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-

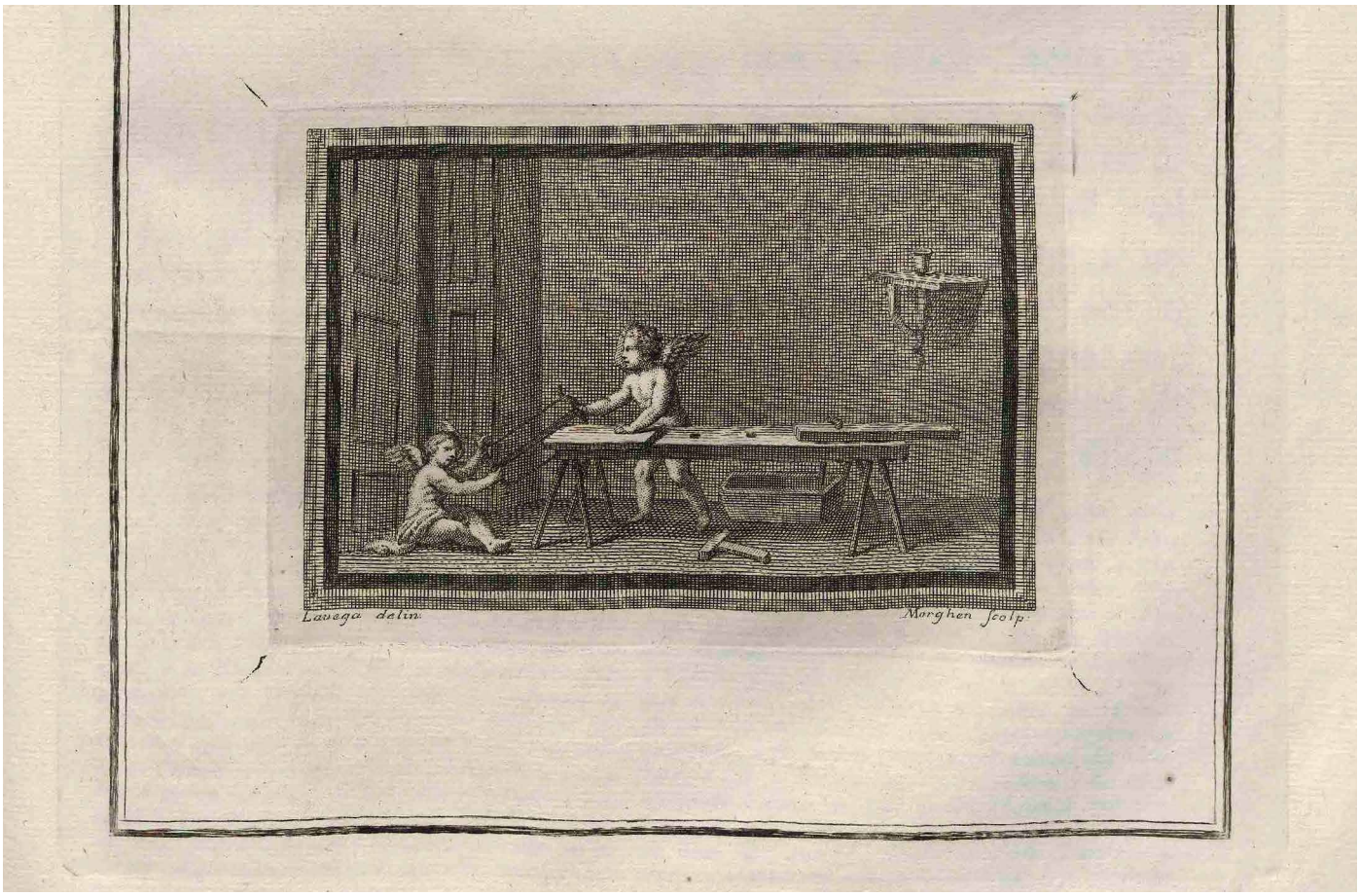


Figure 1.6. Graven image. This copperplate engraving was made by Italian artists shortly after the Herculaneum fresco was discovered. Sadly, the original has deteriorated.

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

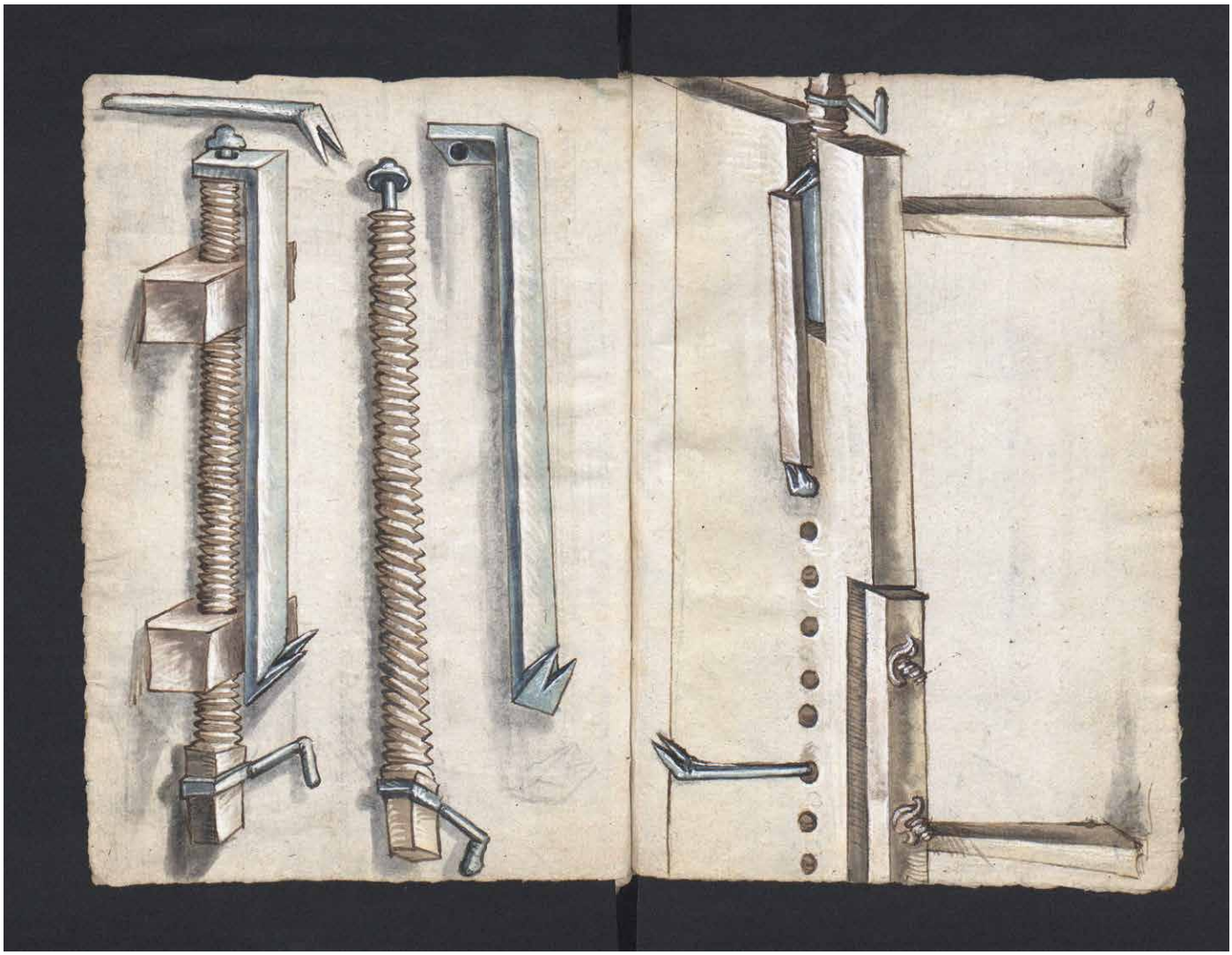


Figure 1.11. German ingenuity. Martin Löffelholz drew two workbenches in a codex dated 1505. Equipped with both a face vise and a tail vise, this appears to be the first modern workbench. The unusual tail vise was the biggest question mark. How well would it work?

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.

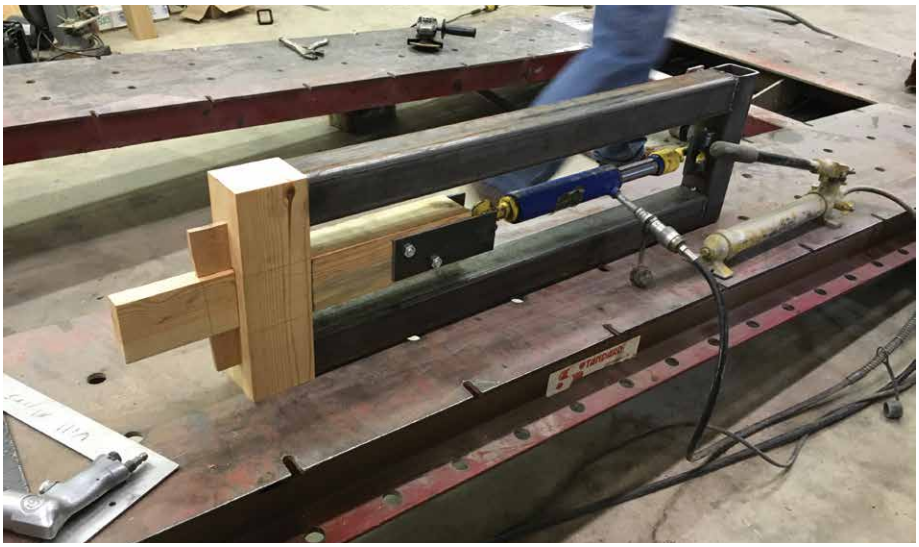


Figure 2.7. Redneck engineering. This ingenious contraption tests how many pounds of force a tusk tenon can withstand. (Tusk tenons are a common workbench joint.) The answer: This joint is well-suited for workbench joinery.

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….

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-

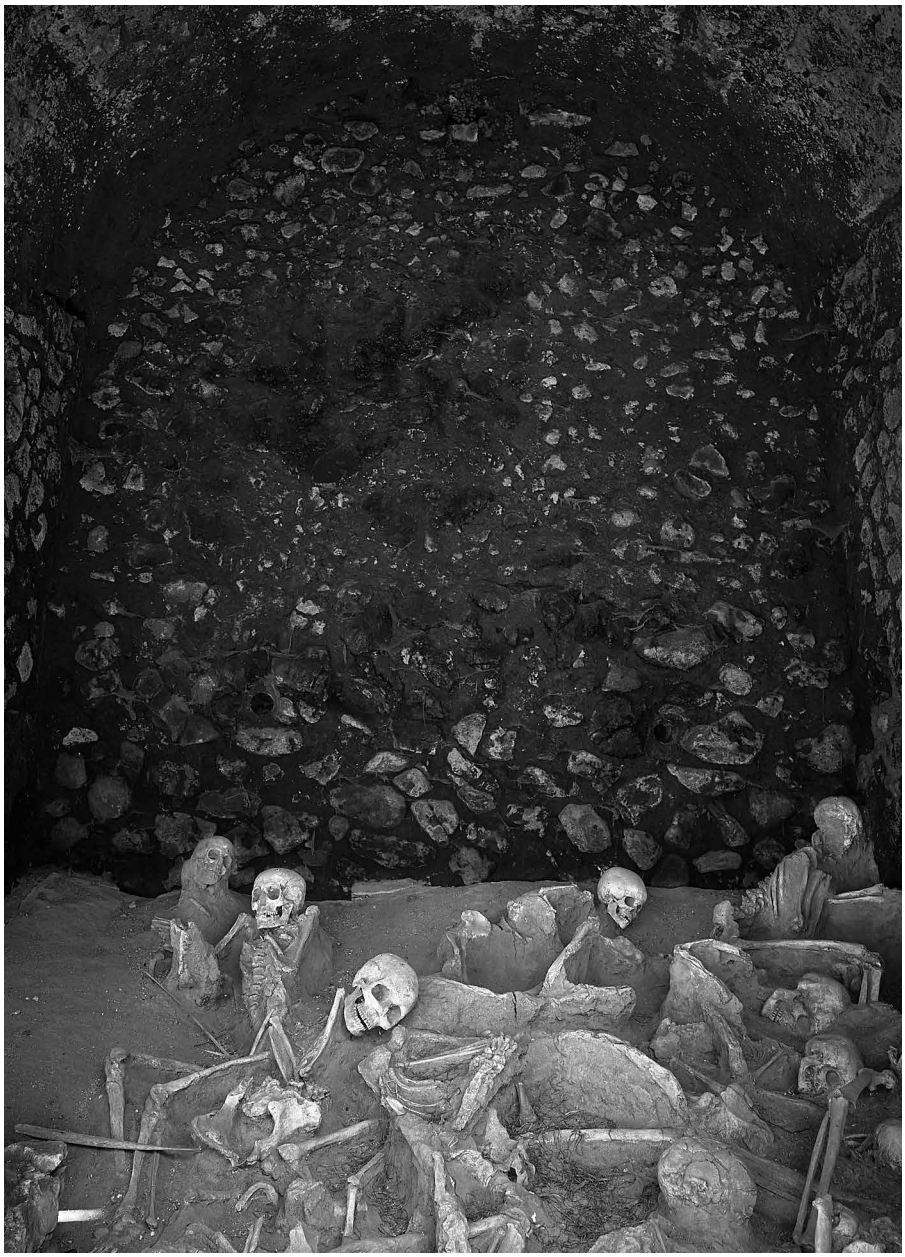


Figure 3.9. Herculaneum. The excavated section of Herculaneum is much smaller than Pompeii, but no less stunning. Particularly chilling: The skeletons at the waterfront. They were waiting to be saved and are still waiting.

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

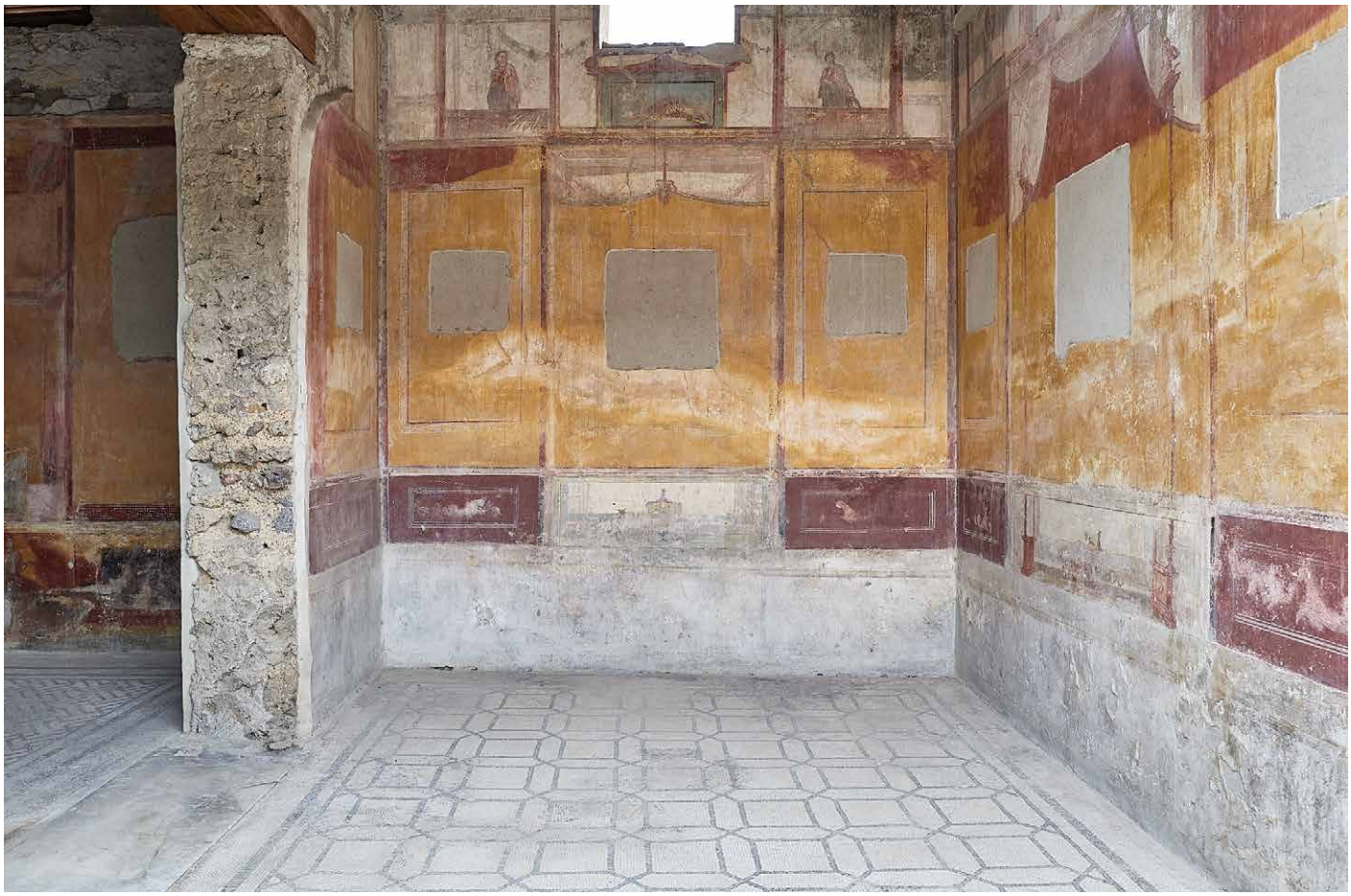


Figure 3.10. Gone away. At both Herculaneum and Pompeii, early explorers removed frescoes to show to them to the royalty. What is left are empty picture frames.
PHOTO BY NN

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).

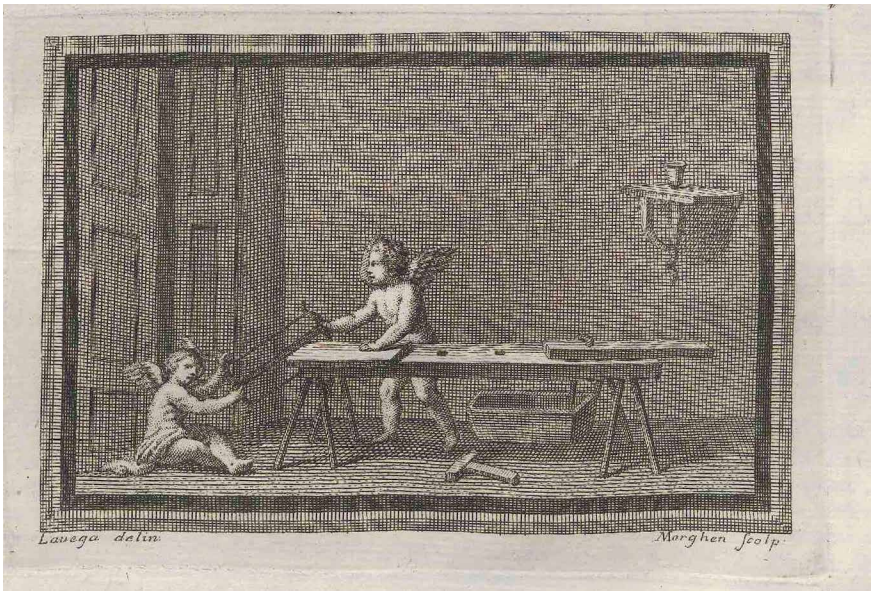


Figure 3.11. Early engraving. After this fresco was discovered, Italian engravers created this facsimile. This engraving is all that survives of the original image.

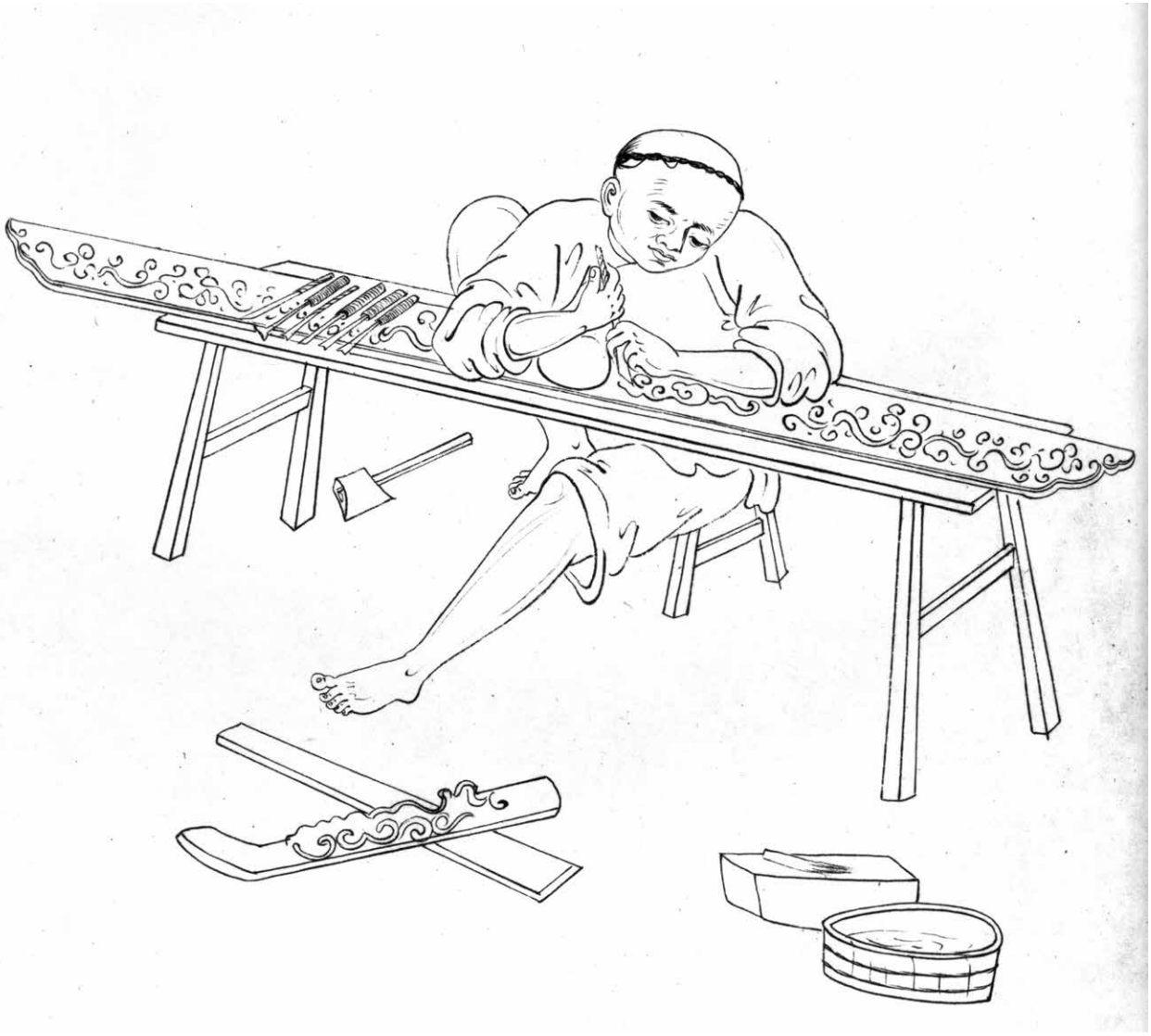


Figure 3.12. Carving in China. A typical Chinese workbench. It's low, has four legs and the two legs at each end are joined by stretchers. This form is surprisingly similar to European forms.

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

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.

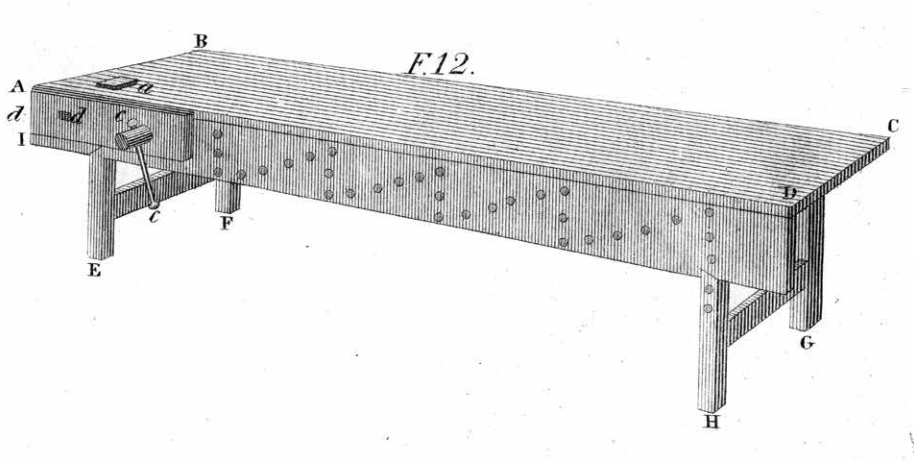


Figure 5.2. Missing in action. These early workbenches have little in way of workholding. Where's the tail vise? Do you need one? (Peter Nicholson's "Mechanic's Companion" (1831)).

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.

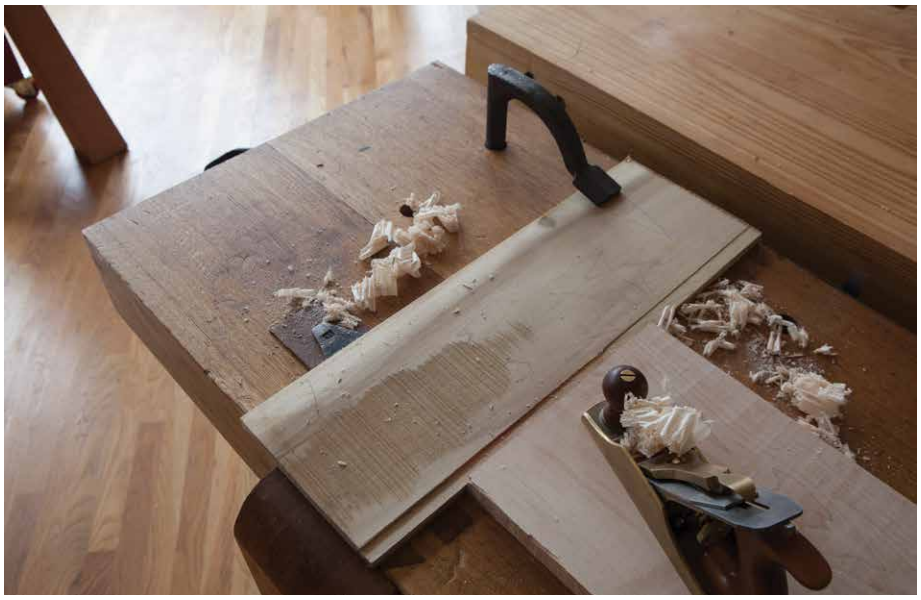


Figure 5.5. Wide planing stop. Add a thin batten in front of your planing stop and you've made an effective planing stop for wide panels.

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.

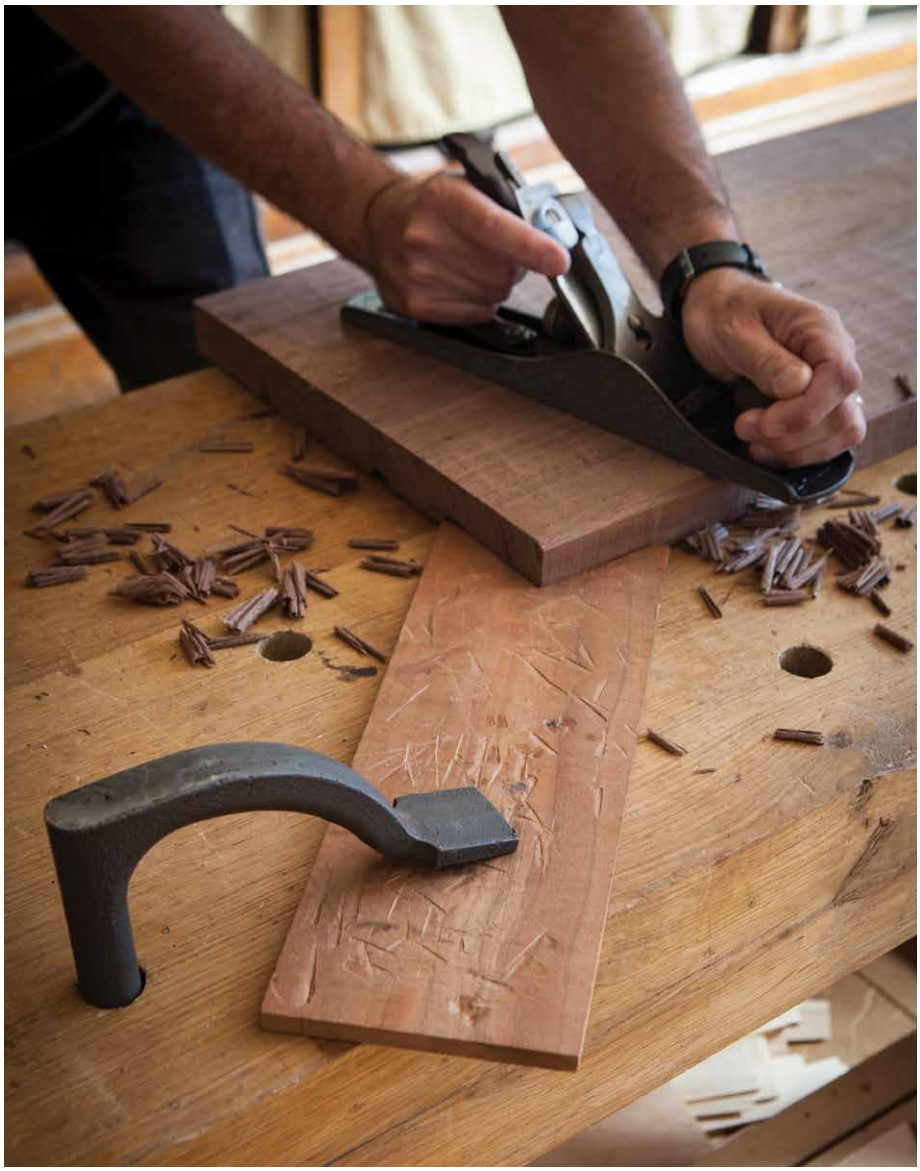


Figure 5.9. No tail vise needed. A notched stick placed at the rear of your work can help immobilize it so you can work across or with the grain of a board.

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.

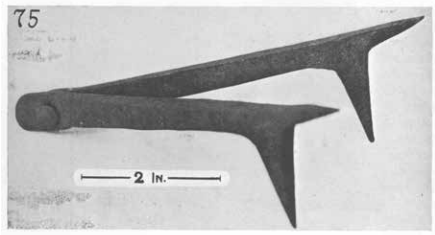


Figure 5.14. On the palm. Rudolf P. Hommel wrote about the "palm" in his landmark book "China at Work" (MIT Press, 1937). Here's an excerpt: "To hold a board in place when planing it, the carpenter uses an instrument like the one shown in Fig. 362. The two spikes pointing downward are driven into the 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.

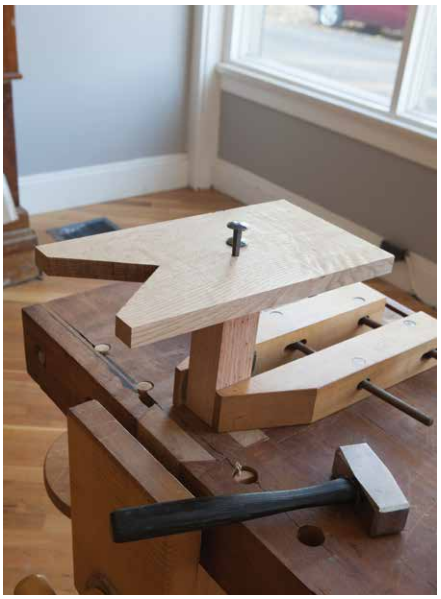


Figure 5.20. Moment of truth. If you have drilled your holes correctly, the nails should go in grudgingly but not split the work.

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.

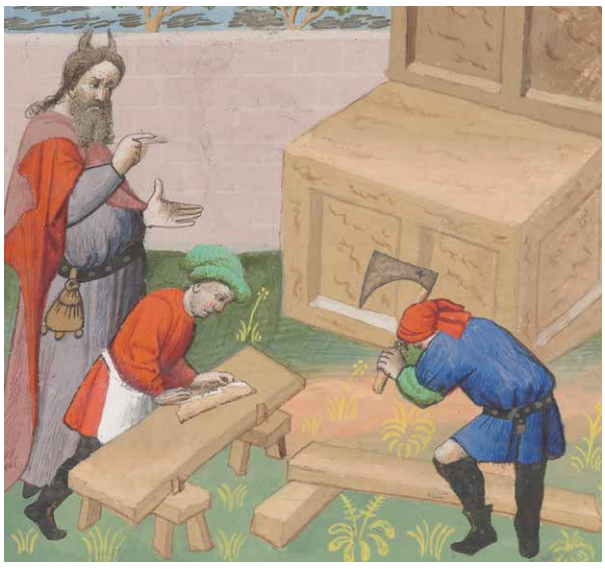


Figure 5.24. More pegs. Here you can see a craftsman traverse-planing a board that rests on sawbenches that feature pegs, much like the Schreyner pegs from Nürnburg.
THE MORGAN LIBRARY & MUSEUM, MS M.394, FOL. 57R. PHOTOGRAPHY BY JANNY CHIU, 2018.

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

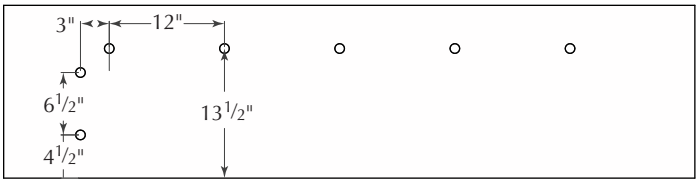


Figure 5.25. Schreyner peg layout.

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 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.

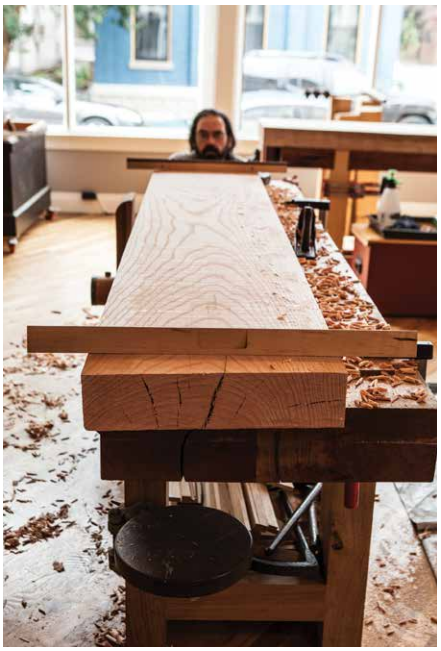


Figure 6.7. Wind out. With large slabs, your eyes can see obvious twisting. But the true test is to use winding sticks.

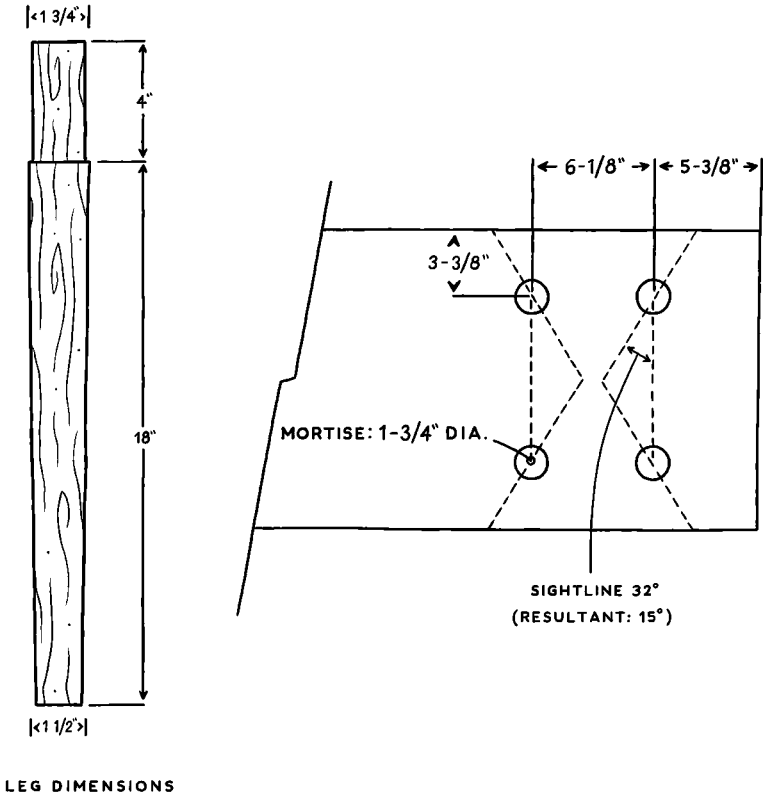
Figure 6.8. Work all around. You might need to work the faces to bring the edges in truth. (The three-dimensional world can be a bitch at times.) Don't be afraid to roll the slab over and remove some errant material. And sometimes (shudder) these slabs twist as you remove material.

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.

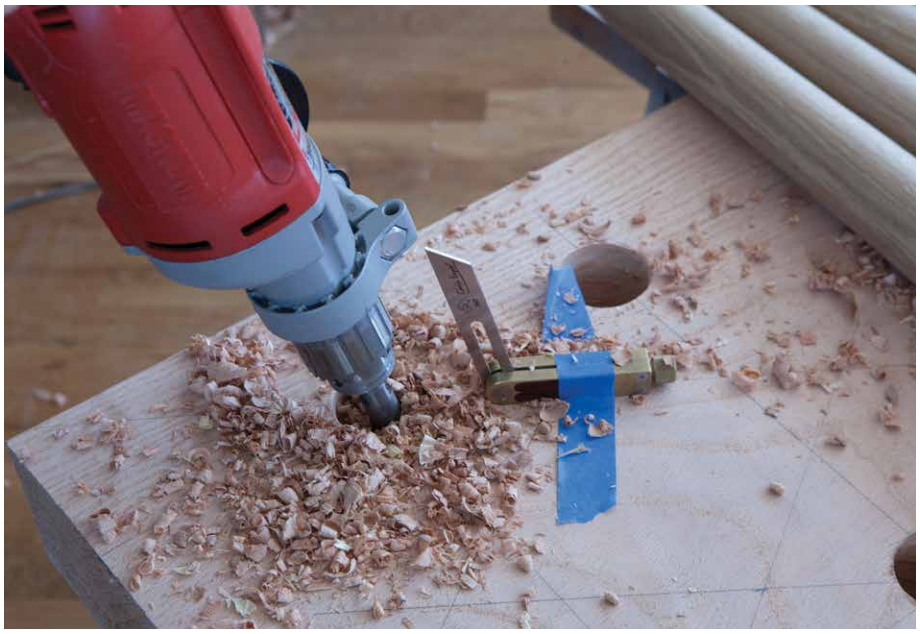


Figure 6.12. Follow the bevel. Here I'm lining up the chuck of the drill with the blade of the sliding bevel. If you are using a long auger bit you can line up the shank of the bit so it's parallel to the blade of the sliding bevel.

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.

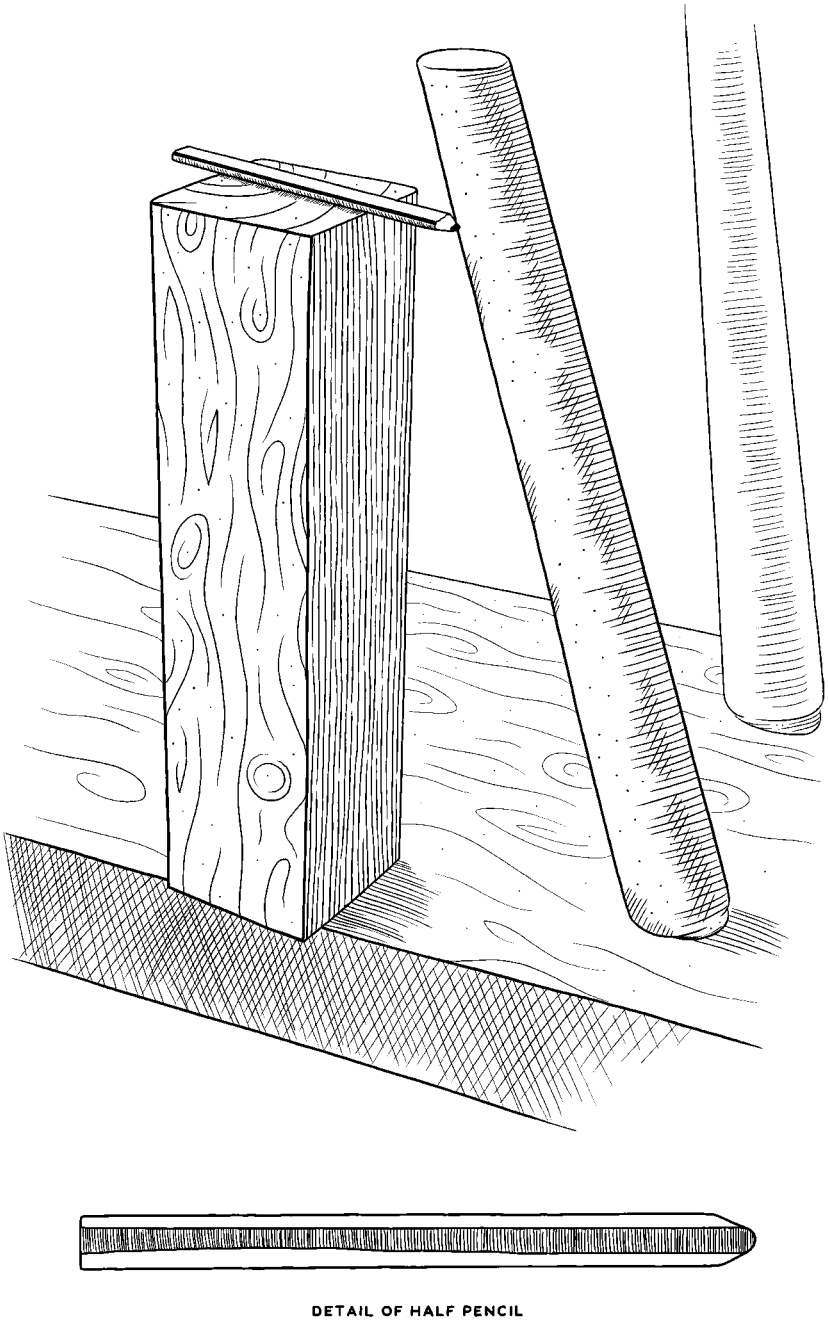


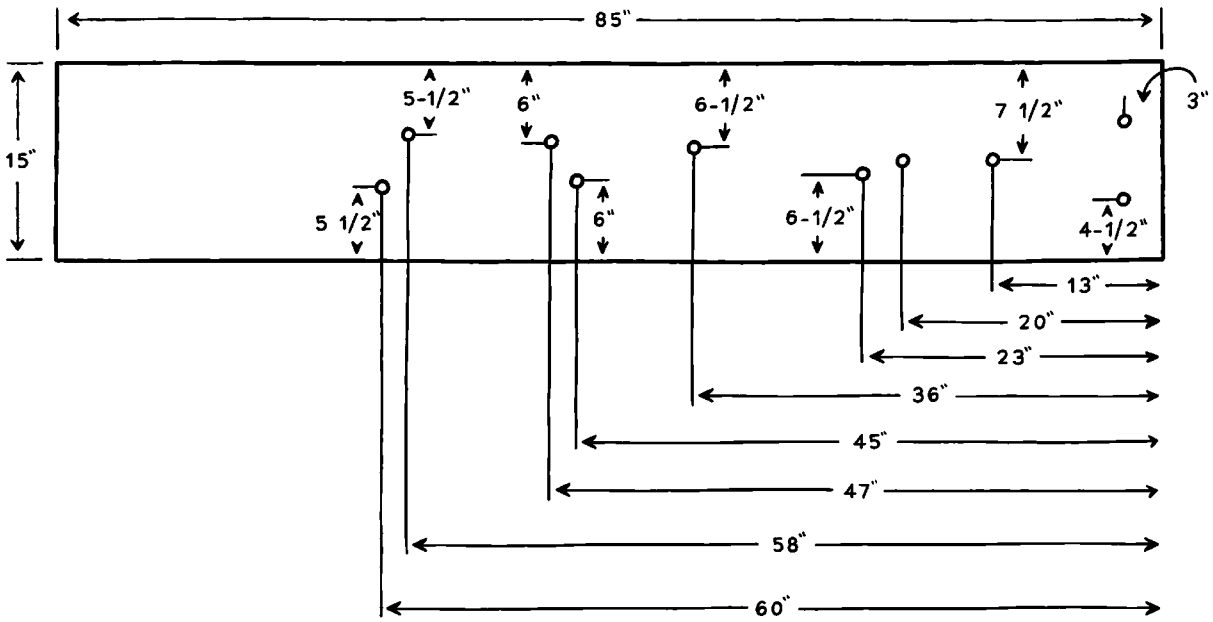
Figure 6.16. The magic half-pencil. Here you can see the 4x4 on the underside of the benchtop and the half-pencil sitting on top of the 4x4.

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.