THE REPAIR SHOP

WOODWIND TENON AND SOCKET REPAIR

by Lars Kirmser

This will be the first of a series of articles describing a re lated set of woodwind competencies. Several of the tasks described may appear to be very similar in their application at first examination, however, I have chosen to separate them into the following isolated descriptions in order that I might address their idiosyncrasies:

- **Grafting a Center Tenon on Soprano Clarinets**
- **Grafting a Barrel Tenon on Soprano Clarinets**
- **Fabricating a Barrel for a Soprano Clarinet**
- **Shortening a Clarinet Barrel**
- **Grafting a Center Tenon on Oboes**
- **Grafting a Bell Tenon on Oboes**
- **Installing a Tenon End Cap**
- **Installing a Tenon Ring**
- **Grafting the Wing Joint Tenon on a Bassoon**
- **Grafting the Long Joint Tenons on a Bassoon**
- **Grafting the Center Socket on Soprano Clarinets**

TENONS & SOCKETS: A NECESSARY EVIL

Looking at them purely from the designer's and builder's perspective, the tenon is, more often than not, a royal pain. They compromise the instrument's physical integrity and often force manufacturers to place tone holes and key mechanisms in less than optimum configurations. The tenon is, never the less, quite necessary to permit the player to disassemble their instrument into a more usable form. The musician must, after all, dry their instrument after each use, and disassemble it into a more convenient "package" so to speak, for ease of transport. In addition, repair technicians appreciate the ease of access to the bore, necessary to complete many routine repair and maintenance tasks. So, let us all agree that the tenon is in fact a necessary evil.

The tenons are in fact the most vulnerable candidates for damage to the body sections, especially when in the hands of younger, less experienced players. Never the less, there are some design features that make some tenons less apt to suffer damage than others. The most critical improvements over the past 100 years have come as the result of improved materials used to manufacture instruments of synthetics.

Tenons will usually be either corked or wrapped with various optional materials (i.e. synthetic cork replacement, nylon thread or linen thread). Under certain circumstances natural cork will be the recommended material. On other occasions, synthetic materials, or a wrapping may be best advised. These applications have been described in some detail in previous issues of the WWQ.

A LITTLE HISTORY

Tenons and sockets (i.e. woodwind bodies in general) have been fabricated from various materials over the past 150 years, beginning with hardwoods such as: Boxwood, African Blackwood, Maple, various Rosewoods, Ebony, etc. The primary attributes of these woods were that they were very close-grained, machined well, could be worked to close tolerances, resisted decomposition from exposure to moisture, were reasonably affordable, and readily available. Some unique one-of-a-kind instruments were fabricated from exotic materials such as ivory or precious metals, however, this was relatively rare due to the expense and availability of these materials. When the expense and availability of hardwoods presented an obstacle, builders began to explore the use of synthetic (man-made) materials. Early on, the choices were very limited. The goal naturally, when selecting replacement materials, was to choose something that was inexpensive, readily available, and close to the weight (specific gravity) and feel of the traditional material. One of the first synthetics used for the smaller woodwinds was a vulcanized rubber. This material is in common use yet today. In fact, some of the very best contemporary clarinet and saxophone mouthpieces utilize this 160-year-old technology. A number of years ago I had the pleasure of touring the J. J. Babbit mouthpiece manufacturing facility in Elkhart Indiana, and was thoroughly fascinated with their operation.

The vulcanizing process was originally invented by Charles Goodyear in 1839, however, it wasn't until about 1906, with the introduction of the first organic accelerators (hardeners), that made it possible for the musical instrument manufacturing industry to use this technology. The vulcanizing process involves the precision-forming of objects (such as mouthpieces or instrument body sections) in molds which are subjected to high levels of heat and pressure. This process then cures the compound of ingredients into a useful, hard, machinable substance. In its original application vulcanized rubber was used primarily for wagon tires, and later, automobile tires, however, today many practical applications abound.

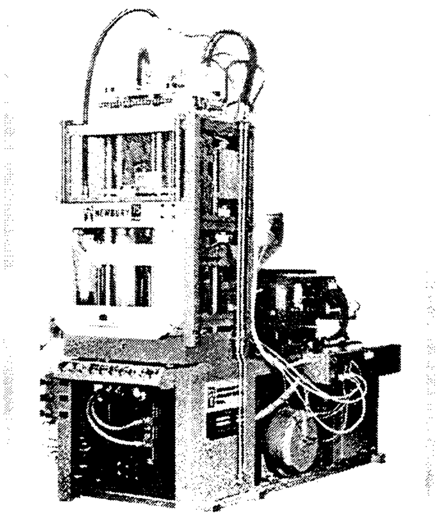
As vulcanized rubber ages, however, it gets brittle. Over time, and as the material is exposed to direct light and elevated temperatures, it looses some of its important ingredients, one of which is sulfur, an element included in the chemistry of the synthetic rubber compound. An indication of this "leached" sulfur is evident when a vulcanized rubber section, or mouthpiece is washed with soap and water, and turns an ugly brown/green color. As you may have already surmised, this aging process is why older vulcanized rubber instrument tenons and sockets eventually fracture so easily.

Another popular material group for the fabrication of woodwinds, are the modern polymers (plastics). It was not until 1868, however, that the first plastic material was commercially produced. The need for replacing ivory for billiard balls led John Wesley Hyatt, a printer, to experiment with a new process, that being the reaction of camphor on cellulose nitrate. The result was a material that could be formed into sheets, but was not suitable for molding. Called cellulose nitrate, this plastic later became know as "Celluloid". Celluloid was quickly adapted for many purposes, one of which was, and continues to be, guitar picks. Other modern uses are in the manufacture of pick guard material, and the binding used on some fretted stringed instruments (i.e. guitars and mandolins).

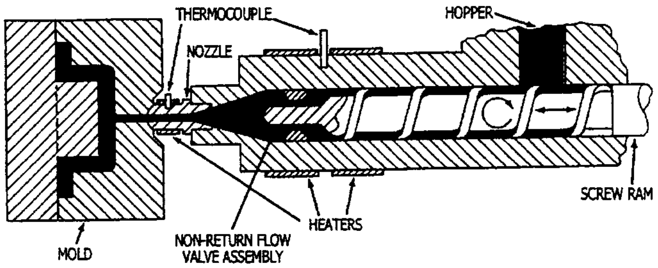
In 1909, Dr. Leo Baekeland discovered a new resin, *phenol formaldehyde*, which was to become a major plastic material in industry. Given the name *Bakelite*, this new material could be molded using heat and pressure. It possessed great resistance to heat, but was relatively brittle. As the result, it had only limited use in the manufacturing of musical instruments. Those of you senior citizens may remember the Bakelite knobs and handles on pots and pans and oven handles of the 1940's.

THERMOPLASTIC VS. THERMOSETTING

Polymers are classified into two distinct groups, *THERMOPLASTIC* or *THERMOSETTING*. The basis for this classification is the manner in which the monomer (an individual molecule) becomes polymerized (formed into long molecular chains). Thermoplastic polymers are characterized by their softening upon heating and hardening by cooling. Since the giant molecules of these materials have no strong bonds between the individual molecules, they can be softened by heat and remolded over and over again. This is an advantage in molding processes such as injection molding where scrap products can be reground and molded again and again. This is the most common polymer type that is used in the fabrication of woodwind musical instrument bodies and inexpensive woodwind mouthpieces today.



Vertical injection molding machines are often used for producing small, close tolerance parts. This machine is a four ounce reciprocating screw type.



Plastic material flow from the hopper to the mold on a reciprocating injection molding machine.

The *thermosetting* polymers (numbering less that the *thermoplastic* group) posses quite different characteristics. Because of the irreversible reaction by which they polymerize, they form a rigid, hard, and often brittle, infusible mass. And, as a result, are not well suited to the manufacture of musical instrument bodies and accessories.

Of the modern thermoplastics, Acrylonitrile–Butadiene–Styrene (ABS), Polyethylene, and Polypropylene resins are used most frequently in the musical instrument manufacturing industry. Even though these modern polymers are an exceptional improvement over the early materials, they will indeed fracture if subjected to undue stress.

REPAIRING VS. REPLACING

It is in fact possible to replace the broken tenons of virtually any woodwind instrument. However, the availability and cost of replacing the entire broken body section on many popular student instruments today is more cost effective than repairing the section. As a rule of thumb, if the section is readily available from your supplier, and the cost of the replacement section to your client (two times your cost plus shipping) plus your fee for transferring the keys to the new section, is equal to, or less than your charge to repair the tenon, then replace the tenon. In my experience, I am usually able to repair a broken tenon faster and less expensively than if I were to completely replace the section. This, of course, depends largely upon the availability of tooling and skills.

On occasion, this decision becomes moot, as some polymers are nearly impossible with which to work. This is often the case with the extremely heat-sensitive ABS plastics. However, when you are forced to repair these types of plastic sections, you must use **very** slow speeds (avoid generating heat) and use cutting tools designed to cut plastics (slightly increased rake angles).

GRAFTING THE CENTER TENON

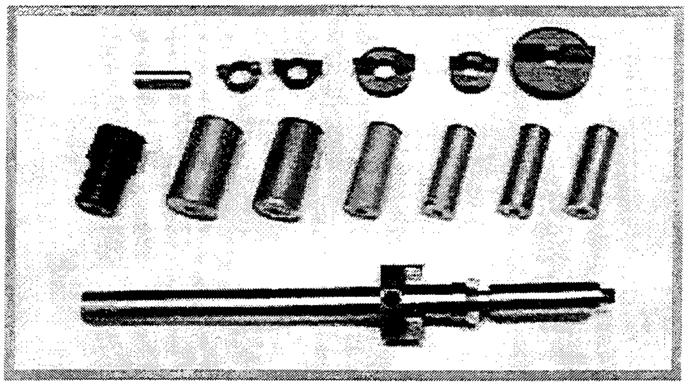
ON SOPRANO CLARINETS

TOOL REQUIREMENTS:

- Machine Lathe
- Lathe Accessories
- Belt Sander
- Drill Press
- HSS Drill Set, Complete (115 piece)
- Ferree's G74 Tone Hole Drilling Jig and Accessories
- Ferree's G84 Small Tenon Set
- Dial Caliper (English)
- Telescopic Gauges
- Tapered Mandrel (N91B N91C)
- Thumb Insert Removing Tool
- Post Removing Tool
- Post Hole Tap and Pilot Drill
- Replacement Tenon Blanks
- 24 Hr. Epoxy Adhesive (incl. Black Dye)

THE TOOL: FERREE'S G84 SMALL TENON SET

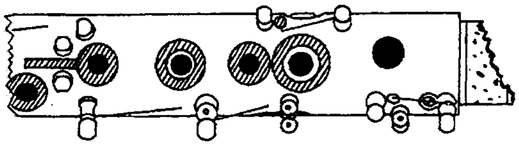
- The G84 Tenon Set is the only commercially-available tenon replacement set that I know of.
- It will assist you in the replacement of the upper and center tenons on most soprano, alto, and bass clarinets. It may also used to shorten the barrels for most soprano clarinets.

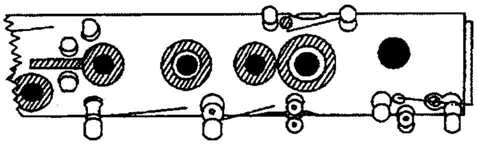


Ferree's G84 Clarinet Tenon Tool Set

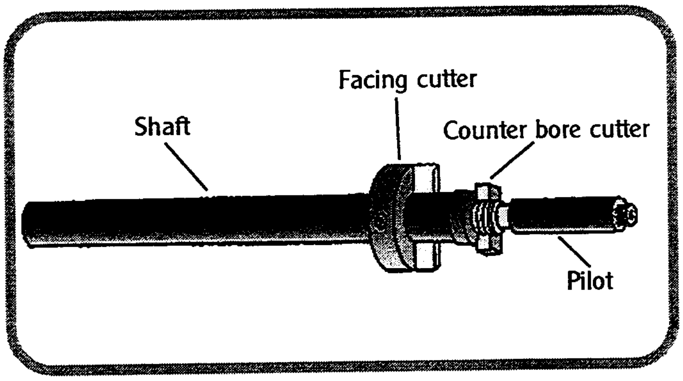
COUNTER BORING THE BROKEN SECTION

1. Disassemble all the keys and levers from the damaged upper section.
2. Remove the lower 4 posts that lie directly over the portion to be counter bored.
3. Remove the Register Pip and Thumb Insert.
   - Insert Ferree's N91B or N91C tapered mandrel into the bore to remove pressed-in pips and inserts.
   - Threaded pips and inserts require special tools for their removal.
4. Sand the remnants of the broken tenon carefully on the belt sander.
   - Remove all but the last 1/16" (2mm) or so, and avoid generating heat.





5. Clean the outside and inside of the section thoroughly.
   - Scrub the plastic section with a soft brush and mild detergent.
   - Scrub the wooden section with a soft brush and Murphy's Oil Soap; rinse and dry the part thoroughly.
   - Scrub the hard rubber section *dry*, with a soft brush; avoid water and detergent. I like to rag the body with white diamond compound. In either case, do not use water or other solvents.
6. Begin by selecting a brass *pilot* from the G84 Tool Set which will fit the bore of the broken section snugly.
   - It should be able to be pushed through the bore without binding or being excessively tight.
7. G84 comes with one pilot which will fit the bore of the upper section of most B^b soprano clarinets perfectly. This will allow the tool to turn while the clarinet body section remains centered with respect to the cutters.
   - Three uncut pilot blanks are included in the tenon set which may be turned down to fit larger bore sizes
8. Assemble the G84 arbor
   - Thread the *tenon cutter* (stamped with a "T") on to the G84 *arbor*. This cutter will counter bore the section.
   - Slip the pilot over the small end and secure with the long *Allen Set Screw*
   - The screw should not be so tight that the pilot will not turn freely on the arbor.
9. Slip the large *Face-off Cutter* over the large end of the arbor (cutter edges first). This larger cutter will face off the remaining 1/16" from the end.
   - Set the cutting edges of the Face-off Cutter exactly 1" from the cutting edges of the threaded Tenon Cutter. Set the cutter in place by tightening the allen set screw.



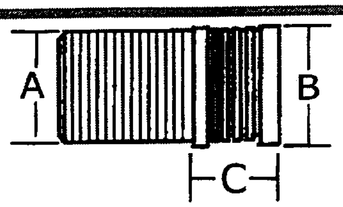
OBSERVE SAFE LATHE PRACTICES!

- **Wear Safety Glasses.**
- **Tie long hair back and secure under a ball cap.**
- **Remove all jewelery (rings, watches, necklaces, etc.)**
- **Do not operate a lathe wearing loose fitting or unbuttoned shirts.**

10. Place the shaft of the arbor in the 3-jawed chuck of your lathe and secure it
11. Set the lathe speed to about 400 RPM (while turned off).
12. Slip the section (i.e. the broken tenon end facing the cutters) over the pilot
13. Run up the tailstock (with a live center) to the undamaged end of the section
    - It is a good idea to place an end cap blank over this end to stabilize the tenon as the live center pushes the section into the cutters.
    - Turn the tailstock until the section is just short of contacting the cutters.
14. Hold the section with your left hand (palm up) to keep it from turning.
    - Use a heavy leather wrap for protection (avoid using gloves, they catch too easily).
15. Turn the lathe on, and feed the tail stock very slowly and cut and clear the chips until the large face-off cutter comes flush with the shoulder of the section.
    - Do not cut beyond the shoulder as this will cause the section to become shortened, and subsequently out of tune (too sharp).
16. Back off the tail stock; turn off the lathe
17. Remove the section from the arbor
18. Remove the arbor from the lathe

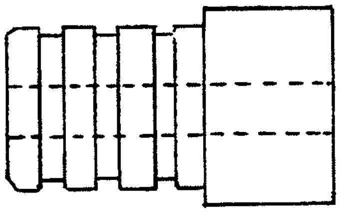
SELECTING AND PREPARING THE TENON BLANK

1. Select a blank material which matches the material from which the body section is made:
    - Hard Rubber
    - Delrin
    - African Blackwood
2. On commercial blanks, the dimensions of the portion fitting into the counter bore will correspond to the cutter dimensions.
    - Pre-finished blanks may be purchased from Allied (Cat. #A950 - A956)



Bore	A	B	C
A950	.566	.852	19/32"
A951	.580	.862	19/32"
A952	.590	.872	19/32"
A953	.566	.836	21/32"
A954	.580	.849	21/32"
A955	.590	.858	21/32"
A956	1/4" Pilot Hole	1.000	21/32"

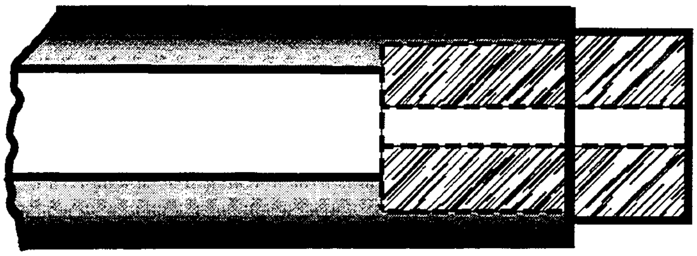
Allied's Precut Replacement Tenons



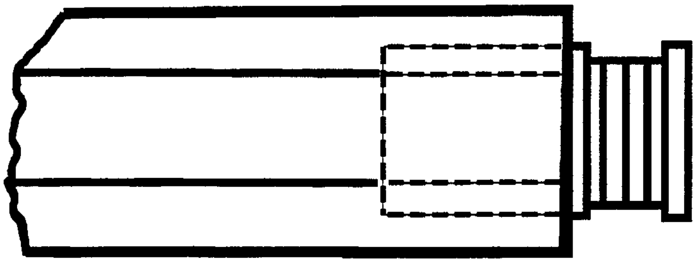
Oversized blanks may be purchased from Ferrees

3. Adjust the blank's fit in the counter bore as follows:
    - Insert the scored end of the blank into the counter bore and check for proper fit.
    - When fit properly, the scored end should slip into the counter bore and fit perfectly with no side-to-side play. The end should touch the bottom of the counter bore at the same instant it comes into contact with the shoulder on the body. Verify this by looking into one of the tone holes.
    - If the plug is slightly oversized, place the large diameter of the blank in your lathe chuck and remove the appropriate amount for a perfect fit (go gently!)
    - If the blank does not bottom out properly, again place the large end of the blank in your lathe chuck and turn back the shoulder until the plug fits perfectly.
4. Adjust the tenon to fit perfectly to its corresponding socket as follows:
    - The actual dimensions of a middle tenon's outside diameter and length may vary to some degree from manufacturer to manufacturer but must, in **all** cases correspond exactly to the relative socket.
    - If you are using a pre-fit tenon blank this step may have already been done for you.
    - If you are using an oversized blank, you must first determine the exact measurements of the socket (I.D. and depth) by measuring it precisely. Be aware that worn sockets offen become slightly tapered through use over time.
    - If oversized, place the blank in your lathe chuck (oversized tenon side facing out) and cut it down so that its outside diameter is approximately 0.004" under that of the internal diameter of the socket.

- When the blank has been turned to size, remove it from the lathe chuck and place it in the corresponding socket to check for the outside diameter fit and relative length of the blank.



- Once you have determined that the blank fits perfectly, you must reinstall the blank in the lathe chuck so that a cork slot measuring approximately 1/32" (.034") deep may be installed. Allow approximately 1/8" shoulder on each side of the cork slot for stability. You may use the old tenon for reference if you still have it.



5. Cut the internal diameter of the blank (if required) to correspond exactly to the bore of the section.
   - If you are using a precut blank, you will probably be able to skip this step altogether.
   - If you are using an oversized blank you must carefully measure the internal diameter of the middle section. Use a telescopic guage to establish this measurement.
   - Grind the cutting bit (on the boring bar) to be slightly rounded so that you may get a smooth cut.
   - Mount a boring bar in your tool post and bore out the inside of the blank to correspond exactly to the internal diameter of the middle section. This measurement should correspond exactly with the I.D. of the bore just beyond the socket of the lower section.
   - When finished, smooth the internal cutting marks with a fine emery cloth glued to a slightly undersized wood dowel. Finish by buffing the bore with a cloth-coated dowell treated with white diamond buffing compound.

INSTALLING THE NEW TENON

1. Prepare a mixture of Armstrong's 24 hour epoxy adhesive (use a small amount of the black dye).
2. Cover (completely) the portion that fits into the counter bore with a thin even coat of the epoxy adhesive.
3. Spread a small amount of the epoxy inside the counter bore (remember, all excess adhesive will squeeze out and have to be cleaned up with the solvent Xylene and Q-tips, so don't use too much).
4. Press the new tenon firmly into place, clean up any squeeze-out, and secure the section in Ferree's G74 clarinet drilling jig for 24 hours.
5. Use some of the remaining epoxy to reinstall the register pip and thumb insert at this time.
6. I will always save any left over epoxy so that I may determine that it did, in fact, hardened properly over night.
7. Drill out the tone holes that have been occluded in the process.
   - Use the shank of the drill bit to verify proper sizing.
   - Set the body and drill the tone holes using Ferree's G74 clarinet drilling jig as prescribed.
8. Drill out the post holes to their original depth (do not drill into the bore!)
9. Chase the threads of the post holes with the appropriate bottoming tap.
10. Recork and adjust the new tenon
11. Reinstall the posts and keys
12. Return the instrument to your customer.