THE REPAIR SHOP

INSTALLING A NEW BELL TENON
ON A B♭ SOPRANO CLARINET

by Lars Kirmser

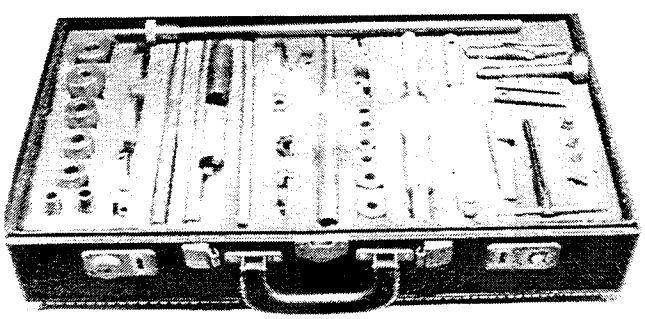
The replacement of the Bell Tenon on the B♭ soprano clarinet is indeed similar to the replacement of the center tenon, with a few significant exceptions. Equipped with the appropriate tools, supplies, and machinery, this task may be accomplished quickly and accurately. Naturally, in order to justify the initial setup expense, one should expect that the need for this tooling would present itself on a fairly regular basis. Otherwise, it may be more economical to subcontract the job to a shop already adequately equipped to perform this task. A typical B♭ soprano clarinet *bell tenon replacement* will take approximately 1.5 hours to complete.

TOOLS, MATERIALS, AND EQUIPMENT REQUIRED:

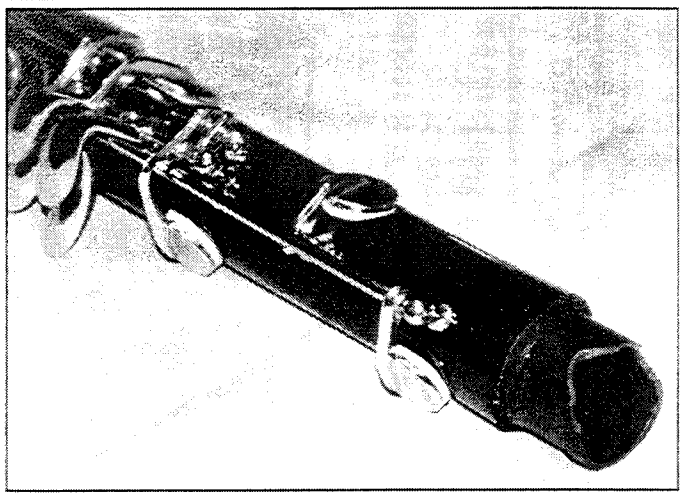
- ☑ Machine Lathe
- ☑ Machine Lathe Accessories:
  - Live Center
  - Jacobs Chuck
  - Lathe Cutting Bits
- ☑ Drill Press w/ complete 115 piece drill-set
- ☑ Tone-hole Drilling Jig (Ferree G74S)
- ☑ Belt Sander
- ☑ Clarinet Bell Tenon Mandrel (Ferree G71B)
- ☑ Clarinet Cutter (Ferree G71C),
- ☑ Clarinet Bell Tenon Reamer (Ferree G106)
- ☑ Tenon Blanks (Ferree G73A, G73B)
- ☑ Lower Tenon Plug Holder (Ferree G66)
- ☑ Armstrong 2-part Epoxy w/Black dye
- ☑ Post Tap (usually 6-32, 8-32, 4 - .5)
- ☑ Leather Wrap (approx. 6" X 6", 1/16" thick)

PROCEDURE:

- Remove the Low A♭/E♭, Low F♯/C♯, and Low E/B Keys
- Remove the lowest post (supporting the Low E/B key)

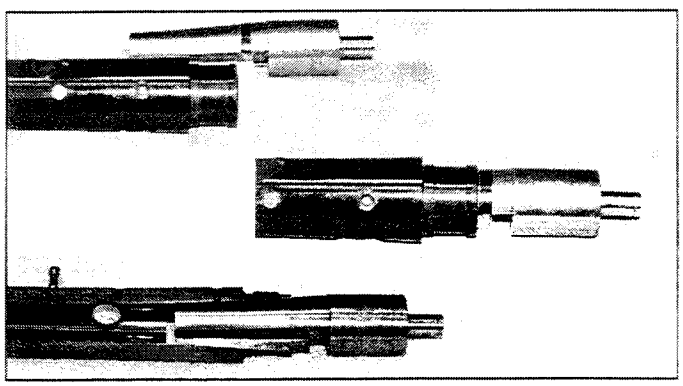


Illus. #1 - I like to keep all my tenon grafting tools in this converted trumpet case

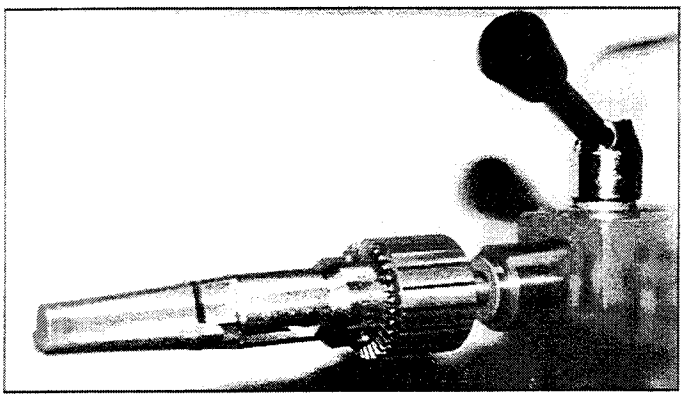


Illus. #2 - The broken tenon as it arrives at the shop

- Prior to removing the remains of the broken tenon, place the Bell Tenon Reamer (G106) inside the bore of the lower clarinet section so that you may determine the exact depth of cut that will be necessary to match the bore of the replacement blank to the existing bore of the lower section (Illus. 3). Place a piece of masking tape on the Bell Tenon Reamer to indicate the precise position where the tenon ends. Remove the Bell Tenon Reamer and set it aside for the time being. Before you establish this position, however, take a moment to check the placement of the blade of the G106 relative to the G106 tool body. The cutting blade of the reamer is held in with two set screws. The success of the reaming process will be determined in part as to the relative positioning of the blade in the slot. For softer polymers (i.e. delrin) position the blade so that it extends approximately 1/8" beyond the end of the tool holder. For wood, extend the blade approximately ¼" beyond the end of the tool holder. You may have to experiment a bit to find the best positioning.

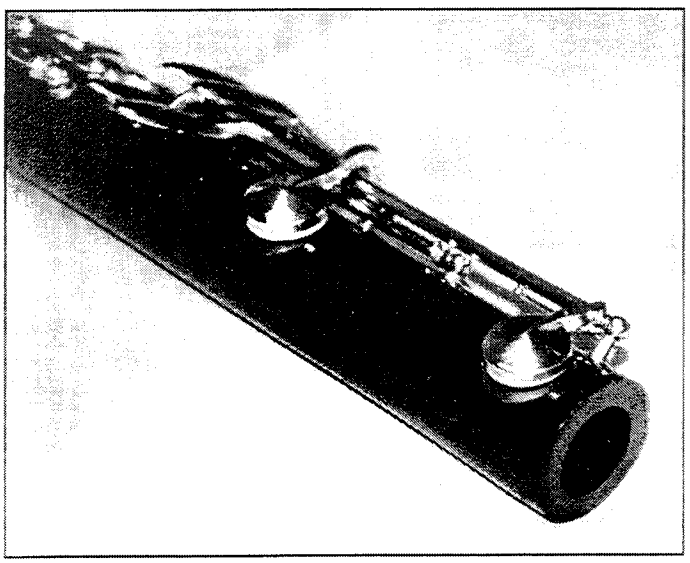


Illus. #3 - Pre-determining the depth-of-cut in the tenon blank



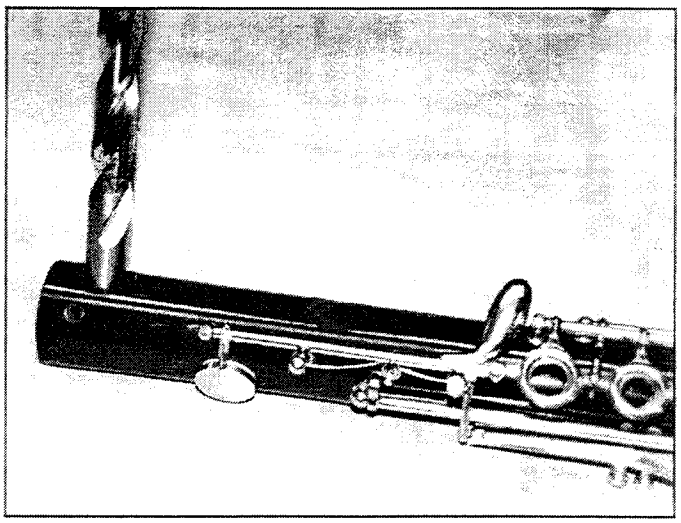
Illus. #4 - The Bell Tenon Reamer set into the lathe tail stock

- Saw off the remaining portion of the bell tenon. This may be accomplished with a band saw, or manually with a hacksaw. Carefully polish the remains of the old tenon flush with the end of the lower section on the belt sander (100 grit). Do not remove any material beyond the old tenon! Save the remaining parts for reference later on when determining the depth of cut for the cork channel and width of the rails on the new tenon blank.



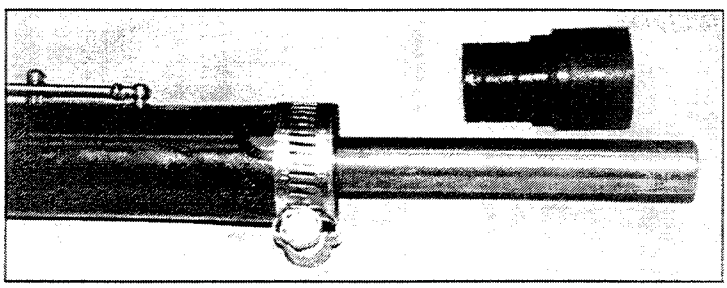
Illus. #5 - The old broken tenon trimmed in preparation for the counterboring process.

- Determine the size of the Low E/B tone hole. If you have a hole caliper, you may measure the exact dimension and record for future use. Otherwise, you may perform this step by selecting a drill bit whose shank fits exactly into the tone hole. This will be the bit that you will use to drill out the occluded tone hole in a later step. Verify the tap size of the post thread at this time.



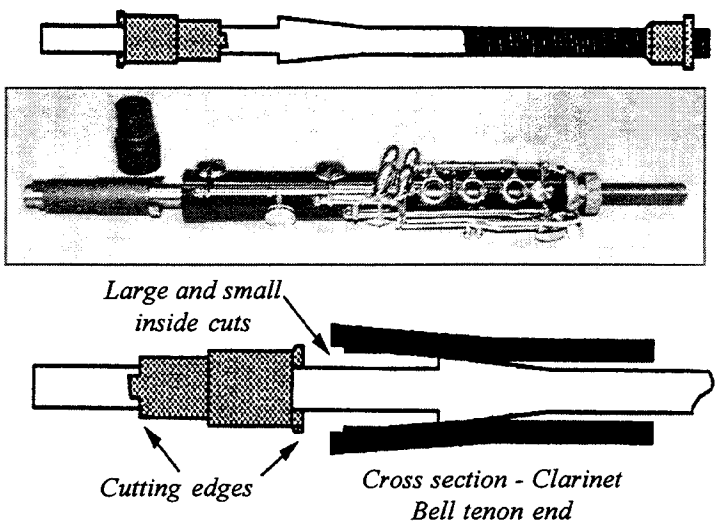
Illus. #6 - Determining the tone hole size

- Install a hose clamp on the lower end of the tenon to reinforce the tenon area of the body as you perform the counter sink operations.



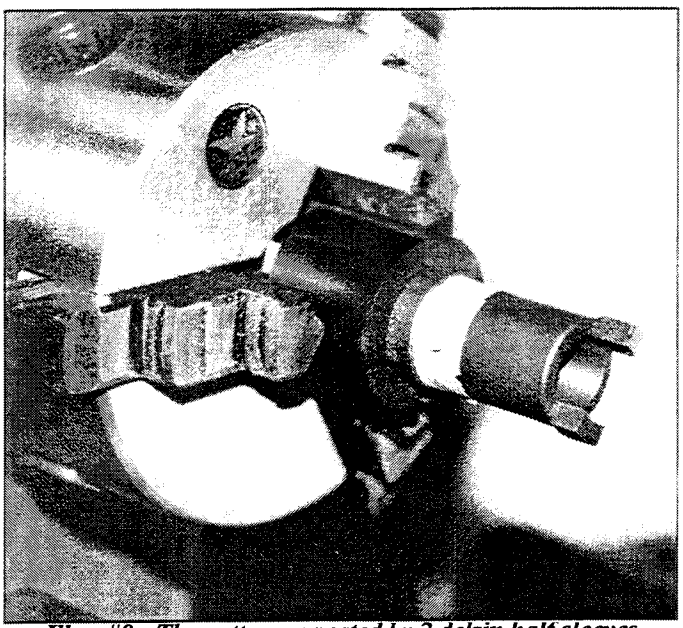
Illus. #7 - Reinforcing the tenon with a hose clamp

- Unscrew the knurled holding nut from the G71B Tenon Mandrel and secure the mandrel into the body of the lower section. You will note that the mandrel has a corresponding flare that will fit snugly inside the bore of the lower section. Slip the threaded end into the lower end first and tighten the holding nut securely; make sure that the mandrel is fit entirely into the bore and that the nut is secure and centered in the middle socket.



Illus. #8 - Ferree's Bell Tenon Mandrel and Cutter

- Mount the double-faced cutter (G71C) in the 3-jaw chuck of the lathe with the smaller cutting side facing outward. I prefer to secure the cutter(s) in the lathes 3-jaw chuck with two delrin half-sleeves, thus protecting the unexposed cutting heads. You may be *required* to do this (depending upon the size of the 3-jaw chuck on your lathe) to avoid damaging the cutters. And of course, make sure that both cutters are very sharp prior to placing in the lathe. Hard rubber and some of the earlier polymers (i.e. Resonite) are so tough that they are extremely hard on cutter edges. These cutters will require frequent sharpening when working with these materials. Use your bench grinder to sharpen the leading cutting edges only (do not attempt to sharpen the sides of the cutters). After several sharpenings, you will be required to purchase a new cutting tool.

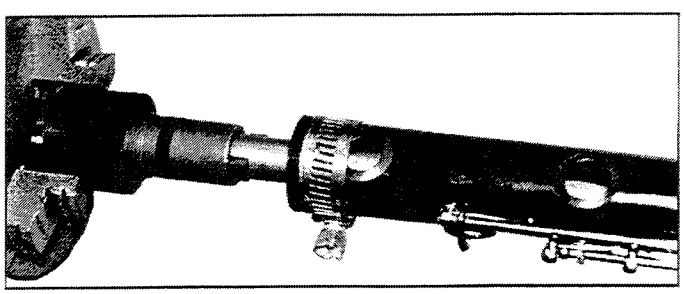


Illus. #9 - The cutter supported by 2 delrin half sleeves.

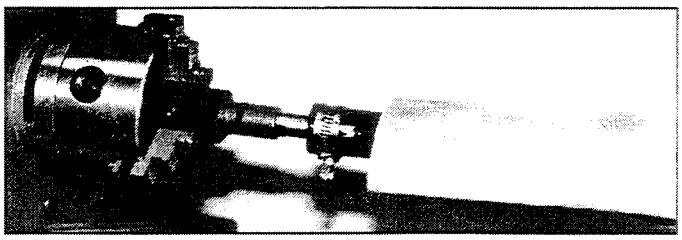
- Set the lathe speed to approximately 200 RPM.

- Turn on the lathe briefly to verify that the cutter is running true. Turn the lathe off and adjust as necessary.

- Place a drop or two of machine oil on the bearing surface of the bore mandrel (where it projects from the bell end of the lower section) and (while the lathe is still off) slip the bearing-end of the mandrel into the cutter and bring the lathe tail stock live-center to fit into the centering recess at the threaded end of the bore mandrel.



Illus. #10a - In preparation for the initial cut



Illus. #10b - A leather wrap is used for safely gripping the Clarinet

- Turn on the lathe as you steady the lower section with your left hand (protected by a leather wrap). Slowly feed the tailstock so that the section feeds into the cutting bit; proceed VERY slowly so as to avoid creating too much heat. Back the section away from the cutter frequently to clear the chip buildup. Proceed until you have counter-bored **exactly** 1" from the end of the section. Pre-measure this distance and mark it with masking tape on the barrel of the cutter so that you may use it as a visual guide when cutting. CAUTION: If you cut too quickly, and/or have a dull cutter, you will experience excessive heat build-up. This will cause the material to expand slightly, so that when it cools, the inner dimensions of the counter bore will contract and be undersized so that the tenon blank will not fit properly into the counter bore. Each material will tolerate this heat buildup to varying degrees (hard rubber, ABS plastic, Polypropylene, East African Blackwood, etc.). If you proceed slowly and have a very sharp cutter, you will be able to avoid this problem considerably. Another consideration is fracturing the body material when you counter bore the section. Earlier polymers (i.e. Ebonite, as was used on the first Conns, Normandys and Bundys) were very brittle and have a propensity to fracture easily if too much force is applied, so be cautious. Too much heat will actually cause ABS sections to begin to melt! So, be very careful.

- Turn off the lathe and back-off the tailstock so that you can fully remove the mandrel from inside the small cutter.

- Remove the cutter from the lathe's 3-jaw chuck and rotate it so that the larger cutting- face is facing outward. Again, use the delrin sleeves to protect the cutters inside the lathe's 3-jaw chuck.

- Turn on the lathe briefly to verify that the cutter is running true; turn the lathe off and adjust as necessary.

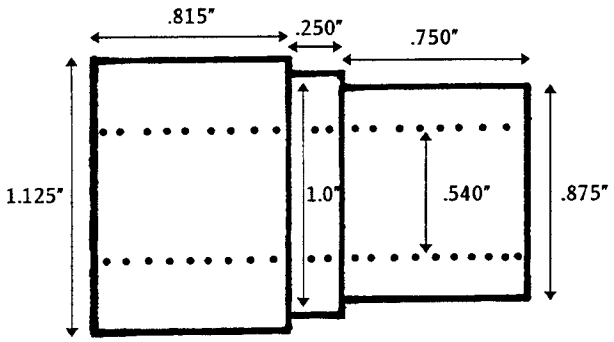
- Place a drop or two of machine oil on the bearing surface of the bore mandrel where it projects from the bell end of the lower section. With the lathe off, slip the bearing end of the mandrel into the cutter and bring the lathe tail stock live-center to fit into the centering recess at the threaded end of the bore mandrel.

- Turn on the lathe as you steady the lower section with your left hand (protected by a leather wrap). Slowly feed the tailstock so that the section feeds into the cutting bit; proceed VERY slowly so as to avoid creating too much heat. Back the section away

from the cutter frequently to clear the chip buildup. Proceed until you have counter-bored **exactly** ¼" from the end of the section. As it turns out, the cutter is exactly ⅛" thick (when new). This may change, however, after it has been sharpened a few times.

- Turn the lathe off; back-off the tailstock feed and remove the mandrel fully from the lathe. Remove the knurled nut from the bore mandrel and gently tap the threaded end with a leather mallet so as to dislodge it from the bore. Replace the knurled nut on the mandrel; clean, lubricate and put the tool away. Remove the cutter from the lathe's 3-jaw chuck; clean, lubricate and put it and the sleeves away.

- Select either the hard rubber tenon blank (G73A) for composition and polymer clarinet sections, or the East African Blackwood tenon blank (G73B) for wood clarinet sections. These may be purchased from Ferree's Tool and Supply Company, or may be easily fabricated from the exact material from which the clarinet being repaired is fabricated. Fabricating your own blanks may be preferable, especially on exotic woods such as Rosewood, Cocobolo, Boxwood, etc. (Illus. 11)



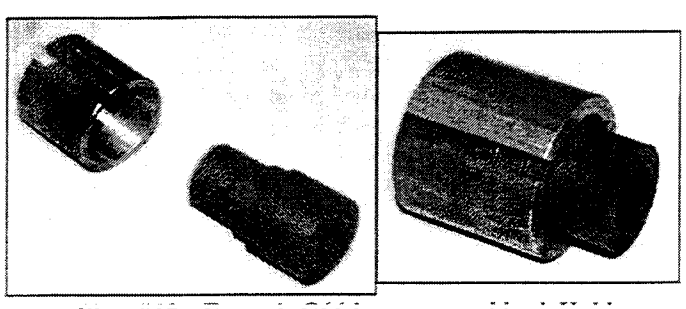
Illus. #11 - Ferree's G73 Tenon Blank Dimensions

COUNTER BORING THE TENON BLANK

WITH THE G 106 BELL TENON REAMER

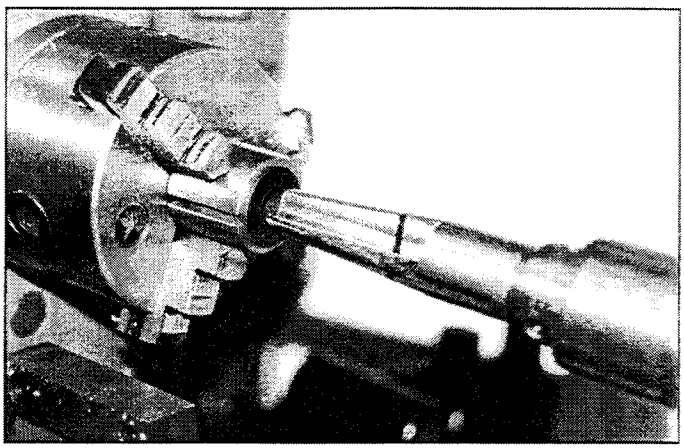
- Select the appropriate replacement tenon blank and secure it firmly in the lathe's 3-jaw chuck with the Lower Tenon Blank Holder (G66); you will note that it will fit correctly in only one position.

- Install the Clarinet Bell Tenon Reamer (G106) in a 3-jaw Jacob's chuck in the tailstock. Note: it has been marked with a piece of masking tape indicating the depth of cut required to match up with the bore of the lower section being repaired. This will help guarantee that the upper and lower ends of the bore of the replacement tenon line up exactly with the bore of the lower section and the bell respectively.



Illus. #12 - Ferree's G66 lower tenon blank holder

- While the lathe is still off, position the tenon reamer up close to the tenon blank so that you may realize the full range of the tailstock feed.



Illus. #13 - Preparing to cut the internal taper in the tenon blank

- With the lathe's speed still set to approximately 200 rpm, turn the lathe on briefly to establish that the blank is centered in the lathe's 3-jaw chuck. Adjust as necessary.

- With the lathe on, run the tenon reamer slowly into the blank making small cuts; back the cutter off each time to allow the chips to be discharged. Continue this operation until you have reached the depth as indicated by the position pre-marked on the masking tape. You may have to stop to tighten the lathe's 3-jaw chuck if the tenon blank starts to turn in the tenon blank holder. Again, try to limit the amount of heat generated during the process.

- Once the depth of cut has been realized, remove the tenon blank from the lathe and check its fit in the lower section. There should be no perceivable "step" inside where the two bores meet. In addition, the blank should fit easily into the counter bore, and be able to turn freely in the tenon counter bore without any perceptible "wobble". As mentioned earlier, the counter bore will sometimes contract after it cools down (especially polymer) resulting in the blank being too tight (or not go in at all). In this case, you will be required to replace the tenon blank in the 3-jaw chuck of your lathe and carefully remove a very small amount, until the fit is correct. Don't take too much off at once!

- In the absence of the Ferree G106 tool, you will be required to perform three individual cuts with a boring bar. Begin by grinding the cutter of your boring bar to a slightly rounded shape. This will render you a much smoother cut. Mount the boring bar in the tool post and prepare to make the first cut. The first cut will be to establish the bore dimensionally, to match exactly with the bore of the lower section. The second cut would be to make a 4-degree tapered cut from the small I.D. of the tenon blank

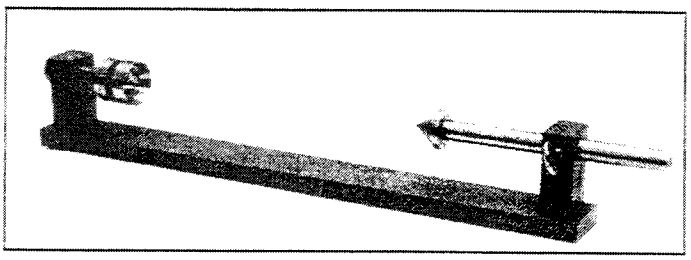
(established by the first cut) to the end that matches up with the bell bore. This you may do by setting your compound cross feed on your lathe to a 4 degree angle, and make a cut from the small I.D. to the larger I.D. (do not enlarge the dimensions of the smaller I.D.) The third cut would be to reset your compound feed to an angle of 8 degrees, and open up the lower end of the plug until the I.D. matches the I.D. of the bell bore. The point in the bore of the tenon blank (where the 4 degree and 8 degree angles meet) may be gently smoothed by polishing the bore with a slotted polishing rod, affixed with a small piece of #320 emery cloth on your bench motor.

- Most technicians like to turn down the tenon portion of the blank at this time. (This step may be done just prior to final assembly, but it is easier to perform it at this time.) The O.D. of the tenon should be able to fit perfectly into the corresponding socket of the Bell. The length of the tenon should be exactly as long as the socket is deep. Both these dimensions are critical. The cork channel may be cut next. If you were able to save enough of the original broken tenon, you may duplicate the rail width and cork channel depth on the new blank. If you were not able to save the original parts for reference, reference the dimensions on the middle tenon. In the absence of these dimensions, allow a width of at least 2.5mm for the rail next to the body and at the termination of the tenon. The depth of the cork channel will usually be somewhere in the range of 1/32" (0.031"), which will allow approximately ½ of a 1/16" cork to exceed the two rails.

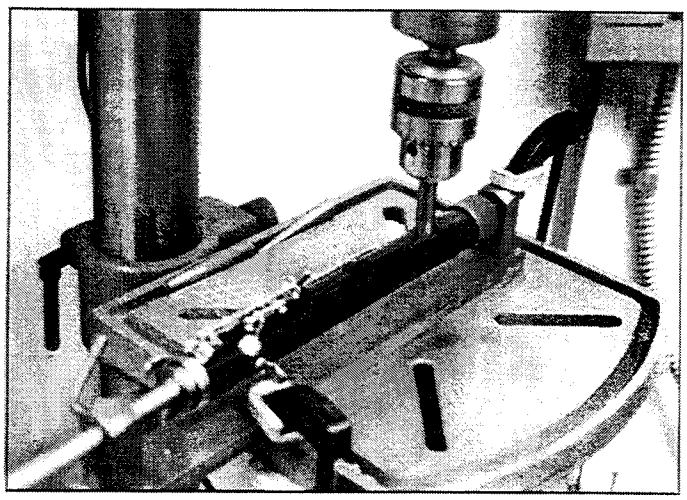
- Epoxy the finished tenon blank into the lower section. I prefer to use the Armstrong's 2-part epoxy (with black dye) for this step. I will firmly press the tenon blank into the lower section coaxing all the extra epoxy out. Clean up the squeeze-out (especially at the lower tone hole and at the post hole). Use Q-tips to remove the squeeze-out in the bore. Set the section in an upright position over night.

- After the epoxy has set up, you may clean up the bore with the Bell Tenon Reamer. This process will remove any remaining epoxy and final-polish the "seam" inside the bore. I do this by securing this reamer in the 3-jaw chuck, and, while the lathe is off, pre-place the lower tenon over the reamer, bringing the tailstock fitted with a live center up to the center socket for stability. I then turn on the lathe slowly rotate the tailstock into the reamer with my right hand, stabilizing the section with my left hand (and leather wrap) as I gently "scrub" the inside of the bore to smooth up any remaining irregularities. Do not apply any significant pressure into the reamer as we are only trying to gently smooth up the internal surface.

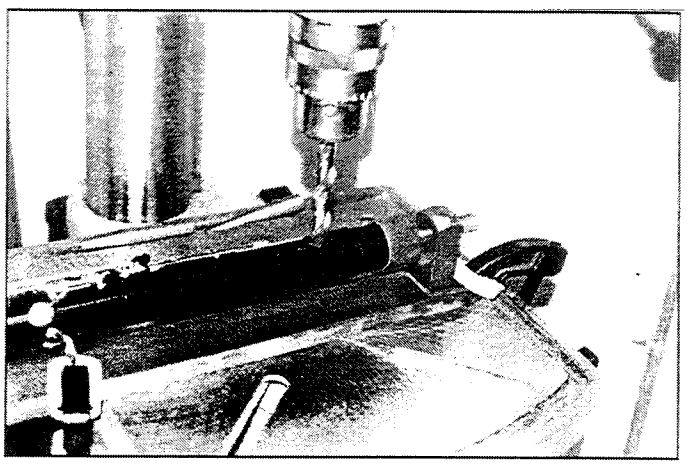
- Drill out the occluded tone hole. Place the lower section on a Tone Hole Drilling Jig (Ferree's G74S) to locate and center your drilling positions. You may establish the vertical alignment by fitting the larger centering pin into the adjacent Low F/C tone hole. Then center and drill with respect to the Low E/B tone hole. You may find that you will have better luck by drilling first with a bit approximately half the tone hole's size. Follow this by drilling the tone hole with the correct sized drill bit. Use a drill speed consistent with the material being drilled. Smooth-up the fraised surface of the tone hole (if necessary) with a fraised tone hole cutter and pilot of the correct size.



Illus. #14 - Ferree's G74S Tone Hole Drilling Jig



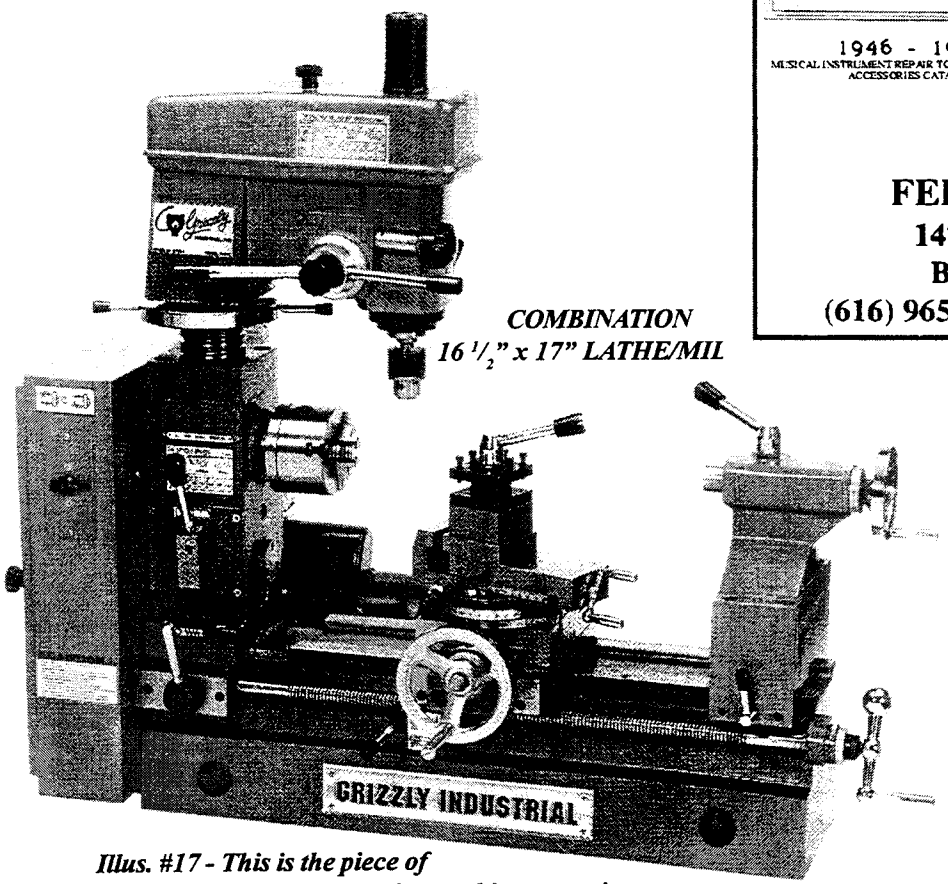
Illus. #15 - Using the G74S drill jig to locate & center on the occluded tone hole.



Illus. #16 - Drilling out the occluded tone hole with the pre-selected drill bit

- Clean out the posthole with the pilot drill for the post thread size. Do not drill completely through to the bore! Follow this step by chasing the thread with the appropriate bottoming tap. The thread size for posts will usually be 6-32 or 8-32 for domestic clarinets, and 3.5 - .6 or 4 - .75 for metric instruments. Some manufacturers (i.e. Artley) do not use threaded posts at all. Instead, they will embed a knurled post directly in the polymer body using a special insertion process. The replacement of this style of post will require that a threaded bushing be installed on the post, after which the body is drilled and tapped to specifications. When replacing posts that have been removed in this fashion, it is a good idea to stabilize the post by applying a small amount of 2-part epoxy as you screw the post into position. Verify the alignment with the key before proceeding.

- Recork and reassemble the instrument.



COMBINATION
16 1/2" x 17" LATHE/MIL

Illus. #17 - This is the piece of equipment we use in our shop for machine operations