INGENIOUS MECHANICKS

Early Workbenches & Workholding

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by Christopher Schwarz

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For Suzanne,
who made sure this book was good

Introduction

The alternative title to this book might have been: "The Book of Workbench Questions."

While I have spent many years investigating early workbenches and workholding, I have only scratched the surface of how they were used. This is evident every time I sit to work at them.

Today, I braced an armchair against my low bench to plane flush the proud tenons on its arms, and it was such an easy and natural operation I was shocked I'd never thought to do that before. Last weekend, my friend Will Myers sat on the work as he traversed a board with a handplane, jamming it against stops in the end of the bench. That same day, Megan Fitzpatrick showed me how she used her leg as a vise when planing edges at my low bench from Herculaneum.

These little discoveries happen almost every day. And so, I am a bit embarrassed to present this book to you more as a kit or a blueprint for something that isn't fully understood.

While I am certain that I understand the different forms of early workbenches and the common workholding contrivances available for them, what remains undiscovered are all the ways they can be used to build furniture.

We saw, plane and chop for the most part. So for non-woodworkers, it's easy to simplify what we do. But how each workpiece is immobilized – regardless of its size – so that we can work on it without it slipping is far from simple. It's the heart of what we do.

Every piece of work, from a chair's arm to a carved rosette, offers a unique challenge to make it sit still. Many times, the answer is not in brute clamping force but in something far more delicate, such as the order of operations when you work.

Case-in-point: chair seats. Recently I demonstrated to some woodworkers how I work chair seats on a low bench, and I became frustrated because nothing was working. Every trick made the seat slide from my grasp like a wet watermelon seed.

I finally realized why I was struggling. I had planed the bevel on the underside of the seat before working the face of the seat. That bevel on the underside made the chair impossible to immobilize. So, note to self: Work the face first, then shape the undersides of your chair seats. Even after years of working with these benches, I sometimes feel like every day is my first day with them.

Are you tempted to close this book right now? I don't blame you.

If you are brave enough to plow forward and perhaps even build one of the workbenches in this book, let me give you some assurances and a warning.

The assurance: These benches work. They have been used to make all manner of complex wooden objects for more than 2,000 years. These benches are not an evolutionary dead end. They are not obsolete.

The warning: This book does not have all the answers. It is more of a series of questions, starting with: If we build these benches, how shall we use them?

It is my fondest hope that we can answer that question together through trial and error. And someday this book will lead to another book. Perhaps I'll be alive to write it. Or maybe your children will. But the only way we'll ever create answers is through work. Lots of head-scratching-what-if-I-tried-this-hold-my-beer work.

So, let's get to work.

Christopher Schwarz
Covington, Kentucky
January 2018

Figure 1.1. The beginning. In the House of the Vetti, this dining room fresco is perhaps the earliest depiction of a workbench in the West.
PHOTO BY NN

I

Why Early Workbenches?

The journey to the summit of Mount Vesuvius has all the romance of visiting an unlicensed reptile farm. It begins in Ercolano, Italy, a touristy village in the shadow of the volcano and home to Herculaneum, one of the towns buried by Vesuvius's eruption in 79 C.E.

As Narayan Nayar (the photographer for the journey) and I stepped off the train from Naples we were assaulted by young, attractive Italians. Their job: Bait tourists to nearby restaurants. We glanced around and saw only one escape route from the train station's cul-de sac. So, we plowed through the crowd of eager human fishing lures.

We emerged from the other side a bit relieved. Then we realized we'd scurried past the bus company that was supposed to drive us up the volcano. We turned around and dove back into the swarm of too-perky people in order to catch our bus.

The twisty-turny bus ride ended 660 feet below the volcano's summit, and we then climbed a steep trail to the volcano's rim. The top resembles a gravel pit where one of Frank Herbert's worms might emerge. There's no deep hole for tossing human sacrifices – throw a virgin into Vesuvius and she's only going to get skinned knees and a sunburn. I looked around the volcano and promptly excused the early settlers of the area for building their homes at the base of Vesuvius. The only evidence you're on a volcano (besides the little gift shops) is the occasional tiny plume of gas and the odd rocks below your feet.

Figure 1.2. Where are the virgins? The cone of Vesuvius is not a fiery hole leading into the bowels of the earth. It looks like a gravel quarry where you might buy stone for your garden.
PHOTO BY NN

I picked up a few rocks. For rocks, they were young – likely the result of the 1944 eruption, which destroyed several villages. I looked out from our 4,200-foot perch at the buildings in every direction below, which are built on top of villages that were covered in ash from earlier eruptions. It's a grim scene if you think about it too much – 600,000 people now live in the so-called "red zone" for a future eruption.

And yet, as I fondled the rocks in my hand I felt only gratitude for this deadly, fire-breathing mountain.

The Earliest Workbenches

The recorded history of woodworking begins with the Egyptians. But the recorded history of workbenches begins (for now) with Vesuvius. Its massive eruption in 79 C.E. buried Pompeii, Herculaneum and other sites, preserving frescoes, buildings, pottery, human remains and even wooden furniture.

Figure 1.3. The red zone. Though Vesuvius hasn't erupted in decades, it is considered one of the world's most dangerous volcanos with 600,000 people at risk below it.
PHOTO BY NN

At Pompeii, the ash blanketed a fresco showing a low, four-legged workbench being used for mortising by a man in Greek attire. At nearby Herculaneum, the eruption preserved a fresco showing "erotes" – what we might call "buck nekkid cupids" – sawing a board at an eight-legged low workbench. It features a holdfast and other holdfast holes. This fresco has since been destroyed, but we have engravings that were made soon after its discovery (more on both the frescoes' stories is ahead).

These two images are the earliest representations of workbenches of which I'm aware. And they launched my interest in exploring knee-high workbenches and how to use them to build furniture, boats, storage containers and wagon wheels.

The conventional wisdom is that these low benches were used in former times for simple work and were replaced by superior modern benches, which are thigh-high or taller. But the more I studied low benches, the more I found that they never disappeared. They are still in use. Additionally, these low benches can be used for complex work, including steam bending compound shapes and lutherie.

The low bench is more than a thick plank of wood with legs. It's also a collection of simple jigs and appliances that allow you to do remarkable work while sitting comfortably on an easy-to-build platform. For centuries, these simple jigs remained hidden in plain sight in paintings and drawings in

museums. And their appliances have been proven to work, both at my low benches and by the modern craftsmen who still use them.

But why bother with this musty old crap? Modern woodworkers are blessed with a wide array of vises, dogs, clamps and other devices that can immobilize a piece of wood so you can work on its faces, edges and ends.

Well, at times I think we tend to make our workholding far more complex than it has to be. And that can affect your approach to the things you build. While your brain might see the logic of a screw-driven tail vise with a series of movable metal dogs, the ingenious early craftsman might find this same vise slow, fragile, fussy to maintain and cumbersome in use.

I empathize with the early woodworker. My brain is wired to look for a simpler solution to a problem instead of creating complexity.

Example: Earlier this year, I spent a couple hours in the dentist's chair and was force-fed several episodes of a home-improvement show focused on carving out storage from oddball places in a home. Some of the examples I remember over the whirring of the dental Dremel include:

• Hinge your steps to create trap doors on the landings of your stairs to make small bins in the wasted space between your stringers.

• Find stud walls that are chases for utilities and turn them into built-in chests of drawers.

• In attic spaces, create sliding racks on the interior of a high-pitched roof. You slide giant plastic bins into the racks – it's a bit like a top-hanging drawer.

Through the entire program I wanted to puke (that was mostly because I have a sensitive gag reflex). But it was also because these "storage solution"

Figure 1.4. Ruined. Even with thousands of tourists around you, Pompeii is so sprawling that it seems deserted.
PHOTO BY NN

Figure 1.5. Teach a Roman to shave. It is a short intellectual leap from the low workbench to other "sit and work" appliances, such as the shavehorse.

programs neglect to mention the easiest way to control clutter:

Get rid of your excess crap.

No one should have so much stuff that they have to slave excessively to make a place to stow it. In the same way, no workbench needs vises on all four corners (I've built these for students and customers) to build fine furniture. You just don't.

With this book, I hope to expose you to early and simple ways of holding your work. While many of these devices were used on low workbenches, most of them work on high workbenches as well. I use both sorts of benches – high and low – in my work for building all manner of things, from stud walls to Welsh stick chairs, dovetailed chests to nailed-together coffins.

The workholding on these benches is truly ingenious and effective. Things change when you sit down to work. And I think you'll be surprised what you can do on your bum: planing, chiseling, shaving and even dovetailing.

The low bench form might not be for everyone. But it might be right for you and you might not know it. Woodworkers with limited mobility use low benches because they can sit and work. Apartment woodworkers use low benches because they take up little space and do double-duty as seating or a coffee table. Curious woodworkers use them because – dammit – they are an interesting form to build and use. Many chairmakers already use a low bench (but they call it a shavehorse), as do many other specialty trades, includ-

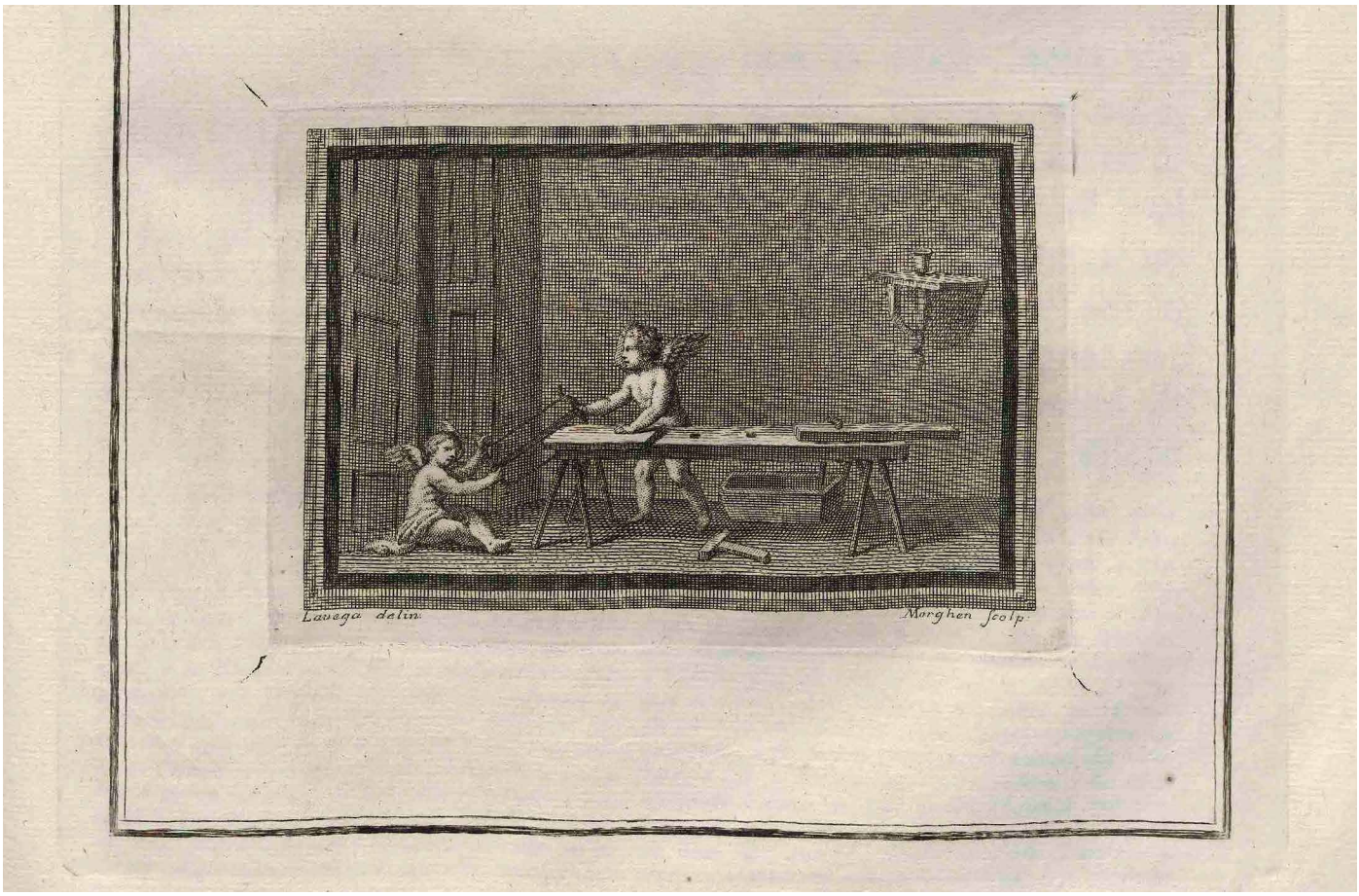

Figure 1.6. Graven image. This copperplate engraving was made by Italian artists shortly after the Herculaneum fresco was discovered. Sadly, the original has deteriorated.

ing coopers and basketmakers. Oh, and a low bench is the best sawbench ever made – promise.

One more plug for these early benches: Using their lessons, you can make almost any surface into a work-surface. A couple drywall screws can turn a picnic table into an English-style workbench. A missing brick in a wall (and a pine wedge) can become a face vise. A shavehorse can be cobbled together with a rock and a scrap of wood strapped to your gut.

Even if you never build a low workbench and reject its appliances as "not whiz-bang-y" enough for your engineering mindset, you might enjoy the journey of discovery required to write this book. It involved trips to exotic Italy, Germany and Indianapolis. (And understanding the low bench might connect your work to Chinese benches.) In the process, we rescued oak slabs from a pallet factory. We flushed $1,000 down a metaphorical toilet to learn about the construction of the first modern workbench in 1505. We ate a ton of Neapolitan pizza.

Workbenches are at the heart of everything we do. So, let's take a brief look at the history of Western workbenches and consider why it's even worth looking at ancient benches.

Meet the 3 Workbenches

For this book, I built three reproduction workbenches, and I refer to them over and over by the place names where each was discovered or the person who drew them. Here's a brief introduction to each one:

Herculaneum Bench

The Herculaneum bench is an eight-legged low workbench I built from the earliest known depiction of a bench – a fresco from 79 C.E. Its workholding is decidedly simple – just holes, a holdfast and pegs. You'll also notice that I added a double-screw vise to one edge to the bench in the photo. This isn't original to the Herculaneum bench, but it allowed me to experiment with this more modern workholding appliance.

Figure 1.7. Toe hold. Almost everyone who uses the Herculaneum bench ends up wrapping their feet around the legs, or pushing against them while working.
PHOTO BY NN

Figure 1.8. Spider bench. This bench, shown in a fresco at Herculaneum in Italy, is perhaps the earliest representation of a workbench in the Western world. Why eight legs? I had to build it to find out.

Figures 1.8 & 1.9. Well made. This Roman bench is a copy of the oldest surviving bench I know of – a circa 187 C.E. bench that was pulled from a Roman well in Saalburg, Germany (at top). The dovetail-shaped notches on the long edge were the biggest mystery.

Saalburg Bench

The Saalburg bench is the oldest surviving bench I know of – approximately 187 C.E. Again, the workholding is dead simple – a planing stop and two unusual side stops that we'll discuss later. I also built a variety of workbench appliances that attach to the Saalburg bench but aren't original to it. So, you'll see this basic bench crop up over and over.

Figure 1.10. Stuck. The planing stop is the heart of the Saalburg workbench. This pointed reproduction was made by blacksmith Peter Ross.
PHOTO BY NN

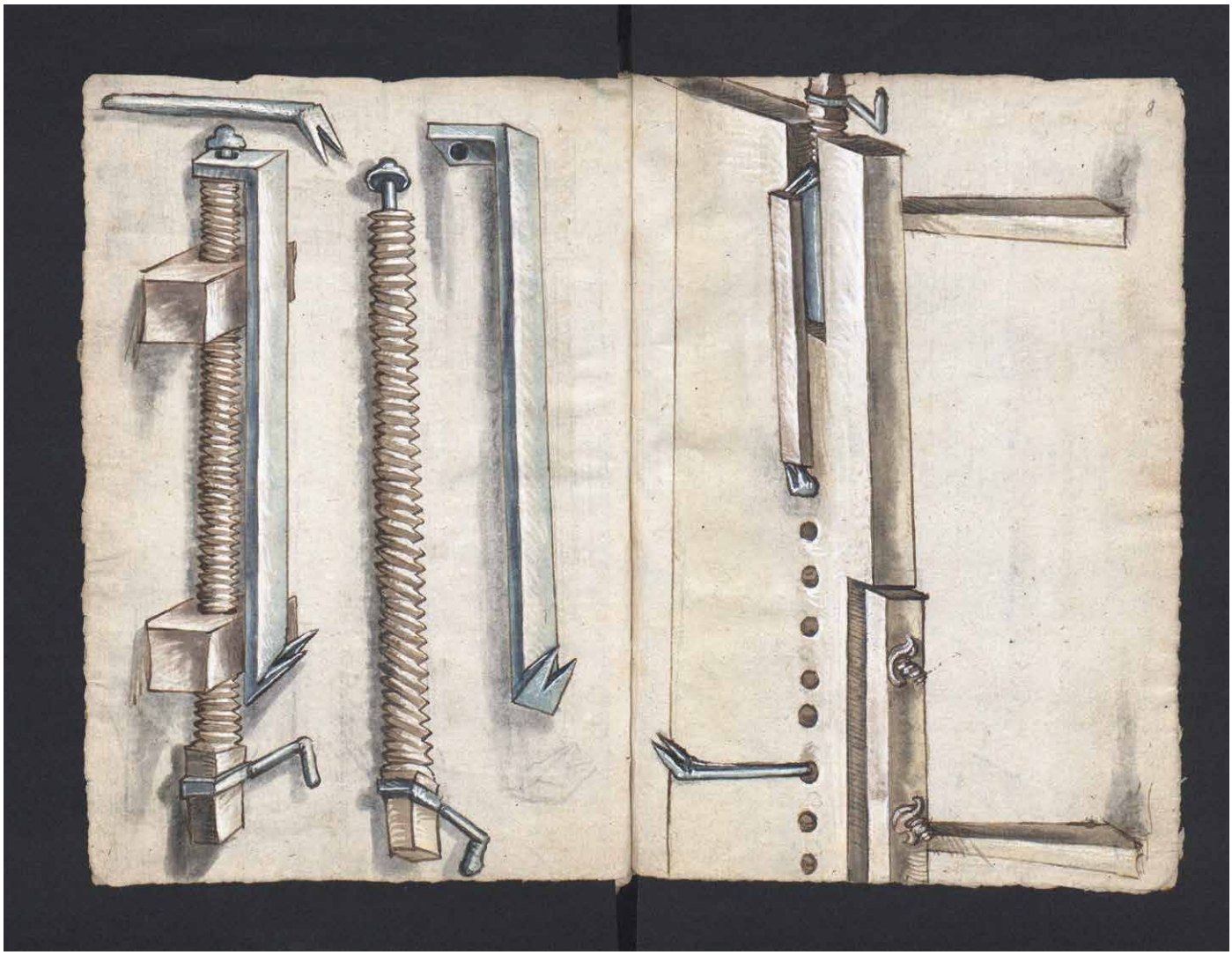

Figure 1.11. German ingenuity. Martin Löffelholz drew two workbenches in a codex dated 1505. Equipped with both a face vise and a tail vise, this appears to be the first modern workbench. The unusual tail vise was the biggest question mark. How well would it work?

Löffelholz Workbench

The Löffelholz workbench (which I also call the "Holy Roman Workbench") is from a 1505 illustration in a German codex and is likely the first "modern" workbench in the historical record. It has both a face vise and a tail vise, but many of its characteristics are typical of a bench trapped somewhere between Roman workbenches and modern workbenches.

Figure 1.12. Novel notches. Many early workbenches feature simple notches in the benchtop, including one of the benches drawn by Löffelholz. Add a softwood wedge and you have an effective face vise.
PHOTO BY NN

Figure 1.13. The first? Löffelholz's tail vise is surprisingly effective in use. But, like all tail vises, it is an involved process to install.

Figure 2.1. Legit. Many forms of workbenches work well for making furniture. Find one that suits your work, your personality and your wardrobe.

II

Workbenches Old & Modern

Woodworking has changed little during the last 2,000 years. The basic set of hand tools, the joints we use and the need to hold things at the bench is the same as when the Egyptians constructed furniture.

Put succinctly: Workbenches need to immobilize the work so you can work on a board's faces, edges and ends. Any workbench from any era can accomplish this task, whether it be a Roman bench, which resembles a log with legs, to a fantastical dovetailed German bench with a shoulder vise, tail vise and series of obedient metal dogs.

The challenge when designing your bench is to make it suit both your work and your personality.

If you are a furniture maker, any of the bench designs you'll find in magazines, woodworking stores and videos will likely suit the work. As I said before, the work itself hasn't changed all that much since Roman times. A hollow-core door on sawhorses can be pressed into service to make fine furniture.

But I urge you to find a bench that also suits your personality. If you are an engineer (or a recovering engineer), you might prefer a bench with metallic screws that move swiftly and smoothly to hold the work. If you are an apartment woodworker with little space or money, you might desire a Roman workbench that can also serve as a sitting bench at the dining table, or as a coffee table in front of the couch.

Figure 2.2. Mt. Bench. These slabs of red oak from North Carolina were cut less than a year before the photo was taken. They are ready to be used as benchtops, despite our urges to make every stick of wood dry as a popcorn fart before working it.

The rest of us are likely somewhere between these extremes. We might have tendencies toward gizmos. Or we might prefer bare-bones simplicity. There is not a "best bench" out there for all of woodworking, full stop.

This book exists to expand the array of benches and workholding ideas available for those who like to keep it simple. It is not a criticism of modern benches. I've built and used many of these. I have an early Ulmia in use in my shop. I understand their advantages and disadvantages. I definitely think they have a place in many modern shops. But they are not the end-all. Our ancient ancestors didn't need them to make fine things.

I won't rejoice if you read this book and melt your tail vise (unless you invite me to what would be an awesome party). Instead, I hope only to expand the range of discussion when it comes to workbenches, and perhaps give the engineering woodworkers additional options for holding the work when they don't have a fancy bench at hand.

But before we do that, I think it's only fair to discuss the ideal characteristics of all workbenches, young and old, low and high, simple and Steampunk-y.

Wood for a Workbench

You can use any wood to make a good workbench. Except for wood that is on fire. I do not think that would work. But other than wood on fire, use whatever you have on hand.

Our society of woodworkers is still in recovery from The Great Malaise of Steamed European Beech, a period during the 20th century when beech was seen as the only sane option for a would-be bench builder. (And if you couldn't get beech, maple was the eyes-cast-downward-in-shame option.)

History has shown that Woodworkers of Old used almost any species for a bench, from white pine to purpleheart. (The earliest surviving bench we know of is made from oak.) The wood doesn't have to be dry or knot-free. To be sure, however, there were some species that were desirable because they were cheap, heavy, strong and readily available.

So, if you lived in Pennsylvania, maple would meet those characteristics. In Hungary, beech was the thing. In France, oak. In England, whatever could be gotten off the boat. In South and Central America, the choices were incredibly vast.

Many woodworkers, myself included, like to use dense softwoods for benches because they are incredibly cheap, available everywhere and (if you choose the right softwood) heavy and plenty strong.

So, please don't fret over the wood species. Any species will do.

In fact, I feel so strongly about this idea that I wrote a poem about it. Note that I so dislike poetry that this is the first poem I've written since my 1978 classic: "The Crowded Hole," which concerns three mice who shared a tiny hole and became shockingly violent. But I digress.

Here it is, with thanks to Megan Fitzpatrick, Tim Henriksen and Narayan Nayar. Apologies to Theodore Geisel.

Figure 2.3. Slabs from the mill. No matter what species you use for your bench, using big slabs is a pleasure. And they look good, to boot.

One Tree, Which Tree, Will You Tell Me?

I want to make a workbench good,
But do not know what kind of wood.

If you would tell me the best tree,
I might not build workbenches three….

If you reveal which tree is best,
I could avoid a workbench fest.

Could I make it out of oak?
Or would I go completely broke?

Well…
You could make it out of pine,
And you will be completely fine.

Hmmmm.
But could I make it out of fir?
Would Master Klausz then call me "sir?"

Would walnut be an OK wood?
Would butternut be twice as good?

Could I make it out of elm?
Or would my friends be underwhelmed?

I could use my pile of birch.
Might that leave me in a lurch?

Figure 2.4. Multi-species Shaker. This Shaker workbench from the Pleasant Hill community was built using several local species (none of them beech).

Should I use the Southern yellow?
Or would I be a stupid fellow?

Might I use the mighty maple?
For this heavy workshop staple?

Should I seek the perfect ash?
On which to thrust my mighty… rasp?

Perhaps I'll try a bench of beech.
What benchery kings would that impeach?

Well…
Make your bench from fir or oak,
Or elm or larch or reclaimed spokes.

You can use some purpleheart
(But for it I won't give a fart).

Make your bench from any tree.
Just make it, make it, you will see.

Workbenches can be any wood.
It is a point not understood.

You can make it out of pine,
And you will be completely fine.

Hmmmm.
What about mahogany?
Would that be too bourgeoisie?

Would sapele be the perfect timber?
Blah blah blah blah blah blah limber?

Would Osage orange be tough enough?
Or should I look for stiffer stuff?

How about some eucalyptus?
Or would that wreck my left meniscus?

Or perhaps some hearty hickory?
Would that be workbench victory?

Figure 2.5. I see benches. You could use mahogany. But that might be too bourgeoisie.

I could procure some primo jarrah.
And working, don a wood tiara.

Would it be nuts to use padauk?
And would that bring a Schwarz rebuke?

I have a pile of curly cherry –
Or would that be just too dang hairy?

What about a torsion box?
With vacuum pads and filled with rocks?

Um.
I think I hear the other phone.
My cat is choking on a bone.

My kids are playing with a spear.
I have to go right now I fear.

But if you make it out of pine.
I know the bench will turn out fine.

On Wet Wood

It's not fair to our early ancestors to put words in their mouths. We don't know how dry their wood was when they started to build their workbenches. Was it fresh from the tree? Dried for 20 years? Something in between?

We can guess, which is what most people do. Or we can build a bunch of workbenches from woods in varying degrees of wetness and observe the results through several years. This second path is much more difficult than sitting naked in the dark at your computer keyboard – fingers covered in the dust of Cheetos – and pontificating online. But it's the path I took.

Here's what I've found: Dry wood is the best. But because you are unlikely to find big slabs of wood that are totally dry, then dry-ish wood is great, too. What I mean by dry-ish is somewhere about 20 percent moisture content (MC) or less. When you use dry-ish wood there are rarely any unhappy endings that involve splitting or warping. The wood will settle down quickly – within a year or so – and the benchtop won't require more than a couple flattenings.

My second choice is wood that I call "moist." This is stock that is somewhere between 20 percent and 50 percent MC. This sort of stock is what I usually look for when building massive oak workbenches for customers. It's stuff that is about 6" thick and has been drying for a decade.

Figure 2.6. That's steam. You can get away with using wet stock if you know the risks.
PHOTO BY MEGAN FITZPATRICK

This wood has some drying to do after you turn it into a workbench. Expect some shrinkage and checking on the end grain. It will calm down after a few years and four or five flattenings of the benchtop. My only other caution with moist stock is to not rely on glue for the joinery. Because of the wetness of the wood, water-based glues (yellow, white and hide) won't be effective. I recommend you rely on drawboring and wedging.

Finally, there is fresh wood, stuff that was a living tree less than a year prior. This stock is fairly easy to find and fairly cheap, but it can be tricky. Water-based glues aren't a good idea. And you can experience significant warping and checking as the wood dries. My first precaution is to use a species that is easy to dry, such as red oak. Look for a slab where the grain runs fairly straight through the face and the edges. Orient the slab so the heart side is your benchtop (with the bark side facing the floor). And paint the end grain of your completed benchtop with a latex paint to slow the drying, especially if your bench will be in a climate-controlled shop.

All these precautions will reduce the risk that your benchtop will warp horribly. But there is no guarantee.

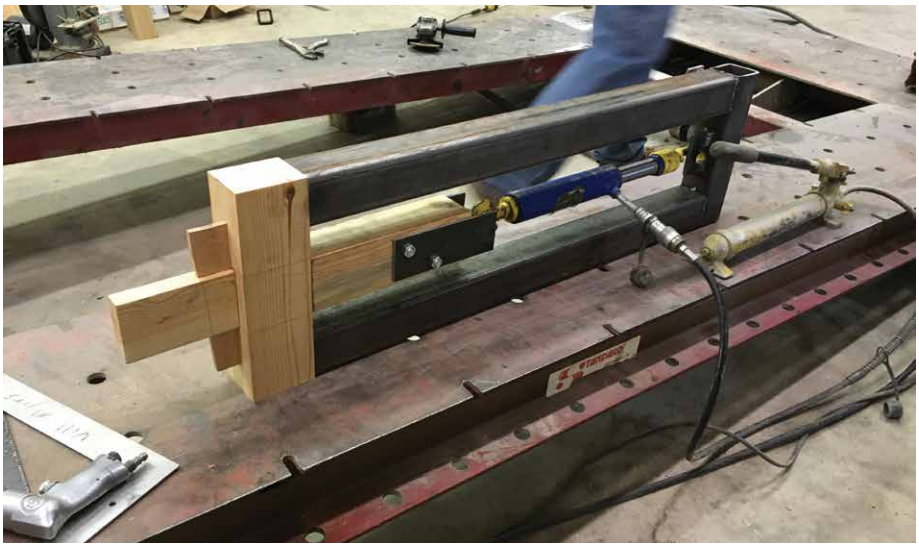

Figure 2.7. Redneck engineering. This ingenious contraption tests how many pounds of force a tusk tenon can withstand. (Tusk tenons are a common workbench joint.) The answer: This joint is well-suited for workbench joinery.

Figure 2.8. Hidden traits. A narrow benchtop has advantages that aren't obvious until you start working with it.

Workbench Joinery

Workbenches take more abuse than a cat in a reform school. Hell, you are supposed to pound the living snot out of it, drag it across the shop and load it up with incredibly heavy items. You are expected to wrack its joints with strenuous sawing and planing. It will get wet, have crap spilled on it and even serve as a bed at times for the weird skin-stalker who just won't leave your shop (or perhaps that's a personal problem).

As a result, the bench's joints should be superb. The best you can muster. The joinery should be overbuilt. Use through-tenons and through-dovetails whenever possible. Drawbore the joints to make a mechanical connection. Use wedges to lock things tight. Don't rely on a glue bond alone, unless you have no other choice.

Building benches is more akin to timber framing than furniture making. The components are thick and heavy. The joinery is robust. The result is a platform that will outlive us all.

Yes, you can make a bench out of MDF and drywall screws, and it will serve admirably for as long as the materials and fasteners can manage it. Problem is, putting termite barf and over-hardened pot metal together is asking for an unhappy ending. If you're OK with that, then I'm amazed you have read this far.

Benchtop Size: Length, Height & Width

Workbenches come in a variety of sizes, depending on the work that needs to be done and the space available in your workshop. As a result, there is no standard size for a bench. There are, however, guidelines that can keep you from doing something stupid.

The length of the benchtop is the easy dimension: Make it as long as possible. For furniture work, an ideal bench is about 9', which allows you to work on 8' runs of moulding with ease. Even if you don't cut moulding by hand, a bench that is 8' or 9' long will allow you to assemble things at one end of the bench while cutting joints at the other end. (No second "assembly bench" necessary.)

If you are cramped for space, a 6' workbench is an ideal length. Once your benchtop gets shorter than that, it becomes tricky to work on standard furniture-sized components, which typically max out at 48" long.

The width of a benchtop often elicits controversy. There is a camp that prefers a 4' x 8' workbench top. (Why not?!) After years at the bench, I prefer a thigh-high bench that is about 18" to 20" wide, a fairly common and traditional width. At this width, you can

Figure 2.9. A mechanical wizard. The modern European workbench is an appealing, effective and successful design. The tail vise holds your work so you can work primarily on its faces. The face vise holds wood so you can work its edges and ends.

reach across it with ease to fetch tools. It will not be overly tippy. And you will find that some workholding tasks – such as planing assembled carcases – are easier on a narrow bench.

A low bench should be even narrower. It is straddled in use, so a too-wide bench will make you feel like you are having an unpleasant examination. A typical width for a low bench is 11" or less, which most people can straddle with ease and comfort. Too narrow, and you will feel like you are riding a telephone pole – not a good feeling for most of us.

The bench's height off the floor depends on your body. For a low workbench, make it a height that is just below your kneecap. This makes it easy to straddle for long periods of time and allows it to be used as a sawbench.

For a tall workbench, the optimal height can vary, depending on your work. A good overall height is somewhere near the top of your thigh, maybe a little higher.

If you work with wooden planes, which are tall, you might lower the bench a few inches. If you do a lot of close-up work with an electric router, raise it a few inches.

My typical advice is to make the bench a little taller than you think it should be. Then use it. If your arms get tired faster than your legs get tired, your bench might be too tall. Lower it 1". Keep working until your legs do most of the work and your torso provides much of the downward pressure. Most furniture-making jobs are not about upper body strength.

For what it's worth, I'm 6'3", and my favorite height for a tall bench is 34". However, I'm just as happy at 32" and 36". Outside of that range, things get uncomfortable.

The Modern Bench

Workholding at a modern bench (18th century to the present) usually involves a face vise and an end vise. If you are right-handed, your face vise will be on the left-hand side of the front edge of benchtop. The end vise will be on the right end of the benchtop. The end vise will work with a series of dogs to clamp boards in place so you can work their faces. The face vise is typically used for holding boards so you can work on their edges and ends.

There are lots of different kinds of face vises and tail vises. A face vise or end vise might be all steel – steel screws and steel jaws. Or it might be all wood – wooden screws and jaws. These vises can have all manner of names: quick-release vise, leg vise, shoulder vise, twin-screw vise, patternmaker's vise, wagon vise and so forth.

Figure 2.10. Deceptively simple. These vises are easy to make, but they ask for a tad more skill and experience to use effectively.

But what is more important than the type of vise is where it is located on the benchtop. That usually (but not always) determines its function.

The chief advantage to the modern bench is that it works well when it is new or well-maintained. The screws clamp tightly. The work stays in place. The world is a beautiful place with puffy clouds.

Thing go awry after the bench is used for extended periods or is (worse) abused. Many end vises will sag in time. Then, when you clamp a board between dogs, the work will lift off the benchtop. This is frustrating to no end. Some end vises don't sag, but most of the commercial ones will in time.

A modern face vise usually has parallel bars that run parallel to the vise's screw. These prevent the vise jaw from wracking. But they also limit the clamping power of the vise and reduce the width of boards that can be effectively clamped. Again, if you maintain your face vise, you might never encounter a problem.

You also should be wary of benches that are assembled with bolts and nuts. Bolts allow you to disassemble a bench, but they also are a weakness. The nuts can come loose. The wood around the nuts can become splintered and deformed, and your bench can sway a bit as a result. If you're going to use nuts and bolts, use beefy hardware and tough woods.

Two final critiques of modern benches: The inexpensive commercial ones are generally lightweight garbage. The vises barely work, the bench's base will wrack and the whole thing will scoot across the floor when you try to use it as a real bench. Buy a good and heavy bench (the price should hurt a bit) or make your own.

And if you decide to build a good modern bench, prepare for a demanding job. These benches can be incredibly complex to build and have lots of moving parts.

Middle-aged Benches

These aren't benches from the Middle Ages, exactly; they are benches from the 14th century until the 18th century. During this middle period of workbench development, you see a wide variety of workholding appliances arise, including early face vises that are screw-driven. These vises are, however, not like our modern quick-release vises. The vise's screws are secured into the edge of the benchtop. A chop with holes in it is mounted over the screws. Threaded nuts control the clamping pressure.

In addition to this face vise, which is sometimes as long as the bench itself,

Figure 2.11. I'll stick around. These vises are simpler to make than modern vises, but they are not as convenient (until you get used to them).

these benches can be equipped with holdfasts, planing stops and other simple wedging devices that use friction or gravity to control the work.

The advantage to these benches is that they are fairly simple. They are easier to build than a bench with a modern face vise and end vise. And they aren't as fussy as a modern bench. Even after centuries of abuse, I've seen benches from this period that still perform quite well. Even with the wooden screws worn (sometimes stripped in places), the vises work.

Simple workholding devices such as planing stops or crochets rarely wear out (in fact, I've never seen a worn-out planing stop or crochet). The only place these benches seem to fail is in the holdfast holes. After a couple hundred years of use, the holes can become too large to work with the holdfast. The fix, however, is simple. Drill new holes. Patch the old ones.

The primary disadvantage of these benches is that they require a degree of cleverness and experience to use effectively. Understanding how to use the planing stop, a holdfast, battens, a doe's foot and so forth requires you to first gain experience with them. You have to understand how skewing a plane will change the rotating forces at the planing stop. You need to have your holdfast holes planned out well in order to make good use of them. You have to occasionally learn to work around the holdfasts.

I won't lie, it can be a bit tricky and intimidating at first. But after a few projects, I think you will get the hang of things and workholding becomes second nature.

Early Workbenches

The oldest workbenches, from 79 C.E. until the 14th century, are usually a simple platform (which can be low or high) with a simple planing stop. Perhaps a holdfast.

These benches are by far the easiest to build but the most difficult to use. I've built a few of them, and even the most complex ones take only a few days to construct. They are a platform with legs.

With only simple workholding, the user is required to use his or her body to hold the work. You use your butt, your knees and your legs to immobilize the work. Sometimes this works to great advantage. I have become quite a fan of sitting on my work while planing it against a planing stop. It's like using a rowing machine, and it doesn't tire me out one bit.

Sawing boards to width and length is also a joy on a simple and low bench. The bench supports most of the board, which is far superior to using two or three sawbenches to rip or crosscut your stock.

However, some joinery operations can be awkward. Until I can find a better method to cut tenons, I find that operation a balancing act.

Some operations require a second bench or stool, or they require you to sit on a stool next to the bench. And that can seem kind of weird at first. In fact, part of the trick to using these simplest of benches is allowing yourself to think: Could I solve this problem with a stool?

Mix & Match

Luckily, we can pick and choose which devices we want on our workbenches. There is nothing to stop you from using a modern tail vise and Roman holdfast. Or a French planing stop and an Iowa wagon vise. You can start with a simple bench and "evolve" slowly, adding appliances and gizmos until you are happy. Or you can begin with a fancy modern bench and experiment with simpler methods until you find a mix that suits your work.

Figure 2.12. All kids love 'log.' The simplest benches don't even look like benches to the modern eye; they look more like a sitting bench that was abused by a teenager. But they can do all the jobs of a modern bench – once you've committed to them.

You don't have to be dogmatic, pedantic or (can't think of another -tic word). Just keep an open mind about all your options when you try to plane that curved crest rail with compound angles cut on its ends. Your European tail vise might fail you in this situation. But look down, below the bench, at those two "does' feet" fixtures and a holdfast….

Background or.... Paintings such as this are governed by many rules of composition and geometry. Are they reliable ways to investigate early woodworking techniques? After the evidence piles up a bit, I think so. Here we see St. Joseph working while sitting down in this 16th-century Spanish painting.

MUSEUM OF FINE ARTS OF VALENCIA

III

The Pleasures & Problems With Paintings

If Jesus Christ hadn't been a carpenter and if Christianity hadn't spread to every corner of the globe, this book likely would be much shorter or not exist.

The vast majority of images that show early workbenches in use depict the "Sacred Family" – Jesus, Mary and Joseph. Usually Joseph is working at the bench, Mary is sitting down and Jesus is in a cradle or helping his father at some woodworking task.

These paintings can be found in the New World and Old, and across great swaths of time. And they are both an incredible and troubling resource.

The paintings are fantastic because they depict a wide variety of workbenches and tools across centuries of their development. Most painters (and people in the general populace for that matter) were unaware of how woodworking tools looked at the time of Christ, so they typically painted scenes of the Sacred Family using tools and workbenches that were contemporary to the painter's time.

This tradition continues today; I have a recent image of Noah building the ark that shows him using a Stanley Sharptooth saw.

Figure 3.1. Time trap. Even people with knowledge of historical tools and practices can get tripped up when depicting early scenes. Here is Jesus using a brace, a tool that wasn't invented until the 14th century, in this 20th-century painting.
PAINTING FROM THE JOHN SINDELAR COLLECTION

So, it's easy to find Victorian paintings of Joseph working at what we would consider a 19th-century English Nicholson-style workbench with front aprons. Or paintings showing Jesus wielding 18th-century handplanes or a modern brace and bit.

Painters usually aren't woodworking historians. And to most people's eye,

woodworking tools haven't changed much since Roman times. Chisels, bowsaws, mallets and even holdfasts are similar enough to ancient tools to make their exact representation a detail worth glossing over.

So, when a painter from the 16th century paints a low bench with a face vise and a shapely bowsaw, those are tools and appliances that were likely contemporary to the 16th century – perhaps tools that the painter saw on a jobsite or in a local shop.

This visual anachronism is what fuels my work, and I'm thankful for the painters' oversights.

On the other hand, you end up with depictions of the craft, workbenches, workholding and tools that are questionable. You'll find vises where the screw pierces the work. Workbenches that hold the work for planing as if by magic. Tenoning operations that could happen only in a zero-gravity.

As a result, you have to examine these paintings with a skeptical eye, and you have to look at a shed-load of them. Finding one example of a workbench in a painting usually isn't enough. I like to find several examples from different time periods before I say (to my long-suffering wife): Yup, that's the way they worked back in 1556.

But before we examine the paintings showing Jesus and Joseph at work, I'd like to begin our investigation with images of workbenches that were likely made at about the time Christ walked the earth.

Beauty & Ruin

The best and earliest image we have of a workbench is a fresco painted on a wall of a dining room in the House of the Vettii in Pompeii, Italy, a city that was destroyed by the volcano Vesuvius in 79 C.E. The image itself is clear, the story being depicted in the painting is famous and the bench is as simple as you can get: four legs and a slab top.

Figure 3.2. Pull, father. Jesus stretches a board. The image is from "Canonical histories and apocryphal legends relating to the New Testament represented in drawings with a Latin text." Edited by Antonio Maria Ceriani, 1873.

Jesus & the 'Board Stretcher'

After growing up in the Presbyterian church, I became fascinated in college by the Gnostic Gospels – a collection of writings from the 2nd to 4th centuries about aspects of Jesus' life that aren't included in the Bible we used in Sunday school.

So, I was intrigued when researcher Jeff Burks passed me the following passage from The Infancy Gospel of Thomas. It was one I hadn't read in college. This one was translated by M.R. James and appears in the popular "The Apocryphal New Testament" (Clarendon Press, 1924). It is the earliest account we have of the mythical board stretcher[1] that has stymied apprentices for centuries. Here's the text:

XIII. 1 Now his (Jesus's) father was a carpenter and made at that time ploughs and yokes. And there was required of him a bed by a certain rich man, that he should make it for him. And whereas one beam, that which is called the shifting one was too short and Joseph knew not what to do, the young child Jesus said to his father Joseph: Lay down the two pieces of wood and make them even at the end next unto thee. And Joseph did as the young child said unto him. And Jesus stood at the other end and took hold upon the shorter beam and stretched it and made it equal with the other. And his father Joseph saw it and marvelled: and he embraced the young child and kissed him, saying: Happy am I for that God hath given me this young child.

[1] New employees in a furniture shop are typically sent by one of the workers to fetch the "board stretcher" from another employee. The greenhorn is then sent from worker to worker, until he or she gets wise or someone lets them in on the joke – board stretchers do not exist. Or do they? Ask St. Thomas.

Figure 3.3. House of the Vettii. Inside the door on the left side of the street is the house with the fresco of Perdix at work on a low workbench.

Figure 3.4. The dining room. On the left side of the room is the fresco that features Perdix with his workbench. The frescoes are astonishing.
PHOTOS BY NN

For those who aren't familiar with Pompeii, the House of the Vettii is one of the most famous restored residences in the ruined city. And despite its age and the toll that time and the environment have taken on its frescoes, encountering them in person will throw your heart right up into your throat.

When I visited in March 2017, I was surprised at how sprawling Pompeii is; you can get lost without a map. As we picked our way through the streets to the House of the Vettii – trying not to break our ankles on the streets' cobblestones – we met dozens of groups of tourists, yet the ruined city somehow makes you feel alone.

After passing through the house's

small entryway, I entered the peaceful atrium. The light there is indirect and soft, except for a shaft of harsh artificial stuff from one corner. If you follow this beam, you'll enter a room called the "red oecus" – a formal dining room with the fresco that shows the earliest workbench in the West.

It's a small room, much smaller than what we think of as a dining room. And this intimate space forces you to look at the frescoes closely.

The scene shows Daedalus (the inventor of carpentry, ship masts and glue) presenting a mechanical or artificial cow to Pasiphaë, the wife of King Minos.

In the extreme foreground is Perdix (Daedalus' nephew and apprentice), who is mortising a post or leg. His work is restrained with iron nails – Romans made tons of nails – and it rests upon a low workbench with four splayed legs.

This fresco is like walking into the middle of a movie. Here is some important backstory.

King Minos had asked Poseidon to grant him a sign that Minos was the legitimate king of Crete. Poseidon sent a magnificent white bull as his answer. Minos did not sacrifice the bull as promised, but sent it to his herd and sacrificed another bull. Poseidon becomes enraged and curses Pasiphaë as revenge. The curse: She experiences unnatural lust for the white bull.

Now we're up to date and can follow the story in the fresco at right. Pasiphaë commands Daedalus to build a cow contrivance that will help her satisfy her lust.

In the next part of the story, Pasiphaë consummates her desire for the bull and gives birth to a half-human, half-monster called the Minotaur, a child that both Pasiphae and Minos have to acknowledge. Once again, Daedalus is called in to design and build another contrivance – a labyrinth – to prevent the man-eating "child" from escaping.

Figure 3.5. The cow contrivance. Ancient Greeks and Romans likely interpreted the story depicted in the fresco differently than I do. But as a woodworker, I focus on the role of Daedalus in the story, who tries to fix problems by building things. The fixes don't always work out.
PHOTOS BY NN

Figures 3.6 & 3.7. Perdix, up close. I was shocked how close I could get to the fresco showing Perdix mortising a leg. The detail is impressive.

The story has a sad ending for Daedalus – the death of his son. For Daedalus, his talent, used in an argument between a god and a king, had terrible consequences.

So now let your eyes drift down to the bottom of the fresco where Perdix is keeping his eye on the mortise, or perhaps he is thinking about how he's going to invent the saw, compass and chisel (before Daedalus tries to kill him and he turns into a partridge and…). And we are left to ponder the bench he is sitting on.

The Pompeii Workbench

So here's what I see when I look at Perdix's workbench. It's about knee-high, so Perdix is sitting down. We don't see exactly what he is sitting on. It could be a stool, or perhaps he is supposed to be sitting on the work and the perspective is decidedly pre-perspective.

The work itself is restrained by at least two Roman nails that are pounded into the benchtop. And this is the first workholding tip for modern users: You can drive nails into your benchtop to secure the work. It's not my first choice when figuring out how to manage an odd-shaped workpiece. But I do it fairly regularly when I get backed into a corner. Sometimes you need the work secured to the bench with nothing sticking up above the work. (If you use electric routers in your work, I hope you are nodding in agreement.)

This bench has four legs that are splayed out toward the corners of the benchtop. This is a fairly typical Roman representation of splay. Yes, I know it looks like the front legs lean left and the rear legs lean right. But after you look at a lot of early images, this is the way they represented rake and splay. The artist is, in my opinion, trying to represent simultaneously the elevation view and the profile view of the bench.

On the ground we see a bow drill and a sort of adze that could have

been used for face- or edge-planing the work. Then we have Perdix himself with a faraway look in his eye and a Roman hammer in his right hand.

When I first saw this image I assumed Perdix was using a mortising stool. It wasn't until I dove into deciphering the image of a workbench from nearby Herculaneum that I decided Perdix was working at a workbench on which he could build almost anything.

Meanwhile, at Herculaneum

Herculaneum is about a 20-minute drive northwest of Pompeii and was destroyed by the same volcanic eruption in 79 C.E. While Herculaneum was wealthier than Pompeii and was rediscovered earlier than its more-famous neighbor, its contribution to our woodworking knowledge is somewhat flawed and uncertain.

Many of the artifacts from Herculaneum have disappeared due to poor excavation or conservation methods, including the image I am obsessed with: Two "erotes" (what we might call cupids) working on an eight-legged workbench that includes holes in the benchtop and a holdfast. It is the earliest image of a holdfast of which I am aware.

The original image of this woodworking scene was removed from Herculaneum's House of the Deer (Casa dei Cervi) in 1748. It was deposited first in the royal palace at Portici and what remains of the fresco is now at the Museo Archeologico Nazionale di Napoli (though it was not on display in 2017 during my visit). For a variety of reasons (exposure to air and damp, haphazard storage and conservation methods, and the way the fresco was made), by 1879 the workbench image had deteriorated to the point where the erotes had disappeared, according to Hugo Blümner's book "Technology and Terminology of Trade and Art of the Greeks and Romans." All we have left of the original painting are 18th-century copperplate engravings that were distributed all over Europe and England – many of them conflicting in their details.

Figure 3.8. Real. Naples is layers and layers of buildings on top of sewers on top of former cities and catacombs. Every street and alley is a feast for the eyes, ears and nose.
PHOTOS BY NN

So, because we cannot see the original painting anymore, that leaves us with a question: How accurate are these 18th-century copperplate engravings?

It was the same sort of question that 18th-century researchers were asking when they saw the copperplate representations of the paintings and couldn't manage to travel to Italy to view the originals. While visitors who saw the paintings in person were impressed, some foreign writers were skeptical.

"(T)hat the artists who were employed at Herculaneum, were of an in-

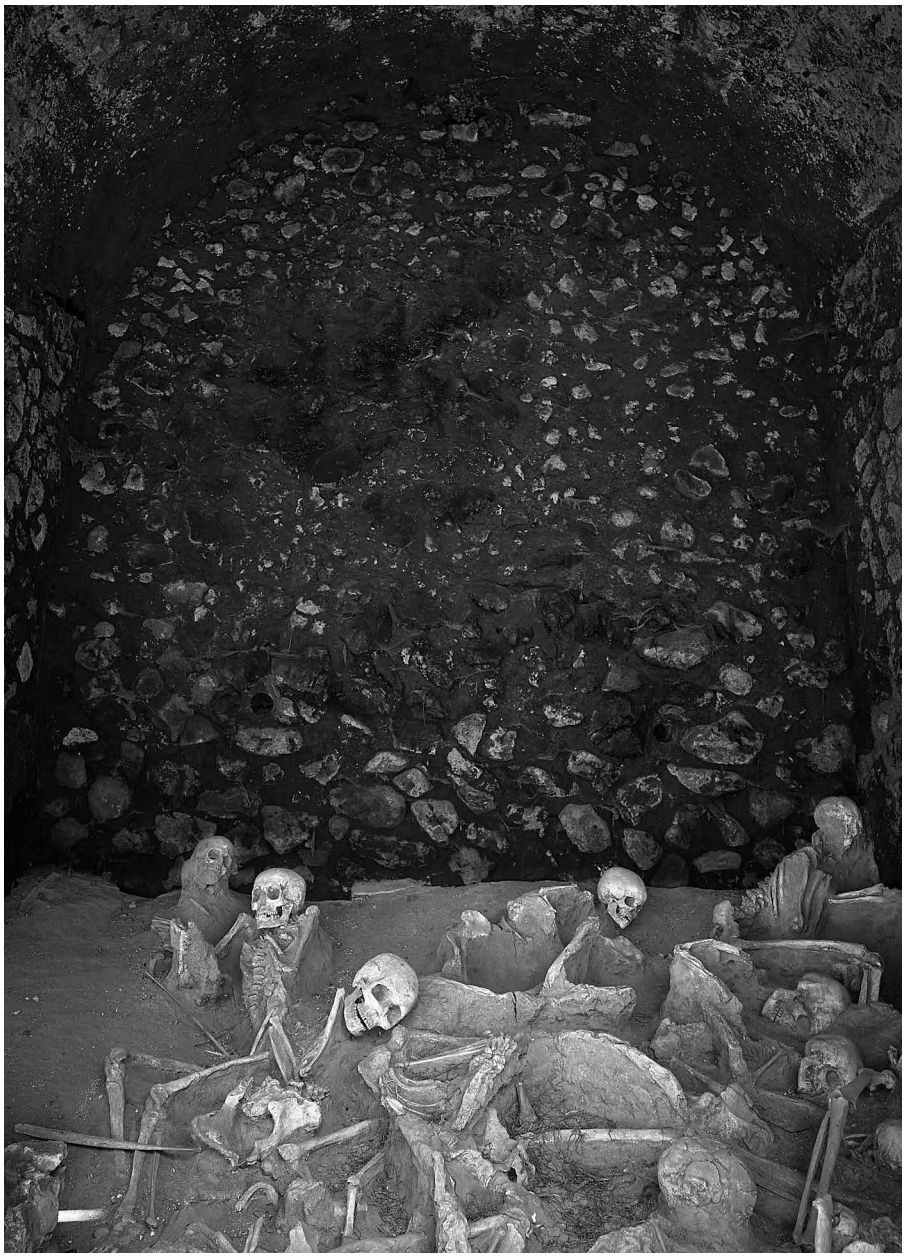

Figure 3.9. Herculaneum. The excavated section of Herculaneum is much smaller than Pompeii, but no less stunning. Particularly chilling: The skeletons at the waterfront. They were waiting to be saved and are still waiting.

ferior rank, is plain from their excelling chiefly in little subjects, as ornaments, animals &etc.; a sure sign of a mediocrity of genius. These paintings were all executed upon the spot, and therefore probably not done by the best hands," according to the first English translation of "The Antiquities of Herculaneum" (1773) by Thomas Martyn and John Lettice.

But after studying the engravings and the original paintings that did survive, it's clear that the Italian artists were meticulous in preserving the details of the paintings. Suzanne and I compared more than a half-dozen surviving paintings to their matching engravings (all executed by the same 18th-century copperplate artist) and concluded that the engraver took almost no artistic liberties in representing the paintings.

The same, however, cannot be said for the Western European engravers who copied the Italian engravers. As the images of these paintings spread across Europe, their details became muddied. In the example of our workbench painting, the bench lost its holdfast holes, it lost four legs, the saw moved and the holdfast disappeared. Additionally, several poor translations of the Italian text describing the paintings amplified the misinformation.

So, the workbench from Herculaneum – Suzanne calls it the "falegname" (Italian for "carpenter or joiner") fresco – is troubling. The original painting is kaput. But the engravings of the falegname fresco are so tantalizing that I couldn't ignore them.

At some point during the four years we worked on this book, Suzanne and I decided to take the early Italian engravers at their word. We accepted that the workbench in the falegname fresco has eight legs. It has a holdfast and a series of holdfast holes. And that the frame saw makes no sense – the blade shouldn't be in the middle of the frame for this sort of saw. (But I'm going to leave this detail to someone who wants to write a monograph on frame saws.)

This wasn't an easy decision to make. A lot has been written about this woodworking scene, and some educated people contend that the image doesn't depict a workbench. Instead, they say, it's a painting of two sawhorses. A piece of work is resting on top of the sawhorses. Yes, there is a holdfast. But it's really a depiction of two sawbenches (or sawbucks).

Because we now know a lot more about low benches I disagree. I say it's a bench with eight legs. (Why eight legs? Who knows.) And there's a piece of work on top of the bench.

After studying this Herculaneum bench and thinking about it for many

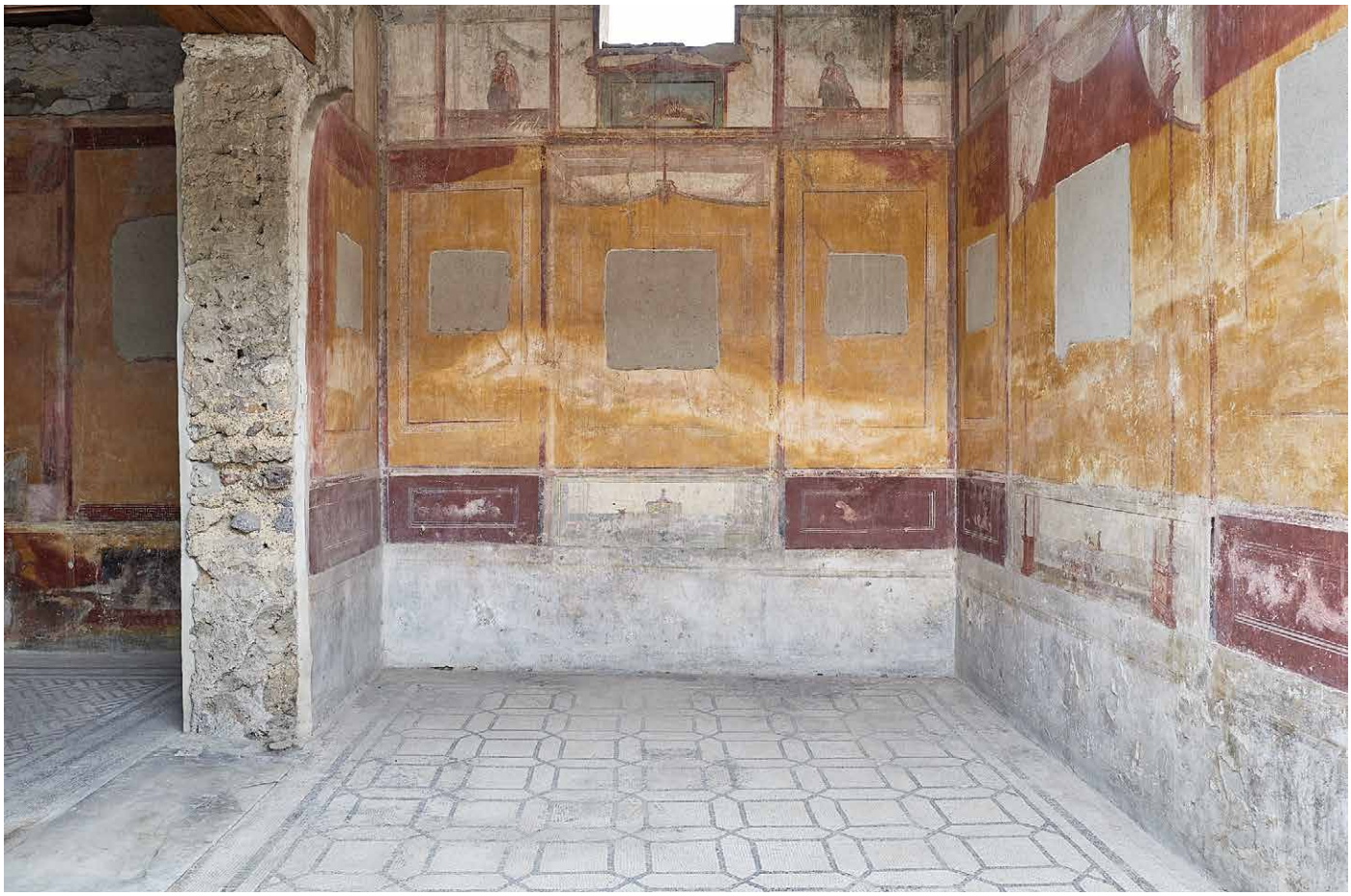

Figure 3.10. Gone away. At both Herculaneum and Pompeii, early explorers removed frescoes to show to them to the royalty. What is left are empty picture frames.
PHOTO BY NN

hours, I built a copy (details later in the book) and built stuff using the bench for many months. I became more enchanted with the workbench form and its many variants. So, Suzanne began digging deep into the museum record in the New World and Old, and turned up stacks of paintings for us to examine. Patterns emerged. And some of the benches' workholding schemes surprised us and sent me scurrying back to my shop to try this or that.

Following are some of the best examples of low benches we found and brief explanations of how we interpreted them. In the next chapter, I detail how they work (or don't work).

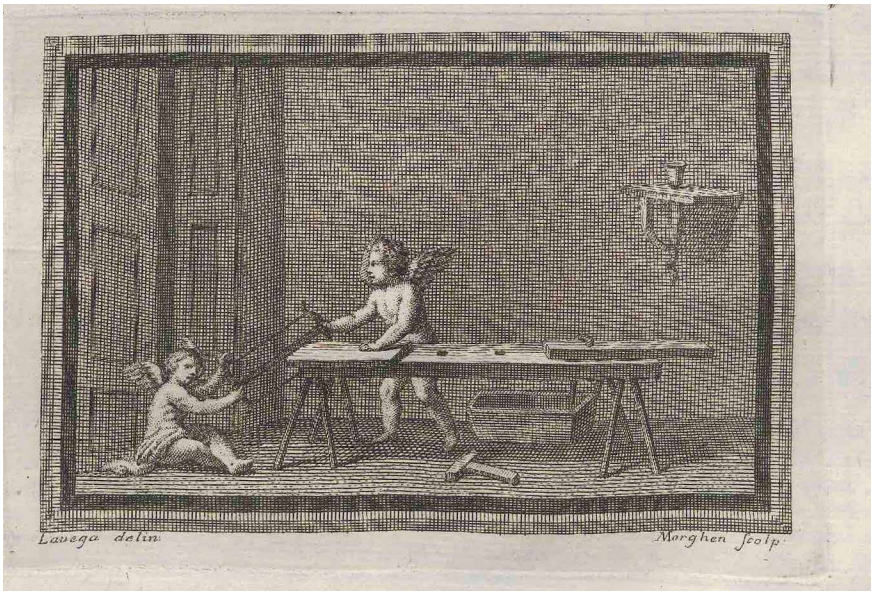

Figure 3.11. Early engraving. After this fresco was discovered, Italian engravers created this facsimile. This engraving is all that survives of the original image.

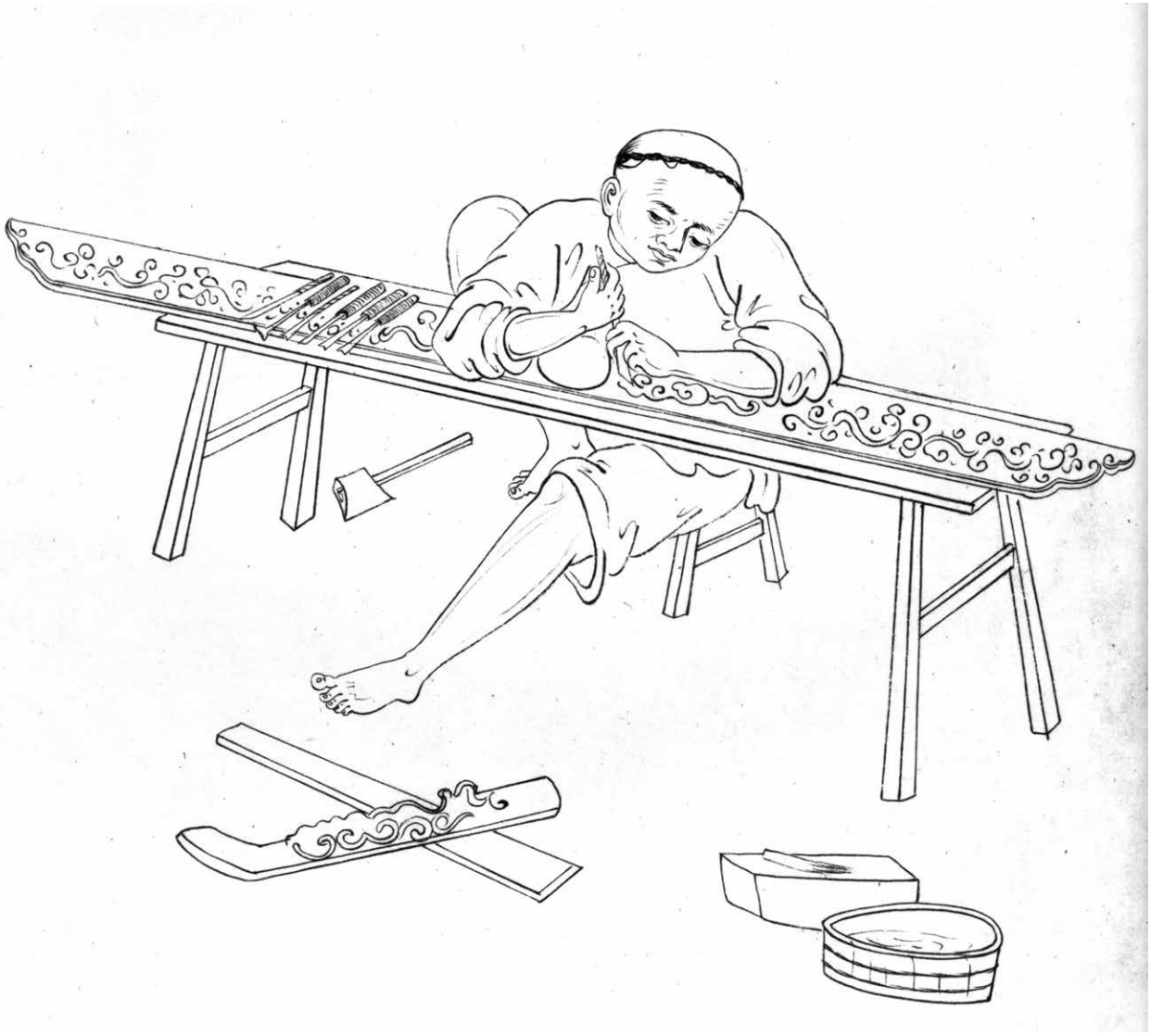

Figure 3.12. Carving in China. A typical Chinese workbench. It's low, has four legs and the two legs at each end are joined by stretchers. This form is surprisingly similar to European forms.

Roman Workbench Forms Through History

The basic Greco-Roman form of workbench shows up continuously in paintings and photographs from 79 C.E. up through the 20th century. The basic form has four legs that are – in section – square, round or occasionally octagonal. Sometimes the legs are shown piercing the benchtop, sometimes not. Sometimes the legs are joined by short stretchers at the ends of the bench, sometimes not.

These end stretchers are interesting to me because benches with end stretchers look similar to Chinese workbenches, which are generally low, have four legs with the legs at the end joined by stretchers. Chinese woodworkers are many times shown using their bodies to hold the work down, and these images of Chinese woodworkers are not just from China. Victorian engravings of Chinese woodworkers show them using these low benches to build Western furniture.

A solid example of this European form with end stretchers is shown in the painting on the next page, "The Holy Family in the Carpenter's Shop," attributed to Jean Tassel (Langres 1608-1667). This French painting shows a low workbench with a thicker-than-typical benchtop. (Note the cat. You'll find that Mr. and Mrs. Christ were cat people.) The legs are square in section and tapered. Between the legs are stretchers that are joined to the legs in an unclear way – it could be half-laps

Figure 3.13. The archetype. Simple, stout and well-proportioned, this low workbench is the most common form you'll find in paintings and drawings. "The Holy Family in the Carpenter's Shop," attributed to Jean Tassel (Langres 1608-1667).
PRIVATE COLLECTION PHOTO © CHRISTIE'S IMAGES/BRIDGEMAN IMAGES

or tenons. My guess is the stretchers intersect the legs with through-tenons.

In the painting, Joseph and Jesus are using a chalk line, likely marking a board to be ripped. The bench and shop are strewn with tools such as a typical bowsaw, jack plane (note the closed tote – very French) and adze. Some of the tools are surprisingly diminutive, especially the hammer. There is no evidence of any additional workholding – no vises or holdfast holes.

Of all the paintings of low benches that Suzanne, Jeff and I dug up, this one is the most simple and typical, including the stretchers.

Another Way to Build a Bench

Almost all the early benches that show up in paintings are of "staked" construction, where the builder drills a hole in the benchtop and drives a stake into the hole to create a leg.

There are, however, some other constructions that show up in the historical record.

Some paintings show benches that are built more like a timber-frame house than a workbench.

The legs of the bench are like the posts in a timber-frame building, and the braces are attached to both the post and the benchtop. While it's likely some workbenches were built this way (and probably still are in some corners of the world), the more common construction method for early benches is to use staked construction. A staked bench is far easier to build. And it's definitely strong enough for woodworking.

A timber-framed bench, on the other hand, would be incredibly strong – and a far more involved affair to build. There are angled shoulders to cut and likely lots of tenon cheeks and rectangular mortises.

A typical example of the timber-framed bench is shown at right in "The Dream of St. Joseph" by Luca Giordano (1632-1705). (First off, note the cat in the lower-left corner.) This painting is rich in detail, from the grass basket of tools in front of the bench, to the tools on a shelf at Joseph's right, to the tools on the floor.

(Side note: I've always been amazed by how many paintings show tools on the floor. Was the painter trying to fill up space in the composition with items (see also, felines)? Or was it common

Figure 3.14. The house of Joseph. Some benches are represented more like a timber-frame. This bench is notable for other reasons, which are covered later. But note the cat on the left. "The Dream of St. Joseph" by Luca Giordano (1632-1705). The painter was from Naples, Italy, but spent a decade in Spain. The painting now hangs at the Indianapolis Museum of Art.
PHOTO BY THE AUTHOR

practice to let your chisels and planes sit in the dirt?)

We'll return to this painting later in this William S. Burroughs chapter to examine the item that looks like a planing stop by Joseph's hand. But for now, take a look at the undercarriage of the bench and note the diagonal braces that keep the benchtop and leg at 90°. That's the look of a timber-frame workbench.

Now Add a Vise

Face vises show up on workbenches about the 14th century. The first image of a face vise I'm aware of is in a northern Italian drawing of woodworkers building Noah's Ark.[2] The vises on low workbenches hold the work for planing edges, ripping, cutting tenons and many other tasks.

It would be tempting to think that vises this massive were used for large-scale work only, but the historical record tends to differ. Take a look at the nuts and chop on Figure 3.16, "La Sagrada Familia," by Juan del Castillo (1634-1636), a Spanish baroque painter.

This bench has a remarkably massive benchtop supported by stubby legs that are joined with end stretchers. The vise chop seems to run the entire length of the benchtop and is driven by massive ellipse-shaped nuts. From the paint-

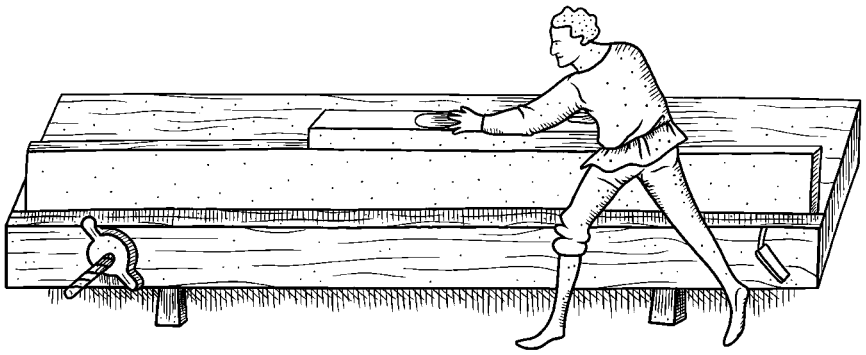

Figure 3.15. Massive and low. These benches are being used for shipbuilding, but you can see how a face vise could be a useful addition to a bench in any woodworking craft.

ing, it appears that you rotate the nuts counterclockwise to tighten the vise screws. This is reverse from the modern "lefty loosey; righty tighty" scheme, and is a fairly common in early representations of bench screws. I'm fascinated as to when (and how) screws became standardized.[3] But that's for another book.

In this scene, Jesus and Joseph use a frame saw together to either rip a board or saw a tenon's cheek. This activity is interesting to me because it echoes the way French menuisiers are shown ripping veneers on a low workbench in the 18th century's "l'Art du menuisier." Also worth putting in your craw: When you start looking at a lot of New World workbenches from areas conquered by the Spanish, you'll see lots of these massive vises and the screws will be longer, sometimes freakishly long. Why? I have no clue.

Also of note: The metal planing stop embedded in the benchtop. For me, this is the most unrealistic aspect of the painting because there is no practical mechanism shown to raise the stop. A planing stop with a shaft that long would be remarkable. You would have little room below the benchtop to knock it upward with a mallet. But the existence of the planing stop on a low bench (which we assume is a Roman-era invention) is worth noting.

Another example of this large and early vise is shown in Figure 3.17, an Italian painting titled "Gesu Faniullo Nella Bottega di San Giuseppe con la Madonna" circa 1775 by Antonio Liborio Crespi (1712-1781).

I suspect the nuts on this vise are tightened by spinning them clockwise – that's only a hunch from looking at the tip of the screw – but many other details are unusual. The way Joseph is holding the try plane with his left hand is wackadoodle – he's grabbing the wedge with his left hand. However, I must award big points to the painter Crespi for putting a Roman-style plane in Joseph's hands – note the grip on the heel of the plane. Roman planes had an open slot or two in the body for the user to grip the plane. For me this is interesting because Roman planes are not shown in 18th-century woodworking books. How did Crespi know how to draw that plane? Was he looking at an earlier source? Were there still planes such as this around?

Note that the painter has not provided a planing stop for the board Joseph is working on, or it is hidden. This is a common omission in paintings – so common that I call it the "divine stop." (Also, where is the cat?)

For me, what is weirder is that the young Jesus is holding a small cross. This fact brings up all sorts of difficult questions ("Don't you think a cross would freak out the pre-pubescent Jesus?") that my Sunday School teacher would answer with: "God knows everything! You, Chris, do not."

In all her digging through old paintings with face vises, Suzanne found two outliers that are worth examining. First, take a look at Figure 3.18, the Spanish painting "El taller de Nazaret" (1651-1700) by an unknown artist (the work is in the Museo Lazaro Galdiano in Madrid, Spain).

In the painting, Joseph is planing a quarter-section of a log against a stop. Behind him, leaning against the wall is a removable double-screw vise, what we today might call a "Moxon vise." These removable vises were well-known in the 17th century in England and France, and it's interesting to see this vise is also known in Spain at the time of this painting.

From a modern woodworker's perspective, pairing this vise with a low bench is interesting. It would be ideal for tenoning, sawing veneer and stabilizing pieces of wood on edge for edge-planing. But it would not be ideal for dovetailing, which is what it is used for by many modern woodworkers, unless you are sitting down.

The other unsettling aspect of this image is the planing stop. See the small wedge-like opening in the stop? That doo-dad is usually facing toward the

[2]The drawing is in the collection of the Mediatheque d'Arras, ms 252, f.95v.

[3]One common theory is that the world standardized the screws to tighten when turned clockwise because most people are right-handed, and it was believed that this arrangement would be easier for right-handed people. Or, if you are into anatomy, the answer is "pronation."

user – for reasons you'll understand shortly. There is little utility in pointing it the other way. But hey, art and stuff.

OK, if you are going to take some drugs while reading this book, now is the time. The next image is what Timothy Leary might do with angel action figures.

The final image of a face vise on a low bench is a bit of a mystery. It's a detail from "The Carpenter's Shop in Nazareth" (Figure 3.19) by an unknown artist in the late 18th century (now held by the Brooklyn Museum of Art, Brooklyn, New York). I've stared at this image for hours, and I'll be danged if I know how the benches' vises are supposed to work.

The painting features low workbenches with huge face vises, such as the ones we've seen elsewhere. But how the vises work is unclear. When I look at these vises, I see rocks or bricks hanging down below the bench that are held by rope or string. I know, that makes no dang sense.

One of the benches is being used for sawing, and the best explanation I can come up with for how the vise works is, ahem, "rock on strings." The other bench, which is being used for planing (perhaps) is even less clear. In addition to the roped rocks, there also is some hint of a couple bench screws in the face vise as well.

Like any old painting, the more you stare at it, the less things make sense to a modern. Hey, Angel No. 2, why mortise on the floor when there's an open bench in front of you? And Angel No. 1, that is not the way I would chalk (or ink) a snap line. But I'm no angel.

And the Very Odd Notches

When I was permitted to inspect the oldest existing workbench at the reconstructed Roman fort in Saalburg, Germany, I had a lot of things I wanted to see with my own eyes, because there are virtually no photographs of the

Figure 3.16. No line necessary. When painters fail to include layout lines on the work, I often wonder if they just neglected to put them in, or they assumed that Jesus didn't need them. Here Joseph is watching the saw closely; Jesus is looking at Joseph or even higher.
PHOTO ILLUSTRATION BY THE AUTHOR

Figure 3.17. That's a big vise. Massive vises such as this appear on Italian benches in the 14th century that were being used for shipbuilding. This form of vise on a low bench survives to this day, especially in Central American countries. While young Jesus holding a cross might seem odd, this is often seen in Holy Family paintings and is prefigure or foreshadow of Christ dying for our sins. The cross is one of the items called the Arma Christi (weapons of Christ), symbols of Christ's Passion.

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bench in the public record.

At the top of the list were a couple "mortises" on one edge of the benchtop that have been described and drawn by various woodworking historians during the last 100 years. Some drawings of these "mortises" show them as a typical square mortise on the edge of a board, like something you would see in a door stile. Other drawings, from the museum staff, show them more as dovetail-ish notches on the edge of the benchtop.

When I saw the two notches, they looked like dovetail-shaped notches in the benchtop, similar to the dovetail socket you see in French workbenches that is part of the joint that connects the legs to the benchtop. They were definitely not square-sided mortises.

When you inspect 1,700-year-old woodwork you have to be less literal than you might expect. This object was fished out of a well after soaking for 1,700 years. Museum staff explained that when the wooden objects were pulled from the well in the 19th and early 20th century they looked remarkably fresh and new (they know this from casts that were made at the time). But as the objects dried out they became quite distorted.

The Saalburg bench looks distorted in many ways, so you have to look at the geometry of the piece and think what it would look like were it undistorted by the drying process. Another issue is that in the Saalburg bench, one of these dovetail notches had been filled in with a modern piece of wood that was glued in place. The "filler" piece definitely is dovetail shaped. The other notch is empty.

I stared at these notches for a long time. I took a lot of photos. I looked for tool marks that might suggest how these two notches had been used. Some of my theories at the time were:

1. The notches held some sort of vise or jig in place on the benchtop for the

Figure 3.18. Look behind Joseph. You can see a removable vise leaning against the lumber. This was a well-known accessory at the time the painting was made, but it is interesting to see it paired with a low workbench. Usually you see it paired with a taller bench.
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convenience of the worker.

2. The notches were used for tenoning. The work would be pushed against the acute angles of the notch to wedge it in place as you sawed the tenon cheeks.

3. The Saalburg benchtop had been recycled from another assembly and the notches were a part of that earlier assembly.

4. The notches were the result of wear and tear to the bench, either while it was in use at the Roman fort or when it was stashed in a well for 1,700 years.

Seeing the dovetailed notches didn't resolve my questions. When I left Saalburg I didn't have any more answers as to what the notches were used for. But later that summer, Suzanne turned up an interesting painting from Colombia: "Jose San Carpintero," artist unknown, probably early 18th century (located at the Museo de Arte Religioso, Duitama, Boyaca, Colombia). (Figure 3.21)

That painting shows a high workbench that has a dovetailed notch in one long edge. The notch is crisply cut – and empty. There's no clue in the painting as to what the notch is used for. The tools and debris on the floor don't help, either. There is the tiniest of chances that the workpiece being held by the subject of the painting is supposed to fit in the notch after it is worked. Also, check out the tool on the benchtop – could it be on top of a planing stop that is used in conjunction with the notch?

Figure 3.19. "The Carpenter's Shop in Nazareth" by an unknown artist in the late 18th century in Spanish Colonial Bolivia (Brooklyn Museum of Art, Brooklyn, New York). This painting is by an anonymous indigenous artist and not based on Dutch engravings used by the Jesuits. This fact helps explain its unusual features.
UNKNOWN. THE CARPENTER'S SHOP IN NAZARETH, LATE 18TH CENTURY. OIL ON CANVAS, 29 5/8 X 31 7/8IN. (75.2 X 81CM). BROOKLYN MUSEUM, FRANK L. BABBOTT FUND, 43.112.

But this painting confirmed that the dovetail-shaped notch wasn't an illusion. It wasn't the result of wear to the Saalburg bench. And it's in Colombia – all the way across the Atlantic Ocean and about 1,500 years after the Saalburg bench was built in what is now Germany.

But what was it used for?

The Smoking Gun Up the Road

For the last 20 years I've visited every museum (grand and small) in every city I've visited, from Melbourne, Australia, to Metten, Germany. No matter where I go, I make it a point to examine any collection of furniture, tools or workbenches. As a result, I've turned up a lot of good theories about benches and how they were used.

But it never fails to amaze me how one determined researcher can eclipse my on-the-ground efforts with a few keystrokes.

"Have you seen this before?" Suzanne wrote on Aug. 17, 2017. Her email was accompanied by an image of Joseph dreaming at his workbench – a typical 17th- or 18th-century painting.

And there it was, down in one corner. The same dang notch from Saalburg. But this one was filled with a piece of wood that resembles a planing stop. And then the puzzle pieces began to fall into place.

I wrote back, "Mein Gott."

The painting (Figure 3.22), which we discussed earlier because of its timber-frame workbench, is called "The Dream of St. Joseph" by Luca Giordano (1632-1705), and the painting hangs in the Indianapolis Museum

Figure 3.20. Perhaps a birdsmouth. The notch on the end of Joseph's bench looks like a V-notch on the end of a sawbench. Or it could be a square notch.

'TALLER DE NAZARETH' BY MANUEL DE SAMANIEGO (ACTIVE 1787-1824). ARCA ARTE COLONIAL AMERICANO, ID: 754.

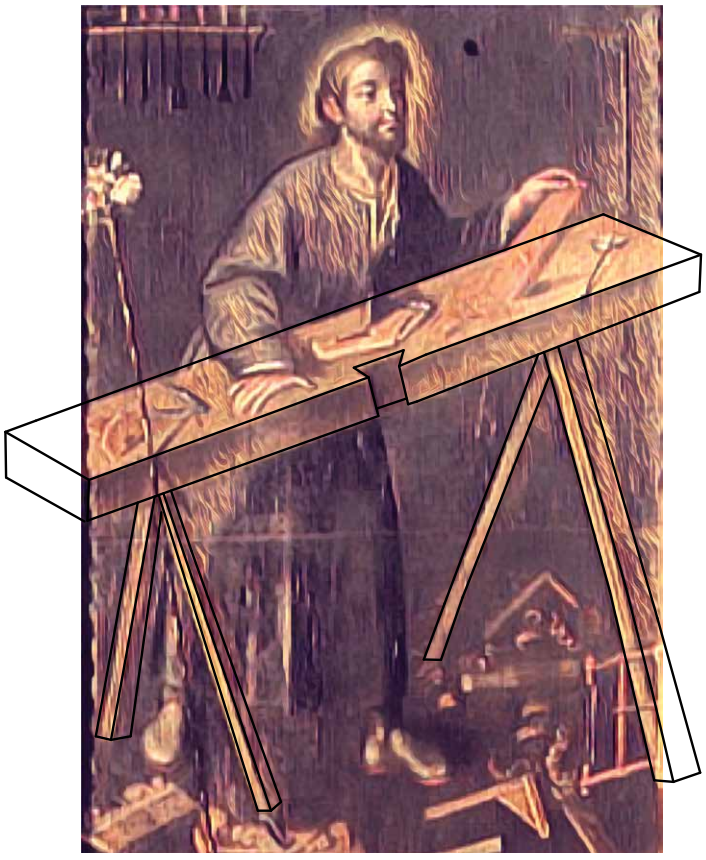


Figure 3.21. An important notch. This New World painting was the first confirmation that the dovetailed notch on the German bench at Saalburg wasn't a fluke.

PHOTO ILLUSTRATION BY THE AUTHOR

of Art – two hours from where I live. (I went and visited it immediately to get a close look.) The notch in Joseph's bench is filled with what appears to be a planing stop with angled edges to fit inside a dovetailed notch in the side of his bench.

The stop protrudes from the notch in three directions. This, I think, is an important detail as it allows the stop to be knocked up and down with a mallet, just like a planing stop. The stop's extra thickness makes it an easier target for a mallet as well.

What does it do? I suspect it is used for a couple things. When planing wide panels, this stop could restrain the long edges of a board to keep it from spinning on the benchtop, like a peg in the benchtop or a doe's foot appliance. One or two of these stops could be a big help when planing.

If you have two of these notches, as the Saalburg bench does, these stops could also be used in tandem to restrain a board while traversing it.

Naturally, the stops adjust up and down to accommodate different thicknesses of work.

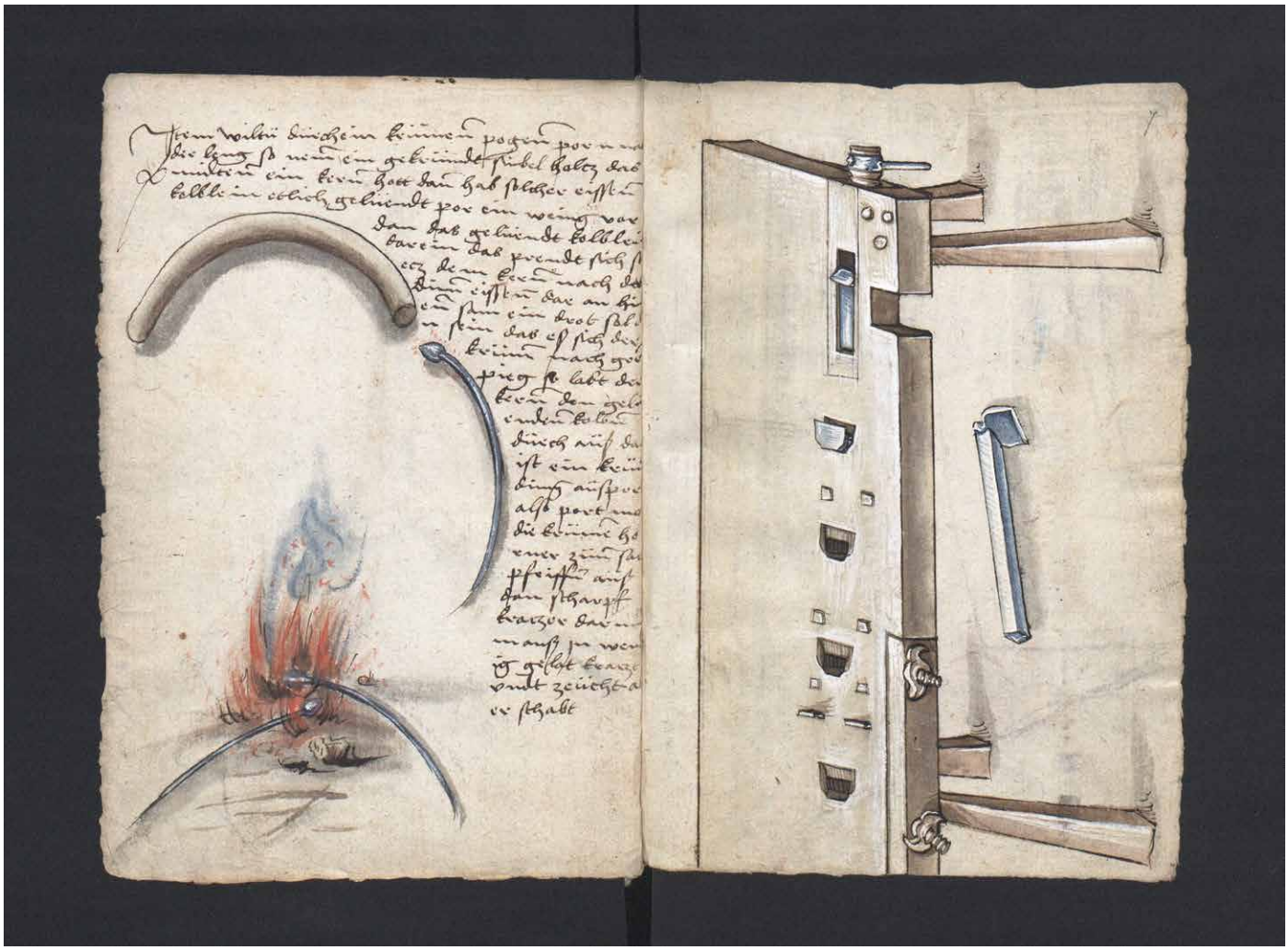
As you'll see later in the book, I built a reproduction of the Saalburg bench with these notches and filled them with planing stops to test my assertions. So, stay tuned.

Other Notches

After dealing with the dovetail-shaped notches, I had to figure out a purpose for some other extant notches in paintings and drawings. In several benches, there are notches with 90° corners – not dovetail-shaped like the notches on the Saalburg bench. These square notches show up on two benches in Nürnberg (about 1505 or 1506), an early 16th century Italian bench and a few others.

The notches are positioned on either the long side of the benchtop (like the Saalburg bench) or on the end of the benchtop. We couldn't find any exam-

Figure 3.22. Not just another religious painting. If I saw this painting in a museum, I'd likely walk right past. Good thing Suzanne has a sharp eye because it turned up a bench detail I've been looking for. (Detail of "The Dream of St. Joseph.")
PHOTO BY THE AUTHOR



Figures 3.23 & 3.24 Note the notch. Other benches feature a notch on the long edge of the benchtop that could be used for cutting tenons or sawing out fretwork. These two illustrations are both from about 1505 in Nuremburg. The painting (right) is the "Holy Family," part of a 10-panel work by Bernhard Strigel. The illustration above is from a codex of tools and technology from Martin Löffelholz.

PAINTING: GERMANISCHES NATIONALMUSEUM, NÜRNBERG (LEIHGABE DER BAYERISCHEN STAATSGEMÄLDESAMMLUNG) FOTO: G.JANSENN

ple of this notch in use, so its purpose is an educated guess.

One likely use for the notch is as a place to wedge a piece of work for tenoning. You would place the workpiece upright in the notch then knock a wedge between the notch and work to secure it for sawing. Again, you'll find this feature in the benches I built for this book.

Another possible use is as a "birdsmouth" or "ripping notch," like you would find on a traditional sawbench. The notch could be used when sawing thin work to prevent it from vibrating or breaking. The work would be placed on the benchtop with the area to be sawn placed over the notch. Then a frame saw (with the blade vertical) would cut the desired shape. The benchtop area around the notch would support the work so it didn't have to be cantilevered off the benchtop. (If you think this sounds far-fetched, you're wrong. These birdsmouth supports were common among those who sawed marquetry or made curved shapes with "Morris saws" – what we now call coping saws.)

More Unusual (and Useful) Structures

Many workbenches before the 18th century had a "crochet" (or hook) in the place where a modern woodworker would put a face vise. The crochet

Figure 3.25 A notch at the end. This notch might have 90° corners or might be V-shaped, like a birdsmouth notch. "Sacra Famiglia," mid-16th century possibly by Giulio Clovio (1498-1578) with a cat on the chair.
VENICE, FONDAZIONE QUERINI STAMPALIA

is a bench attachment with a wedge-shaped opening where you can jam a workpiece. With it jammed in place, you can plane, saw or mortise upon it. By the 19th century, the crochet had vanished from most workbenches and was replaced with a screw-driven face vise.

When I built my first "ancient" French workbench in 2005, I added a crochet and have an immense respect for its versatility. If you can't afford a screw-driven vise, the crochet is an excellent alternative. It's merely a scrap of wood attached to the front edge of the benchtop with pegs, nails or screws.

I've always wondered: Where did the crochet come from? The idea of wedging your work in place is as old as the wedge. The crochet is a wedge on the outside of the benchtop, which allows you to hold large work (such as doors) and smaller work (with the assistance of pegs or holdfasts below the work).

One of the earliest images of a crochet (that I've seen) is in the 1607 Italian painting "La Bottega di San Giuseppe" by Giovanni Barbiani (1566-1641). In this painting, the crochet appears as an integral part of the benchtop – not fastened to the benchtop as is typical.

This is an unlikely construction. The crochet as shown is fragile and likely to split away from the benchtop the first time you jammed a piece of thick stock in there for planing. Typical crochets from the 17th and 18th centuries are represented as a separate piece of wood that has been fastened to the edge of the benchtop, usually with nails. This construction makes it durable and repairable.

But what is important about this painting (and other early crochet im-

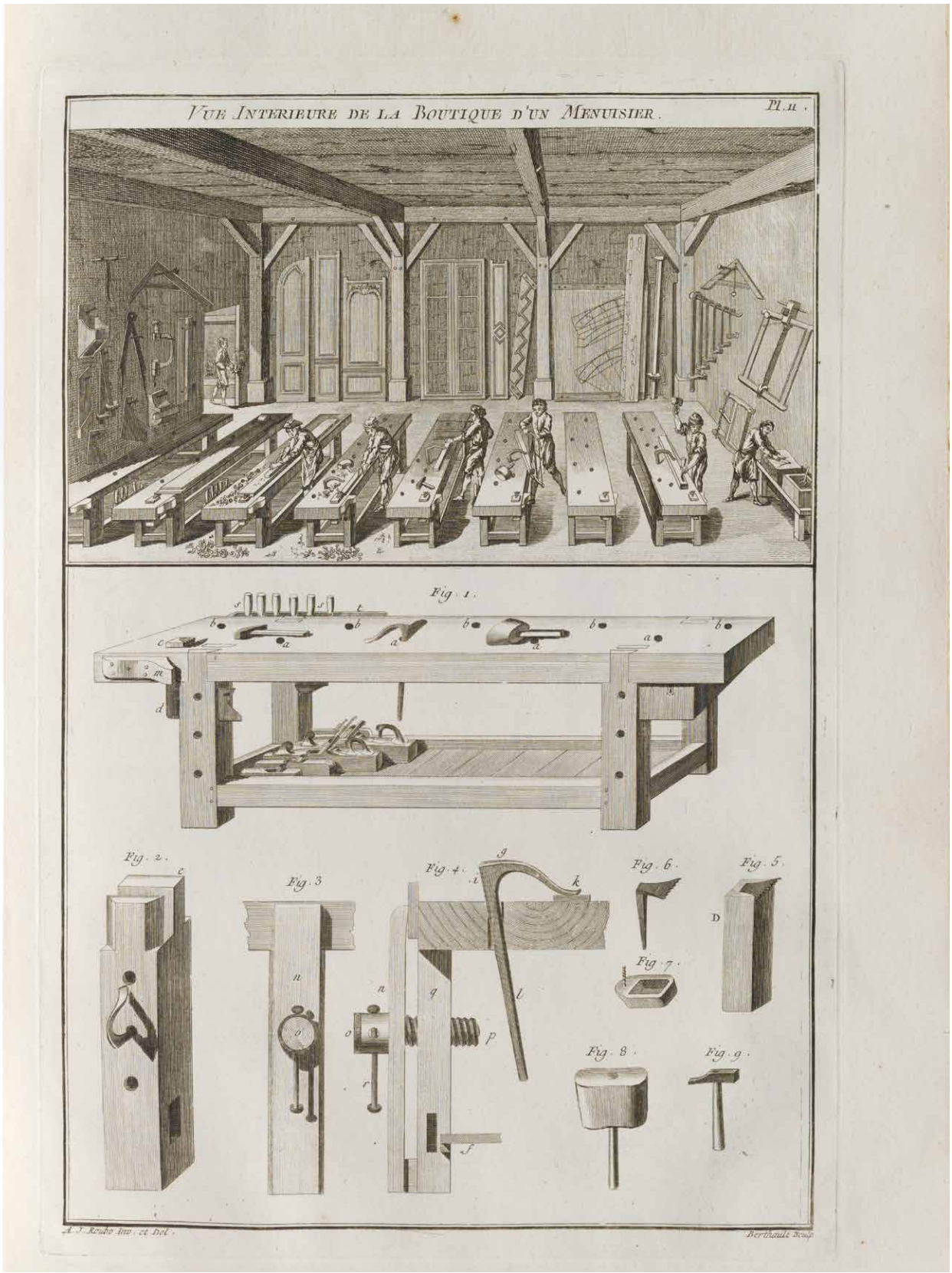


Figure 3.26 The crochet. One of the best-know illustrations of workbenches shows the crochet in place of a face vise. From A.J. Roubo's "l'Art du menuisier."

ages) is that it dates the crochet (possibly) to the late 16th century, which makes its reign longer than the screw-driven face vise (so far).

The Doe's Foot or 'Palm'

Another form of workholding wedge is what is called the "doe's foot" in French and the "palm" in China. It's a V-shaped appliance that is attached to the benchtop and used for planing the faces and edges of boards.

The 17th-century painting "Sagrada Familia y San Juanito en Interior" (Figure 3.28) from Spanish Colonial Alto Peru (artist unknown) gives us a clear look at a doe's foot or palm on the benchtop. Similar in form to the doe's foot shown in A.J. Roubo's "l'Art du menuisier," this appliance is affixed to the bench.

After building one of these and using it, I'm half-convinced it is more useful than the typical metal single-point planing stop found on many benches. The Peruvian appliance is a block of wood with a V-shaped notch cut into it, making it resemble a doe's foot. To work narrow stock, you wedge the work between the doe's toes. This works for planing either edges or ends.

For wider stock, you place the work against the toes, which prevents a wide panel from rotating while planing it.

The only downside to this appliance that I've found is that it doesn't adjust up and down like a traditional planing stop. So, you might need to have a few of them of different thicknesses that you can swap out when dealing with very thin or very thick stock.

The Wide Array of Custom Modifications

All the benches we have looked at so far seem designed for general woodworking and carpentry. But low benches show up in many trades, outfitted with special gear for a particular operation or set of procedures, from chairmaking

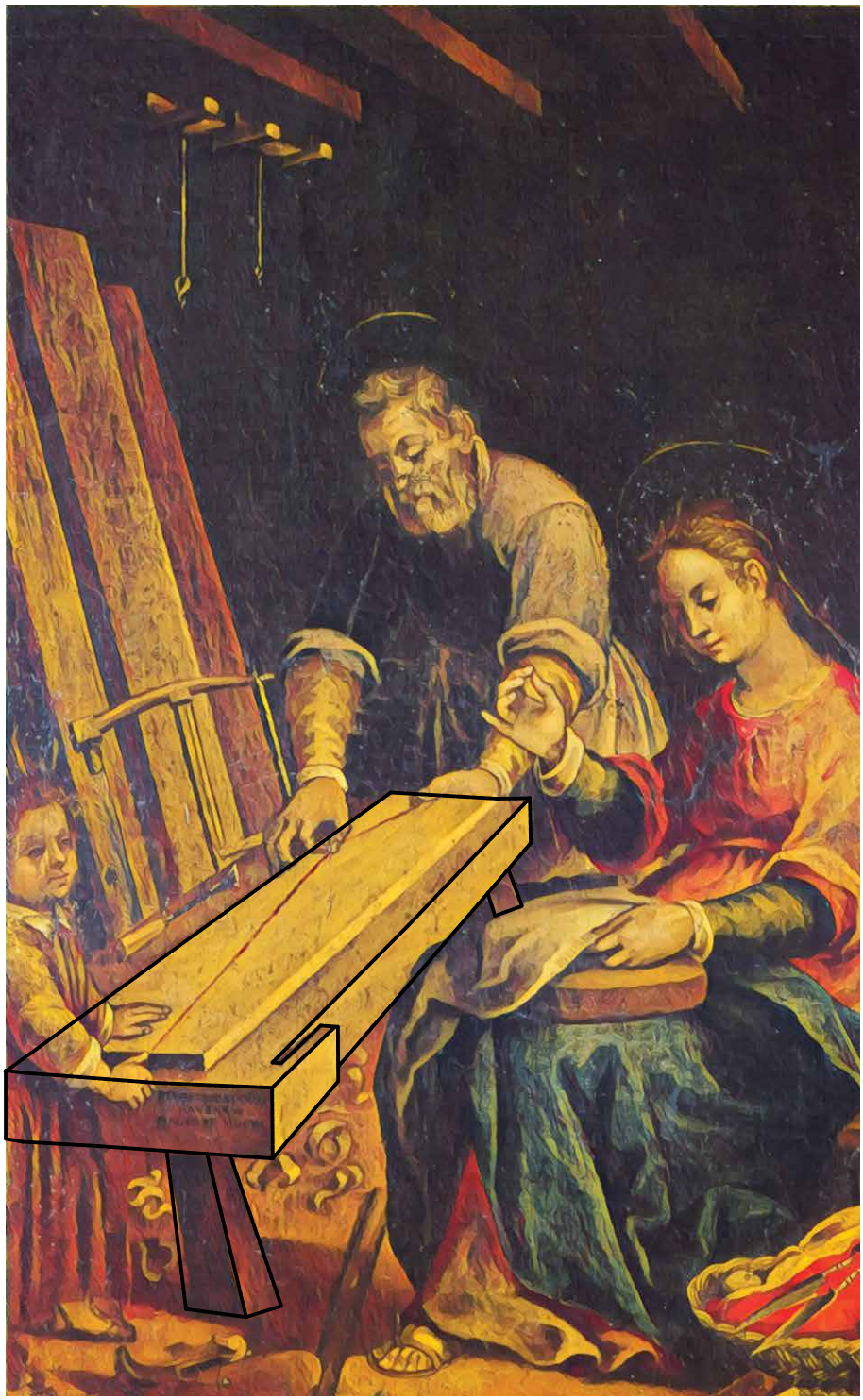


Figure 3.27 A long rip. This crochet appears to be a part of the benchtop, not an attachment. While nothing is impossible, I suggest it's an unlikely and weak way to make a crochet. "La Bottega di San Giuseppe" by Giovanni Barbiani (1566-1641). (Sant'Agata Maggiore, Basilica di Sant'Agata, Ravenna, Italia.)

PHOTO ILLUSTRATION BY THE AUTHOR

Figure 3.28 A different planing stop. This wedge-shaped appliance from this 17th-century Peruvian painting is ingenious. Narrow stock is wedged between the "toes" of the appliance. Wider work is planed against the toes.
IMAGE COURTESY OF JOSÉ ANTONIO CÁMARA

Figure 3.29 Almost any width. With the doe's foot at the head of the bench you can plane narrow or wide stock with the same setup.

to wagon building to steam-bending. Here are a few of the more interesting ones.

"Woodworking in Estonia" (Lost Art Press) is the Rosetta Stone when it comes to how these low workbenches were pressed into use and are still used in traditional cultures. Ants Viires' landmark work, which was first published in 1960 (illegally translated into English in 1969 then legally published in 2016) links the low benches from Roman frescoes with daily craft work that continues to this day in rural areas.

Images of low benches populate the entire book. In fact, it is difficult to find examples of the tall Western workbench in the 304-page work, though these benches are mentioned.

The most familiar modification is shown in the section on cooperage, where Viires illustrates a low bench that has been modified (or purpose-built) to work as a shavehorse. The addition of a foot-powered clamp seems obvious (especially after someone shows it to you), and this sort of bench shows up frequently and is in use by several crafts.

Check out the woodcut from "De Re Metallica" (Figure 3.31) by Georgius Agricola (1561), an early text on mining. Above ground, you have a woodworker working on a low bench outfitted with a "dumbhead-style" clamping mechanism common in continental Europe. And a drawknife.

While we are dealing with cooperage, "Woodworking in Estonia" shows another type of low bench used for bending barrel staves. The mortise in the bench receives the work; a block of wood below the work allows the cooper to bend the stave by pressing the work down. The work is bent while wet. Thick stock has to be heated before bending, according to the text. After bending, the pieces are put into frames so they hold their shape while drying.

One of the advantages of this low bench when bending stock is that it allows the woodworker to get his or her entire weight over the piece with ease. When bending chair parts on a tall workbench, I often find myself jumping on top of the benchtop to gain some mechanical advantage. Low benches offer this without leaping 38" or so into the air.

One of the allied trades to the cooper is the wheelwright, who makes the wheels (and sometimes the carriages) for horse-drawn and other-drawn vehicles. One of the notable benches from this trade uses a two-piece top, what we would call a "split top." The wheelwright would place the hub between the tops and drive in the spokes.

A quick look at the Estonian example of this wheel bench will likely make your eyes skip over it, like a rock across

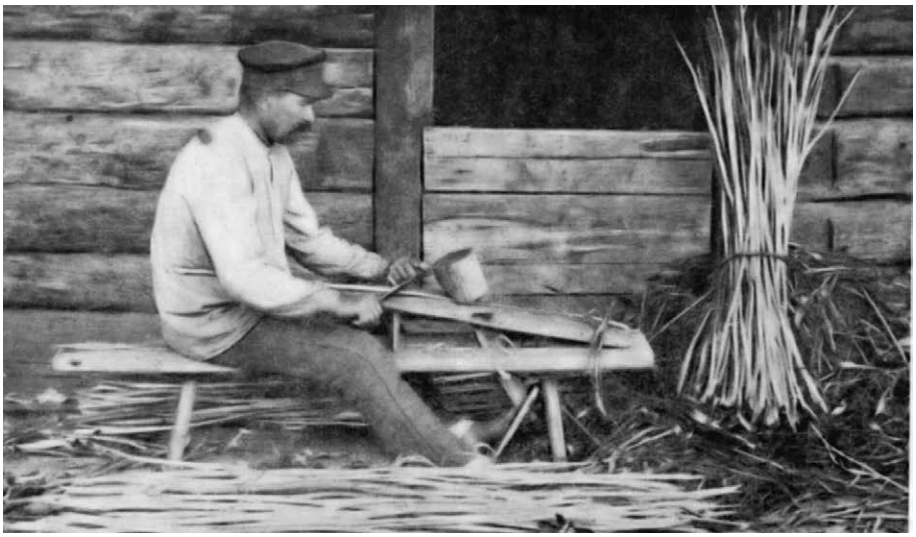


Figure 3.30. Looks familiar. Cutting hoops on cooper's bench, Avinurme, Piilsi village.
PHOTOGRAPH BY E. VITTOFF, 1921. FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 439:313

Figure 3.31. Early shavehorse. What is interesting about this image, compared to the Estonian shavehorse, is that some provision has been made to round or shape the seat of the horse, implying that it was purpose-built as a shavehorse.

Figure 3.32. A bending bench. Avinurme, Enniksaare village.
PHOTOGRAPH BY ANTS VIIRES, 1947, FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 1089:82

a lake. Of course one would assemble a wheel this way – next topic. Yet, this worn bench (it looks almost eroded) is ingenious. Notches in the top cradle the hub on both ends. This arrangement of top, hub and second top creates an environment that supports the wheel during assembly.

A Chairmaker's Bench

Some of the bench appliances on low benches are more complex than a simple (but useful) hole or stick. In M. Hulot's "L'Art du Tourneur Mécanicien" (1775), he describes a bench used by chairmakers who shave their components. And it's not a shavehorse.

Hulot's low bench, which he calls a "saddle," has a number of interesting features, including one detail that is typically French: a bib that the worker wears over the chest while at the bench.

While bibs show up in many cultures, the French have an affinity for them. Hulot's bibs are shown being used for both shaving components and drilling them. The shaving bib turns the worker into a human shavehorse. One end of the work is placed into the "head" of the saddle, which is a notched chunk of wood secured to the benchtop. The other end of the work is placed in a notch in the bib, which Hulot calls the "belly." Then you shave away.

With the drilling bib, the top of the brace is inserted into the bib, which allows the worker to steady the brace and use his or her torso to push the bit into the work. You'll see this in action in the next chapter.

The other interesting aspect of Hulot's bench for chairmakers is what he calls the "assembly saddle." It's an area of the bench that can grasp odd-shaped stock for mortising. The work is surrounded by three dogs and then secured by a wedge. Curved parts are no problem. Nor are round parts.

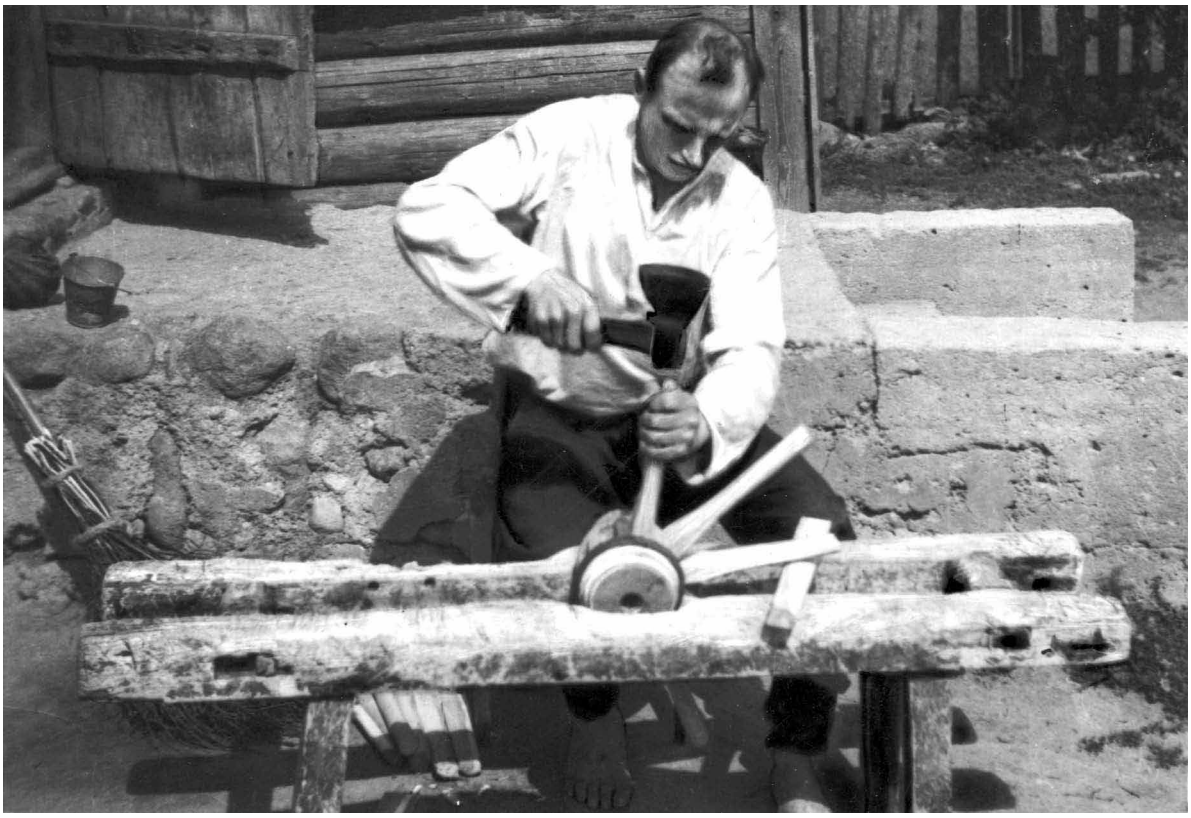


Figure 3.33. Early split-top. Insertion of spokes into hub on a wheel bench, Kodavere, Assikvere village.
PHOTOGRAPH BY ANTS VIIRES, 1948, FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 1105:88

Shipbuilding Benches

And finally, we come to the peak of specialization: making "blocks" for wooden sailing ships. (Blocks are the pulleys that guide the rigging and give the sailors great mechanical advantage.) The two benches shown in "The Elements and Practice of Rigging and Seamanship" (1794) by David Steele demonstrate how specialized these benches can become.

The "clave bench," for example, is a low bench with ends that are 8" thick and a center that is 4" thick. The workpieces are wedged between the ends of the bench so they can be mortised for the sheaves, which are the grooved, circular part of a block that guides the rope.

The "holdfast bench" is what you suspect. The bench is pierced with multiple rows of holes for iron holdfasts. The holdfasts hold components for sawing or trimming. An accessory to the holdfast bench is the brake, which is a lever that holds the sheaves in place while a hole is bored in its center.

And Why? And So What?

My father foolishly asked me about this chapter of the book when we were together at Christmas, and he got an earful about paintings and the development of bench appliances (I suspect his question was prompted by a desire to relieve some insomnia).

But (before nodding off) he asked a question worth addressing: Why did workbenches evolve from simple to complex? Doesn't this evolution imply that the old benches needed to be improved?

I don't have a perfect answer, but I do have some guesses based on being immersed in the craft and its history for the last 25 years. Here goes.

If you look at the history of our craft, there are two major trends that relate to our tools and benches. One trend is that woodworkers themselves went from being generalists to being quite specialized by the 18th century. As the work became more specialized, so did the tools, the benches and the appliances built for them.

The second trend is something that continues today. And that is the desire to invent devices that allow people with few skills to do the work of someone who is highly skilled. A modern example of this trend is the development of random-orbit sanders and modern abrasives. A woodworker can learn to use these tools capably after just a few minutes of training. After a day of work, they can be experts. The random-orbit sander replaces the smoothing plane, which requires much

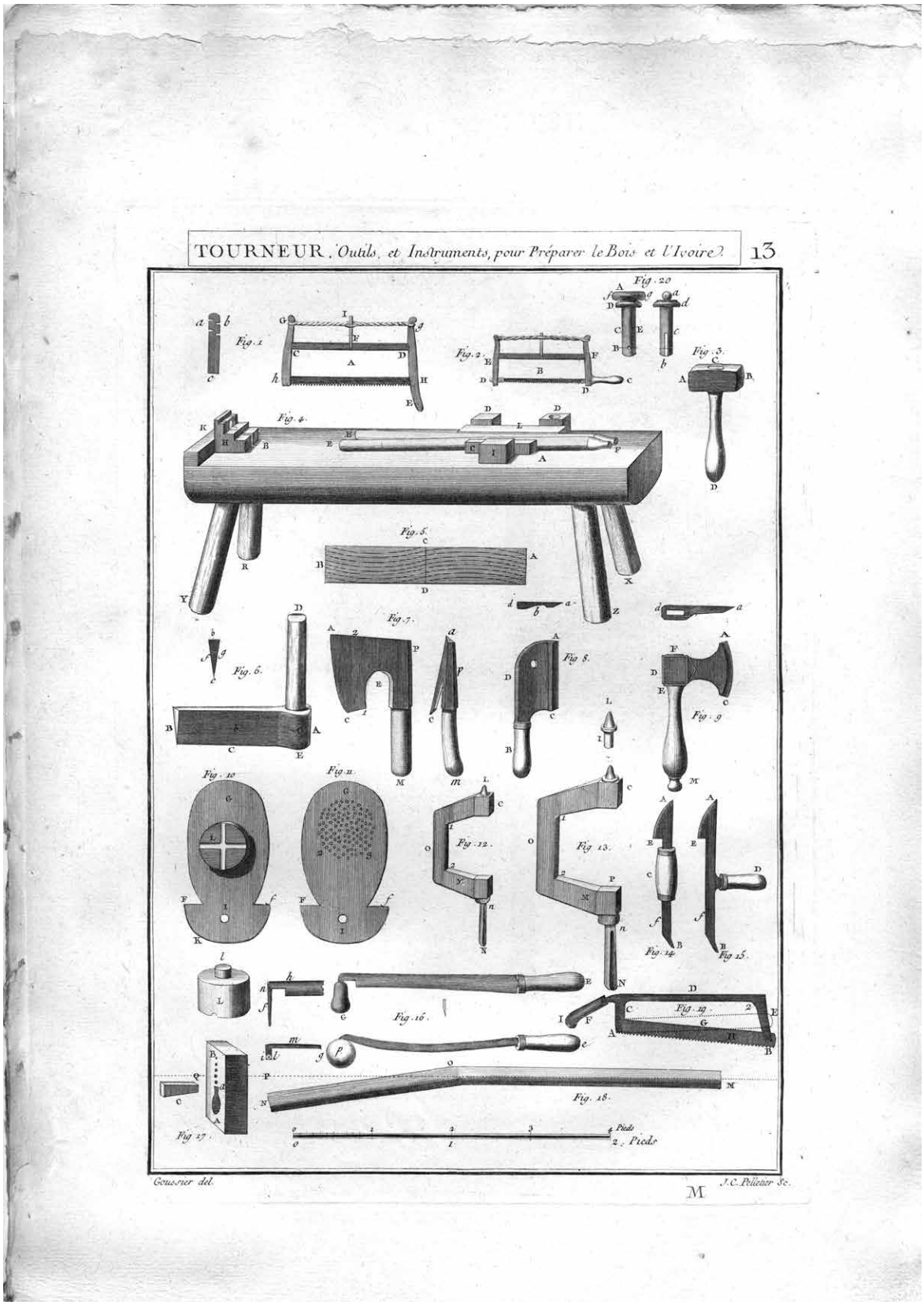


Figure 3.34. In the saddle. M. Hulot's low workbench is designed for chairmaking. It has a shaving station at one end and a clamping station at the other. From "L'Art du Tourneur Mécanicien" (1775).

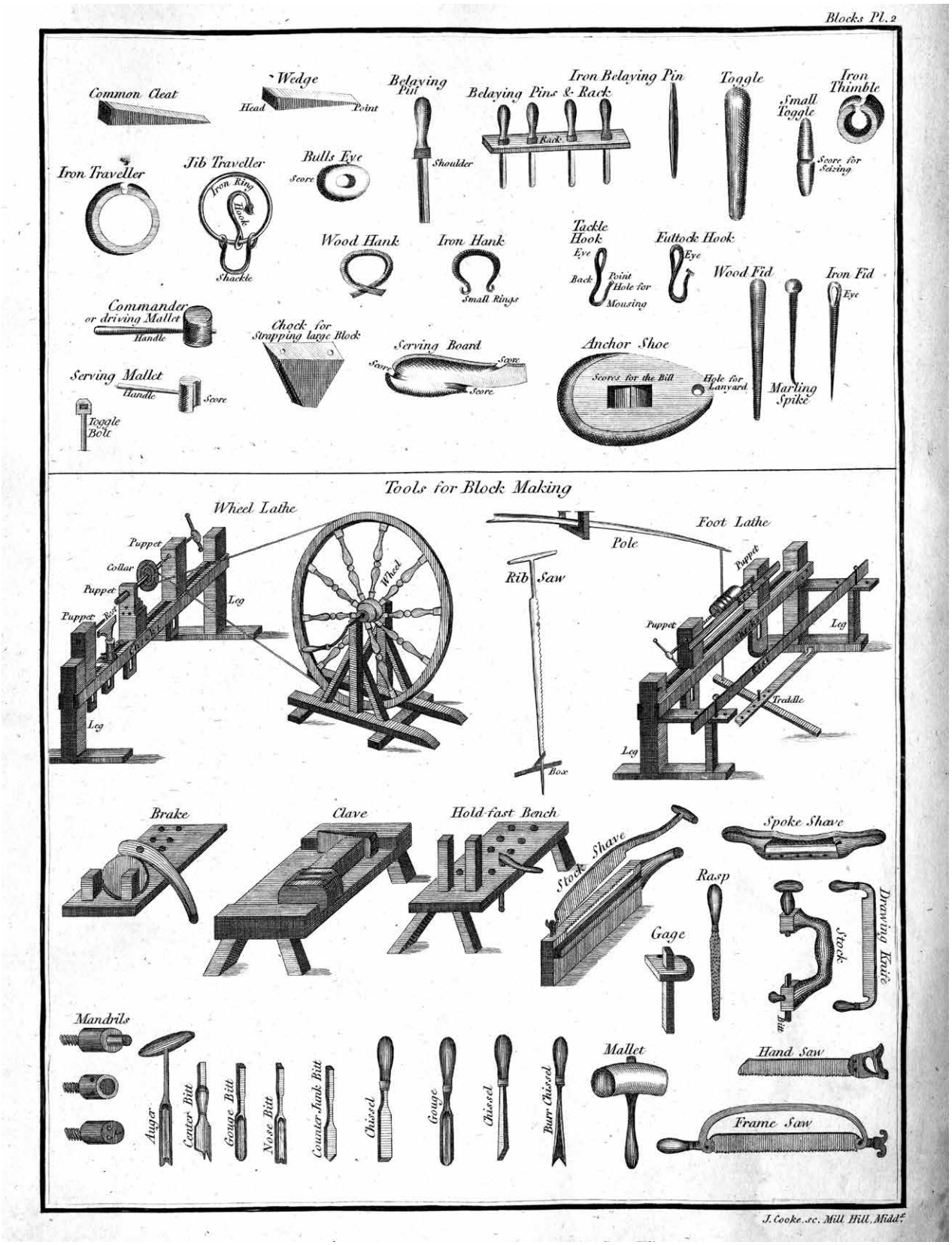


Figure 3.35. Very specialized. These benches for making blocks for sailing ships have features that make them very particular to the operations of the block maker. From "The Elements and Practice of Rigging and Seamanship" (1794) by David Steele.
SPECIAL COLLECTIONS & ARCHIVES DEPARTMENT, NIMITZ LIBRARY, U.S. NAVAL ACADEMY.

more training and practice to master. (There are thousands of examples of this throughout the history of the craft.)

In the world of workbenches, a tail vise and dogs are much easier to use than a simple planing stop. An iron quick-release vise requires 30 seconds of training to use for cutting tenons. Compare that to learning to use a notch and a series of softwood wedges to hold the work.

In many cases, modern devices seem a clear improvement compared to the simpler ancestor.

But this view ignores the monetary cost of the improvement. It ignores the maintenance required to keep the device working smoothly. And, in my experience, the improvement is sometimes minimal.

So, workbenches became more complex as the work became more complex, and the cost of a skilled worker went up.

Are more complex workbenches worth it? I'll leave that for you to decide. The next chapter explores the simple workholding devices shown in many of the paintings discussed here, and it details my experiences with them in the shop.

Figure 4.1. Local color. Keep your eyes open when in museums. Thanks to Suzanne Ellison's sharp eye, this painting provided an important clue about the use of notches in workbenches. And the painting happened to be right up the road from me in Indianapolis.

IV

Workbenches: Where, When & Why

by Suzanne Ellison

Tracing the history of workbenches takes one into the realm of Greek myth, along ancient trade routes, through the harshness of secular and religious empire-building and the glories of golden ages in arts, science and literature. There are many frustrations in the great gaps in the records, and regret over the loss of civilizations, languages and traditions. But the one thing that never disappoints, and alleviates the frustration and regret, is the wonder of human ingenuity.

The research for this topic began in 2014 when Christopher Schwarz asked me to translate an 18th-century description of the fresco from Herculaneum. I picked up the Herculaneum trail again in 2016 to search for contemporary accounts of the excavations and also 19th-century accounts of the condition of the fresco. Here and there, in other research, a low Roman workbench would turn up, but the majority of the images Chris uses in this book, and the workbenches discussed in this chapter, were found in June through September of 2017.

I primarily used publicly available image and text databases maintained by museums, universities, photographic archives, auction houses, academic journals and papers, and used search terms in seven languages. Occasionally, I contacted an archivist or academic researcher, and (with few exceptions) they were more than willing to offer assistance. A conservative estimate of the number of images viewed last summer is 8,000 to 10,000, with images from the Spanish Colonial era contributing about a third of the total.

Verifying the geographic origins of the artwork was the starting point to connecting commonalities in history and development of workbenches with distinctive features.

In the last couple years more public and private museums and universities have collaborated to put collections and other resources online. As we get more access there will be many more discoveries to be made, and I expect the gaps in our timeline will be filled. You may find, as Chris did, a missing piece in the puzzle is in a museum near you.

The Earliest Discoveries: 1st–15th Centuries

As Chris and I unearthed examples of the low Roman-style workbenches, there was an emphasis on dating the benches and thinking in terms of a timeline, especially a timeline of innovations. Thanks to my father's brilliant idea of handing me a map to track our family trips, and to keep me quiet on those trips, I started thinking in terms of maps. I had a workbench-discovery map developing in my head. Date, and place, would become important in solving some of the questions about the technology and the quirky features we found.

Low and higher workbenches and shaving horses are seen in flat outline in Roman funerary iconography, but for our purposes we start with four benches depicted in more dimension and detail. The first four low benches date up to the Roman Empire in the second century. Three are from the heart of the Empire: an engraving of a fresco from Herculaneum; a fresco depicting the myth of Daedalus and Queen Pasiphae from Pompeii; and a piece of decorated Roman glass found in catacombs. The fourth find, and the only extant benches, are the two from Saalburg, the frontier fort on the Limes Germanicus in the Roman province of Raetia. The Saalburg benches had the added interest of puzzling notches, a mystery that was solved, we think, by

a Spanish painting executed more than 1,500 years later.

After a gap of six centuries in our record I found an 8th-century fresco of a carpenter working while sitting astride a low bench. The fresco was in an Umayyad bath house in the desert at Qusayr Amra (present-day Jordan), in a region once part of the Roman Empire. The bath house follows a Roman plan and the fresco is one of several "portraits" of the craftsmen who built the structure.

After another six-century gap, five benches show up in 14th-century Spain and Italy. The Spanish bench is from Teruel Cathedral in the Aragon province of Zaragoza. Two decades before Qusayr Amra was built, the Umayyad led the Muslim invasion of Spain. In Teruel, Mudejar craftsmen (Muslims who remained in Spain after the Reconquista) built the cathedral and are depicted in portraits similar to those in Qusayr Amra. The Mudejar woodworkers were using low Roman workbenches. Of the Italian benches, one is from a Sephardic manuscript and three are scenes from the construction of Noah's ark.

In the 15th century, low benches are depicted in Flemish and French paintings of the Holy Family, and in two books from southwest Germany and central Italy. Karl Schreyner, a woodworker in Nürnberg from about 1425, is one of the woodworkers in "The Mendel and Landauer Hausbücher." In 1485, a woodworker and his bench are on the cover of a novella published in Florence. Both are notable because they are not religious images.

Each time there is a large gap in the image record, huge societal shifts were at work. In the 2nd and 3rd centuries, the Roman Empire was weakened by plague outbreaks that caused troop shortages and disrupted food production. During the 3rd century, there was a 50-year-long crisis that saw the Empire split into three warring parts. The devastation of wars and plague led to population shifts and, despite a reunification late in the century, there were cities in the western part of Europe that never recovered. In the 3rd and 4th centuries, the Empire struggled to keep control over its vast territories. And by the conclusion of the 5th century, the Roman Empire in Western Europe and the age of Classical Antiquity was at an end.

Figure 4.2. Clever Nürnbergers. The city of Nürnberg proved to be a rich source of early woodworking imagry, including this 15th-century portrait of Karl Schreyner and his ingenious pegs. *STADTBIBLIOTHEK NÜRNBERG, AMB.317.2°, F.21R.*

With the advent of the Early Middle Ages, Western Europe splintered into small kingdoms and city states. In the East, the surviving portion of the Roman Empire attempted to retake Italy and other areas lost to invading tribes. It was, to say the least, a time of great social and economic upheaval, and not

every invading or land-grabbing group put record-keeping at the forefront.

Artwork from the time does include scenes of woodworking, usually of a Biblical theme, rendered in manuscripts, frescoes, tapestries and mosaics. Representations of the construction of Noah's ark have yielded a few low workbenches. To Chris's delight, a series of benches in an early 14th-century Northern Italian manuscript have full face vises.

Two things to consider concerning the lack of image records from the last centuries of the Roman Empire and through the Middle Ages are: Who commissioned the art and who controlled what could be made? In other words: Who had the money and who had the power? The answer: wealthy landowners and the Catholic Church. For the wealthy, a nice selection of art might include portraits to exhibit the richness of your garments and jewels, illuminations for your Book of Hours and tapestries illustrating scenes from the Bible (and to keep out the cold). The Church commissioned frescoes to teach illiterate parishioners lessons from the Bible and the life of Christ. The civic authorities of a city state might commission artwork illustrating themes of good government and portraits of city luminaries. Artwork featuring woodworkers and other craftsmen, all of the low end of the social and economic scales, was not desirable.

How the artwork was made also figures into what survived. Manuscripts and paintings were easy to move to safety, or be looted then saved. Frescoes can be incredibly durable, but given the great age of any work created in this time period they are, nevertheless, fragile. Add in questionable conservation methods and the countless wars and conflicts extending well into the 20th century, and it is remarkable we have anything left to ponder and appreciate.

Figure 4.3. A vigorous Joseph. Thanks to the revisions of St. Joseph's history, images began to appear of him actively working at his bench, at times with his son.
IMAGE COURTESY OF JOSÉ ANTONIO CÁMARA

Enter St. Joseph

I wouldn't fault you if you ever wondered, besides St. Joseph, where are the woodworker saints. The roots of his reinvention and popularity started with the miseries and fractures of the 14th century. Millions died in the Great Famine of 1317 to 1319 and the Black Death episodes of 1338 to 1375. France and England began the Hundred Years' War, civil wars broke out in other parts of Europe and the climate got colder with the start of the Little Ice Age, which affected food production and transportation. The Pope moved the Papal Court from Rome to Avignon; the Great Western Schism (along with corruption, hysteria and heresies) rocked the Church.

In the artwork and literature of the time, St. Joseph was a minor figure and there were few mentions of him in the Bible. Early paintings often showed him with graying or white hair and beard. Apocryphal gospels, accepted in the Eastern Church, provided more

of his story. In those gospels, he was described as an older, widowed man and a caring father to Jesus. However, in some popular literature he was ridiculed as an old man married to a much younger woman. An improved image of St. Joseph started gaining steam with the poem "Josephina," written by Jean Gerson, a French theologian. Gerson's contemporary, Bernardino of Siena, also took up the cause and so began a rewrite of St. Joseph's image. He was younger, vigorous and a strong provider for his family.

This renewed image of Saint Joseph resulted in a new popularity and, of course, more paintings were needed. The updated image of St. Joseph was codified during the Counter-Reformation actions of the mid-16th century Council of Trent when it addressed (in general terms) how sacred images should be painted. Much more specific instruction was given later by Johannes Molanus, a theologian and arbiter of sacred art. St. Joseph and the Holy Family became the definition and example of a family unit as determined by religious authority. Any references to the apocryphal gospels were prohibited (no board stretchers allowed). Artists, being artists, did not always comply. A receding hairline, grayed beard and Joseph's flowering staff still made appearances in paintings. But if an artist went too far, the Inquisition came calling.

An artist made his (not often, but sometimes it was a her) living primarily by painting or sculpting sacred religious art. Compositions ranged from scenes of quiet devotion to the miraculous, to torture, sacrifice and martyrdom. From an artist's viewpoint, the new interest in St. Joseph offered an opportunity to paint a common man surrounded by his family as he worked as a carpenter.

At the end of the 15th century, the Age of Discovery began. In the 16th century, devotion and enthusiasm for St. Joseph flourished, and by the middle of that century, he was the patron saint of the Viceroyalty in New Spain (Mexico, parts of Northern and Central America and the Philippines).

Figure 4.4. Via Augusta. Many workbenches we found in Spain showed up along the Roman road called Via Augusta (in red).
MAPS BY BRENDAN GAFFNEY

The Roman Roads: The 16th-18th Centuries

It is not surprising to see low Roman workbenches in Italy or any of the former Roman provinces. By mapping our bench discoveries, we found a strong relationship to locations along the Roman roads and trade routes that continued into the early decades of the 18th century.

After mapping the Spanish workbenches, I put an overlay of the Roman roads of Hispania and found, with a few exceptions, the plot points fell along or very near the Via Augusta (formerly the Via Herculea). Via Augusta, one of the major commercial Roman roads, ran along the Mediterranean coast from the Pyrenees in the northeast, through Valencia, diverted inland to Seville and ended back on the coast at Cadiz. Eight workbenches fall along the Via Augusta, with six benches from Valencia and Seville.

Of the 38 low, Roman-type workbenches we espied, we found 21 benches (or 55 percent) that date from the

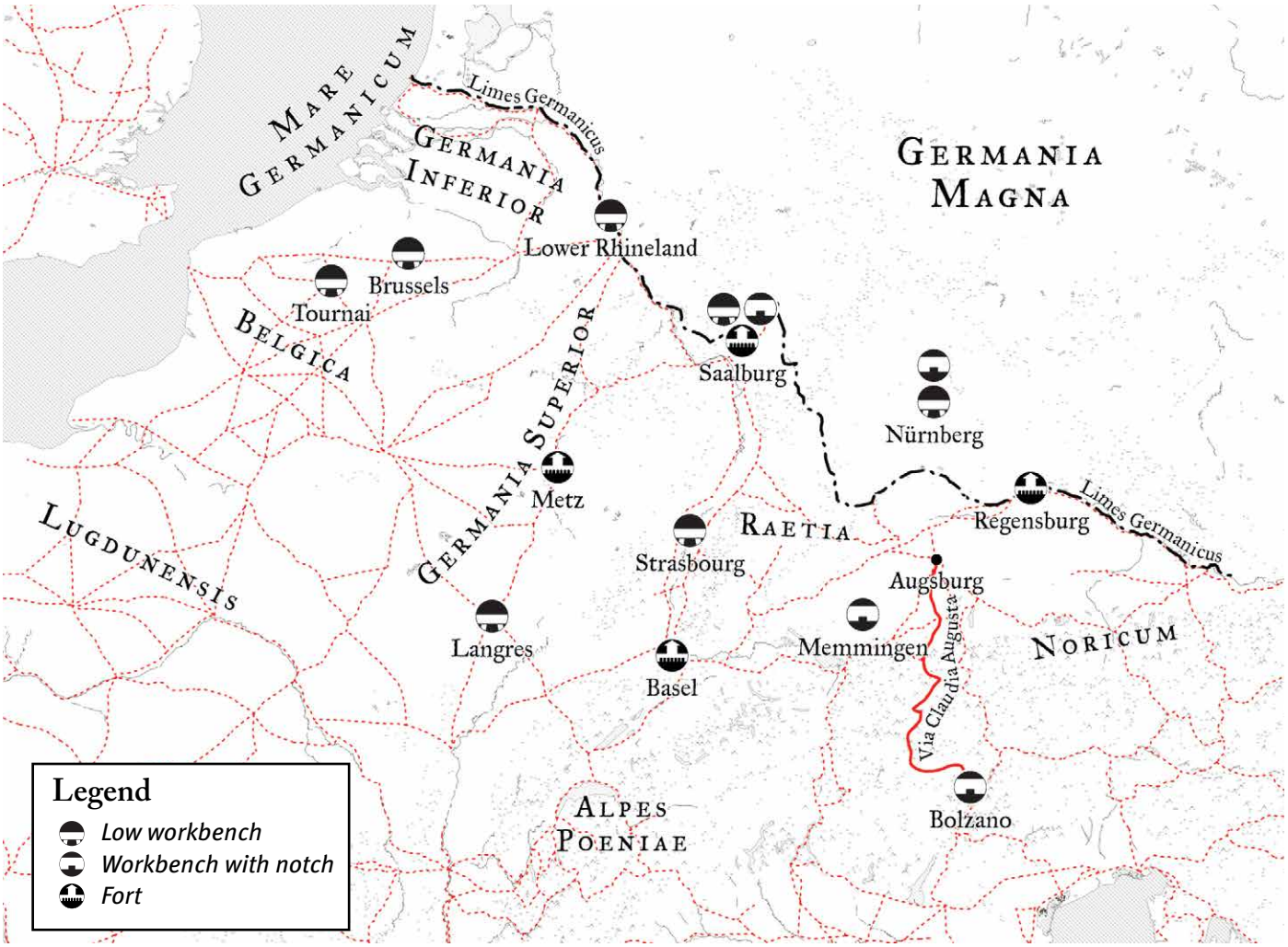


Figure 4.5. The Limes. The northern border of the Roman Empire – the dotted line above – was called the Limes Germanicus. Here you can see the benches and their relationship to the frontier.

first decade of the 16th century to the end of the 18th century. You can thank St. Joseph for that. Thirteen benches were in paintings from Italy and eight from Spain. But wait, the Kingdom of Naples was part of the Spanish Empire for most of the 1442 to 1714 time period. We have cross-pollination! For instance, Jose de Ribera, a major artist from Valencia, completed his mature work in Naples. Luca Giordano, from Naples, spent a decade in Madrid as court painter for Charles II. Adjusting the numbers results in almost a 50-50 split, with 10 benches for Italy and 11 for Spain.

Some features of the low Italian and Spanish workbenches are a massive top with or without a face vise, a twin-screw vise, an early crochet (possibly the earliest depiction so far) and unusual planing stops. Oh yes, two benches with squared-off notches on the bench ends also turned up in our searches. One of the benches would help solve those mysterious notches on the 2nd-century Roman workbench from Saalburg.

The Mystery of the Notches

Beginning with the extant Saalburg workbench, we found seven benches with notches on the side or end of the benchtop. The Saalburg bench and three 16th-century benches have a fairly close regional distribution, while the examples with a notch in the bench ends are from Italy and Spain. The seventh bench has a side notch and originates from the New Kingdom of Granada in present-day Colombia.

The three 16th-century notched benches are from Memmingen ("Holy Family" by Bernhard Strigel), Nürnberg (Löffelholz bench) in southwest Germany and Bolzano (the Hans Kipferle panel) in northern Italy. The German benches are both dated 1505 and the Italian bench is dated 1561. When these benches are mapped along with the Saalburg bench, pos-

sible connections start to emerge. The Via Claudia Augusta, the Roman road that connected the Po River valley with the Raetia province (southern Germany), ran through Bolzano and across the Alps (it is a different road than Via Augusta). The road terminated at the capital of Raetia, Augusta Vindelicorum (present-day Augsburg). A branch off Via Claudia Augusta leads to the Roman city that became Kempten, just south of Memmingen.

Through the Middle Ages, the two main routes to cross the Alps converged in Bolzano and led to Augsburg: the Via Claudia Augusta through the Reschenpass and the Brenner route through the Brenner Pass. East-west Roman roads through Augsburg later also became important trade routes, turning the city into a commercial center. Similarly, Nürnberg benefited from the north-south trade route it shared with Augsburg. The route was a portion of the Amber Road that linked southern Italy with the north and Baltic Seas. Trade routes were also information routes for cultures and technology. In the 15th and 16th centuries, this part of the former Roman Empire (and later Holy Roman Empire) experienced a cultural flowering. Considering the lengthy Roman presence in this region and the continued use of the trade routes, it is possible the side-notch feature survived and was in use on woodworking benches until at least the mid-16th century.

The two end notches were in paintings from Ravenna, Italy, and Madrid, Spain. The Madrid painting, "Dream of Saint Joseph," by Luca Giordano, shows a wedge in the notch and was a key to solving the "Saalburg mystery." I found the image in mid-July and sent it with a few dozen other images to Chris. About a month later while verifying dates, titles, artists and locations of all the paintings I gave "The Dream" a closer look. St. Joseph's side of the painting has an appealing composition

Figure 4.6. All the tools. The title page of the Wierix brothers' "Life of the Infant."

with tremendous detail. One tremendous detail struck me in particular and that evening I emailed Chris asking if he had seen this detail before. The next morning he answered, and you can read about how the notches and wedges work in Chapter 5.

The last bench is from the New World when Colombia was a Spanish colony. The notch is sharply defined and dovetail-shaped. The email I sent to Chris with the image was titled, "Oh Look! What is that Notch in the Bench?" and two minutes later Chris' response was a joyful expletive.

New World Surprises & Oddities

How did a notched workbench and a Chinese workholding device (a "palm," as shown on page 71) end up in the New World? It begins with the rapacious business of empire-building. Spain's control of much of the New World gave them access to a bounty of natural resources and a subjugated and weakened indigenous workforce. Claiming these new lands was also part of the Counter-Reformation. The Jesuits, Franciscans and Dominicans engaged in the religious conversion of the populace by using dialogue and art. The Jesuits commissioned engravings illustrating the Holy Family and the life of Jesus from the Wierix brothers of Antwerp. An example is the "Life of the Infant" series of 12 engravings featuring St. Joseph, Jesus and a host of angels sawing and building. The cover page for the series is well-known by modern woodworkers as it features a workbench and every tool for woodworking (and Mary's tools for spinning and sewing) in the engravings – plus a few musical instruments. These and similar engravings were used in the New World and also in China, Japan and the Philippines.

Part of the conversion effort involved setting up art schools with both missionaries and students painting scenes from the engravings. Paintings were hung in every church, mission and government building. As the indigenous artists became more accomplished they were given leeway to use their preferred colors and textile patterns for the garments of the Holy Family, add local plants and animals, and eventually devise their own compositions. It is in these original compositions we find workbench details that were imported from Europe and Asia.

One of the necessities of empire-building is recruiting skilled carpenters, masons, blacksmiths and other craftsmen to the newly conquered land. They brought their tools with them and on arrival set up their workshops. As the patron saint of the new lands, St. Joseph was a popular subject for the artists and observing an actual carpenter at work at his workbench was entirely possible. The painting of a cheerful St. Joseph working at a notched bench is from Duitama in the department of

Boyacá (emerald country) in Colombia. Although undated, it is estimated to be an 18th-century work. None of the hundreds of engravings used in conversion efforts I surveyed had a workbench with a notch. In fact, few had workbenches. The notch seems to be from an actual workbench in use in a Boyacá settlement or Dominican mission.

Just as the Romans engaged in near-worldwide trade, so the Spanish Empire operated. For 250 years the Spanish controlled trade in the Pacific Ocean, with the New World colonies serving as the "middle man" between Asia and Spain. Twice a year, La Nao de la China (the Manila Galleons) sailed to Manila then back to Mexico or Peru. Asian and New World goods were transferred to galleons that completed the trip to the royal trade house in Seville.

The Manila Galleons were also passenger ships moving free men and slaves to the New World. The technique of encrusting paintings with mother-of-pearl has its origins in Japanese art. Finding a Chinese workholding device, the palm (or a version of it), in a painting from Alto Peru is not surprising. Even less surprising is finding this painting back in Spain where there was, and still is, a market for New World art. Surely, as Chris has mentioned, there is some odd and weird woodworking going on in more than a few of the New World and Old World paintings. The intent of the artwork was to portray a sacred image. The accuracy of the bench, tools, woodworking techniques and perspective will naturally vary from artist to artist. The easiest approach was to show only the end of Joseph's workbench. The much more complicated scene had a foreshortened bench. Add in wood storage, tool storage, tools in use, Joseph's working position, Mary, Jesus, halos, a couple angels all in flowing robes and crammed into a small space, and mistakes and omissions will happen. Chris and I attempted to choose accurate images of woodworking, put the oddities in an "X file," then he went into the shop to recreate and test our findings.

In early September of 2016, we ran out of paintings to evaluate and Chris knew the plan for this book had changed. The expanded version of a book preliminarily titled "Roman Workbenches" had evolved into a study of the ingenuity of woodworkers to solve problems and work more efficiently.

PLANCHE XXX.

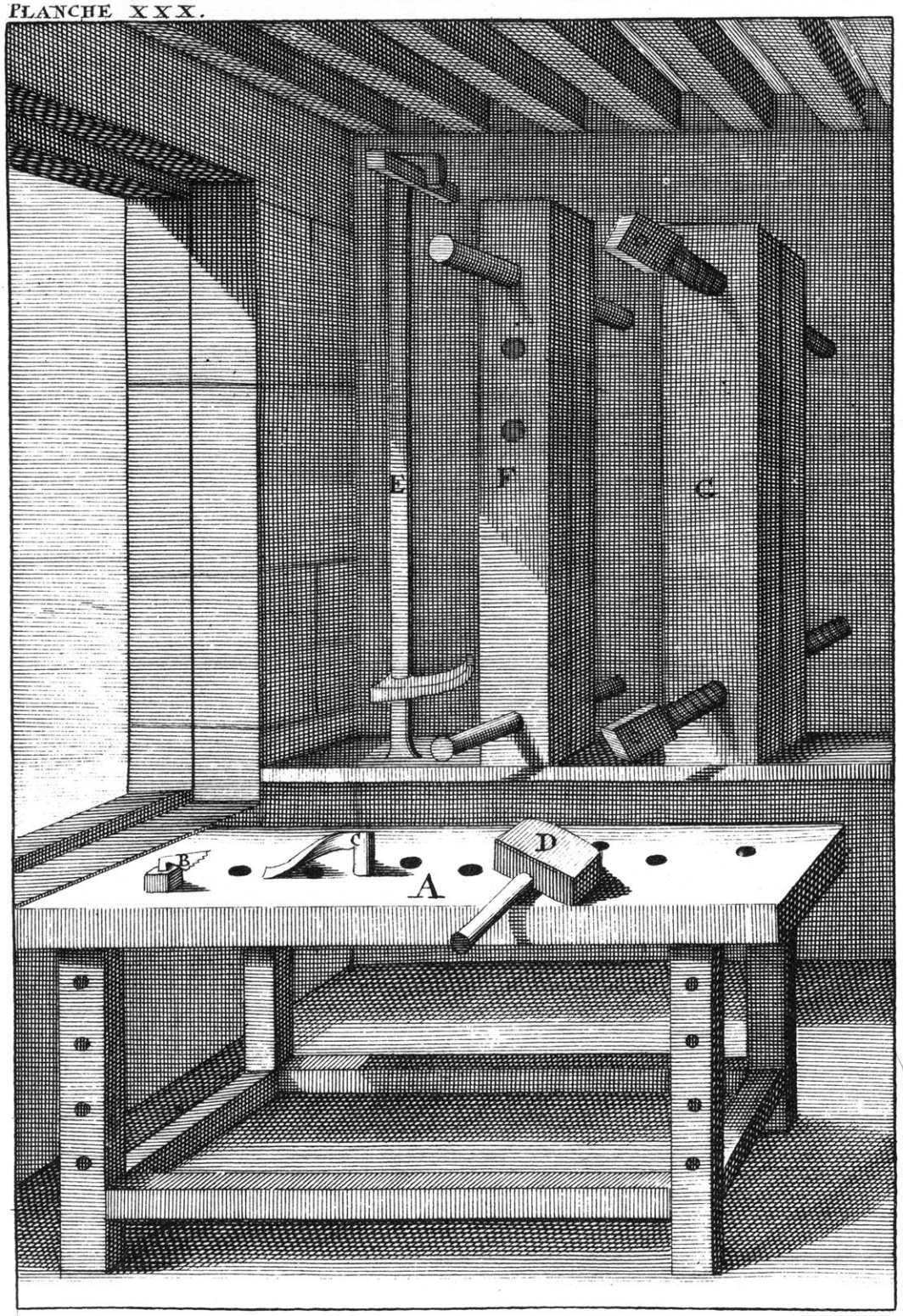


Figure 5.1. The workbench from André Félibien's "Des Principes de L'Architecture" (1676-1690).

V

Early Workholding Devices

The first time I saw the bench in Peter Nicholson's "Mechanic's Companion" (1831), I thought: That's not right – the benchtop (right) has only a planing stop. There are no holes for holdfasts, dogs or other workholding devices. While the front of the bench features a screw-driven face vise, I thought surely the illustrator forgot to draw in some details.

Then I got a copy of André Félibien's "Des Principes de L'Architecture" (1676-1690) and the workbenches shown there (at left) are also stripped down. They feature a planing stop and some holes in the top and legs for a holdfast. As I worked my way backward through the visual record of workbenches in technical manuals and paintings, the message was clear: Early workbenches had simple workholding.

It would be easy to assume that early benches are simple because the screw vise hadn't been invented. Yet, large-scale screws show up in early Greek, Roman, Egyptian and Assyrian writings and drawings. And archaeologists have found evidence of screw-driven vises (likely for metalworking) at Augusta Raurica, a Roman site in Switzerland active from 44 B.C. to 260 C.E.

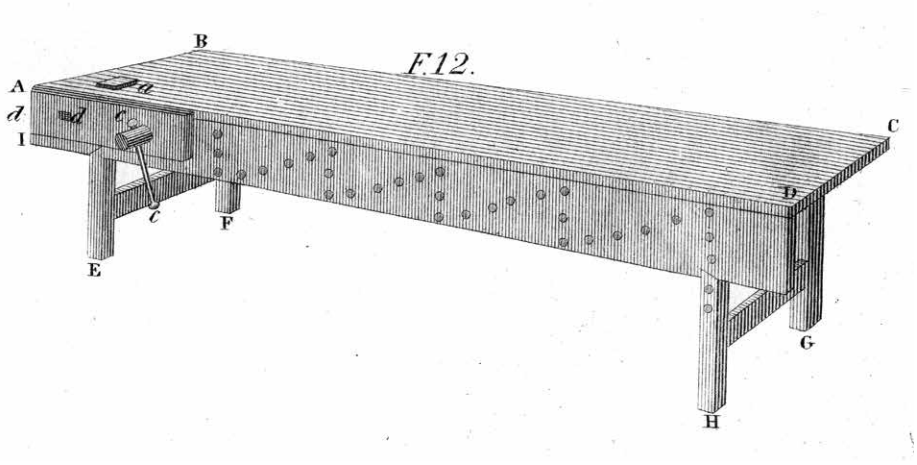


Figure 5.2. Missing in action. These early workbenches have little in way of workholding. Where's the tail vise? Do you need one? (Peter Nicholson's "Mechanic's Companion" (1831)).

They knew about screws. Perhaps the screws were too much trouble to make for a woodworker's workbench. Or they simply preferred to work without them.

So, I stopped using a tail vise and didn't miss it one bit (I still don't). I began to plane up panels with only a planing stop and became quite fast at processing stock. This small taste of success drove me to experiment with pegs, wedges, battens and notched sticks. Things that looked like they could never hold your work (such as a doe's foot) worked brilliantly.

I am convinced there is a world of workholding out there that doesn't require gizmos, but instead requires a little cleverness and some basic skills with the tools. The following account only scratches the surface of what's out there. Every tradesperson, from the armorer to the shoemaker to the block builder, had simple ways of holding the work that don't look like much to the modern eye. These are just a few of the devices that show up repeatedly in the historical record.

Figure 5.3. It bites. A toothed planing stop is an indispensible appliance for a low workbench. Yes, it marks your work, but many times this isn't a problem if you consider carefully the order of operations on a board (i.e. crosscut the marks away at the end).
PHOTO BY NN

Planing Stop

On early workbenches, the simple planing stop is the foundation for all the other bits of workholding for woodworking. In fact, some benches are equipped with only a planing stop. There's a lot you can do with a planing stop and a little skill.

Most planing stops are comprised of a square piece of wood that is long enough to penetrate the benchtop and give the woodworker a lot of height for planing boards on edge – 3" x 3" x 12" is a typical size.

The stop is adjusted up and down with hammer blows so it needs to be a durable wood – oak is typical – and dry.

You might think that fitting the planing stop requires you to consider how wet the benchtop is and the current season. Will the stop and benchtop (or both) shrink as they dry? Or, if the stock is bone dry, will that component swell during the humid season? Most bench builders have a slab that is somewhat wet that might take years to acclimate to the shop, plus stock for a planing stock that is at equilibrium with their shop.

There are formulas and lots speculation for how tight or loose to make things. I ignore it.

When I fit a planing stop, I assume that I'm going to have to adjust it later on if it becomes too tight or make a new one if things get too loose. So, I focus on getting a good snug fit that day. I want the stop to move about 1/8" with each heavy mallet blow.

After I get that fit, I simply pay attention to how it is working during the months ahead. If the stop becomes almost impossible to move, I remove it and plane it a tad. If it's too loose you can glue some veneer onto the existing stop or make a new one. In time, the wood will settle down and your planing stop will do the same.

Figure 5.4. The lockjaw stop. This French bench uses nails, now rusty, to secure the work. I have yet to cut myself on a metal planing stop during the last 12 years. So, this looks worse than it really is.

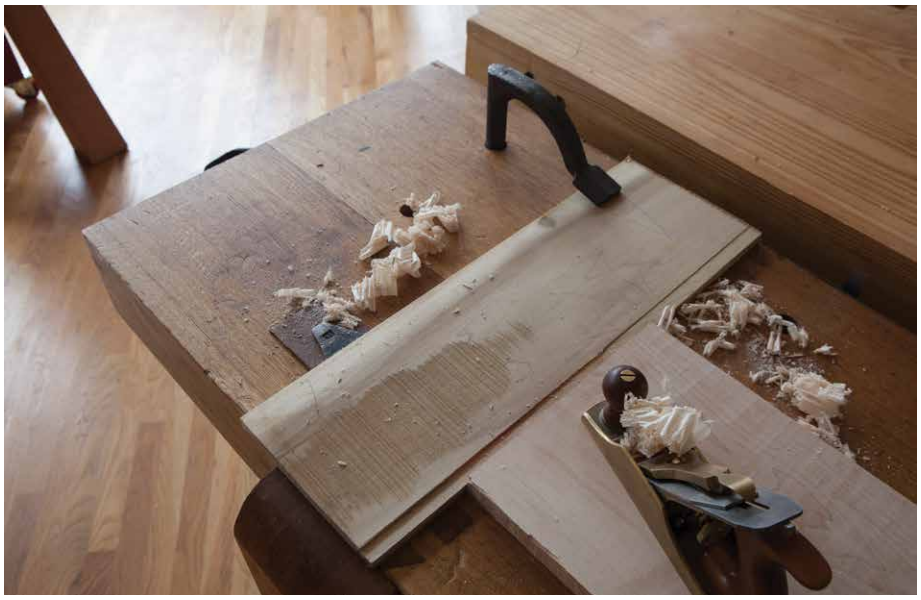


Figure 5.5. Wide planing stop. Add a thin batten in front of your planing stop and you've made an effective planing stop for wide panels.

The Bitey Bits

Most planing stops have some sort of toothed metal on their tops that helps secure the work. This can be as simple as a few nails driven through the stop. Other woodworkers attach a small bit of saw steel to the top of the planing stop and file teeth into it. Still others use a blacksmith-made stop or a commercial version.

They all work. File the teeth sharp and your work will move a lot less. And before you start planing a board, give the board a whack on its far end with a mallet so the teeth bite hard into the end grain of your work.

If you want to avoid getting tooth marks in a particular piece of wood, muzzle the teeth with a stick of wood. I use a stick of wood that is as long as my benchtop is wide. One end goes against the teeth. The other end is secured with a holdfast. It's an instant wide planing stop.

The wide planing stop is indeed a crutch, and sometimes you really need it. But I suggest you try to plane wide boards with the stop alone and see what you can get away with. By slightly shifting the work and skewing your plane, you can control fairly wide boards. With just a little practice, 8"-

Figures 5.6, 5.7 & 5.8. Immobile but movable. Keep the handplane in line with the planing stop and move the workpiece. As the piece starts to hang off the front edge of the bench, press the rear corner with your hip or extend the jaw of your face vise (if you have one) to help stabilize it.

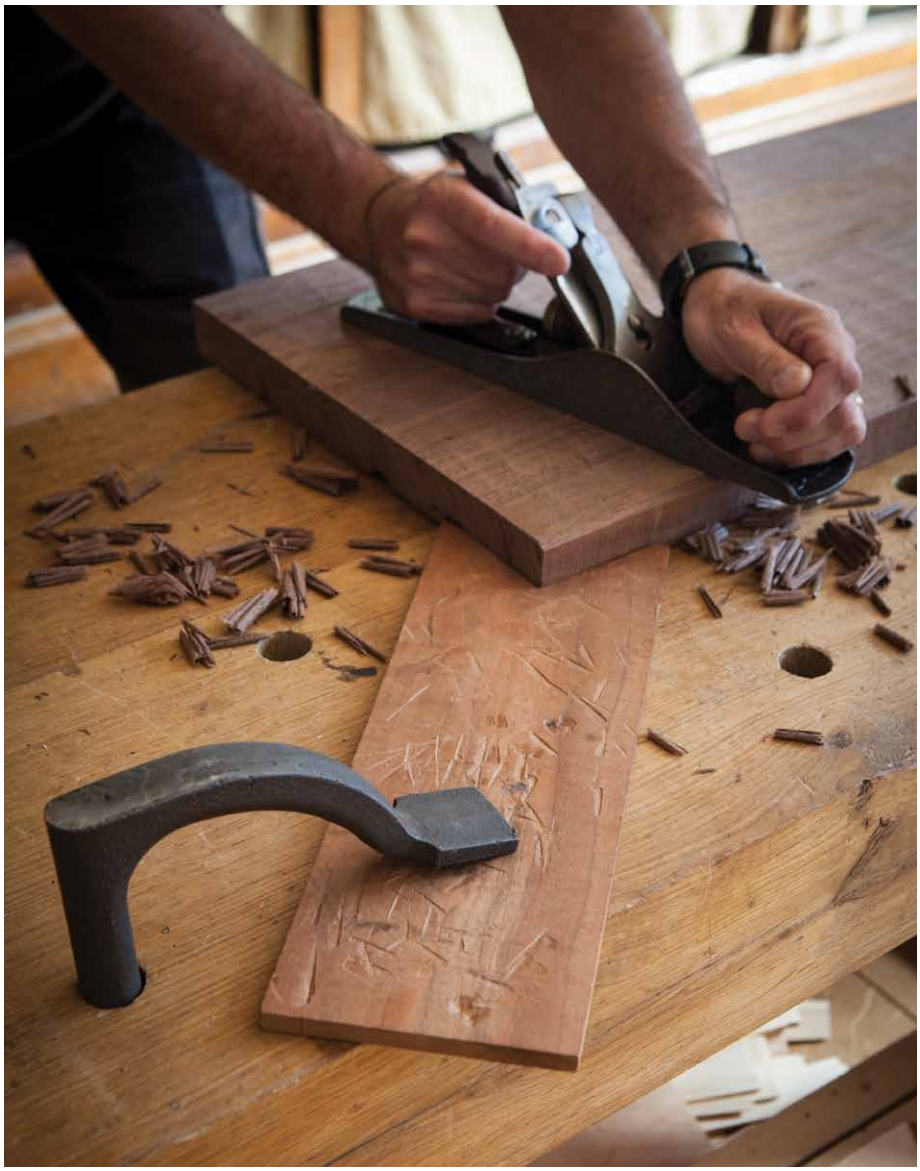


Figure 5.9. No tail vise needed. A notched stick placed at the rear of your work can help immobilize it so you can work across or with the grain of a board.

Figure 5.10. Hard-working toes. The two toes on the end of a doe's foot can be flat or pointed. I prefer flat because they won't mark your work and are more robust.

wide boards will be no problem. Then shoot for 12".

Once you install a planing stop, the first accessory you should make for it is a "doe's foot," a simple appliance that plays nice with the planing stop.

The Doe's Foot

I first became fascinated by the doe's foot after seeing U.K. woodworker Richard Maguire use one in lieu of a tail vise. And after several years of research and trials at my own bench, the doe's foot has become an indispensable part of my workholding.

It's a fiendishly clever and simple appliance.

It gets its name from its appearance, which resembles a deer's cloven hoof. A.J. Roubo calls the device a le pied de biche, which in modern French comes out as "crowbar." But a more literal interpretation is "doe's foot," which is much more evocative.

How Does it Work?

The doe's foot is simply a piece of wood of almost any size with a 90° notch cut into its end. The device works by allowing your workpiece to get snagged in the notch between the two "toes" of the foot, immobilizing it.

The doe's foot can be used both in front of the work or behind the work. It can be secured to the benchtop with a holdfast, clamps, via pegs or even nails driven through the doe's foot and into the benchtop.

To get started, I recommend you make one that is 1/2" x 7" x 12". Cut a 90° notch at one end (as shown at left) that leaves a 1/4" flat at the corners. We'll call these flats the "toes."

Behind the Work

In some old paintings you'll see the doe's foot used in front of the work instead of a planing stop. When used this way, the device is sometimes called a "palm," and we'll discuss that more

Figure 5.11. A kick to your backside. With the doe's foot behind the work you can plane wide panels parallel to the grain or across it.

Figure 5.12. A coarse grip. Sticky-back sandpaper or cork can greatly increase the grip of a doe's foot on your benchtop.

in a moment. When used behind the work you can immobilize work for traversing it with a plane or prevent wide panels from rotating when planing them against a simple planing stop.

Some people don't believe this technique works until they try it. So, if you are doubtful, give it a whirl before you dismiss it.

For planing wide panels, push the front of your workpiece against a planing stop (or a second doe's foot). Then place the notch of a doe's foot against the far corner of the rear of the board. Secure the doe's foot against the benchtop – I use a holdfast.

Now you can plane the board either with the grain or across the grain. Yup, the doe's foot is a lifesaver for traversing. Planing across the grain wedges your board against both the planing stop and the doe's foot like magic.

If your benchtop is slippery for some reason, the doe's foot might rotate at times. Fix this problem by adding sticky-back sandpaper to the underside of your doe's foot. Any coarse grit will do, such as #80 or #120. Alternately, you could use sticky-back rubberized treads. These usually are applied to the rungs of ladders so the ladder doesn't get slippery when wet. Or adhesive-backed cork.

The Chinese Palm

Simple planing stops have been a staple of workbenches for centuries. Many times they are shown as a toothed stop projecting above the bench. The woodworker then rams the wood against the teeth to immobilize the work while planing it.

Planing stops are generally narrow – only a couple inches across. They work great with workpieces that are 8" wide and narrower. But when the work is wider, then you have to do something else:

- Learn to control the work by skewing the plane
- Use a tail vise or a doe's foot to prevent the work from rotating
- Use a wider planing stop, sometimes called a "palm."

A "palm" is a planing stop made from metal or wood that is V-shaped. The open end of the "V" faces the work. One of the references to this sort of stop is from China (called the "Lu ban Qi," or the modern metal "Ban Qi").

Lu Ban, born sometime between 770 and the 5th century B.C.E., is the divine protector of Chinese carpenters and artisans. He is credited with inventing the basic tool kit of the carpenter and the rules, measurements and rituals associated with building construction. He and his wife are fea-

Figure 5.13. Not lazy. Sometimes working while sitting is the right approach. I have long sat while doing close-up work and some dovetailing. Early woodworkers likely sat while planing, sawing and other tasks as well.
PHOTO BY NN

Be Seated; Get Dirty

Many operations on low workbenches seem difficult or a lower-back nightmare until you overcome two obstacles.

The first is that many operations are much easier when you are sitting down. Not just sitting on the bench but sitting on a sawbench or stool that is next to the low workbench. Dovetailing while sitting isn't difficult as long as you allow your sawing arm to swing freely – just like when you are standing while dovetailing.

Likewise, traversing a board with the side stops (detailed below) is fairly easy. The worker remains stationary in front of the side stops and the board is moved from right to left. So, before you dismiss an operation as impossible with a low workbench, sit on it for a while before you pass final judgment.

The other obstacle to consider is your smooth, modern floor. Many low benches will move quite a bit because they lack the mass of many taller workbenches. Many early shops had dirt floors, or the work was performed outside (the book "Woodworking in Estonia" made this clear to me).

So, take your bench into the yard or find a way to immobilize the legs, especially for traversing. A quick solution is to purchase some adhesive anti-skid pads at the hardware store. Those help for all but the heaviest work.

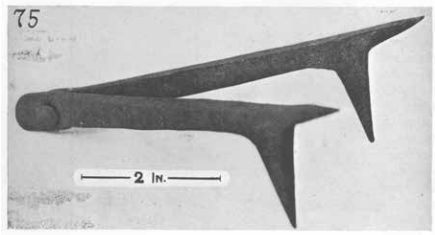


Figure 5.14. On the palm. Rudolf P. Hommel wrote about the "palm" in his landmark book "China at Work" (MIT Press, 1937). Here's an excerpt: "To hold a board in place when planing it, the carpenter uses an instrument like the one shown in Fig. 362. The two spikes pointing downward are driven into the bench or the top of a wooden horse. The board whose surface is to be planed is laid flat upon the work bench and its edge is pressed against the two end spikes of the stop. To plane the narrow edge of a board, the board is set upon edge, pushed between the two legs of this bench stop and thus held firmly in place. The length of the two parts, held together by an iron rivet, is 6-1/4 inches."

tured in many Chinese folktales. One story, as told by the Bai ethnic minority of Yunnan Province, involves how the palm, or planing stop, was invented.

Jessica Marinaccio's 2006 thesis, "Stone Treasure Mountain and Jianchuan Carpentry Tales: Folktales and Ethnic Minorities in Modern China" tells this story of its invention:

> *…(W)hen Lu Ban would plane wood he would call his wife to grasp the lumber with both hands, and, standing in front, she would use all of her strength to prop up the wood…. One time, the strength Lu Ban used on the planer [sic] was too great, and the head of the planer hit his wife's chest, its blade cutting her palm. It pushed Lu Ban's wife to the ground. Both of her hands were drenched in blood, and Lu Ban was scared out of his wits. He dropped the planer and quickly went to pull up his wife.*
>
> *Lu Ban's wife sat on the floor and*

looked, dazedly, at her two hands, not getting up. Lu Ban wrung his hands and did not know what to do.

Lu Ban's wife blankly thought for a while, and, suddenly, smiling, she stood up, grabbed a saw, and sawed two pieces of wood that looked like palms. She nailed them on the top of the rack for the planed wood and had Lu Ban stick the lumber between them so as to plane it….

Master Lu Ban very much admired this method of his wife's and he called the two pieces of wood a "palm."

The wooden version of this device is like a doe's foot – a piece of wood with a V-shaped opening. The metal version is also like a V, with barbs used to secure it to the benchtop. When you look at old Chinese paintings that show the palm, the device definitely looks like two hands arranged in a "V" with the thumbs abutting each other. Whether Lu ban actually invented the planing stop isn't known, but the device is clever. And it shows up in 17th and 18th century images in Europe and the New World.

The 'Moving Palm'

One of the most beautiful woodworking images we encountered in our research for this book is "Sagrada Familia y San Juanito en Interior" (Figure 5.16), a 17th-century painting from the "Escuela Virreinal" era of painting during the Spanish Viceroyalty of Alto Peru, which is now current-day Bolivia. In it we see the Holy family with Jo-

Figure 5.15. A palm. Here I've attached a palm to one of my low workbenches. This arrangement imitates a palm shown on a wheelwright's bench in the "Qingming shanhe tu" scroll made by Zhang Zeduan during the Song Dynasty in the first quarter of the 12th century.

Figure 5.16. The palm in the west. In this Peruvian painting of the Holy family you can plainly see a wooden palm on the benchtop. Does it move up and down? Who knows?
IMAGE COURTESY OF JOSÉ ANTONIO CÁMARA

seph using an adze on a board propped up on his workbench. To the right of the work is a V-shaped bench appliance secured to the bench with a peg.

It's clearly a "palm" and resembles the wooden versions of Chinese planing stops. For some reason, the peg in the palm bothered me, and I kept returning to the image. A round peg that passes through the stop and into the bench doesn't make much sense from a woodworking perspective. No matter how well glued the palm was to the peg, it would tend to rotate free in time. This is why traditional planing stops are square and not round. The square mortise for a planing stop is more time-consuming to make than simply drilling a hole and inserting a round planing stop. But round stops rotate and are frustrating (this comment is based on experience).

In any case, that peg got me thinking about how the palm could (or should) be attached to the bench in "Sagrada Familia y San Juanito en Interior."

At this point I want you to know that I have exited the historical record with this particular device. The palm is an effective device, but it works only with certain thicknesses and widths of lumber. If you have stock that is thinner than the palm, planing it is nearly impossible without ramming your tool into the palm. Likewise, planing wide stock in a small palm is difficult because you have to focus to keep the work balanced on its edge.

This got me thinking: Could you mate the palm with a narrow planing stop? In other words, create a V-shaped palm that moved up and down with raps from a mallet. Here's how I made this simple appliance.

Figure 5.17. The moving palm. The palm is attached to the top of the planing stop with heavy Roman-style nails. It is adjusted up and down with hammer blows.
PHOTO BY NN

Figure 5.18. Every little bit helps. This shallow mortise in the underside of the palm helps prevent the palm from coming loose from the post.

Make the 'Moving Palm'

This palm looks much like the device shown in "Sagrada Familia y San Juanito en Interior." It's about 8" wide with a "V" cut into one end. You can make the palm any thickness you like, just remember that thick palms cannot be used for planing thin stock. Thin palms are fragile and are difficult to use when edge-planing wide boards. So, the thickness of your palm should match the sort of work you do. Mine is about 1/2" thick.

If you want to keep things simple, make the wooden palm and affix it to your bench with wooden pegs, screws or nails.

Figure 5.19. Clearance holes. The holes in the palm should be slightly smaller than the shaft of the nail as measured right under the head.

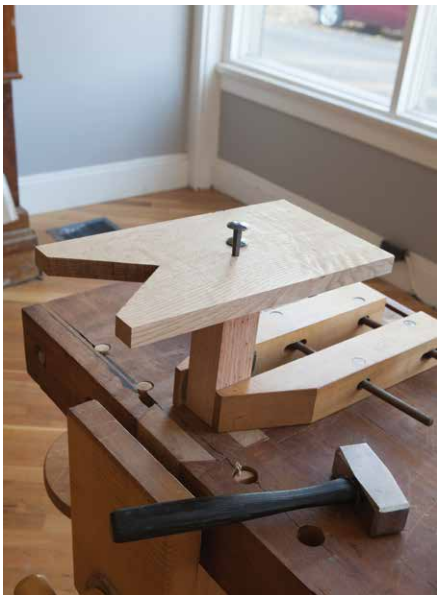


Figure 5.20. Moment of truth. If you have drilled your holes correctly, the nails should go in grudgingly but not split the work.

I decided to make my palm so it could be moved up and down like a planing stop to accommodate thick, thin, wide and narrow boards. So, I attached the palm to the top of a 2" x 2" x 8" post.

Because the palm is thin, I took pains to attach it to the post so it would not be wrenched off – planing stops take heaps of abuse as they are regularly rammed by boards. So, this palm is attached via a shallow mortise, glue and two beefy Roman-style nails.

Chop out a shallow mortise in the underside of your palm to receive the end of the post. Mine was about 1/4" deep. Use a router plane to ensure the bottom of the mortise is flat so the palm and post will join at perfect right angles.

Roman nails hold like the dickens but tend to split the work if you are careless in drilling pilot holes and clearance holes. While the palm is disassembled, drill clearance holes in the mortise for two beefy nails. Mine are 2-3/8" long.

Glue the post into the mortise, checking to ensure it is perpendicular

Figures 5.21 & 5.22. Get over it. The palm effectively restrains your work when planing edges and faces. Most of all, the low bench allows you to get your mass right over the cut.
PHOTOS BY NN

Figure 5.23. Don't monkey around. Here is a reproduction of the painting of Karl Schreyner made by my daughter, Katy Schwarz. Note that Schreyner wasn't a monkey – Katy just drew him that way.

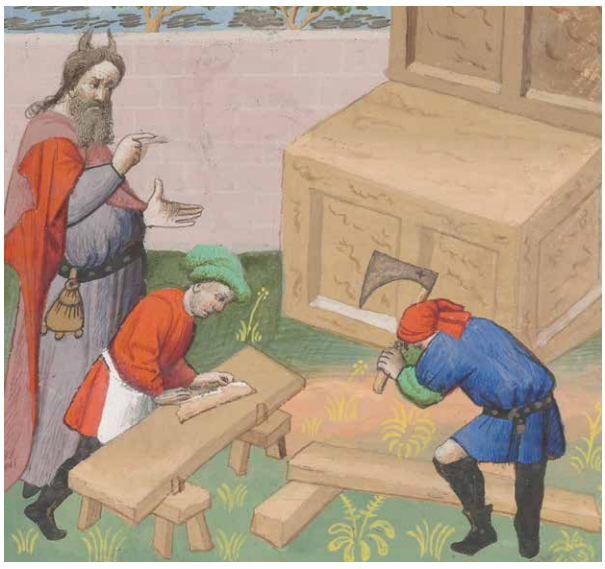


Figure 5.24. More pegs. Here you can see a craftsman traverse-planing a board that rests on sawbenches that feature pegs, much like the Schreyner pegs from Nürnburg.
THE MORGAN LIBRARY & MUSEUM, MS M.394, FOL. 57R. PHOTOGRAPHY BY JANNY CHIU, 2018.

to the palm all around. Once the glue is dry, drill pilot holes into the end of the post. The depth of the holes should be equal to about two-thirds the length of your nail (about 1-1/2" deep in my case) and slightly smaller than the shaft of the nail.

Side Stops – Schreyner Pegs

There are other ways to prevent the work from spinning to the side while you plane it. One of the simplest is a method shown in a circa 1425 painting of woodworker Karl Schreyner at his bench.

His bench shows two round pegs at the end of the bench that work like simple planing stops. Then there are two additional pegs that restrain the board from the side. And, lucky for us, the painting shows Schreyner using the four pegs for planing up some work.

This painting is part of a series of 1,171 paintings of Nürnburg craftsmen who were cared for by two social foundations during the Late Middle Ages through the early 19th century. When a craftsman would die while in the care of the foundation, they would paint his portrait and put it in a book with the other paintings. The paintings, now called "The Mendel and Landauer Hausbücher," reside in Nürnburg, Germany, and are a rich source of visual information on early crafts.

While many craftsmen are shown in the Mendel and Landauer Hausbücher working at their benches, the painting of Schreyner is the one of only a handful of images I'm aware of where the workbench has these pegs to the side of the work.

A second piece that shows similar pegs is from a 1415 Bible in Paris where Moses is supervising some woodworkers. The pegs are on sawbenches, not a workbench. A third image is from a French Bible dated 1244-1254 that shows Noah working on the edge of

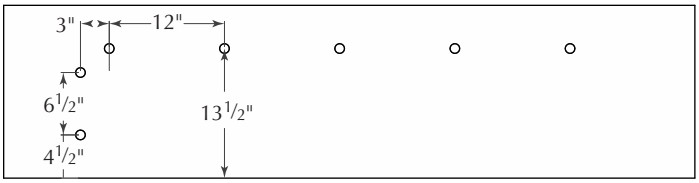


Figure 5.25. Schreyner peg layout.

Figure 5.26. Across the board. For short boards, you'll need to shift the work left or right occasionally to keep the board under control. This is not a big deal.

Figure 5.27. With the board. Planing boards 6"-10" wide can be a little tricky because the work is restrained by only one end stop and can rotate. You can fix this by putting a batten in front of the two end stops, making a wide planing stop.

a board with an axe. The work is restrained by two pegs in a workbench.

And so, I call these "Schreyner pegs" until I find an earlier source (or a catchier name). (Noah Nails? Moses Pins?)

Here's how I installed the Schreyner pegs on my benchtop. I started with a 1"-diameter x 36"-long oak dowel I bought for $4.99 and sawed it into seven 5"-long bits. Then I laid out the positions of the 1" holes. The end stops are located where a simple planing stop would usually go. One is 4-1/2" from the front edge of the bench. The second is 11" from the front edge.

The pegs for the side are all 13-1/2" from the front edge of the bench. The first peg is 3" to the right of the end stops. The remainder are positioned on 12" centers.

Drive the 1" pegs into the holes. They should require mallet taps to move them up or down. Now you have a system of pegs that can handle traversing or planing with the grain.

The Roman Side Stops

Similar to the Schreyner pegs are the side stops found on the Saalburg workbench. Like pegs, these stops move up and down and restrain the edges of boards while working in conjunction with the planing stop.

I first found these Saalburg side stops on a Roman bench that was both low and narrow, but they can be installed on workbenches of any height or width (they show up in historical paintings on taller benches). Like the Schreyner pegs, they can be used on their own while traversing boards with a handplane. Or they can be used in conjunction with a planing stop to prevent wide boards from spinning while planing them.

They also can be used like a bench hook for sawing joinery. Press the work against the side stops and cut your tenon shoulders or dado walls. Again, it's OK to sit while you do this.

Figure 5.28. Or sit on the work. You can traverse a board diagonally with the assistance of the side stops by sitting on the work. This set-up is remarkably effective for right-handers (left-handers should sit facing the other way).
PHOTO BY NN

Figure 5.29. Be seated. When traversing boards on a low bench, sit on a sawbench (or any low seat) to get the job done. Yes, it's OK to sit when you work.

The Roman Workbench's Staggered Pegs

Separate from all the approaches above is a system of pegs in holes that seem to be random at first but reveal their utility when put to use.

While I'm sure this system of pegs could be used on a tall workbench, I've seen it only in use on low benches. These low benches show up in the wild – Jonathan Fisher's 18th-century workbench on display in Blue Hill, Maine. And in books – "Woodworking in Estonia" (Lost Art Press) is packed with them.

When I first started experimenting with this bench, all I could say about the pattern of holes is that they seemed to be in a shallow "V" shape along the length of the bench. But after working with these benches for several months the holes began to make sense. Some of the holes restrained the work from shooting forward; others restrained it

from flying sideways.

What's also important is what you put into these holes. A modern woodworker (such as myself) might assume that you would put low bench dogs into these holes. But what if you had a bunch of tapered stakes of different heights to put into the holes? Would that change the workholding? (Spoiler alert: yes.)

Here's how I tackled all the operations that a furniture maker attempts on a workbench with just holes and a handful of pegs.

Faces of Boards

Working the faces of boards – whether with a plane or saw – is the most straightforward operation on this low Roman bench. Let's dispense with the sawing first.

Crosscutting and ripping on a low bench is luxurious. For most of my adult life, I've worked with two or three sawbenches to rip and crosscut stock. While sawbenches are portable and versatile, you need to move them (or the work) around a lot to keep the important bits supported during a saw cut.

When ripping, you have to push the work backward or forward (depending on your style of ripping) and ensure that the waste doesn't split off because it's unsupported. For crosscutting, you have a slightly different dance, moving the sawbenches to prevent the waste from breaking off or pinching your saw in the kerf.

With the Roman bench – it's essentially like two conjoined sawbenches – you have an enormous amount of support below your work for rips and crosscuts. I occasionally bring in a sawbench or shop stool to help with crosscutting long pieces, but that's rare. (Note: You can also saw joinery on this bench.)

Planing faces is also spectacularly simple. Most of the benches I've ob-

Figure 5.30. Another leg vise. Here Andy Brownell uses his right leg to help immobilize a board for edge planing. This is a trick Megan Fitzpatrick showed us.
PHOTO BY NN

Figure 5.31. Wedges help. Here the 15th-century woodworker has applied wedges between the pegs and the work to immobilize it.
MANUSCRIPTS OF THE LIBRARY OF RAPHAEL DE MARCATELLIS, SINT BAAFSKATHEDRAAL GENT COLLECTION, COPYRIGHT: LUKAS - ART IN FLANDERS VZW, PHOTO HUGO MAERTENS

served in the wild or in paintings have one or two stops at the end of the bench that work much like a traditional planing stop on a workbench. You knock the stops up or down depending on the thickness of your work. This operation is clearly shown in "Woodworking in Estonia."

But what about longer stock? Well, once you get into boards that are longer than your arms can reach, then you start to sit on the work. With workpieces longer than 40" I begin by processing the stock close to the planing stops as shown at far right. When that section is planed I scoot backward about 3' and repeat the process. This operation is also shown in "Woodworking in Estonia."

Traversing boards with a fore plane is also fairly easy with the low bench. You brace the work against the planing stop, then use your knees to lock everything tight against the stops. Finally, you plane the area between your legs. An outboard sawbench helps to support long stock or when you are at the beginning or end of a particular board.

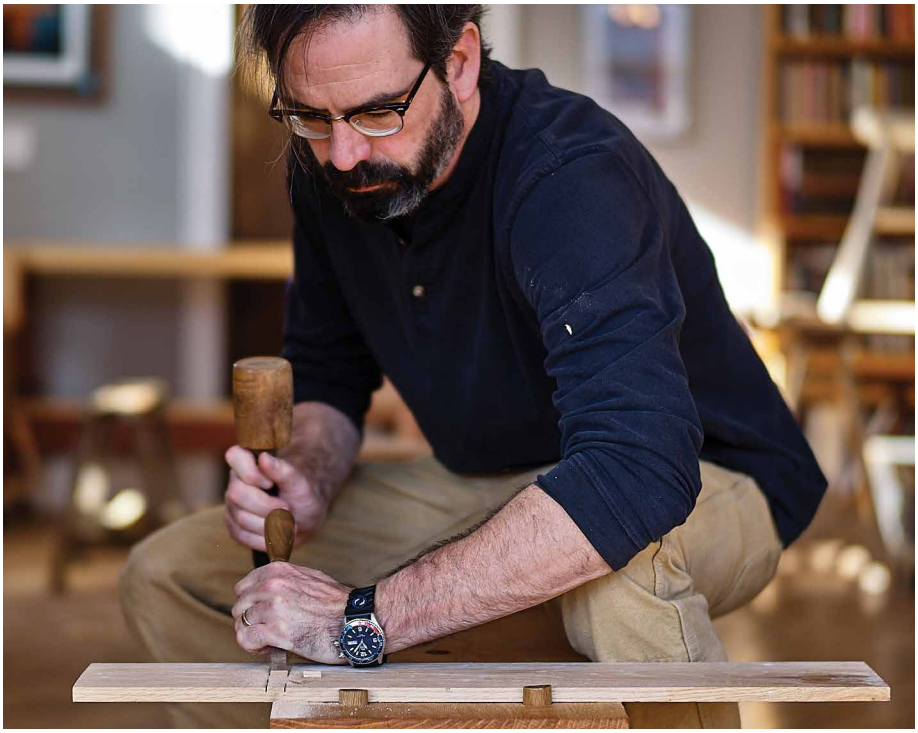
Mortising and other operations on the faces of boards (dadoing) use some combination of the above techniques. For mortising, sit on the work like you would with a mortising stool. For dadoing, saw the sides of the dado with a saw while bracing the work against the planing stops. Waste away most of the stock with a chisel. Then remove the waste with a router plane like you are traversing the work (lock the board against the planing stops with your knees). If you use dado planes, then the operation is exactly like traversing the work with a fore plane.

Edges of Boards

I was skeptical of how easy it would be to plane the edges of boards. For short or narrow boards, it was fairly easy to work against a single planing stop – much like I do on a high bench.

Figure 5.32. An easy rip. Here I'm ripping with one knee on the stock. Occasionally it is more comfortable to rip with both knees on the stock.

Figure 5.33. You won't shave your legs. All eight legs are tucked under the shadow of the benchtop, so it's difficult to nick them with your saw.



Figures 5.34 & 5.35. Knees and force. Cutting a dado with the assistance of the pegs is a totally natural operation. The only caveat is sometimes you need a sawbench to the side to support long stock.
PHOTOS BY NN

Figure 5.36. Double planing stops. Face planing a board against two adjustable stops embedded in the benchtop.
PHOTOGRAPH BY ANTS VIIRES, 1949. FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 1127:13

But for wide boards it seemed too easy to tip the work over, especially if you were trying to correct an edge with a cambered iron. Once again, "Woodworking in Estonia" offered an important clue.

In the Figure 5.40 on the next page, the woodworker is shown edge-planing a board against one planing stop with a peg supporting the work from the side. This single peg helps stabilize the work while planing, but only when pushing mildly against the peg on the side – the work can still flip out of position with mild lateral pressure.

So, I added a peg on the other face of the board – the face you cannot see in the photo from "Woodworking in Estonia." This second peg supports the board from the other face and allows you to plane the board much like it is in a vise. The board resists lateral pressure so you can correct an out-of-square edge with ease. Also, it is a huge help to put a knee up on the bench and

Figure 5.37. Scooting and planing. Planing long boards on a low bench is best done in sections. Each section is as long as your arms can reach.
PHOTOGRAPH BY ANTS VIIRES, 1947, FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 1089:106

Figure 5.38. Bench stops. Traversing short boards is simple; with longer stock I use a stool or sawbench to support the end that is hanging off the benchtop.

Figure 5.39. Rotate and saw. Sawing while sitting is surprisingly easy once you can shift your body away from your sawing arm.

use the lower part of your leg to wedge the work in the pegs. Thanks to Megan Fitzpatrick for discovering this trick.

This small discovery also led to other "a-ha" moments concerning the pattern of holes on the benchtop. The holes seemed to spread out as they moved farther away from the planing stop. After using the bench for a while, this made perfect sense. As you switched to wider and longer stock, these holes were needed to support the board.

While the above guidelines are a good place to start when working with a low bench, after a while you just begin to use whatever holes are open for a particular operation. Typically, I'll put a board on edge on the benchtop and look for a series of three holes that will keep it secure: one hole at the end of the board and two holes to the sides of the board to keep it from tipping over.

Figure 5.40. More Estonian insight. The peg in the foreground was a clue as to how to edge-joint on a low workbench. The woodworker here is shown straddling the bench; I find it more natural to stand to one side.
PHOTOGRAPH BY ANTS VIIRES, 1949, FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 1127:14

Figure 5.41. I've got this pegged. By having a selection of pegs that vary in length and girth you'll find it easy to secure most boards on the benchtop.

Figure 5.42. Pins first. Transferring the shape of the pins onto the tails is the way to go with this workbench.

Figure 5.43. Saw, then flip. I'm kneeling on the tenon to saw the face cheek of this tenon. At the end of the cut my saw is nearly vertical. Then I saw the face shoulders while sitting on the bench.

Any three holes will do. And if the work is still too loose, drive a wedge or two between the work and the pegs.

Ends of Boards – Joinery

Even though I've been surprised a thousand times by the ingenuity of early workholding, I really wasn't sure that cutting dovetails and tenons on a low bench was going to feel natural. But after a few joints, it did.

For making dovetails and tenons, you approach the work as if you are crosscutting or ripping it on a sawbench. Place the work on the benchtop, hold it down with one knee and saw away.

When I first started experimenting with the Roman bench and sawing dovetails I cut the tails first, but Roy Underhill rightly pointed out that sawing pins first was the better method for this bench. Why? Transferring the shape of one board to the other.

If you cut the tails first, then transferring the shape to the pin board puts you high in the air, balancing the two boards while trying to make your marks. If you cut the pins first, however, the transfer is easy. Lay your tail board flat on the benchtop. Place the pin board on the end of the tail board and shift things around until they match. Mark the tails.

Somewhere, Frank Klausz is smiling because of this detail. I'm a tails-first guy, so this is no easy thing to admit.

Tenoning is similar. Saw the cheeks until you hit your baseline. Flip the stock over to finish the cut on the other side. Saw the shoulders like you are crosscutting. It's a little awkward at first, but you'll get over it.

The Crochet

The crochet (French for "hook") could be described as a planing stop attached to the edge of the workbench, but that doesn't quite capture its full utility. A

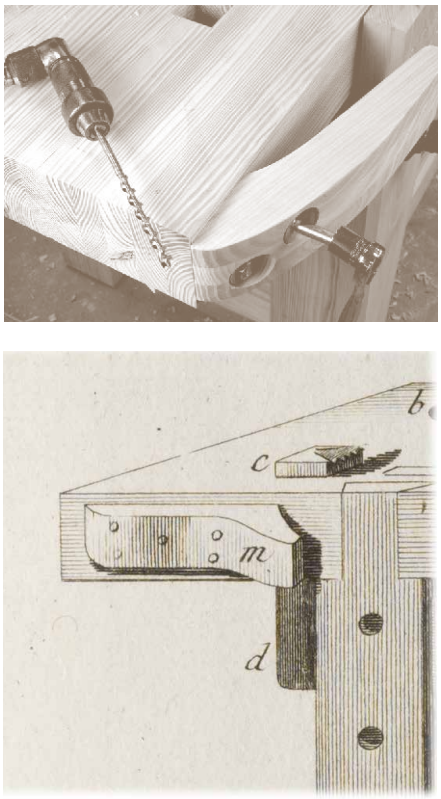


Figure 5.44. Two crochets. A.J. Roubo's crochet from 18th-century France (below) offers little wedging action. It works fine, but is not as "grabby" as the one shown on the bench from 2005 (above).

Figure 5.45. Good enough for dovetailing. A crochet and holdfast (or bar clamp) do a fine job of keeping the work in place for dovetailing.

good crochet is also good for securing work for dovetailing and tenoning.

There are a couple kinds of crochets out there. Some of them are like wedges. You press the work into the opening and its V-shape helps hold the work (though you will still need a holdfast to complete the job). Old French ones, as shown in "l'Art du menuisier," work more like a planing stop as opposed to a wedge. Their opening is square instead of V-shaped. Both forms of crochet work, but I prefer the V-shaped ones on my benches.

I make my crochets out of a tough and springy wood, such as oak or ash. I recommend you make the hook big enough so that it can handle 8/4 stock. So, the opening should be slightly larger than 2". Many early crochets are shown attached with nails. I prefer 6"-long carriage bolts with washers.

Using the crochet for working on the edges of boards is straightforward. Typically, you secure the work to the front of the bench with one or two holdfasts (depending on the length of the work). Then you push the end of the board into the crochet to prevent the work from shifting as you plane it.

If I have a lot of boards of similar widths to work (say for a large tabletop) I take a different approach. I use holdfasts to secure a 2x4 to the front legs of the bench that will act as a platform for my boards. Then I press the end into the crochet. Gravity and the force of the plane immobilize the work.

Crochets can also be used to affix the work so you can cut dovetails or tenons. Put the edge of the work into the crochet and affix it to the front edge of the benchtop with a holdfast (or a bar clamp across the benchtop, if you are sadly holdfast-less).

Notches & Wedges

In many old paintings and drawings you'll see benches that have no vises but instead have a large rectangular notch cut into the edge or end of the benchtop. In many cases, these notches are used as face vises. You put the work in the notch then use a wedge to immobilize it. I've had great – actually, quite spectacular – success using these notches for cutting tenons and shaping the work with chisels, rasps and files.

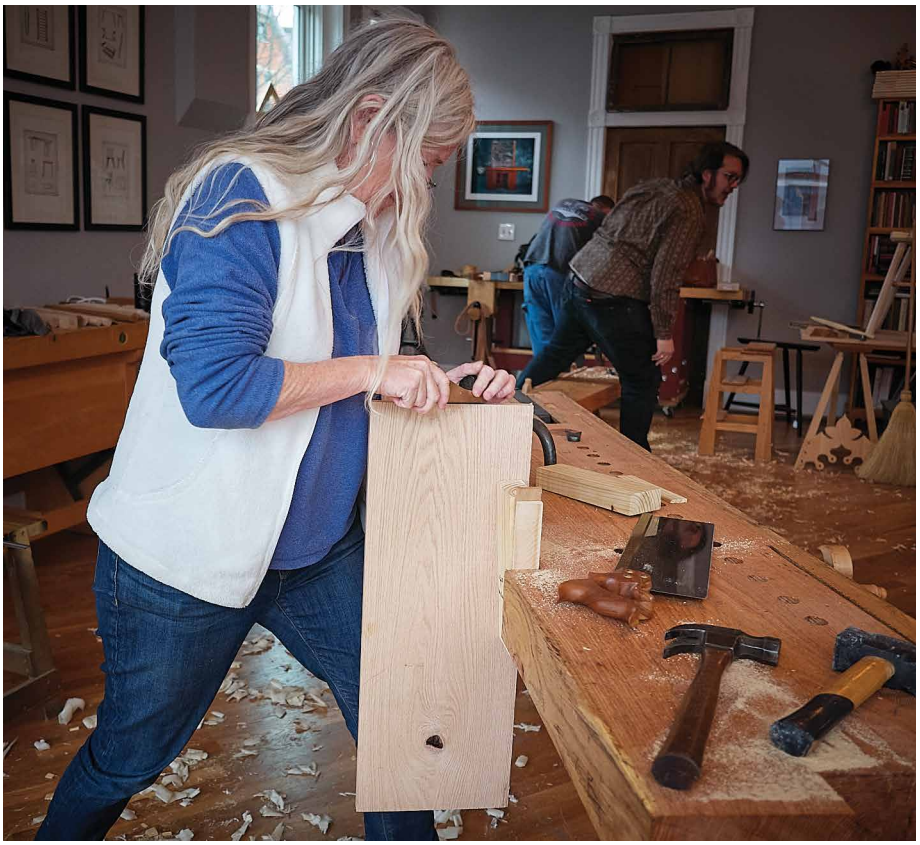
It took a little experimentation, however, to get the wedges right. As it turned out, I was making things too complicated. At first, I used oak wedges in the shape of a right triangle that I planed clean so they had an angle at the tip of about 15°. They held the work, but not reliably. So, I tried isosceles-shaped wedges with a variety of angles, looking for the magic number.

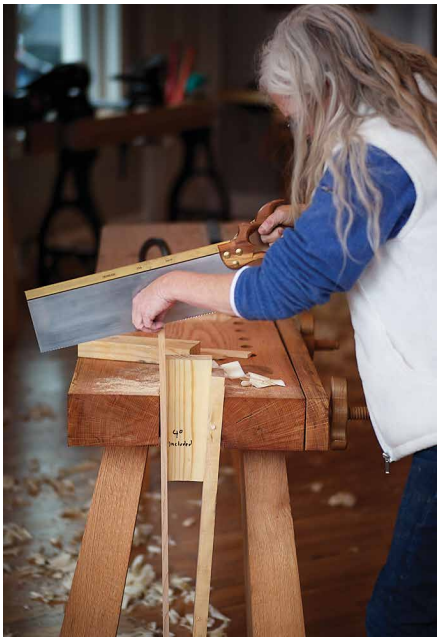
After several hours of messing with the oak wedges, I thought I was headed down the wrong path. So, I went to my scrap pile and grabbed a white pine 2x4. I sawed it to 12" long and tapered one edge with a jack plane (I later measured the angle at 2°). Then I drove it into a notch.

It cinched down as hard as any screw-driven vise I've used. It worked so well I laughed out loud.

If you are interested in making these notches (what do you have to lose?), here are some details. In the old images, the notches have vertical walls. Some fellow woodworkers have suggested cutting them at an angle that is sympathetic to the wedge's angle. I haven't found that necessary.

On some benches, the notches are in the end of the benchtop. In others, they are cut into the edges. I tried both. Functionally, I couldn't tell any difference between them. They both held just fine. Making the two kinds of notches, however, is quite different. The end grain notches take about twice as long to make because the wood is fighting





Figures 5.46 & 5.47. Don't dismiss it. We were all shocked at how much holding power a wedge and a notch could provide. Tenoning and even planing the end of this 12"-wide oak board (shown above) was easy.
PHOTOS BY NN

you the entire time. You have to rip saw the walls of the notch then chisel out the waste like cutting out a huge dovetail. There is a lot of chopping vertically then splitting out the waste. It's not a horrible task, but it's much more difficult than creating a notch in the edge of the benchtop.

There you crosscut the walls (crosscutting is always easier than ripping). Then you split the waste out with a few chisel chops. Splitting wood along the grain is always easier than chopping across it.

Here are the measurements for my notches. Don't feel compelled to copy me, however. The end-grain notch is 4-1/2" wide and 2-1/2" long. The edge notch is 4-1/4" long and 2" wide. I have a variety of softwood wedges scattered about that can handle work from 1" wide to 3" wide.

One more nice use for the notch comes when cutting curves with a bowsaw or coping saw. Place your work over the notch while sawing and it will vibrate less.

Simple Screw Vises

While screw vises were known in Roman times (there is an extant example of one used for jewelry making at Augusta Raurica), they don't start showing up on woodworking benches until much later. The earliest image I know of is from northern Italy in the early 14th century and shows workers constructing Noah's ark.

While these vises appear similar to modern vises, there are significant differences. On these early vises, the screw does not move. Instead, there is a movable nut that presses the chop against the work.

These older screw vises are easier to make than a modern vise and can be installed directly into the benchtop without much effort.

To make these vises, you'll need a threadbox and a matching tap. These

Figure 5.48. Slow going. Chopping out a notch in the end grain is more difficult than performing the same operation in the edge of the benchtop. Saw the sides of the notch. Chop halfway through, then flip the bench and chop the remainder out.

Figure 5.49. Quick work. With the notch on the edge, you saw the walls and pry the waste out easily with a chisel. Then clean the long grain of the notch with paring cuts.

Figure 5.50. Ready to go. With only about 10 minutes of work, you can create a face vise for any work surface. Just make some softwood wedges and get to work.

Figure 5.51. Roll your own. Simple screw vises such as this one are quick and easy to make with a threadbox and scraps. You can make as many as you like and as large as you like – even the entire length of the workbench.
PHOTO BY NN

once-common tools are available used, and it's worth searching out a functioning set because with them you can make all manner of vises and clamps. I also use these tools to make threaded parts for furniture pieces to allow them to be knocked down flat.

Note that the German threading kit shown in the photos cuts a 1-1/8"-diameter (28mm) thread, which is a good size for general workshop use. The 1" version would also work fine and allow you to use a store-bought 1"-diameter dowel to make the screws.

You can make the vise's jaw any size you desire, including the entire length of the benchtop. Because I don't build boats or fear the Great Flood, I made the jaw of my vise (sometimes called a "chop") 1-3/4" x 6" x 36".

Begin by making the screws. Mine are hard maple, 1.10" in diameter (which works with the 28mm threading tool) and 12" long. Turn down 4" of the length to 1". This 1"-diameter section will be glued into the benchtop. Thread the remainder of the stick.

Now lay out the location of the through-holes for the screws on the chop. My holes are 30" apart on centers and located 2" down from the top edge of the chop. Bore 1-3/8" holes through the chop at both locations. The oversized holes will allow your chop to pivot and clamp tapered workpieces.

Show the chop to the front edge of the benchtop and use your 1-3/8" bit to punch centerpoints on the front edge.

Figure 5.52. One slick tool. Lubricate the cutter with a little tallow or wax with each use. Some people soak the screws overnight in linseed oil. This is supposed to result in crisper threads. It's not entirely necessary with a sharp cutter and a little lubricant.

Figure 5.53. The finished screw. The last 4" of the stick is 1" in diameter. The remainder is 1.10" in diameter and threaded.

Drill 1" holes that are 4-1/4" deep into the benchtop. Glue the screws into their holes.

Make the nuts from maple. Before wasting time on shaping the nuts, bore and tap several holes in a board and use the two tapped holes that came out the straightest and cleanest. Cut the nuts to shape using Figure 5.55 as a guide. Then rasp the corners.

Simple screw vises such as this are nice for working on the edges of chair seats, planing the edges of boards or working on anything that needs to be held securely. I have installed them on low benches and tall ones.

Figure 5.54. Go for tight. Ideally, the screws should have to be driven into the bench with mallet taps. Go for a tight fit. The glue should be superfluous.

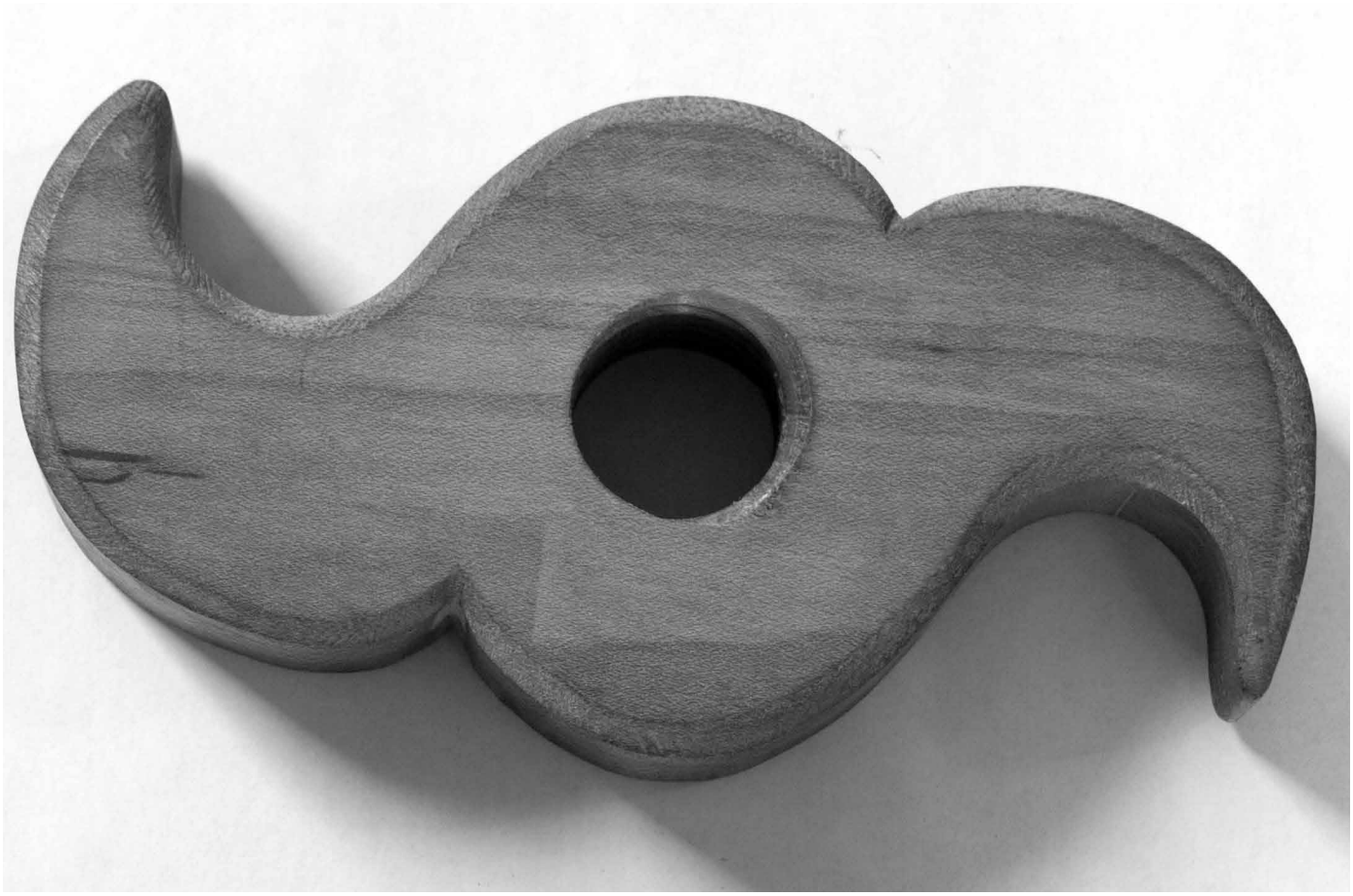


Figure 5.55. Full-size nuts. I tried drawing the nuts and explaining them with geometry. The original, quickly sketched nuts looked better. So here is one of them, shown at full-size.

Figure 5.56. Rasp for comfort. After you drill and tap the holes in the nuts, cut them to shape and ease the corners with a rasp. Shown is an alternative shape to the nut above.

Figure 5.57. Sit and make seats. These screw vises are outstanding for working on the edges of planks, especially chair seats.
PHOTO BY NN

Figure 5.58. Your friend the stool. A sawbench or a stool that is the same height as your bench is a remarkable helper during some operations.
PHOTO BY NN

Figure 5.59. Early shaving horse. This horse is featured in the 1561 book "De Re Metallica" ("On the Nature of Metals") by Georgius Agricola.

Add a Shaving Horse

Many visitors to my shop are intrigued by the low Roman-style workbenches (especially the children, who play Whac-A-Mole with the pegs). The most frequent questions I hear are: Were the Romans Lilliputians? And is this low workbench where the shaving horse came from?

It's impossible to know for sure. But it is a short intellectual hop from a workbench you sit on to a shaving horse. And because there are so many variants to the Roman-style bench – for shipbuilding, steam bending, wagon building and on and on – the shaving horse might just be one of the many flavors of the low bench that developed for the specialty trades.

A small breadcrumb of evidence is the 1561 woodcut in book five of "De Re Metallica" ("On the Nature of Metals") by Georgius Agricola. In the image, a German woodworker is shown shaving a stick to a fan shape so it can be used in a mine. Miners would use these dry sticks to help dislodge the ore they were seeking. The fan shape made the sticks easy to light on fire.

The first time I saw this woodcut, my brain saw a low Roman workbench instead of a shaving horse. Perhaps you can see the same thing I did – perhaps not. In any case, this image inspired me to add a removable shaving horse to one of my low benches.

The type of shavehorse shown in "De Re Metallica" is called a "dumbhead" or "Continental" style. These shavehorses have the pivoting clamp in the center of the bench and you squeeze your work either to the left or right of the clamp. The variation I built is commonly called an English shaving horse, which appears much later in the visual record.

Instead of a central pivot, the English shavehorse has two arms on the outside of the bench.

I've used both styles (including the mutant Shave Pony), and I decline to participate in the Shavehorse Holy Wars. I chose the English style because it is the style I have used the most and it was the easiest to adapt to an existing low workbench. All credit is due to Jennie Alexander for introducing me to

Figure 5.60. An easy accessory. Adding a shaving horse to a low workbench takes about a day. This one was made using oak scraps (hence the different species) that I pulled from my burn pile.
PHOTO BY NN

this style of horse through her writing.

Here's how it works: It starts with a 2" x 2" x 8" post that is friction fit into the mortise that also holds the workbench's planing stop. That post is joined to the "stage" of the shavehorse (the work surface of the horse). The two pieces are joined with a 5/8"-diameter dowel, which allows the stage to pivot up and down – just like the leaf of a hinge.

Below the stage is a large wedge-shaped assembly, called the "chock" by Alexander, that looks a bit like an odd drawer. This assembly is not attached to either the stage or the workbench. Moving it forward and back moves the stage up and down so you can clamp workpieces both small and large.

The clamping action is controlled by the arms. The arms pivot on pegs, which are inserted into holes in the edge of the benchtop. Between the two arms are the foot pedal and the head of the shaving horse. You press the pedal at the floor, and the head (sometimes called the "yoke") clamps the work to the stage.

This horse can hold both short spindles and long legs. While it looks like long workpieces might hit the benchtop, you can simply knock the 2" x 2" post up an inch or so, and the work will clear the benchtop.

Build the Horse

Begin by cutting the stage to size. Make it a little narrower than your benchtop. Mine is 1-3/4" x 7-1/4" x 24". The stage starts out longer than it needs to be – you'll cut it to final length at the end. Cut a notch centered on one end of the stage for the 2" x 2" post. The notch needs to be a bit bigger than the post – 2-1/16" x 2-1/16" will work fine. Plane a 3/4" x 3/4" bevel on one end of the stage, which will help the stage pivot.

Bore the 5/8" hole in the stage and the post. Note that the hole is centered in the notch, but the hole is not centered on the post. It's about 1/4" off center so the stage can pivot without hitting the post.

Join the stage and the post. Put a little glue in the blind hole in the stage and drive a 5/8" dowel through the stage and the post. Drive the post into the mortise in the benchtop.

Now you need to find a working

Figure 5.61. Bore the barrel. Bore a 5/8"-diameter hole for the barrel of the hinge. It doesn't need to pass all the way through the width of the stage.

Figure 5.62. Off center. Here you can see how the post protrudes from the rear of the notch. This is because the hole in the post is off center. This allows the stage to move freely.

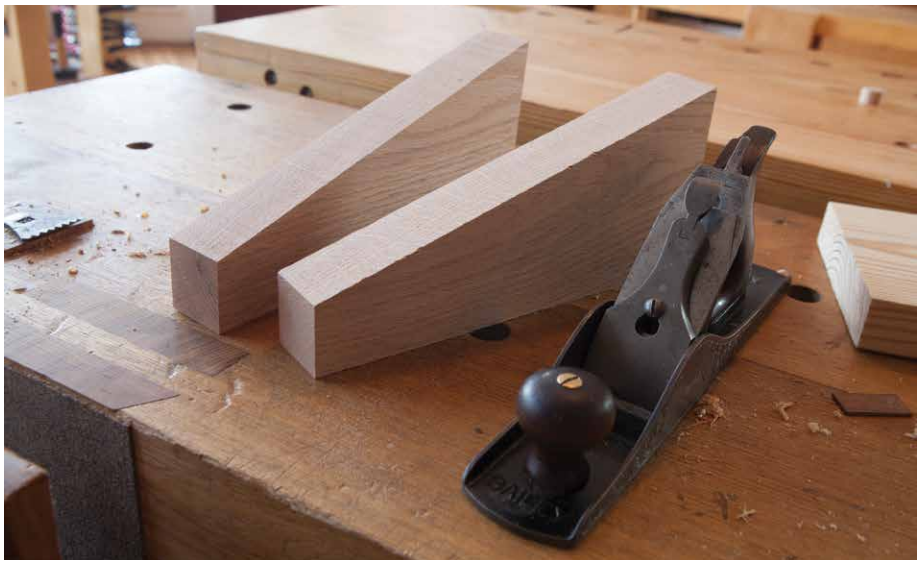
Figure 5.63. About right. I like to have the workpiece right above my belly button. I found that position and noted the distance between the benchtop and the bottom of the stage.

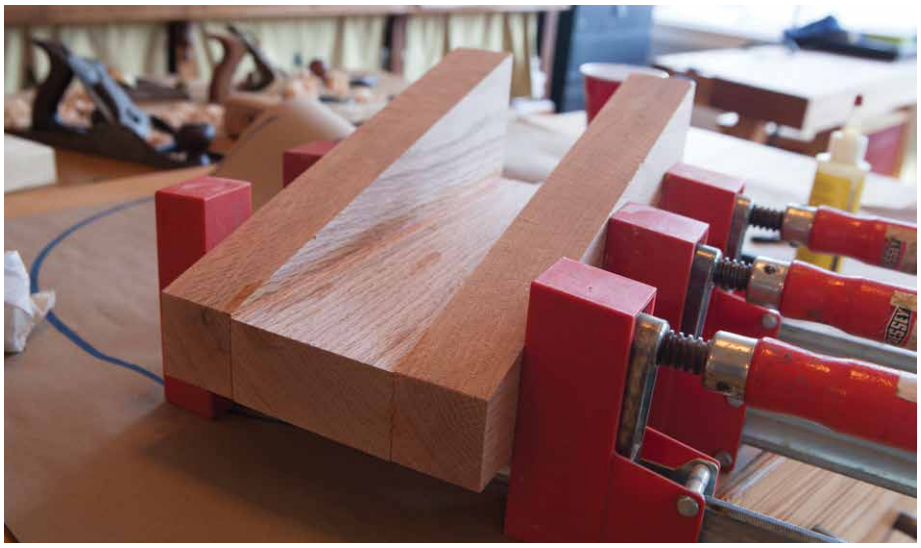
height for the stage that is comfortable for you. The stage will move up and down a little depending on the thickness of your work, but probably not as much as you might initially think. So, prop up the stage with some scraps to find a good working height – mine is 7" off the benchtop.

Now make the chock. The height of the chock should give you the ideal working height for the stage. You can then move the chock forward and back for larger or smaller workpieces.

The chock is made from three pieces of wood. Two are wedge-shaped. The third serves as the base of the chock. Cut the side pieces of the chock so they fit snugly under the stage when it is at your ideal working height. Glue the three bits together and you have a chock.

The remainder of the shavehorse is figuring out how to get the arms to pivot. For me, the calculations were based on the legs of the workbench – I didn't want to ram into them while





Figures 5.64. 5.65 & 5.66. It's a chock. The chock of the shavehorse is three bits of wood planed up and glued together. Nothing fancy.

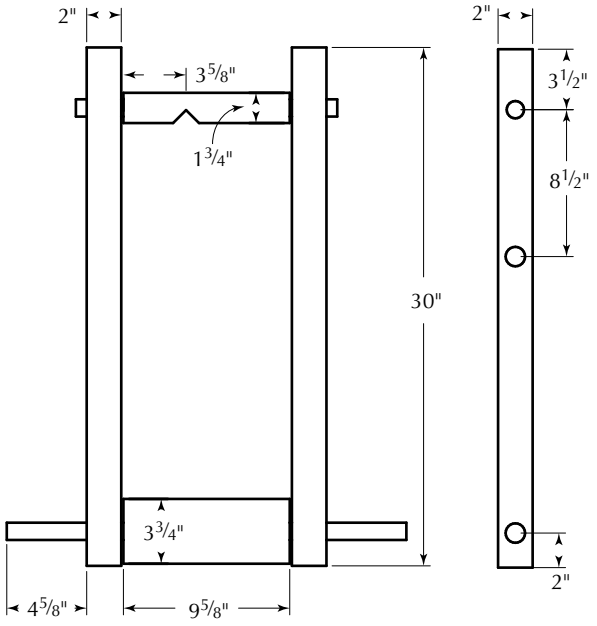
working. And I had to account for the dovetail-shaped notches already in my bench. Likely you won't have to deal with the same set of variables.

The arms should be about 5" to 6" behind the front edge of the (cut-to-final length) stage if you are using my dimensions. Mock up the location of the arms with your stage and chock in place. The goal is to get the yoke to pivot onto the stage. The 1" holes should be up near the top edge of the benchtop – mine are on 1" centers from the top edge. The closer you get the yoke and the pivot points, the more mechanical advantage you will get.

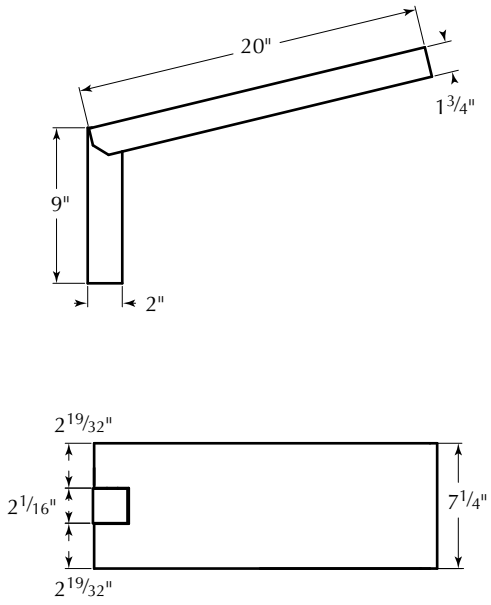
Drill the holes in the edge of the benchtop 2-3/4" deep. Drill 1-1/8" through-holes in the arms for the pivot points.

Now make the handles that the arms pivot upon. The only key point about the shape of the handles is that the 1"-diameter dowel should protrude 4-7/8". This length will cause the han-

Figure 5.67. Compress the dowels. How do you fit 1" dowels in a 1" hole and allow them to spin freely? Compress the dowels a bit with nylon-jawed pliers.



Arms



Platform

dles to bottom out in the holes in the benchtop, allowing the arms to swing.

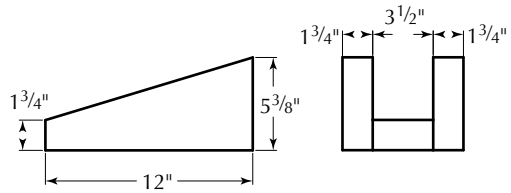
Insert the handles through the arms, set your stage to your desired height and play with the arms a bit. Find a location on the arms where the yoke will pinch the stage without too much motion. (My drawings are a good place to start.)

Now drill 1" through-holes in the arms for the yoke and the pedal.

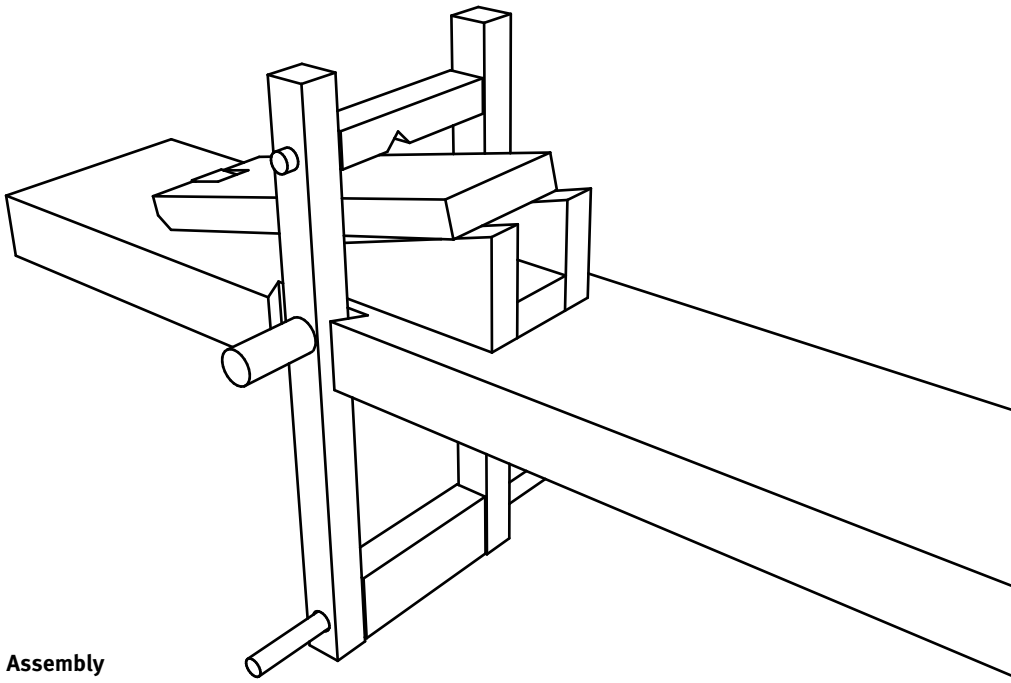
You can turn the yoke and the pedal. Or you can make them from blocks of wood and 1"-diameter dowels. If you make them from dowels, bore 1" holes in the end grain and glue dowels into the blocks.

The yoke and pedal should fit loosely in their holes. You can scrape the dowels to fit or compress them a bit using pliers with nylon jaws (sometimes sold as "non-scratch pliers").

To complete the yoke, I cut a 3/4" x 3/4" V-notch on one face to hold spindles. Then I added some hard Neoprene rubber to the clamping surfaces. The last touch: I glued a layer of leather to the top of the stage.



Yoke



Assembly

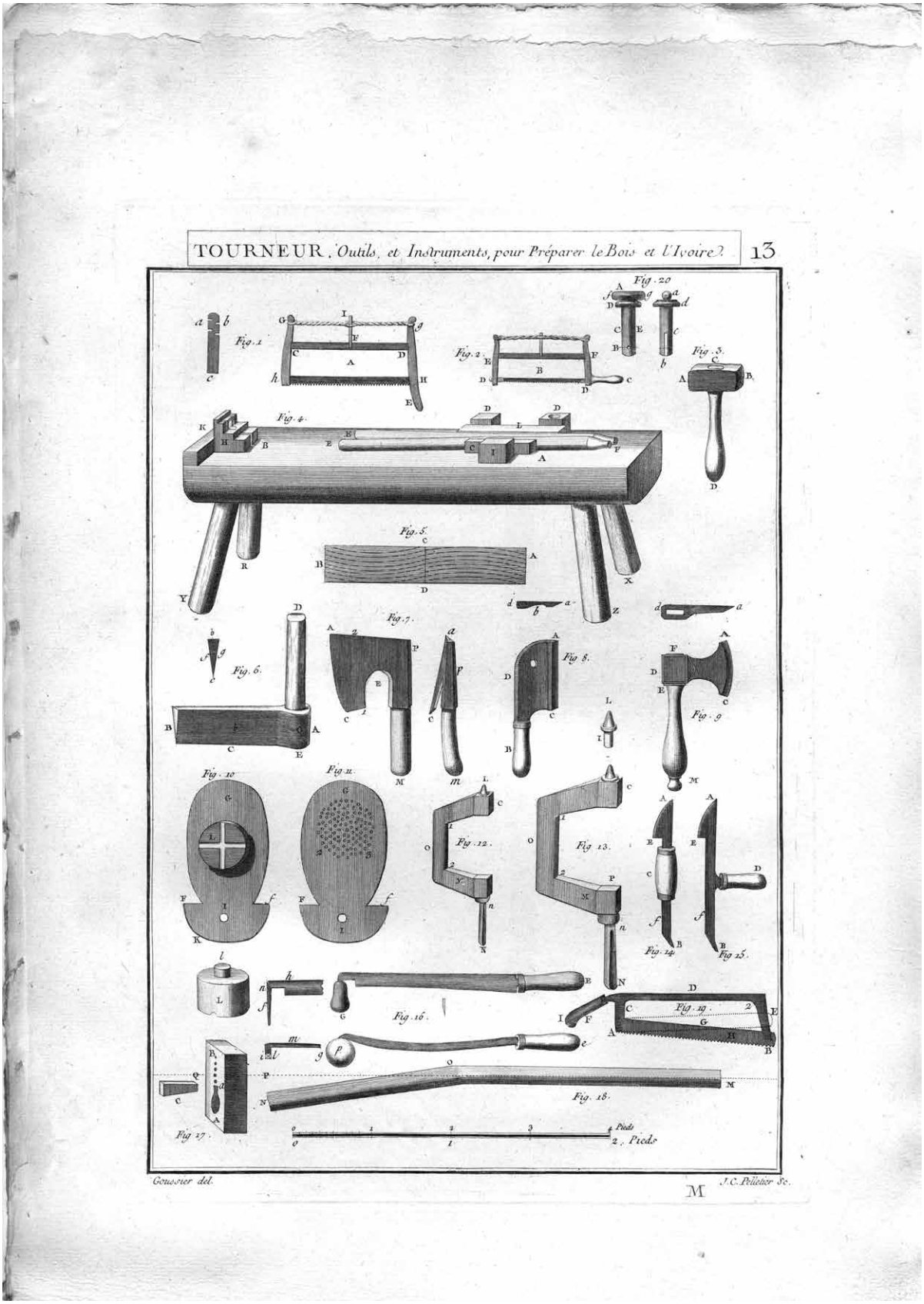


Figure 5.68. Plate 13 from M. Hulot's "L'Art du Tourneur Mécanicien" (1775).

PLATE COURTESY OF JOHN AND ELEANOR KEBABIAN

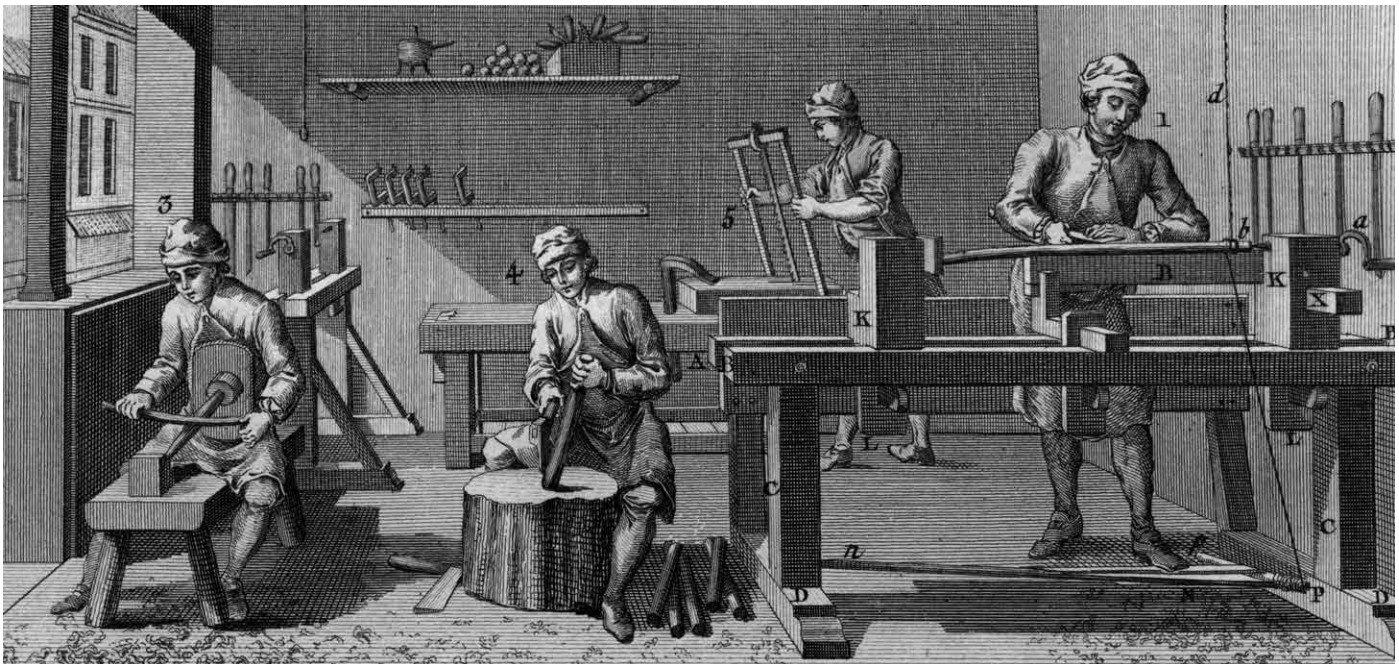


Figure 5.69. Detail of Plate 31 from M. Hulot's "L'Art du Tourneur Mécanicien" (1775).
PLATE COURTESY OF JOHN AND ELEANOR KEBABIAN

The Head & the Belly

If the shaving horse seems too complex, consider shaving spindles and legs using a setup from M. Hulot's "L'Art du Tourneur Mécanicien" (1775). Hulot details a low bench he calls a "saddle" for chairmaking. The bench includes a "head" for shaving pieces and wedge-based clamps for holding chair pieces.

To shave pieces, you don the "belly" in front of your belly and immobilize the wood between the belly and the head, as shown in the plate above.

We translated the original text (thanks Tom Bonamici) and offer it here for you to interpret.

The Figure 4, Plate 13, represents a type of bench which is named a Saddle for planing and assembling; it's a piece of oak of 5 feet in length by 12 to 14 inches in width, and very thick, carried on four strong legs below, R, Y, X,

Figure 5.70. Minute made. The "belly" is a remarkable appliance for shaving chair components. While it's not as adept at shaving long, thin spindles, it excels when shaping legs or short spindles.
PHOTO BY NN

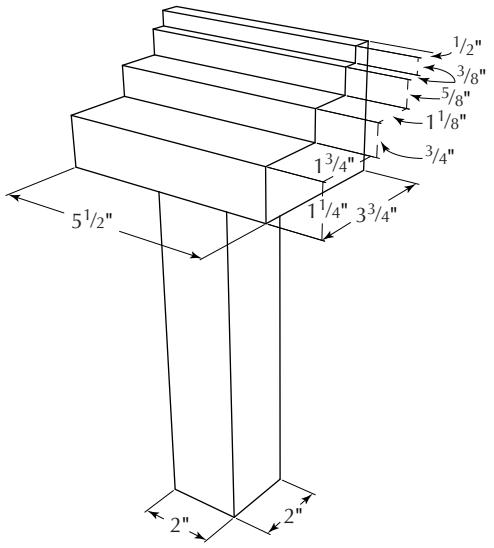
Figure 5.71. Good design. The block in the middle is thick for good reason. Its thickness allows you to get your drawknife right up to the end of the work with remarkable control.
PHOTO BY NN

Z, which enter through as many round holes drilled in the bottom of the Saddle, A B. The Worker has his face turned toward the head, H B, which is a big piece of softwood, such as alder, and of which the bottom forms a flat tenon which passes through a mortise in the Saddle; the upper part [of the alder head] forms a type of stepped stop, of which the steps are notched in different ways, some perpendicular and shallow, for receiving the end of flat pieces to be planed on their edge [see vertical notch just to the left of the letter B, Fig. 4, Pl. 13]; the flat steps receive pieces to be planed on their face. Other steps are notched horizontally and vertically in the form of a little spoon, for receiving the end of a baton. There are more little vertical notches next to this hollow, which can be seen in the figure [Fig. 4]. Independently of the tenon which fixes the head H, it [the head] is supported by the cross beam K, also named the transom, head, or buttress of the head, & which is supported at the end & across the Saddle, by two strong pegs of strong and binding wood, such as ash or dogwood, which pass perpendicularly across the cross beam and the Saddle.

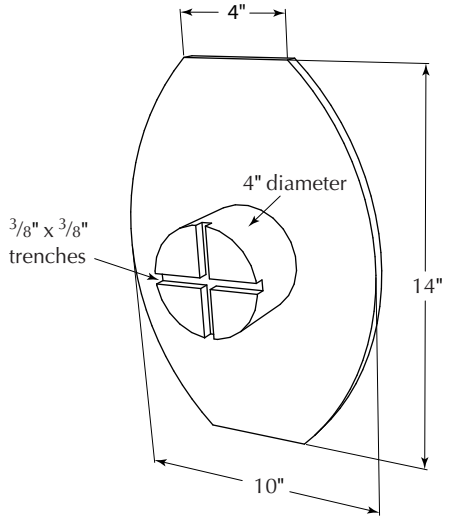
If the wood to be planed is big & long, one doesn't sit on the Saddle, but one stands upright, & one places the end of the wood in the corner H K formed by the cross beam and the side of the head of the Saddle.

The Worker is obliged, in planing a piece of wood, to support its end against his stomach; & so as not to hurt himself, he has in front of him a mass or block of wood that's named the Belly.

This Belly is a type of wooden piece of oak, a foot long, 6 inches wide, & about 1/3 of an inch thick, Pl. 13, fig. 10. The top part is cut in a roughly oval shape, F I, f G; the bottom part, F I, f k, is made in a roughly semicircular shape; & as the Turner places this Belly in front of himself, the cord of his apron passes from F to f, and by this method the Belly is held fast. In the middle of the oval, one places a block L, of softwood, round, 3 to 4 inches in diameter, by around 2 to 3 inches in thickness, made of end grain, and in the center of which has been inserted a pin l of hardwood, & which is held by a friction fit



Head



Belly

in a hole in the center of the Belly's oval; one cuts the end of this pin flush off at the back so that it doesn't hurt the Artist. On the face of this block, one makes a very shallow groove in the shape of a cross, which serves to hold the flat pieces to be planed, either on their face or on their edge. See Pl. 31, vignette, fig. 3, where the Turner is occupied in planing. Below figure 10, Pl. 13, we see the block shown in perspective; l, is the tenon or pin which enters in the hole in the middle of this block. The holes I, I, which are at the bottom, in the semicircle of these Bellies, serve to hang them on the wall when not in use.

Making the head is simple. Like the shaving horse, the palm and the planing stop, these fit into a 2" x 2" mortise in the benchtop. Construction begins with a post that is 2" x 2" x 9-3/4". Plane it so it fits into the benchtop mortise with mallet blows.

Now mortise the post into the 3" x 3-3/4" x 5-1/2" head. Cut a mortise that is 3/4" deep. Glue the post into the head.

Cut a series of rabbets in the head. I made mine roughly match the plate in Hulot. There also is a blind hole in the middle and a few kerfs. All these notches and kerfs are used to hold onto one end of the work. And, judging by the plate showing the head in use, you place the stick's tenon in the hole when working a spindle or leg.

The belly is a thin plate of wood that you wear – like an armored breastplate. A block of softwood with two trenches plowed across the end grain serves as the other end of the clamping action.

Hulot specifies that the block is friction-fit into a hole into the breastplate, which I assume will allow the block to rotate (if needed).

I made the breastplate from a thin piece of poplar – 1/2" x 10" x 14" cut to a rough oval shape. The block is white pine – 4" in diameter x 2-3/4" long. The 3/8" x 3/8" trenches cross in the middle of the block. I attached the block to the breastplate with a large screw, which allows it to rotate.

Hulot says the worker's shop apron string can secure the belly while working. However, my shop apron doesn't look anything like the aprons shown in the plate. So, I riveted the belly to a pair of $6 suspenders (a couple screws could also do the job of the rivets).

If you are shaving only a couple of pieces, you can prop the belly up on your legs. For long sessions, you'll want it tethered to you in some way.

The belly is remarkably effective for shaving legs and other chair components. The block holds the work so you can knife the end of your workpiece without the drawknife's handles hitting your body. Also, the rabbets on the head are all useful – especially the small rabbet at the top, which allows you to shave small components along their entire length.

The belly is an effective alternative to a shavehorse in many cases. It can be used at a high or low bench. It takes up no floor space. It allows you to shave the entire length of a leg or spindle in one swipe. It's as fast as a shavehorse.

It's not as effective when dealing with long, thin spindles, such as the 5/8"-diameter back spindles on a

Figure 5.72. Gag order. A rope makes a surprisingly effective hold-down.
PHOTOGRAPH BY ANTS VIIRES, 1947, FROM "WOODWORKING IN ESTONIA" (LOST ART PRESS). PHOTO LIBRARY 1089:42

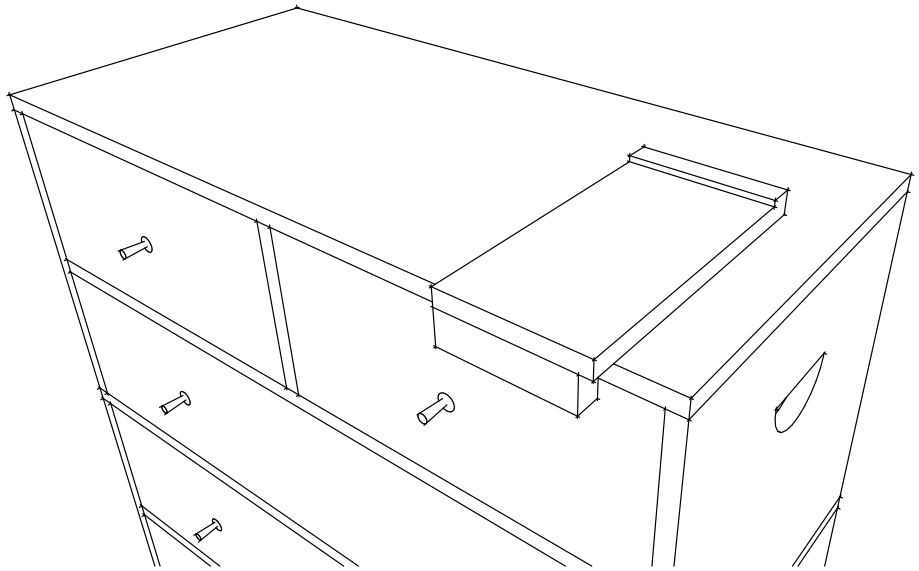


Figure 5.73. Make do. While this isn't a Roman, Greek or even an Estonian solution, there is a kinship. Transforming a stable platform into a work surface is the heart of bench building.

Windsor chair. They are so long and flexible that they are a handful when using the belly.

Belts & Ropes

One bonus operation: You can hold assemblies to the benchtop to work on their faces using a rope (or a belt) and your feet to create a primitive vise. I first saw this in an Egyptian painting. I've also been experimenting with using a leather belt to hold the work down. I have found that the belt and rope work best when holding objects that are fairly tall (as shown at left). With thin stock, the edges of the benchtop interfere with the grip of the rope or belt.

The Bureau Shop

Building furniture without a dedicated workshop or even a workbench has always been a challenge. While there are lots of ways to get around the problem, one of my favorites is what is called the "bureau-shop."

This is where you transform an old chest of drawers into a complete hand-tool shop for light work. The top of the bureau is used as the benchtop (more on that in a minute). The top drawers store tools, while the bottom drawers hold the wood, the assemblies you are working on and even the shavings and the sawdust from the work.

As a result, you have the ability to work inside the house without disrupting the look of a guest bedroom or office.

I first discovered the "bureau-shop" when reading a charming series of four books from 1864 titled "John Gay; or Work for Boys" (Hurd & Houghton) by Jacob Abbott. The books follow the adventures of young John Gay and his efforts to become a woodworker.

What is fascinating to me is how the author took great pains to describe how to work on the top of the bureau without scarring it. Planing and saw-

ing is done with a bench hook. Sawing large pieces of work is handled by sawing it on a sitting bench, with all the waste falling into the lower drawer.

If you were willing to scar the top of the bureau a bit you could install some planing stops and pegs to restrain the work from spinning on the bureau's top.

The book doesn't address how to cut tenons, mortises or dovetails. Most of John Gay's projects are nailed together. But I'm sure you could manage by clamping the workpieces to the bureau. I also tried to think of a way to use the top drawer as a vise, but it was getting too complicated.

While a bureau-shop might not be perfect, you can bet that when they shut me away in a retirement home I'm going to continue woodworking using any means necessary, even the bureau-shop.

Figure 6.1. No toga required. Whether you choose four legs or eight, this is the simplest workbench I've built to date.

VI

Herculaneum Workbench

The act of building the workbench from Herculaneum is simple. You true up a slab. You make eight legs (or just four if you please). You drill eight holes in the slab. You drive in the legs and wedge them.

The real challenge is what happens next: using this low bench for making furniture.

However, I don't want to assume that making this workbench is a simple thing. If it were, you would have already built one and skipped this part of the book, right? There are compound angles, tapered legs, wedges and other details to manage. So, let's start at the beginning of the process and walk through every step like it's important (it is), especially if you ever want to take the knowledge used in building the bench and apply it to building chairs.

Figure 6.2. On the edge. I'm lucky that I have a bench I can use to build this bench. But you don't have to have a bench to make one. Throw it on sawhorses and you'll be fine.

True Your Slab

My bench began as a slab of wood that I could straddle – 3" x 15" x 85". I have gangly praying-mantis legs that can grip a 15"-wide slab with ease. I am not proud of this; it's just the way I came from the factory.

Pick your width. Start at 15" and work your way down until it doesn't feel like the wood is a speculum when you perch upon it. Most people like a slab that is 11" to 13" wide.

Here's the routine: Plane the faces of the slab until they are flat and parallel. Then work one edge of your slab so it's flat and straight. This is the "true edge." The true edge should be 90° to the faces of the work. Once you get that under control, you can rein in the other edge of the slab.

What about the ends of the slab?

Figure 6.3. All 90°. There are times when square-ness is overrated. This is not one of them. If you make your faces and edges square to one another, it will make the leg joinery easier.

Figure 6.4. Gauge the width. Use a panel gauge or a large combination square to gauge the final width of your slab. The head of the square should run against the true edge.

Figures 6.5 & 6.6. True all around. With big slabs you can use fore planes or scrub planes to traverse all the surfaces (even the edges, as shown at left) and bring them into truth.

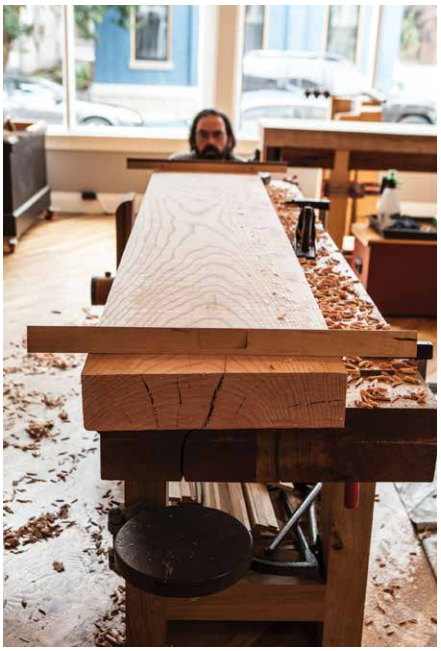


Figure 6.7. Wind out. With large slabs, your eyes can see obvious twisting. But the true test is to use winding sticks.

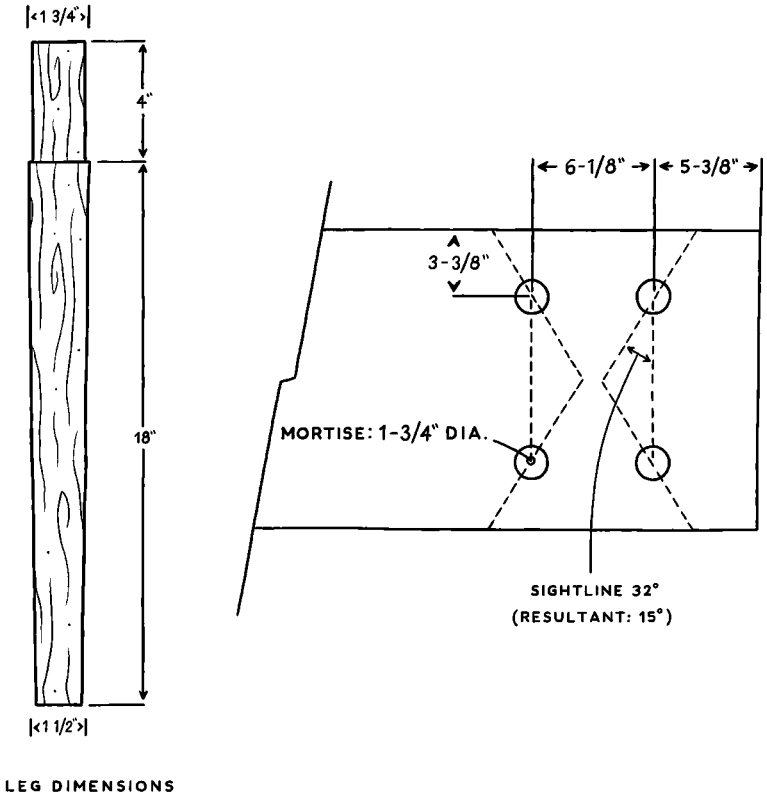
Figure 6.8. Work all around. You might need to work the faces to bring the edges in truth. (The three-dimensional world can be a bitch at times.) Don't be afraid to roll the slab over and remove some errant material. And sometimes (shudder) these slabs twist as you remove material.

Forget them. Mine are as rough as when they came from the forest.

Turn or Shave the Legs

I have a lathe, and I can turn. So, I make my life easier at every turn (apologies) with this machine. If you don't have a lathe, make the legs with a drawknife or a spokeshave. The legs don't have to be round, by the way. Square, octagonal or straight from the tree with bark is OK.

The legs are tapered cones with a tenon at the thick end. The legs start at 2" at their thickest, are 22" long and taper to 1-1/2" at the foot. The 1-3/4"-diameter tenon on the end of each leg is 4" long (this really depends on the thickness of your benchtop). Details are in the drawing at right. The bench will end up as tall as the distance from the bottom of your kneecap to the floor. But don't worry about height now – you'll cut the legs to final length at the end.



LEG DIMENSIONS

Splay & the Easy Way Out

The legs of this bench have both rake and splay, so the mortise is drilled at a compound angle. Wait, did you just think about closing this book? About 20 years ago I would have had that identical urge.

Compound-angle joinery is easy. The trigonometry to describe it is what hurts your membrane. I'm going to describe how to lay out and execute the compound-angle mortises with no math. All you'll need is to do is draw a few lines on the underside of the benchtop, set a sliding bevel to one angle, then drill a hole that matches that angle on the sliding bevel. It really is that easy.

When we think about a compound angle, we usually try to break it down into two separate angles that push the leg off both an X and Y axis. We have two angles – tilt the leg X° off the X axis, and then tilt it Y° off the Y axis. If you follow these two angles simultaneously you will drill the correct hole.

And this is minotaur shit.

There's a better way to drill a compound angle and it uses a "sightline" and a "resultant angle." The sightline is an imaginary line that runs through the leg. The following explanation might sound a bit daft, but it works. I pretend that the sightline is a laser beam that shoots out of my eye when the leg appears to be at 90° to my laser eye. That angle – when the leg appears to be 90° – is the sightline.

Then we tilt the leg toward the eye or away from the eye. That is the resultant angle of this equation. So, if we can find the sightline (when the leg appears vertical to our eye) then we can find the resultant angle.

I do this by making half-scale models of the project using MDF and wire hangers. But I'm getting ahead of myself. Really, the simplest thing to do in this case is give you the directions for drawing out the sightline then sup-

Figure 6.9. Turn and scrape. After turning the tapered legs round and forming the tenon, I scraped the oak clean with a card scraper. This removed little bits of tear-out that annoyed me.

Figure 6.10. The first four finished legs. These are just the right size for a pirate's peg leg. However, I wouldn't want to make that mortise.

Figure 6.11. Before boring. After I made the model, I confirmed the compound angle looked correct with a large sliding bevel square. You can skip this step if you trust me.

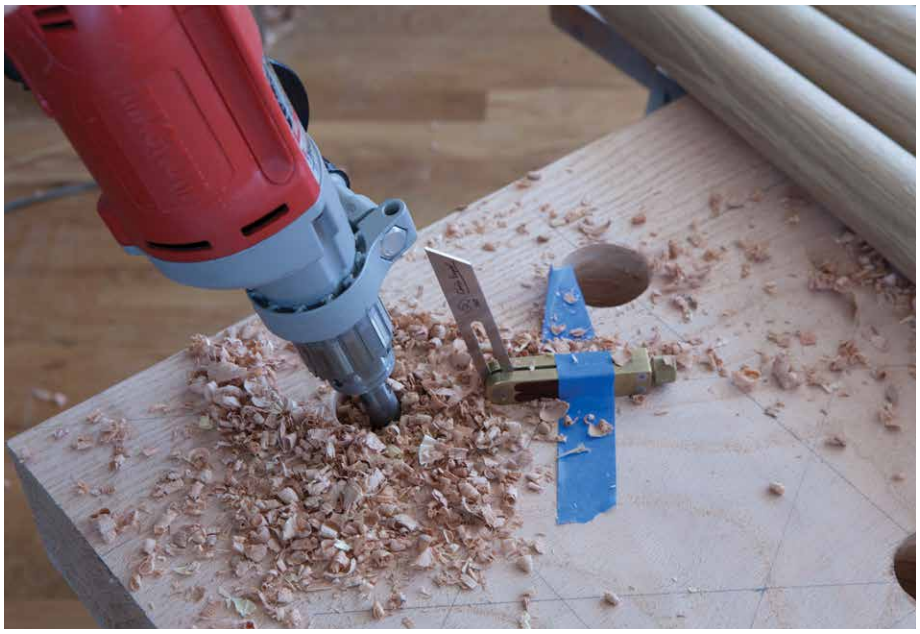


Figure 6.12. Follow the bevel. Here I'm lining up the chuck of the drill with the blade of the sliding bevel. If you are using a long auger bit you can line up the shank of the bit so it's parallel to the blade of the sliding bevel.

ply the resultant angle for your sliding bevel. (If you want a full education in calculating sightlines and resultants without numbers, check out "The Anarchist's Design Book." Here ends the commercial.)

Use the illustration on the previous spread to lay out the position of the eight mortises (or four if you suffer from arachnophobia) in the underside of the benchtop. As you can see, the legs are in pairs – the outside pairs and the inside pairs. Draw a line (as shown) to join the two mortises for the outside pairs, then the inside pairs. Let's call these lines the "baselines."

Use a protractor to create lines that are 32° off the baselines and that intersect the mortises. This will create a squat triangle. These 32° lines are your sightlines. You are almost ready to drill.

Fetch your sliding bevel. Use the protractor to set the bevel to 15° off vertical. Tape the stock of the bevel to the sightline with the blade poking up in the direction the leg should

Why 8 Legs?

This bench doesn't need eight legs. Four legs will do the job. But I've built more than 100 benches with four legs. And, until I built this bench, I'd built exactly zero that had eight legs.

When constructing this bench, I started out with four legs. I jumped up and down on it. I tried to find something wrong with four legs. I couldn't.

But the eight legs called to me, like a spider with a dusky voice. What if eight legs made the bench feel different? More stable? Perhaps it would rock less on uneven ground. Or something.

When I build recreations of old pieces, I try not to stray from the original. Modern "improvements" are rarely that in my experience.

So, I made this bench with eight legs and can confirm that the four extra legs don't do too much. They help a bit when face-planing boards – the extra legs are a great place to hook or press your feet – but they aren't a game changer.

Add the extra legs if you like the look. But don't think you are getting twice the functionality with the something-something relating to legs, phases of the moon and such. You aren't.

go. Clamp a backer board to prevent splintering to the top of the benchtop where the mortise will emerge. Chuck a 1-3/4"-diameter bit in your drill or brace and position it so it is in line with the sightline and tilted at 15° to match your sliding bevel. Drill the mortise, with the assistance of a spotter if you have one.

Drill all eight mortises. Then test the tenons on the legs to make sure they fit. Now is a good time to assign each tenon to a mortise by numbering or lettering all the parts. All the legs should be interchangeable, but I'd hate to discover the opposite when everything is covered in glue.

Assembly & Wedging

Like a Windsor chair, you should wedge the bench's tenons in place. I make wedge material from 1-3/4"-thick oak. I saw out wedges so they are about 2-1/4" long and slope 4° to a fine point. I recommend you make about three times as many wedges as you need at assembly time because things go wrong. For starters: Wedges split, their tips get mushed and they bounce out of the tenon at times.

After sawing out your wedges, you have two choices about how to drive them in. You can be a daredevil: Glue the tenons into their mortises, then use a wide chisel to split the tenon to receive the wedge. This works well if your tenons are a loose fit in their mortises. If the tenons fit tightly, then bon chance with that approach.

The other path is to saw a 2"-deep kerf into each tenon with a handsaw before assembly. The kerf makes it easier to insert the tenon into its mortise. And it makes it easier to start the wedge. It took me about 15 minutes to kerf the eight tenons. Holding a debate with yourself as to whether or not you should kerf the legs can take considerably longer.

Paint hide glue on the inside of the mortises and on the tenons. Drive each leg into its mortise then rotate each leg until its kerf is perpendicular to the grain of the benchtop.

Paint the wedges with glue and drive them in with a hand sledge or big hammer – now is not the time for half measures. Hit each wedge until it stops moving. When your blow has no effect, you're done.

Figure 6.13. Driven. Drive the tenons into their mortises. Flip the bench over and prepare to wedge the tenons.

Figure 6.14. Wedge the tenons. Note how the wedges are perpendicular to the grain of the benchtop. This is the typical arrangement when building furniture. In the next chapter, you'll learn another way to do it.

Figure 6.15. One way to do it. My oak legs were incredibly dense. So, I had to break out the full-size crosscut saw. To protect the benchtop from the set of the saw teeth, I taped a thin bit of cardboard to the bench.

After the glue dries, trim the wedges and tenons flush with a saw. Then plane the benchtop flat. Again.

Trim the Legs

First flip your bench upside down so it looks like a dead spider-pig.

Leveling the feet of the bench is like leveling the feet of a chair. First you have to decide how tall the bench should be. I recommend it come to just below your kneecap. This height will make it comfortable for sitting and working.

Once you know this dimension (let's say it's 17"), then subtract the thickness of the benchtop (3") to get the result: 14". And that's the length of the magic 4x4 that will mark your legs.

Cut a 4x4 to your magic length. Then plane a carpenter's pencil in half – yes, I'm serious here. This is what we call the "half-pencil" and it is good. Place the half-pencil on top of the magic 4x4 and set the 4x4 on the underside of the benchtop.

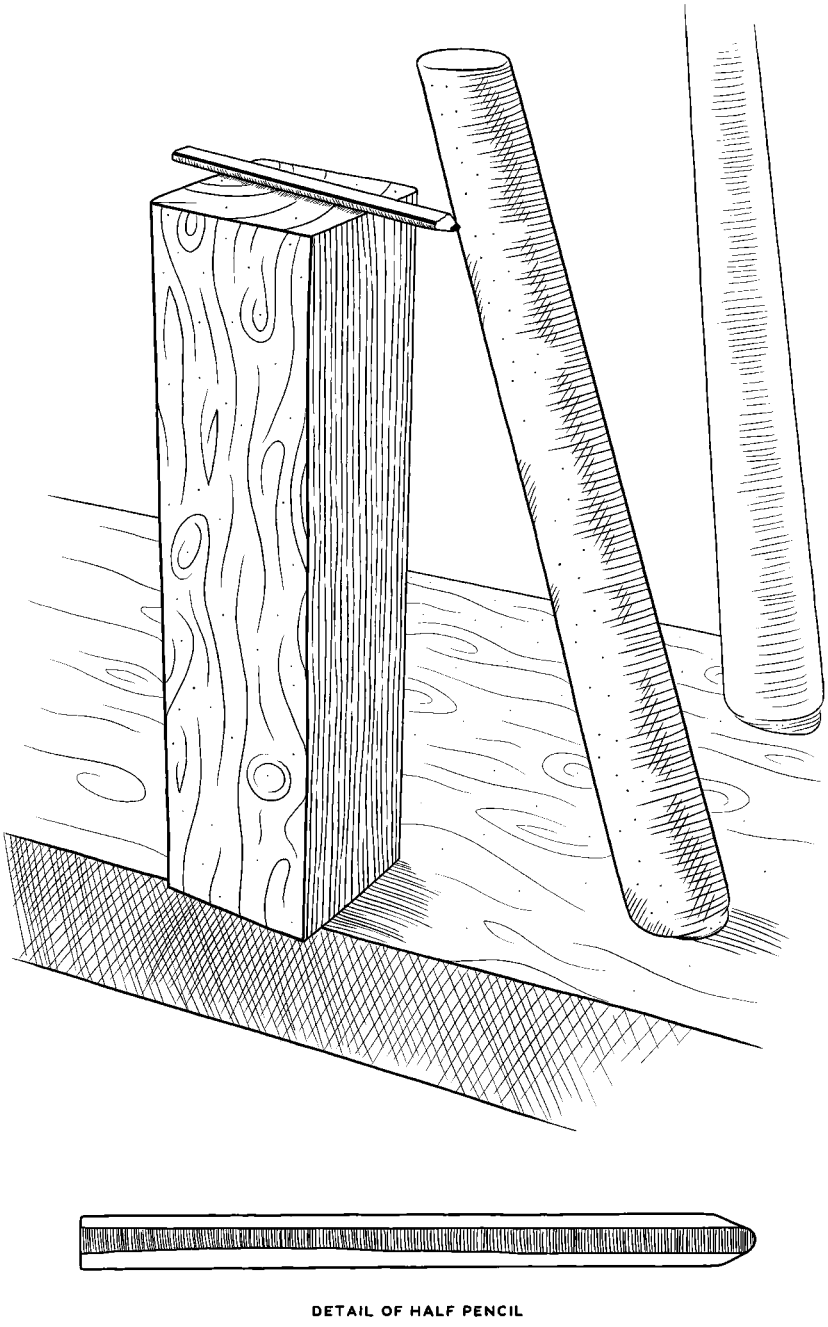


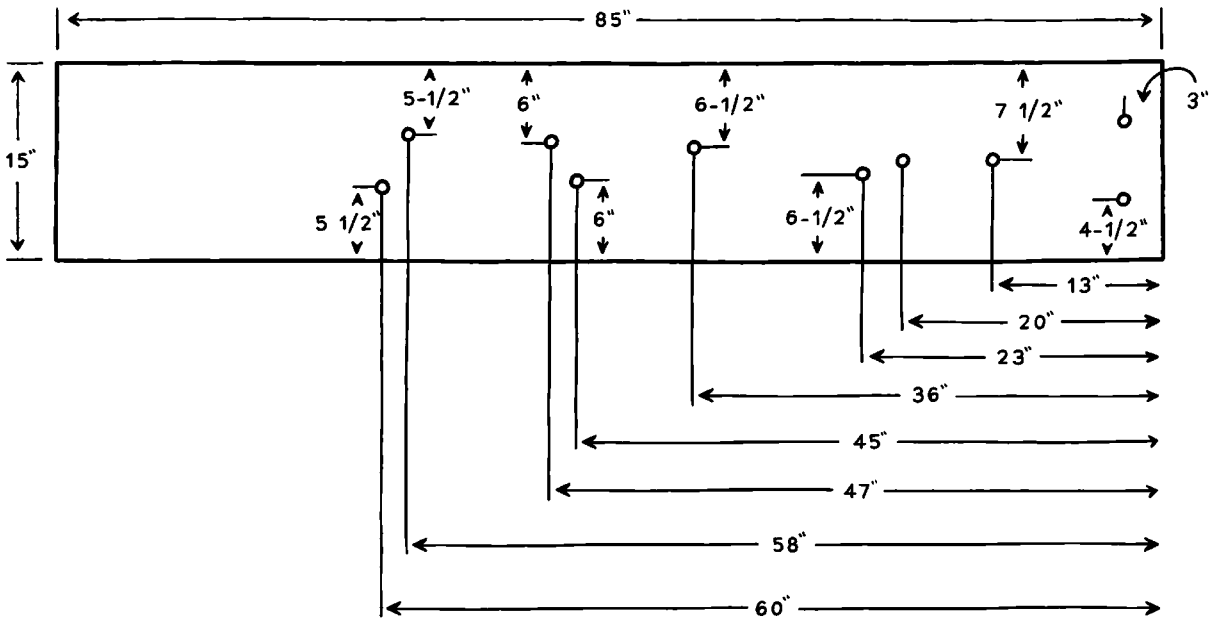
Figure 6.16. The magic half-pencil. Here you can see the 4x4 on the underside of the benchtop and the half-pencil sitting on top of the 4x4.

Move the 4x4 so you can mark the final length of all the legs with ease.

Then set the bench on its side and saw all the legs to length. Ease the sharp corners of the feet with a rasp.

The Benchtop's Peg Holes

The top is pierced with a series of 1"-diameter holes that restrain the work for sawing and planing. The location of these holes is not arbitrary (though



Hole Layout

I encourage you to consider other arrangements as you work with your completed bench). The hole pattern shown here is based on studying old benches and messing around with them.

After decades of using a brace (I think I was 12 when I first used my dad's Craftsman brace) it's easy to drill a perpendicular hole.

If you aren't confident, I recommend you make a drilling jig that makes it easier. The first step is to drill a 1" hole through the width of a 2x4 that is perfectly plumb. Then use that perfect hole as a guide for the other holes.

Clamp the 2x4 to your benchtop and use the plumb hole to drill all the holes in the benchtop as shown in the illustration above.

After you drill all the holes, tidy up your work. Break any sharp edges and apply a few coats of boiled linseed oil to the workbench. While the finish is drying, take some 1-1/4" dowels and shave the end of each one so it tapers to 1". These pegs will restrain your work; having several at different lengths – from 5" to 12" – will do the trick.

Read the chapter on workholding for more information on using these pegs.

After a year of using this bench in my workshop, I've become attached to it, as have my customers. In fact, it's just as likely to get sat upon as worked upon. When kids visit the shop, they enjoy knocking the pegs in and out of the holes. A couple of kids have taken a nap on the bench. I eat my lunch while perched upon it (and think about naps).

Unlike my tall benches, my low benches are good for many things other than just planing and sawing. It's one of the charms of the low bench. And this chameleon-like character is probably why so many of them have gone undetected for centuries as workbenches.

Figure 6.17. A big doweling jig. The 2x4 guides the 1" auger bit as it makes the holes for the workbench's pegs.

Figure 6.18. Finished. It's not fine furniture, but it can easily masquerade as a sitting bench or oversized cribbage board.

Well-made. Knock the side stops level and knock out the planing stop, and the Saalburg bench can serve as Thanksgiving seating.

VII

Saalburg Workbench

German archaeologists are a good deal more practical than the French, British or American ones I've worked with. But that knowledge didn't prepare me for the three little words Rüdiger Schwarz said to me on June 8, 2017.

"Pick it up."

The "it" was a low workbench that had been recovered in 1901 from well No. 49 at the Roman fort in Saalburg, Germany. Though the scientists at Saalburg haven't been able to date this particular workbench, a second similar bench from well No. 49 was dated to 187 C.E.

That would make this "it" the oldest surviving workbench of which I am aware. And "it" was between my legs. Dutifully, I reached down, grasped one end of the cool black surface of the oak bench and lifted it a few inches off the floor. Rüdiger grasped the other end.

We guided the bench about 3' into a small hallway. I put it down as gently I could – my hands trembling and my stomach lurching.

Then, like a team of coroners, Rüdiger, Bengt Nilsson, Görge Jonuschat and I examined every detail of the bench, from toolmarks on its underside to the interior configuration of the mortise for the planing stop. We measured the bench. Photographed everything. We took a break, then we came back and repeated the process to make sure we hadn't missed anything.

Figure 7.1. Still with us. What is likely the oldest surviving workbench, this low bench was recovered from a well at a Roman fort outside Frankfurt, Germany.

And yet, I hesitate to call my version of this bench a copy or a reproduction. Here's why.

Throw the Bench Down the Well

It's not unusual to find Roman artifacts stashed in wells. Archaeologists have recovered thousands of tools, domestic goods, nails and even coins from the bottoms of Roman wells. The reason: Stashing valuable goods in wells was

Figures 7.2 &7.3. Well, well, well. Some of the restored wells outside the walls of the Saalburg Roman fort. Many of these wells were filled with Roman artifacts. During our visit we failed, however, to locate well No. 49.

Figure 7.4. Return to Rome. The reconstructed Roman fort at Saalburg offers a glimpse of the fort as it likely stood 1,800 years ago. Walking through one of the fort's four gates is thrilling. Even more fascinating are the objects on display in the fort's museum.

a typical Roman reaction to the threat of an overwhelming attack. If the Romans threw their precious bits down wells before retreating, there's a chance they could recover their valuables later. And if they weren't able to recover their items, there's a chance their attackers wouldn't find them, either.

But before we start discussing the fall of Saalburg, let's look at how it started.

The Saalburg fort was founded about 85 C.E. as two earthen enclosures to protect a mountain pass. This was later improved to a wood and earth fort. In the second century C.E., Saalburg was expanded to become an impressive stone fort that housed a "cohort," a unit of about 500-600 Romans. The fort served as one of the important links in the "limes" (pronounced "lee-mez" and not like the citrus), which was the frontier between the Roman Empire and the hostile Germanic tribes to the north.

About 260 C.E., the Roman limes fell. All areas east of the Rhine River were lost to the Germanic tribes of the north. Saalburg was abandoned during this time, apparently without a fight. Yet the fact that the fort's wells were filled with tools and other important commercial objects suggests that its occupants felt threatened.

After the fort was abandoned, it was used as a quarry. And its history and very existence faded away until the late 19th century. After decades of research into the Saalburg fort by archaeologists, Kaiser Wilhelm II ordered in 1897 for the fort to be reconstructed. It is now an open-air museum and research center for archaeologists who study the limes and Roman technology.

We Go Below

Today, below the museum is a climate-controlled room with thousands of Roman objects. That's where museum educator Rüdiger Schwarz took us one summer day in June. Its entrance is be-

low grade, like a cellar door. Then you traipse down a few steps to a masonry-lined room that looks like the mechanical area of a school or office building. There's equipment to control humidity. Lots of locked doors. Any janitor would feel at home.

Rüdiger unlocks a couple of doors and the scenery changes. It's still a climate-controlled basement, but the hallways are lined with wooden shelves that go from floor to ceiling. And they are filled with bricks, pottery and woodwork. All of it neatly labeled. Though we're walking at a normal pace, I stumble when my eye latches onto a label or an interesting ceramic. My feet don't know what to do – move or stop.

We make a left turn; as do the shelves. To my left are banks of wide and shallow drawers filled with hundreds of artifacts. The only sound is a buzz from the lights above as they flicker on and warm up. I don't suffer vertigo, but the floor seems to sweep upward as we pass into a cluster of wooden objects – wheels, stools and pieces of bridges that are bound in iron. Every wooden object is blackened from its time in a well that had no oxygen but lots and lots of iron objects.

And then there it is – the workbench standing on four legs like a lame dog. None of its legs are in the same plane, likely the result of it being waterlogged for hundreds of years and then being dried out in 1901.[1] At some point, the benchtop split in its middle across its width, but it has been mended and looks sturdy and ready for straddling. There's a piece removed from the back end where archaeologists attempted to date the bench – the offcut is also handy so you can see the annular rings of the tree and the way the iron has leached its way deep into the fibers of the workbench. It is black through and through.

I want to sit down, but the only seats available are 1,800-year-old stools and benches. And that's when I realized the bench was between my legs.

Figure 7.5. Another bench? Two halves of a similar low bench were found in the same well. This bench, however, did not have a visible hole for a planing stop.

"Pick it up."

For me, the Saalburg workbench is a touchstone and a mystery. As the earliest surviving workbench, it is a link to woodworkers who existed centuries before us. Their tools are remarkably similar to ours. Yet their workbenches are a bit foreign. Many of the benches are knee-high and have workholding schemes that are dirt simple and somewhat alien.

When I've shown images of these early benches to other woodworkers, many have ready explanations for what this peg did or that notch was used for. But they don't really know. The only way to find out – aside from cloning an old Roman woodworker – is to build these benches and build furniture using them. And even then, it's difficult to be certain you are on the right path.

The following is an account of how I built the Saalburg bench. It's incredibly simple – just eight pieces of wood. In fact, thinking about building the bench took much longer than actually constructing it. We'll be discussing both the thinking and the building so that future generations can easily take issue with my assumptions and decisions. Yup, I'm pulling down my pants, academically speaking.

Design Details

There's little doubt that the benchtop that was pulled out of well No. 49 was a low bench, despite the fact that its legs were missing. The top is too narrow (10" on one end; 11" on the other) for a tall bench, and its mortises are angled in such a manner that a low bench makes sense.

But it's impossible to know at exactly what angle the legs were originally oriented because modern legs were wedged into the original mortises when the workbench was put on display at Saalburg many years ago. The legs are still wedged in there, and I don't think they're coming out anytime soon.

So, deciding on the rake and splay for the legs required a little practical imagination. From a woodworking perspective, it makes sense for the rake and splay to be equal – that would make chopping the mortises straightforward and simple because there is only one angle to follow during the process.

[1] The primary problem in interpreting the bench is what 1,800 years in a well will do to a slab of wood. Rüdiger Schwarz at Saalburg explained the problem perfectly that summer when he showed us a wooden yoke that had been pulled from one of the wells. The wooden yoke was shriveled and distorted, like someone had made a Shrinky Dink of a yoke and left it in the oven too long. Next to the yoke was a casting that had been made of the yoke right after it has been rescued from the well. It looked like a new farm implement. Schwarz explained that wooden objects, such as the workbench and the yoke, had distorted noticeably after they dried. So the workbench was likely much less twisted than it is today.

[2] For woodworkers who use "resultant" and "sightline" angles, the legs have a 12.6° resultant angle with a 45° sightline.

After some experimentation on a small model of the bench, I decided to use 9° rake and 9° splay.[2] These somewhat shallow angles kicked the legs out to a sweet spot: With the benchtop at kneecap height, the legs would add stability to the bench but not be a tripping hazard by jutting out wildly from the shadow of its top.

Also, the shallow rake and splay angles ensured that the legs' tenons would be surrounded by plenty of wood on the underside of the benchtop. More radical angles would thin the mortise wall near the edge of the benchtop, weakening the joint.

The second design detail involved the workbench top itself. The original benchtop tapers both in its thickness and its width. The original is 10" wide at the front end and 11" wide at the rear. The thickness is 2-1/2" on the long edge with the dovetail-shaped slots. On the other edge, the slab measures 3" thick in most places and 3-1/2" in a couple places.

After talking about the bench with chairmaker and green woodworker Peter Galbert (and showing him all my photos of the slab), he suspected the top might have been rived from an oak log, not sawn. Aside from the large knot in the benchtop, the grain runs quite straight, which supports Peter's suggestion. Plus, riving a piece of this size would take minutes. Sawing it would take hours. So, if I had built this bench in 187 C.E., I'd have used wedges and a sledge – not a saw.

Today, however, I don't have access to oak trunks of this diameter and quality, so I ended up using a sawn slab of red oak that came from North Carolina. It's 3-7/16" thick. I thought about thinning the slab's thickness on one edge to match the dimensions from Saalburg, but I couldn't see any advantage (other than burning calories). So, my top is of a consistent thickness.

For the legs, I was in the dark. We

Figure 7.6. Broad shoulders. If you are going to rive the cheeks of your tenons, first saw the 1/8"-deep shoulders all around. Mark the depth of the shoulder to guide your sawing.

Figure 7.7. Scribe and rive. Before riving the tenon cheeks, use a cutting gauge to mark out the tenon's cheek shape on both the end grain and the long grain. These knife lines will guide your chisel. Place the chisel directly in the gauge line and knock the chisel in. The cheek will peel off as if by witchcraft.

have no way of knowing their exact size or shape. Based on old paintings, they were square in section, octagonal, round or irregular (branch-shaped). I went with untapered, square legs. Oak. And 2" square x 23" long to fit into the 1-5/8" square mortises. Making the legs this size ensured I'd have a little bit of a shoulder all around to strengthen the mortise-and-tenon joint.

I'm just shooting in the dark with these legs. I chose a square, untapered leg because those are less work than octagonal legs and could be made without a lathe, a specialty machine that might not have been available on the Roman frontier.

I chose oak because it is plentiful, rives easily and is the same species as the benchtop.

Begin with the Legs

I made the legs with their 1-5/8" x 1-5/8" x 4"-long tenons first, knowing I could cut the mortises to a smaller size if I botched a tenon (I didn't). I selected stock with dead-straight grain so I could rive the tenon cheeks instead of sawing them; riving them is much faster.

After cutting the legs to length, I scribed a shoulder line around each leg that was 4" from the top of the leg. Then I used a carcase saw to saw 1/8"-deep shoulders all around, then placed each leg upright in a vise and rived the cheeks away from the leg using a wide chisel and a mallet.

Clean up the legs with a handplane – but don't fuss with cleaning up the tenon cheeks. You never know what results the mortising chisel will give you.

Make Mortises

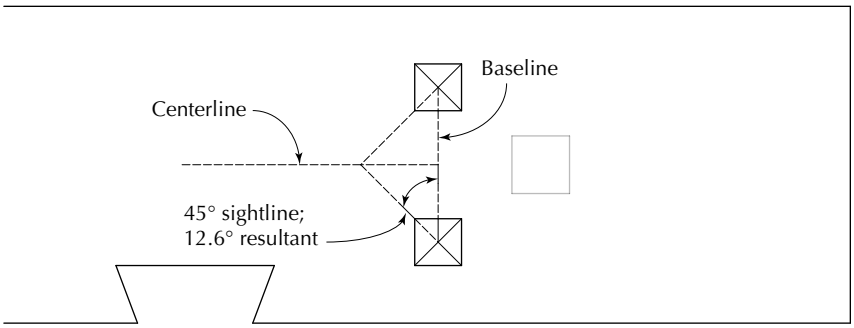
Compound-angle mortises are nothing to be afraid of if you cut them by hand. If you intend to cut them by machine, I suggest you have your head examined. By the time you gizmo up this joint with a router shizmitz, you could have the entire bench assembled and finished.

Because this bench is more like a timber-frame piece than a cabinet door, we're going to mortise this like a carpenter: Bore out most of the waste with a 1-1/2" auger and finish the job with a big chisel.

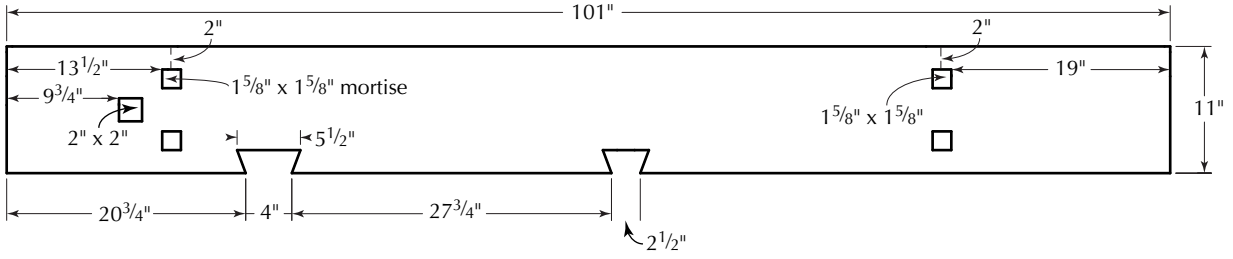
Lay out the mortises using the construction drawing on the top surface of the benchtop. Then lay out the 45° sightlines shown on the drawing. Clamp a sacrificial board to the underside of the benchtop to reduce splintering. Now set a bevel gauge to 12.6°. Place the gauge on the sightline and bore a hole through the benchtop. Use the bevel gauge to guide you.

After boring all four holes, reset your bevel gauge to 9°. This is the setting you'll use for all the chiseling. If you have a second bevel gauge, set it to 81°. This will reduce eyeball gymnastics as you work the four walls of the mortises, but it isn't required.

Use the gauge to guide your chiseling. Work your way down gradually on



Sightlines



Workbench Top

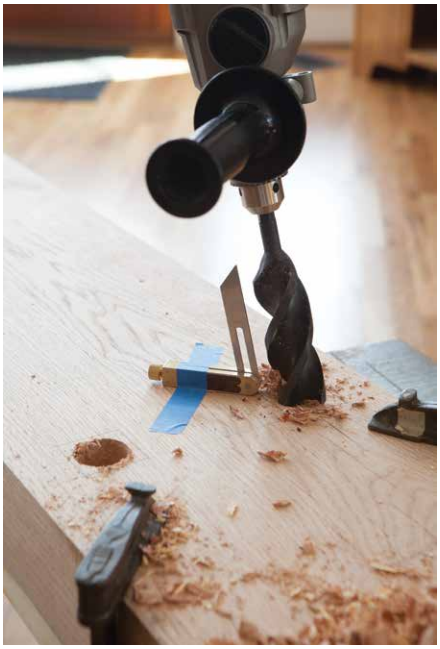


Figure 7.8. Not a masochist. I don't own a 1-1/2" hand-powered auger, so I gladly grabbed my electric drill for this operation. Note the right-angle grip on my drill. If you have one, use it. Your unbroken wrists will thank you.

Figure 7.9. Accurate eyes. If you take your time, you'll be surprised by how accurate your compound-angle mortises can be. Just make sure you eyeball the blade of your bevel gauge with the back face of your chisel before every strike. This might seem a slow way to work, but it's faster than fixing overcuts or undercuts.

Figure 7.10. On your feet. Drive in all four legs, turn the bench over and check your work. If your bench doesn't immediately capsize, you're in good shape.

all four walls of the mortise, moving the gauge as you switch to a new wall.

After you are about four-fifths of the way through the mortise, flip the benchtop over and begin beavering on the underside. You'll be able to lay out the mortise on the underside using the existing mortise and the waste left around the mortise's hole. You don't need this part of the mortise to be perfect. If it ends up a little wider than expected at the bottom, the leg will fit fine. Glue and some good wedges will fix minor inaccuracies.

After you finish a mortise, fit a leg to that mortise and drive it home. Mark that leg and mortise to marry them. Then cut the next mortise.

One More Mortise

Before you put your beefy chisel away, cut the 2" x 2" mortise for the planing stop. Compared to the compound-angle mortises, this hole is kid's stuff. It's so easy that it could have been a nice little warm-up before tacking the leg mortises. Um. Oops. Oh well.

Bore out the majority of the waste with the same auger you used for the leg mortises. Clean up the walls with the same wide chisel. The only difference is that you can use a try square (instead of a bevel gauge) to guide your chiseling. And you can easily mark out the exit wound on the underside of the benchtop.

With the planing stop's mortise complete, fit the wooden stop to the hole. This is a matter of driving it in and planing away the high spots until you get a tight fit. The stop should be adjustable with one-handed mallet blows, moving about 1/8" up or down with each blow.

If it moves .001" with each strike or falls lifelessly out of its hole, try again.

If you have a metal planing stop, this is the time to marry it to the wooden one. Usually metal planing stops have a tapered metal tenon that is square in section. For the mortise, I drill a stepped hole. The first hole is the same size as the dimension of the metal tenon at its top, right under the teeth. For my stop, this was 3/4". So, I drilled a 3/4" hole into the stop. The hole's depth was equal to about half the length of the tenon.[3]

Now measure the tenon's thickness at its smaller tip (mine was 5/8" thick). Drill a 5/8" hole that is a little bit

[3] "But wait," I know you are asking. "If the hole is the same size as the tenon's width, how will things stick together? The answer is to measure the metal tenon from corner-to-corner. That dimension is larger than when measuring the tenon from cheek-to-cheek.

Figure 7.11. All marked up. Here is the underside of the benchtop as I finish the mortise for the planing stop. Lots of pencil lines. Lots of sneaking up on the right dimension. Lots of sharpenings (after each mortise) ensures the walls are crisp.

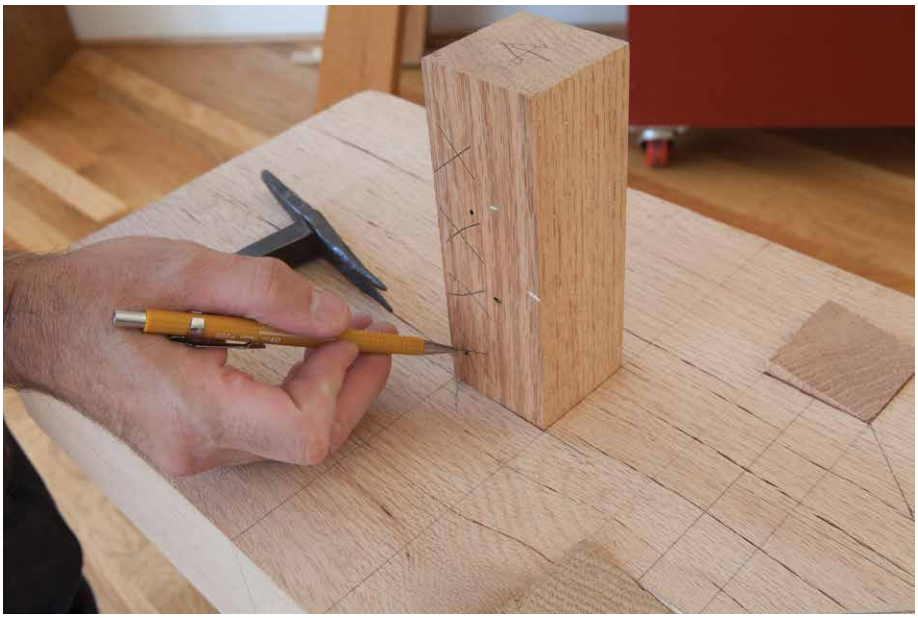


Figure 7.12. Fit the stop. Drive the 2" x 2" x 8" stop into the mortise until it stops. Mark where things are too tight and plane away those areas. Repeat.

deeper than the tenon is long.

Now, if you drive the planing stop into this stepped hole, it will stick just fine. You can go this route, or you can also put some epoxy in there (because you secretly love epoxy, your grandfather used it for everything and you have some lying around).

Now for the Weird Notches

I call the dovetail-shaped notches (and the wood that goes in them) "side stops." This name isn't based on anything in old books. Instead, the name is based on their function. I use these bits of wood like planing stops. And they restrain the work from the side (instead of the end). Hence, side stops. Call them what you like.

Lay out the dovetail-shaped notches using the construction drawing as a guide. The notches are 1-1/2" deep, and the ends angle at 25° off 90°. The length of each stop is a little different – the one toward the front is 5-11/16" at its widest. The other stop is 4-3/16" at its widest. These measurements and angles are based on the original bench.

Saw the walls of the notch (I used a panel saw), then saw a few kerfs in the middle of the waste to make it easier to remove. Chisel out the majority of the waste in big chunks. As you get close to the baseline of the notch, pare the flat area with care so you don't cross the baseline – it's just like dovetailing.

Now make the wooden stops that fit into the notches. I made my stops 2" thick, which makes them protrude from the 1-1/2"-deep notch. This is a detail found in one of the old paintings of Joseph at his bench. Is this necessary? I don't know.

Just like with your planing stops, the side stops should fit snugly and require a mallet blow to adjust.

Assemble the Bench

The bench is easy to assemble. The only critical detail is to make it easy to re-

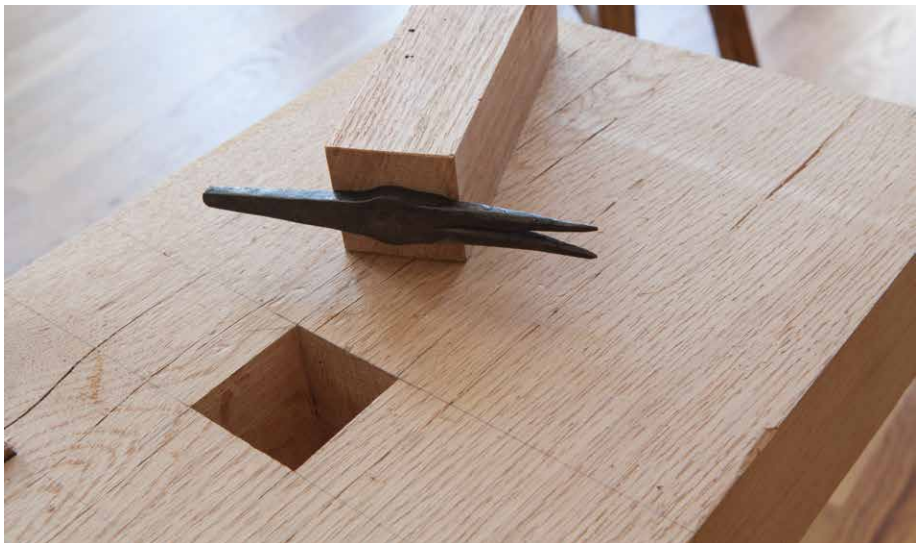


Figure 7.13. Ready for stopping. An adjustable metal planing stop is a wondrous thing. This iron one was made by blacksmith Peter Ross and is based on a stop recovered from Saalburg. And that is why you need to get to know your local smith.

Figure 7.14. Both sides now. Lay out the notches for the side stops on the top and bottom of the benchtop to assist accuracy.

Figure 7.15. Big chunks, please. Chisel out most of the waste using a wide chisel. Try not to cross the baseline.

pair in case the bench ever falls into a well. For that reason, hide glue is the best choice as an adhesive. (In fact, you could probably skip the adhesive if your joints are snug.) Also, it's best to wedge the tenons in place. If the bench ever requires repair, you can soften the glue with heat and water, pry out the wedges and remove the problem leg.

For some large-scale work with square tenons, I prefer to orient my wedges diagonally across the tenon. This spreads out the tenon against all four walls of the mortise. The disadvantage to this approach is that there's a chance of splitting the benchtop. In large-scale work, however, this is a minimal risk.

Begin by sawing a kerf through each tenon to accept a wedge.

The wedges need to be about 3" long and 2-3/4" wide (or you can use two smaller wedges). I prefer oak wedges because they can take a beating, but I had only ash available in the right size. Ash is a good second choice.

Saw out the wedges so they have a fine tip – a 4° included angle is what I shoot for. If the tip is too fragile, you can make it blunter by quickly cutting away the fragile part during assembly.

Paint hide glue on the walls of the mortise. Then paint a fine coat on the tenon cheeks as well (this assists in wetting the joints' components). Then do the same with the remaining three legs. Turn the bench over and prepare to wedge the tenons.

It's easy for things to turn south at this point. The wedges could split or even bounce out of the kerfs when you drive them in. So, it pays to have plenty of wedges on hand with different tips. My first action is to open the kerf in the tenon a bit with a cold chisel. I drive this in with a small sledge, deforming the opening of the kerf. This makes it easier to insert a wedge. Then I pick a wedge with a tip that looks right for the opening I've created.

Figure 7.16. Corner to corner. Choose your saw based on how tight the joint is. If your joint is loose, use a fine tenon saw. If it's tight, use a rip panel saw or full-size ripsaw. Mark your diagonals with care so they line up in some sort of pattern or it will look disconcerting.

Figure 7.17. Ready to go. No matter how simple or complex the assembly is, it's best to place all the parts near their joints and double-check your work.

I paint a thin coat of hide glue on the faces of the wedge and drive it in with a small sledge. During this process, I keep my eyes on the wedge. If the wedge moves when I strike it firmly, I hit the wedge again. If it stops moving and the "thunk" sound changes, I stop hitting the wedge.

While the glue is still wet, I clean it up with an old toothbrush, rags and warm water.

After the glue has dried overnight, flush the tenons to the benchtop. I protect the benchtop with some masking tape and use a flush-cut saw. This approach leaves only a little material to plane away afterward.

Clean up any tool marks with a plane.

Level the Legs

The best height for the bench is right below your kneecap. That will make it ideal for sitting and handsawing. My bench ended up at 21" tall. Determine the desired height of your bench, sub-

Figure 7.18. That's cold. Open the kerf with a cold chisel before driving in the wedge. This reduces the chance that the wedge's tip will crumple as you drive it.

Figure 7.19. Saw around. Kerf the tenon on all four cheeks before committing to sawing all the way through. The kerf will help guide the saw and prevent it from scarring the benchtop.

Figure 7.20. Marking a compound cut. The top of the 4x4 represents the floor of your shop. Move the "floor" around and use a half-pencil to scribe the "floor" onto each leg.

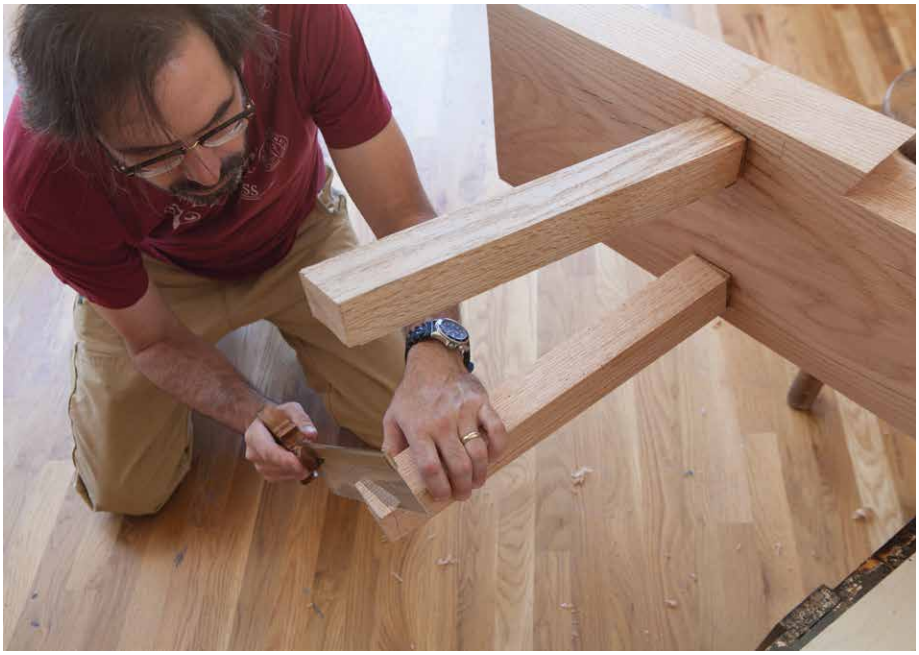


Figure 7.21. Follow three lines. Kerf the one line on the foot. Then tilt the saw to kerf the two adjoining lines that you can see. Then saw through.

tract the thickness of your benchtop and cut a 4x4 to that length. That 4x4 will mark your legs so the feet sit flat on the floor.

Turn the bench over and place the 4x4 on the underside of the benchtop. Plane a carpenter's pencil in half and place it on the end grain of the 4x4. Maneuver the 4x4 around each leg so you can mark all four faces.

Turn the bench on its side and cut the four feet to final length.

I finished the bench with a coat of boiled linseed oil, which doesn't impart a slippery film finish and offers a little protection against glue spills. The finish is pretty irrelevant because this bench is going to see a hard life, and its top will become pocked with dings and cuts.

With some luck, however, the bench will also see a long life that's free from wells and Germanic invaders.

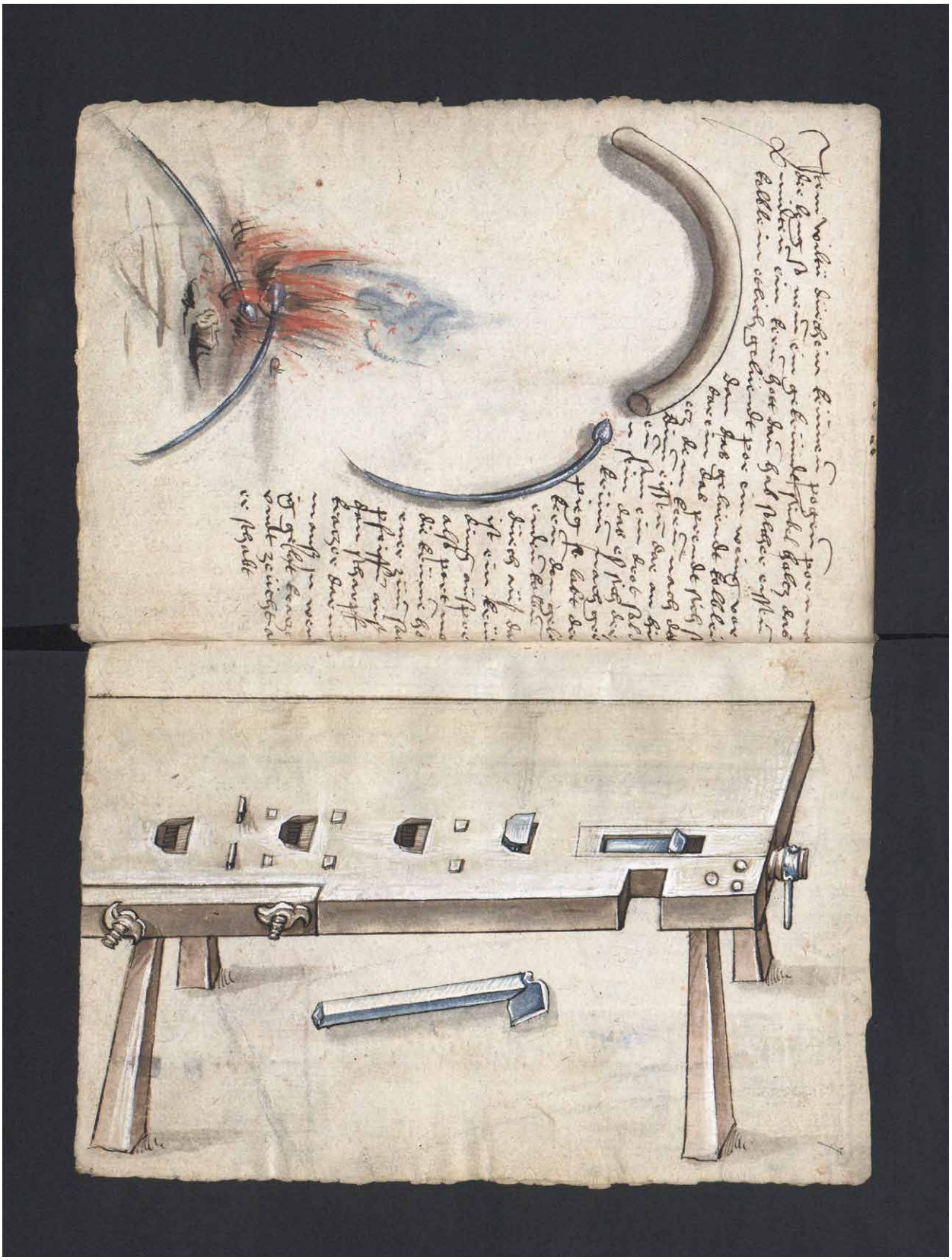


Figure 8.1. The other Löffelholz bench. Shown opposite instructions for burning out the center of a branch, this workbench image shows heavy square dogs and a notch for tenoning.

VIII

'Auf Wiedersehen' to Your Dollars

My research on the 1505 workbench drawn by Martin Löffelholz began when I saw a sketch of it in "Das Werkzeug Des Schreiners und Drechslers" ("The Tools of the Woodworkers and Turners") by Günther Heine.

The bench also shows up in Scott Landis's "The Workbench Book" (Taunton Press), which is where most bench nerds have spotted it.

It's a shocking image for 1505: a staked workbench complete with a twin-screw face vise, a screw-driven wagon vise and a series of dogs.

To me, that image represents the 16th-century woodworker flipping the bird to all future centuries. By 1505 (and perhaps earlier), engineering minds had created the modern workbench – 200 years before it became commonplace.

But who was Löffelholz? Did he invent the bench or see it in a workshop? How did Löffelholz describe the bench and its mechanisms?

At the time I saw the image, there was no internet to speak of. And I couldn't learn much about Löffelholz in our local library or find a copy of the 1505 text that the image came from.

So, during the last 15 years, "Martin Löffelholz" became one of the things I would idly search for during late nights with my laptop. I hoped that someone would scan something in some European library, and that I would get lucky. In early 2016 – like living a letter in *Penthouse* magazine – that actually happened.

Figure 8.2. Martin Löffelholz.

I found a document in the digital archives at Jagiellonian University in Kraków, Poland, titled: "Löffelholtz-Kodex…" (Löffelholz Codex: Illustrations and descriptions of all kinds of hand tools, torture instruments, hunting devices, weapons ... and other items of entertainment"). How did the codex get to Poland? I don't know. Earlier it was listed in the collection of the Berlin State Library.

In any case, there it was: 82 images of a codex (a codex is an ancient handwritten form of book) filled with color illustrations and descriptions of tools, torture devices, office equipment and two workbenches. In addition to the two workbenches, which are similar, Löffelholz drew a separate page that illustrated the inner workings of the wagon vise.

I squealed.

As exciting as the drawings were, I was more intrigued by the text. Each drawing was accompanied by tightly written script, presumably describing the items on the page. Here, finally, was an explanation of the workbenches and vises in the codex.

My German language skills are limited to ordering weissbier at a gasthaus (hold the ball gag, bitte), so I needed help. Luckily, a fair number of German speakers read my blogs, despite the language obstacle. (Finally, the

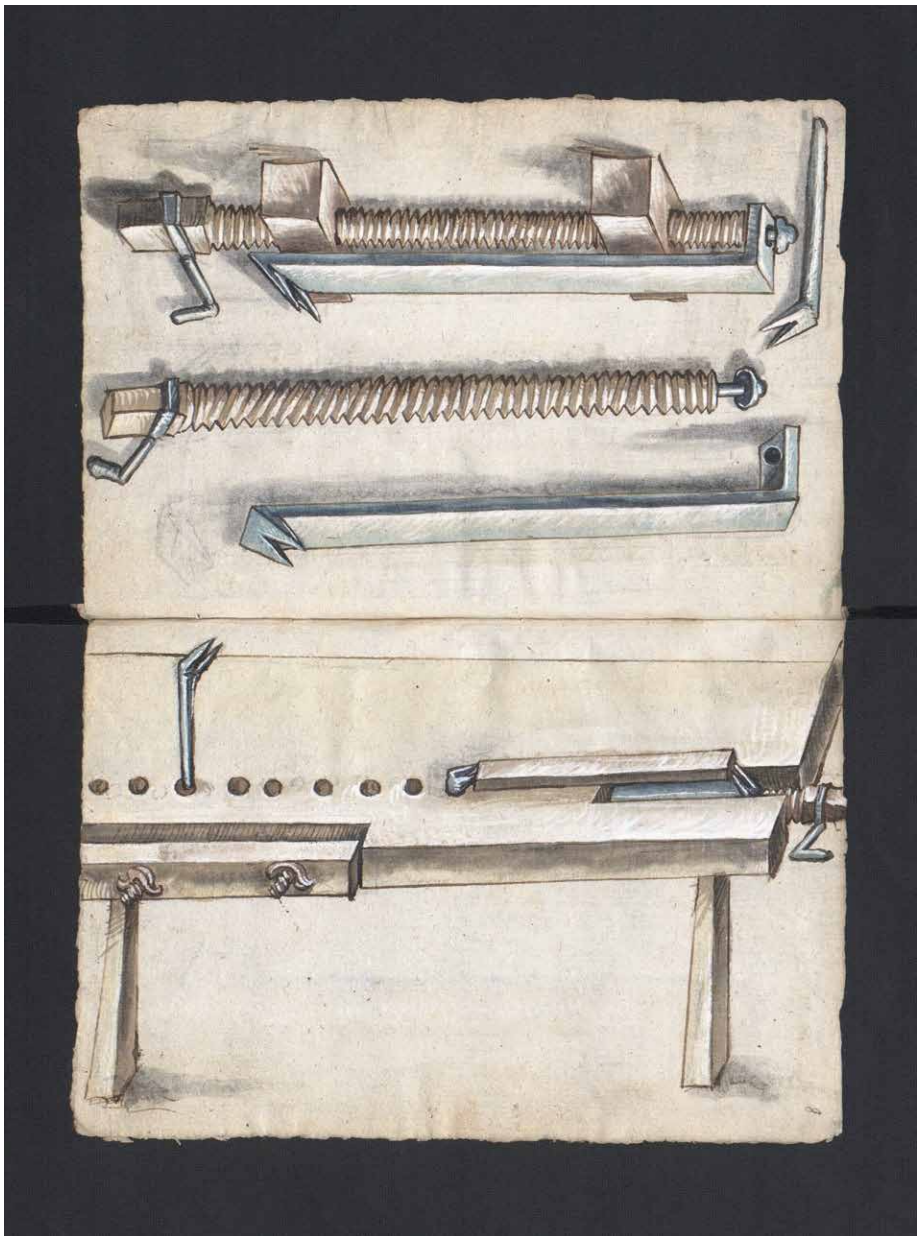


Figure 8.3. Hold this. This 1505 drawing of a workbench is perhaps the first representation of a modern workbench with a tail vise and a face vise.

Schwarz name pays off.)

I received dozens of offers of help. After reading their qualifications I selected a handful of people who seemed promising – they were woodworkers, perhaps did some translating for their jobs and were enthusiastic.

I sent the codex to all of them and asked: What do you think? All of them gave me the same answer: I cannot read Löffelholz's handwriting.

I had braced myself for this reply. I myself had tried to make sense of the handwriting on the page next to the workbench. To my eye, the script looked more like a venereal disease under a microscope than written word.

So now I had to first find someone who could read the handwriting and transcribe it. Then translate it. And then I might know what Löffelholz wrote about workbenches in 1505.

Luckily, one of the Germans who volunteered to help was Görge "doesn't take nein for an answer" Jonuschat.

Enter the Görge

Görge is an architect, woodworker, tinkerer and someone who always seeks to be busy with interesting projects. "If there's nothing to do, I get bored easily – frankly speaking," he wrote to me. "I can hardly just sit around."

So, between architecture projects, Görge looked for someone who could read 16th-century handwriting. He had no luck in Poland with the university that owns the codex, but he eventually found Dr. Walter Bauernfeind at Stadtarchiv Nürnberg (the City Archives at Nürnberg).

After some negotiations and persistently polite letters from Görge, Dr. Bauernfeind kindly agreed to transcribe sections of the codex for an hourly fee. Transcribing the entire codex would have been a massive project and cost more than a new automobile. So Görge went through the codex and isolated the sections related to woodworking, tools and carpentry.

Note that as a result of this process, we saved thousands of American dollars (thank you, Görge!), but we also missed out on a 1505 love potion as a result (Boo!). Such is woodworking journalism.

In April 2016, Görge sent me an enormous electronic document that was the result of years of searching, months of investigating and weeks of transcribing and translating. It's a fascinating 154-page document that reflects Dr. Bauernfeind's lifelong mastery of early German text and Görge's dedication to untangling that early German into a translation I could read.

But there's not a single word about the workbenches.

Because it hurts, let me repeat that: After untold hours of research and more than a thousand dollars spent

on this or that, we had nothing. Every other image in the codex had a caption we could translate and turn into a master's thesis.

Löffelholz went into great detail on how to keep wolves from following you in the forest. He gleefully related how to split logs with gunpowder. There's a recipe for stew. An explanation for how to pick a lock with gunpowder and details on how to make a portable woodworking vise (more on that topic some other day).

But not a word on the workbenches. Nothing.

Mr. Spoonwood is Silent

There are a few possible explanations for why the codex does not describe the workbenches or vises. Quite possibly, Löffelholz had nothing to say (though he wrote about every other image in the codex in some detail). Another explanation: the pages were lost or removed some time after the codex was written.

The second theory has not been legitimized by any scholar that I know of, but a 1933 essay by Franz M. Feldhaus in "Mitteilungen des Vereins fur Geschichte der Stadt Nürnberg" ("News from the Association for the History of the City of Nuremberg") offers an oblique suggestion.

Note that the Rugsamt mentioned below was a jurisdictional court specifically for hearing issues on trade and craft. This essay was also translated by the ever-steady Görge.

(W)e know the Council of the City of Nürnberg and the Nürnberg Rugsamt made trade people's lives difficult, because they were eager to hear reports and complaints of envious guild fellows.

This is the reason for a series of significant inventions in Nürnberg, that we know of that have never been put into full practice. It would be beyond the scope of this chapter to elaborate

Figure 8.4. Can you read this? Me neither. That's why we had to get the handwriting transcribed into German and then translated into English. By the way, these are instructions for splitting a tree trunk with gunpowder (not Peter Follansbee approved, I suspect).

Figure 8.5. Is that You Mr. Ed? Sometimes I wonder if this redacted portion of the codex is some missing text that discusses the workbenches. The barnyard animals aren't telling, unfortunately.

on these. Suffice it to say that the concept of a modern lathe spinning at high speed has been known to Nürnberg and already implemented centuries ago.

But the Rugsamt, respectively the Council, intervened every time, prohibiting use of such lathes by craftsmen, having the machines crushed or the owner locked up in the tower.

The minutes of such meetings are extremely brief. Only in a few cases it has been possible at all to recognize the technical value of such inventions from Nürnberg. But in the illustrated Löffelholz manuscript we may witness the high technical standard that had been achieved in Nürnberg 425 years ago….

It doesn't take a Fox Mulder to weave a conspiracy theory about the workbench images shown in the codex: Someone redacted the descriptions of the workbenches. The obvious objection to this conspiracy theory is, however, this: Why not remove all the pages on the workbenches, including the drawings?

After all, even a half-clever woodworker could build these benches with the drawings (as you are about to see).

So, after months of effort and lots of dollars flushed down the toilet, I knew exactly as much about this bench as the first time I saw the Löffelholz workbench in a German book while sitting on the bed of a Chicagoland hotel room in the early 2000s.

It was disheartening, but we had explored the text in full (thanks again, Görge). So the only task left was to decode the three drawings in order to bring the Löffelholz workbench to life.

Who was Martin Löffelholz?

Martin Löffelholz didn't sign his name to the 1505 codex. Instead, his identity was determined by the document's date, the coat of arms on its cover, a genea-

logical register of patricians from higher nobility and handwriting samples.

The Europeans love their history stuff. It's amateur hour over here on our side of the Atlantic.

As an addendum to Feldhaus's 1933 essay on the codex, Dr. Emil Reicke offered a biographical sketch of Löffelholz, who Reicke characterized as a knight and technician. The following is my attempt to summarize Reicke's account.

We don't know when Löffelholz was born, but his parents were married in 1465. In his youth, he left Nürnberg for Bohemia to become an armed cavalier in service of Herr von Tschornhorra.

He shows up in the historical record in 1496 when he participates in a tournament with other knights, including the Margrave Friedrich the Elder. During the tourney, Löffelholz unwittingly unhorsed the Margrave – the Margrave had been in disguise. (Note: This is like trouncing your date at Galaga; no good can come of it.)

Once Löffelholz realized what he had done, he let the Margrave unhorse him later in the tourney and Löffelholz told the Margrave: Wow, you hit me hard.

After sucking up hard to the Margrave, Löffelholz got married a year later to Anna Haug, who belonged to an important family. They had one child, who died from the plague.

Right after getting married, Löffelholz was named the caretaker of Nürnberg's Castle Lichtenau near Ansbach. On Christmas Eve in 1507 (two years after starting the codex), Löffelholz rode out to hunt some rabbits.

Figure 8.6. The Löffelholz family crest.

This was a bad idea. Local Nürnberg council members had warned Löffelholz that things were unsettled in the area (aka, the Margrave was still pissed about being unhorsed) and that perhaps Löffelholz should avoid hunting.

At the time, it was common for people of wealth to be captured and ransomed back to the family for crazy sums of money. And that's what happened to Löffelholz. Captured by four chevaliers, Löffelholz and his farm hand were taken to Freystadt near Allersberg. The farm hand and the horses were released, but Löffelholz was locked in a vermin-infested tower of Schwarzenburg Castle (no relation, I hope).

The Nürnberg council observed a ban on paying ransoms, even after Löffelholz wrote a pathetic letter about the "uncanny worms" in his tower and how he was locked up by hand and feet. As the hostage situation dragged on, the captors threatened to cut off his hands, feet and all his hair above his ears.

In the meantime, his poor wife tried to make ends meet by renting out the castle at Castle Lichtenau for baby showers, parties and weddings. (Alas, the Nürnberg council shut that down.)

Meanwhile, Löffelholz attempted to escape by stealing a rapier off a guard, hiding it in his clothes then trying to run off after going out for a pee. He failed and was severely wounded during his attempt.

After 60 weeks of confinement, Löffelholz was released after the captors were paid half of what they asked, plus a sum for feeding him for 60 weeks (I know; weird).

After his release, he remained the Keeper of Lichtenau for 18 years. His first wife died in about 1520; he remarried, then was fired from his job in 1527 due to his "dissolute and inept nature." He died in 1533 and was buried at St. Johannis, a district in Nürnberg.

Did he invent the devices in his codex? Scholars can't say. Many patricians were also inventors. But other scholars, including Feldhaus, suggest Löffelholz collaborated with the artistic blacksmith Hans Ehmann.

We may never know. But we do know that Löffelholz wrote the words and drew the pictures – they are from the same hand and were entered into the codex during a long period of time.

Figure 9.1. It's real now. "The wish is the father to the thought." English expression, perhaps taken from William Shakespeare's play "King Henry IV Part 2" (1597).

IX

Holy Roman Workbench

The 1505 workbench drawn by Martin Löffelholz during the reign of the Holy Roman Empire is separated from the bench at Herculaneum by almost 1,500 years. But the differences between the two seem cosmetic at first.

Both stand on feet that are staked into the benchtop with compound angles to add stability to the bench. Both have holes in the benchtop for workholding devices. Neither has stretchers nor a shelf. But the Löffelholz bench features two stunning details that earn it the title of the first modern workbench (until we dig up an earlier one, that is).

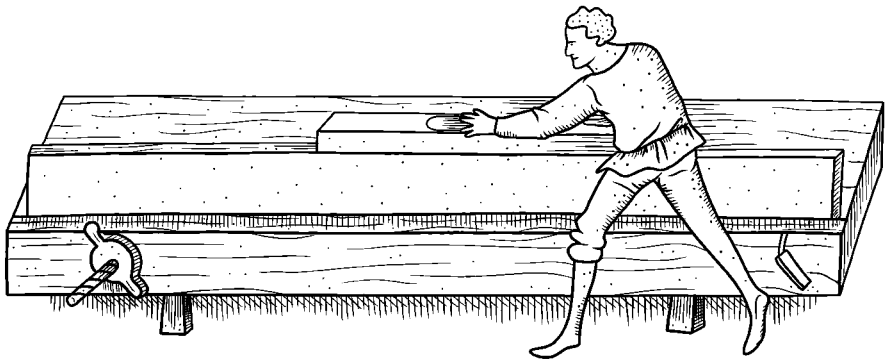


Figure 9.2. Early vise. Face vises were known before Martin Löffelholz drew his workbenches. This is a 14th-century Italian vise.

The bench has a twin-screw face vise on the left side of the benchtop. While this on its own might seem as if it's big news, it's not. Twin-screw vises on the front of a workbench have been around since at least the 14th century.

Instead, what's important about this "Holy Roman bench" is the vise on the right side of the benchtop. It's a screw-driven end vise and is indeed a "new thing" for 1505. It's the combination of the twin-screw vise, the end vise and a series of holes for dogs that is historically stunning.

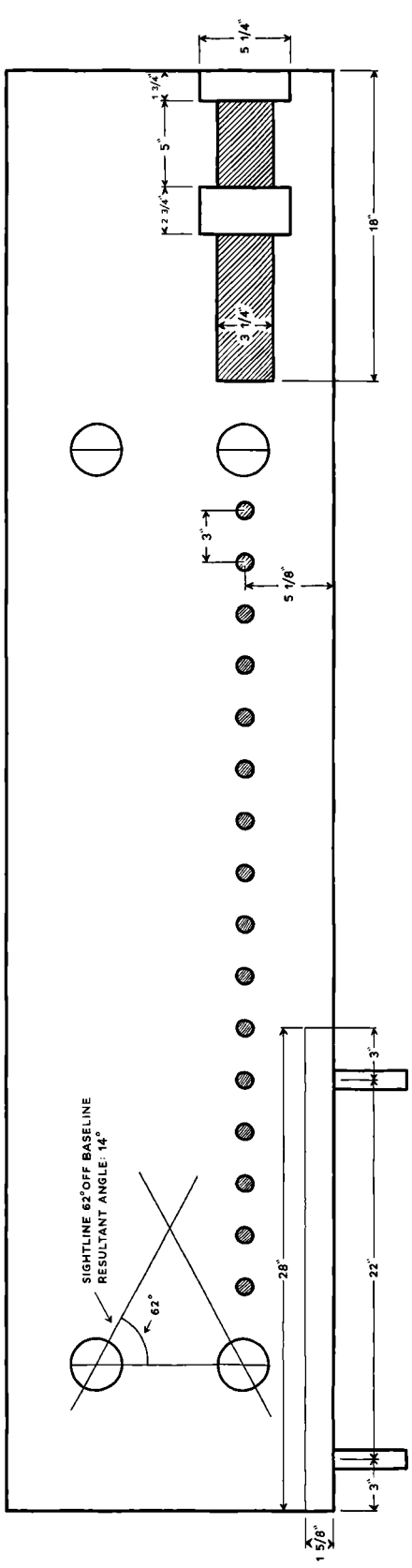
Throw on a couple stretchers and the bench would be functionally identical to a German workbench from the 19th or 20th century. So, the Löffelholz workbench is important because you could easily say it represents the peak of workbench evolution; almost everything else from that point on was a copy, an adaptation or was retrograde.

Five Slabs

My bench is built using massive red oak components. The top is 4-1/4" x 19" x 83-1/2". The legs are 5" x 5" x 34". All the parts came to me sopping wet. So wet, in fact, that my moisture meter said they were off the charts (meaning they were 60 percent moisture content or more).

If you can use wet wood for a bench, that greatly simplifies things for the builder. You can buy fresh-cut thick slabs (4" to 6" thick) from sawyers and not have to pay to have it kiln-dried. Drying a thick slab correctly is a difficult task for standard commercial kilns.

There are some challenges to overcome when using wet wood, but it's definitely doable.



Benchtop Plan

Figure 9.3. Two true. Plane one face flat. True one edge of the slab. Then make the opposite edge parallel to the first. Finally, make the second face parallel to the second. All this fussing will make installing the vise hardware much easier.

The first challenge comes when processing the stock. Unless you have industrial machinery, you are best off using hand tools. Regular home-shop machinery isn't up to the task. The wood is just too thick and wet. I attempted to work on the legs with my 3-horsepower table saw. No luck. The saw froze up immediately. I then tried my 14" band saw, which never stalls. Dead in the water (literally, because the wood was so wet).

Hand tools have no problem; in fact, wet wood is easier to work by hand in most instances.

So, I planed the top and legs to size with a jack. For the benchtop, it's best to four-square the slab because the joinery is measured and marked on the underside of the top.

The legs need to be tapered. They start at 5" x 5" at the feet and taper to 3-3/8" at the top. The jack plane is the tool for this job. It's easier than you think when the wood is wet and you're planing downhill.

The biggest challenge in processing the stock was crosscutting it. The moisture in the wood was not going to give my 8-point handsaw passage through its fibers. As I began to saw, the wet wood heated up and swelled the kerf shut, grabbing my sawblade like a politician's handshake.

The solution: A jobsite handsaw with induction-hardened teeth. These $20 saws are deliberately overset. That's annoying when doing nice woodworking in fine hardwoods. But it's exactly what you need when slicing up sopping-wet slabs.

Lay Out the Mortises

Use the illustration at left to lay out the location of the mortises and the 62° sightlines on the underside of your benchtop. Set your sliding bevel to 14° off 90° – that's your resultant angle for the legs. Place the sliding bevel on the sightline.

The mortises are 3" in diameter. I used a saw-tooth Forstner bit equipped with a lead screw. This bit, normally used in the construction trade, is a bit expensive, but it makes short work of the boring.

To drive the bit, I used a corded drill. And to ensure I drilled at the correct

resultant, I had a spotter watch my progress during the cut.

This is when I discovered another oddity of wet wood. During the first mortise, the spotter yelped: "Stop. I think the wood is on fire."

Sure enough there was a plume of smoke rising from the mortise. But it didn't smell like fire. It smelled like someone had barfed in a Pier 1 store. After pulling the bit out we realized the "smoke" was actually steam. The bit was hot, but it's difficult to light a swamp on fire.

I drilled on. Also, and I hate to remind you, don't forget to clamp a backing board to your work to prevent splintering when your bit forces its way through to the other side.

Tenons

The tenons on the legs are 5" long and are best made on a lathe. I mounted the legs in a midi-lathe (I believe each leg weighed as much as the lathe) and turned the tenons at the slowest speed possible.

If your legs are green wood, I'd turn the tenons to 3-1/8" in diameter. The wood will shrink in short order, especially if you are building the bench in a climate-controlled shop. My recommendation is to use dry wood for the legs and let the benchtop shrink around them. But I didn't have that luxury.

If you can, set the legs aside for a week, month or more to let them calm down a bit. If the tenons are still too big after a rest, turn them down until they fit tight into the mortises. The last step before assembly is to kerf each tenon for a wedge. I cut the kerf with a ripsaw and sawed just shy of the tenon shoulder.

Assembly

Putting the bench together is just like assembling a simple bench or stool. Paint the mortise and tenon with hide glue. Drive the leg home – be sure to

Figure 9.4. Where there's smoke. The heat of the bit combined with the sopping wet wood resulted in a plume of steam. It was alarming at first, amusing at second and annoying at third.
PHOTO BY MEGAN FITZPATRICK

Figure 9.5. A steady hand. When turning heavy and wet work, start with a slow speed to avoid vibration. You can creep the speed up a bit as the tenon is roundish. You'll definitely know when it's running too fast.

Figure 9.6. Not the last time. As everything dries out, you will need to plane the tops of the tenons flush to the benchtop several times. A heavy plane helps get things close to flush. A small plane finishes the job.

Figure 9.7. Below grade. If you cut your tenons a tad short, it will be easier to flatten the benchtop after assembly.

On Second Thought

After assembling this bench, the legs shrank considerably and had to be re-glued and re-wedged. That's when I got smart and cut the tenons a bit short.

When the bench was reassembled, the ends of the tenons were about 1/16" below the benchtop's surface. This made flattening the benchtop a snap. I first chiseled the wedge down flush to the tenon, then planed the benchtop.

Because the end of the tenon was recessed, the flattening went much faster – I only had to plane the tough end grain for a couple passes during the process.

rotate the leg so the kerf in the tenon is perpendicular to the grain in the benchtop.

Flip the bench over. Take your wedges (my wedges were 4" long and had a 4° included angle at the tip) and paint them with glue. Drive the wedges home and wait for the glue to dry.

After everything is dry, cut down the protruding tenons and plane the top flat. During the next month, keep an eye on the tenons. If they continue to shrink as they dry, drive wedges into any gaps that appear. Everything will settle down within a year or so.

In my case, the legs were quite wet and shrank more than the top. As a result, I had to re-glue and re-wedge the legs twice during the first year of service.

The Face Vise

The face vise is a fairly standard twin-screw vise with one exception: The vise's jaw is notched into the benchtop instead of being proud of it. I am fairly certain that this example is the only one I know of – though I have no doubt it's been done before.

Which raises the question: Why? My best guess is that it's a way to conserve wood. If you are careful, you can notch the benchtop and use the off-fall as the jaw.

Having the vise's jaw inset into the front edge presents some difficulties when working. Edge-jointing pieces longer than about 5' is awkward. You can clamp them in the jaw one of two ways: so the excess protrudes off the left side of the bench, or so the excess is elevated over the benchtop.

Both methods work. Having the work suspended over the benchtop has the fun advantage of being able to plane downhill.

The jaw is 1-5/8" wide x 28" long. When you add the screws and vise nuts, you want to end up with about 20" of clamping area between the two

screws. That 20" dimension is about as wide a board most people have to dovetail.

The first step is to make the notch and remove the jaw piece from the benchtop. Lay out the rip and the crosscut. I started with the rip cut. After making the 28"-long rip with a ripsaw, I clamped the jaw and the benchtop together so the jaw wouldn't splinter off as I finished the crosscut.

Crosscut the jaw free of the benchtop. Clean up the inside of the jaw and the notch in the benchtop with planes and chisels. Try not to remove too much material.

The Vise Screws

I made my own vise screws and vise nuts using hard maple, a fine-grained wood that holds good detail. I made the screws and tapped the nuts with a 28mm German threadbox and tap that's metric. To do the job correctly, you'll also need a 23mm Forstner bit.

Begin by making the screws. Turn down some 12"-long maple sticks to 1.10" in diameter. Leave 2" of each stick square or shave each to an octagon. After turning the sticks, clamp the square section of each stick in a vise and use the threadbox to cut the threads. Keep the threadbox's cutter lubricated with something dense and slippery, such as mutton tallow.

Next bore the 23mm holes in the benchtop. Make them about 4" deep or whatever your bit can handle. Tap the 23mm holes with your tap and clean the debris from the holes. Cut your screws to final length. You want the screws to protrude about 6" from the jaw.

Carve a detail on the end of each screw if you like – a sphere is traditional – then glue the screws into their threaded holes. The fit will be a bit loose. So, use epoxy, which will fill the gaps, and clamp the screws so they protrude perpendicularly from the hole.

Figure 9.8. Overhand ripping. Ripping the chop is a fantastic lesson in overhand ripping. This technique can be used with the teeth facing the operator or away.

Figure 9.9. Finish it. Clamp the chop as shown to prevent it from splintering when you have sawn it free. Clean up the chop and the notch with chisels and planes.

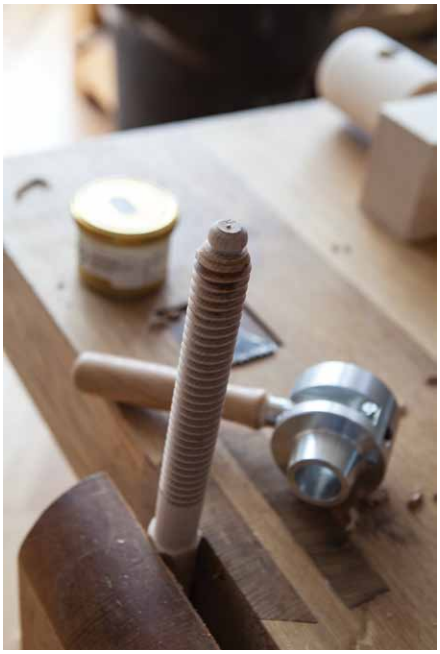


Figure 9.10. Around and around. Threading wood is about steady pressure, steady rotation and avoiding cross-threading the post (with either too much or too little pressure). Practice on a couple sticks before you go for broke.

Figure 9.11. Drill and tap. The hole for the post should be deeper than you want the post to go. Tap the hole. Here I'm using an adjustable wrench to hold the tap. This is not ideal, but you can do the job this way if you focus on keeping things vertical.

Figure 9.12. Keep it up. There will be slop between the fit of the screws and holes. Epoxy will fill the gap. A try square can confirm the post is truly vertical to the front edge of the benchtop.

(Note: Another other option for installing the screws is to do what I did in the chapter on workholding: Leave one end of your screws unthreaded and glue that section into a hole in the benchtop.)

Check them with a square. Check them again.

The jaw, also called a chop, is easy. Drill 1-1/4"-diameter holes in the chop to clear the vise screws. Apply cork or suede to the interior of the jaw and the notch to improve its grip.

The vise nuts can be any shape you please. I used 1" x 5" scraps of maple. I bored a 23mm hole through the center of each, then shaped the nut like a hurricane on a weather map. This is a traditional shape for the time.

I made several attempts to make the nuts. I twice used geometry and it failed me (it looked too sterile). So, I drew the shape of the nuts entirely freehand and those organic nuts were perfectly imperfect.

I cut them out using a coping saw

Figures 9.13 & 9.14. First nut. This nut shape was based on simple geometry. I didn't like it.

Figure 9.15. Third nut. This shape I drew freehand. No compasses or French curve. This nut I liked.

Figure 9.16. In place. Most of your questions about the layout for the tail vise can be answered by laying out the components on the benchtop. Use the components – not measurements – to draw in your lines.

Figure 9.17. Two long rips. Lay out the long rips for the notch and saw them with a coarse ripsaw. When the saw is vertical it will cut quickly. Varying the angle – forward and back – will help the saw track vertically.

Figure 9.18. Drill and chop. Remove the waste between your two long rips. I bored a few holes at the end of the notch and levered out the waste with a heavy chisel.

and shaped them with a rasp. Be sure to round over all the edges of the nuts with a rasp. The soft edges are what your fingertips need to operate the vise.

The End Vise

Löffelholz's drawings for the end vise are a bit of a puzzle. The drawing of the overall bench shows the vise screw suspended without even a vise nut. (It also shows a bench leg sticking right into the vise area.) Perhaps Löffelholz didn't draw the vise nut so you could see clearly that the vise screw was threaded. Perhaps he thought the construction was obvious because of the other drawing dedicated to the end vise.

The end vise drawing shows the vise screw and the moving dog by themselves at the top of the drawing. Below is shown the vise assembled with two additional blocks of wood. At least one of these has to be the tapped vise nut. The second one could be a vise nut or just a bushing that guides the screw and supports the moving dog.

I played around with making both blocks of wood tapped. The complication with that idea was that the blocks had to be precisely located a certain interval from one another or the screw jammed. The much simpler solution was to make one of them a threaded vise nut and the other one a simple bushing.

After some thought, I decided to make the left block as the threaded vise nut; the right one is a simple bushing. The vise would likely work just as well if you reversed their positions.

All this thinking is the easy part. Excavating the cavity for the screw and blocks is a fussy task that took as much time as building the remainder of the bench. You need to keep multiple sur-

Figures 9.19 & 9.20. Kerf and chop. Waste away as much as possible of the material for the bushing with saw cuts. Then chop the remaining waste away. Confirm the walls are perpendicular and square throughout the process.

faces in alignment for things to work. I had the further challenge of dealing with a benchtop that was still drying and moving. Anticipating this problem, I made the vise nut somewhat adjustable, and I'm glad I did.

The cavity for the vise screw is 18" long and 3-1/4" wide. I decided on this measurement to accommodate a commercially available 2-1/2"-diameter wooden screw. Lay out this long trench on the benchtop so it begins 3-1/2" from the front edge of the benchtop. Cut the two long walls with a ripsaw. To remove the waste between the walls, bore a series of overlapping large-diameter holes at the end of the trench and knock the waste free with a chisel and mallet.

The walls of this trench aren't critical. As long as the vise's screw can pass you're in good shape. So don't bother truing up the walls so they are perfectly parallel to each other and perpendicular to the benchtop.

What is critical is the next step: making the cavities for the vise nut and the bushing.

Figure 9.21. Fit and functional. Once you get the vise block bolted in place, the next step is to knock the bushing block up and down until things move smoothly. I thought I would have to secure the bushing block with screws at some point, but everything has shrunk around the bushing block nicely.

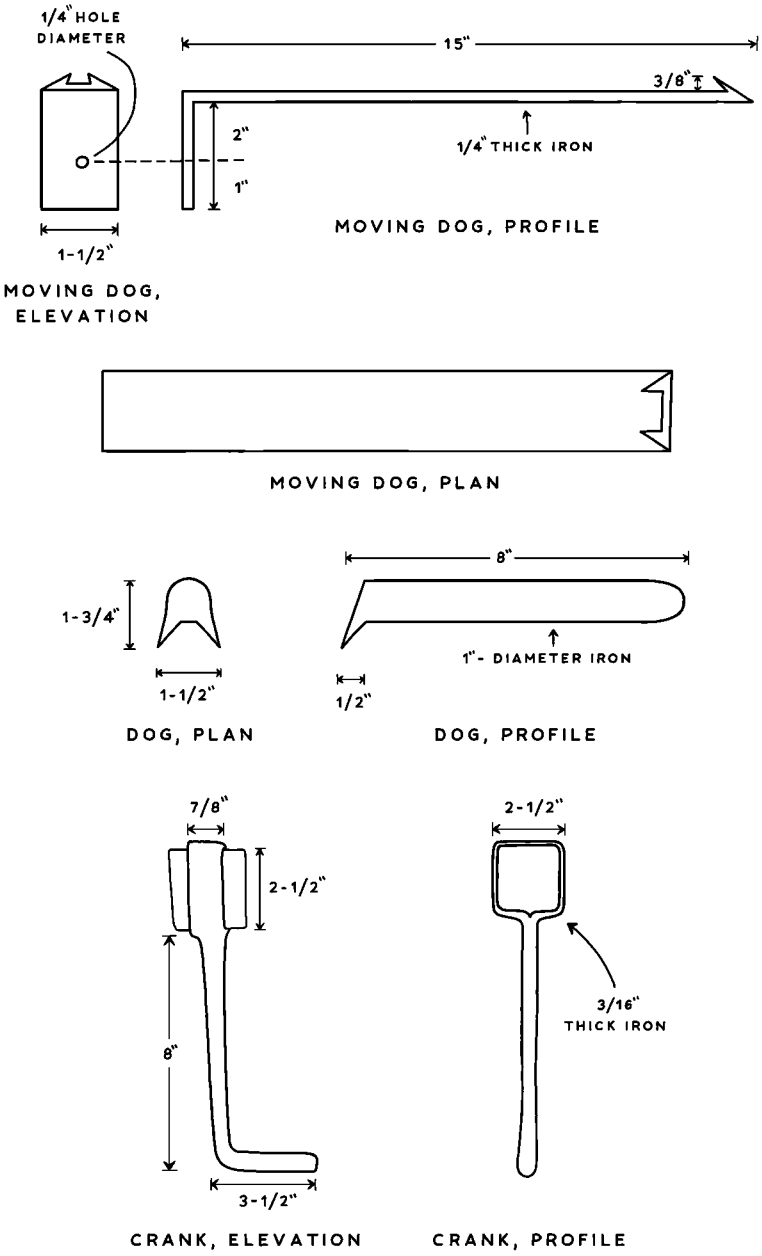
Begin by making the bushing. It's 1-3/4" x 3-3/4" x 5-1/4" with a hole drilled in its center that allows the vise screw to just pass. Use the bushing to lay out the cavity that will hold it on the end of the benchtop. Use a ripsaw – with care – to define the two walls of this cavity. These walls need to be perpendicular to the benchtop and parallel to one another.

To remove the waste, bore out what you can then chop the rest out with a chisel. Use a square to pare the walls of the cavity so everything is perpendicular to the benchtop. Fit the bushing to the cavity.

Fitting the 2-3/4" x 4" x 5-1/4" vise block is the fussiest part. Use the illustration to lay it out on both the top and the underside of the benchtop. (Hint: Use the front edge of the benchtop as the reference for your measurements and try squares.) Join the layouts on the benchtop and underside with knife lines across the main trench.

Now it's time to chop. Chop from both sides of the benchtop. I recommend you stay about 1/16" away from your layout lines then pare those back to fit your vise block. Note that you need to keep everything square and parallel with the bushing's cavity to get a smooth-turning vise. It's not difficult; it's just tedious.

Ultimately, you want the vise block to fit snugly in its cavity so it can be adjusted up and down with firm mallet taps, like a bench's planing stop. This will give you the adjustment you need as the benchtop dries.



Once you get the vise block fit in its cavity, you can assemble things. Note that part of this equation is the vise hardware. All my hardware was made by blacksmith Peter Ross in North Carolina. It's straightforward stuff that could be made by any talented smith. The details of construction are in the illustration.

No matter who makes your hardware, be prepared to make adjustments to suit the metal. Wood is easier to tweak than iron.

The movable bench dog is secured to the end of the wooden vise screw with a piece of all-thread rod embedded in the end of the vise screw and a couple jam nuts.

Originally, I had Peter make a nice dome-head screw to attach the movable dog to the vise screw, but it snapped when I first installed it (my pilot hole was too small – totally my fault). That turned out to be a fortunate accident because using jam nuts makes it easier to remove the moving dog for adjustments.

The all-thread rod is 1/4" x 20 that I

epoxied into the end of the vise screw. Then I used two 1/4" x 20 nuts to lock everything together. The movable dog needs a little slop to work; you'll figure it out.

In the end, here is what you want: The movable dog should rest on top of the vise block and bushing. Nothing except for the vise's teeth should protrude above the benchtop. In my case, I needed to put the vise block and bushing block about 1/4" below the benchtop to get things to work.

After lining everything up, I attached the threaded vise block to the benchtop with 4"-long lag bolts. These pass through the face of the block and into the end grain of the benchtop.

For cosmetic reasons, I added a couple strips of 1/4"-thick oak bestride the moveable dog. These strips also made the vise work a little more smoothly by creating a channel for the metal parts of the vise to run in.

The last bit was to add the blacksmith-made crank. This is entirely optional and is a fair amount of work. You could simply use the standard tommy bar that comes with your wooden vise screw.

Instead, I sawed down the hub of the vise screw and fit the collar of the crank around it – just like in the Löffelholz illustrations. Fasten the crank to the vise screw with a countersunk wood screw.

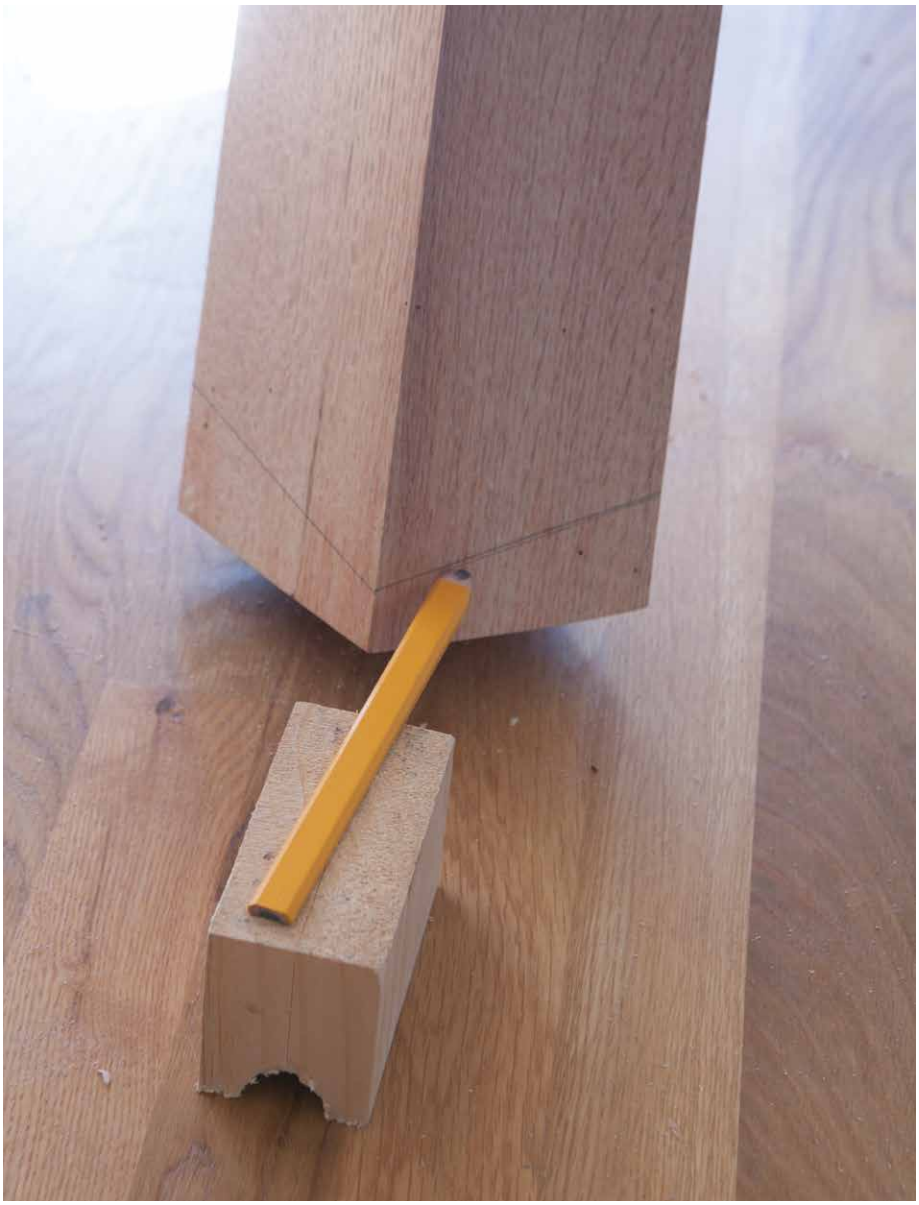


Figure 9.22. Level the feet. Use wedges to level the benchtop then scribe a line around the feet of the bench. Crosscut them to their final length.

Dog & Holdfast Holes

Drill 1"-diameter dog holes on 3" centers in line with the teeth of your movable dog (this should be about 5-1/8" from the front edge of the benchtop). I also added holdfast holes, though Löffelholz didn't show any on his illustrations.

Details on Use

If you have used a modern workbench, then most of the controls should feel familiar, though sometimes you might find yourself reaching for the choke to change the air-fuel mixture.

The face vise feels familiar until you start to edge-joint long boards. As I noted above, things get awkward with long boards because the face vise is inset into the benchtop. For me, the solution was to instead use the end vise and dog. With the bench configured with this end vise, I can clamp boards on edge that are about 80" long.

My bench is low (about 32"), so planing 12"-wide boards on edge with the grip of the teeth is easy.

The end vise was surprising in every way. As it was the first end vise in the historical record (so far), I expected it to be clunky and fussy. In truth, it outworks many modern end vises I have suffered since 1993.

Most end vises have a tendency to lift the work off the bench, which makes planing with them a frustrating exercise. Why do they lift your work

off the benchtop? Because the movable dog mechanism gets saggy. So, when you clamp your work, the saggy dog starts low then ends up as much as 1/4" off the top surface of the benchtop.

This is not a good way to plane stuff.

The Löffelholz vise is like a wagon vise in that it is almost impossible for it to lift the work off the benchtop.

Some people will be put off by the fact that the Löffelholz end vise and dog (I call it the "bitey dog") leave tooth marks in your work. If you build traditional furniture, then you know that these marks are part and parcel when building stuff by hand. Most of us have gotten over it.

If you haven't gotten over it, I recommend you try the vise before condemning it. After about 10 minutes, I was in love. Here's why: Once the teeth of the dogs bite into your work you can do anything. Anything. Really anything. Plane across the grain, what Joseph Moxon calls "traversing." Plane diagonally. Saw across the grain. Plow out dados. Oh, and plane with the grain. This vise will not give up its grip.

Yes, it leaves it mark. But if you are like me, you want to leave your mark, too.

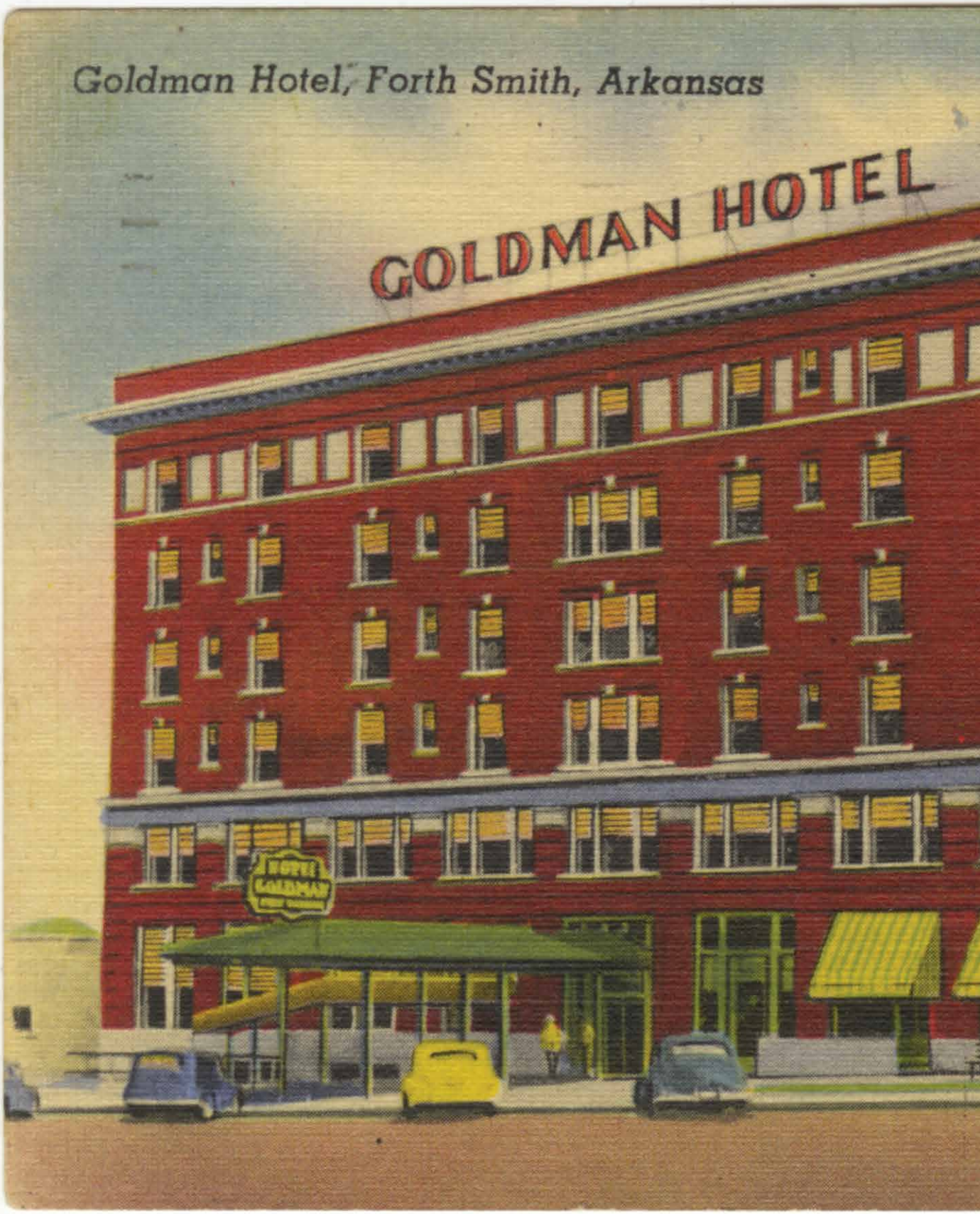

Goldman Hotel, Forth Smith, Arkansas
GOLDMAN HOTEL
HOTEL GOLDMAN


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Figure 10.1. No trespassing. I like to go places that haven't been interpreted by museum personnel or academics (nothing against these people, but I like to draw my own conclusions). This unrestored coastal artillery facility is nothing like the touristy one down the road.

X

'Experto Crede'

Sometimes I wonder why I research old workbenches, build them and write about them. I know my critics and friends wonder the same thing.

The truth is, I have a gland – well, it feels like a gland – deep inside my torso. It's located a bit above my tailbone and in front of the base of my spine. Ever since I was a boy, that area would tingle and throb when I ventured into places I wasn't allowed.

(My critics would say the location of that gland – or whatever it is – is also where a lot of crap is produced in the human body.)

I was 6 or 7 the first time I felt it. My family attended First Presbyterian Church in Fort Smith, Ark., which is downtown and surrounded by empty buildings from the town's 19th-century heyday. Next to the church was the derelict Goldman Hotel, a landmark six-story building built in 1910 that was the center of the town's social scene until World War II.

The building was shut to the public at about the time my family moved to Fort Smith in 1973 (and demolished in the 1990s). But I spent every Sunday and Wednesday in its shadow and soon began sneaking out of Sunday school to explore the hotel through an opening on the building's west side.

Though the Goldman was dilapidated – it had been an apartment building in its last days – there were remnants of its glory and its rich ornamentation throughout. Furniture. Light fixtures. Tiles. Mouldings.

That was the first time I ever felt that odd tingle. It was better than any high I have achieved with alcohol (or the banana peels I smoked in college). And I have chased after that feeling my entire life.

I have a thing for old and abandoned places. I love to explore overgrown concrete battlements that line harbors and rivers. Abandoned houses – we had a creepy overgrown one on our farm – are like a sip of bourbon. Multi-level factories filled with garbage, graffiti and old equipment are like a multi-day bender.

I knew I was wrong in the head (or the gland) in 2012 when I became half-crazed about buying an old brewery in Covington, Ky. It had two flooded sub-basements and a network of unexplored lagering tunnels that staggered off below the old city.

During a tour of that building, I encountered a deep pit in its basement. I threw a rock down the hole and didn't hear it splash or hit bottom.

"Where does it go?" I asked the real estate agent.

Her reply: "We have no idea."

I thought: "I have a flashlight and rope in my truck." Behind me, I heard my wife, Lucy, call out: "Nope! We are done here!"

It probably was the right decision.

At other times, the gland acts up when I'm not in physical danger, but when I'm on the precipice of obsession. One week I flew to New York City and visited Joel Moskowitz of Tools for Working Wood. The highlight of that trip was paging through his 20th-century reprint of A.J. Roubo's "l'Art du menuisier." Like most woodworkers, I had seen the workbench illustrated in Plate 11 of Roubo's multi-volume book many times before. But I hadn't seen Roubo's whole work – nearly 400 pages of plates. And many of the plates showed this simple bench in use for all manner of operations, from installing moulding in an apartment to sand-shading veneer for marquetry.

While sitting on Joel's couch with this giant tome on my lap, I became as intoxicated as the day I first ducked into a broken window at the Goldman Hotel. The feeling was so powerful that

it verged on physical pain.

When I returned to Cincinnati, I felt physically compelled to build that workbench. I ripped up the editorial calendar for the 2005 issue of *Woodworking Magazine* and presented a new plan to the magazine's staff to satisfy my personal lust: Build the 18th-century Roubo workbench using yellow pine (to make it less expensive).

I offered to do all the work – building, writing and illustrating – so no one objected. Or perhaps they were wary of crossing me because I looked a bit crazed. I had drafted my plan the night before and hadn't slept much.

Building that first Roubo workbench and putting it to work was like mainlining the unknown for me – like exploring a forgotten Soviet missile silo or finding a passage to catacombs beneath my house.

Building that Roubo bench led to making the Holtzapffel workbench – a German/English hybrid. Then a Nicholson bench – the classic English workbench – and about a dozen variants of benches from Europe, the U.K. and North America.

It has been a 13-year obsession with no end in sight. (Side note: By purchasing this book, you have fed and encouraged my single-minded research, which feels like a non-lethal opioid addiction. My mystery gland thanks you.)

As a result of my confession above, you might wonder if there's any value to the book you've holding. Perhaps it's

just some cruel trick from a guy who refuses to take pleasure from kinky sex or hard drugs and instead tortures woodworkers with odd books.

I hope that's not the case. What drives my obsession with artifacts of the unknown is not just discovering that they exist, but finding out that they have something important to teach me about making furniture.

Ancient benches have given me several lifetimes of lessons. What are these lessons? I'll give you a hint.

As a lover of old cities, I dislike one-way streets. They are designed to do one thing: Rapidly flush modern cars in and out of a place that was designed for horses and pedestrians. These one-way streets allow the populace to live in less-expensive or less-crowded suburbs and commute. Invariably, this network of one-way streets creates urban cores with a less-lively street life. Without pedestrians and without population density the inner city becomes fragile and is easily pushed into decline.

Modern tools, process and benches are designed to make woodworking cheaper, easier and faster. But is that always the best thing for the craft? Or for your work specifically?

The only way to answer those questions is to pick up the tools and try some of the ideas in this book – and other books put out by people with a similar bent. You might not get the same answers as I did, but I think you will become a more thoughtful woodworker for it.

Acknowledgments

Suzanne Ellison: Suzo devoured thousands of paintings and distilled that research into the essence of this book. Without her, this book would be a pamphlet at best.

Görge Jonuschat: Much of my research has been stymied by the fact that I'm a stupid American who doesn't speak multiple languages. Görge acted as my right hand throughout Europe, helping me unlock doors and – most importantly – inspect the workbench at the Saalburg Roman fort.

Narayan Nayar: When I decided to go to Naples, Italy, to see Pompeii and Herculaneum, Narayan agreed in an instant to document the trip. As always, he has been the extra set of eyes I need to see things clearly. Photos throughout this book are designated with NN.

Nicholas Moegly: Nicholas worked with sketches and ancient original material to produce the beautiful line art illustrations throughout the book.

Will Myers: Every book needs a skeptic. Will watched this book with a careful eye. He helped me at every turn, especially with obtaining the wood I needed for the benches. And, when I needed it the most, he put these benches to use and gave me honest opinions on my findings.

Megan Fitzpatrick: Every book needs an editor. This book would have been a bizarre and discursive work without Megan's red pen and raised eyebrows. She has always supported my research but has never fallen for my bullshit.

Brendan Gaffney: A newcomer to the circle of people I trust, Brendan has eagerly put my benches and ideas to the test. Unlike many woodworkers, Brendan will give any half-decent idea a fair trial. He also constructed the maps in Chapter 4.

Andy Brownell: Andy helped me rethink how our bodies intertwine with our workbenches.

Justin Leib: I need naysayers. Lots of them. Justin offered the most cutting comment on these benches: "I sit all day at a computer. Why would I want to sit down to build furniture?"

Lesley Caudle: If you need a thick oak benchtop, Lesley is your man.

Peter Ross: My work would be incomplete without blacksmith Peter Ross. He has always indulged my crazy ideas and brought his deep understanding of craft and history to this book.

Rüdiger Schwarz: Many caretakers keep their artifacts to themselves. I was shocked and awed by Rüdiger's openness during my June 2017 visit. His practical approach to the artifacts in his care led to a much better understanding of the Saalburg workbench.

Bengt Nilsson: Whenever I do something crazy, Bengt is there.

Kara Gebhart Uhl: This book would be mostly empty rectangles without Kara. She dealt with museums, churches and governments all over the world to ensure we could publish the paintings Suzo uncovered.

Herculaneum. Buried below the modern city of Ercolano, many of the ruins of Herculaneum have yet to be unearthed.
PHOTO BY NN

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