Courtesy, DAR Museum, acc. 59.126

FIGURE 1 **Low-back Windsor armchair, Pennsylvania, 1755–1775. H: 28⅝″, W: 23½″, D: 16¾″.**

The Use Of Stretcher Compression In Preindustrial American Windsor Chairs

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Abstract

One of the most striking features of well-made Windsor furniture from the preindustrial period is the dramatic angles formed by the legs in relation to the seat, generally referred to as splay (*fig. 1*). The primary joint used in the framing of Windsor chairs is the round mortise and tenon. The legs are socketed into the seat and the stretchers are socketed into the legs, all using the round mortise and tenon. The purpose of the stretchers is to add strength and stability to the leg frame structure. Considering the splay of the legs, it appears the stretchers would be placed in tension in order to restrain the splayed legs from spreading apart even more, especially when the weight of the sitter is placed in the chair. Using X-ray analysis it is the intent of this paper to determine if the exact opposite condition is actually at work in Windsor furniture; that the stretchers are purposely placed in compression during the initial assembly of the chair. Using stretcher compression as a method of framing goes a long way to overcoming the problem of creating a stable and enduring undercarriage in a form that utilizes leg splay as a design element.

Introduction

How did Windsor chairmakers overcome the problem of producing a strong, stable and long-lasting chair that employs this concept of leg splay? This is an important question for conservators as well as other historians, as Cyril Stanley Smith reminds us, "Conservation can only be done properly when the techniques that were used for making the object originally are understood" (1965, 20). It is the purpose of this paper to identify if stretcher compression was a technique actually used by period Windsor craftsmen in the construction of their chairs.

The holy grail of evidence in this kind of research would be an explicit construction manual written by the chairmakers of the day, but as expected, the efforts of this researcher have not identified any written notes or instructions by period chairmakers that describe their construction techniques for the production of Windsor chairs. Therefore, other sources of information must be identified and interpreted to draw possible conclusions that are believable. Fortunately, there is one kind of excellent primary document still with us for examination; in fact there are lots of these documents–the chairs themselves. If observed critically, the evidence they contain can be *read* much as one does a written record once the researcher first understands the vocabulary of material, construction, design and function and then how they are put together. In this study inferences will be drawn from many shops' practices to determine if a particular construction technique was in general use. Forty-five Windsor chairs have been identified from twenty-three different shops, ten of these are shops attributed to known Windsor chairmakers. These forty-five chairs were examined visually and by x-ray analysis to determine if any previously unknown or unexpected construction methods were used in the stretcher-to-leg joinery used to stiffen the leg framing.

Another source of construction techniques, in the absence of shop notes from period chairmakers, are the ever-increasing number of instructional articles, manuals and books by modern-day craftsmen. Many of these sources describe *old* techniques used in the process of traditional chair building that appear quite reasonable and ingenious at times while at other times may cause confusion. These sources and ideas will be reviewed and related to other documents, artifactual and ephemeral, to sort out the confusion from the evidence.

A third source of valuable information lies in craftsmen's advertisements and inventories of the day. These documents often state the nature of the tools and materials they were using or provide insight into the quantity and quality of their production. This information can be very useful when considered carefully in the context of the other evidence.

Chair construction methods

The primary joint used in the framing of Windsor chairs is the round mortise and tenon. The legs are socketed into the seat and the stretchers are socketed into the legs, all using this joint. The purpose of the stretchers is to add strength and stability to the leg frame structure. But research has shown that round mortise and tenon joints have many inherent weaknesses, including: the glue surfaces are poor due to imperfect machining of the parts, the proportion of side-grain to side-grain gluing surface is limited, the best gluing area is at the mid-line of the dowel where it has the least racking resistance, and the tendency of these joints to develop compression-set loosening at the top and bottom edges (Hoadley 1995, 168–67).

Over the years there have been many attempts to overcome these inherent weaknesses of the round mortise and tenon joint. One technique was the construction of chairs using parts with varying degrees of moisture content and thus differential shrinkage characteristics to improve the success of the round mortise and tenon "A chairmaker could turn his posts [legs] with much of their original moisture content in them and could dry his cross-pieces [stretchers], or at least their tenons, so that they would absorb moisture from the posts and swell to create a tight finished joint" (Forman 1988, 80).

Shrinking mortises and swelling tenons did not completely solve the problems of the round mortise and tenon joint. "That such chairs can and often do come apart—John Alexander, Jr., describes them as 'failure chairs'—indicates that shrinkage techniques were governed by complex factors…" (Forman 1988, 80). For a taste of how complex these factors can be, Alexander explains how dry the tenons should be before assembling the chair:

> "A 5% moisture content prior to tenoning seems about right for chairs in most parts of the United States…the temperature of the rungs should be raised 13° F above room temperature in a room with 60% humidity in order to obtain a moisture content of 4% to 5%. The temperature should be raised 10°F for a 50% humidity, 6° F for 40%, 2° F for 30%, and zero for 20%" (Alexander 1994, 69).

These recommendations are for the moisture content of the tenons only. The moisture content of the mortises must also be considered, as Alexander continues:

> "If the mortise is too wet, the tenon, which absorbs water, will swell too much. The top and bottom of the tenon then press against parts of the mortise that do move appreciably as they dry, and tenon fibers become over-compressed. When the fibers are compressed beyond their limit of elasticity, they fail and set permanently in the compressed shape. Later in the life of the chair, lower moisture conditions (for example, in heated rooms in winter) cause the tenon to shrink and the compressed parts pull away from the mortise. The joint loosens. Too much moisture in the joint when it is made destroys it later on.…I've concluded

> that at the time of mortising and assembly, the post should contain about 15% to 20% moisture, and the rungs about 5%" (Alexander 1994, 79–81).

These moisture content and temperature parameters seem to be lofty goals for the preindustrial chairmaker as Forman observes "…in an urban craftsman's shop…moisture content was difficult to control" (Forman 1988, 80). With chairmakers unable to meet these strict criteria for differing moisture content of chair parts some chairs became so-called "failure chairs." Something more was needed to hold the round mortise and tenon together.

This something more was the notched tenon. In this technique a notch is cut into the dry tenon which is then inserted into a wet mortise, and as the mortise dries and shrinks, a ridge of wood from the wall of the mortise is forced into this notch thereby locking the tenon into the mortise. Now, even if the joint should fail due to less than perfect wood moisture content at the time of assembly, the joint is locked together mechanically as a kind of safety valve.

The techniques described above for improving the round mortise and tenon have the expressed purpose of preventing the tenon from withdrawing from its mortise. In the case of the ladder-back chair, if the tenons fail and begin to withdraw from their mortises, the leg posts connected by the stretchers are moving away from each other until eventually the tenons are completely removed from their mortises. If all the tenons were to come out of their mortises the chair would collapse. Another way to look at the stress on the mortise and tenon of a ladder-back chair is to think of the leg posts as pulling on the tenons. With stresses occurring at both ends of the stretcher, and these forces being in opposite directions, the stretcher is actually being stretched. A stretcher in this situation is said to be in *tension*. The unnotched mortise and tenon joint has no mechanical resistance to tension. For a chair that utilizes stretcher tension, it is apparent how important it is to create a joint where the tenon will not back out of its mortise.

The converse of *tension* in a mortise-and-tenon is a joint that is in *compression*. In the case of compression, the legs of the chair are pushing on the ends of the stretchers rather than pulling on them. Compression occurs where the tenon is in contact with the bottom of the mortise. Michael Dunbar purports that the force of stretcher compression is used in Windsor style chairs (1984, 26). To help understand how this is possible, an explanation of Windsor design is in order.

In most joined and post-and-rung seating furniture forms the rear legs and back posts from one continuous piece of wood, called the rear post, with the seat rails connected to these rear posts. However, Windsor furniture is constructed with the leg framing completely separated from the chair back by a thick plank of wood comprising the seat. This independence of the upper and lower sections of the chair, and the fact that the tops of all four legs are firmly secured in the seat plank, allow for the possibility of a unique construction methodology. As the chair is being assembled, a measurement is taken between the legs in order to determine the length of the stretcher to be placed there. Then when the stretcher is cut to length it is purposely made slightly longer than the specified measurement so that when the extra long stretcher is forced between the legs it pushes the legs further apart. Because of their attachment in the seat plank, the legs resist the pushing of the stretcher and place the stretcher in compression. Dunbar refers to this addition of extra length as "pre-loading" the stretcher. By pre-loading the leg frame of a Windsor chair with stretcher compression, the splaying legs are effectively pushed apart to their workable limit even before the first person sits in the chair. This anticipates the tendency of the legs to splay further and cancels out the possibility of more splay occurring. In the case of a chair stretcher, the extra length could be added to the entire stretcher forcing it to contact the bottom of the mortise, or the length could be added between the tenon shoulders (if shoulders are present), in which case the tenon shoulders would contact the surface of the leg around the mortise. In either case, compression would still be at work. And as Hoadley states, "A mortise-and-tenon joint has positive resistance to compression…even without glue" (Hoadley 1995, 167). When a round mortise and tenon joint is in compression the inherent weaknesses of that joint are effectively nullified.

Evidence of stretcher compression

The essential condition necessary in stretcher compression is that the stretcher is in contact with both legs in such a way that the stretcher can push the legs away from each other. The first real evidence of stretcher compression is the existence of points of contact where this pushing can happen. The second bit of evidence for stretcher compression is the shape of the stretcher tenons. Remember that a stretcher under tension must hold the legs together, and to facilitate this, the notched tenon was developed. Since a stretcher that is in compression does not attempt to hold the legs together, the tenons on such a stretcher can be left straight, with no consequence. The third bit of evidence is concerned with the moisture content of the legs and stretchers at the time of assembly of the leg frame of the chair; it can be expected that it is equally unnecessary to resort to shrinking wet mortises around dry tenons. Stretcher tenons that are in compression between two chair legs cannot withdraw from their mortises, and therefore, all the wood used in the construction of the Windsor chair could be of similar moisture content. This moisture content level would be most practical if it were as dry as possible, to avoid any unexpected changes in the dimensions of the wood parts if they were to dry further after assembly of the chair.

Materials of windsor chairmakers

As presented previously, one of the three pieces of evidence that indicates that chairmakers were using stretcher compression in their chairs is the use of dry, or seasoned wood, at the time of assembly for their stretchers and more importantly the legs. To determine the nature of the wood being used by chairmakers, two avenues of inquiry have been pursued. First, shop practices have been studied to determine how wood was acquired, when the parts were fabricated, and how long the parts may have been stored before they were used in the assembly of a chair. Secondly, advertisements of period chairmakers have been studied since they often indicate the quality of materials used in their product and sometimes even specify the seasoned nature of the wood used.

Whether chair parts were produced in-house, or out-sourced, Windsor chairmakers took advantage of labor specialization. Since it was cheaper to either produce, or purchase turned parts in quantity, chairmakers amassed huge numbers of chair legs and stretchers to be used as needed. An inventory of Ansel Goodrich's shop in 1803 included, "…about 500 rounds," [legs and stretchers]. (Keno 1980, 1101) A probate inventory for David Haven, of Framingham, Massachusetts, lists, "266 dozen [equivalent to 3192] chair rounds at 0.07 cents/doz." (Haven Registry of Probate 1801) An even larger inventory is that of Ebenezer Tracy, Sr. who had on hand, "6,400 Chair rounds & legs," (Evans 1996, 287) when he died in 1803. An extremely large stockpile of chair parts was indicated by Francis Trumble when he advertised in 1775 that he had on hand, "Twelve hundred Windsor chairs" (Evans 1964, 222–23). "Although the chairs were unassembled, the parts were ready to be framed on short notice for local sale or exportation." (Evans 1996, 96) Since the leg frame of one Windsor chair requires seven turned parts, the twelve hundred chairs in Trumble's advertisement represents a combined total of at least 8,400 legs and stretchers.

It is not known how long these chair parts were held in inventory, and thus allowed to dry, before being assembled into a chair frame. For the purposes of approximating the moisture content of these parts, it will be assumed that the inventory was used as soon as it was established. To roughly determine the moisture content of the legs and stretchers at the time of assembly, consider the work processes required to transform the raw material into an assembled chair. The tree, of course, would have to be felled and delivered to the turner. To be conservative, it will be assumed the turner is starting with wood parts that are green, or at their highest possible level of moisture content, even though some moisture loss would have commenced once the turning blanks were roughed-out of the log. In the case of the Tracy family of chairmakers there was a maximum of six men capable of producing turned elements, and for a brief time there were six lathes available for all six men to work simultaneously (Evans 1996, 286). Assuming each man could produce eight turned elements in an hour (Dunbar 1990, 9), and an average working day being eleven hours, six days per week, a total of 3,168 turned parts could be produced in one working week, not counting breaks for eating, or other necessities. This means the 6,400 legs and stretchers in the Tracy inventory would have taken a minimum of two weeks to produce.

Then we come to the question, how long did it take to assemble a Windsor chair? We are told by Hummel that, "just before and after 1800 labor costs approximated the number of days required to make a particular furniture form and the retail price of furniture was an average of three and one-half times the labor cost." (Hummel 1979, 56) During this time period, the retail price of a bow-back side chair, one of the most common forms of the Windsor, was 9s., or about 1½ days pay (Evans 1997). If we apply Hummel's rule, a chairmaker could produce, on average, about 2½ chairs per day. Using the Tracy shop as an example, with a possible maximum of six men capable of assembling finished chairs, fifteen chairs could be made in a day, or ninety chairs in a six-day work week. Again, counting seven turned parts per chair, the 6,400 parts in the Tracy inventory represents 914 assembled chairs. Working at breakneck speed, it would have taken the Tracy shop ten weeks to use up their inventory of "chair rounds and legs."

Exact drying times are impossible to predict for the lumber used by the Tracy family, or any other chairmaking shop, but a few generalities can be made. Although several different woods were used for the stretchers and legs, maple is the most commonly found. The approximate time required to air-dry one-inch thick maple lumber to a 20% moisture content ranges from 30–200 days (Hoadley, 241). A moisture content of 20% is well below the amount necessary for dimensional shrinkage to occur in most wood species. In fact, at 20% moisture content, the lumber has already manifested half of its potential shrinkage considering its moisture content will bottom out around 10 or 12% in a typical eighteenth-century shop with no central heating. Since the average annual relative humidity in the Northeast is typically in the 70% range, the environment in an uncontrolled shop could be expected to hover around the same 70%, which translates into an equilibrium moisture content of 12% for typical wood species. In the case of the Tracys, the very least amount of time required to transform the raw material from the tree into the finished product is twelve weeks, or eighty-four days. By this time, the chair parts have either dried to 20% moisture content, are well on their way, or may even have reached a lower moisture content level.

The minimum projection of eighty-four days being necessary may be quite generous in that it assumes six men in the Tracy shop assembling chairs. Leigh Keno mentions that is was the master's job to assemble the parts that were being produced by apprentices or journeymen (1980, 1101). In the Tracy shop, Ebenezer, Sr. would have been the master, with Ebenezer, Jr., and his cousin, Stephen Tracy, both being old enough, and sufficiently skilled to conceivably take part in actual chair assembly. This more realistic scenario of three men working together at the assembly of the chairs, while the other workers performed other duties, greatly increases both the time required to turn the 6,400 parts, and the time required to assemble the chairs. In this light, it is quite believable that the inventoried parts were well dried before assembly.

The storage of chair parts was more than just a convenience, or an economy of time. It was a deliberate attempt to let the parts dry before assembly. Chairmakers often advertised in local newspapers, many times describing the nature of the materials used in their goods. Benjamin H. Henshaw, a chairmaker from Northampton, Massachusetts, advertised that, "All articles in his line of business shall be furnished upon short notice & made of the best materials and warranted from 3 to 10 years" (Keno 1980, 1106). The hopeful, yet vague phrase, "best materials," is further described by other chairmakers, such as Stephen Prentiss, Jr., of Walpole, New Hampshire, who, "offered in 1791 to receive almost any kind of Produce…in payment for Chairs constructed of seasoned…stuff" (Evans 1996, 397). Even more specific was this advertisement in 1787 from Providence, Rhode Island, that states, "Daniel Lawrence informs the respectable citizens that he carries on the chair-making Business in Westminster street where he makes and sells all kinds of Windsor Chairs…warranted of good seasoned Materials so firmly put to-gether as not to deceive the Purchasers by an untimely coming to pieces" (Bjerkoe 1957, 142). These last two advertisements specifically state the "seasoned" or low moisture content of the materials used in their chairs.

Physical evidence

As stated previously, the final two pieces of evidence of stretcher compression are straight (unnotched) tenons, and points of contact where the tenons are pushing the legs apart. To determine whether either of these conditions exist in preindustrial Windsor chairs, X-rays were taken of the stretcher-to-leg joinery of the sample set of chairs.

The first chair examined is a sack-back chair made by Joseph Birdseye, ca. 1790–1810, in Huntington, Connecticut. The tenons in this chair are straight. In addition, the tenons, which are rounded at their ends, fit snugly into similarly round-bottom mortises in the legs. The rounded ends of these tenons are touching the bottom of their respective mortises. This condition of tenon contact with the chair leg was found on all of the stretcher tenons of this chair, which suggests a consistency of workmanship.

A set of six, bow-back side chairs, ca. 1768–1780 made by Henry Bacon of Providence, Rhode Island, also show rounded tenons fit into round-bottom mortises. The only difference is that Bacon's tenons are rounded to a slightly larger radius than the mortise bottoms are. The larger radius of the tenon does not allow it to fit completely to the bottom of the mortise. However, the tenons go as far as possible into the mortises until they contact the beginning of the rounded mortises. In the case of the Bacon chairs, the points of contact occur at an arbitrary location along the radius of the mortise bottoms, rather than at the very bottom of the mortises. This condition is present in all six of the chairs in this set, suggesting a very deliberate and consistent habit of workmanship. Also, all of the tenons in the Bacon set of chairs are straight.

Another set of six chairs, in the bow-back style, made in Boston, ca. 1790–1825, exhibits a different, but consistent habit of workmanship. The tenons on these chairs are straight, but here the similarity ends. The mortises are flat-bottomed, as are the ends of the tenons. But the tenons do not contact the bottoms of the mortises. In fact, there is quite a large space between the end of the tenons and the mortise bottoms. The tenons on all of the stretchers are formed with definite shoulders that have a larger diameter than the tenons and cannot fit into the leg mortises. These tenon shoulders are in contact with the chair legs around the mortise openings. It is at this location that the stretchers may push on the chair legs.

A sack-back chair attributed to Ebenezer Tracy of Lisbon, Connecticut, ca. 1790–1800, presents different scenario than any of the chairs mentioned so far. The tenons on this chair are clearly notched. As was explained earlier, notched tenons indicate a situation where the maker expected the stretchers to be placed in tension. Some of the tenons in the Tracy chair do contact the mortise bottoms while others do not. There are very small and gradual tenon shoulders present that do not clearly provide a contact point with the chair legs.

Conclusions

Chairmakers inventories, work habits, and advertisements indicate that the parts used to frame the undercarriage of preindustrial Windsor chairs were purposely allowed to become seasoned prior to chair assembly. This suggests that these chairmakers were not relying on differential shrinkage of wet mortises around dry tenons to create a tight mortise and tenon joint. Of the forty-five chairs examined by X-radiography, forty-two chairs have straight tenons and exhibit points of contact for stretcher compression to occur, either by the tenon touching the mortise bottom, or by the tenon shoulder touching the chair leg. Two chairs have pins through the mortise and tenon joints, raising the possibility of later repairs and disqualifying them as proper study samples. Only the chair attributed to Ebenezer Tracy has notched tenons. Notched tenons indicate the intention of placing the stretcher in tension. With the exception of the Tracy chair, it is likely that preindustrial Windsor chairmakers utilized stretcher compression in the leg framing of Windsor chairs. Further study is required concerning the shop practices of Ebenezer Tracy.

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