Conical Bushings

Over its many years, the process of violin restoration has undergone umpteen changes. Throughout the 18th-, 19th- and part of the 20th centuries, restoring violins was generally approached in much the same way as repairing furniture, which is to say the strength and function of the repair were of primary interest to the craftsman. Of less concern was the preservation of the original wood and varnish. Not surprisingly, this repair philosophy was most commonly on display in regions removed from the traditional centres of restoration, and we now recognize that where little care was taken in restoring a fine instrument, irreversible damage has unfortunately occurred.

In more recent times, however, the restoration community has realised the ethical importance of preserving as much of the original wood as possible and of treating fine instruments as irreplaceable antiques. This realisation, which has naturally been encouraged by a growing awareness of the investment value of well-preserved instruments, has contributed to a fundamental change of attitude with regard to repairs.

Fig. 1 *Pegbox crack*

We've now arrived at a point where safe and reliable restoration techniques are practiced by the majority of experienced restorers. Methods developed to produce the best balance of aesthetic charm and structural integrity are widely used to good ends, although occasionally a more reliable, and altogether more successful technique is discovered. One such procedure, not yet widely known, is used for the delicate task of repairing pegbox cracks.

Many pegboxes are cracked or damaged as a result of heavy instrument use and the pressure exerted by the peg's wedge-like shape. Any crack requires a strong repair in order to withstand the tremendous force of these pressures, and to avoid the risk of being reopened by leverage from the peg. Owing in part to the limited space inside the pegbox, many restorers have mangled repairs to this vital part of the instrument and, in doing so have sealed the fates of countless pegboxes. While the traditional techniques of

'cheeking' or 'patching' pegboxes are effective, they aren't entirely satisfactory as they require a great deal of visible wood and varnish to be replaced. This seems a great shame, and it's our belief that techniques which cause the loss of original material should be challenged and ultimately replaced with new methods that manage to not only effect a strong repair, but preserve the maximum amount of original material as well.

Working according to this belief, we've developed an innovative technique called Conical Bushing, which has thus far proven itself as strong and safe as previous practices, but much more considerate with regard to the conspicuousness of the repair. The main benefits of the technique are as follows:

+As the repair is effected from inside the pegbox, it's neither visible from the front nor the outside of the box
+It preserves more original wood and varnish than the traditional 'cheeking' method
+It equals the function of a patch, reliably replacing the cracked wood while maintaining and reinforcing the natural strength of the pegbox.

Fig. 2 *Tools and bushings developed by Florian Leonhard Fine Violins*

As with a traditional repair, Conical Bushing removes as much of the cracked wood as possible, and provides a large gluing surface for the new wood – vital in creating a strong repair. Unlike with other methods, however, little or no original wood or varnish is lost from the external side of the pegbox, and while this is of tremendous benefit, it provides no margin for error, which means the execution needs to be extremely precise.

Bearing this in mind, let's put the Conical Bushing technique to work on the repair of a conventional pegbox crack. The necessary tools for the job include: a conventional G-clamp to repair the crack, a router[†], another G-clamp to glue the bushing, and packing[‡] (see Fig. 3) to place around the peg hole. (It's worth noting that the packing should be covered with cling film to prevent glue from sticking it to the varnish. Also, the G-clamp may need to be filed down to enable it to fit inside the pegbox.)

The router employed in this technique must possess very special properties. It requires a cutting face angle of 45-degrees (its shape therefore resembles a cone) with only two or three cutters on the head. The rake of the cutters must be precisely calculated: too steep and one risks shattering the wood while turning at such a slow speed; too shallow and the cutters will clog with wood dust and won't be able to cut effectively. Although at its widest point the router is much larger in diameter than the peg hole, this isn't at all problematic because the head smoothly tapers off to the size of the hole itself. Please note that the 45-degree cutter angle is essential as it enables the shape of the router to be easily reproduced in wood for the bushing itself, which must fit tightly and precisely into the pegbox wall.

Fig. 3 *The packing and G-clamp*

To begin, the crack should be cleaned and prepared before it's glued in the conventional manner, using clamps to secure the area. After the glue has dried, the hardened-steel router is placed inside the pegbox, and the handle is screwed on through the opposite peg hole. With the thumb placed on the outside of the pegbox for support and control, the router is turned by hand at a reasonably slow speed, thus clearing out the cracked wood. (nb. The use of a drill is not advised as its speed may limit one's ability to make a controlled cut.) During the routing process, the repair area should be cleared of wood dust regularly to avoid placing unnecessary pressure against the thinning pegbox wall. Also, it's important to feel the router as it cuts the wood, and to observe its progress so as to be certain it doesn't reopen the crack or break the fragile outer edge. You'll know to stop when the cutting head appears through the peg hole, and the outside edge of the wall becomes almost wafer thin. To remove the router, hold it by the tip and unscrew anticlockwise. Finally, remove the handle through the peg hole, and the router head from the pegbox.


Fig. 4 *Cutting the hole*

Next on the docket is the fabrication and installation of the conical bushing. We've found that the bushing needs to be made from a well-seasoned hardwood, such as boxwood or maple, to avoid shrinking. In order to avoid even the slightest movement when it's fitted into the hole, the bushing should be turned on a lathe where a 45-degree angle can be precisely calibrated. To begin the process, the length and diameter of the bushing are turned from a larger piece of wood. The tapering face is then turned to a true 45-degree angle, leaving a flat face approximately 3mm wide at the narrow end of the bushing. Done in this manner, the conical bushing will be exactly the same size and shape as the router bit without its cutting edges (see Fig. 2). As they're rather labour intensive to produce, it's advisable to prepare a good number of such bushings at once.


Fig. 5 *Drilled hole ready for the bushing*

Before inserting the conical bushing, apply some thin glue to it, and allow the glue to dry before continuing. Doing so prevents the glue from being absorbed by the end grain, and ensures that the entire bushing is securely attached to the pegbox wall. Once the bushing

is prepared, hard-surfaced packing needs to be made to surround the cracked peg hole. It's important that the centre of the bushing can protrude through, and a G-clamp can be used to ensure the bushing fits tightly.

Warm the scroll and bushing with a hairdryer, and cover both surfaces with plenty of glue. In order to ensure a secure bond, it's crucial that the consistency of the glue isn't too runny. Place the bushing in the routered pegbox wall, and apply the G-clamps with the necessary packing (and its cling film covering), allowing the glue to dry. Once the inserted bushing is dry, the peg hole must be re-drilled in its original position. The conical bushing, invisible from the outside, must now be cut back to the thickness of the pegbox. Sometimes it's better to leave the bushing a little thicker in the centre for maximum strength, particularly if the pegbox has especially thin walls.

Fig. 6 *Gluing the conical bushing*

We've observed that when the router reaches the outer pegbox wall, it creates a feather edge at the hole. Since the pegbox has a tapered shape, the router will reach one part of the edge earlier than the rest, which means one has to stop routing out the area, thereby creating a small step. In this case, an extra bushing needs to be inserted to adjust the hole to its required size. We've found a technique called Shaving Bushings (described in a later article) to be the most successful solution to this problem. Not only does it keep the peg hole in its original location, it also reinforces the pegbox by providing a tightly wound spiral of wood, the grain of which runs perpendicular to the grain of the pegbox. These thin and tightly wound strips of wood are extremely strong (comparable to laminate), and help to prevent the peg from causing another, or reopening the original, pegbox crack.

Fig. 7 *Gluing the shaving*

While the basic application of Conical Bushings can be used in the majority of cases, there are unique circumstances that call for a slight adjustment to the technique. For instance, if the original hole was too close to the throat of the pegbox, the peg hole may need to be slightly shifted towards the centre of the pegbox wall. This can also be done by the Shaving Bushings method. By building up and gluing turns of the shaving bushings, a hole is formed into which a solid piece of wood can be put, thus allowing the hole to be re-drilled.

In another case, the position of the peg hole might be too low, preventing the router itself from being introduced without touching the floor of the pegbox. In this instance, a conventional bushing should be used to plug the old hole, and then a new peg hole, with a new centre, can be drilled. This peg hole relocation procedure usually takes place near the A-peg, where there is the shortest grain, and where maximum strength is required to avoid the crack reappearing. If a peg hole needs to be totally or even partially relocated, then, as previously mentioned, a conventional bushing should be used to plug the old hole, thereby providing a relatively solid surface into which the hole can be re-drilled. A Shaving Bushing can also be used to reinforce this new hole in order to prevent the feathered edges from becoming a weak point. Please note that when gluing a conventional bushing, a clamp should always be used to prevent the crack from reopening.

Fig. 8 *Glued crack with Conical and Shaving Bushings ready for varnish retouch*

Because it's not under the same amount of stress as the peg-bearing walls, the inside floor of the pegbox, if cracked, can be glued normally and reinforced with a patch. A plaster cast of the outside of the pegbox needs to be made and used as the packing,, then the inside carved more thinly and the ends feather-edged. This can be done in the usual manner, as the area's readily accessible to a chisel and mallet. The pegbox walls may then be repaired using the Conical Bushings technique and reinforced with Shaving Bushings inserted into the peg holes to resist pressure from the pegs. This process will eliminate any possibility of the pegbox re-splitting.

It's been our experience that using the Conical Bushing technique can render the process of retouching extremely simple. The peg holes needn't be relocated, and no original wood on the outside of the pegbox has to be altered. The method requires a small amount of retouch, but this in and of itself won't cause a problem as the retouched area – the joint parallel to the peg – is extremely small, and is often adorned with a ring of patina, making a slightly opaque retouch colour acceptable.

It seems rather apparent that the Conical Bushing method's benefits far outweigh its drawbacks. Not only is the cracked wood completely replaced with solid wood, but the repair is almost invisible when compared to traditional methods. It's our contention that a technique that manages to preserve a high proportion of original wood and varnish, while at the same time effecting a robust repair, represents a vast improvement on the aesthetically conspicuous, and ethically questionable, practice of cheeking.

Footnotes:

[†]Exhaustive research into cutters and cutting techniques has led us to develop our own special hardened-steel routing tool, which allows this technique to be performed with extreme precision. The router is constructed to ensure that it seats itself in the hole, doesn't shatter the wood, and doesn't collect too much wood dust and clog, thereby preventing cutting. For further details please contact: www.florianleonhard.com

‡In this case, packing refers to a piece of wood with a hole in the centre that allows the bushing to protrude while still providing a solid surface to support the pegbox wall. The composition is most important.

Fig. 9 *The composition of the packing*

The top of the packing is composed of a layer of hard wood, then cork, with a final layer of hard plastic. This composition allows for a strong, flat surface that will accommodate any imperfections in the pegbox wall. The plastic on top of the layer of cork needs to give slightly, but mustn't be too soft as it wouldn't then provide the pegbox wall with adequate support during clamping.