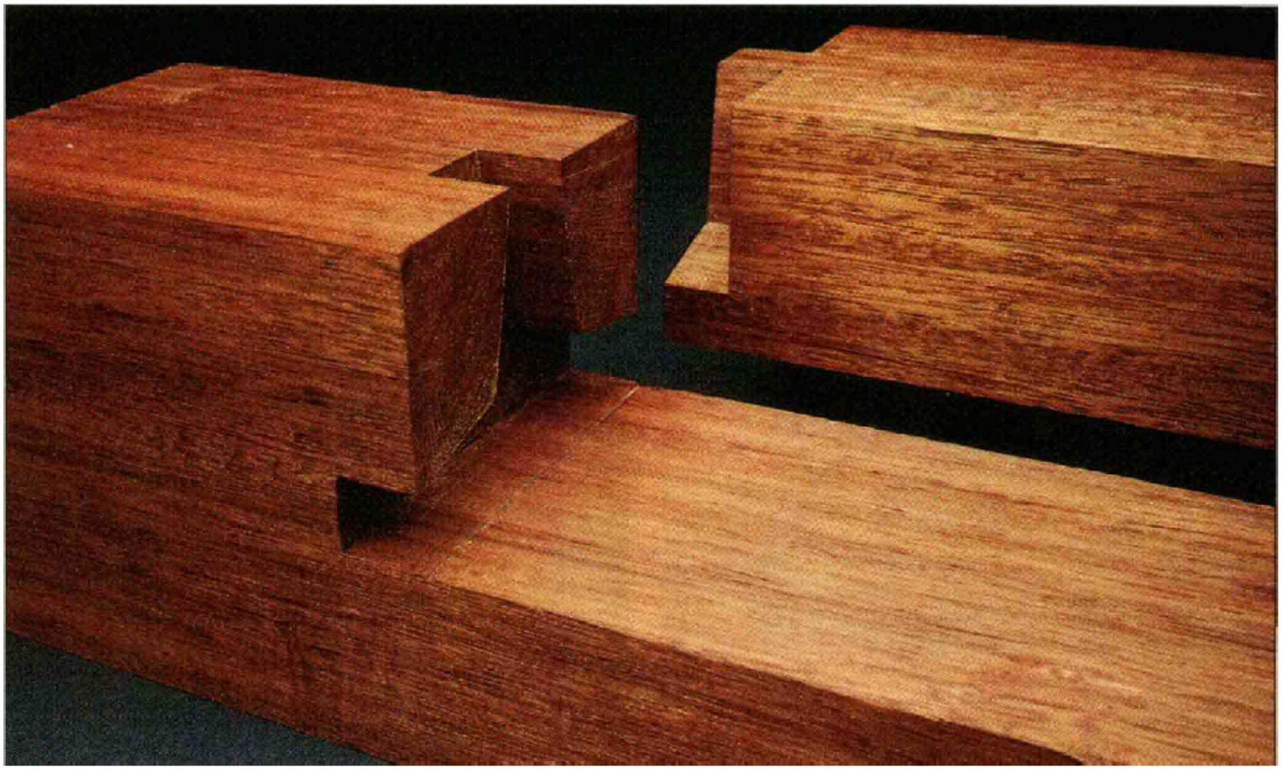


JOINERY LESSONS *from the* DISTANT PAST

NAUTICAL ARCHAEOLOGISTS ARE BRINGING UP STRUCTURES THAT ARE WORTH A THOROUGH LOOK

BY TOM JACKSON

PHOTOGRAPHS BY DAREL BRIDGES

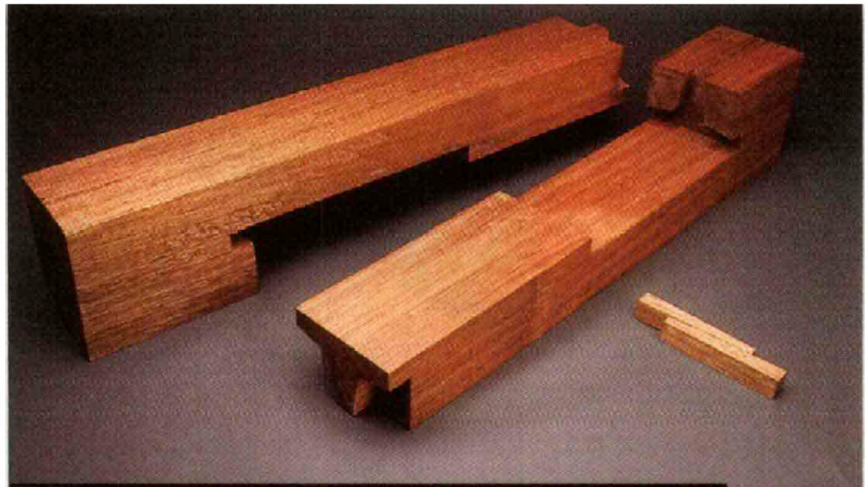
Fitting a scarf joint well, especially in a large timber, is one of the marks of a Boatbuilder. Some are born with an eye for good joints and others develop one, but all boatbuilders make a habit of studying structures—whether barns or bedlogs, cathedrals or keelsons—and mentally noting ways to adapt or improve them. In our times, that study can extend even to the work of the most ancient boatbuilders.

Some would say there's nothing to be gained by such an exercise. But I disagree. Having become intrigued with the many technical drawings reprinted in J. Richard Steffy's book *Wooden Ship Building and the Interpretation of Shipwrecks,* I set out to build five complex joints. They aren't full-sized—it might be interesting to scarf two 12"-square timbers just for sport, but it's no job for a solo boatbuilder and a great waste of lumber. I could learn what I wanted in boat-sized, rather than ship-sized, reconstructions. Still, there's nothing hypothetical about these joint designs, since all were used in average vessels, most of them merchantmen.

Just as archaeology has put seafaring into its proper historical perspective (see sidebar, page 56), so it has the story of boatbuilding. As fastenings improved with time, as relative labor costs increased, and as production boatbuilding emerged, techniques were greatly simplified. We rely today on excellent metal fastenings, and the powerful glues used in some boatbuilding techniques seem to have replaced joinery altogether. It may be true that in today's world few of these ancient joints have practical applications; nevertheless, all of them provide insights into basic problems of building a wooden hull. Like wooden boats themselves, they are worth looking at and preserving for their own sakes.

I was able to obtain offcuts of angelique (see WB No. 153) in suitable sizes. I used a circular saw, a hand-held power plane, and a bandsaw for roughing out. Because of the shapes involved in these joints, much of the finishing work had to be done with hand tools. I found a variety of chisels and planes, especially rabbet planes, to be most useful. One indispensable tool was a Japanese saw. For clarity, I omitted planking rabbets.

The joints I chose cover a huge span of history—from hundreds of years before Christ to the middle of the 1600s. They represent viable and elegant solutions in the technology of their times. I am certain that the anonymous builders who conceived them and made them a part of their routine had traits any boatbuilder would recognize. They knew that an accurate joint starts with careful measurement and careful marking. They knew that a sharp blade makes work a joy and that a dull one makes it an agony. They knew patience, the value of planning, and the importance of using wood properly seasoned for the job at hand. They knew how much effort it takes to make a timber perfectly dimensioned and perfectly square, with flat surfaces and fair curves. If they were anything like me, they knew how to recognize their own fatigue and when to walk away from a difficult or a disorienting cut—when to come back fresh in the morning. These are lessons boatbuilders today learn on their own or from one another.



Functional sculpture: Roman keel scarf technique, 100 B.C. (this page and opposite).

Functional Sculpture

It's difficult to imagine a scarf joint more perfectly engineered than this one. It shouldn't come as a surprise, then, that a ship built by Romans—the engineer's engineers—used two joints of this design in a complex keel assembly.

The wreck is known as the Madrague de Giens ship, excavated off the south coast of France in the 1970s under the leadership of Dr. Patrice Pomey of the Centre Camille Jullian. She was about 131' long and sank about 100 B.C. No royal pleasure barge or state-of-the-art warship, she was a merchant vessel laden with wine, large at 400 tons' capacity but not extraordinary. The principal keel timber was elm, sided 14" wide at its top surface and molded about 16" deep but deepened by 14" with the addition of a false keel beneath, the two timbers being attached to each other by mortise-and-tenon joints.

I replicated this joint at a smaller size: 5" x 6". At its heart, this is a keyed scarf joint, but this variation expands on the concept. When its distinctive Y-shaped tenons slide into their matching mortises with a deep and satisfying *"thunk,"* a square hole opens up, allowing simple opposing wedges to be driven into place to secure the joint. There are no other fastenings.

The shape of the tenons is a beautiful adaptation of the principle of the wedge. Getting a good fit between the tenons and their matching mortises is by far the hardest part of the job. They would have been much easier to mark and shape had they been squared and T-shaped rather than Y-shaped. But consider the vertical "leg" of the tenon by itself for a moment: it is a section of a wedge, viewed from the side, that will slip into its matching mortise. This locks the joint, preventing movement side-to-side, but even if the "arms" of the Y were cut away, this wedge would still effectively block any tendency of the butt of the joint to slip vertically. The same is true of the athwartship shape of the arms of the Y. They, too, form sections of wedges, locking the joint vertically but serving the secondary role of assisting the vertical leg in halting any side-to-side movement. In a phrase, these shapes disperse stresses. Once the key wedges are tapped into place, this joint is remarkably immobile and very, very tough.

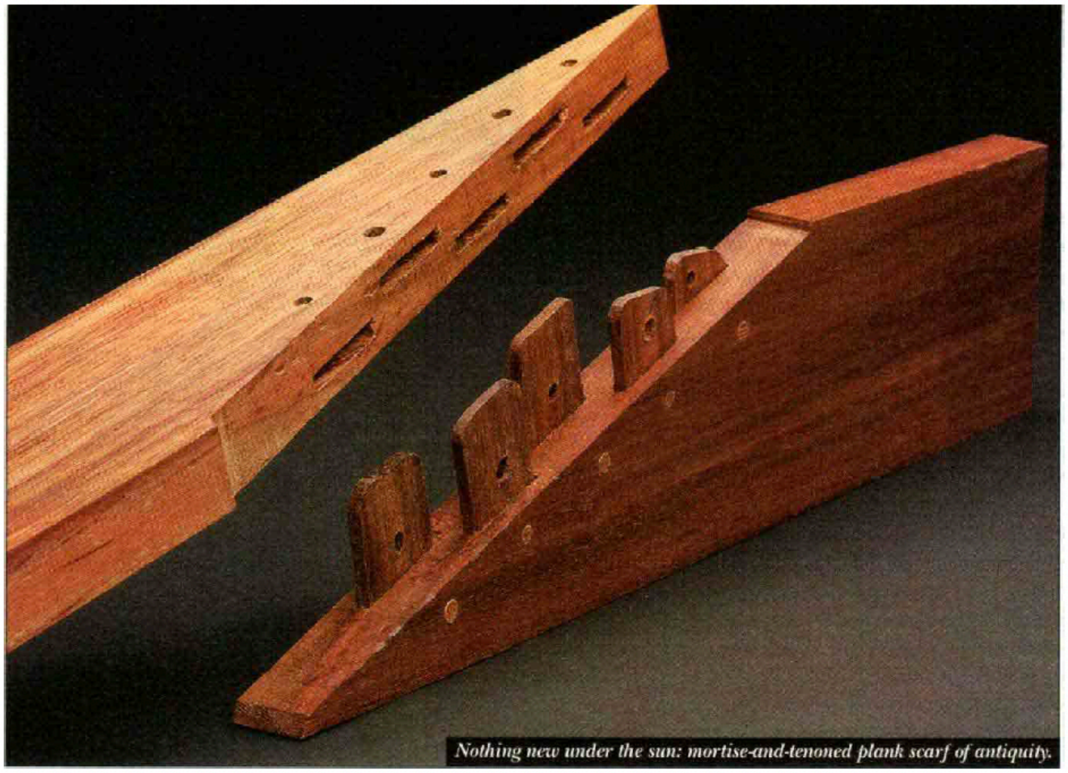
There's another advantage: Whenever this joint is taken apart and then reassembled, it returns exactly to its previous alignment. Once finished, it could be taken apart and slathered with tar and then reassembled without skidding even slightly out of kilter.

There is a compelling elegance in this design. Its principles are elementary but timeless. Every part contributes to the integrity of adjacent parts. When I first saw this joint, I knew I had to build one like it. If nothing else, it is a salute to the craftsman who developed it, not for show but for strength deep in the keel of an ordinary vessel, where he alone would be aware of its existence.

Nothing New under the Sun

A glance at this mortise-and-tenon-joined plank scarf will prove instantly that it is impossibly archaic and completely foreign to the interests of modern construction. It may come as a shock, then, that this ancient technique has more in common with modern cold-molded construction than it does with "traditional" boatbuilding.

First, the scarf. Not representative of any particular joint from any particular vessel, this is my adaptation of a fastening system found on many classical-period Mediterranean wrecks, including the Madrague de Giens ship. Planking scarfs like this were never nibbed; they were either straight or given a very slack S-shape, the feather edges being nailed down. This being a joint I



Nothing new under the sun: mortise-and-tenoned plank scarf of antiquity.

wanted to be able to take apart and reassemble many times, I chose to break with tradition by making it straight with nibbed ends to avoid the feather edges. This finished piece measures 1 ½ thick x 6" wide, not much different from the plank dimensions of a famous and beautifully documented shipwreck—the Kyrenia ship of the fourth century B.C. (see sidebar), excavated off the coast of Cyprus under the leadership of Michael Katzev, then of the University of Pennsylvania and later of Oberlin College and the Institute of Nautical Archaeology (INA).

My five tenons are ¼" thick, 2" wide, and about 4" long, except where they are truncated near the scarf ends to avoid breaching the plank edge. These are fairly small: according to Steffy, the Kyrenia ship tenons averaged 6.5" long, and in large Roman ships the tenons reached dimensions of ½" thick, 3" wide, and 9" to 10" long. Such tenons are not only a fastening system, they double as a kind of internal framing.

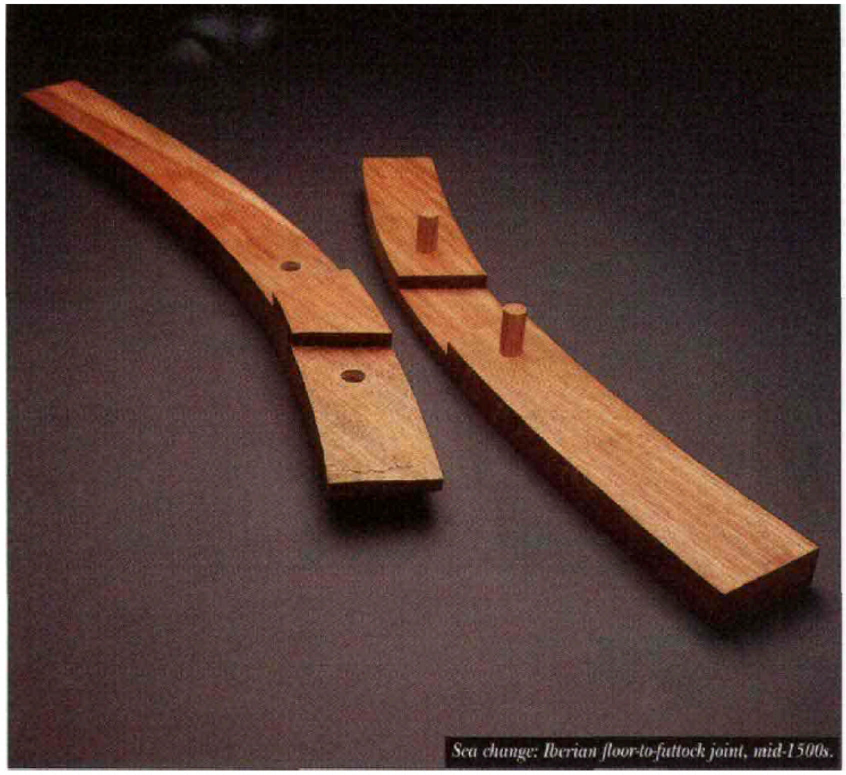
The scarf itself is fairly short and steep—a ratio of only 3:1—to avoid ends that would be too narrow to accommodate tenons. The tenons run perpendicular to the scarf, a pattern associated with two lengths of planking scarfed together off the boat to make a full run that could then have been fitted as a unit. (Another method involved scarfing the plank in place on the boat, with tenons set perpendicular to the run of the planking. The reason will become clear below.) Note also that these tenons are staggered, forming a two-line pattern usually found on heavier planks or wales.

In this form of shipbuilding, not only were scarfs mortise-and-tenon fastened, but every plank was joined to its neighbor, and the garboards to the keel, and the keel timbers to one another, using the same technique. Planking tenons were set remarkably close—on about 5" centers. (A scarf fitted on the boat had to have tenons set parallel to those joining the planks themselves, otherwise it would be impossible to slide the plank into place.) Of course, all of the tenons would have to be individually fitted, changing angles with the rolling bevels of a typical round-bottomed, double-ended hull. The only caulking was an exterior coating of pitch, but because wood swells more across the grain of the plank than with the grain of the tenons, the joint would pull itself together when immersed.

The labor involved is impressive. This joint took me the better part of a day to finish. I shaped the first of the 10 mortises using only my relatively poor selection of chisels. On the second one, I first bored lines of holes with a brace and bit before chiseling. By the third, I had resorted to a drill press. My best time for a finished mortise was about one-half hour. Let's say an experienced hand could double my rate by using specialized mortising chisels, with an apprentice to sharpen them frequently. It would still take 2,000 man-hours, 250 man-days, just to cut mortises—8,000 of them for the 4,000 tenons that were estimated to have been used in the Kyrenia ship. The Madrague de Giens wreck was about three times as long as the Kyrenia ship and was double-planked to boot, giving her a great many more of these fastenings.

Judging by the creaking sound these pieces made when the clamps brought them together with surprising ease, boats joined this way must have made beautiful music below decks when underway. With the tenons in place and the joint tightly clamped, I bored for the 3/8" white oak pegs. These I turned on a lathe for a snug fit, drove firmly, then cut off flush. When I freed the clamps, I was amazed at how tightly the joint held. A few passes with a jointer plane and a little work with a cabinet scraper cleaned up the surface beautifully, and the joint never moved.

So what does any of this have to do with modern boatbuilding? It isn't its vague resemblance to biscuit joinery, as several people joked when they saw it. It's just this: these boats—like today's cold-molded craft—derive their greatest hull strength from their skin. Skin-first construction is the earliest known wooden-hull boatbuilding technology, and it dominated for millennia, first with elaborate lashings and later with these mortise-and-tenon fastenings. The concept persists to the present day in some lapstrake construction, and even lashings survive in some corners of the world.



Sea change: Iberian floor-to-futtock joint, mid-1500s.

Floor timbers might have been fitted when the planking reached the turn of the bilge, then futtocks followed after the planking was finished to the sheer. The Kyrenia ship's frames were fastened with two trunnels per plank driven into bored holes perpendicular to the plank face and extending right through the frame. Then a long copper clench nail was driven through the heart of of each trunnel—lengthwise—and clenched back into the inside face of its respective frame. Steffy says it best: the frames were fastened to the planking, rather than the planking to the frames. Like the framing systems used in cold-molded craft, the skeletal structure needed using this method is much lighter than that needed for frame-first construction. In the Kyrenia ship, not only are the floor timbers not fastened to the keel—they don't even touch it.

Nobody will ever use this technique again, other than in building the rare historically accurate replica. But its tradition persisted until the rise of what we recognize as traditional frame-first construction, whose arrival just about coincided, ironically, with the Dark Ages. For sheer engineering and technical mastery, this concept is admirable and its execution is impressive.

Sea Change

By the turn of the 15th century, frame-first construction had been state-of-the-art for hundreds of years. To the shipwrights of Spain and Portugal, the technique meant using this floor-timber-to-first-futtock dovetail joint as standard practice in naos, caravels, and galleons. Its use has been documented in a 1565 wreck near a Basque whaling station in Labrador and several vessels that came to grief in the Caribbean in the few decades just after Columbus's first voyage. This reconstruction is much-reduced in scantlings, and is sided 1 ½" and molded an average of 3".

Thomas Oertling, one of the archaeologists who excavated and documented joints like these in the Caribbean under the auspices of the INA, thinks they were important primarily in the sequence of construction. Using premade curved patterns that could be adjusted to determine the shape of a frame based on its position on a keel—a technique similar to "whole molding"—shipwrights planned and built a series of frames, as many as a dozen out of 35 or so, starting with a 'midship master pair. They shaped these off the boat, then hoisted them one by one onto the keel, where some were through-fastened. These defined the body shape of the hull, the profile being determined by the backbone, including the stem, sternpost, knees, and transom framing. Then, heavy battens were sprung longitudinally, and the remaining frames forward and aft were fitted to the battened-off shape. The technique is still used today in such far-flung parts of the world as Turkey and Brazil, and it is a distant

New world joinery: Iberian keel-to-sternpost assembly, mid-1500s.

cousin to the one-station small-boat construction method described in WB No. 146.

The reason scientists know the frames were prefabricated is that their close spacing wouldn't have allowed clearance for nails driven at the head of the floor timbers into the futtocks and at the heel of the futtocks into the floor timbers. Only the pre-shaped frames were given the dovetail joints. Maybe their extra strength withstood the pressure of numerous sprung battens in the early, and relatively flimsy, stage of construction. Maybe as a frame came together the futtocks were removed numerous times to allow work on pieces of manageable size, and the joints helped realign the frame exactly before final trunnel fastening. Surely, that extra strength would have done no harm in the completed hull.

"Since I finished my work on those sites [Caribbean wrecks at Molasses Reef and Highborn Cay] over 10 years ago," Oertling told me, "many more wrecks of the Iberian type have been discovered. All display some form of mortise and tenon, usually the dovetail type. The Portuguese have been finding these right and left." The number of vessels and the fact thay they all have a common tradition has led Oertling to theorize that the Iberians, standing at the crossroads of Mediterranean and Northern European influences, developed a breakthrough type he calls the Atlantic Vessel—though there's dissension on this subject. They owed their construction sequence to the Mediterranean tradition, but their heavy construction and design may have drawn from experience of the Atlantic's very different sea characteristics, particularly among Basque fishermen and whalers. Such ships carried Portuguese explorers around the Horn of Africa and the Cape of Good Hope, one of the great open-ocean exploration sagas in maritime history and one that opened the way for Columbus's official discovery of the New World.

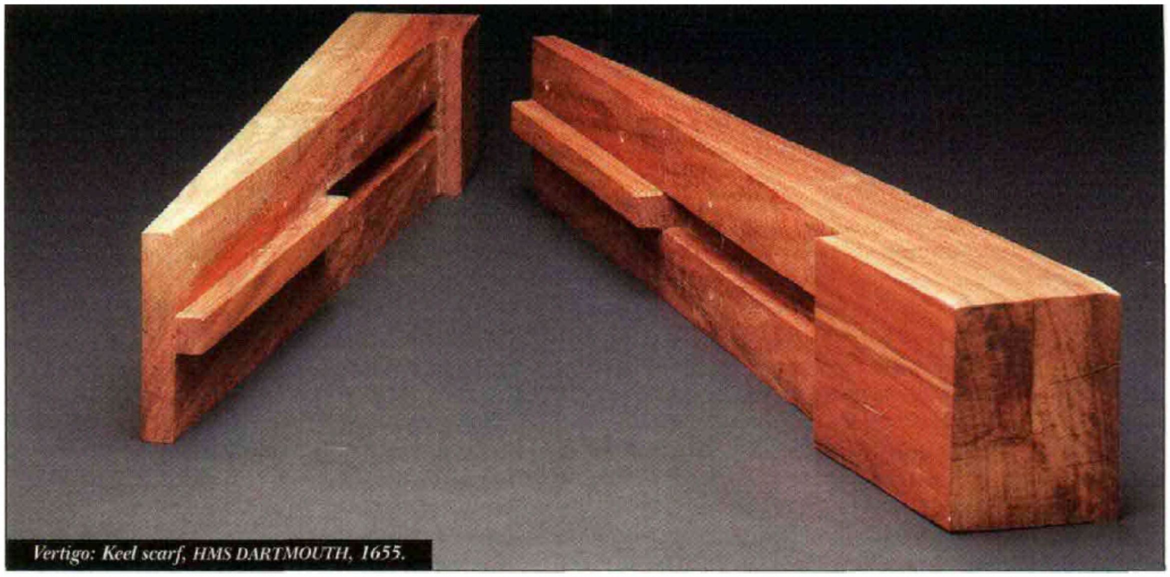
This joint is a great example of how archaeologists are contributing to maritime history. Precious little hard information about these vessels was available before wrecks were documented. One feature that stands out is how small they were: Oertling estimates the wrecks at Molasses Reef—thought to be the oldest yet found in the New World—at 65'6" on deck, with a beam of 25'6", and the very similar wreck at Highborn Cay at 65' long, with a beam of 18' or 19'. Pretty humble, really, for ships that changed the world.

New World Joinery

I can't look at this keel-and-sternpost assembly from a 1554 wreck without thinking about how neatly it would work for a Whitehall or wherry. The original was found in the remains of a Spanish nao of perhaps 65' or 70' long wrecked off the south coast of Texas and excavated in the early 1970s under the auspices of the Texas Antiquities Committee. Jay Rosloff and J. Barto Arnold III, now of the INA, documented the construction.

I gave this reconstruction a boat-sized sided dimension of 1 ½", with the sternpost molded 2 ½" at the heel and the keel molded 3" except where it sweeps up to meet the forward face of the sternpost—miniature compared with the original keel siding of 12" and molding of 10½". If—or maybe I should say *when*—I use this joint in an actual boat, I would look for compass timber for the curve in the keel and also for the unusual curved stern knee.

The vertical scarf of the keel and the sternpost makes a lot of sense to me, both for strength and for alignment. On the wreck, the lowest gudgeon, whose long straps ran well forward of the rabbet and to the outside of the plank-



Vertigo: Keel scarf, HMS DARTMOUTH, 1655.

ing, was fitted dead in the middle of the scarf, further supporting it—yet another example of a single construction feature serving dual purposes.

Originally, the feather edge of the keel where it sweeps upward to meet the sternpost bothered me. But the construction sequence changed my mind. I first fitted the keel and sternpost together and fastened them with screws. Without even bothering to line off, I shaped the keel to the tightest fair curve my flat-soled spokeshave would allow. I placed the knee stock up against the side of the completed assembly, scribed it, and then it was an easy thing to plane—carefully—to the resulting curve. I cut the top of the knee to the approximate profile of the original, using my judgment about its dimensions and giving it a fair curve. The feather edge never again became an issue until I disassembled the joint, when I had to be careful not to bump it.

As in the original, the sternpost and keel would be through-bolted to the knee, being careful not to interfere with planking rabbets or frame locations. A sacrificial keel shoe would also be added. The planking rabbets in the original ran very low on the keel and very far aft on the sternpost, the equivalent of, say, 5/8" from their outer extremities in this reconstruction. It would be an unusual-looking Whitehall, but it could be very handsome.

Vertigo

Vertical keel scarfs were the most common type during Medieval times. This scarf, with its interlocking keys, may lack the sculptural quality of the Roman one in the first example, but it has a wonderfully businesslike air about it.

This diminutive reconstruction is sided 4 ¼" and molded 5", with a scarf length of 32", for a ratio of 7½:1. The original was a keel scarf recovered from the wreck of the English warship HMS DARTMOUTH (1655), whose robust 13" x 13" elm keel with its 4'3" long scarf was documented by Colin Martin of the Scottish Institute of Maritime Studies at the University of St. Andrews. The original was through-fastened with eight iron bolts, and the completed joint's seam was inlaid top and bottom with wooden capping pieces caulked with hair and tar. A rising deadwood was fastened atop the keel, further covering the joint and supporting the first futtocks and the garboards.

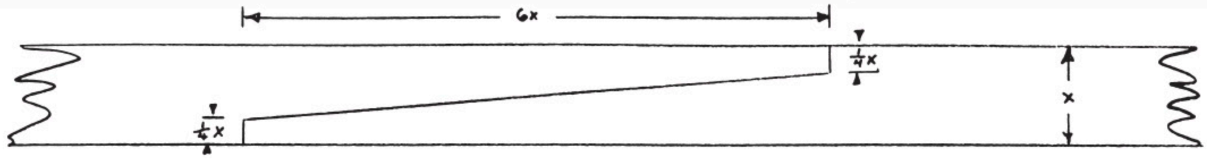
More than anything else, I am drawn to the way this joint's keys interlock, using the wood's inherent strength

to augment the through-bolts, seeming to imply that the builders didn't quite trust fastenings alone. Even loosely held together, this joint proved very strong in the vertical plane—as if the bolts were there simply to pinch all that brawn into place. That seems to be a common refrain in ancient craftsmanship: you see it still in timber-frame buildings today, in which one of the most primitive fastenings—the peg—merely applies what little strength is needed to hold a tenon in place so the joint itself can do the heavy lifting. The bolts in this keel scarf augment the advantages of the structure, and the structure augments the advantages of the bolts.

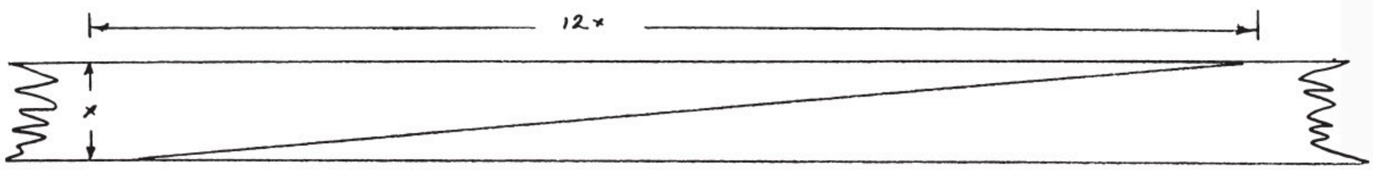
Like the Roman scarf, this joint always returns to its original alignment. A plain scarf, particularly in a curving assembly like a gripe-to-stem-knee or stem-knee-to-stem joint, can be a slippery thing to clamp together while boring bolt holes. A hook in such a scarf can help, but keys like these would do an even better job of holding such a joint tightly together and in perfect alignment. Disassembled so that its faying surfaces could be tarred, this joint would be a simple thing to put back into exactly the right position for through-bolting. Plus, it would provide greater structural integrity and reduce shearing loads on fastenings.

People in Renaissance times tried to emulate all things classical. Some things, like the keel scarfs of ancient Rome, were lost to them but are now known to us. Nevertheless, here's proof that the craftsmen of that age—like those of any age—worked out their own solutions with ingenuity and intelligence.

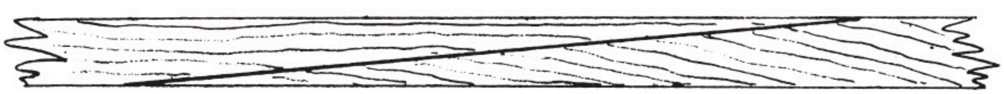
Tom Jackson is the associate editor of WoodenBoat.



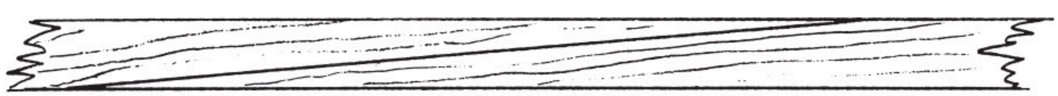
NIBBED SCARPH



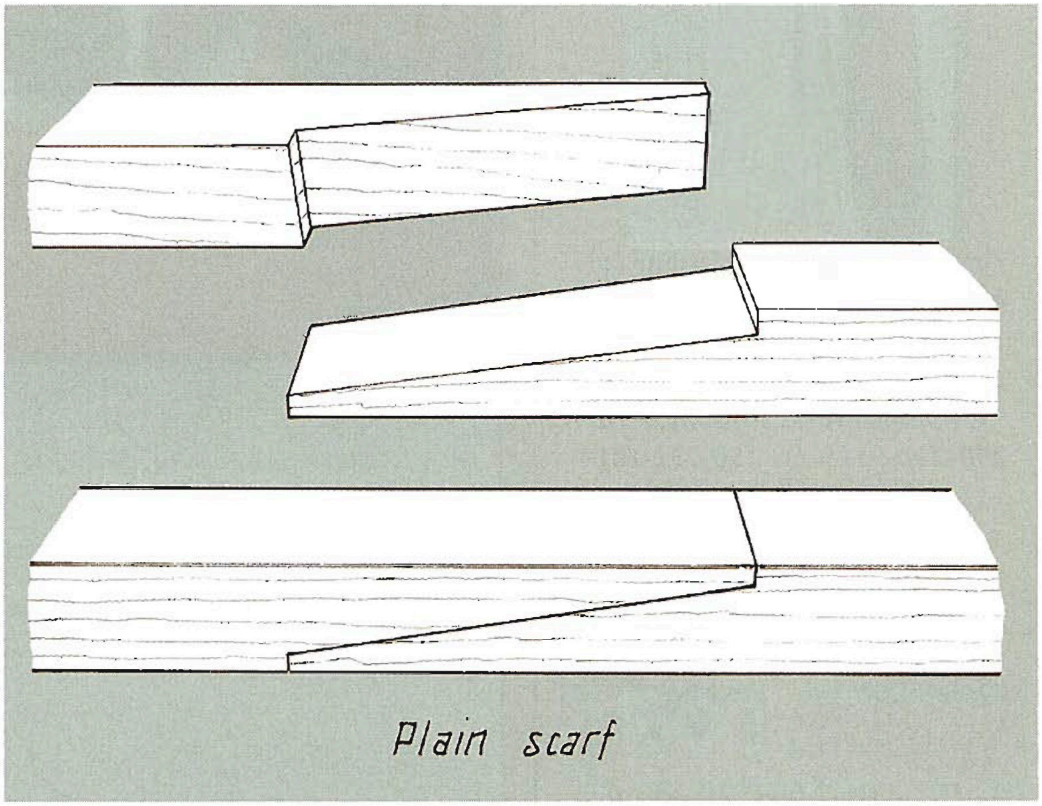
FEATHER-EDGE SCARPH



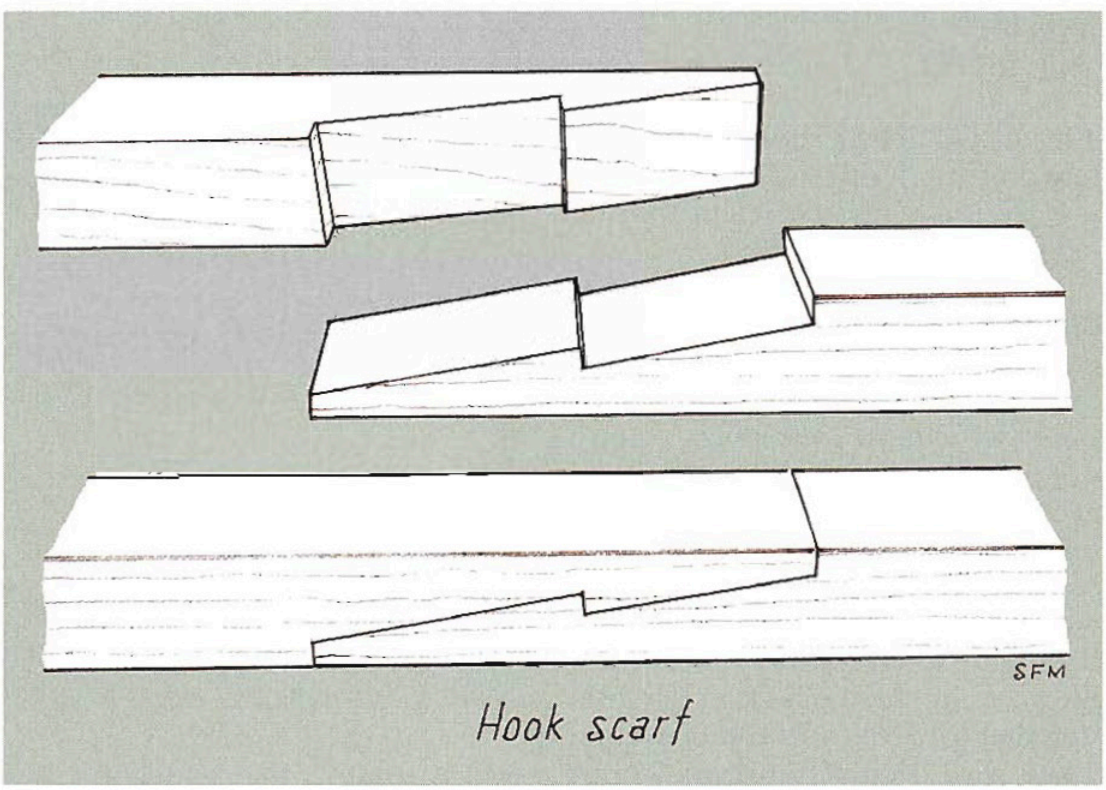
SCARPH CUT AGAINST THE GRAIN



BETTER: SCARPH CUT WITH THE GRAIN

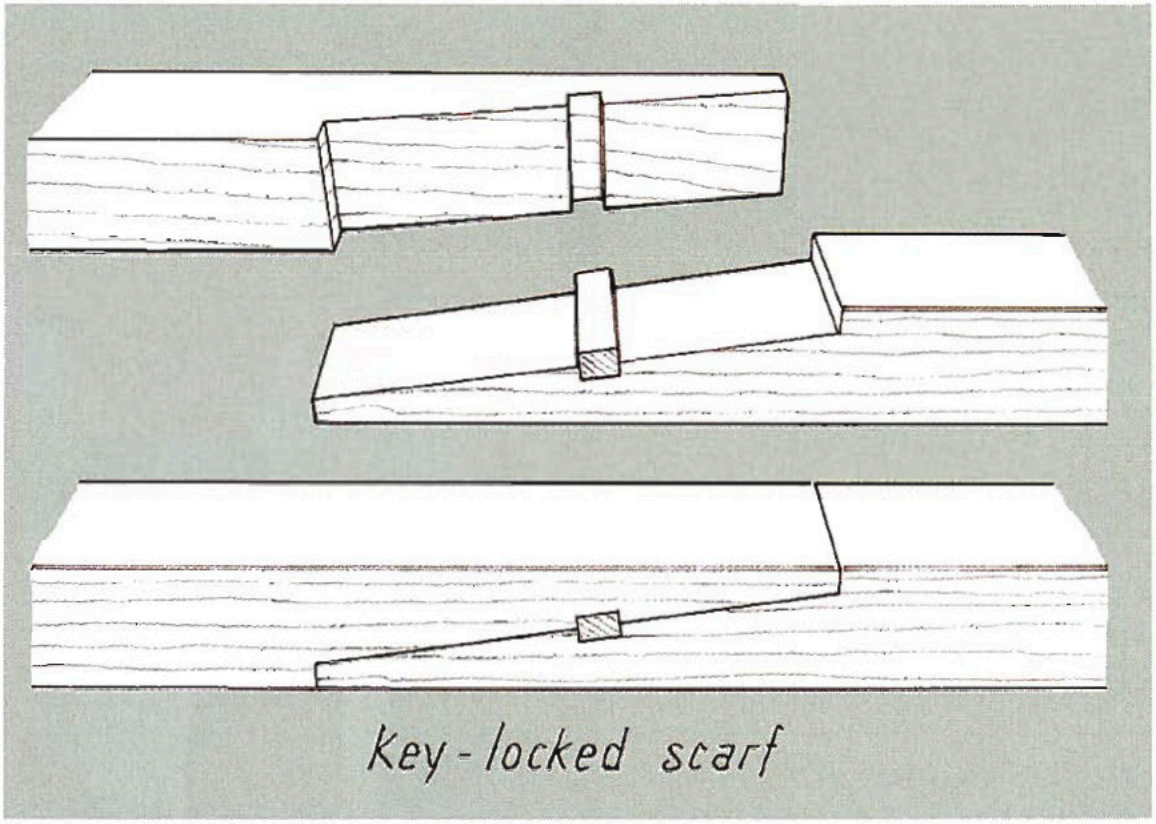


The plain scarf is easy to make and has many applications. The ends may be feathered if the joint is glued rather than bolted.

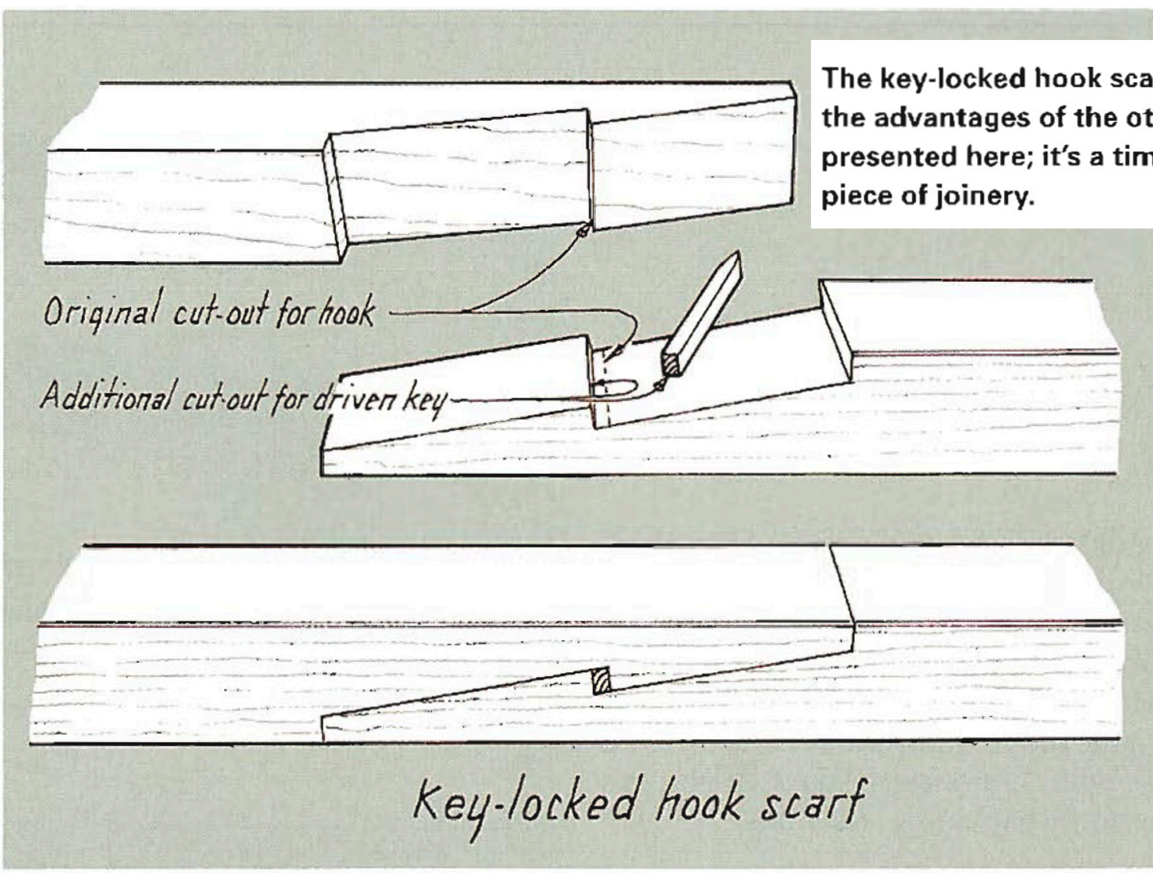


The Hook scarf is a step above the plain scarf, as it resists tension much better.

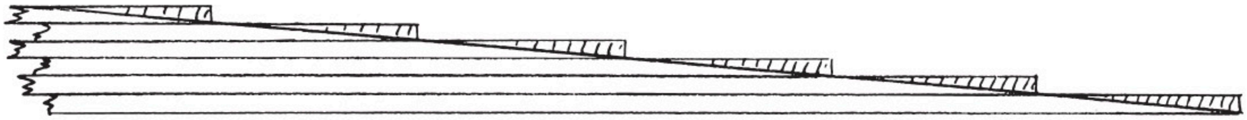
The key-locked scarf is locked together by a tightly fitted key—also called a coak.



The key-locked hook scarf incorporates the advantages of the other three joints presented here; it's a time-consuming piece of joinery.



14-3: Stacking stock at a 12:1 ratio for scarfing with a portable power planer.



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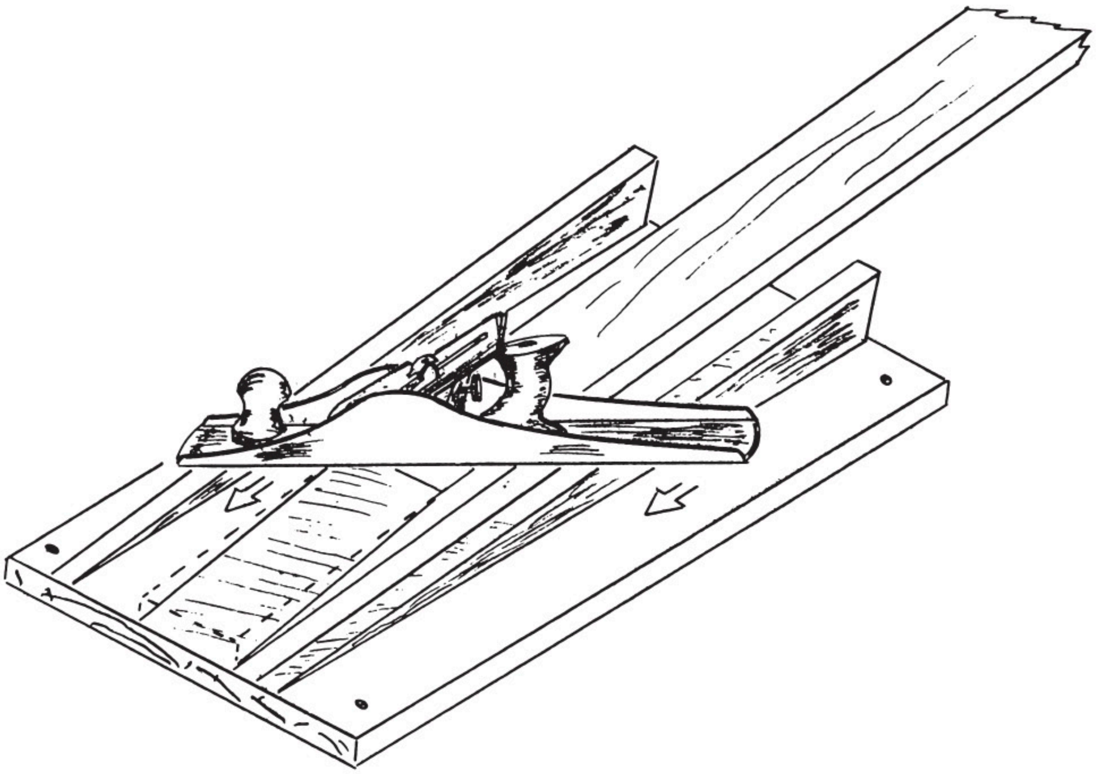
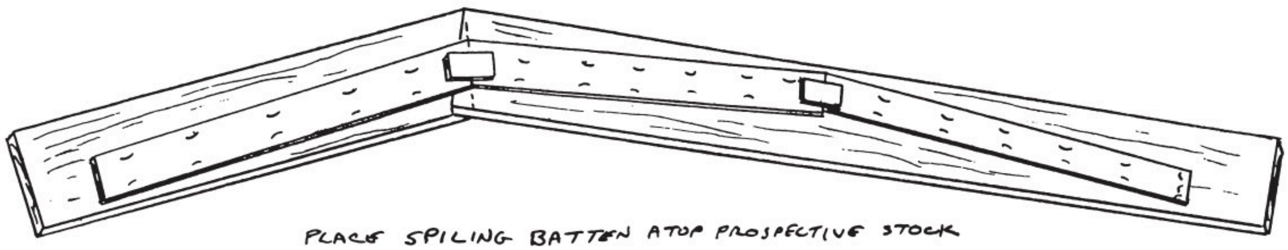
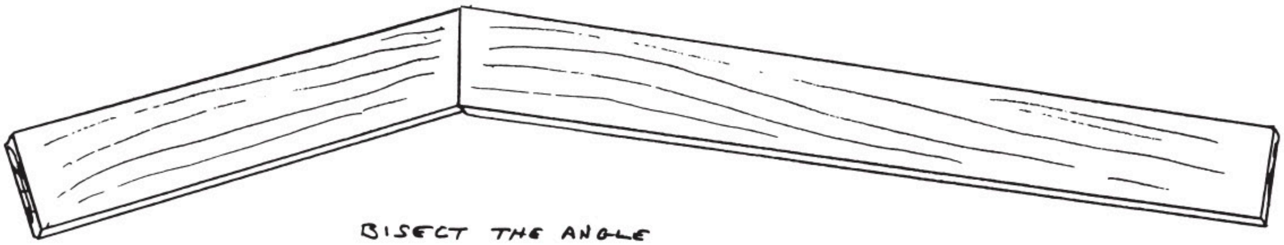


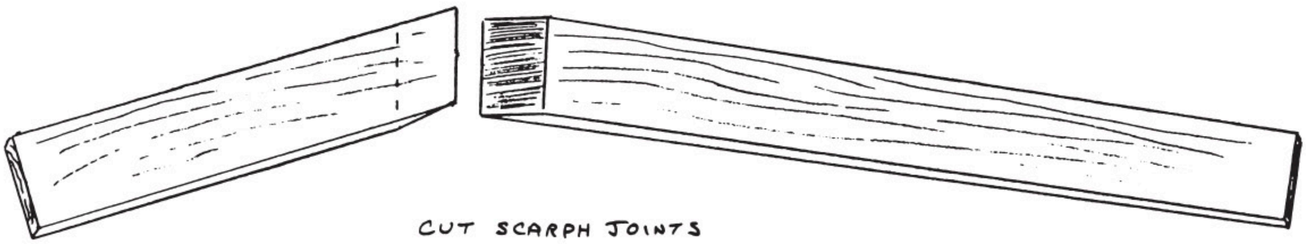
14-2: A homemade scarfing jig in action.



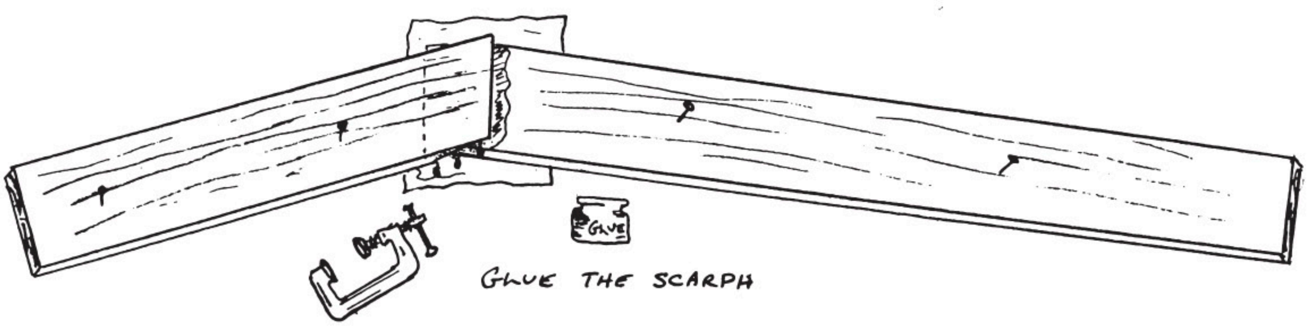
PLACE SPILING BATTEN ATOP PROSPECTIVE STOCK



BISECT THE ANGLE



CUT SCARPH JOINTS



GLUE THE SCARPH

CUT OUT PLANK