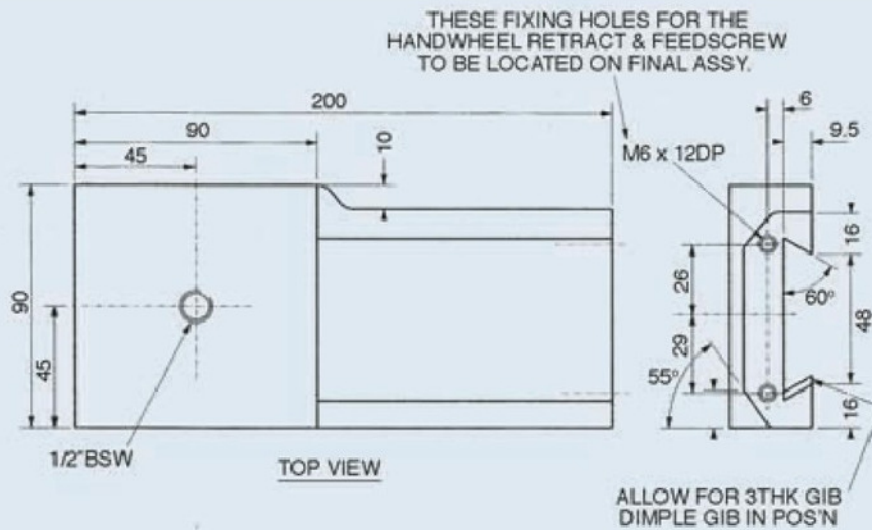
## Screwcutting Retract

The screwcutting retract arrangement is also personal preference and steals most



9. Underside view of annulus showing T bars.





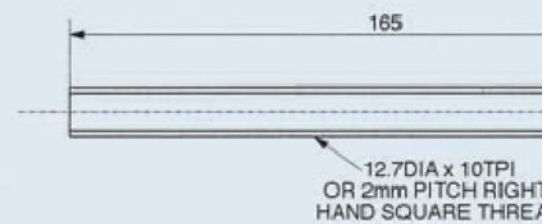
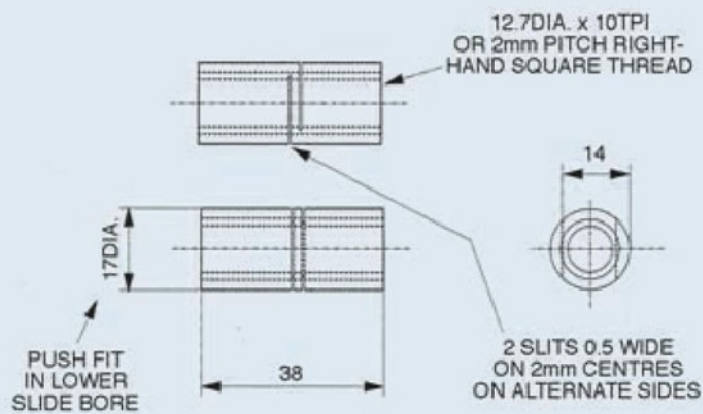
LOWER SLIDE  
MAT'L CAST IRON

VERNIER SCALE GRADUATION  
SEE TEXT FOR DESCRIPTION

DRILL & C/BORE  
FOR 6BA

44R & CHAMFER  
45DEG TO CLEAR

SWarf GUARD  
MAT'L MILD STEEL



FEED S  
MAT'L M









10. Annulus assembled to topline.

of its concept from George Thomas's design. I think it differs inasmuch that it has an extra gear and does not have an adjustable stop for internal threads. It can be moved in either direction from its stopped position for external or internal threads. There is little I can add to his guidance and design for feed dials etc. The main advantage apart from when screw cutting is to be able to position the feed dial and hand wheel higher and further away from the tailstock, I have maximised this. This also allows for a large handle and dial, which is heavier for smoother operation. It is quite possible to omit the retract part if desired as it is also possible to fit a hand wheel directly on the feed screw if preferred.

## Toolpost

The toolpost in **photo 2** (part 1) was made from a piece of mild steel I acquired (from the odds box). It could have been a bit thicker for the socket screws and it had some extra notches that I could not eliminate so they became design features! However it has served me well. It can hold two conventional cutting tools and a parting tool, which unfortunately has no height adjustment so tools have to be ground to fit but it does hold the blade rigidly. There are two grub screws in the face that can be set to get the blade vertical. This allows various blade thicknesses to be used. It is mainly used for small grooves etc. I use a rear mounted parting toolpost for larger applications. There are also two sockets 0.720in. dia. for mounting boring tools. The eccentric boring tool holders can be rotated to bring the cutting tool to centre height. This works very well and is nice and rigid.

The toolpost does not obviously have the height adjustment and variety of toolholders of a Dickson style toolpost (or the bulk and expense), but it has been entirely adequate for my needs. I have

made adjustable packing pieces that fit beneath the lathe tools and this helps centre height adjustment. The method of attaching the toolpost to the top slide will be to suit the type of toolpost being used. So, for example, allowance for a suitable tee slot at the desired height in the top slide will have to be incorporated if that is what you require.

## Making it

Castings would be nice for the upper and lower top slide parts but blocks of cast iron can be obtained from College Engineering etc. I am not quite sure about the level of detail required for constructional notes. So I will confine my description to the essentially different parts of this design. There have been many good articles covering very similar machining operations, which also occur in constructing this design. It also depends on the equipment at your disposal. I made mine on a 1940s 4.5in. Denham lathe and a Dore Westbury Vertical Mill/Drill.

Detail drawings are shown in **Figure 5** and **photo 7** in part1 showed the top slide dismantled. The only tricky parts to make were the lower top slide body and the stirrup shaped locking lever. From distant memory this is how I made these components.

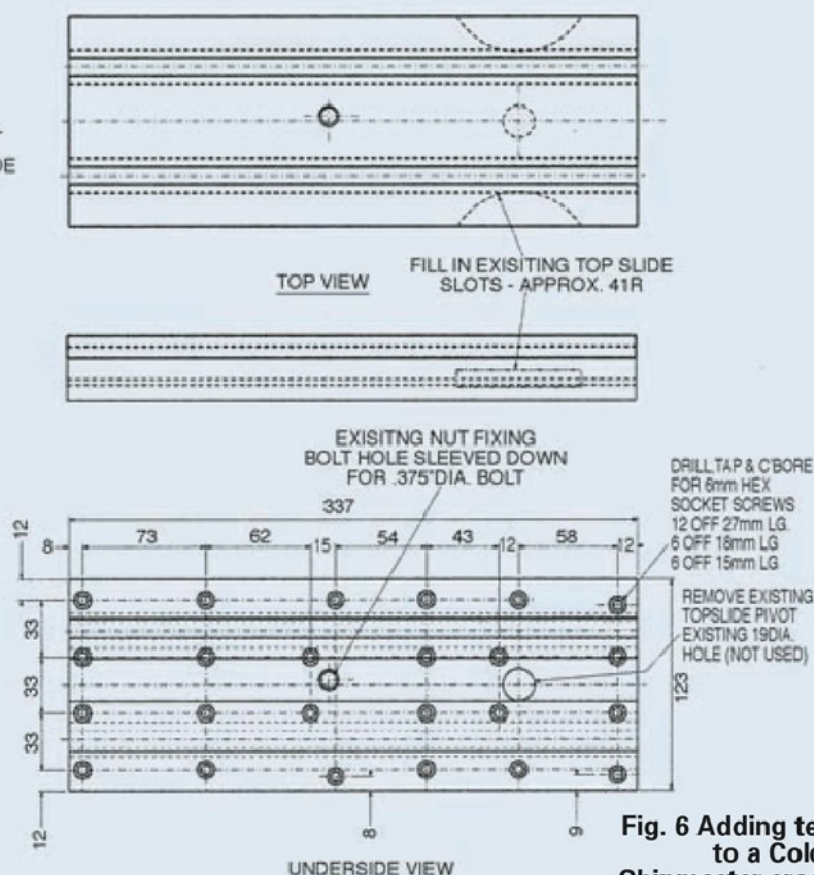
## Lower topline body and stirrup lever

1. Machine all faces of the rectangular block, for the lower slide, square and slightly oversize, say 30 thou, although the length can be the finished size. The excess material each side of the vee slide should also be removed, leaving a raised square sided centre section.
2. Bore the hole for the feedscrew

through the block. Pack it to the correct height on the cross slide with the feed screw nut end facing the chuck. Drill through and bore the nut recess to size and depth. The tapped holes that retain the nut should be made with the nut in position and orientated at 30deg so that the slits in the nut can be compressed by the retaining screws. The hole for the operating spindle should be bored next. Rotate the block so that the counterbore faces the headstock; pack it to the correct height. Drill then ream the bore to size and finally machine the counterbore for the retaining screw. The tapped holes for the stirrup lever should also be completed at this stage because it will be difficult to do this into the sloped vee slide surface. Please note that the holes should be tapped deep enough for the outer sections only Oh! I nearly forgot to mention that you may have to make a cross slide with tee slots first before you can do this - jeez what a dummy!

3. Partially make the stirrup lever, (**photo 8**) just the top section, making the vertical arms (undrilled) to the overall largest section and parallel and the lower contact face area oversize to allow for machining. The radius ends and reduced arm section will be completed later. The plan is to machine the annulus recess with the stirrup lever in situ. This will ensure that the contact face of the stirrup lever is correctly shaped. End mill a rectangular recess in the lower slide contact face so that the stirrup lever can be fitted tightly into its position. Drill and file the vertical rectangular section holes to a close fit for the stirrup arms. Fit the stirrup lever fully in position and drill the holes for the stirrup lever pivots using the lower slide body as a drilling jig. Remove the stirrup lever and pivots for the next operations.
4. Mill the raised vee slide on a vertical mill parallel to the feed screw hole.
5. The next operation is to machine the recess for the annulus so it would be handy to have the annulus available as a gauge. It does not need to be completely finished, just the outer diameter, chamfer and thickness. Refit the stirrup lever and retain it with its pivots. This assembly can now be mounted in the lathe using a faceplate or 4 jaw chuck with the annulus recess on centre. Skim the contact face fully. Machine the annulus recess to the final dimensions with a smooth finish to the annulus contact face. The location recess for the centre pad should also be completed at this stage.
6. Remove the stirrup lever carefully so as not to disturb the mounted position of the block. The next operation is to remove half of the recess to allow the annulus to be inserted in position. I did this by rotating the chuck 180 degrees by hand taking small cuts with the top slide. It would be good if stops can be arranged against the





## Annulus

1. I think I made mine from a piece of stainless steel I found and of unknown specification. A disc cut from a bar or plate of mild steel should be adequate. Bore the centre first and skim the top face then mount via the bore and machine the other face, O/D and chamfered periphery.
2. The tee bars or tee bar and two cylindrical mushroom shapes (see **photo 9**). One should be an easy sliding fit in say the tee slot closest to the chuck and the other should fit a bit freer to avoid jamming. An identifying punch dot should be made on the upper surface at the end of the locating tee bar. This is so that the top slide can be replaced with the tee bars in their correct slots after it has been removed. Concentric dowels, around the fixing screws, position the tee bars to the annulus. The starting point for the graduations could be a bit tricky. I think I positioned the disc using the tee bar fitted and used a square to line it up. Graduate the periphery every degree and stamp  $\frac{1}{16}$ in. numbers every 10degrees. I used 0 to 90 four times. But that again is preference. The portion of tee bar that protrudes outside of the annulus must be reduced to be below the surface of the cross slide when it is in its uppermost position by say .020in. If this is not done the top of the tee bars will contact the underside of the top slide and prevent the top slide from locking to the cross slide when the top slide is set at an angle.

(See **photo 11** and **Figure 6**) I have added 1/4 in. thick mild steel strips to the original cross slide to form tee slots. 6mm socket screws secure the pre-machined tee slots bolted from below. The narrowest part of

the tee slot should be left undersize and machined to the correct width in situ to ensure parallel slots. It is still possible to access the gib retaining screws through the right hand tee slot. I have also filled the existing recesses in the sides of the cross slide, which used to provide access for the top slide bolts, the mild steel inserts were made a close fit and superglued in position.

The final section of the article which will appear in the next issue, will give further construction notes, detail drawings of the retract mechanism and also suggest a design suitable for a Myford 7. Meantime, should any reader have queries or suggestions, I can be contacted at: [alan@jackary.plus.com](mailto:alan@jackary.plus.com)



**11. Underside of cross slide showing attachment bolts for steel strips.**





1. 3-D view of U-bend tool.



2. Stage two closing tool.

## More sophisticated presswork

The curling of sheet metal parts, such as might be applied to the manufacture of hinges, is an operation which is certainly within the scope of the home workshop. One method often adopted by model engineers, is to silver solder a length of rod or tube to a sheet metal plate. That's fine, if you don't need twenty. So we move on to some slightly more clever presswork and take a look at the tools required. I've included two sets of drawings relating to typical tool designs. The first set of these shows two separate tools whereby the first stage of the process forms the blank into a "U" type bend. The component is then transferred to the second stage tool, which completes the rolled hinge. This set of tools, was designed around a 23 x 30 x 1mm sheet metal blank. Unfortunately, these tools are no longer available to me, and I don't have any photographs to substantiate their existence, as they were made for a third party many years ago. The hinge, itself, was designed for a special purpose, and bears no resemblance to the hinge that holds up your back door.

However, the second tool was designed to produce hinges similar to the door hinge. This tool incorporates the first and second stages in the one tool. The blank size for this tool is, 40.42 x 50 x 1mm. For the tool to work, the initial "curl" must be first introduced. This is done by placing the blank in the nest, which is set, to allow the blank to rest on the corner of the die. The amount will have to be adjusted, to suit the "curl". The component is then placed in the slot, to complete the curl. Both sets of tools are suitable for the manufacture of the "hinge" But the principle for rolling the hinge curl, remains the same whatever the shape and size required. However, hinges of very long lengths, and large diameter are best left to the expertise of sheet metal "brake press operators" (if there are any left) who have the necessary tools for performing such operations, either for hinge rolling or for the edge trimming of sheet metal parts.

# CURLING TOOLS

Mike Tierney moves forward from his discussion of simple press tools in Issue 117 and looks at precision bending, with particular reference to hinges.

## Precision bending

During the previous article, mention was made of precision bending tools, which embody means of accurately locating the blank, then bending to an accurate 90 degree angle. Two such tools are

illustrated in Fig 8. The work is located in a nest which checks lateral movement. A spring loaded pressure plate serves a downwards clamping function in one instance, and in the other exerts upward pressure, holding the blank in firm contact against the punch during the down stroke, finally operating as an ejector.

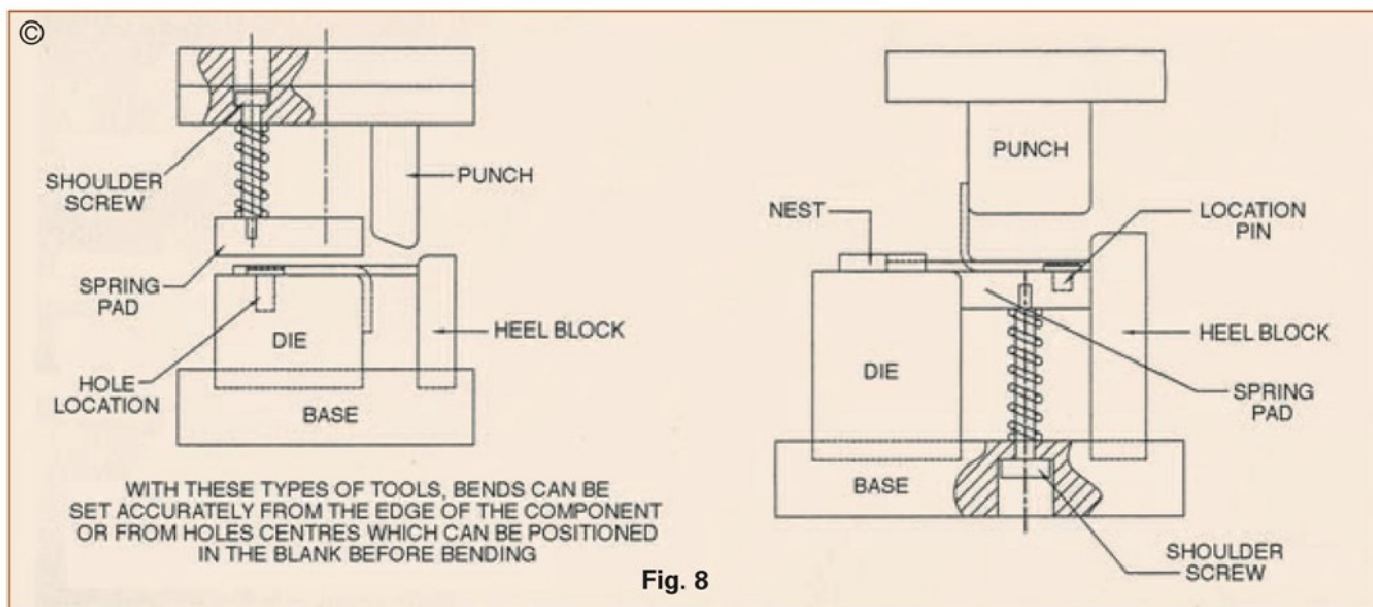
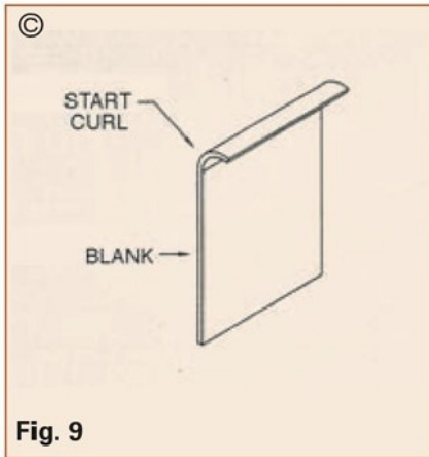
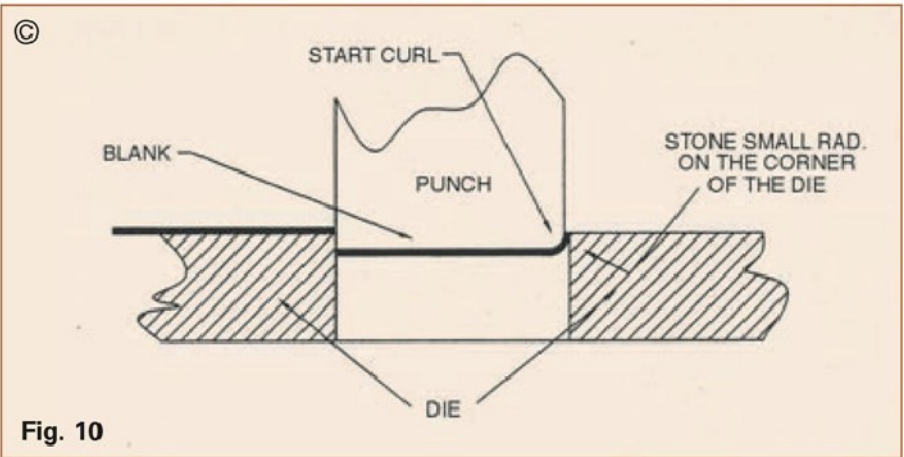


Fig. 8





The drawings illustrating these tools, are only for the engineering techniques involved in their manufacture. And the dimensions shown are based on the 23 x 30 x 1mm and 40.4 x 50 x 1mm sheet metal blanks, already mentioned, and may not be suitable for the reader's inclinations. Therefore, no detailed text as been included for the machining and positioning of component parts, and it is assumed that the reader has the necessary expertise for the satisfactory conclusion of his own projects. These tools are simple in design, but will require a certain amount of engineering skill, and may not be suitable for the beginner. Successful operation of these tools depends on the accurate alignment of the top and bottom tools,

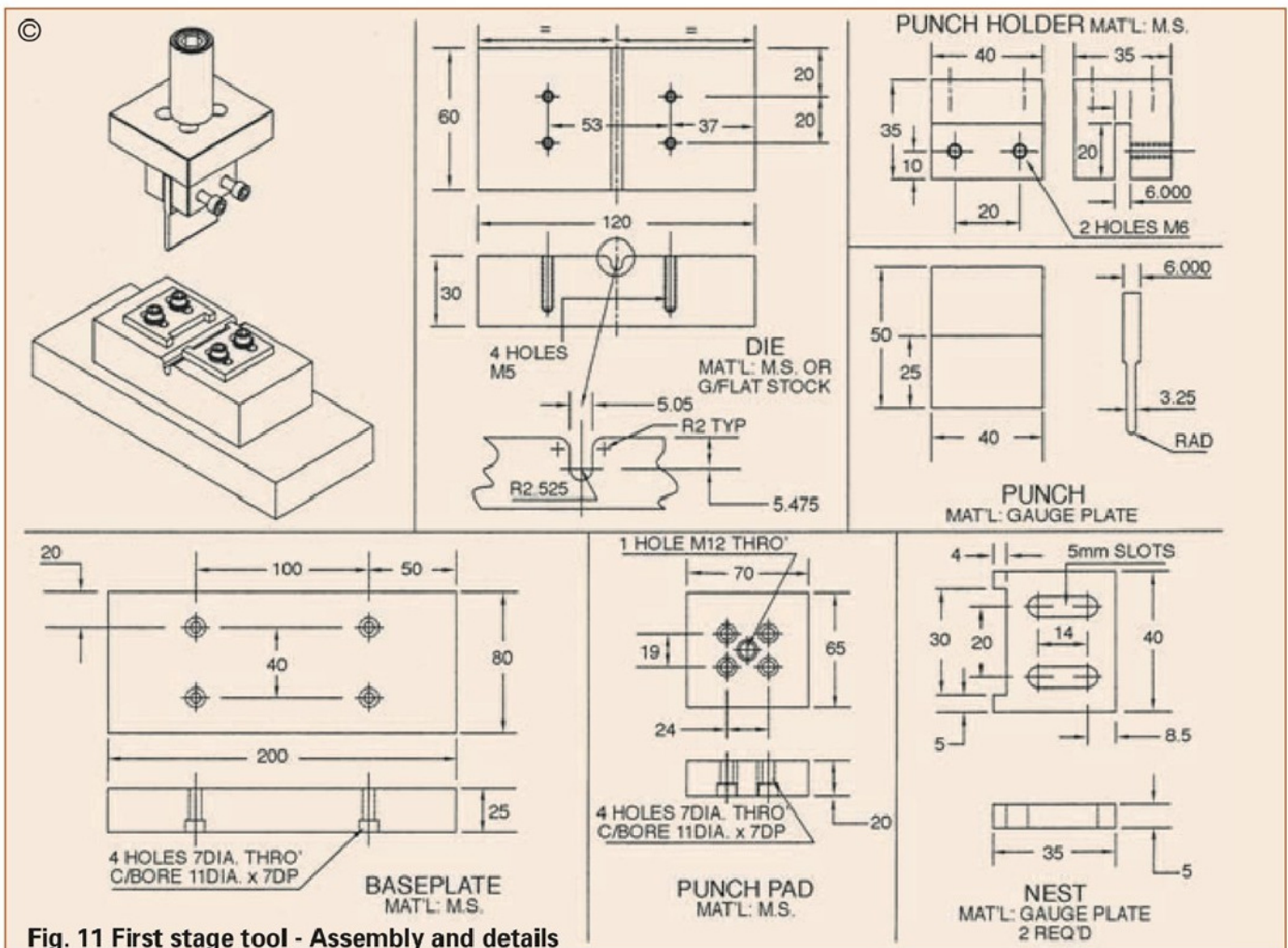


therefore, it is absolutely essential that all parts are machined square, otherwise, problems will arise when trying to form the curl. Sometime in the near future, I would like to complete the series, by including the principles involved in the design for the manufacture of a "Piece and Blank Tool" to produce both parts of the hinge described, in the one press tool.

## The curling operation

The secret of successful curling depends on the "start curl" Fig 9. In a commercial volume production activity, the start curl is usually introduced at the blanking stage Fig 10. This shows a

tool that in one operation, punches out the shaped blank, and creates the initial bend, ready for the form tool. In the first set of tools tool described here, the "start curl" has been replaced by a complete U-bend in a first stage tool. This is a good 50% of the rolled hinge. To successfully complete the curl, we transfer the first stage form, to the hinge-closing tool. The reader will now require a tooling aid, a length of rod, the inside diameter of the proposed hinge. This is placed inside the u-bend and acts as a gauge for the internal diameter of the hinge. It is left in this position as the press descends to roll the final curl. The rod should not be clamped tight inside the curl, therefore





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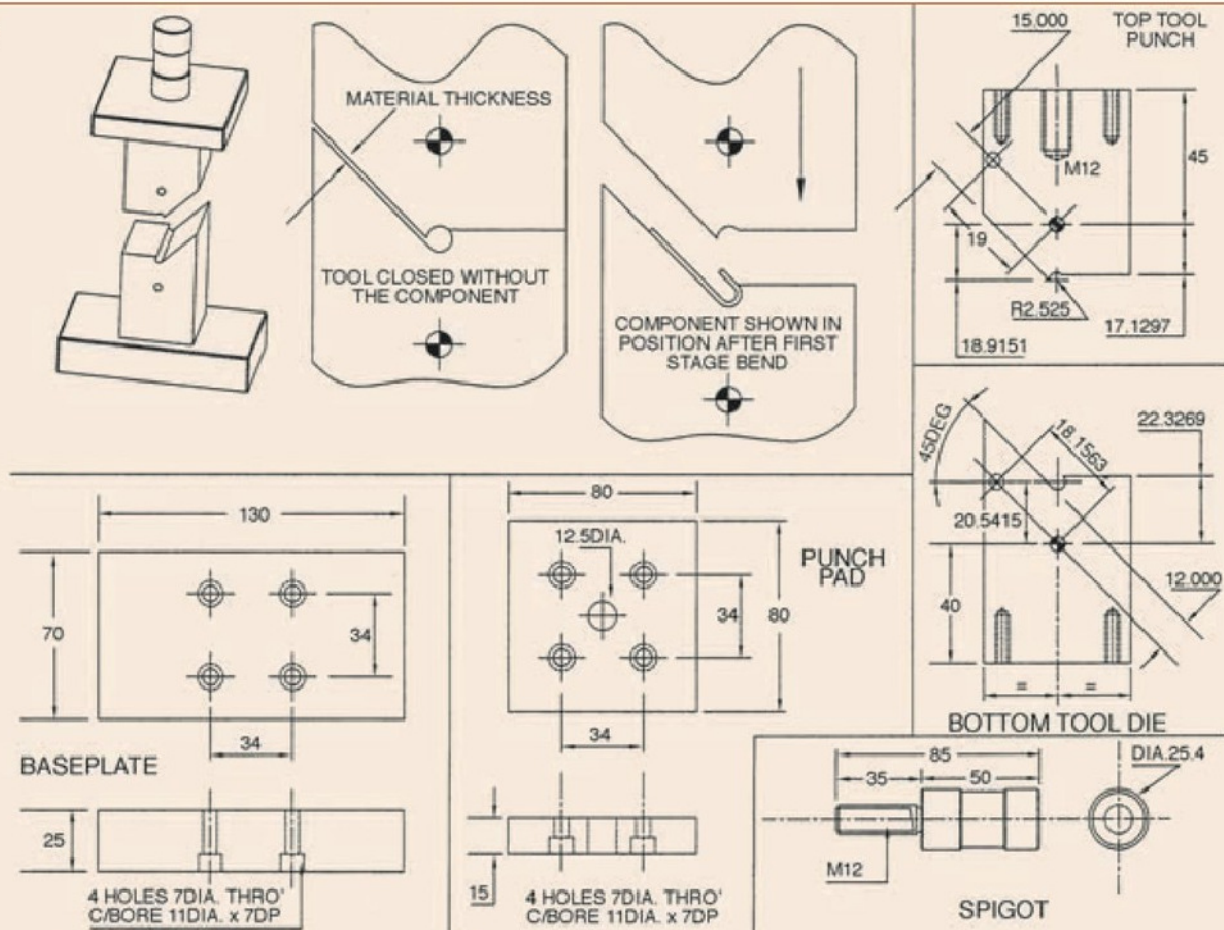


Fig. 12 Second stage tool - Assembly and details

careful setting of the press is to be considered. Again, I stress the importance of machining the parts square. We will look now at these two separate tools.

## First stage tool

The make up of this may be seen in photo 1. Fig 11 then gives an isometric view and the details of the components. The manufacture of the tool is based upon the same set-up, as the 'vee tool'. The only difference is that the "vee" is replaced by the U-type shape. The guide plate is removed, and adjustable nests are located on the die face, and the punch to suit the die form. The main parts tools can be made from either, mild steel, or tool steel, and gauge plate is suggested for the punch. But whichever material is used, heat treatment may be considered as an option which would be beneficial for the life of the tool; mild steel, case hardened, and tool steel hardened to 56-58R. The problem here is that, distortion would almost certainly take place, and that the forms would need finish grinding square with the, base of the tools. In a professional situation where industrial tools are made for high volume production, the cost of heat treatment and grinding is easily justified by the increased tool life. In the home workshop, such facilities may not be immediately available, and for the amount of use expected, it may not be worth the expense of paying for commercial services.

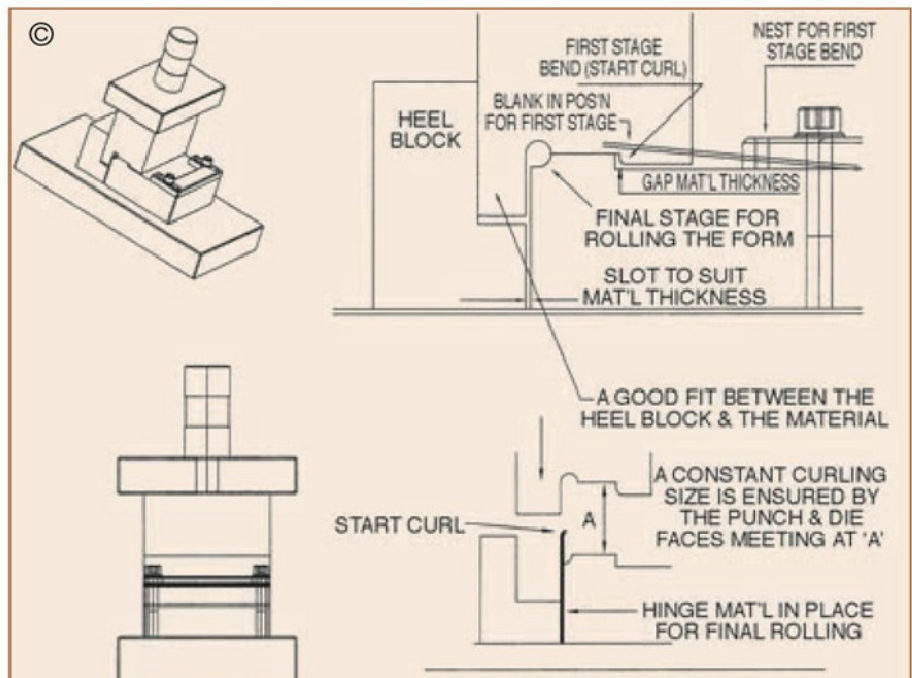


Fig. 13 Combination tool - Assembly and operation

## The hinge closing tool

This tool is depicted in photo 2, with the component drawings appearing in Fig 12. Both top and bottom tools were made from a piece of 50mm square bar, which was suitable for the size of the hinge to be manufactured. Initially, the top tool will

have to be longer than that specified on the drawing, because of the form radius, which will first have to be a bored hole to produce the required radius. But most importantly, the tooling holes will have to be introduced, before any work can take place on the form shape. Two of these are denoted on the drawings by the dowel



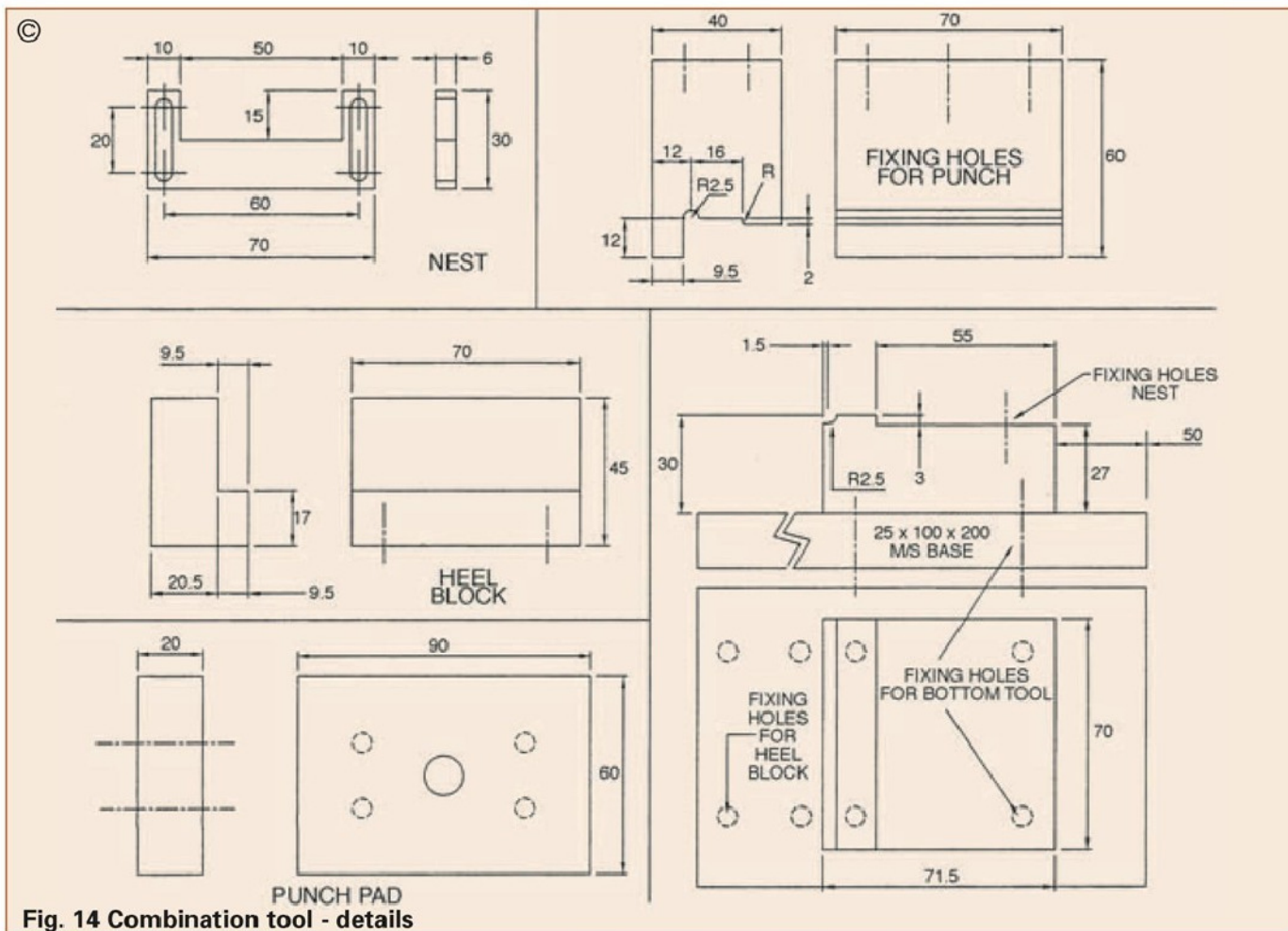


Fig. 14 Combination tool - details

symbol (somewhat reminiscent of a German car maker and also the centre of gravity for model aircraft plans). Fitting dowels is one approach to achieving accurate measurements. The tooling holes provide datum locations from where all the dimensions are related. These must be in place before any work can start on the die and punch forms. The dimensions related to these tooling holes, help line up the two tools correctly, also assist in ensuring their correct relationship.

## Machining the forms

With the holes bored in the top and bottom tools. The 17.1297 and the 22.3269 faces can be machined. Note that I have presented an order of accuracy that would be applicable to high quality toolmaking. The reality of course is that most of us will not be able to measure reliably to such levels, never mind work to tolerances of a tenth of a thou. The 45-degree angles must be also be machined to 15.000 for the top tool, and 12.000 for the bottom tool. The 45 degree angle, and its associated dimensions, will need setting accurately with the aid of a sine bar, or sine table. For those readers who do not have one, then I've included dimensions for a second tooling hole, which can be utilised for setting the 45 degree angle, by inserting two 5mm dia pins in the tooling holes clocking the two holes parallel in the machine vice. Then, with the aid of depth mike, the 15.000 and the 12.000 dimensions can be checked with some accuracy.

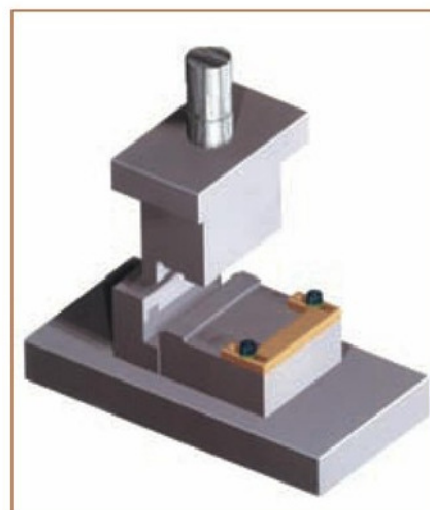
## The combination tool

The second arrangement is a slightly different set-up. Here, location of the work in one part of the tool creates that extremely important "start curl". It is then moved to a second position to successfully roll the hinge. This two stage operation is shown on Fig 13. This requires only a slight bend on the end of the blank to make it work. To produce the start curl, the blank is placed in the nest (see drawing) and set on the edge of the first stage bend with a slight over-lap. The nest will have to be adjusted to obtain the best position; also the D.L. will first have to be calculated. Having established the first stage bend, the component is placed in the slot to complete the curl. Making sure, that the punch is a good fit between the "heel block" and the component. It will be seen that the action here takes a slightly different form, in that the work is forced to slide around the tool in contrast to the earlier action, which was principally bending. It is likely that the application of a lubricant would be of benefit. Fig 14 gives the component details.

## Conclusion

Both sets of tools are dimensioned for a particular size of component, and of course, the specific sizes given may not be suitable for a particular project. But for the enthusiast, who may require to produce hinges for model making, or other applications, then I hope that the

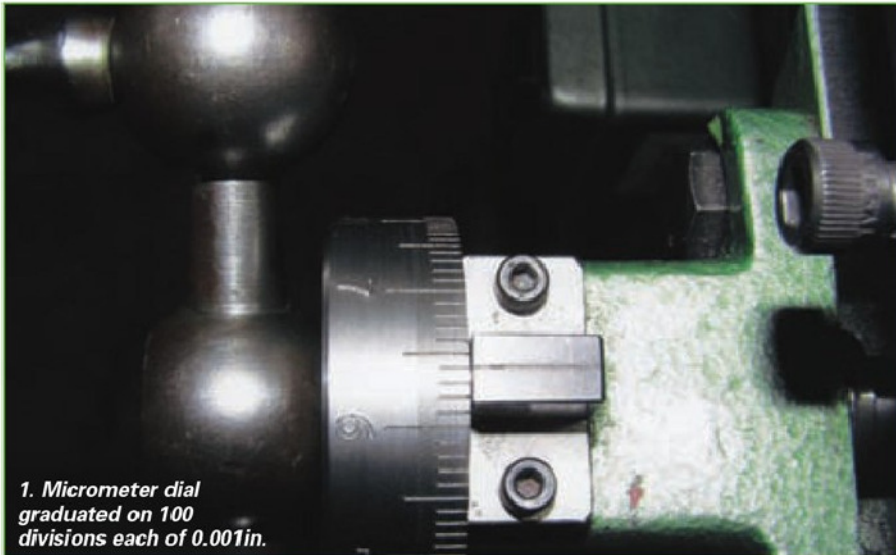
information will be of some assistance. Both types of tools work very well. It should be borne in mind, however, that with most tool making, some trial and error work will be necessary obtain the desired results. One final point to note is that results can be quite sensitive to any variation in material thickness. It is not unknown for sheet material to vary by several thou across the width. So, make sure you use the same material for both the development and production of the component, otherwise you may not get the same or consistent results.



3. Combination tool.



# SOME THOUGHTS ON CUTTER GRINDING



1. Micrometer dial graduated on 100 divisions each of 0.001in.

**T**he enjoyment of our hobby is enhanced by having really sharp tools. Soon after I acquired a milling machine this aspect rapidly became apparent and the prospect of frequent visits to the nearest commercial tool grinding outfit was off-putting to say the least. That, and the innate desire of all model engineers for independence and self-sufficiency, prompted a decision to invest in a cutter grinder. The question of course then arose - make one or buy one? Fortunately the decision would not be constrained by workshop space so I opted for an industrial type machine on the basis of "what's good enough for them is good enough for me"!

One of the most popular and reasonably priced tool and cutter grinders must be the Clarkson Mark I and, after World War II, many thousands of these were produced, some even being provided on a loan basis

to their larger contracted buyers of cutters. This model was followed by the Mark II and Mark III versions, which were more complicated and considerably more expensive. Some twenty years ago, manufacture and spares for Clarkson machines was taken over by March Engineering Ltd., of Nuneaton - who subsequently re-branded them as March Cutter Grinders - but they have now gone the way of so much of our country's engineering industry. Some spares are available from **Machine Spares Ltd.**, of Oldbury, West Midlands, Tel: 0870 870 2550. (usual disclaimer). Its simplicity and adaptability is an undeniable attraction of the Mk I. Examples appear quite frequently on the second hand market, at little more than it would cost to build a proprietary kit machine and it was one of these that I purchased. (Later acquisition of Clarkson

**Shelley Curtis discusses modifications, accessories and techniques for the Clarkson Mark One.**

attachments increased the total investment somewhat, which I justified by reminding myself that I'm "getting on a bit" - and "they don't put pockets in shrouds"!)

This is not intended to be a treatise on tool and cutter grinding theory and practice, but a reflection on machine improvements and alternatives to some of the methods described in the Operator's Handbook; the objective being to achieve the same end, but in ways which I feel are easier for amateur enthusiasts. Some fixtures and accessories - simple to make - are required, as can be seen in the various photographs.

The Mk I machine was not supplied with a micrometer dial on the 10 TPI cross slide feed screw. It is well worth making one (Photo 1); in fact I would now regard it as essential, if you want to make a grooving tool of exact width or use the machine for other than tool sharpening - for example grinding to length hardened dowels for use as gudgeon pins and crankpins in small engines. Another useful modification is to fit a crank to the end of the head actuating screw as this makes raising and lowering the head much simpler (Photo 2). In both these cases, fitting PTFE thrust washers makes operation much smoother.

## Relieving end teeth - end mills and slot drills

For grinding end teeth with the original equipment, the cutter is placed in a bush fitted in a hardened and ground sleeve and



2. Crank handle fitted to head actuating screw.



3. Workhead fitted with ballraces.





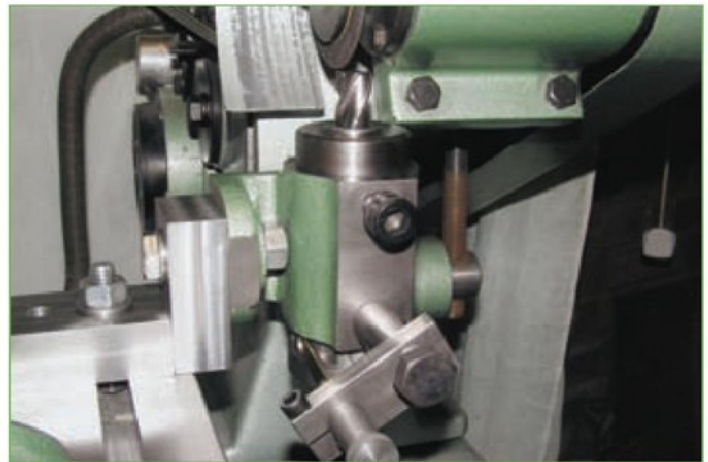
4. Twelve step ratchet wheel fitted to read of workhead.



5. Set up for reforming end teeth on slot drill.



6. Slot drill end teeth viewed from different angle.



7. Gashing teeth using thin cut off wheel.

secured with a grub screw, the sleeve rotating in a cast iron workhead. This system has shortcomings in that the securing screw tends to push the cutter off centre and any excess clearance between the sleeve and the workhead, due to wear, contributes to inaccuracy. Indexing is achieved in the conventional manner by the tooth which is being ground bearing on a tooth rest. Getting this at the correct position at the outset is a fiddling job and then, depending on how much one has to grind back, its position may have to be adjusted.

I have replaced this original equipment with a ball raced workhead supporting a spindle with taper collets to hold the cutter. At the rear end is a twelve toothed

indexing wheel controlled by a blade attached to a micrometer adjuster (Photos 3 and 4). The result is that my reground cutters now cut on every tooth whereas before there was often audible evidence of one tooth being more prominent than the others. There is also a big improvement in surface finish. This successful outcome resulted in a similar workhead being made for the Radius attachment.

## Reforming end teeth - slot drills

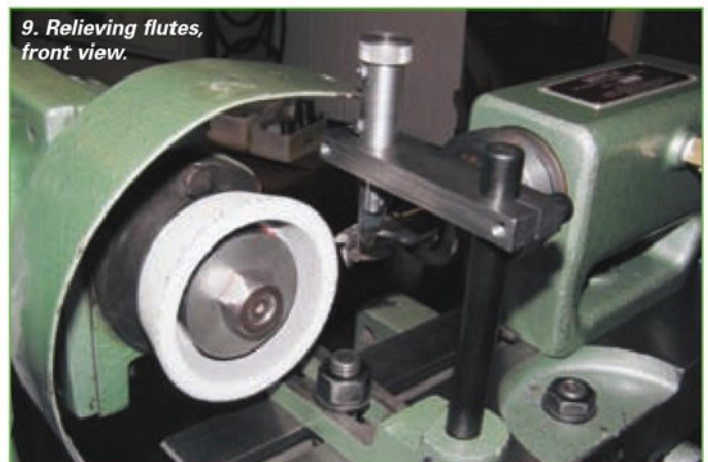
After several regrinds, slot drills need to

have their end teeth reformed. I found the procedure described in the handbook very awkward. My method is to mount the drill in the standard Clarkson workhead but present it to the underside of the wheel (Photos 5 and 6). The workhead is fixed to a bracket angled to give the 10 degrees positive rake and can be tilted to provide the different angles required to form the unequal tooth lengths.

Set the cutter so that the tips of the teeth are in a line at 90 degrees to the grinding spindle, the setting being locked by a  $\frac{1}{16}$  inch BSW cap screw and brass pad in one of the tapped holes in the workhead (turned finger tight is sufficient!). Touch the wheel with the side of the cutter,



8. Gashing viewed from rear.



9. Relieving flutes, front view.





10. Flute relief from rear.

withdraw clear of the wheel and move the cross slide half the cutter diameter. Cut is applied by lowering the wheel in increments of 0.001in. to 0.002in. For the other tooth, tilt the workhead to the required angle, index the cutter 180 degrees and repeat the procedure. The twelve toothed ratchet wheel enables this to be done with accuracy.

## Gashing end mills

After many regrinds there will be insufficient depth in the centre of the cutter to back off the teeth properly and they will have to be re-gashed. With a 4 flute end mill I position it vertically and pass it completely under the wheel (Photos 7 and 8). I find a 1.60 or 2.00 mm thick cutting wheel admirable for this purpose. (These are listed in suppliers' catalogues as Toolroom Cutting Wheels - not to be confused with cutting wheels for angle grinders).

The setting up method is the same as for reforming slot drill end teeth except that, after touching the wheel with the side of the cutter, the cross slide should be moved half the diameter plus half the thickness of the wheel. Index through 90 degrees for the second pair of teeth.

Examination of new end mills reveals different manufacturers' designs regarding the end teeth - some have positive rake in the gash and others seem to be neutral, the positive rake being provided by the helix angle. This seems logical as end teeth are ground to give a measure of concavity and, in normal use, end mills are not plunged.

Some have the cutting edge on the centre line, others behind it. My method

puts it half the thickness of the cutting wheel behind the centre line which seems to be satisfactory. A gash depth of 2 - 3 mm provides for several regrinds before repeating the procedure. (End mills with 3 flutes have to be dealt with as described in the handbook, i.e. presented to the front of the wheel and below its centreline.)

## Relieving flutes - end mills and slot drills

In the handbook this operation is shown as being carried out against the periphery of a plate wheel (cutter axis parallel to grinder spindle axis), with a toothrest under the flute being ground.

I prefer to use a taper cup wheel with the table - and, therefore, the cutter axis at 90 degrees to the grinding spindle and the toothrest positioned above the flute opposite to that being ground (Photos 9 and 10). I find it easier to set up for the primary clearance with reference to a vertical plane rather than an arc. The secondary clearance is obtained by raising the toothrest by means of a micrometer adjuster.

The taper cup wheel is dressed slightly concave.

## Surface grinding

Small components (such as hardened thrust washers) can be satisfactorily ground, using a plate wheel mounted on an extension spindle (Photo 11).



11. For surface grinding, a plate wheel is mounted on an extended spindle.

## Lathe tools

Using the standard workhead fitted with a protractor ring, special tool configurations are easily achieved. For a parting or grooving tool, for instance, back relief is set by the angle of the tool to the wheel and side relief on both sides by 180 degrees rotation, plus or minus the relief angle. In this operation it is useful to have a positive stop for the table to limit its movement to the required length of the tip being formed (Photos 12 and 13). Bushes are easily made from bar stock to accommodate square section tool steel. Blade type parting tools can be sharpened accurately with the aid of an easily made fixture (Photo 14).

## Cylindrical grinding

Small components can be cylindrically ground using my grinding headstock attachment, as described in MEW Issue No 114.

## In conclusion

It is said that "a bad workman blames his tools" - but a good workman could be forgiven a likewise sentiment if he's struggling with mangled cutters! When you find that you need muscles like Popeye to turn the handles and a 'bow wave' is forming ahead of the cutter, it's well past time for a regrind!

Like so many things in life, little and often is the best practice!



12. Protractor ring permits accurate control of angles on part off or grooving tool.



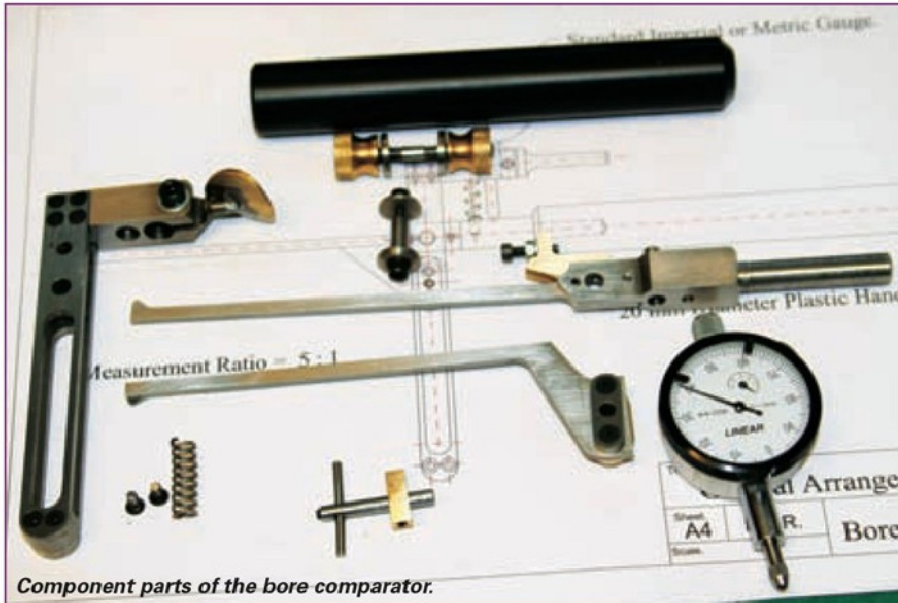
13. A positive stop limits table travel



14. Fixture specifically for parting blades. That shown is a Churchill Emperite, which is ground only on the end.



# A PAIR OF COMPARATORS 1



Component parts of the bore comparator.

In 1997 when I first started writing articles for this magazine, I did all my drawings on an old fashioned board with a rule and pencil. Things have changed somewhat. In 1998, I purchased a new computer at what seems like an exorbitant figure when compared to the prices today and especially when the performance and specifications are compared. What a difference in less than a decade! In those early days I came up with a basic design for a bore comparator but did not proceed to make it for a number of years. It was then dragged out of the CAD archive, (sounds posh) revamped and built. This was some two years ago and has been used regularly since. It was also realised that the general design principle could be translated to a second instrument for measuring outside dimensions. However, as noted later, after constructing the outside device, it was realised that it was not convenient to use and hence a "Mark II" was designed and built.

Let me at this stage, give some idea of the use and limitations of the bore

comparator. The measurement of the bore of a hole can be done in a variety of ways and this starts out with a standard ruler. The second is the internal telescopic gauge, which comes in various sizes from 3 mm up to 150 mm. The next would be the inside micrometers which come in a variety of forms and can now be purchased for measurements of up to 5M.

There are also many very specialised bore measurement devices especially for use in the mass production environment. I have included pictures of various instruments that I have acquired over the years. The ones used in professional circumstances, mostly in the past, which I like to think of as the early back bones of the industry, are the telescopic gauges. These are used in conjunction with a micrometer and are really a little long winded to use, as you first set the gauge to the bore, then measure the gauge with the micrometer.

In this first of two articles, Peter Rawlinson describes an instrument for internal measurement.

For a given size, the comparator is set up only once using either a micrometer or a set of slip gauges. After that the device is applied to the work and the reading is "compared" to the set up reading on the gauge. Here it must be stated that there is a ratio with my design and this must be taken into account. The ratio that I have used is 5:1 but this could be any ratio required and could even be made adjustable by the introduction of removable arms of various lengths.

**Photo 1.** Shows the telescopic gauges.

**Photo 2.** Shows standard Internal Micrometers.

**Photo 3.** Shows the Slip Gauges.

**Photo 4.** Adjustable Slip Gauges.

**Photo 5.** Very specialised gauge which is no better than the design put forward.

**Photo 6.** Setting the comparator with a micrometer.

**Photo 7.** The finished comparator in its box.

## Design

The design that I have used incorporates a spring, in this way there is a pressure applied at the measurement tips. Before someone comments, I realise that a spring will give a pressure loading which will increase as it is compressed and this will in turn give rise to variable amount of deflection, notably in the arms (nothing is completely rigid). However, using the device as a comparator, we are only interested in the finished size for which the tool is set up, and hence the spring compression and pressure and any resultant deflections will be repeatable. It might be possible to apply this pressure

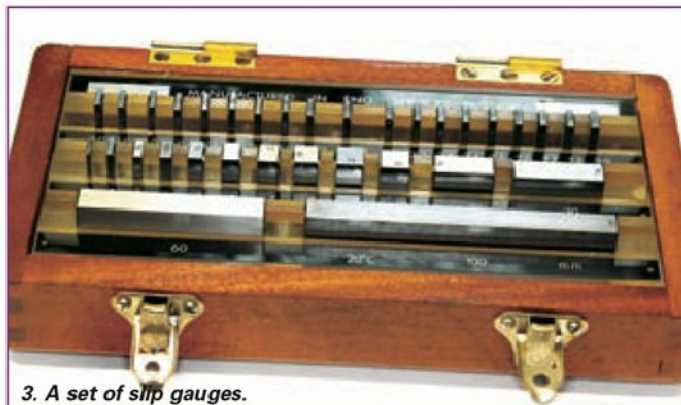


2. Box set of telescopic ball gauges.



3. Two internal micrometers.





3. A set of slip gauges.



4. A set of adjustable slip gauges.  
(Adjustment is by sliding along taper)



5. Specialised bore micrometer.

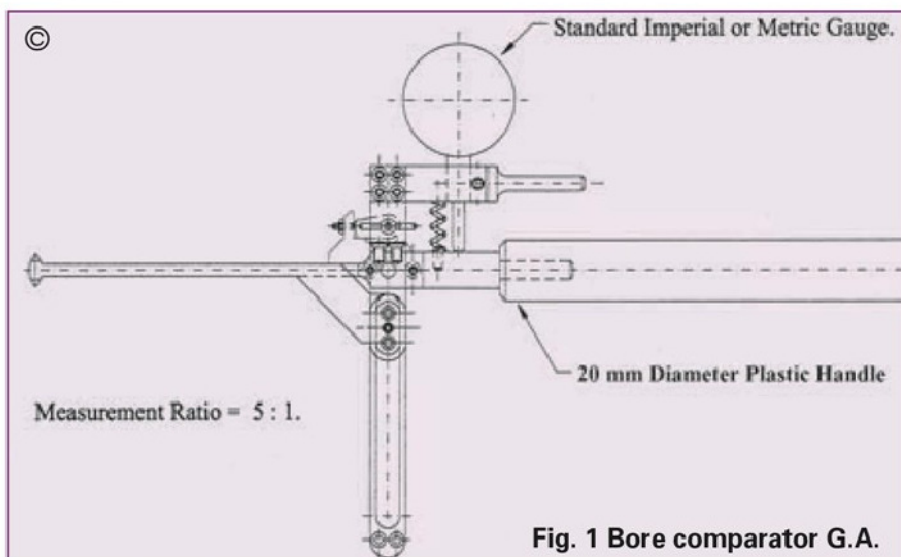
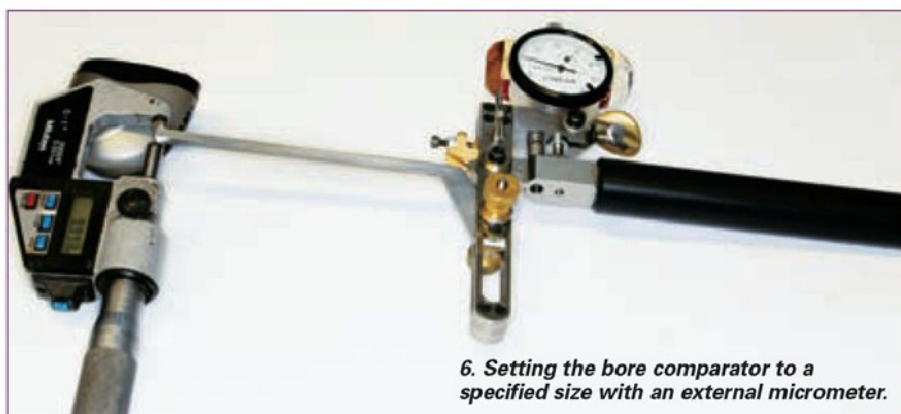


Fig. 1 Bore comparator G.A.



6. Setting the bore comparator to a specified size with an external micrometer.

manually, but this would probably give rise to variation in hand pressure and ache in the hands during reading.

Manufacture of the bore comparator is straight forward but it is most important that accuracy is maintained. However anybody making this type of equipment should realise where this is particularly required, namely the pivot points, the arm lengths, the slides and the ratio of the arms.

## Machining the slide frames

The machining of the slide slots is not difficult as I have found that if both sides are supported by the vice jaws over the whole length and these jaws extend to cover a small amount of the solid end material that is to be left there is no

problem. I made all the parts from gauge plate, this gives a good starting point as it is already ground on its face and edges. Due to the "thinness" of these side bars (2.37mm or  $\frac{1}{8}$ in.) it will be necessary to support the  $\frac{1}{8}$ in. wide gauge plate on two x 1.6 mm thick parallels. The problem with this thickness of parallels is that they always fall over before the material is in place and the vice tightened, I have solved this problem by putting a piece of folded foam sponge between the parallels to give sufficient pressure to hold them out against the vice jaws.

I proceeded to machine these by firstly drilling a 5 mm hole on the centre line and at a radius point at one end, say the right side of the mill. I then use a 6 mm "Ripper" cutter as I have always found that they are easier on the mill and heavier cuts can be taken.

The cutter is then fed right through the hole and the table fed to the right, this gives a clean slot up the middle for the full length. Historically, these cutters have only one drawback in that they do not give a good finish. More recently however a version of these same cutters has become available that will give a good finish.

However to continue, I then moved the table and therefore the job towards me by 0.9mm and fed the table to the left. At the end of this cut, the table was then moved away by 1.8mm and the table again fed to the right. Next came the finishing. I finished by draw filing and made the slide guides out of brass to a dead 8mm width. The draw filing would have taken just a thou or two to give a neat sliding fit. The other way is to change the cutter to a standard end or slot drill and take another cut, but make sure you repeat the above sequence and ensure that you avoid climb milling which could bring problems. See photo 8. On left two finishing cutters, on right one standard slot drill, centre two cutters standard "Ripper" or roughing cutters.

I have since made a total of ten components all similar in concept and they have always come out without problems. If you have a vice which does not have wide enough jaws then you might wish to remove the hardened jaws and replace with wider bright mild steel jaws. Use the hardened jaws as a template for drilling your MS jaws (clean off the BMS on both sides with a fine file first) and while you are at it, include the facility for an adjustable stop. A short cut approach here might be to add a length of rectangular section BMS on either side of the work and sufficiently long to grip the ends.



## Adjustable stop

The machinery and tooling available will determine the methods adopted, but one way to ensure the two slots to line up perfectly on the gauge holder is to make up an adjustable stop for use on the milling machine. The one I use is shown in **photo 9**. Always machine the end of the bar perfectly square before fitting up to the stop and always make sure that the point of the adjustable stop is as close to the centre of the job as possible. This will allow work on all four sides to be lined up accurately.

The adjustable stop in my case is fixed in place on a 10 mm dia. rod and this is fitted in a reamed hole which goes right through the rear fixed vice jaw. This jaw is made from mild steel and is a little thicker than the standard, it is always fitted and no problems have been encountered in its use over many years. The adjustable rod is clamped in place in the jaw by two grub screws and this is the only draw back as to adjust it, the swarf has to be dug out to allow the Alan key to fit. (As an aside the grub screws are drilled out from the pointed side and a brass pad is Loctited into place this then does not damage the rod.) Other approaches to setting up a milling work stop might include a bar located on the table via a convenient tee slot.

The closure lock, shown in **Photo 10**, was something of an afterthought which initially proved awkward. The drawing shows a revised version which is now satisfactory. With a little ingenuity it would be possible to redesign so that the feature would be more "integral" and less of an "add on".

One point of interest is the thumb rest. I chanced upon a very easy way of making this. A short piece of brass, copper, or steel tube about 40 mm dia. was held in the vice. I then put a "Rota Broach" through and instead of throwing away the disc I retrieved this, de-burred and soft soldered it onto the spigot. (This may be the only time when the hole is thrown away.) Other methods might include trepanning, punching, or going back to basics and cutting from sheet with snips and filing to size.

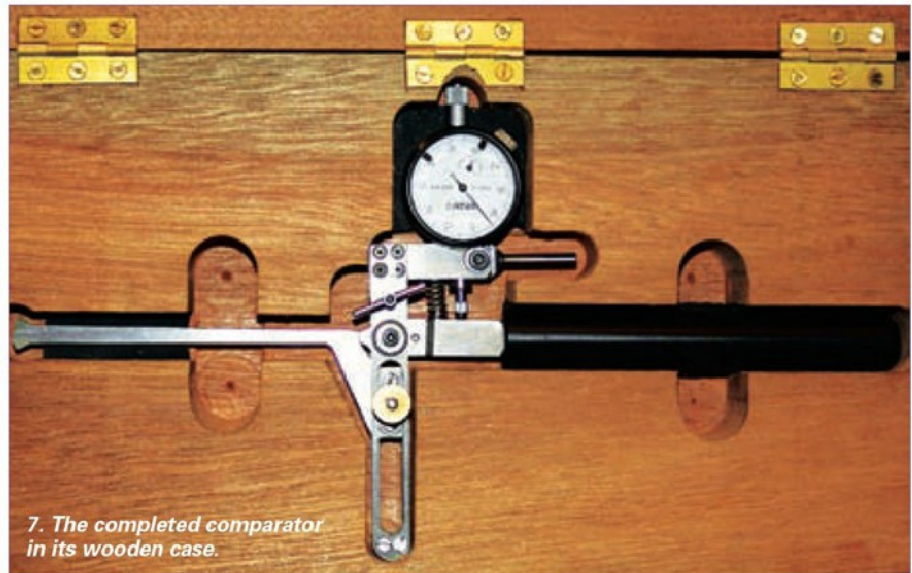
## Operation

In use the bore unit can be set up simply by using a micrometer, vernier, height gauge, or a series of slip gauges. (Don't even think of ring gauges as the price is a king's ransom for each size.) You could though, try the inner race of a ball bearing.

The setting up of the outside unit can be by slip gauge, inside vernier, or even a drill shank and at a pinch a piece of silver steel.

Don't forget the lever arm ratio will need mathematical correction getting down to the finished size. A standard gauge will give a reading of 0.001mm and with a 5:1 ratio this is 0.005 mm at the measurement tips. For more sensitivity, you might choose a different gauge. E.g. a "tenth clock" reading to 0.0001in. would give 0.0005in. at the tips.

At the time of writing, the gauge shown is on offer from J & L and is a standard 38mm dia with a 5mm movement, and it is a simple matter to swap one gauge between tools.



7. The completed comparator in its wooden case.

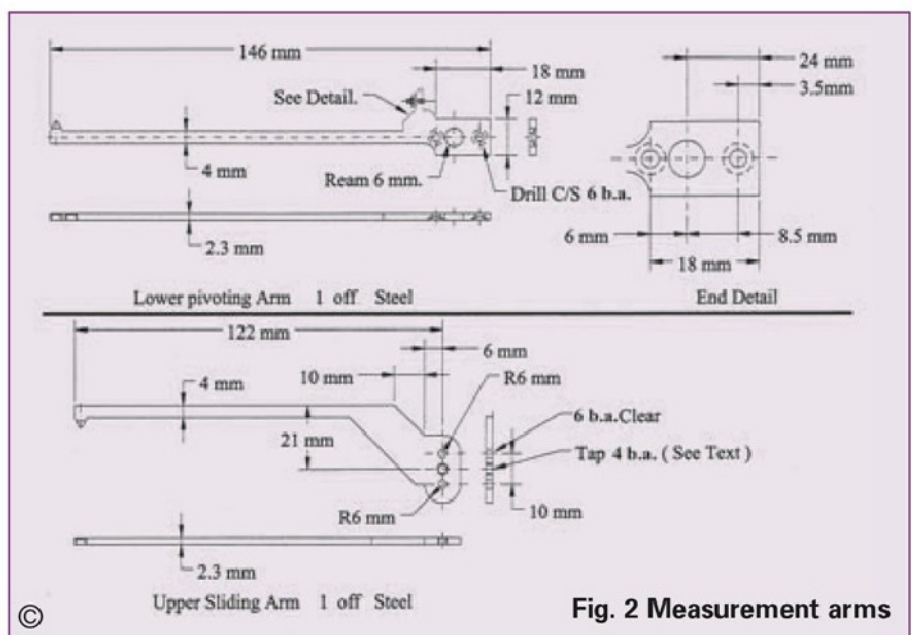


Fig. 2 Measurement arms

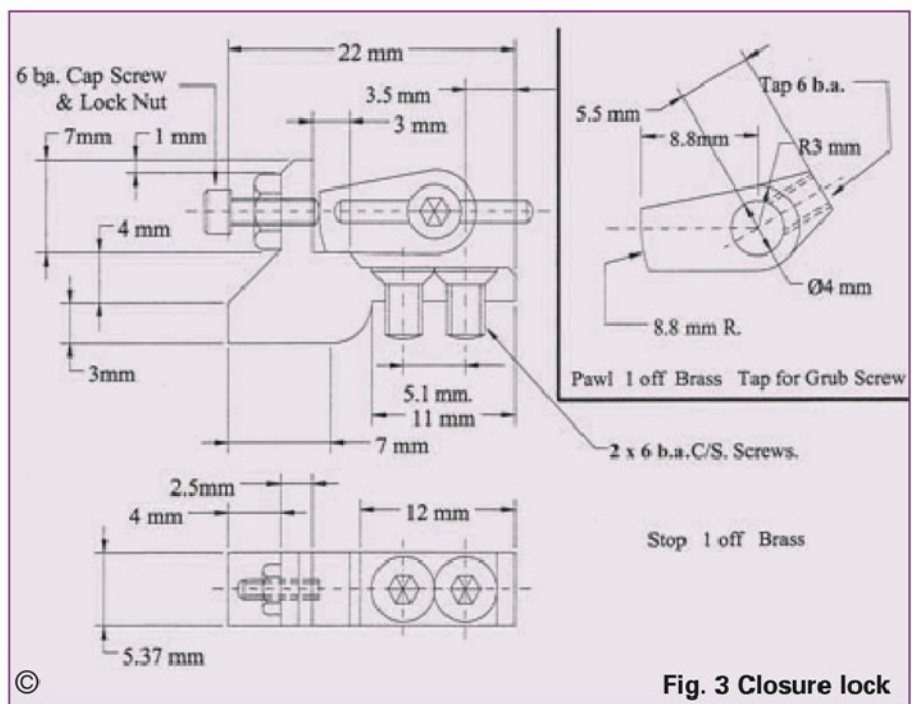
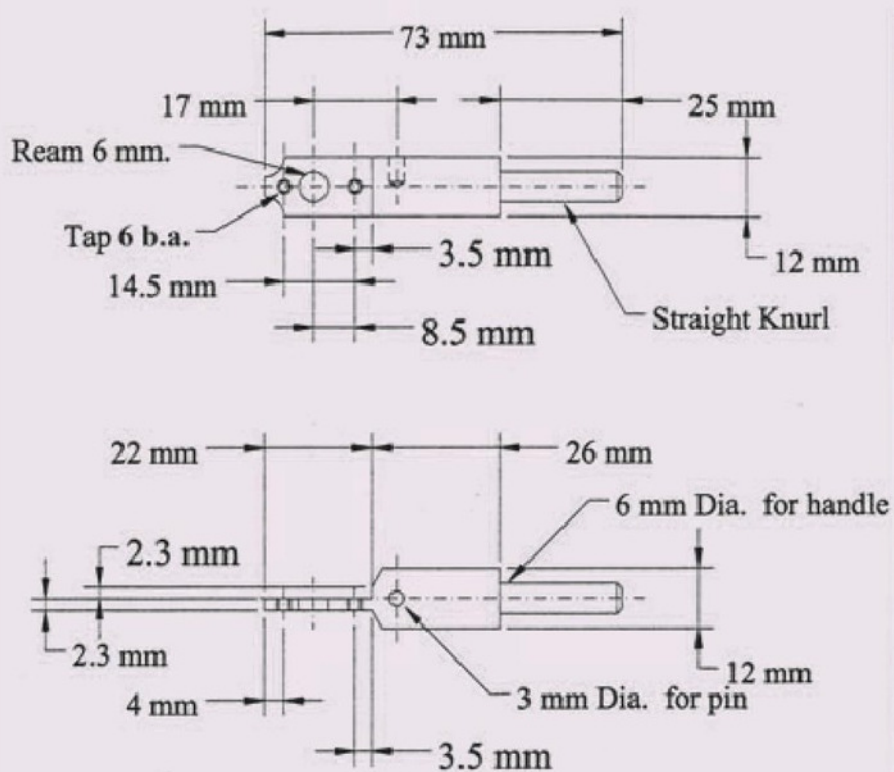


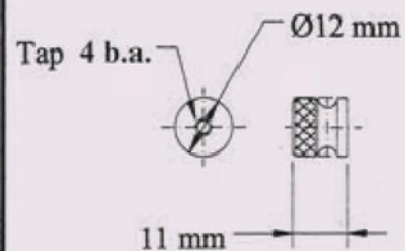
Fig. 3 Closure lock



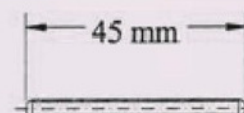
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Handle support Steel 1 off



Clamp Knob 2 off Brass

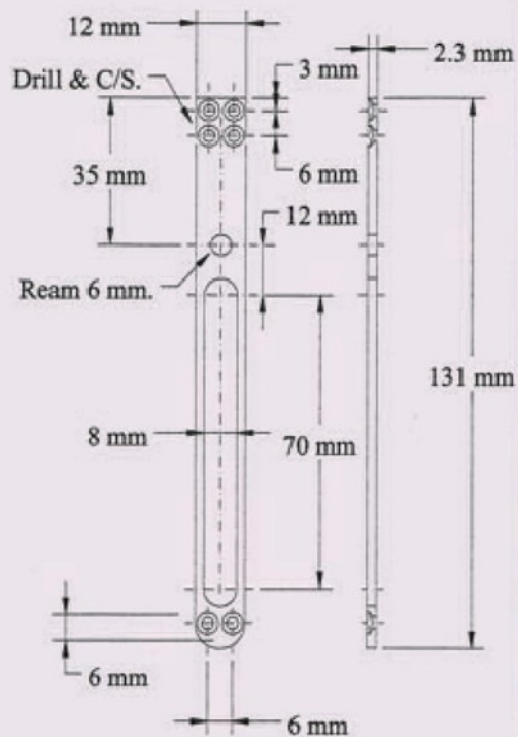


4 b.a. Studding

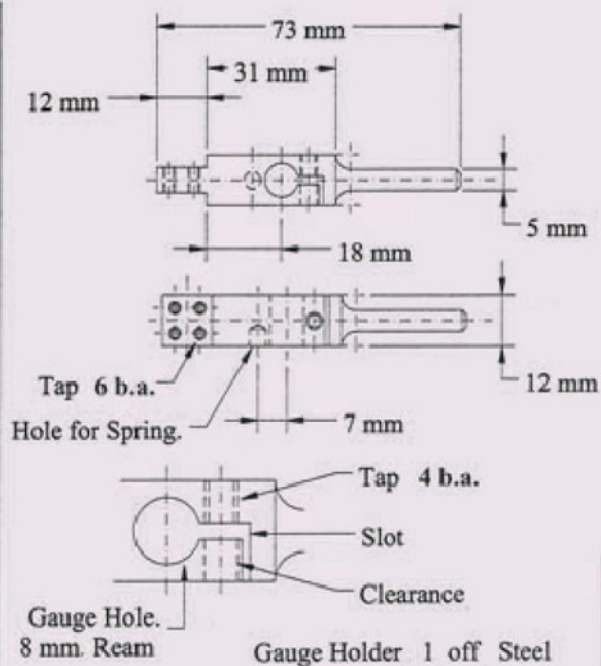
Clamp Shaft 1 off Steel

Fig. 4 Handle pivot

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Slide Frame 2 off Steel



Gauge Holder 1 off Steel

Fig. 5 Frame and gauge holder



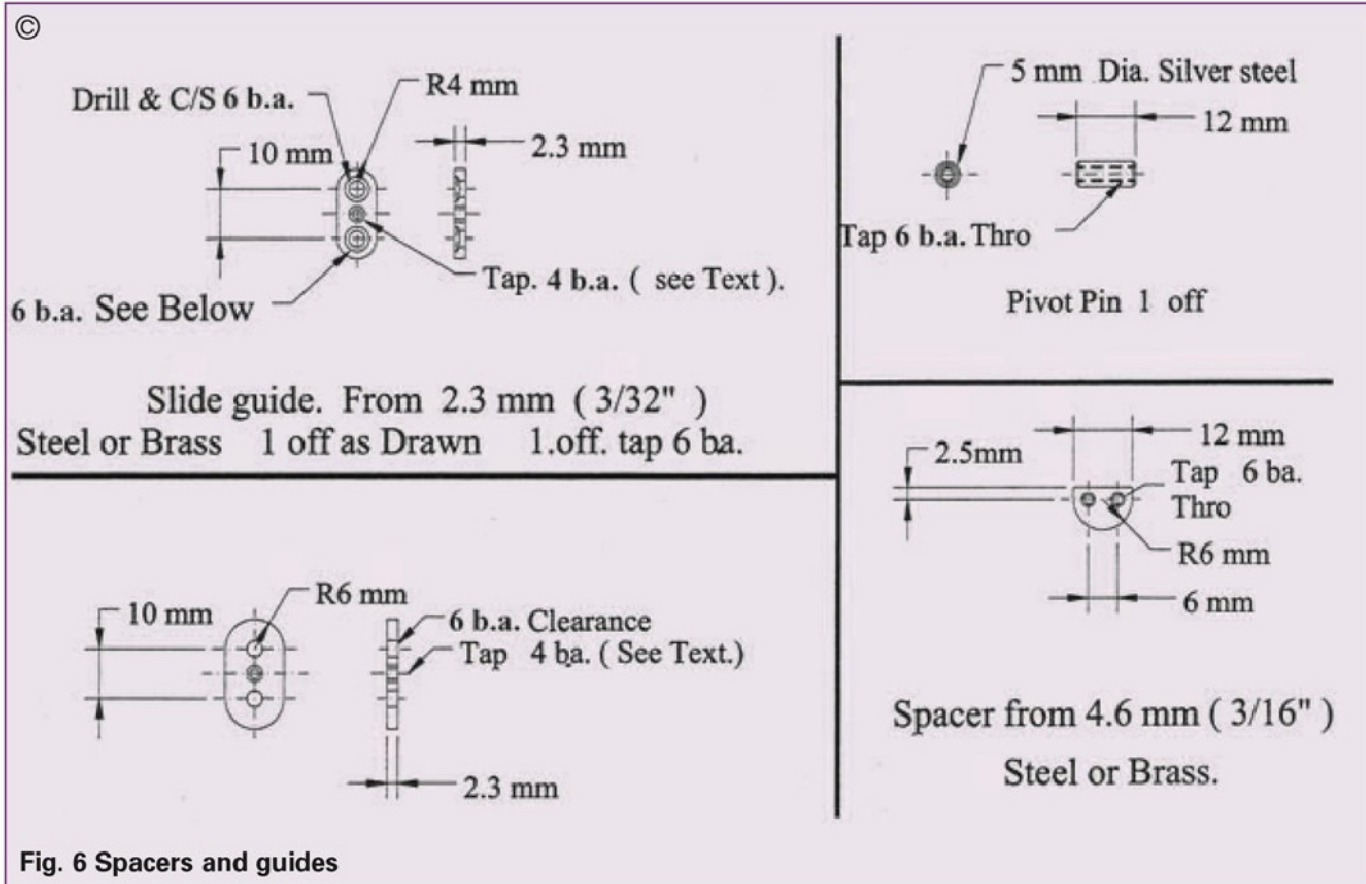


Fig. 6 Spacers and guides



8. A selection of milling cutters (see text).

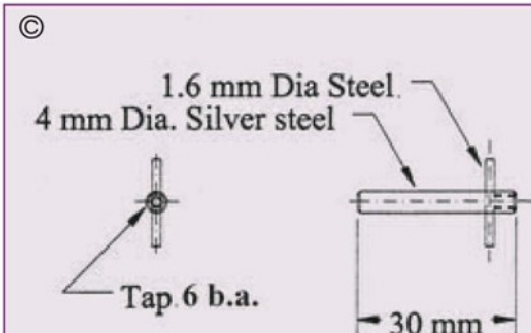


Fig. 7 Pawl shaft 1 off Silver steel

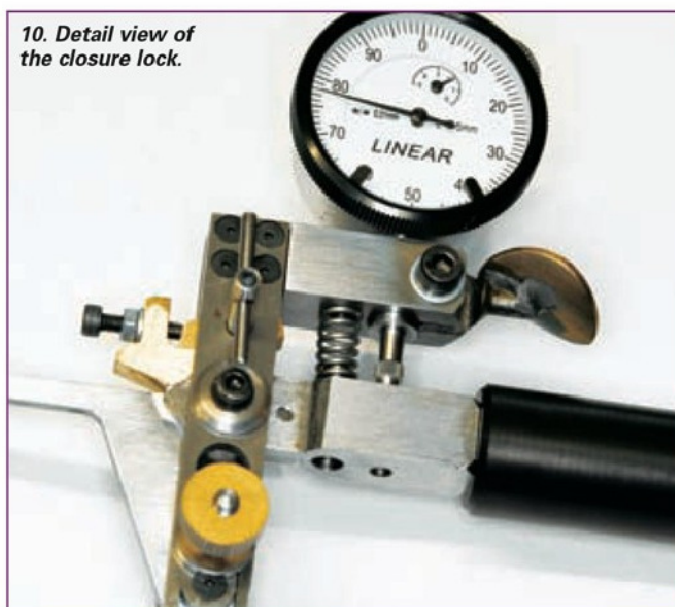
The next article will present a related design intended for measurement of external features.

I hope that the device described here will give those that build it many years of use and if I can be of help I shall be pleased to assist; but phone only please and I will not ring back for obvious reasons.

Peter Rawlinson, Charing, Kent. 01233 712158.



9. View of the adjustable length stop fitted to the milling vice.

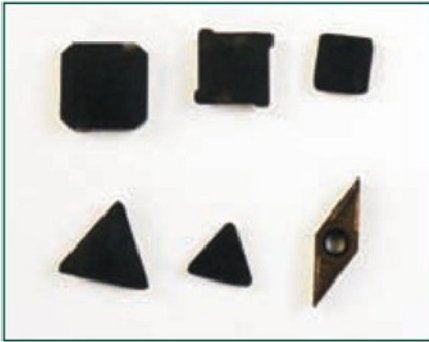


10. Detail view of the closure lock.



# TUNGSTEN CARBIDE THE HOME

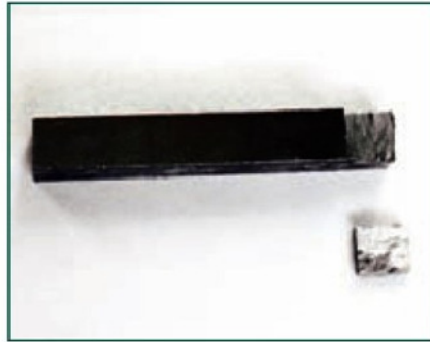
Stephen Bondfield discusses home made tooling using recycled tips.



1. A variety of "Throwaway" Tungsten Carbide tool tips, that can be redeemed from scrap and re-used simply by silver soldering them to prepared mild steel shanks and re-grinding. In this way it is possible to alter the geometry of the tool from conventional commercially made forms.

**A**lmost all of the various examples of tungsten carbide tool tips included in **photo 1**, are those known as "Throw Away", disposable or indexable tips, that are designed to fit and be clamped or screwed onto a machined steel tool holder. I have sometimes found severe limitations when using this sort of tool holder for the following reasons:

1. The design and shape and bulk of the tool holder inhibit clearance space



2. Mild steel tool shank with end piece removed by hacksaw. The surface of the shank can then be filed to shape and the required rake angles can be created.

between the tool tip and the workpiece, thereby affecting the depth of cut and metal removal.

2. The size and shape of the tool holder inhibit clearance space between that and other parts of the machine such as the tailstock and revolving centres when used.

In the industrial situation, quite heavy cuts will be taken. One lathe manufacturer used to demonstrate taking two inch bar down to  $\frac{1}{8}$ in. diameter in one pass. However in the typical amateur shop, with lightweight machinery, much lighter cuts will be the order of the day so that only 1-2



3. Tool shank with surface covered by borax or "easy flow" flux. This end of the shank is then heated and the fluxed area is "tinned" with silver solder.

millimetres of the edge is actually involved in the cutting action. When this surface edge and area is destroyed either by continual abrasion or by chipping and damage, the tool tip has to be unclamped and re-positioned in order to give a new cutting edge. With some designs of tool tip, it is possible to make three or even six changes of cutting edge before discarding or "throwing away" the tool tip. At this stage it may be argued that much of the remaining surface area of the tool tip is wasted.

Harking back to the industrial production process, time is money, and hence the replaceable tool tip with tight tolerance repeatability, represents a real saving, as the machine downtime is minimised compared to the older system where the tool might be removed, ground, and repositioned.

To a home workshop enthusiast or model engineer or someone who is not subject to the same restrictions of "time and motion" to be found in an industrial environment, the idea of re-using tool tips that can be "brazed on" or silver soldered to a mild steel shank, might be more acceptable than using disposable, "throw away" tips. This is especially true if you can fall heir to worn tips discarded by a local factory.

## Advantages of home made tool bits

The entire surface area of the tip can be used over the course of time because they can be re-shaped by grinding on a "green grit" or silicone carbide grinding wheel. Thus there is less waste involved compared to using disposable tips. It is also possible to vary clearance and rake angles involved in the cutting actions applied to various metals to a greater



4. Finished workpieces after the tips have been silver soldered to the shanks and then ground to shape using a "Green Grit" silicone carbide grinding wheel.



# DE TOOL TIPS FOR WORKSHOP

extent, when using "brazed on" tips, as the geometry of the tool bit can be re-created simply by hand, using a bench grinder. This also allows larger clearance space between the workpiece and the tool bit and tool shank than in a situation where using a tool bit holder, it is found that clearance angles and spaces are restricted because of the design and construction of the manufactured tool holder. Similarly the tool shank itself can be shaped and adapted to give the necessary clearances between tool and machine.

The advantages of using "brazed on" tipped tools are therefore that they are much more adaptable and versatile to the needs of "home workshop" engineering. They are also very cheap to make, ideally using tips supplied gratis and shanks of simple steel bar.

## Concluding footnotes

In my comments I have referred to sharpening only with a green grit wheel. I have not yet tried a diamond wheel I understand that one of these would give a finer finish to the edge and thus further advantages in the "degree of sharpness" attainable.

Tungsten carbide tool bits are particularly useful when machining stainless steels and cast iron. In some situations, in the home

workshop it is not necessary to use coolant on the workpiece, and tool tip, as the nature, density and basic structure of the tungsten tip, is such that it can withstand high temperatures and pressures during the cutting actions of machining. It is usually in high number, repetitive production processes that the need for coolant arises, although it may also be beneficial in improving surface finish.

As a conclusion, these "throw away" inserts can be salvaged and adapted to meet the needs of the home workshop and model engineer in making lathe tools and milling cutters that have had the necessary surfaces created or machined to accept "brazed on" tips or inserts.

As a point of differentiation, I have used the descriptions "brazed on" and "silver soldered", and although the two describe a similar action, "brazing" requires a considerably higher temperature to melt the "brazing rod" (brass) than does "silver soldering" (silver alloy). Due to its lower process temperature, silver soldering is, for our purposes a more suitable method to attach the tungsten carbide tips to mild steel tool shanks. It is sufficiently strong and heat resistant to enable the tool tips to cut at temperatures considerably higher than those likely to be encountered in the home workshop. For the purpose of this article; "brazed on" and "silver soldered" mean one and the same action.



**5. A small boring bar made by silver soldering a short length of carbide rod.**



**6. A boring/grooving tool which uses a recycled parting off insert.**

## Production sequence

For the benefit of those readers who may not have developed their own techniques for silver soldering work, my preferred sequence of actions is as follows.

1. Select a piece of square profile mild steel or a piece that will fit the tool post of the particular lathe to be used.
2. Using a hacksaw, bench grinder, milling machine or file, creates a flat surface on one end of the piece of mild steel that is to be used as a shank, make the surface below that of the upper surface of the shank, slightly deeper than the thickness of the tip that is to be brazed on, conventional rake angles can be used when creating this surface.
3. Select the tungsten carbide tip that is to be used and compare it to fit the surface area that has been created on the tool shank.
4. De-grease and clean all surfaces that are to be "silver soldered".
5. A liquid solution of water and borax based flux, such as "Easy Flo" may be painted on to the pre-warmed surfaces of both shank and tool tip.
6. Using a combination of gas and air to attain the right temperature, heat the shank in order to melt and liquefy the flux. At this time apply the silver solder (strip or rod form) to the molten surface or the workpiece until all surfaces to be joined are covered or "tinned" with a layer of "molten silver solder, allow the workpiece to cool.
7. Clean off any solidified flux and any areas that have been oxidised or tarnished by the heating effects of the gas torch. File the "tinned" surfaces, clean and flat.
8. Again apply cold liquefied flux solution to the tinned surface using an artist's small paintbrush.
9. Place the tungsten carbide tool tip upon this surface - if possible hold the tip in position on the workpiece with a screw clamp or crocodile spring clip (or anything that isn't too costly or complex a fitting), as it will be affected by the heat of the gas torch.
10. Apply the flame of the gas torch to the area underneath the shank, below the surface where the tip has been placed. Heat this area until the temperature is sufficient to cause the flux to liquefy. The tip itself will also be hot and at the point when the solder liquefies all surfaces should be covered in molten flux and silver solder. The action of the spring clip or clamp will cause a slight compression between the tip and the shank and the molten solder between the two. This will cause an even distribution of silver solder, eventually creating a tight fusion between tip and shank without any air bubbles or voids. This helps to increase the strength and cutting efficiency of the finished tool.
11. Allow the workpiece to cool and do not quench in water.
12. When cold, any solidified flux will be removed in the action of grinding the tool tip to the required shape and geometry.
13. Using a "green grit" silicone carbide grinding wheel, create clearance and rake angles according to particular needs. Do not allow the tool to become too hot during grinding. If necessary, use a piece of shoe thickness leather to hold and support the shank against the grinding wheel, this will absorb the heat from the grinding action and protect the fingers of the user.
14. The tool bit is now ready to use and the user will find that it is possible to machine all metals at much higher speeds and rates of feed than when using conventional high speed steel.



# 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.

## New products from Chronos



**Laser centre finder** I have previously mentioned the very neat quarter inch shank laser centre/edge finder supplied by the company. When trying it out, I followed the recommendation to blue the work. This had the effect of reducing the reflected light and improving the achievable accuracy so that I was able to get about 2 thou repeatability. A polarising attachment is now offered which is simply pushed over the end of the laser. Rotation of the accessory then has the effect of varying the intensity of the laser light striking the target surface. It is thus possible to reduce the halo effect and improve accuracy. This is now rather more convenient than reaching for the marking blue and actually allows you to adjust the laser output to virtually zero to near maximum.

The laser centre finder is identified by Chronos product code LCEF costs £56.95 while the polarising attachment is code LCEP and costs £16.95. In both cases, prices include VAT and UK mainland postage.

Chronos have also introduced a new Keats type angle plate suitable for use on a number of lathes including the Myford ML7 and Super 7. Typically one of these angle plates might be used for operations such as boring cylinders. As supplied it is described as having a nominal capacity of 1.75in. diameter, however the this limitation is likely to result from the length of the clamping bolts. The vee length is 45mm and width of each vee flat is 35mm, which suggests to me, that you could, in the limit, clamp up to nearly 70mm diameter (2.75in.) All the important surfaces are ground, and the reversible clamp bar will cover a wide range of diameters.

The Keats angle plate is priced at £35.00 again including VAT and UK mainland carriage.

Chronos can be contacted at Unit 14 Dukeminster Estate, Church St. Dunstable, LU5 4HU telephone 01582 471 900 or see their website [www.chronos.ltd.uk](http://www.chronos.ltd.uk)

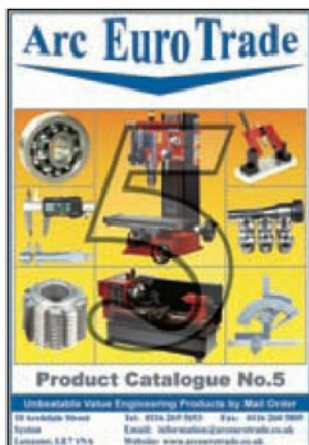


*Centre finder fitted with polariser*

## Woking Precision Models joins Hemingway Kits

Under the ownership of Kirk and Sandra Burwell, Hemingway Kits has enjoyed a renaissance over the last couple of years. The range of workshop tooling has expanded to around 80 unique project kits and the company has begun to build and ship John Payne's Quick-Step Mill to customers around the world. Now, in a fresh development, Hemingway Kits have announced the acquisition of Woking Precision Models for an undisclosed sum.

Kirk notes that "The Woking range of Westbury IC engines and Potts workshop tooling has a leading reputation among those who appreciate great design. We look forward to both growing our workshop range still further and beginning to develop a new range of 'prime movers' to power marine, aero and automotive models. Woking has been trading successfully since 1946 and the acquisition includes over 300 foundry patterns. We'll appreciate everyone's patience as we get to grips. Please watch our website ([www.hemingwaykits.com](http://www.hemingwaykits.com)) for the latest developments."



## New Catalogue from Arc Euro Trade

Depending on where and how you purchase this magazine, you may have received with it the latest catalogue (No.5) from Arc Euro Trade. It is of course packed with the range of quality engineering items we have come to expect from them at extremely competitive prices and if you do not have a copy, give them a phone on 0116 269 5693, and they will be delighted to post one out.



# Scribe a Line

## Wolfgang Vogelbein writes:

In his article in issue 118, Harold Hall invited a response on the subject of tribology and the appropriate choice of friction pairs, in particular about the use of a brass/steel combination. The answer has nothing to do with tribology, it is plain metallurgy, as some thought will quickly show.

There is nothing magic about dissimilar metals as friction pairings, in fact such pairs are as often beneficial as they may be harmful. The selection of such pairs for a particular purpose follows some simple rules.

The first rule is: all surfaces are dirty. Clean surfaces, and with clean I mean clean at the atomic level, require special laboratory conditions, i.e. an ultra-high vacuum at least as good as in a vacuum tube after gettering (those with an electronics background, you should understand what that implies). Oil is added to metal surfaces just for that – to keep them dirty and thus apart.

The second rule is: wherever solids touch, (local) welding takes place. Instead of the term "local welding" words such as "galling" or "seizing" are often used, clouding the issue. What commonly is called "welding" is just a method to make the interface between two pieces of metal smooth and clean enough that welding is not restricted to the few spots where normally pieces actually touch.

The third rule is: Friction pairings are meaningful only in situations where this dirt is not present: Local welding has taken place. Thus, the friction force is the force needed to break the local weld apart. Graphically, this may be represented by the following figures:

In Fig. 1, each black circle represents one atom of the first metal of the friction pair and the magenta circles are atoms of the other. Blue is then the dirt in between. If the dirt is some liquid, e.g. oil, after some movement the graphic will look as in Fig. 2, i.e. the liquid layer will shear: all deformation will have taken place inside the liquid (oil) layer. If the dirt is some solid, there are two possibilities:

1. The solid has less strength than either friction pair. Then what has been said about liquid dirt applies to solid dirt as well.
2. The solid is stronger than the weaker part of the friction pair. In this case, the weaker part will shear, and the situation is the same as if local welding would have taken place.

So far, the assumption has been that the mating surfaces are smooth at the atomic level, i.e. both mating surfaces are perfectly polished. This is of course never true. When this is taken into account as in Fig. 3, we have a magenta protrusion touching (and welding onto) the black material, after some shear the interface looks as shown in Fig. 4 and we have a

blob of magenta transferred onto the black metal. Here, it was assumed that magenta was the weaker material. If it were otherwise, some atoms would have been broken loose from the black metal.

So much about friction per se. Rub some brass on steel, and you will see that the rubbed surface will turn yellow, indicating that some brass has been transferred onto the steel.

Published "friction coefficients" must therefore be taken with a large pinch of salt, since both the surface roughness and the dirt layer between them is essentially undefined.

Which are now useful friction pairs? As has been shown, friction is essentially determined by the strength of the dirt layer between the two materials, plus the effect of local welding. Since friction pairs are chosen such that low friction is achieved even when the dirt (oil) interlayer is insufficient to keep the materials apart, they should be selected such that they differ substantially in (shear) strength. This makes graphite a good choice, because it has low shear strength but high compression strength but diamond a very poor one, even though both being the same material (carbon). If the choice is restricted to metals, one side should have a high melting point (e.g. steel) and the other a low melting point, because of the correlation between strength and melting point found between metals and their alloys.

This is the reason why the so-called "bearing metals" are all the one or other alloy of some of the low-melting elements such as tin, lead, antimony, bismuth, etc.

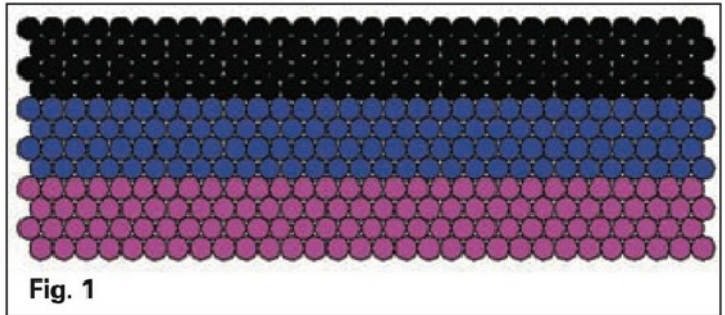


Fig. 1

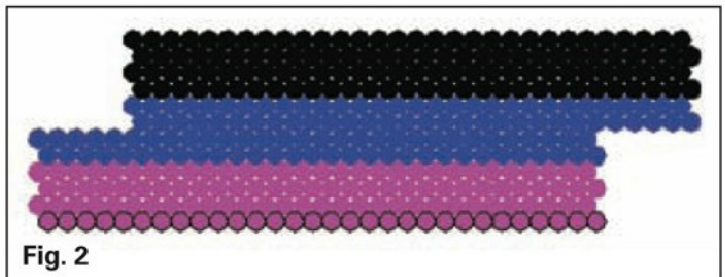


Fig. 2

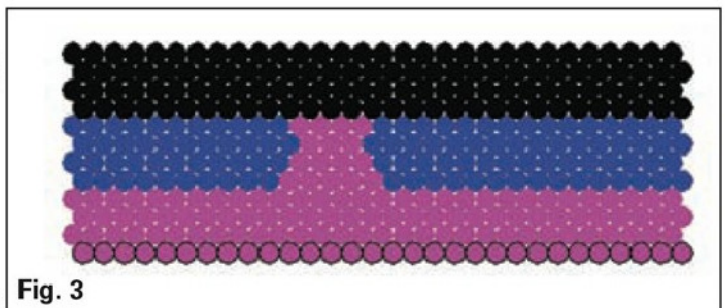


Fig. 3

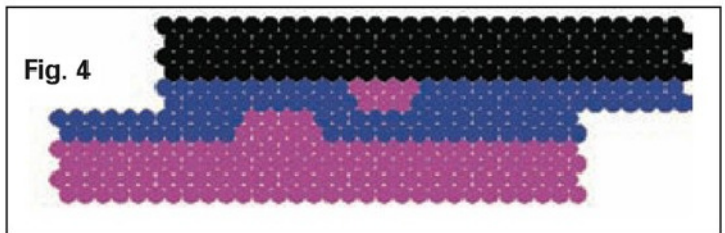


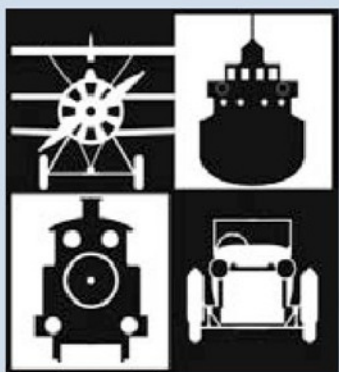
Fig. 4

Brass/steel is a poor choice in terms of friction forces, but it is better than steel/steel or even steel/tungsten.

Effort expended in manufacturing a bearing surface is another argument. Here, brass is king, since all you need to do is mate one surface to another, once. Using a bearing metal, and soft solder is one readily available to us, is a much more arduous job. First, the two surfaces must be mated. Then, they are removed from the mandrel so that the bearing surface can be coated with it, then they must be mated again . . . For some very heavy load applications, this coating process is repeated three or more times, with coats of increasingly lower melting points, because other solutions are simply not strong enough.

Can you imagine why most people rather use roller bearings?





# THE MODEL ENGINEER EXHIBITION

Please return completed form to:  
Model Engineer Competition,  
9 Tranmore Lane, Eggborough,  
E. Yorkshire DN14 0PR

ENTRY NO.



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### PERSONAL DETAILS (Please print)

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Have you entered before? (Y/N) \_\_\_\_\_

Do you purchase or subscribe to an Encanta Media Ltd 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 (Encanta Media Ltd will not insure the model unless a value is entered) £ \_\_\_\_\_

Name and address of your 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!

## Engineering Section

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

## Railway Section

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

## 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 medal.

## Model Vehicle Section

- K1 Non-working cars, including small commercial vehicles (e.g. Ford Transit) all scales down to 1/42.
- K2 Non-working trucks, articulated tractor and trailer units, plus other large commercial vehicles based on truck-type chassis, all scales down to 1/42.
- K3 Non-working motor bikes, including push bikes, all scales down to 1/42.
- K4 Non-working emergency vehicles, fire, police and ambulance, all scales down to 1/42.
- K5 Non-working vehicles including small commercial vehicles (e.g. Ford Transit) scale from 1/43 or smaller.
- K6 Any available body shells including Concours, in any scale or material, to be judged on appearance only.
- K7 Functional model cars/vehicles which must be able to move under its own power of any type. Can be either free-running, tethered 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 ENCANTA MEDIA LTD.
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 ENCANTA MEDIA LTD, 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 ENCANTA MEDIA LTD
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 which 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. ENCANTA MEDIA LTD 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 ENCANTA MEDIA LTD
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 ENCANTA MEDIA LTD are eligible to re-enter their model for the 'Duke of Edinburgh Challenge Trophy'. Past winners at any of the exhibitions promoted by ENCANTA MEDIA LTD will not be eligible for re-entry into the competition unless it has been substantially altered in any way.
7. ENCANTA MEDIA LTD 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 and 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 ENCANTA MEDIA LTD WILL NOT ACCEPT LIABILITY FOR ANY LOSS.**



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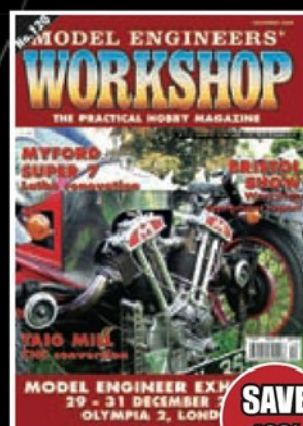
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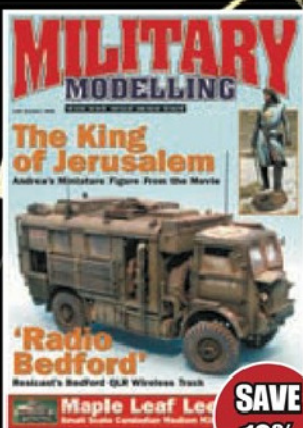
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| BRASS ROUNDS                        |                                                                        |  |        |
| E1                                  | 1/8 - 3/16 - 1/4 - 5/16 - 3/8 - 1/2                                    |  | 15.40  |
| E2                                  | 1/16 - 3/32 - 5/32 - 7/32 - 9/32 - 7/16 - 9/16 - 5/8                   |  | 24.00  |
| BRASS SQUARES                       |                                                                        |  |        |
| F1                                  | 1/8 - 3/16 - 1/4 - 5/16 - 3/8                                          |  | 13.10  |
| F2                                  | 1/4 - 5/16 - 3/8 - 7/16 - 1/2                                          |  | 26.95  |
| BRASS HEXAGONS                      |                                                                        |  |        |
| G1                                  | 5/32 - 3/16 - 7/32 - 1/4 - 9/31 - 5/16                                 |  | 11.00  |
| G2                                  | 1/4 - 9/32 - 5/16 - 3/8 - 7/16 - 1/2 - 5/8                             |  | 31.25  |
| BRASS ANGLE                         |                                                                        |  |        |
| H1                                  | 1/4 x 1/4 x 1/16 5/16 x 5/16 x 1/16                                    |  | 13.75  |
| H2                                  | 3/8 x 3/8 x 1/16 1/2 x 1/2 x 1/16                                      |  | 21.30  |
|                                     | 5/16 x 5/16 x 1/16 3/8 x 3/8 x 1/16                                    |  |        |
|                                     | 1/2 x 1/2 x 1/8 3/4 x 3/4 x 1/8                                        |  |        |
| DRAWN STEEL ANGLE                   |                                                                        |  |        |
| H3                                  | 16mm x 16mm x 3mm, 20mm x 20mm x 3mm 25mm x 25mm x 3mm                 |  | £13.50 |
| SEAMLESS COPPER TUBE                |                                                                        |  |        |
| J1                                  | 1/16 x 28g - 3/32 x 28g - 1/8 x 28g - 5/32 x 24g                       |  | 09.10  |
| J2                                  | 3/16 x 22g - 1/4 x 20g - 5/16 x 20g                                    |  | 07.45  |
| STAINLESS STEEL ROUND 303 F/C       |                                                                        |  |        |
| K1                                  | 3/32 - 1/8 - 5/32 - 3/16 - 7/32 - 1/4                                  |  | 10.00  |
| K2                                  | 3/16 - 7/32 - 1/4 - 5/16 - 3/8 - 7/16 - 1/2                            |  | 25.90  |
| BA STAINLESS STEEL HEXAGONS 303 F/C |                                                                        |  |        |
| L1                                  | .152" - .193" - .220" - .248" - .275" - .324"                          |  | 15.45  |
| BA BRASS HEXAGONS                   |                                                                        |  |        |
| M1                                  | .152" - .193" - .220" - .248" - .275" - .324"                          |  | 11.60  |
| BA STEEL HEXAGONS                   |                                                                        |  |        |
| M2                                  | .152" - .193" - .220" - .248" - .275" - .324"                          |  | 05.15  |
| BRASS FLATS                         |                                                                        |  |        |
| N1                                  | 1/16 x 1/4 - 3/8 - 1/2 - 3/4 - 1                                       |  | 09.50  |
| N3                                  | 1/8 x 1/4 - 3/8 - 1/2 - 3/4 - 1                                        |  | 20.50  |
| N4                                  | 3/16 x 1/4 - 3/8 - 1/2 - 3/4 - 1                                       |  | 29.35  |
| N5                                  | 1/4 x 3/8 - 1/2 - 3/4 - 1                                              |  | 30.70  |
| ALUMINIUM ROUND F/C                 |                                                                        |  |        |
| P1                                  | 3/16 - 1/4 - 5/16 - 3/8 - 7/16 - 1/2                                   |  | 13.65  |
| P2                                  | 5/8 - 3/4 - 1                                                          |  | 23.75  |
| PHOSPHOR BRONZE ROUND               |                                                                        |  |        |
| Q1                                  | 1/8 - 5/32 - 3/16 - 1/4                                                |  | 12.75  |
| Q2                                  | 5/16 - 3/8 - 7/16                                                      |  | 31.50  |
| SILVER STEEL 1 X 13" OF EACH        |                                                                        |  |        |
| S1                                  | 3/32 - 1/8 - 5/32 - 3/16 - 7/32 - 1/4 - 9/32 - 5/16 - 3/8 - 7/16 - 1/2 |  | 22.45  |
| S2                                  | 3mm - 4mm - 5mm - 6mm - 7mm - 8mm - 9mm - 10mm - 12mm                  |  | 19.50  |
| ALUMINIUM FLATS                     |                                                                        |  |        |
| R1                                  | 1/8 x 1/2 - 1/8 x 1 - 1/4 x 1/2 - 1/4 x 1 - 1/4 x 1 1/2 - 1/4 x 2      |  | 18.90  |
| R2                                  | 3/8 x 1/2 - 3/8 x 1 - 3/8 x 1 1/2                                      |  | 15.55  |
| R3                                  | 1/2 x 1 - 1/2 x 1 1/2 - 1/2 x 2                                        |  | 23.75  |
| R4                                  | 1/2 x 2 1/2 - 1/2 x 3                                                  |  | 27.85  |

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| 7.1/4"G | 1366         | 0-6-0  | 3.1/2"G | Molly                                | 0-6-0 |
| 5"NG    | Dholpur      | 2-8-4  | 3.1/2"G | Cant. Lamb                           | 0-4-0 |
| 5"G     | Butch        | 0-6-0  | 3.1/2"G | Petrolea                             | 2-4-0 |
| 5"G     | Chub         | 0-4-0  | 3.1/2"G | Iris                                 | 0-6-0 |
| 5"G     | Simplex      | 0-6-0  | 3.1/2"G | Doris                                | 4-6-0 |
| 5"G     | Springbok    | 4-6-0  | 3.1/2"G | Rainhill                             | 0-2-2 |
| 5"G     | King John    | 4-6-0  | 3.1/2"G | Hellam Lass.                         | 4-6-2 |
| 5"G     | Dean Goods   | 0-6-0  | 3.1/2"G | Rob Roy                              | 0-6-0 |
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| 5"G     | Twin Sisters | 0-6-0  | 3.1/2"G | City of Truro                        | 4-4-0 |
| 5"G     | Pansy        | 0-6-0  | 3.1/2"G | P.V. Baker                           | 0-6-0 |
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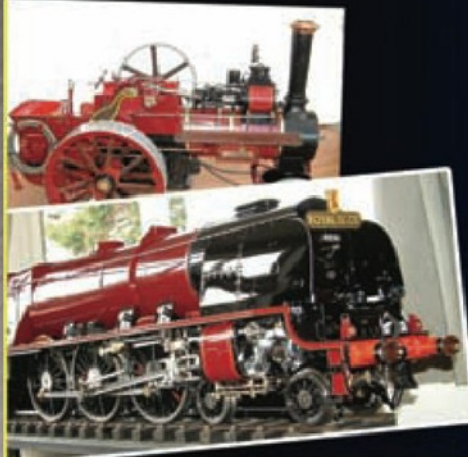
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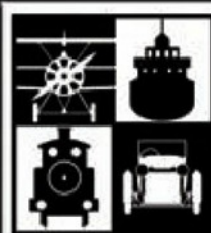
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56 & 57

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|                                                                         |           |
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| Boxford taper turning attachment                                        | £150      |
| Myford Minicop copy turning lathe on cabinet                            | P.O.A.    |
| Wadkin Universal Cutter Grinder Type N.H. with lots of tooling          | £1500     |
| Harrison L5 Lathe Gap Bed with Tooling                                  | £800      |
| 3 x Harrison L5 lathes tooling                                          | £700 each |
| Grimston drill floor stand with tapping plus x-y compound table         | £850      |
| Colchester master straight bed lathe with clutch. Has electrical fault. | £600      |

|                                                              |      |
|--------------------------------------------------------------|------|
| Schaubling Vertical Head as new                              | £800 |
| Versa tool, tool cabinet                                     | £150 |
| 3 Point steady for Boxford 5" lathe                          | £100 |
| 3 Point steady for Dean Smith and Grace lathe                | £200 |
| 3 Point steady for Colchester Master model 2500/student 1800 | £200 |
| Colchester student collett chuck                             | £120 |
| Colchester student capstan hardly used                       | £300 |

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Clarkson MK1 tool and cutter grinder + equipment



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Keetona 1 metre 16g guillotine + stops



Myford MA99E (collet chuck) type collets



SIP New HDP245B bench drill



Viceroy vertical milling machine/30INT



Crompton Parkinson Motors NEW 3/4HP ideal for Myford & Boxfords etc.



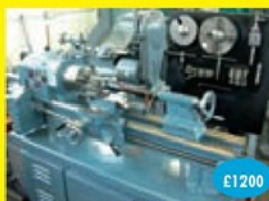
Colchester Student 1800 lathe complete with inverter on single phase



Viceroy 2MT 16mm pedestal drill



Tom Senior 'S' Type milling machine in very nice order



Boxford CUD MK111 lathe + equipment and inverter



Tom Senior vertical head



Archer No.2 tapping head, 2MT, 1/4-1/2



Grinder (pedestal) 300mm/12



Harrison Graduate wood lathe



Bridgeport turret milling machine + DRO



Eclipse De-Magnetiser



Adcock and Shipley vertical head



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Myford dividing attachment £375  
Myford vertical slides from £85 - £225  
Lister generator 3.6kva £625  
Record 114 bench vice The large one! £175  
Record 84 bench vice Almost new! £100  
Harrison LS / LSA / L6 micrometer  
carriage stops £70 each  
Flamefast hearth £140  
Cope and Drags/moulding boxes (metal) £30 each  
Harrison / Burner 'LOO' 4 jaw chuck Sepial £140

Startrite vertical metal cutting bandsaw £625  
Loads of horizontal / vertical milling cutters, reamers Special / £2 each  
Flamefast Rapid crucible furnace £425  
Granite / cast iron surface plates £20 - £425  
Clarkson radius attachment £425  
Jones and Shipman 4" universal grinding vice Special £195  
Lathe carriers / dogs up to 4" capacity £3.00 each  
Kosent crucible furnace £140



Myford Super 7B, gearbox, power cross feed, cabinet



Bridgeport Slotting head



Startrite 20 RWH (hydraulic) vertical metal cutting bandsaw



Myford Super 7 lathe



Steadies for many lathes



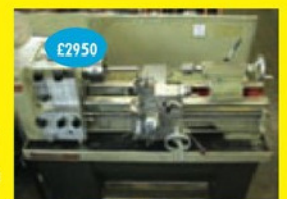
Boxford 1130, 5/8"x30"



Milling/Drilling grinding X-Y table



RJH 4" finisher complete on dust extraction cabinet stand



Harrison M300 lathe complete with gap and tooling



Boxford collets



Flamefast DS130 ceramic chip forge



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SWING OVER BED 210MM  
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RANGE OF SPINDLE SPEEDS 50-2000RPM  
MOTOR 3/4HP  
DIMENSIONS (LxWxH) 1050x560x570MM

## CHAMPION 16V

£725.00



MAX. DRILLING CAPACITY 16MM  
MAX. END MILLING CAP. 16MM  
MAX. FACE MILLING CAP. 50MM  
TABLE SIZE 400x120MM  
SPINDLE TAPER MT2  
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MOTOR 3/4HP  
DIMENSIONS 500x450x760MM

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MOTOR 1 1/2HP  
DIMENSIONS (LxWxH) 1080x660x610MM

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£775.00



MAX. DRILLING CAPACITY 20MM  
MAX. END MILLING CAP. 20MM  
MAX. FACE MILLING CAP. 63MM  
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SPINDLE TAPER MT2  
RANGE OF SPEEDS 50-2200RPM  
MOTOR 1HP  
DIMENSIONS 670x550x860MM

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SPINDLE BORE 26MM  
RANGE OF SPINDLE SPEEDS 50-2500RPM  
MOTOR 1HP  
DIMENSIONS (LxWxH) 1150x1350x570MM

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DISTANCE BETWEEN CENTRES 700MM  
SWING OVER BED 280MM  
SPINDLE BORE 26MM  
RANGE OF SPINDLE SPEEDS 125-2500RPM  
MOTOR 1HP  
DIMENSIONS (LxWxH) 1390x700x630MM

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