Making a hollow mainstock – Part I, Making the hollow shell – *Bill Haneman*

The Mainstock – the missing piece?

Over the past seven years, *Iris na bPíobairí* has included excellent articles on the concert pitch chanter bore, including data from a reputable Leo Rowsome original [1], articles on springs and keys[2], making boring and reaming tools[3], drilling toneholes[4], making Taylor-style drones[5], making a stitched bellows[6], and the making of Taylor-style regulators[7]. With an airtight stitched or riveted bag (which can be obtained from several sources, including NPU), and the straightforward addition of bag stocks, the components of an entire set of pipes have been covered – excepting the mainstock.

At first glance the mainstock may seem a simple affair. While it is true that a basic and minimally functional mainstock can be a straightforward thing to make, the stock can have a significant impact on the comfort, airtightness, and acoustical functioning of a set. Thus I believe the mainstock merits some care in design and execution, in order to get the most out of a set of pipes. In this article I describe my current method for making a thin-walled, hollow mainstock. I have made a sufficient number of these hollow stocks[8] to feel confident that my method is thoroughly shop-tested, but not so many that the method has become routine; however I have no doubt that there are plenty of alternative, or superior, ways of doing things. I will try to set out a "snapshot" of what works for me, in a way approachable by hobbyists or those relatively new to pipemaking. It's my hope that this article may also contain some ideas or observations of possible interest to journeyman pipemakers as well.

Why hollow?

One often hears the assertion that sets of drones featuring hollow mainstocks are superior to drones in solid stocks either in sound or stability. My own experience to date seems to bear this out; drones sharing a common cavity seem to phase lock[9] (i.e. synchronize) more easily and more tenaciously than they do in a solid stock, and a considerable amount of high frequency sound seems to come from the mainstock itself. Placing a hand between the stock and the listener blocks this sound considerably, but placing a hand *on* the mainstock seems to mute it even further. The muting effect is, however, less if the hand is placed on the back/sides of the stock (i.e. so that the part of the mainstock facing the listener remains unobscured). This suggests to me that two things are happening – the drone quills themselves are being heard *through* the walls of the stock, and to a lesser extent the stock walls themselves are participating in the

1 "Phrenology", Craig Fischer, *Iris na bPíobairí,* Vol XVIII No. 4, Autumn 1999, pp 2 – 9.
2 "...Thoughts of Springs", D. M. Quinn, *Iris na bPíobairí,* Vol XXI No. 2, Spring 2002, pp 2 – 8.
3 "Simple Boring and Reaming Tools", D. M. Quinn, *Iris na bPíobairí,* Vol XXII No. 3, Summer 2003, pp 2 - 6.
4 "A Method of Laying Out and Boring Tone Holes", D. M. Quinn, *Iris na bPíobairí,* Vol XXII No. 1, Winter 2003, pp 2 - 6.
5 "Notes on Drones by the Taylor Brothers, Parts 1, 2, 3", D. M. Quinn, *Iris na bPíobairí,* Vol XX No. 2, Spring 2001, pp 2 – 6; Vol. XX No. 3, Summer 2001, pp 3 – 8; Vol XX No. 4, Autumn 2001, pp 2 – 8.
6 "Making a Stitched Bellows, Parts 1 – 4", D. M. Quinn, *Iris na bPíobairí,* Vol XXIII No. 1, Winter 2004, pp 8 – 11; Vol XXIII No. 2, Spring 2004, pp 2 – 6; Vol XXIII No. 3, Summer 2004, pp 2 – 6; Vol XXIII No. 4, Autumn 2004, pp 2 – 8.
7 "A Modern Take on Taylor-style Keywork, Parts 1 – 5", D. M. Quinn, *Iris na bPíobairí,* Vol XXIV No. 1, Winter 2005, pp 3 – 6; Vol XXIV No. 2, Spring 2005, pp 2 – 10; Vol XXIV No. 3, Summer 2005, pp 2 – 9; Vol XXV No. 1, Winter 2006, pp 2 – 7; Vol XXV No. 2, Spring 2006, pp 3 – 9.
8 As of this writing, I have constructed 11 such mainstocks including those currently being completed.
9 Phase-locking is the name given to the phenomenon whereby oscillations or repeating motions tend to synchronize with one another, in unison or in integer ratios of one another, via a connection via a common linkage or medium (such as nearby, surrounding air).

resonance phenomena somewhat (since damping the stock walls with the hand changes the sound more than just placing the hand between the stock and the ear).

While the phase locking advantages of a hollow stock can be achieved by any approach that places the drone quills in a shared cavity, the benefits of these second phenomena can only be achieved with a thin-walled stock of the sort occasionally found in original 19th century union pipes. Notable makers who used hollow stocks (though possibly not exclusively) include Kenna, Coyne, and Harrington. A few modern makers still make this sort of hollow stock as a standard part of their sets, and a number of others will make them on request. For the reasons outlined in the previous paragraph, I believe that a hollow mainstock is well worth the extra effort for someone building their own set of pipes.

A 19th century example

One of the finest surviving examples of an original 19th century hollow stock that is available for close examination is part of a Kenna set pitched approximately in modern C. This stock was described in detail in Volume 2 of the Sean Reid Society Journal, in an article by Ken McLeod and Wilbert Garvin[10]. Fortunately Ken and Wilbert have been generous enough to allow me to reproduce some of the drawings that accompanied that original article, so we shall have an excellent original example for our model.

I have kept to the original model fairly closely in my own design, but having said that I should draw attention to a few places where I have diverged from the original. For one thing, Kenna would have formed the tubes into which the regulator reeds and reed tenons fit from rolled sheet brass; because we want our tubes to be light and as round as possible, I take advantage of modern seamless hobby tubing for this. Some have suggested that tapered tubes are preferable, but the Kenna original does not seem to have had appreciable taper. Those interested in doing the additional work to taper the tubes may find the results rewarding. Secondly, the Kenna original stock had a most ingenious and unusual shaft for the drone switch, which tapered along its length and incorporated a leaf spring. No doubt this helps keep the stock switch connection air tight when the drones are on, and helps prevent the switch from opening or shutting accidentally. However in the interest of simplicity I have substituted manufactured brass bar of constant diameter, and using a low-friction, close-fitting bushing of Delrin to help keep the switch airtight. Many makers, including Coyne and Harrington, seem to have used cork for this same purpose. Again, interested readers may consult the original drawings (Illustrations 1 and 2) if they wish to attempt a more faithful reproduction of the switch assembly. I am however retaining the rear guide and convex valve sealing arrangement from the original Kenna drone switch, which I find ingenious, not too difficult to make, and superior to other arrangements which I've encountered.

While I think it advantageous to use the original stock as a model , I have no qualms about using modern tooling or equipment to do the job, if they suit the tasks at hand. While the entire act of hollowing the stock can be accomplished with boring bars alone, I find it much faster and surer to use modern sawtooth and Forstner bits. Likewise I have no objection to electric lathe power and incandescent light in lieu of a foot treadle and a south facing shop window!

The regulator feed tubes have two important roles; firstly they enclose and isolate the regulator reeds from the drone chamber, which prevents them from interfering with vibration of the phase-locked drone reeds (a problem observed in early Union Pipes, before the regulator feed tube innovation was introduced, probably in the 1780's); secondly and more obviously, they allow the regulators to be sounded even when the drones are shut off.

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10 "A Timothy Kenna set of c. 1835 pitched about modern C", Ken McLeod and Wilbert Garvin, *The Seán Reid Society Journal,* Vol. 2, Chapter 2, March 2001.

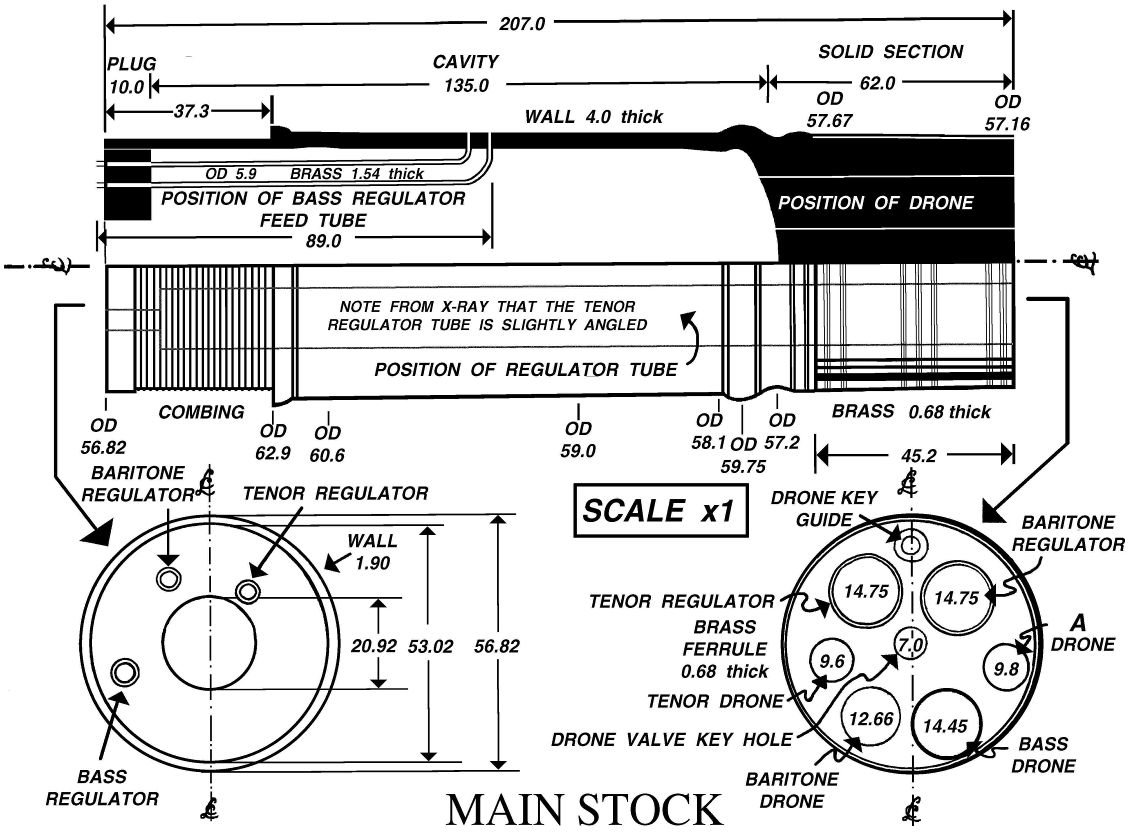


Illustration 1: Side and end views of the Kenna mainstock, with dimensions (Courtesy Wilbert Garvin and the Seán Reid Society)

Tooling and workholding considerations

The biggest challenge you will face in making a hollow stock may be the secure holding of the workpiece (i.e. wood which will become the mainstock) and tools. Boring a wide, deep hole into a piece of hardwood requires lots of torque unless done in many stages, and you are liable to put strongly off-center/unbalanced forces on the wood as you work (this is one reason why modern Forstner bits hold some advantage over the use of a boring bar). Holding the wood in an ordinary chuck will simply not do, nor will flimsy boring bars or steady rests. The more secure and vibration free your setup, the less likely the workpiece or tooling will come loose – and if it does comes loose, you will almost certainly destroy the workpiece and you may risk personal injury as well.

In the end I found that the most secure way to hold the workpiece in the headstock was to use a faceplate chuck with multiple woodscrews. Even so, not all woods hold screws well, so you may wish to pre-drill the holes and fill them with polyurethene glue before inserting the screws. Tightening loose screws after you start work will be difficult at best, so try to avoid the need.

While boxmakers often hold wood in a faceplate chuck without any additional support, hollow stocks are quite long and the bores quite deep compared to pillboxes. You will need a sturdily built ball bearing steady at the "outboard" end of the stock blank as well. Moderate speeds are called for when hollowing the inside of the stock – I use speeds of under 200 RPM for the boring stages both to increase torque and reduce heat generation while boring, and to reduce chatter. When turning the outside of the stock, higher speeds are OK, but bear in mind that the relatively larger diameter of the stock when compared to most spindle turned workpieces still calls for modest speeds (say, no more than 800

rpm). This range of speeds conveniently lies within the range of most metal lathes, which also offer the rigidity and tool cross-feed arrangements which one needs for this task.

What you'll need

In keeping with my previous article on making a triple-bored bass drone, I give a suggested list of tools and materials below. You may wish to amend the list based on your own existing tooling and setup, after you've read the step-by-step description of the process.

- a lathe (preferably a metal-turning lathc), minimum 35 – 40 swing over the cross slide, and 250 - 300mm between centers
- a sturdy three-point ball-bearing steady which can accept at least a 63 mm diameter spindle
- a boring cradle which mounts to the lathe cross-slide (plans provided below)
- boring bits: 10 mm, 12 mm, 15 mm, 16 mm
- a rigid, tailstock-mounted 18 mm bit (optional)
- Forstner or sawtooth bits: 25 mm, 32 mm (optional), 40 mm, 50 mm
- a short boring bar
- suitable timber, minimum 65 x 65 x 250 mm
- live center
- sturdy faceplate (sometimes called "faceplate chuck")
- 2 prong drive center
- machining-style facing cutter for toolpost (for 'machining' operations on the timber)
- hand turning tools and toolrest (for beads and decorative turning on the mainstock)
- brass rod, 4 to 5 mm diameter and 225mm long, for the switch shaft
- brass bar stock for the switch key (may forge this integral to switch shaft if you prefer)
- brass pin or rod, 3 mm diameter and 40 mm long
- brass seamless "hobby tubing", 19/32", and 5/8" outer diameter, 1/32" wall
- 16 mm brass rod (short length)
- clear silicone caulk
- hide glue (liquid or pearl form)
- brass sheet 1.0 to 2.0 mm thick, min. 40 mm x 12 mm.
- 2 short brass screws
- brass sheet, 0.7 mm thick, 50 x 200 mm.
- 'silver solder' or brazing rod, torch, and borax-based flux powder.
- soft leather, 30 x 30 mm scrap
- 30 mm diameter metal coin or disc

Turning the shell

Steps:

1) Select a suitable billet and true one end while turning between centres. (Illustration 2)

Illustration 2: Facing the end of a new billet

2) Mount the billet's trued side on a faceplate (Illustration 3), grease the headstock threads or morse taper socket, and mount the billet in the lathe.

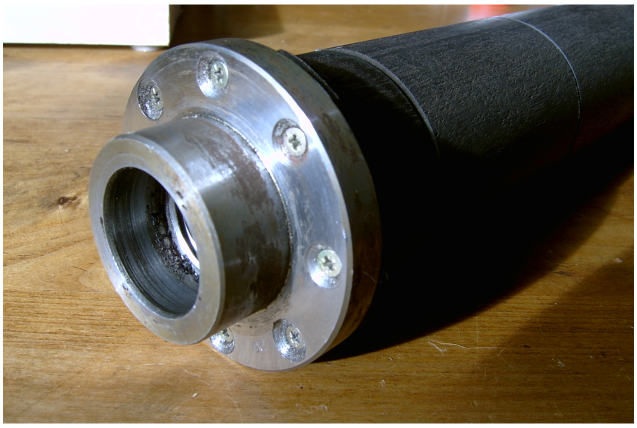


Illustration 3: Faceplate, attached to the end of a billet

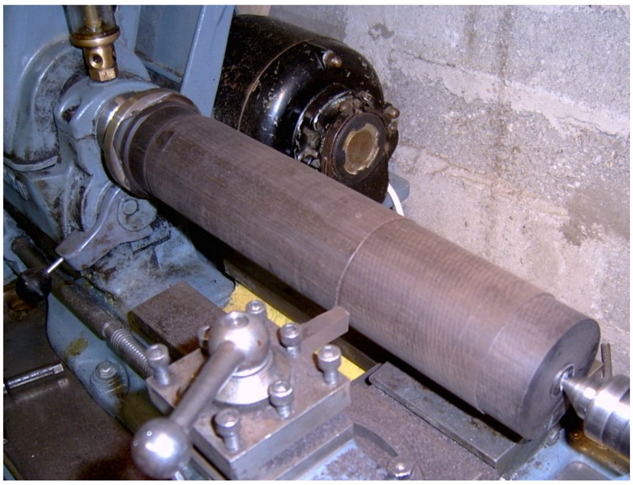


Illustration 4: Rough-turning the billet

3) Rough-turn the blank at moderate speed, turning a smooth cylindrical bearing surface at the outboard end. (Illustration 4)

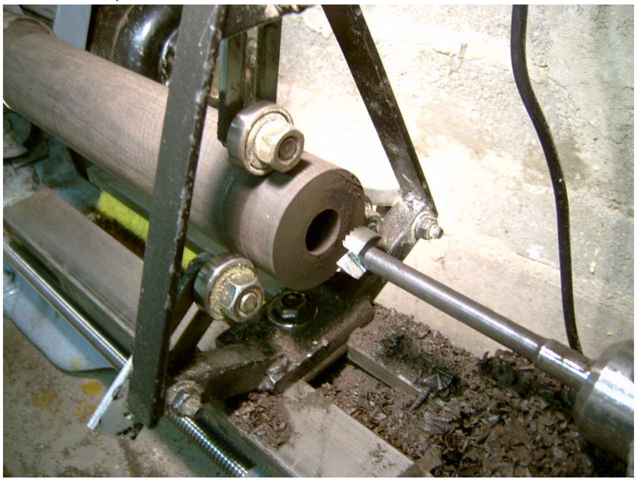


Illustration 5: The three point ball-bearing steady after the 25 mm boring pass

4) Using the lathe tailstock to keep the blank centered, mount the blank firmly in the ball bearing steady. Lubricate the bearing surface of the timber with some hard wax (for instance carnauba wax or "woodturner's stick"). (Illustration 5)

Illustration 6: The 40mm boring pass, in ebony

5) Bore to 40mm inner diameter to the target depth (145mm in our example) in stages; for very hard timber such as ebony I start by boring a 17.5mm diameter hole with a tailstock-mounted drill, then switch to sawtooth or Forstner bits of 25mm, 32mm, and finally 40mm. (Illustration 6) A Forstner bit extension may be required for the deep boring, which in our example is 145 mm deep).
6) Remove the billet, still mounted to the faceplate, and set aside to settle for weeks or months.
7) Mount the billet again; mount a plug in the billet at the outboard end, re-center, and take a very thin shaving from the bearing surface to restore it to circular cross-section if it has gone oval. You may wish to "start" the 50mm inner bore using a boring bar for a few mm before switching to the Forstner or sawtooth bit.
8) Bore to 50mm inner diameter. Set aside for weeks or months.

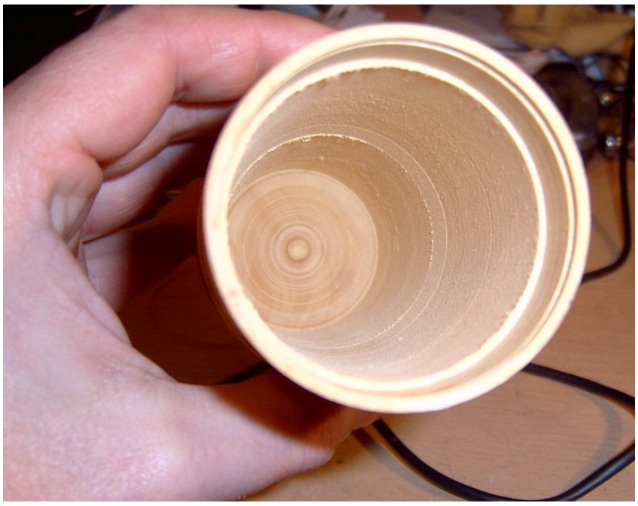


Illustration 7: Boring complete, the shell walls have reached their final thickness

9) Repeat step 7, and use a boring bar to turn a short "step" of about 52 to 53 mm inner diameter at the outboard end. The resulting shoulder will hold the stock end plug firmly in place for final assembly. (Illustrations 7, 8)
10) Turn the outside of the stock, including the decorative beads and coves.
11) Seal and finish the outside of the stock as appropriate, fine-tune the outer diameter of the end of the stock where the reed tenons will be inserted to match the metal

ferrule you have prepared. Part off the mainstock in the lathe.

12) Turn an end plug for the stock which mates against the inner diameter and shoulder.

Illustration 8: The completed hollow stock shell, finished and ready for parting-off

While I don't finish the outside of the stock before boring, I advise rough turning the blank to a few millimeters larger than the largest finished diameter – this helps balance the stock and reduces the amount of roughing out required after the inner chamber is bored, while keeping the walls a little thicker than their final value while boring, and allowing for a millimeter or so of eccentricity in boring the inner diameter. After the center diameter is finished, I fit a close-fitting plug and re-center the stock around the inner diameter before bringing the walls to their finished thickness.

I turn the outside of the mainstock with a combination of “machining” style technique, using a toolpost mounted on a slide adjusted for a slightly tapered cut for the cylindrical sections of the stock outer dimensions, and woodturning techniques using a tool rest for the ornamental beads. It pays off to keep the tools as sharp as possible, especially when making the final passes; even so. machining techniques (as opposed to spindle turning techniques using such tools as sharp skew chisels) tend to leave a poor surface finish on some timbers. Depending on the timber I may make the last passes with a skew. In the case of highly figured timber or timber with interlocking grain, relatively coarse abrasives (120 grit and downwards) may be required; in any case I work downwards to at least 400 grit and finish off with “0000” grade steel wool (000 is too coarse).

While some timbers, such as ebony, need little or no exterior finish, I do apply a shellac based sanding sealer to the ouside of all my hollow stocks. Eventually a near perfect finish with little openness in the grain can be obtained for most wood, without building up a thick finish. For lighter woods I sometimes use a shellac-based finish similar to french polish. Shellac finishes are not resistant to alcohol, so you may wish to apply a hard wax finish to the outside. I use “woodturner's stick” which contains carnauba wax, followed by a beeswax/carnauba formulation of paste wax, rubbed in and then lightly buffed.

One timber which I have heard recommended due to its lack of “movement in service” (i.e. its stability) is Bubinga. However the people who have recommended this timber use it for solid mainstocks. On the occasion when I used this timber, many coats of shellac were required inside and out, to seal the pores of the wood. Prior to this treatment, the entire stock exhibited very little resistance to airflow! Ebony certainly does not share this disadvantage, though it does tend to be somewhat brittle. Some makers routinely make hollow stocks from ebony; these probably deserve to be treated with considerable care. Other timbers which seem suitable in my experience or the experience of other makers of hollow stocks include pearwood, cherry (European or American), boxwood, rosewood, and narra; maple or close-grained walnut can be used as well, although it should be well seasoned and both timbers reportedly move a fair bit with changes in humidity.

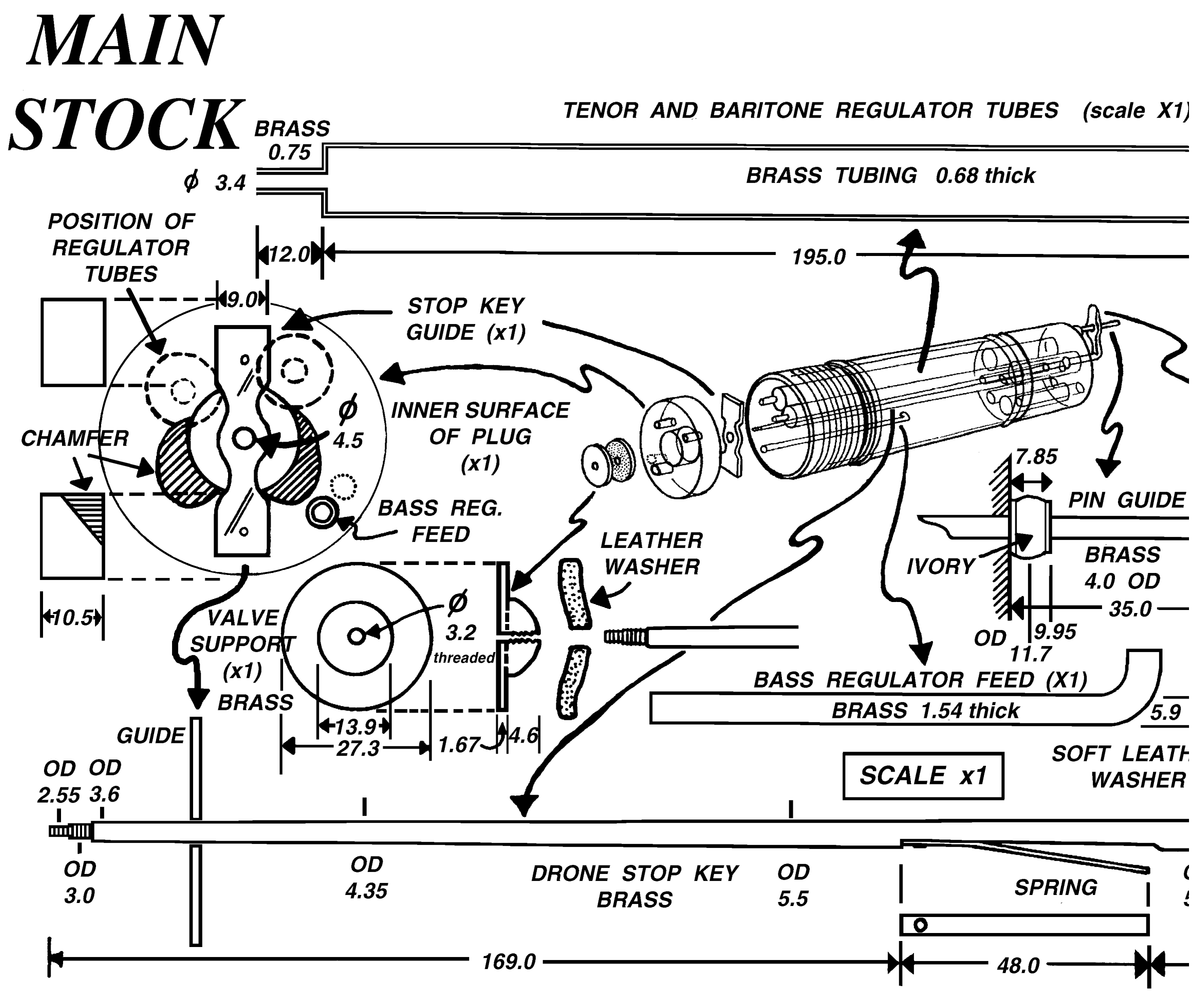
I have been preparing the ferrules (both the stock cup ferrule, into which the removeable end of the mainstock fits, and the semi-permanent ferrule at the outboard end of the mainstock) before the final preparation and parting off of the stock itself; this makes the business of fitting the ferrules a bit easier in the event that the ferrules are not precisely the size one intended. Once I am confident in the dimensions of the ferrules, I turn the rear tenon 2 to 3mm smaller than the inner diameter of the stock cup, to allow for

ample thread packing (this helps with airtightness and stock removal). I turn the front ferrule tenon to a tighter fit, snug at front and rear or even 0.1mm oversize, with a central recess of about 1.2mm diameter less, to allow for a thin layer of thread packing under this ferrule.

At this stage the body of the hollow stock is complete, and the hollow stock can be parted off (or nearly so) at the target length of 205mm, using a very thin parting tool. The last few millimeters should be parted off with a thin saw blade, with the lathe off, and sanded flush, to prevent any mishap when the rotating stock separates from the portion still attached to the faceplate.

If the close-fitting plug that was used to turn the outside of the stock after the end shoulder was turned was only a temporary plug, an end plug of matching timber can be turned from the wood that remains on the faceplate. This should be a reasonably close, even snug, fit, but not so tight as to wedge against the inside of the stock, since this would tend to split the thin walls of the stock. Some original hollow stocks seem to have used plugs of boxwood even when this was not the primary timber; I have no strong opinion on whether this practice is a good or bad idea, but I would advise using well-seasoned end-grain boxwood if you choose this approach. Before parting off the end plug, I bore a 19 to 20 mm hole in the center of the end plug, so that the end plug is not so much a disc as a “washer shape”. Since the shoulder in my mainstock end only extends for about 5 mm into the stock, my end plug has a mating shoulder which fits into it, thus for a 50mm inner diameter stock with a 53 mm shoulder, I turn an end plug of 50mm minimum diameter with a 5mm wide, 53 mm diameter shoulder.

In the next installment of this article, we'll discuss making the regulator feed tubes, boring the tenon sockets, building the drone switch, and final assembly. In the meantime, a more complete set of photos documenting the process will be available at http://www.billhaneman.ie/making#hollowstock. If you have questions about this article, please feel free to email me at bill@billhaneman.ie.



Making a Hollow Mainstock – Part II, Air supply and assembly – *Bill Haneman*

Boring and fitting the regulator feed tubes

Illustration 10: Layout of tenon bores on the outboard end of the stock

It now remains to bore the holes in the stock into which the various drone and regulator tenons will fit, to bore the axial hole into which the stock drone switch shaft will fit, assemble the switch itself, and to fit regulator tubes and guide plates into the end plug. (See Illustration 9 for an "exploded view" diagram of the original Kenna mainstock) I suggest checking your plan for the tenon bores, including the expected diameters of the reed tenon "shoulders", by drawing it on the stock end, as in Illustration 10.

Doing this securely requires some sort of boring cradle. Personally I prefer doing this on the lathe rather than attempting to bore the holes in a drill press with some sort of vertical cradle. A shopbuilt boring cradle can be attached to the cross slide of the lathe and advanced securely into a headstock-mounted bit using the leadscrew feed. Because not all of my stocks have the same outer diameter, the cradle "jaws" are V-shaped

rather than semicircular. When the top jaw is tightened down, the four points of contact distribute the gripping forces among four equidistant points on the stock. Being solid, the front of the stock can be gripped quite tightly; the rear may need a more modest grip, but the cradle does need an “end stop” at the back to prevent the stock from slipping readwards as it is advanced into the boring bit. If the front and rear ferrule surfaces, where the cradle jaws make contact, are different diameters, I can keep the stock level by shimming with closed-cell foam.

The center of the mainstock as held in the cradle need not be exactly at the lathe center height; a little contemplation will show that a combination of rotation of the stock within the cradle and lateral movement of the cross-slide will bring almost any point of the stock in line with the drilling axis. However in order to drill the hole for the switch shaft exactly on-center, the stock does of course need to be at lathe center height. In practice it is a good idea to plan the cradle accordingly. Also, if you wish to angle one of the regulator tubes upwards or downwards (see discussion below), this can be accomplished by angling the cradle a bit with respect to the cross-feed; this means that your attachment design should allow for one or two degrees of movement in this direction.

The exact cradle design which suits you best depends of course on your lathe. My own boring cradle, constructed of hardwood, is shown in Illustration 11. The cradle is mounted to the cross slide using three 'T' bolts, only one of which is visible. You may wish to add another T bolt and a strip across the top 'V' sections for extra rigidity. Lastly, note that the bottom points of contact with the stock may rotate by a couple

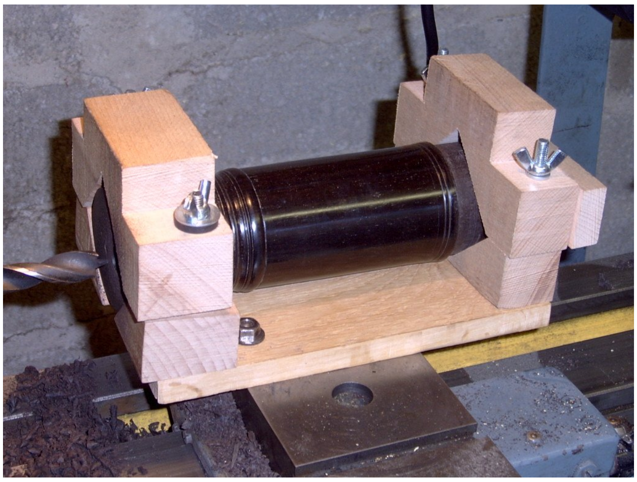


Illustration 11: Boring cradle in position

of degrees around the vertical bolts – this allows them to securely grip slightly the slightly tapered ferrule seat.

In the original Kenna mainstock, the tubes housing the regulator tenons are not exactly parallel to one another. This is a feature that I have observed on other original hollow stocks as well, and I believe it to have been intentional. A common complaint of regulators is that, due to the difference in elevation of long keys such as the baritone D when compared with short keys such as the tenor regulator's F# and G keys, the tops of the keys do not “line up” evenly along the length of the regulator. Typically the D baritone regulator key is “too high” compared to the tenor, which means that the line along which the wrist must fall when playing the regulators has a sort of “twist” as one goes from top to bottom. Angling the baritone regulator downwards somewhat relative to the tenor addresses this problem, causing the tops of the keys to be more even in height. This is achieved in the original Kenna stock not by angling the baritone downwards, but rather by angling the tenor upwards slightly (the reason for this being that angling a regulator downwards is impeded by contact between the regulator tube and the inside wall of the stock).

Depending on how you have constructed your boring cradle, this may be achieved when boring the holes for the regulator tubes, and by a corresponding shift in the small holes in the end plug. Note that in Illustration 1 of the previous article, the tenor regulator's feed tube is nearer the stock axis than the baritone's, demonstrating the fact that the tenor regulator is slightly angled.

While it is possible to bore the regulator with standard brad-and-spur bits, better results are obtained with small Forstner bits. Alternatively, the brad and spur bits can be used to bore holes slightly undersize, which are then “cleaned up” with either manufactured straight reamers or homemade D bits. Some original stocks seem to have had slightly tapered regulator tenon tubes; this means that regulators are tightened or loosened easily with a satisfying 'pop' rather than being laboriously coaxed into and out of a

cylindrical socket. While this is worth trying, it means doing without the near-perfection of commercially drawn seamless tubing, and may require a larger tenon on the regulator if you don't want to restrict the width of the regulator reed which will fit.

Personally I still use commercially drawn tubing; the most conveniently available, and thinnest-walled tubing, seems to be the “hobby shop” tubing from K&S which comes in Imperial sized 1/32” increments. Sizes between 9/16” and 21/32” O. D. seem to be the most useful – taking into account the constraints of reed head size, tenon size, mainstock size, and necessary clearance between tenons and the shoulders of the regulator “ring” mounts (which prevent the tenons from being inserted too deeply into the sockets). While on the original, the feed tube diameters are nearly identical, I like to use a smaller diameter for the tenor regulator than the baritone. On the other hand, making them the same allows for a switch from right-handed to left-handed.

Thoughts about the bass regulator

Attaching a bass regulator to a hollow mainstock presents some additional engineering challenges. I won't go into great detail in this article (preferring to leave our example as a ¾ set), except to observe that many of the bass regulators on surviving 19th century examples of hollow mainstocks appear to have been later additions. Even in cases where the bass regulator seems original, cracking or other damage is often evident at the point of attachment. If you wish to consider adding a bass regulator, I would suggest that the method of attachment of the bass bar is important. Personally I suggest eschewing wood screws in favor of using bolts or machine screws to “sandwich” the thin wooden wall between outer and inner plates, with thin leather gaskets between; this to reduce stress on the timber itself. (I will freely admit, however, that I have not seen a historic example which uses the two-plate attachment method.) I have seen bolts used in lieu of screws. The original Coyne stock formerly owned by Willy Clancy (Illustrations 12 - 14), which featured a bass bar, appears to have used screws (though it is hard to know now, since the bass bar has since been attached to a replacement stock), but had walls noticeably thicker than our Kenna example, perhaps because of the additional strain of the bass regulator.

Illustration 12: The Willy Clancy Coyne stock, showing the bass regulator's point of attachment

At this stage I bore the axial hole for the drone switch shaft, at either 4mm, or 5mm depending on whether I have chosen to use 3/16” or 5mm shaft stock. Especially if I go with 5mm for both, I use a rat-tailed file to enlarge the hole so that the shaft will not bind when the stock shrinks (as it inevitably will) during dry weather. I also bore a rather shorter hole, concentric with the first, of either 8 and 10mm diameter (depending on the size of the shaft). This hole doesn't go all the way through the solid section of the mainstock, but only 15 mm or so; this hole forms a socket into which a bushing will be placed to keep the drone switch airtight. (see below).

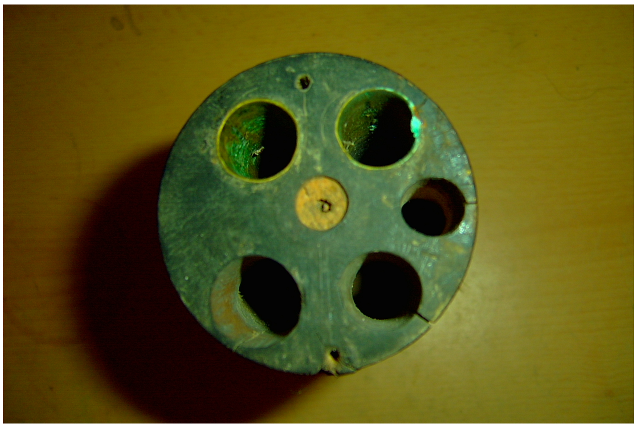


Illustration 13: Front view of the Clancy Coyne mainstock

Illustration 14: Rear view of (damaged) Clancy stock, showing full-length regulator feed tubes

Illustration 15: End view of the original Kenna mainstock

Some original hollow stocks, like "Clancy Coyne" stock (Figure 14), have regulator tubes which extend at full diameter through the end plug. This may make the whole affair a few millimeters shorter, but it may also reduce the isolation the regulator reeds have from the rest of the acoustic system. The consensus (if one can call it that) among union pipe antiquarians I have spoken to seem to be that Kenna had the better idea in this respect (Illustration 15), and so I follow the practice of using reduced size feed tubes for the regulators. To accomplish this I turn end plugs from 16mm brass stock that fit into the seamless tube, drilled to accept 4mm inner diameter hobby tubing, and braze the whole assembly together. I then bore holes into the end plug at the appropriate positions, prepare a guide plate for the switch shaft, attach the guide plate to the end plug with short screws, and test- fit the whole assembly together. The component parts are shown in Illustration 16.

Illustration 16: Regulator feed tube components, pre-assembly

When boring the holes that will accept the regulator tubes, I bore then a bit oversize (choosing the next size up in mm from my Forstner bits). This helps prevent the "metal inside wood" dilemma which so often leads to cracking, and gives room for a sufficient layer of the caulking material which makes the whole assembly airtight.

I confess to not knowing what the Kennas and Coynes used to make their hollow stocks airtight; in some cases it looks like a mixture of thread and cobbler's wax which served so many needs in 19^{th} century pipemaking. For my part I use

clear silicone caulking compound to seal the gap between regulator tubes and the holes in which they fit, for several reasons; it's readily available, gives plenty of working time, seals gaps very reliably, and can be removed when necessary with a bit of effort. I emphatically do NOT recommend using epoxy – not only is it suspect in the airtightness department (as bubbles and air gaps are likely to form), its permanence will mean that your hard work is essentially unmaintainable in the long run – any repairs down the road are likely to mean serious damage to the stock. I have encountered an original 19th century hollow stock which was "repaired" in this manner, and as a consequence it is impossible to make any further repairs on it and it has had to be permanently retired. It may be that old-fashioned pearl glue (made from animal hides, and applied hot) is actually the best material, but it takes some practice to use effectively. Poorly applied, it would probably fail the airtightness requirement and could "gum up" the workings of the switch shaft. It's worth noting that this is not a load-bearing joint; the main requirements are airtightness and maintainability.

Illustration 17: Regulator feed tubes, "potted in" to place with caulk; showing Delrin bushing

Once the regulator tubes are bedded in (Illustration 17), while the caulk has not fully set, I caulk the narrow "feed tube" ends and fit the end plug into the stock. To hold the end plug in place I use hide glue (the convenient liquid hide glue form seems fine for this, though it's weaker than the fresh hot form). You will find that the exact rotation of the end plug in its socket will have a profound effect on the orientation of the regulators; so it's a good idea to either place dowels (or regulators!) into the tubes to check their alignment, both with one another and with respect to the drones. Since rotating the end plug as little as a degree will alter the angle between the regulators, this is a final opportunity to fine-tune the angling of the tenor with respect to the baritone which we mentioned earlier. (Illustration 18)

Fitting the switch

As I have mentioned earlier, the original Kenna drone switch was ingenious in several ways. I won't propose to replicate it here, but I do copy the form of the "switch plate" which serves as the valve itself. Rather than a flat disc, the metal plate against which the leather gasket fits takes the form of a dome which fits against a disc, in a shape reminiscent of an inverted bowl, or a flat bowler hat. This shape seems to improve the airtightness of the switch seal while being "self centering" (an advantage since we have chosen to make the switch shaft a somewhat loose fit in its guide). The additional thickness also makes it feasible to thread the disc securely, While I still usually fit a "locking nut" at the far end, it's only a precaution and the risk of stripping either male or female threads seems less than with the traditional thin metal disc. I turn the dome from

16 mm solid brass rod. I do defer to the more recent "tradition" of using a coin for the disc portion of the shape (brazing the coin to the dome), but, inflation being what it is, I now use a 2 euro coin rather than the traditional 19th century farthing. (Illustration 19)

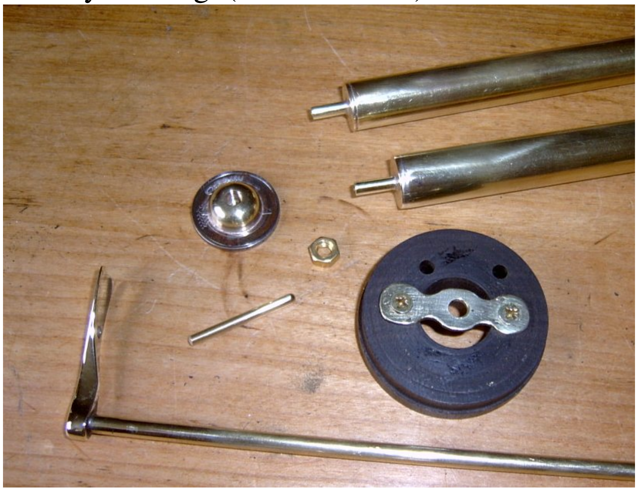


Illustration 18: Regulator feed tubes and switch components, including the convex switch plate, brass guide plate (attached to the end plug), switch key guide pin, and locking nut

Before fitting everything together, I make a small bushing that fits closely into the 8 to 10 mm central socket at the front of the hole where the switch shaft will be inserted. I bore a in this bushing so that it is a sliding fit against the shaft; too loose, and air will escape around the shaft; too tight, and the drone switch may bind if the timber shrinks and compresses the bushing. I figure that this bushing will eventually wear and may become less air-tight over the years, but it is easily replaced. I use a relatively low-grab water-soluble glue to hold this bushing into the timber, but in fact since it's constrained by the switch it is not important that the bushing stay fixed in its socket.

The switch can be constrained from rocking between the regulators either by a pair of pins, one on each side, or by a single pin which passes through a hole in the switch key, as in the original Kenna. The fit in the hole, if you use the original design, should not be tight, since the key will flex a bit with the leverage used to open the switch and this can cause the switch to bind. I turn two small wooden bushings that fit against the outside of the stock, corresponding to the ivory bushings on the original; one fits around the locating pin, and the other around the switch shaft. The completed assembly is shown in Illustration 20.

Illustration 19: Completed mainstock for half-set showing switch bushings, regulator plugs, and drones (in background)

Tying it all up

At this stage, we have finished our hollow stock, and all that remains is thread wrapping our drone and regulator tenons to fit, fitting the stock cup, and tying the stock into the bag.

If you have made it this far, either in the workshop or the armchair, I sincerely hope that this description of my method has been helpful, entertaining, or both. If you have any questions or comments about the article, please feel free to contact me at the email address bill@billhaneman.ie.
You can also find a slightly expanded range of full color photographs documenting the process, and illustrating some hollow stocks, at http://www.billhaneman.ie/making.html#hollowstock

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