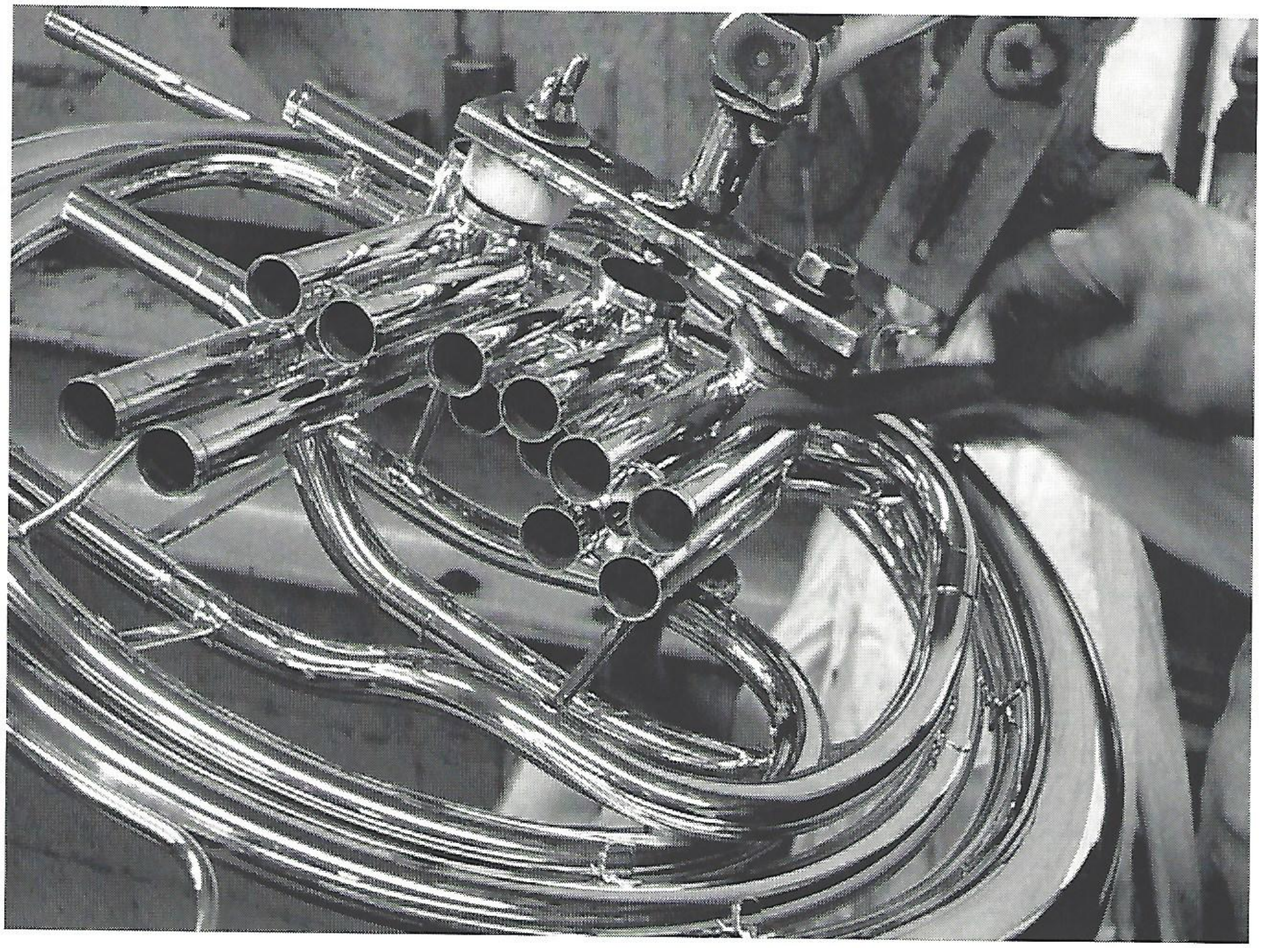
TechniCom

The bi-monthly publication of the National Association of Professional Band Instrument Repair Technicians (NAPBIRT)®



September - October 2005
Volume 30, Number 5

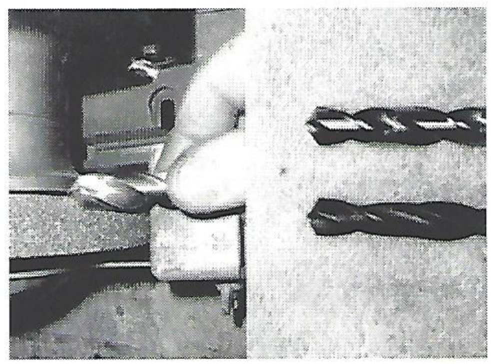
Custom Saxophone Key Fabrication by Mark Nagy

Recently I had a unique situation arise in the repair shop. I had a saxophone that required an overhaul, but one of the keys was missing! Since the saxophone was made in Germany by the B and S Company, it would take far too long to order the necessary parts. I decided to make the key myself.

Fortunately, I work with Ted McDowell. Ted, in addition to being an accomplished repair technician, is an expert machinist with over 25 years experience. Over the years, he has fabricated various parts from trumpet bottom valve caps to saxophone keys. Ted was my mentor in making the missing low D key. With his guidance, I began to construct the missing key. I used alloy 360 brass for all of the parts. This alloy is the industry standard and is easily machinable. McMaster and Carr (*www.mcmaster.com*) or Enco (*www.use-enco.com*) carries this in a variety of dimensions.

The first part I constructed was the hinge tube. This was a fairly straightforward process, especially in light of what was yet to come! I measured the O.D. (outer diameter) of the rod and of the neighboring keys to determine the hinge tube dimensions. The O.D. (in inches) needed to be .200" and the I.D. (inner diameter) .118". Then, I measured the distance between the two posts; the post to post distance was 1.75". I used a 7/32" (.218") diameter piece of brass stock. To be safe, I cut the stock slightly longer than necessary. I chucked the piece of brass stock in the lathe. Since a drill bit couldn't start the hole, I used a number 3 center drill to start the cut. It is important that the pilot on the center drill be smaller than the diameter of the hinge tube or the hole at the end of the hinge tube will be wider than the rod. A number 3 center drill has a .108" pilot. The purpose of the center drill is to start the cut, since the tip of a standard drill bit has no cutting power and will tend to wander off center as the drill flexes. The drill bits I used needed to be modified for cutting brass.

The helix (spiral) angle in an ordinary jobber's twist drill is great for drilling steel. But the angle the cutting lips form is too acute for the crystalline structure of the brass. It will spiral into the brass and lock up, possibly breaking the drill or grabbing the workpiece and damaging it. Low helix angle drill bits can be difficult to find or costly. An ordinary jobber's bit can be modified by grinding. The side of the grinding wheel does the work. The bit is held on the right side of the rotating wheel and the web is brought near, but not touching the circumference. The axis of the drill bit moves in the plane of the side of the wheel. The edge of the rotating wheel enters the hollow of the flute without touching any portion of the drill bit until the lip is just touched against the side of the wheel. In essence, the drill bit is modified so it uses a scraping process rather than a shearing process to remove the metal. An excellent resource book entitled *Handbook for Drillers* is available from Lindsay Publications (*www.lindsaybks.com*).



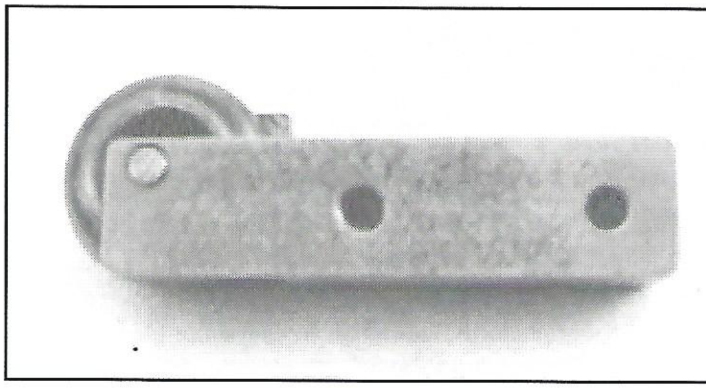
Modifying the drill bit

Once the hole was started, I used a series of drill bits starting with 41 (.096") then 36 (.1065") and finally 35 (.110") to cut the hinge tube. The challenge was to get a straight cut. I slowly put the drill into the stock with a pecking motion. As soon as I heard a chirp I removed the bit. The chirp indicates that chips are building up inside of the workpiece and would cause the drill to veer off and not cut a true cut. Backing out the drill bit will free any chips that are building up. After using the drill bits, I finished the cuts with a set of reamers (sizes .113", .116" and .118"). Unfortunately, my hinge tube interior was not perfectly straight. So I lapped the hinge tube with the rod. Since the piece was slightly longer than necessary, I used a hinge tube cutter to shorten the tube to the proper dimensions.

The next piece I manufactured was the keycup. This was the most challenging of all the pieces to make. The first step was to create a form to spin the brass around to shape the keycup. The O.D. of the tonehole was 1 5/8". I wanted extra clearance around the edge of the key, so I made the form 1 ¾" in diameter. Then I needed to form the shape of the top of the keycup. I made a convex shape on the end of the form to match the shape of the other keys. This was done on the lathe. I used a piece of aluminum stock; the only reason I used aluminum was that it was the only material I had on hand that was close to the dimension I needed. Cutting aluminum requires a special cutting fluid due to its tendency to adhere to the cutting tool. The fluid I used is called *AlumTap*, made by Winfield Brooks Company (*www.tapfree.com*).

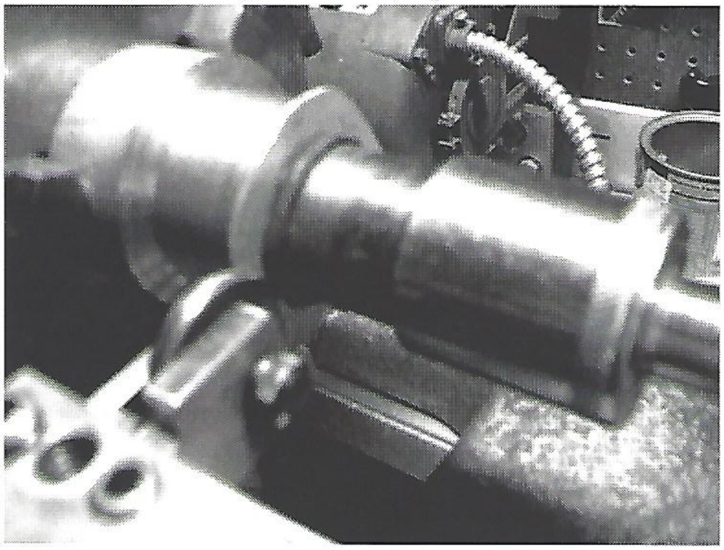
To create the keycup I used a sheet of .035" brass. First, I annealed the brass. As I annealed the brass the sheet buckled. The reason this happened is the stress that was created when the brass was rolled in the factory was being relieved. Since the metal was so soft, I used thumb pressure to get it back to its original shape. Then I drew a 1¾" circle on the brass sheet using a compass (just like the kind you would use in high school geometry class). I cut the circle out with a pair of tin snips and smoothed any rough edges with a belt sander. I chucked my keycup form into the headstock of the lathe and chucked a concave live center into the endstock of the lathe to hold the brass in place. I used a piece of rubber to keep the live center from marring the surface of the keycup.

Once this was set up I was ready to begin spinning the keycup. In the past, Ted has made saxophone keys and he developed a special tool to spin the keycup. It is roller tool that is clamped into the tool post. This method of spinning the brass is slightly different than the traditional method of using a burnishing tool. This roller has a wheel that spins as it pulls brass from the center of the stock over the keycup form. The process of forming the keycup is a slow one; the brass is stretched out slowly over the keyform. Each pass with the roller only moves a little bit of the brass, otherwise the metal may tear. If the material becomes workhardened it will develop ridges like a bottlecap or Hollywood style saxophone resonator. If this occurs the metal must be reannealed.



Key Spinning Tool

The first step was to bring the edge of the brass down over the the key form. Then, using the roller I slowly bent the brass (or *spun* the brass, as the process is formally known) over the keyform. Once the keycup edge was down and the keycup was in a rough shape, more brass was moved over from the center. The brass stretched out quite a bit during this process. Once the brass starts to take the shape of the keycup, it will grab onto the keyform and the live center support can be removed. At this point, the final passes are being made to smooth out the surface of the keycup. Finally, using a parting tool mounted in the toolpost, the excess material was removed to create the proper depth of the keycup.



Forming the Key Cup

The next piece I made was the ball at the end of the key. Ted helped me make a cutting tool out of an old file that was lying in a junk drawer in the shop. I determined the size of the ball and found a stone Dremel bit to shape the file into a cutting tool. The cutting edge of the tool needs to be slightly beveled in order to cut properly. Using the lathe, I shaped the ball out of ¼" brass stock. Ted helped me set up a support rest for the cutting tool and I created the shape of the ball by using a free hand turning technique rather than using the dials of the lathe to manipulate the cutting tool. When shaping the ball I used a scraping process just like when I made the hinge tube. The balls of the other keys had a hole tapped into them to allow a screw to be placed in them. The screws govern the key height. Before removing the ball from the lathe, I drilled a hole in it and tapped it to 10-32 thread size. This tap is .195", so I used a #21 drill bit (.159") to create a pilot hole.

The next step was to manufacture the arms of the key, imitating the shapes of the arms of the neighboring keys. First, I cut the rough shape of the arms on the bandsaw. While the pieces were still in a rough shape I drilled the holes for them to fit on the hingetube. Since I had already determined that the hingetube diameter was 7/32" I used a machining vise to hold the stock while cutting the holes with a drill bit modified for cutting brass. After that, I used a beltsander to shape the arms further. I did the final shaping using hand held files and 240 grit sanding wand. The sanding wands are available in a variety of grits (400, 320, 240, and 120) from Micromark (*www.micromark.com*). For the spring saddle, I used a file to start the cut and used Mitchell's abrasive cord (no. 01) to finish the cut, since the file tip was too large to do the final cuts.

The last part I needed to make was the pearl holder. Ted gave me a pearl he had made from abalone. (This was the only part of the key that was not made of the alloy 360 brass.) The pearl's diameter was .555". I found a piece of brass stock in a junk drawer. I used a ½" milling bit in the chuck to cut the pearl holder. Even though it wasn't designed to be used in this manner it worked quite well. To finish the cut I used a boring bar to get the proper I.D.. Then, I used a file to bevel the sides of the pearl holder to match the appearance of the pearl holders on the other keys.

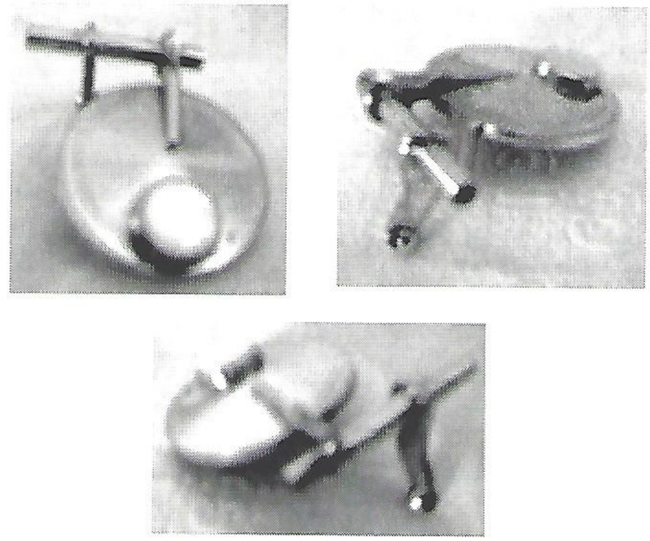
Now I had all of the parts for my key manufactured! I was in the home stretch. I began brazing the parts together. I used a 45% silver bearing braze available from McMaster and Carr ((7676AZ) $3/16^{th}$ diameter. This braze contains cadmium and should only be used with adequate ventilation.) The first thing I did was to braze one of the arms to the top of the keycup. I used a dapping punch (which makes an oversize hole slightly smaller) to make a snug fit between the hinge tube and the arm. Then I mounted the key on the saxophone to determine where to braze the keycup onto the hinge tube. I determined it needed to be .275" from the end of the hinge tube. I also determined the key height at this time. Then I brazed that arm to the hinge tube. Next, I brazed the ball to the remaining arm. Before I could braze the pearlholder onto the keycup, I needed to shape the bottom of the pearlholder to match the contour of the keycup surface. I put a piece of 250 grit sandpaper face up on the surface of the keycup. Then I placed the pearl holder over it and moved in back and forth until the bottom of the pearl holder matched the contour of the keycap. Now the pearl holder was ready to be brazed to the keycup.

After brazing all of the pieces together my key was taking shape! I used a riffling file to remove the excess braze. The riffling file set I used is from Micromark (33111A); it has a variety of shaped files so you can get in the corners. Fortunately, since the brass was new there wasn't too much clean up necessary. Then I immersed the key in muriatic acid to further clean it. I cleaned the remaining braze with a 7/8" Tripoli impregnated rubber wheel on a Dremel tool. These wheels (T2040) can be purchased from Allied Supply Corporation.

Then I began buffing the key in preparation of lacquering it. To get into the corners of the key I used a Muslin Buff Knife wheel (17.560) from Grobet USA. (*www.GrobetUSA.com*). This wheel is very thin and is good for tight spots. I used yellow rouge (A8099) from Allied Supply for the initial buff. Then I moved up to a larger wheel for the flat surfaces of the key. Once I had the entire key buffed with the yellow rouge, I moved to a fluffy wheel and buffed the entire key with Burn's red rouge (A813). Then, I degreased it using a degreaser from Lawson Products (*www.lawsonproducts.com*) called Citrisolv.

I was now ready to lacquer the key. I used Nikolas Special Gold Colored Lacquer 2105. This is available from Ferree's tools (*www.ferreestools.com*). After the lacquer dried I was ready to glue the pearl in place. I now had a complete saxophone key!

After completing this project, I realized that I had learned many things. I learned about the properties of various metals and cutting fluids. I learned how the different surfaces of drills bits are related to each other. In addition to techniques, I also discovered that empirical experience is the best way to learn to something. Learning information out of a book is great but there is no substitution for trying something yourself. During the course of manufacturing these parts I had to usually try several times before I created one that was the right size or shape. Having patience and getting over the disappointment when things didn't go as planned was difficult at first. But with all of this practicing, each attempt became easier. Having a practical project to do is great for learning various machining techniques. The advantage of having someone with a great deal of knowledge and experience like Ted McDowell is a definite plus. If you look around you can usually find someone who is willing to share their knowledge if you ask. There always seems to be someone that knows a little more than you do. ♫



The Finished Product