# 1. A spherical turning attachment

*Figure 1.1: The author's spherical turning tool*

## Introduction

The ability to make ball handles is essential for the serious workshop accessory constructor, and the J A Radford spherical turning attachment has always appealed to me. Recently did I make one, though I felt a cross-slide mounted attachment with a rotary handle worm drive would be a sturdier variation than one fitted to the top slide.

The design draws on that described by J A Radford*, and a constructor will need some familiarity with workshop tooling construction. The base is made from the casting for the Geo. H Thomas dividing head tailstock, which at the time of writing is available from several model engineering suppliers, e.g. Hemingway Kits.

* Improvements and accessories for your lathe, J A Radford, TEE Publishing, 1998. ISBN 1 85761 105 5

## Design

The idea of a rear-mounted cross-slide attachment is based on one by Alfred Herbert, Ltd. – Figure 1.2. The mounting is far more robust than a toolpost mounting, especially on a light lathe such as the Myford Super 7.

* Illustrated in Workshop Technology, Part III, WAJ Chapman, Edward Arnold (Publishers) Ltd, 1961. ISBN 0 7131 3035 0

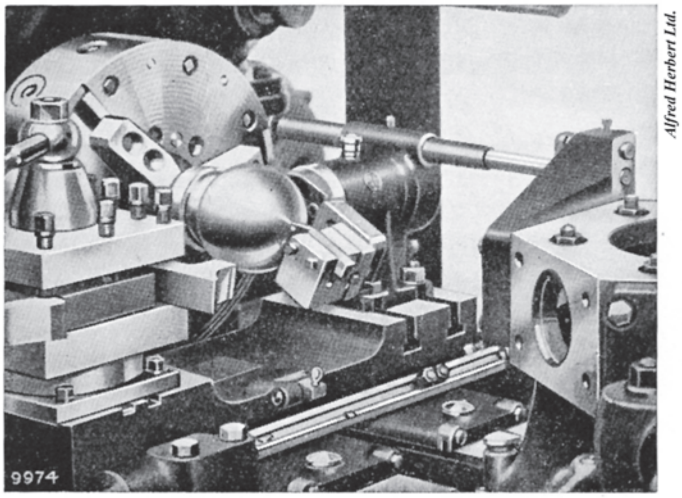



*Figure 1.2: The basis for the author's design*

The principal objection to rear cross-slide mounting design is that, if fitted to a lathe with a screw-on lathe chuck such as the Myford, the cutting needs to take place below the work if the risk of the lathe chuck unscrewing is to be eliminated. Clearly a lathe fitted with a Camlock or similar tapered spindle nose will not suffer from this problem. There is no doubt that cutting on the underside is a little more inconvenient, but it has not been found to be too much of a problem in practise as cutting progress can be easily inspected from above.

If the cutting is to be undertaken below the workpiece, for convenient tool setting the orientation of the tool slide locking screw ideally needs to be reversed (as I have shown in my drawings) compared to the Radford attachment used from the front of the lathe.

As mentioned, the design makes use of the casting for a Geo. H Thomas dividing head tailstock, though it does require some modification. In many other respects the design is heavily based on the Radford design. My design also has a tool bit holder that can be repositioned at three different radii which, coupled with the 2 inch diameter head rather than a rectangular head, minimises the extension of the attachment tool slide, which enables the work to be held closer to the chuck than would otherwise be possible.

The worm drive is angled at 12 degrees to match the slope of the sides of the casting, which is also more convenient for operation of the feed handle. Feed is applied via a 12 tooth single enveloping worm wheel engaged by a 1-start worm; this typically requires five full turns ($\approx$150 degrees) of the feed handle to make a ball-ended handle.

## Manufacture

Starting with the base casting, the first thing to do is machine the base to leave the cylindrical part of the casting at the correct centre height (2 $^{1}/_{16}$ inch on the Myford), after which the front and back faces and sides are machined square. The left hand side of the Thomas base flange will also need to be largely removed to minimise the saddle overhang due to the gap bed in the lathe shears. Once this has been done the two bosses for the dividing head clamping arrangement need to be machined off at 12 degrees before fettling/blending-in with a disc grinder.

Much of the above machining is facilitated if the cross-slide is fitted with the Myford boring table originally sold as an accessory for the Myford 254 lathe, its use not only giving greater flexibility for the position of clamping dogs but also the need for fewer packing strips to centre the flycutter and end mills for machining the casting surfaces.

Once the casting is reasonably square, the $^5/_8$ inch hole is bored using a between centres boring bar followed (if available) by a $^5/_8$ inch machine reamer. A length of $^5/_8$ inch diameter bar is end-drilled to take a Myford tee-slot stud and fitted to the boring table to provide a post from which the centre of the worm shaft cross hole can be measured. With a test bar fitted between the lathe centres and a little arithmetic, the cross-slide is then brought to the position that will give the correct pitch centres between worm and wheel, and locked. The casting can then be slipped over the $^5/_8$ inch post and clamped at 12 degrees after which the cross hole is through-drilled, bored and reamed to the diameter of the worm shaft sleeve.

The bolt holes can now be drilled on a 1 $^9/_{16}$ (Myford tee-slot spacing) grid, which is best done with the casting upside down as two of the four $^1/_4$ inch BSF clearance holes cannot be drilled from the top. These two holes must be spot-faced with a back-facing spot cutter, mine being of my own manufacture from hardened and tempered silver steel. Tee strips and turned washers were made to facilitate assembly, the $^1/_4$ BSF studs being secured into the tee-strips with an anaerobic adhesive.

## The wormshaft assembly

Attention can now be turned to the worm shaft. I purchased a worm and wheel from HPC Gears, Ltd., their boss-less worm integral with the shaft simplifying manufacture.

* HPC gears 2021 catalogue part numbers PM1-12/1 and SW1-1. Wheel tip o/d = 15 mm, worm o/d = 17 mm pitch, centres 12.00 mm (1.0 mod 12 tooth 1-start pair. Single-enveloping wheel.).

The worm is mounted in bronze bushes in an eccentric sleeve to give a fine adjustment of the pitch centres, the eccentric sleeve cut away for about 50% of its central periphery in order to clear the main shaft. The eccentric sleeve was bored $^5/_8$ inch from a piece of 1 inch diameter mild steel, this outside diameter being turned down to $^7/_8$ inch diameter for about two-thirds of its length at an eccentricity of 0.02 inches. A locking grub screw is fitted in the casting where the feedscrew would go in the dividing head tailstock casting.

The outer end of the worm shaft is fitted with a friction thimble graduated from 0 to 30 (each fiducial mark equating to 1 degree rotation of the spherical turning head), and finished off with a standard Myford curved spring washer and cross-slide handle.

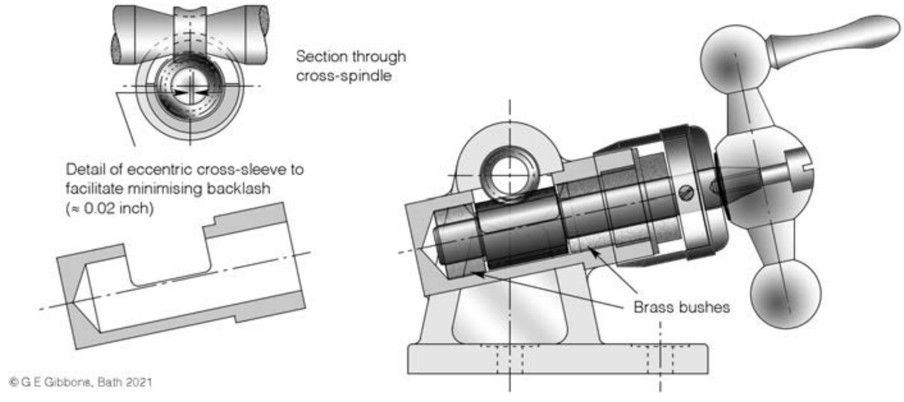



*Figure 1.3: Schematic of the worm drive arrangement*

## The spindle

If one is cutting the worm wheel directly in the $^5/_8$ inch silver steel spindle, then a hob will be required, but if using purchased gears (as I did), the spindle will need to be made in two halves connected by a double-ended M6 stud, the worm wheel locating on an accurately-turned plain portion of the stud in between and the two halves clamped tightly together using machined spanner flats on each half of the spindle.

The spindle includes a separate screw-on flange, a recess being incorporated into the head body for its location and secured with four 2 BA hex skt csk screws. The length of the front portion of the spindle is critical if the worm is to be accurately centred in the concave section of the worm wheel and this will need to be determined by trial and error during adjustment of the eccentric worm shaft housing for minimum backlash. One fibre washer to the rear and two $^5/_8$ x 26 tpi locknuts complete the spindle.

*Figure 1.4: The wormshaft*

It should also be possible to fit an adjustable 2 or 3 inch diameter rotational stop plate and finger to the rear should batch production of ball handles be a likely consideration. Not designed and fitted in my attachment, his would enable a repeatable angle of cutting arc to be achieved for each ball.

## The head body and sliding head

The head body is much the same as the Radford design, though mine was machined from 2 inch diameter bar. In addition and unlike Radford, I used a gib strip to achieve a smoother action than I felt would be possible without one. In addition, the sliding head is flanged (the underside of the flange is about 10 thou clear of the head body face) to provide a bolting face for the tool holder. I also made a pair of slides (one as a spare(?)) from 1 x $^1/_2$ inch rectangular section, the $^1/_2$ feedscrew bore being made with the pair clamped together.

*Figure 1.5: The spindle*

The body was cross-drilled and reamed to form the other half of the $^1/_2$ inch diameter bore before the dovetail was machined, some of the dovetail machining operations being illustrated in Figure 1.6. The gib strip arrangement is conventional; initially fitted with a central 2 BA hex skt cap screw with a turned down outer diameter head to form the clamp screw, this was replaced with a ball handle made with this attachment (see later).

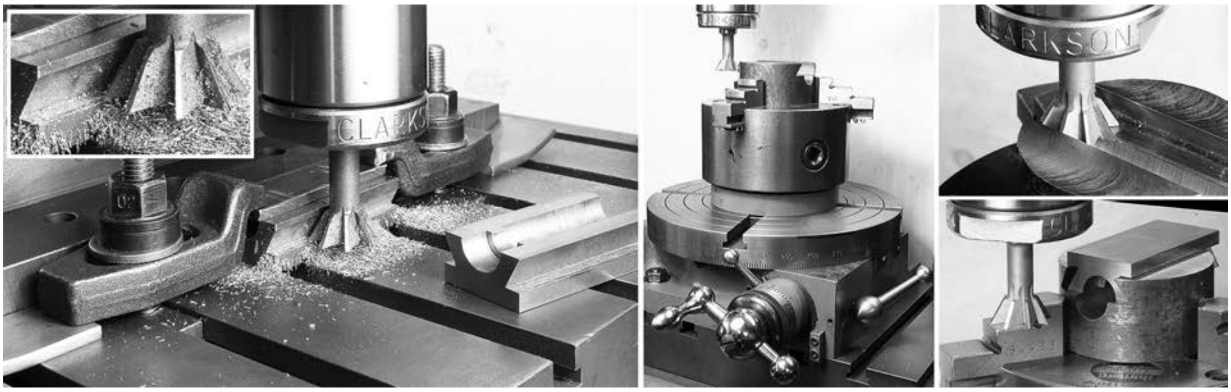


*Figure 1.6: Machining the cross slide and rotating body*

The feedscrew was cut with a $^1/_4$ x 20 tpi Whit. thread as I thought 40 tpi was unnecessarily fine, and the socket for the adjusting wrench made by inserting a 2 BA hex skt cap screw into the end. Loctited into position, it was selected to require the same size key as the original toolslide clamp screw before the latter was replaced by a ball handle.

The gib strip adjusting screws are 6 BA hex skt set screws locked with 8 BA thin hex nuts opened out to 6 BA. The screw tips are turned parallel to fit into matching partially-drilled holes in the gib strip to prevent the gib strip sliding when the sliding head is adjusted.

## The tool holder

Shown in Figure 1.7, this is significantly different from the Radford design, and includes a three-step coarse adjustment to minimise the tool slide overhang at large and small radii so reducing the chance of interference with the lathe chuck holding the work. Held by four 6 BA hex skt cap screws, the maximum radius is suitable for turning 2 inch diameter balls, and reduces in two $^1/_4$ inch steps to a minimum radius suitable for turning balls down to zero radius; consequentially the slide overhang at one end or the other never exceeds about 0.4 inches and is generally a lot less.

*Figure 1.7: The tool holder, and (right) showing a broken BS2 centre drill from which the tool bit can be ground*

The $^{3}/_{16}$ inch diameter HSS toolbit can be ground from a broken BS2 centre drill - Figure 1.7. It has two flat sides relieved at 5 degrees set at 75 degrees to one another, and the tip is ground on the Quorn tool and cutter grinder at 15 degrees to the top face. The toolbit is designed to cut on its end, so a tiny radius can be stoned at the intersection of the two flat sides; if side cutting is required for a finer turned finish, this radius should be omitted. For good strength, the length of the back rake should be about $^{1}/_{4}$ inch back from the cutting edge.

## Finishing the attachment

The index collar is heat blued after which the portion with the fiducial marks is lightly polished with 600 grit paper to make the marks stand out. Having adjusted the eccentirc sleeve for minimum worm/wheel backlash, permanently fitted the worm shaft housing with a few dabs of Loctite and faired it in using Milliput epoxy putty to simulate a casting. Deceitful, perhaps, but it is optional; the pre-putty arrangement during an initial backlash- minimisation trial is shown at the top right inset in Figure 1.8.

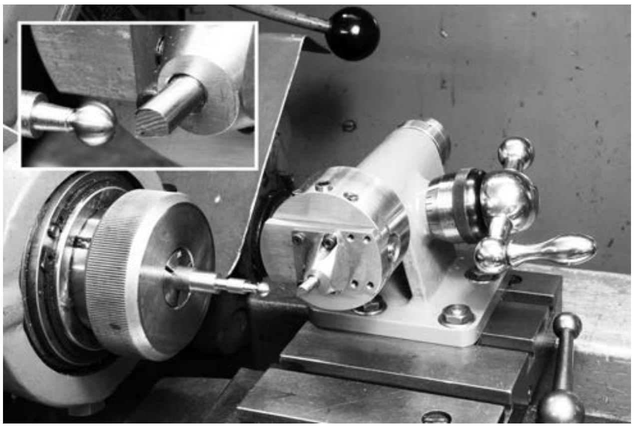
*Figure 1.8: The completed body and associated Tee strips*

*Figure 1.9: The completed turning attachment*

The casting is degreased, prepared and primed with red oxide paint before painting in an appropriate colour. Some of the unpainted surfaces are finely grained on a stone and/or grit paper, and the whole finally assembled with dabs of grease to the worm, worm wheel, the dovetail slides and feedscrew. No lubrication arrangements are fitted as I do not think they are necessary for an attachment that rotates at effectively zero speed for a limited number of lifetime revolutions; the attachment is effectively 'lubricated for life'.

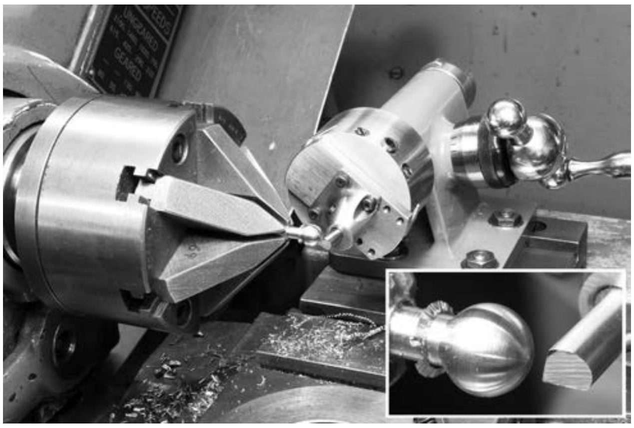
## Using the attachment

The attachment can be used for producing spherical 'spiders' for Cardan shaft Hooke joints, but it was primarily designed for ball handle production, and typical styles and dimensions of handle are shown in the table later on in this Chapter. Dimensions are in inches, but could equally well be calculated in millimetres, the handle being furnished with an equivalent metric thread. Of course, the arrangements may be interchanged (e.g. straight or angled, open or blind-threaded hole, etc.), and other dimensions are perfectly possible.



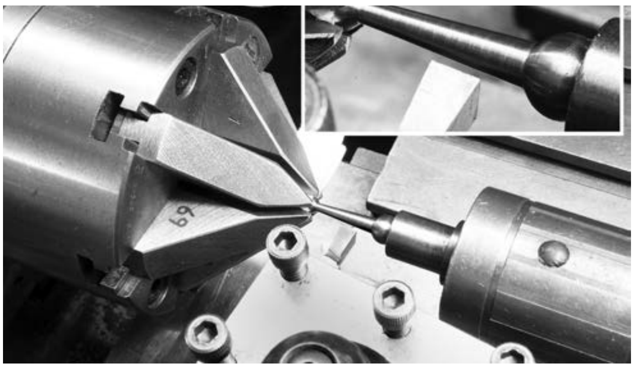
Step 1. Gaps have been cut in the bar stock and the small ball has just been turned. The toolholder is set to the innermost position to minimise interference with the lathe collet holder.

Protuberance of the workpiece from the collet is large, and better might have been to use the 6-jaw drill chuck (next photograph).



Step 2. The work has been reversed and the large ball is being turned. This time a 6-jaw drill grinding chuck is used, which minimises the workpiece overhang, the jaws also offering better clearance for the tool head than is achievable using a collet or standard 3-jaw chuck.

Not yet tapered, the handle is gripped by the parallel portion of the shank that has been left at a very slightly larger diameter than the small ball.



Step 3. Finally the shank is taper-turned with the lathe tool set-over to the taper angle. A strip of card protects the small ball from being marked by the chuck jaws, and the cut is in the direction of the hollow revolving centre in order to minimise the chuck jaw tightening pressure.

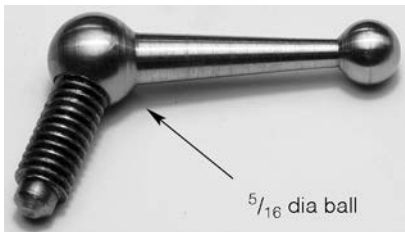
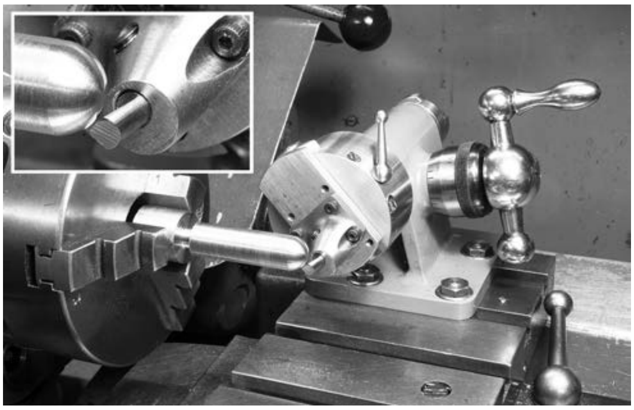
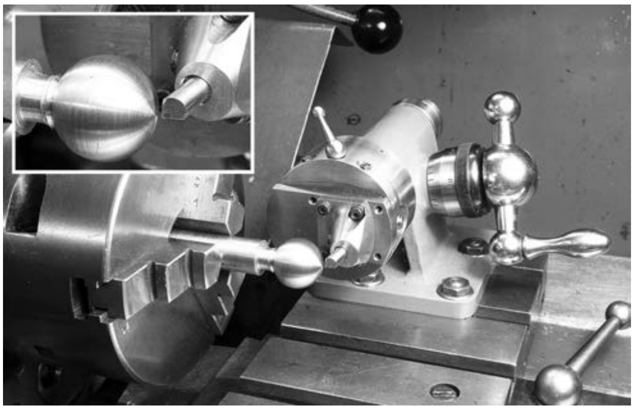



*Figure 1.10: Making a two-ball handle, this one being the ball handle used for the spherical attachment itself as shown on drawing sheet 8*



Step 1. After turning down the outer length, a gap has been cut in the bar stock and the domed outer end is being turned. The toolholder of the spherical head is set at its second innermost (middle) position.



Step 2. The work has been reversed in the chuck and the ball is being turned. Not yet being tapered, the handle is gripped by the parallel portion of the shank.

Step 3. Gripping the ball with a thin strip of aluminium to prevent marking the ball, the shank is taper turned with the lathe tool set-over to the taper angle and the hemispherical end steadied in the tailstock hollow rotating centre. As before, the cut is in the direction of the hollow revolving centre in order to ensure the handle does not creep out of position during cutting.

Step 4. A special fixture is used to grip the handle at 20 degrees for facing the side of the ball and drilling and tapping the hole. A strip of copper in the form of a partial sleeve prevents the ball from being marked by the clamping set screws. .


*Figure 1.11: Making a one-ball lever handle*

The sequence for turning ball handles is critical, but as the sequence has been described a number of times elsewhere, I shall restrict my observations to the photographs shown in Figures 1.10 and 1.11. Figure 1.10 shows the sequence (steps) for turning a two-ball handle and a short series lever clamp handle; this is size B2 as tabulated later on. Fitted with a 4 BA stud set at 20 degrees, it can be seen used as the completed clamp screw for the spherical attachment in the introductory photograph, Figure 1.1.

The longer 'Standard series' single ball lever handle is based on DIN 99:1995, and a root radius is recommended as the taper is the wrong way*. A sharp corner at the lever to ball transition is more likely to induce cracking in operation, especially if it is found necessary to tap an over-tightened lever with a mallet. The short series single ball lever handle is probably more appropriate for heavy-duty and/or handles with $^1/_2$ inch (12 mm) diameter and smaller balls.

* A cantilever needs the larger taper diameter (section modulus) at the cantilever root furthest away from the tightening force, which is the opposite of the smaller root of the aesthetically more pleasing shape drawn.

The short series lever clamp handle with a $^3/_4$ inch diameter ball (size LS6 as tabulated at the end of this Chapter) is shown in Figure 1.11. As before the sequence of operations is critical to ensure work-holding is possible.

Apart from noting the adjusted position of the tool holder, the only other comment worthy of additional mention is the use of a chuck-mounted facing and drilling attachment in the fourth photograph of the Figure 1.11 sequence. This attachment is of the style described by Professor Chaddock for the Quorn tool and cutter grinder and holds the handle at 20 degrees in order to make an angled lever. Tapped $^5/_{16}$ inch BSF, the completed handle is shown alongside. (The short length of the small Figure 1.10 two ball handle coupled with the extended jaws of the 6-jaw chuck rendered the use of this angular facing and drilling attachment unnecessary, one of the six jaws being removed to allow the handle to be set at 20 degrees.)

Which style of ball/lever handle one prefers is a personal matter, though it is probably slightly easier to make the single-ball lever clamp handle.

Finally, decorative heat bluing or blackening is always possible, especially if it is required to match an additional or replacement handle to those blued or blacked by the original manufacturer of, say, a lathe or milling machine - Figure 1.12.

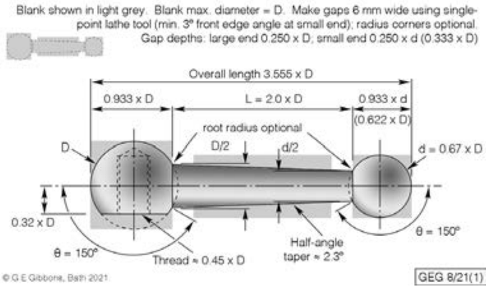
*Figure 1.12: Two heat-blued 'workshop quality' ball handles made by the author*

## Ball clamping handles

### Typical nominal dimensions

| | Overall handle length | Large ball diameter | Suggested thread* |
|---|---|---|---|
| B1 | 0.90 | 1/4 | 5 BA |
| B2 | 1.20 | 5/16 | 4 BA |
| B3 | 1.40 | 3/8 | 2 BA |
| B4 | 1.80 | 1/2 | 1/4 BSF |
| B5 | 2.30 | 5/8 | 1/4 BSF |
| B6 | 2.70 | 3/4 | 5/16 BSF |
| B7 | 3.20 | 7/8 | 3/8 BSF |
| B8 | 3.60 | 1 | 7/16 BSF |
| B9 | 4.10 | 1 1/8 | 1/2 BSF |
| B10 | 4.50 | 1 1/4 | 1/2 BSF |
| B11 | 4.90 | 1 3/8 | 5/8 BSF |
| B12 | 5.40 | 1 1/2 | 5/8 BSF |

* The angle at which the thread/flat is cut/machined to the axis of the handle is to suit the application. If angled, 20 degrees is typical.



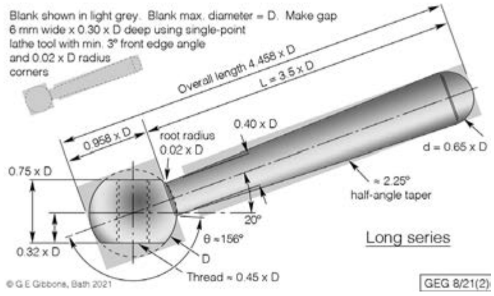

| | Maufacturing dimensions: Large ball | | | | : Small ball | | | Other manufacturing information | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Large ball diameter, D | D/2 | 0.933 x D | 0.32 x D* | Small ball diameter, d | d/2 | 0.933 x d (0.622 x D) | Length, L | Length overall | Thread diameter 0.45 x D | Taper half-angle (degrees) | Spherical tool rotation (degrees) |
| B1 | 0.250 | 0.125 | 0.233 | 0.080 | 0.168 | 0.084 | 0.156 | 0.500 | 0.890 | 0.11 | 2.4 | 150.0 |
| B2 | 0.312 | 0.156 | 0.291 | 0.100 | 0.209 | 0.105 | 0.195 | 0.624 | 1.110 | 0.14 | 2.4 | 150.0 |
| B3 | 0.375 | 0.188 | 0.350 | 0.120 | 0.251 | 0.126 | 0.234 | 0.750 | 1.334 | 0.17 | 2.4 | 150.0 |
| B4 | 0.500 | 0.250 | 0.467 | 0.160 | 0.335 | 0.168 | 0.313 | 1.000 | 1.779 | 0.23 | 2.4 | 150.0 |
| B5 | 0.625 | 0.313 | 0.583 | 0.200 | 0.419 | 0.209 | 0.391 | 1.250 | 2.224 | 0.28 | 2.4 | 150.0 |
| B6 | 0.750 | 0.375 | 0.700 | 0.240 | 0.503 | 0.251 | 0.469 | 1.500 | 2.669 | 0.34 | 2.4 | 150.0 |
| B7 | 0.875 | 0.438 | 0.816 | 0.280 | 0.586 | 0.293 | 0.547 | 1.750 | 3.113 | 0.39 | 2.3 | 150.0 |
| B8 | 1.000 | 0.500 | 0.933 | 0.320 | 0.670 | 0.335 | 0.625 | 2.000 | 3.558 | 0.45 | 2.3 | 150.0 |
| B9 | 1.125 | 0.563 | 1.050 | 0.360 | 0.754 | 0.377 | 0.703 | 2.250 | 4.003 | 0.51 | 2.3 | 150.0 |
| B10 | 1.250 | 0.625 | 1.166 | 0.400 | 0.838 | 0.419 | 0.781 | 2.500 | 4.448 | 0.56 | 2.3 | 150.0 |
| B11 | 1.375 | 0.688 | 1.283 | 0.440 | 0.921 | 0.461 | 0.860 | 2.750 | 4.892 | 0.62 | 2.3 | 150.0 |
| B12 | 1.500 | 0.750 | 1.400 | 0.480 | 1.005 | 0.503 | 0.938 | 3.000 | 5.337 | 0.68 | 2.3 | 150.0 |

## Lever clamping handles - long series

### Typical nominal dimensions

| | Overall handle length | Large ball diameter | Suggested thread* |
|---|---|---|---|
| LL1 | 1.20 | 1/4 | 5 BA |
| LL2 | 1.40 | 5/16 | 4 BA |
| LL3 | 1.70 | 3/8 | 2 BA |
| LL4 | 2.30 | 1/2 | 1/4 BSF |
| LL5 | 2.80 | 5/8 | 1/4 BSF |
| LL6 | 3.40 | 3/4 | 5/16 BSF |
| LL7 | 4.00 | 7/8 | 3/8 BSF |
| LL8 | 4.50 | 1 | 7/16 BSF |
| LL9 | 5.10 | 1 1/8 | 1/2 BSF |
| LL10 | 5.60 | 1 1/4 | 1/2 BSF |
| LL11 | 6.20 | 1 3/8 | 5/8 BSF |
| LL12 | 6.70 | 1 1/2 | 5/8 BSF |

* The angle at which the thread/flat is cut/machined to the axis of the handle is to suit the application. If angled, 20 degrees is typical.



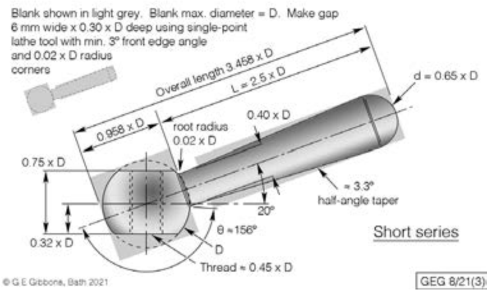

| | Maufacturing dimensions: Ball | | | | | Other manufacturing information | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ball diameter, D | 0.40 x D | 0.958 x D | 0.32 x D* | 0.75 x D | End diameter, d | Length, L | Length overall | Thread diameter 0.45 x D | Taper half-angle (degrees) | Root radius | Spherical tool rotation (degrees) |
| LL1 | 0.250 | 0.100 | 0.240 | 0.080 | 0.1875 | 0.163 | 0.875 | 1.115 | 0.11 | 2.3 | 0.005 | 156 |
| LL2 | 0.312 | 0.125 | 0.299 | 0.100 | 0.234 | 0.203 | 1.092 | 1.391 | 0.14 | 2.3 | 0.006 | 156 |
| LL3 | 0.375 | 0.150 | 0.359 | 0.120 | 0.28125 | 0.244 | 1.313 | 1.672 | 0.17 | 2.3 | 0.008 | 156 |
| LL4 | 0.500 | 0.200 | 0.479 | 0.160 | 0.375 | 0.325 | 1.750 | 2.229 | 0.23 | 2.3 | 0.010 | 156 |
| LL5 | 0.625 | 0.250 | 0.599 | 0.200 | 0.46875 | 0.406 | 2.188 | 2.786 | 0.28 | 2.3 | 0.013 | 156 |
| LL6 | 0.750 | 0.300 | 0.719 | 0.240 | 0.5625 | 0.488 | 2.625 | 3.344 | 0.34 | 2.2 | 0.015 | 156 |
| LL7 | 0.875 | 0.350 | 0.838 | 0.280 | 0.65625 | 0.569 | 3.063 | 3.901 | 0.39 | 2.2 | 0.018 | 156 |
| LL8 | 1.000 | 0.400 | 0.958 | 0.320 | 0.75 | 0.650 | 3.500 | 4.458 | 0.45 | 2.2 | 0.020 | 156 |
| LL9 | 1.125 | 0.450 | 1.078 | 0.360 | 0.84375 | 0.731 | 3.938 | 5.015 | 0.51 | 2.2 | 0.023 | 156 |
| LL10 | 1.250 | 0.500 | 1.198 | 0.400 | 0.9375 | 0.813 | 4.375 | 5.573 | 0.56 | 2.2 | 0.025 | 156 |
| LL11 | 1.375 | 0.550 | 1.317 | 0.440 | 1.03125 | 0.894 | 4.813 | 6.130 | 0.62 | 2.2 | 0.028 | 156 |
| LL12 | 1.500 | 0.600 | 1.437 | 0.480 | 1.125 | 0.975 | 5.250 | 6.687 | 0.68 | 2.2 | 0.030 | 156 |

## Lever clamping handles - short series

### Typical nominal dimensions

| | Overall handle length | Large ball diameter | Suggested thread* |
|---|---|---|---|
| LS1 | 0.90 | 1/4 | 5 BA |
| LS2 | 1.10 | 5/16 | 4 BA |
| LS3 | 1.30 | 3/8 | 2 BA |
| LS4 | 1.80 | 1/2 | 1/4 BSF |
| LS5 | 2.20 | 5/8 | 1/4 BSF |
| LS6 | 2.60 | 3/4 | 5/16 BSF |
| LS7 | 3.10 | 7/8 | 3/8 BSF |
| LS8 | 3.50 | 1 | 7/16 BSF |
| LS9 | 3.90 | 1 1/8 | 1/2 BSF |
| LS10 | 4.40 | 1 1/4 | 1/2 BSF |
| LS11 | 4.80 | 1 3/8 | 5/8 BSF |
| LS12 | 5.20 | 1 1/2 | 5/8 BSF |

* The angle at which the thread/flat is cut/machined to the axis of the handle is to suit the application. If angled, 20 degrees is typical.

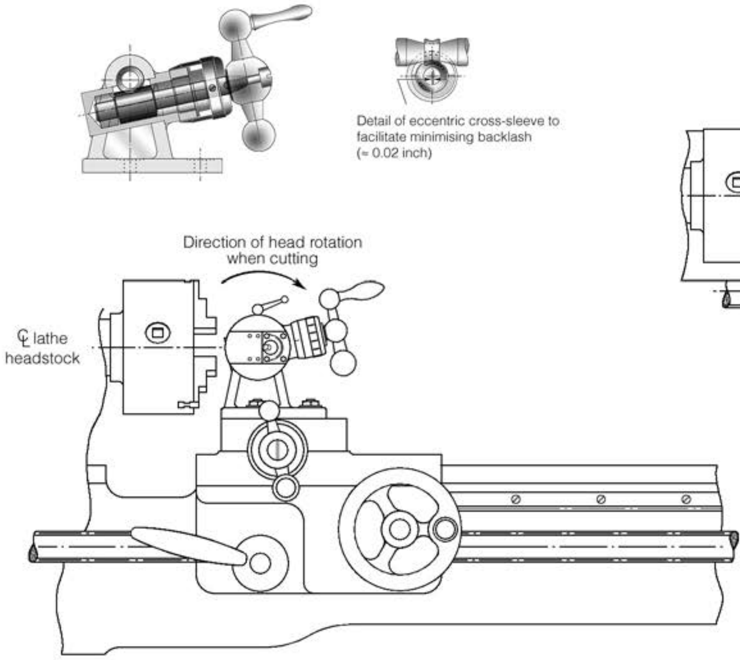


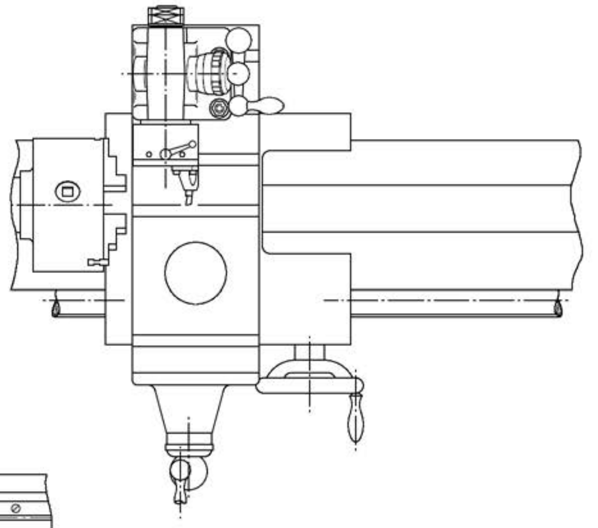

| | Maufacturing dimensions: Ball | | | | | Other manufacturing information | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ball diameter, D | 0.40 x D | 0.958 x D | 0.32 x D* | 0.75 x D | End diameter, d | Length, L | Length overall | Thread diameter 0.45 x D | Taper half-angle (degrees) | Root radius | Spherical tool rotation (degrees) |
| LS1 | 0.250 | 0.100 | 0.240 | 0.080 | 0.1875 | 0.163 | 0.625 | 0.865 | 0.11 | 3.3 | 0.005 | 156 |
| LS2 | 0.312 | 0.125 | 0.299 | 0.100 | 0.234 | 0.203 | 0.780 | 1.079 | 0.14 | 3.3 | 0.006 | 156 |
| LS3 | 0.375 | 0.150 | 0.359 | 0.120 | 0.28125 | 0.244 | 0.938 | 1.297 | 0.17 | 3.3 | 0.008 | 156 |
| LS4 | 0.500 | 0.200 | 0.479 | 0.160 | 0.375 | 0.325 | 1.250 | 1.729 | 0.23 | 3.3 | 0.010 | 156 |
| LS5 | 0.625 | 0.250 | 0.599 | 0.200 | 0.46875 | 0.406 | 1.563 | 2.161 | 0.28 | 3.3 | 0.013 | 156 |
| LS6 | 0.750 | 0.300 | 0.719 | 0.240 | 0.5625 | 0.488 | 1.875 | 2.594 | 0.34 | 3.3 | 0.015 | 156 |
| LS7 | 0.875 | 0.350 | 0.838 | 0.280 | 0.65625 | 0.569 | 2.188 | 3.026 | 0.39 | 3.3 | 0.018 | 156 |
| LS8 | 1.000 | 0.400 | 0.958 | 0.320 | 0.75 | 0.650 | 2.500 | 3.458 | 0.45 | 3.3 | 0.020 | 156 |
| LS9 | 1.125 | 0.450 | 1.078 | 0.360 | 0.84375 | 0.731 | 2.813 | 3.890 | 0.51 | 3.3 | 0.023 | 156 |
| LS10 | 1.250 | 0.500 | 1.198 | 0.400 | 0.9375 | 0.813 | 3.125 | 4.323 | 0.56 | 3.3 | 0.025 | 156 |
| LS11 | 1.375 | 0.550 | 1.317 | 0.440 | 1.03125 | 0.894 | 3.438 | 4.755 | 0.62 | 3.3 | 0.028 | 156 |
| LS12 | 1.500 | 0.600 | 1.437 | 0.480 | 1.125 | 0.975 | 3.750 | 5.187 | 0.68 | 3.3 | 0.030 | 156 |

# Spherical turning attachment

Drawn to suit the Myford Super 7 lathe

## Schematic sketches



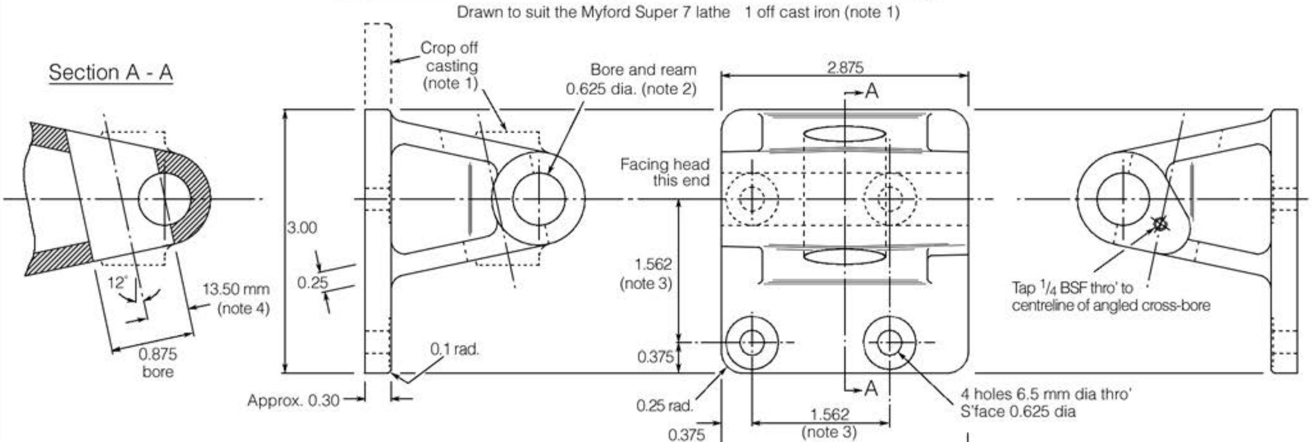
Suitable for turning spheres (balls) and ball handles ranging from 0 to 2 inches in diameter
Cutting is on the underside of the sphere when the lathe is running in its normal direction (recommended for a lathe with a screw-on chuck)

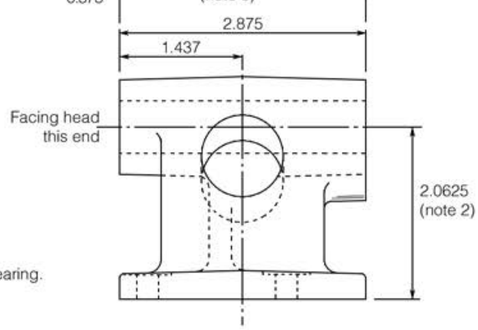


Third angle projection. All dimensions in inches unless stated. GEG 12/21(1)

# Spherical turning attachment - body

Drawn to suit the Myford Super 7 lathe 1 off cast iron (note 1)



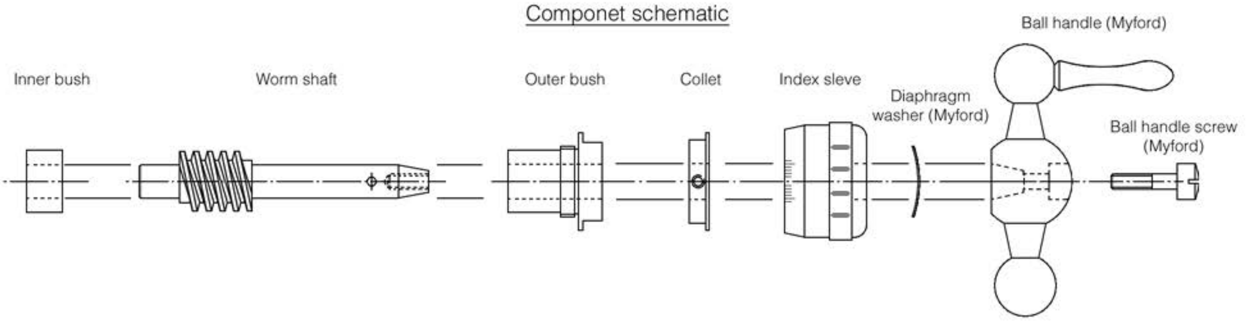

NOTES
1. Body adapted from Geo. H Thomas tailtock dividing attachment casting with 12° sides. Cut/grind/dress off the areas indicated.
2. Lathe centre height above cross-slide. After machining base and securing holes bolt, the casting to the cross-slide and bore and ream the $^5/_8$ diameter hole in order to ensure it is exactly at the lathe centre height.
3. 1.562 (1 $^9/_{16}$) is the standard Myford Series 7 lathe Tee slot spacing.
4. 13.50 mm (0.531 in.) is the centre distance for the selected 12T 1 mod worm gearing.
5. Standard part: 1 off $^1/_4$ BSF x 1 inch long hex skt set screw.



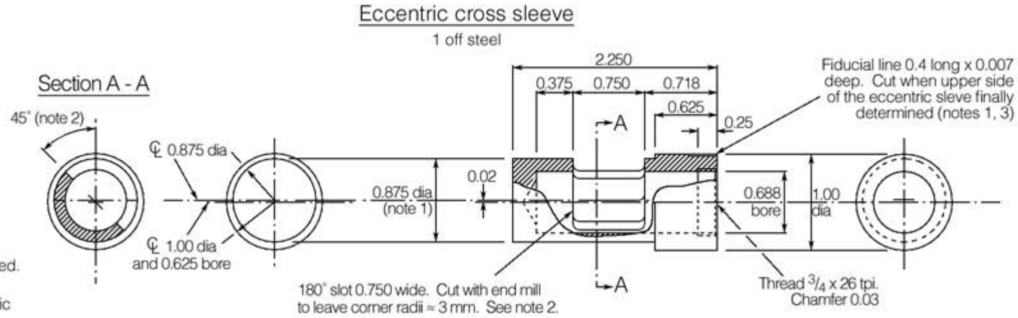
Third angle projection. All dimensions in inches unless stated. GEG 12/21(2)

# Spherical turning attachment - cross shaft (1)

Drawn to suit the Myford Super 7 lathe




NOTES
1. Eccentric cross sleeve adjusted in body to give accurate meshing between worm and wheel and locked in position using 1/4 BSF set screw (Sheet 2). Fairing into body with epoxy putty optional.
2. With the slot set at 45°, a 0.02 (20 thou) eccentricity allows up to ± 0.005 (5 thou) adjustment of the worm and wheel mesh in order to correct for a pitch centre error. As a single enveloping wheel is fitted, slight adjustment of the axial position of the wheel shaft will be needed.
3. Single fiducial line marked once the correct angular position of the eccentric sleeve has been finally determined.

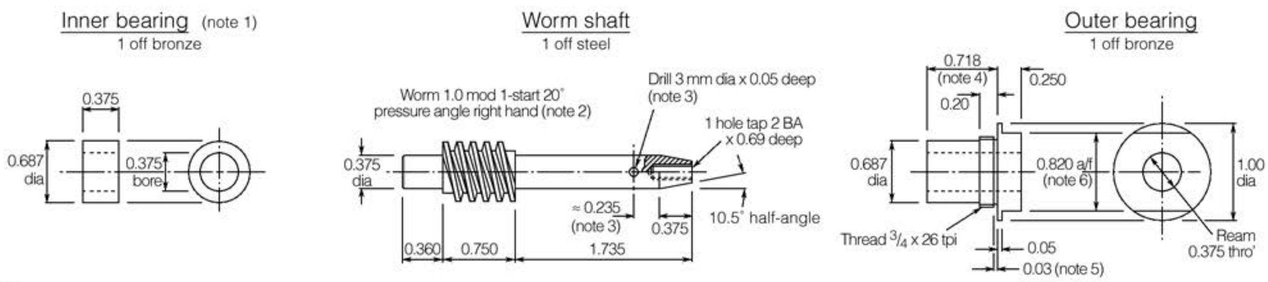




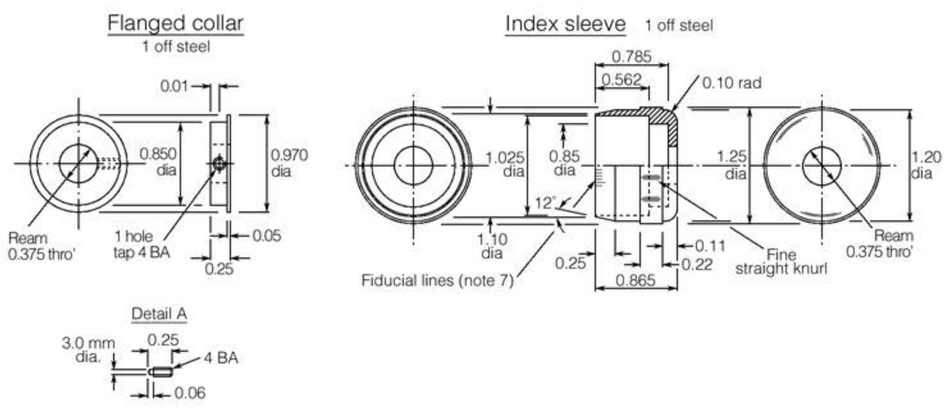

Third angle projection. All dimensions in inches unless stated. GEG 12/25(3)

# Spherical turning attachment - cross shaft (2)

Drawn to suit the Myford Super 7 lathe



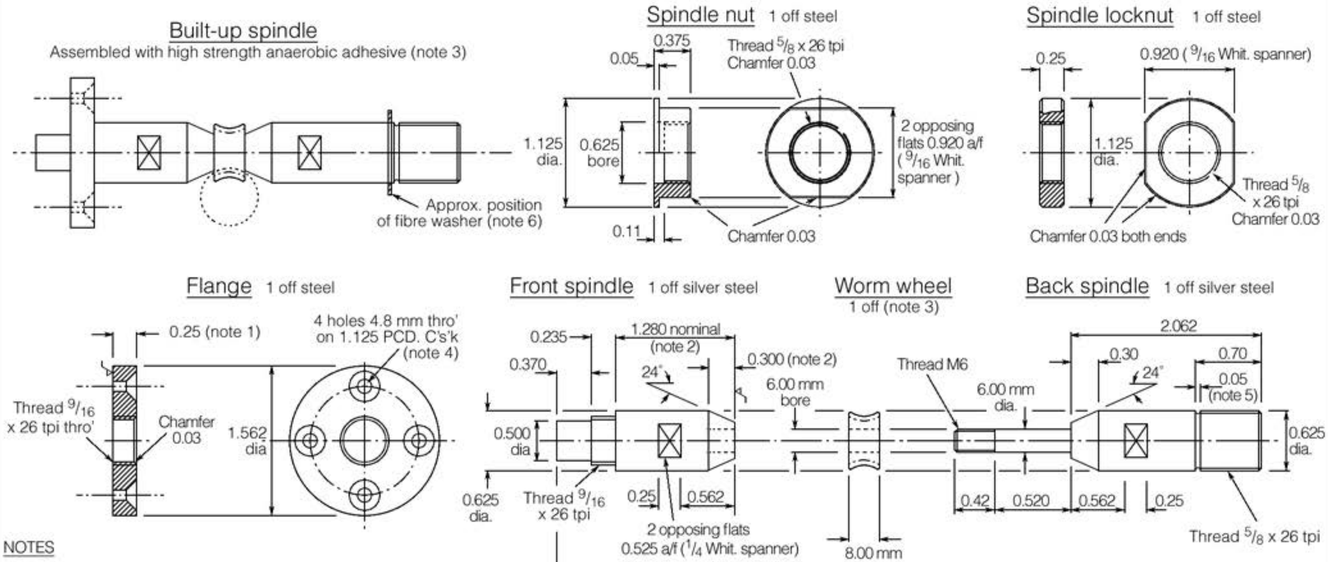

NOTES
1. Inner bearing secured with a low strength anaerobic adhesive on final assembly
2. Modified HPC Gears Ltd. worm cat. PM1-12/1. Worm o/dia 17.00 mm, PCD 15.00 mm.
3. On trial assembly, spot to give good friction grip of spring washer on thimble (see sheet 3).
4. If necessary, adjust to give 0.001 to 0.002 axial backlash clearance to worm on assembly.
5. Thread root clearance cut to a depth of 0.04
6. To suit 7/16 in. Whit. or 1/2 in. BSF spanner
7. 30 in number equally spaced fiducial lines cut 0.007 deep with a 55° Vee-point tool. Units: 0.10 long, fives: 0.13 long, tens: 0.16 long. 1.5 mm high numeral stamp 0, 5, 10, 15, 20, 25
8. Standard parts:
   1 off 4 BA x 1/4 hex skt set screw. Turn down point to match drill point angle as shown in Detail 'A'.
   1 off Myford diaphragm washer, cat. A2058
   1 off Myford cross slide ball handle, cat. A2073
   1 off Myford cross slide ball handle securing screw, cat. A1541/1

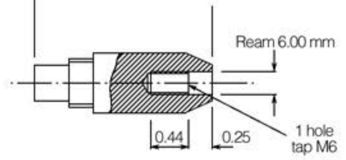





Third angle projection. All dimensions in inches unless stated. GEG 12/21(4)

# Spherical turning attachment - spindle




NOTES

1. Skim outer face (√) to 0.240 on completion of final assemby to spindle (after securing with high-strength anaerobic adhesive).
2. Initially machine to 1.285 length. On adjusting the eccentric sleeve (Sheet 3), check for correct mesh of the single enveloping wheel with worm and skim face indicated (√) as necessary before final assembly with high strength anaerobic adhesive.
3. Accuracy of assembly is essential in order to assure smooth action. Aim for an out-of-concentricity of less than ±0.0005 (TIR < 0.001)
4. Ensure c's'k head of screw lies below face of flange.
5. Thread root clearance cut to a depth of 0.04

NOTES (continued)

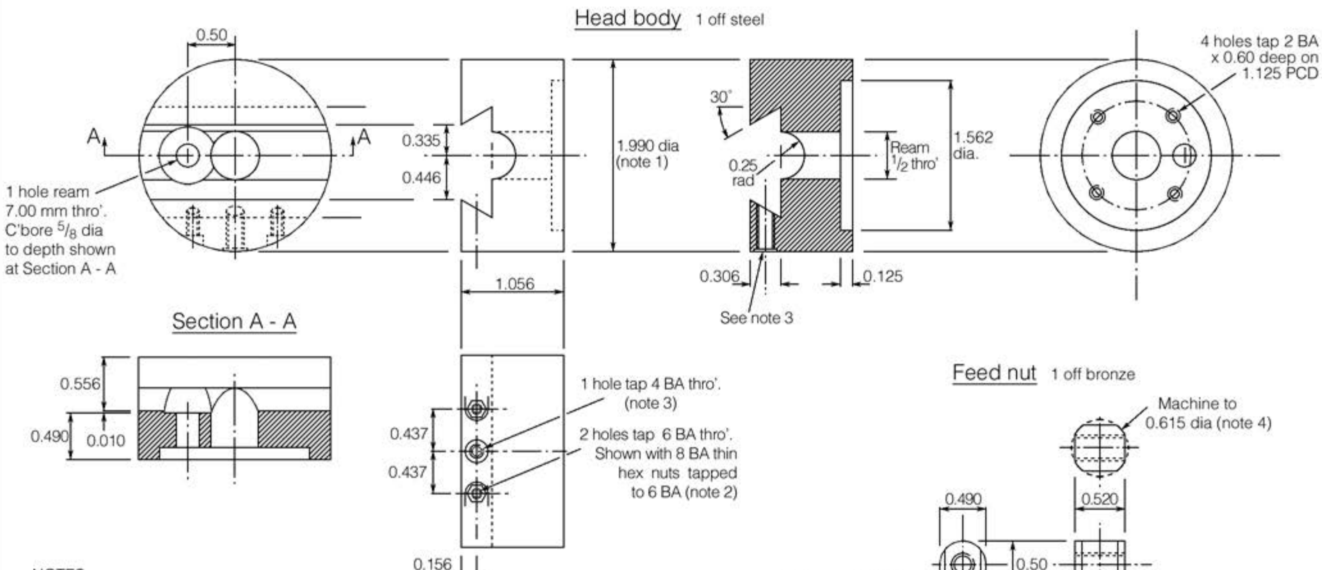
6. Standard parts: 1 off worm wheel 12 T 1.0 mod 1-start single enveloping right hand bronze wheel, 6 mm bore (HPC Gears Ltd cat. PM1-12).
4 off 2 BA x 5/8 hex skt c's'k screws.
1 off fibre washer 0.06 thick x 5/8 bore x 1.0 o/dia.

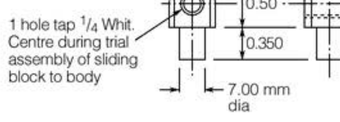


Third angle projection. All dimensions in inches unless stated. **GEG 12/21(5)**

# Spherical turning attachment - head and feed nut

Drawn to suit the Myford Super 7 lathe




NOTES

1. Make from 2 inch diameter bar stock and skim machine to ≈ 1.990 after assembly of sliding block.
2. Outer gib strip adjusting screws: spotface 0.250 dia to a depth that permits full seating of the BA thin locknut (Sheet 8).
3. Centre 4 BA slide locking screw thread: shallow spotface 0.250 dia
4. To fit within 0.625 spotface - see Section A - A

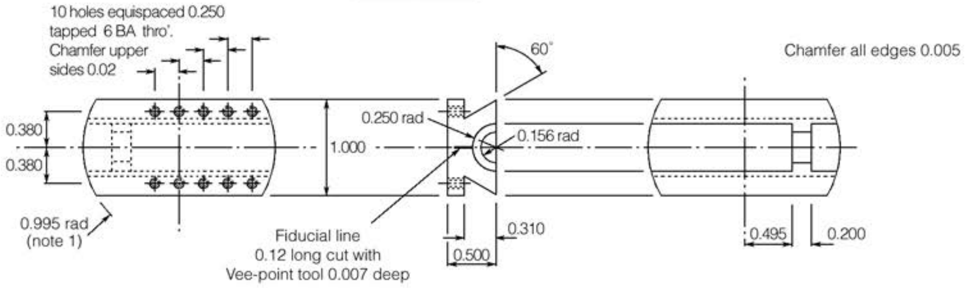


Third angle projection. All dimensions in inches unless stated. **GEG 12/21(6)**

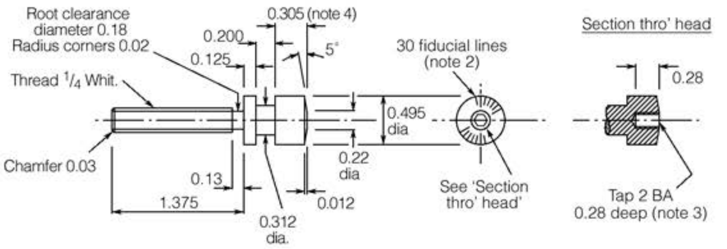
## Spherical turning attachment - sliding block and feedscrew

Drawn to suit the Myford Super 7 lathe

### Sliding block
1 off steel




### Feedscrew
1 off steel




NOTES
1. Make overlong and finish machine to ≈ 0.995 rad. (1.990 dia) after assembly on head body.
2. Fiducial lines: 30 divisions 0.007 deep spaced at 12°. Tens: 0.12 long, twos: 0.10 long.
3. Drive 2 BA x $^{1}/_{4}$ hex hex skt set screw to refusal after coating with an anaerobic adhesive. Skim face on completion to leave head flush with end of shaft.
4. Check 0.305 dimension o/c of finishing body and slide overall end radius (0.995) (note 1). The periphery of the feedscrew head should be level with the slide fiducial line (centreline)
5. Standard parts: 4 off 6 BA x $^{5}/_{16}$ hex skt cap screws
   1 off 2 BA x $^{1}/_{4}$ hex skt set screw

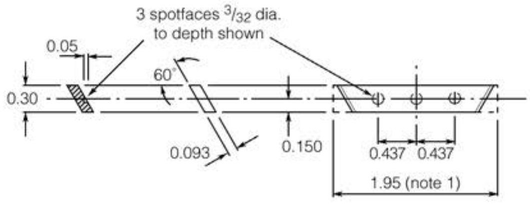


Third angle projection. All dimensions in inches unless stated. GEG 12/21(7)

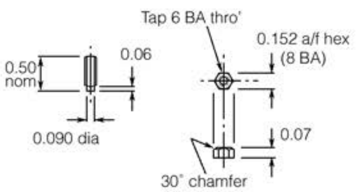
## Spherical turning attachment - gib strip, ball handle and Tee strips

Drawn to suit the Myford Super 7 lathe

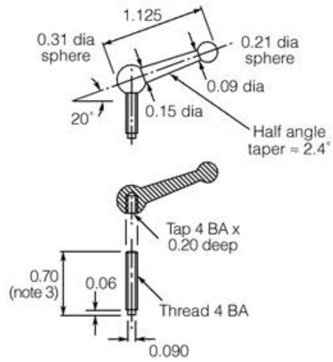
### Gib strip
1 off mild steel



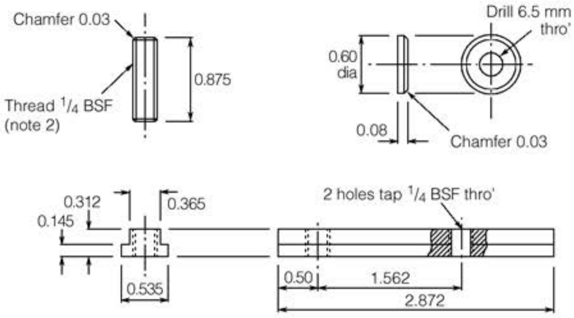

### Gib strip adjusting screws and nuts
2 off from 6 BA x $^{1}/_{2}$ hex skt set screw
2 off from 8 BA steel nut




### Ball handle
1 off mild steel assembly




### Tee strips
Tee strips: 2 off. Studs: 4 off. Washers: 4 off. Material: steel




NOTES
1. Machine to length in-situ after fitting sliding block to head body.
2. With one end a few thou short of the lower side of the Tee strip, secure each stud to the Tee strips with high strength anaerobic adhesive.
3. On final assembly, ajust length to ensure handle does not interfere with operation of the spherical turning attachment in use. Once satisfied, secure 4 BA stud into ball handle with high strength anaerobic adhesive. (If a temporary slide block locking screw is used, making this ball handle can be the first job using the attachment.)
4. Standard parts: 2 off 6 BA x $^{1}/_{2}$ hex skt set screws
   2 off 8 BA steel nuts (or 2 off 8 BA thin nuts)
   4 off $^{1}/_{4}$ BSF thin nuts (0.130 height)



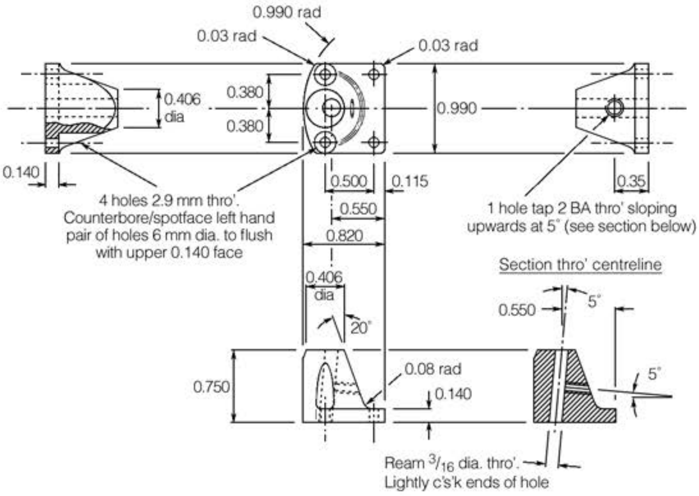
Third angle projection. All dimensions in inches unless stated. GEG 12/21(8)

# Spherical turning attachment - tool post

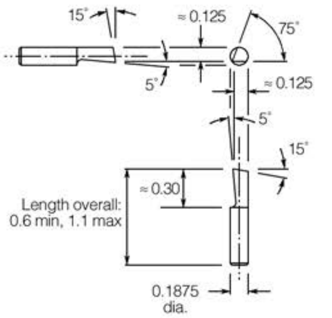
Drawn to suit the Myford Super 7 lathe

## Tool post
1 off mild steel

Drawn to take 3/16 dia HSS toolbit




## Tool bit
1 off High Speed Steel (HSS) (note 1)




NOTES

1. The tool bit may also be ground from a broken BS2 centre drill.
2. Unlike a conventional lathe tool, the tool bit primarily cuts on the end and not the side. Adjustment of the lathe cross slide in order to use the side cutting edge of the tool bit may be beneficial in getting a smooth finish to the sphere (ball) for the final few skim cuts (last few thou), though it will be at the expense of a slight lack of sphericity where the ball joins the tapered handle.
3. A tool tip radius is not recommended, and a smooth finish is better assured by side cutting during finishing (note 2).
4. Standard parts: 1 off 2 BA x 1/4 hex skt set screw
   4 off 6 BA x 5/16 hex skt cap screws.



Third angle projection. All dimensions in inches unless stated. GEG 12/21(9)