

2.07 A Method of Making Reamers.

John Hughes

Reamer making is a neglected subject. The attitude that seems to prevail is for pipe-makers to delegate the manufacture of reamers to their local engineering company. Where a sympathetic firm can be found to tackle such work, there are still problems, mainly, the reamer which results is often a compromise, that is, it will take the form that the machinist is capable of making, rather than the shape that is ideally suited to a chanter bore. I have seen square-section reamers made using a surface-grinder, maintaining a square section throughout its length. That is something of an engineering achievement in itself, but it means the pipe-maker is stuck with perfectly conical bores in his instrument. The other problem is that the person you engage to make your reamers might not give a toss about union pipes or the music they produce, so is happy enough to make anything that has any old taper on it.

In this article I will deal with reamers of semi-circular section and $\frac{3}{4}$ section, simply because that is what I have experience of making. I confess to be rather against flat section reamers, because they can 'orbit' in use, and can actually produce a tri-lobed section bore, which will be difficult to measure once you have made your chanter.

The minimum equipment you will need to make reamers is a small centre lathe of a distance between centres of not less than the overall length of the reamer you want to make. If, for example, you want to make a reamer for a $14\frac{1}{4}$ inch chanter, your reamer will have a $14\frac{1}{4}$ inch cutting edge, plus a shank of about 2 inches, so $16\frac{1}{4}$ inches between centres is an absolute minimum. It is, however, perfectly possible to form a chanter bore with a number of short reamers rather than one long one. If you do take the single reamer approach, you will want an even longer lathe if, like me, you like flat pipes.

I would rule out the possibility of making reamers on a woodturner's lathe. Having said that, I suspect that someone somewhere will write to me disputing that last statement, and informing me that they have managed to make a conical blank for a reamer using nothing but a woodturning lathe, a micrometer, and a file. Theoretically, it is possible, but it is a bit like reed-making without a knife, so, what follows is addressed primarily to users of metalwork lathes.

At this point I have to confess that I am not the best person to argue as to what shape a union pipe chanter bore should be, but what I and others can do is to reproduce the bore of an existing instrument, preferably one that we know works well and that can be easily fitted with a reed.

I hope we have progressed since the days when it was believed that all that was necessary in measuring chanters was the hole positions and diameters, plus the diameter of the bore at the bottom and top of the chanter and regulators. With a little extra effort we can actually measure and plot the bore of a chanter. The process merely consists of inserting accurately made gauges into the bore of the chanter we wish to measure, and measuring how far into the chanter bore they go. The results are then plotted on a graph, bore diameter against distance from the top (or bottom if you prefer) of the chanter or regulator.

Ideally, the gauges should be made of a material, which will not damage the bore of a chanter, which means in real terms, non-metal. While I have used metal gauges myself, I have taken the utmost care to remove all traces of sharp edges, which might dig into the bore on insertion. Nylon or some similar easily machined plastic would seem ideal. Remember also that a round gauge will only measure the chanter bore at its narrowest point, and while a true oval is difficult to machine, a reasonable compromise would be a round-section gauge with flats on either side.

It goes without saying that the more gauges you have and the smaller divisions by which they increase, the greater detail you will have of the chanter you are measuring. I started off by making myself a set of gauges in 0.020 inch increments (approximately 0.5 of a millimetre) and thought I was being pretty accurate, until I met Craig Fischer of Adelaide, Australia who, on my questioning, revealed that he used gauges of 0.1mm increments between the throat of the chanter and the thumbhole and 0.25mm between the thumbhole and the bottom of the chanter. He was also using both round and oval gauges to take into account the shrinkage of the wood into an oval shape, a phenomenon that I had overlooked.

Having obtained all the necessary data of your coveted chanter, (or designed your own if you have done more of your homework than I) the next stage is to plot the data on a graph. In this day and age it seems natural to plot your graph using one of the spreadsheet computer programs available, but if you can't use spreadsheets, then fear not, as you can get just as satisfactory results using good old fashioned graph paper (less need to worry about a hard-disk crash!) I have a preference for using graph paper for the simple reason that I find it easier to extract data from between the plotted co-ordinates. There is probably some way of doing this using a computer program, but I have not found it yet.

So, having got over my favorite gripe about the importance of plotting chanter bores, I shall now get down to the actual business of making a reamer. In brief, the method consists of turning a tapered blank with the chanter bore undulations reproduced in it. The cutting edge is then formed in the conical blank, either by milling it out with a milling machine (for those who have access to one) or splitting it down the middle with a hacksaw and dressing up the resultant cut edge with a die grinder or file. Before you read that and tell yourself "Oh that's good, you get two reamers for the price of one" I must remind you that unfortunately you don't, as you will be cutting to one side of a centre line, so if all goes well, you will get one semi-circular section reamer and one piece of less than semi-circular scrap.

A brief word about materials is appropriate at this point. It is as easy to make a reamer out of good material as it is to make it out of bad. I recommend making it out of silver steel bar, which is a high carbon steel, accurately ground cylindrically, and which can be heat-treated to harden it. I must confess to never having attempted to heat-treat a chanter reamer, fearing that the resultant distortion would make it unusable. Silver steel in its unhardened state is in my experience adequate, but then, I have only ever made instruments in ones and twos. Mild steel may also produce successful results where a very small number of chanters are to be made, but what I specifically do not recommend is free-cutting mild steel, which is beautiful stuff to machine, but noticeably softer than mild steel.

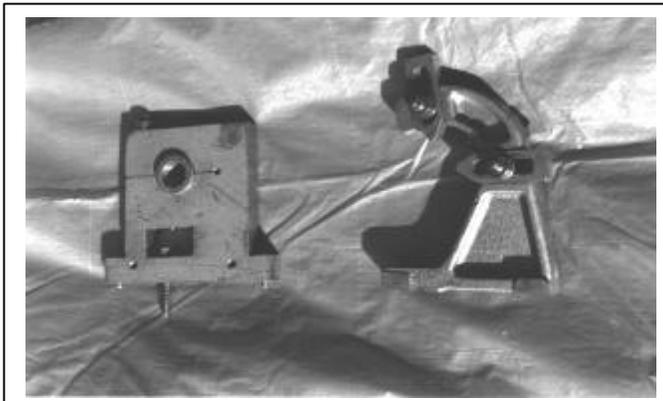
I once made a set of reamers for a flute maker out of free-cutting mild steel. He reported back to me that the reamers did not hold their cutting edge.

Silver steel is generally available from engineering suppliers in 13-inch lengths. While it is available in longer lengths, you will invariably find it difficult to obtain. The most reliable source I have found is :-

Electromail,
P.O.Box 33
Corby,
Northants NN17 9EL
U.K.
Telephone No:- (01536) 204555

Electromail is part of the R.S.Components Group, which has branches worldwide. The catalogue number of a 6-foot length of $\frac{1}{2}$ inch diameter silver steel is 770248.

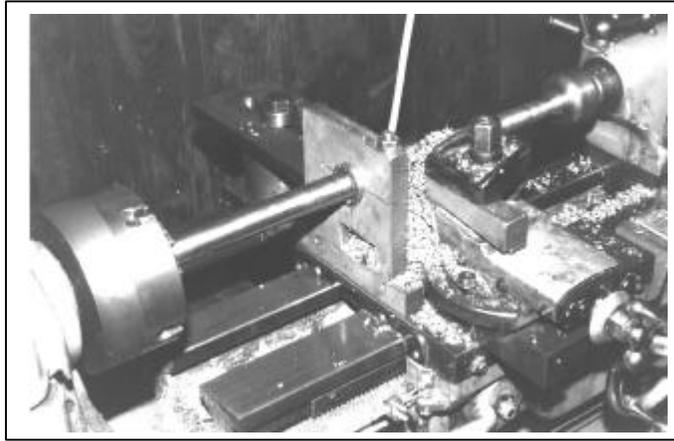
The first problem that will confront anyone trying to machine the conical blank for a reamer is that the reamer for a chanter is so long and slender that it bows in the middle, away from the cutting tool, to a point where accuracy cannot be maintained. We must therefore use some type of travelling steady. A travelling steady is so called because it is attached to the saddle of the lathe, and therefore travels along the bedways of the lathe with the saddle.



Travelling steadies

Conventional travelling steadies, as made by lathe manufacturers, consist of a device with two bronze tips, which bear against the workpiece just ahead of the cutting tool. Personally speaking, I have almost totally given up using such steadies, as the tips wear considerably, especially on small diameter workpieces thus leading to unacceptable inaccuracies.

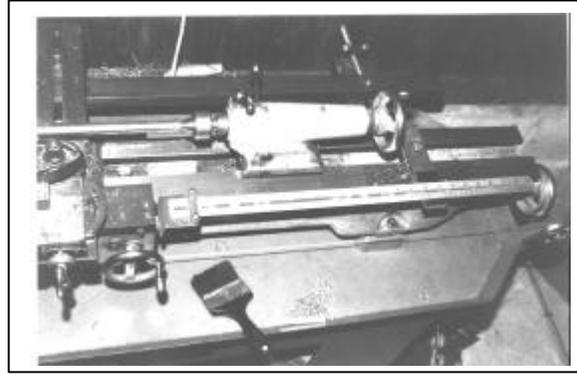
The photograph above shows a conventional steady (on the right) alongside a steady of my own design. My steady consists of a steel plate, bolted and pinned accurately onto the lathe saddle, and bored using a rotating cutting tool held in the lathe spindle, to ensure that the centre-line of the hole falls exactly on the axis of the lathe. A brass or bronze bush, which you will machine yourself, is clamped in the plate using the pinch bolt. While the bush does eventually wear, it will last considerably longer and require less attention than conventional steady tips, because of its larger bearing area.



The steady in use (in conjunction with a taper turning attachment)

I have also experimented with sealed ball bearings held in the plate, but the problem here is that the inner race of the ball bearing tends to be a press fit onto the silver steel workpiece, rather than a sliding fit. It requires considerable work with emery paper to reduce evenly the diameter of the stock silver steel to make it run freely through the ball bearing.

The actual machining of the blank consists of taking a series of facing cuts, using a square-ended tool, into the workpiece and forming a step, or cylinder, whose diameter is determined by reading off its value from the plot. I make my steps (or cylinders) exactly of an inch long (in practice, each step is formed by two facing cuts of $\frac{1}{16}$ of an inch wide. Facing cuts $\frac{1}{8}$ of an inch wide are rather grandiose for my own lathe, the reason being that I use a Myford ML7 lathe, which is equipped with a lead-screw of 8 threads per inch (T.P.I.), and a very convenient handle for rotating the lead-screw. One complete turn of the lead-screw advances the saddle exactly of an inch lengthwise along the reamer/workpiece. Other lathes are not equipped with this handle for rotating the lead-screw; moreover, some lathes – known as ‘plain’ lathes – do not have a lead-screw, in which case the best course of action is to obtain a 24 inch steel ruler and clamp it to the bed, or saddle, of the lathe in such a way as to facilitate the accurate advancing of the lathe saddle by convenient increments. I have attached such a ruler, graduated in eighths of an inch, to my own lathe, because it helps me keep count of the number of steps I have completed. Believe me, it is very frustrating when you lose count and find you have a step too many, or a step too few, and have to scrap your reamer and start again. For this reason, also, it is advisable to cross off each step on your plot as you complete it.

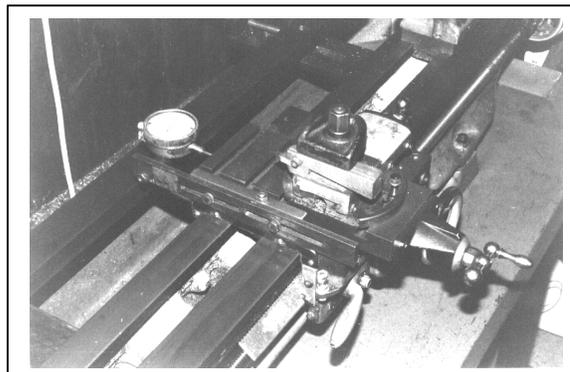


Use of the attached ruler

I work mostly in imperial units, for the above-mentioned reason of the imperial lathe. There is no reason why metric dimensions should not be used. At times I have ended up working in imperial dimensions for length measurements of the reamer, and metric dimensions for the diametral co-ordinates of the same reamer, because my gauges are in metric. Highly unconventional I admit, but it gets the job done.

To facilitate making the individual facing cuts, I calculate and mark off on my plot how far I have to advance into the work piece on the lathe cross-slide. For example, if I am using $\frac{1}{2}$ inch round bar stock, and I have determined and read off from my plot that an individual step diameter is 0.380 inches, I will then have to advance my tool by 0.060 inches $[(0.500 - 0.380) / 2 = 0.060]$, taking the point at which the tool makes contact with the work piece as a zero reference point. I find this takes much of the drudgery out of the task, and it is then only necessary to measure every fourth step with a micrometer, rather than every step. For further convenience, I have attached a dial test indicator (D.T.I.) to the saddle of my lathe, acting on the cross-slide. I find a D.T.I. particularly useful and convenient when used in this way – much easier to read than the cross-slide screw graduation dial – and it can be set to zero. D.T.I.s being available in both metric and imperial, this technique makes it easy to work in metric diameters on a lathe fitted with an imperial cross-slide and vice versa. Any potential causes of inaccuracy due to wear in the steady bush, or the edge going off the tool, are quickly discovered, and a corrective offset applied by rotating the dial on the D.T.I.

Use of dial test indicator



Having completed all of the steps on the reamer blank, the next stage is to smooth off the peaks with a fine cut file, until what you have appears to be a perfectly smooth cone shape (except we know better, having put all that work into it !) Work safely and use a chuck guard at this point, as your hands would otherwise come into proximity with the rotating lathe chuck.

The next stage of the operation is to cut the flute, which, unless you are fortunate enough to have access to a milling machine, will involve cutting the reamer down its centreline with a hacksaw. Work as accurately as possible at this stage, as time spent will make the process of cleaning up the saw cut much easier. First you must scribe the centre-line on the reamer both front and back. To do this, paint the entire reamer with layout fluid and clamp the shank in the chuck of the lathe, supporting the narrow end with a centre in the tailstock. With the tool post removed and a scribing block set with its scriber point exactly to the lathe center height, scribe a line along the entire length of the reamer blank. Now rotate the lathe chuck exactly through 180 degrees and scribe another line along the reamer. Keep the scriber point as sharp as possible for this operation, and make the scribe lines as deep and clear as possible, as the layout fluid tends to come off when the reamer is held in the vice during the sawing operation.

Now we come to the tedious bit! Make life as easy for yourself as possible and invest in a brand spanking new hacksaw blade of 24 teeth per inch or finer. I prefer to use an Eclipse No 60B hacksaw, as it has a handle like that of a file, unlike the more popular pistol grip type hacksaws, which are all very well, until you come to rotate the frame of the hacksaw through 90 degrees to make deep cuts, as on this occasion. Clamp the reamer blank vertically, using soft jaws in the vice to avoid marking the reamer, with the narrow end protruding about ½ an inch out of the jaws, ensuring that the scribe lines are at the front



Eclipse 60b Hacksaw

and back of the vice. Take long gentle strokes, cutting as near to the line as you can without actually erasing the line with the saw cut. Take no more than two strokes between looking where your cut is relative to the front and rear lines. Believe me, you will save time by taking the utmost care at this stage, rather than trying to clean up an untidy saw cut at the next stage, or worse, finding yourself on the wrong side of the line and having to scrap your reamer and start again. Move the reamer up through the jaws of the vice as you cut, not taking the point at which you are cutting too far from the jaws. Remember also that you are gripping a taper, which tends to work itself loose in the vice as you cut. I hope it goes without saying – leave a round shank on the end of the reamer, don't cut it down the middle!

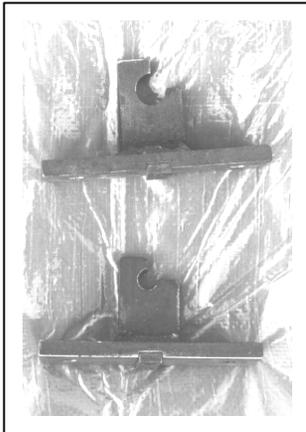
You will notice an unfortunate tendency for the reamer to bow away from the saw cut. There is not much I can recommend you do about this, except gently and painstakingly bend it back when you have finished your saw cut, holding the shank in the vice, sighting along the length of the reamer and applying force with your hands at the point of greatest

curvature. You can check the straightness of your reamer by clamping the shank in the lathe chuck and rotating it by hand. When the reamer is actually in use in the chanter being made, it will tend to follow the stepped bore in any case, so don't lose too much sleep over a slight warp appearing in your reamer.

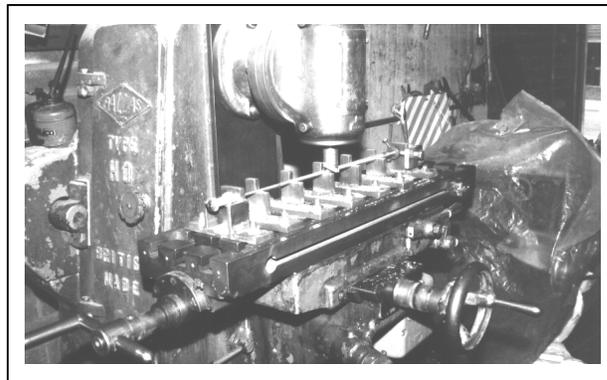
The final stage is to dress up the flat face of your reamer to produce a sharp cutting edge. A flat file can be used although a die grinder will make the work much easier.

Three-quarter section reamers have the advantage over 'D' section reamers in that there is less tendency to warp, but it requires a milling machine to make them. As the same problems occur when milling such a long and slender work piece as when turning them, it is necessary to support the reamer being fluted with a number of fixtures. Fortunately, the vast majority of milling machines (my own included) have a number of 'Tee-slots' running the length of the table. The individual fixture pieces locate into the centre of these Tee slots and can be slid along the reamer/work piece until they grip it firmly.

Reamer milling fixture



Milling fixtures in use



It is important that, when making the fixtures, the axis of the holes and of the end supports all coincide, as distortion of the reamer may otherwise occur. My method of making the fixtures is to fabricate and machine their undersides first, and bolt them one at a time to the same common fixture to machine their bores, taking care not to move the position of the milling table between each one.

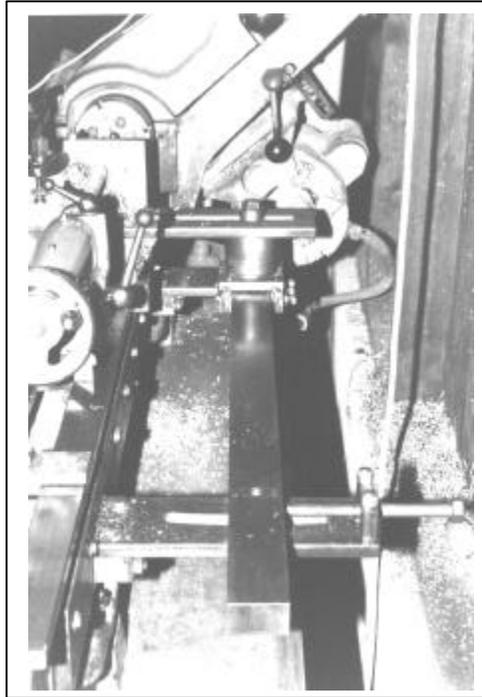
Raising a burr on the forward edge of the flute with a file forms the cutting edge on a 3/4-section reamer. Another advantage here is that, as the burr edge wears off through use, it is a simple matter to raise another burr edge.

Generating Conical Reamers

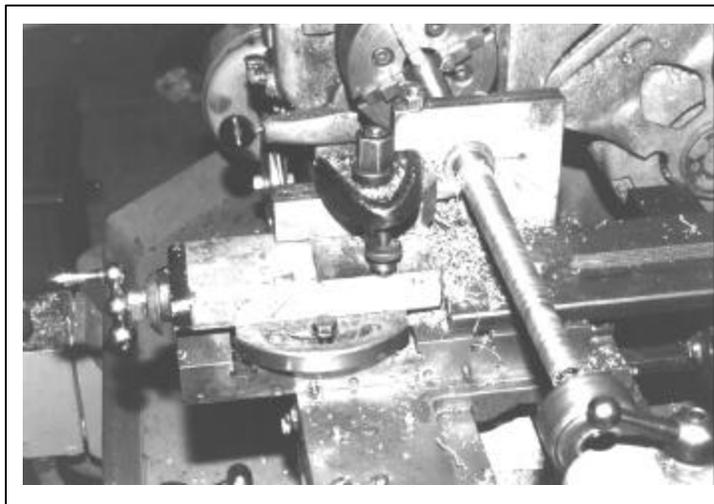
On second thoughts, it would be unwise to omit conical reamers here, as they do have their uses. Having put a lot of effort into making a reamer that reproduces the undulations of an existing instrument bore, it makes sense to save wear and tear on it and use a conical reamer to do the initial cutting on a step-bored chanter, finally finishing off with the 'profiled' reamer.

Most lathe manufacturers provide a taper turning attachment for use with their products, but few provide for the manufacture of tapers of 14 inches or longer. Consequently, I had to make my own. My taper turning attachment works in the way of many others, but a description here might be in order.

Homemade taper turning attachment



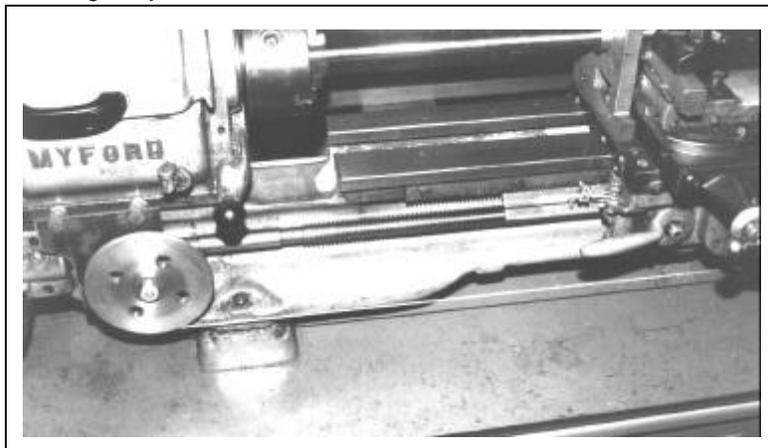
Top-slide turned through 90 degrees to index tool



A length of bright mild steel is attached via two brackets to the rear face of the lathe bed casting. The B.M.S. bar is mounted in such a way that it can be set at any angle to the bed ways of the lathe up to a maximum of plus or minus 5 degrees. On the B.M.S. bar runs a follower, which is connected to an extension piece, attached to the cross slide, the cross slide indexing screw being removed. As the saddle progresses along the bed ways, the cross slide will move across the saddle according to the angle to which the B.M.S. bar is set. Manual indexing of the tool is done by the top slide, which is rotated by 90 degrees on its mountings, and now lies parallel to the cross slide. The taper must be machined in only one pass of the tool. As the cut commences at a depth of typically $\frac{1}{4}$ inch (6mm) it is not possible to use the lathe's own power feed unless you can gear your feed down very slowly. I'm talking in the order of taking about 6 or 8 hours to travel the entire length of the work piece. In the past, I have overcome this problem merely by manually applying a gentle pressure to the saddle advance wheel (in case you haven't already guessed, reamer making can be tedious in the extreme). More recently, I have devised a gravity feed consisting of a weight, which acts on the saddle via a system of wires and pulleys. Gravity feeds have their own set of problems, the main one is that as the cut gets lighter, then the saddle tends to move increasingly faster. If you get your sums wrong and the tool comes out of the cut, then the saddle takes a leap towards the revolving chuck and the lathe goes into a comprehensive self-destruct mode. **YOU HAVE BEEN WARNED!**



The gravity feed



Finally, a brief note about using these reamers. Avoid using them dry; use plenty of Vaseline, linseed oil or other vegetable oil. Step-bore the chanter prior to using the reamer, and form the chanter bore prior to turning the outside of the chanter, as the wood is less likely to split due to the cutting forces involved in the reaming process. Don't let the reamer get so hot that you can't touch it, as it is undesirable to overheat the wood.

Thanks to Sam Murray for sharing his experience and advice on $\frac{3}{4}$ section reamer forms and to Craig Fischer for information and advice freely given on this specialized subject.