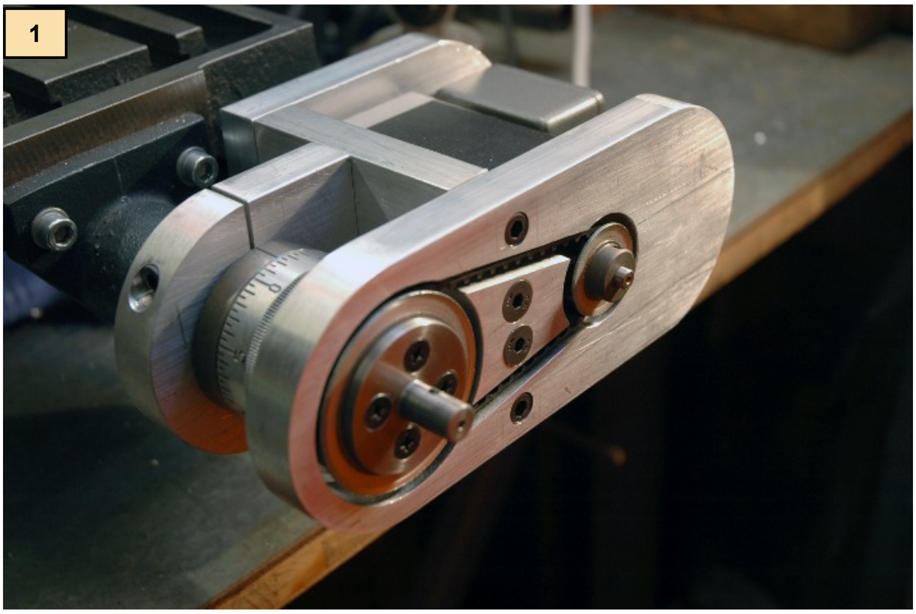
More Power at Your Elbow

David Haythornthwaite explores the possibilities of fitting a powered table feed to the popular Wabeco milling machine.



Background

About 3 years ago I purchased a Wabeco vertical mill model 1210 which I find to be superb. My experience is that the machine is well built and gives a good finish on milled items. However I have always been aware that a powered traverse to the milling machine table would improve the finish that is obtainable.

At the time of purchase, there was (and still is) a CNC version of the machine available, but I felt that for my type of work, I could not justify the extra cost of this. I enquired about the cost of obtaining a power feed for X direction only, but felt that I couldn't do without the arm and a leg that they were asking for!

I recently set about designing and making a powered feed for the X direction using a stepper motor and controller available from Arc Euro Trade (usual disclaimer).

Design Considerations

The first consideration taken into account was that any motor drive should not extend above the level of the top of the milling table so that long materials could still be bolted directly to the table without interfering with the motor drive. I have the long-table version of the Wabeco, model 1210, and it did not matter to me if the motor drive extended below the end of the table as I never screw the table so far to the left as to cause the motor to impact with the base of the machine. I did however design the drive so that it can be rotated about the leadscrew and used in any position, as I believe is the case with the factory supplied drive. To the left of the graduated dial is a machined recess 30mm Dia. and 15mm wide to which Wabeco attach their motor drives and I decided that my fixture would clamp to and swivel about this point.

I wished to retain both the original indexed collar and the hand wheel, but to fit a belt drive to the leadscrew meant that the end of the leadscrew would be 30mm too short and would need extending. I decided not to fit a clutch to the motor drive as this would add complication and require a further extension to the leadscrew. However as stepper motors are "locked" in their stopped position, it is necessary to have a switch to provide power to the "free" terminal on the controller which allows the motor to be turned by hand. You should be aware that this is not entirely free running, but in practice I have found the extra drag to be perfectly acceptable. I did not wish to make drastic changes to the actual Wabeco machine, so in order to extend the leadscrew, I arranged to fix the drive pulley onto the 10mm section of the leadscrew where the manual handle was originally fixed, and to fix a flanged 10mm extension shaft (Part E.) to the side of the drive pulley using four countersunk setscrews. The existing handle is then be fitted to this extension piece.

First Purchases

Stepper Motor AC570764525M from Arc Euro Trade (Usual disclaimer)

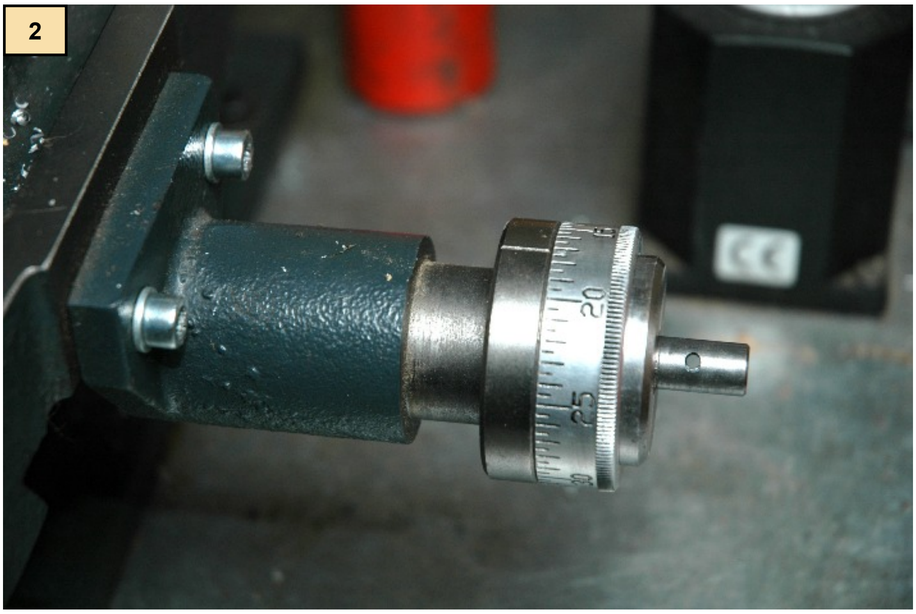
Bi Polar Stepper Motor Controller from Arc Euro Trade (Usual disclaimer)

Leadscrew Pulley	30XL 037
Motor Pulley	15XL 037
Belt	110XL 037

from local Bearing Factors shop.

Construction

The first task is to remove the handwheel from the Wabeco leadscrew by gently tapping out the 3mm roll pin fixing it to the shaft. If it is tight, support the leadscrew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to eliminate any tendency to bend the end of the leadscrew shaft. Once the handwheel is removed, it is possible (but not advisable) to slide the graduated collar from the leadscrew. I recommend that you leave it in situ, but if you really must remove it then remove it enclosed in a polythene bag. The graduated collar is friction held onto a central bush by a 4mm ball bearing which bears on a groove on the inside of the graduated collar. The ball bearing is situated in a 4mm hole in the central bush and is spring loaded. When you slide the collar from the bush, the ball bearing and spring are expelled at great speed. If anyone wishes to have a spare, they are welcome to search the far corners of my workshop where lie the original parts!! Not one of my best tricks !! Even with help from the management section of the household I couldn't locate them. The collar and shaft are illustrated in **Photo.2.**

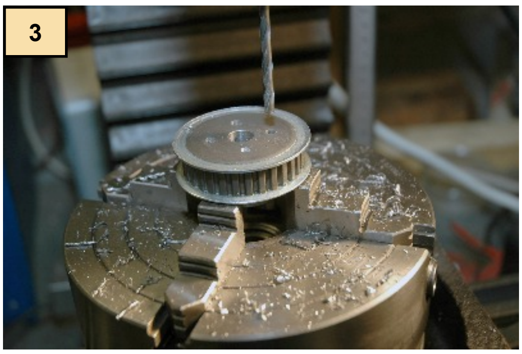
The leadscrew pulley is a toothed belt pulley bearing the code 30XL037 and this, together with the motor pulley 15XL 037 provides a 2:1 step down ratio between motor and leadscrew. Of course a small v-belt would also be suitable, but I kept to a toothed belt with a recognisable reduction ratio in case I ever decided to go down the full CNC route. Fitting the belt to the pulleys resulted in a linear distance of 80.5 mm between shaft centres and this decided the layout dimensions. I did not allow for any belt adjustment but decided to fit this retrospectively only if necessary. This would take the form of a tensioning ball race running on the outside of the belt. Having used the device with no re-tensioning arrangement, it does not seem to be necessary.

Pulleys

Both pulleys as supplied had a 6mm bore and had two grub screws at 90^0 to fix them to the shaft. Luckily the smaller pulley fitted the 6mm shaft on the stepper motor and so needed no adjustment. However the larger pulley needed boring out to fit the 10mm section on the end of the leadscrew.

The 30 tooth pulley was mounted in the 4 jaw chuck on the lathe and set to run true by the centre hole using a verdict. The centre hole was then drilled to 9.5mm and finally bored out to 10.1mm. The material was fairly hard but machined well. I held the pulley by the fixing flange **(as in Photos 3 & 4)** rather than risk damage to the aluminium belt flanges. You will remember to remove the grub screws before drilling and boring won't you?

Transfer the 4 jaw chuck, complete with pulley to the dividing head or rotary table, if you have one, and set up on the Wabeco table. Centre the hole under the spindle and then move the milling table 12mm in X direction to offset the pulley. Centre drill, and then drill, 4 indexed holes in the face of the pulley at this setting, 4.2mm dia and 15mm deep. This will give you 4 holes at 24mm pitch circle for fixing the leadscrew extender (Part E) to the pulley. Exchange the milling machine drill chuck for a lathe centre and use this to guide a 5mm tap in the holes at the same settings. **Photos 3 & 4** show the operation. Pay attention to the position of the grub screws when carrying out this operation. You should drill the new fixing holes so that they do not interfere with the existing grub screw holes. If you don't need your milling machine, leave the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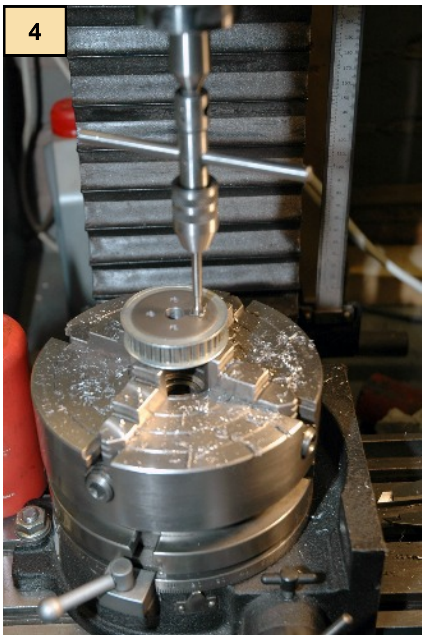
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Rotary Table in situ at 12mm offset.

Leadscrew Extension

The leadscrew extension (Part E) was made from a piece of 41 mm ($1^5/_8$") dia. Free cutting mild steel. A length of 45 mm was sewn off on the bandsaw and chucked in the 3 jaw S.C. chuck using outside jaws. I have a 4" S.C chuck and I feel that this diameter is too big for the normal jaws as several teeth would not be in contact with the scroll, thus putting too much strain on the remaining teeth. I closed the jaws, and being a self taught machinist with lots of bad (but safe) habits, I slightly slackened the grip of the chuck jaws and ran the back of a lathe tool against the side of the extended end whilst running the lathe very slowly (by hand) until the piece ran true on the outside end. Then I tightened the jaws fully. Purists may frown, but it does work extremely well to true up a length of bar on which the chuck end is not guaranteed to be EXACTLY at right angles.

Centre and face the end and bring up the tailstock. Take a light skim over the outside of the bar to tidy up the outside diameter to 40mm, taking this as far as the chuck jaws will allow. Then turn the end of the piece down to 10mm dia. For a length of 19mm. Use the Wabeco handle as a guide to your final fit. Whilst still in the chuck, transfer it to the milling machine face up on the Rotary Table which in my case I had left in situ on the Milling table offset at 12mm after tapping the pulley. Centre drill, Drill 5mm, and countersink the 4 holes for the 5mm countersunk grub screws. **Photo 5**. illustrates that a fairly small countersink is called for. Mine was ½" dia. and worked just fine.

While you have the piece in the chuck and on the Rotary Table it is a good time to drill the 3mm cross hole for the 3mm roll pin which attaches the handle. The centre of the cross hole should be 6.5mm from the face of the flange. We all have our own way of doing these things, but I set the Rotary Table vertical and used an edge finder (wiggler) to locate the position of the flange face and to find the centre of the shaft as shown in **Photo.6**. If you locate the flange face this way, do not forget to move your table by half of the width of the edge finder (.050" in my case) before setting your dials or zeroing the DRO. Then move 6.5mm along the shaft, centre drill and ream or drill 3mm. **Photos 6 & 7** illustrate this.

Some time ago I fitted a BW Electronics DRO shared between my Myford Lathe and the Wabeco mill. Using a DRO transforms the way you can work and almost does away with marking out altogether. It certainly helped with locating the 3mm cross hole.

Still in the chuck, return part E to the lathe and part off. You need to part off at a position which will give a flange thickness of 3mm plus a spigot length of 5mm after cleaning up. Then reverse the item in the lathe either centering accurately in the 4 jaw or as I did fitting the 10mm section into a collet chuck ready for turning the spigot and facing the other side of the flange, as in **Photo 8.** The spigot needs to be concentric with the shaft extension on the other side of the flange. The leadscrew does not quite reach through to the end of the pulley and the spigot locates in the recess thus formed in the pulley at the end of the shaft.

Having taken trouble to get my cross hole truly radial, I found that the cross hole in the handwheel supplied with the Wabeco would not line up and it was way off centre. Not what we expect from the well made Wabeco! I decided to

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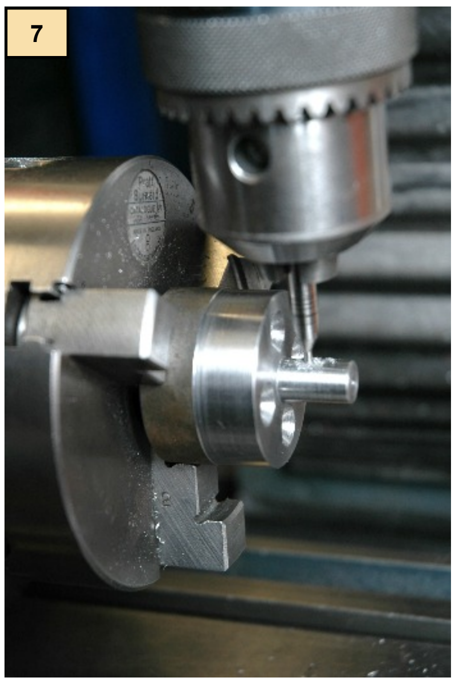

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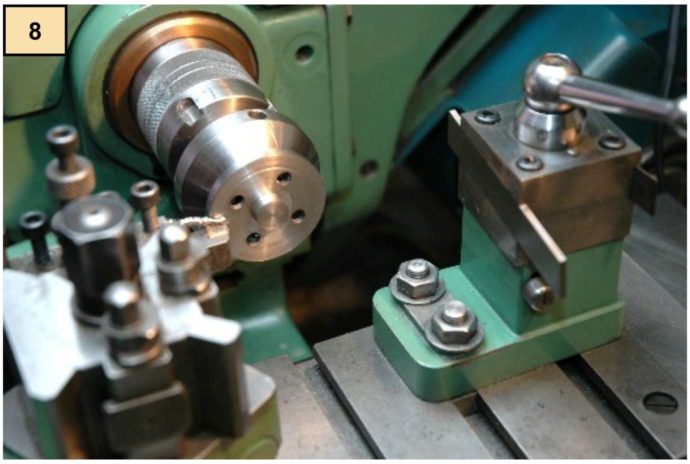


cross drill the handwheel accurately at 90º to the original but couldn't drill right through without a long series 3mm drill which wasn't available. I therefore drilled half through with a 3.3mm drill and tapped it for a 4mm grubscrew to bear on my "perfectly aligned" cross hole. A friend of mine used to say that all quick simple jobs are actually slow complicated jobs in disguise. How true.

Stepper Motor

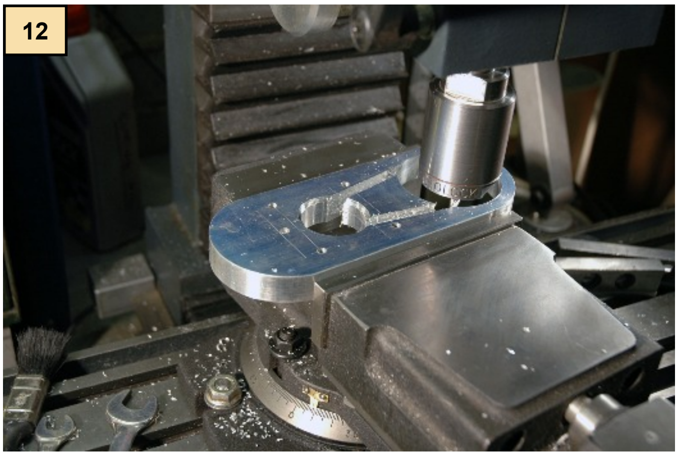
Having refitted the handwheel, we now proceed to motorise the shaft. I actually made the power supply, pulse generator (oscillator) and wired the controller first so that I had a control system to try the motor as I progressed. I used a 555 chip for the pulse generator and would have published the details except that Issue no 110 arrived as I typed this and I see that Peter Rawlinson describes an almost identical control system in his tailstock power system. Unless the editor demands it, I see no reason to duplicate this information. I would however reiterate Peter's warning about the maximum voltage not going over 40v. My original power supply also had an off load voltage of 44v and I therefore played safe and used an alternative transformer of 26v a.c. which I remember gave me a finished maximum off load d.c. voltage of around 34v. Well within the specification of the controller.

As stated previously, the motor comes with a 6mm shaft, front and back and this fitted the motor pulley which I purchased. However I did not wish to retain the rear drive shaft and so I shortened this (more later). Electrically, the motor has 8 wires coming from it and can be wired in several configurations. However, as supplied it has no terminal box and this must be addressed to ensure that no cutting fluid or swarf enters the motor. I purchased a small cast aluminium box from Maplin which is 48mm sq. and 30mm deep. I drilled a hole in the bottom, clearance size for the grommet on the cable outlet from the motor, and fitted a cable exit sheath on the side of the box. At this stage you should consider in which direction you wish the cable to exit from the terminal box. Mine goes in a downward direction. I then superglued the box to the motor case, not wishing to drill the motor casing. I would suggest that Araldite would probably be stronger and would carry less risk of adhesive entering the motor.

The motor must be configured as series wound. On my motor, this meant that the purple and brown wires should be connected together, as should the yellow and blue wires. This then gives you two coil circuits across the white & green wires and the red & black wires respectively. The information leaflet supplied by Arco gives details. The two circuits should be soldered to a 4 core flex leading out of the cable exit sheath. All connections should be insulated with tape – or preferably with shrink wrap sleeving and the wires carefully coiled inside the terminal box for closure. I did not shorten my motor wires – you never know when you may need the length. My motor does not seem to interfere with television or radio and the 4 core flex is unscreened. However if you wish to remain in harmony with the neighbours and "the boss indoors" then screened cable is to be advised. This cable is carrying considerable current which is being chopped into a square waveform at varying frequency depending upon the set motor speed. It is likely to give off radio frequency interference. I simply did not have any screened lead to hand. **Photo 10** shows the finished motor, but please note that the pulley is fitted to the shaft incorrectly in the photo. In reality the pulley is fitted with the flange against the motor and the fixing boss towards the shaft end.

Motor Mount and Guard

The main motor mount and guard chassis is constructed from rectan-



gular aluminium bar and as drawn it uses 80mm x 15mm bar. This would clamp nicely into the 30mm diameter clamping slot in the Wabeco leadscrew housing which is 15mm wide. Unfortunately the nearest that I could find was 3" x ¾" so I purchased a length of 20" (or 500mm) from Mallard Metals (www.mallardmetals.co.uk) to make the 4 main pieces A,B,C & D. Sorry for the mixture of metric and imperial measures but imperial was all I could obtain. I shall try to describe construction from 80mm x 15mm even though I adjusted mine for the imperial bar.
A clamping piece (A) clamps onto the machined clamping recess on the leadscrew housing and onto the end of this clamping piece is fixed another aluminium bar (D) which lies parallel to and behind the leadscrew. On the outer end (right hand end) of piece D is fixed a 192mm long aluminium bar rounded off at both ends (C) which supports the motor and encloses both pulleys and drive belt. Thus this piece acts as motor support and is an integral part of the guarding arrangement. On the left end of part D is fastened a shaped aluminium bar (B) which is situated behind the motor (to the left) and acts to support the rear of the motor chip guard. I decided to fully enclose the motor in this way as stepper motor casings are magnetic and therefore attract steel swarf. I dislike holding aluminium together by tapped setscrews, but I used ¼" Whitworth for those setscrews holding the frame together as the coarse thread of Whitworth is better in Aluminium than the finer metric threads.

Marking Out and Machining Part C

Out of the 4 Aluminium bar parts I made part "C" first as I like to do the difficult bits first and once this is made and the motor mounted on it, you can prove that the dimensions in the drawing are suitable for your machine, pulleys and belt. Start by sawing off 192 mm from the aluminium bar and milling one end truly square as a reference end. Mark out a centre line down the length 40mm from the edge – or 38.1mm if you are using 3" wide bar. Then mark points 40mm 120.5mm and 151mm from the reference end for the leadscrew centre, the motor shaft centre and the centre of the rear curve respectively. Whilst doing this you may also mark out for the four 5mm fixing holes for attaching the motor, 97 & 144mm from end, (later to be blind drilled 4.2mm and tapped 5mm x 0.8). The specification sheet from Arc Euro Trade shows these holes to be spaced at 47.14mm centres which must make sense to some designer somewhere! but I drilled them at 47mm centres with no problems. I also drew the curved ends with dividers (40mm radius for 80mm bar or 38.1mm for 3" bar) and marked out r17.5mm and r30mm circles for the two pulley cut-outs. You may also mark out the position of the two holes for fixing to part D. These are at points 84mm from the end, but I waited until parts C,A&D were completed before drilling in order to prove the layout dimensions. Remember that the marking out side is the INSIDE side of the finished piece and therefore DO NOT countersink these fixing holes, which are countersunk on the OUTSIDE edge. Finally mark out the two lines shown at 9° to horizontal from pulley to pulley representing the outside of the belt. Note that these are not tangential to the pulley cut-outs as the belt runs at a smaller diameter than the pulley flanges. If you are using 3" bar and put the setscrew holes 10mm from the edge BEWARE. The countersink holes are very close to these 9° lines and the motor fixing screws are also very close. Careful marking out and checking pays off.
The method for forming the end curve depends upon your equipment, but I proceeded as follows :-
Make, or find an existing, mandrel to fit into the centre of your rotary table. I have a box of these so I selected a $^{3}/_{16}$" mandrel. Drill through part C at the point 40mm from the reference edge at the diameter of your mandrel ($^{3}/_{16}$") for centering on the rotary table and drill partially through from the inside at the 151mm mark for the

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hole with a boring head bringing it up to 60mm diameter. This I found to be about the limit for the Wabeco spindle but it coped quite well using light cuts. Move the table 85 mm left in the x axis and cut the 35mm

centre point of the rear curve. You could drill right through if you wish but it would leave you with a hole of no apparent use on the outside of the finished product.
Insert you mandrel into your rotary table and mount the bar for part C on the table with one of the centre holes (those at 40mm or 151mm) located onto the mandrel spigot. i.e. at the centre of the table. Pack the aluminium bar up from the rotary table surface by clamping onto some $^1/_8$" strips or by clamping onto some MDF. Pack so that the bar can be rotated through the full 180° without the packing or clamps interfering with the cutter path. A 6" table is perfectly capable of this. Round off the end of the bar by rotating the bar against a $^5/_8$" endmill set for the full depth of the bar and taking shallow cuts making sure that you rotate the rotary table in the direction that does not cause "climb milling" i.e. cutter resisting the rotation of the rotary table. Gradually move the rotary table nearer to the cutter until a 180° rotation of the table results in a smooth arc from one side of the bar to the opposite side as shown in **Photos 11-13**. Once both ends have been rounded off, set up part C on parallels in the machine vice with the leadscrew centre point (40mm from the end) directly under the milling head and take out the majority of the 60 mm diameter hole with a hole saw. Then finish the

hole for the motor pulley in the same way. The motor has a 38mm dia. locating ring on the fixing flange so while you have the boring head all lined up over the hole, bore a recessed circle of 38mm dia and 2mm deep making this a nice locating fit on your motor.
If you haven't already drilled and tapped your motor fixing holes (12 mm deep for 5mm setscrews) now is a good time to do this.
Now to take out the centre piece where the belt runs. Mount the part at 9° to the x direction using the swivel vice if you have one. Using a ¼" slot drill take out the first line of the belt , rotate by 18° and remove the second line as shown in Photo 12. Check your belt and pulleys on the bench but in my set-up the centre line of these cuts were tangents between a 26mm radius at the leadscrew end and a 14mm radius at the motor pulley end. If you get it right first time, then your belt will miss all the bolt holes and you will have a nice triangular centre piece to insert later as part of the belt guard. Keep this seemingly waste part for refitting later. Part C should now look like Photo 13. Attach the motor and hold the part in position over the leadscrew pulley with the belt held tight to ensure that all angles and dimensions are correct. Saw off the shaft from the rear of the motor with a hack saw (unless you wish to retain it and have it poking through part B).

Parts A, B & D

Cut parts A B & D from the stock aluminium bar, mill square and to length and mark out, ensuring that you mark right across the centreline of the clamping hole in part A as you will need this reference later to saw the part into two parts. You may wish to drill and tap the ¼" Whitworth fixing holes in the flat side of part A before shaping the curve as it helps you to hold it straight in the vice. Shape one end of parts A & B to a semicircle on the rotary table as already described for part C. At the same time, bore a 30mm hole in part A to clamp to the leadscrew housing. If you are using ¾" thick bar as I was, the fixing recess on the Wabeco is only 15mm wide and so the ¾" thick bar will not fit into it. You must therefore bore a recess round the 30mm clamping hole to allow part A to clamp successfully to the leadscrew housing. This recess is to be 40mm dia and 4.1mm deep thus reducing the effective thickness of part A at the clamping point to 15mm. The recess will be on the opposite side to the graduated collar (left).

The fixing holes through the clamping line on part A are again ¼" Whitworth. Start with a slot drill, the size of the head of the set-screw, 9.5mm, and take it gently as you enter the curved edge. Drill full depth with a tapping size drill (5.1mm although I used 5mm in aluminium) and you will open the first section out to ¼" clearance once the piece is split. Mount on parallels in the vice and slit across with a moderately fine slitting saw, as in **Photo 14**. Finally tap the holes ¼" Whitworth and fit onto the leadscrew housing.
Drill the fixing and counterbore holes in part B and drill and tap ¼" Whitworth on the ends of part D. I did not drill the holes in part D for fixing to part A until now,


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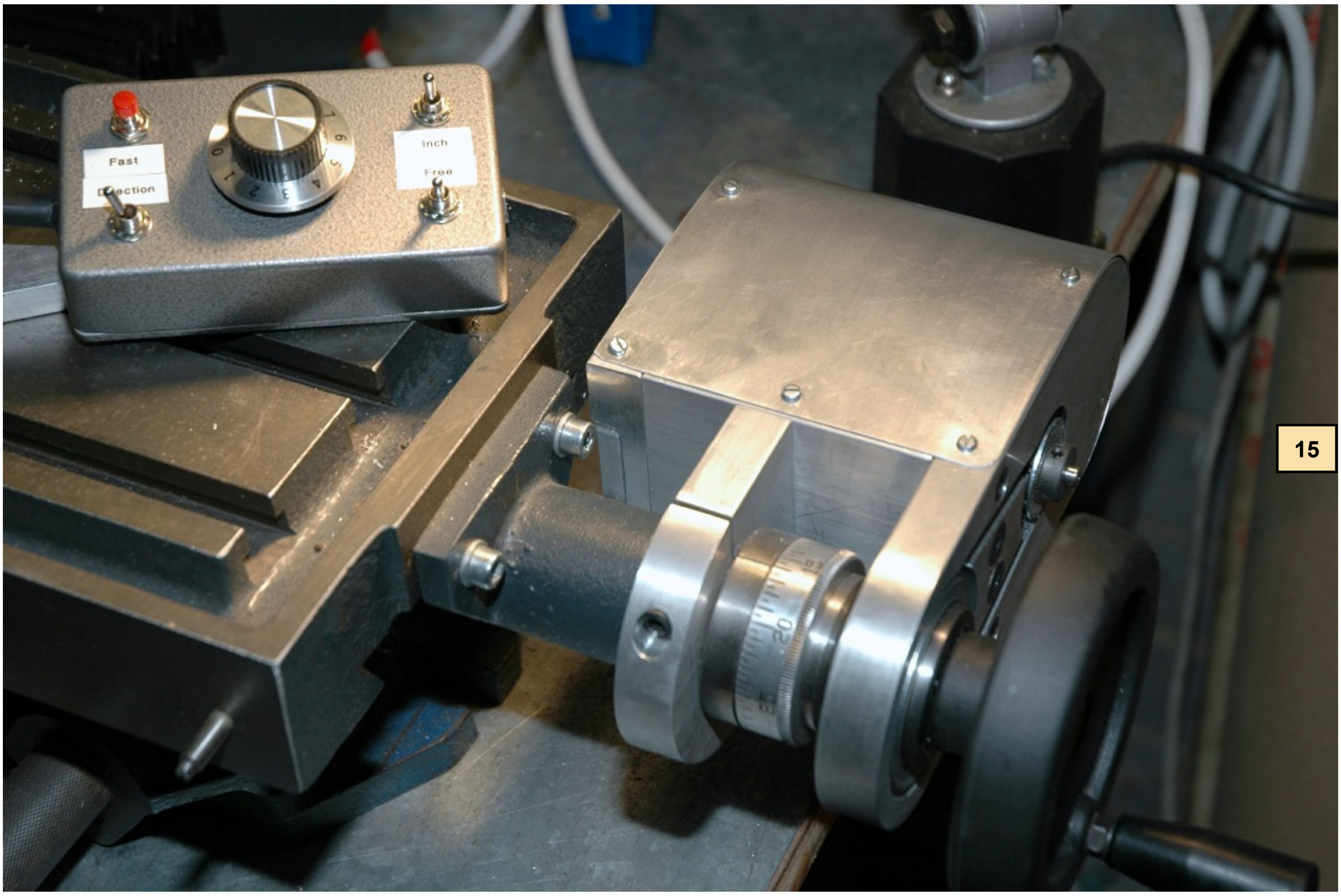
nor did I drill the holes in part C for the fixing set-screws to attach to part D. Having clamped part A to the Wabeco, I assembled the whole thing "loose" and made sure that the required position for the fixing holes and counterbores in parts D & C were actually where the drawing stated once the belt was tight and running truly in the middle of part C. In my case all was in order, so the holes were duly drilled. Please note that you cannot assemble the unit and then fit it to the machine. Part C has to be loosened from part D whilst the unit is fitted to the Wabeco. I removed the leadscrew pulley, slackened the setscrews attaching parts C&D, and jiggled the whole thing onto the leadscrew housing with the belt on the pulleys. It is fiddly but it does go . Once the unit is assembled, take the triangular centre portion which you saved when you removed it from the middle of the belt drive and fit it to the end of part D using either cheese head or, in my case, countersunk set-screws (**see photo 1**). I must admit here to being surprised to find that the whole unit would not swivel around the leadscrew housing as intended in the design. I had to mill a slight recess in the flat end of part D to allow this to clear the set-screws which attach the leadscrew housing to the milling table. This is just visible in **Photo 15**. and now allows the unit to be positioned anywhere in a 360° arc axially about the leadscrew.

Chip guard for the motor

Photo 1 was taken before the chip guard was fitted. The guard could be made from either aluminium sheet or flexible plastic Mine was made from 0.5mm aluminium sheet. I cut a rectangular shape 275mm long x 110mm wide using a hand "nibbler" type of sheet metal cutter. This does not distort the metal sheet but cuts a long thin strip out of the metal leaving both sides undistorted. This guard is either screwed or clipped to the top edge of part D, wrapped round the curved ends of parts B & C, being clipped or screwed to the bottom edge of part D. Depending on your motor wiring layout you will need to cut a slot to allow the cable to pass through. If making in aluminium, you should bear in mind that stepper motors do generate vibration when running slowly



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and I planned to slice open a length of flat, flexible, cable sheathing and to glue this round the outside edge of the sheet. This would make a neat appearance to the edge of the guard and make a flexible plastic "gasket" between the aluminium sheet and parts B,C,&D to eliminate any sympathetic vibrations. However in practice I screwed the un-edged sheet to the aluminium frame using small self tapping screws and there has been no vibration at all. The finished item is shown in **Photo.15** complete with chip guard.

I am quite happy with the finished appearance of the drive which looks professional and in keeping with the Wabeco machine.

Electronics and Control Box

As already stated the electronics are very similar to those described in issue 110, but upon using the device I found that having the speed and inch controls on the power supply / control box was very inconvenient and I therefore purchased another die cast aluminium box from Maplin (110mm x 60mm x 30mm) and used it to house the direction switch, the inch / run switch, the free / control switch, the speed potentiometer and the "fast" button. All this makes a convenient hand held control box, and I connected it to the stepper controller and pulse generator by a 9 pin D connector as used on computer serial ports, available from Maplin Electronics. This is clearly shown in **Photo 15**.

It is important to have a "free" switch as when stepper motors are under power they are locked solid when stopped and without a free switch you cannot use the manual leadscrew handle while the unit is powered up.

The electronics are shown in the next article.