A GRINDING SPINDLE

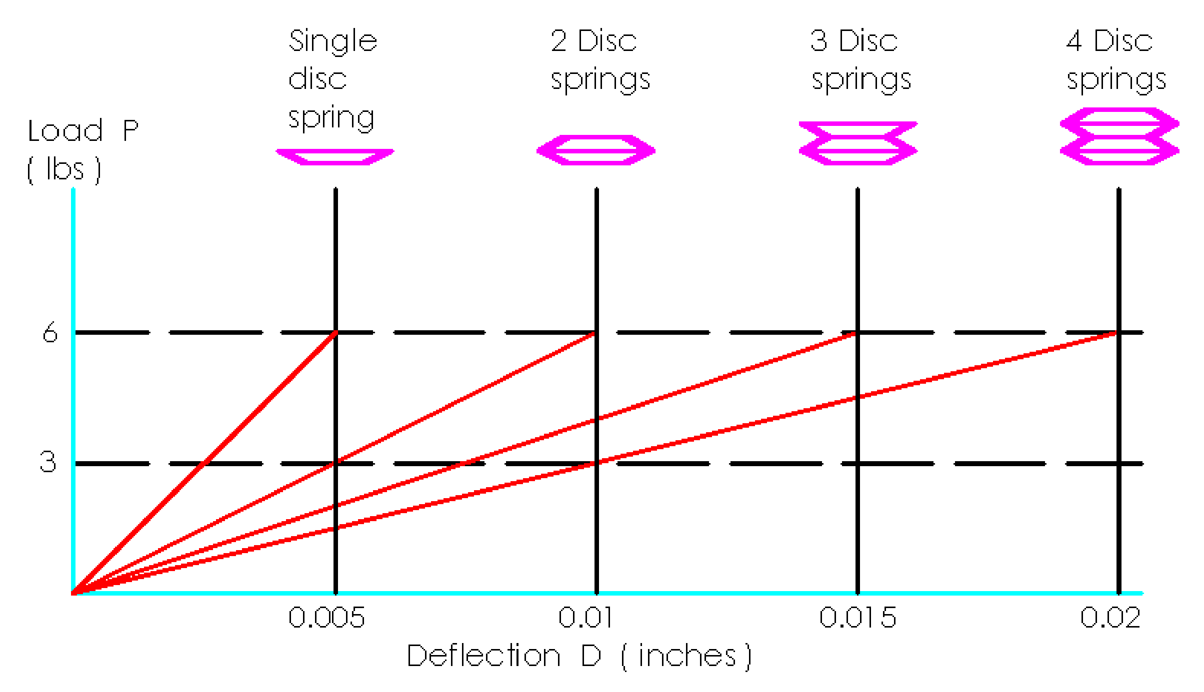
D. Broadley, describes the factors influencing the design and then tells how to make a grinding spindle head.

Part 1 'Model Engineer' 19 June 1992

[Part 2 – 7 July 1992, Part 3 – 21 August 1992]

The real heart of a good machine tool stems from the quality of its machine spindle. The lathe is a prime example of this statement, the lathe spindle having a particularly heavy duty to perform even in a light duty machine. However the model engineer has a requirement for a variety of light but precise machine spindles which are, with care, within the capability of the average amateur and of modest cost. This series of articles will deal mainly with the design and manufacture of a light but precise grinding spindle but will finally extend the exercise to the design of a unit capable of carrying an MT2 spindle of somewhat greater load carrying capacity. The design principles are however the same.

The Grinding Spindle
Much has already been written on the subject of grinding spindle head design, and it is difficult to state anything which has not been said or written before. However it is necessary to state the design principles involved. What we are after is a 4800 rpm free running and accurate spindle without end float in order basically to ensure stability of the grinding wheel. The loads involved are very low apart from loads in the grinding wheel itself and any preloads we must build into the spindle to ensure stability. These latter are also low but important to get right. Finally we need to be able to replace wheels easily and accurately in order to avoid regrinding and hence wheel wastage every time we change a wheel. The satisfaction of making such a spindle which, apart from the wheel itself, looks as though it is stationary is reward enough for the effort involved apart from the fact that we finish up with a most universally useful tool.



LOAD/DEFLECTION CHARACTERISTICS FOR DISC SPRINGS USED IN PARALLEL Fig.1

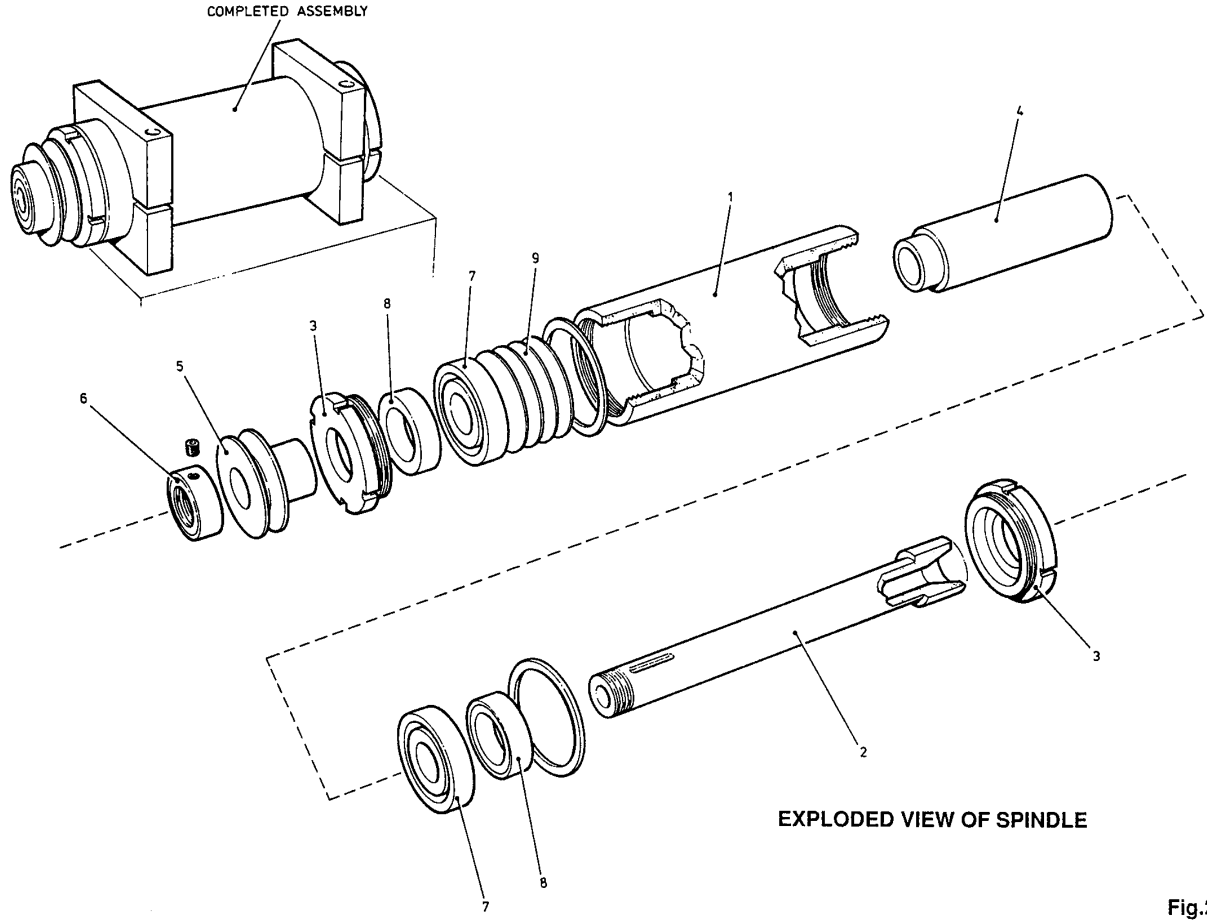


Fig.2

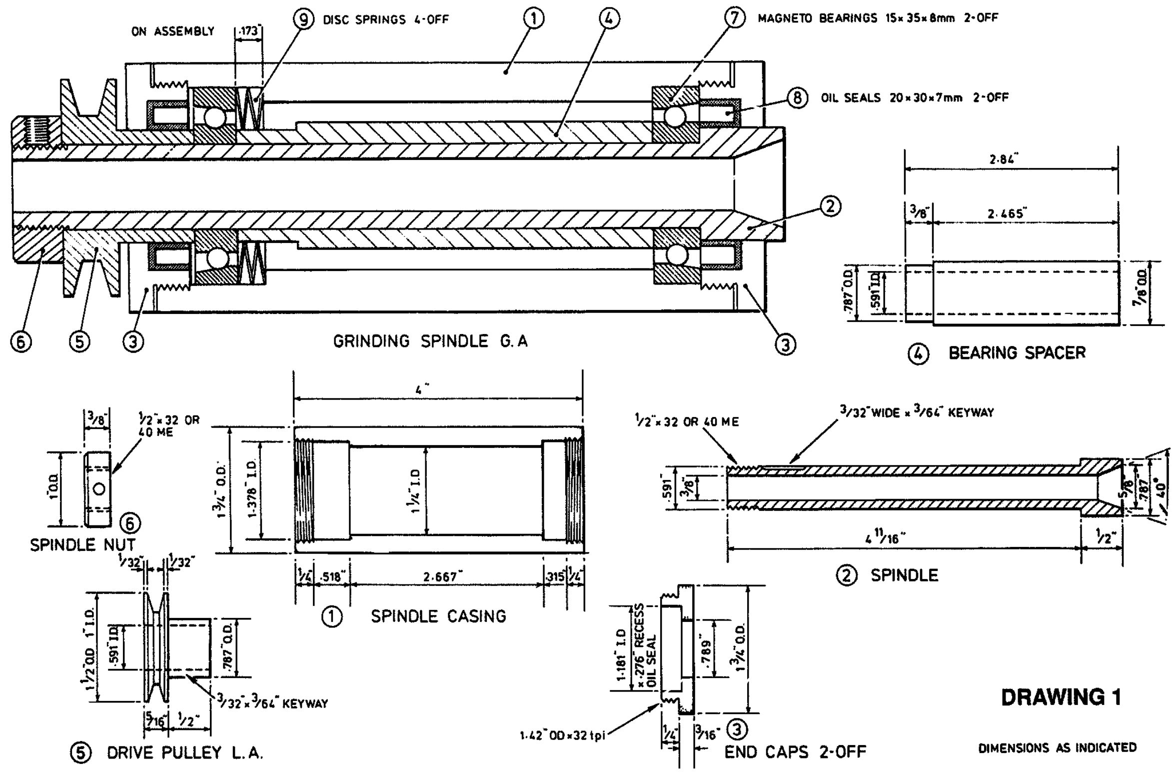
The main element of our grinding spindle is to choose the correct bearings in an accurately machined housing with correct internal preload. All preloads consists of is a method of spring loading one of the two ball races to adjust end float caused by axial tolerances (the difficulty of accurately measuring the distance between the inner races on the shaft and outer races in the housing) and any differential thermal expansion as inevitably one part of the spindle achieves working temperatures compared with another. A good high speed spindle is that critical.

The bearings chosen are relatively inexpensive angular contact or 'magneto' type which lend themselves particularly well to simple and practical methods of preload. There are numerous ways of providing the necessary preload but the one chosen here is what I consider to give the most reliable and, for the amateur the simplest and least expensive method. It is based on bearing disc springs which are readily available and which cover the complete range of sizes for the projects in hand. They can be obtained through the many bearing factors in most large towns and also are available from N.S.&A. Hemingway.

The spring characteristic for single and multi-stacked discs is shown in **Fig. 1**. it being necessary to use 4 springs for this application in order to achieve the preload of 5 to 6 lbs requiring a compression of 15 to 20 thou respectively, but more about this later. Enough of the preamble, how do we go about making it! **Fig. 2** shows an exploded view of the system.

The casing, spindle and the bearing spacer require some fairly accurate machining so take your time. Free cutting mild steel is recommended throughout for which well ground HSS tools are quite capable of giving the accuracy and finish that we require. The extent to which strength is lost due to addition of a trace of lead is so small in the vast majority of model applications I am amazed that it is not more

widely used and available. It is perfectly adequate for this project and its advantages in machineability is in my view outstanding.



Drawing 1
Starting with the spindle housing (**Item 1**) mount one end in the 4 jaw and the other in the fixed steady end true it up with the D.T1. after cleaning off any rust etc. from the outer diameter. This arrangement is shown in **Photo 2** [part 2]. You should be able to achieve a very few tenths (of a thou.) with care. Drill the casing through and bore it out to 1.25 in. at least half way and preferably through.

Carefully bore for the outer ball race. If you are using a magneto bearing the outer race is separable and can be used as a reference if this helps (carefully clean it afterwards). The bore you need for a light push fit is only 3 tenths smaller than the outside of the bearing. You can bore for a 0.002 in. clearance and use Loctite if you wish. I personally go for a light push fit every time but if a mistake is made I would not hesitate to use the remarkable Loctite products, in this case Loctite 64 Bearing Fit. Next thread the end 32 TPI x ¼ in, before turning the casing round, truing it up again with the D.T.I. and repeating the procedure from the other end but this time making the outer race a nice sliding fit in the casing. Finally thread what is the drive end 32 TPI also. Just a word on screwcutting in the lathe. The depth of thread for 32 TBI Whitworth form is 0.031 in. but if you are using a pointed screwcutting tool, most do, do not forget to add on the extra sixth for the bottom of the thread i.e. the actual depth of thread is 0.036 in.

The spindle **(Item 2)** is handled in a similar way to the casing but from a piece of 1 in. OD FCMS and leaving sufficient length to machine the complete spindle, hold it in the 3 jaw and centre the free end using the fixed steady. Remove the steady and using a rotating centre carefully turn the whole of the outside of the spindle including the 7/8 in. nose. Unless you use Loctite you will require great care to achieve the necessary light push fit since the interference you require on this small diameter is only a tenth of a thou. or so but this is only necessary where the bearings locate. Lapping, which in my view docs not receive the attention it deserves, is the best way of achieving the accuracy required. If you use Loctite

NOT YET. Screwcut the ½in. x 32 TPI thread in the lathe, finishing it off with a die. Next fit the fixed steady, not over the bearing location, and remove the centre.

The 3/8 in. bore we are going to tackle next is accomplished by truing up the spindle, now in a fixed steady, with the D.T.I. and bore the spindle to 3/8 in. by step drilling, preferably making the final cut with the D bit. The bore is long and you are unlikely to have a long enough drill to go right through. So reverse the spindle and again using the fixed steady on the 7/8 in. nose true the outside as accurately as possible with the D.T.1. then, drill until the bores meet, leaving the last say 20 thou, to the D bit. You really can do this without being able to see the join. All that needs to be done to finish the nose is to machine the 40 deg. taper.

This I did quite successfully at the same setting but you may choose to follow the procedure of Professor Chaddock in his excellent book on the ***Quorn Tool and Cutter Grinder***. In this the whole of the spindle housing is held in the in the fixed steady, the spindle itself being driven in the preloaded bearings. I cannot fault this method but feel that beginners at least will find the method that I have outlined to be satisfactory. The necessary skill to true up a component in the lathe to the accuracies required is not that difficult, but take your time.

Next tackle the bearing spacer (**Item 4**) to a slide fit on the spindle. The length of the tube is fairly critical to maintain the differential between the housing and the length of the spacer. This differential must be 0.168 in. to 0.173 in, to give a preload of 6 to 5 lbs. respectively. This necessitates some simple arithmetic involving measuring the length of the housing, subtracting the outer bearing recess dimensions and adding 0.173 in. as shown on the drawing to obtain the length of the spacer. You must check it this way because it is almost certain that you will not have controlled the length scales accurately enough. If you use an angular contact bearing, which are cheaper and more readily available than magneto bearings, it is necessary to adjust the length scales because they are 3mm wider, i.e. 11mm wide.

Ensure that the ends of the spacer are parallel when machining it to length by supporting it in the fixed steady and again check with the D.T.I. The spacer tube is reduced at the disc spring end in order to support the stack. This diameter is important but not critical to provide the correct internal support for the disc spring stack. To repeat the length of the spacer is important as it automatically gives the correct preload and for these particular disc springs 1 lb preload = 0.004 inch. A simple way of measuring the housing and bearing recesses in order to achieve the correct length of the bearing spacer is given later.

Finally make the screwed end caps which are identical. There are other ways to retain the spindle and contain the oil or grease than screwed end caps and oil seals which I have shown on the drawing. Oil seals of the full bearing diameter are readily available but in my case I was anxious to provide the maximum spacing between the bearing and the design shown does this nicely. I also machined thin brass washers between the casing and the end caps which add a decorative as well as useful oil retaining role. Whichever type of seal you use it is advisable to lap the seating to speed running in and minimum wear on the seal lip. The oil seals do unfortunately give significant drag particularly when new. A light grease rather than oil and either a lapped fit or felt seal are I am sure perfectly good alternatives. The bearings are good for 20,000 rpm with grease and 25.000 rpm with oil, but please not with a grinding wheel on it. The absolute need to keep within the rpm limit of the largest wheel cannot be over emphasized (the maximum speed is stamped by law on all but the very small wheels).