Roger Delgado

Wood Finishing Tips & Techniques

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Paul McGoldrick describes

FINISHING A PIANO

My career in restoring pianos began like a lot of opportunities in life—by chance. When I was 23 I had a cabinetmaking shop in Montréal; next door was a Parisian cabinetmaker, Jean Gilles Jozon. Jean was a cabinetmaker of the old tradition and I spent many hours in his atelier learning about different finishing methods—techniques that haven't changed for generations. I later followed him to Paris and spent a working holiday there restoring antiques.

Through mutual friends I met a piano technician named Gilles Losier, and I began doing finishing work on pianos he was restoring. In his youth, Gilles had a foreman who could select the wood for a piano case, install the soundboard, string the piano, cut the keys, and assemble and regulate the mechanism. He could even sit down and play a tune. Sadly, craftsmen with that range of expertise in the piano trade have all but vanished.

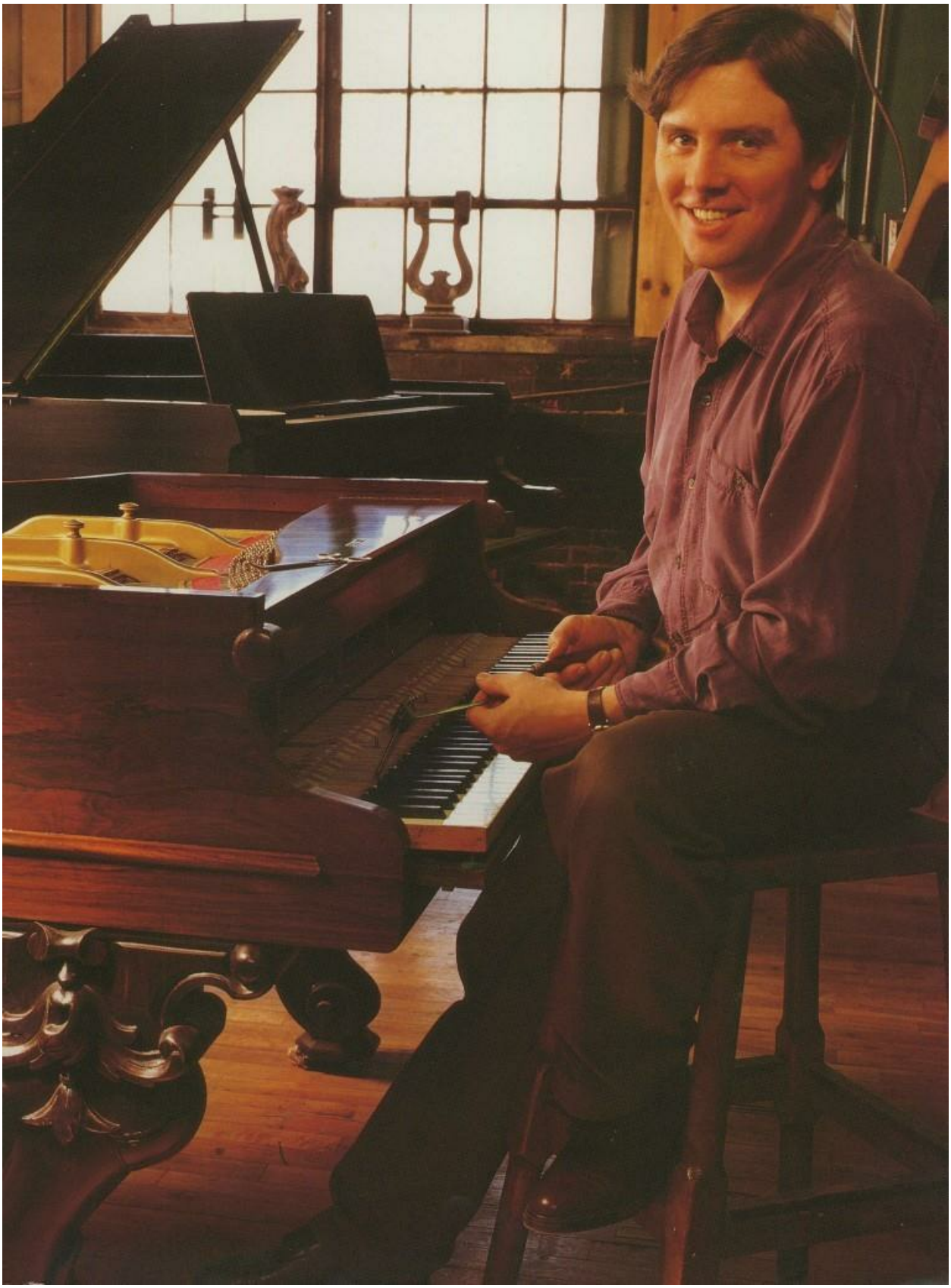
Restoring pianos presents many challenges: The instrument must not only look great; it must also sound superb and respond well mechanically. The instrument shown in the photograph is a 7-foot Chickering and Sons grand piano built in Boston in 1875. I counted 10 different woods used in its making, although the entire surface is veneered with Brazilian rosewood.

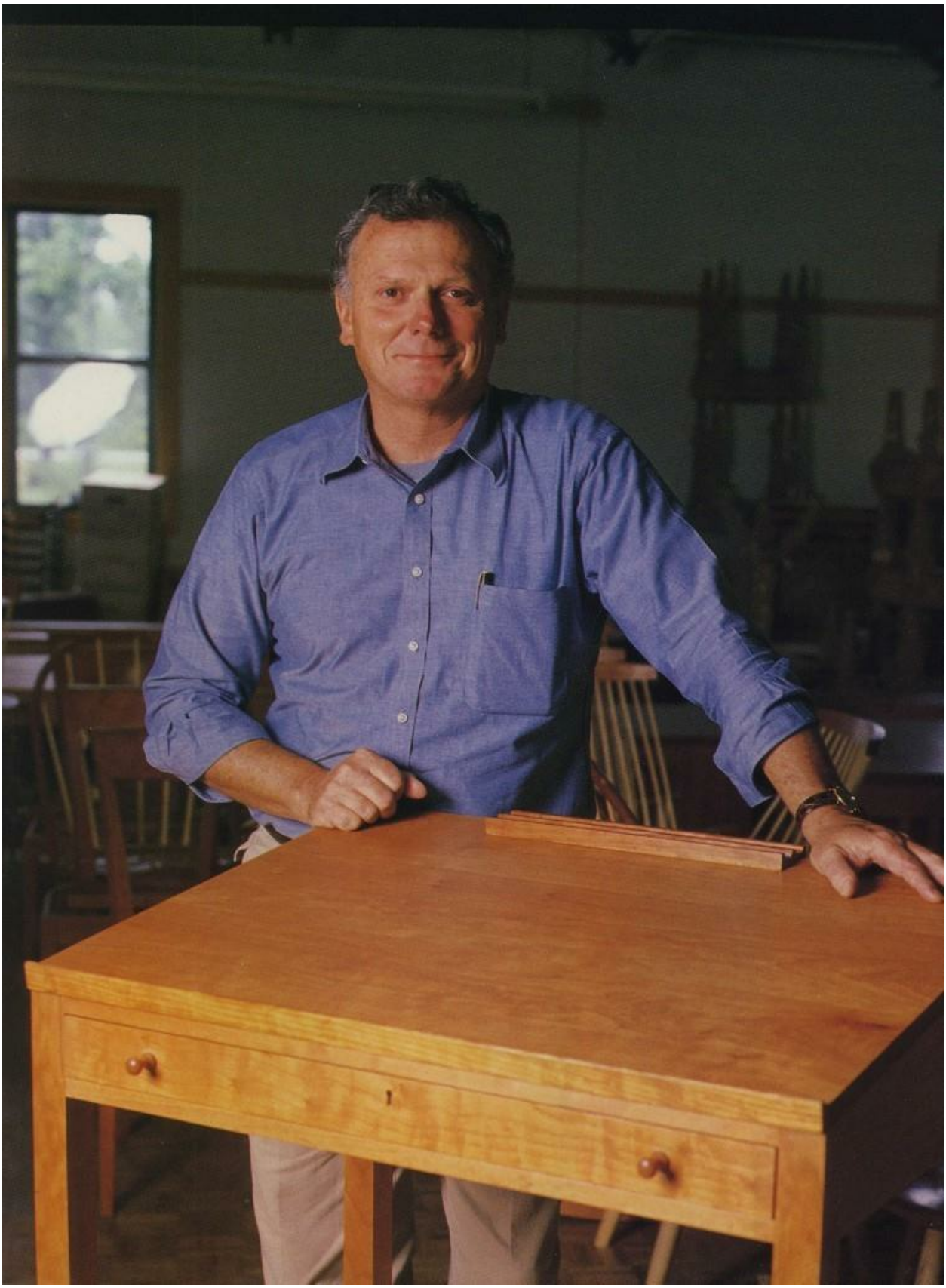
My first task involved filling the grain of the wood with a dark paste filler. I then applied a coat of sanding sealer, and next sprayed on eight coats of lacquer. To keep the final finish thin and to level any depressions caused by the large pores of the rosewood veneer, I cut every second lacquer coating with 220-grit sandpaper.

The legs demanded special attention. They were made from large blocks of poplar wood so I had to create my own stain, blending in just enough yellow and red to simulate rosewood's distinctive hue. I sketched in grain lines using a combination of feathers and brushes, with the top of the piano standing nearby as a guide. The grain patterns in rosewood can get quite wild, so you can take artistic liberties in trying to simulate it as long as you respect a few rules, such as keeping the grain lines running parallel.

The final coat of finish was sanded with 220-grit and then 400-grit paper. All that remained at the time this photo was taken was to rub the finish to a soft gloss with 0000 steel wool, buff with a cotton cloth and apply a carnauba-based wax.

Paul McGoldrick finishes and restores pianos in his shop in Montréal, Québec.





Thomas Moser talks about

LINSEED OIL

My introduction to the craft of building furniture was with 19th-Century American antiques and remnants of antiques. I would buy a chest of drawers without drawers, for example, and that would lead me to figuring out how drawers were made. Because of my fascination with older pieces, I was attracted to buttermilk paint, early varnishes and French polish.

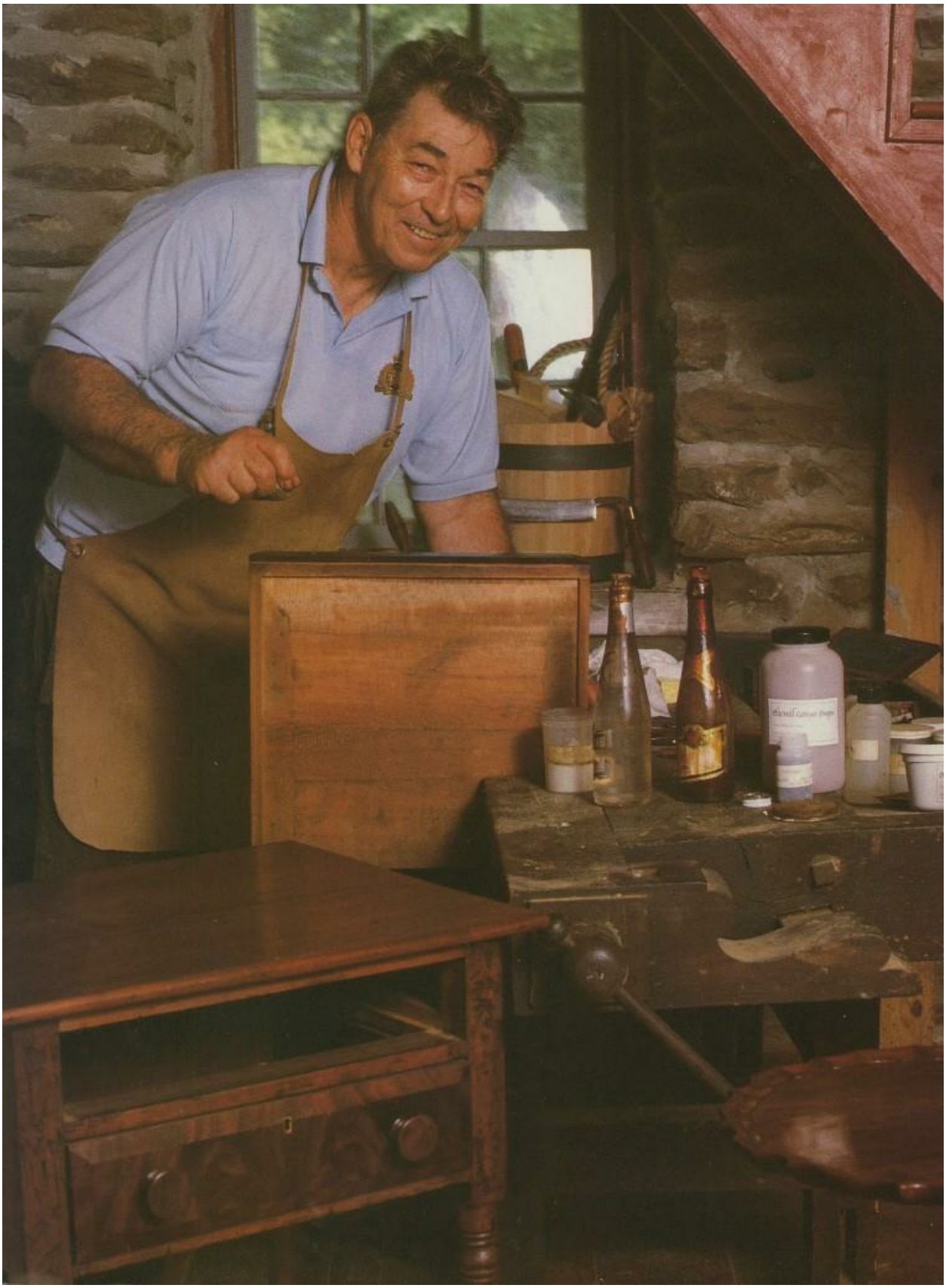
Gradually my interest was drawn to the austerely elegant furniture made by the Shakers and one of their favorite finishes—boiled linseed oil. I experimented and came up with my own way of applying the oil and then paste wax to create a clear finish like the one used on the piece in the photograph. Made of cherry, it is what I call the "Bob Cratchet desk." It's a desk for an accountant or schoolteacher, although it can just as well be used as a lectern or telephone table. It has a drawer and a removable pencil rack.

Linseed oil has been used to finish wood for centuries. Unless it is applied with a shellac or varnish base, it penetrates the wood rather than creating a membrane over it. It is this penetration that I feel enhances the wood's grain and color, and accelerates the development of a natural patina, which is caused by exposure to sunlight and air. The color that is created, I feel, is far richer and more honest than any pigment that comes out of a can. You just have to be a little patient. You also have to be sure to start with a well-prepared, polished piece. In many shops, a finish serves to conceal flaws. I believe that a piece should be virtually defect-free before you begin to apply a finish.

There are three major risks associated with boiled linseed oil. The first involves safety. Left in a folded rag, linseed oil can combust spontaneously, becoming almost explosive. Second, the finish affords no protection for wood against water and other kinds of stains. This is why we apply a paste wax over the oil as a sealant. Third, linseed oil does not seal wood against moisture penetration the same way lacquers and varnishes do. Oiled pieces tend to shrink and swell with the seasons more than painted or lacquered pieces do. So in designing furniture, this expansion has to be taken into account.

The principal advantage of a finish like linseed oil is its repairability. Scratches, burns and chips can be sanded and polished with the oil. In a short time, the color will come back and you won't even know it was affected. But if a membrane finish—especially one applied over a stain—is chipped, scratched or burned, more often than not it has to be entirely refinished.

Thomas Moser is president and co-founder of Thomas Moser Cabinetmakers, headquartered in Auburn, Maine.



Prew Savoy on

THE CRAFT ETHIC

The piece I am working on in the photograph is a Sheraton-style, two-drawer work table, typical of early 19th-Century American furniture building. Knowing how to apply the appropriate finish takes a good appreciation of furniture style. You have to approximate the original as closely as possible—in color as well as in topcoat composition. The best way to get onto the right track is to study furniture styles as thoroughly as you can. Talk to people experienced with period pieces—museum curators, serious collectors and restoration or conservation craftsmen. They are usually very willing to share technical information. Also try to see as many original examples as possible.

For this piece, I selected natural and chemical dyes to make the color appropriate to its history. The table is made of cherry with a figured veneer applied to the drawer fronts. Two different combinations were used: logwood extract (a natural dye) and potassium dichromate (a chemical mordant) on the veneer; and lye and walnut crystals on the cherry.

For the topcoat, I padded a 3-pound-cut orange shellac on the wood. I like using a pad made up of a wool interior and a linen exterior, but other finishers prefer polishing cloths—perhaps because good-quality linen is hard to find. The technique is called French polishing, but the term can be misleading. There are several ways to apply a French polish, some using pumice and oil to fill the pores of the wood completely, providing a mirror-like finish. That is not always appropriate for all American pieces.

I trace my interest in fine furniture back to my childhood and my parents who were collectors themselves. As an adult I spent two summers working with a boat builder, and much later studied with George Frank in China. When I started collecting fine furniture, I couldn't afford the pieces I liked, so I learned to build replicas instead.

I believe that cabinetmakers should consider themselves as caretakers of a sort, building something that will be passed down from generation to generation. You need to develop what I call a "craft ethic." You have to love what you do, not for the result or for a wage, but simply for the sake of finding the finest way of doing each step.

Prew Savoy specializes in furniture finishing and restoration. He also teaches wood finishing at the Olde Mill Cabinet Shoppe in York, Pennsylvania.

SAFETY

Finishing can be a dangerous business if you are not well informed and properly prepared. From wood fillers to waxes, polyurethane varnishes and tung oil, finishing products frequently depend on toxic organic solvents to do their work. Without the proper safety gear and precautions, short-term exposure to these solvents can result in irritation to the skin, eyes and throat, as well as dizziness, headache, nausea and shortness of breath. Longer-term exposure poses more potential risks; some effects may not be apparent until you have used the substances for months or even years.

In addition to the health risks, most of these solvents are flammable. Some oil-derived products like linseed oil can combust spontaneously at room temperature if the vapors are sufficiently concentrated. When vaporized in a small enough concentration of air, a small quantity of lacquer thinner can cause a life-threatening explosion.

All this is not to suggest that working with finishing products has to be dangerous—only that it can be if you take a cavalier attitude towards the risks. If you spray finishes, consider buying a spray booth *(page 13)* or constructing a spray room of your own *(page 102)*. As most of the harm from organic solvents comes from inhalation, wear a dual-cartridge

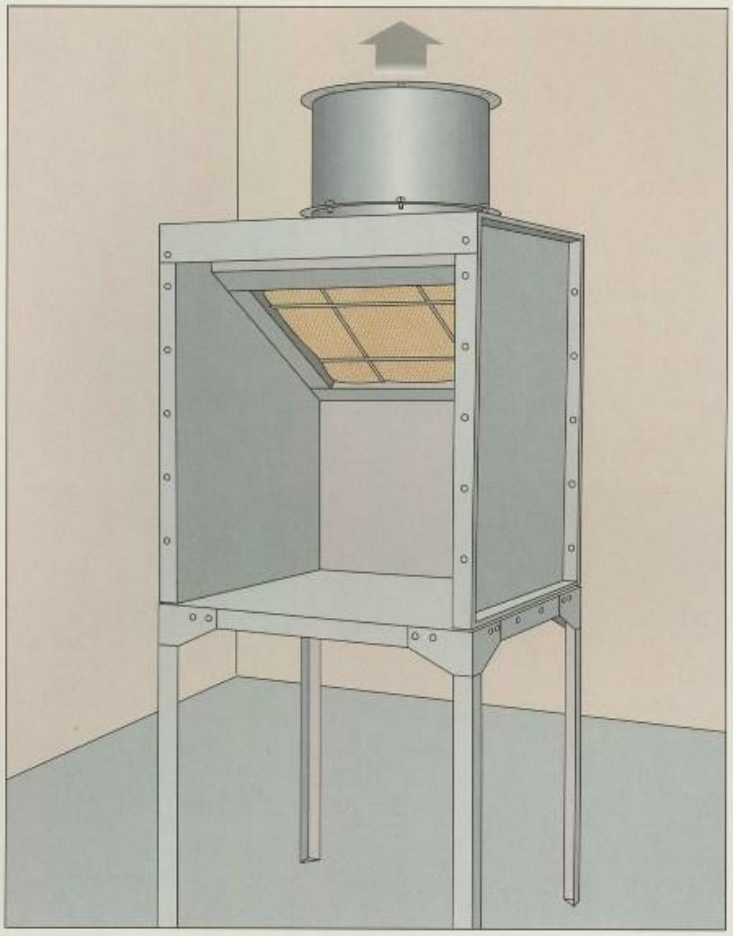
respirator *(page 14)*, particularly if you are spraying or will be exposed to fumes for more than an hour. To prevent eye injury, wear safety goggles, and don rubber gloves when working with caustic or toxic finishing products.

Whenever possible, choose a product that combines the finish you want with low volatility and toxicity *(page 19)*. Work with the windows open and use a certified spark-proof fan to keep the air moving. This will help prevent the fumes in your work area from reaching a toxic or flammable level. If you experience drowsiness, fatigue, headache, blurred vision, weakness, numbness, irritation of the eyes, skin or throat, shortness of breath or a loss of coordination while finishing, stop immediately and leave the work area until the symptoms clear. Afterwards, ventilate the work area thoroughly and use a different finishing product.

SAFETY TIPS

- Do not eat, drink or smoke when using finishing products.
- Keep finishing products away from children.
- Avoid exposure to organic solvents if you are pregnant or breast-feeding.
- Install at least one smoke detector on the ceiling of your shop above potential fire hazards; keep a fully charged ABC fire extinguisher nearby.
- Never store solvents or chemicals in unmarked containers. Chemical solutions should always be stored in dark glass jars to shield them from light, which may change their composition.
- Do not flush used solvents down the drain. Consult the Yellow Pages to find out who handles chemical disposal in your area, or check with your local fire department.

SPRAYING SAFELY



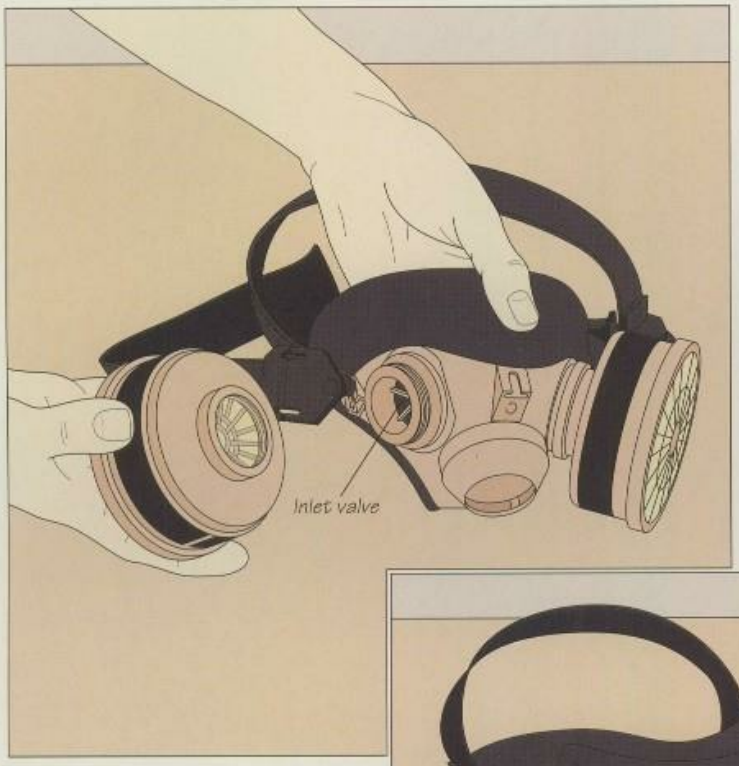
Using a spray booth

Spraying any finishing material produces potentially toxic or flammable vapors, or both. Even the fumes resulting from spraying water-based resins with lower organic solvent counts can be hazardous unless they are properly ventilated.

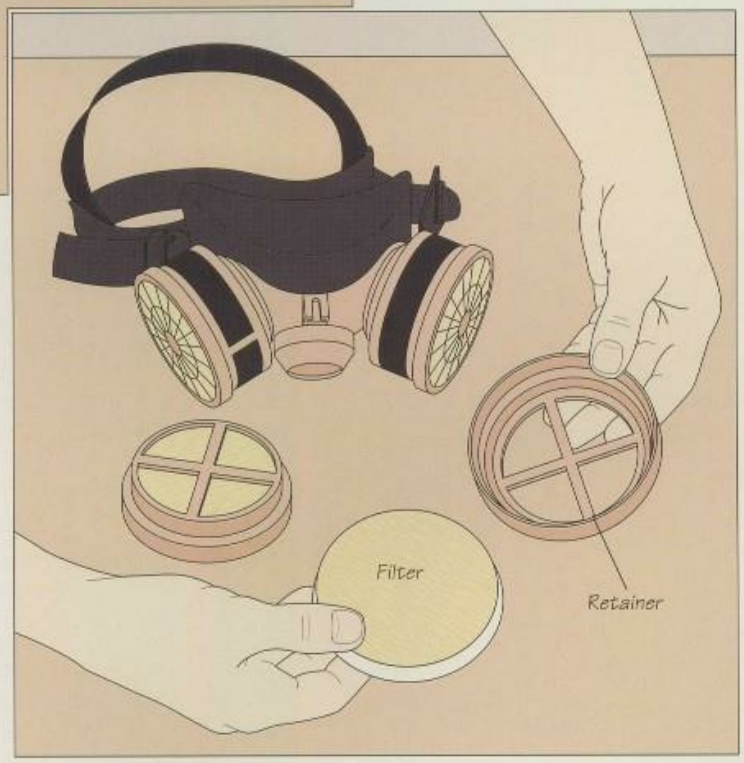
A spray booth makes spraying cleaner and safer, reducing health hazards by containing the overspray and fumes, then filtering and exhausting them. There are different models designed for different spraying applications. They range in size from complete rooms to portable models like the one shown above, which may be your best bet if space is a priority in your workshop or if you only spray small pieces of furniture.

Because of the toxic and volatile nature of most finishing products, all spray booths must meet Occupational Safety and Health Association (OSHA) guidelines. In some states, spraying is illegal in urban areas unless you have a properly built spray room *(page 102)*.

USING A RESPIRATOR



1 Installing the cartridges
Wear a dual-cartridge respirator approved by the National Institute of Occupational Safety and Health (NIOSH) whenever you spray lacquers or varnishes that contain volatile organic solvents, or when you mix chemical stains or work with ammonia. (If you have a beard, you need a full face mask or hood). To install the cartridges on the model of respirator shown, screw them onto the inlet valves (*left*). Always buy cartridges in pairs, and keep track of the hours they have been used.



2 Installing filters
Use dust filters in conjunction with respirator cartridges if you are sanding chemically treated wood or applying finishing materials such as shellac, lacquer or nonwater-based stains. Choose the appropriate filter for the task at hand, then fit a filter into each retainer (*right*). Snap the retainer onto the cartridge.

3 Testing the respirator
Place the respirator on your face, with the top strap over the crown of your head. Pull on the sidestraps until the facepiece of the respirator fits snugly. Test the device by blocking the outlet valve with your hand and exhaling gently *(above)*. There should be no air leakage around the facepiece. If there are any gaps, adjust the straps for a tighter fit. If necessary, replace the facepiece according to the manufacturer's instructions, or replace the respirator.

SHOP TIP

Storing respirator cartridges
Even water vapor can deplete the purifying chemicals in respirator cartridges. To extend their life, store the cartridges in a dry, airtight environment, such as a plastic freezer bag. Record the amount of time the cartridges have been used and replace them after eight hours of use or as soon as you can smell the finishing product through them.

CLEANING UP A TOXIC SOLVENT OR CHEMICAL SPILL

Disposing of soiled rags

Immediately open all doors and windows, extinguish any sources of heat and turn off all electrical sources. Wearing a rubber apron, rubber boots, heavy rubber gloves, safety goggles and a respirator, soak up the spill with rags or paper towels; then place them in a metal can double-lined with heavy-duty plastic garbage bags. Add a small amount of water to prevent spontaneous combustion. You can also spread the rags outside and allow the solvent to evaporate before disposing of them. Clean up any residue with the appropriate solvent listed in the chart below. If the product is extremely flammable or poisonous and more than one gallon has been spilled, leave the work area and call the fire department. Otherwise, dispose of the soiled rags following the environmental regulations in effect in your community.

THE RIGHT SOLVENT FOR A SPILL

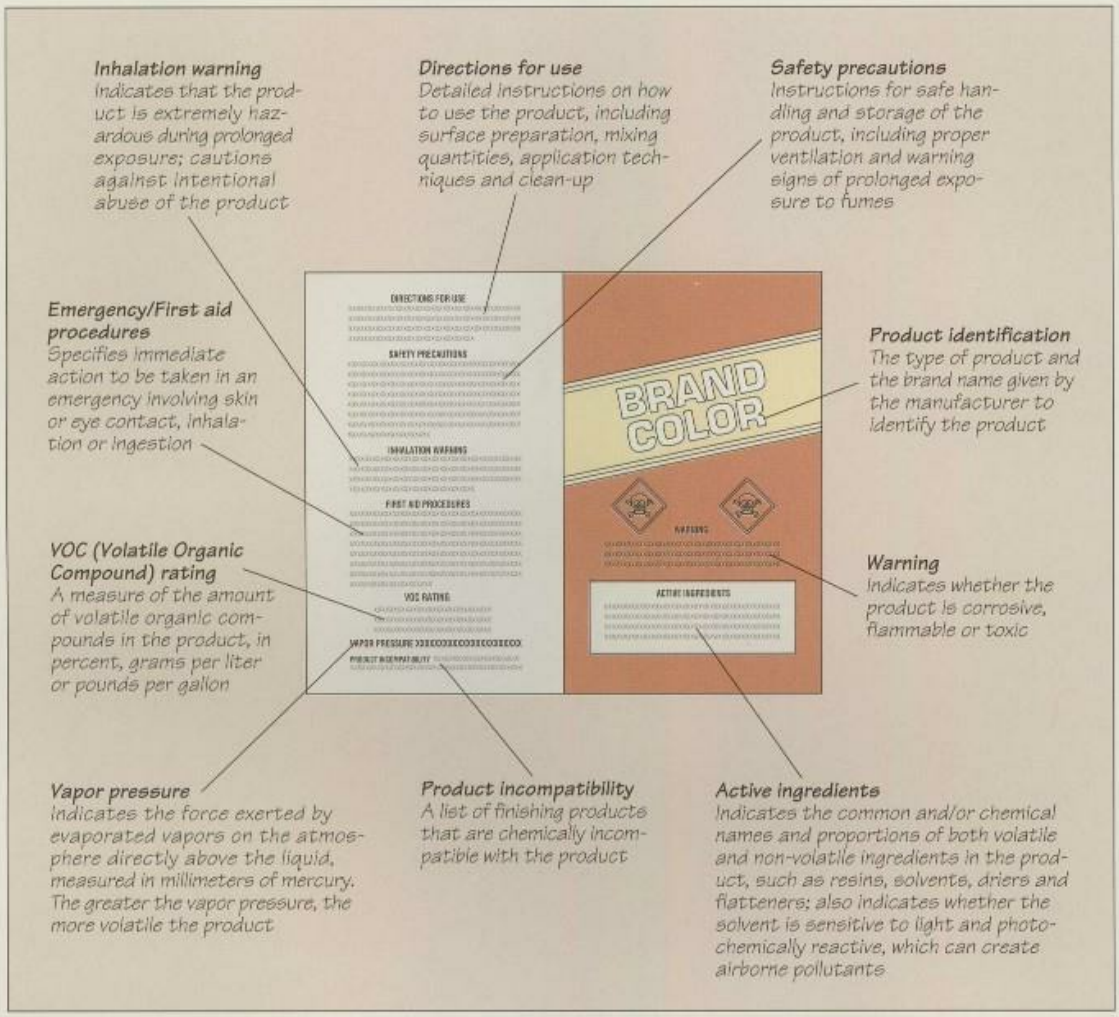
PRODUCT SPILLED	SOLVENT REQUIRED
Mineral spirits	Household detergent and water
Turpentine	Household detergent and water
Paint remover	Household detergent and water; or mineral spirits or paint thinner, then household detergent and water
Denatured alcohol	None
Methyl alcohol	None
Acetone	None
Lacquer thinner	None
Water-based stain or latex paint	Household detergent and water
Oil-based stain	Mineral spirits or paint thinner, then household detergent and water
Urethane or polyurethane	Mineral spirits or paint thinner, then household detergent and water
Varnish	Mineral spirits or paint thinner, then household detergent and water
Lacquer	Lacquer thinner
Shellac	Denatured alcohol (ethyl alcohol) or methyl alcohol
Linseed oil	Mineral spirits or paint thinner, then household detergent and water
Tung oil	Mineral spirits or paint thinner, then household detergent and water
Oxalic acid or two-part wood bleach	Water and baking soda
Lye	Water and vinegar, mixed in equal parts

BEING PREPARED FOR A CHEMICAL FIRE

Using a fire extinguisher
To control a small, contained fire, use a dry-chemical fire extinguisher rated ABC. Position yourself safely away from the fire with your back to the nearest exit. Holding the extinguisher upright on a level surface, pull the lock pin out of the handle *(inset)*, and aim the nozzle at the base of the flames. Squeeze the handle levers together and spray in a quick, side-to-side motion *(right)* until the fire is extinguished. If the flames spread, leave the area immediately and call the fire department. Dispose of burned waste following the advice of the fire department. Have the extinguisher recharged.

Checking a smoke detector
A smoke detector is an essential safety feature in a finishing shop. Test the device once every month. First, press the test button. Then, blow out a lit match below a vent, letting smoke enter it, or hold a flame below it *(left)*. Replace the battery if the alarm does not sound for both tests—or if it emits a chirping sound, indicating the battery is worn.

DECIPHERING THE LABEL INFORMATION



Reading a product label

The label on a container of finish is more than just a trademark and a set of instructions. It is both the key to comparing the finish's characteristics with those of other products and a guide to using the substance safely in the shop. The composite label shown above includes the features you should look for when choosing a finishing product, such as toxicity rating, VOC rating, vapor pressure and flammability. Refer to the chart on page 19 to determine the toxicity of a product's active ingredients and compare them with those of other similar products to help you choose the least toxic finish. Follow the safety precautions specified on the label to set up the proper ventilation and working conditions, and familiarize yourself with the first aid instructions in the event of an accident.

Some states allow the use of Trade Secret Registry numbers for a product's ingredients to protect patented chemical formulas. If you find the information on the label too vague, request a Material Safety Data Sheet (MSDS) from the manufacturer if one is available. An MSDS will explicitly detail the product's hazardous ingredients as well as precautions for safe handling and use.

CHOOSING A SAFE FINISH

Finishing chemistry has changed radically in recent years. The most significant advance has been the development of water-based finishes in response to both the health risks posed by solvents and clean-air legislation that limits the percentage of VOCs, or volatile organic compounds, in solvent-based finishes. Most of these regulations are primarily intended for furnituremakers who use more than one gallon of finish per day, yet industry experts predict that by the mid-1990s, VOC-compliant finishes will be the rule rather than the exception for everyone in the United States.

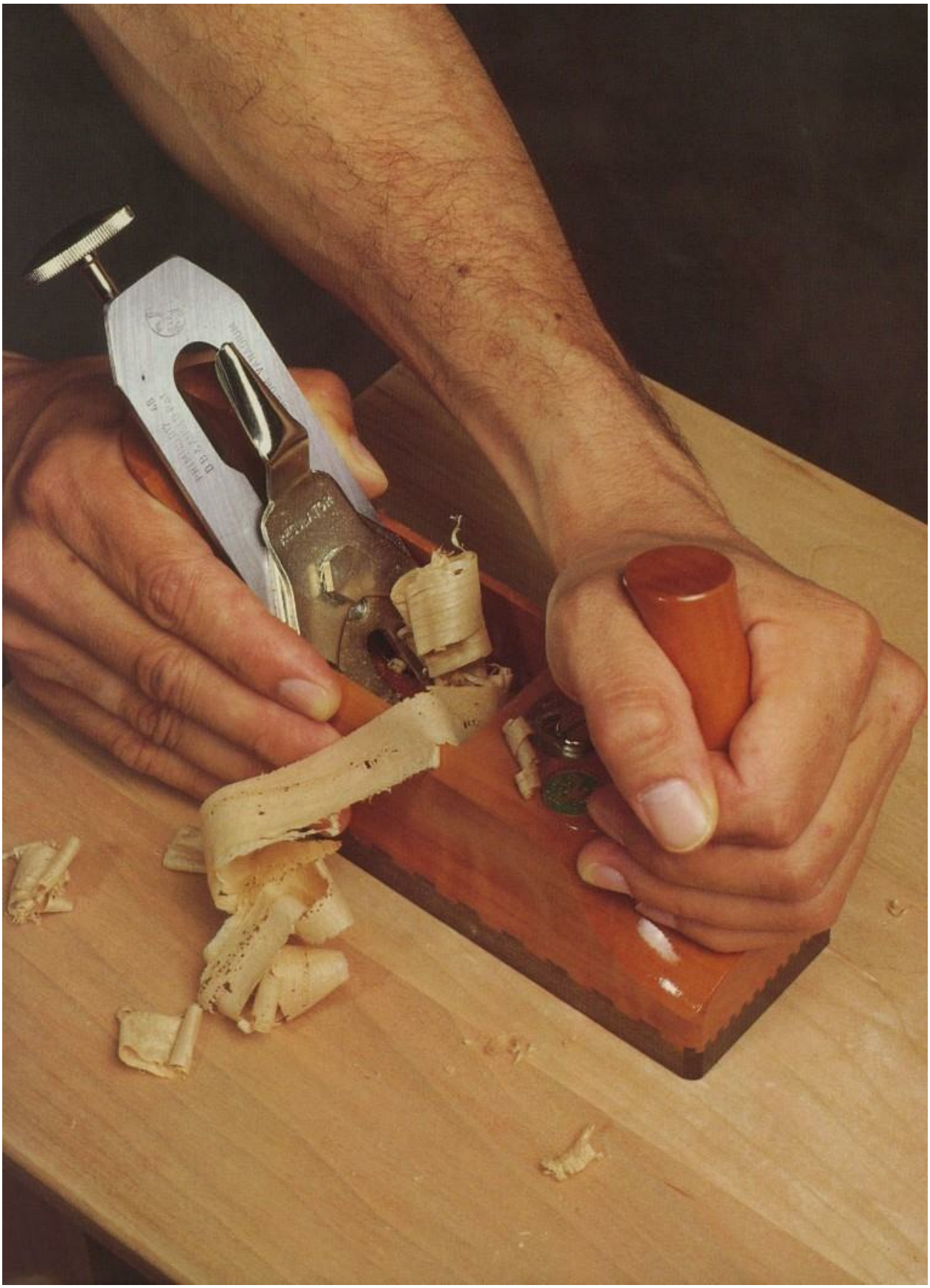
Inhalation is the most common way that solvents are absorbed into the bloodstream, but toxins can also be ingested from food and beverages left in the shop. Others can be absorbed directly through the skin or even by swallowing vapors in saliva.

In their most poisonous form, solvents can cause damage to the central nervous system and respiratory tract. Methylene chloride, for example, is suspected of being a carcinogen, while some glycol ethers have been linked to birth defects. Keep in mind, however, that the health hazards of any finishing product depend on a number of factors. Most products on the market are actually benign when used only on occasion, and could only be considered poisonous if swallowed directly. Some can even be made non-toxic; shellac is commonly used as an ingredient in confectioners' glaze.

When choosing a finishing product, be aware of the combination and concentration of organic solvents in its makeup, particularly if you intend to use the substance for extended periods of time; prolonged exposure may be hazardous. The chart below lists the solvents contained in a variety of finishing products and evaluates the relative toxicity of each one. Always choose the safest product for the job at hand.

TOXIC SOLVENTS

FINISHING PRODUCT	SOLVENT
Wood filler (paste and liquid)	Petroleum naphtha*, mineral spirits*, acetone**, methyl ethyl ketone**, methyl isopropanol**, isobutyl ketone***
Stains (aniline, wiping, NGR, gel and glazing stains; color pigments)	Ethanol*, mineral spirits*, toluene***, xylene***, methanol***, glycol ethers***
Shellacs (white and orange)	Ethanol*, methanol***
Lacquers (spray and brush, sanding sealers)	Acetone**, methyl ethyl ketone**, isopropanol**, methanol***, xylene***, glycol ethers***
Lacquer thinner	Acetone**, methyl ethyl ketone**, isopropanol**, glycol ethers***, toluene***
Rubbing oils (Danish oil, antique oil)	VM&P naphtha*, turpentine**, toluene***
Drying oils (boiled linseed oil, polymerized tung oil)	Mineral spirits*, turpentine**
Varnishes (tung oil varnish, spar varnish, varnish stain)	Mineral spirits*, VM&P naphtha*
Polyurethanes (poly varnish, urethane stains)	Mineral spirits*, toluene***
Lacquer/varnish removers	Acetone**, xylene***, methanol***, methyl isobutyl ketone***, toluene***
Waxes (paste wax, furniture wax)	Petroleum naphtha*, turpentine**
	* **Safest product** ** **Mildly hazardous product** *** **Product to be avoided if possible**



PREPARING THE SURFACE

Among its many uses, the hand scraper can help clear away dried adhesive after gluing up a carcase or drawer.

Old-time wood finishers smoothed wood with sharkskin and rush, filled its pores with plaster of Paris and pulverized brick, colored it with materials such as iron filings and walnut shells, and finished it with secret combinations of oils and beeswax. Modern finishing techniques are mundane by comparison, but the object is the same: to bring out the beauty of the wood. Whether this means a glassy film on the surface of the wood or a finish that softly glows from within depends on the type of protection the wood needs and the effect you wish to achieve. Because taste is involved, there is no single right answer to every finishing question. But all professional-quality finishes have one thing in common: painstaking surface preparation, which readies the wood to accept the finishing materials.

The amount of time you spend on surface preparation and the tools you use depend in large part on your work habits and your wood. Surfaces speckled with dried glue obviously require more work to smooth. Loose knots, splits and other defects need repair prior to finishing; so does every dent and chisel nick. The wood probably has jointer and planer marks, which you can remove with shallow cuts using a smoothing plane. The plane must be properly adjusted and sharp, so it cuts wood fibers rather than tearing them and roughening the surface. If the wood has an irregular pattern, so you cannot avoid tearing the grain as it changes direction, substitute a cabinet scraper—a thin, flat piece of steel with a burred edge. (For ultimate smoothness of straight-grained wood, use both the smoothing plane and cabinet scraper.) Cabinet scrapers take practice to sharpen and use, but once mastered they can substantially reduce your sanding time. Beware of an improperly sharpened edge, however, which can scratch the wood as badly as coarse sandpaper.

Sanding with successively finer grits completes the surface preparation. For hand-sanding a fairly smooth surface, a typical progression is 150 grit, followed by 220 and then 280 grit. (If you did not smooth the wood with a cabinet scraper, you might need to start with 80 or 120 grit.) Never skip an intermediate grit or you will leave scratches in the wood that the finish will magnify. With an orbital sander, use the same grit sequence; plan on hand-sanding with the final grit to remove any whorls. After final sanding, you may wish to "raise the grain" and then resand, to remove the whiskery fibers that might otherwise pop up through the finish on the first humid day. This step is essential when applying any material with a water, rather than solvent, base.

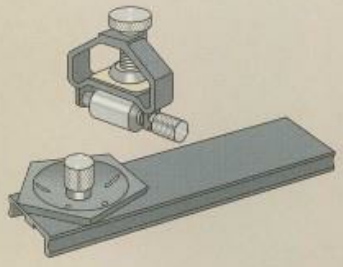
Whether or not you fill the pores of the wood is again a matter of taste. If you like a natural-looking finish that allows you to "read the wood grain," do not use filler. Close-grained species such as pine and cherry do not require filling in any case, but if you want a glassy finish on an open-grained species, such as oak or mahogany, you must fill the wood.

A wash coat may be applied to the wood before or after staining—or not at all if you are applying a penetrating oil finish. A wash coat can be nothing more than a half-and-half solution of your final finish and the solvent recommended by its manufacturer (for lacquer, use sanding sealer). The point of using a wash coat is to prevent the wood from uneven or excessive absorption of finishing materials. When applied before the final finish, the wash coat keeps the wood from drinking up the finish, thereby reducing the number of coats required to build up the proper thickness.

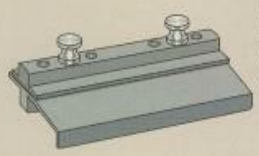
Despite a modern blade adjustment mechanism that enables the tool to slice off paper-thin shavings, this smoothing plane retains the handcrafted quality of a traditional hand tool. Producing smooth surfaces is a crucial step in finishing furniture.

TOOLS AND ACCESSORIES

Honing guide and angle jig
For honing plane blades. Device holds blade at appropriate angle for honing a bevel; rotating the wheel on top of the jig sets angles between 15° and 35°



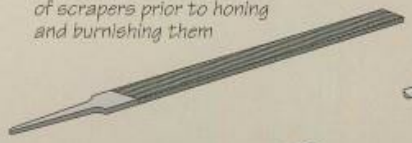
Smoothing plane
For smoothing wood surfaces with the grain, usually prior to scraping and sanding. Blade must be sharpened and properly adjusted before use



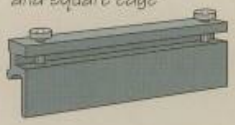
Grinding jig
For holding plane blades in alignment with grinding wheel during sharpening

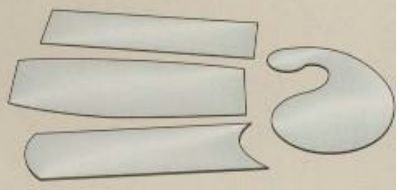
Tri-burnisher
Used to form small burr, or hook, on cutting edges of scraper after honing; combines round, triangular and oval burnishers in one tool

Mill bastard file
For squaring cutting edges of scrapers prior to honing and burnishing them

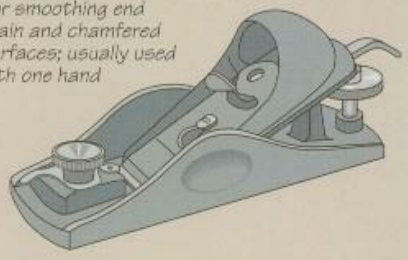


File clamp
Holds file perpendicular to cutting edge of scraper during sharpening of scraper, ensuring straight and square edge



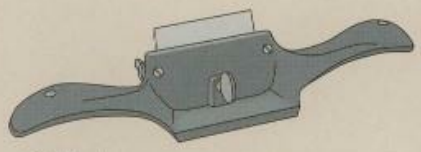


Block plane
For smoothing end grain and chamfered surfaces; usually used with one hand

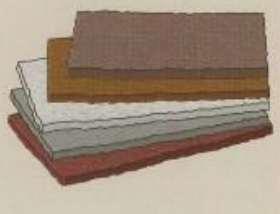


Combination sharpening stone
For sharpening plane blades. Coarse side removes metal quickly; fine side creates smooth edge. Lubricated with water or oil depending on the type of stone

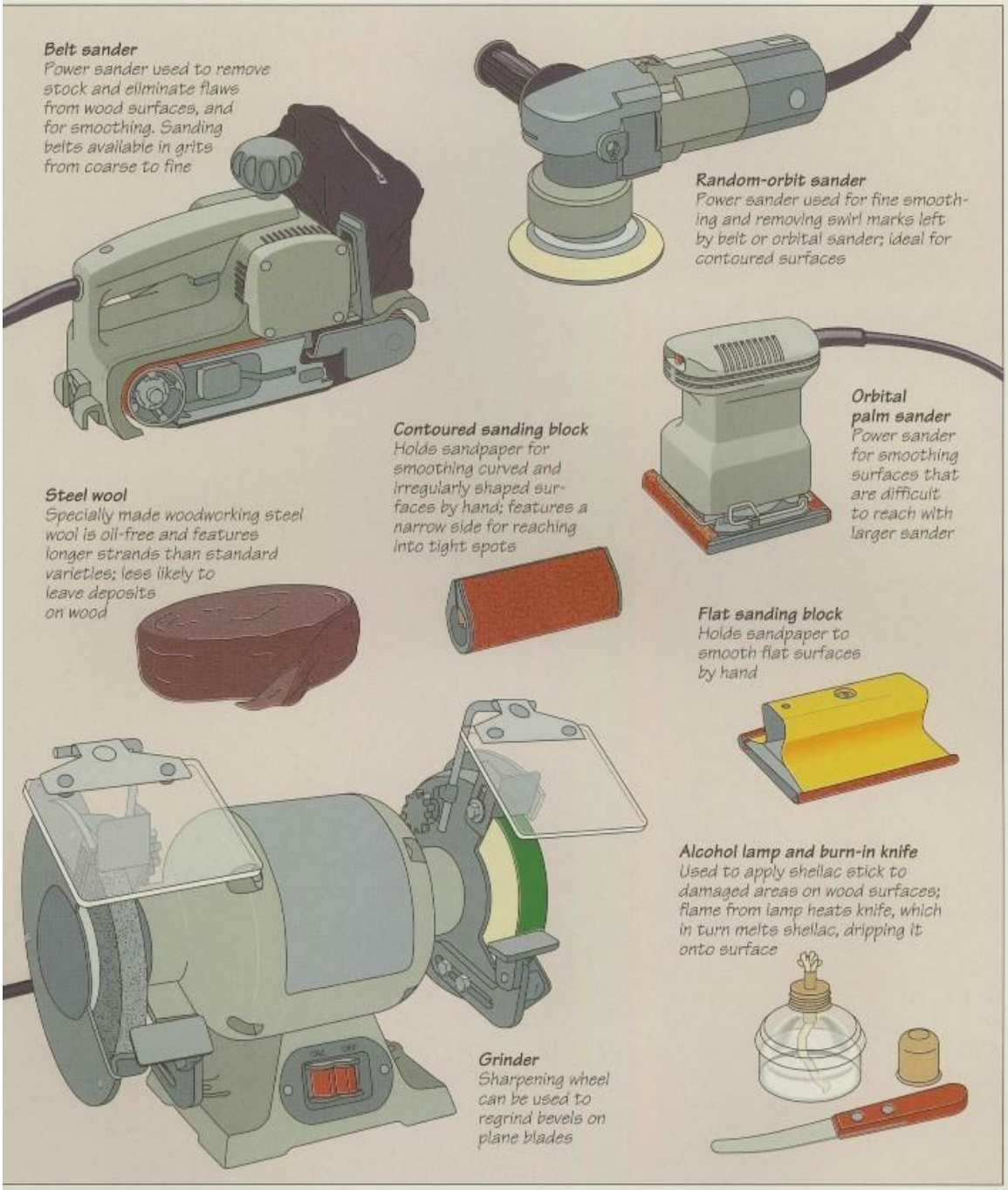
Hand scrapers
Rectangular scraper smooths flat surfaces; curved models work well on contoured surfaces, moldings and spindles



Abrasive pads
An alternative to sandpaper for smoothing wood surfaces and abrading intermediate finish coats by hand; abrasive particles of aluminum oxide and silicon carbide are bonded to synthetic fiber pads. Last longer than sandpaper; can be washed and reused



Cabinet scraper
For smoothing wood surfaces, typically after planing; well suited for leveling knots and cutting away dried glue. Blade scrapes a paper-thin shaving from surface; has twin handles for greater convenience and control than hand scraper


Belt sander
Power sander used to remove stock and eliminate flaws from wood surfaces, and for smoothing. Sanding belts available in grits from coarse to fine
Random-orbit sander
Power sander used for fine smoothing and removing swirl marks left by belt or orbital sander; ideal for contoured surfaces
Orbital palm sander
Power sander for smoothing surfaces that are difficult to reach with larger sander
Contoured sanding block
Holds sandpaper for smoothing curved and irregularly shaped surfaces by hand; features a narrow side for reaching into tight spots
Steel wool
Specially made woodworking steel wool is oil-free and features longer strands than standard varieties; less likely to leave deposits on wood
Flat sanding block
Holds sandpaper to smooth flat surfaces by hand
Alcohol lamp and burn-in knife
Used to apply shellac stick to damaged areas on wood surfaces; flame from lamp heats knife, which in turn melts shellac, dripping it onto surface
Grinder
Sharpening wheel can be used to regrind bevels on plane blades

PLANING

Choosing the best way to smooth a wood surface is a matter of individual preference. There are no ordained steps or prescribed rules. Some woodworkers plane and then sand; others plane and scrape before sanding.

Whichever sequence you decide to follow, the object is to produce a surface that is as smooth as glass and just as flat. This section of the book explains the use of a smoothing plane to begin the process of preparing a wood surface to accept a finish.

A well-sharpened blade in a properly adjusted plane can shear off fine shavings of wood. You can make all the adjustments with only a screwdriver, despite the plane's apparently complicated design *(below)*.

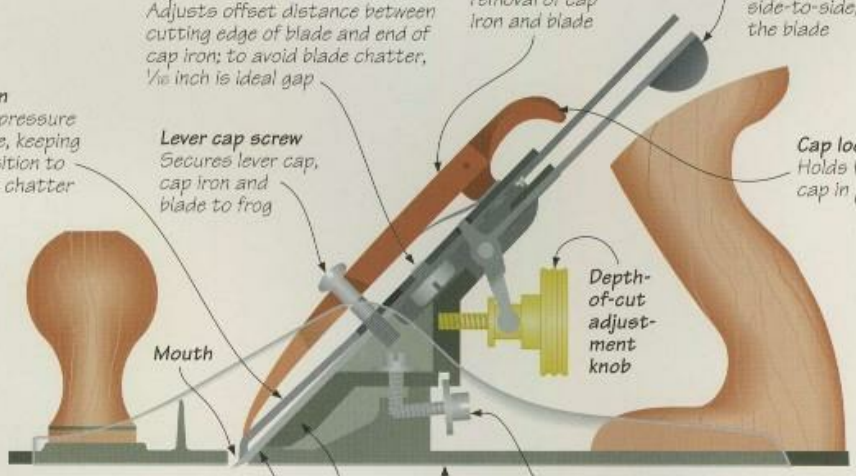
Plane blades require regular sharpening. Although you can hone a blade by hand *(page 26)*, a grinder is the best tool to bring a cutting edge to peak performance. For a nicked blade or an old out-of-square one you wish to salvage, square its end *(page 25, step 1)*. For a new blade or one that has had its bevel worn away, hone a new bevel on the cutting edge *(step 2)*. To maintain a keen edge, hone the blade frequently on a sharpening stone *(step 3)*.

Planing the edges of a workpiece with a smoothing plane—also known as edge jointing—is usually done before planing the faces. This allows you to remove any blemishes from the faces left by the jaws of a clamp or a vise.

Before using a plane, set the depth of cut to remove only a thin shaving on each stroke. Because an excessive depth setting may produce gouges in the workpiece, you should test your setting first on a scrap board. For best results on a large surface use a long plane; a short one will be more likely to follow existing contours.

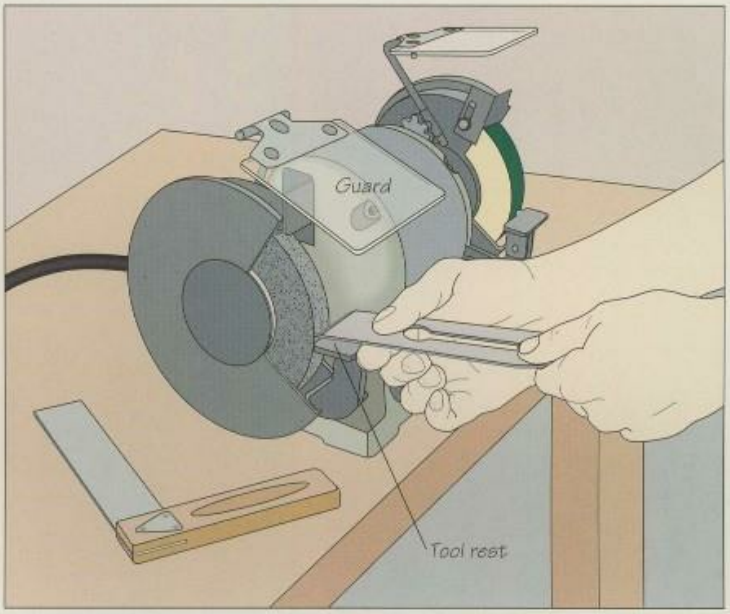
Set a plane on its bottom when storing the tool to prevent the iron from getting nicked by other tools. Occasionally rub a thin film of light machine oil on the blade to prevent rust. Once a year, or depending on the amount of use, take the tool apart for a general cleaning.

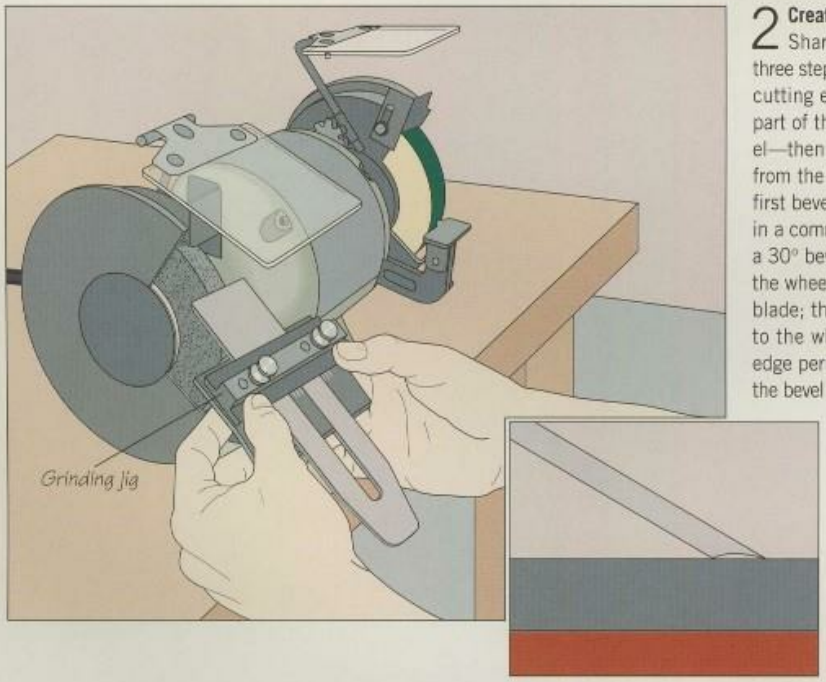
ANATOMY OF A SMOOTHING PLANE



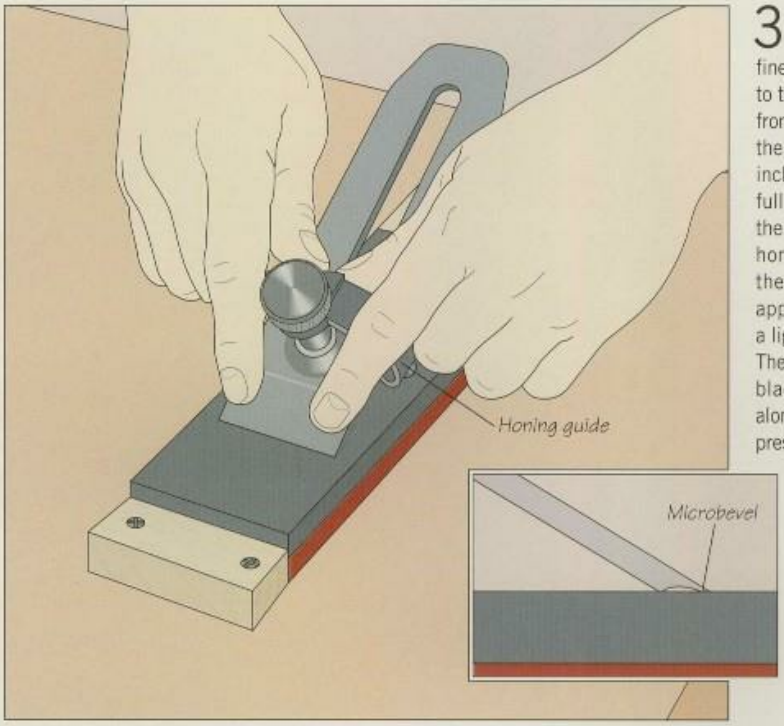
SHARPENING A PLANE BLADE WITH A MACHINE

1 Squaring the end of the blade
Use a try square to check whether the cutting edge of the blade is square. If it is not, square it on a grinder with a rough wheel. With the guard properly positioned and the blade clear of the wheel, switch on the machine. Holding the blade between the index finger and thumb of your right hand, set it bevel up on the grinder's tool rest and advance it toward the wheel until your index finger contacts the tool rest *(right)*. Slide the blade side-to-side across the wheel, pressing lightly while keeping your finger on the tool rest. The tip of the blade should stay perpendicular to the wheel throughout the operation. Dip the blade in water occasionally to prevent it from overheating. Check the blade for square regularly.





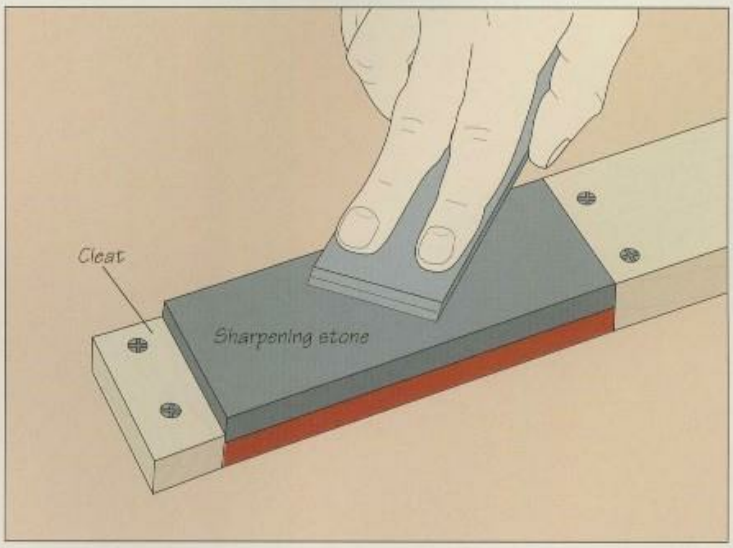
2 Creating a hollow-ground bevel
Sharpening a plane blade involves three steps: creating a bevel on the blade's cutting edge, honing another bevel on part of the first one—called a microbevel—then removing the burr that results from the honing process. To create the first bevel, clamp the blade top face up in a commercial grinding jig set to create a 30° bevel. Run the cutting edge across the wheel as you would for squaring the blade; the jig will keep the blade square to the wheel *(left)*. Check the cutting edge periodically and stop grinding when the bevel forms *(inset)*. As a rule of thumb, the bevel is correct when most of the sparks showering from the grinder fall on the top face of the blade, rather than below it.

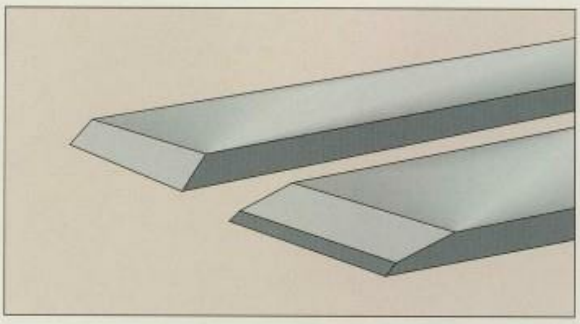


3 Honing the microbevel
Place a combination sharpening stone fine side up on a work surface. Nail cleats to the table against the stone to keep it from moving. One of the cleats should be the same height as the stone and 4 to 5 inches long; this will allow you to use the full length of the abrasive surface. Clamp the blade in a commercial angle-setting honing guide with the bevel touching the stone. Saturate the stone with the appropriate lubricant—either water or a light oil—until it pools on the surface. Then, holding the honing guide, slide the blade back and forth from end to end along the stone *(left)*, applying moderate pressure until a microbevel forms *(inset)*. Continue until a burr—a thin ridge of metal—forms on the flat face of the blade. Then lap the burr as you would when sharpening a plane by hand *(step below)*.

SHARPENING A PLANE BLADE BY HAND

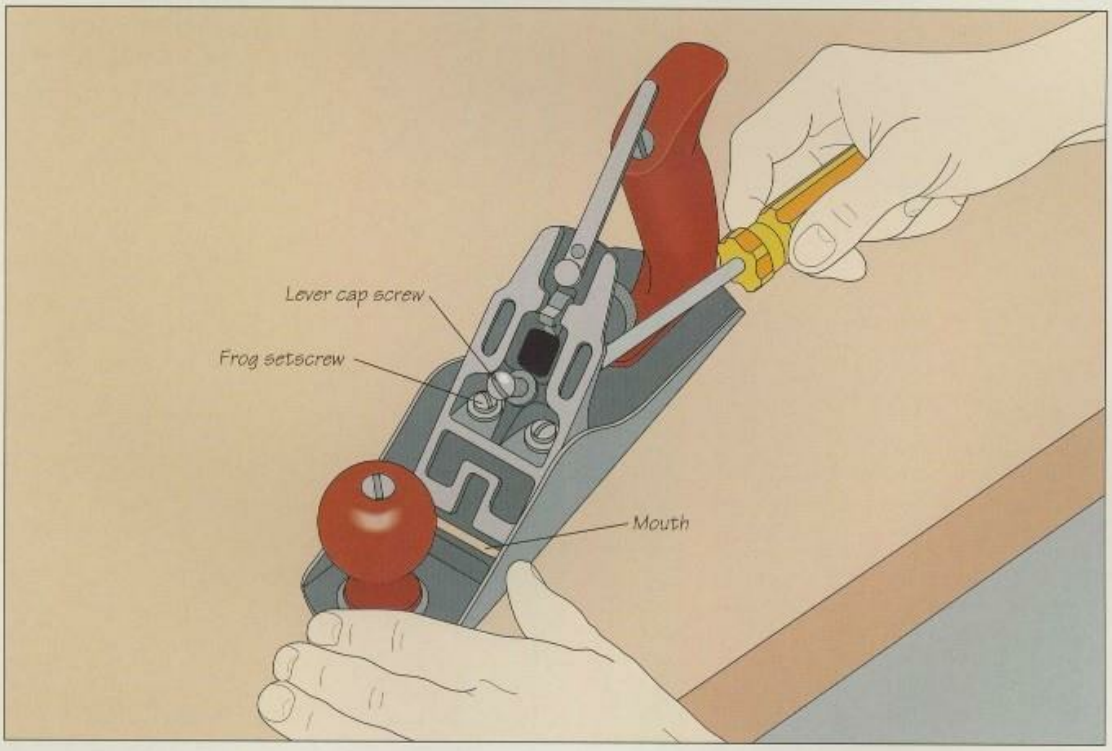
Lapping the burr
Clamp the blade in a commercial guide *(step above)* and grind a 30° bevel using the coarse side of the stone. Then reposition the blade in the guide and turn the stone over to hone the microbevel. To remove the burr from the blade—a process woodworkers call "lapping" the burr—remove the blade from the honing guide and saturate the stone once again. Holding the blade flush on the stone, bevel side up, move it in a circular pattern on the stone *(right)* until the flat side of the cutting edge is smooth to the touch. A few strokes should suffice to eliminate the burr. Test the sharpness of the cutting edge on a piece of paper; a sharp blade will slice a sliver from the edge.





Assessing a plane blade's cutting edge
No matter how well it is adjusted, a dull or poorly sharpened plane blade will do a poor job of smoothing the wood surfaces of your furniture. Moreover, its condition will only deteriorate if you persist in using it, losing its beveled cutting edge and possibly even going out-of-square, as in the blade shown *(far left)*. Such a blade would need to be squared and sharpened on a grinder. A well-sharpened blade *(near left)* has a visible bevel and microbevel, making it a razor-sharp cutting implement. This blade needs only an occasional honing on a sharpening stone.

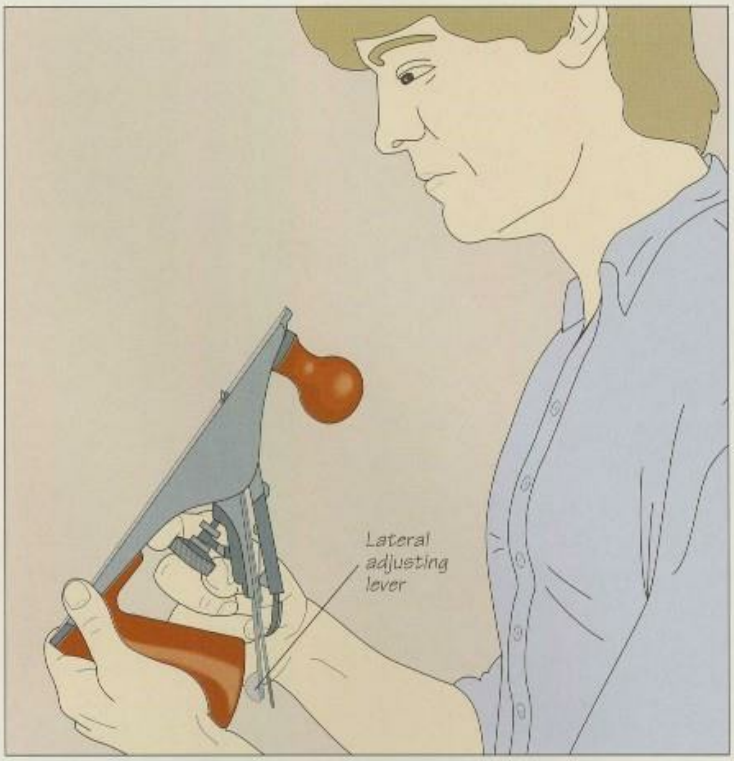
ADJUSTING A PLANE



1 Positioning the cutting edge
Loosen the lever cap screw and remove the blade assembly—including the lever cap, cap iron and blade—from the plane. Then loosen the cap iron screw and slide the cap iron on the face of the blade to leave a gap of about 1/16 inch between the end of the cap iron and the cutting edge of the blade. Tighten the cap iron screw. Next, place the blade assembly in position on the frog. The gap between the front edge of the blade and the front of the mouth should be about 1/16 inch. If not, loosen both frog setscrews about 1/4 turn, then turn the frog adjusting screw with a screwdriver to set the proper gap *(above)*. Lock the blade assembly in position.

2 Centering the blade and setting the depth of cut

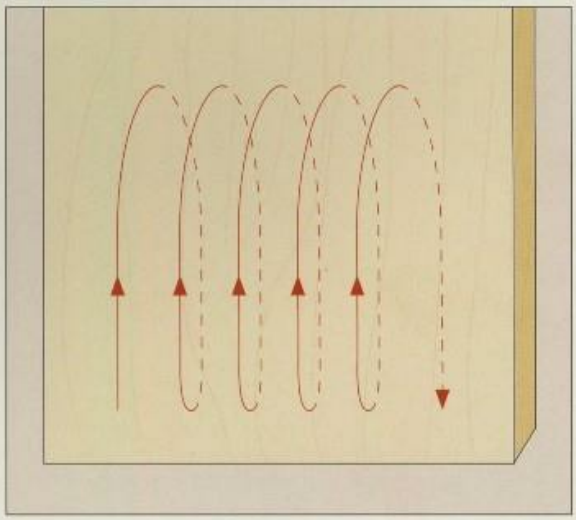
Holding the plane as shown, shift the lateral adjusting lever to one side or the other to center the cutting edge in the mouth. To set the cutting depth, turn the depth-of-cut adjustment knob so that no more than about 1/32 inch of the cutting edge protrudes from the mouth. Check the depth of cut by eye *(right)*, then confirm the setting by making a test cut on a scrap board. The shavings should be paper-thin; the finer the cut, the more transparent the shavings. Adjust the cutting depth, if necessary.

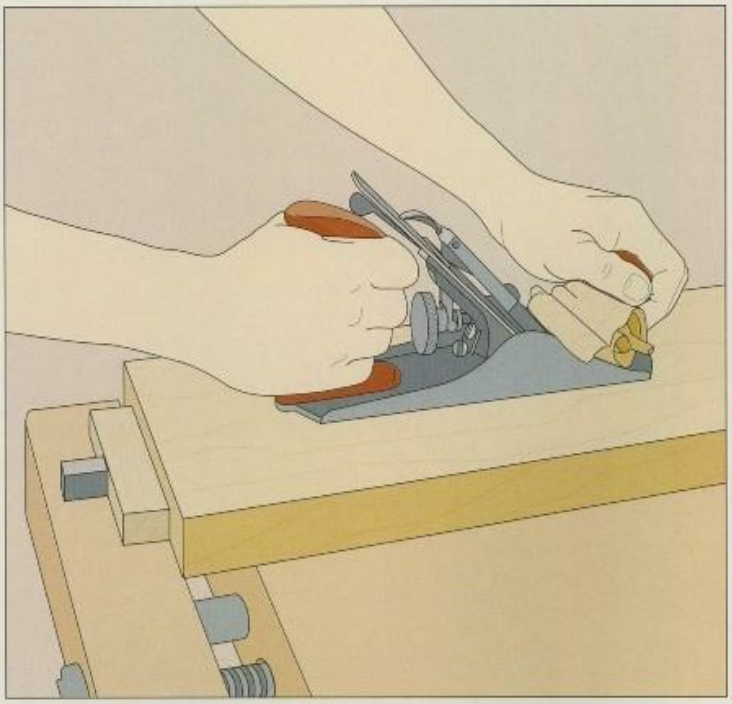


SMOOTHING WITH HAND PLANES

Using a smoothing plane

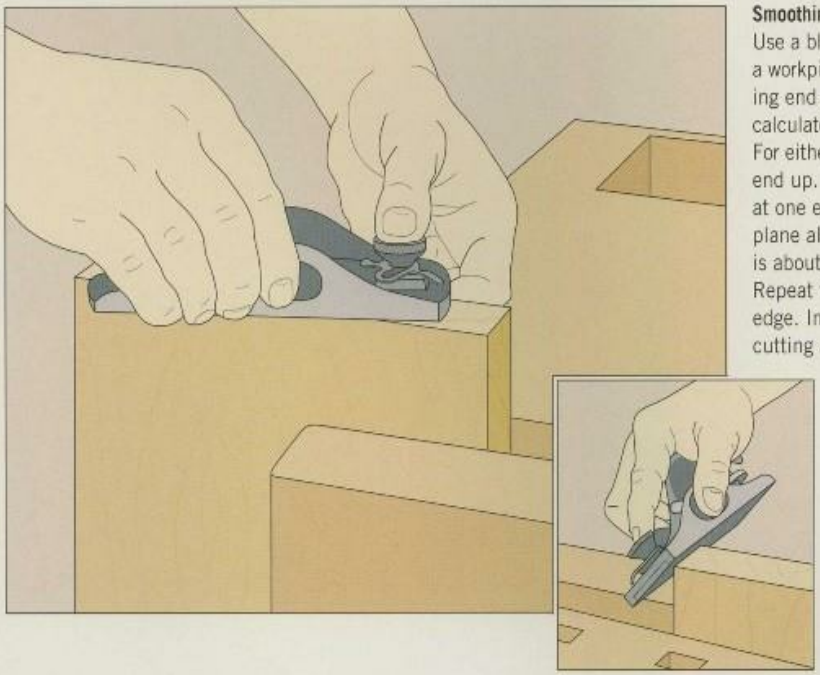
Guide a hand plane along a wood surface with smooth, even strokes. Always cut with the grain of the wood; planing against the grain will tear the wood, rather than shaving it off cleanly. If you cannot determine the orientation of the grain, lightly slide the plane parallel to an edge in one direction, then repeat in the opposite direction. The cutting edge will chatter or catch on the wood fibers when it is cutting against the grain. If the grain orientation changes on the surface, switch the direction of your stroke to follow the grain. To smooth a surface such as a tabletop, move the plane back and forth using a series of straight passes that slightly overlap, as shown in the diagram at right. When pulling the plane back after each forward stroke, tilt the tool to one side to lift the cutting edge clear of the surface.





Smoothing a face

Secure the workpiece face up on a work surface. Once you have oriented the plane with the wood grain, line up your shoulder and hip with the tool to help you maintain full control of the cut. Gripping the plane with both hands as shown, push the tool along the surface away from your body. Apply firm and sustained pressure during the stroke, pressing down on the front of the plane at the start of the pass. Once the plane is completely on the surface, even out the pressure, shifting the pressure to the rear of the plane at the end of the stroke. Examine the shavings as you work and adjust the cutting depth if you want a finer cut. Keep planing until the surface becomes shiny and smooth to the touch.



Smoothing end grain

Use a block plane to smooth the ends of a workpiece. There are two ways of planing end grain, both involving two steps calculated to avoid tearout at the edges. For either method, secure the workpiece end up. In one method, begin a stroke at one edge of the board, guiding the plane along the surface until the blade is about halfway across the end *(left)*. Repeat the process from the opposite edge. In the second method, start by cutting a chamfer at one edge of the board, holding the plane at an angle to flatten the corner *(inset)*. Then make a pass across the entire end, beginning the stroke at the other edge.

SCRAPING

Scraping wood surfaces is an intermediate step between planing and sanding. A sharp scraper can remove high spots, tearout and glue lines, smooth a surface, and clean up marks left by a plane. The tool is inexpensive, easy to use and relatively simple to sharpen. Two commonly used types are the hand scraper—a single blade of steel—and the cabinet scraper, a blade mounted in a metal or wood body that resembles a spokeshave. This implement features winged handles for two-handed pushing or pulling.

Scraper blades are made from thin sheets of spring steel and sharpened to form a cutting edge. They are available in different thicknesses, depending on the work you want them to perform. Thick scrapers are suitable for heavy cuts; light scrapers are used for finer work. Unlike a plane blade, the scraper has a hook—a small flare along the length of the cutting edge *(inset, page 32)*. The hook's cutting action allows the scraper to be pulled or pushed in any direction, so you can reach corners and tight spots inaccessible to a plane.

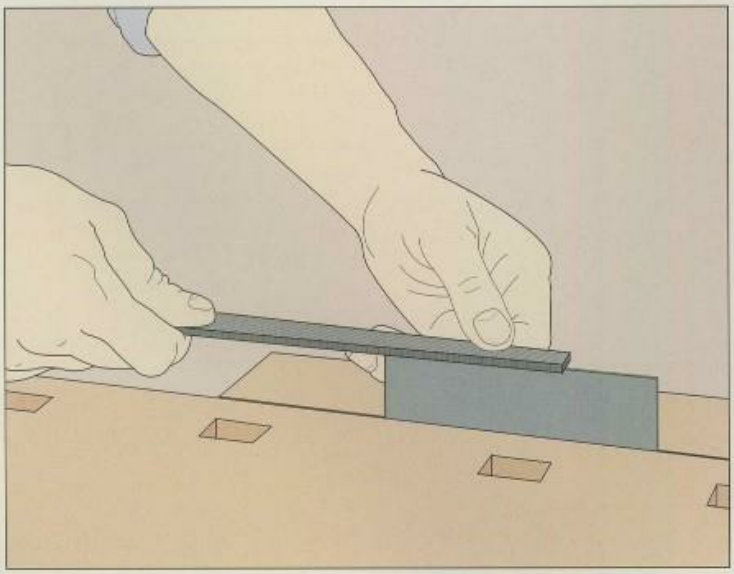
A scraper's cutting edges dull quickly and require regular sharpening, which involves filing, honing and burnishing. The size of the scraper's shavings signal its condition: the duller the blade, the smaller the shavings, until finally the tool produces only sawdust.

Properly sharpened, a scraper will produce finer and shorter shavings than a plane.

Most new scrapers need to be filed smooth before use. It may help to apply a little lubricating oil on the cutting edge of the scraper before burnishing, but be careful with the oil: If it gets on your hands or bench it could end up staining the workpiece.

Apart from maintaining the cutting edges of a scraper, keep in mind that the tool will perform well only if you hold it at an angle to the wood surface and push or pull it while applying a fair amount of pressure close to the cutting edge. If you hold the scraper almost perpendicular to the surface and apply heavy pressure, the tool will quickly remove wood, but it may also gouge, dent or scratch the surface. Held at more of an angle, the scraper removes less wood, but produces a smoother surface. One method of finding the right angle is to hold the tool almost parallel to the work surface; begin scraping while gradually raising the angle of the blade until it bites into the wood.

SHARPENING A SCRAPER

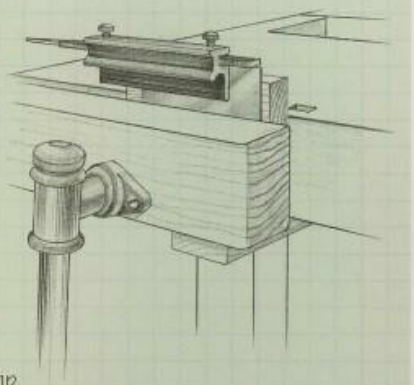


1 Filing the edges square

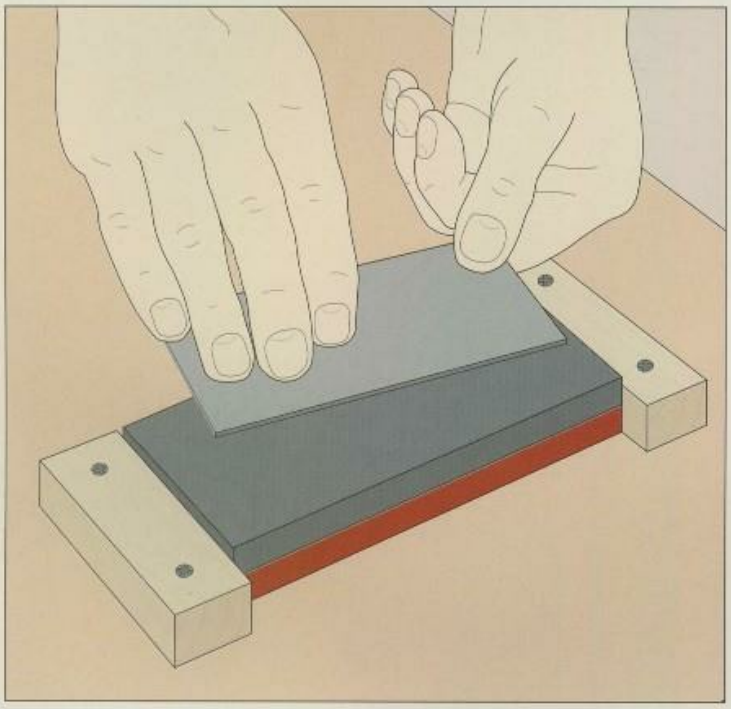
To file off the existing hook on a scraper, clamp the tool in a vise with one long edge facing up. Holding a sharp mill bastard file firmly with both hands as shown, make several passes back and forth along the edge of the scraper, exerting moderate downward pressure until the burr disappears and the edges are flat. To remove filings, periodically tap the file on a firm surface or use a file card. Turn the scraper over and repeat the process for the other edge.

SHOP TIP

Using a file clamp

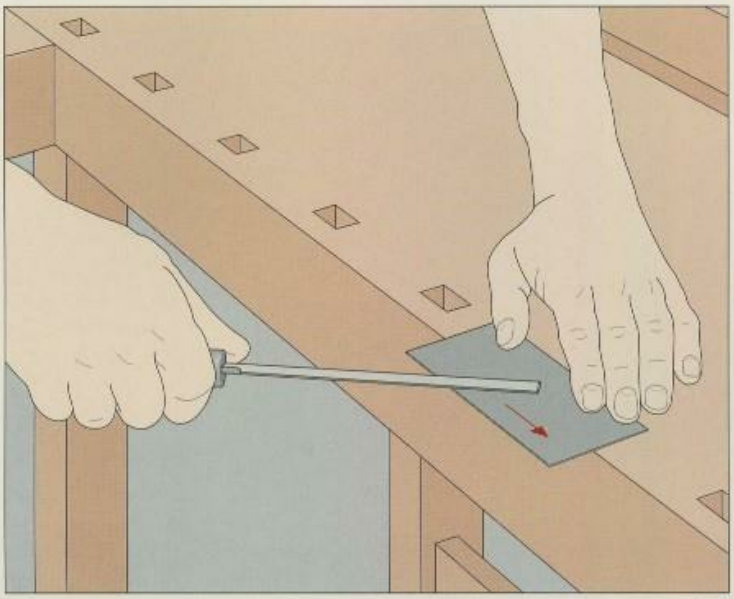


Designed to hold a file perpendicular to the edge of a scraper, a file clamp makes it easy to remove hooks and file straight edges on the tool. To use the file clamp, secure the scraper in a vise along with a wood block on one side to keep it rigid. Insert the file in the clamp and fix it in place using the thumbscrews on top of the implement. Position the clamp on the edge of the scraper and file the scraper's edge until it feels sharp, taking care not to cut yourself when testing.



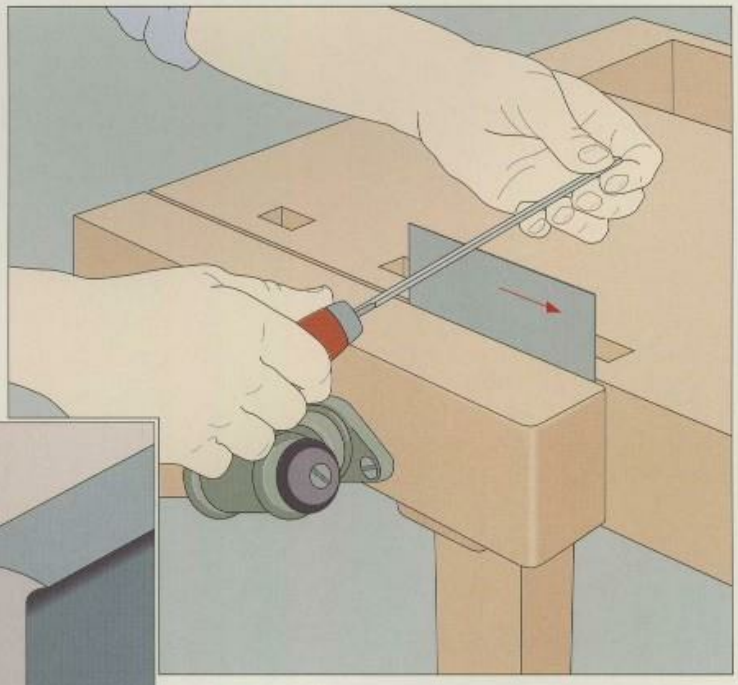
2 Honing the edges

Secure a combination sharpening stone fine side up to a work surface with cleats and lubricate it as you would when honing a plane blade *(page 26)*. Holding the scraper flat against the stone, rub the face on the stone with a circular motion *(left)*. Apply moderate pressure and continue until any roughness produced by filing disappears. Turn the scraper over and repeat for the other face. To complete the honing, hold the scraper edge down and slide it back and forth diagonally across the stone until the edge is smooth with sharp corners. Repeat for the other edge.



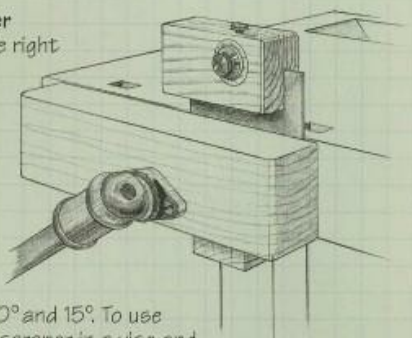
3 Burnishing the edges to start a hook
Place the scraper flat on a work surface with the edge to be sharpened extending off the table. Holding a burnisher at a slight angle to the scraper, make several passes back and forth along the edge *(left)*, applying strong downward pressure to start turning over the edge into a hook. Burnish the other cutting edge the same way; turn the scraper over and burnish the edges on the other face.

4 Completing the hook
Secure the scraper edge up in a vise. Hold the burnisher almost perpendicular to the edge and run it along the edge in one direction until the edge swells slightly, turning outward on one side *(right)*. For best results, apply moderate pressure. Then hold the burnisher so that the handle is at a 10° to 15° angle above the edge of the scraper and continue burnishing until the edge turns over. Repeat the process to form a hook on the other side of the edge *(inset)*, this time holding the handle with your other hand. The greater the pressure you apply, the bigger the hook. Turn the scraper over and burnish the opposite edge. Test the cutting edges on a piece of scrap wood, burnishing them again, if necessary, until you have the hook you need for the job at hand.

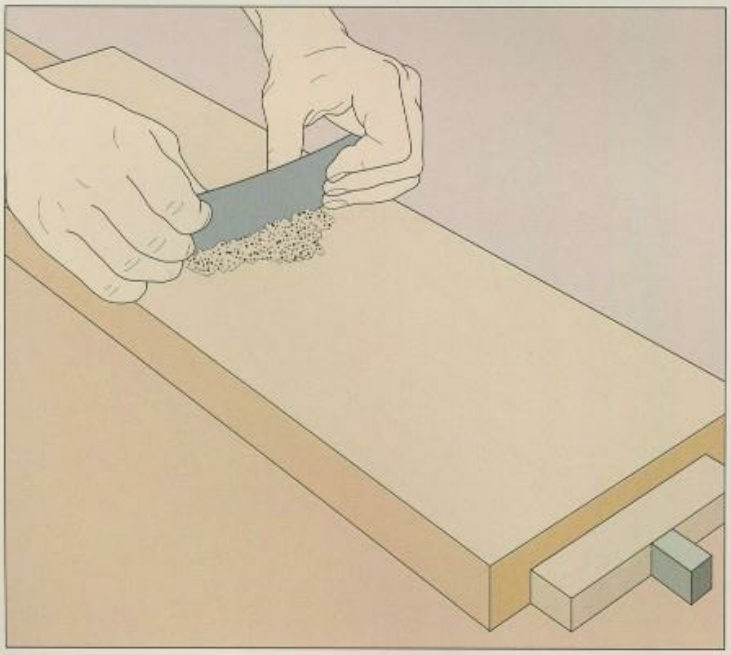


SHOP TIP

Using a variable burnisher
Holding a burnisher at the right angle for turning over a hook on a scraper is no easy task. One answer is a commercial jig that provides precise control of the burnishing angle. The actual burnisher is a carbide rod mounted within the body; a knob on the top adjusts the angle of the rod between 0° and 15°. To use the burnisher, secure the scraper in a vise and fit its blade in the burnisher's slot; running the burnisher back and forth along the blade with moderate downward pressure creates a hook of the appropriate angle.

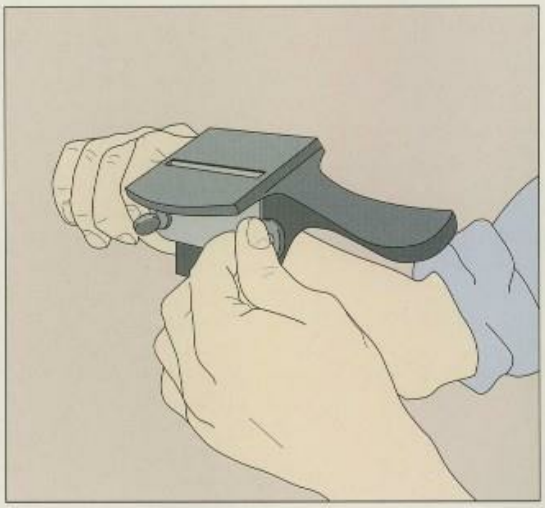


SMOOTHING A SURFACE WITH A HAND SCRAPER



Using a hand scraper
Secure the stock to a work surface. Standing at one end of the workpiece, curl your fingers around the front of the scraper and press on the back with your thumbs to make the tool bow slightly outward. Tilt the scraper forward about 20° from the vertical and scrape the surface in the direction that the bow is facing *(left)*. If the cutting edge does not bite into the wood properly, adjust the angle of the tool slightly. Work at a slight angle to the grain, applying moderate pressure and making long, fluid, overlapping strokes. At the end of each stroke, lift the scraper off the surface before stopping. You can also pull with the scraper, but be sure to flex the bow toward you.

SMOOTHING WITH A CABINET SCRAPER

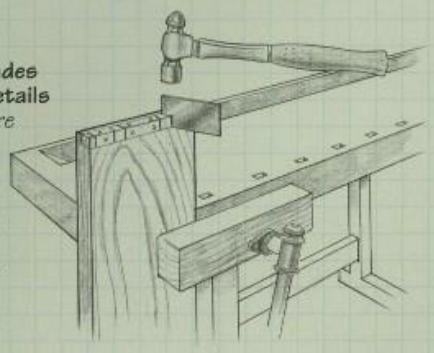


1 Adjusting the blade
Install the blade in the scraper with the hooked edge facing forward and protruding 1/32 inch from the sole of the scraper. Lock the blade in place by turning the two thumbscrews on the front of the scraper clockwise *(above)*. Then bow it slightly by turning the thumbscrew that presses against the center of the blade at the back of the scraper.

2 Using the scraper
Secure the workpiece. Then, standing at one end of the stock and holding the scraper firmly with both hands with the hook facing away from you, push the tool with moderate pressure along the surface *(above)*. At the end of each stroke, lift the scraper off the surface and turn the tool upside-down to dislodge the shavings and prevent the blade from clogging.

SHOP TIP

Using old scraper blades to cut half-blind dovetails
You can get some more mileage out of an old scraper by using it to complete the saw cuts made to fashion half-blind dovetails. Place the blade in the kerf and tap it with a hammer until it reaches the shoulder line of the joint. This will make it easier to finish the cut with a chisel.



SANDING

Sanding is the final stage in smoothing a piece of furniture and is also indispensable in eliminating any blemishes left by planes and scrapers. Both tools sometimes leave marks and ridges on wood surfaces. They can also compress wood fibers and close the pores in the wood, inhibiting its capacity to properly accept a finish. Sanding as the final step opens closed pores, allowing the finish to penetrate the surface.

A wide variety of natural and man-made sandpaper abrasives are available for the woodworker, from natural materials such as flint, garnet and emery to artificial ones like aluminum oxide and silicon carbide. For most applications, you need a sandpaper with hard, sharp-edged particles that are not easily dislodged from their paper backing. Garnet, silicon carbide and aluminum oxide are the abrasives that best satisfy these criteria.

A typical sanding sequence begins with a 120- or 150-grit paper, depending on whether or not you used a scraper *(page 30)*. You may first need an 80-grit abrasive to eliminate defects or irregularities from a surface. Continue sanding with a 220-grit paper, moving to increasingly finer abrasives to remove the scratches left by the preceding operation. For a surface that is to receive a glossy finish, you will need to use a paper at least as fine as 320 grit. How high up the grit scale you climb depends on the finishing product you intend to apply and the effect you wish to achieve. Keep in mind, however, that polishing a surface to a high gloss with an ultra-fine paper may keep a stain from penetrating evenly. Refer to the chart on page 37 for information on the different sandpaper grades and grits and when to use them.

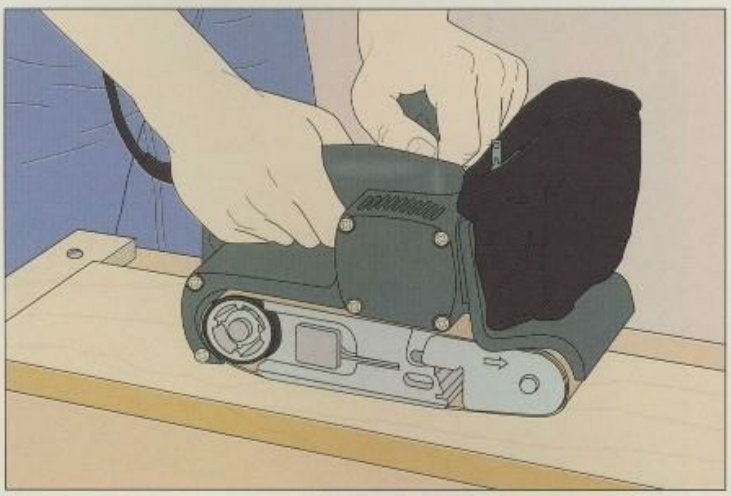
Combining the convenience of a power tool with the fine touch of hand sanding, a palm sander readies a cabinet for a finish.

Apart from selecting the appropriate grit, you also need to choose between open- and closed-coat paper. The abrasive particles on closed-coat papers cover almost the entire surface of the backing, and are best suited to sanding hardwoods. Open-coat papers have more widely dispersed particles, covering only 40% to 70% of the backing. These are your best bet for softwoods because they are less prone to clogging by more resinous wood.

As shown on the following pages, sanding can be equally well accomplished by hand or with power tools. Although hand sanding is laborious, it allows you greater control over the process, especially when working on contoured surfaces or in corners and tight spots.

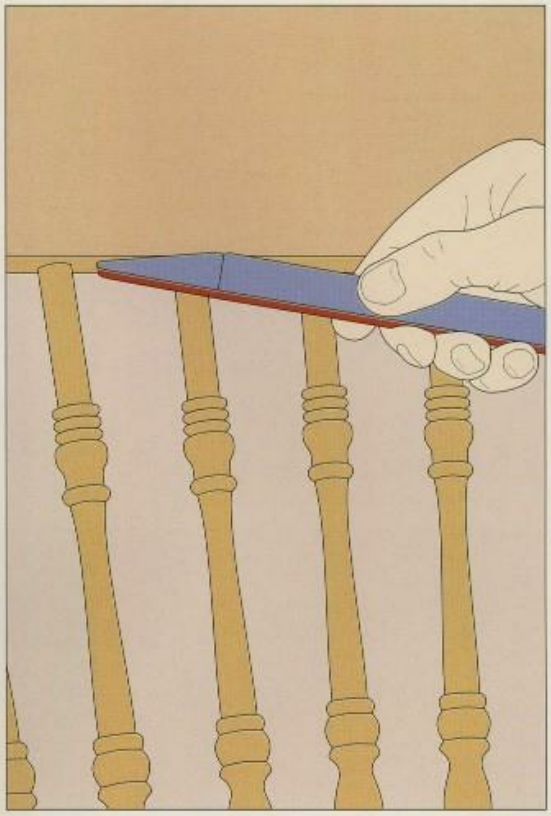
Whichever method you select, you can judge whether the surface is smooth enough by pulling a piece of fine nylon fabric over the wood; the cloth will snag on rough spots. Then examine the wood under a beam of light played across the surface at a low angle. The light will expose any remaining imperfections.

SANDING FLAT SURFACES



Using a belt sander

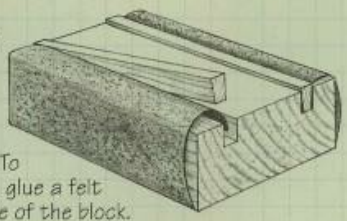
Clamp the workpiece down and install a sanding belt of the appropriate grit on your belt sander. Holding the tool above the stock with both hands, switch it on and gently lower it flat onto the surface. Guide the sander from one end of the workpiece to the other in smooth and straight overlapping passes that follow the grain of the wood *(left)*. Keep the sander flat and moving at all times until the surface is uniformly smooth. Avoid leaving the tool on one spot while it is running; it can cut into the surface quickly, leaving a gouge. Clean up the sanding particles *(page 42)* before repeating with a finer-grit belt.



Hand sanding
Attach a piece of sandpaper of the appropriate grit to a sanding block. Grip the block firmly and sand the surface with straight, overlapping, back-and-forth strokes, applying moderate pressure and working with the grain of the wood *(above, left)*. Keep the block flat on the surface at all times, particularly when you reach an end or edge. To smooth a small or restricted surface, such as the areas between the spindles of a chair as shown, use a commercial sanding stick *(above, right)*.

SHOP TIP

Shop-made sanding block
Cut a wood block that you can grip comfortably. On the top face of the block, cut two narrow grooves, then cut two wedge-shaped wood strips that fit in the grooves snugly. To provide even sanding pressure, glue a felt or cork pad to the bottom face of the block. To use the block, wrap a piece of sandpaper around it, insert the ends into the grooves, then tap in the wedges to hold the paper in place.



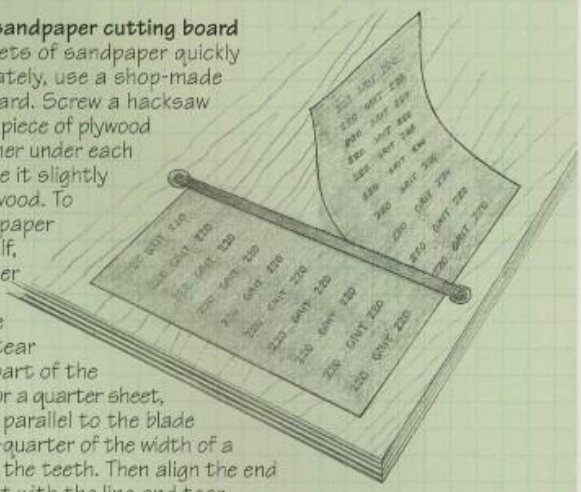
ABRASIVE GRADES AND GRITS

SANDPAPER		
Grade	**Grit**	**Uses**
Medium	80, 100, 120	Initial smoothing; removing shallow depressions and scratches
Fine	150, 180	Intermediate smoothing
Very fine	220, 240	Final smoothing before applying a finish
Extra fine	280, 320	Removing dust particles and air bubbles between finish coats
	360, 400	Final sanding before final coat of finish; initial sanding for high gloss finish
Super fine	600, 1200	Rubbing down the final coat of high gloss finish
STEEL WOOL		
Medium	1	Light removal of particles and raised fibers; smoothing of shallow depressions and scratches
Fine	00	Smoothing before applying a clear finish
Extra fine	000	Smoothing between coats of finish; light cleaning and deglossing of a finish or polish
Super fine	0000	Polishing; waxing

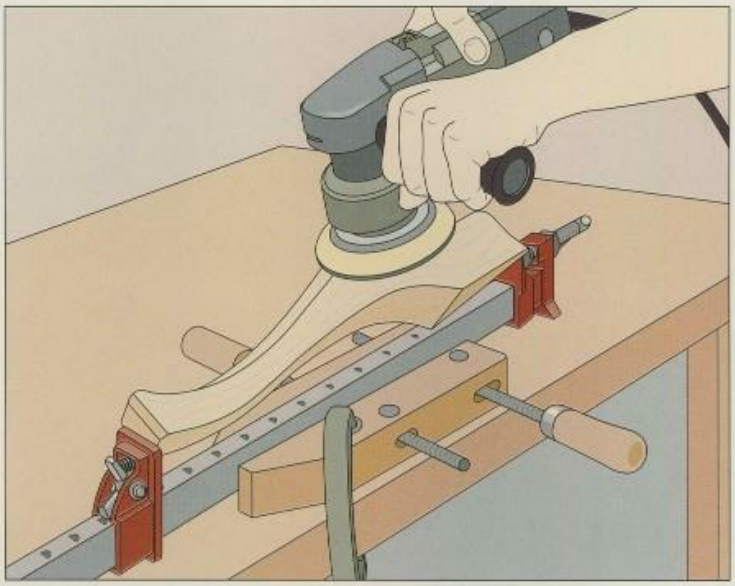
Choosing sandpaper
The range of sandpaper grits in the chart at left will serve for almost any finishing job. When buying sandpaper, consider its composition. Aluminum oxide paper works best with a belt sander. Choose silicon carbide paper in grits above 220 for finish sanding with an orbital sander.

SHOP TIP

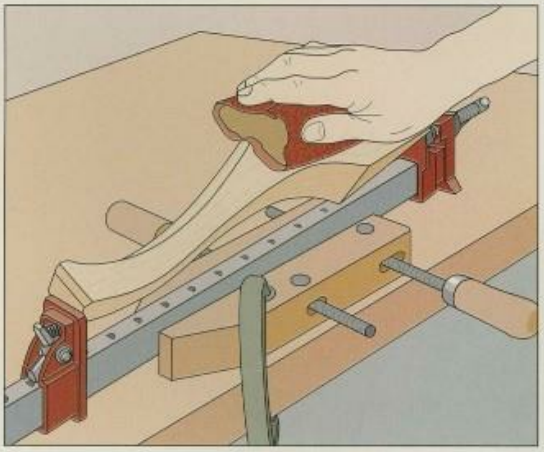
Making a sandpaper cutting board
To cut sheets of sandpaper quickly and accurately, use a shop-made cutting board. Screw a hacksaw blade to a piece of plywood with a washer under each end to raise it slightly off the plywood. To cut a sandpaper sheet in half, slide it under the blade. Holding one end down, tear the other part of the sheet off. For a quarter sheet, mark a line parallel to the blade that is one-quarter of the width of a sheet from the teeth. Then align the end of the sheet with the line and tear.



SANDING CURVED SURFACES



Using a random-orbit sander
With its compact and pliable sanding pad, the random-orbit sander is ideal for sanding contours such as a cabriole leg *(left)*. Clamp down the workpiece and fasten a sanding disk to the sander's pad. With the tool clear of the stock, switch it on and lower the pad onto the surface. Applying moderate pressure, work along the length of the workpiece in back-and-forth passes until the surface is smooth. Reposition the piece in the clamp as necessary to smooth adjacent surfaces.



Hand sanding
Smoothing contoured surfaces using only sandpaper risks creating blemishes on the wood or flattening out the curves with excessive pressure. For a shop-made sanding pad that can follow contours without oversanding, wrap a sheet of sandpaper around a thick sponge that you can comfortably grip. Hold the paper around the sponge and sand along the length of the surface with firm pressure.

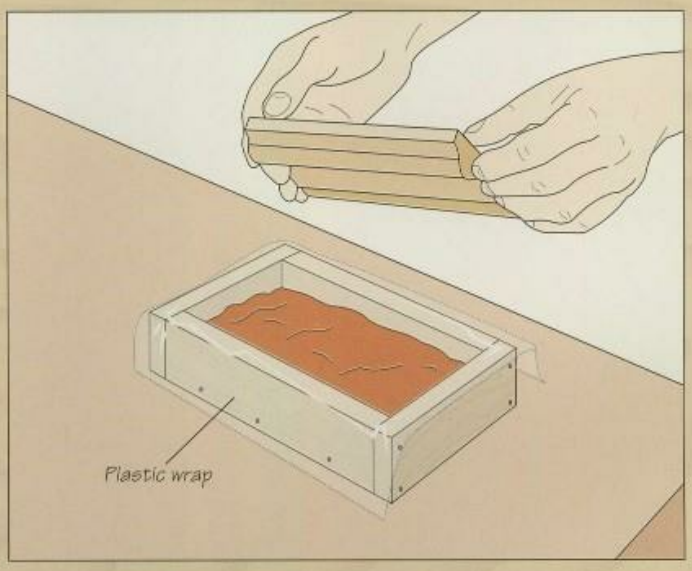
Using a sanding block
Secure the workpiece and attach a piece of sandpaper to a commercial contour sanding block. On the type shown, the ends of the paper are pinched together and held in a slot on the narrow side of the block. For most contours, sand with the circular side of the block against the wood *(above)*. For crevices and other tight spots, wrap a sheet of sandpaper around the block, hold it in place and sand with the narrow side.

BUILD IT YOURSELF

CONTOURED SANDING BLOCK

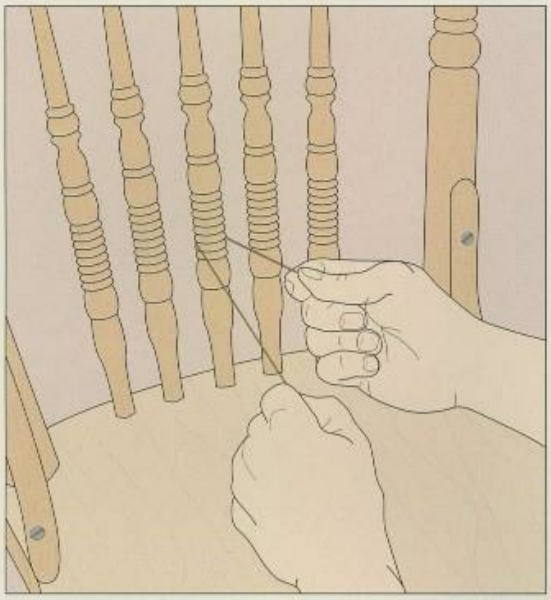
Smoothing the contours of a piece of molding evenly without damaging its contours is a difficult task with only sandpaper or a conventional sanding block. However, you can use a short sample of the molding to shape your own sanding block that corresponds exactly to the surface of the workpiece. Fashioning the block requires body filler or modeling rubber, used to make a mold of the profile.

To prepare the mold, nail together a small box slightly longer and wider than the sample molding and about ¼ inch deeper than the thickest part of the molding. Prepare the filler following the manufacturer's instructions, then fill about half the box with it. Lay a single thickness of plastic wrap over the box. While the filler is still soft, press the molding sample into the box and clamp it firmly against the filler. Let the filler harden, then carefully remove the molding sample from the box. Saw off the ends of the box.



To transform the box into a sanding block, stretch a piece of sandpaper abrasive side up across the molded side of the box. Use the molding sample to press the paper against the hardened filler, then staple the ends to the sides of the box.

To use the block, clamp the workpiece down and slide the block back and forth along the molding *(left)*.



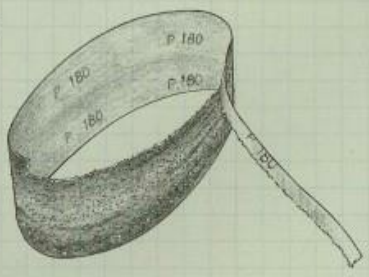
Smoothing grooves and turnings

To sand narrow grooves in turned pieces such as chair spindles, use commercial abrasive cord. Cut a piece of cord long enough to extend a few inches on each side and wrap it around the groove. Pull one end and then the other repeatedly to sand half the circumference of the groove *(above, left)*. Work from the opposite side to smooth the other half. To sand turnings or larger grooves, use abrasive tape *(above, right)*, which is wider than abrasive cord but handled identically. Smooth intricate turnings and moldings using steel wool or abrasive pads.

SHOP TIP

Shop-made abrasive tape

Sanding belts are an excellent source of abrasive tapes. The belts readily tear in parallel strips, making it easy to obtain a length of abrasive of the width you need. Since using abrasive tape involves cross-grain sanding, use only strips from fine-grit belts. Coarser abrasives may leave scratches and make abraded areas prone to absorbing more stain than surrounding areas.



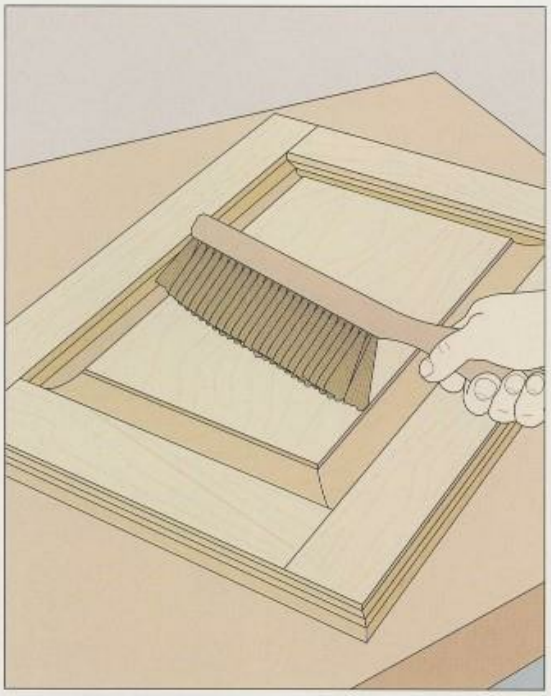
SANDING IN TIGHT SPOTS

Smoothing a raised panel's edges
Some sanding jobs call for a certain degree of improvisation. For example, to smooth the beveled edges of a raised panel *(above)* without rounding the square edges of the frame, use a piece of sandpaper folded in thirds to about the width of the beveled section. Hold the paper in a U shape and place one finger behind it; the folded paper cannot slip against your finger. Sand the edges, applying even pressure and working parallel to the wood grain.

SHOP TIP

Finding flaws
Some blemishes on the surface of a piece of furniture may not be apparent to the touch or under ordinary light, but become obvious in a flood of light. To check your work after sanding a workpiece, clean off the sanding particles (page 42), then aim a beam from a flashlight at the surface, bouncing it off the wood at an oblique angle. Bright direct sunlight works equally well. Closely examine the surface, bobbing your head up and down slowly to benefit from every angle. Take note of any flaws you missed earlier.

CLEANING SANDING PARTICLES



Removing sanding dust from a wood surface
Clean particles off wood surfaces after every stage of sanding before moving on to a finer grit abrasive or applying a finish. Remove as much dust and grit as possible with a vacuum cleaner, rag or bench brush *(above, left)*. Then wipe the surface clean with a tack cloth *(above, right)*. Sweep your hand across the surface to check for any remaining particles. Wipe again with the tack cloth if necessary.

SHOP TIP

Making a tack cloth
Make a tack cloth to match the finishing product you intend to use. For a water-based finish, simply dampen a clean piece of cheesecloth with water. For a solvent-based finish, dampen the cloth with mineral spirits, then work in a few drops of varnish. Squeeze the cloth repeatedly until it begins to feel sticky. Add varnish when it loses its tacky feel. Store a tack cloth in a plastic bag with a label identifying it as either water- or solvent-based.

REPAIRING SURFACE DAMAGE

Flaws on a wood surface can show through almost any finish. In fact, a clear finish like lacquer may magnify imperfections. Before you apply a finish to a piece of furniture, you need to find and mend any surface damage. Most defects stick out, but you need to find and eliminate the less obvious blemishes as well. Try running a hand across the wood and feeling for them. You can also wash the surface with low angle light *(page 41)* and look for them.

The best approach to a repair and the materials required depend on the nature of the damage. A suitable repair for a dent, for example, is to lift it with steam *(page 44)*. However, if the wood fibers are severed rather than simply crushed, steam will not work; a wood filler may be the best remedy. For small blemishes, wax or shellac sticks can produce a virtually invisible fix. Both are available in a variety of colors to match many wood species.

You can buy special burn-in kits for applying shellac sticks. The typical package includes a burn-in knife with a gently bent, stainless steel blade; an alcohol lamp for heating the knife; and a special solution for soaking a felt block that levels the repair with the surrounding surface.

Most larger blemishes are best concealed with wood filler. Although many types are pre-colored, you can tint filler yourself for a perfect match. Test the filler on a scrap of the target wood before committing yourself to a particular formulation. In situations where a filler is inappropriate—because the damaged area is too large or the filler would be conspicuous—you can mend the defect with a shop-made patch fashioned from a wood scrap of the same species *(page 47)*.

Most modern patching compounds are formulated to be chemically compatible with a variety of finishes, but in cases where the two products contain the same solvent, the finish can dissolve the filler. Use the chart below to help choose the appropriate compound.

For all your fixes, whether lifting a dent or filling a gouge, lightly sand the repair once you are done to level it with the surrounding surface.

A traditional shellac stick remains one of the best methods of repairing minor damage in wood. Heated by the flame from an alcohol lamp, a burn-in knife melts a small bit of the shellac stick, which fills the hole level with the surface.

WOOD PATCHING COMPOUNDS

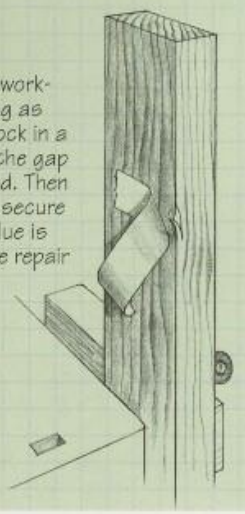
TYPE	CHARACTERISTICS	USES	COMPATIBILITIES
Wood filler	Solvent- or water-based; depending on type, can be tinted with stain or purchased pre-tinted	Filling large holes, gouges, cracks and dents	Compatible with most finishes; apply before or after stain
Wax stick	Wax- and resin-based; available in a variety of colors. Sets quickly	Filling small holes, scratches and cracks	May be incompatible with lacquer; apply after finishing
Shellac stick	Shellac- and resin-based; available in a variety of colors. Sets quickly to form a hard surface	Filling scratches, dents and gouges	May be incompatible with alcohol- or lacquer-based finishes; apply before or after finishing
Shop-made filler	Sawdust mixed with binder, such as hide glue or shellac; can be tinted with stain	Filling narrow cracks, gaps and small holes	Compatible with most finishes

LIFTING DENTS

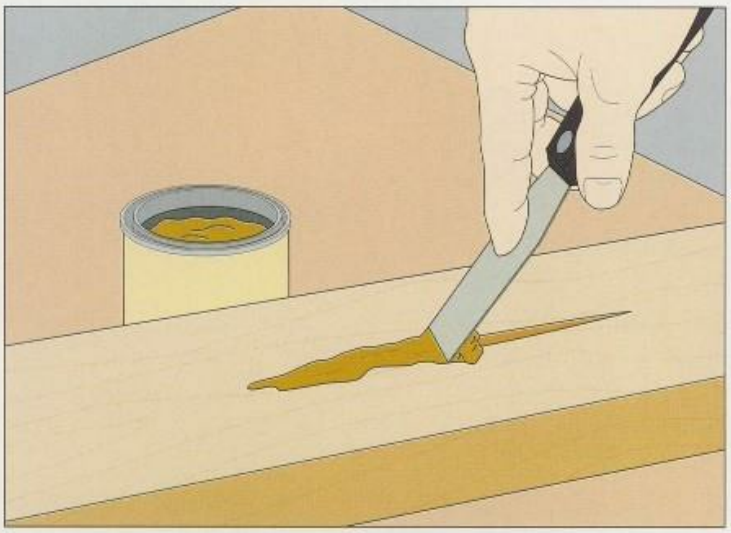
Repairing a dented surface
One way to fix a dent in wood is to swell crushed wood fibers to their original shape. Turn a household iron to its highest setting and allow it to heat up. Meanwhile, soak a clean cloth in water, fold it over a few times and place it on the dent. Press the tip of the iron against the cloth over the dent *(above)*, holding it in place until the cloth steams. The steam will swell the wood fibers, lifting out the dent. Add water to the cloth as necessary and avoid leaving the iron on the cloth for too long, which may scorch the wood.

SHOP TIP

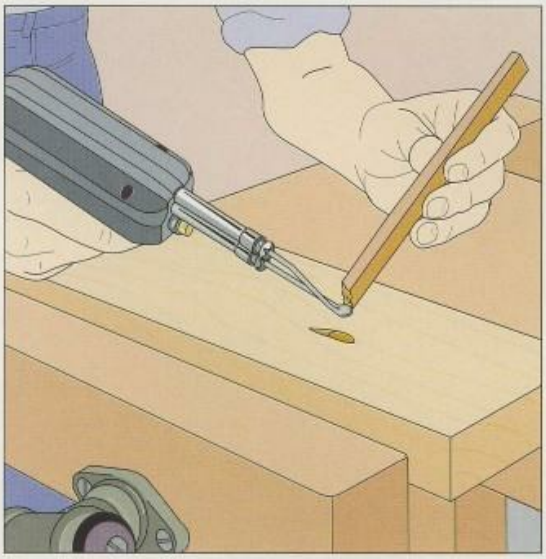
Gluing an edge splinter back
A small splinter on the edge of a workpiece can be glued in place, as long as it is still attached. Clamp the stock in a vise and squeeze some glue into the gap between the splinter and the wood. Then press the splinter into place and secure it with masking tape. Once the glue is dry, remove the tape and sand the repair flush with adjacent surfaces.

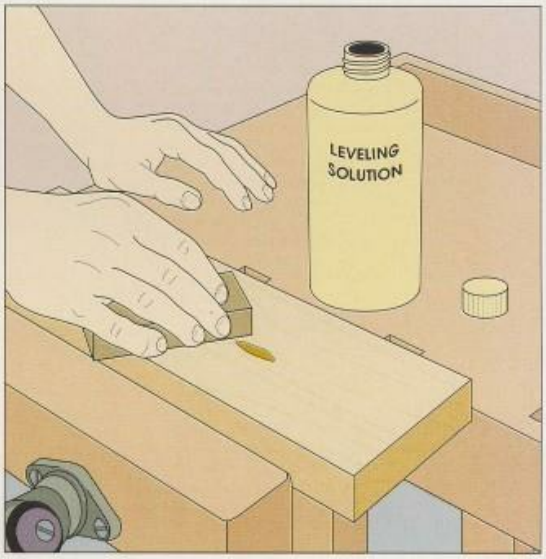


FILLING SMALL NICKS AND NAIL HOLES

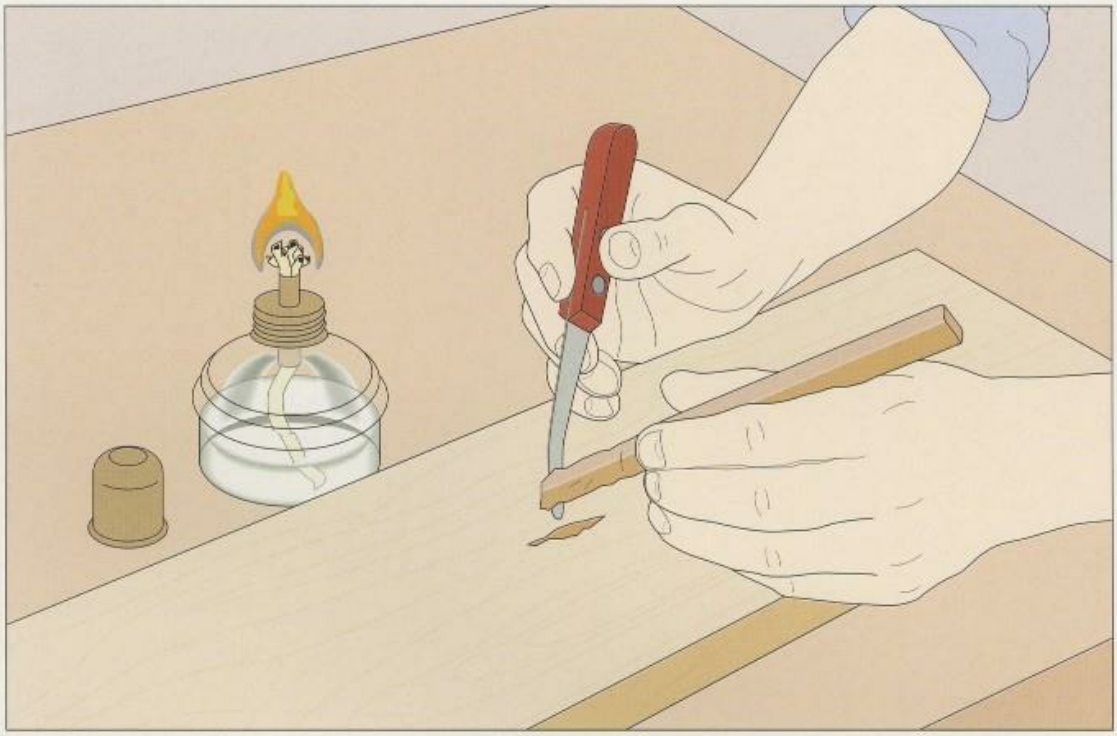


Applying wood filler
Choose a filler that is compatible with the ingredients and color of the finish you will be applying. Use a putty knife to work the filler into the hole and overfill it slightly *(left)*, then scrape off the excess to level it with the surrounding surface. Avoid spreading filler onto undamaged areas, where it may cause uneven coloring if a stain is applied.





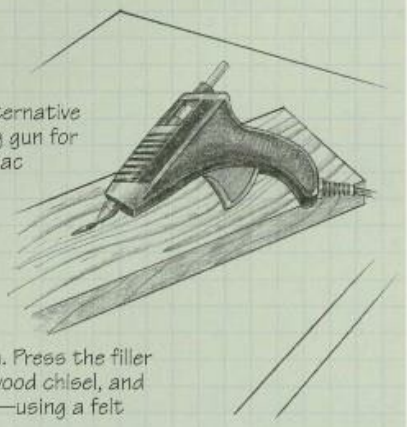
Melting shellac stick with a soldering gun
Select a shellac stick of the appropriate color and set a soldering gun on Low. Holding the stick over the hole, melt it with the tip of the gun *(above, left)*. Drip enough of the product to fill the hole. While the filler is still soft, use a knife or a wood chisel to press it evenly into the damaged area. Work carefully to avoid marring the surrounding area with the knife or chisel blade. Allow the filler to cool. To level the filler with the surrounding surface, soak the bottom of a felt block with a small amount of commercial leveling solution and lightly rub the block back and forth across the repair *(above, right)*. The slow-acting solvent in the solution dissolves excess filler without harming the wood.



Applying shellac stick with a burn-in knife
Light the alcohol torch and hold the burn-in knife over the wick for several seconds. With the shellac stick over the damaged area, press the knife against the stick so that enough filler melts and drips into the hole *(above)*. Reheat the knife as necessary until the hole is filled. Use the knife to spread the filler evenly. Finish the repair with leveling solution and a felt block *(page 45)*.

SHOP TIP

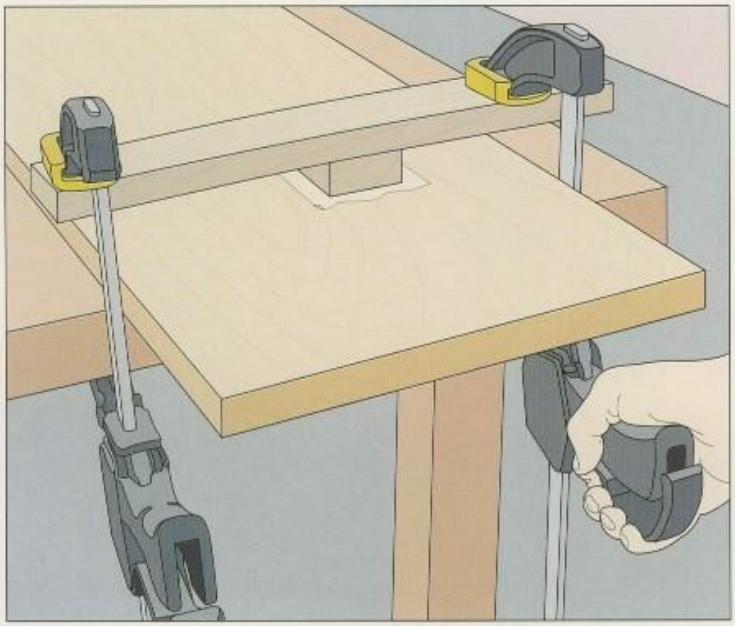
Using a glue gun to apply shellac stick
A glue gun offers a simple alternative to a burn-in knife or soldering gun for repairing damage with a shellac stick. Use a sharp knife to whittle a shellac stick so that it fits in the barrel of your glue gun. To melt the filler, pull the trigger as you would to apply glue, then drip the melted shellac stick onto the damaged area. Press the filler into the hole with a knife or wood chisel, and level it as shown on page 45—using a felt block and leveling solution.



PATCHING A LARGER HOLE

1 Making and outlining the patch
An effective way to mend a larger hole on a wood surface is to cut a patch and a matching mortise over the hole, then glue the patch in place. Using a cut-off scrap from the workpiece, or a piece of veneer with similar grain and color, cut a patch that is slightly larger than the hole. Give the patch a diamond shape, less conspicuous than a square or rectangular patch after the finish is applied. Use a wood chisel to bevel the edges of the bottom face of the patch, then sand both faces. Place the patch over the hole, aligning its grain with the surface grain, and mark its outline with a sharp pencil *(right)*.

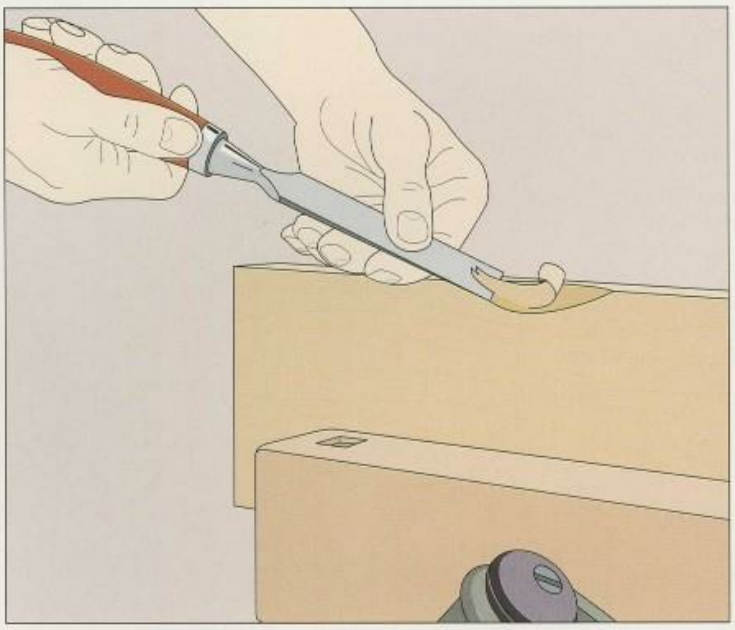
2 Chiseling the mortise
Secure the workpiece with a clamp if necessary. Select a wood chisel slightly narrower than the sides of the mortise to cut along the outline. Tilt the tool with its bevel facing up to produce an angle corresponding to that on the edges of the patch. Remove the remaining waste from the outline with the chisel bevel facing down *(left)*. Periodically test-fit the patch in the mortise until the mortise is slightly shallower than the patch is thick.

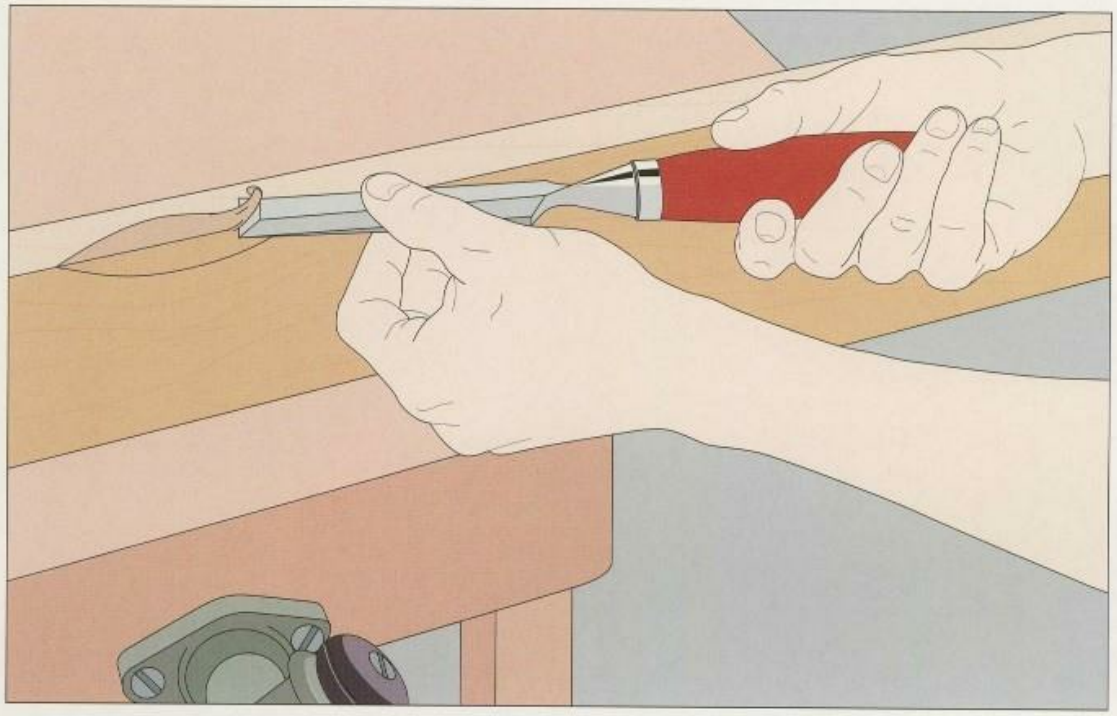


3 Gluing down the patch
Spread some glue in the mortise and set the patch in place. Lay a piece of wax paper over the patch, then position a wood block on top. (The paper will keep the patch from adhering to the block.) If the patch is located where you cannot clamp it directly, set a board atop the block and clamp the ends to focus the clamping pressure on the patch *(left)*. Work quickly to prevent the patch from absorbing moisture from the glue and swelling.

PATCHING A DAMAGED CORNER

1 Preparing the damaged area
A damaged corner is best repaired with a patch. If the edges of the break are ragged or sharp, use a wood chisel to cut a shallow, oval-shaped mortise with smooth edges around the damage. Hold the chisel with the bevel facing down and work with the grain of the wood *(right)*.

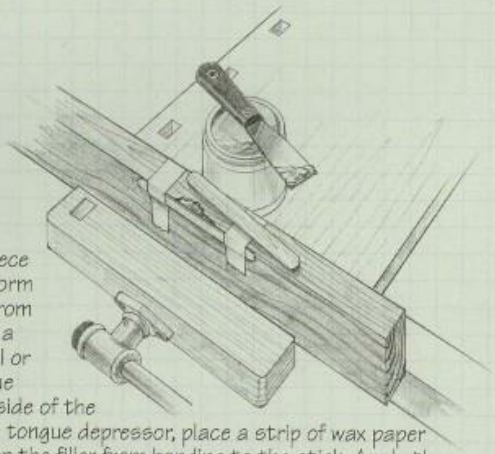




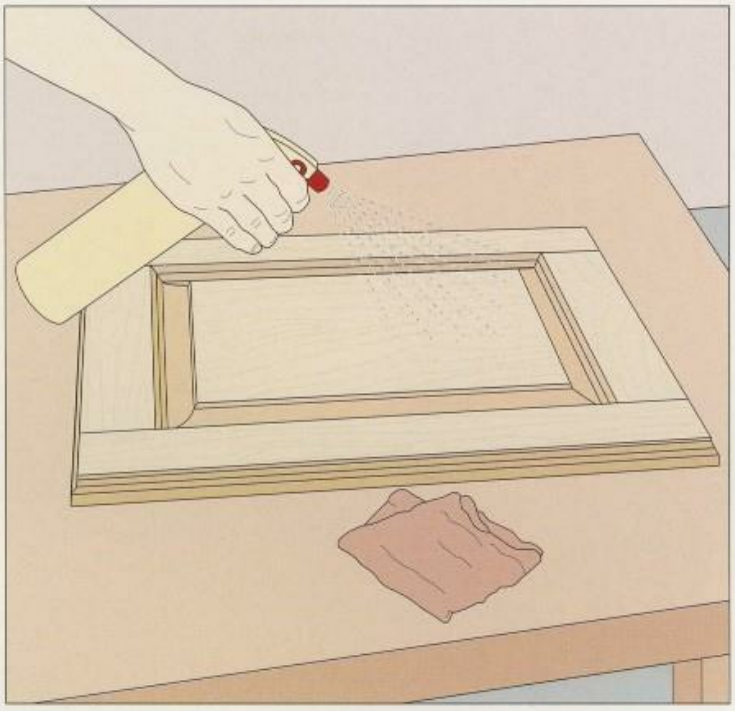
2 Installing the patch
Cut a patch that roughly fits the mortise, then shape it with sandpaper or a chisel until it fits perfectly. Spread some glue in the mortise and set the patch in position, aligning its grain with that of the workpiece. Use masking tape to keep the patch in place while the glue dries. To level the patch with the surrounding surfaces, pare away the excess with the chisel *(above)*. Cut with the grain, keeping the chisel bevel side up.

SHOP TIP

Filling a damaged corner
An alternative to patching a damaged corner is to reconstruct it with wood filler. Secure the workpiece in a vise. Make a form to keep the filler from sagging by taping a thin piece of metal or plastic, or a tongue depressor to the side of the stock. If you use a tongue depressor, place a strip of wax paper underneath to keep the filler from bonding to the stick. Apply the filler with a putty knife, then tape a second form to the top surface.



RAISING THE GRAIN



Wetting the surface
Every phase of working with wood—from jointing and sawing boards to planing and scraping them—compresses the fibers on the surface. Exposure to water causes the fibers to stand up, roughening the surface. If you intend to use a water-based finish, wet the surface to raise the grain before applying the finishing solution. Spray water on the surface *(left)*, then wipe off the excess with a clean cloth. Allow the surface to dry, then lightly scuff the wood with very fine (220-grit) sandpaper. Avoid oversanding, which might expose fresh grain, making it necessary to repeat the process. Raising the grain has other benefits, such as lifting shallow dents, exposing defects and helping a finish adhere.

SHOP TIP

Coloring grain filler
Untinted grain filler can be colored to match or contrast with the stain on your workpiece. For a water-based filler, use an oil-free pigment in liquid or powder form, such as universal tinting or dry earth colors. Tint an oil-based filler with an oil-based pigment, such as artist's oil or japan colors. To prepare the filler, pour it into a dish and add a small amount of the coloring agent. Mix the two ingredients with a putty knife. Continue adding coloring agent until the filler takes on the desired color. Test the filler on a scrap board before applying it to your workpiece. Add more coloring agent to darken the mixture; add filler to lighten it.

FILLING THE GRAIN

Filling the wood grain is the easiest way to achieve a high gloss, mirror-like finish on open-grained species like ash, oak and mahogany. Grain filler, also known as pore filler or paste wood filler, is not appropriate for every job, however. A closed-grain wood has no need for filler, and some woodworkers avoid fillers altogether in favor of a more natural look.

If you decide to fill the grain of your wood, you should understand the various options regarding when to apply the filler and exactly what type to use. Filler is usually applied before stain; if you choose to stain before filling you must be careful not to damage the stain when removing the excess filler. Yet another alternative is to apply the stain and filler together on the raw wood, although the result is often a flat, monochromatic appearance. To bring out the character of a species like mahogany, try staining the wood, then sealing the stain with a wash coat *(page 53)*, and finally applying a filler with a contrasting color.

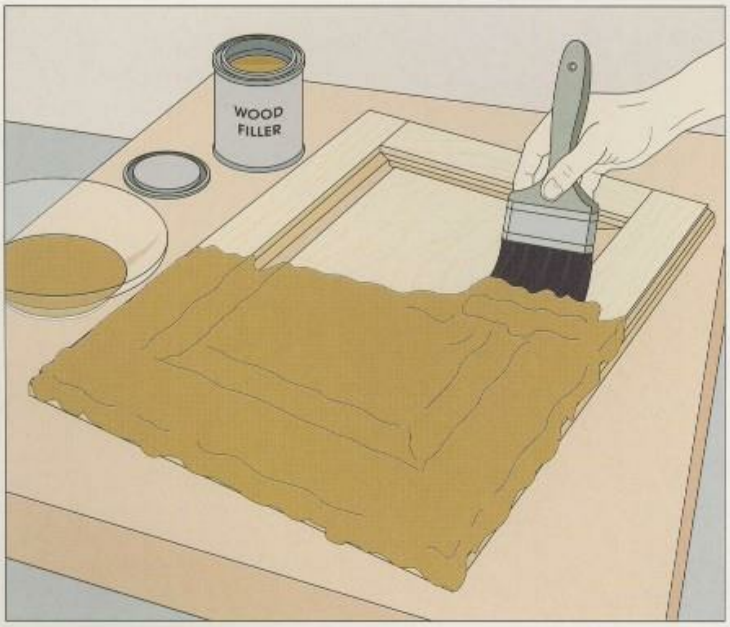
Filler comes in several colors; choose a shade slightly deeper than the wood so it will match as the wood darkens with age. You can also buy untinted filler and color it yourself in the shop *(page 50)*. Before committing yourself to a particular sequence or color, apply the filler to pieces of scrap wood both before and after staining, and choose the best combination.

Applying a filler to an open-grained species like oak does more than simply fill the wood pores. In contrast with the natural surface on the right, the filler added to the sample on the left has accentuated the wood's grain pattern.

For best results, make sure that the workpiece is clean and dust-free. Then prepare the filler following the manufacturer's directions; it should have the consistency of thick cream.

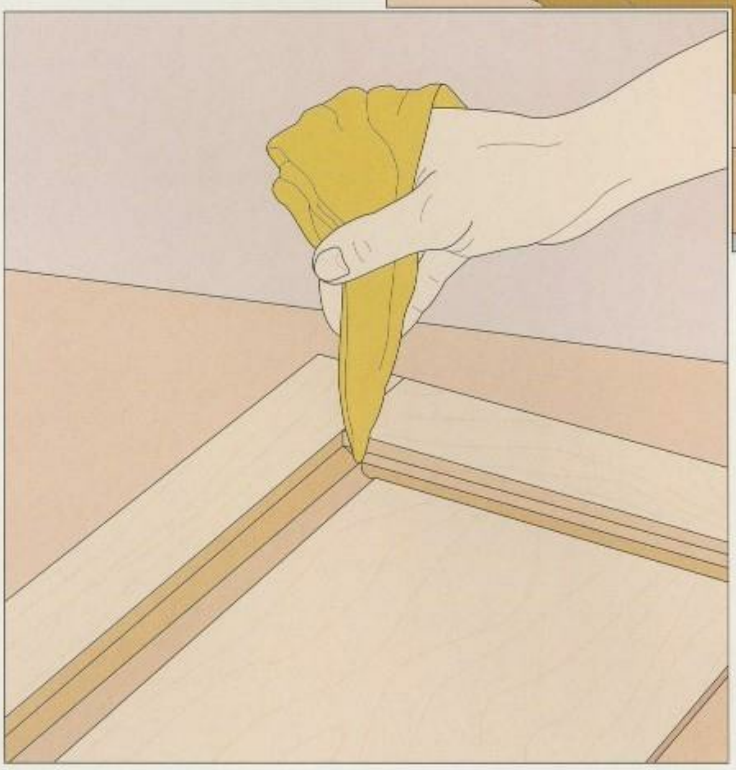
Because grain filler can absorb a lot of finish, always apply a wash coat to a filled surface before staining or finishing it. The wash coat, consisting of the finish you plan to use diluted by the appropriate thinner, creates a barrier between the filler and the finish. With some species like mahogany, a wash coat is advisable before filling, to prevent the filler from developing unsightly white spots several months after it is applied.

APPLYING A FILLER



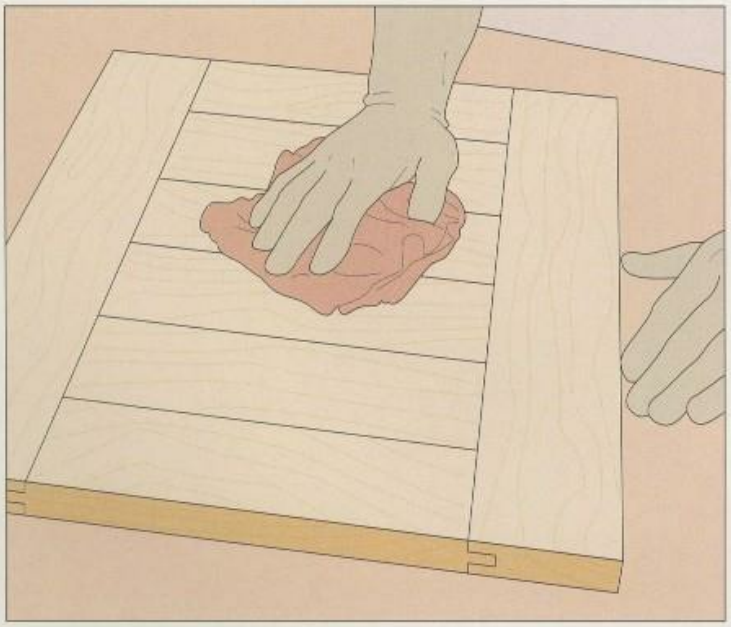
1 Brushing on the filler
With the workpiece face up on a work surface, pour some of the filler into a container. Apply the filler with a paintbrush *(left)* or abrasive pads. Using back-and-forth, overlapping strokes, cover the surface completely with the filler, working first with the grain, then across it. Examine the workpiece under direct light to confirm that the surface is covered thoroughly. Apply more filler, if necessary.

2 Wiping off excess filler
Once the filler begins to dry, losing its shine and turning hazy, wipe it with a piece of clean burlap folded into a pad *(right)*. Starting at one end of the workpiece, work with a circular motion to pack the filler into the wood pores and remove the excess.



3 Cleaning up
On a detailed workpiece such as a raised panel, remove excess filler from hard-to-reach spots with a sharpened tongue depressor wrapped in a clean piece of burlap *(left)*. Dab the pointed end into corners and along edges to remove excess filler. Allow the filler to dry, then smooth the surface with 220- to 320-grit sandpaper. If a second coat is required, apply it the same way.

APPLYING A WASH COAT



1 Brushing on the wash coat
Prepare a 50/50 solution of the finish you intend to use, diluted with the appropriate thinner. Brush along the wood grain to apply a light, even coat of the solution to the surface *(above)*.

2 Rubbing in the wash coat
Use a clean, lint-free cloth to work the wash coat into the pores of the wood *(left)*. Allow the wash coat to dry, then smooth the surface with extra fine sandpaper.

CHANGING THE COLOR

Staining allows you to dramatically alter the outward appearance of wood. This maple piano bench was ebonized, or colored black, with multiple applications of tinted lacquer.

From the deep, clear and bright tones of dye-tinted stains to the dense richness of the pigment-tinted varieties, the materials used in coloring wood afford a great degree of latitude. Stains allow you to make white woods colorful, light woods dark, plain woods fancy and streaked woods uniform.

Throughout the long history of furnituremaking, stains have been called upon to fool the eye. They have helped common woods take on the appearance of more desirable ones, adding color and figure where it was lacking. They have also produced colors and patterns that nature never imagined.

One trick involved inlaying mahogany surfaces with patterns of white holly. The challenge was to darken the surrounding wood without discoloring the inlay, and the solution lay in a wash of potassium permanganate or dichromate. The wash reacted with the high tannin content in the mahogany, bringing out rich reds and browns, but it left the tannin-free holly unchanged.

Modern stains fall into two broad categories: those containing dyes and those with pigments. Dyes impart translucent color to wood, altering nature's palette while leaving the intricate grain patterns visible. Pigment stains contain opaque colorants that cling to the surface of the wood. Pigments can be used to add patterns and contrast to the wood grain, or to bring definition and highlights to corners and carvings.

Of course, not all wood cries out to be changed; some species are best left *au naturel*. It is hard to imagine improving on the rich patterns of rosewood, Macassar ebony or Carpathian elm burl, just as it seems futile to alter the shocking intensity of purpleheart, padauk or Osage orange. But for most woodworkers, opportunities to work with perfect specimens are rare. The typical project involves making do with whatever materials are available and affordable. Stains help to make this feasible.

Ebony—costly and difficult to work, but strikingly beautiful—offers a prime example of the special effects that staining makes possible. Even when the wood is available, the small tree diameter makes it impossible to obtain wide boards and the natural instability of the wood virtually assures that a good-sized piece of ebony will crack sooner or later. Fortunately, a widely used staining technique called "ebonizing" gives the appearance of ebony to more stable and affordable woods like mahogany and maple.

Perhaps more important than mere fakery is the ability of stains to create new woods by adding unlikely colors to familiar materials. But not all staining is so blatantly obvious. A more subtle, but equally valuable use of stain is to add to furniture that most elusive of traits: age. More than one "antique" has come to market with adroitly applied mixtures of wax and rottenstone, or even shop dust and japan colors, hiding the fact that the piece only recently left its maker's hands.

A colonial red aniline dye stain enlivens a pale piece of oak. Whether it colors the wood fibers or merely covers the surface with a layer of pigments, staining can change the look of a workpiece more radically than any other step in the finishing process.

TOOLS AND ACCESSORIES

Along with an assortment of stains, pigments and dyes, there are a number of implements and accessories that every finisher needs. A sampling of the most useful items is featured below.

Changing the color of wood involves as much art as science, but in some instances precise measuring is helpful. For example, if you are attempting to match an earlier staining job, it helps to know the exact proportions in which the original ingredients were mixed together. Use graduated cylinders and cups to measure out liquids accurately, and a scale for determining precise weights of powders, crystals and other dry components.

Brushes, sponges, rags and pad applicators of varying sizes are the most common tools for applying stains and bleaches. Brushes are categorized by the nature of their bristles. The brush you choose for a particular project will depend on the substances you need to apply. Solvent-based stains should be spread on with natural-fiber brushes; use synthetic brushes to apply water-based products. An oil-based product, such as a pigmented wiping stain, can be applied with either type of brush.

All of the products presented in this chapter are toxic to varying degrees. Whether mixing or applying a stain or bleach, wear safety goggles, neoprene rubber gloves and a dual-cartridge respirator.

BLEACHING

Bleaches are highly reactive chemicals that break down the natural colorants in wood. For years, woodworkers have used bleach to lighten the color of their stock. The effect can be startling. Mahogany turns a tone of pale rose when bleached; walnut becomes creamy in color.

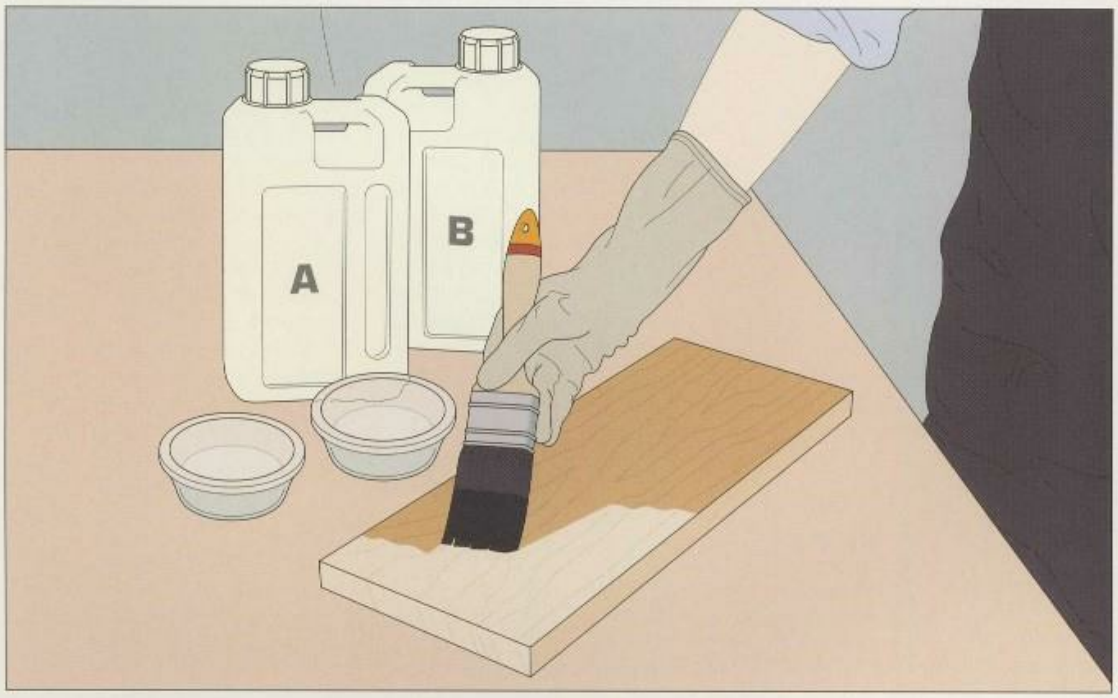
Bleaching has other applications, however, that go beyond simply washing out color. The process can be the first step in preparing a piece for a specific stain, such as a blond finish for mahogany; it is also used to ready a dark oak for liming. In addition, bleaching is an effective way to suppress the color variations between the sapwood and heartwood of a species like poplar and make them more uniform. It also rids wood of water and rust stains.

There are three common types of wood bleach. Oxalic acid, sold in liquid form as "deck brightener," is your best choice for removing stains from wood. Sodium hypochlorite will do an excellent job of removing an aniline dye stain from a workpiece. This product is available as liquid laundry bleach. But the most effective all-purpose wood lightener is two-part A/B wood bleach. Using this variety of bleach involves combining lye and peroxide; the resulting effect is stronger than that of either ingredient on its own.

Wood bleach can affect your tools as drastically as the wood. Use a synthetic brush or sponge to apply bleach; a natural-bristle brush will eventually disintegrate in the solution. Mix and store bleach in glass containers; the chemicals may react with metal. Bleaching leaves residues on wood that can become hazardous airborne irritants when the surface is sanded. The three main types of bleach can all be washed away by rinsing the wood with water.

Bleach can be dangerous if handled improperly, so follow the manufacturer's instructions. Never mix bleach with another chemical, and always work with a fresh batch.

BLEACHING WOOD



Applying the bleach
Clean the workpiece of any dirt or oil, then ready the two-part bleach by pouring a quantity of each solution into separate glass bowls. Do not mix the two parts together; they will be applied in separate steps. Spread a generous but even coat of Part A on the wood surface with a paintbrush or a rag. Let the product do its work for about 5 minutes, then apply Part B the same way. Let the workpiece sit for at least 4 hours, then rinse the surface with water or the neutralizer supplied with the bleach. Allow the workpiece to dry overnight before applying a stain or finish. Two-part bleach is usually strong enough so that one application is sufficient; however, to lighten the wood further, repeat the process.

SHOP TIP

Lightening wood with grain filler
To lighten wood without bleaching it, use an oil-based grain filler mixed with some white pigment. First apply a wash coat to the workpiece (page 53), then prepare a batch of filler (page 51), adding enough white japan or other oil-based pigments to obtain the shade you want. You can apply the mixture as you would any grain filler. The process will accentuate the grain of open-pore species like oak, ash, mahogany and elm.

THE VARIETIES OF WOOD STAINS

Staining was once key to the cabinetmaker's subtle art of forgery. Armed with natural dyes, chemical mordants and secret recipes, cabinetmakers could imitate the look of prized, exotic woods, or give newly built chairs, chests and cabinets the patina that antiques acquire with the passage of time.

Today, camouflaging and enhancing wood with stains are still important aspects of woodworking. Whether a stain penetrates and dyes the fibers of the wood, or merely covers the surface with a thin layer of pigments, no other step in the finishing process brings about such a radical change. Staining can highlight grain patterns, mask homely surfaces, add color or impart a uniform hue to different woods within a single piece of furniture.

All stains consist of a coloring agent mixed in a liquid. The two basic types of coloring agents are dyes and pigments. Dye stains work much like the coloring agents used on cloth. Dissolved in water, oil or alcohol, they penetrate the surface and bond to the wood fibers. Pigment stains contain finely ground colored powders suspended in a liquid such as linseed oil. They work more like very thin paints. When applied to wood, the liquid dries, binding the pigment to the surface.

Dyes for staining wood are most commonly sold as aniline powders, which must be mixed with a liquid before use *(page 68)*. Their intense colors can be combined in varying proportions to provide a virtual rainbow of hues and tones. Pigment stains are available in the same wide range of colors, yet come in ready-to-use liquid, gel or glaze form. Pigments can also be purchased in concentrated form as earth pigments or japan colors; the concentrate is added to a ready-to-use stain for enhanced effects. Both dyes and pigments can be mixed with lacquer, varnish, wax or shellac to provide colored finishes.

When choosing a stain, remember that most dye stains are brilliant and transparent, but generally not as lightfast, or impervious to fading, as pigment stains. Dye stains are excellent for highlighting grain. Pigment stains are opaque and tend to cloud the grain. Some newer liquid stains contain both dyes and pigments, providing the useful properties of both types of coloring agents with added ease of application.

The most desirable liquid base for a stain depends on the effect you are seeking. The deeper the vehicle penetrates the wood, the darker and richer the resulting color. Because water penetrates deepest, water-soluble stains are generally the best choice for hardwoods. One drawback of water, however, is that it raises the grain, necessitating further sanding of the surface.

Available in easy-to-apply liquid form, the gel stain shown in use below contains pigments that will impart a dark brown mahogany tone.

DYE STAINS

Derived from plants, insects and animals, the wood dyes used in the 18th Century ranged from concoctions with exotic names such as dragon's blood, verdigris, madder root and cochineal to more earthy tints extracted from tea, urine, vinegar and walnut husks. A hundred years later, the first aniline dye was extracted from coal tar. Today, such dyes are the industry standard, usually mixed with one of three solvents: water, oil or alcohol. Dyes not yet combined with a solvent are also available in either powder or liquid form. Premixed stains are more convenient to use, but mixing them yourself gives you more flexibility when you need to produce a particular effect. A fourth type of dye product, known as non-grain-raising (NGR) stain, is only available in liquid form. The dyes in NGR stains are dissolved in an anhydrous, or waterless, solution of organic hydrocarbons, such as petroleum. Whichever type of dye stain you apply, the factor that will determine the eventual color of the wood is the amount of dye in the solution, not the amount of solution applied.

Water-soluble stains are a good choice for emphasizing the grain of hardwoods. Although a water-based stain will raise the grain, many woodworkers prefer to take care of that step before applying a stain *(page 50)*, thereby saving a sanding step that might affect the final color of the wood.

Mahogany
Natural

Mahogany
Golden fruitwood

Mahogany
Light yellow maple

Maple
Natural

Maple
Golden fruitwood

Maple
Light yellow maple

Alcohol-soluble dyes, also called "spirit stains," do not raise the grain as much as water-based stains and they produce somewhat brighter hues.

Oil-soluble dyes are transparent and also non-grain-raising. The drying times of these stains will vary, depending on the solvent used. Mineral spirit-based stains generally have a slow drying time, while stains containing toluene or xylene dry considerably faster. The trade-off is that toluene and xylene are more toxic than mineral spirits. Another potential problem with oil-based stains is their tendency to bleed through a protective finish. Although this should only occur if the stain is still wet when the topcoat is applied, it is a good practice nonetheless to use a finish with a different solvent than your stain.

For best results, NGR stains should be sprayed on wood. If you use a brush, you will need to add a retarder to the solution to extend its drying time.

Choosing the right stain for a project can involve experimentation. From pages 60 to 63 is a series of photos that illustrate the effects of five different dye stains on some of the most popular hardwood species. The samples on the far left are unstained, followed by pieces cut from the same board, each one colored by a different dye stain. For further information on the characteristics and uses of stains, refer to the chart provided on page 70.

Mahogany
Colonial dark red

Mahogany
Honeytone amber

Mahogany
Ebony black

Maple
Colonial dark red

Maple
Honeytone amber

Maple
Ebony black

Oak
Natural

Oak
Golden fruitwood

Oak
Light yellow maple

Walnut
Natural

Walnut
Golden fruitwood

Walnut
Light yellow maple

Cherry
Natural

Cherry
Golden fruitwood

Cherry
Light yellow maple

Oak
Colonial dark red

Oak
Honeytone amber

Oak
Ebony black

Walnut
Colonial dark red

Walnut
Honeytone amber

Walnut
Ebony black

Cherry
Colonial dark red

Cherry
Honeytone amber

Cherry
Ebony black

PIGMENT STAINS

Any substance that can be reduced to a powder can become a pigment that will impart color to wood. Minerals, ores, metallic oxides and many other naturally occurring earth compounds can all be ground into very fine particles. Once they are suspended in a solvent such as oil, varnish, polyurethane or water, these powders become spreadable pigment stains. Because the particles are suspended, rather than dissolved in the solution, pigment stains dry to a thin, paint-like coating on the surface of the wood.

Whereas dye stains color wood fibers and tend to accentuate the grain, pigment stains are opaque and hide the wood patterns. As a result, pigment stains are often used for glazing, graining and other finishing techniques that compensate for the lack of distinct grain patterns in certain varieties of wood. These are described in detail in Decorative Finishes *(page 110)*.

Today, pigments are produced synthetically, with binders and driers added to help them adhere to the wood as the solvent dries. Pigment stains come in different liquid and gel forms. The most popular and best-known are pigmented wiping stains. These ready-to-use finishing products contain a finely ground pigment suspended in linseed oil, which doubles as solvent and binding agent. Wiping stains are slow-drying, allowing plenty of time to spread them on or wipe

Maple
Antique white wiping stain

Maple
Cherry wiping stain

Maple
Mahogany light wiping stain

Walnut
Antique white wiping stain

Walnut
Cherry wiping stain

Walnut
Mahogany light wiping stain

off any excess. Either sprayed on or applied with a rag or a brush, they are particularly useful when the wood surface is made up of heartwood and contrasting sapwood.

Other popular pigment stains include japan colors, glazing stains and gel stains. Japan colors offer a more vibrant range of hues than wiping stains, but they need to be thinned before use. They can be used to tint other stains when you are trying to match an existing surface.

The main selling point of glazing stains is that they are heavier and thicker than wiping stains—and thus useful for concealing grain. Gel stains, meanwhile, are easy to apply and they set quickly, reducing drips on vertical surfaces. Refer to the chart on page 70 for more information on these and other pigment stains.

Pigments are also available in powdered or concentrated form. Earth pigments, like siennas, umbers and ochres, are mined from the earth and processed in deoxygenated conditions at high heat to bring out their bright colors. Different pigment stains can be mixed together or with powdered or concentrated varieties to produce unique colors and tones, provided the solvents are compatible; an oil-based stain cannot be mixed with a water-based stain, for example.

Pages 64 to 67 illustrate the effects of various pigment stains on five different types of hardwoods.

Maple
Golden oak wiping stain

Maple
Mahogany dark wiping stain

Maple
Pine wiping stain

Walnut
Golden oak wiping stain

Walnut
Mahogany dark wiping stain

Walnut
Pine wiping stain

Birch
Flake white japan color

Birch
French ochre yellow japan color

Birch
Chrome green japan color

Ash
Van Dyke brown glazing stain

Ash
Raw umber glazing stain

Ash
Burnt umber glazing stain

Oak
Chrome green gel stain

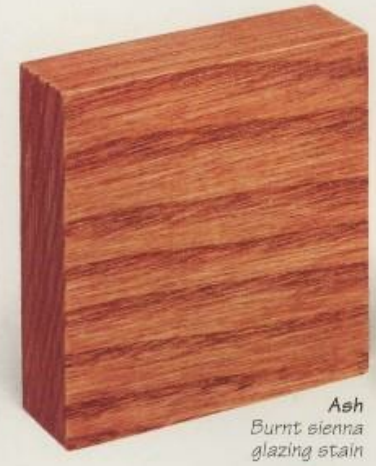
Oak
Majestic mahogany gel stain

Oak
Classic colonial gel stain

Birch
Chrome yellow japan color

Birch
Permanent blue japan color

Birch
Bulletin red japan color



Ash
Burnt sienna glazing stain

Ash
Yellow glazing stain

Ash
Black glazing stain

Oak
Blue gel stain

Oak
Van Dyke brown gel stain

Oak
Burnt sienna gel stain

STAINING WOOD

Woodworkers are quite naturally disappointed when a carefully applied and apparently uniform coating of stain produces uneven results on a piece of furniture. Unfortunately, different parts of the same board cannot be expected to absorb liquid evenly. Unless exposed end grain is sealed, for example, it will usually take in more of a stain than faces or edges, making the ends appear darker. As shown on page 69, sealing end grain is simply a matter of brushing on the appropriate sealer before you stain.

There are other preparations you should make at this stage. While a grain filler can be applied either before or after staining, you need to raise the grain of the wood *(page 50)* before applying a water-based stain. Otherwise, the stain will lift the wood fibers, requiring sanding that may remove the stain.

A test strip takes the guesswork out of staining. This sample illustrates the effects on unstained oak of one, two and three coats of stain (moving from left to right). The bottom half of the strip is topcoated to show how the stain looks under a clear finish.

Many stains can be bought premixed and ready to use. However, if you enjoy experimenting, you may also prefer to custom mix your colors. As shown in the photo at left, a test strip can help you produce the right combination of ingredients and determine the number of applications you will need to make.

From paintbrushes and rags to pad applicators and spray guns, there are alternatives in applying stains as well. Whichever method you choose, wear safety goggles and rubber gloves. It is a good practice also to don a dual-cartridge respirator to filter out toxic fumes produced as a stain evaporates *(page 19)*.

PREPARING A STAIN

Mixing the ingredients

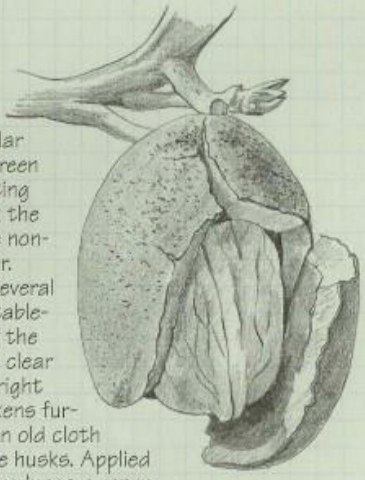
When working with dyes or pigments in powder form, use a wooden stick to mix some of the powder with the appropriate solvent in a glass container *(left)*. Apply the stain to a sample strip of the wood that you will be coloring. Allow the strip to dry. To darken the color of the stain, add a small amount of powder to the solution. To lighten the stain, mix in a little more solvent. Make another test strip, adjusting the color of the stain until you are satisfied with the results.

READYING THE WORKPIECE

Sealing end grain
Use a rag or paintbrush to apply a sealer to the end grain of your workpiece. Make certain that the product you use for this task is compatible with the stain and finish you will be using. Spread on shellac for water- or oil-based stains or finishes; for alcohol-based products, seal end grain with an oil-based wood conditioner. Avoid slopping the sealer onto the face or edge of the workpiece; this could affect the evenness of the stain.

SHOP TIP

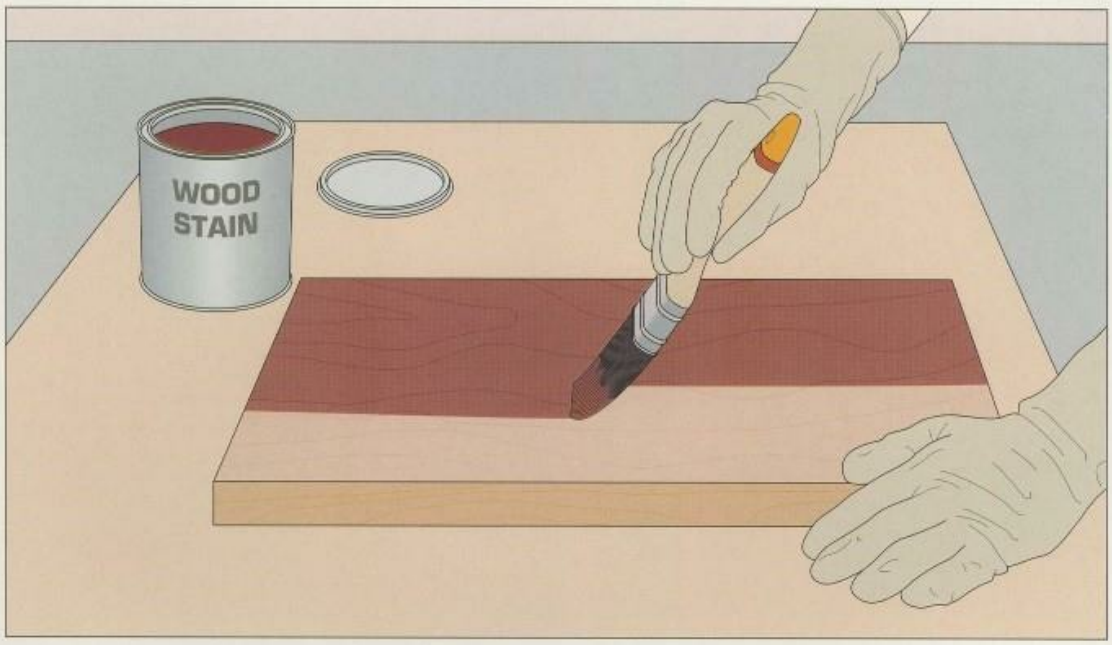
Preparing a natural walnut stain
To make "broue de noix," a natural walnut dye stain popular in the 1800s, collect several green husks from fallen walnuts, letting them dry and turn black. Soak the husks for a few days in a large nonstick steel pot filled with water. Then simmer the mixture for several hours on a stove, adding one tablespoon of lye for every gallon of the mixture. Bottle the solution in clear glass jars and leave them in bright sunlight until the mixture darkens further. Strain the dye through an old cloth and re-bottle it, discarding the husks. Applied with a brush, "broue de noix" produces a range of rich brown tones on wood.



A GALLERY OF STAINS

TYPE	AVAILABLE FORM	CHARACTERISTICS AND USES	PREPARATION AND APPLICATION
DYE STAINS			
Water-based stain	Powdered; water-soluble	Penetrating; not very lightfast; transparent; brilliant; tends to raise grain; good for hardwoods; compatible with any finish	Raise grain. Add to water, strain. Apply with brush, rag or spray gun.
Spirit stain	Powdered; alcohol-soluble	Penetrating; not lightfast; dries quickly, but tends to leave lap and streak marks	Mix with alcohol and strain. Brush or wipe on. Best for small areas.
Oil stain	Powdered; oil-soluble	Penetrating; transparent; does not obscure grain; slow-drying; bleeds; needs sealer coat of shellac; good for softwoods	Dissolve in mineral or spirit petroleum distillate and strain. Apply with nylon-bristle brush and wipe off excess.
NGR stain	Liquid; dissolved in methanol and petroleum distillate solution	Does not raise grain; transparent and lightfast; good for veneers	Thin to desired consistency. Apply with spray gun. If applying with a brush or rag, use retarder.
Penetrating oil stain	Liquid; dissolved in mineral spirits	Penetrates open-grained wood; moderately lightfast; transparent; easy to apply; colors can be mixed; does not raise or obscure grain; bleeds; needs wash coat; good for softwoods	Apply with brush or rag. Wipe off excess after desired color is achieved.
Varnish stain	Liquid; dissolved in varnish	Highly transparent; lightfast; non-penetrating; adds filler, color and gloss in one operation; good for lower grades of lumber	Apply with a rag and wipe off, or use a spray gun.
PIGMENT STAINS			
Wiping stain	Liquid; suspended in oil and mineral spirits	Lightfast; will not bleed; non-penetrating; opaque; tends to hide grain	Apply with brush, rag or spray gun. Wipe off excess after desired color is achieved.
Earth pigment	Powder; soluble in any liquid	Easy to use; lightfast; opaque; hides grain; good for wood with indistinct grain or tinting protective finish	Mix with oil or varnish. Apply with brush, rag or spray gun.
Japan color	Liquid; concentrated in varnish	Excellent for tinting varnish, stain, lacquer	Apply with synthetic brush.
Gel stain	Liquid; suspended in petroleum-based gel	Easy to use; hides grain	Apply with rag; wipe off excess after desired color is achieved.
Glazing stain	Liquid; suspended in varnish	Excellent for figuring, shading, or correcting sap streaks; hides grain; wears off; needs a hard finish coat	Apply with brush or rag; allow to set. Wipe off with grain if desired.
Water-based stain	Liquid; suspended in an acrylic and water base	Non-penetrating; lightfast; brilliant; colors can be mixed together; non-toxic and non-flammable	Raise grain. Apply with brush, rag or spray gun.

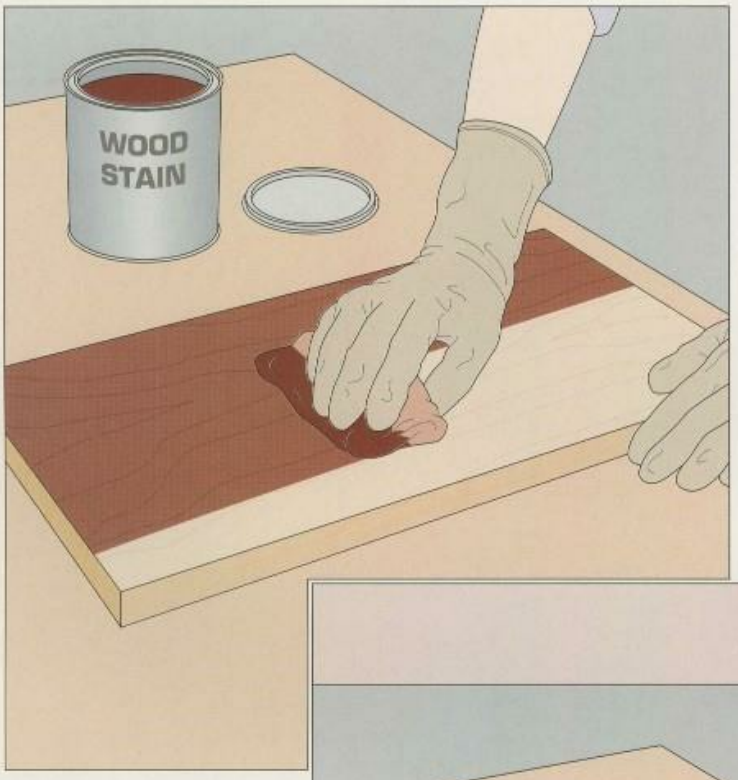
APPLYING A STAIN



Brushing on stain
Dip a clean paintbrush into the stain, coating about half the bristle length. To minimize lap marks, flood the surface with stain and brush along the wood grain in light, even strokes *(above)*. Once the surface is completely covered, wipe it with a clean, dry, lint-free cloth to even out the color and soak up excess liquid. For uniform coverage with an alcohol-based stain, wipe the surface as soon as possible after brushing it on.

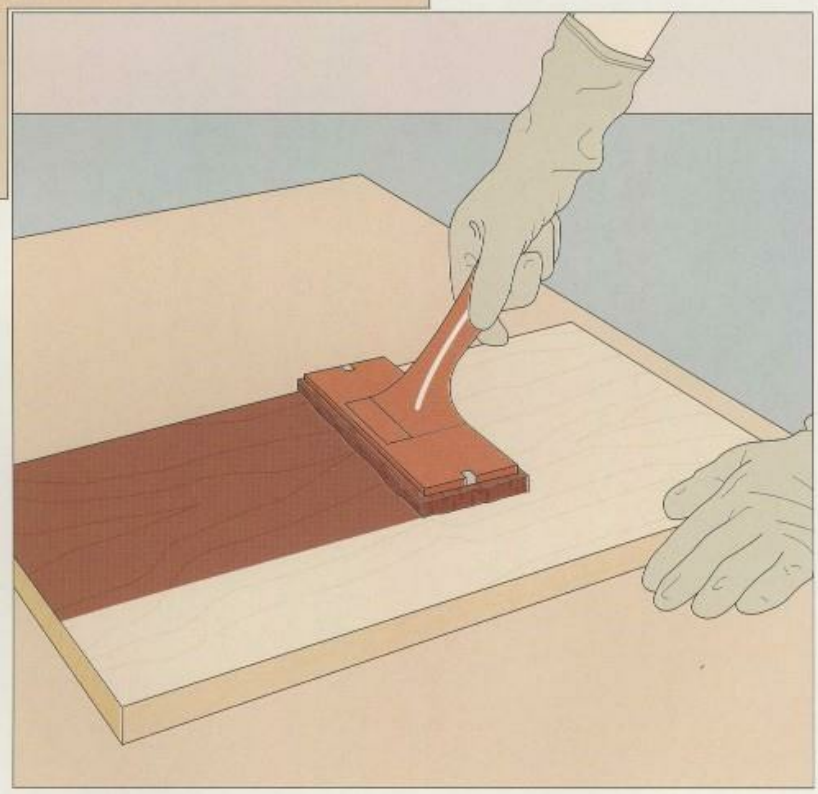
SHOP TIP

Controlling the flow of stain
Although flooding on stain is the recommended practice when working on a horizontal surface, doing the same when the wood is vertical will result in dripping, and make a mess of your project. One answer is to rig up a clean metal can to regulate the flow of liquid from your brush. Punch two holes on opposite sides of the can near the rim. String a wire between the holes and pour stain into the container. After dipping the brush, draw the bristles across the wire, squeezing any excess liquid back into the can.



Wiping on the stain
Fold a clean, dry, lint-free cloth into a pad and soak it with stain, squeezing out the excess until the pad does not drip. Wipe the stain on the surface, working parallel to the grain (*left*). Rub off the excess with a clean cloth.

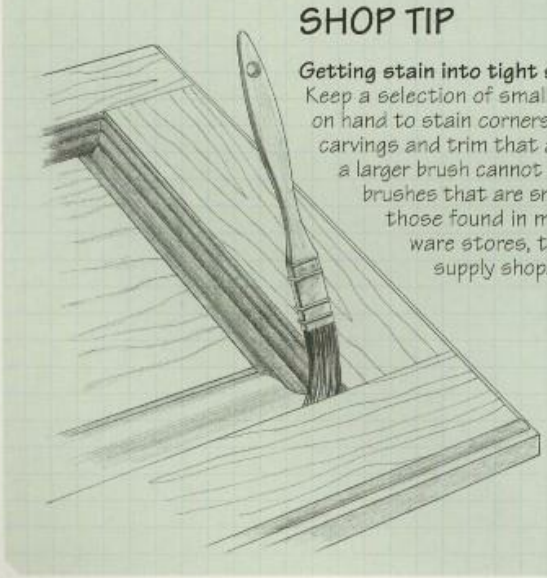
Using a pad applicator
Fill the well of a pad applicator tray half full of stain and pull the pad over the roller, loading it with the liquid. Draw the applicator along the workpiece following the grain *(below)*, wetting the surface liberally. Use a clean cloth to wipe away the excess.

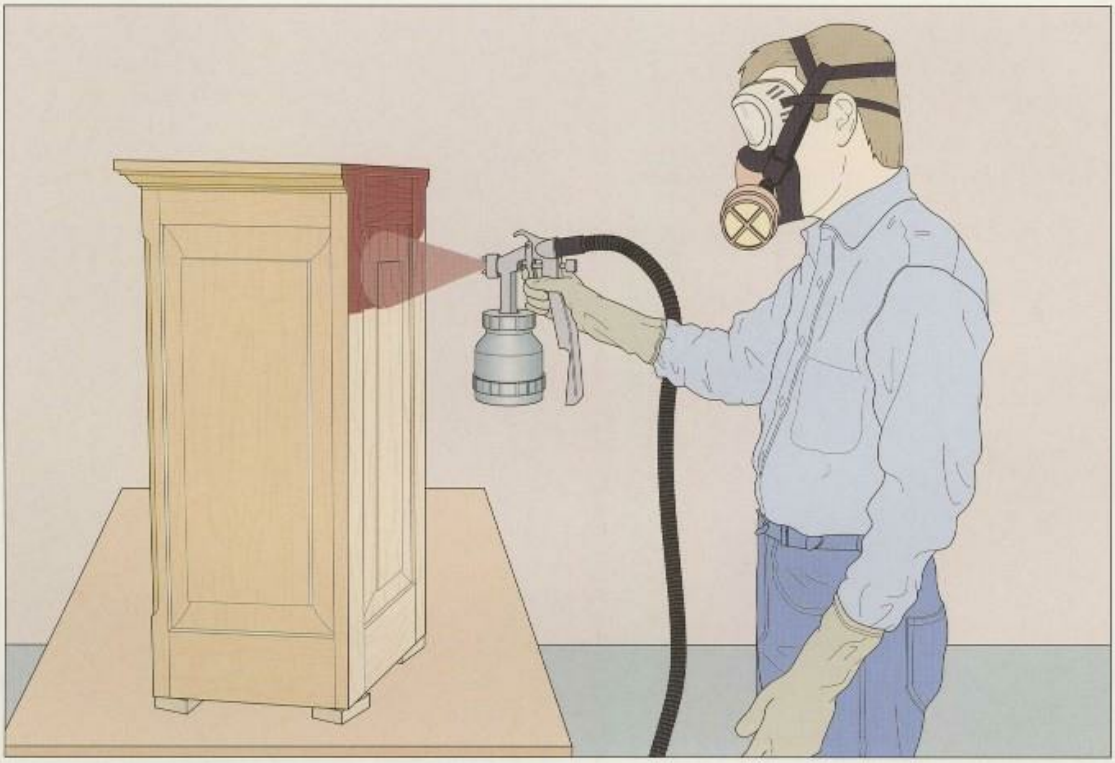


Dipping a small workpiece
To color a workpiece that is too small for brushing or wiping, dip it right into a container filled with the stain *(above)*. Hold the piece over the can to let the excess liquid run off. Then hold the piece by the corners and wipe it with a clean cloth.

SHOP TIP

Getting stain into tight spots
Keep a selection of small brushes on hand to stain corners, moldings, carvings and trim that a cloth or a larger brush cannot reach. For brushes that are smaller than those found in most hardware stores, try an art supply shop.

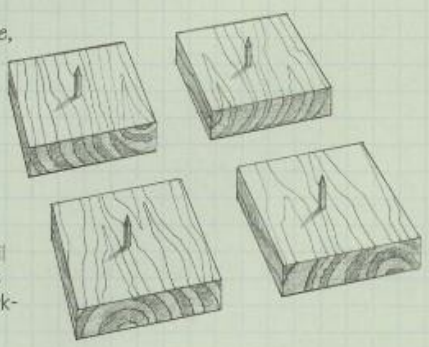




Spraying a stain
Prepare the spray gun following the manufacturer's instructions. To stain a piece of furniture like the one shown above, hold the gun about 6 to 10 inches from the surface with the nozzle perpendicular to the wood. Starting at the top of the piece, squeeze the trigger to apply the stain, moving the gun from side to side in overlapping sweeps until you reach the bottom. For more information on adjusting and using spray equipment, refer to page 93. Before spraying a stain, contact your local authorities to ensure that your spray area satisfies local safety regulations *(page 102)*.

SHOP TIP

Supports for drying
After staining a workpiece, let it dry evenly and blemish-free on a set of shop-made supports. Cut four 2-inch-square wood blocks and drive a small nail through the middle of each one. Arrange the blocks on a level surface with the nail tips pointing up so that they will support the workpiece at its corners.



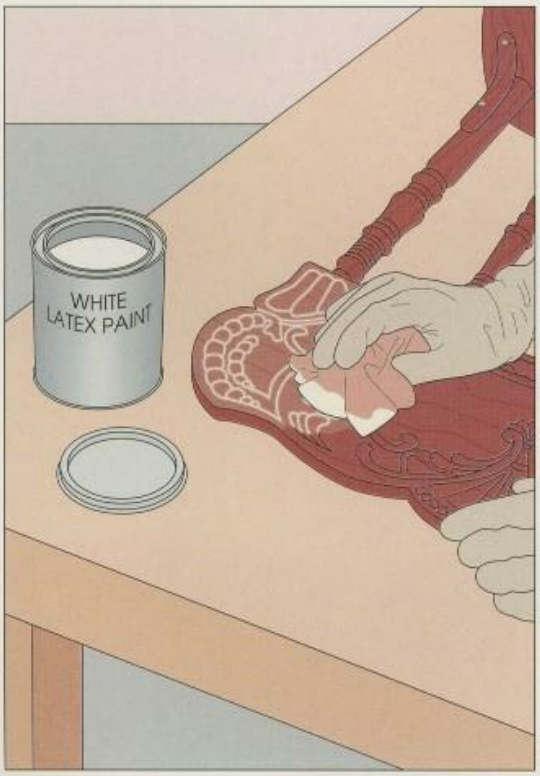
PICKLING A WOOD SURFACE

Pickling, or liming, refers to any one of a number of antiquing techniques intended to impart an aged and weathered look to light-colored wood. Traditionally, woodworkers have pickled furniture with such chemicals as nitric acid, lye and lime. As shown below, however, you can achieve comparable results by applying a coat of white paint, pigmented white shellac or white glaze to the workpiece. The trick is to wipe off the bulk of the stain, leaving traces in moldings and corners.

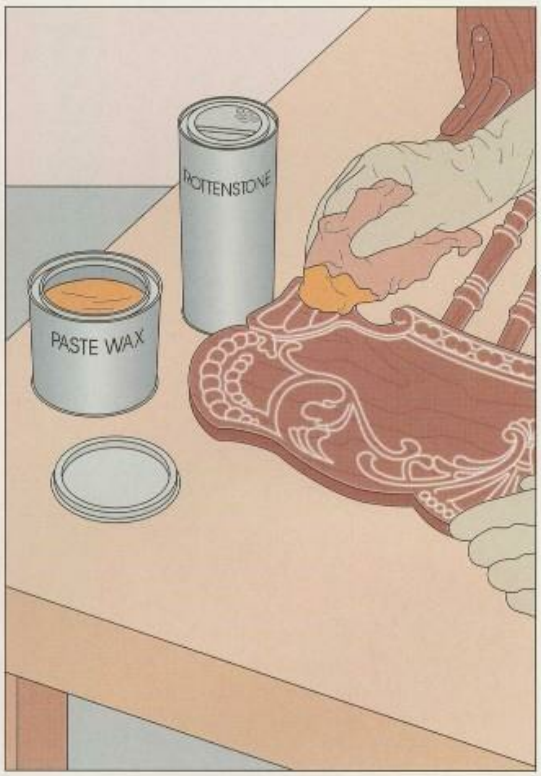
A pickled finish can give a newly made chair the time-worn appearance of a vintage antique.

Once the pickled stain is dry, it should be sealed with a light topcoat. You can pickle either bare or stained wood surfaces, but if you have used a water-based dye on the wood, you will also need to seal it prior to applying a latex paint or glaze. Pickling can be attempted with any species, but the process works best with oak or pine.

APPLYING A PICKLED FINISH



1 Applying the white stain
Use a rag to spread white paint or stain on the surfaces. While the paint is still wet, wipe off the bulk of it with a burlap rag, leaving a whitish glaze on flat surfaces and streaks of white in crevices and carvings *(above)*. Let the stain dry. If the effect is too pronounced, abrade the surface with 220-grit sandpaper until you obtain the look you want.



2 "Aging" the surface
To give the wood an antique appearance, use a rag to rub a mixture of rottenstone and paste wax over the surface *(above)*. Wipe off the excess with a burlap rag, taking care to leave some residue in the crevices and carvings.

CHEMICAL STAINS

Before the advent of synthetic dyes, staining wood was an art form that rivaled alchemy. With natural dyes derived from plants and insects, and chemical mordants extracted from tin, iron, aluminum and chrome, staining required knowledge of botany and chemistry as well as experience with wood.

Applied by themselves, natural dyes produce pleasant shades of red and brown on many species of wood. Tea, for example, is used occasionally on antique reproductions to produce a warm golden hue. But in combination with chemical mordants, natural dyes can bring out a rainbow of superb, brilliant colors. The photos below and opposite illustrate the effects of a few selected dyes and mordants on four popular hardwoods. The species is indicated in bold type with the dye or mordant listed directly below. For more information on a full range of mordants and natural dyes, refer to the chart on page 78.

The term mordant comes from the French verb *mordre*, meaning "to bite." Mordants do two things for natural dyes: They change the color of a dye through a chemical reaction with either the dye or the wood. They also help a dye penetrate wood and bind with the fibers.

Some natural dyes are available as powdered extracts, but others must be extracted from natural products in the shop. Mordants come in crystal, powder or liquid form. When preparing a

Ash
Logwood

Ash
Potassium dichromate and tannic acid

Ash
Logwood and copper sulfate

Cherry
Potassium permanganate

Cherry
Brazilwood and alum

Cherry
Brazilwood and potassium dichromate

chemical stain, mix a 15 percent solution of the dry ingredients and distilled water. It is better to make the concentration too weak than too strong; it is easier to darken the wood than to lighten it. Allow each coat to dry completely before applying the next; color can be misleading when the stain is wet.

Some natural dyes can cause allergic reactions, but most are relatively benign. Many chemical mordants, however, are caustic and sometimes toxic. Prepare and apply these products carefully, wearing safety goggles, neoprene gloves and a rubber apron. A dual-cartridge respirator is a must for a mixture producing toxic fumes. Do not spread a chemical stain on bleached wood or you risk creating poisonous chlorine gas. To avoid splashes when diluting a mordant, add the chemical to the water, a little at a time.

There are no hard and fast rules for applying chemical stains. Typically, the dye solution is spread on the wood, then the mordant is added while the dye is still wet. The solutions should be mixed separately and applied when cool. Experimentation is the key to good results; keep a record of your recipes and the colors they produce.

Chemical staining is becoming a dying art. Many products can be found only at photography and chemical supply houses. But if you are after striking and unique effects, they can be well worth the trouble of seeking them out.

Oak
Brazilwood

Oak
Potassium permanganate

Oak
Ferrous sulfate and alum

Mahogany
Logwood and potassium dichromate

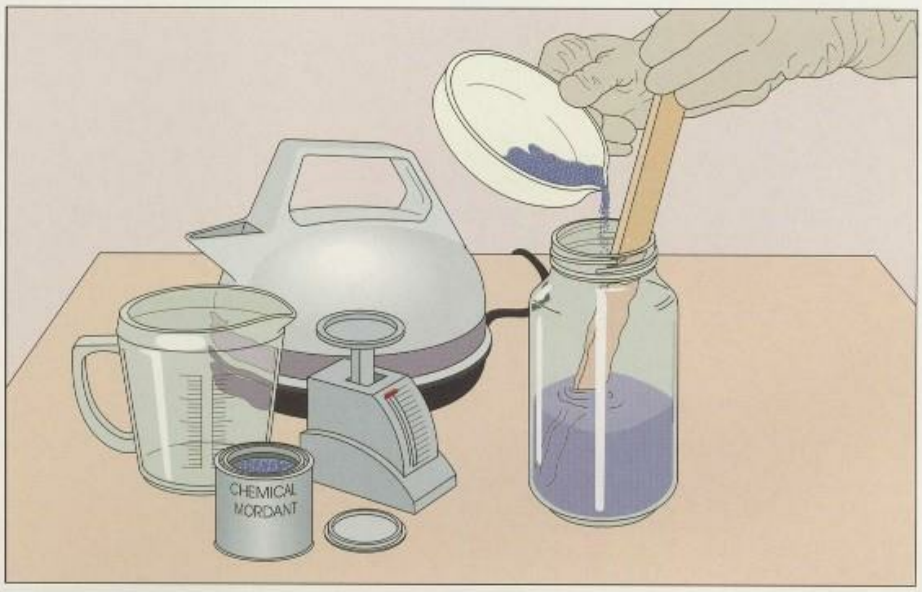
Mahogany
Sumac and copper sulfate

Mahogany
Logwood and alum

CHEMICAL MORDANTS AND NATURAL DYES

MORDANT	FORM AND CHARACTERISTICS	COLORS PRODUCED
Alum	White mineral salts; non-toxic	Purplish and dark crimson tones
Ammonia	28% liquid solution; highly toxic	(For fuming) Dark violet browns with logwood dye; light yellow browns with brazilwood dye
Copper sulfate (blue vitriol)	Blue copper crystals; highly toxic	(For preserving wood) Dark gray and olive tones with logwood dye
Ferrous sulfate (copperas)	Iron crystals; highly toxic; reacts with tannin in wood	Steel gray to bluish tones; ebony-like black with logwood dye or alum
Hydrated lime (quicklime)	Calcium oxide crystals; toxic	Antique limed finish on hardwoods such as cherry and walnut; must be neutralized with vinegar
Potassium carbonate	Potash crystals; mildly toxic	A range of greens with alum and fustic
Potassium dichromate	Orange chrome crystals; extremely toxic; reacts to high tannin content	Deep reds to rich browns; combines well with aniline dyes
Potassium permanganate	Violet potash crystals; mildly toxic	(For ebonizing) Turns wood with high tannin content a purplish brown
Sodium hydroxide	White lye powder; toxic	Darkens cherry and oak; must be neutralized with vinegar
Stannous chloride	White tin crystals; moderately toxic	Light red with brazilwood dye; pink with alizarin; combines well with many dyes
Tannic acid	Yellow powder extracted from hemlock and oak; mildly toxic	Boosts tannin content in wood
NATURAL DYE	**FORM AND ORIGIN**	**COLORS PRODUCED**
Alizarin	A synthetic dye or the active coloring agent of madder root	"Turkish red"; crimson, orange, yellow and brown, depending on the mordant
Alkanet root	An ancient organic dye from the borage family	(For French polishing) Gray tones with alum; a range of reds with linseed oil
Annato	Seeds from a Central American tree	Oranges and golds with chrome, tin or alum; oak brown with lye
Brazilwood	A popular dye from several species of South American redwood trees	Vibrant reds, browns, and purples, depending on the mordant
Cochineal	Dried tropical insects	Many shades of red mixed with alum
Cutch	An extract of the heartwood of the Asian acacia tree	Various lightfast shades of brown, from beige to chocolate
Dragon's blood	A resin from the fruit of the rattan palm	Bright, lightfast reds
Fustic	An extract from the heartwood of the American mulberry tree	Orange-yellow on its own; yellows to greenish-yellows with alum
Indigo	A dye extracted from Indian indigo plants	Deep blue; yellow-white with sodium hydroxide
Logwood	An extract from Central American campeche hardwoods	Lightfast grays, browns, blacks, blues and purples, depending on the mordant
Madder root	Extracted from the roots of the Eurasian madder plant	Reds, blues, browns and yellows, depending on the mordant

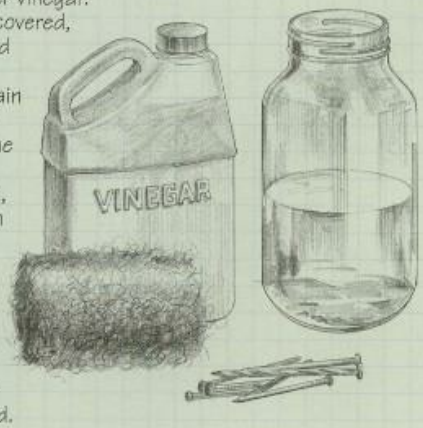
APPLYING A CHEMICAL STAIN



Mixing the ingredients
In preparing a natural dye solution or a chemical mordant, you will generally be following the directions supplied with the coloring agent. But it is important to be very precise in combining these ingredients. Measure out the dry ingredients with a scale and set them aside in a dish. If your recipe calls for boiling or hot water, you can use a kettle to heat up the liquid. Fill a measuring cup with the volume of water you need, then pour it into a glass jar. Add the dry ingredients to the water slowly *(above)*, stirring the solution with a wood stick until the powder dissolves. Apply the mixture to your workpiece with a synthetic sponge, following the procedure for wiping on a stain with a cloth *(page 72)*.

SHOP TIP

A chemical stain for ebonizing
To make your own stain for turning a wood black, submerge a steel wool pad and a few rusty nails in a large glass jar filled with cider vinegar. Let the mixture sit, uncovered, until it turns cloudy and gray; this should take about a week. Then strain the solution through a coffee filter. To apply the stain, sponge several coats of it on the wood, letting each application dry before putting on the next. After the last coat, brush on some liquid ammonia or flood the surface with water to neutralize the acid in the vinegar. Then sand the wood.



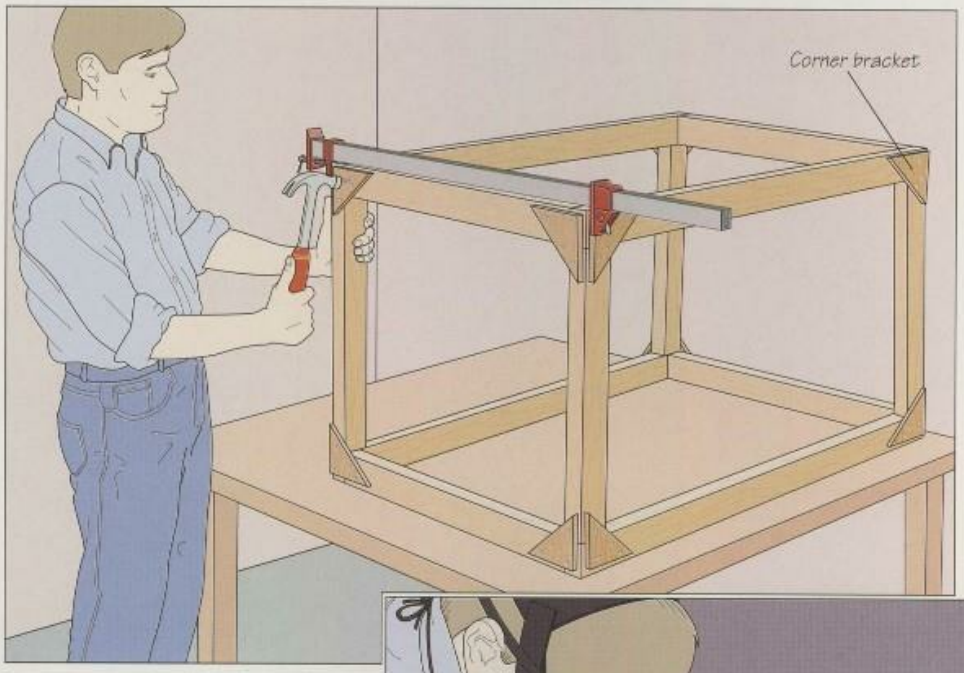
FUMING

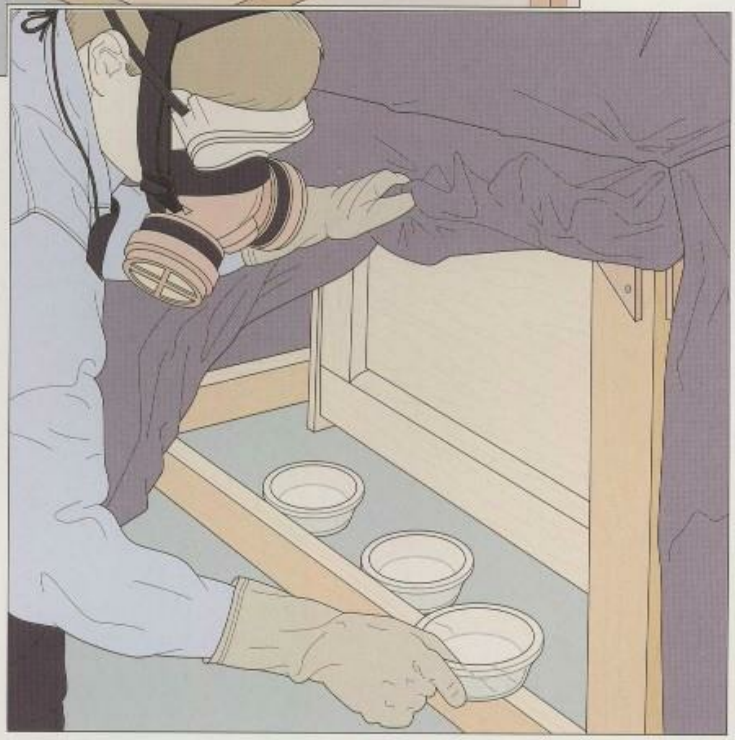
One of the characteristics of ammonia is its tendency to react with the tannin in wood. Exposed to a piece of furniture, this water-soluble liquid will darken the wood, giving it the classic look of an antique. In oak and cherry, ammonia will bring out a variety of hues ranging from light honey to dark brown. Depending on the amount of exposure, the chemical will turn some species almost black.

Ammonia can be applied by either sponging or brushing the liquid or by suffusing the wood in ammonia vapor inside a shop-built tent. This second option, called fuming, has definite advantages. The process colors exposed surfaces evenly without lap marks or streaks. And although the fumes penetrate the wood more deeply than brushed-on liquid ammonia, fuming does not raise the grain, since no liquid contacts the wood.

You can fume wood with regular household ammonia, but aqueous ammonia, available from chemical supply houses in a 28 percent solution, works much more quickly. Both products are caustic and harmful to the eyes, skin and respiratory system; concentrated ammonia fumes can even be fatal if inhaled. If possible, fume wood outdoors; wear rubber gloves, safety goggles and a dual-cartridge respirator.

EXPOSING FURNITURE TO AMMONIA FUMES





Using a fuming tent
Build a wood frame that is a little larger than your workpiece. Use triangular brackets to reinforce the corners and a bar clamp to hold the corners square as you nail the frame together *(above)*. Remove any metal hardware from your workpiece before placing it in the frame; otherwise, the ammonia will tarnish the metal. To complete the tent, drape a black plastic tarp over the frame. Use duct tape to seal any openings in the tarp and gather it tightly around the frame, leaving one flap open. Fill several dishes with ammonia and set the containers in the tent *(right)*. Seal the flap and let the fumes work for about 24 hours, checking on the workpiece periodically and topping up the dishes with fresh ammonia. Remove the piece when it has the color you want, keeping in mind that it will darken a little more after it is exposed to the air.

PROTECTIVE FINISHES

Unlike a cabinetmaking project in which wood is cut away until you are satisfied with the shape that remains, a finish is built up layer by layer. Simply put, finishing is the process of spreading a fluid over wood to dry in thin sheets. And while it is a slower and less dramatic stage of a project, the end result is equally important in producing a beautiful piece of furniture.

Perhaps the most impressive aspect of a finish is the amount of protection it will provide. Most commercial finishes are no thicker than the page of a book, yet they must guard the wood on which they rest from dirt, moisture and even mild abrasion.

A varnish topcoat brings out the luster of an oak table. Finishing a piece by hand demands care. Loading the brush with too much finish, particularly when coating vertical surfaces, can result in drips and runs.

The earliest clear finishes were probably applied in the simplest way—wiped on with whatever was at hand. A true oil finish consists of nothing more than natural drying oils flooded onto the wood. The excess is then wiped off, leaving a thin film to dry. One or two coats seal the surface and subsequent layers can be built up to almost any thickness or sheen. Even today, the term "hand-rubbed finish" conjures up an image of luster and quality. Shellac, a naturally occurring resin, can be handled in much the same way as oil. One or two coats seal the wood, but you can keep adding coats to develop the deep, glossy surface known as French polish *(page 106)*.

Most topcoats can be applied by hand, and wiping ranks as one of the best and easiest ways to ensure thin, even coverage of a wood surface. Because of its structure—under a microscope, wood looks like a bundle of straws—wood absorbs finish at different rates. Applying a uniform coating of a finish often results in what appears to be uneven coverage. The reason is that end grain absorbs more finish, leaving its surface looking bare, while the adjacent faces and edges appear adequately covered. The solution is to flood on a coat of finish and allow different amounts to be taken in by the end and flat grain areas. The wood will then be properly covered when you wipe off the excess.

Over time, finishers must have grown impatient with the thin coats that wiping produces, and brushes were introduced to the process. Brushes enable you to get into the most inaccessible of carvings and crevices, to apply finish quickly in thicker coats and, not incidentally, to keep your hands clean. Today, with the various bristle types and brush configurations available, there is a brush for virtually every variety of finishing product.

Application times were further reduced starting in the 1920s with the development of the spray gun. Spraying is by far the quickest way to apply a finish, blanketing the wood in a cloud of finely atomized fluid. But technology comes with its drawbacks. Spray guns can be wasteful, for a substantial portion of that cloud generally misses its mark. One of the goals of finishing equipment designers is to create a new generation of spray guns that preserve their traditional speed of operation while curbing wastefulness.

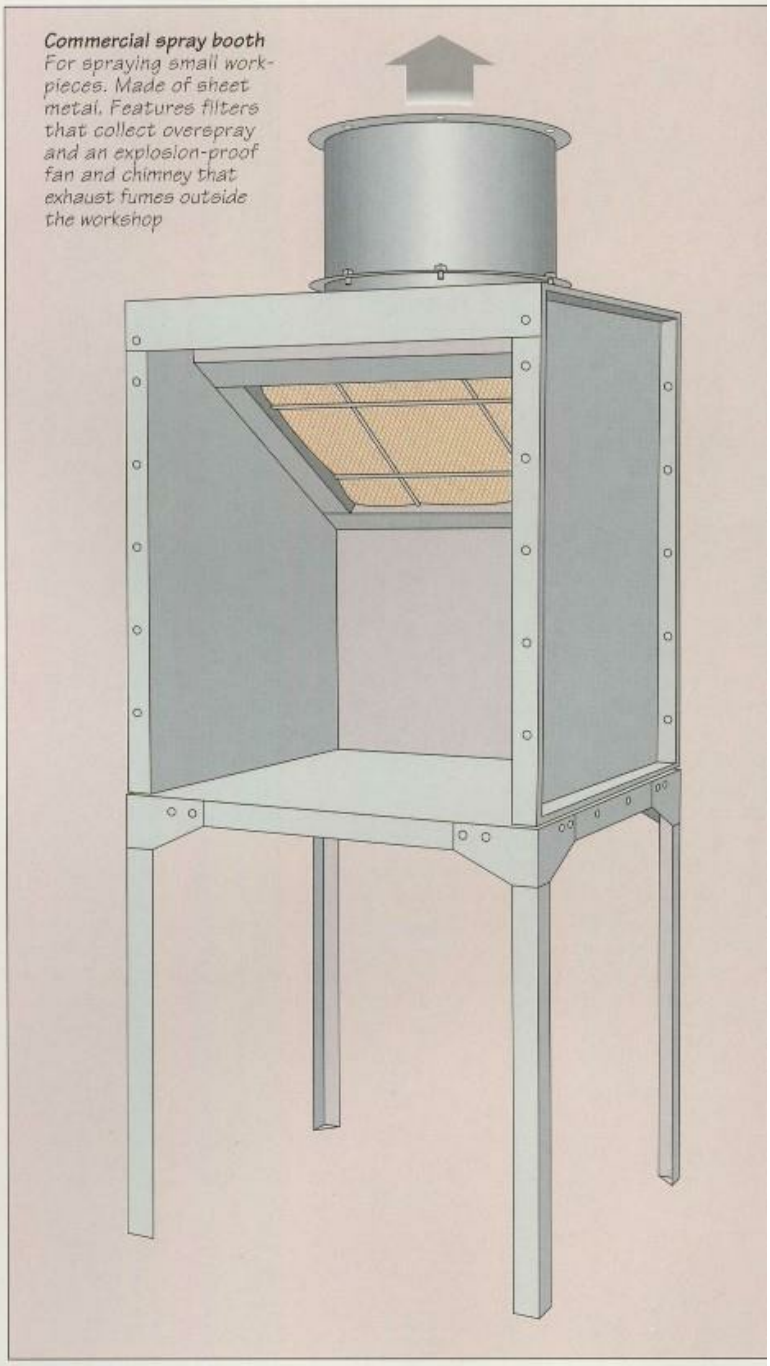
Spraying makes quick work of finishing intricate turnings. Quick-drying finishes like lacquer and shellac are ideal for this technique.

TOOLS AND ACCESSORIES

As with all the other stages of a finishing project, the application stage will be helped along by a few specialized accessories. If you have the patience and energy to apply a little elbow grease, there are a wide assortment of cloths, pads and brushes for covering a surface. Cloths and pads can be made and prepared in the shop from old sheets or linen; you can also fashion your own foam brush *(page 92)*. Brushes come in different styles, sizes and price ranges. Should you opt for the bristle over the foam variety, a high-quality brush is a good, long-term investment. It will outlast a cheaper brush, but, more importantly, it will also produce a better finish.

There are two principal types of spray systems on the market. Until recently, the only system available featured a compressor hooked up to a spray gun. Today, the more compact high-volume, low-pressure (HVLP) system is becoming more prevalent. With less overspray and hence less waste, the HVLP is more economical to operate and easier on the environment.

With both spray systems, you need to contain the fumes and exhaust them safely. The commercial spray booth shown at right is a good alternative, provided the workpiece is small enough to fit inside the booth.



Commercial spray booth
For spraying small workpieces. Made of sheet metal. Features filters that collect overspray and an explosion-proof fan and chimney that exhaust fumes outside the workshop

High-volume, low-pressure spray system
Features an electric turbine that supplies a great deal of air at low pressure to spray gun; allows high percentage of finish to contact workpiece
Viscosity cup
Helps in mixing finish to proper consistency for spraying. Cup is dipped into finish and filled with liquid; the time it takes cup to empty through hole in bottom should correspond to elapsed time specified by manufacturer
Foam brush
An inexpensive option for applying finishes without leaving streaks or stray bristles on surface; ideal for contoured surfaces and tight spots
Paint brush
Natural or synthetic bristles for applying a finish; spreads a thicker, more even coat than foam brush
Conventional spray system
Compressor supplies stream of pressurized air through hose to spray gun. Air regulator controls volume and pressure of air; regulator includes filter that removes moisture and other impurities
Spray gun and cup
Cup serves as finish reservoir; suction feeds finish through metal tube to gun, where compressed air atomizes the liquid into a mist when trigger is pulled

CHOOSING A PROTECTIVE FINISH

The protective finish you choose for a project has a lot to do with your personal taste and the effect you wish to achieve. The principal feature of a product like tung oil, for example, is its capacity to penetrate wood, giving the surface a warm glow and accentuating the grain and its pattern. A varnish or polyurethane topcoat provides a higher degree of protection by drying to a plastic-like film; however, it will also mask the surface details to some degree.

Many protective finishes, including varnish, polyurethane and lacquer, are now available in two formulations: solvent- and water-based. Years ago, solvent-based products monopolized the marketplace, but recent environmental concerns have spurred the development of water-based finishes. Solvent-based finishes are generally flammable; water-based products are not. Another selling point of water-based finishes is that they do not release toxic solvents into the atmosphere except when they are sprayed, and thus comply with increasingly stringent air quality standards in states like California. The procedures for preparing and applying a water-based finish may differ from the methods used for its solvent-based counterpart. Always refer to the manufacturer's instructions for mixing and applying a topcoat.

Whichever finish you select, applying it entails more than slopping on a few coats of the product and letting them dry. The wood surface has to be properly prepared: If you want to fill the grain *(page 50)* of an open-pore species like oak, you will need to do so before applying the finish. Before applying a lacquer topcoat to an open-pore wood surface, a sealer coat may be in order. Finally, you will need to bleach or stain the piece ahead of time if changing its color *(page 54)* is part of your game plan.

Before preparing your tools and opening up your container of finish, make sure that any filler, wash coat or stain is completely dry. As a final preparation, go over the wood surfaces with a tack cloth to be sure they are free of sanding particles and dust.

The procedures for applying a topcoat depend on the product you are using and the application method you have selected. Pages 87 to 90 detail the steps for applying a wide range of products by hand or, where appropriate, with the help of spray equipment.

Easy to apply, a coat of polymerized tung oil is wiped onto the surface of this cherry toy chest, protecting the wood and giving it a warm luster.

DRYING OILS

Drying oils, such as linseed, tung and walnut oil, are a group of natural finishes that cure to form a relatively hard film on a wood surface. Tung oil, also known as China wood oil, is one of the most popular drying oil finishes. Extracted from the nut of the tung tree, the oil is available in pure, modified and polymerized form.

Because it contains no additives, pure tung oil is a good choice for finishing children's toys and eating utensils such as salad bowls. If you are planning to use it, check the label to make sure that the contents are 100 percent pure. The main benefit of modified tung oils is that they contain chemical additives that allow them to dry more quickly. Polymerized tung oil undergoes a special heat treatment; it dries faster still and produces a glossier sheen.

Drying oils are reactive finishes, meaning that they dry and harden when exposed to air—even in a sealed container. When you store a drying oil, use a container that is as small as possible to reduce the volume of air to which the oil is exposed. A couple of other suggestions are discussed in the Shop Tip below.

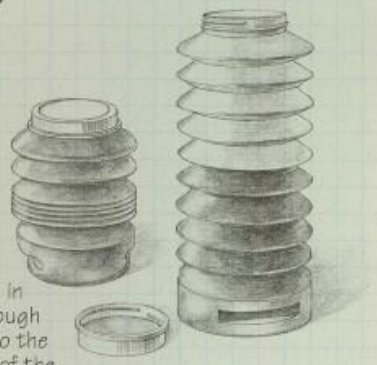
APPLICATION SEQUENCE

1. Wipe the oil on the surface with a cloth; it should be applied straight from the container.
2. Let the oil soak into the wood (typically for 15 minutes), then use a clean cloth to wipe off the excess.
3. Let the surface dry, usually overnight.
4. Sand the surface with 400-grit paper and remove sanding particles.
5. Repeat steps 1 to 4 as many times as necessary to achieve the finish you want. Depending on the wood, five coats of oil will typically yield a semi-gloss sheen.
6. Let the surface cure for at least a week before rubbing out the finish *(page 126)*.

SHOP TIP

Preventing reactive finishes from drying out

To expose a reactive finish to as little air as possible, pour it into a collapsible plastic container like those used for photographic chemicals (far right). Collapse the folds of the container to expel all the air, then cap it tightly (near right). If you are keeping a reactive finish in a glass container, drop enough small stones or marbles into the liquid to raise it to the level of the brim, then screw on the cap. Whichever storage method you choose, fix a label to the container identifying the contents.



VARNISH

Varnish is a highly durable protective coating for wood, more resistant to heat and alcohol damage than products like shellac and lacquer. Whether you are brushing it on or using spray equipment, it is also relatively easy to apply. If you are brushing, try to work with a white wall or a window in back of the workpiece. The reflected light will help you see if you are skipping an area or if you are picking up dust.

Varnishes were once made with natural resins and oils like linseed oil. These materials have since been supplanted by synthetic resins, but the old system of classifying varnish based on the proportion of oil-to-resin still prevails. Accordingly, varnishes are designated as either short, medium or long oil. Long-oil varnish is slow drying, producing a soft and elastic coating. Short-oil varnish is hard, and glossy—good for withstanding abrasion. Medium-oil varnish provides a finish that falls between the two in gloss and durability.

APPLICATION SEQUENCE (BRUSHING)

1. Dilute the varnish and spread a thin coat on the surface with a high-quality bristle brush; work first against the grain, then with it.
2. Let the surface dry, typically for 12 to 24 hours.
3. Sand the surface with a self-lubricating 240- or 280-grit sandpaper.
4. Repeat steps 1 to 3, using a stronger dilution of varnish and sanding the surface with a finer grit sandpaper (280- to 320-grit).
5. Brush on an undiluted coat of varnish.
6. Let the surface dry and sand with 400-grit sandpaper.
7. Repeat steps 5 and 6 two or three times.
8. Let the surface cure for 24 to 72 hours before rubbing out the finish.

APPLICATION SEQUENCE (SPRAYING)

1. Dilute the varnish to the proper viscosity *(page 96)*.
2. Set the spray gun at low pressure to minimize overspray and pooling.
3. Spray a thin coat on the surface.
4. Let the surface dry, then sand with 320-grit sandpaper.
5. Repeat steps 3 and 4 two or three times.
6. Let the surface cure for 24 to 72 hours before rubbing out the finish.

POLYURETHANE

Polyurethane is a transparent, varnish-like finish that is durable, abrasion-resistant and easy to apply. Formulated with synthetic resin, it dries more quickly than varnish, making it an ideal choice when you have limited time for the finishing work. Like varnish, polyurethane can be brushed or sprayed on furniture.

Polyurethanes are available in a variety of lusters, ranging from flat to glossy. Because they do not release toxic solvents into the atmosphere while drying, water-based polyurethanes are safer for the environment than their solvent-based counterparts. If you plan to spray a water-based polyurethane, be sure your spray equipment is scrupulously clean; oil will contaminate the water-based product.

APPLICATION SEQUENCE (BRUSHING)

1. Apply a thin and even coat with a paint brush or pad applicator, always brushing with the grain.
2. Let the surface dry for about 2 hours.
3. Sand the surface with a 320- to 400-grit sandpaper.
4. Repeat steps 1 to 3, abrading the surface with a finer grit sandpaper.
5. Apply a final coat, giving the surface 18 to 24 hours to dry before rubbing out the finish.

APPLICATION SEQUENCE (SPRAYING)

1. Spray the workpiece as you would for varnish, allowing 30 to 60 minutes for the coat to dry.
2. Sand the surface with a 320- to 400-grit sandpaper.
3. Apply two more coats, using progressively finer grit sandpaper to abrade the surface after each application.
4. Wait at least 18 to 24 hours before rubbing out the finish.

SHELLAC

Shellac is a natural finish produced from the secretions of the lac insect, which is indigenous to Indochina and India. The bugs feed on tree sap and expel a resin that forms a protective shell around their bodies. Eventually this material builds up and is deposited on tree twigs and branches; it is then harvested and processed.

In its commercial forms, shellac is available both as a liquid and in flakes. Liquid shellac is ready for use, but the flakes must be mixed first with denatured alcohol. In some regard, however, the flakes are the more convenient form of the product since you can prepare only as much of the solution as you need for a particular project. Both types of shellac are available in a variety of shades, ranging from dark brown and orange to blond and white.

Shellac is also classified according to its "pound cut," which refers to the amount of resin in the solvent. A 1-pound-cut shellac, for instance, has one pound of resin for each gallon of solvent.

Shellac comes in different grades, depending on where and when the product was harvested. Coarse shellac has bits of twigs and bugs; the super-refined variety is virtually pure liquid.

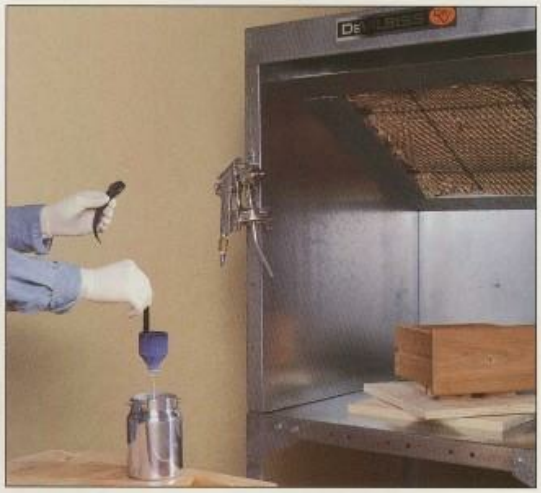
While shellac provides a durable finish that protects wood from humidity and abrasion, it does not stand up well to water, alcohol or heat. Like other solvent-release finishes, shellac forms a milky cloud on a surface—called blushing—if it is sprayed in high humidity or with excessive moisture in the solvent. Keep the solvent in a sealed container.

APPLICATION SEQUENCE (BRUSHING)

1. Either buy or prepare a 1- or 2-pound-cut shellac with which to apply two or three wash coats to the surface *(page 53)*. Brush the finish on quickly and evenly with as few strokes as possible, working with the grain only. Avoid overlapping the brushstrokes.
2. Let the surface dry, typically for at least 2 hours.
3. Sand the surface with a self-lubricating 360- or 400-grit sandpaper. Remove sanding particles.
4. Brush on another coat, using a 3-pound-cut shellac, then sand.
5. Apply three or more coats with a 5-pound-cut shellac, sanding before each application.
6. Allow 24 to 72 hours of drying time before rubbing out the finish.

APPLICATION SEQUENCE (SPRAYING)

1. Prepare a solution with the proper consistency for spraying following the manufacturer's instructions; a 1- or 2-pound-cut shellac is typical. If you are using liquid shellac, you may have to dilute it.
2. Adjust the spray gun for a light coat to keep drips and runs to a minimum.
3. Spray on two or three wash coats.
4. Let the surface dry for about 30 minutes, then sand it with a self-lubricating 360- or 400-grit sandpaper. Remove sanding particles.
5. Spray on three or four additional coats using a more concentrated solution and sanding between applications.
6. Let the finish dry for 48 to 72 hours before rubbing out.



A viscosity cup is used to test the consistency of a finish for spraying. Proper dilution of the finish will ensure that it coats a workpiece uniformly and with a minimum of dripping.

LACQUER

APPLICATION SEQUENCE (BRUSHING)

1. Dilute the sanding sealer according to the manufacturer's instructions and apply it to the workpiece. Let dry and sand with 320-grit paper.
2. Dilute the lacquer with a retarding solvent as specified by the manufacturer. (The retarder keeps the lacquer from hardening too quickly.)
3. Coat the workpiece with the finish using a soft, long-bristled brush. Work at a 45° angle to the surface and brush with the grain. Do not overlap brushstrokes.
4. Let the lacquer dry (typically 2 hours), then sand with a self-lubricating 360- to 400-grit sandpaper. Remove sanding particles.
5. Repeat steps 2 to 4, using a slightly more concentrated lacquer solution.
6. Apply at least two or three additional coats. Avoid brushing undiluted lacquer on the surface; you should add at least a small amount of retarder to the lacquer.
7. Let the finish dry for at least 24 hours before rubbing it out.

APPLICATION SEQUENCE (SPRAYING)

1. Dilute the sanding sealer according to the manufacturer's instructions and apply it to the workpiece. Let dry and sand with 320-grit paper.
2. Prepare a diluted lacquer solution with the solvent recommended by the manufacturer and spray it onto the surface. Make sure the lacquer has the proper consistency for spraying; use a viscosity cup *(page 96)*.
3. Let the finish dry for about an hour.
4. Sand with a self-lubricating 320-grit paper.
5. Repeat steps 2 and 3, sanding the surface lightly. (This step is optional.)
6. Spray on at least 3 more coats, diluting each application with only a small amount of retarder and sanding the surface with a 360-grit paper.
7. Let the finish dry completely before rubbing out.

Lacquer has been used as a protective finish for wood furniture in the Far East for more than 2000 years, but it did not become popular in the West until the 17th Century. The first lacquers used during China's Chou dynasty were derived from natural resins; today's products are formulated synthetically.

Lacquer can be brushed onto a surface, but be sure to use a brush with bristles set in rubber, otherwise the solvent in the finish may cause the tool to shed. The rapid drying time of lacquer also makes it well-suited for spraying. A lacquer topcoat hardens to a clear and durable finish. It is a good choice for furniture that may be exposed to water or high heat.

Unlike polyurethanes and varnishes, which form separate layers with each new coating, each application of lacquer dissolves the previous coats to create a single film. Finishers usually try to limit themselves to four coats of lacquer. But these are generally in addition to one or two coats of sanding sealer. The thicker a lacquer finish is built up, the greater the risk of cracking. However, obtaining a mirror-like lacquer finish on species like rosewood or oak may sometimes involve as many as 10 applications. Finishers in ancient China were known to apply more than 300 coats on a single piece of furniture. To prevent cracking, they would carefully abrade the surface after each new application had dried and they kept each coat as thin as possible.

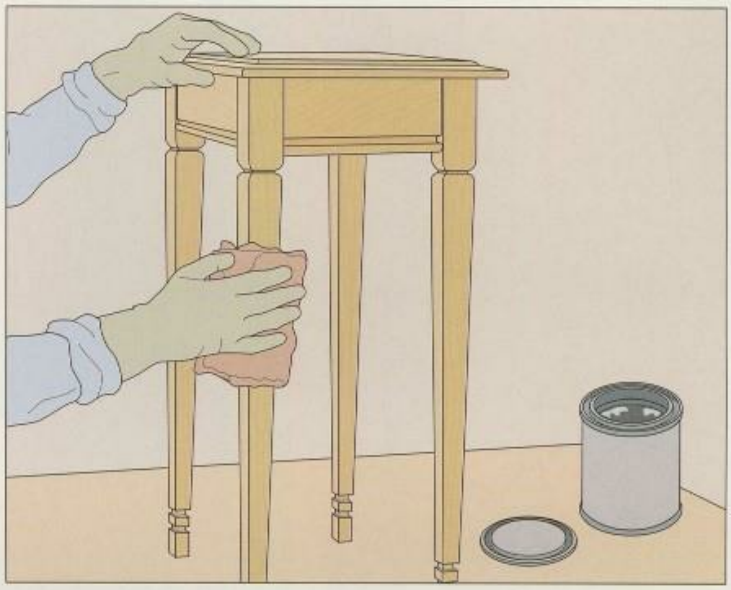
Lacquer is available in a range of sheens from flat to glossy. There are different tints to choose from as well, and a clear formulation that heightens the grain and color without altering the hue.

FINISHING BY HAND

There are essentially three methods of applying protective finishes by hand: wiping the finishing material on with a cloth or sponge, padding it on or using a brush. The method you choose should depend on the type of finish you are applying. Wiping, for example, is the best way to apply a drying oil. Varnish, polyurethane, shellac and lacquer are better applied with a brush.

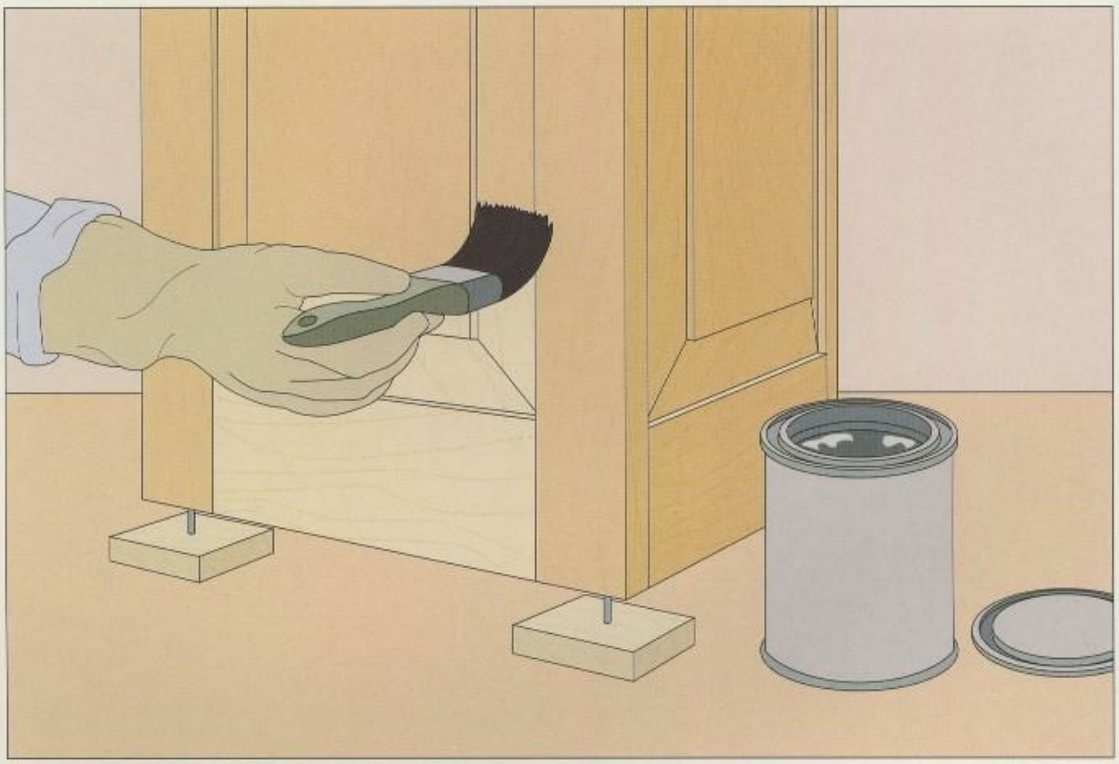
Some finishing products, called padding finishes, are made to be padded onto a surface; they provide something approaching the luster of French polished or lacquered wood with considerably less effort. However, because these finishes do not readily build up into a thick coating, they still require a fair amount of time and work to apply. As a result, they are most often used to touch up damaged finishes. As finishes for newly built furniture, they are best suited to ornamental details, turnings or small pieces like the table shown below. To reduce the amount of time required to build up a padding finish, first apply a sealer coat of varnish, shellac or lacquer.

WIPING OR PADDING ON A FINISH



Using a cloth or sponge
Wet a clean cloth or a sponge with the finish and wipe a thin coat of the liquid onto the surface *(above)*. Make sure you cover the wood surfaces completely. Let the finish soak into the wood for several minutes, then use another clean cloth to wipe away the excess. Check the manufacturer's instructions for drying times, then apply subsequent coats the same way.

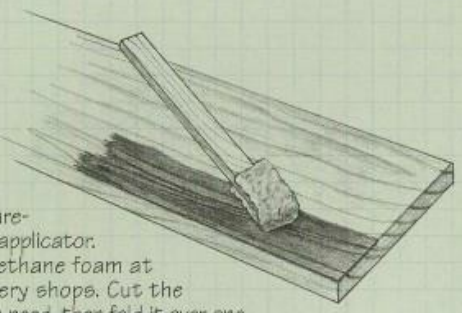
Working with a pad
Use a piece of linen and some wool to make a finishing pad as you would for French polishing *(page 106)*. Pour a little of the finish on the pad, then tap it against the palm of your hand to get the pad uniformly damp. Wipe the pad along the surface following the direction of the grain *(left)*. Overlap your strokes until you have covered the entire workpiece and the surface has a smooth, glossy sheen. Consult the manufacturer's instructions for drying times, then apply subsequent coats. Padding finishes usually require several applications.



Brushing on a finish
Set the workpiece slightly above your work surface so you can cover the wood right to the bottom without slopping finish on the table. For a shop-made stand, prop the corners on wood blocks with small nails driven through them. If you are using a bristle brush, dip about one-third of the bristle length in the finish and brush along the grain leaving behind thin, even coats. Resist the temptation to spread the finish thickly or the liquid will run, sag or pool. To avoid air bubbles and lap marks on the surface, use as few brushstrokes as possible. Use tweezers to remove stray bristles from the finish before it has a chance to dry. A foam brush will cut down on the problem of lap marks.

SHOP TIP

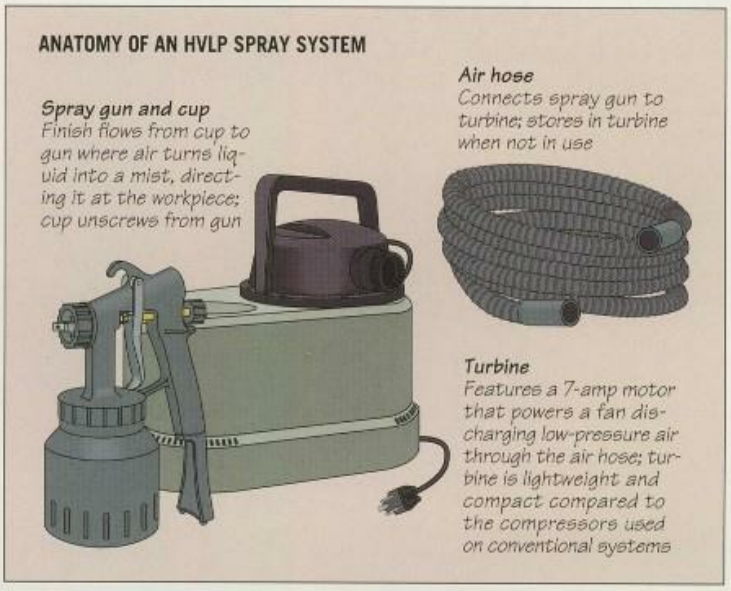
A foam brush
You can make your own disposable foam brushes to suit any job at hand. Use scrap wood for the handle and a piece of polyurethane foam for the applicator. You can buy polyurethane foam at fabric and upholstery shops. Cut the foam to the size you need, then fold it over one end of the handle and staple it in place. Use scissors to trim the foam to the right profile for your workpiece.

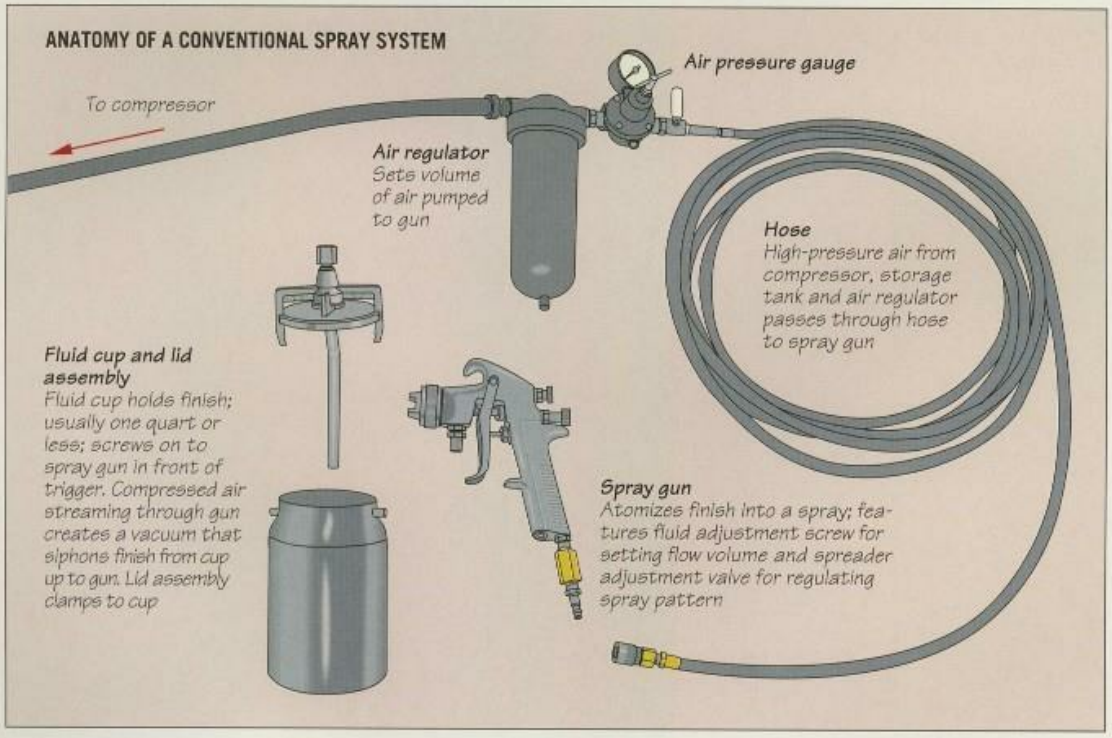


SETTING UP YOUR SPRAY EQUIPMENT

With a bit of practice, spraying is a highly efficient method of applying professional-looking finishes. High-volume, low-pressure (HVLP) systems offer the best transfer efficiency—that is, they land a high percentage of the spray on the workpiece and waste less as overspray. Since they use low-pressure air to create a mist of finish, HVLP systems also create less "bounce back" than conventional systems. Bounce back often occurs when spraying is done in an enclosed space: The overspray rebounds toward the spray gun and settles on other surfaces.

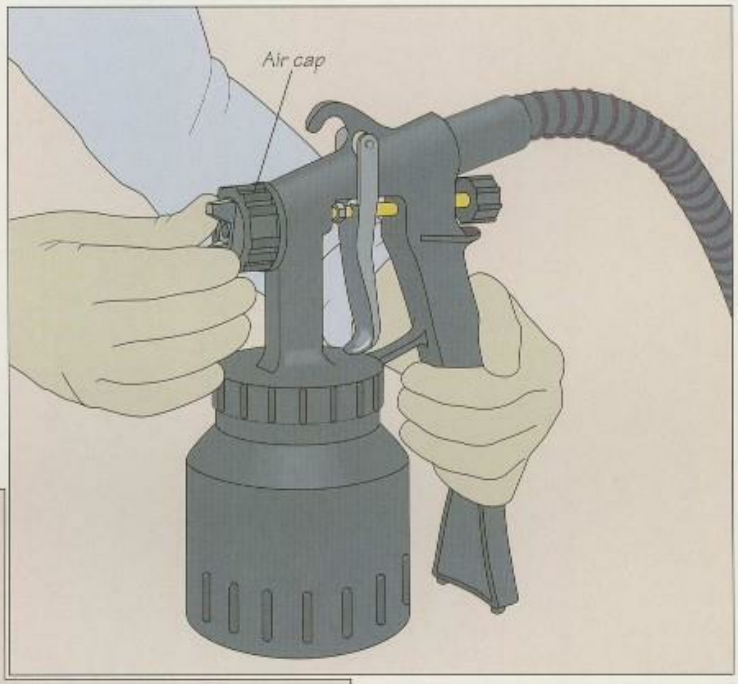
The key to successful spraying is to keep your equipment properly adjusted. With both HVLP and conventional systems the adjustments are made with the actual solution you will be using, so you will need to start the process by preparing a batch of finish *(page 96)*.

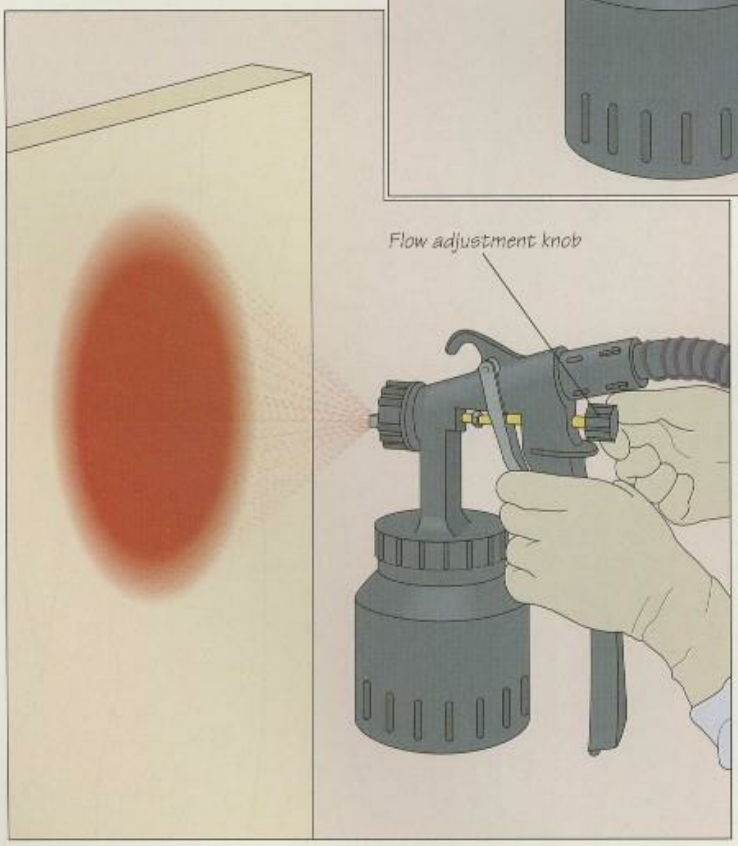




ADJUSTING AN HVLP SYSTEM

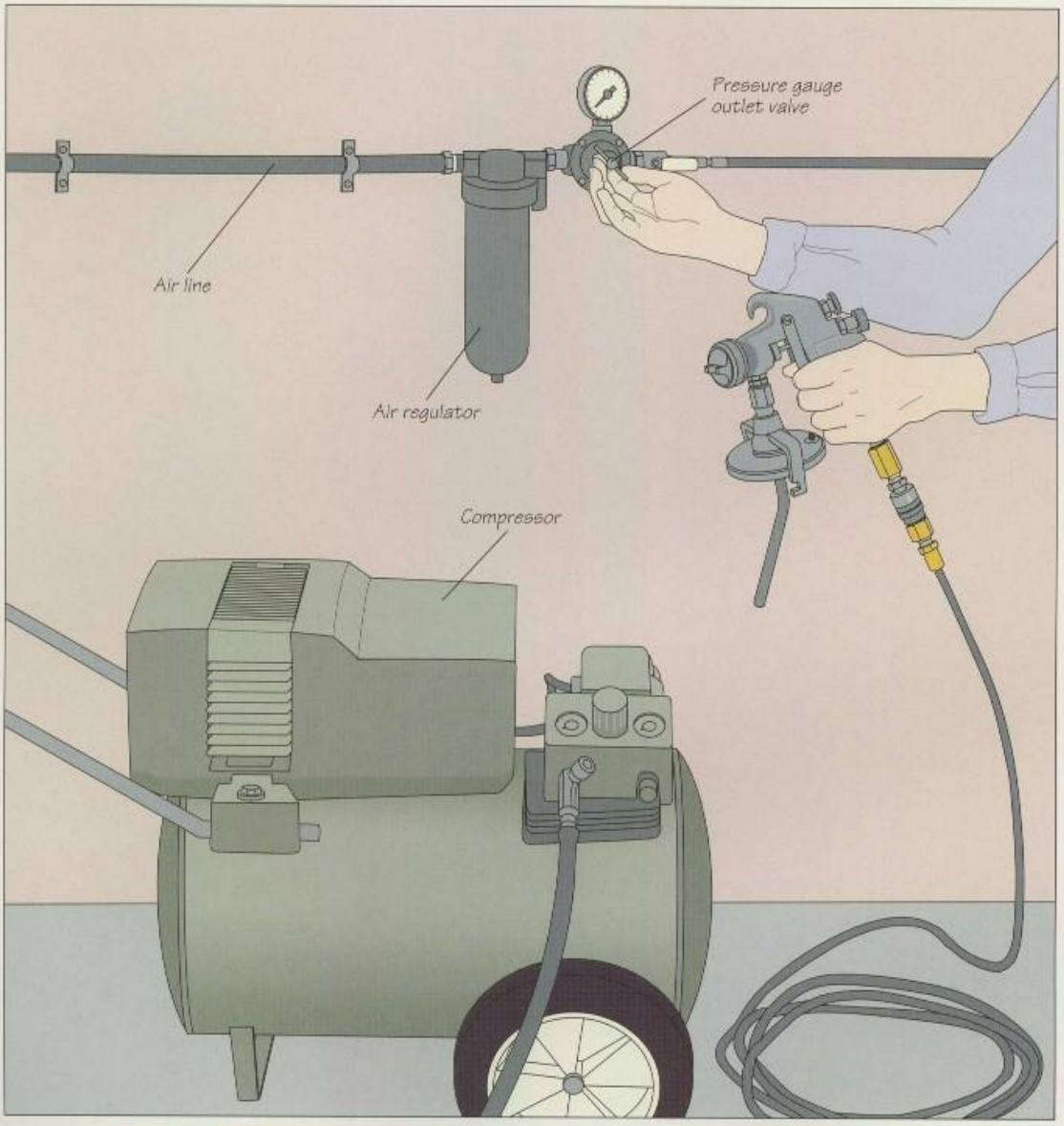
1 Adjusting the spray pattern
Fill the cup with finish and screw it to the spray gun. For the model shown, turn the system on at the turbine, then adjust the air cap to produce either a vertical, horizontal or circular spray pattern. As a rule of thumb, use the vertical setting to spray tops and other horizontal surfaces, and the horizontal setting to spray vertical surfaces. The circular pattern is wider than the other two and can be used on any type of surface. Test all three patterns on scrap wood before turning your attention to the workpiece.





2 Adjusting the flow
To set the volume of finish to be sprayed from the gun, turn the flow adjustment knob. Holding the gun nozzle about 8 inches from a test surface, pull the trigger to start the spray. The finish should cover the surface evenly without dripping or pooling. If the coating is too thin, increase the flow by turning the knob counterclockwise; if the finish drips or pools, decrease the flow by turning the knob in the opposite direction. To change the size of the spray pattern, either increase or decrease the distance between the gun and the surface. This may throw off the flow adjustment, however. Moving the gun closer to the surface may require a decrease in the flow; similarly, as you draw the gun away you may have to increase the flow.

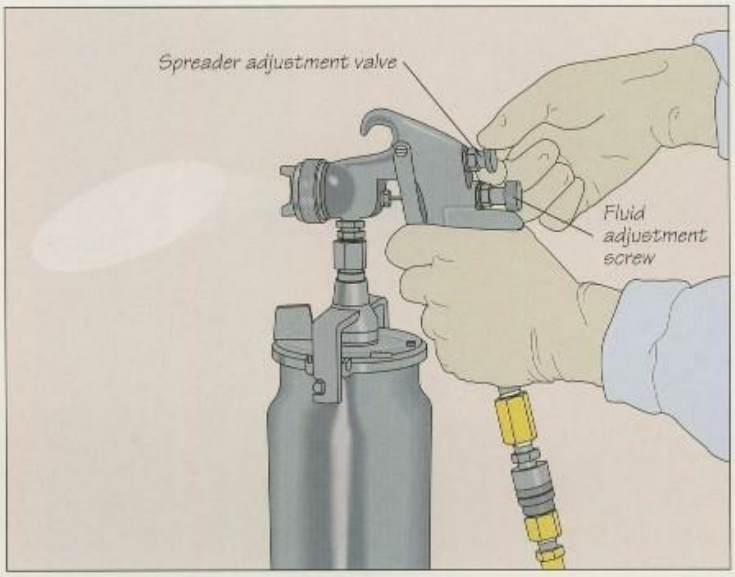
ADJUSTING A CONVENTIONAL SPRAY SYSTEM



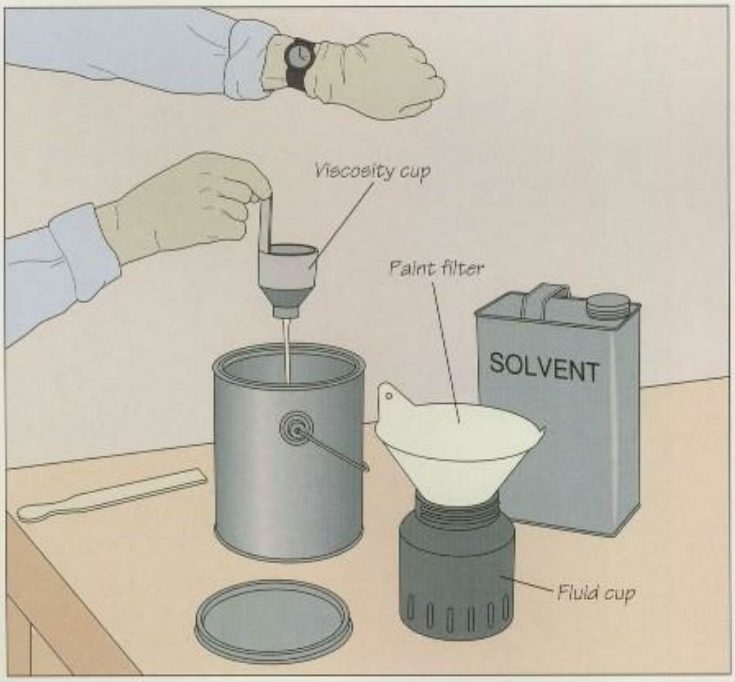
1 Setting the air pressure

Attach the air line from the compressor to the air inlet on the regulator. Then install the hose, connecting one end to the air outlet on the regulator and the other to the air inlet on the gun. To adjust the air pressure on the model shown, take the fluid cup off the spray gun and turn on the compressor, allowing the tank to pressurize. Open the outlet valve on the pressure gauge to the level specified by the manufacturer *(above)*, typically about 50 psi.

2 Adjusting the spray pattern and flow
Fill the fluid cup with finish and attach it to the spray gun. Adjust the spray pattern and the flow of the finish in the same way that you would for an HVLP system *(page 94)*. Turn the fluid adjustment screw counterclockwise to increase the flow and clockwise to decrease it. Use the spreader adjustment valve to set the size of the spray pattern *(right)*, turning it counterclockwise to produce a larger pattern and in the opposite direction to narrow the scope of the spray.



PREPARING A FINISH



Adjusting the consistency of a finish
A finish may need to be thinned to the proper consistency before it can be sprayed. To determine the consistency of a finishing product, dip a viscosity cup into the fluid, then lift it out and time how long it takes for the cup to empty *(left)*. If the time exceeds the interval specified by the manufacturer, dilute the finish with the appropriate solvent. Test the solution as many times as necessary, but make sure that you get it to the proper consistency. Before filling the fluid cup, strain the finish through a paint filter to remove impurities that might otherwise clog the spray system or mar the finish.

WORKING WITH SPRAY EQUIPMENT

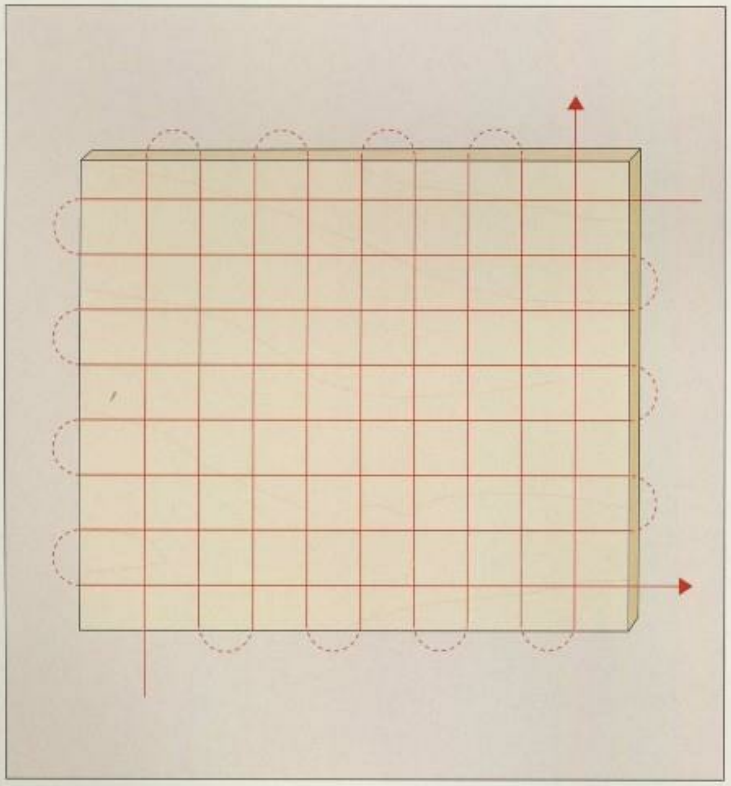
Both your own safety and that of your neighbors should be a major concern associated with spraying a finish. Do not fail to put on the appropriate gear for the task: safety goggles, rubber gloves, a rubber apron and a dual-cartridge respirator. If you can smell the finishing product through your respirator, it is not doing a good enough job. Adjust the device to fit properly on your face, change the filters or replace the respirator. Refer to the chapter on safety *(page 12)* for more information on protecting yourself.

Whether you are using water- or solvent-based products, you must set up your spray area and exhaust the fumes you generate in a manner that complies with federal, state and municipal requirements. Pages 102 and 103 show a typical spray room with some of the elements that may be necessary. However, it is essential to check your local regulations before outfitting your spray room.

The ideal distance between a spray gun nozzle and the surface to be sprayed is about 8 inches. You can use your outstretched fingers to quickly gauge the distance.

While you are actually spraying, hold your arm straight out in front of your body. Whenever possible, keep the gun as nearly perpendicular to the wood surface as you can. As illustrated in the diagram below, a surface is covered with a series of back-and-forth strokes that overlap each other and the edges of the wood. Before actually spraying the finish on a piece of furniture, practice a little on some cardboard or scrap wood until you have refined your technique.

SPRAYING A FINISH



Applying a full and even coat

The diagram at left illustrates a spraying sequence for applying clear finishes. The key is to start at one corner and make a series of straight, overlapping passes that wend their way to the opposite corner. This first series should run across the grain of the wood. Then make another series of passes, this time working parallel to the grain. As you work, release the trigger each time you pass off the edge of the wood. To ensure an even coat, hold the gun perpendicular to the surface and keep it moving at all times.

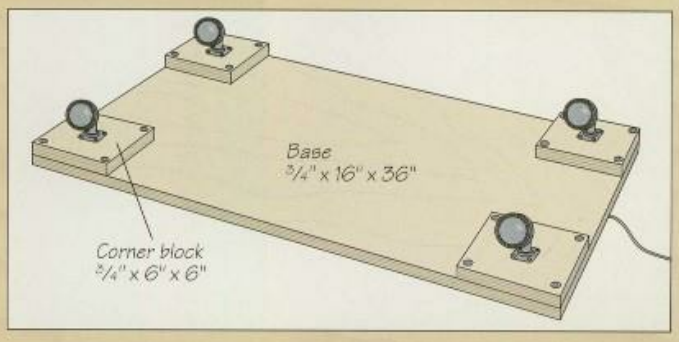
BUILD IT YOURSELF

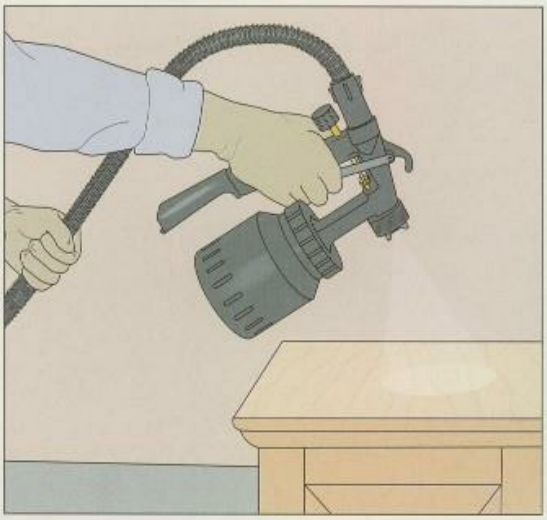
A SPRAY ROOM DOLLY

To wheel a workpiece in and out of your spray room, and to move it around without having to set hands on the drying wood, use the shop-built dolly shown at right and below. The dimensions in the illustration will yield a dolly that is large enough for most furniture projects.

Cut a piece of ¾-inch plywood for the base, then screw the corner blocks in place. Screw a caster onto each corner block. To set up the dolly for the piece to be sprayed, drive nails through the centers of four wood blocks. Position the blocks on the base with the nail tips pointing up so they will support the corners of the workpiece.

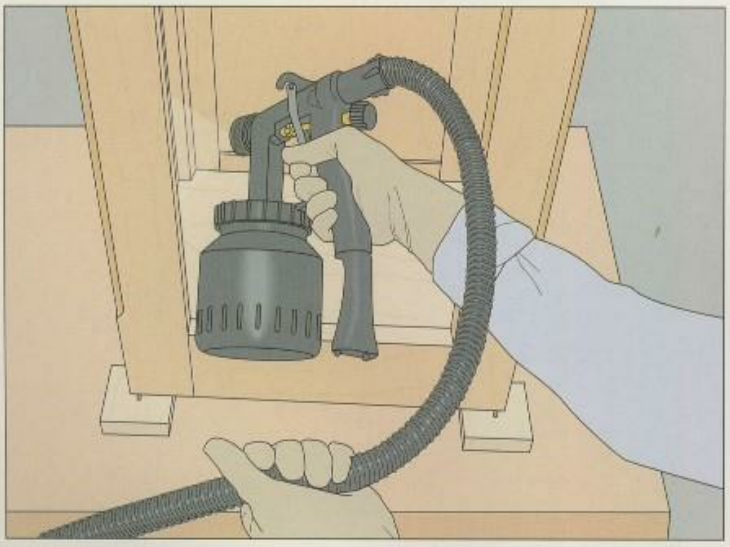
To use the dolly, set the piece on the nails. To avoid touching the workpiece after spraying it, use your foot to move the dolly. You can also attach a tow rope to the base and use it to pull the dolly along.





Spraying the flat surfaces

To finish a piece of furniture, start with the outside surfaces, first spraying the top and then the sides. In preparation for the job, set the piece slightly above your work surface, propping it up on wood blocks with nails driven through them as shown overleaf. For the top, be sure to adjust the air cap to the vertical spray pattern position *(page 94)* and use a spray pattern that works first across the grain and then with it. Holding the gun at a slight angle to the surface, start at the edge closest to you and work toward the opposite edge *(above, left)*. For the sides, set the air cap to the horizontal spray pattern position and work with the gun perpendicular to the surface *(above, right)*. To ensure even coverage, hold your arm out straight to maintain a uniform distance between the gun and the wood. Always work in straight lines; circular spraying patterns will leave the edges with a thinner coating than the center.



Spraying the inside surfaces

To cover the inside of a piece of furniture, start with the least conspicuous surface. For the cabinet shown, first spray the underside of the top, beginning at the back and moving toward the opening at the front. Be careful not to aim the spray at yourself. Spray the corners, the sides, the back and finally the bottom of the cabinet.

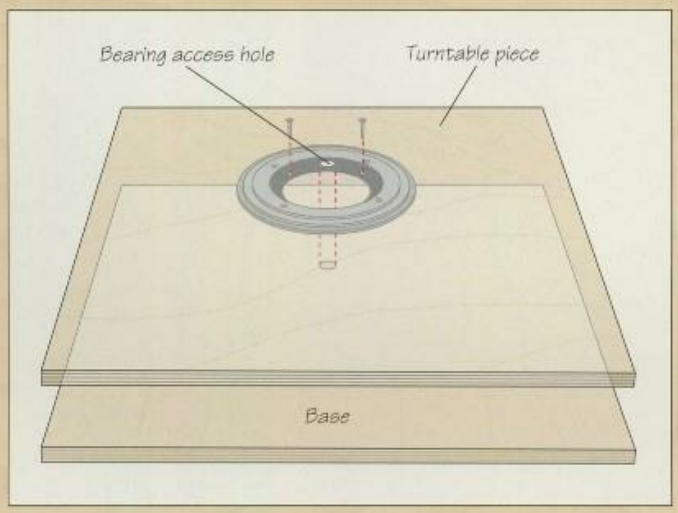
BUILD IT YOURSELF

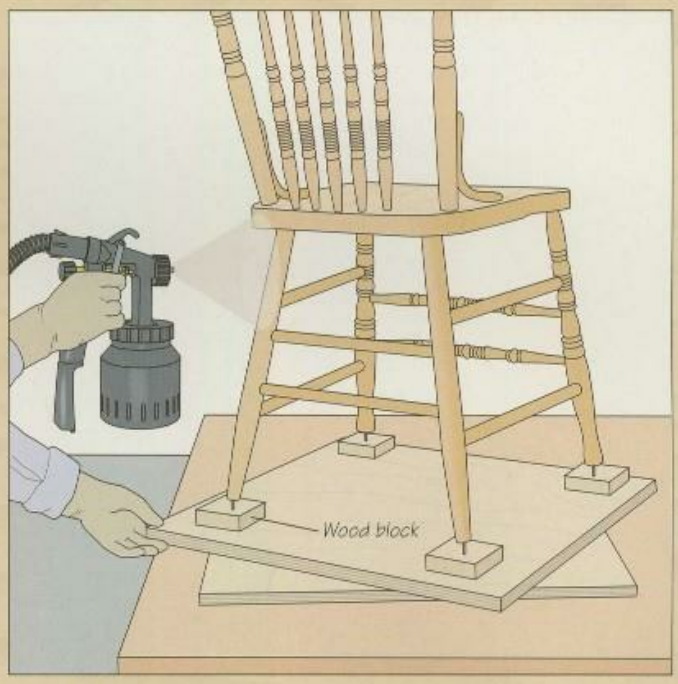
A TURNTABLE FOR SPRAYING

To spray all the surfaces of a piece of furniture without having to move your equipment, use the shop-made turntable shown at right. The device consists of two pieces of plywood with a "Lazy Susan" bearing fastened in between. The setup allows a piece of furniture to be rotated at any speed as it is being sprayed.

To make the turntable, cut two pieces of ¾-inch plywood slightly larger than the width of the piece of furniture to be finished. Set the base on a work surface and center the bearing on top of it. On the base, mark the access hole and the four screw holes in the inner ring of the bearing. Bore the access hole through the base and drill four pilot holes, then attach the bearing to the base with screws. To fasten the turntable piece, set the base on top of it with the bearing sandwiched between the two pieces of wood. Aligning the edges of the pieces, slowly rotate the base until the access hole in it lines up with one of the four screw holes in the outer ring of the bearing. Screw the bearing to the turntable piece and repeat the process at the other three holes.

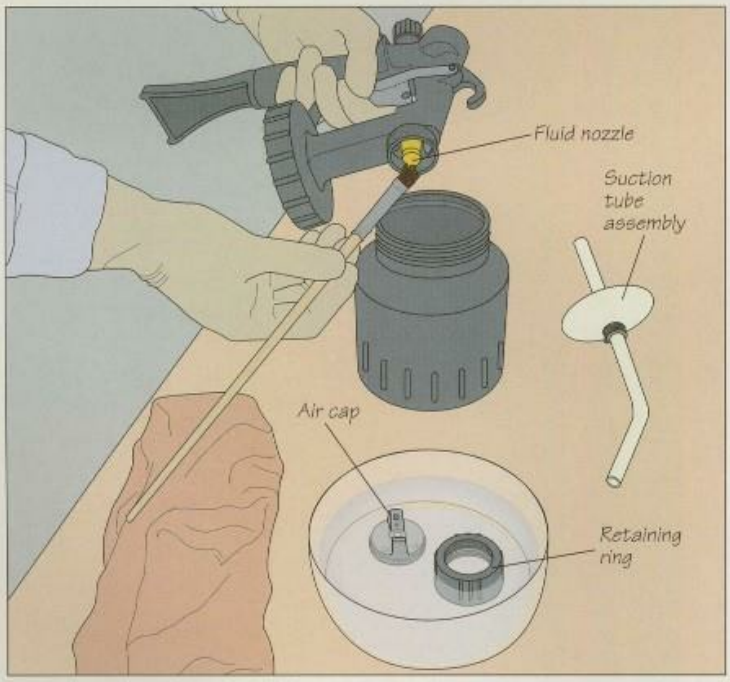
To use the turntable, cut four small wood blocks and drive nails through them. Set the workpiece on the tips of the nails, then slowly rotate the turntable with one hand while operating the spray gun with the other *(right, bottom)*.





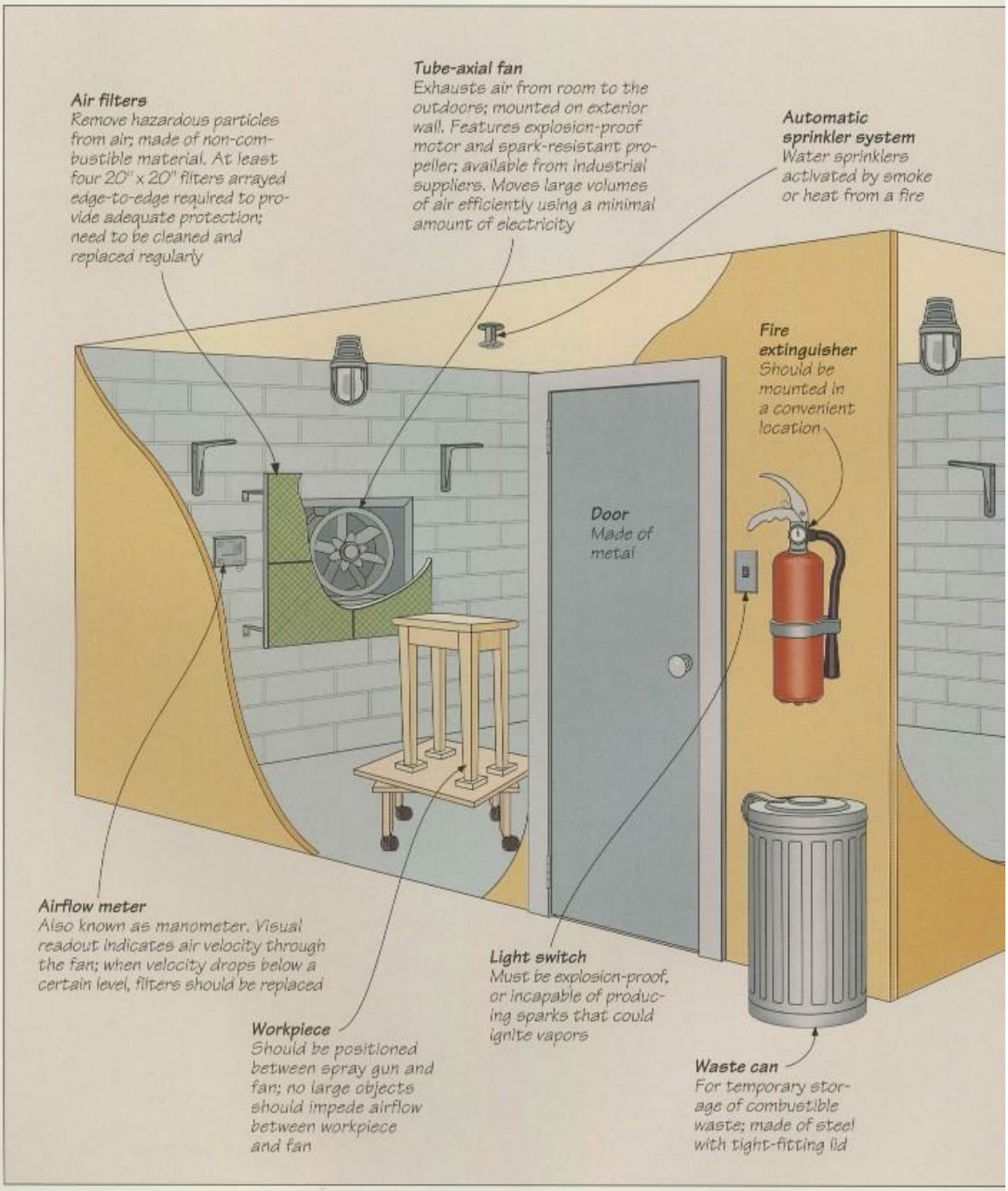
Spraying contoured surfaces
When spraying, treat contoured surfaces, such as chair spindles and legs, as if they were four-sided objects. Holding the gun at a slight angle to the wood, spray each side in turn.

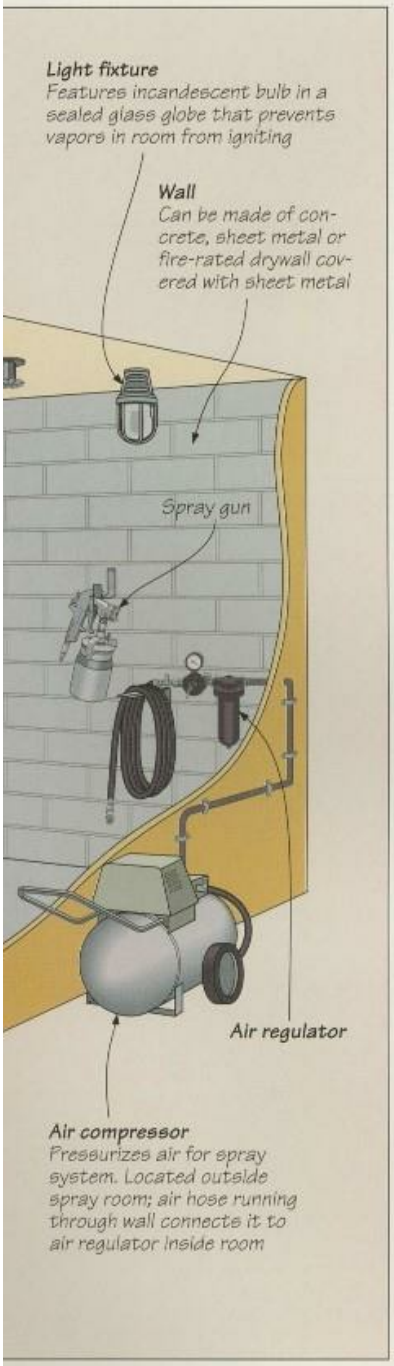
CLEANING THE SPRAY EQUIPMENT



Cleaning the spray gun and fluid cup
To keep your spray equipment in good working order, clean the gun and fluid cup after each use. For the HVLP system shown, unscrew the cup from the gun and pour any finish left in the cup into a container for storage or disposal. Then pour a small amount of the appropriate solvent into the cup and reattach it to the gun. Spray the solvent into an empty can. Repeat as many times as necessary until the solvent comes out clean. Wipe the outside of the cup and gun, then pull the suction tube assembly from the gun. Remove the air cap by unscrewing its retaining ring from the gun; soak the two pieces briefly in solvent. Clean the fluid nozzle, suction tube assembly and air cap with a soft brush dampened with solvent *(left)*. Reassemble the gun and screw the fluid cup to it.

ANATOMY OF A SPRAY ROOM





Because of the hazards associated with spraying finishes, the practice is strictly controlled by law. You cannot, for example, set up a furniture spraying facility in your garage without adequately guarding against fire and environmental contamination.

Spraying generates toxic and flammable vapors, solvents and particles, making the air in the immediate area harmful to breathe and potentially explosive. Toxic vapors must be filtered out before the air can be exhausted; and the spray area must be contained in the event of fire. Although water-based products pose less of a fire hazard than solvent-based finishes, making them a safer alternative for the finisher, both types produce harmful vapors when sprayed.

If you want to spray furniture, you have two options: You can use a commercial booth *(page 84)* or you can build a spray room. The latter alternative is a complex undertaking, however. According to one of the regulatory agencies, the National Fire Protection Association (NFPA), a spray room must be fully enclosed and feature a power-operated ventilation system.

The illustration at left shows some of the elements that might be incorporated in a typical spray room. A powerful electric fan pulls air from the room through a panel of filters, which remove toxic substances before the air is exhausted. The walls are constructed in such a way as to prevent the spread of fire. The electrical system is explosion-proof: the switches, outlets and fixtures will not create a spark or produce a voltage level that could cause an explosion.

Before designing a spray room, there are several important preliminary steps. First, consult your local, state and federal inspection authorities to make certain your design complies with the fire, electrical, building and environmental codes in effect in your community. For example, your spray room will have to meet NFPA and Occupational Safety and Health Administration (OSHA) safety guidelines. Also check with your home insurance carrier. You may discover that operating a spray room voids your insurance policy. If you still see fit to proceed, consult a ventilation engineer who can give you expert guidance on properly situating and designing your system.

SPRAY ROOM SAFETY TIPS

- Consult the fire department as well as pertinent local, state and federal authorities before choosing a site for your air exhaust outlet. Depending on the area in which you live, levels of certain contaminants may be restricted by specific regulations. In general, locate an outlet to avoid exposing passersby, children and pets to the exhaust.
- Check with your local authorities about noise regulations; the ventilation system in your spray room may create noise levels that are deemed excessive for residential areas.
- Do not wear clothing or safety gear used during spraying outside of the spray room; store these items in a metal locker.
- Keep the walls, floor and other surfaces of your spray room scrupulously clean to prevent toxic or flammable substances from accumulating.
- Always wear protective safety gear when spraying: long pants, a long-sleeved shirt, safety goggles, rubber gloves, a rubber apron and a dual-cartridge respirator.
- Replace air filters regularly, as indicated by the airflow meter.
- Dispose of used air filters according to local fire regulations.
- Store finishing products safely *(page 136)*.

IDENTIFYING AND AVOIDING SPRAY PROBLEMS

Good spraying technique alone does not guarantee first-rate results. Other factors, including the characteristics of the spray room, the equipment or even the weather can also influence the quality of the finish.

A clean, dust-free work area is essential. One answer is to vacuum regularly. If you spray frequently, you should consider setting aside part of your workshop for drying. To prevent any dust from settling on a newly finished workpiece, provide yourself with several makeshift dust covers. These can be nothing more than pieces of plywood sitting atop tall supports. When you finish spraying a piece of furniture, place it under a dust cover to catch any dust that might otherwise fall on the workpiece.

Humidity and warm temperatures can wreak havoc on finishes, leaving shellac with a milky look or causing lacquer to dry poorly. Keeping the room at the right temperature—roughly 72°—is not quite as difficult as controlling humidity. It is best to do your spraying on a dry day.

Even with optimum conditions and proper technique, snags will arise from time to time. If there is a problem with the spraying system, consult your owner's manual. Most manufacturers provide detailed troubleshooting guides for their equipment. The following chart details some of the most common spraying problems, their causes and ways to prevent them from occurring.

Fisheye

Crazing

Sag

Run

Pinholes

DEFECT	DESCRIPTION AND CAUSE	PREVENTION
Crazing	Fine cracks caused by solvent or material incompatibility.	Make sure your thinner and finishing materials are compatible, according to the manufacturer's specifications.
Checking	Subtle, grid-like cracks in the finish caused by a rapid shift in temperature. If the workpiece is exposed to warm temperatures and then suddenly brought into a cold room, the finish will contract at a different rate than the wood.	Keep the finished workpiece in a temperature-controlled environment.
Blushing	Milky-white clouds in the finish usually occurring when a finish is sprayed on a humid day.	Spray on dry days; keep the temperature constant. A retarder added to the finishing material on humid days will allow the finish to dry more slowly and counteract the problem of the top layer drying too quickly.
Orange peel	A rough, "orange peel" texture, the result of holding the spray gun too close or too far from the surface, using too little thinner or setting the wrong pressure for the material being applied.	Hold the gun at the proper distance from the work surface—about 8 inches—and adjust the air pressure for the finish that you are spraying; check the material viscosity.
Run	A large drip that runs down a vertical surface after too much finish has been sprayed in one spot.	Move the gun evenly and more quickly. Reduce the material feed adjustment and ensure that the finish is thinned to the proper consistency.
Sag	Similar to a run, but covers a larger area.	Hold the gun at the correct angle and keep it moving at an even pace. Reduce the material feed adjustment and check that the finish is thinned to spray consistency.
Overspray	Material that dries before it reaches the workpiece because it is being sprayed from too far away.	Hold the gun closer to the surface or reduce the air pressure.
Fisheye	Small, circular, occasionally iridescent shapes caused by contamination from silicone or wax from blades or tools.	Wipe the workpiece with naphtha and diluted ammonia before finishing. Avoid touching the workpiece if you have come into contact with silicone or wax.
Pinholes	Small holes caused by spraying at too high a velocity or by spraying too close to the work surface.	Add a moisture retarder to the finishing material; it will slow down the drying time, allowing the finish to flow over the holes. Reduce the air pressure and make sure you are using the proper spraying technique.

FRENCH POLISHING

After the top of this table was French polished, the legs were given a similar look by brushing on three coats of shellac and then wiping on a fourth coat with a pad.

French polishing is a time-honored method of finishing that involves padding on shellac with a cloth. The result is a lustrous, almost three-dimensional finish typical of fine antique furniture. The look does not come easily, however. French polishing takes time to master and a lot of elbow grease. For commercial woodworking shops, the labor and time requirements generally rule out this type of finish for most jobs; it is much easier to rely on lacquers and modern spray equipment. Still, for an amateur woodworker, French polishing can be a rewarding way—some purists would argue the very best way—to finish a special project. Although the finish does not stand up to water, alcohol or heat, it is relatively easy to repair once the piece is completed.

The materials required for French polishing are wool and linen rags (pieces of old sweaters and shirts or a well-washed bedsheet will work fine), shellac flakes, denatured alcohol, mineral oil, pumice and polishing compound. Shellac is measured by the "cut"—the number of pounds of shellac flakes dissolved in each gallon of alcohol. So, a 5-pound cut refers to 5 pounds of shellac dissolved in a gallon of alcohol. For French polishing, use a 2½- to a 3½-pound cut, although you will, of course, be dealing in quantities smaller than a gallon.

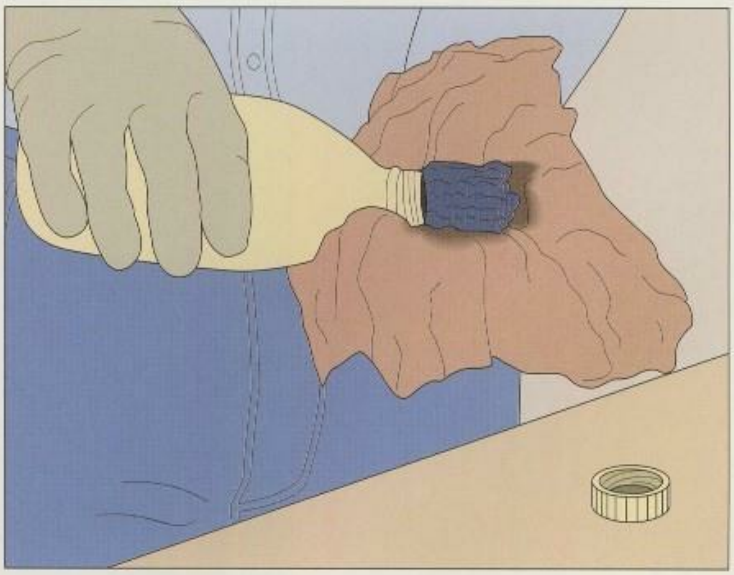
The process consists of several steps that are done to the following schedule: On the first day, a coat of oil is applied to the wood and the excess is wiped off. Then the pores are filled with pumice. On the second day, additional coats of shellac are padded on to build up the body of the finish. On the third day, the oil film is removed with a clean cloth. This is the time to examine the surface under a light and build up the body where you notice dull spots or open grain.

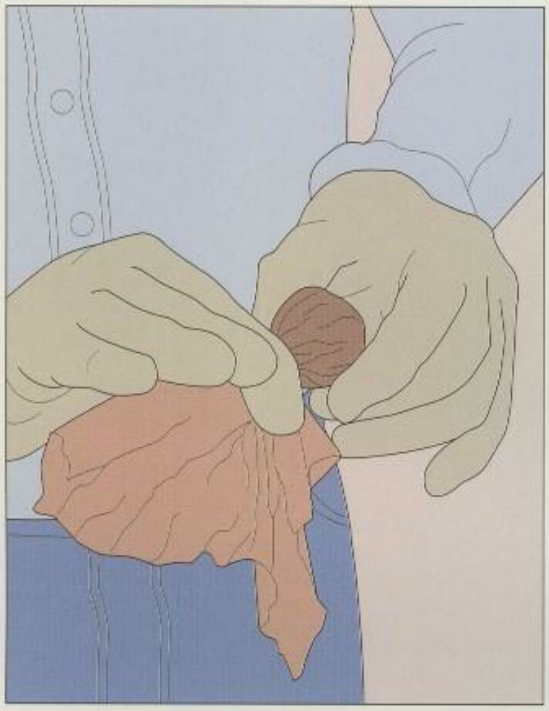
If you cannot afford the time required for a French polish, there are substitutes called padding lacquers that provide a similar look without the same level of effort. Padding lacquers are frequently used to repair old finishes, but can also be applied to new wood.

PADDING ON THE SHELLAC

1 Making a pad

Take a piece of wool roughly 3 inches square and fold the corners toward the center, stretching the wool with each fold. Then squeeze the wool pad into an oval and add a few drops of 2½- to 3½-pound-cut shellac. Disperse the shellac throughout the wool by crumpling the pad in your hand, then place it in the middle of a single thickness of coarse linen. Add several drops of alcohol to the pad *(right)*.



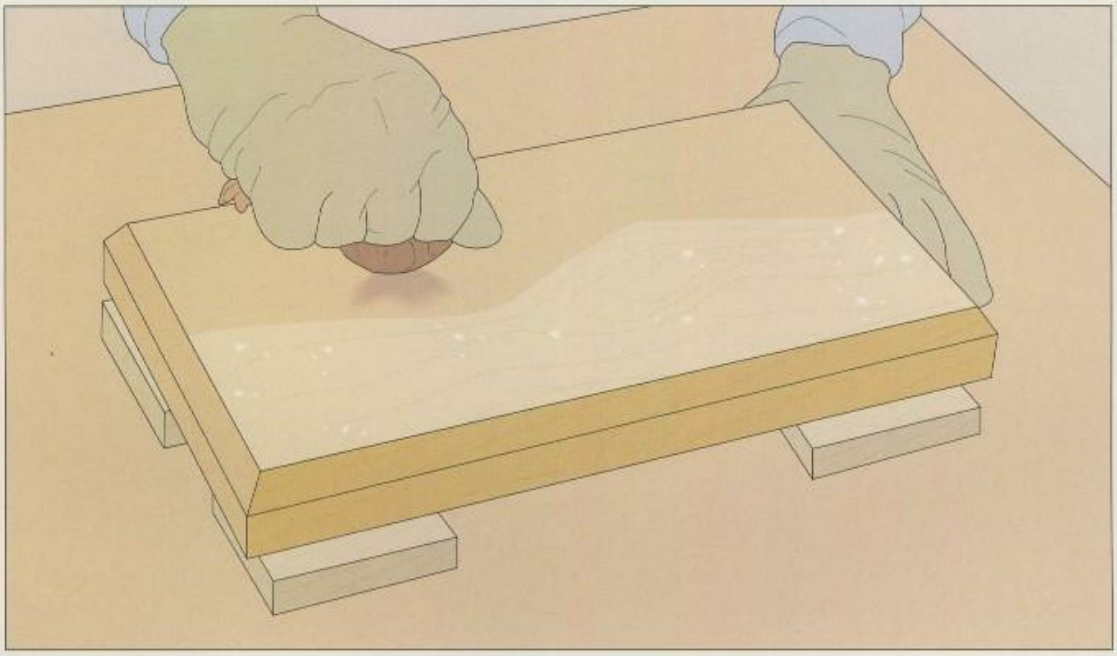


2 Preparing the pad for French polishing

Gather the linen around the ball of wool and twist the linen until the pad is held firmly in place *(above, left)*. Then tap the pad against the palm of your hand to spread out the shellac and alcohol and form a flat surface *(above, right)*. If the pad is too wet, squeeze out the excess liquid. (When not in use, the pad should be stored moist in an airtight container to prevent it from stiffening.)

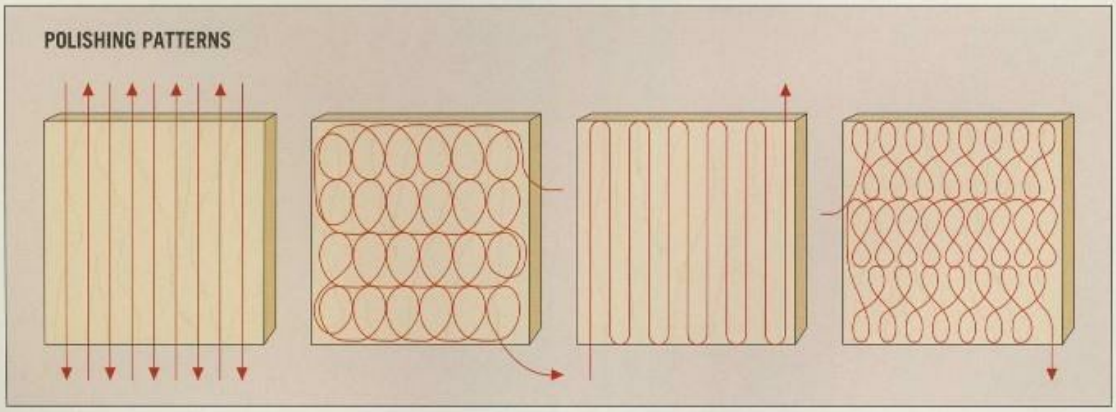
SHOP TIP

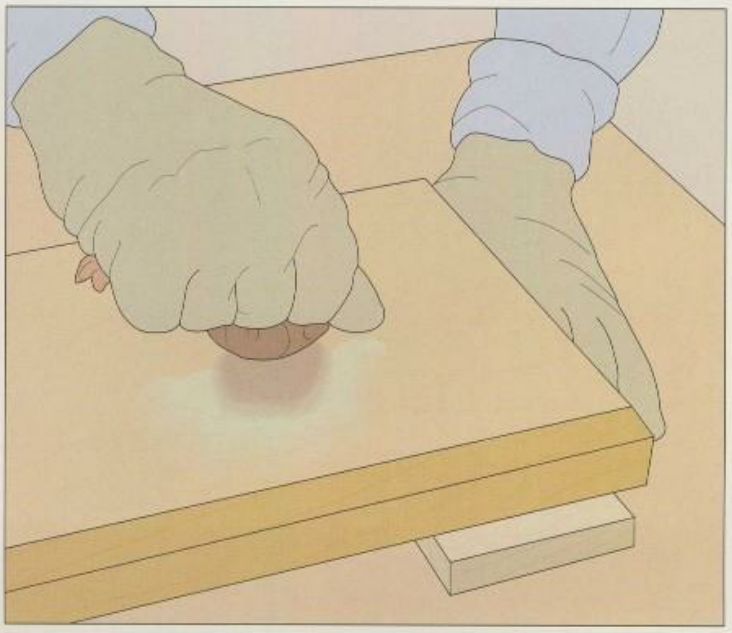
Making a pumice dispenser
Some finishers use a salt shaker to sprinkle on pumice for French polishing (page 108, step 3). You can also fashion a more traditional dispenser. Pour a small amount of pumice into a piece of linen. Fold the linen over and tie the top with a small piece of string to form a ball. To use the dispenser, shake the bag, sprinkling a small amount of pumice through the cloth and onto the wood.



3 Filling the pores

Apply a sealer coat of shellac with a brush and allow it to dry. (This procedure can be done before making the pad.) Then sprinkle pumice on the workpiece and shake a small amount on the pad. Grip the pad tightly between your fingers and thumb and work the pumice into the wood with any of the strokes shown in the diagram below; choose the one that proves most comfortable. Keep the pad moving while it is on the surface to prevent the alcohol on the pad from leaving a mark on the wood *(above)*. Pay particular attention to the edges so as not to leave them untouched. At first, the pumice will sound scratchy as you rub. The more the pores fill, the less scratchy the pumice will sound. Continue to pad, occasionally sprinkling on fresh pumice and adding more alcohol, until the pores are completely filled and the surface has a matte look. Depending on the size of the workpiece, this procedure may require 30 minutes or more. After filling the pores, set the workpiece aside for a day.





4 Building up the film

Prepare a new pad and dab a drop of oil onto it with a finger to provide lubrication for padding the surface *(above, left)*. Polish with the same strokes you used to fill the pores. Use light pressure with a wet pad. As the pad dries and the friction increases, apply more pressure. Recharge the pad with shellac and alcohol, as needed. Repeat the process until the look of the finish pleases you and the polishing streaks disappear *(above, right)*. Set aside the workpiece for a day. After the shellac has dried you will notice a milky clouding of the surface, as in the upper half of the workpiece in the photo *(below)*. This is the oil used to lubricate the pad; having risen to the surface it must now be removed. Moisten a pad with alcohol and rub the surface with long strokes (or polish with a fine glazing compound) until the oil disappears. This will reveal the final look of the French polish as shown in the lower half of workpiece in the photo.

DECORATIVE FINISHES

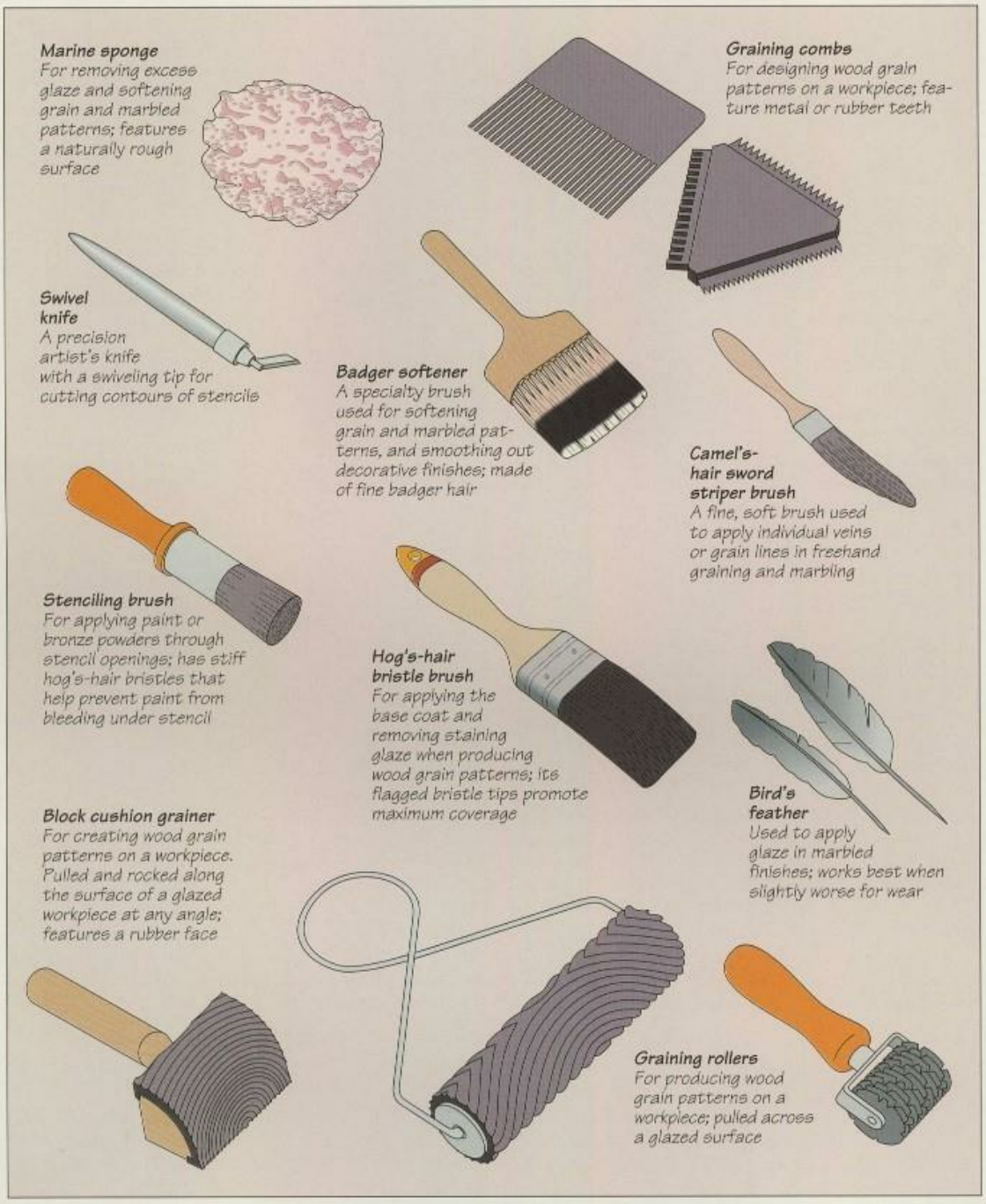
Stenciling has developed from a crude interior decorating technique into a minor art form. The top rail of this Boston rocker, stenciled with bronze powder, is typical of 19th Century designs.

Decorative painting traces its history back to about 3000 BC, when artisans in Egypt, India and the Orient learned to transform ordinary materials and objects into ornamental ones through marbling, graining, stenciling and other practices. Along with more traditional prizes of the trading route, the techniques of decorative painting were carried to the West, where they have cycled in and out of fashion down through the centuries. Stenciling, in particular, found favor among the early colonists of North America. Colonial furnituremakers used stencils to embellish their inexpensive chairs; householders of modest means stenciled their rough floors and plaster walls to mimic the beauty of the wallpaper and rugs they could not afford. During the Victorian era, artisans both in the United States and abroad took inspiration from the Arts and Crafts Movement, elevating the faux (or false) finishes—marbling and graining—to the realm of high style. In the hand of an expert, a pot of glaze and a feather could transform bland tabletops and small boxes into rich marble look-alikes; a deftly wielded graining brush could give an item of plain pine furniture the luxurious look of walnut burl.

While the techniques and materials of stenciling changed little over time, the methodology of marbling and graining grew ever more refined. Close-mouthed professionals kept their trade secrets close to the vest, even carrying the particulars of their artistry with them to the grave. Novices may not be able to duplicate the finishes of the masters, but pleasing results are usually obtainable with a little patience. The glaze is brushed, ragged, combed, sponged, or even spattered over an opaque base coat. In all decorative finishes except stenciling, the color of the base coat is visible through the glaze which imparts to the finish a deep, subtle glow. It is generally a good idea to mix more glaze than you think you will need, because it is next to impossible to match such a finish exactly. The real challenge of decorative painting is in the patterning of the glaze. Stenciling is the least complex technique—you can just stipple the color on over the base coat with a brush or a sponge, working through a paper or acetate template. Marbling and graining are more difficult to execute, because both color and pattern must be fairly realistic for the finish to be attractive. In marbling, this means you must first create a believable cloud of background colors, then shoot it through with natural-looking veins. Because the patterns of heartwood and sapwood are less free-flowing than the veins in marble, graining requires even more skill than it takes to disguise wood as marble. In both cases, finishing will go more smoothly if you continually refer to a sample of the material you are trying to simulate. With any decorative finish, always test the appearance of the glaze over the base coat before beginning work; with marbling and graining, practice patterning on large pieces of illustration board until you are confident of your technique.

In contrast to the violent natural forces that create real marble, this bird feather requires a deft touch to transform tinted oil paint and a glaze coating into a marble finish on wood.

TOOLS AND ACCESSORIES



STENCILING

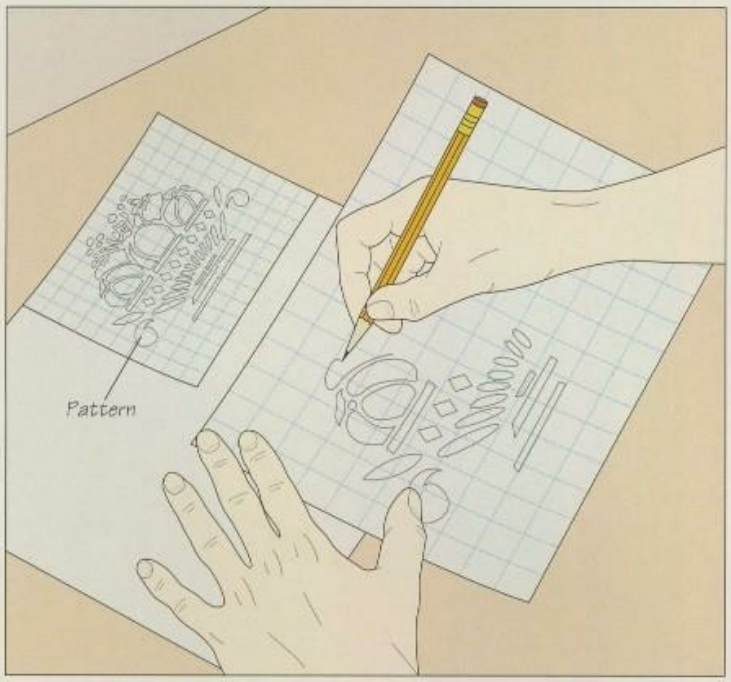
Ever since the Egyptians in ancient times began decorating mummy cases with stencils, such decorative patterns have been a ubiquitous feature of furniture design. They have appeared on everything from shields to chairs and toy chests.

As simple as a fine-veined leaf or as complex as a multicolored, repeating motif of fruits and flowers, a stencil can be applied to a piece of furniture either before or after the last coat of finish. The stencil is typically reduced or enlarged from a master pattern and cut from either stencil board or acetate. Because acetate can be cleaned with mineral spirits and reused, it is more durable than paper. The translucent material can be bought at most drafting supply stores.

Stencil designs can be sprayed on or applied with a special short-bristled stenciling brush. While early American settlers stenciled with milk paint, any thick-bodied paint, such as quick-drying japan colors or an oil-based or acrylic paint, will fit the bill equally well. Bronze powders can be combined in the same stencil to yield a variety of metallic colors within a single design, creating the illusion of light and shadow—a technique made famous by the Hitchcock chairs of the mid-1800s.

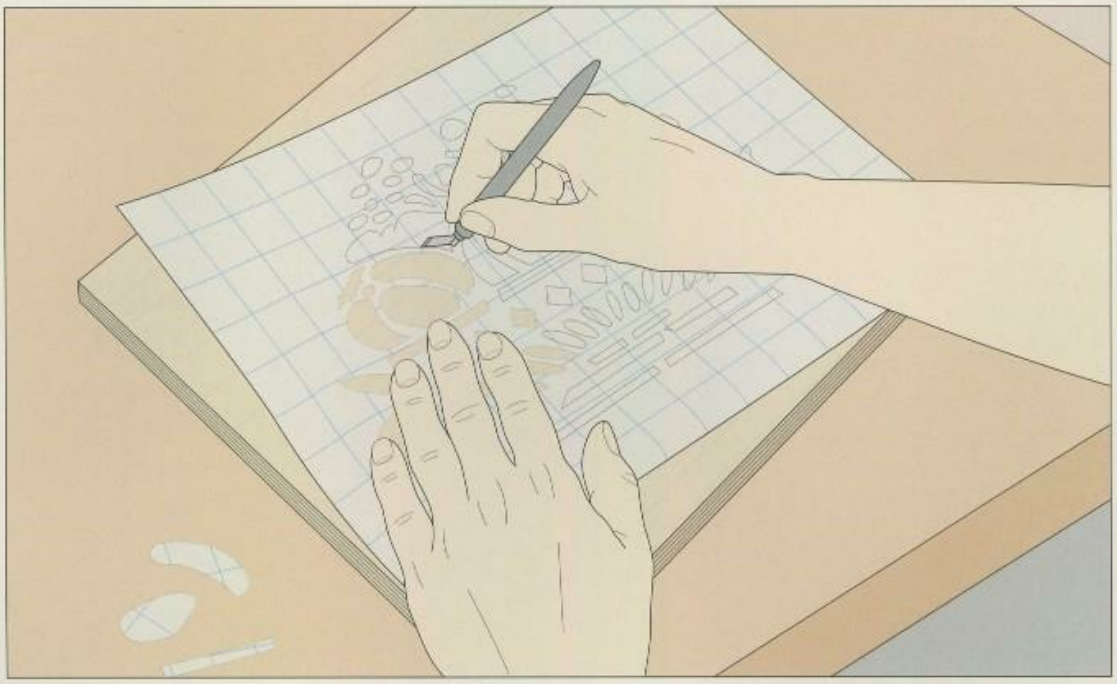
Designs are generally stenciled with either paint (above, left) *or bronze powders* (above, right). *The application techniques are different, as are the range of effects. Bronze powders, for example, can create a burnished, three-dimensional look.*

MAKING THE STENCIL



1 Enlarging a pattern

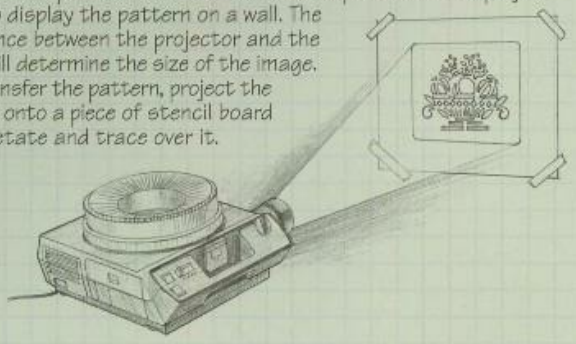
One way to produce a larger version of a pattern for stenciling is to use a photocopier with an enlargement feature; another way is to transfer the shape using a grid. Draw a grid of squares over the pattern, using a ruled straightedge to make all the squares exactly the same size. (The smaller you make the squares, the easier it will be to reproduce the pattern.) Then, on a blank sheet of graph paper or acetate, make a larger grid, increasing the size of the squares by the same amount you wish to enlarge the pattern. For example, if you need a stencil design that is twice the size of the pattern, make the second set of squares twice as large as the first. To produce the stencil design, draw in each square of the enlarged grid the part of the pattern that is in the corresponding square of the smaller grid *(left)*. To make a stencil smaller than the original pattern, follow the same steps, but make the second grid smaller than the first one.



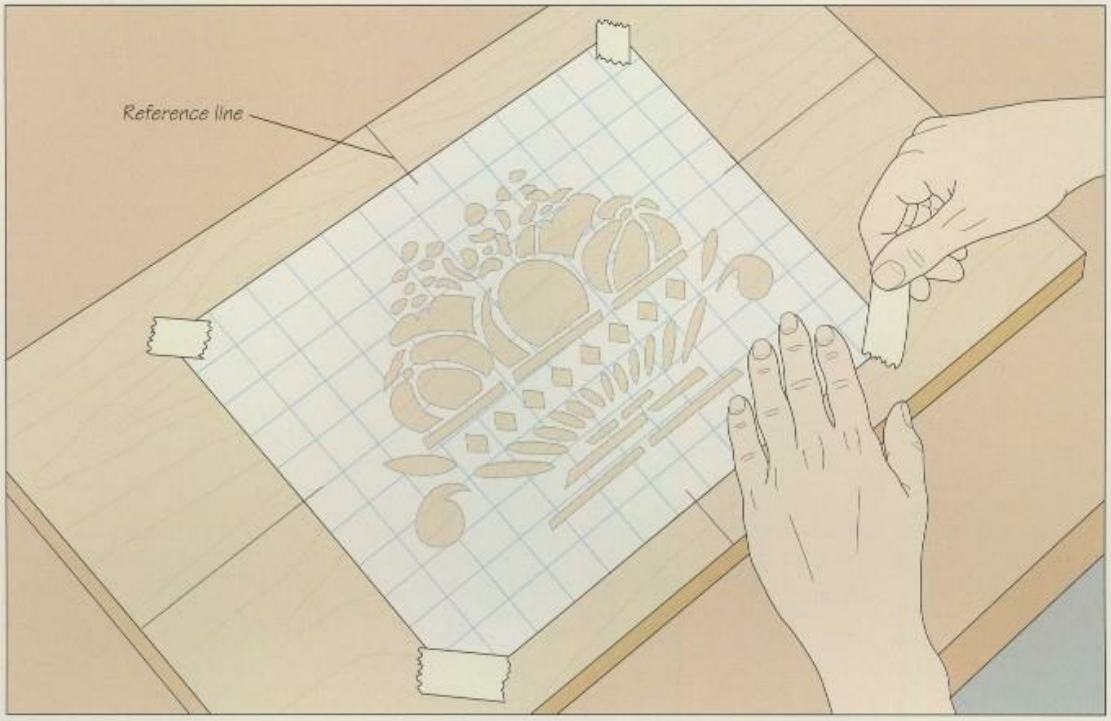
2 Cutting out the pattern
Transfer your design to a piece of stencil board or acetate. With the stencil board, use carbon paper; for an acetate stencil, simply place the sheet over your design and trace it in ink. If your design will include more than one color, make a separate stencil for each color. Use a swivel knife to cut out the pattern, pulling the knife toward you *(above)*. Keep your free hand out of the blade's path.

SHOP TIP

Projecting a pattern
Another way to reproduce a stencil in a different size involves projecting the design onto a wall. First take a photograph of the pattern using slide film. To avoid distortion, shoot from directly in front of the pattern. Once the film is developed use a slide projector to display the pattern on a wall. The distance between the projector and the wall will determine the size of the image. To transfer the pattern, project the image onto a piece of stencil board or acetate and trace over it.



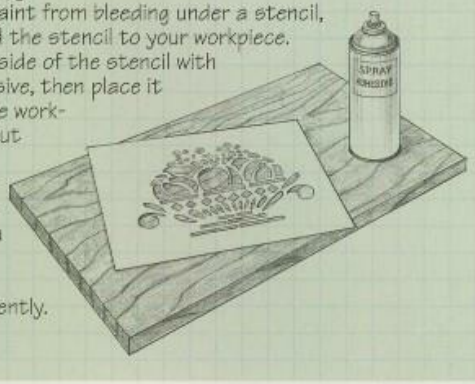
PAINT STENCILING

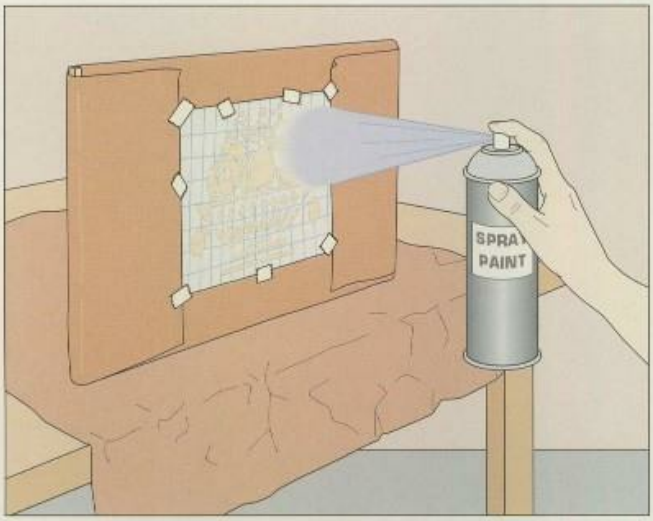


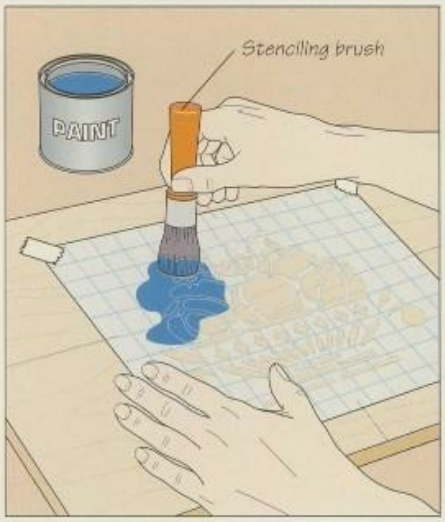
1 Taping down the stencil
To help align the stencil precisely, draw a reference line centered along each side of both the workpiece and the stencil. Then secure the stencil to the workpiece with masking tape, making sure the reference lines match up properly *(above)*.

SHOP TIP

A cure for bleeding
To prevent wet paint from bleeding under a stencil, temporarily bond the stencil to your workpiece. Spray the underside of the stencil with an aerosol adhesive, then place it in position on the workpiece, pressing out any air pockets. Apply the paint as soon as possible so that you can peel off the stencil before it adheres permanently.

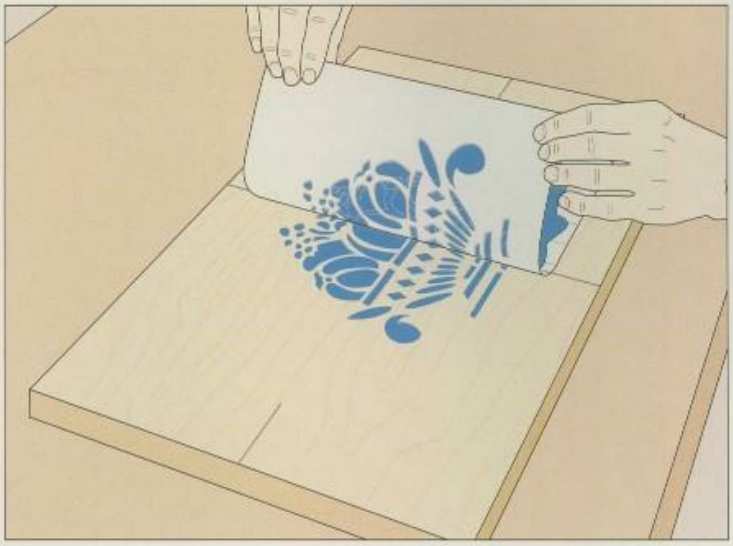






2 Applying the paint

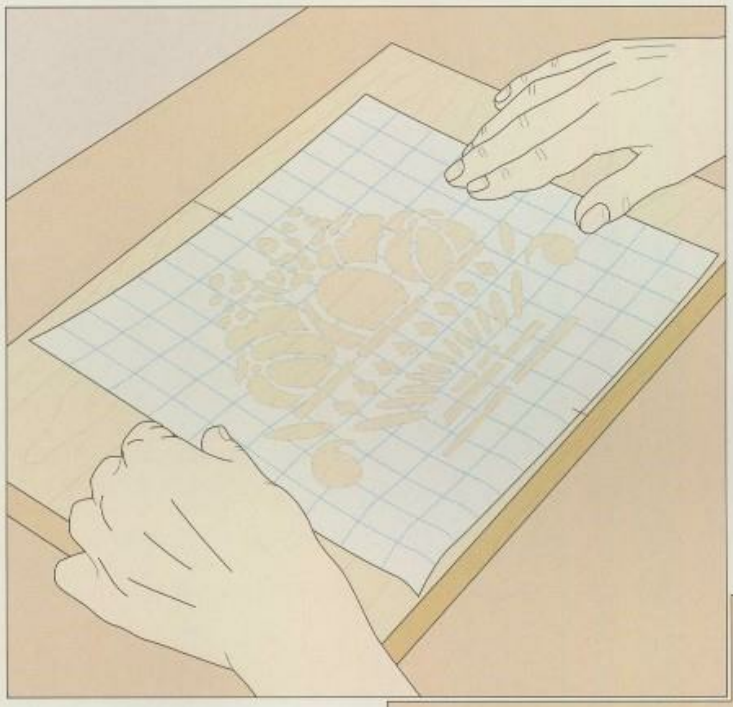
Transfer the stencil design to your workpiece by spraying or brushing on paint. If you are spraying, mask the surfaces surrounding the stencil with paper and set the workpiece edge up on a work surface. Holding an aerosol paint can about 6 to 10 inches from the workpiece, direct the spray at the stencil until the exposed wood is coated lightly with paint *(above, left)*. To prevent paint from bleeding under the stencil, keep the nozzle level with the stencil and spray in a straight line. To use a stenciling brush, set the workpiece flat on a work surface and dip only the tips of the bristles in the paint. This will result in a light coat and thus reduce bleeding. Holding the brush perpendicular to the surface, jab the bristles up and down on the stencil until the wood is covered *(above, right)*, reloading the brush as necessary. If you are using more than one stencil to apply several colors, let each coat dry before spraying or brushing on the next.



3 Removing the stencil

To avoid any bleeding, remove the stencil while the paint is wet. Peel the masking tape from two adjoining corners, then gently lift the stencil off the workpiece, pulling up the two sides evenly *(left)*. Avoid sliding the stencil along the surface or you may smear some of paint. Once the paint is dry, remove any adhesive residue with naphtha before topcoating the workpiece.

BRONZE POWDER STENCILING



1 Positioning the stencil
Draw the stencil on acetate and cut out the pattern. Place the bronze powder in a bowl or on a palette and set it aside. Prepare the workpiece by applying a thin coat of slow-drying varnish to the surface you will be stenciling. Let the varnish dry until it is firm but still tacky. Place the acetate in position on the workpiece glossy side down so that it adheres to the surface *(left)*.

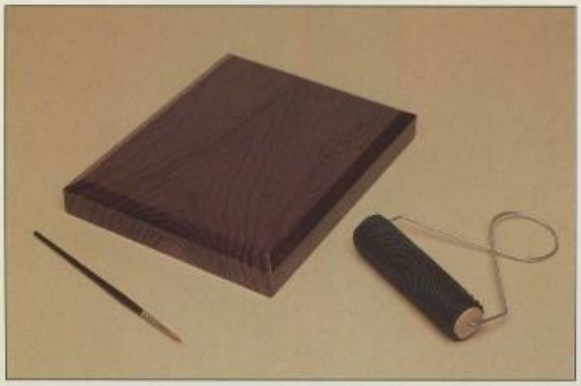
2 Rubbing on the powder
With the varnish still tacky, wrap a piece of chamois or a clean, soft cloth around your index finger and dip it into the bronze powder. Rub the powder onto the surface exposed by the cutouts in the stencil. Rub the areas you wish to highlight relatively hard; rub more lightly on areas you want to shade. Apply additional powder as necessary until the surface is colored to your satisfaction, but work quickly to keep the varnish from drying completely before you are finished. Then peel off the stencil. To highlight the three-dimensional quality, apply several layers of bronze powder, separated by thin layers of varnish. When you are finished stenciling, protect the surface with two final coats of varnish.

GRAINING

Graining is a process in which the appearance of one type of wood is re-created on another for decorative purposes. On species with muted grain, the technique can be used to imitate the texture and warmth of more exotic species. But graining can also camouflage visual defects—like a wood patch used to repair a damaged surface. With practice, experimentation and careful study of the species you wish to emulate, you can produce a diverse range of styles, from the close grain of beech to the free-flowing pattern of pine.

Graining was especially popular in the 1800s among westward-moving American pioneers. With hardwood in scarce supply, woodworkers harvested softwoods and grained them to resemble more highly figured woods like cherry, oak and mahogany.

Graining involves several stages. First, the surface is painted with a flat base coat and the base is allowed to dry. A color glaze is then applied and the grain pattern is traced into the glaze with special graining tools such as combs, ray markers, mottlers and rollers. Finally, a protective topcoat is added.

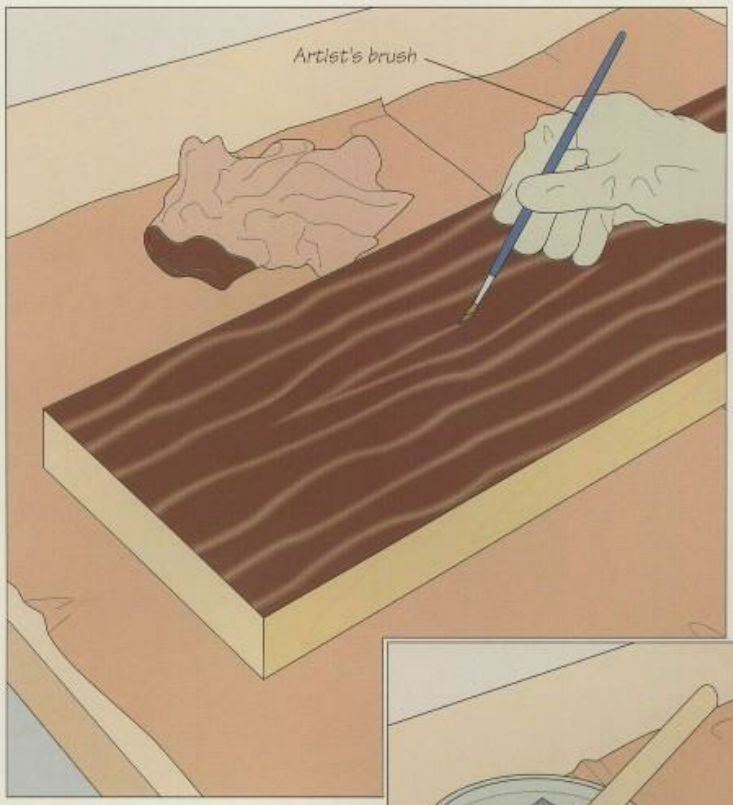


A deftly wielded artist's brush and a graining roller combined to etch a vivid pattern of heart grain on a piece of particleboard.

Graining glazes can be prepared in the shop, but commercial, ready-to-use glazing stains are just as effective; they can be tinted with japan colors to produce virtually any shade you wish. The glazes you make yourself will usually consist of one part boiled linseed oil and two parts varnish; they are tinted with artists' colors. You need a heavy-bodied consistency, but not so heavy that the drying time is slow or the grain patterns will tend to flow back together. You can buy special additives to speed up the drying time.

GRAINING A SURFACE BY HAND

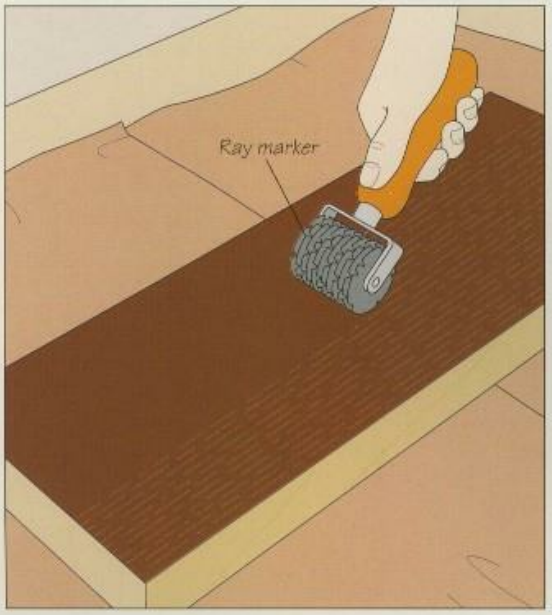
1 Preparing and applying the glaze
Tint a container of flat oil-based paint with artists' colors so that it matches the hue of the wood you wish to imitate. Spread a layer of the paint on your workpiece as a base coat and allow it to dry. Then apply a graining glaze on the painted surface with a foam brush or pad applicator. To begin the process of creating a grain pattern on the wood, wrap a soft cloth tightly around three of your fingers, then draw the cloth along the surface several times, drawing thin, wavy, parallel lines *(right)*.

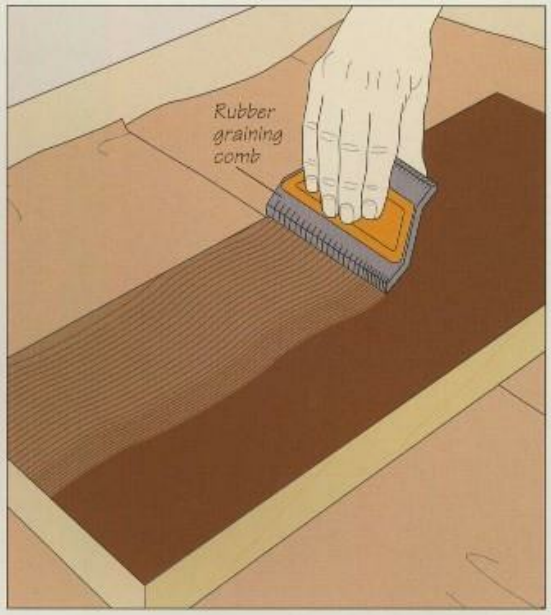


2 Refining the grain lines
To make the grain lines from step 1 a little more delicate, dip an artist's brush or a camel's hair sword striper in the glaze, and draw it slowly along the surface within the original lines *(left)*. For best results, hold the brush at an angle to the surface. If you wish to simulate a knot on your workpiece, rub in lines for a rough oval or diamond shape around where you will be adding the knot. Experiment with the brush until the surface has the grain pattern you are seeking.

3 Drawing in knots
Wrap a cloth around one finger and dip the fingertip in the glaze. Then gently touch the surface to make the knot *(right)*. To smooth out the patterns and blend them into the background, brush the surface back and forth with a soft, dry brush following the direction of the grain. A badger softener is ideal for this stage of the process. Once the surface is dry, apply a topcoat, then polish it with rottenstone and paste wax.

WORKING WITH GRAINING TOOLS





1 Simulating other grain patterns
Spread a base coat of tinted paint and then a glazing stain following the procedures described on page 118. To simulate the random grain markings characteristic of oak, run a ray marker along the surface of the board in straight lines, parallel to the edges *(above, left)*. To reproduce the broad grain pattern typical of mahogany, draw a metal or rubber graining comb along the surface, creating a series of slightly wavy but parallel lines *(above, right)*.

2 Blending in the grain
While the glaze is still wet, gently draw a soft, dry paint brush, such as a badger softener, back and forth over the surface, following the direction of the grain *(right)*. This will fan out the grain lines and give the surface a more uniform and natural appearance.

BUILD IT YOURSELF

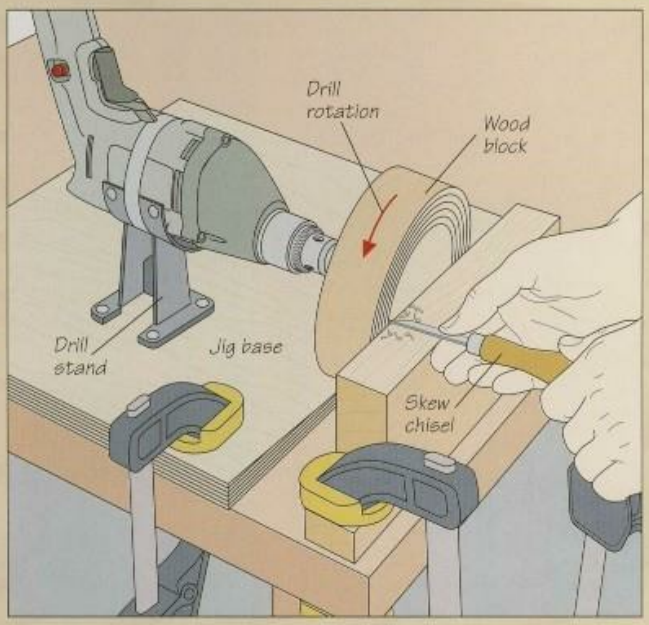
A BLOCK CUSHION GRAINER

With a molding jig and silicone rubber, you can make a block cushion grainer to suit your needs. For the jig, cut a circular block of 1½-inch-thick wood that will fit on the sanding disk of your electric drill. Screw the block to the disk, then install the disk in the drill chuck. Attach a commercial drill stand to a ¾-inch plywood base, then install the drill. Clamp the base to a work surface and secure a short scrap of 2-by-4 just in front of the block to serve as a tool rest. Cut notches in the 2-by-4 for clamps.

To shape the wood block, lock the drill in the On position and hold the tip of a small skew chisel against the rotating surface, etching a ⅛-inch-deep groove into the wood. Rest the chisel blade on the 2-by-4 to keep it steady. Cut on the left-hand side of the block to prevent the chisel from being kicked up. Carve a series of concentric grooves in the block *(above,right)*, varying their widths and the intervals between them to suit the grain pattern you wish to design. Closely spaced grooves will produce a hardwood look; grooves that are spread farther apart are better for simulating softwoods.

To make the actual grainer, remove the block from the sanding disk and coat its grooved face with paste wax. Then apply a ⅛-inch-thick layer of silicone rubber over the wax. Let the rubber cure for about 24 hours, then peel it off the block *(below, right)*. Trim the rubber imprint and glue it to a rounded piece of 2-by-2 with a plywood handle. Remove any residual paste wax with naphtha.

The tool is used the same way as traditional grainers *(page 120)*, but remember to push it along the surface with a forward rocking motion.



MARBLING

In the past, when structural considerations ruled out the use of real marble, faux marbre, or false marble, finishes were commonly used as a substitute on everything from walls and floors to mantels and furniture.

Real marble is a by-product of intense natural forces that occur when limestone is melted under great heat and pressure. Minerals running through the molten rock cool and crystallize. The result is layer upon layer of veins colored white, black and other hues, which together form a lattice that is somehow both opaque and translucent.

Of the many techniques for replicating the appearance of marble on wood, most involve working with two or three colored paints on a wet, glazed surface. Tools for manipulating the paints range from rags to newspapers to sponges. Fine brushes or a feather are the best implements for simulating the depth and pattern of the veins.

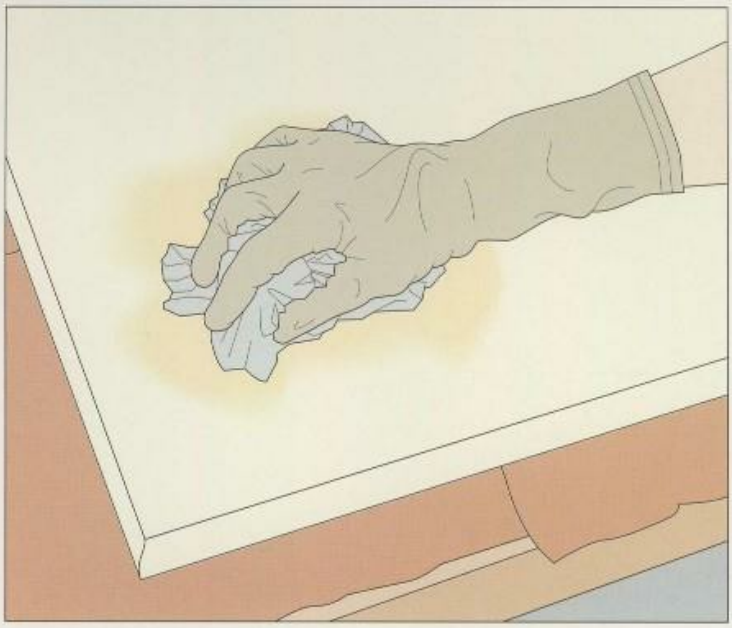
As a rule of thumb, the colors on a marbled surface should be limited to a maximum of three, including the base color. The choice of colors is best restricted to the natural colors found in marble. The constituent parts of marble actually flow during the formation of the stone, and it is vital to capture this appearance of fluidity. To produce a realistic design, work with good reference photographs or keep a sample of the real thing on hand.

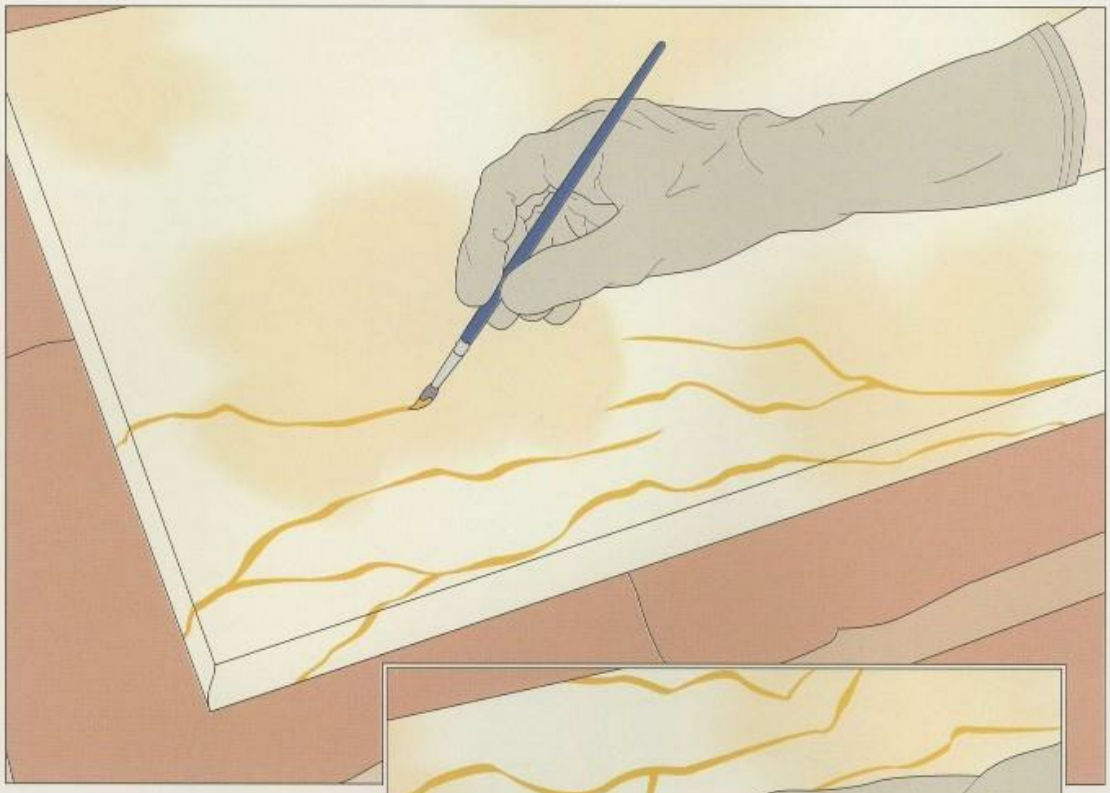
White and green marbled wood simulates the fluid appearance and misty depth of real marble.

MARBLING WITH A BRUSH

1 Applying the glaze

For the base coat of a white marble finish, brush a coat of white, semigloss oil-based paint on your workpiece as a base coat and allow it to dry. To eliminate any brush marks, lightly sand the surface with a 320-grit sandpaper. Tint a container of white glaze with a small amount of one of the artists' colors that you will be using in the finish. Then use a cloth or a creased piece of newspaper to coat the painted surface with glaze *(right)*.

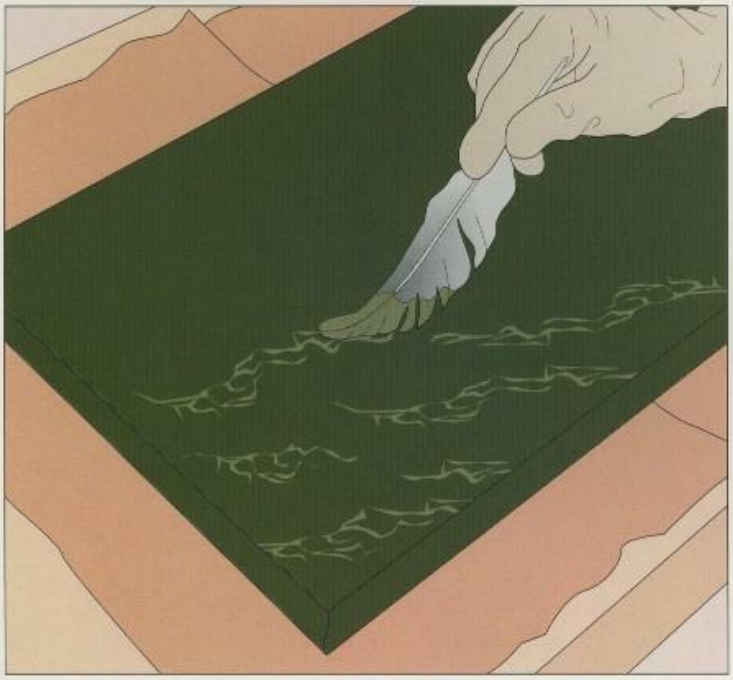




2 Sketching in the marble veins
While the surface is still wet, squeeze some of the artists' color used in step 1 onto a palette. Dip an artists' brush into the color and use wavy strokes to paint imitation-marble veins in the glaze *(above)*. The veins should appear to wander randomly about the surface, forking right and left. Rolling the brush between your fingers while you paint can also produce a realistic effect. Once you have painted in all the veins, remove the excess glaze and soften the veins by pulling a soft cloth diagonally across the surface *(right)*. Repeat the process to paint in more marble veins in a second color. If you wish to layer on additional veins, reverse the order of the colors, or mix them together to provide contrast and depth to the surface.

3 Smoothing the pattern
While the surface is still wet, gently draw a soft, dry paint brush, such as a badger softener, back and forth across the veins *(right)*. Continue until the surface looks misty and translucent. Once the surface is dry, let it sit for about 24 hours and apply a coat of semigloss or high-gloss polyurethane varnish. Polish the workpiece with a soft cloth.

FEATHERING A MARBLED SURFACE



1 Sketching broad veins
For a green marble finish, spread a base coat of green paint and then a glaze tinted a lighter color on your workpiece following the procedure on page 122. Dip a bird feather into the glaze and draw it diagonally across the surface to produce broad marble-like veins *(left)*. Smooth and soften the pattern by brushing the veins lightly with a marine sponge, a badger softener or a soft cloth. While the surface is still wet, prepare another batch of glaze and tint it lighter than the first coating. Apply and feather this glaze the same way you did the first one, but this time, make the veins cross over the ones already in place.

2 Opening up the pattern
To produce a mottled effect on the surface, dip a clean, stiff-bristled paint brush into a container of mineral spirits. Holding the brush a few inches above the workpiece, run a gloved finger along the bristles, moistening the veins with a fine spray *(right)*.

3 Completing the pattern
Dip a bird feather in white artists' color and allow the excess to drip off to prevent any blobbing. Then use the feather tip to sketch in a series of thin white veins within the broad veins already on the surface. When all the fine veins have been painted, smooth, varnish and polish the surface as described in step 3 on page 124.

PORTER+CABLE

FINISHING TOUCHES

The varnish topcoat on this 19th-Century farmhouse-style table was rubbed out with extra fine steel wool and buffed with paste wax.

Although woodworking catalogs abound with a wide variety of rubbing compounds and fancy electric polishers, purists still rely on the centuries-old process of "rubbing out" a finish with traditional abrasives. Rubbing a finish to a satin sheen with pumice, a powdered form of volcanic rock, imparts a soft look suggestive of brushed brass and leaves the wood smooth and silky to the touch. Taking the process yet another step further with an even finer powder called rottenstone removes the abrasions caused by the pumice to add an extra measure of shine—even to glossy topcoats of varnish or lacquer.

The notion of rubbing out a meticulously applied topcoat with abrasive compounds may have an incongruous ring to it. But the final coat of finish on a piece of furniture seldom leaves the surface clear and perfectly smooth. It is not unusual for the topcoat to be speckled with random dust and dirt particles that settle on the finish before it dries. In addition, some "signature" of the tool used to apply the finish may be visible. Even when brushes are adroitly handled, they often leave behind faint bristle marks, and a sprayed surface may show a texture similar to that of an orange peel. The first step in the rubbing process therefore is to level the surface as perfectly as possible. The smoother it is, the better the look and feel of the topcoat. Once the surface is level, it can be buffed to almost any sheen.

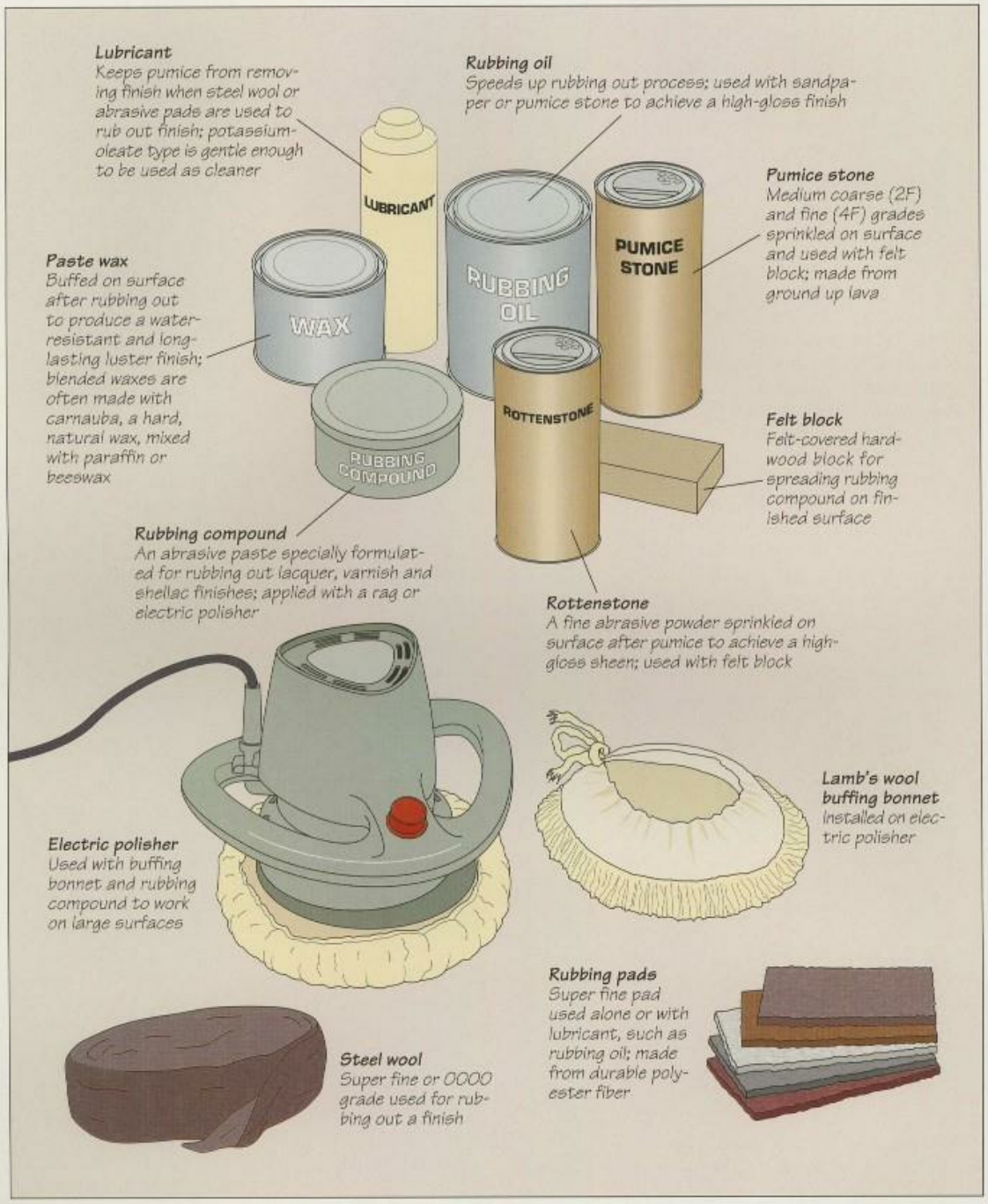
The difference between a rubbed satin finish and one that is buffed to a gloss depends on the grit of the abrasive you choose. Rubbing compounds, for example, contain particles that leave minute scratches on a surface. Coarser-grit compounds produce a fairly large pattern that makes the surface appear dull, or satin. Finer-grit compounds leave marks that are harder to see, creating a glossier look. Virtually anything that abrades can be used for rubbing out. In addition to rubbing compounds, finishers rely on sandpaper, steel wool and nylon abrasive pads. In each case, the size of the scratch pattern dictates the level of sheen.

If rubbing out has an inherent problem, it is the risk of rubbing through the finish. Since the process involves grinding small amounts of the thinly layered topcoat, there is always the possibility of cutting right through the coating to the wood. You need to be especially careful near the edges. With some varnishes, rubbing through even the very top layer will create a blemish. The resulting outline of the cut area, called a "halo" or "witness line," is a faint but visible reminder of just how thin each layer of a finish really is.

While most of the rubbing out process is a removal of material, the last step puts a tiny amount back. Waxing a surface adds an ultra-thin layer of protection atop the rubbed topcoat, imparting a little more sheen and durability to the finish.

Fitted with a lamb's wool buffing bonnet, a random-orbit sander serves as an electric polisher, rubbing out the finish and then buffing the topcoat to a high-gloss sheen.

TOOLS AND ACCESSORIES



Lubricant
Keeps pumice from removing finish when steel wool or abrasive pads are used to rub out finish; potassium-oleate type is gentle enough to be used as cleaner

Rubbing oil
Speeds up rubbing out process; used with sandpaper or pumice stone to achieve a high-gloss finish

Pumice stone
Medium coarse (2F) and fine (4F) grades sprinkled on surface and used with felt block; made from ground up lava

Paste wax
Buffed on surface after rubbing out to produce a water-resistant and long-lasting luster finish; blended waxes are often made with carnauba, a hard, natural wax, mixed with paraffin or beeswax

Felt block
Felt-covered hardwood block for spreading rubbing compound on finished surface

Rubbing compound
An abrasive paste specially formulated for rubbing out lacquer, varnish and shellac finishes; applied with a rag or electric polisher

Rottenstone
A fine abrasive powder sprinkled on surface after pumice to achieve a high-gloss sheen; used with felt block

Lamb's wool buffing bonnet
Installed on electric polisher

Electric polisher
Used with buffing bonnet and rubbing compound to work on large surfaces

Rubbing pads
Super fine pad used alone or with lubricant, such as rubbing oil; made from durable polyester fiber

Steel wool
Super fine or 0000 grade used for rubbing out a finish

PREPARING TO RUB OUT THE FINISH

Having graced your workpiece with a final coat of finish and waited for it to dry, you may be impatient to move on to the next step. However, before a topcoat can be rubbed out, it must first dry and set, so as to be hard enough to be worked over with very fine abrasives. Before rubbing out your workpiece, you must wait for the topcoat to cure—that is, you must allow it ample time to become as hard as it will get. Without time to cure, you are likely to scratch the finish during the rubbing out phase.

No two finishes take the same amount of time to cure. The duration of the process depends on several factors, including the type of finishing product you use, the number of coats you apply, and the amount of time that elapses between subsequent coats. For example, shellac and the water-based finishes can usually be rubbed out after 24 hours. For lacquer, the wait is more like 48 hours, while varnish takes three or four days. Oil finishes can require weeks to cure. The greater the number of coats on a surface, the longer the curing time. But remember that a finish cures more rapidly if more time is left for drying between coats. Always read the instructions before applying a finish; a suggested curing time will usually be indicated.

The type of sheen you end up with after rubbing out a finish hinges on the abrasives you use. For a satin gloss, use 400-grit paper, then buff the surface. Use 0000 steel wool in conjunction with 400-grit paper for a semigloss. An even finer grit sandpaper, such as 600, combined with rubbing compound will result in a high gloss. The same effect can also be achieved with a 600-grit paper and pumice or rottenstone.

Start by abrading the topcoat to a matte sheen. If you choose a wet/dry sandpaper, select a grit that is finer than the one used to prepare the surface for the final coat of finish. The next step is to remove dust and sanding particles *(page 42)*, then repeat the abrading process several times with successively finer-grit papers. For a dull- or flat-looking surface, stop at 400-grit paper. Move up to a higher grit for a glossier finish.

TESTING A FINISH TO SEE IF IT IS CURED

Checking the finish

Perform the following simple tests to determine whether a topcoat has cured. Try to dig a fingernail into the finish on an inconspicuous part of the workpiece *(left)*. You should not be able to leave an indentation. If you do, the finish needs additional curing time. Smell is another good indication. If you can detect the odor of the solvent on the workpiece, the topcoat is not ready for rubbing out. Once the finish passes both of these tests, sand a hidden area lightly. If the paper clogs, allow more time for curing. If the paper glides over the surface, turning some of the finish to powder, the topcoat is fully cured.

RUBBING OUT A FINISH

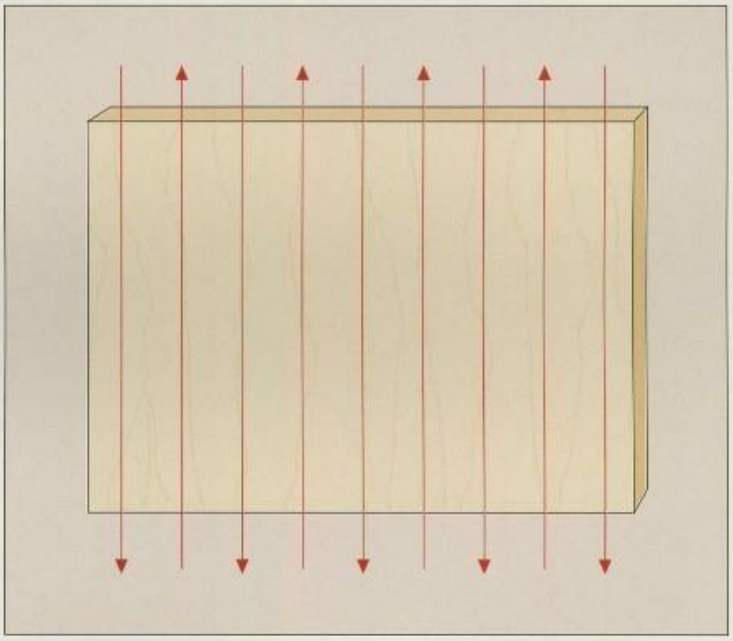
There are two competing schools of thought on the best way to rub out a finish. The traditional approach is to painstakingly work pumice and rottenstone over the topcoated surfaces using a felt block. A less hidebound method involves the use of one or more modern abrasives, such as rubbing compounds, steel wool or sandpaper, and may even make use of an electric polisher. Both methods have their advantages. Working with pumice and rottenstone is laborious, but wins the woodworking purist's stamp of approval. The modern way is easier and cuts down on elbow grease, but some argue that it involves less craft. Both methods are demonstrated on the pages that follow.

Whichever route you take, keep in mind that the finer the abrasive you use, the glossier the sheen you will produce. The photo above shows one sheen you can achieve using either rubbing out technique. Any luster can be enhanced by buffing the finish with wax. But do not rely solely on the wax to heighten the gloss; it will not turn a satin finish into a semigloss, for example. Instead, the wax will only intensify what is already there. Although all the surfaces of a workpiece will have to be rubbed out, pay particular attention to tops, since they are the most visible features of most furniture.

If you choose to go the traditional route, you will need to use a lubricant with the pumice and rottenstone. Water and oils, like paraffin and mineral oil, are the most commonly used lubricants. Working with water offers two advantages: It cuts pumice more rapidly than oil, speeding up the process, and it also does not leave any oily residue. Avoid using water on shellac, however; it will turn the finish white. Paraffin oil, the traditional rubbing out lubricant, is a better choice for shellac topcoats.

Rubbing out with fine steel wool and 400-grit sandpaper added a semigloss sheen to the wood sample at right. To create a glossier look, even finer abrasives would be used.

A GUIDE TO THE LAST STAGE OF FINISHING

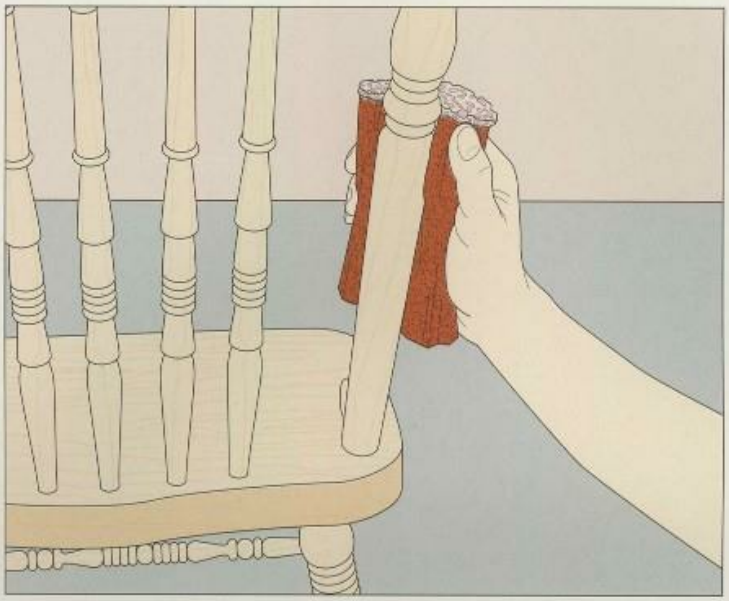


Strokes suitable for a flat surface

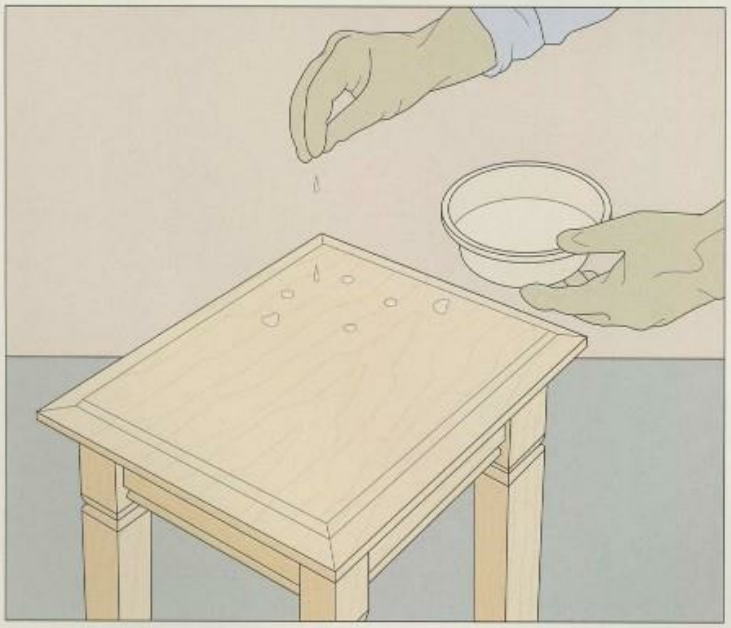
For tabletops and other flat surfaces, keep every stroke parallel to the wood grain, as shown in the diagram at right. Start near a corner and move in a straight line along the edge, rubbing the surface with moderate pressure from one end to the other. Alternate directions with each subsequent stroke until you reach the other edge. Keep the abrasive moving; the friction resulting from rubbing a single spot too long may leave the finish slightly burned. Avoid making arc-like strokes, which are apt to make any scratches on the surface more visible.

WORKING WITH CONTOURED SURFACES

Rubbing out a contoured surface
For rounded surfaces that are awkward to work with a rigid abrasive pad, use a shop-made rubbing pad that will follow the curves of your workpiece. If you are working with pumice, sprinkle it on the surface with a short, stiff-bristled brush. Then wrap a sheet of sandpaper around a thick sponge small enough to comfortably grip in your hand. Clasp the paper around the sponge as you rub out the finish on the surface *(right)*. With some types of finishes, you can also use steel wool or a commercial rubbing pad.



RUBBING OUT A FINISH WITH ROTTENSTONE

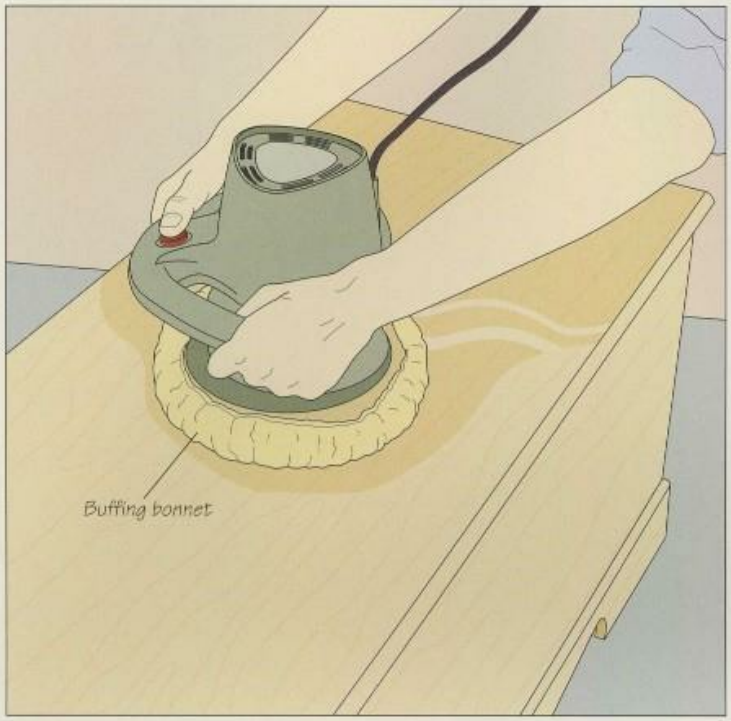


1 Applying the lubricant
Dip the tips of your fingers in a bowl of the lubricant and sprinkle several drops on the surface to be rubbed out *(left)*. Wear rubber gloves if you are using oil as a lubricant.

2 Abrading the surface
Shake a little pumice onto the surface, then begin lightly abrading the surface with a felt block *(left)*. Follow the pattern shown on page 130. If you do not have a felt block, wrap a piece of burlap around a scrap of wood. Continue rubbing the surface until a mixture of the rottenstone and lubricant forms. Use a soft cloth to wipe off a small area of the surface periodically to inspect the finish. You want to make certain that you are not rubbing through the topcoat.

3 Removing the pumice and lubricant
Wipe off the abrasive and lubricant with a clean cloth *(right)*. Check the surface sheen; the finish should have a satin luster. You can either stop the process at this point or repeat it to obtain a glossier sheen.

MORE RECENT OPTIONS FOR RUBBING OUT



Using an electric polisher
Fit a buffing bonnet on the machine's polishing disk and spread a wood rubbing compound on the bonnet. Start the polisher near the center of the surface and work out toward the edges, moving the bonnet continuously *(left)*. Electric polishers work quickly, so stop the tool often and wipe off a small area of the surface with a cloth to check the condition of the topcoat. Once the surface takes on a satin look, you can either stop the process or continue with a finer-grit rubbing compound for a glossier luster.

SHOP TIP

Keeping a buffing bonnet grit-free
Particles of dust or grit on a buffing bonnet can ruin a topcoat during the rubbing out process. To make sure your bonnet stays clean, never set it down on potentially dusty surfaces. Instead, rest it on a clean plastic bag. Between finishing jobs, store the bonnet in a sealable plastic bag.

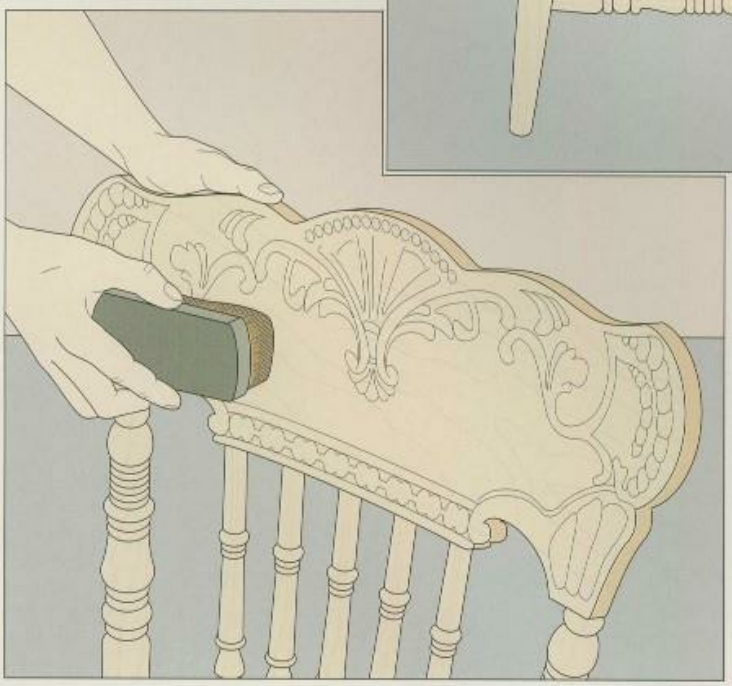
Using rubbing compounds
Scoop up a little rubbing compound with a clean cloth and rub it along the wood surface *(right)* as you would pumice. Once you have abraded the entire surface, wipe the compound off the surface with another cloth. For a glossier sheen, repeat the process with a finer-grit compound. To obtain a softer gloss than is possible with rubbing compound, some finishers rub out the finish with a lubricant and super fine steel wool or a commercial rubbing pad.

CLEANING AND REPAIR TIPS FOR FINISHES

FINISH	CLEANING TIPS	REPAIR TIPS
Lacquer	Wipe using clean cloth dampened with light detergent, potassium oleate or naphtha; avoid using thinners	Repair cracks with lacquer stick *(page 45)* or shop-made lacquer putty by letting a small amount of lacquer dry to a honey-like consistency. For white spots, carefully dig out the damage with a putty knife and apply lacquer thinner until the white portion turns clear; then apply lacquer stick or putty, let dry and sand lightly.
Shellac	Wipe using clean cloth dampened with naphtha; Avoid using water; it will turn shellac white	Lightly sand away scratches. Repair discolored areas by padding the surface with shellac as in French polishing *(page 106)*.
Varnish	Wipe using light detergent, potassium oleate or naphtha; avoid using methyl hydrate	Repair small cracks or gouges with lacquer stick *(page 45)*.
Oils	Use naphtha on polymerized oil finishes; use soap and water on pure oil surfaces	Sand away scratches, then recoat with oil. Recoat discolored or dull areas.

WAXING FOR A PROTECTIVE SHEEN

1 Applying the wax
A coating of wax will protect a rubbed-out topcoat from damage, but select a product with a consistency that is slightly thicker than a liquid or cream wax. Scoop a bit of the wax onto a clean cloth, then spread a thin, even coat on the surface, rubbing the wax into one small area at a time *(right)*. If you try to work on too large a surface area at a time, the solvent in the wax may evaporate before you can rub it over the surface, causing the wax to harden prematurely. Let the wax dry according to the manufacturer's instructions, typically about 15 minutes.



2 Buffing the wax
Rub with a clean cloth until the waxed surface shines. For contours or surfaces with details, as shown at left, buff the wax with a stiff-bristled brush, giving the wood short, brisk strokes.

CLEANING AND STORAGE

A finishing project is not quite finished until you clean and put away your brushes, store the solvents, and dispose of any oily rags. While foam brushes are usually discarded after a single use, bristle brushes and pad applicators can be cleaned and reused. With the proper care, a high-quality brush can provide many years of service.

But good cleanup habits will do more than protect your investment; they are also key elements of shop safety and environmental responsibility. To keep finishing products out of the reach of children, store containers in a locked metal cabinet. Avoid throwing out wet, oily rags with the trash; this increases the risk that they will catch fire. For temporary storage, dampen the rags and place them in a sealed metal container. This will isolate them from any sparks or flames and quickly starve any spontaneous fire of needed oxygen. The safest way to dispose of oily rags is to first spread them out to dry out of doors.

Store finishing products in sealed, properly labeled containers. Avoid using bottles or jars that normally contain food or liquids; a visitor to your shop could mistake a chemical product for something drinkable.

Always store stains and finishes at room temperature; a water-based product will be ruined if allowed to freeze. Reactive finishes such as tung oil or varnish, which eventually harden when exposed to air, should be stored in airless containers. Rather than keeping a small volume of a reactive finish in a large container, transfer the product to a smaller one, exposing the liquid to less air. A better solution is to buy finishing products in smaller quantities or to store them in collapsible plastic containers *(page 87)*.

Do not flush any finishing product down the drain. Even a water-based finish can pose problems by coagulating in drain pipes and backing up your plumbing system. To dispose of small quantities of a product let it sit in an uncovered container outside until the solvent evaporates. For larger volumes, consult the waste disposal service in your community.

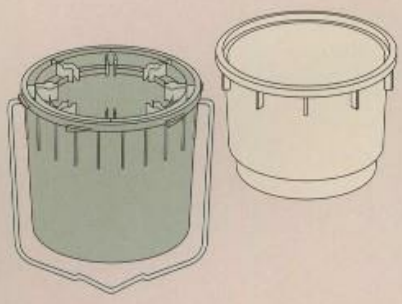
CLEANING AND STORAGE TIPS

- Avoid standing a brush on its bristles; this may bend them permanently and ruin the brush.
- Break in a new brush by suspending it up to the ferrule in a solvent that is compatible with the finish you will apply. Soak the bristles for about 10 minutes, then clean the brush with detergent and warm water.
- After breaking in a new brush or cleaning a used one, wrap it in paper for storage.
- Salvage a hardened brush by soaking the bristles overnight in a mixture of 2 parts xylene, 1 part acetone and 1 part denatured alcohol. Use a brush comb to remove fragments of hardened finish from the bristles.
- To dispose of a water-based finish, pour or brush it onto scraps of cardboard; let it dry and discard the cardboard.
- Instead of discarding a container of used mineral spirits, recycle it. Let the solvent sit in a cool spot for a week or two, then decant the spirits that have risen to the top in a clean container and dispose of the residue.

SHOP AIDS FOR BRUSHES

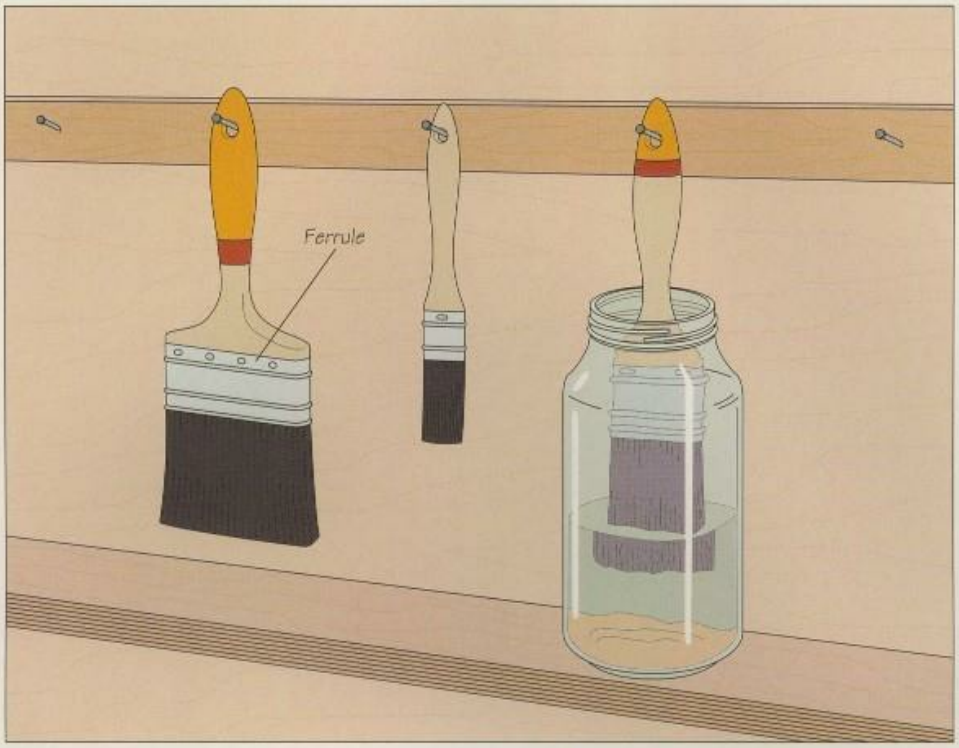
Brush comb
A metal comb for cleaning solid finish residues from brush bristles

Brush bucket and lid
An airtight storage container for suspending brushes in a solvent; features plastic clips that hold brushes with the bristles above the bottom of the container



Brush spinner
Uses centrifugal force to spin solvent from brush bristles; one end of the device holds the brush while the pump-like handle at the other end creates the spinning action

STORING A BRUSH OVERNIGHT



Soaking brushes in solvent
There is no point cleaning a brush *(page 138)* if you plan to use it the following day. Instead, suspend the brush in the appropriate solvent for the finishing product you are using: for varnish, a mixture of turpentine and varnish; for shellac, denatured alcohol; for lacquer, lacquer thinner; for a stain, a "brush keeper" solution of 2 parts raw linseed oil and 1 part turpentine. (For oil-based finishing products, just wrap the brush in plastic wrap.) When soaking a brush, submerge only the bristles, and not the ferrule, making sure they are suspended above the bottom of the container. Keep the brush in a commercial brush bucket *(page 136)*, or hang it from a nail in a shop-made rack *(above)*.

SHOP TIP

Punching drip holes
It takes very little time for the rim of a can of finish to fill up with liquid. The result is often a messy dripping and a splash when the lid is tapped closed. To keep a container from overflowing its rim, punch a series of holes around its circumference with a nail. This will allow liquid to fall through the holes back into the container.

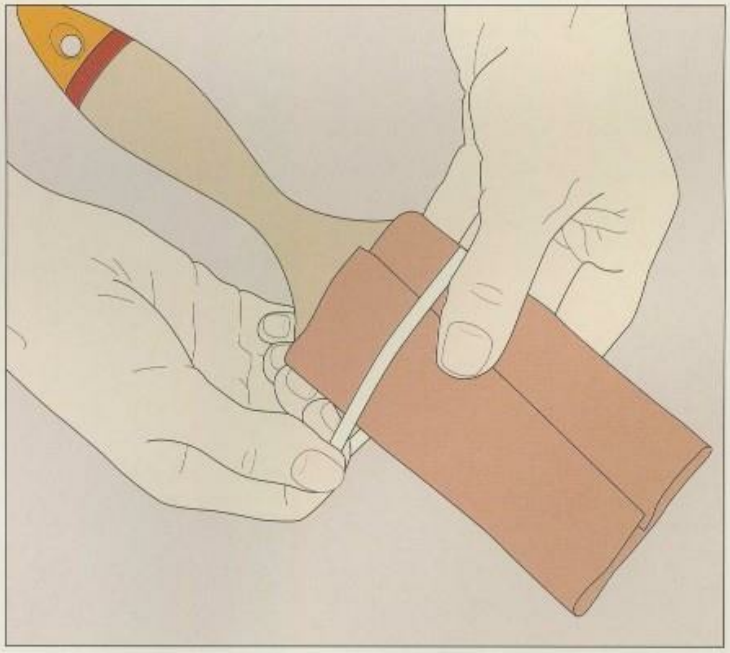
CLEANING A BRUSH

1 Rinsing the brush in solvent
Submerge the brush's bristles in the appropriate solvent for the finishing product used *(page 16)*. Swirl the brush in the solvent, pressing the bristles against the sides of the container. Work the solvent through the bristles with your hands until the brush is clean *(left)*. To remove all the residue from the brush, wash the bristles in a solution of mild detergent and warm water, then pull a brush comb through them as many times as necessary *(below)*.

2 Spinning the brush dry
To rid a brush of solvent, shake it by hand or use a brush spinner. In both cases, hold the brush inside a 5-gallon can to catch the solvent as it sprays from the bristles. To use a spinner, insert the brush handle into the device and, holding the brush in the can, pump the handle to set it spinning *(left)*. Continue until there is no longer any solvent flying off the brush.

STORING A BRUSH

Wrapping the bristles
A well-cleaned brush can be stored indefinitely. Wrap the bristles a few times in thick, absorbent paper. Avoid using plastic wrap, which will keep the bristles from drying properly and may leave them limp. The paper should cover the bristles completely, extending beyond the tips and over the ferrule. Use a rubber band to hold the wrapper in place, making sure the elastic grips the ferrule rather than the bristles *(right)*. Hang the brush up to dry.



GLOSSARY

A-B

Abrasive: Either a coarse powder, or a piece of paper or fabric coated with grit particles used to smooth wood in preparation for finishing or to abrade finish coats; includes sandpaper, abrasive pads, steel wool, pumice and rottenstone.

Aniline dye: A lightfast, permanent synthetic dye derived from coal tars; soluble in water, alcohol or oil.

Artists' colors: Rich, colored pigments mixed in linseed oil; used to tint paints and stains.

Base coat: An undercoat of glaze or paint applied as the first step in many decorative finishing techniques.

Bleach: A liquid that chemically alters wood; used to lighten the color.

Bleeding: The tendency of a stain or grain filler to seep through to the topcoat. Best avoided by applying a wash coat on the stain or filler.

Brazilwood: A natural dyestuff extracted from the South American redwood tree; used in chemical staining of wood.

Bristle brush: A paintbrush with bristles made from the hair of animals, such as ox, badger, boar or sable.

Bronze powder: Metallic, powdered pigment used in stenciling or for other decorative finishes, such as gilding.

Burnisher: A rod-like tool used to sharpen scrapers.

C

Catalytic finish: A two-part finish comprising resins and chemical catalysts; the resins react with the catalysts to oxidize and harden the finish.

Crazing: The tendency of a finish to fracture erratically as it dries; results from solvent incompatibility.

Curing: The process by which a finish hardens completely, leaving it ready for rubbing out. Curing time varies according to the type of finish and the number of coats.

Cut: The number of pounds of shellac flakes dissolved in each gallon of denatured alcohol. A 3-pound-cut shellac, for example, contains 3 pounds of shellac for every gallon of alcohol.

D-E

Distressing: A finishing technique that involves adding scratches, dents and other blemishes to the wood or topcoat to simulate the well-worn look of an antique.

Driers: Chemicals added to a finishing product to speed up the drying time.

Drying oil: One of a group of organic oils that harden when exposed to the air; tung oil and boiled linseed oil are examples.

Dyestuff: A natural coloring agent extracted from plants or animals and used as a base for dye stains.

F-G

Fisheye: The tendency of a finish to show small circular depressions when contaminated by silicone or wax.

Flat finish: A finish with no sheen; one that contains flattening agents, which reduce light reflection.

French polishing: A traditional finish typically built up with many layers of shellac to produce a deep, lustrous sheen.

Gel stain: A blend of pigments and dyes in a gel that becomes liquid when stirred.

Glaze: A heavy-bodied stain used in decorative finishes such as graining and marbling.

Glossy finish: A finish with a reflective, shiny surface.

Graining: A decorative finishing technique in which a specific grain pattern is replicated on a prepared surface.

H-I-J-K-L

Heartwood: Wood from the center of a log; generally darker than sapwood.

HVLP: Abbreviation of high-volume, low-pressure; in finishing, a system for spraying that uses large volumes of air at low pressure to turn a liquid into a fine mist.

Japan color: Highly refined colored pigments; used to tint stains or protective finishes such as lacquer or shellac.

Lacquer: A tough, clear synthetic finish usually derived from nitrocellulose; dries quickly to a flat or glossy finish.

Lightfast: Describes a stain or dye that does not readily fade after prolonged exposure to light.

Long-oil varnish: Varnish containing 100 pounds of resin for each 40 to 100 gallons of oil, resulting in a product that dries slowly to a durable and elastic finish. *See short-oil varnish.*

M-N-O

MSDS: Abbreviation of manufacturer's safety data sheet; the information describes the flammability, volatility and health hazards of a finishing product.

Marbling: A decorative finishing technique used to imitate the appearance of marble.

Mineral spirits: A petroleum-based solvent commonly used for thinning various finishes and for cleaning application tools.

Mordant: A chemical substance that changes the color of wood; often used in conjunction with natural dyes.

NGR stain: Abbreviation of non-grain-raising stain; NGR stains are made from aniline dyes in a waterless solution of methanol and petroleum products; they are designed to avoid raising the grain of wood.

Orange peel: The tendency of a topcoat to take on the texture of an orange peel when the finish is sprayed poorly or at the wrong viscosity.

Overspray: Dried finish particles that adhere to the surface, or finish spray that misses the workpiece and is dispersed into the air.

P-Q

Padding: A technique for wiping on a finish with a cloth pad.

Photochemically reactive: Describes a finishing product that breaks down in its chemical structure when exposed to light.

Pickled finish: An antique finish consisting of a light-colored glaze wiped over a basecoat.

Pigment: Finely ground, colored particles of earth or metallic oxides suspended in a liquid to create a stain or a tint for protective finishes.

Polymerized tung oil: Tung oil that has been treated with heat to accelerate its drying time.

Polyurethane: A synthetic, durable, oil-modified urethane varnish that is resistant to abrasion; available in lusters ranging from flat to glossy.

Pumice: A volcanic rock that is ground to a powdery consistency for use as an abrasive.

R

Ray marker: A tool used to produce grain patterns typical of oak.

Reactive finish: A finish that hardens when exposed to the air; tung oil, varnish and polyurethane are examples.

Rottenstone: A fine abrasive made from pulverized limestone used to rub out finishes to a high gloss; texture is finer than that of pumice.

Rubbing oil: A light oil used as a lubricant when rubbing out finishes.

Rubbing out: The process of abrading a topcoat to level the surface and add sheen to the finish.

S-T-U

Sanding sealer: A preliminary coat for a lacquer finish.

Sap streak: Pockets of pitch in wood that tend to bleed into a finish unless first sealed.

Sapwood: The live wood near the outside of a log; generally lighter in color than the interior. *See heartwood.*

Satin finish: A finish of intermediate sheen; not as dull as a flat finish, nor as shiny or reflective as a high-gloss sheen.

Shellac: A clear finish derived from the natural secretions of the lac beetle; sold ready to use or in flakes, which are then mixed with denatured alcohol.

Short-oil varnish: Varnish containing 100 pounds of resin for each 5 to 12 gallons of oil, resulting in a product that dries to a hard, glossy finish. *See long-oil varnish.*

Smoothing plane: For shaving wood surfaces smooth and level; longer than the average jack plane.

Solvent-release finish: A finish that forms a solid film after the solvent has evaporated; shellac and lacquer are examples.

Solvent: A liquid used to dissolve another substance; examples are turpentine, mineral spirits, toluene, acetone and water.

Stain: A finishing product used to color wood; may contain dyes, pigments or chemicals.

Tack cloth: A cloth dampened with an oil-and-varnish mixture or with water; used to remove sanding particles from wood surfaces.

Tannic acid: A naturally occurring acid found in wood; changes color when exposed to certain chemicals.

Thinner: A solvent used to reduce the consistency of a finish.

Topcoat: The final finishing product applied to the workpiece.

Tung oil: A water-resistant drying oil derived from the seeds of the Chinese tung tree; available in pure, modified and polymerized forms. Also known as China wood oil.

Universal color: Concentrated pigments used to tint protective finishes, such as varnish or lacquer.

V-W-X-Y-Z

Varnish: A clear finish made with synthetic oils that excels at resisting water and alchohol.

VOC rating: Indicates the amount of hazardous organic solvents in a finish; provided in percent, grams per liter or pounds per gallon.

Wash coat: A coat of diluted finishing material for sealing wood pores.

Water-based finish: A product in which the solvent is primarily water.

Wiping stain: A non-fading stain containing pigments suspended in oil.

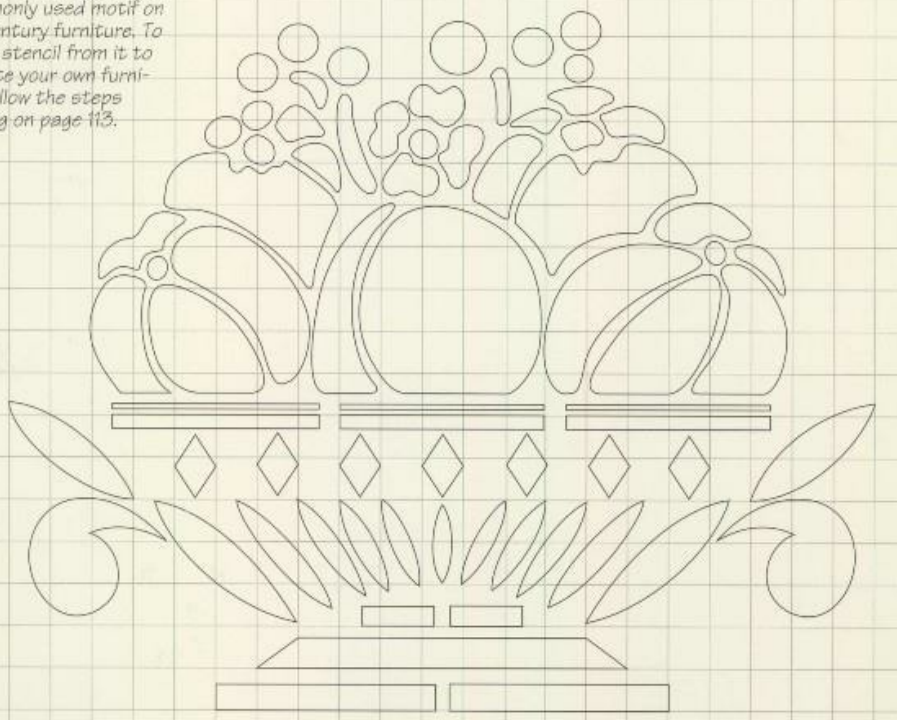
Wood filler: A putty product used for repairing surface damage in wood, or a paste used for filling open grain.

WORKSHOP GUIDE

U.S. AND METRIC CONVERSION

To find the metric measure equivalent of a U.S. measure in the left-hand column, multiply by the conversion factor in the center column. To find the U.S. measure equivalent of a metric measure in the right-hand column, divide by the conversion factor.

U.S. MEASURE		CONVERSION FACTOR	METRIC MEASURE
Weight			
Pound		0.454	Kilogram
Ounce		28.350	Gram
Volume (Liquid)			
Gallon	4 Quarts	3.785	Liter
	16 Pints	3.785	Liter
	128 Fluidounces	3.785	Liter
Quart	2 Pints	0.946	Liter
	32 Fluidounces	0.946	Liter
Pint	16 Fluidounces	0.473	Liter
Half pint	8 Fluidounces	0.236	Liter
Fluidounce		29.573	Milliliter

STENCIL PATTERN

This fruit-bowl pattern was a commonly used motif on 19th Century furniture. To make a stencil from it to decorate your own furniture, follow the steps starting on page 113.