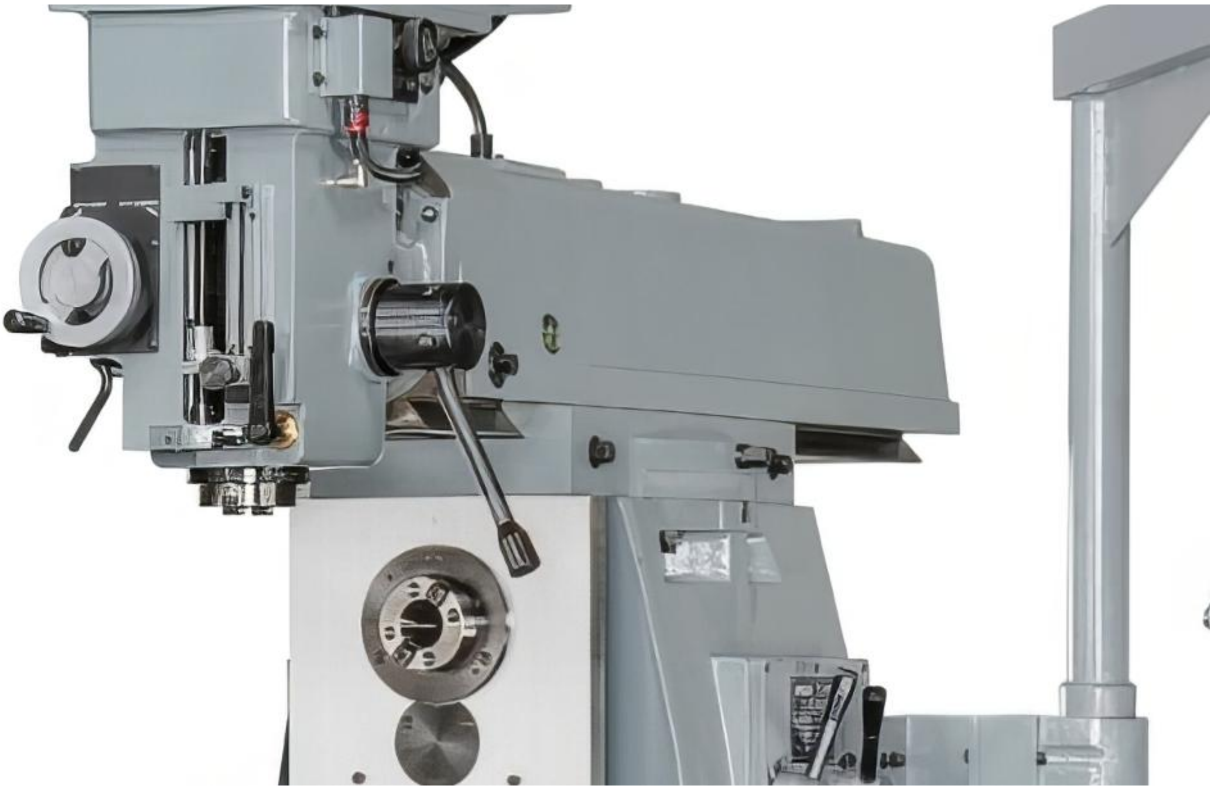
Home made horizontal milling spindle.

(c) Tony Foale Dec. 2024.

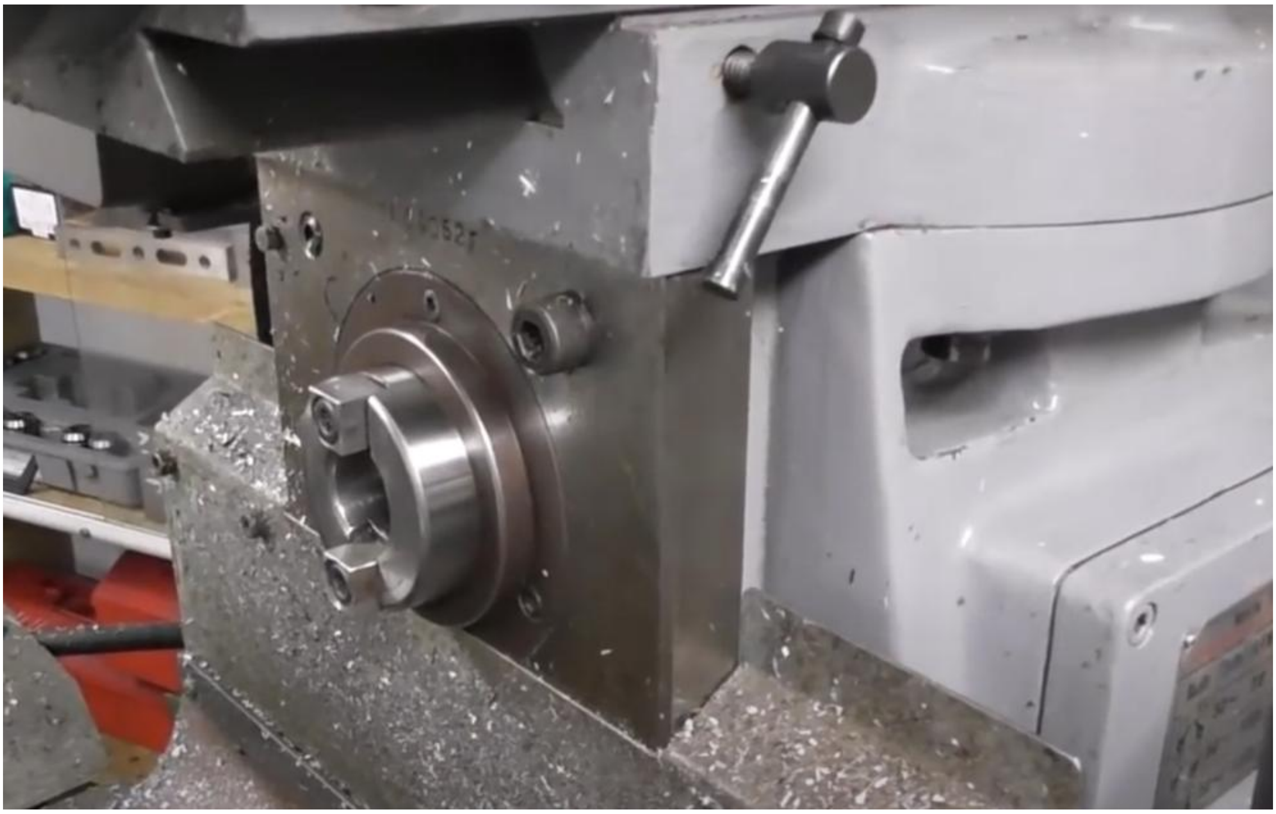
I imagine that most HMT forum readers who have a milling machine will have a vertical mill. As useful and universal as they are, there are times when a horizontal mill would be a better choice. I have a vertical Bridgeport mill and there have been times when I would have liked to have had a horizontal spindle on it. Every now and then I have thought about how best to to do a home made conversion or addition.

Of course I am not the only person to have had these thoughts and there have been universal mills produced with both vertical and horizontal spindles. I have the Bridgeport and my needs for a horizontal spindle are not sufficient to send me out looking for a new mill.

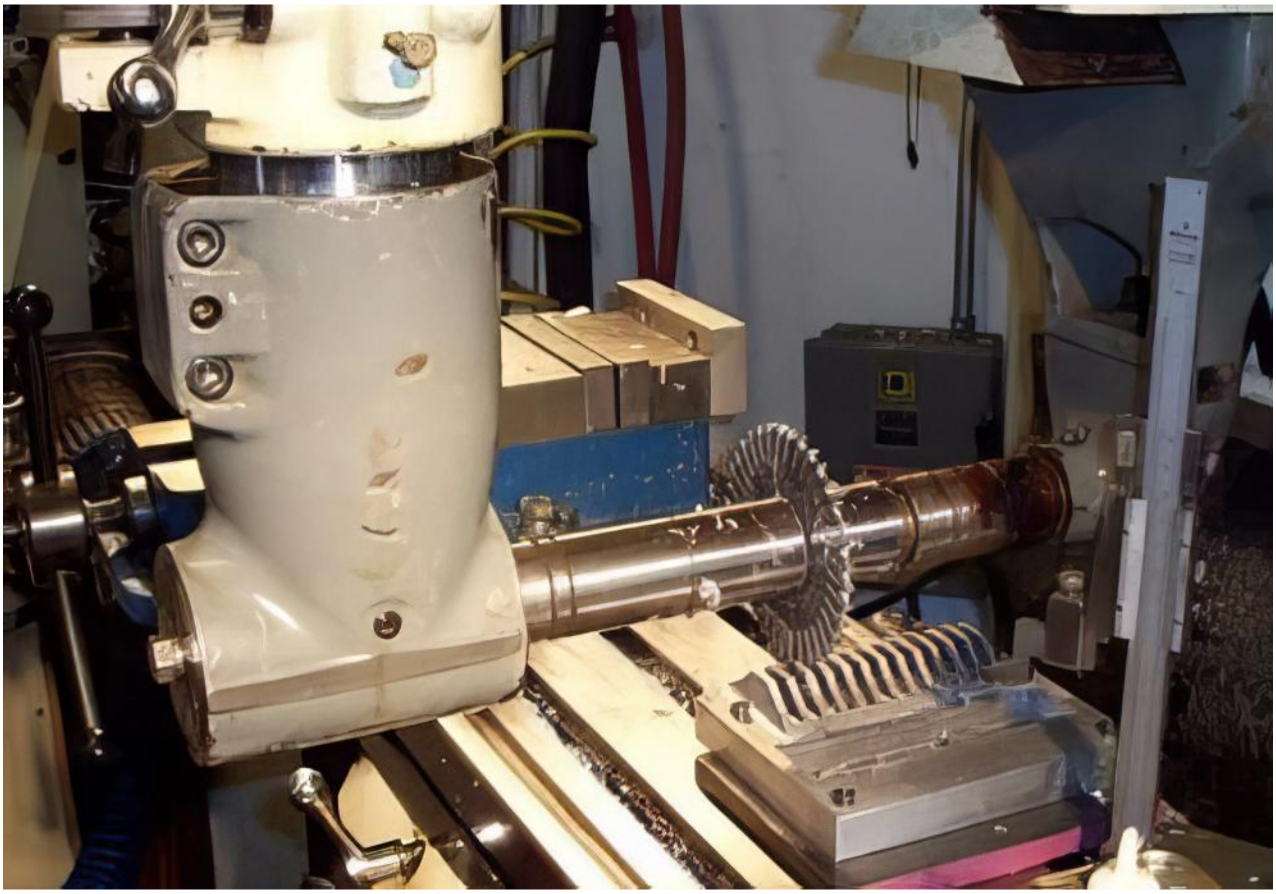


This Kent mill is an example of a Bridgeport style machine with two spindles.

My initial thoughts were to bore through the column using live tooling mounted on the mill table and fit a bearing sleeve right through. Then fit a standard Bridgeport R8 spindle with a belt drive and motor on the back side of the column. As a stiffer and more accurate mounting for the bearing sleeve I considered bolting a thick block to the column similar to that in the following photo (lifted from a video off the Threadexpress youtube channel, watch https://www.youtube.com/watch?v=ij-1Q8ayQtk for a good overview of different tool holding tapers – R8, BT30 and TTS)



An alternative approach would be to buy a used Bridgeport made, or new clone, right angle attachment like this example. These clamp to the quill and can be aligned with either the X or Y axis. As shown here they can also be used with a support as per a true horizontal machine :



I wanted to use an R8 fitting to enable the use of the R8 tooling that I have for the vertical spindle. However, the stock Bridgeport spindles are designed for a drawbar which requires access to the non-working end of the spindle. That would be awkward with the plan to use a sleeve through the column. In addition to that the non-trivial amount of work to implement such a solution always relegated the plan to the bottom of the todo list.

Recently the needs of a couple of jobs would have been better served with a horizontal spindle and implementing that changed from idle thoughts to more serious thoughts. One of which was to mount the “thing” in whatever form it took onto a plate bolted to the upper part of the slides for the knee travel. The upper section of the slides is beyond the range of knee movement that would ever be required, so there would be no loss of mill function.

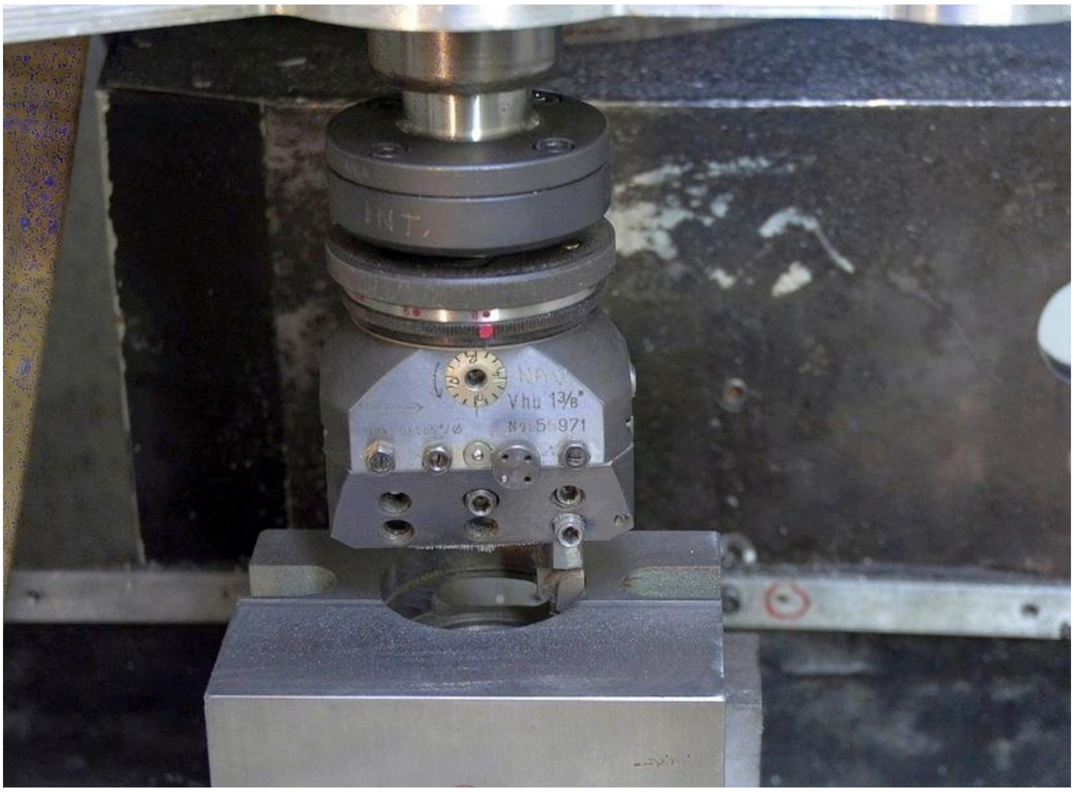
Although my first preference was for an R8 spindle I decided that ER32 collets would fulfill the majority of foreseeable requirements and the ready availability of ER32 collet holders with straight shanks in common bearing diameters made it a good choice. Although the straight shanks are available in several sizes, I wanted a rigid setup and so I went for 32 mm rather than 25 or 20 mm. I have some tooling which is mounted on ¾” shafts, such as a slitting saw arbor and small fly cutter and that diameter is within the range of standard ER32 collets, so that also also drove the decision to go for the ER32.

ER32 collet holder with 32 mm straight 150 mm long shank.

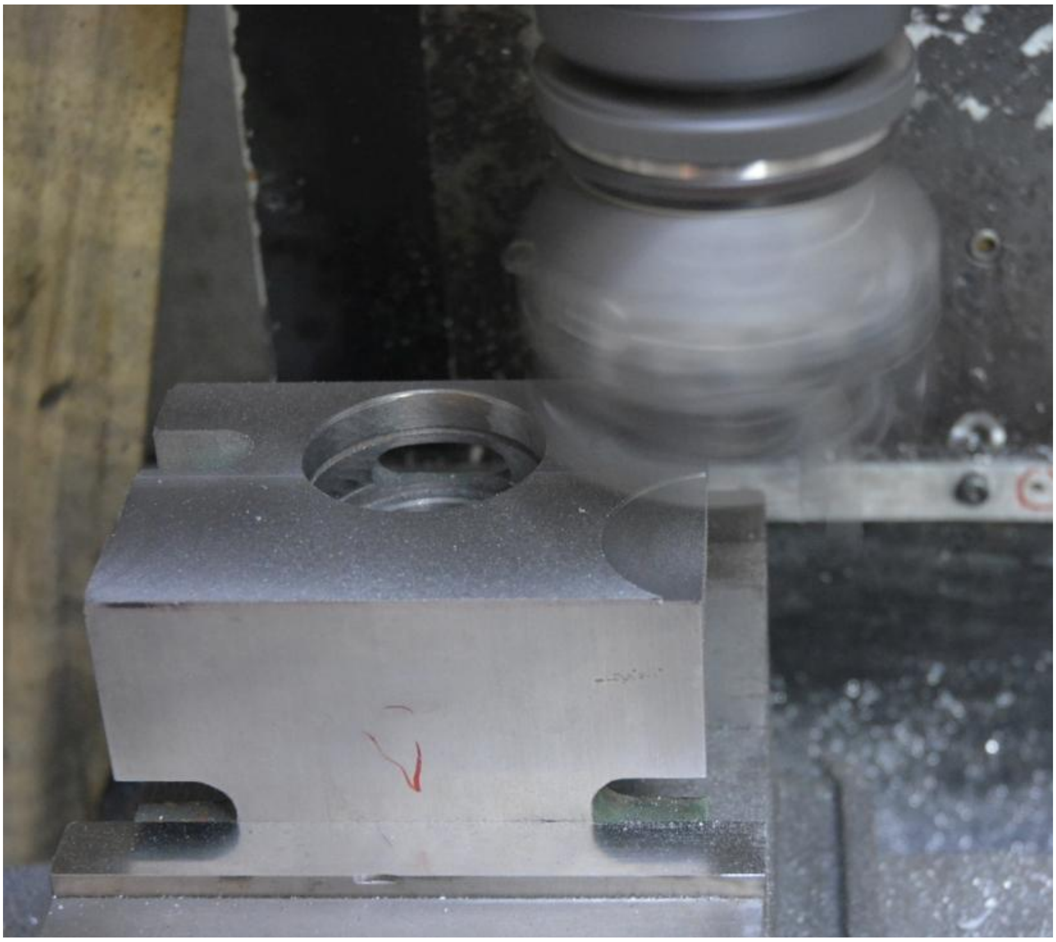
To contain this spindle I needed a bearing housing, but as I started looking in the scrap box for a suitable metal block I remembered that I had a 5C collet holder, as shown below, that I bought some years ago because I thought that it would be useful. The truth is that in all that time I never used it. Stripping it out left me with a nice solid cast iron bearing housing.

The two ends had different hole diameters. The larger was 52+ mm, just a tad too loose to use a 52 mm bearing, the other end was 44 mm which allowed boring out for a 47 mm bearing. So the 52 mm size needed boring out to take a 55 mm bearing. Both 47 and 55 mm bearing ODs are available with 32 mm IDs to suit the spindle.

Notice how the top part (top as in the photo) has been factory machined flat leaving less material around the bores, not a problem at the 44 mm end, visible in the photo, but it did not leave much spare material for boring out the 52 mm end. To avoid thinning the material any more I simply offset the centre of the bearing bores by 1.5 mm. This resulted in the lower part of the hole being cut 3 mm more into the thick material with no material being machined away at the thinner top.

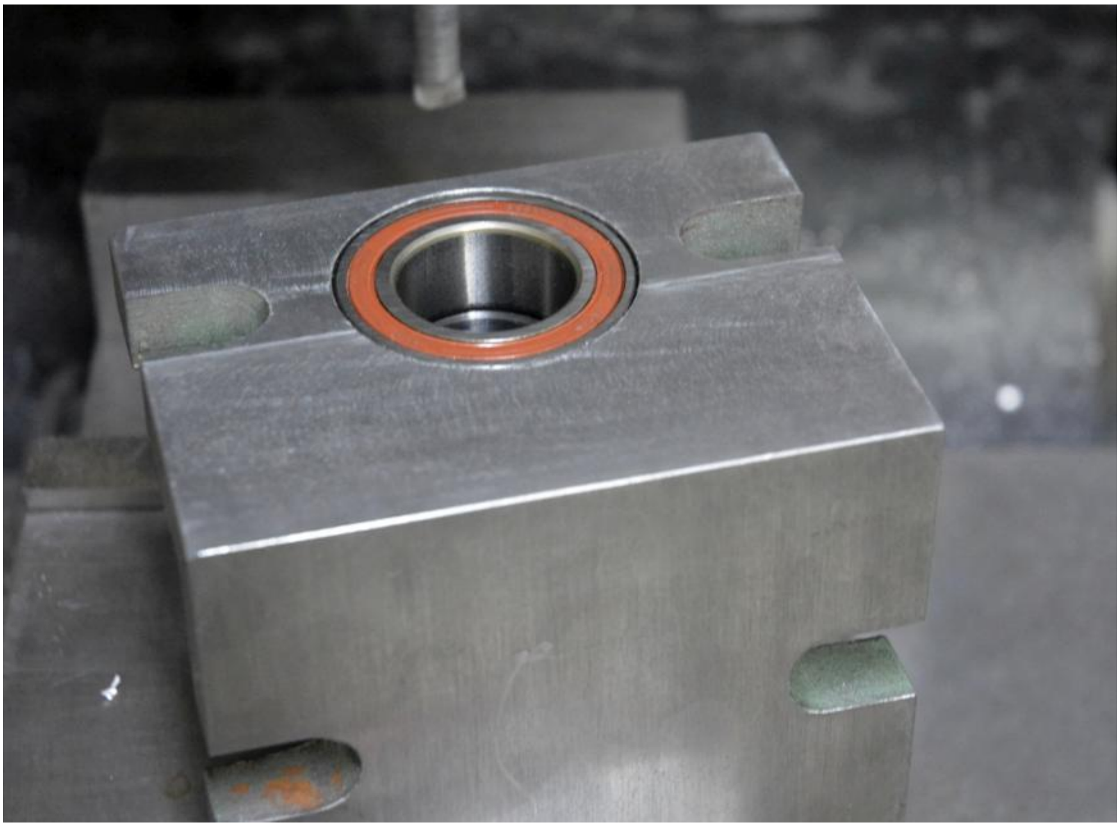


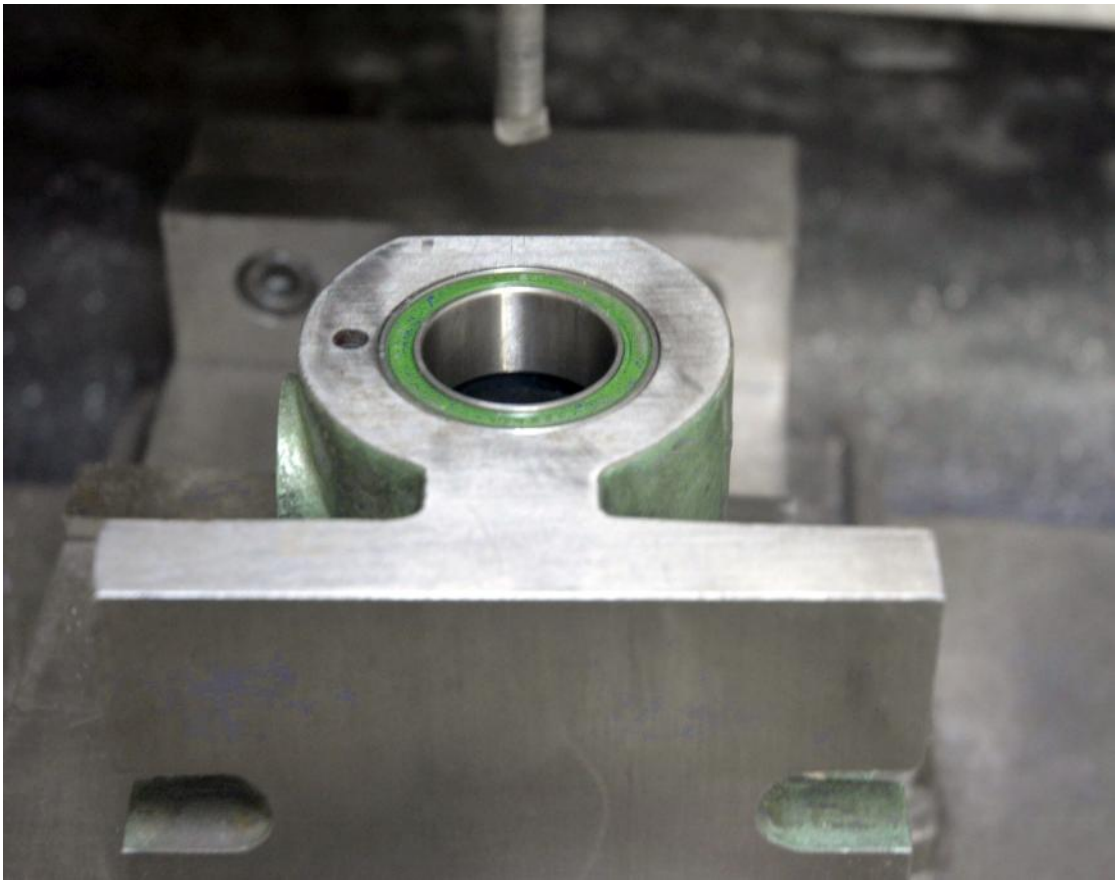
The above photo shows boring the 55 mm hole using a Narex boring head. After boring for the 55 mm bearing I faced off the surface around the hole to ensure that surface was true to the bore.
The following photo shows the Narex taking a truing cut off the surrounding surface.



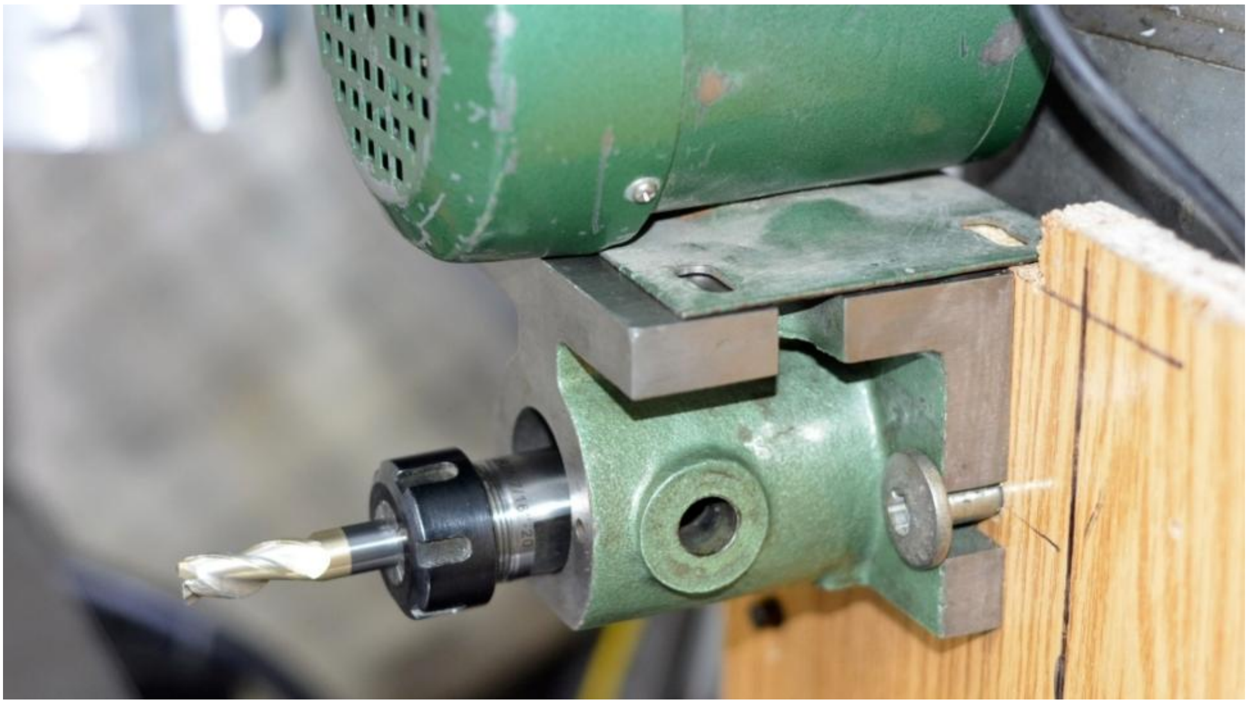
I wanted a locating step for the 44 mm bearing, which is easier to achieve by boring from the other end. So I flipped the housing over and used a long stylus with what is known as a centricator to true up on the 55 mm bore, now at the bottom. (next photo) Once true it was a simple matter to bore the 44 mm hole out to 47 mm for the bearing. I also bored through to the other end with a diameter of 44 mm (remember that the bearing bores were offset from the original) to allow clearance for a bearing spacer on the spindle.

The top photo, below, shows the 55 mm bearing installed. Note the minimal material thickness at the top of the photo. There is plenty of support for the bearing from the rest of the bore though. The lower photo shows the 47 mm bearing installed in the other end.

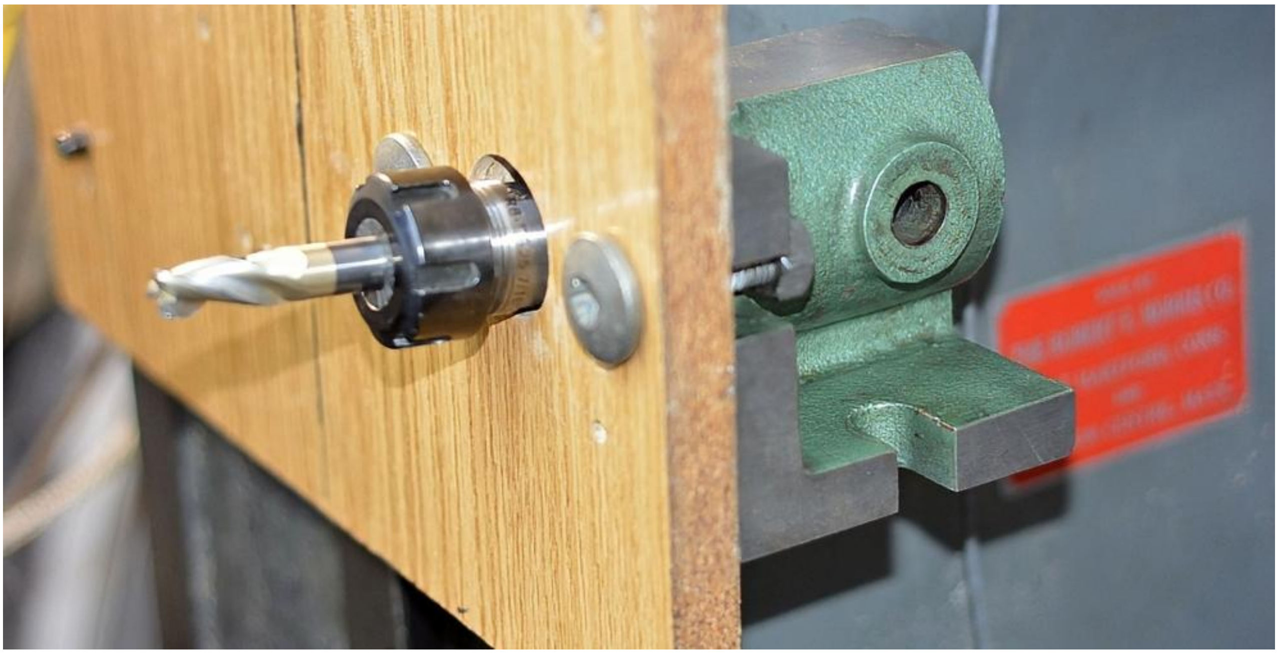




Before doing the machining described above I did a couple of quick mockups using some chip-board in place of a steel plate. The first idea was to mount it centrally on the front of the plate with the motor above driving a belt behind the plate. As shown in the next photos there is a considerable intrusion into the normal working space of the mill which would likely mean that the new spindle would need frequent removal and refitting when needed. That would be somewhat defeating the object of the exercise, which is to add utility to the mill not to result in a working inconvenience. In addition, for many tasks the vertical spindle assembly would be in the way of using the horizontal spindle. So although a centrally located spindle held an attraction there was too much against it. That meant that the spindle and its housing had to be mounted to one side, either side would do but I chose the RHS simply because I am right handed.

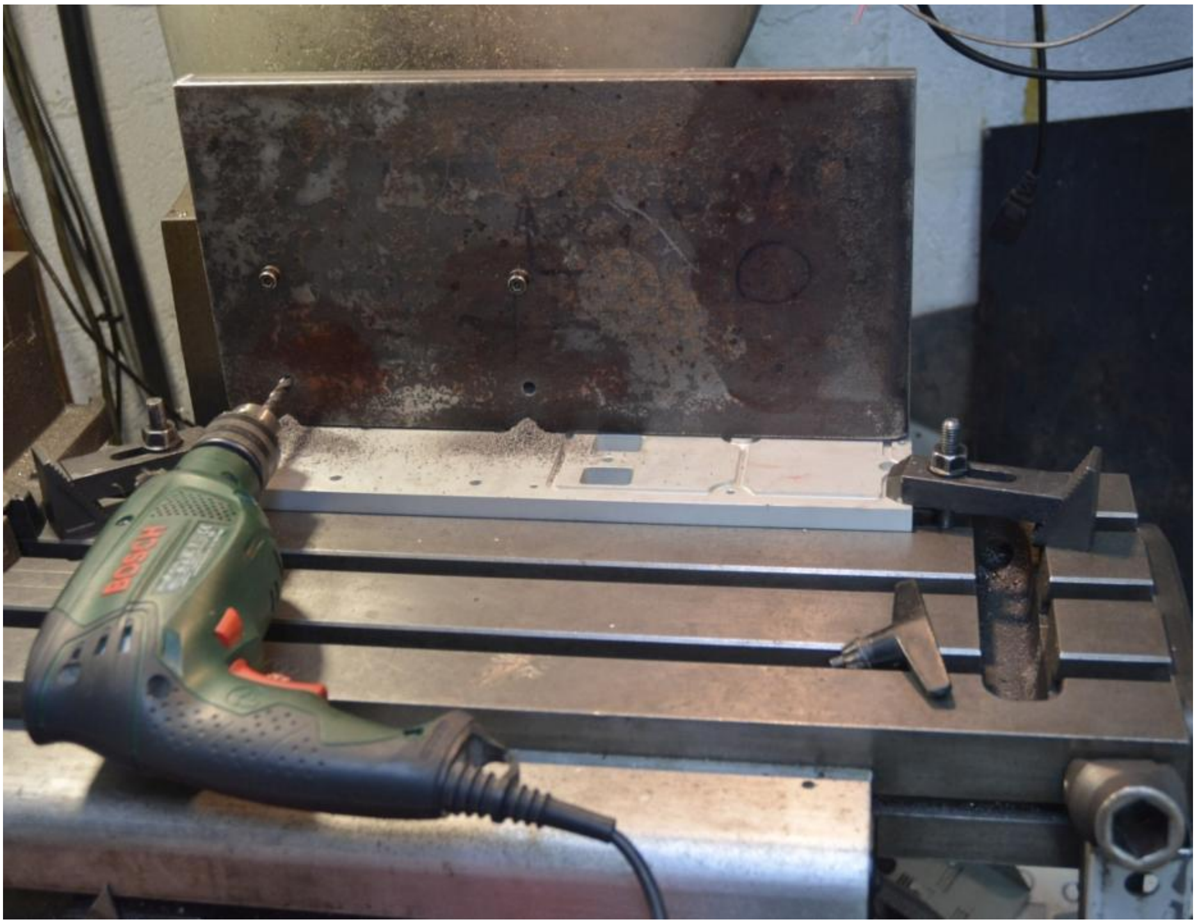


The side mounting allowed the assembly to be mounted behind the plate with only a small intrusion into the working space. The protrusion being little more than the width of the collet nut. That would only create a possible problem if the knee was at its maximum height and the Y axis was fully forward. I do not recall ever needing that combination. I would have liked to have mounted the spindle a bit higher but the shape of the column in that area would mean that higher also meant wider, so the decided position was a compromise between ideal height and lateral overhang on the plate.



The next step was to get some thick steel plate to replace the chip board. I decided that 25 mm thick would be preferable but 22 mm acceptable. I had plenty of 13 mm and I did consider sandwiching two together which would give more damping but less stiffness than a single 26 mm plate. A visit to a scrap metal yard yielded some 20 mm plate by 200 mm width. They cut a 380 mm length for me. Not quite the thickness that I was after but lifting it around the workshop from drill press to surface table to milling table was quite enough for my ancient body. So a thicker plate would not be all good. Here is the plate as I got it:

In the photo above the Aluminium plate clamped to the table is purely a support for the weight of the steel plate while I was measuring up and drilling etc. The dovetail slides on the column already had a hole drilled and tapped in each one for mounting a swarf apron. I drilled two matching holes in the plate and another two below for a better fixation. Resting a drill on the table I drilled those in the column to an 8 mm tapping size. Shown below:

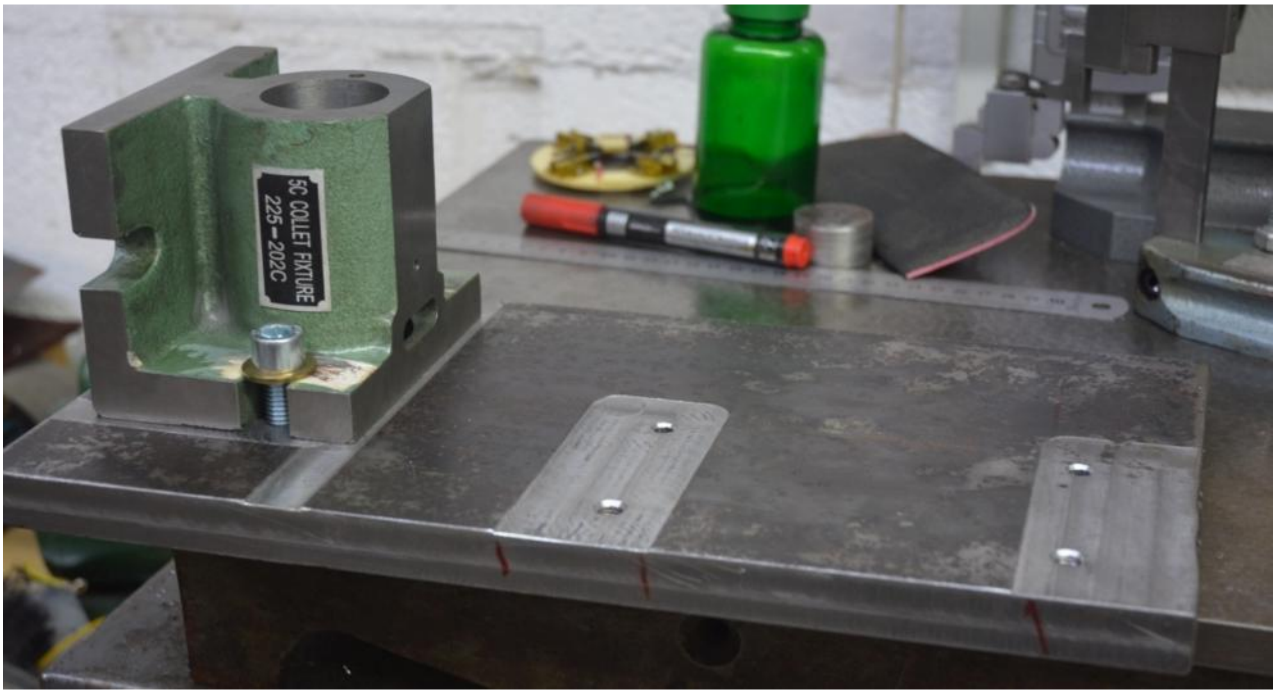


Using the holes in the plate as an alignment guide I manually tapped the lower holes. The plate was mounted on the upper 110 mm of the dovetail slides. A casual thought might indicate that I would lose the same amount of vertical travel. In practice this is not the case because with the knee at its new maximum height it is possible for a cutter to reach the table with only a small stick out of the quill. That will do me OK. Also the plate thickness might look like it will limit inward Y axis movement by 20 mm, but the table is well clear of the plate when in its most forward position.

One advantage of this way of mounting the spindle assembly on the back side of the plate is the ease of machining the plate so that the spindle is true, or very close, to the rest of the milling machine. Assuming that Bridgeport machined the flat surfaces of the column dovetails true then all I had to do was to surface the mounting areas of the plate, and the mounting area for the spindle bearing block, parallel to each other. That is an easy thing to do with a single setup on the mill table, but being careful that no bending is induced in the plate due to the clamping method.

It was not necessary to surface mill the whole of the plate and it could have an unwanted effect. Removing the mill scale layer and some steel just below the surface may relieve some inbuilt stresses from the rolling process resulting in a small amount of warping of the plate. I chose to only machine the relatively small areas where the plate contacts the mill and the spindle block, to minimise any warping problems.

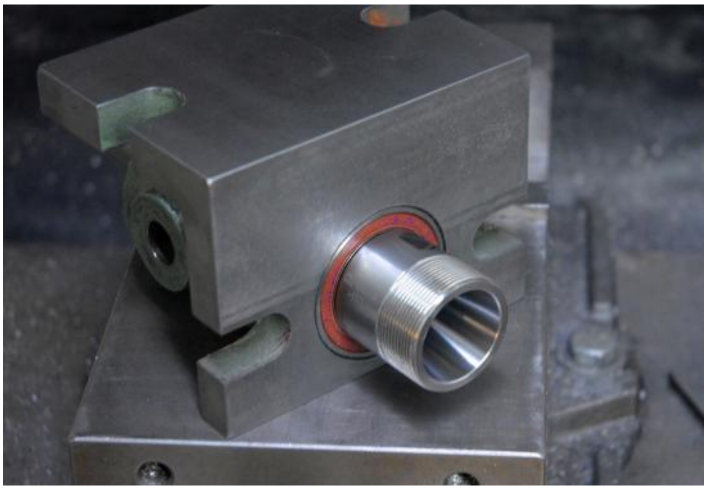
After doing the surfacing I had to make a hole for the working end of the ER32 collet holder to pass through. The hole size needed to be 40 mm plus a small amount of clearance. To start with I used a hole saw which gave a hole almost spot on 40 mm but no that had no clearance around the spindle. I finished the hole with the Narex boring head.

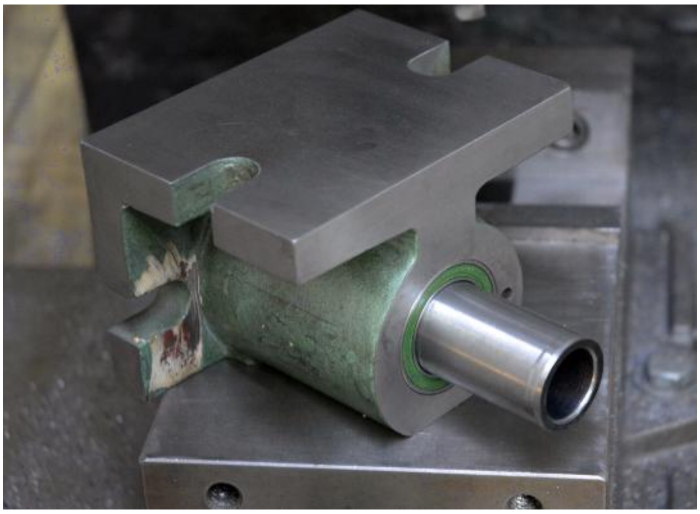


In this photo of the hole saw, and the boring head in the next photo, we can see one of the original tapped holes in the column surface near the top of the dovetail slides, as mentioned previously. These tapped holes are used to hold the plate in place.

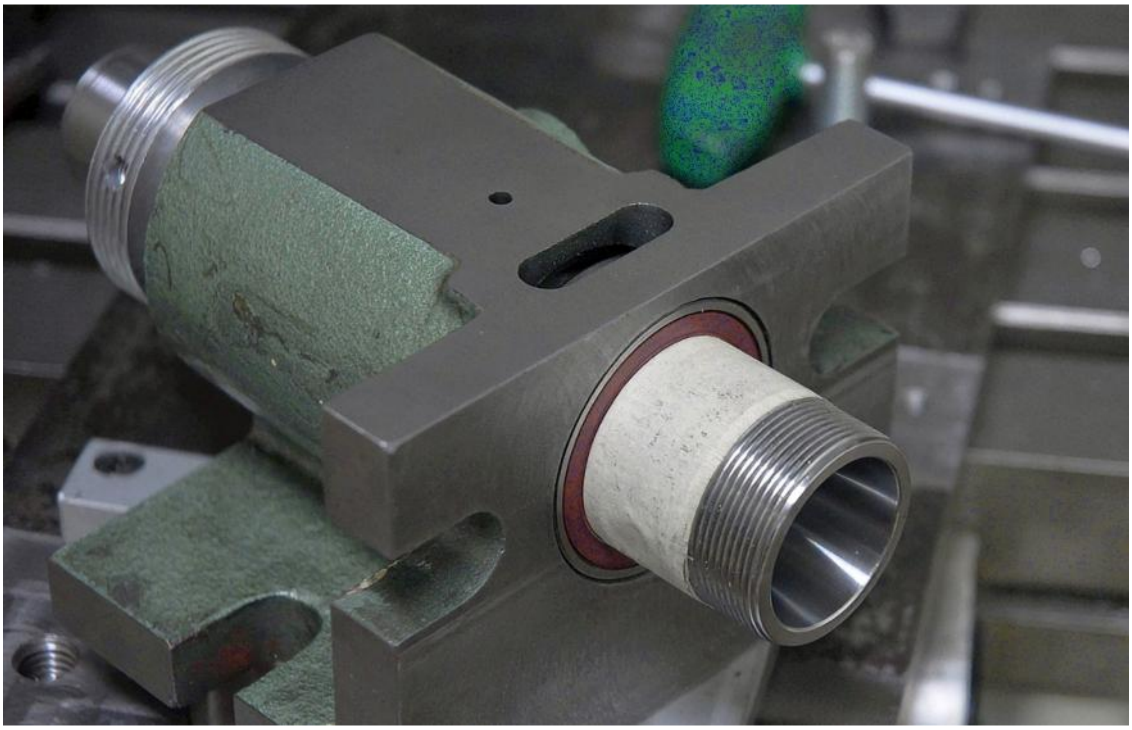
Here is the plate mounted to the mill column after being machined on the back side.

The next photos show the spindle mounted in its bearings.

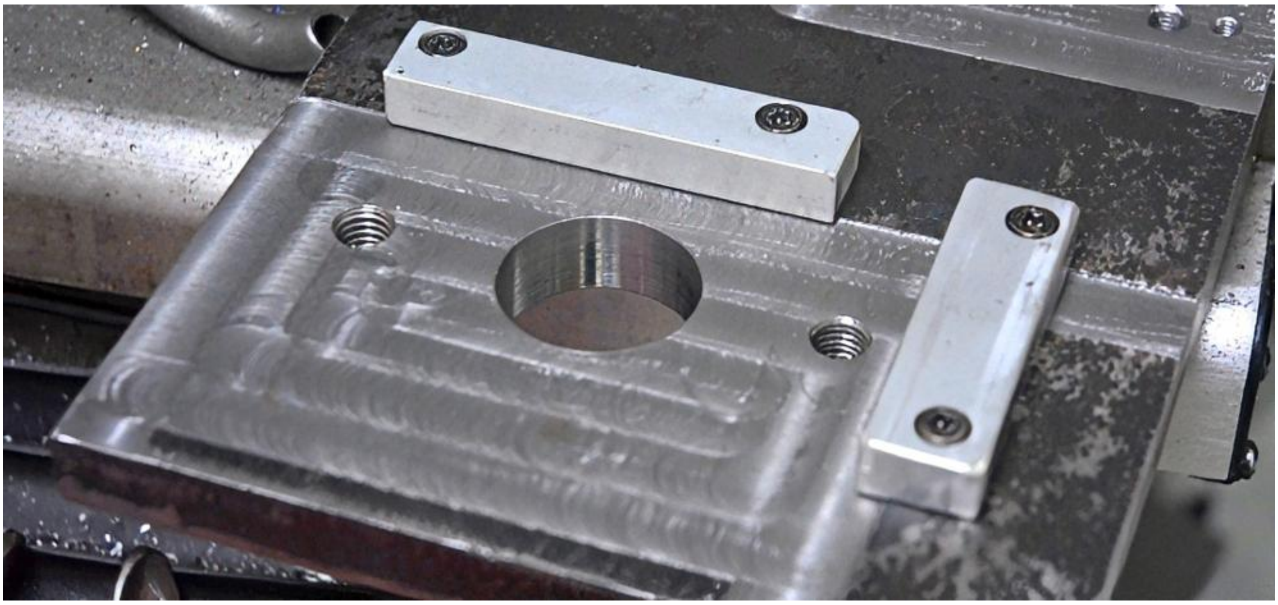




The spindle was wrapped with masking tape, as shown below, to locate it centrally in the clearance hole machined in the steel mounting plate, but only for its first alignment.



Once the spindle had been aligned in the hole and the housing bolted down tightly, it was necessary to implement a method such that the assembly could be removed and replaced easily in the same position once the tape had been removed. Dowels are often used but they add a layer of difficulty to removal and replacement. Instead of dowels I often use what I call “fences”. The following photo shows the idea. With the bearing housing aligned, the fences are clamped against their respective edges of the housing, and the plate is drilled and tapped using the pre-drilled fences as drill guides. When bolted down the fences are considered as part of the plate and should never need removal. Obviously there is no impediment to removal of the housing and on assembly it is only necessary to feed the spindle through the hole and then push the housing against both fences whilst bolting it down.



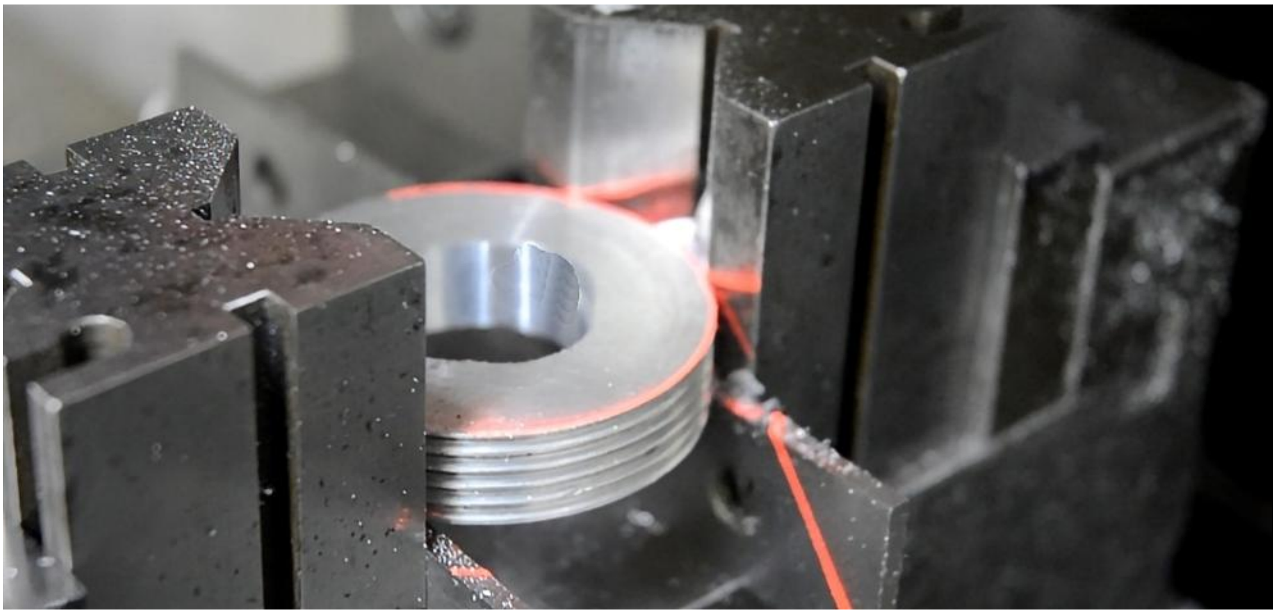
Now all that remained to do was to make the drive system. At this stage I did not know how often this spindle would be used nor how heavy the work would be that it would be used for. Only time will tell me that. So I decided to use a small single phase ½ HP induction motor that I had on a shelf. Although a 1500 rpm motor I wanted to spin the spindle at about 2000 RPM as a workable single speed to cater for different size cutters. A poly-Vee belt would connect motor and spindle so I needed two pulleys. I had one of suitable diameter for the spindle and I had to make one to fit the motor.

My lathe was setup for another job which I did not want to disturb so I decided to use the mill as a vertical lathe. A bandsawed circle was drilled and reamed for the motor shaft in a drill press and then transferred to the mill where it was held by an expanding mandrel in the mill vertical spindle. A parting blade was sharpened to a 40 degree included angle, according to the poly-Vee belt specifications. The tool in a standard parting blade holder was clamped in a vice on the table. The 5 grooves for the chosen belt were then formed by plunging the tool to the required depth, and moving along the Z axis for the next groove.

The pulley that I had for the new spindle needed a larger hole but the existing hole was damaged so I could not use that for alignment. My laser aligner seemed the ideal tool for this job. That tool was described in an earlier HMT post. Laser alignment tool.
That worked very well and later checks showed good concentricity between the hole and the belt grooves. This pulley was given a light shrink fit on the spindle. A hot air gun was used to warm the pulley.

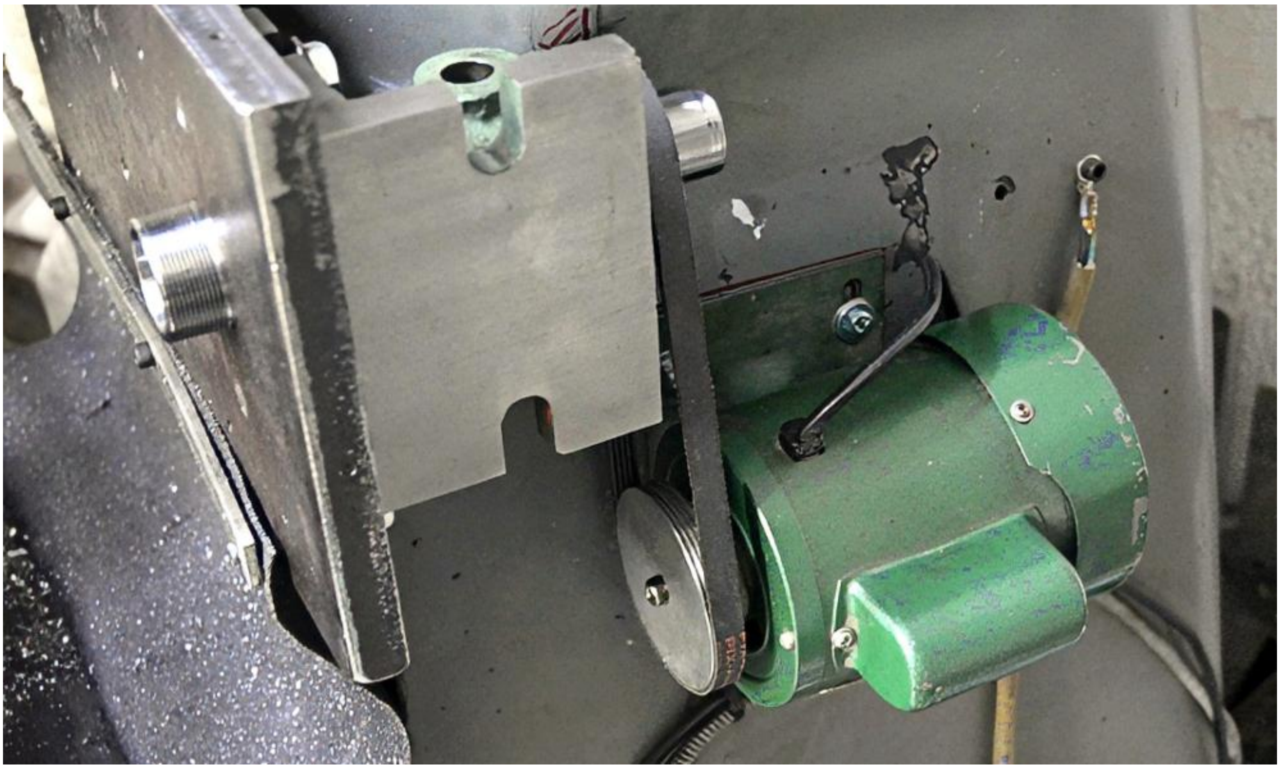
Above. Making the motor pulley.

Below. Aligning the spindle pulley using the laser aligner. This photo was taken after the hole was bored.



Assembly followed next. As a potential source of vibration the motor was bolted to the mill column rather than a bracket of some kind off the plate. The column has a lot of mass to resist vibration induced movements and the inherent damping of cast iron is always helpful. No vibration can be felt on either the column or the plate. The whole thing runs very smoothly and quietly.

I fitted a blanking plate inside an ER32 nut as a swarf excluder when using the vertical spindle, as a finishing touch



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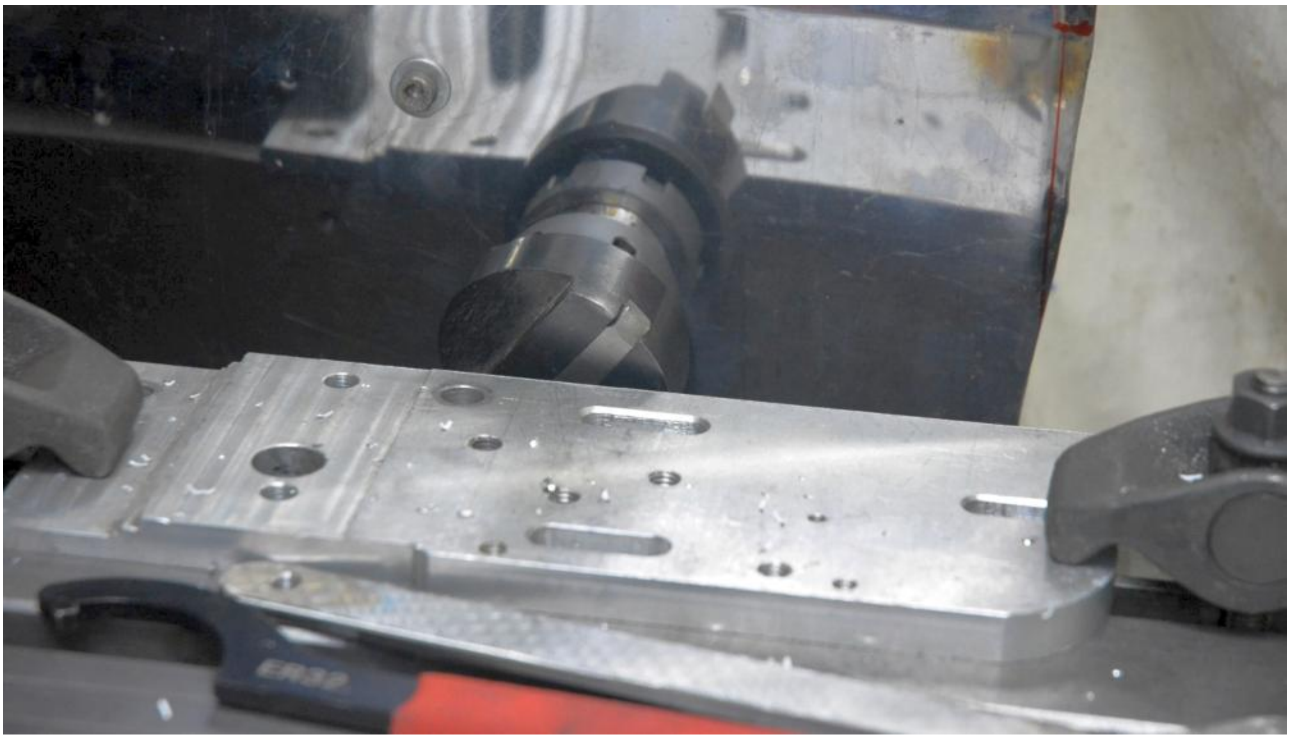
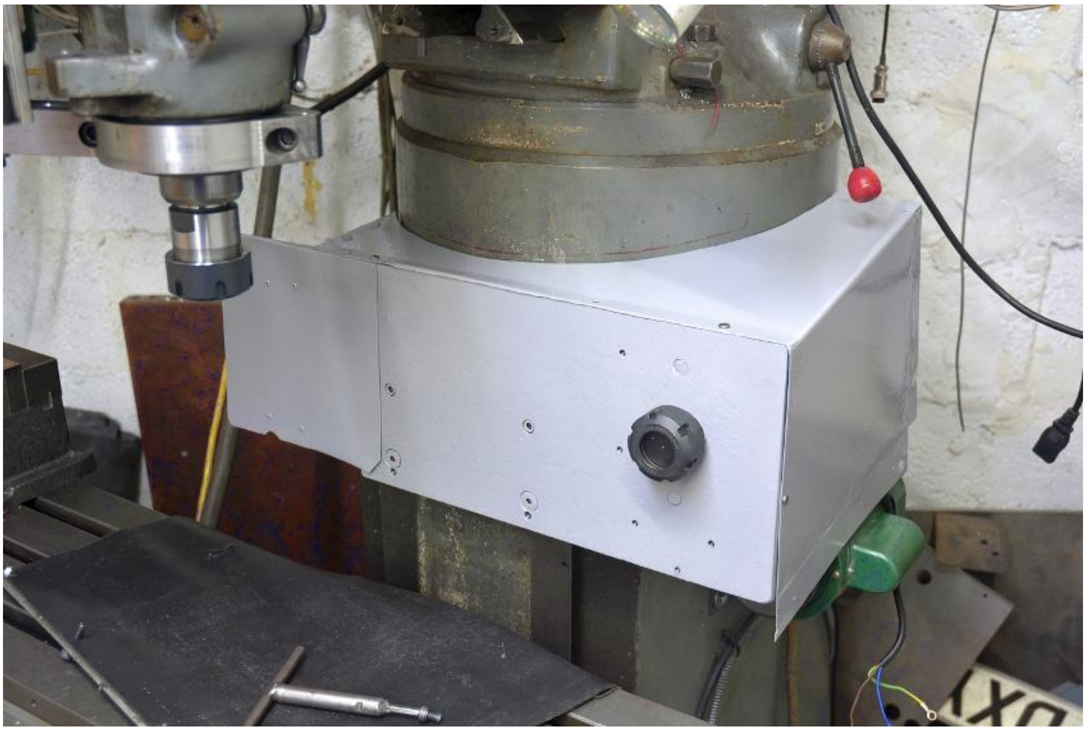
Now that it was up and running all that remained was to check the tram of the spindle and do some test cutting. The tram was out in both the Z and X directions by 0.01 mm over 100 mm travel. I mounted the steel plate back on the table and with some careful shimming to set the plate with the opposite error to the bearing housing area I took a light correcting cut. On reassembly another tram check came out close enough to perfect to satisfy me.

One type of job that comes up sometimes is to edge a piece of wide plate. This is a job made easier with a horizontal spindle because you only need to clamp the plate to the table. If held in a vice for vertical milling it is common to get chatter with such tasks. My first test cut was on a piece of Aluminium plate using a small fly cutter, as shown below.



The cutting test was successful, there was no sign of chatter and the finish was typical for a fly cutter. I could have done with this capability when preparing the steel mounting plate but that is the old chicken and egg problem. Here is a shot of the finished edge.

Not really part of the horizontal spindle addition but the plate provided a useful base for an additional swarf guard to keep chips off the motor, etc. It was made from the cover of an old propane/butane room heater.   What a difference a coat of tough paint makes.



The following photo shows the height relationship between vertical and horizontal spindles. The practical difference is less than it might seem because the cutting edges of the vertical spindle will be lower with a cutter fitted. The polished stainless steel swarf guard does nothing to enhance the photo but the reflected light certainly helps seeing what is happening and mirroring the back side of a workpiece often gives a useful extra view. The thin SS sheet was rescued from the cover of a kitchen appliance, fridge or dish washer.

Summing up

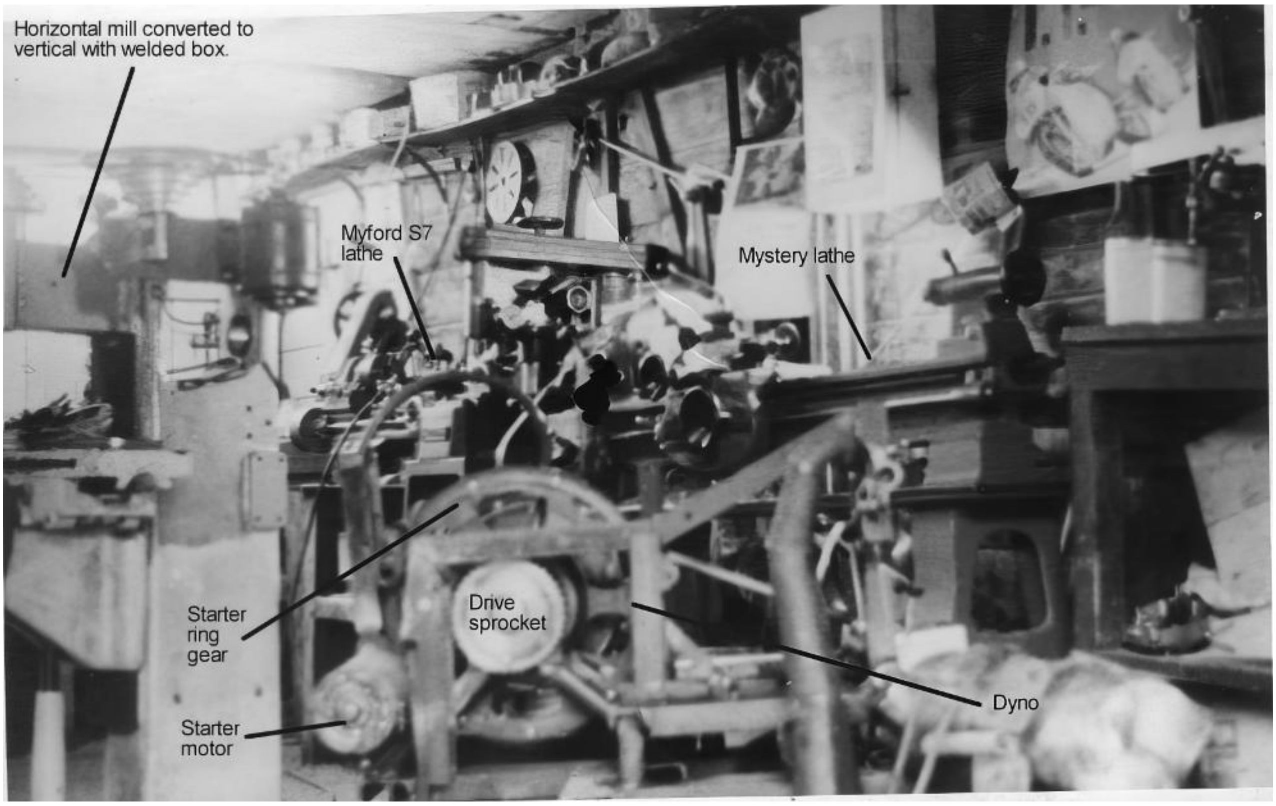
For a relatively small amount of work a horizontal spindle has been added to a vertical mill. Although the machine in question was a Bridgeport the techniques used could be applied to many other types of milling machine. The cost in money terms was not large, the bought-in items being:

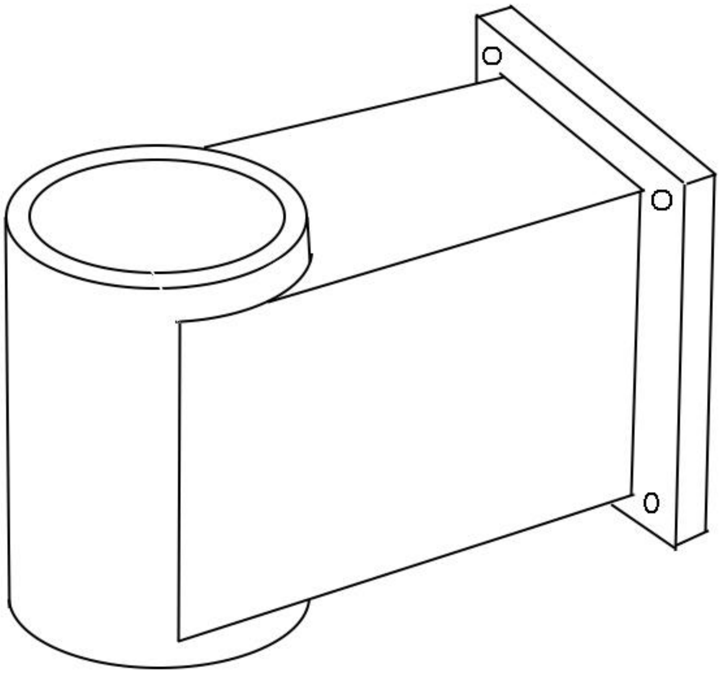
380 x 200 x 20 mm steel plate.
2 bearings.
1 ER32 parallel shank collet chuck.

The rest was stuff that I had. I use an ER32 in the vertical spindle so I have a selection of collets and collet chuck nuts so I only needed to get the new chuck. Anyone wanting to follow with a smaller milling machine might want to consider using ER25 or ER20 collets.

Only the passage of time will tell how much use it will get. If it proves to be a much used feature then I will consider fitting a more powerful motor with speed control. At the moment that is the only “improvement” that I can foresee. Otherwise it is “job done”.

The addition of a horizontal spindle to a vertical mill is somewhat ironic for me. It was only around 65 years ago that I converted a horizontal mill to a vertical machine using a fabricated head. See this HMT post [Horizontal to vertical mill.]() For more details. Below is the only photo that I have of it, on the left side of the image:





Vertical head for horizontal mill.
c. 1960