Dividing with a Rotary Table and Gear cutting.

By Steven ‘Skiprat’ Jackson

For IAP Members

You may remember that I posted a pic of an old drill press that I scored when one of the departments of the company I work for, moved and cleared house. I was very pleased with the drill and even ran it before taking it away. It ‘seemed’ to run like a dream….

But all was not well. When I put some load on the spindle, it grumbled and groaned like mad.

Oh boy…what to do? Take it to the dump? Buy some spares? Try to fix it?

My issue is cost, as it has a three phase motor and I will at least have to either buy a new single phase motor or a single to 3 phase convertor.

After a bit of thought, I decided to go down the ‘repair’ route and have a go at making new gears myself. I figured that if I recorded my efforts, then they might be of use to someone else too.

The drill press has a gearbox that has metal driving gears and phenolic driven gears on the quill spindle. There is a label on the machine that says to switch of the machine off before changing gear ratios.

Over the years, this poor machine has been abused and both phenolic gear are trashed.

I put one back in to take this pic.

I have suitable material available (Tufnol) so decided to have a go. There are two gears required. I used the original larger one to make the blank for the new smaller one and cut new material for the big one.

My new material is much thicker than the original but I think it will be ok. If not, easy enough to thin it down afterwards.

I have never attempted to cut gears and I don't have a lot of experience with dividing on a rotary table. So with my books all read I ordered a set of gear cutters from China. (I could have bought a single cutter locally for the same price as a set of 8 from China, including postage !!)

So, where to start??

Let's list the 'given' info first and work out the rest.

I measured the diameter and counted the number of teeth on the trashed ones. I got the machine manual from the manufacturer and found the PCD or Pitch Circle Diameter. Having read the books, what I still didn't know was which size, shape or type of cutters to get.

I wasn't really sure on how to choose and set up the indexing plates on the rotary table either. Turns out it's not that complex. The theory behind the cutters can get VERY complex but once you understand the very basics, it's actually pretty easy……

Let's start with the indexing.

A rotary table is a simple device. It basically is a crank driving a worm gear. The crank is rotated a number of times to rotate the table an appropriate amount. It takes many turns of the crank to rotate the table one full revolution. Ratios of 40/1 , 60/1 and 90/1 are the most common. Mine is a 90:1 Ratio. This means that the crank is rotated 90 times to rotate the table once.

As we all know, there are 360 degrees in a full rotation. The table has the degrees marked around it's circumference and the crank even incorporates a Vernier so it is possible to use it as is but it becomes very difficult to divide accurately using these alone.

This is where the Index plates come into play. These are normally a set of three discs with various numbers of holes in them. The discs used in conjunction with the table ratio (90/1 in my case) allows *almost* any number of divisions to be made. My two gears needed 56 and 89 teeth respectively.

Remember my Rotary Table ratio is 90;1.

From the table in the Dividing book I get bad news…

D = Divisions (number of teeth)

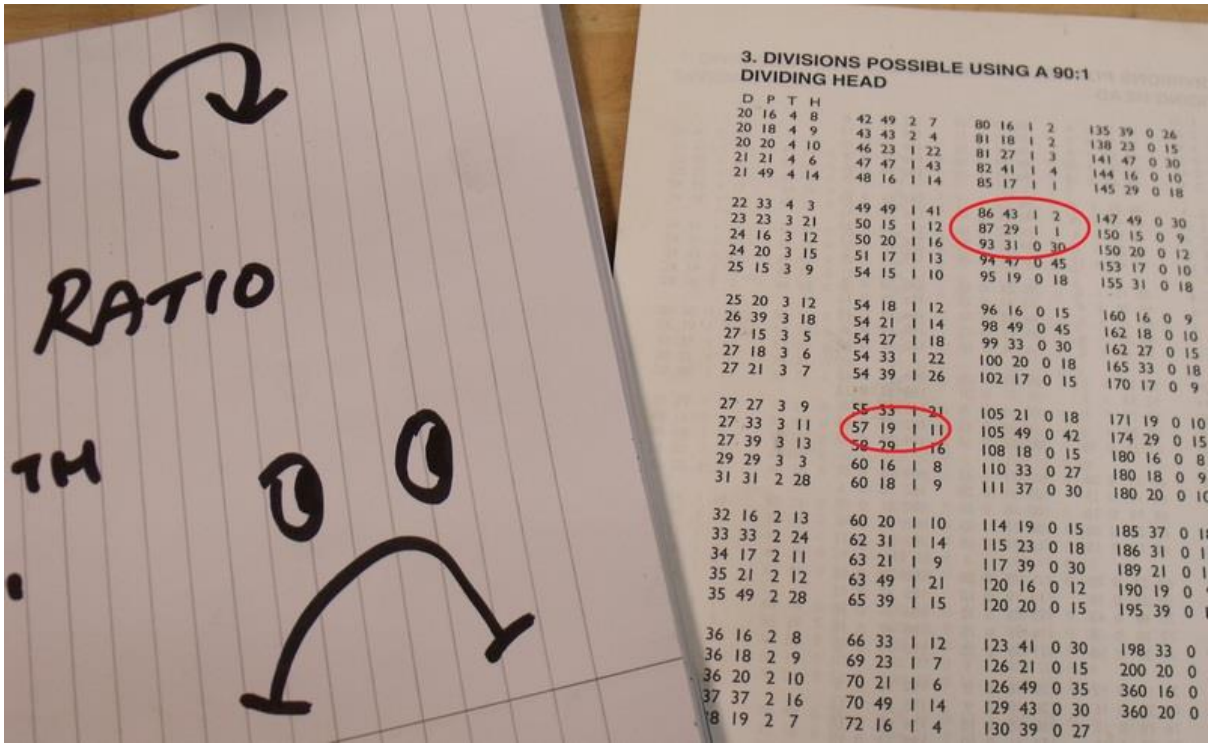
P = Index Plate

T = Turns of the crank

H = Additional number of holes on the disc.

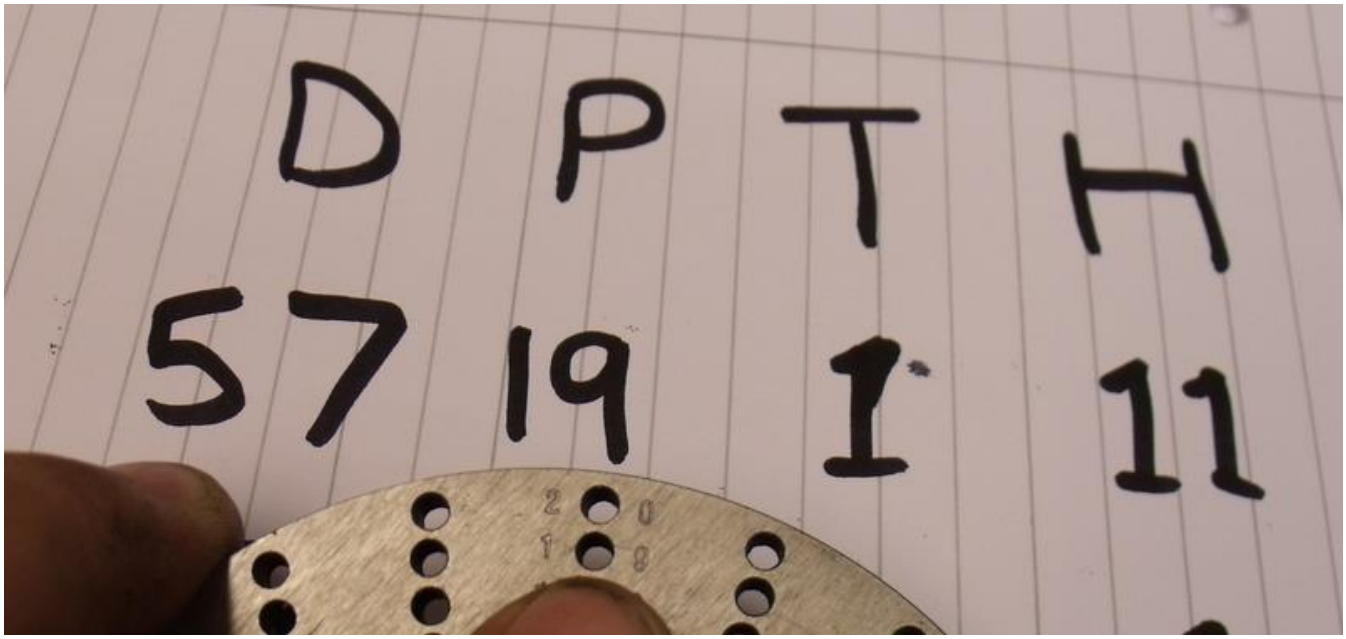
As you can see, there is not an option for 56 or 89 teeth using a 90:1 ratio table !!

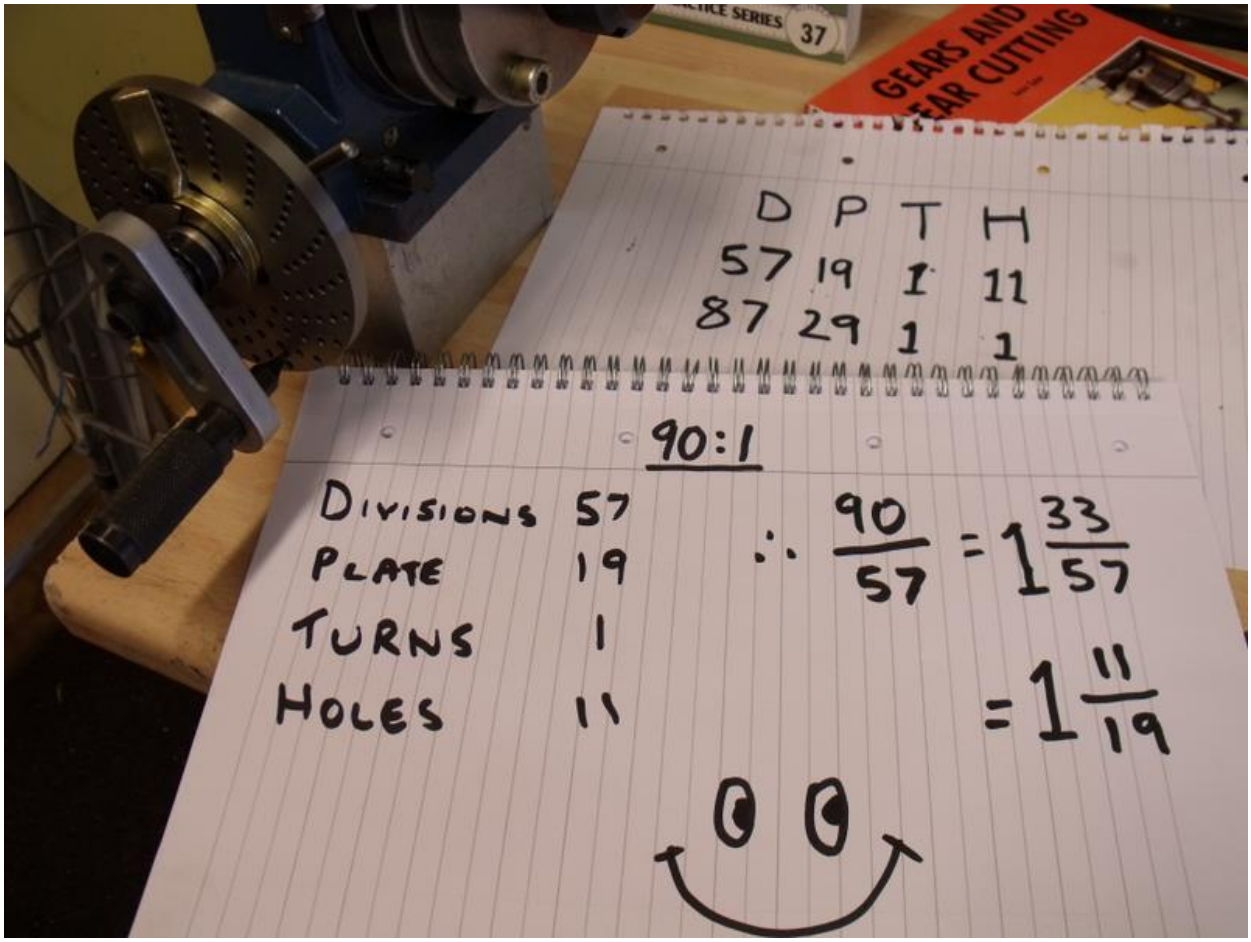
Ok, so I just choose 57 and 87. I think it will be ok.



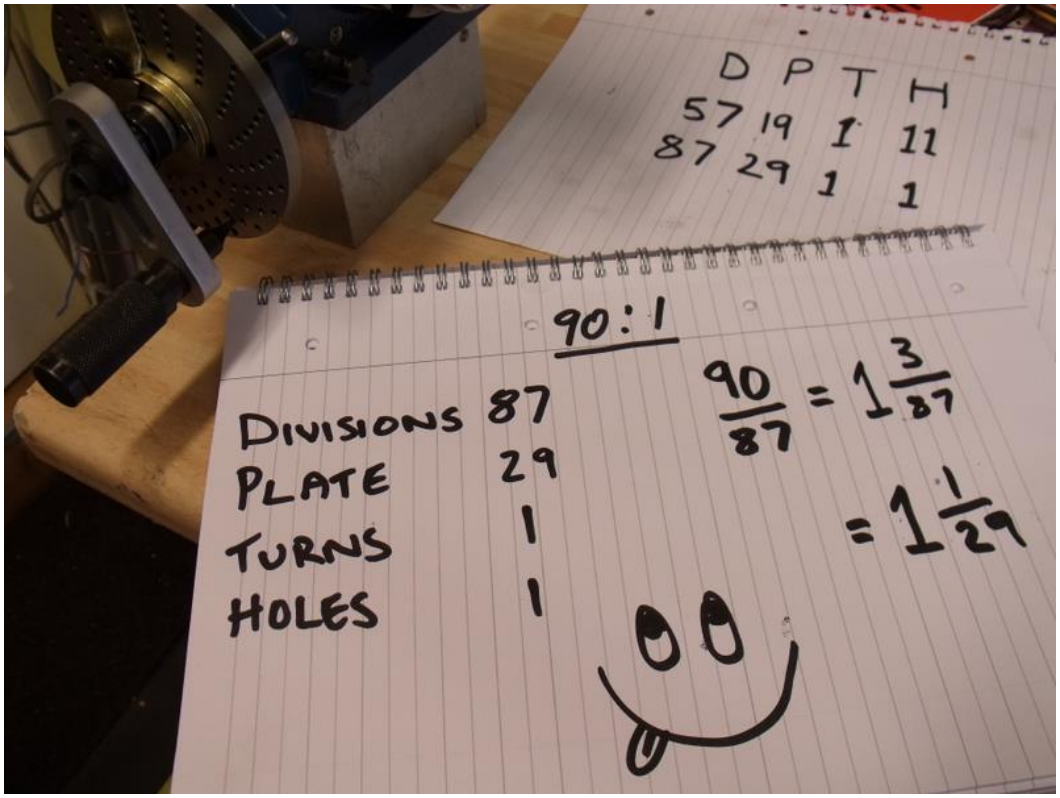
Ok, let's look at the first gear. I want 57 teeth on it. The table tells me to use the disc with 19 holes and then tells me to do one full rotation of the crank PLUS and extra 11 holes of the 19 set of holes. That's easy enough to do but how did they get those numbers and what if I didn't have the tables?

Look at these pic, you can see where the numbers come from. Simple simplification of the fractions gives all the answers.


D P T H
57 19 1 11

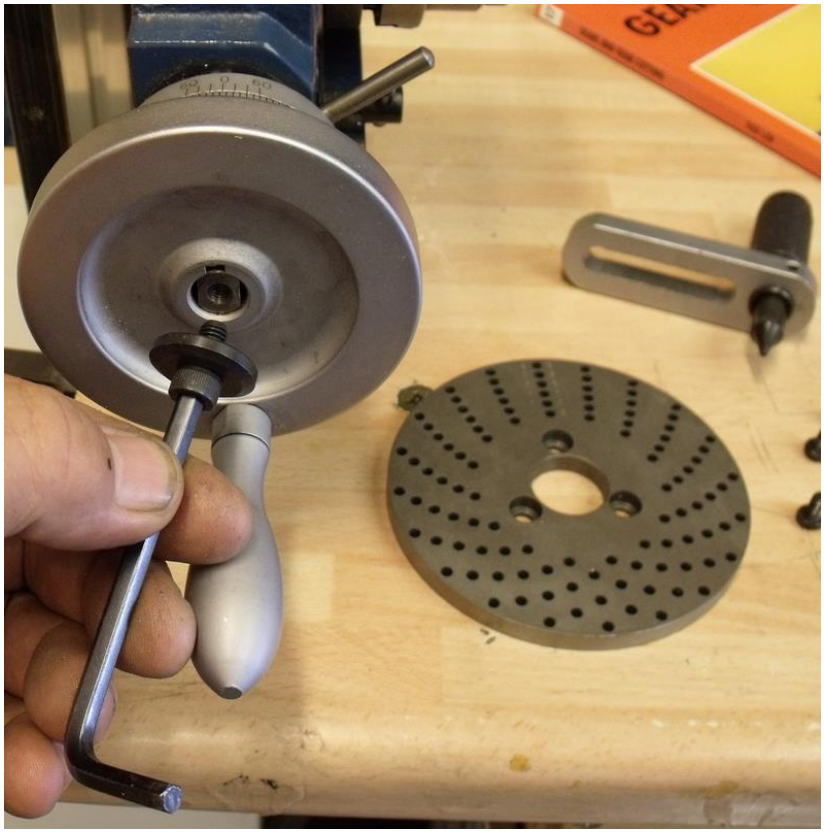

GEARS AND
EAR CUTTING
D P T H
57 19 1 11
87 29 1 1
90:1
DIVISIONS 57
PLATE 19
TURNS 1
HOLES 11
∴ 90/57 = 1 33/57
= 1 11/19

And similarly for the other gear…



Let's set up the Rotary Table for the first gear.

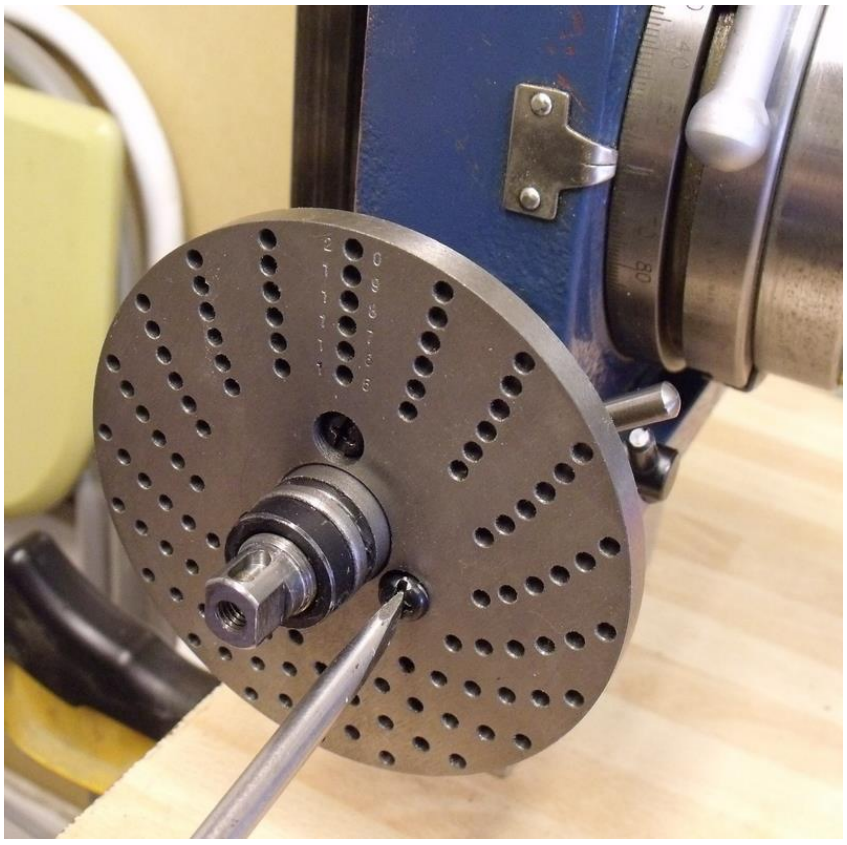
First, remove the crank handle…



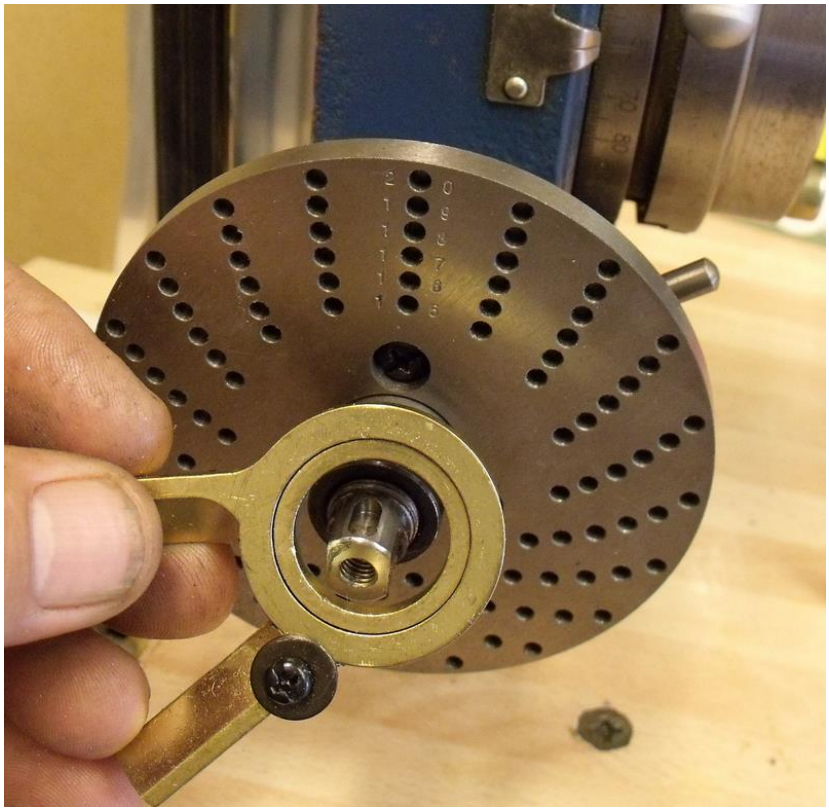
Watch out you don’t lose the key..

Remove the key for safekeeping.

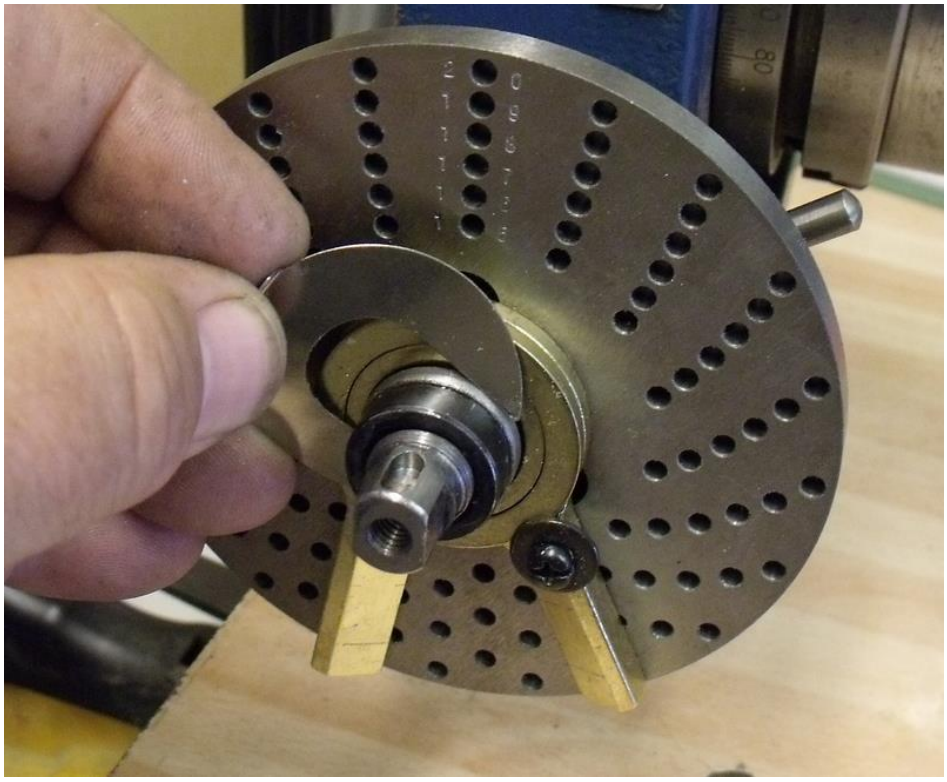
Using the three screws that come with the disc set, attach the selected disc with the required number of holes.



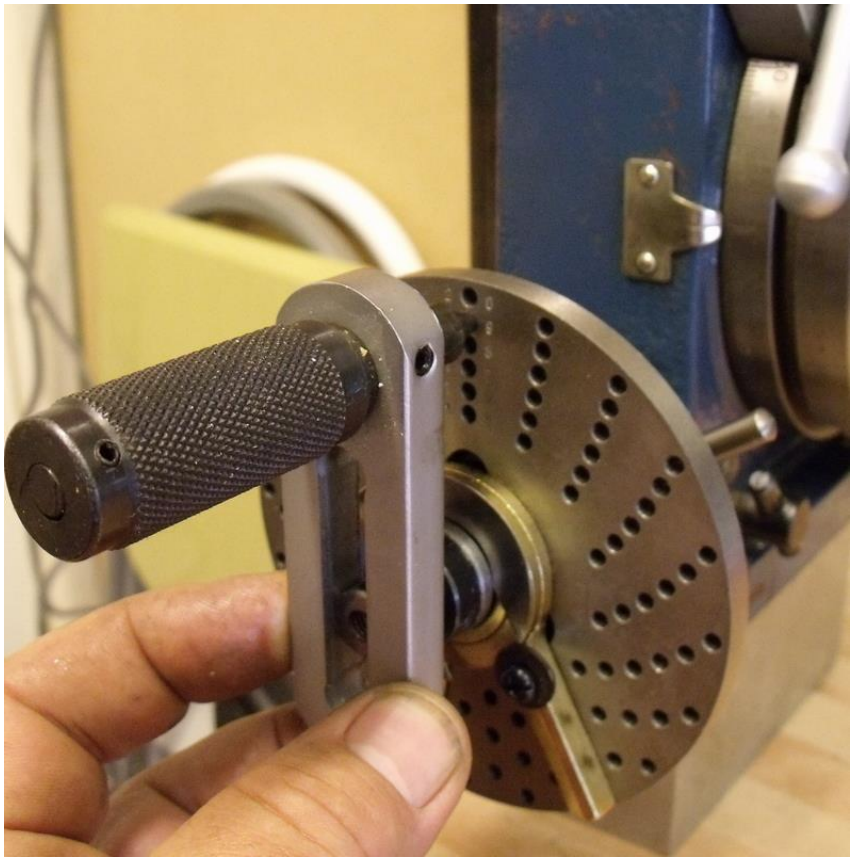
Fit the dividing arms. The little screw and washer keeps them stiff. Don’t be tempted to lube or loosen it !!!



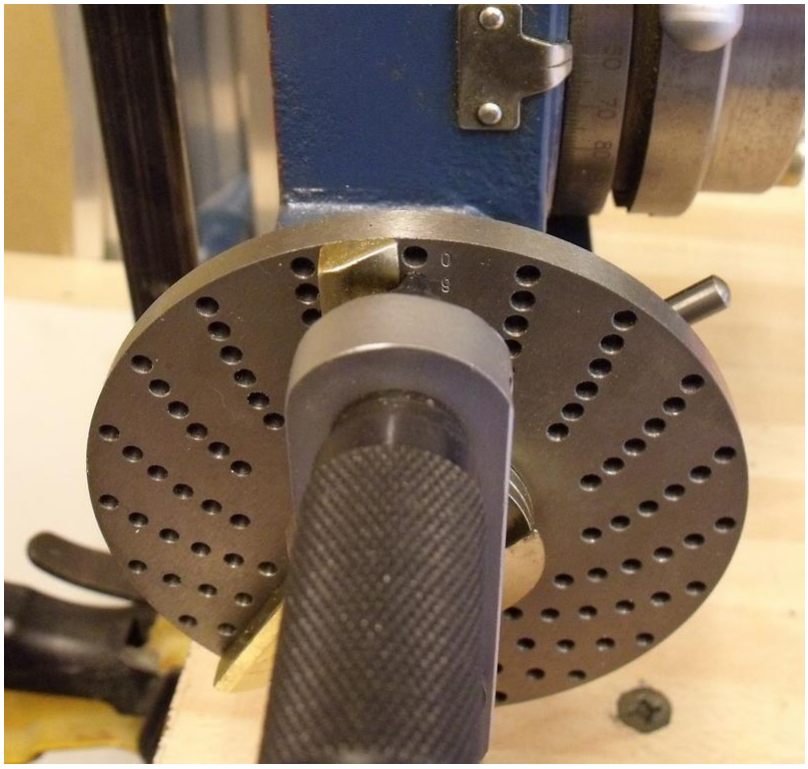
…and the spring retaining clip..



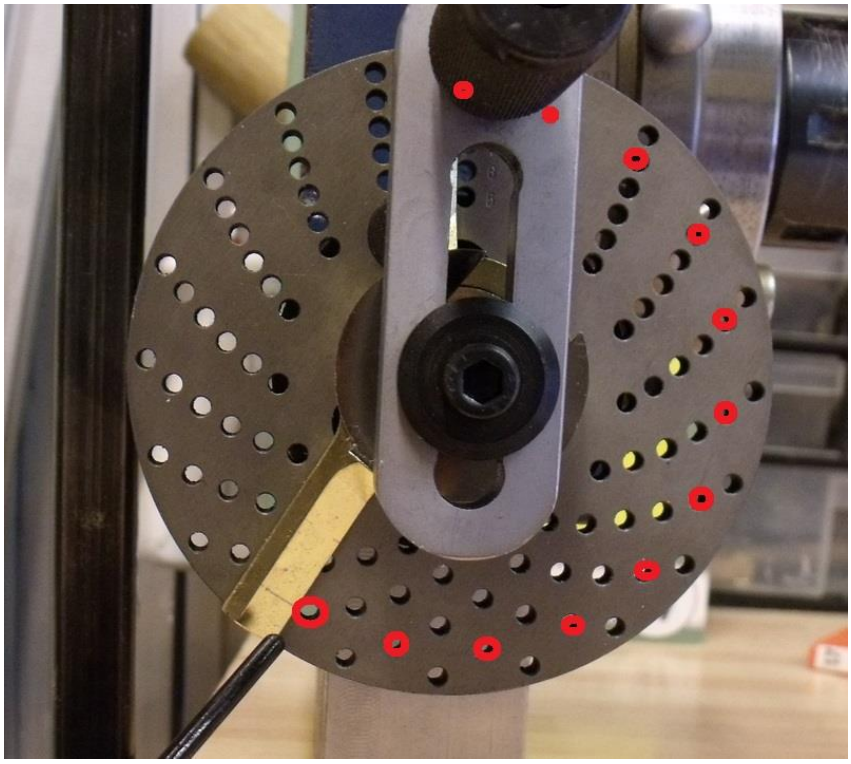
Now fit the crank arm so that it lines up with the require ring of holes.



Let's see where we are and have a practice to make sure we are correct. With the spring loaded crank handle located in the first hole in the '19 ring' the first arm is placed against the left side of the crank.

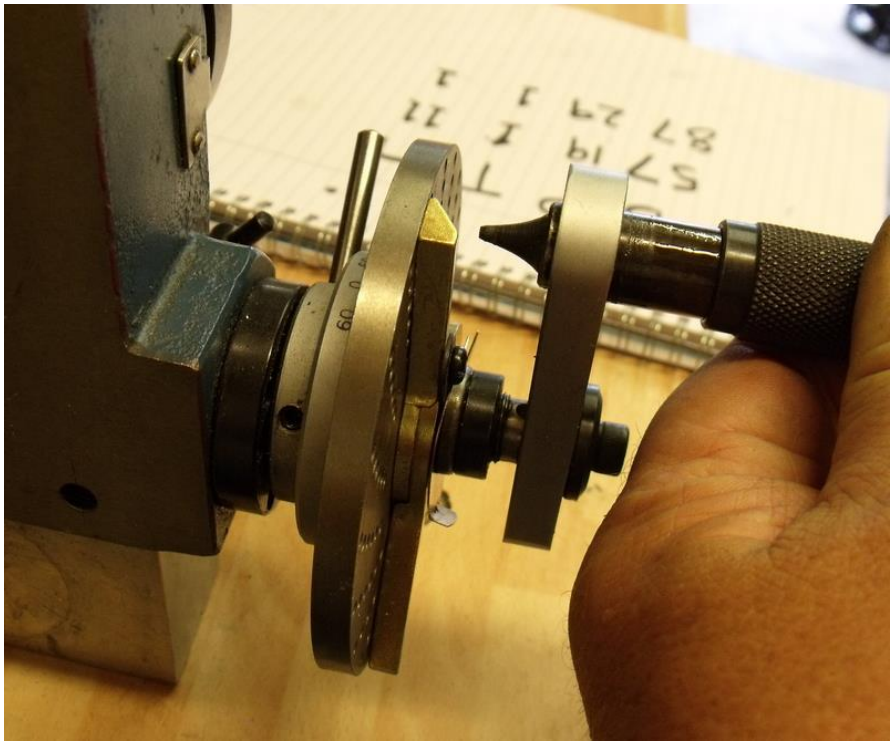


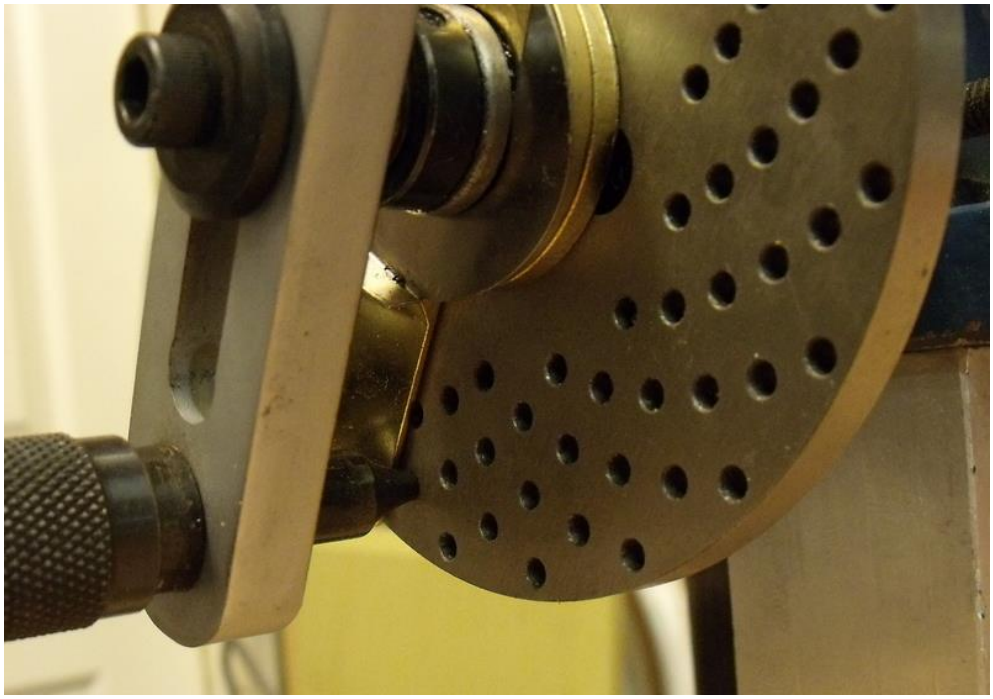
Now rotate the other arm so it sits just after the 11th hole going clockwise.



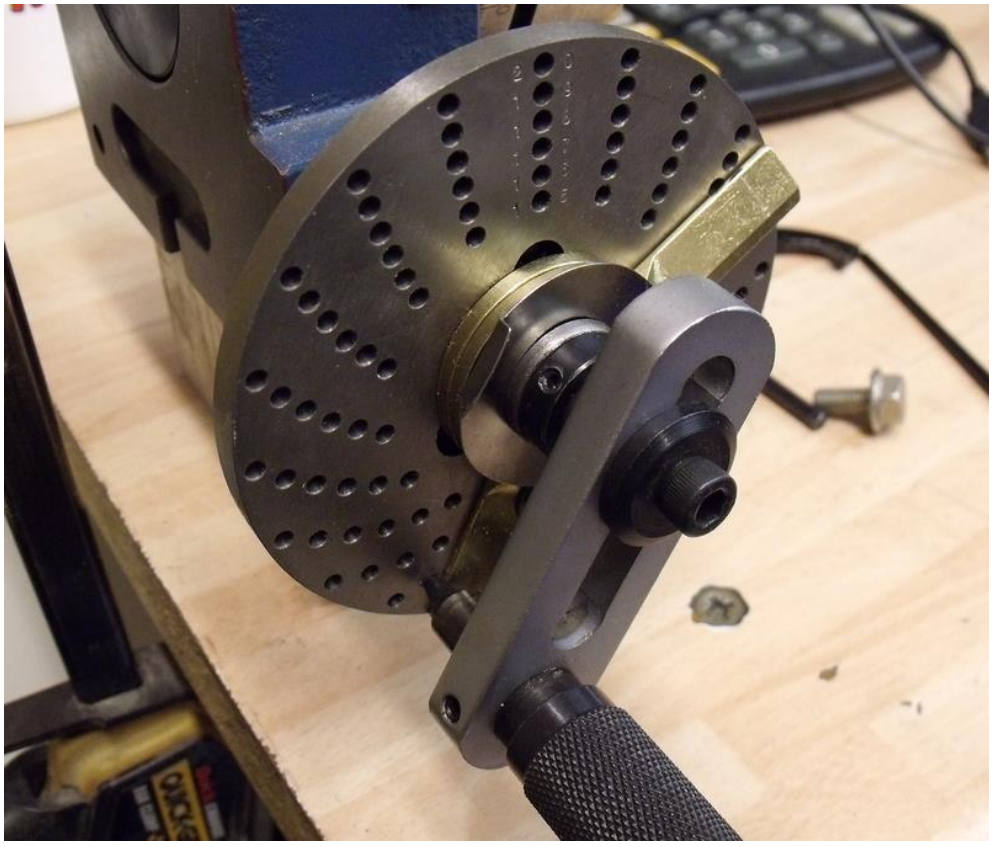
With the setup like it is now, the first gear tooth would be cut.

Now we pull the spring loaded crank and rotate the crank one full rotation clockwise (which obviously will return it to the same position, but now we continue to the 11th hole before releasing the crank. Be very careful to fully pull on the crank and don't snag the dividing arms when rotating..





The table is now in the position for cutting the second of the 57 teeth. But it is good common practice to carefully rotate the dividing arms clockwise so the first arm touches the pin again.



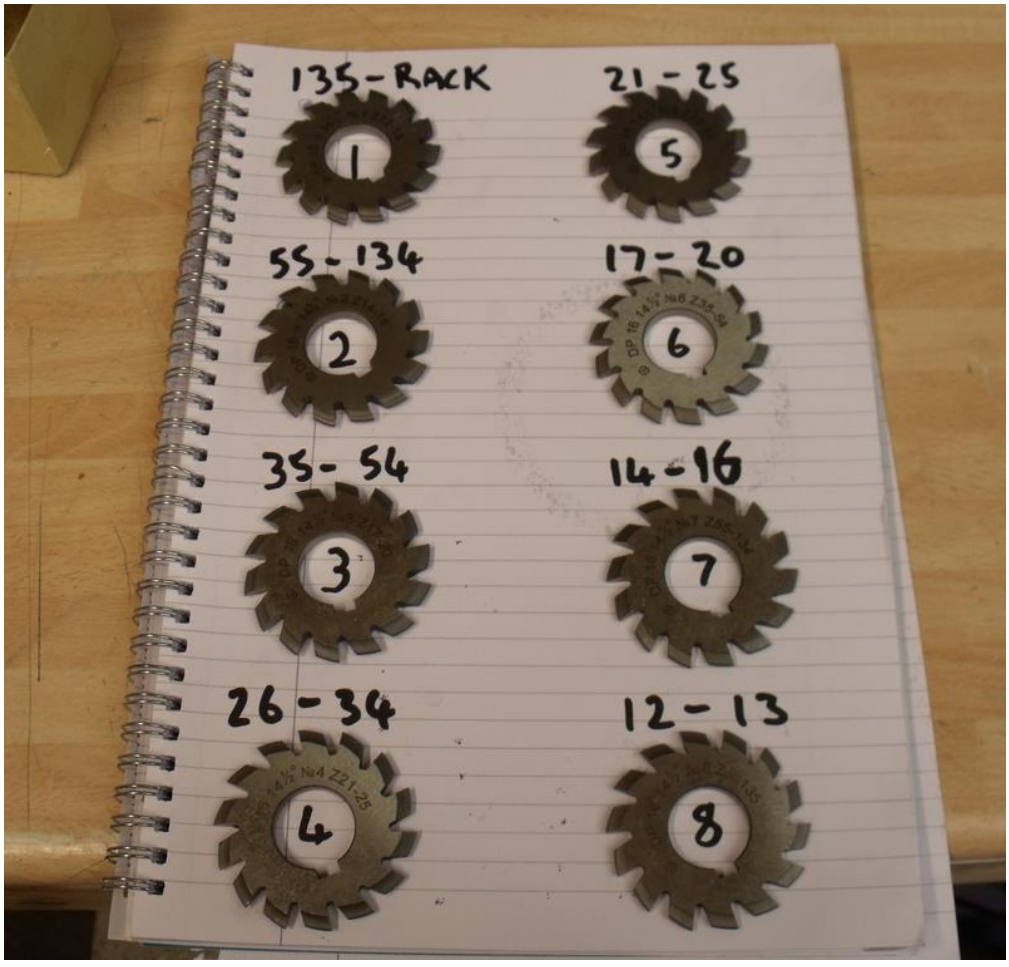
Now that the indexing is sorted, let's look at the cutters and how they are chosen.

Involute Gear Cutters come in many sizes and in two types. Essentially they are either Metric or Imperial. The Imperial variants are called Diametric Pitch, known as DP and the Metric variants are called Module.

Either way, both are determined by the number of teeth either per inch or millimetres around the circumference of the gear. In fact it's not the very outside of the circumference, but a line somewhere between the top of a tooth and the bottom, called the PCD, Pitch Circle Diameter.

There are other details like Pressure Angles but don't worry too much. It seems that 14 ½ degrees is the most common and therefore the default to choose unless you know otherwise.

The cutters can be bought individually or as a full set of 8 cutters. Each cutter is shaped to cut a certain numbers of teeth. This pic shows how many teeth each cutter is suitable for.



Two matching gears must have the same size teeth, but they may have a slightly different shape.

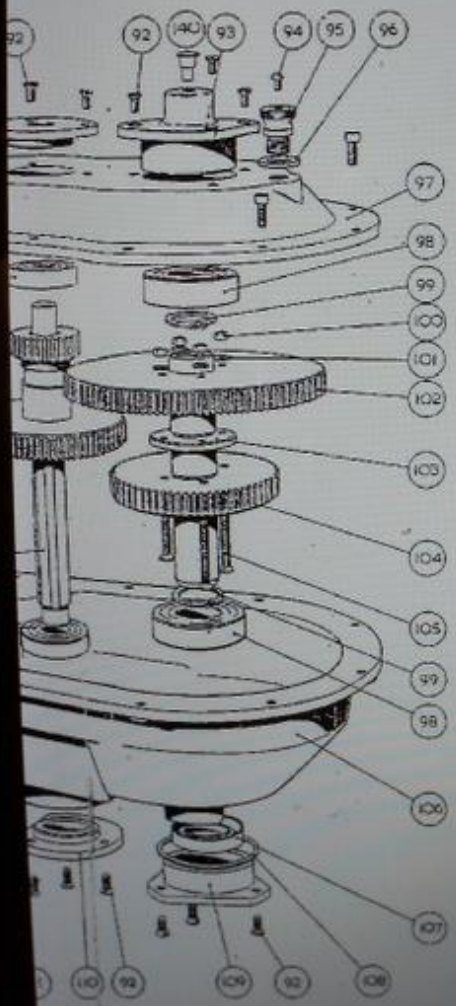
Imagine a gear with say 200 teeth on it matching with a smaller gear with only 40 teeth on it. The Vee groove will be wider on the smaller gear.

Hold up your hand with your fingers almost touching each other. This could represent a very large diameter gear with hundreds of teeth. Now open your fingers as wide as you can. You can see the gap between your fingers (the teeth) is now much wider. So we need cutters to cover the range of these gaps to be cut.

The difference is not massive, but is important. Not a great pic, but you can see the profile difference between these two cutters.

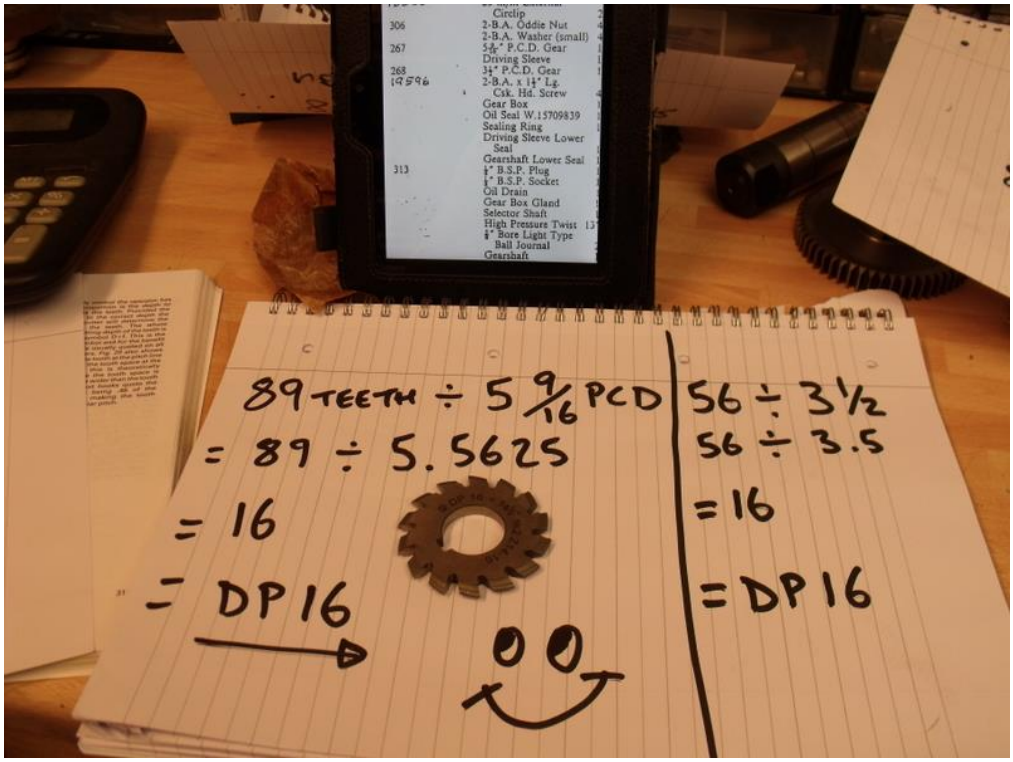
How did I know what cutters to buy?

We know that my first gear had 56 teeth and my second gear had 89 We know from the manual and from measuring that the PCDs are 3 ½ inch and the other is 5 9/16 inch.



GEAR BOX

Item No.	Part No.	Description
90		⅛" B.S.F. x ½" L Cap Head Scre
91		Gearshaft Upper
92	5469	2-B.A. x ⅜" Csk. Hd. Screw
93		Driving Sleeve U Seal
94		Vent Screw (Rem before using)
95		Oil Filler Plug
96		Leather Washer
97		Gear Box Cover
98		25 m/m Light Ty Ball Journal
99	16309	25 m/m External Circlip
100	306	2-B.A. Oddie Nu
101		2-B.A. Washer (½
102	267	5⅛" P.C.D. Gea
103		Driving Sleeve
104	268	3½" P.C.D. Gear
105	19596	2-B.A. x 1½" Lg. Csk. Hd. Screw
106		Gear Box
107		Oil Seal W.1570
108		Sealing Ring
109		Driving Sleeve L Seal
110		Gearshaft Lower
111	313	¼" B.S.P. Plug
112		¼" B.S.P. Socket
113		Oil Drain
114		Gear Box Gland
115		Selector Shaft
116		High Pressure T
117		½" Bore Light T Ball Journal
118		Gearshaft
119	301	¼" dia. Ball
120	311	Gear Catch Spri
121	286	Driving Gear
122		Selector Lever
123	514 (10-4764)	¼" B.S.F. x ¼" L Allen Grub Sc
124	271	Selector Pad
140		No. 3 Flip Flap
141		¼" B.S.P. Backn
142	6515	¼" B.S.F. x ¼" L Grub Screw



From the above simple maths we can see that I need to use DP 16 cutters to make my gears.

It can also be seen from the pic of the gears, above, that the #2 cutter will do for both gears.

It can also be surmised from the above that the choice of cutters is actually a compromise, as there isn't a cutter for every possible tooth number required. I mean, we know that the shape of the gap changes as the diameter changes, but as with our requirements, the same cutter is used to cut a gear with 56 teeth as for 89 teeth.

I hope this will helps someone that thinks it's a mysterious dark art and they will now be less afraid to have a go…. ☺

I'll follow this up with some description on how the gear blanks are held in the collet and how the actual cuts are made and set up in the mill.

Cheers for now. ☺

Steven

AKA Skiprat