# Curved Timber

## How one timber framer hews, bandsaws and steambends straight stock into curves

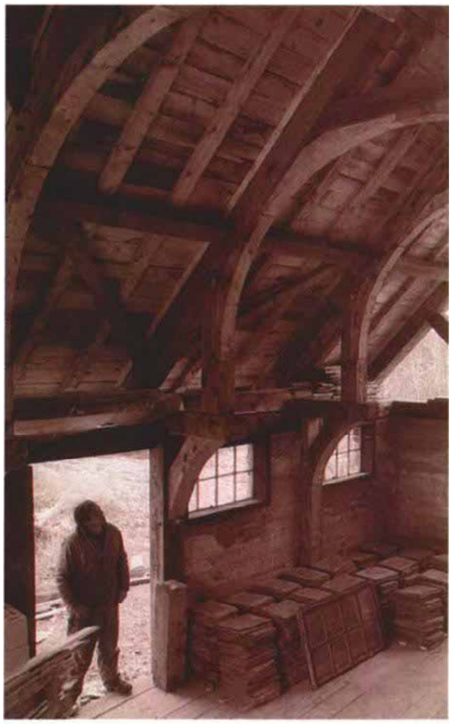
by Ed Levin

The process of turning trees into lumber is largely a matter of turning irregular curves into smooth, straight lines. It's an uphill battle, as any woodworker can tell you. So if straight and square is the lumberman's Holy Grail, why is curved work the highest expression of the woodworker's art? Windsor chairs, Chippendale highboys, the flowing lines of a wooden hull and the soaring heights of a vaulted church all attest to this mystery. The process is fraught with paradox: in order to round the wood, I must first make it straight and square, yet sometimes when working on a curved brace, it seems that I am trying to turn lumber back to a tree again.

The only curved timbers that start out as such are found curves, which are curved trees or limbs that are sawn or hewn along their natural lines. In the medieval heyday of timber framing when elaborate curved work was common, supplying curved stock must have been an established business. Even today, some boatbuilders have a standing order for hackmatack knees—the curved, exposed roots and limbs of larch trees. Found curves are also seen in matched pairs as wind braces or cruck frames (for more about cruck frames, see *FHB* #42, pp. 40-44).

**Curves shaped by hewing**—Shaped curves are sawn or hewn from straight stock. These days most of the work done by me and my partners is bandsawn, but once we did hew a curve in a timber, serendipitously. A friend wanted the focus of a timber-frame addition to be a 20-ft. long summer beam, hewn from a tree in his woodlot. We felled and hauled in the only tree large enough to make the required 8x12. After we crosscut and peeled it, the trimmed log was predictably smaller and less straight than it looked on the stump, and it would have made a very waney 8x12. We decided to hew only three sides, leaving the bottom of the beam in the round. After rough hewing the three sides with a 12-in. broadaxe, we shaved them clean with a 6½-in. lipped adze. The completed summer beam was handsome and reasonably square and straight, and we quit for the day well satisfied.

But by the next morning, the tension in the undressed sapwood side had pulled the beam into a curve and the midspan of our formerly straight summer was now displaced more than 2 in. out of line with the ends.



**A four-part curved arch joins a hammer post to the hammer beam. Rather than feather into the post, the arch is cut with blunt ends for bearing strength.**

Since attempts to straighten the timber by additional hewing would probably only cause it to bend further, we concluded that we'd found a new method for curving timber and had better make the most of it. We raised the joists so that their tops would clear the high point of the summer beam. The counterpoint of the straight joists against the gently curved summer beam gives a slightly domed effect to the room.

**Curves shaped by bandsaw—**The simplest way to introduce a curve into a timber frame is to use curved wind braces. We first attempted this by cutting a radius only in the inner edge of the brace, then tried rounding both inner and outer surfaces. This was better but still not right. We were looking for a shape that would look both tense and limber. We finally settled on a broken-back brace with the inner face radiused and the outer face faceted (photo facing page). Here, the brace seems to be flexing its muscles against the load. This shape also works well for a curved collar beam, where the collar strains against the inward thrust of the rafters at midspan.

To make a curved brace, we start with 3x10 stock. We rough cut it with a 14-in. bandsaw, then clean up flat surfaces with a power plane and curves with a compass plane, removing any blemishes with a steel scraper. An alternative to the power plane would be to use a powerful router with a long straight bit, guided by a radiused fence. A well tuned spindle shaper can make a reasonable substitute for the compass plane.

Another curved timber that is easily incorporated into an otherwise straight frame is a flared post. The extra width at the top can accommodate tenons from both the plate and tie beam. Folklore tells us that such posts were cut from butt logs using the natural taper of the trunk to obtain the flare. These days we saw flared posts from oversize straight timbers.

**Bandsaw technique**—A word about bandsaw technique with heavy timber: You can easily run braces and other light members through a bandsaw, but as the stock gets bigger, you'll have to improvise. Rather than horse around with a giant green timber on your saw table, you might want to consider moving the saw rather than the stock.

You'll need a flat, stiff shop floor and a small bandsaw on casters. Support the stock on sawhorses (it's useful to have three or four because you'll have to shift them during cutting) and wheel the saw through the cut. The beam must be raised above the saw table, or you can remove the table entirely to provide additional clearance for thick stock. Timbers heavy enough to warrant this procedure will not flex under the downward pressure of the saw blade.

For repetitive work like sawing flared posts, we use a portable bandsaw mill. We cut 2x guides to the correct radius and fasten them to the timber. The mill rides on the curved guides. This produces a smooth, accurate cut requiring little cleanup.

**A hammer-beam roof**—Although we enjoy using curves as accents, we also like the opportunity of building a frame with curved work throughout. My neighbor Dimitri Gerakaris began construction of his new blacksmith shop in 1973. For a year he laid stone walls, and we talked about what his roof should look like. We met one evening at the Dartmouth College library, where I was researching carpentry in the Middle Ages. Thumbing through engravings of medieval buildings, Dimitri turned to a section on church roofs. A single look was enough—he would have a hammer-beam roof.

If you were an Englishman building a church in the 14th century and a vaulted stone ceiling was beyond your means, you might have built a hammer-beam roof. Such a roof features brackets that project from the top of the wall to support roof trusses, allowing relatively short timbers to span a wide room (photo, facing page). Often the oak timbers were richly molded, with winged angels on the ends of the hammer beams. This would be a blacksmith shop, not a church, so we built a plain version (no angels).

Curves spring from wall post to hammer beam and flow up through the semicircular arch, which ties hammer posts, principal rafters and collars into a rigid frame. The arch is made up of four segments, each with two long tenons connecting the rafter to post or collar. The curved segments have blunt ends both for bearing and to avoid the weakness inherent in a feather edge in short grain.

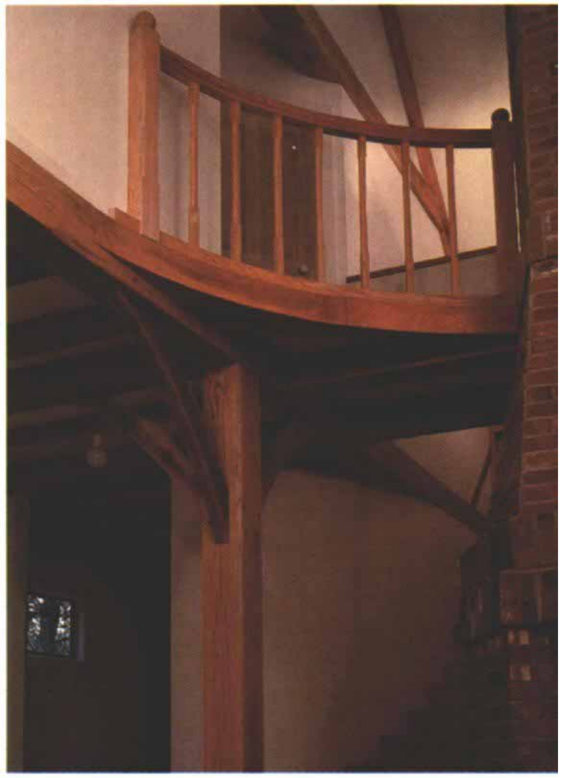
**One house, many bandsawn curves**—Several years passed between the raising of the blacksmith shop and our next major curved work. Steve Manning asked me to design and build a house in Greenwich, Conn. Following his program, I designed a house with curved spaces defined or accented by curved framing. The second-floor landing is defined by a 12-ft. dia. semicircle and is open to both the living room below and the peak of the gable above (photo at right). In order to frame each of the two quadrants of the curved landing with a single piece sawn from solid wood, the raw stock would need to be 24-in. wide. In addition to the impracticality of searching out such enormous pieces of wood, the resulting structure would be unstable—the curve is so deep that a point load at midspan would torque the ends. We solved this problem by making each of the quadrants from two pieces joined together like halves of a pair of scissors. To avoid the feather-edge problem mentioned earlier, we used a strengthened halving joint. The inside of each quadrant is cut to a 6-ft. radius and the outside face is faceted in the broken-back profile (drawing below).

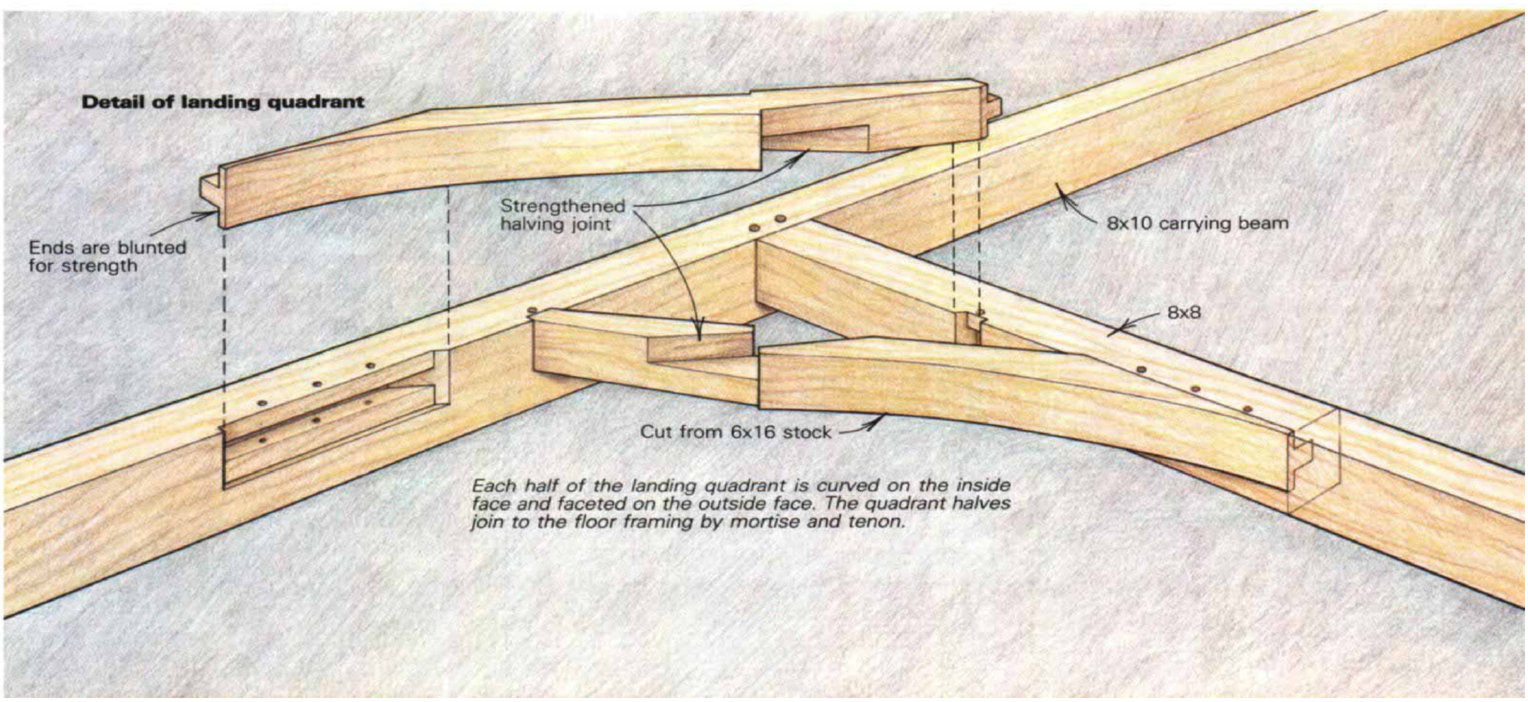
We also designed a solarium with five arches, each made up of two quadrants sawn from 5x15 stock (photo, next page). The quadrants are fastened into posts, girts and plates, and tenons running the full length of the straight side of each quadrant are shouldered at the bottom for more bearing (drawing, next page). The plate (dubbed the "serpentine plate" because of its sinuous lower edge) receives tenons from three arches and two posts so that it contains a continuous mortise.

**Curves shaped by steam**—In the spring of 1985, Bill and Tom Webster asked us to design and build a small house with a timber frame that would enclose one large space. We designed a roof formed by two intersecting gables, with windows in the four gable ends and a lantern set atop the crossing (for more on this house, see *FHB* #45, pp. 4448).

The 24-ft. by 32-ft. open space under the crossing presented a structural problem because we wanted to avoid interior columns. To resist the thrust of the roof and to stabilize the roof frame, we linked the four posts that support the valleys with tie beams and braces to form an octagon, 10 ft. on a side. The connection between valley posts and rafters was stiffened by the addition of arched braces that join these elements together into the continuous ribs of a cross vault. Pairs of curved wind braces would branch upward from the corner posts and arches would rise from tie beams to collar beams in the gable ends. As we designed the frame, the catalog of curved timber grew un-

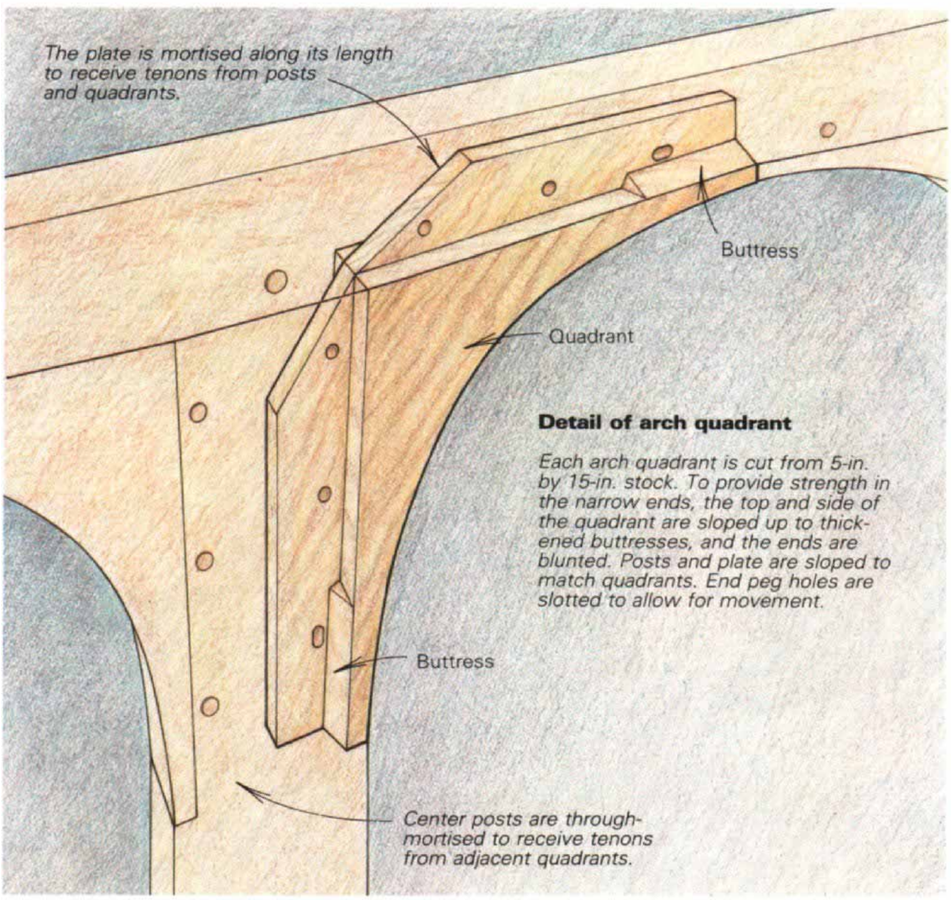
**The two curved timbers in this floor opening are joined by a strengthened halving joint (drawn below). The post is stiffened by two broken-back braces.**





*Each half of the landing quadrant is curved on the inside face and faceted on the outside face. The quadrant halves join to the floor framing by mortise and tenon.*

**Each arch in this sunroom is made up of two quadrants sawn from wide stock (drawing below). The 5x5 plate waves slightly along its lower edge as it reflects the slope of the arch quadrants. The plate is mortised along its entire length. *Photo by Karen Bussolini.***




til it comprised one-quarter of the lumber, engendering a crisis.

For some time, doubts had been growing in our shop about the wisdom of bandsawing these curves from oversize stock. First of all, there was the waste. The sizes of stock for this frame ranged from 5x12 to 6x18, most of which would end up as firewood. And the sawn curves would invariably cut through the heart of the tree resulting in unsightly checking as the wood dried out. Finally, the straight-grain pattern would conflict with the curved edges of the stock. On all counts we would be much better off bending rather than sawing our curves.

Taking the plunge, we ordered straight-grained 6x6 oak timbers and got in touch with Ed McClave, a boatbuilder and repairer from Noank, Conn., who, more than anyone, has turned steambending into a science.

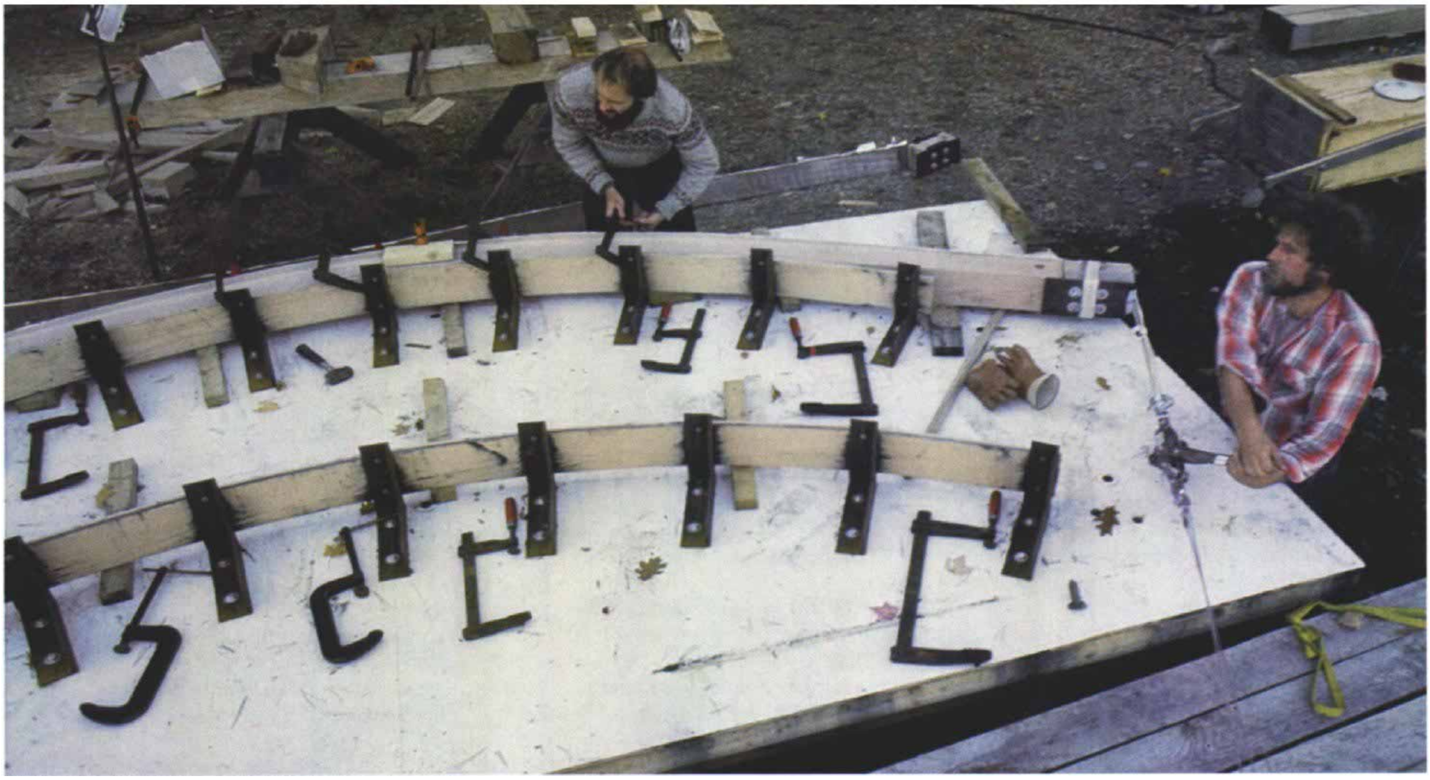
**The physics of steambending—**The most difficult of the obstacles encountered in bending heavy stock are springback and overbend. Under normal conditions wood is an elastic material—it bends in proportion to an applied load and straightens out when the load is removed. Steam performs two functions in bending timber. It heats up and plasticizes the wood fibers so that the stock does not return to its original shape after the bending load is removed. Steam also keeps the wood moist and moderates the effects of too-rapid drying.

But the wood is never completely plasticized (nor would you want it to be for any kind of structural application), and the elasticity left after steaming and bending causes the timber to move partway back toward its undeflected shape. In order to compensate for this movement, or springback, you must overbend. The trick lies in determining the amount of the overbend. Paradoxically, the milder the bend, the more elastic the wood remains, requiring greater overbend. Conversely, for sharper bends less overbend is called for, since the stock is more completely plasticized.

Careful observation over years of boatbuilding, coupled with a strong engineering background, allowed McClave to work out the physics of steambending. He gave us the basis for calculating the correct overbend radius for a given species, stock thickness and finished radius.

**Steambending apparatus—**We began by building a bending table and steambox. The bending table was a 90° grid of timbers stacked and bolted together. The top layer of beams was closely spaced, then sheathed with ¾-in. plywood (photos, facing page). After screwing down the plywood, we sealed it with two coats of waterproofing primer and marked out the overbend radius, which was about 9 ft. for 5-in. thick stock that we wanted to bend to a finished radius of 11-ft. 6-in. Cleats fabricated out of 4-in. by 3-in. by ¼-in. angle iron were then bolted to each timber to define the inner edge of the curved piece.

Drawings: Heather Lambert



**A timber, hot from the steam box, is pulled against a curved form with a come-along and clamps.**

Our table could accommodate two nested bends, so we made our steambox large enough to hold two 16-ft. 6x6 timbers.

We set up the steambox, a long, open-ended pine box on sawhorses (photo above) and pitched it slightly toward one end so condensed water would drain. We added sleepers to elevate the stock and allow the steam to circulate, and attached plywood doors and felt seals at each end. The temperature inside the box was monitored by several meat thermometers. We fashioned a steam generator from a 250,000-Btu propane torch set inside an open-topped metal drum that supported a water-filled 5-gal. fuel can. Steam from the can was fed into the steambox through a radiator hose. The water level was maintained through a Rube Goldberg arrangement we devised after a near-meltdown. A garden hose regulated by a toilet float valve fills a bucket with water, which then siphons into the fuel can. At peak output, we converted a gallon of water to steam every three to five minutes, consuming 40 lb. to 50 lb. of gas per day. We also had a backup steam generator on loan from the town road crew, which used it to thaw frozen culverts in the winter. We used it to apply steam to the stock as it was being bent, in an effort to keep the wood from cooling too quickly.

**The bending moment arrives**—The scene at the first bend, with crew members dressed in protective clothing and ready for fast action, resembled a pitstop at the Indy 500. At the signal, the torch was killed and the doors to the box flung open. We hustled the timber onto the bending table shrouded in great clouds of steam, and each crew member took up his assigned station. Two men worked come-alongs, two others applied the clamps as the timber came up against the cleats and the last man used the town's antique boiler to play live steam over the stock, once again enveloping us in fog. After a couple of bends, it dawned on us that steaming wood was like working iron in a forge—small pieces heat up and cool down rapidly but large pieces heat up slowly and cool slowly. We realized that we could ease off the frenetic pace and dispense with the secondary steaming, so subsequent bends were more relaxed, workmanlike affairs.

**After the steamed timber was clamped into place on the bending table, Levin hosed it down to keep it from checking.**

Once out of the protective environment of the steambox, the timber's internal heat would cause rapid drying and would also cause checking. So as soon as a piece was securely clamped in the bending form, we would hose it thoroughly with cold water, cover it with with wet burlap and keep it wet with a soaker hose until it cooled completely.

As we learned more over the course of the job, we incorporated other improvements. Rather than bending smoothly, the timbers would tend to kink around the clamping stations, so we made a continuous inner form of laminated oak and fastened it to the angle iron cleats. A ⅛-in. by 6-in. sheet-metal compression strap clamped to the outside radius with end blocks let us bend pieces that would not otherwise have held up under the tension of the bend (photo, left). We also clamped the stock to the table vertically to control the tendency of the timber to twist.

Midway through the job, the bending routine was well established. We placed two 6x6s in the steambox at the end of each day, and the first person in the shop in the morning fired up the boiler. Following the rule of about one hour of steaming per inch of thickness, we kept the interior of the steambox at or above 207° F for at least five hours for a 6x6 timber. Just before the new sticks were to come out of the cooker, we would remove the previous day's work from the table. But first, we'd secure and tension each bend with straps and a come-along ("stringing the bow"), then release the come-alongs and clamps holding the pieces to the bending table and tilt the curved timber up off the table. Finally, we nailed stay laths to both sides of each piece, slackened the bowstrings and stockpiled our newest bends. □

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