UNDERSTANDING WOOD FINISHING

How To Select And Apply The Right Finish

By Bob Flexner

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WHY FINISH WOOD ANYWAY?

Why do we finish wood? It's an extra step, or steps, that most woodworkers don't find at all enjoyable. It's smelly and messy, and all sorts of things can go wrong. In addition, most woods look pretty good unfinished. Why bother? There are three good reasons for finishing wood: to help keep it clean, to help stabilize it, and to decorate it.

SANITATION

Wood is a porous material. It contains countless holes of various sizes. These holes can accumulate dirt and grime from handling, atmospheric contaminants, and food. Grimy wood is unattractive, and it can be a health hazard, providing a breeding place for bacteria. A finish seals the porous surface, making it less susceptible to soiling and easier to clean.

STABILIZATION

Besides being porous, wood is hygroscopic: It absorbs and releases moisture. Moisture within wood is called moisture content- moisture in the environment is either liquid water or water vapor (humidity). Wood responds to changes in the level of moisture around it. If you put very dry wood in water or in an area of high humidity, the wood will absorb moisture and swell. If you put wood that has a high moisture content in a relatively dry climate, the wood will release moisture and shrink.

These dimensional changes, commonly called wood movement, do not occur consistently throughout a piece of wood. The surface of wood, for instance, responds more readily than the core. Wood swells and shrinks mainly across the grain; that is, in the width and thickness of boards, not appreciably in the length. And wood swells and shrinks more around the annular rings than it does perpendicular to the rings. The result of these different responses is that wood movement generates great stresses in wood and on the joints that hold pieces of wood together. The stresses cause splitting, checking, warping, and weakening of the joints. A finish slows moisture exchange, thus reducing the stresses and stabilizing the wood.

As a general rule, the thicker the coating of finish, the better it limits moisture exchange. This is the reason you should coat all sides of a piece of furniture-top and bottom, inside and outequally. Another important understanding is that moisture exchange in wood does not have to be in the form of liquid water. It can be, and usually is, water vapor. Water-vapor exchange causes much damage to otherwise sheltered wood furniture and woodwork. It just does this more slowly than in wood subjected to liquid-water exchange.

Splits, Checks, and Warps

To better understand how moisture exchange causes splits, checks, and warps, look at Figure 1-1. A solid piece of kiln-dried wood is clamped securely so that it can't expand in width. Then it is saturated with water. The cell walls swell and try to expand but are constrained by the clamps. So the cell walls compress, changing from cylindrical to oval in shape.

If the board is released from the clamps, the cells don't return to their cylindrical shape: They remain flattened. When the water evaporates and the cell walls shrink to their previous thickness, the board shrinks, becoming narrower than it was originally. The amount of shrinkage is as usual, but the starting point is now the clamped width rather than the width the board would have swollen to without the clamps. If the board is reclamped and made wet and dry again, it will shrink further. This phenomenon is called compression shrinkage (also compression set). It explains why nails and screws work loose in wood, and why the wooden handles of hammers and hatchets loosen over time, after becoming repeatedly wet and then dry.

Compression shrinkage also accounts for splits developing in the ends of a board, checks in the middle of a board, and cupping (a type of warp) on the side of a board that is exposed to the most moisture (Photos 1-1 through 1-3). In each case part of the board tries to expand more than the rest of the board will allow it to. After a number of cycles of restricted expansion followed by full contraction, that part of the board changes shape or splits.

Joint Failure

Joint failure also is accelerated by excessive moisture exchange. The cells in wood are like soda straws running lengthwise in boards. The cell walls swell and shrink, changing the width and thickness of boards, but not the length. When boards are joined with the grain running perpendicularly, as they inevitably are in wood structures, the swelling and shrinking in different directions put great stress on the joints. As the glue ages and loses its flexibility, the contrary movement in any cross-grain construction causes joint failure. This is why glued furniture comes apart in time (Figure 1-2).

The speed at which moisture exchange damages wood or breaks the glue bond in joints varies depending on the environmental conditions. Wood or furniture left outside in the weather develops splits, checks, warps, and joint failure much sooner than wood or furniture stored under cover. Wood or furniture stored under cover develops problems much faster than wood or furniture stored in a controlled environment (such as inside your house). The best environment for storing wood or wooden objects is an environment of constant temperature and humidity. This is the type of environment museums try to maintain.

A finish slows moisture exchange no matter what temperature or humidity conditions surround the wood. A finish makes the wood, or the object made of wood, last longer (Figure 1-3).

DECORATION

In addition to stabilizing wood and protecting it from dirt and grime, finishing wood is decorative. Even if you apply nothing more than a simple oil or wax finish, you are making a decorative choice. There are an infinite number of ways you can decorate wood, but finish decoration divides into three categories: color, texture, and sheen.

Color

There are three ways you can apply color to wood. In a broad sense all three are a type of staining. The term staining commonly means applying color directly to wood. But you can also apply color in between coats of finish. This is called glazing. Or you can add color to the finish itself and apply it to the wood. This is called shading or toning if you can still see the wood through the colored finish, and painting if you can't. Each of these methods produces a different decorative effect:

- Stain applied to bare wood amplifies the figure and grain of the wood. Stain also highlights problems in the wood, such as scratches, gouges, machine marks, and uneven density.
- Glaze, applied thinly, changes the tone of the wood's color and adds the appearance of depth and age by highlighting pores and recesses. Applied thick, glaze can be manipulated to imitate wood grain, marble, or leather. These are called faux (false) finishes.
- Shading, toning, and painting change the tone of the wood's color without highlighting pores and recesses. Shading and toning allow you to see the figure and grain of the wood. Painting totally obscures the wood's features. Shading changes the color tone only in the areas you want. Toning changes the color tone evenly over the entire surface.

Texture

All woods have a natural texture dependent upon the size and distribution of the pores. You can preserve this texture by keeping your finish very thin. This thin-finish look is very popular. It's often called a natural wood look, and it is what you get when you finish with oil or wax. You can get the same look with film finishes, such as varnish, shellac, lacquer, or water base, as long as you keep them thin.

By filling, or partially filling, the pores, you can completely change the texture of the wood. You can fill the pores with pastewood filler or with many coats of finish that you sand or scrape back. The most refined finishes (for example, those commonly used on very expensive dining table tops) have filled pores.

Sheen

Sheen is the amount of gloss the finish has. There are two ways to control sheen. The first is by choosing a finish that has the sheen you want built into it: high-gloss, satin, or flat. The second is by rubbing and polishing the cured finish to the sheen you want.

PREPARING THE WOOD SURFACE

A quality finish is impossible to obtain if you don't prepare the wood properly. You probably know this already. I'm sure you've at least heard it. Most woodworkers dread the preparation steps, skip through them, and get a poor finish as a result. Others spend more time and effort than they need to-scraping, sanding, patching, sanding, steaming out dents, sanding, and more sanding. Both extremes are probably caused by a lack of understanding of what needs to be achieved.

The most glaring examples of how poor understanding leads to lower-quality work occur when the woodworker and the finisher are different people, and the communication between them is poor. This is common in house construction, where cabinetmakers and trim carpenters often pay scant attention to the little things they can do to make the finisher's job easier and of better quality. "Oh, the finishers will take care of that," they'll tell you. The usual cause for over-preparation is the belief that sanding to 400 grit or finer produces better results. The wood looks better when sanded to 400 grit, after all. Why shouldn't the finish? When you have control of a project from beginning to end, you'll find that it pays to begin thinking of the finish from the start. In fact, the old wisdom holds that a good finish begins with the selection of the lumber itself.

There are four stages in preparing wood for finishing:

- Selecting, cutting out, and shaping the lumber. Many potential finish problems can be avoided by proper attention here.
- Sanding or smoothing the surface. This is the most unpleasant operation for most woodworkers, so knowledge of the tools and some thought about what you're trying to achieve can go a long way toward reducing the drudgery and improving results.
- Dealing with glue that gets on the surface of the wood. Glue will show up as light splotches through the stain and finish.
- Correcting surface imperfections in the wood, such as dents, gouges, and checks, and filling gaps in the joints left by a less than-successful glue-up. This step could be called "the woodworker's eternal quest for a wood putty that takes stain."

PREPARING THE LUMBER

Wood varies greatly in color and figure-even wood of the same species and boards from the same tree. You need to pay attention to how boards look when you're putting them next to one another in a project. Otherwise, you may end up with color and figure differences that will detract from the appearance and be difficult to disguise with a finish.

Whether you're choosing boards at a lumberyard or from your own inventory, look through the supply and imagine how different grain and figure patterns would look if placed in various parts of your project (Photos 2-1 and 2-2). Be conscious of knots, splits, checks, and other defects, and determine how you would either use them to advantage or work around them. If you're using veneered plywood or plan to veneer the wood yourself, think of how the figure in the veneer can be used to best advantage. Above all, pay attention to color variations, unless you intend to paint the piece you're making.

For a table or chest top, lay the boards out in different groupings, flipping and turning them, until you find the best arrangement. Then mark the boards so you won't mix them up as you prepare them (Figure 2-1). If you're making the top from veneered plywood, decide what part of the 4 x 8 sheet you can use most advantageously. On a chest-of-drawers, give the same attention to picking the drawer fronts. When people look at what you've built, they won't see the wonderful joints you've spent so much time and effort making. They'll see the design, which includes your choice of boards and their positioning, and they'll see the finish. You won't regret the time you spent selecting and arranging your wood.

Before you begin working your lumber, make sure your tools are sharp and your machines are adjusted properly. Dull planer, jointer, or shaper knives and worn-out router bits will leave pronounced washboard-like mill marks in your wood that will require extra effort to remove (Photo 2-3). Chipped knives will leave unsightly ridges. And if the cutters on your machine tools are dull enough to burn or glaze the wood, they could ruin your project altogether. Poorly adjusted machinery can snipe the ends of boards and also cause glazing or burning. Always work toward the smoothest surface possible.

If you're joining a number of boards together to make a tabletop, you may want to use splines, dowels, or biscuits to line up the boards so the surface is as flat and even as possible. If, after glue-up, uneven alignment is more than you want to try flattening by hand and you don't have power equipment large enough to handle the job, look for a local millwork shop that will run the top through its wide-belt sander for you. The price and the trip are often worth it. If the top is too wide for any of the sanders in your area, plan to make the top in several sections; flatten each section separately; and then join them together with splines, dowels, or biscuits to line them up.

SANDING AND SMOOTHING

Of all the steps involved in making and finishing something of wood, sanding is the most universally detested. At the same time, curiously, it's the step that consumes the most wasted effort. There seems to be some mystique that the more you sand, the better the end product will be. But as an old finisher I knew used to say, "When you're in the bathtub and you're clean, get out!" Once the wood is smooth and the mill marks and other defects are gone, there's no reason to continue sanding. You're finished. Your goal should be to reach that end with as little work as possible.

It will. help to remember that just about the only reason you need to sand at all is to remove the washboard-like mill marks left in the wood by planers, jointers, shapers, and to a lesser degree, routers. Before the invention of these machine tools, there was seldom any reason to sand; indeed, there was no sandpaper.

The tools used to smooth and finish off furniture parts before the introduction of machines were hand tools-bench planes, molding planes, and scrapers of several sorts. These tools are still available, of course, and can often be used very effectively to remove mill marks. In fact, for some woodworking projects, a finely planed surface can be regarded as a final surface. In some applications, the evidence of hand-plane work-ridges from the edge of the plane iron or hollows from a scrub plane-add character to a surface. And for any woodworker who can't afford or is uninterested in large power sanding equipment, a simple tool like a scraper can be a godsend.

Before discussing the pros and cons of the various smoothing tools, however, I want to point out that whichever tools you use, you'll usually get a better job if you prepare all of the parts before assembling. You'll be able to secure each part to your workbench, where you can see what you're doing clearly in good light. And you'll be able to do your preparation in a comfortable position with any tool you choose. You'll also avoid the difficulty of trying to sand or scrape already-assembled, right-angle joints, such as stiles and rails, or legs and rails, without putting cross-grain scratches in the perpendicular pieces.

Turned and carved pieces shouldn't need any additional preparation. Turnings should be sanded while still on the lathe. Carvings shouldn't be sanded at all, as sanding inevitably softens the crisp lines left by the carving tools.

Table and chest tops, sides, panels, rails, door and drawer fronts, and most moldings, however, will contain mill marks that should be removed. The two most efficient tools you have, besides hand planes, to accomplish this task are sandpaper and scrapers.

Sanding Basics

There are several types of sandpaper, but for almost all woodworking tasks, you will get the best performance from garnet paper, which is orange-to-red in color, or from *aluminum-oxide* paper, which is tan-to-brown.

Sandpaper comes in a series of numbered grits, from coarse to fine. The sequence is 60, 80, 100, 120, 150, 180, 220, 240, 280, 320, 360, 400, 500, 600, 1000, 1200, 1500, 2000. 1 usually start with 80 or 100 grit and rarely sand past 220 grit.

For finishes, *silicon carbide* is usually the better choice, and 280 grit is about as coarse as you'll ever need. There are two types of silicon carbide sandpaper: stearated, which is usually gray in color, and wet/dry, which is black.

Stearated silicon carbide sandpaper contains metallic soap (the stearate) to lubricate the sandpaper so it doesn't clog up as easily as unstearated sandpaper. Stearated sandpaper is also called no-load and self-lubricating sandpaper.

Wet/dry silicon carbide sandpaper is made with waterproof glue which continues to hold the grit to the paper backing even when the paper gets wet.

You can do your sanding with the aid of a machine, or you can sand by hand. Whichever way you choose, the process is basically the same.

There are two steps:

- Remove the blemishes using the coarsest grit sandpaper necessary to do the job efficiently.
- Remove the scratches left by the sandpaper, using increasingly finer grits. Sand with any given grit until you can see no more improvement. Then move to a finer grit

If you switch to a finer grit before you've totally removed the blemishes or before you've removed all the scratches of the previous grit, it will take you much longer. It's like trying to smooth over the hoed rows in a garden with a fine-toothed rake: If you use a coarse cultivator first, then a fine rake, it will go much faster and you'll get more consistent results. The most common error made in sanding is skipping to finer grits before you've made the sanding scratches of the prior grit uniform.

When you're sanding by hand, don't skip any grits. When you're sanding by machine, you can usually skip one or two grits, even with coarse papers. The greater speed of the machine makes up the difference. Always clean off the sanding dust before moving to the next finer grit. The dust will contain some of the grit from the coarser sandpaper, and this coarser grit will keep you from getting a uniform scratch pattern with the finer grit.

The second most common error in sanding is continuing to use sandpaper after it has become dull. Pay attention to what's happening. The cutting efficiency of sandpaper deteriorates fairly rapidly. You'll cut your sanding time significantly by changing sandpaper more often.

To what grit should you sand? Probably no question in woodworking elicits as much passionate controversy as this one. Most of the passion is based on how good the wood looks before the finish is applied. The finer the grit sandpaper you use, the more polished the wood will appear. But highly polished wood Won't look more polished after you apply the finish. In fact, from about 120 grit up, it's difficult to see the difference once the finish is applied. For perspective, consider that furniture factories seldom sand above 150 grit.

My own preference is to sand to 180 grit when I'm applying a film (shellac, lacquer, varnish, conversion, or water-based) finish, and to 220 grit when I'm applying a thin oil finish. (The higher grit for oil finishes makes the wood feel smoother; it doesn't improve the appearance.) Sanding to 220 grit and above will polish the surface and hinder pigment-stain penetration.

No matter how fine the final grit you use, you won't remove all of the tiny wood fibers that swell and make the wood rough to the touch if water is applied. If you intend to use a stain or finish that contains water, you should sponge the wood after your normal sanding. Wet the wood and resand it smooth after the water dries out.

Sanding Machines

There are three common hand-held sanding machines: belt sander, orbital pad sander, and random-orbit sander. The way each works determines the surface it produces (Figure 2-2).

Belt sanders will remove a lot of wood very fast. This can be an advantage when wood removal is the goal. But when you're trying to achieve flatness and smoothness, a belt sander is a dangerous tool to use. You must keep the sander flat on the surface, moving at all times, and avoid even the slightest rocking motion side-to-side or front-to-back-or the sander will dig into the wood, leaving hollows or ridges. Make one mistake with this tool on solid wood, and you may find yourself spending hours correcting it, especially if, as is often the case, you don't notice the problem until you apply the finish. Veneer should never be belt-sanded. Except for those instances where I really do want to remove a lot of wood quickly, I don't find using a belt sander worth the risk, so I seldom use mine.

On the other hand, I have friends who use belt sanders and are pleased with the results they get. They tell me they damaged a lot of wood in the beginning but finally mastered the "touch" needed to avoid gouging.

Orbital pad sanders are much tamer than belt sanders, but they're also much less effective. Because this sander works with an orbital motion, it inevitably leaves small orbital scratches on the wood surface. These scratches are almost invisible until you put on a stain and finish. Then they scream at you. To reduce the scratching, don't set the sander down on the wood until it's running at full speed, and don't slow the sander down by pressing on it. Sand to what would normally be your finest grit if you were hand sanding. Move the sander back and forth slowly in the direction of the grain, and check often to make sure no splinter or other foreign object has become lodged between the sandpaper and the wood, as this will leave deeper orbital scratches. It's almost always wise to finish off by hand with fine sandpaper and a sanding block, sanding in the direction of the grain.

Personally, I find the orbital pad sander too slow, and I don't use mine very often. But pad sanders are very popular with many woodworkers.

Random-orbit sanders, which incorporate an orbital as well as a revolving movement, fall between belt sanders and pad sanders for their ability to remove wood. They are not as aggressive as belt sanders and are far more effective than pad sanders. Random-orbit sanders are also far less likely than belt sanders to gouge the wood and somewhat less likely than pad sanders to leave scratches in the wood. For most sanding operations a random-orbit sander is the best machine choice.

Random-orbit sanders are so efficient because of their speed and the randomness of their scratch pattern. These two factors increase the cutting effectiveness while minimizing scratching.

For best results, start the sander while it is on the wood. (This is opposite of the way you start a pad sander. If you wait until the random-orbit sander is running at full speed to set it on the wood, the sander tends to gouge.) Use a light touch, and move the sander at an even speed in regular patterns, aiming to keep the surface as flat as possible.

Contrary to the publicity you hear about random-orbit sanders, they do leave scratches in the wood. It's best to finish off by hand sanding, the same as you should with pad sanders.

Hand Sanding

Sanding by hand is almost a lost art, but I've always enjoyed it and found it a very effective way to sand wood. You can hold the sandpaper directly in your hand, or you can wrap the sandpaper around a block made of cork, felt, rubber, or wood. If you use a wood block, glue a piece of 1/4-inch cork, felt, or rubber onto the bottom to provide a cushion behind the sandpaper to reduce clogging. A chalkboard eraser or a material like ceiling tile can also be used to back your sandpaper.

It's almost always better, when sanding flat surfaces, to back up sandpaper with a sanding block (Figure 2-3) rather than your hand. Your hand will tend to dig out the softer grain in the wood, resulting in a dimpled or ridged effect that's noticeable after you apply the finish. On moldings and other curved surfaces you can't use a flat block. But if you have a large number of pieces to sand, you may find it advantageous to make a negative of the molding from wood, Styrofoam, or other firm material to give good backing to the sandpaper. (A dowel rod of the proper diameter can aid in sanding coves, for instance.) Otherwise, you can hold the sandpaper in your hand. The dimples you create won't show as badly on moldings or curved surfaces as they would on flat surfaces.

When I sand by hand, I tear the 9 x 11-inch sheets in thirds across the width (Figure 24). If I'm using a sanding block, I fold one -of the thirds in half and wrap it around the sides of the block, holding it in place with my thumb and fingers. When one side is well used, I flip the sandpaper. When that is used, I unfold the sandpaper and wrap it all around the block so that the crease is under the block. This way, there is no waste.

If I'm using my hand to back the sandpaper, I fold one of the thirds into thirds again and overlap them. This gives me three fresh surfaces that stay in place as I sand, and it reduces waste.

Whether you're sanding with your hand or with a block, you should always sand in the direction of the grain, or you will surely produce cross-grain scratches that will show through the finish. It's also wiser to move the sandpaper with the folded edge facing the direction of travel. An open edge of sandpaper is more likely to catch under a sliver of wood and lift it, which will, at the least, tear the sandpaper and could jam painfully into your hand.

As your final step, run the sandpaper lightly over every right angled edge of the wood to remove sharp corners that can easily dent, can feel unfriendly to the hand, and might be too sharp to hold the finish. This is sometimes called breaking the edges.

Scrapers

The fastest, cleanest, safest, and most enjoyable tool to use for removing mill marks and other defects in wood is the scraper. There are two kinds: the hand scraper, which you hold directly in your hand, and the cabinet scraper, which is held in a cast-iron body that has a flat sole and two handles. (There is also the common paint scraper; however, this tool has limited use in woodworking.) Both scrapers are misnamed because they don't scrape the wood at all but rather slice very thin shavings.

These scrapers fit a category of hand tools that almost totally disappeared from use in the United States as a result of our love affair with power machinery. Recently, scrapers have begun returning to favor. I first encountered scrapers in the mid-1970s, when I was working in Denmark. Every cabinetmaker there had several hand scrapers in his tool kit. I was employed as the shop finisher at the time and was taught to use the hand scraper to remove cured runs and sags in my finishes and to cut back and level a finish rapidly in order to create a mirror-flat surface. The hand scraper cuts off ribbons of finish far faster than sandpaper can scratch the finish off. It doesn't gum up the way sandpaper does, and it's more economical.

A scraper is to sandpaper what a word processor is to a typewriter. I've never known a woodworker who learned to use a scraper, or a writer a word processor, who wanted to go back. Scrapers and word processors both increase efficiency many times over. True woodworkers would rather make shavings than sawdust anyway!

To use the hand scraper, hold it between the thumbs and forefingers of both hands at an angle of about 50 to 70 degrees above the wood surface or until you feel the burr on the scraper edge catch. Then push it away from you or pull it toward you, cutting a ribbonlike shaving as you go (Photos 2-7 and 2-8). You can also shift one hand to the reverse position and scrape sideways, perpendicular to your body (Photo 2-9). If dust is your only product, the scraper is not sharp. (See "Sharpening a Hand Scraper" on page 21 and "Sharpening a Cabinet Scraper" on page 24.)

When you push the scraper, it will tend to bow out slightly in the middle from the pressure of your thumbs. This will create a slightly convex edge and almost imperceptible hollows in the surface you're scraping. This unevenness could show up under a finish. You should sand out these hollows or scrape them flat using one of the other two hand positions, scraping toward you or sideways. But pushing the scraper is the most effective way to remove the most wood. To keep the scraper from heating up, turn it often to another edge. If the scraper gets too hot to hold, set it aside and let it cool for a moment.

When you're using a hand scraper to remove mill marks, hold it at a slight angle to the washboard-like rows, so you cut off the ridges rather than dip in and out of the hollows, accentuating the defect. Change your angle of cut with each pass.

Hand scrapers can also be used to smooth contoured surfaces: A straight hand scraper will follow a convex curve, and a French-curved scraper will get into concave contours.

The cabinet scraper cuts the same way as the hand scraper. However, the cabinet scraper has a flat sole, which makes it easier to maintain a level surface (Photo 2-10). 1 find it particularly useful when I want to even the raised edges of glued-up boards that didn't come together flat. I begin by scraping off the greater part of the raised edge (this could also be done with a belt sander). Next I scrape diagonally across the grain, alternating from a left diagonal to a right diagonal, until the top is flat. Then I scrape a few passes with the grain. A light sanding, and the panel is ready to finish.

Either scraper is more forgiving than a hand plane. Because of the high cutting angle, a scraper tends not to tear the grain; you don't have to worry as much about grain direction, swirls, or knots. You can scrape with, against, or across the grain.

Unless the scraper has been sharpened (See A, B, C, D, E) perfectly, it will leave tiny ridges on the surface of the wood, finer than those left by a planer or jointer that has nicks in its knives. These ridges can be removed easily by a light sanding with 180-grit or finer sandpaper.

Cleaning Off the Dust

Whenever the last step involves using sandpaper, you will leave dust on the wood. This dust must be cleaned off before applying a finish. There are four ways to remove the dust:

- Brush it off.
- Wipe it off with a tack cloth (a cloth made sticky by the application of a very thin, varnish-like material that leaves a gummy residue).
- Vacuum it off.
- Blow it off with compressed air.

Brushing is usually the easiest and most convenient, but probably the least efficient, way of removing dust. Some very fine dust will always be left on the surface and in the pores. Nevertheless, brushing is usually adequate.

A tack cloth can be used after brushing to remove the rest of the surface dust. But a tack cloth still won't pull much of the dust out of the pores of porous woods like oak. Tack cloths are more effective when used between coats of finish. (You shouldn't use a tack cloth when you're using water-based stain or finish. The varnish-like substance will hinder good flow-out and bonding.)

A vacuum is the most efficient way to remove dust if kicking dust into the air might create a problem in your finishing room. Otherwise, compressed air is the most efficient way. Use compressed air outdoors or in a well-ventilated space, where the airborne dust will be evacuated.

Though it seems logical that a better finish will be achieved if absolutely all of the dust is removed from the pores, don't be compulsive about it. You won't be able to see the difference anyway.

GLUE SPLOTCHES

No matter how hard you try to avoid it, it's likely that now and then you will get glue on the surface of the wood during glue-up (Photo 2-19). Either the glue will squeeze out of the joints as you clamp the pieces together, or you will transfer glue to the wood with your fingers.

Here are some tips to help you avoid getting glue on the wood:

- Don't put excessive amounts of glue in the joints. Only when gluing up boards edge to edge should you apply glue liberally. In this case you will want squeeze-out to indicate that you've applied enough glue and tightened the clamps adequately.
- Cut your mortises or dowel holes a little deeper to allow excess glue to collect at the bottom instead of being squeezed out.
- Cut a chamfer around the edge of your mortises and a countersink in your dowel holes to hold excess glue and to keep it from squeezing out (Photo 2-20). You can cut the chamfer with a chisel or rasp and the countersink with a needle-nose rasp, a countersink bit, or an oversized drill bit, used carefully so it doesn't cut too deeply.
- Have both a damp and a dry cloth nearby so you can remove any glue you might get on your hands. Wipe your hands with the damp cloth, then quickly dry them so you won't wet the wood.

Removing Glue from the Wood

There are two ways to remove glue from the wood:

- Re-dissolve it and wash it off.
- Scrape or sand it off.

If the glue is still wet, it will be easier to wash it off. If the glue has cured, it's usually easier to scrape it off. But it's also possible to wash off cured glue as long as you can dissolve it with water or a solvent. (See "Solvents for Removing Cured Glues")

If you choose to wash the glue off with water (hot water will work more quickly), you'll have to follow this by sanding the washed area, once it has dried. Or you'll have to wash the entire project. All areas have to be treated alike because any part of the wood that has become wet will show up darker when stained. The problem is worse on soft woods, such as pine, poplar, and soft maple.

To avoid swelling the grain, substitute acetone or lacquer thinner (which contains acetone) for the water. Acetone, toluene, and xylene break down (in effect, strip) white and yellow glue. Taking glue out of the pores with one of these solvents is much like taking paint out of the pores with stripper. You need to scrub the wet surface with a stiff bristle or brass-wire brush. Scrub with the grain so the scratching will be less visible. You'll have to resand the area you've scrubbed to match the surrounding areas.

Instead of dissolving the glue out of the wood, you can always scrape or sand the glue off. The disadvantage of removing glue splotches this way is that it's hard to tell when you've gone deep enough to get all of the glue out of the pores. The glue will still show up lighter under a stain. The advantage is that you don't damage the wood with water. Neither washing nor scraping is necessarily better. I've used both methods, and the one I choose depends on the situation, including whether a rag or a scraper is handy at the moment.

If you are prone to getting a lot of glue on the surface of your work, I suggest you do most of your sanding after you've assembled the piece. I also suggest that you sponge your work after you've finished sanding it. Sponging will highlight deposits of glue in the wood (they'll show up lighter than the surrounding wood) so you can be sure to remove them.

Removing Glue Splotches After Staining

Despite your best efforts, you may still have glue splotches after staining. Then what do you do? It's usually best to scrape or sand the splotches to below the depth of the glue. Then restain. You can use a hand scraper, a paint scraper, or the sharp edge of a chisel used as a scraper. Whether you scrape or sand, you'll have to sand the area back to the same grit you've sanded everywhere else. Then reapply the stain. If there is any color difference between the repaired and unrepaired parts, apply more stain and sand the entire section with the same grit sandpaper while the stain is still wet. (If you are using water-based stain, you will have to use wet/dry sandpaper.) Then wipe off the excess stain. This wet sanding almost always blends the parts.

If you still have a color difference that you can't live with, you may have to strip the entire piece, resand (it's not necessary to get all of the color out of the wood), and start all over with staining.

DENTS, GOUGES, AND HOLES

No matter how careful you are, you will probably dent or gouge your wood somewhere in the preparation or assembly steps, and you may also have small holes, like finish-nail holes, that you'd like to cover up.

Steaming Dents

Dents are compressed wood. They often can be steamed flush, as long as the fibers have not been broken. Steaming swells the wood fibers, filling out the depression. Dents are easiest to steam flush if the surface is horizontal. Put a drop or two of water in the dent with an eyedropper or syringe. Let the water soak in a little. Add some more water, if needed to form a bead over the dent, and then touch the water with a very hot object to turn it into steam (Photo 2-21). You can use a soldering gun, the tip of an iron, or simply a pointed metal object that has been heated over a flame (wipe off any deposited soot before touching the metal to the water).

Steaming out dents is not 100 percent effective or predictable. But it's nearly so. If you'll let the raised grain dry thoroughly before sanding it smooth, you'll usually get away with a mark so slight you can barely see it.

When the grain has been severed, however, it's seldom possible to raise it flush again. Severed grain should be treated as a gouge. The wood will have to be either cut out and patched with another piece of wood or filled with a foreign material.

Wood Patches

If the gouge is large, a wood patch is best because it will be easier to disguise, and it will be permanent (Photo 2-22). A wood patch is also best for filling splits in the wood and gaps left by poorly fitted joints. A wood patch, its grain aligned with that of the surrounding wood, will shrink and expand with the surrounding wood and be less likely to crack and come out at a later date. Foreign materials, such as wood putty, are not flexible and are seldom permanent when used to fill large gouges, splits, or gaps.

The principle for patching a gouge with wood is the same as for plugging a screw hole. The patch will be less visible, however, if it is diamond shaped, or at least elongated, instead of round or square. Determine the shape you want to use and cut it out of another piece of wood that has a color and grain pattern close to the wood you are replacing. Trace the pattern onto the surface you're repairing, and cut out the necessary wood with a chisel. If the damaged area is large, you can use a router together with a jig to control the cut more exactly. (Alternatively, you can cut out the shape in your damaged surface first, and then transfer the shape to the patch with tracing paper.) It's best to make the patch a little thicker than necessary so it protrudes above the surface of the wood. Trim it flush with a chisel, plane, or hand scraper after the glue has dried.

Patching splits in wood or gaps in joints is easy. Simply cut some thin slivers out of the same type of wood, or use already cut veneer, and insert the correct thickness into the opening. It's sometimes helpful to taper the sliver a bit so it will slide in easily and fill the gap. After the glue dries, trim the insert flush. This type of repair is usually easy to disguise and is almost as permanent as the surrounding wood.

Wood Putty

It's much less work to use wood putty to fill a gouge, split, or gap than it is to insert a wood patch. Wood putty can be quite effective for filling small defects.

Wood putty is simply a binder such as finish, glue, or gypsum (plaster of paris), and some solid material such as sawdust, whiting (calcium carbonate), or wood flour (very fine sawdust). The binder cures and holds the solid particles together to make the patch. You may not have thought of it before, but most of the wood putties available commercially are the same as the finishes you use, only with some wood flour or whiting added to provide bulk. This explains why wood putties don't take stain easily. Neither do finishes once they have cured.

There are three common types of commercial wood putties- those based on nitrocellulose lacquer, those based on water-based acrylic finish, and those based on gypsum. (See "Wood Putties," below.) You can tell which kind you have by the instructions on the container:

- Nitrocellulose-based wood putties can be thinned or cleaned up with acetone or lacquer thinner (which contains acetone).
- Water-based acrylic wood putties can be cleaned up with water until they harden.
- Gypsum-based wood putties come in powder form. You mix them with water.

Homemade wood putties are usually made from glue and sawdust. Take some fine sawdust, preferably from the same wood you are going to patch, and mix it with any type of glue. Epoxy, white glue, and yellow glue are preferred. Use a minimum amount of glue with a maximum amount of sawdust. If you use too much glue, the patch will be much darker than the surrounding wood.

Whichever wood putty you use, apply it the same way. Take a little putty on a putty knife (or dull screwdriver if the hole is small), and push it down in the hole or gouge. If the depression is not very deep, smooth off the top by pulling the knife across the surface toward you. You want the putty to form a very slight mound so that when it shrinks as it dries, it won't leave a hollow. It's best not to manipulate the putty any more than necessary, since it becomes increasingly unworkable the longer it's exposed to air. Don't be sloppy. The binder in the putty is finish, glue, or plaster, so it will bond to any part of the wood it comes in contact with, preventing stain penetration and leaving a splotch.

Once the putty is thoroughly cured, sand it level with the surrounding wood. If you're working on a flat surface, back the sandpaper with a flat block.

To match the surrounding area, wood putty patches can be colored in one of two ways:

- Color the putty while it's still in paste form.
- Color the patch after it has cured.

To color the putty itself, you can use universal tinting colors, available at most paint or art-supply stores. Universal tinting colors will work with the three commercial types of wood putty as well as with homemade glue-and-sawdust mix. The color you want to match is the color the wood will be after it is stained and finished. It may take some experimentation to arrive at that color. You can practice on some scrap wood. The trick is to judge the colors while they are still damp. At that stage, the colors will be close to what you'll get when the finish is applied. The color of the dry stain or putty will not be accurate.

It's usually easier to color the putty before applying it, but you can get better results by coloring the patch after it is dry and has been sanded smooth. This is because wood is seldom uniform in color. It almost always has subtle differences as a result of grain and figure variations.

To color a putty patch, you should apply your stain (if you're using one) and your first coat of finish (the sealer coat) to the entire surface, in order to see the correct colors you want to imitate. (See "Sealers and Sanding Sealers") Once this sealer coat is dry, you need to paint in the grain and figure and the background color. The background color is the lightest color visible in the surrounding wood. You may also want to scratch pores into the patch with the point of a knife in order to imitate deep-porous woods such as oak, mahogany, or walnut. (For instructions on graining a solid-colored patch to look like wood, see Chapter 16: "Repairing Finishes.")

No matter what you use to patch gouges, and no matter how well you color the patch, it will probably show after a few years. The surrounding wood will darken or lighten differently than the patch, causing the patch to stand out. The only way to avoid this problem entirely is not to patch. The closest you can come to keeping the colors the same is to make the patch from wood taken from scraps of the board it is set into.

Wax Crayons
It's seldom worth trying to fill small nail holes with wood putty. You'll make a mess around the hole because the putty will stick wherever it touches the wood. It's usually easier to wait until you complete the finishing. Then rub over the hole with a wax crayon of a close color. Wax crayons in wood tones are available at most paint stores and home centers. As long as the hole is small, you won't see the patch unless you look for it.

TOOLS FOR APPLYING FINISHES

There are only four tools for applying finishes: rags, brushes, rubbing pads, and spray guns. This minimal tool kit is a main difference between finishing and woodworking. In woodworking there are countless tools, with new ones coming on the market all the time. If you're a woodworker, you spend a good deal of time learning about the different tools, how they work, and the tricks they're capable of.

Finishing is very different. There aren't many tricks you can do with the four tools. The sole purpose of using one of these finishing tools, other than to keep your hands clean, is to apply the finish so it's smooth and level. You could, after all, pour a finish onto the wood and spread it around with your hand. After the finish cured hard, you could sand it level, rub it with rubbing compounds, and achieve presentable results. But it would be much easier if you applied the finish smoothly enough in the first place for you not to have to sand at all, or at least very little, to make the surface level.

You use the four finishing tools to apply smooth, level coats of finish. Here's what you need to know about these tools.

RAGS

The rags you use in finishing should be made of cotton. Polyester and other synthetic fabrics don't work well because they aren't absorbent enough. You can often substitute cheap paper towels for cloth rags if you don't have a supply of used rags-especially when working with products that don't contain water. When working with products that do contain water, you can substitute Scott Rags, which are a paper product available at many home centers and discount stores. These rags won't fall apart when they get wet.

BRUSHES

Brushes are among the earliest finishing tools. Though the increasing popularity of spray equipment is making brushes less important, it's rare that a finisher doesn't own at least a few brushes.

Choosing a Brush
A good-quality brush is important if you expect good results. Good-quality brushes hold more finishing material (so you don't have to replenish the brush as often), and they spread the material more smoothly than poor-quality brushes.

There are three types of brushes: natural bristle, synthetic bristle, and sponge. There are also pad applicators, which may be regarded as a type of brush, since they are used in the same manner.

Natural and synthetic- bristle brushes are made of bristles glued together at the top with epoxy and held to a wooden or plastic handle by a metal wrapping called a ferrule. The quality of the handle, glue, and ferrule varies and usually corresponds to the quality of the bristles. You can almost always judge the quality of a brush by its bristles (Figure 3-1).

There are three good qualities to look for in bristles:

- The bristles are arranged to form a chisel shape; the brush is not cut off square.
- Each bristle is tapered-thinner at the tip than at the ferrule.
- The tip of each bristle is flagged-that is, split into several strands.

Chisel-edged brushes (the center bristles are longer than the bristles on each flat side) do a much better job of putting on a smooth coat of finish than square-edged brushes. Square-edged brushes are cheaper and are useful for applying stripper or bleach, where smoothness is not important.

Tapered bristles perform better than non-tapered bristles. The thickness of the bristles near the ferrule provides strength. The thinness at the tip allows more bristles to come in contact with the surface. More bristles means the brush will hold more finish and spread it more smoothly.

Flagging doubles or triples the number of bristle fibers that contact the surface. As a result, flagged bristles carry more finish and apply it more smoothly than bristles that are not flagged.

The difference between natural and synthetic bristles is the difference between hair and plastic. Hair softens and becomes uncontrollable in water; plastic doesn't. Therefore, natural-bristle brushes do not perform well in water-based stains or finishes; synthetic-bristle brushes do. Both types perform well with all solvent-based stains and finishes, though most painters and finishers prefer the results they get from natural bristles.

Natural-bristle brushes are made from animal hair. The best brushes for applying solvent-based finishes are made from the hair of Chinese hogs. Synthetic-bristle brushes are made from polyester or nylon or both. For most people the best size brush for applying a finish is 2 to 3 inches wide with bristles 2 to 3 inches long.

Foam brushes are popular because they don't leave brush marks. But they do tend to leave distinct ridges at the edge of each brush stroke, where more finish is deposited. Foam brushes are cheap and, therefore, especially useful when you want to throw the brush away after using it rather than clean it. Foam brushes will dissolve in lacquer thinner and, depending on the type of foam used, possibly in alcohol. This means you shouldn't use these tools with lacquer or shellac.

Pad applicators have thousands of short filaments attached to a foam backing. They perform much like foam brushes, except that they're mounted in a flat plastic or metal holder, so they are useful only on flat surfaces. Because they hold a lot of finish, and they come in large sizes, they are popular with floor finishers. Pad applicators, like foam brushes, should not be used with lacquer or shellac.

Using Brushes

Here are the essentials for brushing a finish. Remember, your goal is to get the finish as smooth and level as you can.

- If your brush is new, hit the ferrule against your hand to shake out any loose bristles.
- Pour enough finish for the job at hand into another container, such as a coffee can or wide-mouthed jar. This way you won't contaminate your entire supply if your brush picks up some dirt.
- Hold the brush by the metal ferrule with the handle resting between your thumb and first finger. Dip the brush into the finish so about one-third to one-half of the bristle length is submerged in the liquid. Raise the brush and tap it against the side of the container to remove enough of the excess liquid so the brush won't drip.

- On large, flat surfaces, don't begin brushing with a fully loaded brush right at the edge of the panel, or else your finish material will run over the edge. Begin brushing about 2 inches from the edges. Brush toward the edges and then away from them, gradually covering the whole panel. You can begin brushing at either the front or back edge of a horizontal surface. Just be sure to position your container of finish so you won't be passing your finish-laden brush over just-coated wood.
- With each new brushload of finish, begin brushing a few inches ahead of your last stroke, and work back to it and then away from it.
- Brush with the grain of the wood so the ridges left by your brush will be less noticeable.
- On turnings, carvings, moldings, and other irregular surfaces, reduce the amount of liquid in your brush so you don't cause runs or puddles in recesses. It's easier to brush around rather than along the length of turnings.

Cleaning and Storing Brushes

You must clean and store your brushes properly after use, or they can become ruined and you may have to throw them out. Shellac and lacquer are the only finishes that allow you to fully reclaim a brush after the finish has cured.

If you are planning to use the brush with the same finish later that day or the next day, you can store the brush in the appropriate solvent or thinner (mineral spirits for oil, varnish, or polyurethane; alcohol for shellac; lacquer thinner for lacquer; and water for water base). Or you can wrap the brush in plastic wrap to shield it from air. If you store the brush in solvent or thinner, run a dowel rod or string through the hole in the handle (or drill one closer to the ferrule) and suspend the bristles in the solvent or thinner so the bristles aren't bent under the weight of the brush (Photo 3-2). You can reduce solvent or thinner evaporation from the container by covering it with a plastic coffee-can lid. Cut a hole in the middle of the lid for the brush handle to pass through.

If the finish you're using is water base, you can clean your brush by washing it in a bucket of water. After removing most of the finish with water alone, wash the brush again in soap and water. If you're using any other type of finish, follow these steps:

1. Wash the brush in the proper solvent or thinner. Sometimes you can wash the brush successfully by squeezing it against the bottom of a container that has an inch or two of solvent or thinner in it. But you may have to swish the solvent or thinner through the bristles with your fingers to get the finish loose near the ferrule. Wear gloves when doing this.
2. Repeat Step I in clean solvent or thinner until the brush is almost clean.
3. Wash again, this time in lacquer thinner. Lacquer thinner will remove the oiliness left by mineral spirits thinner, and it will remove any remaining finish.
4. After each cleaning, remove the excess solvent or thinner by shaking the brush or holding it between the palms of both hands and twirling it inside an empty finish can.
5. Wash the brush in soap and water, running your fingers through the bristles to be sure there isn't any remaining finish stuck to them. (This step is optional. Many finishers don't like to put water on their brushes. Personally, I don't see that it does any harm, and it does clean the brush better.)
6. If the bristles aren't straight, comb them out with a brush comb, available at paint stores. (A fork will also work.)
7. If you use the brush solely for oil or varnish finishes, rub a couple of drops of a light oil, such as mineral oil, onto the bristles. The oil will help keep the bristles soft, but it will interfere with all other finishes, so don't apply oil to general-purpose brushes.
8. Wrap the brush in heavy, absorbent paper such as construction paper, a brown paper bag, or heavy paper towels. Hold the paper in place with a rubber band or masking tape (Photo 3-3). This step is very important for keeping the bristles straight and clean as they dry out.
9. Store the brush flat in a drawer or hang it from a hook.

Keeping brushes in good shape is more mental than physical (it takes only 5 or 10 minutes). Make cleaning your brush a part of your routine. You will feel so much better the next time you use the brush if it is soft and springy instead of stiff and difficult to work. If you keep a brush clean and the bristles straight, it will provide good service for years. Only when the flagged bristles wear off will you have to buy a new brush. Use your worn brushes for less exacting tasks, such as applying stripper.

RUBBING PADS

Rubbing pads are very useful tools for French polishing and padding, and for rubbing out finishes. Make your own rubbing pad with two pieces of cloth-an outer cloth that doesn't stretch and an inner cloth that will absorb and hold liquid. Tightly woven cheesecloth, cotton, or linen is best for the outer cloth. Loosely woven cheesecloth, T-shirt cotton, or sweater wool is best for the inner cloth. (Polyester and other synthetics don't work well for either the outer or inner cloth.) Wrap the outer cloth tightly around a wad of the inner cloth to make the pad, as shown in Photos 3-4, 3-5, 3-6. Draw the outer cloth tight during use to remove wrinkles from the bottom of the pad.

SPRAY GUNS AND EQUIPMENT '

A spray gun is the most efficient of the four tools for applying finishes. You can lay down an almost perfectly smooth and level coat of finish on a large surface in a short time. Spray guns shoot a stream of fluid that is broken up into a mist of tiny droplets by two jets of air coming out of the horns on the air nozzle. The droplets hit the wood and flow together to make a smooth film. The breaking up of the finish into droplets is called atomization. It's important that the atomization be thorough, or the droplets won't flow together well.

The trick to achieving proper atomization is getting the right amount of air striking the fluid as it comes out of the tip of the gun. If you have too little air, the atomization won't be great enough, and the finish won't flow together. It will cure looking like the surface of an orange; the effect is called orange peel If you have too much air, the finish will dry before it hits the wood, producing a dusty look. This is called dry spray. (See "Common Spraying Problems")

The two air jets that direct the atomizing air have an additional function. Because they are placed 180 degrees apart, in the horns of the air nozzle, they force the atomized air into an oval-shaped pattern called a fan. The fan is perpendicular to the line of the horns. By increasing the air flow through these jets, you widen the fan, so you can coat a wider area with each pass. By decreasing the airflow, you shrink the fan to a very small circular pattern, which you can use to fill in small defects (Figure 3-2). By rotating the air nozzle, you can change the angle of the fan relative to the gun.

Most spray guns have two control knobs on the back side of the gun (Figure 3-3). The lower knob sets the amount you can depress the trigger, and therefore how much finish will be discharged. The upper knob controls the amount of air discharged, and therefore the amount of atomization and the width of the fan. Some spray guns have only the knob that controls the trigger and finish discharge. The airflow is constant. These spray guns usually let you control the fan pattern by turning the air nozzle.

There are two common types of spray guns used in finishing, and two common sources of air to the guns:

- Conventional (low volume/high pressure) spray guns work with compressed air and blast the finish onto the wood at 25 to 80 psi (pounds per square inch).

- HVLP (high volume/low pressure) spray guns work with either compressed air or turbine air and lay the finish onto the wood softly at 4 to10 psi. These guns create much less overspray.

Conventional Spray Guns and Compressors

Conventional spray guns and compressors were developed around the turn of the century, and their design has changed little since then (Photo 3-7). Air is compressed in a holding tank and then fed through a hose, either directly to the spray gun or simultaneously to the spray gun and to a separate pressure pot that holds the finish or paint. When the air is fed directly to the gun, the air siphons the finishing material out of a cup, which is attached to the gun, by creating a vacuum in the fluid nozzle. When the air is fed through a pressure pot, the liquid material is pushed to the gun, where it is atomized by air supplied directly from the compressor. Pressure pots are used in high-production situations; cups are used for low production.

Conventional spray guns have proven their value during a century of use. They provide excellent control of the liquid material that reaches the surface. But they have one serious drawback: They are only about 20 to 30 percent efficient. This means that well over half of the material you're spraying is wasted: It goes into the air. (Some of this overspray settles back onto the finished surface, making it feel dusty or sandy.) This waste was tolerated until recently, when many states and localities began passing laws aimed at reducing the release of pollutants into the atmosphere.

HVLP

HVLP spray guns were developed more than 30 years ago but are only recently becoming popular. HVLP guns can work with either compressed air or continuous air supplied by a turbine. Either way, the result is a low-pressure spray that creates very little overspray. HVLP guns are 65 to 90 percent efficient, which means that most of the material you're spraying ends up on the wood.

There are two advantages to using a turbine over a compressor with an HVLP spray gun:

- A turbine passes a high volume of air directly to the gun at about 4 psi. A compressor generates much higher pressure at lower volume. In order to raise the volume enough to operate the HVLP gun, the high-pressure air must be sent through a regulator. This transforms the high pressure to high volume and low pressure. It takes a large, expensive 3- to 5-horsepower compressor to adequately supply an HVLP gun, compared to a small, inexpensive turbine.
- Turbines warm and dry the air, which speeds curing and helps reduce blushing (a moisture-related, off-white color that appears as some finishes cure).

There are also two advantages to using a compressor over a turbine:

- A compressor that is large enough (5-horsepower or larger) can generate more pressure at the gun than do commonly available turbines-up to 10 psi. This translates into more finish material being deposited onto the wood surface at a faster rate. The increase allows you to coat an object in less time. Turbinesupplied HVLP spray guns don't put out as much material as compressor-supplied HVLP guns or, for that matter, compressor-supplied conventional guns.
- A compressor can be used for other shop tasks, such as powering compressed-air woodworking tools and blowing dust off your work. Turbines are ineffective at these tasks.

Generally, amateurs and low-production shops use turbinesupplied air to run their HVLP spray guns (Photo 3-8). Often, large shops that have compressed air for other purposes will use it to run their guns.

Comparing Conventional and HVLP Spray Systems

Conventional spray guns continue to be used because the investment has already been made, and many people like to stick with tools they're used to. But HVLP guns and turbines are gaining favor, especially for low-production situations. If you are just starting out and don't already have a large compressor, I suggest you get an HVLP spray gun and run it with a turbine.

Whichever type spray gun or spray system you choose, deciding which specific one to buy is much like deciding on a woodworking machine tool. Generally, the more you pay the greater your possibilities for fine adjustment.

Using Spray Guns

There are three tricks for using a spray gun successfully.

- Use the fluid nozzle, air nozzle, and needle-valve stem sizes recommended by the manufacturer for the type of finish you're applying.
- Get optimum atomization of the finishing material.
- Use proper techniques for applying the finish to the wood.

Various sizes of fluid nozzles, air nozzles, and needle-valve stems are offered by most spray-gun manufacturers. Generally, the standard parts that come with your gun are appropriate for all types of clear finish. But you may need different sizes for paint or colored lacquers. Check with your supplier or the manufacturer.

Optimum atomization can be attained, as I've described on page 43, by manipulating the discharge ratio of finishing material to airflow. It can also be attained by using thinners. The thinner the fluid, the less air pressure it takes to atomize it.

Manufacturers of finishes often recommend the optimum viscosity for spraying their finishes. You can follow those recommendations for thinning the finish, or you can use the following rule of thumb::Thin the finish until the stream of liquid that runs off a stirring stick breaks cleanly into drops, and there's no longer any stringiness in the liquid. This viscosity will give you good results.

Proper spraying techniques are very logical. They take a little practice, but they're not hard to learn. Here are the basic principles for quality spraying:

- Plan a systematic spraying routine that will reduce waste and overspray. On a chair, for example, spray the insides of the legs and stretchers first, then work around the outside. Follow by spraying the back of the chair back, the arms and chair seat (if there are any), and then the front of the chair back. Always work from less visible to more visible areas.
- Arrange a light source above and in front of you so you can see what's happening by looking at the reflection in the surface.
- Keep the spray gun pointed perpendicular to the surface of the wood. Don't rock the gun from side to side, or you will get an uneven build (Figure 34).
- Set your gun to a fan pattern that covers the surface with the fewest passes and the least overspray. Use a small fan pattern on edges, rails, turnings, and other narrow surfaces. Use a wide fan pattern on large, wide surfaces.
- Begin spraying 6 inches to the side of the wood, and move the spray onto the wood. Keep moving at a uniform speed-about what you would use if you were brushing.
- Keep the gun a uniform distance from the surface of the wood between 6 and 10 inches. If you move it too close, you will make runs; move it too far away, and you will have dry spray. You usually have to hold an HVLP gun several inches closer to the wood than you do a conventional gun.
- Finish your stroke several inches past the edge of the wood. Make it a habit to release the trigger of the gun at the end of each stroke. Otherwise, you may deposit excessive amounts of finish in situations where the stroke doesn't go off the wood, such as where a stretcher joins a leg.
- Overlap each previous stroke by half. This will give an even thickness overall. This is especially critical when you're applying colored material. Uneven thickness will result in streaking.
- Spray the edges of tabletops or flat panels before you spray the top.
- Don't spray directly into inside corners. Spray each side of the corner instead.

- Don't be intimidated by stories you may hear about how hard it is to do good spraying. It's not. Learning to use a spray gun is no harder than learning to use a table saw or router. The first time you pull the trigger, you won't feel much control. Within an hour or so, you'll get comfortable.

Cleaning and Storing Spray Guns

Cleaning your spray gun thoroughly is very important. If you leave finish to harden in the gun, the gun will become unusable, and it may be very difficult to get it clean again. Follow these steps:

1. Spray solvent through the gun after each day of use, or anytime you won't be using the gun for several hours. This is especially critical with water base and varnish, which are difficult to remove once cured. The best solvent to use for all finishes is lacquer thinner.
2. Remove the air nozzle and needle-valve stem after each day of use. Store them in lacquer thinner solvent, or clean them and put them back in the gun.
3. Some finishers also like to remove the fluid nozzle and clean it. This step is especially important when you finish a project and won't be using your gun for a while.
4. If you're using a cup with the spray gun, clean the cup thoroughly, including the gasket. Be sure to keep the air inlet hole at the top of the cup clean and open at all times. The spray gun will sputter if this hole gets clogged with finish. If you're spraying finish through a pressure pot, clean it and the hose thoroughly.

Where to Spray

You can spray in a garage with the doors open, or outdoors, preferably in the shade when there's a very slight breeze. Or you can spray indoors with an exhaust system to remove the fumes and overspray. The best setup for indoors is a spray booth, which exhausts the air through a filter that catches all the solid finish particles. Don't use a fan in a window unless it is an explosion-proof fan, which has a shielded motor. Otherwise, sparks from the motor might ignite lacquer and varnish fumes; also, the solid particles from your overspray will build up on the fan's electrical components, increasing the fire hazard.

OIL FINISHES

In the last few decades, oil finishes have become among the most popular finishes used by woodworkers. This is partly due to the pleasing, close-to-the-wood look that oil finishes produce. But it is primarily due to how easy they are to apply. In most cases all you have to do is wipe on and then wipe off a couple of coats. (See "Applying 'Oil' Finishes – A, B")In spite of the ease of application (or maybe because of it) there is a great deal of confusion about oil finishes. Here are some of the most commonly asked questions about oil finishes:

- Does oil protect as well from inside the wood as other finishes do on the surface of the wood?
- Is it better to rub the oil into the wood?
- Do more coats produce more gloss?
- Is boiled linseed oil made by boiling raw linseed oil? Can you make your own?
- Is tung oil better than linseed oil?
- What is Danish oil or teak oil? Moreover, what is antique oil or Val-Oil?
- What is the best way to maintain an oil finish?

To answer these questions-to know what to expect from oil finishes and how to choose between them-you need to overcome three prevalent myths. These myths are perpetuated in books, articles, and manufacturers' advertising. Even if you are new to woodworking and are not familiar with these myths, you will no doubt encounter them. They need to be debunked.

MYTH # 1: Oil finishes were the favored wood finish used by our eighteenth- and nineteenth-century predecessors.
FACT. There's no evidence at all that oil was a well-regarded finish until the rapid growth of the consumer market beginning in the 1960s.

MYTH #2: Oil finishes penetrate into the wood and protect the wood from the inside.
FACT: The penetrating qualities of oil finishes are of very little significance in protecting wood.

MYTH #3: All finishes sold as "oil" are some type of oil.
FACT. There are four significantly different types of finish that are sold as "oil." Not all are oil.

OUR ANCESTORS AND LINSEED OIL

One of the primary rationalizations for using oil as a finish is that eighteenth- and nineteenth-century craftspeople used and valued oil for finishing-specifically, linseed oil. If you've done much woodworking, you've surely developed a profound respect for our ancestors' woodworking skills. It's not a big jump to assume that if these craftspeople were so good at woodworking, they must also have been good finishers. And if they used linseed oil, they must have chosen to do so because linseed oil made a great finish.

The idea that our forebears were skilled finishers pops up now and then in woodworking books and articles. It's often bolstered by the suggestion that if you follow their practice of rubbing coats of linseed oil into the wood once a day for a week, once a week for a month, once a month for a year, and then once every year thereafter, you will produce one of the most beautiful and durable finishes possible-maybe even better than anything that has been invented since.

This is all myth:

- It's myth that our ancestors thought linseed oil was a great finish. They used linseed oil, of course. It was cheap, compared to other finishes, and it was available. But there is no evidence from surviving records, such as cabinetmakers' account books, that linseed oil was well thought of as a finish. On the contrary, most of the finer, eighteenth-century, city-made furniture, and almost all nineteenth-century, factory-made furniture, was finished with shellac or varnish.
- It's myth that our predecessors expended much effort applying linseed oil when they did use it. Rubbing linseed oil into the wood does absolutely no good. There is some mention in cabinetmakers' account books of rubbing linseed oil, in combination with brick dust or pumice, to fill the pores of wood. But you have to get into the twentieth century before you find written reference to anyone in the eighteenth century rubbing oil alone into wood. (How could the writers have known?)
- It's myth that linseed oil applied in any manner is a durable finish. A linseed oil finish is too thin and soft to protect well against heat, stains, or wear. And linseed oil, no matter how you apply it, or how many coats you apply, is quickly and easily penetrated by water and water vapor.
- It's even myth that eighteenth- and nineteenth-century woodworkers were skilled finishers by today's standards. Surviving cabinetmakers' account books indicate that only minimal attention was given to finishing wood. Finishing is a twentieth century craft.

So the fact that our predecessors used oil now and then as a finish is no reason for us to use oil-especially linseed oil. They used linseed oil when they had nothing better. We have an entire array of finishes that are better in almost every way.

OIL FINISHES AND PENETRATION

Oil finishes are penetrating finishes, and they are sometimes marketed as protecting the wood from the inside. They are contrasted with film finishes, such as shellac, lacquer, varnish, and water base, which protect the wood by building a film on the surface of the wood. To assess the accuracy of the claim that penetrating finishes protect from the inside, you need to understand how penetration occurs and what value it has (or does not have) in protecting the wood.

Liquids penetrate wood by means of capillary action. It's the same way that water and nutrients rise in the live tree. It doesn't matter whether the liquid is on top, on the side, or on the bottom of the wood. If it is in contact with the wood, the liquid will work its way through the wood channels.

The trick to achieving deep penetration is to keep the surface of the wood wet for a while. You can put a straight-grained piece of wood into a jar containing about an inch of oil finish, and the finish will work its way up through the wood and come out the top. Only if the finish cures hard in the wood, preventing further penetration, or if it hardens in the jar, will penetration stop (Photo 4-1).

But what good does penetration do? Very little. You can totally fill a piece of wood with a linseed oil finish, and it will do nothing to protect the surface (See A, B) of the wood from damage. Coarse objects will scratch the wood, stains will stain the wood, and water will smudge the wood almost as easily as if there were no finish in the wood. The only possible advantage gained by filling the wood with finish is to stabilize the wood from shrinkage and swelling caused by water-vapor exchange. You plasticize the wood by filling all the cavities with cured finish. But if you are looking for a finish to provide protection to the surface, the amount that a finish penetrates is of no significance. (See "How Oil and Oil/Varnish Finishes Protect")

TYPES OF "OIL”

Much of the confusion about oil is generated by the marketplace, which offers four significantly different finishes, all called oil:

- Straight oil, of which there are two principal kinds-tung oil and linseed oil. Tung oil is usually sold as "pure” or "100 percent" tung oil or "China wood oil." Linseed oil comes in two forms, raw and boiled.
- Poiymerized oil, of which there are two principal kinds-polymerized tung oil and polymerized linseed oil. Polymerized oils perform more like varnish than like straight oil. They are expensive and not widely available.
- Regular varnish (including polyurethane) that has been thinned with two to three parts mineral spirits to one part varnish. This finish is often sold as oil but is actually a wiping varnish.
- A blend of straight oil and varnish (including polyurethane). This oil/varnish mixture is often sold as Danish oil.

These "oil" finishes look different: They range from glossy to flat, and from very thin on the wood to quite thick. They perform differently: Some are very effective barriers against scratches, stains, water, and water-vapor exchange, while others aren't. And they can be applied differently: Some can be left wet on the wood, others have to be wiped almost dry. (See Photo 4-2 and "Guide to 'Oil' Finishes")

Straight Oil

Oil is a natural substance that is extracted from plants, nuts, fish, and petroleum. Some oils, such as linseed oil and tung oil, cure- they change from a liquid to a solid by absorbing oxygen from the air. Linseed oil absorbs so much oxygen when it cures that its weight increases as much as 12 percent. Oils that cure can be used as finishes. Other oils, such as mineral oil, olive oil, and motor oil, don't absorb oxygen and therefore don't cure. Because they don't solidify, they are ineffective as finishes. Still other oils, such as walnut oil, soybean oil, and safflower oil, are semi-curing: They cure very slowly and never very hard. They are only marginally effective as finishes. (See "Safety and Oil Finishes")

Straight oils used as finishes have certain characteristics in common. They cure slowly compared to every other finish, and they cure to a satin (not glossy) sheen after you apply several coats. They also cure soft. This makes them impractical for use as finishes unless you wipe off the excess after each application. Straight-oil finishes are true penetrating finishes. You can't build a thick, hard, protective film on the surface of the wood the way you can with film finishes. If you have some cured overspill around the top of a can of linseed oil or tung oil, push your fingernail into it and notice how soft it is compared to other finishes.

Linseed oil is extracted from seeds of the flax plant. This oil, in its raw state, is an inefficient finish because it takes many days to cure. So, to make it more effective, metallic driers are added. These driers are usually salts of cobalt, manganese, or zinc. They act as catalysts to speed the curing. (Lead was once used as a drier but is no longer, because it is a health hazard.) With driers added, linseed oil cures in about a day and is called "boiled" linseed oil. Unless you want an oil that cures very slowly, there's no reason to use raw linseed oil.

Of all finishes except wax, linseed oil is the least protective. (See "Using Wax as a Finish") It's a soft, thin finish, so it provides no significant barrier against scratching. It's also easily penetrated by water and water vapor. Liquid water will work through a linseed oil finish and cause a smudge within 5 to 10 seconds (Photo 4-3). Water vapor will pass through a linseed oil finish almost as if it weren't there.

You may find it interesting that old paints based on linseed oil performed well precisely because water vapor could pass through so easily. These paints allowed moisture to escape through the walls of houses without blistering the paint film. Modern alkyd-based paints blister easily because they form a much better barrier to water-vapor exchange. This is why water-based, latex paint is recommended for use on the outsides of houses. Like linseed oil-based paint, latex paint "breathes."

Tung oil is extracted from nuts of the tung tree, which is native to China. Tung oil has been used for centuries in China, but it was not introduced into the West until the very end of the nineteenth century. It is now cultivated in South America. Though tung oil is more expensive than linseed oil, tung oil has established a firm position in the paint and coatings industry because it is one of the most water-resistant oils. Many high-quality varnishes are made with tung oil. But, contrary to what you might think, tung oil is seldom used as a finish in its own right.

Tung oil can be made fairly water-resistant after five or six coats. But it is too soft and thin to resist scratching or water-vapor exchange, and it is difficult to make the finish look nice. The first three or four coats appear flat and splotchy on the wood and feel rough to the touch. Only after five or six coats, sanding between each coat, can you get an even, satin sheen. But the finish is still not as smooth to the touch as linseed oil.

In addition, tung oil cures very slowly, and it turns white if left to cure in any thickness. The curing is faster than raw linseed oil but slower than boiled linseed oil, so you need to wait several days between coats. This makes tung oil an inefficient finish to use. The white color can cause problems in large pores and cracks in the wood. There is no way to remove the white color if it occurs, short of stripping the wood and starting all over.

About the only advantage tung oil has over linseed oil, other than better water resistance after five or six coats, is that tung oil yellows less than linseed oil. This can be important on blonde woods that you don't want to darken too much.

Polymerized Oil

Any curing or semi-curing oil can be heated in an oxygen-free environment to around 500 degrees Fahrenheit to increase its gloss and hardness and reduce its curing time. Oil processed in this manner is called polymerized or heat-bodied oil. Polymerized oil is commmonly used in ink and outdoor paint.

Polymerized oil is sometimes used as a finish by itself. It cures very fast and very hard and resists water and water-vapor penetration. Many gun owners like the results they get when they rub this oil (usually sold by other names, such as Tru-Oil) onto their gun stocks. Because the oil is hard when cured, its possible to build a film from many thin coats.

There are two problems with using polymerized oil as a finish on large surfaces such as furniture: It's expensive, and it cures too fast to be applied and wiped off unless it has been thinned a lot with mineral spirits. (You can't apply polymerized oil in thick layers as you can varnish, or tiny cracks will develop in the cured film.) Besides, there's no evidence that polymerized oil protects significantly better than varnish. For these reasons polymerized oil is not widely used as a furniture finish.

Wiping Varnish

Most of the "oil" finishes you see on store shelves are varnishes that have been thinned enough so you can wipe them on the wood. Many of these wiping varnishes have names that lead you to believe they are oil. They're not oil, they're varnish. There's a big difference between oil and varnish.

I've described oil above. Varnish is made by cooking one or more oils with natural or synthetic resins. The heat causes the oil and resin to combine chemically, forming an entirely new substance. Manufacturers use linseed oil and tung oil, or semi-curing oils such as soybean oil and safflower oil. They once used natural resins (fossilized sap of pine trees) that were imported from Africa and New Zealand. Now, most varnishes are made from synthetic resins such as alkyd, phenolic, and polyurethane. (For more on these resins, see "Varnish.")

Varnish cures much faster than oil. It also cures glossy (unless the manufacturer adds flatting agents to give a satin or flat sheen). And it is hard when cured (again, check the overspill around the caps of your cans of varnish or wiping varnish).

The most important difference is the hardness. This permits you to build up varnish in relatively thick coats to a significant film on the surface of the wood. When varnish is built up, it protects the wood from all but the most severe scratches, and it forms an excellent barrier against stains, water, and water-vapor exchange. Though it might be easier to wipe on a thinned varnish than it is to brush on an unthinned varnish, it will take many more coats to achieve the same thickness and therefore the same amount of protection.

Wiping varnishes vary in hardness and water resistance, depending on the types and ratios of resins and oils used to make the varnish. But no wiping varnish I know of lists these variables on the container. For wipe-on/wipe-off applications, it probably doesn't matter what quality the varnish is-the film is too thin. But it does matter if you intend to build the varnish to a thicker film on the surface of the wood. You don't want a soft varnish film on a heavily used surface such as a tabletop, for example. So, in some cases, you may be wise to buy the type and quality of varnish you want and thin it yourself. (For an explanation of the differences, see Chapter 10: "Varnish.")

The amount of thinner used varies. But most brands of common wiping varnishes contain at least 2 parts mineral spirits to 1 part varnish.

Oil / Varnish Blends

Oil and varnish (including polyurethane) are compatible, so they can be mixed. The resulting finish performs with some of the characteristics of each. The oil part of the blend reduces the gloss and makes the finish cure slowly. Application is therefore easy because you have plenty of time. But the oil also makes the finish cure soft (again, test the overspill around the container spout of your oil/varnish blend). This means you can't build oil/varnish blends to a more protective thickness. The varnish part of the blend gives the finish more body and more gloss. As a result, you can achieve an even satin sheen with only two coats instead of the three to six it usually takes with straight oil. The varnish also makes the oil/varnish blend more protective than straight oil, because varnish is harder when cured and more water- and water-vapor-resistant than oil.

As you would expect, not all mixtures of oil and varnish give the same protection. Some combinations are better than others, though the differences are often too subtle to detect. Since store-bought blends seldom tell you the types or ratios of oil and varnish used, many woodworkers have chosen to make their own.

There are many variables, but the following generalizations should help you decide on a formula:

- The higher the varnish-to-oil ratio, the better the scratch, water, water-vapor, and stain resistance. But if you get the percentage of varnish too high, you will lose some ease of application. A ratio of 90 percent varnish to 10 percent oil, for instance, will perform very much like varnish alone. Begin by mixing half and-half, and vary the formulation from there.
- Using tung oil rather than linseed oil in the mixture will make the finish significantly more water-resistant. But the higher the percentage of tung oil you use, the more coats it will take to achieve an even, satin sheen.
- Though there are significant differences in the protective qualities of the various varnishes you might use, the differences are difficult to detect when the film is thin. Your choice of varnish is not as significant as your choice of oil.
- You can thin any blend with mineral spirits. This will make the oil/varnish mixture easier to spread over large surfaces. But it will also thin the coating, so it won't stop up the pores as well on the first application. And it will increase the likelihood of bleeding. (See "Bleeding Oil Finishes – A, B")

WHICH ONE IS WHICH?

Manufacturers use the name "tung oil" on all four types of "oil" finish. They also use nondescript names such as Antique Oil, Val-Oil, Profin, and Seal-a-Cell. In most cases, when you buy an "oil" finish, you don't know what you're getting. You need to know how to tell which you have.

Straight oils- linseed oil and tung oil-have distinct smells. Once you've smelled one of these oils, you will always be able to recognize it. Both are nutty smells. Tung oil is sweeter-smelling than linseed oil, which is more pungent.

Most polymerized oils, wiping varnishes, and oil/varnish blends smell like mineral spirits, because they contain a significant percentage of mineral spirits. This means smell won't aid in distinguishing them. I don't know any way to tell if you have a polymerized oil unless the container tells you. (This is probably not a problem since there are so few on the market.)

But there are three indicators you can look for to tell whether you have a wiping varnish or an oil/varnish blend:

- How fast the finish cures. Oil/varnish blends cure slowly. They can take up to an hour or more to become tacky, depending on the ratio of oil to varnish. Wiping varnish becomes tacky in 20 minutes or less. (Times will vary depending on temperatureand humidity.)
- Whether the finish is hard when cured. Wiping varnish cures hard. Oil/varnish blends cure soft enough to dig your fingernail into, especially if the film is thick.
- Whether the finish wrinkles severely when it cures thick. Any finish containing oil (10 percent or more oil-to-varnish ratio) will wrinkle when it cures in a thick film. Varnish won't wrinkle unless the film is exceptionally thick (Photo 4-5). (See also "How to Tell Which Oil You Have”)

Additional Confusion

The confusion about oil finishes doesn't stop with the four types. Some manufacturers market different "oils" for different woods. I saw the most outrageous example of this marketing ploy in a furniture store in Denmark. The store had an entire cabinet full of 2 ounce bottles of teak oil, rosewood oil, walnut oil, oak oil, birch oil, ash oil-a special oil for every type of wood furniture the store carried. Customers were instructed to use only the proper oil on each of the woods in their house!

Teak oil creates the greatest confusion. There are at least three different types of finish that are sold in the United States as "teak oil." There is mineral oil, which doesn't cure. There is a mix of wax and mineral oil, which also doesn't cure. And there is a mix of linseed oil and varnish, which does cure. The teak oil that is sold by Watco, Behlen, and most Scandinavian furniture stores is this third kind. This "oil" is essentially the same as other oil / varnish blends. None have anything added to make them better suited for teak or other oily woods.

Oily woods, such as teak, rosewood, cocobolo, and ebony, present a problem in finishing because the wood's natural oil inhibits the curing of oil and varnish finishes. (The oil also prevents other finishes, such as lacquer and water base, from establishing a good bond with the wood.) Since no "oil" finish contains anything to counteract the problems caused by wood's oil, it's usually best to wipe the wood down with a fast-evaporating solvent, such as naphtha, acetone, or lacquer thinner, before applying the finish. The solvent temporarily removes the wood's oil from the surface of the wood. The finish then has time to bond well and cure thoroughly before more of the wood's oil seeps back to the surface.

Choosing an "Oil' Finish

With so many different types of oil, how do you choose which one to use? Of the four types of "oil," two can be eliminated from consideration: straight oil and polymerized oil. Neither of the two straight oils-linseed oil or tung oil-performs well, so it would be rare that you would want to use one of these. Polymerized oil performs well, but it is expensive, is not widely available, and offers no advantage over wiping varnish (with the possible exception of an unthinned variety used on small objects such as gun stocks because it cures so quickly).

That leaves oil/varnish blend and wiping varnish. Oil/varnish blend is the easier of the two to use, because you have plenty of time to apply it and get the excess wiped off. Oil/varnish blend also produces a pleasing satin sheen that is very popular. But it doesn't protect the wood very well against water, water-vapor exchange, or wear. Oil/varnish blend should be your choice when protection is not of primary importance and you want maximum ease of application and a satin ("rubbed") appearance. Oil/varnish blend is a poor choice for a tabletop, for example, but might be used on a rocking chair, bed, or decorative object.

Wiping varnish is more difficult to apply than oil/varnish blend because it cures much faster. You have less time before it begins to set up. Also, if you choose to build a thicker film on the wood by not wiping off all the excess, you will have problems with dust settling on and becoming embedded in the finish-just as with unthinned varnish. Wiping varnish produces a glossy sheen unless you use a brand that is made to cure to a satin sheen (in which case you should stir or shake the finish before using), or unless you buff out the gloss with fine steel wool or synthetic steel wool (Scotch-Brite) after the finish has cured. Wiping varnish should be your choice if you want a gloss sheen, or if you want to build a thicker film on the wood. (See "Guide to 'Oil' Finishes")

HOW TO MAINTAIN AND REPAIR "OIL” FINISHES

Maintaining a thin, wiped-on/wiped-off "oil" finish is usually more critical than maintaining any other finish except wax. Even slight wear will create voids in the film, leaving bare wood exposed to spills. The best way to maintain a thin "oil" finish is to recoat it now and then, anytime it begins to look a little dry or show wear. Recoating can be done with the same finish you used originally, or with any other "oil" finish.

"Oil" finishes can also be maintained with paste wax. Paste wax will raise the sheen of a dull surface and will reduce scratching significantly by making the surface slick. But once you've used wax, you should remove it with mineral spirits before applying another coat of finish. Otherwise, the finish will cure softer and srfiudge easier. (For more on using wax to maintain finishes, see Chapter 15: "Caring for the Finish.")

Woodworkers often cite the easy repairability of "oil" finishes as one of their primary advantages. Repairing a thin finish is often successful precisely because of its thinness. When you wipe another coat of finish over the surface, it penetrates and darkens all scratches. Unless the scratches are severe, the new coat often disguises them

(Photo 4-6). But the scratches haven't disappeared: The finish has blended in the color. Any finish can be repaired equally well if it is thin enough.

The problems that are difficult to repair in "oil" finishes are water smudges and color differences. Water smudges usually raise the grain of the wood, creating a visually different texture than the surrounding wood. Applying a coat of finish to the smudge seldom removes it from view. It usually helps to rub the surface with steel wool or to sand it lightly with 400- or 600-grit sandpaper and then apply more finish. (You can also apply more finish and then rub or sand while the finish is still wet.) If this doesn't remove the smudge, continue applying more coats of finish to the damaged area until the two sheens blend.

Color differences can be caused by heat or spills staining the wood, or by removal of patina (changing the color of the wood itself), or by eliminating the original stain. You can remove heat or burn stains only by sanding through the damage. You can sometimes bleach out spill stains with oxalic acid or household bleach (see "Bleaching Wood"). You can sometimes fake patina with stain or bleach. And you can sometimes replace the original stain successfully. All of these problems can be difficult to repair to perfection. (For more on repairing finishes, see Chapter 16: "Repairing Finishes.")

If you realize, after you've applied the finish, that one piece of wood or a part of a piece of wood is lighter than the rest, you can darken it with any dye stain that uses alcohol or lacquer thinner as a solvent. (See Chapter 5: "Staining Wood.") The solvent/dye solution will bite into the finish enough so that you won't remove the color when you wipe on and wipe off the next coat of finish.

STAINING WOOD

Of all the steps in finishing, staining causes the most problems. Because of such difficulties as splotching, streaking, color unevenness, and incompatibility between stain and finish, many woodworkers avoid the use of stains altogether. I'm convinced that the popularity of the "natural wood look" among woodworkers is at least partly because they think stains are difficult to use.

Used properly, though, stains beautify wood, and they solve problems rather than create them. Stains add richness, depth, and color to wood. They help disguise problem areas and smooth color variations between different boards, and between heartwood and sapwood in the same board. They even allow you to make cheap, uninteresting woods like poplar and soft maple resemble higher-quality woods like walnut and mahogany (Photo 5-1).

You probably think of staining as simply applying a colored liquid to bare wood. Staining is this, but it is also much more. It includes glazing, toning, and shading, all ways of applying a colorant so that you can still see the wood through the color.

Unfortunately, most books treat glazing, toning, and shading as specialized techniques, not as part of staining. This obscures their real value for solving problems. Often, applying stain directly to wood just won't produce the look you want, while glazing, toning, or shading will. Therefore, I'm treating these operations in this chapter, so you will see how they complement staining.

Most likely, you choose a stain for its color. You're probably not thinking about other important considerations, such as what the stain is made of, how fast it dries, or how it will behave on the wood. Manufacturers don't make it easy to find out what is in their stains, or what you can expect from them. Reading the can won't tell you what to expect-except, of course, "professional results."

This is unfortunate because ignoring the differences in stains can lead to results you don't want. Some stains, such as Watco and Minwax, penetrate deep into the wood; others, such as WoodKote and Bartley, very little.

Some stains, such as Behlen 15 Minute, dry fast; others, such as Red Devil, slowly. Some stains, such as Carver Tripp Safe and Simple, raise the grain of the wood; others, such as Carver Tripp Wood Stain, don't. If you've done much staining, you've surely noticed some of these differences.

Woods also differ, and stains act differently on different woods. Some woods, such as mahogany, look nice with any stain. Other woods, such as pine, present problems no matter which stain you use. But no wood is consistent in color, porosity, or density; therefore different pieces of the same species and even different parts of the same board may stain differently. In addition, veneered plywood usually stains lighter than solid wood because the veneer is so thin, and the glue blocks deep penetration.

Most staining problems aren't caused by the way you apply the stain. They're caused by choosing the wrong stain for the effect you're after or by peculiarities in the wood. If you are going to use stains successfully, you need to understand how various stains and woods interact (Photos 5-2, 5-3, and 5-4; see also "Common Staining Problems, Their Causes, and Solutions – A, B, C, D).

UNDERSTANDING STAINS

There are a number of ways to classify stains. Understanding the ingredients, their properties, and how they interact helps in predicting how a stain will perform. (See "What Makes a Stain" and "A Guide to Stains") Here are the things that make a difference:

- Colorant-is it a pigment or a dye?
- Binder-is it an oil-, varnish-, lacquer-, or water-based finish?
- Thickness-is it a liquid or a gel?

Pigment

Pigment is finely ground solid, colored particles that resemble colored earth. Until recently, all pigment actually was colored earth, mined in various parts of Europe and America. Now, most pigments are synthetic. Since pigment is opaque, it is used as the colorant in paint. When you pile enough pigment particles on top of each other, you can no longer see through to the wood. Because pigment is heavier than the liquid it is suspended in, pigment particles settle to the bottom of the container and have to be stirred back into suspension before use. Most manufactured stains are made with pigment.

Pigment colors wood by lodging in depressions, such as pores, scratches, and gouges. The larger the cavity, the greater the amount of pigment that will lodge there, and the darker and more opaque the cavity becomes. This is why pigment stains highlight large pores, gouges, and cross-grain sanding scratches (Photos 5-5 and 5-6). (Pigment lodged in sanding scratches running in the direction of the grain is usually difficult to distinguish from the grain itself.)

Pigment can also color wood by building to a thickness on the surface. Building occurs when you don't wipe off all the excess stain, and it is equivalent to painting the wood with a thinned paint. You can control how much you obscure the wood by how much pigment you leave on the surface. Some stains, such as Behlen 15 Minute, dry rapidly and are difficult to wipe off entirely. Not removing all the excess pigment stain can produce a more even color, like paint, but the wood doesn't show through.

Dye

The coloring in coffee, tea, berries, and walnut husks is dye. These and other natural materials such as logwood, alkanet root, cochineal, and dragon's blood were once used to dye wood. (Chemicals are also used; see "Bleaching Wood- A, B" and "Chemical Stains") Now, far superior, synthetic aniline dyes are available. Aniline dyes are made from aniline and related chemicals. Aniline is derived from petroleum. These dyes were developed in the late nineteenth century and quickly came to dominate the dye industry because of their greater range of colors, ease of use, and better resistance to fading (lightfastness).

Dye is molecular. Each individual unit of dye is a molecule. In contrast to pigment, which colors wood by lodging in crevices, dye colors wood by saturating the wood fibers with color. Dye molecules, much tinier than pigment particles, penetrate into the very composition of the wood (Figure 5-1).

Unlike pigment particles, dye molecules adhere to the wood on their own. Dye does not require a separate binder to glue it to the wood as pigment does. All that is necessary is a solvent to put the dye into solution. Once dye is dissolved in the solvent, it doesn't settle out-even after years of sitting on the shelf.

Because dye is a soluble colorant, it can be redissolved by its solvent long after it has been applied to the wood. This can be an advantage, allowing you to lighten the color of the dye or change it to another color after you've applied it to the wood. Simply apply more solvent or another color dissolved in the same solvent and wipe off the excess. On the other hand, this characteristic can be a disadvantage. If your finish contains the solvent for the dye, the finish will redissolve the dye, causing it to smear or bleed into the finish. (See "Using Aniline Dyes- A, B, C ")

There are literally thousands of dyes synthesized from aniline and related chemicals. Each of these dyes dissolves naturally in a solvent. Some dyes dissolve in water, some in alcohol, some in mineral spirits or lacquer thinner. (See "What Makes a Stain") The dyes are usually sold in powder form and are labeled according to their solvent: "water," "alcohol," or "oil." (Those that dissolve in mineral spirits or lacquer thinner are called oil-soluble dyes.) Make your own stains by mixing the powder with the appropriate solvent or with a finish that is compatible with the dye solvent-water dye with water-based finish; alcohol dye with shellac; oil dye with oil, varnish, or lacquer.

Generally speaking, water-soluble dyes are the most lightfast of the three types. Lightfastness is an important quality, because it means the colors will remain true longer. As a result, alcohol and oil-soluble dyes are not as popular. Also, water-soluble dyes are the slowest drying, so you have more time to remove the excess stain (but longer to wait before going on to your next step). The slow drying allows the dye to penetrate deeper, bringing out more richness and depth in the wood.

The use of water as the solvent in water-soluble dyes makes these dyes cheap, devoid of toxic fumes, non-flammable, and nonpolluting to the atmosphere. But water raises the grain of the wood. In order to get around this problem, chemists have come up with a way of dissolving these dyes without using water. They first dissolve the dye in a special solvent called glycol ether. (See "Glycol Ether") Then they thin the solution with alcohol and lacquer thinner. You buy these dyes as non-grain-raising (NGR) dyes. They almost always come in liquid form. You can thin them with more alcohol or lacquer thinner. You can also add them to water-based finish, shellac, or lacquer to make these finishes into colored stains or toners. (See "Shading Stains and Toners")

Dissolving water-soluble dyes in a solvent minimizes grain raising and preserves the dye's lightfastness, but it nullifies the advantages of cheapness and safety. (Dyes dissolved in lacquer thinner, mineral spirits, or alcohol also raise the grain minimally or not at all. But they aren't called non-grain-raising stains.)

You can buy aniline dyes in pure colors or wood tones. If you want a wood-tone color and you aren't experienced at mixing colors, I suggest you stay away from the pure colors. It is not easy to create the color of walnut from red, yellow, and black. (See "Matching Color")

Dyes versus Pigments

There are three significant differences between dye and pigment:

- Dye is transparent; pigment is opaque (Photo 5-11; see also "Ebonizing Wood").
- Dye penetrates everywhere more or less equally. Pigment lodges only in places that are large enough to hold it (Photo 5-2).

- Dye, dissolved in a solvent, is much easier than pigment stain to lighten, darken, or change to another color after it has been applied to the wood (Photo 5-9).

Some stains contain both pigment and dye. These stains must include a binder to glue the pigment to the wood. Many woodworkers like this type of stain because the dye colors dense woods or dense parts of wood that the pigment doesn't (Photo 5-13).

Manufacturers seldom tell you what type of colorant-pigment or dye-they use. You can tell a stain contains pigment if sediment settles to the bottom of the can. You can tell a stain contains dye if after all pigment (if any) has settled to the bottom, the liquid portion will color a light piece of wood.

Some manufacturers confuse the difference between Pigment and dye stains when they market pigment stains as "penetrating" stains. Pigment doesn't actually penetrate into the wood fibers; it lodges in depressions such as pores and scratches. Dye is a true penetrating stain, because it saturates the wood fibers.

Binder

Binder is the glue that holds pigment particles to the wood (Figure 5-2). Without binder, the particles could be brushed or blown off the wood like dust once the solvent evaporated. All binders are one of the four common finishes: oil, varnish, lacquer, or water base.

You can make your own stain by mixing some pigment with the appropriate binder and thinning if necessary: Use ground-in oil pigment with oil or varnish. Use artists' acrylic colors with water-based finishes. Use universal-tinting pigment with oil, varnish, lacquer, or water-based finishes.

The choice of binder doesn't affect the way the stain looks on the wood. The binder determines how much time you have to wipe off excess stain. Oil binder cures slowly. Varnish and waterbased binders cure moderately quickly. Lacquer binder cures rapidly. (Some "lacquer" stains are actually based on a very short-oil varnish, which is explained in Chapter 10: "Varnish." Since these stains act just like lacquer stains and are usually referred to as lacquer stains in the finishing trade, it's easier to lump the two together.) Temperature and humidity affect the curing time of each of these stains. The higher the temperature and the lower the humidity, the faster the stain will cure. (For more on how these finishes cure, see the chapters on these specific finishes.)

Manufacturers seldom tell you which binder they are using, but they usually provide clues on the container:

- Stains using an oil or varnish binder list mineral spirits (petroleum distillate) as a thinner or clean-up solvent.
- Stains using a lacquer (or short-oil varnish) binder list lacquer thinner (or xylene) as a thinner or clean-up solvent.
- Stains using water-based acrylic or emulsified oil list water as the thinner or clean-up solvent.

It doesn't matter whether the water-based binder is acrylic or emulsified oil. I can't tell any difference between them in drying time. But what is important is whether the binder is oil or varnish. Oil cures much more slowly than varnish. (Mixtures of oil and varnish cure slowly like oil, so I treat them as oil for the purpose of understanding stains.) It's rare that manufacturers give you enough information to determine whether the binder is oil or varnish. You can look for clues such as "Allow overnight for drying," which indicates oil, or "Can be coated over within several hours," which indicates varnish. The instructions also imply how much time you have to remove excess stain. If the manufacturer instructs you to wait overnight before applying a finish, you have more time to remove the excess than if the manufacturer requires only two hours before applying a finish. The less time the manufacturer suggests to wait before applying a finish, the more quickly you must remove the excess.

If there are no clues and you want to know which you have before using the stain, pour a puddle of stain onto a piece of glass; let the puddle cure overnight. If it cures soft and wrinkled, the binder is oil. If it cures hard and smooth, the binder is varnish. (For more information on the difference between the way oil and varnish cure, see Chapter 4: "Oil Finishes.")

Some stains contain a much higher ratio of binder to pigment. These stains often are sold as a combined stain and finish (for example, Minwax Polyshades). When using these stains, there is no reason to wipe off the excess because the point is to get a build on the wood. You should treat these stains as thinned paint, because that is what they are.

Solvents and Thinners

Solvents and thinners make it possible to apply dyes and pigment stains. Solvents are used in dye stains to put the powder dye into solution. Thinners are used in pigment stains to thin the binder so the stain is easy to apply to the wood. Each dye and each binder has a specific solvent or thinner that is appropriate for it. Other solvents or thinners won't work. You need to learn which goes with which. (See "Compatibility of Stains and Finishes") The term "vehicle," which sometimes appears on cans, indicates a binder and thinner combined. The vehicle is the entire liquid portion of the stain.

Since each solvent or thinner is tied to a particular dye or binder, you have little control over which solvent or thinner to use once you've chosen the dye or binder (see "Solvents and Thinners for Dyes and Stains," below). Dyes that use water as a solvent, and water-based binders that use water as a thinner, present a problem in that the water raises the grain of the wood. To get a smooth finish with either of these types of stain, you usually have to sponge and sand the wood before applying the stain. (See "Sponging") If you apply the stain and then try to smooth the raised grain with sandpaper, you may cut through the stain and create light spots.

Thickness

The thickness of stains varies. Most stains are liquid, but some are thicker and usually are sold as gel or paste stains. Gel stains are a relatively recent innovation. Most gel stains are made with pigment in a varnish binder. Some gel stains use dye in a varnish or water-based binder. All gel stains are unique in that they don't flow. You can sometimes turn an open can of gel stain upside down, and the stain won't come out. Gel stain doesn't flow because it is made with a thixotropic agent that resists flow unless it is mechanically disturbed. Ketchup is an example of a thixotropic substance. You have to shake the bottle to get the ketchup out. When it hits your food, it remains as it landed until you spread it with your knife.

Marketers of gel stains usually tout them for their no-drip property. This property may appeal to you if you are worried about dripping stain on your workshop or garage floor. But it is not the main reason for choosing a gel stain over other stains. The main reason to use (or not to use) a gel stain is that it penetrates the wood much less than liquid stains.

On problem woods such as pine, birch, and cherry, reduced stain penetration means reduced splotching (Photo 5-14). It also means you'll get less contrast between side grain and end grain on carvings, turnings, and other objects that feature the two grain orientations. And though it's a minor point, reduced stain penetration means greater coverage, because less stain is absorbed into the wood. This means you'll have less stain to buy for a given job.

On the other hand, when you're working with highly figured woods, such as burls, curly maple, or mottled mahogany, you usually want maximum stain penetration to emphasize depth and contrasting figure. Gel stain is not a good choice in these situations (Photo 5-15).

Gel stains are not all the same. Some are much thicker than others, and thus much less likely to penetrate into the wood. Wood-Kote is the thickest gel stain. Minwax is the thinnest (Photo 5-16).

There is no one "best" stain. All stains have advantages in certain situations and disadvantages in others. With so many different possibilities, how do you choose the stain that is best for you or for the piece you're finishing? For my thoughts on this, see Chapter 17: "Finishing Different Woods."

HOW WOODS REACT TO STAINS

When you look at wood microscopically, you see the reasons wood can be decorated with stain and the causes of many staining problems. Wood is composed of countless, tightly packed channels that resemble soda straws. The fibrous walls of these channels are proportionately thicker than the walls of soda straws, and the cores are seldom totally empty as they are in soda straws, but the resemblance is there (Photo 5-17).

The wood's channels carry water and nutrients through the tree when it is alive. When the tree is sawed into boards, these channels are cut through, creating a porous surface. Compare the effects of staining wood with the effects of applying stain to a piece of glass, which has no pores. When you wipe the excess stain off of glass, all the stain comes off. There are no pores or fibrous channel walls in glass to retain any stain.

The same pores and fibers that make decoration possible cause many staining problems. You should be familiar with these potential problems before you choose and apply a stain, because fixing the problems after the fact is often difficult. There are four areas to consider:

- the size of the pores
- the distribution of different-sized pores in a board
- the angle at which the pores are cut through
- irregular density in the walls of the pores

Pore Size

The size of the pores varies in different woods. The pores in some woods such as maple and birch are very small. As a result, it is difficult to color these woods with pigment stains. There is not much room in the pores for pigment to lodge (Figure 5-3). Dye stains usually are the better choice for these woods, because dye saturates the wood fibers with color.

Pore Distribution

The uneven distribution of different-sized pores makes it difficult to get good-looking results on woods such as pine and oak, and almost impossible to stain these woods to look like other woods, especially if you use a pigment stain. More pigment lodges in the large pores, making them much darker than the small pores. While dye also makes these large pores darker, it colors the dense areas in between the large pores much better than pigment does (Photo 5-18). With dye there is much less contrast between the different-sized pores.

Minwax, Benjamin Moore Penetrating Stain, Valspar Kleartone, Devoe Wonder Woodstain, Grayseal Designer Wood Stain, and the walnut colors of Watco and Deft stains also work well on uneven woods. In addition to pigment, they contain either dye or asphaltum, which colors dense parts of uneven woods such as oak. As a result, the overall color is more even than with stain containing only pigment.

Pore Angle

The angle at which pores are cut through is significant. You get the most extreme variations in light and dark where stained sidegrain is next to stained end-grain. Side grain results from cutting pores lengthwise. End grain results from cutting pores crosswise. Just as there is much less depth in a soda straw cut lengthwise than crosswise, there is much less depth for stain to penetrate into side grain than into end grain (Figure 5-4). The uneven stain penetration occurs with both pigment and dye stains, but it is usually more evident with pigment stains. Dye stain's greater penetration into side grain makes the contrast less pronounced.

You don't have to encounter the extremes of side grain and end grain to get variations in stain penetration, however. Trees don't grow in a straight line, boards aren't always cut from trees directly in line with the grain, and your tooling of the boards (especially in turnings and carvings) often cuts through pores at various angles. The greater the angle at which the pore is cut through, the darker the wood in that area will appear (Photo 5-19).

Fiber Density

The irregular density of pore wall fibers is a primary cause of stain splotching. Pine is the worst offender. Other woods such as cherry, birch, and maple can also be a problem. It is impossible to get an even color on a wood that has areas of uneven density if the stain penetrates into the wood (Photo 5-20).

APPLYING STAIN

There are two ways to stain wood. You can apply the colorant to bare wood, so that it soaks in. Or you can apply the colorant to sealed or partially sealed wood, so that the colorant remains on top of the wood or penetrates only very little.

Letting the colorant soak into the wood emphasizes the wood's grain. It also highlights any problems in the wood, such as uneven density, scratches, gouges, and mill marks. Put colorant into the wood when the wood has a natural beauty you want to amplify.

Applying a colorant on top of sealed or partially sealed wood adds color without highlighting the wood's figure or problems. You apply colorant this way when the wood has characteristics you don't want to call attention to. You can also apply colorant on top of sealed wood to highlight pores or recesses without changing the color of the wood itself, or to change its overall tone.

Applying Stain to Bare Wood

There is not much involved in applying stain to bare wood. You wipe, brush, or spray the stain onto the wood, or you dip the wood into the stain. Then you either wipe off all the excess stain before it dries, or leave it to dry as is (Photo 5-21).

You can't darken the color by applying a second coat of stain and wiping off all the excess. Since the pores or wood fibers are already filled with the first coat, you will just remove all the second coat when you wipe. But you can darken the color if you don't remove the excess. If you're using a dye stain, not removing the excess is equivalent to increasing the strength of the dye that is already in the wood from the first coat. After all the solvent evaporates, it is as if you had used a stronger solution of dye in the first place. If you're using a pigment stain, not removing the excess is equivalent to applying a thinned coat of paint on top of the wood. The stain will obscure the wood slightly.

Applying Stain to Sealed or Partially Sealed Wood

In coloring wood there are many reasons you may want to control the stain's penetration. These include the following:

- reduce or eliminate contrast between side grain and end grain
- reduce or eliminate splotching caused by irregularities in the wood's density
- mute the visual impact of the wood's color, figure, and grain
- highlight the wood's pores without changing the color of the wood itself
- make two or more different woods resemble each other
- fine-tune a color match
- mask splotching caused by uneven stain penetration

You can control stain penetration by partially sealing the wood before applying the stain, or you can eliminate stain penetration by completely sealing the wood before staining. Partially sealing the wood is called *washcoating.* If you completely seal the wood and then apply a colorant, the procedure is called *glazing* (applying colorant between coats of finish, Figure 5-5) or *shading* and *toning* (putting colorant into the coats of finish). These are forms of staining, though they are not generally referred to as staining.

Washcoating partially fills the pores of the wood (Figure 5-6). You washcoat wood when you want to reduce, but not totally eliminate, stain penetration. The most common reason to washcoat is to reduce splotching. The results you get by staining over a washcoat are very similar to what you get when using gel stain. In both cases the stain doesn't soak deeply into the wood.

There are two methods for washcoating wood:

- You can use a slow-evaporating solvent that remains in the pores while you are staining. Any slow-evaporating solvent, such as mineral spirits, will do. You can also use a commercial washcoat that operates on the same principle (Photo 5-22). Flood the wood with the solvent. Allow the solvent to soak in. Wipe off the excess. Then apply the stain before the solvent evaporates out of the wood.
- You can use a highly thinned finish that only partially seals the wood. Any finish will work, and you can thin it to whatever degree you want. The traditional choice is 1/2- to 1-pound-cut shellac. (See Chapter 8: "Shellac" for how to prepare shellac from solid flakes.) A shellac washcoat can be mixed from liquid shellac, as it's sold in cans at hardware stores (typically a 3-pound-cut), by diluting I part with 2 to 5 parts of alcohol. You can also use a commercial washcoat that operates on the same principle (Photo 5-23). Whatever you use for a washcoat, the more thinner you add, the less the finish will stop up (seal) the pores, and the more the stain you apply afterwards will penetrate. This type of washcoat is permanent in the wood. Once the washcoat has cured, you can apply the stain over it at any time.

Both methods reduce the amount of colorant you can get into the wood. Both methods, therefore, prevent you from getting the wood as dark as you could if you applied the stain to bare wood. But neither method totally eliminates splotching, because neither method entirely eliminates stain penetration (Photo 5-24).

(When washcoating with a thinned finish, sand the wood's surface lightly with 280-grit sandpaper before applying the stain. This will remove the washcoat from the surface of very dense areas, such as the latewood on pine, so more stain can penetrate there.)

Personally, I don't find washcoating wood to be as effective a method of achieving even stain penetration as using a gel stain. It's hard to know how much washcoat you should apply to be effective. If your washcoat is too heavy, you won't get any stain penetration at all. If your washcoat is too light, you'll get too much stain penetration, and you won't be able to correct the problem short of sanding out the color.

Glazing is applying a thin coat of colorant between coats of finish, and either brushing the colorant out evenly or wiping it off high spots (Figure 5-7). The glaze can be applied by spray gun, brush, or cloth. (See "Applying Glaze") The colorant is almost always pigment. Glazes contain a binder to glue the pigment to the previous finish coat.

Most high-quality, factory furniture has one or more layers of glaze in the finish. Glaze offers many decorative possibilities:

- As a corrective colorant, it can be used to darken wood, refine a color match, blend heartwood and sapwood, or blend differently colored woods. (See Photo)
- It can add the appearance of richness and depth to the wood. (See Photo)
- It can subdue the brightness of a stain to produce a mellowed or softened look.
- It can add decoration on top of a painted surface, such as making a solid-colored surface look like marble or wood grain.
- It can highlight pores.
- It can be used to imitate a worn, antique appearance.

Most glazes are pigment suspended in an oil-, varnish-, or water-based binder. Essentially, they are thinned paint or thick stain. You can use your own thinned paint or common stain if you want. However, commercially prepared glazes are formulated to flow out evenly and cure at just the right speed.

You can make your own glaze by thinning some japan color (pigment ground in a varnish binder) with mineral spirits or naphtha. If the glaze cures too fast, add a few drops of boiled linseed oil. (Japan color is available from stores and mail-order suppliers that sell to professional finishers.)

The most common color used for glazing is brown. But you can use whatever color gives you the effect you want.

Glazes made with an oil- or varnish-based binder have a couple of advantages compared with glazes based on a water-based binder:

- Oil- and varnish-based glazes are slower-curing, and so afford more time to manipulate.
- Oil- and varnish-based glazes don't bite into the underlying coat of finish, so you can completely remove them before they cure by wiping with mineral spirits. Water-based glazes won't entirely wash off with water.

The disadvantage of oil- or varnish-based glazes is that they contain much more solvent. If you're glazing a number of cabinets or a room filled with paneling, solvent evaporation can be a health and safety problem.

Glaze is the material used to do *marbling, graining,* and other types of *faux (false) finishes.* You manipulate coats of glaze to make one material resemble another. Glaze can also be used to *pickle* wood. Pickling means to apply a white stain (or thinned white paint) directly to the wood, or to a sealed or partially sealed surface. (See "Pickling")

Shading stains and toners represent another way to apply a colorant to the surface of the wood. These are finishes with a pigment or dye added. They can be used to achieve all the same decorative effects as a glaze, except for highlighting the pores. (You can wipe off excess glaze, leaving a little color in the pores. You can't do this with shading stains or toners.)

You can buy shading stains and toners from stores or catalogs that supply professional finishers. Or you can make your own. Just add a compatible colorant to lacquer or water-based finish. Add lacquer-based pigment stain, universal-pigment colorant, oil-soluble dye, or NGR dye to lacquer. Add water-based pigment stain, universal-pigment colorant, water-soluble dye, or NGR dye to water-based finish.

Shading stain and toner actually are the same material; the different terms refer to different uses. Shading stain is used to darken some parts of wood in order to highlight other parts or to color sapwood (or lighter boards) to match heartwood (or darker boards). Toner is used to change the color tone of the entire surface of the wood (Photo 5-28 and 5-29). Sometimes the terms *shading stain and toner* are used to distinguish whether the colorant is a pigment or a dye. This usage is incorrect and causes confusion.

Unlike glazes, shading stains and toners are always applied by spraying and are not wiped off or manipulated after spraying. When lacquer is used as the binder, the colorant is always a shading stain or a toner. This is because lacquer dissolves part of the previous coat and then cures very rapidly. As a result, you can't touch it or you'll make a mess. When oil, varnish, or water base is used as the binder, the colorant can be either a shading stain/toner or a glaze. It's rare that oil- or varnish-based stains are used as shading stains or toners, because they cure too slowly.

Whether you use pigment or dye in your toner or shading stain makes a big difference. Pigment, applied heavily, muddies the appearance of the wood's figure and grain. Pigmented toners and shading stains were used a lot on factory-made oak furniture in the 1920s and 1930s. Dye is transparent, so it adds color without obscuring the wood. Dye toners and shading stains are often used to adjust a color after a coat of finish has been applied (Photo 5-30).

Apply shading stains and toners with a spray gun. Build the color slowly, that is, with many highly thinned coats. u can always add another coat to darken the color. But if you get the color too dark, you can't remove a coat; you'll have to strip everything and start all over. Once you have the color you want, apply several coats of finish over it to protect it (Photo 5-31). Because the color is in the finish and not the wood, scratches are very difficult to repair. You can't simply apply a colored stain to the scratch. It will color the wood, giving a different effect than color in the finish.

FILLING THE PORES

All woods have a natural texture that results from the size and distribution of the wood's pores. Some woods, such as maple and cherry, have a smooth, even texture because their pores are small and uniformly distributed. Other woods, such as walnut and mahogany, have a coarse, even texture because their pores are fairly large and uniformly distributed. Still other woods, such as oak and ash, have an uneven (alternately smooth and coarse) texture because their pores vary in size, the spring-growth pores being much larger than the summer-growth pores.

The texture of the wood largely determines how the wood looks with a finish on it. The textures of maple and oak, for example, are so different that it is nearly impossible to make one of them look like the other-even if you get the color the same.

Though you often can't make one wood look like another, you can affect a wood's texture by the finish you choose and how you apply it. If you apply a very thin finish, the finished wood will have almost the same texture as the unfinished wood. If you fill or partially fill the wood's pores while you're applying the finish, you can significantly change the wood's appearance. A mirror finish results when you totally fill the pores, so that there is no evidence of pitting in reflected light. You will often see this elegant effect on the tops of high-priced tables, but it doesn't require expensive materials or equipment -to achieve (Photos 6-1 6-2, and 6-3 on page 120).

There are primarily two ways to fill or partially fill the pores of wood-with the finish and with paste-wood filler. Filling the pores with the finish is less problematic and, with small-pored woods, quicker. Also, it produces a surface that has more clarity Filling pores with paste-wood filler is faster with large-pored woods, and the filler shrinks less in the pores. Also, paste-wood fillers offer a greater range of effects. (See "Filling the Pores: Finish versus Paste-Wood Filler" on the facing page.)

FILLING THE PORES WITH THE FINISH

To fill the pores of wood with finish, you apply a number of coats of finish and cut back the coats by sanding or scraping finish off the high areas between the pores. When the finish in the pores builds to the same level as the surrounding area, no more pitting will show. It's possible to do this with any finish except wax, oil, and oil/varnish blends. These finishes don't cure hard, so they shouldn't be built up to a thick film. Shellac, lacquer, varnish, and water base all can be used to fill the pores.

You can apply a number of coats and then cut them back all at once, or you can cut back each coat a little, until the surface is mirror smooth. Cutting back the coats all at once is more efficient, especially if your goal is to fill the pores entirely. But if you cut back the finish one coat at a time, you can simultaneously sand out dust and other flaws between coats. Either way, be careful not to cut through the finish and dig into the wood. This is especially important if the wood is stained. If you do, you will find it almost impossible to repair the damage without starting over. If you've never cut back a finish before, I recommend you practice on a test board before you tackle an important project.

There are two tools you can use to cut back the finish-sandpaper and a scraper.

Using Sandpaper to Cut Back the Finish

Most finishers use sandpaper to cut back the finish. It's slower than using a scraper, but it's safer. You're less likely to cut through to the wood. If you're sanding after every coat, use stearated sandpaper on the first couple of coats to reduce sandpaper clogging. If you're sanding after applying several coats, use wet/dry sandpaper and a lubricant to increase efficiency. Here are some suggestions for how to proceed:

- Begin with 220- to 320-grit sandpaper.
- To remove finish evenly on flat surfaces, back the sandpaper with a flat cork, felt, or rubber block
- If you're using mineral spirits as a lubricant, you can add a little mineral oil to slow evaporation. Using a soap-and-water lubricant is risky because if you cut through the finish, the water will raise the grain of the wood. The damage will be difficult to repair.
- When you're satisfied with the amount of finish you've sanded off, sand with finer-grit sandpaper to remove the coarse-grit scratches. (See Chapter 14: "Finishing the Finish.")
- You can continue abrading with increasingly finer grit sandpaper (up to 600-grit or finer) followed by rubbing compounds (fine abrasive powders described under "Rubbing compounds" on page 214) until you get the sheen you want, or you can apply more finish. If you choose to apply more finish, wipe the surface first with naphtha to remove any oiliness remaining from the lubricant.

Using a Scraper to Cut Back the Finish

A scraper can greatly reduce the amount of sanding needed to cut back a finish. But with a scraper there's a greater chance of cutting through the finish.

You scrape a finish just as you do wood (see "Scrapers"). When the surface is level, sand the finish as described above to remove scratches left by the scraper.

FILLING THE PORES WITH PASTE-WOOD FILLER

Paste-wood filler is essentially a binder (finish) with silica (finely ground sand or quartz) added to provide bulk. A pigmented colorant is added, either at the factory or by you, to provide color. The silica fills the pores and is held in place by the binder, which is either a thinned oil/varnish blend or a water-based finish. The colorant colors the filler, but it also can be used to stain the wood. Paste-wood fillers do not look good under wax, oil, or oil/varnish blend, because these finishes are too thin.

Paste-wood filler is not the same as wood putty, which is used to fill nail holes and gouges and is sometimes called wood filler

There are three differences between paste-wood filler and wood putty:

- Paste-wood filler is thinned much more than wood putty.
- Paste-wood filler uses silica instead of wood dust for the bulking agent.
- Most paste-wood fillers use oil and varnish for the binder, while wood putties use lacquer or water base. (Some paste-wood fillers use water-based binders.)

You can buy paste-wood filler in wood-tone colors, or you can buy it without colorant (called neutral) and color it yourself. Oil/varnish paste-wood filler won't take stain after it has cured, so you have to make it the color you want before applying it. Water-based paste-wood filler will take some stains, but you'll get better results if you color it before application. To color paste-wood filler, you can add a compatible stain: oil- or varnish-based stain to oil/varnish-based filler, or water-based stain to water-based filler. But it's usually better to add compatible pigment and thin the paste-wood filler with the appropriate thinner if needed. Different binders and thinners in the stain may alter the drying time of the paste-wood filler. Ground-in-oil and japancolor pigment are compatible with oil/varnish-based filler. Universal- and base-color pigment are compatible with water-based filler.

You can apply colored paste-wood filler directly to the wood, in which case it serves as both the stain and the filler. Or you can apply it over a thin first coat of finish (the sealer coat), so the filler colors only the pores. The difference is one of aesthetics. If you want the pores and the wood to be the same color, apply the paste-wood filler to unsealed wood. If you want to highlight the pores, making them a different color than the rest of the wood (whether stained or not), seal the wood before applying the paste-wood filler (Photo 6-4).

(It's very difficult to stain wood successfully after you've filled it with oil/varnish paste-wood filler, because stain won't penetrate evenly through the binder that remains on the wood's surface. It is possible to stain wood after you've filled it with water-based paste-wood filler, but only with certain stains such as lacquer or water base, which penetrate through the binder. You can glaze, shade, or tone over either paste-wood filler, however. See Chapter 5: "Staining Wood.")

If you choose to seal the wood before applying paste-wood filler (the most common procedure), keep the sealer coat very thin. This way the edges at the tops of the pores will still be sharp. Rounded-over edges, caused by a thick coat of finish, make it likely you'll pull the filler back out of the pores when you remove the excess filler (Figure 6-1).

Types of Paste-Wood Filler

There are two basic types of paste-wood filler-those based on a linseed-oil-and-varnish binder and those based on a water-based binder (Photo 6-5).

Linseed-oil-and-varnish-based paste-wood fillers are by far the most common. (See "Using Oil/Varnish Paste-Wood Filler- A, B, C") They vary in drying time, depending on the ratio of linseed, oil to varnish used. The higher the percentage of linseed oil, the more time you have to remove the excess filler. Of course, more linseed oil also means you have to wait longer before you can apply the finish. (For more on the differences between oil and varnish, see Chapter 4: "Oil Finishes.")

The problem is that manufacturers seldom tell you the ratio of oil to varnish used, so you can't know in advance what the working properties of the paste-wood filler will be. You can learn only by trying different brands. If the paste-wood filler cures too fast, you can slow it by adding a very small amount of boiled linseed oil to the filler before applying it. Begin by adding no more than I teaspoon to 1 quart of filler. The linseed oil will keep the paste-wood filler soft and moist longer. If the paste-wood filler cures too slowly, you can shorten its curing time by adding japan drier. Begin by adding a few drops to a quart of filler, and work up from there. It's always best, however, to find a brand of filler that gives you the working characteristics you want. Tampering with manufacturers' formulations sometimes causes curing problems.

Problems using oil/varnish-based paste-wood fillers are almost always caused by waiting too long to remove a fast-curing paste-wood filler, or by not giving a slow-curing paste-wood filler long enough to cure before applying the finish.

If you don't get all the excess paste-wood filler removed before it cures, you'll have cross-grain streaks that will be very difficult to remove later.

If the paste-wood filler isn't totally cured when you apply a finish, the following problems could occur:

- The finish and paste-wood filler won't bond to one another.
- The filler will turn gray in the pores.
- The paste-wood filler will swell, causing it to protrude from the pores.
- The.finish will develop a pronounced orange-peel texture and will cure soft.

The only correction for any of these problems is to strip the finish and the paste-wood filler and begin all over.

Water-based paste-wood fillers use water-based finish for the binder. Water-based finish cures very fast, so you don't have much time to remove the excess filler before it gets hard. Adding water won't slow the curing much, but adding glycol ether will. (See "Using Water-Based Paste-Wood Filler- A, B")
Water-based paste-wood filler is more difficult to use than oil/varnish-based, because the water-based filler cures so fast. But it's the better filler to use with water-based finish, since you are less likely to have bonding problems with it.

INTRODUCTION TO FILM FINISHES

Film finishes can be divided into two groups: penetrating and film. Penetrating finishes contain straight oil and don't cure hard, so they shouldn't be built up on the surface of the wood. (See Chapter 4: "Oil Finishes.") Film finishes cure hard and can be built up to any thickness you want. There are five common film finishes used in woodworking (see "What's in a Name?"):

- shellac
- lacquer
- varnish (polyurethane is a type of varnish)
- water base
- conversion (conversion varnish and catalyzed lacquer)

Film finishes protect better than penetrating finishes because of their thickness on the surface of the wood. The thicker the finish, the better it protects the wood from scratches, water, and water-vapor (humidity) exchange. (There are practical limits to film thickness, however, because if the finish is too thick it may develop cracks as a result of expansion and contraction of the wood underneath.)

Film finishes also offer more possibilities for decoration than penetrating finishes. You build a finish film the way you make a sandwich-in layers. The first layer, or coat, of finish is called the sealer coat. It stops up, or seals, the pores of the wood. (See "Sealers and Sanding Sealers- A, B") Subsequent coats, called topcoats, increase the thickness of the film, add decorative color, and increase or reduce the sheen if you choose.

- You can incorporate decorative color in a film finish in several ways (Figure 7-1):
- You can add color by putting it in the finish-called toning if the coat covers the entire surface or shading if it covers only part of the surface.
- You can add color by putting it in between coats of finish called glazing.

(For more detailed information, see Chapter 5: "Staining Wood.")

You can control the sheen of the finish by rubbing the last coat with abrasive compounds (see Chapter 14: "Finishing the Finish"), or by using a finish that has a flatting agent included (Figure 7-2). The most commonly used flatting agent is silica (finely ground sand or quartz). It reduces the gloss of the finish by partially absorbing and scattering reflected light. Scattering light also reduces transparency, so finishes with flatting agent aren't as clear as gloss finishes.

Lacquer, varnish, conversion, and water base can all be purchased with flatting agent added, or you can add flatting agent yourself. When the manufacturer adds the flatting agent, the finishes are sold as semi-gloss, satin (eggshell), flat, and dead flat, depending on how much has been added. Flatting agent settles, so be sure to stir these finishes thoroughly before using, in order to mix it in.
Flatting agent has a cumulative effect. Each additional coat with flatting agent decreases clarity. You don't have to put the same amount of flatting agent in every coat. For example, you can apply several coats of gloss followed

by one or two coats with flatting agent in order to avoid accumulating too much of the flatting effect. You can also blend cans with different sheens if you want, as long as they are the same finish. The inclusion of silica to reduce the gloss doesn't have any significant effect on the durability of the finish.

THE WAY FINISHES CURE

All finishes fall into one of three types-evaporative, reactive, and coalescing. Each type cures differently. (See "Finishing Materials: How They Cure") The way a finish cures-that is, changes from a liquid to a solid on the wood-and the role of solvents and thinners in the curing tell you a lot about that finish. Among other things these tell you the following: 0 how water-resistant or water-vapor-resistant the finish will be o how well the finish will hold up to heat, wear, solvents, acids, and alkalis

- how easy the finish will be to rub to a pleasing sheen
- how easy the finish will be to repair or strip
- how compatible the finish will be with stains and other finishes (see "Stain and Finish Compatibility")
- how to handle many of the problems you may have applying the finish

Shellac and lacquer are evaporative finishes. They cure by the evaporation of their solvents-alcohol for shellac, and lacquer thinner for lacquer.

Varnish, curing oil, and conversion finishes are reactive finishes. They cure by a chemical reaction that takes place within the finish after most of the thinner has evaporated. Varnish and oil cure by reacting with oxygen in the air. Conversion finish cures when a catalyst is added.

Water base is a coalescing finish. It is made up of already cured droplets of finish emulsified in water. It cures into a film when the water evaporates and the droplets come together, or coalesce. (See "Classifying Finishes")

Evaporative Finishes

Evaporative finishes are made of solids that have been dissolved in a solvent. The more solvent you put in, the thinner the solution; the less solvent, the thicker the solution. When all the solvent evaporates from the solution, only the solids are left. These solids are essentially the same as they were before they were dissolved. They've just changed shape from solid flakes or pellets to a film on the wood.

The molecules in evaporative finishes are long and stringy. You can picture them as microscopic strands of spaghetti. Just like spaghetti, the strands intertwine when they are softened. When they dry out, they harden, interlocking to form a continuous film. But nothing bonds the strands together. So when the solvent is reintroduced, the strands soften and separate. Evaporative finishes can change back and forth between liquid and solid by the introduction or evaporation of the solvent (Figure 74).

Common evaporative finishes include shellac and lacquer. Wax is also technically an evaporative finish. It is dissolved by petroleum or pine-sap distillates. But wax is more of a polish than a finish, so I'm not including it in this discussion.

When you apply one coat of an evaporative finish on top of another, the solvent in the new coat partially dissolves the previous coat. (It also dissolves any finish dust left from sanding previous coats.) The solvent puts the spaghetti-like strands back into solution, so the coats interlock or fuse, making one thicker layer (Figure 7-5).

If you touch the finish while it is wet, you will make a depression through the top coat into the coats underneath. The finish may be softened all the way through. When you apply a new coat of evaporative finish, don't touch it for any reason (for example, trying to remove a speck of dust or a hair) while it is still wet. You will make the problem much worse. Wait until the finish has cured. Then sand out the problem.

Evaporative finishes cure from the bottom up. The solvent at the bottom of the coat has to work its way through the film layer to get out. As a result the top is the last part to cure. This is the reason evaporative finishes don't skin over in the can. You can apply coats of evaporative finish over coats that haven't totally cured. In fact, they can be still wet. It will just take longer for all the solvent to work its way out of the finish. When the top becomes hard, you can be sure the film is hard all the way through.

Reactive Finishes

Reactive finishes change chemically when they cure. As the thinner evaporates, the resin molecules come closer together. Then, a chemical reaction occurs: The molecules link together in a tinker-toy-like network that can't be broken by reapplying the thinner (Figure 7-6). This chemical reaction is often referred to as crosslinking or polymerization.

Reactive finishes fall into two categories: those that cure by reacting with oxygen and those that cure by reacting when a chemical catalyst is introduced, much like epoxy glue does. Varnish is an oxygen-curing finish. (Linseed oil and tung oil also cure by reacting with oxygen, but they are penetrating, not film finishes.) Catalyst-curing finishes, called conversion finishes, include conversion varnish and catalyzed lacquer. These finishes are not as well known or commonly available as other finishes, but they are often used by professional finishers.

Varnish differs from all evaporative finishes in that when you apply an additional coat of finish, the thinner in it (mineral spirits) does not soften the existing cured coat. The cured coat has crosslinked and can no longer be dissolved. So there is no bonding between coats. If you want to remove the new coat before it has cured, you can do so easily and without affecting the existing coat by wiping it off with a cloth soaked with mineral spirits or naphtha. (You may want to do this if the new coat is too thick and won't flow out, if it has dirt in it, or if the color of an oil/varnishbased glaze is not right.)

You can also remove dust specks or hairs, if you are brushing the finish, without fear of damaging the finish deeper than the coat you are applying. If you are brushing varnish, for example, you can smooth over the area you've just touched with another brush stroke.

Since a new coat of varnish won't fuse to the previous coat, you have to sand the previous coat to make fine scratches for the new coat to lock onto mechanically (Figure 7-7). You also have to remove all sanding dust, because it won't be redissolved into the new coat of finish.

Conversion finishes differ from varnish in that there is a window of time specified by the manufacturer during which they bond like evaporative finishes. You can apply another coat of finish, and it will fuse with the previous coat. You don't have to sand to get a mechanical bond. But once the window has passed, the rules are basically the same as with varnish over varnish: You must scuff the surface with sandpaper or steel wool to create a mechanical bond.

You can apply varnish over other finishes, but it's necessary to sand the other finish first so a mechanical bond can be achieved. If you apply a conversion finish over other finishes, the solvents may damage the underlying finish. (See "Solvents and Thinners for Various Finishes")

Another difference between varnish and conversion finishes is how the film cures. Since varnish cures by reacting with oxygen in the air, it cures from the top down. Oxygen makes contact with the top of the finish coat first, and has to work its way through to cure the bottom of the coat. Once the top cures and skins over, the oxygen is inhibited from penetrating to cure the rest of the coat. This is why you should keep coats thin. Thick coats take much longer to cure all the way through. (Varnish that has skinned over in a can is an extreme example of this phenomenon.) It's also why you shouldn't apply a fresh coat of varnish until the underlying coat is thoroughly cured. If the underlying coat is not cured, it will wrinkle the overlying coat when oxygen does finally work its way through to cure it.

Conversion finishes cure like evaporative finishes-from the bottom up. The solvent or thinner has to work its way out of the film so the finish molecules can crosslink.

Coalescing Finishes

Coalescing finishes, typically water-based finishes, are more complex than evaporative or reactive finishes. Coalescing finishes are actually a combination of evaporative and reactive finishes, and most finish chemists don't consider coalescing a separate group. But I find them easier to understand when treated separately.

Coalescing finishes are tiny dispersions, or droplets, of a cured reactive finish (crosslinked within the droplets) emulsified in water. The water serves as a thinner. A very slow evaporating solvent (usually glycol ether) is added so the droplets can cure as a film. As the water evaporates, the droplets come closer together (coalesce). The solvent, which evaporates more slowly than the water, softens the droplets so the outer molecules of each droplet relax and extend outward to become intertwined with the outer molecules of other droplets. When the solvent evaporates, the droplets become interlocked much the way evaporative molecules do; they are not crosslinked. Just as with evaporative finishes, contact with solvents, such as alcohol or lacquer thinner, after the finish has cured, disconnects the droplets, putting the finish back into solution (Figure 7-8).

Water-based finish uses water as a thinner and glycol ether as a solvent (see "Solvents and Thinners" on page 143). You may find it revealing that white and yellow glues also cure by the coalescing method. This explains why the glues don't redissolve in water, but do redissolve in solvents such as acetone and lacquer thinner. (See "Glue Splotches")

The droplets in water-based finish take several weeks to achieve their maximum bond. For a short time additional coats of finish will bond to the previous coats. The solvent softens the outer molecules of the droplets in the existing coat so they interlock with the outer molecules of the droplets in the new coat (Figure 7-9). No sanding is required between coats. But after a day or two, the solvent in a new coat may not adequately soften the existing coat. So it is wise to scratch the surface with sandpaper or synthetic steel wool (Scotch-Brite) to achieve a mechanical bond.

Since the molecules in evaporative finishes and the outer molecules of the droplets in coalescing finishes interlock in the same way, you can apply an evaporative finish over a coalescing finish and achieve a good bond. But the solvent in coalescing finishes is usually not sufficient to make a strong bond with evaporative finishes after the evaporative finish has had time to cure thoroughly. To achieve a good bond, scuff an evaporative finish with fine sandpaper or synthetic steel wool before applying a coalescing finish over it.

Coalescing finishes cure like evaporative finishes-from the bottom up. Enough water has to evaporate for the droplets to coalesce and interlock. Nevertheless, it's quite common for coalescing finishes to skin over a little near the tops of cans. Enough water evaporates for the droplets to coalesce and bond together. For this reason it's a good idea to strain a coalescing finish before using it.

One significant difference between evaporative and coalescing finishes is the amount of solvent in each. Evaporative finishes have a lot of solvent, so new coats can redissolve the existing finish all the way through. Coalescing finishes have very little solvent (most of the finish is already cured in droplets), so only the surface of the existing finish is redissolved. This small amount of solvent is often enough, however, to interfere with washing off all of the new coat if you don't like it. Some of the new and the old will stick together. Thus, if you try to remove a water-based glaze from the top of a water-based finish, some of the glaze color will remain.

Another difference between evaporative and coalescing finishes is curing speed. Evaporative finishes cure rapidly as the solvent evaporates. Coalescing finishes become gummy as soon as the water evaporates and then remain that way for some time until the solvent evaporates. If you touch a coalescing finish while it's gummy, you won't be able to smooth out the damage, even by applying more finish. You'll have to leave the finish to cure entirely, and then sand out the damage.

A third difference is that you shouldn't apply another coat of water base over a previous coat until it has hardened (several hours at least). Otherwise, you may trap water in the existing coat. This is different from evaporative finishes, where it is all right to pile wet coat on top of wet coat. The solvent in evaporative finishes will keep the newly applied finish soft until it all works its way out. The water in coalescing finishes can't do this.

COMPARING THE THREE TYPES

The key difference between the three ways of curing is whether or not the molecules crosslink. Crosslinking makes the resulting film far more resistant to heat, scratches, solvents, acids, and alkalis, and less penetrable. Crosslinked molecules are difficult to break apart, and there's little space between them for liquids (water) or gases (water vapor) to pass through.

Evaporative finishes contain no crosslinking, so they are the easiest to scratch, redissolve, and penetrate. Sharp objects, heat, and a large number of solvents and chemicals have little trouble separating the molecules. Also, spaces within the non-crosslinked molecular structure are large enough for water and water-vapor molecules to find a way through.

The easy separation of the molecules in evaporative finishes has some advantages, however. Evaporative finishes are the easiest of all finishes to rub to an even sheen. They scratch easily and evenly with sandpaper, steel wool, and abrasive rubbing compounds. Evaporative finishes are also the easiest to strip and repair. You can redissolve these finishes with several different solvents, and you can add new finish to a damaged area without leaving a line between old and new: The two layers fuse completely.

By the same token, crosslinking in reactive finishes has its disadvantages: The strong bonds produce a more durable film, but for that very reason the finish is difficult to rub out, repair, or strip. Sandpaper, steel wool, and abrasive rubbing compounds tend not to produce a fine, even scratch pattern. A new coat of finish won't dissolve into the old, so a visible line will separate a repair from the original finish. And few solvents or chemicals will dissolve the finish for easy removal; most just soften or swell it enough to be scraped off the wood.

Coalescing finishes crosslink in batches, forming droplets, each of which is resistant to scratching, redissolving, and penetration. But the droplets then join together like evaporative finishes-without crosslinking. So coalescing finishes occupy a middle ground between evaporative and reactive finishes. Coalescing finishes are difficult to scratch (evenly or unevenly), because crosslinking occupies most of the surface area. But they are easily softened or dissolved by heat and a number of solvents and chemicals. And they can be penetrated by water and water vapor at the junctures where the droplets come together, just like evaporative finishes.

SOLVENTS AND THINNERS

When I was first learning finishing, I once asked my foreman how he knew which solvent to use with which finish. He just knew, he said; he didn't have an explanation. I've concluded that he was on to something. There is no explanation. You just have to learn which solvent or thinner works with which finish. (See "Solvents and Thinners for Various Finishes")

It does help to understand the difference between a solvent and a thinner, however. A solvent dissolves a cured finish; it turns a solid into a liquid. A thinner just thins a liquid. One substance can be a solvent for one finish and a thinner for another, or both a solvent and thinner for the same finish. Here's how they sort out:

- Mineral spirits, naphtha, and turpentine are solvents for wax and thinners for wax, oil, and varnish. They dissolve solid wax, but they don't dissolve cured oil or varnish. Neither do they dissolve any other finish, so they are used in furniture polishes and cleaners. (See "Turpentine and Petroleum-Distillate Solvents, A, B, C")
- Alcohol is a solvent and thinner for shellac and a weak solvent for lacquer and water base. It will dissolve lacquer and water base very slowly. Alcohol won't damage reactive finishes. (See "Alcohol")
- Lacquer thinner is a solvent and thinner for lacquer and a thinner for catalyzed lacquer. It is also a solvent for shellac and water base. It will redissolve these finishes after they cure. Lacquer thinner will soften and sometimes blister reactive finishes, but it won't dissolve them. (See "Lacquer Thinner")

- Glycol ether is a solvent and thinner for water-base. It is also a weak solvent for shellac and lacquer. Glycol ether doesn't damage reactive finishes. (See "Glycol Ether" on page 187)
- Water is a thinner for water base.

Keep in mind that each of these substances is also a solvent for one of the dye stains. Water and glycol ether dissolve water dye. Alcohol dissolves alcohol dye. Mineral spirits, naphtha, turpentine, and lacquer thinner dissolve oil dye. (See "Solvents and Thinners for Dyes and Stains")

SHELLAC

Shellac is the most underrated of all finishes. It is well known for its weaknesses-short shelf life and poor resistance to water, alcohol, heat, and alkalis. It is seldom mentioned for its strengths, which include some attractive characteristics:

- Shellac is the only finish with a proven track record for longevity. It was the favored finish for quality furniture throughout the nineteenth and early part of the twentieth century. Much of this furniture has survived with its original shellac finish in very good shape.
- Shellac forms an excellent barrier against water-vapor (humidity) exchange, silicone contamination, and existing stains caused by water, grease, crayons, or natural wood resins. (See "Shellac as Sealer, Washcoat, and Barrier Coat") Many professional refinishers use shellac regularly for their first "sealer" coat because of this quality.
- Shellac is unsurpassed as a touch-up material for repairing rubs, scratches, and gouges in other finishes. It bonds well to almost all finishes without damaging them, and it dries quickly.
- Shellac resin is so safe it is approved by the Food and Drug Administration (FDA) for use as a coating on candy and pills.
- Shellac's solvent, denatured alcohol, is not as polluting to the atmosphere as mineral spirits or lacquer thinner, and it is not harmful to you unless you drink it or breathe excessive amounts of it. (As with most liquids in the shop, you should also protect your eyes.)

Shellac is a natural resin secreted by insects, called lac bugs, which attach themselves to certain trees in and around northern India. (The word lac means "one hundred thousand," referring to the number of insects found on a single branch. Approximately 1.5 million bugs must be harvested to make 1 pound of shellac.) The resin is scraped from the twigs and branches of the trees. It's then melted, strained to remove bug parts and other foreign matter, and formed into large thin sheets that are broken up into flakes and shipped around the world.

HOW SHELLAC PERFORMS

Shellac is probably best known for its limited resistance to water, alcohol, heat, and alkalis. Here's what happens:

- If there is too much water in the alcohol used to dissolve the shellac, or in the air (in the form of humidity) when you apply the shellac, the shellac will turn white. This is called blushing. (See "Common Problems Applying Shellac" on page 147.) If you leave water on a cured shellac finish for long, the shellac will also turn white (as in a water ring), and it may separate from the wood. Shellac with wax in it is more susceptible to water damage than shellac with the wax removed.

- If you spill an alcoholic beverage on a shellac finish, the alcohol may damage the shellac. It will depend on the percent alcohol in the beverage and the length of time the alcohol is in contact with the finish.
- If you set a hot object on a shellac finish, the heat will soften the shellac and the object will leave an impression.
- If you wash a shellac finish with an alkali soap or detergent, you will dissolve the shellac. Alkalis, such as lye, ammonia, borax, and soaps with phosphate, dissolve shellac. Use a natural soap, such as Ivory or Murphy's Oil Soap, if you want to wash a shellac surface.

Because of shellac's poor resistance to water, alcohol, heat, and alkali, it's not the best finish for tabletops or other surfaces that are subject to frequent use. But shellac can be used almost everywhere else.

Interestingly, while shellac is a weak barrier against water penetration, it is one of the best barriers against the passage of water vapor. Since one of the main purposes of a finish is to slow water-vapor exchange (see Chapter 1: "Why Finish Wood, Anyway?"), shellac rates high in this respect as a protective finish.

CATEGORIES OF SHELLAC

Natural shellac resin is orange in color and contains about 5 percent wax. You can buy shellac with its color intact or bleached out, with its wax included or removed, and in liquid or solid-flake form.

Coloring

Shellac is either orange (also called amber, garnet, or button) or bleached (called clear or white). You can use orange shellac to advantage on dark woods to add warmth. Clear shellac is better for light, or bleached, woods when you don't want the finish to add color.

The orange color is the remainder of a red dye which gave shellac its original value. The dye was separated from the resin and used to color cloth. Orange shellac is a natural toner. It will darken the color of the wood without obscuring it. (See Chapter 5: "Staining Wood.") You can also add your own alcohol-soluble dye to make shellac any color you want. As long as you keep the color weak, you can usually brush the toner on without causing streaks. Otherwise, it's better to spray it on.

Wax in Shellac

Most shellac still contains its natural wax. This wax settles to the bottom of the container (Photo 8-2). When you stir a can of shellac, you often see the lighter-colored wax rise to the top and become mixed in with the finish. (The wax makes clear shellac appear white, which accounts for the name "white" shellac.)

The wax reduces the transparency of the shellac on the wood. It also makes the shellac even less water-resistant, and it prevents good bonding when nonevaporative finishes (varnish, water base, and conversion) are applied over shellac. You can buy dewaxed clear shellac (often sold as "blond" shellac), but dewaxed orange shellac is difficult to find in small quantities. You can dewax your own shellac by letting the wax settle, and then pouring or siphoning off the clear part (straining is less effective). If you pour the dewaxed shellac off, do so very gently. The wax is easily stirred up. You can see what you're doing better if you work from a glass jar.

Liquid and Flake Shellac

You can buy shellac as a liquid or as solid flakes that you make into a liquid yourself. Liquid shellac is sold in 3-, 4-, and 5-pound "cuts." Cut is a measuring term used universally to indicate how many pounds of shellac flakes are dissolved in 1 gallon of alcohol. The higher the cut number, the more concentrated the shellac and the thicker the solution. For example, you are getting twice as much shellac in a quart of 4-pound-cut solution as you are in a quart of 2-poundcut solution.

Most of the shellac sold in paint stores is 3-pound cut: 3 pounds of shellac to every gallon of alcohol. You can use the shellac right out of the can, or you can thin it to whatever degree you want. You should use denatured alcohol, sometimes sold as shellac thinner, for thinning. (See "Alcohol" on the facing page.)

The problem with buying shellac in liquid form is that it is seldom very fresh. Shellac is like milk: It has a shelf life. From the moment the shellac flakes are combined with alcohol, the resin begins losing some of its water resistance and its ability to cure hard. For some time the curing is just slowed. Eventually, the shellac refuses to cure at all. It remains gummy on the wood.

The process is very slow-you couldn't measure it day to day, and there's no clear point at which the shellac should no longer be used. Just as with milk, the deterioration is accelerated by higher temperatures. If shellac is kept cool, it may cure hard for a couple of years. (Some manufacturers claim up to three years.) But the curing will definitely take much longer. It's a common rule among finishers never to use shellac that is more than six months old without checking it first.

To check shellac for freshness, put a drop of 2- or 3-pound-cut shellac on the top of the shellac can or other non-porous surface such as glass, and let it cure overnight. If you can push your fingernail into any part of the drop the next day, the shellac is questionable. Wait several more days to make sure the shellac will still cure hard before you use it.

Clear (bleached) shellac has a shorter shelf life than orange shellac. The bleaching that's done to take the color out of the shellac causes it to deteriorate faster. You should be more diligent in checking clear shellac for its ability to cure hard. Unlike orange shellac, bleached shellac deteriorates in flake form as well as in liquid form. You will have difficulty dissolving old bleached shellac flakes, and the solution may not cure hard.

If you find out after you've applied the shellac that it doesn't cure hard, you'll have to remove it with alcohol or paint-and-varnish remover and begin all over again with fresh shellac. You cannot fix a gummy shellac finish by applying a new coat of fresh shellac on top. Though this may give the appearance of correcting the problem, it will lead to greater problems later. The fresh coat will begin cracking much sooner because of the soft coat underneath. One of the oldest painter's rules is, "Never apply a hard finish over a soft one."

To ensure maximum freshness, many finishers dissolve their own shellac from solid shellac flakes. Here's how to do it:

1. Using a non-metal container, combine the correct proportions of shellac flakes and alcohol for the pound cut you want (Photo 8-3). 1 suggest you begin by making a 2-pound cut, adding I pint of denatured alcohol to a quart jar containing 1/4 pound of shellac flakes. This will give you the feel of how to do it. You can then try thicker solutions.
2. Stir the mixture several times during the next couple of hours to keep the flakes from solidifying into a lump at the bottom of the jar (Photo 8-4).
3. Keep the jar covered when you're not stirring the shellac so moisture from the air isn't absorbed by the alcohol.
4. When the flakes are totally in solution, strain the shellac through a paint strainer or loose-weave cheesecloth into another quart jar. This will remove impurities (Photo 8-5).
5. Write the current date on the jar so that later you will know when you mixed the shellac.
6. If you want to dewax the shellac, let the wax settle (this could take weeks). Then pour or siphon off the dewaxed layer into another jar. If you're in a hurry, you can try straining the shellac several times through tightly woven cloth until the solution is clear.

APPLYING SHELLAC

Shellac is very user-friendly. You can brush or spray shellac easily as long as the shellac is not too thick. (See "Brushing and Spraying Shellac" on the facing page.) By adding a drop or two of oil to a rubbing pad, you can apply the shellac to wood by a method called French polishing. French polishing is time-consuming, but it produces excellent results, and it is fun to do. (See "French Polishing, A, B, C, D, E") In addition, the common thinner for shellac, denatured alcohol, doesn't smell bad and is not harmful to breathe in moderate amounts.

LACQUER

When lacquer became available in the 1920s, it was widely believed to be the ultimate finish. It had all the superior application and repair qualities of shellac, but it was more resistant to water, heat, alcohol, acids, and alkalis. In addition, it was a synthetic, so supply didn't depend on exotic natural materials, and it was easily manufactured. Indeed, the belief in lacquer's superiority has proven prophetic. Lacquer is still the most widely used furniture finish.

There are two types of lacquer produced for wood-nitrocellulose and cellulose acetate butyrate (also called "CAB," "water-white," or simply "butyrate"). Nitrocellulose is by far the more widely used of the two. CAB is much less amber in color than nitrocellulose lacquer, and it yellows less over time. This has always been the primary reason for using CAB even though it is more expensive. With the introduction of water-based finishes, which don't yellow at all, CAB is losing its principal rationale. Partly for this reason, and partly because its characteristics are almost exactly the same as nitrocellulose's, I won't discuss CAB further in this book.

NITROCELLULOSE LACQUER

Nitrocellulose lacquer became a viable finish after World War 1. Large stockpiles of cotton for making gun cotton, used in smokeless gun powder, remained after the war. Chemists discovered they could turn this cotton into a very fastdrying finish. The automobile industry had been using varnish, which required a long wait between coats. The furniture industry also saw the advantage of lacquer compared with shellac and varnish. Lacquer quickly became the standard finish for furniture.

Lacquer is a complex finishing material. Only a part of the finish is actually nitrocellulose. Most of it is a resin-usually an alkyd or a mastic-though other resins can be used. Nitrocellulose, made by treating the cellulose fibers of cotton or wood with nitric and sulphuric acid, gives the finish its fast-drying properties. By itself, though, nitrocellulose has poor build and flexibility. So the resin is added to improve these characteristics, and oily chemicals, called plasticizers, are added to further improve flexibility. Manufacturers vary the amounts and types of these resins and plasticizers to produce lacquers that cure with varying degrees of elasticity, color, and resistance to water, solvents, acids, and alkalis. Generally the more elastic, colorless, and resistant the lacquer is, the more it costs. Your supplier should be able to tell you which lacquer is best-suited to your needs.

CHARACTERISTICS OF LACQUER

The characteristics of lacquer are defined more by the way it cures than by which resins or plasticizers are added. The curing occurs when the solvent, lacquer thinner, evaporates. Since the solvent evaporates rapidly, curing occurs rapidly. Rapid curing makes lacquer difficult to brush, so it's usually sprayed (see "Spraying Lacquer"). Because there's no crosslinking in the cured finish, even the best-quality lacquers are not very resistant to heat, solvent, or chemical damage. (See Chapter 7: "Introduction to Film Finishes.")
The qualities of lacquer that have contributed to its continuing popularity include the following:

- ease of application with spray equipment

- very quick drying time, which speeds production and all but eliminates dust problems. You can apply three or four coats in a day.
- large variety of thinner/solvent blends, which makes application possible in all types of weather conditions
- ease of repair and removal due to lacquer's evaporative-curing characteristics
- exceptional film clarity, producing the appearance of great depth
- excellent rubbing qualities, due to lacquer's evaporative-curing characteristics
- wide range of possible formulations for specific situations, including lacquers that look like an oil or wax finish, lacquers that will crack to look like an old finish, and lacquers in many colors to be used like paints
- great versatility for color matching, because there are so many colors available (both pigment and dye), and because you can build the colors very slowly and evenly with a spray gun
- relatively low cost

The qualities that may bring an end to lacquer's dominance include these:

- the necessity of using a high percentage of toxic, flammable, air-polluting solvents to apply the finish
- limited heat, solvent, acid, and alkali resistance (even though much better than shellac)
- limited scratch resistance (the flip side of good rubbing qualities)
- poor film-build due to low solids content. Only about 10 to 20 percent of the liquid lacquer you apply will remain as a solid film.

APPLYING LACQUER

The working qualities of lacquer are determined by the solvents used to put the lacquer into solution. The solvents must dissolve all the elements in the finish and then evaporate in the proper order so the finish cures thoroughly. There are a wide range of solvents that dissolve lacquer. These solvents evaporate at different rates, so you can control how fast the lacquer will cure by which solvent blend you choose. (See "Lacquer Thinner") No other common finish gives you this control. It's one of the major reasons lacquer is so popular with professional finishers.

The solvents are combined by manufacturers into three broad categories:

- standard lacquer thinner, which evaporates at "normal" speed
- lacquer retarder, which evaporates more slowly than standard lacquer thinner
- fast lacquer thinner, which evaporates faster than standard lacquer thinner

Standard lacquer thinner and lacquer retarder are available at stores that carry lacquer. Fast lacquer thinner is not so widely available, but is usually sold by auto-body paint stores.

Begin with standard lacquer thinner. If you want to slow the curing, add some lacquer retarder. If you want to speed the curing, add some fast lacquer thinner. It's rare that you would need to use lacquer retarder or fast lacquer thinner straight.

There are four situations where using different thinners to control curing can be useful:

- to compensate for abnormal weather conditions (normal meaning temperature in the 70s Fahrenheit, humidity in the 40s)
- to improve flow-out (reduce orange peel)
- to keep a large area wet until you complete your spraying
- to slow the curing enough so you can brush the lacquer

(The occurrence of fish eye, small crater-like depressions in the finish, can not be corrected by varying the amount or type of thinner you use. For solutions to fish-eye problems, see "Fish Eye and Silicone A,B C")

Abnormal Weather

The control that the three types of lacquer thinner give you in abnormal weather conditions is very valuable. In hot or damp weather standard lacquer thinner evaporates too fast. In hot weather the lacquer won't have time to flow out on the surface; it may even dry before it gets to the surface. In humid weather the cooling effect of the rapidly evaporating solvents will draw moisture into the finish, causing it to blush (turn white). In both cases you can slow the curing and solve the problems by adding lacquer retarder.

In cold weather, standard lacquer thinner will evaporate very slowly, prolonging the cure. The lacquer will have time to run, sag, and collect dust. You can speed the curing by substituting some fast lacquer thinner for the standard lacquer thinner.

There aren't any rules for how much lacquer retarder or fast lacquer thinner you should add in any given situation. Weather conditions vary and so do the solvent blends in the various thinners. You will have to experiment. Being exact is not important, however, and you can vary the mixture as you go.

Improving Flow-Out and Reducing Orange Peel

One of the biggest problems in spraying any finish is getting the finish to flow out level-that is, not cure pitted like the surface of an orange (Photo 9-1). There are two ways to reduce orange peel One is by adjusting your spray gun for better atomization. (See Chapter 3: "Tools for Applying Finishes.") The other is to slow the curing of the finish so it has time to flow out and flatten.

If you are getting too much orange peel in your lacquer finish, you can increase the flow-out time on horizontal surfaces (and, to a lesser extent, on vertical surfaces) by adding some lacquer retarder. (For solutions to additional problems, see "Common Problems Applying Lacquer")

Keeping the Surface Wet

When you spray a finish, you always have some overspray, caused by the finish bouncing off the object back into the air or missing the object entirely, floating about, and settling later. On complex objects, you may want to keep the finish wet for the entire time you're applying the finish so that the overspray that settles back onto the object will redissolve and integrate into the finish. Keeping four chair legs and stretchers wet until you get them all coated is an example. You can slow the curing by adding some retarder to your lacquer.

Brushing Lacquer

Most lacquers are made to be sprayed. They cure too fast for brushing. If you want to brush a spraying lacquer, you can thin it with lacquer retarder. Even better, you can use a brushing lacquer-lacquer that has had the slower-evaporating solvents added by the manufacturer (Photo 9-2). You apply brushing lacquer much as you apply shellac. (See "Brushing and Spraying Shellac" on page 154.) You must work quickly and avoid rebrushing the same area to keep from dragging the lacquer. If you don't own spray equipment, you may find that using a brushing lacquer is a good substitute for shellac or varnish. Brushing lacquer is more durable than shellac but just as forgiving, and it doesn't have the inherent dust problems of varnish.

THE PROBLEM WITH LACQUER

The problem with lacquer is the high percentage of thinner required to put the lacquer into solution. Not only does the lacquer thinner cause air pollution, which is leading to lacquer being restricted in some parts of the country, but it is also highly flammable and bad for your health. The fumes of lacquer thinner can damage your central nervous system, liver, and kidneys and make you irritable, euphoric, or nauseous. Avoid using lacquer near any source of flame or spark, and protect yourself from breathing the lacquer thinner fumes by arranging air movement away from you and wearing a NIOSH-approved, organic-vapor respirator.

In spite of these problems, there is much resistance within the finishing trade to switching away from lacquer. It's hard to give up a finish you feel comfortable with and have control over. Nevertheless, many finishers who have made the switch find there are advantages to the alternatives, particularly the reduced exposure to toxic fumes.

VARNISH

Varnish (including polyurethane) is the most durable of the commonly available finishes. It resists heat, wear, solvents, acids, and alkalis, and it's also a barrier against water and watervapor penetration. It's cheap and it builds fast. It has all the good qualities you probably want in a finish, except one: It's difficult to apply.

Varnish is made by cooking a curing, or semi-curing, oil with a resin. Driers are added to speed the curing. Traditionally, the oil used was linseed oil, because it was the best oil available. In the late nineteenth century, tung oil was introduced into the Western world from China and began to be used in some furniture rubbing varnishes and in spar varnishes meant for outdoor use. By the mid-twentieth century, chemists had learned how to modify semi-curing oils, such as soybean (soya) oil and safflower oils were cheaper, and they yellowed less than linseed oil and tung oil, so they became the primary oils used in varnish. (All varnishes yellow over time.)

Traditional resins were fossilized sap from various species of pine trees. The best pine-tree resins were imported. (American pine-tree resin is too soft to make good varnish.) The resins came from eastern Asia, New Zealand, Africa, and northern Europe. The best resins were copals, such as kauri, congo, and manila (Photo 10-1). Amber was also used. Amber is the fossilized sap from an extinct pine that once grew in northern Europe. You often see amber in gift stores, sold for making into necklaces and jewelry. Natural resins are rarely used anymore to make varnish.

Beginning in the early twentieth century chemists began developing synthetic resins which were more consistent in quality and availability. The first to be developed was phenolic resin (a combination of phenol and formaldehyde). Originally it was used as a plastic and, in fact, saw widespread use in early radio cases. Phenolic resin is a solid, just like natural resin. To use it for finishing, chemists developed a way of making the resin into liquid by heating it with oil. The liquid resin/oil combination changed to a solid when exposed to oxygen in the air. This process is called oxidation. Phenolic-resin varnish was the first synthetic finish.

The next was alkyd-resin varnish, a type of polyester finish, develop ed in the 1920s. The name "alkyd" is a contraction of the names of the two main ingredients used to make the resin-alcohol and acid. Alkyd resin is also cooked with oil to make varnish. It is cheaper than phenolic resin and has become a workhorse in the finish industry. It's not only the most common resin used in varnish, it's also used in lacquer, conversion finishes, and oilbased paint.

The last of the three main varnish resins is polyurethane. It was developed in the 1930s and is commonly used as a plastic. Polyurethane is very tough. There are several varieties of polyurethane finish. Pure polyurethane finishes come in two parts (like epoxy glue), or they cure with heat or by absorbing moisture. The polyurethane you most often see in paint stores is actually an alkyd varnish modified with polyurethane resin, a uralkyd. Since the base of the finish is alkyd varnish, it applies and cures like alkyd varnish. This type of varnish has become the most popular of the three varnish types because it is the most scratch-resistant.

Varnish made from oil and resin alone doesn't cure fast enough to be useful as a finish, so metallic driers are added to speed the curing. The driers act as a catalyst, accelerating oxidation. Originally, lead was used as a drier because it was available and it worked. Other metallic driers have since been developed, and when it was discovered that lead caused health problems, these other driers were substituted. These include cobalt, manganese, zinc, and zirconium. These driers are all approved by the Food and Drug Administration (FDA) for use in oil, varnish, and paint. They are not known to cause any health problems as long as the oil, varnish, or paint is formulated so that it cures thoroughly. Lead is no longer used in common varnish and paint.

You can buy driers separately and add them to oil, varnish, or oil-based paint to speed the curing. The driers are a combination of the metals in solution and are usually sold as japan drier. Adding your own japan drier to varnish is risky. First, the combination of driers in the pre-packaged can may not be optimal for the finish you're using. Second, adding driers to the finish will not only speed the curing, it will make the film more brittle and promote cracking. Add only a few drops at a time, and proceed cautiously until you get a feel for the effect the driers have.

THE MIX OF OIL AND RESIN

Whichever oils and resins are used in making a varnish, the greatest difference is made by the ratio of oil to resin. The more oil, the softer and more flexible the resulting cured-varnish film. The less oil, the harder and more brittle the resulting cured-varnish film.

Varnish made with a high percentage of oil is called long-oil varnish. It is commonly sold as "spar" or "marine" varnish and is intended for outdoor use, where more flexibility is needed to accommodate greater wood movement. Varnish made with a low percentage of oil is called short-oil or medium-oil varnish. It is meant to be used indoors, where extreme wood movement is not a problem and a harder finish is usually desired.

It makes a difference which oils and which resins are used to make a varnish. (It also makes a difference which driers are used, but only in the speed and thoroughness of the curing, not in the physical properties of the cured film.) Here is how resins and oils affect the characteristics of varnish:

- Phenolic resin cures tough and flexible. It also yellows significantly (as seen in the old radio cases). Phenolic resin is often combined with tung oil to make spar varnish for use outdoors or rubbing varnish for use on rubbed tabletops (see Chapter 14: "Finishing the Finish"). The difference in the two types is the ratio of oil to resin used. Combining phenolic resin with a high percentage of tung oil makes a varnish that is flexible and very water-resistant. Combining phenolic resin with a small amount of tung oil makes a varnish that cures hard enough to be rubbed to a high gloss.
- Alkyd resin is not as tough as phenolic resin, but it is adequate for most situations, and it is cheaper and doesn't yellow as much. Alkyd is therefore the most common resin used in varnish.
- Polyurethane resin combined with alkyd is the toughest of the three varnish resins. But it has three shortcomings: It has a slightly cloudy appearance (one reason for its being singled out as a "plastic"). It doesn't bond well with any other finish, nor does any other finish bond well with it. It doesn't even bond well to itself after it has cured thoroughly. (Always scuff it with sandpaper or steel wool before recoating.) Finally, it doesn't hold up well in sunlight. Ultraviolet rays destroy its bond to the wood and cause it to peel. Despite some polyurethanes being called "exterior," they will perform well only when kept out of direct sunlight. (For a guide to the various varnishes, see "Identifying Varnish Types,")

CHARACTERISTICS OF VARNISH

Varnish has six primary characteristics, each of which is the result of its reactive curing. (See Chapter 7: "Introduction to Film Finishes.")

- *Resistance to heat, wear, solvents, acids, and alkalis:* Due to the crosslinking of the resin molecules, varnish is an exceptionally durable finish. The molecules are hard to break apart, so it takes high heat, sharp force, or strong solvents or chemicals to cause damage.
- *Resistance to water and water-vapor exchange:* The crosslinked molecular network reduces the size of spaces for water or water vapor to pass through.
- *Long curing time:* Slow oxidation allows you plenty of time to brush varnish without it getting tacky and dragging. But this also causes dust problems. Any dust that settles on the surface while the varnish is still wet or tacky will stick, detracting from the finished object.
- *Difficulty in repairing and stripping.-* This is the flip side of good solvent and chemical resistance.
- *Difficulty in rubbing to an even sheen:* This is the flip side of good scratch resistance.
- *Skinning over in the can.-* Since varnish cures by absorbing oxygen, any air left in a can of varnish will begin to cure it. If there is enough air, the varnish will skin over. (If the varnish hasn't begun to gel under the skin, it is still good. Remove the skin and strain the remaining varnish into a smaller container, such as a glass jar or a collapsible plastic container, so little or no air remains to cause skinning. Label the jar.)

APPLYING VARNISH

Varnish takes a long time to cure. It takes an hour or more to cure enough for dust not to stick to it, and it takes at least overnight to cure enough to apply another coat. For these reasons varnish is seldom used in factories or by professional finishers. It is primarily used by amateurs who don't own spray equipment. (See "Brushing Varnish A, B") Many of these amateurs erroneously believe they're using an inferior finish because it's not used by professionals who must know better.

Varnish is a joy to brush and a misery to spray. It brushes well because you have plenty of time to spread it out evenly on the wood. It's troublesome to spray because small particles of uncured varnish float around in the air and when they settle, they make everything, including you, sticky.

It takes very few coats of full-strength varnish to build a significant thickness of film. Varnish has a high-solids content. Two or three coats of varnish after the first "sealer" coat is almost always enough.

The weather affects the speed at which varnish cures. Cold and damp weather slows the curing significantly. Don't apply varnish in temperatures below 60 degrees Fahrenheit: It may take days to cure. Hot weather speeds the curing. The thinner evaporates more quickly, and the varnish reacts more quickly with oxygen. You may find it difficult to brush varnish on a large surface if the temperature is 90 degrees or higher. Brush marks may not have time to smooth out, and air bubbles in the varnish film may not have time to pop out before the varnish cures. (See "Common Problems Applying Varnish")

There's nothing you can do to speed up the curing on cold or damp days except raise the temperature in the area you're working in. You can slow the curing somewhat on hot days, however, by adding 10 to 20 percent mineral spirits (paint thinner) to the varnish. (See "Turpentine and Petroleum-Distillate Solvents A, B, C,")

Adding a little mineral spirits to varnish makes it spread more easily and flow out more smoothly in addition to giving air bubbles more time to pop out of the finish. Many finishers make it a practice to thin each coat. The downside, of course, is thinner coats, so you may have to apply more coats.

WATER-BASED FINISHES

The technology for making water-based finishes has existed for almost half a century. It's the same technology that's used in making latex paint and white and yellow glues. There was no demand for water-based finishes because they were more expensive than other finishes to produce, and they were more difficult to use. They still are, and only recently, with society's growing concern over air pollution, has a demand been created. Local and state governments have changed the marketplace by passing laws that limit the amount of solvent (volatile organic compounds, or VOCS) a finish or paint can contain. In areas where strict laws are in effect, you don't find high-solvent content finishes, such as nitrocellulose lacquer, on paint-store shelves.

WHAT IS WATER-BASED FINISH?

What's commonly called water-based finish, or water base, is really a solvent-based finish, usually acrylic or polyurethane, that is dispersed in water. Calling it water base distinguishes it from those finishes known as solvent-based finishes-shellac, lacquer, and varnish-which don't use water. A true water-based finish would be impractical for use on household objects, since it would redissolve in water.

For water base, the acrylic and polyurethane are manufactured in tiny, cured droplets, which are then dispersed in water. A solvent that evaporates slower than water, usually glycol ether, is added. (See "Glycol Ether") After the water evaporates, the tiny droplets of finish come very close together (coalesce). The solvent then softens the outer molecules of the droplets so they can interlock in much the same way as the molecules in shellac and lacquer interlock. As the solvent then evaporates, the connected droplets form a continuous film. (See Chapter 7: "Introduction to Film Finishes.")

Most water-based finishes use acrylic, which is very hard and tough. Some use a blend of acrylic and polyurethane. The addition of polyurethane makes the finish even tougher but somewhat cloudy, just as it does in solvent-based varnish finishes. Both types of finish are usually sold under names that indicate the use of water in the formula. But they are sometimes sold as "lacquer," "varnish," or "polyurethane," with no indication in the names that they are different from solvent-based lacquer, varnish, or polyurethane. Manufacturers do this to make an entirely new type of finish seem familiar, and it causes confusion. All water-based finishes, no matter which resins are included, have far more in common with each other than with traditional lacquer, varnish, or solvent-based polyurethane. (See "What's in a Name?") Look for the thinning or cleanup material listed on the can. If it's water, then the finish is water-based. If it's a solvent, the finish is solvent-based.

CHARACTERISTICS OF WATER-BASED FINISH

Water-based finishes are highly touted by manufacturers for their scratch resistance. They are very tough finishes, resembling solvent-based polyurethane. But they differ from solvent-based polyurethane in almost every other respect. Water-based finishes are less resistant to heat, solvents, acids, or alkalis, and they provide a weaker barrier against water penetration and water-vapor exchange. In these respects water-based finishes resemble nitrocellulose lacquer.

This is not to say that water-based finishes are not good finishes, only that film toughness isn't everything. It's better that you know in advance that a hot coffee cup, a little bit of fingernailpolish remover, or a washing with an alkali soap will cause damage; that you can get water rings on a cured water-based finish; and that the finish won't do much to stop wood from moving with humidity changes compared to solvent-based polyurethane. (Latex paint, which is chemically related to clear water base, is valued for use on the outside of houses precisely because of its ability to "breathe," or let water vapor pass through.)

Water-based finishes differ from all solvent-based finishes in the following respects:

- They have reduced solvent content.

- They clean up with water.
- The cured finish is colorless.

Solvent Content

Water-based finishes contain very little solvent compared to solvent-based finishes. There is therefore less solvent to evaporate into the atmosphere and cause pollution, less solvent to fuel a fire, and less solvent to breathe. Though reducing air pollution is the rationale for the introduction of water-based finishes, reduced fire and health hazards are of more immediate benefit to you in your shop. Water-based finishes don't contain enough solvent to burn in their liquid state, and they are much less toxic than varnish, lacquer, or conversion finish. Finishers who have switched to water base always cite reduced smell and irritability as the principal benefits. Floor finishers, especially, who can't always ventilate their work locations, appreciate breathing less solvent. You will often see water-based finishes marketed as floor finishes for this reason.

Water Cleanup

Like latex paint, water-based finishes are relatively easy to clean up. If you wash your brush or spray gun in water before the finish begins to cure, the finish comes off easily. But if you wait too long, water doesn't work anymore, and you have to use a solvent. Lacquer thinner, acetone, toluene, and xylene will all dissolve water base. So will all paint-and-varnish removers.

Color in Water Base

You may not realize the amount of color other finishes add to wood until you see a piece of wood finished with water base (Photo 17-12). Water base is colorless. On certain surfaces, such as light-colored and pickled (white-stained) woods, a colorless finish is desirable. But lack of color causes darker woods, such as walnut and mahogany, to look washed out and lifeless. There are two ways to overcome this problem:

- Stain the wood before applying the finish.
- Add a dye stain to the finish to imitate the natural color of other finishes. Some manufacturers already do this, and more will surely follow. But this will require you to be especially careful about the water-based finish you use. You won't want to use a tinted finish on pickled wood.

APPLYING WATER-BASED FINISH

You can apply water-based finishes just like other finishes-with a brush, spray gun, or cloth. (See "Brushing and Spraying Water Base A, B) What makes water-based finishes different to apply is the inclusion of water in the finish.

Substituting water for most of the solvent is great for preserving the environment, your shop, and your health, but water causes a number of problems:

- Rust
- grain raising
- poor flow-out or excessive foaming
- application difficulties except in moderate weather (For solutions to additional problems, see "Common Problems Applying Water Base" on the facing page.)

Rust

Rust is a problem if you are applying water base to objects that have metal parts, or if you are using a spray gun. Remove metal parts from whatever you're finishing, or seal them with dewaxed shellac before applying water base. If your spray gun contains metal parts other than brass or stainless steel, clean the gun by spraying lacquer thinner through it after each use. Alternatively, use a spray gun made of plastic or stainless steel.

You also need to be careful of rust around the tops of metal cans used to contain water base. You will usually chip off some of the protective coating while opening and closing the can, leaving the metal exposed. Rust develops, chips off into the finish, and causes black spots when the finish is applied. It's a good practice to strain water base each time before using.

Grain Raising

All finishes that contain water raise the grain of wood. It's unfortunate, but there's probably no way around this. (It's also unfortunate that some manufacturers are causing confusion by claiming their water-based products don't raise the grain.) You will find that spraying results in less grain raising than brushing, and that sanding to a finer grit reduces the problem by making the raised fibers smaller. But grain raising still occurs anytime you put water on wood.

There are four ways to deal with the problem:

- Sponge the wood and sand off the raised grain before applying the water-based finish. (See "Sponging" on page 15.)
- Use a solvent-based stain before applying the water-based finish. The binder in the stain will seal the wood enough to significantly reduce grain raising when you apply water base.
- Seal the wood with a coat of 1-pound-cut dewaxed shellac before applying the water-based finish. The shellac will prevent the finish from raising the grain. Water base will bond well as long as the shellac is dewaxed (wax keeps most finishes from bonding well) and the coat is thin and has been scuffed lightly with sandpaper.
- Apply a thin coat of water-based sanding sealer or water-based finish, and sand off the raised grain. Then apply another thin coat, which you may have to sand again if it's rough. Then proceed normally. A thin coat will cure hard faster and will be easier to sand.

Flow-Out and Foaming

Water has high surface tension. It doesn't spread out well on many surfaces. You experience this high surface tension when you spill water on a finished tabletop, or when you try to clean your car windshield with water. The water beads up. It doesn't flow out and cover the surface as mineral spirits or oil would, since they have a lower surface tension.

To make water flow out and clean your windshield better, you add a substance that reduces the surface tension, such as soap or ammonia. Manufacturers do the same sort of thing with waterbased finish. They add soap or ammonia-like substances, called surfactants, to the finish. The problem with adding these surfactants is that they tend to foam when stirred, so defoamers are also added. Defoamers are fatty or oily substances. The balance is critical. If there is not enough surfactant, the finish won't flow out; it will bunch up in ridges, somewhat like lacquer does when it fish-eyes (see "Fish Eye and Silicone"). If there is too much surfactant, or if you agitate the finish too much, as you might do when you brush it, bubbles will form and cure in the film.

Many problems applying water-based finishes are caused by using a finish whose additives are not in balance with the surface of the object you're coating, or with the means you're using to apply the finish. Some manufacturers market water-based finishes designed for specific tasks. Most don't; they try to hit a happy medium.

You will find it very difficult to brush a water-based finish if the finish is not designed for brushing. The finish will foam, and it will be difficult to get the bubbles out before the finish cures. You may hear suggestions for correcting the problem, such as adding milk, mineral spirits, glycerin, and other commonly available defoamers, to the finish. Following one of these suggestions might work. But it might not. It will depend on the compatibility of the defoamer you add with the particular finish you add it to. The safest technique for reducing bubbles is to brush your coats as thin as possible. You might also add 10 to 20 percent distilled water to aid in applying the finish thin. (Distilled water doesn't contain metal residue that might spot the wood.) Adding this amount of water won't harm the finish. If this doesn't work, the weather may be the problem, as described below. If the weather isn't the culprit, try another brand of water base.

Weather Sensitivity

Water is far more weather-sensitive than solvents. The curing time of water-based finishes varies much more in different weather conditions than the curing time of other finishes. On warm, dry days water base will usually dry rapidly enough to preclude dust problems. On cool or humid days the finish may take quite some time to become dust-free. During extreme weather you may have difficulty applying water-based finishes. Here are some tips:

- If the finish cures too slowly because of high humidity, create airflow over the finish to speed water evaporation.
- If the finish cures too rapidly to flow out well because of hot or dry conditions, add 10 to 20 percent distilled water to lengthen evaporation time, or add a solvent provided by the manufacturer for that purpose.
- If the finish doesn't flow out normally because of cold conditions, warm the room you're working in or wait for a warmer day. You will often have trouble below 65 degrees Fahrenheit.

CONVERSION FINISHES

You may not be familiar with the name "conversion finish." This is not surprising, because conversion finishes are used primarily in the furniture industry. These finishes combine the fast-curing properties of lacquer with the heat, wear, solvent, acid, alkali, water, and water-vapor resistance of varnish. Furniture factories like these finishes because they are fast-curing and they provide the tough, protective coatings that consumers often demand.

Conversion finishes include conversion varnish, catalyzed lacquer, epoxy finish, moisture-curing polyurethane, two-part polyurethane, polyester finish, and ultraviolet curing finish. Because most of these are rarely used outside of industry, I won't discuss all of them here. The exceptions are conversion varnish and catalyzed lacquer, which are used by many professional finishers and some amateurs.

Conversion varnish is composed of amino resins (urea formaldehyde and melamine formaldehyde) and alkyd resin. When you add an acid catalyst to the finish, these resins crosslink to form a very durable film. (See Chapter 7: "Introduction to Film Finishes.")

Catalyzed lacquer is the same as conversion varnish, except that it has nitrocellulose lacquer added to make the finish cure faster. The nitrocellulose speeds the initial curing, but it weakens the resulting film. Catalyzed lacquer, though exceptionally durable, is not as durable as conversion varnish. Like conversion varnish, catalyzed lacquer requires that you add an acid catalyst to make it cure.

Some catalyzed lacquers include the catalyst. These precatalyzed lacquers have enough solvent to keep the curing reaction from starting. As the solvent evaporates after the finish is applied, the catalyst kicks in, and the curing begins. Pre-catalyzed lacquers have a fairly short shelf life, which should be indicated on the label; if it's not, contact the manufacturer. Just as with lacquer, lacquer retarder can be added to pre-catalyzed lacquer to slow its curing enough that it can be brushed.

Conversion finishes were developed in the 1930s. They are often used on furniture for schools, laboratories, and other institutions, and sometimes on tabletops of household furniture. (Imported Scandinavian teak furniture is commonly finished with conversion finish.) But despite the greater durability, conversion finishes haven't replaced nitrocellulose lacquer as the preferred finish for medium- and high-quality furniture. Conversion finishes are almost always limited to simple, non-decorative coatings, because compared with nitrocellulose they're more difficult to apply and they don't look as good. Conversion finishes can't be rubbed out as nicely, and they don't bring out the richness in the wood or give the appearance of as much depth. They're also more difficult to repair, especially when the problem is color related.

Because of their high solvent content, conversion finishes are becoming restricted, as more and more areas of the country pass laws aimed at reducing solvent emissions. As a result, manufacturers are developing water-based conversion finishes. These are regular conversion finishes dispersed in water. They overcome the problems associated with atmosphere-polluting solvents, but they share the problems typical of water-based finishes. (See Chapter 11: "Water-Based Finishes.")

Characteristics of Conversion Finishes

Conversion finishes have the following advantages:

- Excellent wear, heat, solvent, acid, alkali, water, and water-vapor resistance: These finishes are usually tougher and more protective than solvent-based polyurethane.
- Excellent film-building properties: It takes half as many coats of conversion finish to achieve the same thickness as nitrocellulose lacquer.
- Short curing time, much like nitrocellulose lacquer.
- Easy spraying and thinning characteristics much like nitrocellulose lacquer.

Conversion finishes have the following disadvantages:

Short pot life: Once the acid catalyst has been added, the finish begins to cure. Products vary, so follow the manufacturer's instructions.

- Limited application time: There is a time frame during which you have to apply all coats, or else the coats won't bond properly. Products vary, so follow the manufacturer's instructions.
- Poor rubbing properties compared with nitrocellulose lacquer.
- Lack of clarity, compared with nitrocellulose lacquer.
- Extremely irritating formaldehyde emissions while curing- You should protect yourself with good cross-ventilation and an organic-vapor respirator mask.
- High use of toxic, flammable, air-polluting solvents.
- Extreme difficulty, often impossibility, of repair or touch-up: You can't get the repair to bond to and blend in with the finish.
- Very poor stripping characteristics: the flip side of excellent solvent and chemical resistance.

Applying Conversion Finishes

The working characteristics of catalyzed lacquer are almost identical to those of nitrocellulose lacquer. The rules for thinning, their effect on the speed of curing, and the problems that can occur are similar. (See Chapter 9: "Lacquer.") Only the build and the time frame for getting all the coats applied are different. Catalyzed lacquer builds about twice as fast as nitrocellulose lacquer, and new coats don't dissolve into the existing coats after a certain time (specified by the manufacturer). Conversion varnish cures more slowly than catalyzed lacquer, so be careful to avoid runs and sags, and allow more time between coats. Otherwise, conversion varnish applies in much the same way. It usually uses xylene as a thinner.

Neither finish bonds well to shellac or sanding sealer, so avoid using either of these as a sealer coat. Some catalyzed lacquers will bond to vinyl sealer. In most situations it's safest to use the finish itself for the first coat.

Be especially diligent in cleaning your spray gun after using a conversion finish. These finishes have a very short pot life. They will cure in your spray gun and cup, usually within several hours to several days, depending on the makeup of the finish. If you allow the finish to cure in your spray gun, you won't be able to clean it with solvents; you'll have to abrade the finish off, and this may ruin the gun.

CHOOSING A FINISH

One of the most common questions you hear in any discussion about finishing is, "What finish do you use?" The question presumes the existence of a "best" finish-one that should be used in all situations. Unfortunately, there is no best finish. There are only better finishes for given situations, depending on the qualities you're looking for. (See "Guide to Finishes" on page 208.)

When you're choosing a finish for any given project, you should take each of these qualities into account:

- Appearance
- Protection
- Durability
- ease of application
- safety
- reversibility
- ease of rubbing

Appearance

You have three choices when picking a finish for its appearance: potential film build, clarity, and color. (A fourth choice, sheen, is not dependent upon the finish you choose, but upon whether or not flatting agents-gloss-reducing solid particles-have been added.)

Film Build

The film build, or thickness of the finish on wood, greatly affects the wood's appearance. Wax and finishes that contain straight oil (linseed oil, tung oil, and oil/varnish blend) don't cure hard, so they should be kept very thin, not built-up on the wood. They produce a "natural" or "close-to-the-wood" look, in which the pores of the wood are left looking open and are very sharply defined (even though they are actually sealed). Film finishes (shellac, lacquer, varnish, water base, and conversion) can be built up on the wood. But they can also be applied thin to look like oil or wax finishes. Imported Scandinavian teak furniture, for instance, is finished with very thin coats of conversion finish, not oil as is commonly believed.

Consequently, you can use any finish if you want a thin, close-to-the-wood look, but if you want a build, you must use a film finish. A built-up film finish can look cheap if it rounds over into the pores of very open-pored woods such as oak and mahogany. Or it can look very refined, giving the wood the appearance of great depth, if the pores are filled level to the surface and the finish is rubbed and polished to an even sheen (Photos 13-1, 13-2, and 13-3). (See Chapter 6: "Filling the Pores.")

Clarity

The clarity of a particular finish may be important to your choice, though it's hard to see a difference unless you closely compare two finished boards. Dewaxed shellac, lacquer, alkyd varnish, and phenolic varnish are the most transparent finishes, giving the wood the appearance of greatest depth. Wax-containing shellac, solvent-based polyurethane, water base, and conversion are the least transparent finishes. In extreme situations, these finishes can appear almost cloudy, but their usual appearance is more like that of cellophane laid over the wood.

Color

All finishes, except water base and wax, impart a warm tone to wood. Orange shellac has the most pronounced color (Photo 17-12 on page 268). Any finish containing oil, including varnish, yellows with age. Yellowing is not generally a problem on dark or dark-stained woods. In fact, it's usually a plus: It makes the wood appear warmer. But yellowing can be objectionable on blonde woods and over the white stain used to pickle wood.

PROTECTION

A finish protects the wood and glue joints by slowing the penetration of water and the exchange of water vapor. Resistance to water penetration is important when choosing a finish for tabletops. Resistance to water-vapor exchange is one of the most important functions a finish performs on any wood object. Excessive water-vapor exchange between the wood and the atmosphere causes splits, warps, and joint failure. (See Chapter 1: "Why Finish Wood, Anyway?")

Resistance to water and water vapor depends as much on the thickness of the finish as it does on the type of finish. The three types of varnish (alkyd, phenolic, and polyurethane), which are nearly impermeable to water and water vapor when built up to a thick film, lose almost all of their resistance when applied thin in the form of a wiping varnish. Wax, which offers virtually no resistance to water and water-vapor penetration when used as a rubbed-out finish, is one of the best protective coatings when brushed thick on the ends of recently milled boards. It follows that all oil-containing finishes offer very little protection against water and water vapor, because they are also very thin.

Among the film finishes, the best water and water-vapor protection is provided by varnish and conversion finishes. Shellac also provides good water-vapor resistance, but it is the least water-resistant finish. The least water-vapor-resistant finishes are lacquer and water base.

DURABILITY

Finish durability divides almost exactly between crosslinking and non-crosslinking finishes. (See Chapter 7: "Introduction to Film Finishes.") Crosslinking finishes (varnish and conversion) are far more durable than non-crosslinking finishes (shellac, lacquer, and water base). The exceptions are oil and oil/varnish blends, which, though crosslinking, give poor durability because of their thinness. There are two concerns when considering finish durability:

- wear or scratch resistance
- solvent, acid, alkali, and heat resistance

Wear or Scratch Resistance

This quality is the most touted, and, as a result, it has become one of the most sought-after qualities in a finish. The most wear-resistant finishes are conversion finishes, solvent-based polyurethane, and water base. (Though water base doesn't cure by crosslinking, the droplets are composed entirely of crosslinked resins.) The least wear-resistant are wax and oil-containing finishes. Alkyd and phenolic varnish are less wear-resistant than polyurethane varnish but more wear-resistant than shellac or lacquer. Wear resistance can be an important consideration on floors and tabletops.

Solvent, Acid, Alkali, and Heat Resistance

These four properties tend to go together. A finish easily damaged by solvents is also easily damaged by acids, alkalis, and heat. Wax, shellac, lacquer, and water base are all susceptible to solvent, acid, alkali, and heat damage. Varnish and conversion finishes are very resistant to solvents, acids, alkalis, and heat. Oil-containing finishes are in between. Oil, though it crosslinks when it cures, breaks down more easily than varnish and conversion. Resistance to solvents, acids, alkalis, and heat can be an important factor when choosing a finish for countertops and tabletops.

EASE OF APPLICATION

The ease with which you can apply a finish depends on two factors:

- availability of spray equipment
- speed at which the finish cures

Spray Equipment

With spray equipment, all finishes except wax are easier to apply. Without spray equipment, only oil, oil/varnish blend, and wiping varnish are easy to apply.

The ease with which fast-curing shellac, lacquer, water base, and conversion finishes can be applied with spray equipment is so significant that most professional finishers never even consider using any other finish. The various characteristics of these four finishes provide almost every individual quality a finisher might want.

Speed of Curing

Unless you wipe off all the excess finish, finishes that cure slowly cause problems no matter how you apply them, because dust has time to settle and become embedded in the finish. On the other hand, finishes that cure rapidly are difficult to apply with a brush, because one brush stroke may already be tacky by the time your next brush stroke overlaps it. As a result, you drag the finish.

The comparative ease with which oil, oil/varnish blend, and wiping varnish can be applied is so significant for those without spray equipment that they are often reluctant to try other finishes.

SAFETY

There are three issues of safety:

- safety to you, the finisher, during application
- safety to the environment during application
- safety to the ultimate consumer if food or mouth will come in contact with the finish

Safety to You

All finishes except water base are combustible or flammable, so don't use them near flames or a source of possible sparks.

All finishes, including water base, contain solvents that can be damaging to your health. No matter which finish you use, you should ensure good cross ventilation in your work area so you always breath relatively clean air.

Respirator masks can be an aid when you're forced to work in an enclosed area, but respirator masks lose their effectiveness over time, thereby leading to a false sense of security. If you can smell the solvent fumes with your respirator mask on, either you have a leak or the cartridges are worn out and should be replaced. The only truly reliable respirator masks are those that provide an outside source of air. (Nuisance particle masks provide no protection against solvent fumes.)

The finishes that cause the least problems for your health are water base and shellac. Water base contains very little solvent, and denatured alcohol, the solvent for shellac, is relatively safe unless you drink it or breathe it in excessive amounts.

Safety to the Environment

All solvents evaporate into the atmosphere. Some have been shown to be factors in causing air pollution. As a result, many states and localities have passed laws aimed at limiting the amount of solvent or thinner that can be contained in a finish. These laws are the primary impetus for the substitution of waterbased finishes for solvent-based finishes.

Of the common solvents used in finishes, petroleum distillates and lacquer thinner-used in most varnishes and in lacquer, respectively-cause the greatest problems. Alcohol, shellac's solvent, and glycol ether, used in water base, also cause pollution. But alcohol causes less polution than petroleum-distillate solvents, and there is so little glycol ether used in water base that the problems are minimal. (See "Disposing of Your Solvent Waste A, B")

Safety to the Consumer

The safety of finishes for food or mouth contact is an ambiguous issue. The Food and Drug Administration (FDA) lists all the common ingredients used in finishes (except solvents that evaporate) as being safe for food contact as long as the finishes are formulated properly. Proper formulation is necessary to ensure that no potentially harmful ingredients will leach out once the finish has cured. Since improper formulation would more than likely show up as improper curing, all finishes that cure thoroughly are probably safe to eat off of or to put in your mouth. But the only finish that is specifically approved by the FDA for these purposes is shellac. It is even approved as being safe to eat.

REVERSIBILITY

Reversibility refers to the ease of repair and ease of removal of a finish. Reversibility is the opposite of solvent resistance. The finishes that are most easily repaired or removed are also the least solvent-resistant. Thus, your choice of using a reversible finish for its ease of repairing and removing must be weighed against your need for solvent resistance.

RUBBING QUALITIES

There are two qualities in finishes that make them easier to rub to an even sheen: the hardness of the cured finish, and the ability of finish coats to fuse together to form a single layer. Both of these properties are a function of the way the finish cures.

Hardness

There are two types of hardness in finishes. One is hardness like that of slate-a brittle hardness that is easily scratched. Shellac and lacquer cure brittle-hard. The other type of hardness is like that of an automobile tire-a tough hardness that is difficult to scratch. Since rubbing out finishes means scratching them with abrasives to get the sheen you want, tough-curing finishes are more difficult to rub to an even sheen. Varnish, conversion, and water-based finishes cure tough.

Of course, all finishes can be rubbed with steel wool or abrasive compounds. Some finishes are just easier than others to rub to an even sheen.

Fusing of Layers

When you rub a finish, you cut some of it away. If you cut enough away to penetrate through the topcoat in places, you may leave a visible line between the layers. But some finishes fuse into one layer as additional layers are applied, and thus it's impossible to cut through a layer, unless you cut all the way through to the wood. Shellac and lacquer fuse best. Conversion and water base also fuse well enough (if the coats are applied soon after one another) that layering is rarely a problem. Varnish doesn't fuse between coats, another reason it is not easy to rub out.

HOW TO CHOOSE

So how can you use this information in choosing a finish? First, it should be clear that there is no best finish. All finishes have certain positive qualities and certain shortcomings. Which finish you choose depends on which qualities you want most in the finish. (See "Guide to Finishes")

In my opinion, the primary variable in choosing a finish is whether or not you have access to spray equipment. If you do, you should probably stick with shellac, lacquer, conversion, or water base.

- If you want maximum protection and durability-resistance to water, water vapor, wear, solvent, acid, alkali, and heat-use a conversion finish.
- If you want reversibility, as you might on an antique, use shellac or lacquer.
- If you want to minimize the amount of toxic, flammable, and airpolluting solvents, use water base.
- If you want the, best clarity and rubbing qualities, use lacquer or dewaxed shellac.
- If you can't buy lacquer because of strict air-pollution laws in your area, substitute dewaxed shellac or water base.
- If you want a totally non-yellowing finish, use water base.

If you don't have access to spray equipment, you're limited in your choices. Ease of application becomes more significant. The finish that will give you the most protection and durability will be solvent-based polyurethane, with phenolic varnish and alkyd varnish close behind. You can get reversibility by brushing shellac or using a brushing lacquer. You can reduce flammable, toxic, and air-polluting solvents by brushing water base. But all of these finishes can be problematic when applied with a brush. Ease of application could lead you to choose one of the wipe-on finishes. Of these, wiping varnish will give the most protection, as long as it is built up. But oil/varnish blends will be easier to apply.

FINISHING THE FINISH

The difference between a quality finish and one that is nothing special has less to do with how you apply the finish than with what you do afterwards-with how you finish the finish. To finish a finish, you rub it with abrasives, such as sandpaper, steel wool, rubbing compounds, or a combination of these, sometimes using a lubricant such as wax, mineral spirits, oil, or soapy water. The idea is the same as sanding wood. You smooth and level the surface, putting finer and finer scratches into it until you are happy with the way it feels and looks. (Don't confuse a hand-rubbed finish using abrasives with a handrubbed finish that refers to "rubbing in" an oil finish-see "Oil Finishes and Penetration".)

Rubbing a finish does two things: It makes the finish feel smoother, and it gives the finish a softer appearance. Both are difficult to describe and virtually impossible to capture in a photograph.

Whenever you apply several coats of a film finish (a finish that you build to a thickness on the wood), you will always get some roughness caused by embedded dust. You will also get a harsh-looking shine when you view the surface in reflected light, and you will be able to see brush marks or orange peel, depending on whether the finish was brushed or sprayed. No matter how careful you are, you can't apply a perfect finish.

Rubbing a finish cuts off (or at least rounds over) dust nibs, softens the harsh reflected shine, and removes (or at least disguises) brush marks and orange peel. Rubbing does all this by putting fine scratches in the surface. The scratches become what you feel and see, thus replacing the problems. By making the scratches too fine to feel, you make the surface feel smooth. You control the amount of shine by how fine you make the scratches. The finer the scratches the higher the gloss. The coarser the scratches the lower the gloss. (For example, a diamond is polished to a high gloss with very fine abrasive rubbing compounds.) The word for degree of gloss is sheen. A high sheen is a high gloss. A low sheen is a satin or flat finish (Figure 14-1 and Photo 14-1).

Many woodworkers avoid rubbing out a finish because they don't understand it, or they consider it too complicated. This is usually a mistake. There's not much to understand, and the complication is only in the number of ways to do it. If you've never rubbed out a finish before, I suggest you begin simply by rubbing with steel wool. (See "Rubbing with Steel Wool A, B".) You will smooth and disguise flaws in your finish and produce a satin sheen. Next, try sanding a finish level before rubbing with steel wool. This will eliminate flaws and produce a satin sheen. From there, you can begin rubbing with finer abrasive compounds to raise the sheen if you want. (See "Leveling and Rubbing to a High Gloss A, B, C".) You can raise or lower the sheen using different rubbing abrasives as many times as you want-until you finally cut through the finish to the wood.

You don't have to rub out any finish. But you will always improve the results if you do.

FACTORS IN RUBBING A FINISH

The results you get rubbing a finish are influenced by a number of factors:

- the type of finish you are rubbing
- how thoroughly the finish has cured
- the type of rubbing abrasives you use
- the type of rubbing lubricants you use
- the rubbing schedule
- the cleanup
- the final waxing or polishing

Type of Finish

Hard, brittle finishes are easier than tough finishes to rub to a smooth, even sheen because hard finishes yield a clean, sharp scratch pattern when rubbed. Tough finishes are difficult to scratch, and the scratches you do make are uneven tears rather than smooth, clean cuts. Shellac and lacquer are the best rubbing finishes. Varnish (including polyurethane), conversion and water base are the most difficult finishes to rub to an even sheen. You can still rub these finishes, but the results won't be as nice. Keep in mind, however, that there are variations within each of these types of finishes depending on how the particular finish is made. It's possible, for example, to make a water-based finish with good rubbing qualities and a lacquer with poor rubbing qualities. (See Chapter 7: "Introduction to Film Finishes.")

There is a practical limit to good rubbing qualities. The harder, more brittle the finish, the easier it will scratch, but also the sooner it will crack. Many of the varnishes used on furniture made around 1900 severely cracked after a short time, because manufacturers went too far in trying to get good rubbing qualities.

Many film finishes are sold as semi-gloss, satin (eggshell), or flat because they contain flatting agents (see Figure 7-2). These finishes can be rubbed just as easily as gloss finishes, but the effect will be different. Gloss finishes have more clarity, so the wood will appear deeper. You can make satin and flat finishes appear shiny when viewed in reflected light, but they will be cloudy when you look straight into them. You can take advantage of this effect to imitate the appearance of an old finish that has been well maintained but has clouded with age.

Thoroughness of Curing

A finish begins as a liquid and becomes a solid when it cures. Between these extremes, it goes through various stages of hardness. If you try to abrade a finish before it has adequately cured, the scratch pattern will be uneven, and the scratches you make may disappear in places as the finish continues to cure. This will result in a splotchy and uneven sheen. In addition, since finishes shrink as they cure, pores that you have filled (see "Filling the Pores with the Finish" on page 120) may open, leaving a pitted surface again.

There are no absolute rules for how long you should let a finish cure before you rub it. A good rule of thumb is to wait a month. Longer is even better. Unfortunately, most finishers rush this operation, rubbing out the finish within a few days of application, which impairs the results. See

Choice of Abrasives

There are three types of abrasives for rubbing finishes:

- sandpaper
- steel wool (including synthetic steel wool, also known as 3M Scotch-Brite)
- rubbing compounds

Sandpaper is used to cut back the surface, eliminating irregularities such as orange peel, brush marks, and dust nibs. You can back the sandpaper with your hand or with a flat rubber, cork, or felt block. Using a block will produce a more level surface.

Silicon-carbide paper is best for sanding finishes. If you are sanding without a liquid lubricant, use stearated silicon-carbide sandpaper (sometimes sold as "no-load" or "self-lubricating" sandpaper). If you are using a lubricant, then wet/dry silicon-carbide sandpaper is better because of its water resistance and its hard paper backing. Stearated sandpaper is available up to 400 grit. Wet/dry sandpaper is available up to 2000 grit. Stearated sandpaper is usually a light gray color; wet/dry sandpaper is black. (See "Sanding Basics").

Both types of sandpaper still clog when used on a finish, particularly if the finish hasn't totally cured. They just clog less than other types. The finish rolls up into little balls, called corns, and sticks in the sandpaper grit (Photo 14-2). You should check the sandpaper often and remove these corns with a dull scraper, or change to new sandpaper. The corns will put deep scratches in the finish.

Steel wool is used to put an even, satin scratch pattern in the finish without as much risk of corning. You can buy steel wool in natural or synthetic (compressed fiber) form, and in various degrees of coarseness. (See "Synthetic Steel Wool" Also See A, B.) The finest steel wool is #0000. You should use this or #000 when rubbing a finish.

Rubbing compounds are very fine powders suspended in a paste or liquid. These compounds use grits of powders that are almost always finer than the grit of the finest steel wool. They usually produce sheens higher than that produced by #0000 steel wool. Pumice (finely ground lava) and rottenstone (finely ground limestone) are powders that you can make into your own rubbing compound by mixing them into a thin paste with water or mineral oil. Pumice and rottenstone are traditional rubbing abrasives, but they've been largely replaced by synthetics you can buy already prepared in paste or liquid form. It's often difficult to compare grits between brands, so it's best to stay within one brand if you're rubbing to a progressively higher sheen (Photo 14-3). Also See.

Choice of Lubricants

You use a lubricant with sandpaper and steel wool to reduce corning and to float away grit and abraded material, maintaining the abrasive's effectiveness. The lubricant also holds down dust and steel-wool particles so you don't breathe them. There are four types of lubricant for rubbing out:

- mineral spirits or naphtha
- liquid or paste wax
- oil
- soapy water

Each of these lubricants is effective and has its advocates. To use them, wet the surface liberally and keep it wet as long as you are rubbing. Mineral spirits evaporates slower than naphtha, so it's usually the better choice between the two. Mineral spirits allows for fast cutting with very little corning. Liquid or paste wax and non-curing oils, such as mineral oil and vegetable oil, almost totally eliminate corning but significantly slow cutting. You can mix mineral spirits with wax or oil to blend the characteristics if you want.

Soapy water works well with steel wool, but it is not very effective in preventing corning on sandpaper. Using water can cause its own problems. If you cut through the finish, the water may raise the grain of the wood, a defect that will be very difficult to repair. However, you don't have to worry about rust unless you intend to apply another coat of water-based finish on top, in which case, be sure to first clean the surface well. Some manufacturers sell paste soap under names like "Wooling Wax," "Wol Wax," "Wool Lube," and "Murphy's Oil Soap." None of these products contains any wax or oil, and the reference to wool means they will lubricate steel wool.

Any of these lubricants will reduce the scratching of the steel wool a little, and the liquid will keep the steel-wool particles from circulating in the air you breathe. But the lubricant will disguise rub-throughs so you won't know they're there until the lubricant has evaporated. By then you've usually done considerable damage. A lubricant also makes it difficult to judge the sheen being produced. You can't see what you're doing.

I suggest you use a lubricant with sandpaper to reduce corning, but not with steel wool until you've rubbed a few finishes without it. Then you'll have a better feel for how much you can rub without cutting through. See.

Rubbing Schedule

There are two procedures, or schedules, you can use to rub a finish:

- Level the surface with sandpaper before rubbing with steel wool and rubbing compounds.
- Skip the leveling and begin with steel wool or rubbing compounds.

If you skip the leveling step, your finish will include imperfections such as orange peel, brush marks, and dust nibs, all visible in reflected light. Leveling with sandpaper removes these imperfections. But leveling is an extra, time-consuming step, and it's not always needed. If you're not aiming for perfection, you can often skip the leveling step and simply rub with steel wool. The satin sheen it produces will disguise all but the most severe imperfections. Also, you can usually skip the leveling step on curved, turned, molded, and carved surfaces, and it is seldom required on chairs or table legs.

If you have to sand a lot to level a finish, you run the risk of cutting through the top layer of finish and exposing the layer underneath. You may see a clear line separating the two layers. This phenomenon is called layering, and it occurs only on finishes that don't fuse between coats (Photo 14-4). It always occurs between coats of varnish and polyurethane, and it often occurs between coats of water-based finish.

The only way to repair layering is to apply another coat of finish. This will completely hide the problem. If you do experience layering, continue to sand until the surface is level, apply another coat of the same finish, and level it again. You shouldn't have to sand deep enough to cut through a second time. See.

Cleaning Up

If you use several grits in your rubbing, clean the surface well between each grit. The reason is the same as in sanding wood: Particles from a previous grit will scratch the finish more than the grit you're switching to.

When you've finished rubbing, you'll have dust or sludge on the surface. You should blow the worst of the dust off with compressed air, if you have it. If you don't have compressed air, wipe lightly with the grain using a tack rag or a cloth dampened with mineral spirits. Wipe with the grain to avoid cross-grain scratches from the loose grit. If you have sludge left over from using a lubricant, wash it off quickly after you've finished rubbing. (Use naphtha for sludge made with mineral spirits, oil, or wax; use water for sludge made with water.) Sludge remaining in scratches, pores, and recesses will dry opaque (see Photo 14-5). It may cause a haze on flat surfaces and put solid color into recesses. Use a toothbrush to get the sludge out of narrow recesses.

Waxing and Polishing

It's almost always a good idea to apply paste wax or furniture polish to a rubbed surface to reduce wear. Rubbed finishes show scratches more than non-rubbed finishes. This is because the rubbed scratch pattern exaggerates any scratches that cross it.

Paste wax protects much longer than furniture polish because paste wax doesn't evaporate. Dark-colored paste wax can be used to advantage on dark woods, since it reduces hazing by coloring any rubbing residue. Furniture polish is effective only until it evaporates. Since it is smeary until it evaporates, keeping furniture polish on a rubbed finish all the time means keeping the surface smeary all the time. (See Chapter 15: "Caring for the Finish.")

CARING FOR THE FINISH

Of all finishing subjects, caring for the finish is by far the most misrepresented by manufacturers. Claims range from half-truths, such as "furniture polish preserves the finish," to outright absurdities, such as "furniture polish replaces the natural oils in wood." The success of the furniture polish industry in convincing millions of consumers that there's oil in wood that needs replacing has to rank among the great scams of American marketing.

Deceptive marketing has shifted the emphasis away from the real benefits of furniture polish as an aid in dusting, cleaning, and adding scent to a room. In addition, some furniture-polish manufacturers have totally misrepresented the beneficial role of wax. Instead of pointing out its long-lasting shine and wear resistance, they've made wax into a problem, claiming that it keeps wood from breathing by stopping up its pores, and that it builds up to create a smeary surface. Enough confusion has been created to spawn a thriving sub-industry, operating out of antique and home-and-garden shows, which specializes in miracle remedies. This "snake-oil" business markets essentially the same substances as the primary industry at three to four times the price. Its success demonstrates that there are serious misunderstandings about furniture care.

To get a grasp on what you're trying to accomplish in caring for the finish on your furniture, you need to understand why finishes deteriorate in the first place, and how the deterioration can be slowed. It also helps to understand exactly what paste wax and liquid furniture polish are and what they do. Then you can make intelligent decisions about how you want to care for your furniture.

CAUSES OF FINISH DETERIORATION

Finishes deteriorate as a result of the following conditions:

- exposure to strong light
- oxidation
- physical abuse, including contact with heat, water, solvents, and chemicals

Strong Light

Light, especially sunlight, is the natural element most destructive of finishes. Consider how much faster paint deteriorates on the south side of a house than on the north side. Or how much faster the paint on a car dulls when it's parked daily in the sun instead of under cover. Even indoor light eventually takes its toll on a finish. You can confirm this by removing hardware from furniture that is 40 or more years old. The newly exposed finish will be in far better shape than the surrounding area. (This will be so whether or not the surrounding area has been waxed or polished on a regular basis. Neither paste wax nor liquid furniture polish obstructs the penetration of light.)

Oxidation

Oxidation is the second most destructive natural element. Oxygen combines with almost all materials, changing them into their oxides. The process is usually slow, but it's an important factor in the deterioration of materials. Oxidation causes most finishes to darken, and all finishes eventually to crack, even without the additional effect of light.

Physical Abuse

All finishes can be physically damaged by rough objects, heat, water, solvents, acids, and alkalis. Some finishes, such as polyurethane and conversion, are more resistant than others, but still they can be damaged.

PREVENTING FINISH DETERIORATION

So what can you do to prevent deterioration caused by light, oxidation, and physical abuse? Most of what you can do is fairly passive. Active care does relatively little. (See "Causes and Prevention of Finish Deterioration".)

Passive Care

The best way to care for the finish on your furniture is to keep it covered or away from destructive elements.

- To shield furniture from strong light, place it away from direct sunlight, keep lights turned off in rooms not in use, keep your tabletops covered with a tablecloth, and throw a sheet over your better furniture when you're on vacation.
- To slow oxidation, don't store furniture in an attic or other area that gets extremely hot. Heat accelerates oxidation.

- To minimize physical damage, use coasters, tablecloths, and hot pads. (But don't cover your tables with plastic pads for long periods; the plastic and the finish may stick together.)

Active Care

Active care entails applying paste wax or a liquid furniture polish to your furniture regularly. But neither paste wax nor furniture polish retards the destructive forces of light or oxidation. Nor does wax or polish protect against damage from heat, solvents, or water. Polish and wax protect only against wear. They reduce friction, so objects tend to slide over, rather than dig into, the finish.

In addition to wear protection, paste wax and liquid furniture polish add shine to dull surfaces (Photos 15-1 and 15-2). They do this by filling tiny voids in the finish caused by scratches or natural finish deterioration. When you look into the finish, light reflects back at you instead of scattering in all directions. This makes the wood underneath the finish appear richer and deeper, and makes the finish appear less damaged. (To some people it might even look as if you've put oil in the wood, underneath the finish.)

Paste wax doesn't evaporate. Liquid furniture polishes that don't contain wax do evaporate. That's the most significant difference between paste wax and liquid polish. It means that paste wax will continue to provide wear protection and shine until it is worn or washed off. But waxless polish will provide wear protection and shine only until it evaporates.

Liquid furniture polish is a far better cleaner than paste wax, because it's better at picking up dust and dirt. Most liquid polishes also add a pleasant scent to the room. See A, B, C, D, E

Paste wax is the traditional furniture care product. It has been used for centuries. Until fairly recently beeswax was the primary wax used because it was the only wax available. It's still the only wax in many commercial and homemade paste waxes. (See "How to Make Your Own Paste Wax") But now there are also a large number of natural and synthetic waxes, which are often blended to make paste-wax polishes.

All waxes are solid at room temperature. They are made into a paste (and sometimes a liquid) by being dissolved in a solvent. Traditionally, turpentine was used because it was the only solvent available. Now petroleum-distillate solvents are generally used. (See "Turpentine and Petroleum-Distillate Solvents A, B, C,".)

Commercial paste waxes are often made by blending several individual waxes. The waxes are chosen for qualities such as cost, color, and slip resistance (for floors). But the individual waxes also vary in hardness, gloss, and melting point, so the blend has to be adjusted to take these qualities into account.

Melting point is an indication of hardness and gloss. Generally, the higher the melting point, the harder and glossier the wax. Here are some examples of natural waxes you may be familiar with, though manufacturers usually use synthetic waxes that have similar qualities but are less expensive.

- Beeswax (taken from the hives of bees) melts at about 140 to 150 degrees Fahrenheit, is medium-soft, and produces a medium-gloss sheen. It is easy to use as a polish.
- Paraffin wax (derived from petroleum) melts at about 130 degrees Fahrenheit, is softer than beeswax, and has a slightly lower sheen. It is never used alone as a furniture polish.
- Carnauba wax (taken from the leaves of a Brazilian palm tree) melts at about 180 degrees Fahrenheit, is very hard, and produces a higher shine than beeswax. It is too hard to buff out when used alone.

In order to use very hard waxes, such as carnauba, manufacturers blend in softer waxes, such as paraffin. The blending reduces the melting point, hardness, and gloss of the hard waxes. The melting point comes down to the range of 140 to 150 degrees Fahrenheit, the same as for pure beeswax. All common paste-wax blends melt at this temperature. Therefore, all common paste waxes have about the same hardness and gloss. If you notice any differences, they are probably due to differences in the surfaces you've waxed, not due to the paste waxes you've used. (Try polishing adjacent parts of a surface with two or more different paste waxes, and prove this to yourself.)

Major manufacturers of paste wax seldom use natural beeswax, either alone or in combination with other waxes. Beeswax is expensive. Also, beeswax has a grainy texture, which causes it to smudge easily. Pure beeswax polishes are usually made by small companies tapping into the mystique of beeswax being the traditional paste wax.

The only significant difference among commercially available waxes is the length of time you should wait before wiping off the excess wax. The waiting period depends on the evaporation rate of the solvent that was used to make the solid wax into a paste or a liquid. Some paste waxes, such as Trewax and Briwax, contain solvents that evaporate very quickly (as quickly as naphtha). Others, such as Minwax, contain slower-evaporating solvents (evaporating at a rate similar to mineral spirits). When all the solvent evaporates, the wax is solid again. As explained in "Applying Paste Wax A, B" on the facing page, you don't want to give the solid wax too much time to harden before you wipe it off. If you want to apply wax to a large area before you start wiping, choose a wax with a solvent that evaporates more slowly (Photo 15-3).

Some paste waxes are sold in colors. The color in the wax is dye or pigment. (See Chapter 5: "Staining Wood.") You can use a colored paste wax to color in nicks and scratches while you're waxing the finish. The dye or pigment in the paste wax will color the wood wherever a nick or scratch has cut through the finish. The color you add to the wood will be long-lasting. Contrary to what you often hear, colored paste waxes won't add any noticeable color to finished surfaces. Once you've buffed off the excess wax, there's not enough color left to be seen.

Commercial paste waxes designed for use on cars often contain very fine abrasives to help remove chalking. They often also contain silicone oil to increase the gloss and ease of removal. Shoe waxes also contain silicone oil for better water repellency. Paste waxes that contain silicone oil will be more glossy than paste waxes that don't. They will also be more slippery, so you shouldn't use them on floors. (See "Fish Eye and Silicone")

Liquid furniture polishes are made primarily from petroleum distillate solvents. The solvents range from mineral spirits (paint thinner) to kerosene. The solvents are therefore rather oily, which is why furniture polishes are often thought of as oil. The petroleum smell is removed and usually replaced with a more pleasant scent. You can use the less expensive mineral spirits or kerosene on your furniture if you don't mind the smell, but I don't recommend it. Neither will damage any finish. (See "Turpentine and Petroleum-Distillate Solvents A, B, C")

Just like paste wax, liquid furniture polishes reduce wear and add shine. But the wear protection and added shine last only until the furniture polish evaporates. Some furniture polishes evaporate in an hour, others in a few days. As long as the furniture polish remains on the surface, however, it will smear when you rub your finger over it. Unfortunately, you can't have wear protection and shine with an oily, solvent-based furniture polish without also having smear. Once the smear is gone, so is the wear protection and shine. (See "Furniture Polish in Brief")

A few furniture polishes contain a small amount of wax, silicone oil, or both (Pledge is the best-known example). These polishes don't evaporate as quickly as polishes containing only petroleum-distillate solvent. In fact, if there is enough wax in the polish, it will act similar to paste wax by giving long-lasting scratch resistance and shine.

Manufacturers don't tell you when their polishes contain wax or silicone oil. This is because industry advertising has told us that silicone oil is bad for finishes and that wax "builds up" on the surface. But the extended shine provided by wax and silicone oil makes polishes that contain them extremely popular.

As mentioned above, liquid furniture polishes are excellent cleaners. They remove dust because they make your cloth damp with the dust-attracting, oily solvent. You wipe the dampened cloth over the surface, and it picks up the dust. (See "Applying Liquid Furniture Polish")

Most furniture polishes are solvent alone, so they clean only solvent-soluble dirt, that is, grease, oil, and wax. These furniture polishes appear as a clear liquid. There is no significant difference in cleaning power among various solvent-based polishes.

Some furniture polishes are solvent emulsified in water, so they clean both solvent- and water-soluble dirt. In addition to grease, oil, and wax, these polishes clean sticky fingerprints. Water-emulsified furniture polishes are opaque and off-white in color. There's no significant difference in cleaning power among emulsified furniture polishes (Photos 15-6 and 15-7).
The scent added to furniture polishes makes the room smell nice. Though it may seem trivial, improving a room's atmosphere is actually a major function of furniture polishes. See A, B, C, D, E

HOW TO CHOOSE

Choosing a method of caring for your furniture is not nearly as complicated as the large number of products on store shelves would make you think. Whatever you decide about using a paste wax or furniture polish, you should always follow the passive care suggestions outlined earlier in this chapter. These methods will provide the maximum protection for the finish on your furniture.

To decide on which active-care product to use, determine which is more important to you- long-lasting shine and wear protection, or easy dusting and cleaning (you can always add scent by means other than furniture polish).

If you want permanent shine and wear protection, use a paste wax. Choose one that you find buffs easily. You'll have to experiment. The differences are in the evaporation rate, of the solvent, and preferences vary. Once you've applied the paste wax, dust it with a feather duster or with a dry or water-dampened cloth or chamois. Don't use a liquid furniture polish, or you'll streak and remove the wax.

If you want a product that makes dusting and cleaning easier, use a liquid furniture polish. You have three criteria for choosing which polish to use:

- Evaporation rate: If you want a furniture polish that gives maximum shine and wear protection, choose one that evaporates very slowly. The downside of these polishes is that they will be smeary on the surface for as long as they provide the shine and wear protection. If you want a furniture polish primarily for dusting and cleaning and don't want a smeary surface, choose one that evaporates quickly. Since manufacturers don't identify these characteristics, you may have to experiment a little.
- Cleaning ability- For normal cleaning use a solvent-based polish. For cleaning sticky fingerprints and other water-soluble dirt use a water-emulsified furniture polish. You'll recognize it by its milky-white color.
- Scent- Choose a furniture polish with a scent you like.

REPAIRING FINISHES

Finishes deteriorate, they get damaged, and they can be repaired. Some finishes are easier to repair than others, as I've explained in previous chapters, but most damage that occurs to most finishes can be fixed. Within the furniture industry a specialty, distinct from finishing itself, is dedicated to repairing finishes. It's concentrated in furniture factories, furniture stores, and moving companies, where most damage to finishes occurs. There are four general types of damage that occur to finishes, and sometimes through the finishes into the wood beneath:

- superficial damage to the surface of the finish in the form of light scratching, light cracking, and dullness
- damage to the color in the finish
- damage to the color in the wood
- damage through the finish and into the wood itself in the form of deep scratches or gouges

Superficial damage to penetrating finishes (oil, oil/varnish blends, a wiping varnish applied thin) is easy to repair. More substantial damage (color problems, gouges, and deep scratches) on surfaces finished with these penetrating finishes is almost impossible to repair, because there is no film thickness to work with. Once damaged, they'll never look undamaged. All types of damage to film finishes, on the other hand, can be repaired, but concealing color problems, gouges, and deep scratches often requires a high degree of skill.

REPAIRING SUPERFICIAL DAMAGE

Superficial wear or surface deterioration is the most common type of damage and is the easiest to repair. There are three ways to repair this kind of damage:

- Apply a coat of paste wax or oil/varnish blend to the surface and wipe off the excess.
- Rub the surface of film finishes with steel wool or rubbing compounds to cut through the damage or dullness and expose unaffected finish below.
- Apply another coat of the original finish, or apply French polish or padding lacquer on top of the damaged finish, to cover up the problem.

Applying Paste Wax or Oil/Varnish Blend

Applying paste wax or oil/varnish blend to the finish is the easiest of all repairs. It is very effective in disguising superficial wear and raising the sheen of dull surfaces. Both paste wax and oil/varnish blend will have about the same effect, but oil/varnish blend will be permanent while paste wax will be removed by furniture polish or soap and water.

I've discussed methods for applying paste wax and oil/varnish blend in previous chapters. (See "Applying Paste Wax A, B and "Applying 'Oil' Finishes A, B") You can apply either of these substances over any finish as long as the surface is clean. Be sure to remove all of the excess of either product, or the surface may become smudgy and sticky. Remember that oil/varnish blend cures soft, so don't apply it more than approximately once a year over a harder finish. You don't want to build the finish. Paste wax doesn't build, so it won't make any difference how often you apply it as long as you remove the excess each time. See

Cutting Back the Finish

If the finish is thick enough, you can cut it back to expose a better surface. You do this in exactly the same way you rub out new finishes. (See "Finishing the Finish.") You can level the surface by sanding first with 1000-grit or finer sandpaper and a lubricant, or you can skip this step and simply rub with steel wool or rubbing compounds. The risk in cutting back a finish someone else has applied is that you don't know how much thickness you have to work with. Proceed cautiously. The alternative to sanding is often refinishing anyway, so it won't hurt to try cutting back the finish first.

Applying More Finish on Top

You can usually correct superficial damage by applying another coat of the same finish. You can sand or rub the surface with steel -wool to smooth it before applying the new coat, just as you might do normally between coats. If you finished the piece originally yourself, you know which finish you used, so you know which finish to use again. (Using the same brand is not as important as using the same type-polyurethane, lacquer, shellac, etc.) But if you didn't do the original finishing, you are taking more risk in applying another coat. Test the original finish to determine whether it is shellac, lacquer, water base, or one of the reactive finishes. (See the “Tip”) Then apply the same finish over the existing finish.

There is always some risk in applying a fresh coat of finish over an old finish. Unpredictable things can happen, from poor flow-out to blistering. It's also often inconvenient: You have to move the furniture to an area set up for finishing, and the piece of furniture may be out of use for some time. A more convenient and less risky method of applying a new finish on top of the original is to French polish the surface with shellac, or French pad the surface with padding lacquer. This is the traditional way of keeping old finishes in good shape, and it is still a very effective method to "shine up" shellac, lacquer, and water-based finishes. It also works over varnish, but because there isn't a good bond between the newly applied coats and the varnish, the new coats may peel after a number of years.

I've described how to French polish. (See "French Polishing A, B, C, D, E" on page 155.) Padding lacquer is easier to apply, and it is usually more water-resistant than French polish (which is shellac). Because the technique of French polishing existed for a hundred years before the introduction of padding lacquer in the 1930s, the tradition was established of French polishing bare wood and repairing a French-polished surface with more French polish. Padding lacquer is seldom used on bare wood or over French polish. Padding lacquer is most often used to repair damage to finishes other than shellac. (See "Applying Padding Lacquer A, B, C") But there is no particular reason it has to be this way. You could just as easily apply padding lacquer--to bare wood or over shellac, or apply French polish over another finish.

Padding lacquer, or French finish as it's sometimes called, can be thought of as a modern French polish. In spite of its name, it is not based on lacquer, but on shellac. Other resins are often added to the shellac to increase its water resistance, and stronger ether and ester solvents are used in place of alcohol. In addition, padding lacquer has the lubricant built in. You don't have to (in fact, you shouldn't) add any oil to your polishing pad as you do when you French polish. The built-in lubricant is pine-tree- or petroleum-distillate solvent that evaporates at a rate between that of mineral spirits and kerosene. The lubricant stays in the polish while you're applying it, but evaporates soon after, so you don't have to remove it as you do the oil you use in French polishing. This saves a step and allows you to finish a job quickly without having to wait overnight for all the oil to rise to the surface for removal.

There are two companies that make most of the padding lacquer available in the United States-Mohawk/Behlen and Star. Each company makes several versions of padding lacquer that vary in solvent-evaporation rate, oil content, solids content, and color (from amber to clear). I find Ultra Qualasole from Mohawk/Behlen and Star-Lite French from Star to be the easiest to use (Photo 16-1).

If you've never used padding lacquer before, I suggest you buy a fresh pint or quart of Ultra Qualasole or Star-Lite French and try it on a piece of furniture you intend to refinish anyway. You'll develop a feel for padding techniques without worrying about making mistakes, and you'll learn the product's limitations. At the worst, you'll have to go ahead with your plans to refinish. If all goes well, the padding lacquer may make refinishing unnecessary. See

REPAIRING COLOR DAMAGE IN THE FINISH

Damage to the color of the finish is of three sorts:

- damage caused by water (water rings)
- damage caused by heat
- damage caused by rubbing off part of the color that was originally in the finish

Removing Water Rings

Water rings occur when moisture gets into the finish, eliminating the film's transparency. The film appears cloudy or white, usually in the sha pe of a ring because it's most commonly caused by a wet drinking glass or a hot cup under which moisture condenses on the finish. Heat accelerates the penetration. Water rings are more common on finishes that have aged and developed minute cracks. The cracks allow moisture to enter. Alcohol can also cause water rings by taking moisture along with it as it penetrates into a finish.

To remove water rings, you need to remove the water from the finish. There are three ways to do this, and I suggest you try them in the following order (the easiest and least destructive ones first) until you get a feel for the process. Success is unpredictable because of variables such as what type and how old the finish is., how long the water ring has been in the finish, and how deep the water damage goes.

- Apply an oily substance, such as furniture polish, petroleum jelly, or mayonnaise, to the damaged area and allow it to remain overnight. The oil has a greater affinity to the finish than water and will sometimes replace the water if the damage is superficial.
- Dampen a cloth with any commonly available alcohol (denatured alcohol is best) and wipe it gently over the damaged area. Since alcohol will dissolve shellac and damage lacquer and water base, in addition to causing water rings itself, begin with a very slight dampening and add more alcohol if necessary, observing closely what is happening (Photo 16-5). You will have the cloth dampened enough when it leaves the appearance of a comet's tail trailing as you wipe. The comet's tail is caused by the alcohol evaporating. Don't rub hard. Wiping with alcohol will remove water rings in all but the most severe cases.
- Cut through the damage by rubbing with a mild abrasive. Cigarette ashes, mixed with water or oil to make a paste, and toothpaste are often suggested. But these abrasives will probably be too mild if the alcohol didn't work. (You can try them in place of the alcohol, however.) Rottenstone, or possibly pumice (which is coarser), in combination with a light oil, such as mineral oil or even a furniture polish, will be more effective. Fine #0000 steel wool lubricated with a light oil will be even more effective, but it will also scratch the surface more severely, so you should use steel wool only as a last resort. Rub the damaged area until the water damage is gone, being careful not to rub through the finish. Then, even the sheen over the entire surface by rubbing it with the same abrasives you used to remove the water ring, or with finer abrasives to raise the sheen. (See Chapter 14: "Finishing the Finish.")

Repairing Heat Damage

Heat damage appears similar to water damage. The film becomes cloudy and off-white in color. Heat may also cause an indentation in the finish. Heat damage is usually impossible to repair without stripping and refinishing. It might be possible for you to apply alcohol to a shellac finish or lacquer thinner to a lacquer finish and correct the problem by redissolving the finish and letting it cure again. It's often worth a try, but it probably won't work.

It's also sometimes possible to correct the color, but not the transparency, by painting over the damage as described below.

Replacing Missing Color

Damage caused by rubbing off part of the color originally in the finish is difficult to repair, but it can usually be done if you have a good sense of color and some patience. (See "Matching Color" on page 84.) Since the wood is still sealed (all the finish hasn't been rubbed off), you have to apply new color on top of what is left. You can't simply apply some stain, because the stain won't penetrate.

To make the repair, apply a colorant on top of the damage. The colorant can be pigment or dye, but it must include a binder to lock the color in. The binder can be shellac, padding lacquer, lacquer, or varnish. The application tools can be a rubbing pad, artists' brush, or spray gun. The idea is to get the color correct, make the grain look natural, seal the repair so it doesn't fade or wash back out, and then make the sheen match that of the surrounding area. It will help if you think of yourself as an artist with a palette of colors, binders, and abrasives. The smaller the damaged area, the easier it will be to disguise. And darker colors will be much easier to match than lighter colors. (See "Touching Up Color A, B, C" on the facing page.)

Here are some tips for touching up damage to the color in the finish:

- If the color in the surrounding area is transparent, use dyes.
- If the color in the surrounding area is opaque, use pigments.

- Shellac and padding lacquer are the most popular binders to use with dyes or pigments because they are less likely to damage the original finish, they dry quickly, and, if you make a mistake, they can be wiped off with an alcohol-dampened cloth without damaging most finishes.
- Varnish can also be used, but it will take almost a day to dry between coats. Varnish can be removed with mineral spirits if you do so before the varnish cures.
- Lacquer can be used only with a spray gun, and if you get the color wrong, you won't be able to remove it without making the damaged area larger. Reduce your spray pattern as much as possible, and mask off the surrounding area with a piece of paper that has a hole cut in it the size of the damage you want to color.

Your colors must be compatible with the binder, of course. (See "Compatibility of Colors and Binders") You will probably have the greatest success using an artists' brush to apply most colored finish, but you can also use a rubbing pad.

You can use these same touch-up techniques to disguise heat damage, glue splotches, burn-in repairs (see "Using a Burn-In Stick A, B"), and wood putty that didn't take the stain. You paint the affected area to fake the grain and color of the surrounding wood. Again, the smaller the area you're trying to disguise, the better your chances of success.

REPAIRING COLOR DAMAGE IN THE WOOD

When the damage cuts through the finish and removes stain that was originally in the wood, repairs are usually fairly easy. You need only replace the missing stain and ensure that it is sealed so it won't fade or wash off. There are several ways to do this: 0 Use a neutral or colored oil/varnish blend, such as Watco or Deft Danish Oil, to put the color back into nicks and scratches. This is especially effective on table and chair legs and on baseboards and paneling. Wipe a generous coat of the proper-colored Danish oil (the color doesn't have to be exact.) over the entire affected surface (Photo 16-10). Then remove all the excess. The oil/varnish blend will penetrate everywhere the damage has cut through to the wood. (See "Applying 'Oil' Finishes" on page 51.) If you can't find the proper color ready-made, make your own by adding oil-soluble dye or universal-color, artists'-oil-color, or japan-color pigment to an oil/varnish blend.

- Use an oil/varnish-based pigment stain to color in nicks and scratches. Wipe the stain over the entire surface, then wipe off the excess. These stains contain very little binder, so you should seal the color in the wood by applying a coat of oil/varnish blend the next day.
- Use colored paste wax to color in nicks and scratches.

If the finish is thin, coloring the scratch may be sufficient. If the finish is thick and otherwise in good shape, you may have to fill the scratch. See

REPAIRING DEEP SCRATCHES AND GOUGES

Scratches and gouges that go through the finish into the wood have to be filled. It's very difficult to do this successfully with wood putty because the putty will stick to the finish everywhere it comes in contact, and it will be almost impossible to remove. It's better to melt solid finish into the depression, smooth it level with the surrounding surface, and then add coloring and graining to make the filling blend in. (See "Using a Burn-In Stick" on page 254 and "Touching Up Color" on page 249.)

The solid finish used is shellac or lacquer, because these finishes can be changed from solid to liquid and back again by applying and removing heat. (See Chapter 7: "Introduction to Film Finishes.") These finishes are formed into solid sticks of many colors. They are commonly called bum-in sticks. The process of melting them into damaged areas is called burning in.

The most difficult part of burning in is getting the filling level without damaging the good finish around it. It's common for beginners to start off with a very small hole and end up with quite a large area of damaged finish. You should practice on a finished scrap of wood before tackling a piece of furniture.

FINISHING DIFFERENT WOODS

Understanding finishes and how to apply them is not the whole story. Woods vary in color, density, and texture. You need to consider the characteristics of a specific wood in deciding how to finish it. In most cases the woods you use are the same as those used hundreds of years ago. You're not the first to struggle with the choices of how best to finish a particular wood. You can learn a great deal by looking at how previous generations solved the problems. Often an image of how a wood should look comes from having seen it in a given style. You might aim to reproduce the look of a period piece, echo a familiar effect, or present a wood differently than people are used to seeing it.

Following is a discussion of the major considerations and problems you will encounter in finishing different woods and some choices for finishes to use. The step-by-step finishing schedules I present in the side columns are only suggestions meant to illustrate the variety of ways to finish wood. They correspond to the furniture pieces shown, (263, 264a, 264b, 265a, 265b, 266a, 266b, 267, 268a, 268b, 269, 270a, 270b, 271, 272a, 272b, 273, 274, 275,276, 277, 278a, 278b) where you'll see how each schedule finally looks. When I think one brand of finishing material is significantly better or more widely available than others, I name it. But in most cases there's not enough difference between brands of one type of product-oil/varnish-based pigment stains, paste-wood filler, nitrocellulose lacquer-to be concerned with which brand you use. Keep in mind, too, that every stain, paste-wood filler, glaze, and finish can be applied to every wood. You are making aesthetic decisions, so there are no absolute rules. People will disagree about what's best and what they prefer.

PINE

Pine is often the first wood used by beginning woodworkers. It's widely available, relatively inexpensive, and one of the easiest woods to cut and shape with machine and hand tools.

Yet pine may be the most difficult of all woods to finish. The earlywood (spring growth) of both white and yellow pine is soft, porous, and off-white. The latewood (summer growth) is very hard, dense, and orange. Thus, the earlywood and latewood react differently when sanded, stained, and finished, causing an uneven appearance that frustrates beginning and experienced woodworkers alike.

When you sand pine by hand, without the aid of a cork-, felt-, or rubber-backed sanding block, you cut away the softer earlywood much faster than the latewood. This leaves depressions that show up when you apply a finish.

When you stain pine with common pigment and dye stains, the stain penetrates deep into the porous earlywood but very little, or not at all, into the dense latewood. This uneven stain penetration causes a color reversal in the grain pattern. The white earlywood darkens, while the orange latewood stays about the same (Photo 17-2).

When you finish pine with nonbuilding finishes, such as oil and oil/varnish blend, or slow-building finishes, such as wiping varnish, the finish soaks deep into the porous earlywood but hardly at all into the dense latewood. This results in an uneven sheen. The earlywood appears flat, even after several coats, while the latewood becomes glossy.

Pine also varies randomly in density throughout, in addition to earlywood and latewood variations. No matter how well you sand pine before staining, you often get darker splotches when you apply a stain. These splotches are caused by deeper stain penetration in the less-dense areas that occur naturally in the growth of pine trees.

Historically, pine has usually been painted or finished unstained. Only recently, with the increase in do-it-yourself projects, has there been much interest in staining pine. Often, staining is an attempt to make pine resemble another wood, such as walnut or mahogany. But imitating other woods is almost impossible with pine because the grain is too pronounced to disguise.

Your best option for finishing pine (other than painting) is probably to leave it unstained and apply a film finish, such as varnish, lacquer, or water base. Unstained pine is quite attractive. The wood turns a warm yellow-orange as it ages. All finishes except water base will warm and deepen the coloring, which will get darker and richer with age. This look on pine has been popular in northern Europe for many years and was once popular in the United States. Applying several coats of a film finish gives you an even sheen across the porous earlywood and the dense latewood.

If you do decide to stain pine, there are two ways to reduce the problems of grain color reversal and splotching:

- Washcoat the wood prior to staining.
- Use a gel stain.

The method most commonly recommended is to apply a washcoat of finish, which partially seals the wood. Traditionally, 1/2- to I-pound-cut shellac was used. (See "Liquid and Flake Shellac") Now it's more common to use manufactured products that do the same thing. (See “Washcoating") I don't find washcoating to be a good solution for pine, however. The variations in wood density are often too great and unpredictable. It's difficult to know how much washcoat material to apply to produce an even staining. If you don't seal the wood adequately, you will still get splotches, which you can't remove without sanding below the depth to which the stain has penetrated. If you apply the washcoat heavily enough to ensure against splotching, you may seal the wood so completely that little or no stain will penetrate. You will get very little coloring unless you leave a thickness of stain on the surface. If you're using a pigment stain, a thick layer will obscure the wood.

Your best option for staining pine, in my opinion, is to use a thick gel stain, such as Wood-Kote. Thick gel stains don't penetrate much because they don't flow. The result is a more even color with little splotching.

In addition to the above two options, you can seal the wood entirely with a full coat of whichever finish you're using and build all the color on top. There are two ways to build the color on top: Use a glaze or tone the wood.

To use a glaze, first apply a full coat of finish and let it dry at least overnight. After sanding lightly, wipe glaze over the surface and remove the amount necessary to give you the appearance you want. You can use a gel stain as a glaze. Wipe with the grain.

To tone the wood, add a compatible dye or pigment (see "Compatibility of Stains and Finishes") to your finish and apply it to the wood as a second coat. You will get the best results if you spray this colored finish, called a toner (see "Shading stains and toners"). You can also brush a colored finish, such as Minwax Polyshades, that won't obscure the wood much because it has so little pigment. It's best to apply several coats of clear finish over the toner to protect it from being scratched off the wood.

Personally, I like pine best when it's unstained and finished with a film finish, such as brushing lacquer. I don't think I've ever applied a stain to pine except when experimenting.

OAK

Oak is almost as difficult to finish as pine. Like pine, oak varies greatly in density between earlywood and latewood. In contrast to pine, however, the earlywood pores of both red oak and white oak are very large-large enough to see with your naked eye. These pores give plain-sawn oak, the most commonly used type, its coarse appearance.

When you sand plain-sawn oak by hand without using a flat block to back the sandpaper, you cut away more of the porous earlywood than the dense latewood. You may not notice this while you're sanding. But when you apply a finish, you will see pronounced depressions in all the earlywood areas.

When you stain oak with a common pigment stain, the pigment lodges heavily in the large pores of the earlywood but penetrates hardly at all into the dense latewood areas. The large-pored areas are thus highlighted in a way that accentuates the coarseness of the wood. This is especially the case with plainsawn oak (Photo 5-2). I don't find this effect attractive.

When you apply a thick finish to oak without first filling the large pores level with the surrounding surface, you get a rounding over into the pores that makes the wood look like plastic (Photo 13-3). Before the age of plastic this look may have been attractive. But I don't think it is now.

On the other hand, the deep pores of oak offer certain advantages for decoration not found in most other woods. Colored paste-wood filler or glaze can be used to make the pores a different color than the surrounding dense wood to add decorative effects. (See "Filling the Pores with Paste-Wood Filler" and "Glazing") Any color combination can be used.

Three very popular furniture styles feature oak: Old English (which is very dark), Turn-of-the-Century (an even brown), and Modern (natural, unstained). These styles have one important characteristic in common: The earlywood/latewood contrast in the wood is de-emphasized.

Old English furniture, particularly that of the Tudor period, employed English brown oak (a darker variety of oak than American red or white oak), which became darker over the centuries as the soot from open wood fireplaces and coal-burning stoves penetrated the commonly used wax finish.

Turn-of-the-Century (also called Craftsman or Mission) oak furniture was commonly made with quarter-sawn oak; that is, oak sawn radially, with the growth rings perpendicular to the face of the boards (Figure 17-1). Quarter-sawn oak has much more evenly spaced pores than plain-sawn oak and a distinctive grain configuration called ray fleck (Photo 17-8). Rays are hardwood cells that extend radially in a tree stem; in quarter-sawn oak they appear as elongated, dense, light-colored flecks. At the turn of the century, the oak was colored by a process known as himing. The furniture was placed in a room filled with the fumes of ammonia, which reacted with the tannic acid in the oak to darken it chemically. Fuming produces an even brown color on both earlywood and latewood but dosn't darken the rays. The lighter rays resemble tiger stripes on the oak, so fumed quarter-sawn oak is sometimes called tiger oak.

You can imitate the even coloring of Old English oak by using a dye stain. Dye stains penetrate everywhere in oak, so the dense latewood is colored almost as completely as the porous earlywood. Any type of dye stain will work, but a water dye won't color the pores well: They come out lighter. You can solve this problem by applying a dark pigment stain over the dye stain (after it has dried) and wiping off the excess. The pigment will lodge in the pores, evening the color over the entire surface. Alternatively, you can use an alcohol, oil, or NGR (non-grain-raising) dye stain to avoid the problem. A convenient alternative is walnut-colored Watco or Deft Danish oil. The coloring in these oil/varnish blends is asphaltum, which penetrates much like a dye. (See "What's in Watco?" on page 85.) You will achieve an even dark-walnut color.

You can imitate fumed oak in the same way, by applying a dye stain of the proper color. But there are no ready-made oil/varnish blends that contain the proper-colored dye. So you'll have to do the coloring with separate dyes. Remember that turn-of-the-century fuming was almost always done on quarter-sawn oak. You'll never achieve the same look using plain-sawn oak.

Another way to imitate the even coloring of Old English or fumed oak is to seal the oak and then add a colorant to the finish; that is, by toning. You can use either pigment or dye for the colorant. You will find that pigment is usually more effective for imitating the look of Old English oak (you want to obscure the wood somewhat) and dye is more effective for imitating fumed oak.

Personally, I like oak best when the coarseness of the contrasting grain is de-emphasized and the pores are left sharply defined. So I usually finish oak unstained, stained with a dye, or toned with pigment or dye. And I usually use an oil/varnish blend or wiping varnish, or I keep my film-finish coats thin on the wood. I also like oak pickled with white color in the pores. This look is currently very popular for kitchen cabinets and interior trim.

WALNUT

Walnut is America's supreme native furniture hardwood. It is a hard, durable wood with a beautiful figure and rich, dark coloring. It has a smooth, medium-porous texture that accepts all stains evenly, and it finishes nicely with any finish. The coloring of air-dried walnut heartwood is a warm, rust red. The coloring of kiln-dried heartwood, which is commonly steamed to reduce heartwood and sapwood color variations, has a colder charcoal gray cast. As steamed walnut ages, the gray warms to a tan with a slight reddish tint. The reddish tint in aged walnut makes it difficult to distinguish from mahogany in old furniture.

There are two finishing problems presented by walnut: the color contrast between the dark heartwood and the almost-white sapwood, and the coolness of steamed walnut.

There are four ways to overcome the color contrast between heartwood and sapwood:

- Cut off all the sapwood so you're using only heartwood.
- Arrange your boards so you use the color differences to decorative advantage.
- Bleach the wood to a uniform off-white color and then stain it back to whatever color you want. (See "Bleaching Wood" on page 80.)
- Stain the sapwood to the color of the heartwood with a dye stain, and then stain the whole to the color you want.

Woodworkers making one-of-a-kind furniture usually choose one of the first two methods: They cut away the sapwood or they use it decoratively. Bleaching walnut was common in factories when blonde furniture was popular in the 1950s. Today furniture factories use stains to blend sapwood and heartwood.

You can warm the tone of walnut by staining it or by putting color in the finish. You can use any type of stain, though a gel stain will not bring out the full richness of the figure. Most finishes contain a natural amber tint that warms the wood a little. Orange shellac contains the most color, and it is often used on walnut for this reason, though it's not a durable finish for tabletops. Water-based finishes are totally devoid of color, so there is more reason to use a stain under water base than under any other finish.

Personally, I like just about any finish on walnut. I've used oil/varnish blend, wiping varnish, and film finishes. For objects other than tabletops, my favorite finish is orange shellac because of the warmth it adds to walnut (Photo 17-12 on page 268). When using other finishes, I often add warmth by staining the wood (a dark rust, commonly sold as American walnut) or adding dye to the finish (again, dark rust) and toning the wood.

MAHOGANY

The mahogany available in the eighteenth and early nineteenth centuries was considered at the time to be the premier furniture hardwood. This mahogany was very dense and rich reddish brown in color. It was generally known as Cuban or Santo Domingan mahogany, because it came from those islands.

Cuban and Santo Domingan mahogany was generally left unstained and unfilled. The natural color was so rich it didn't need stain, and the wood was so dense (its pores are smaller than those of walnut) it had a pleasing appearance without being filled. Because of the great widths available, new styles of tabletops were developed-most notably, large pie-crust tables.

Unfortunately, this mahogany is no longer available. The best mahogany available today is Honduras mahogany. Though Honduras mahogany is the same botanical species as Cuban and Santo Domingan mahogany, it is softer, is less rich in color, and has larger pores as a result of different soil and growing conditions. Still, Honduras mahogany is a fine furniture wood.

Honduras mahogany grows in Honduras and other countries in Central America and northern South America. Right after being milled, it is pink in color. It darkens in air and light to a rich coppery red. Honduras mahogany is very stable and works easily, though when the grain is wavy, it can be difficult to hand plane.

Other mahoganies available are African mahogany and Philippine mahogany. Though neither of these woods is a true mahogany in a botanical sense, both resemble Honduras mahogany and are commonly sold as mahogany.

African mahogany is coarser, less stable, and weaker than Honduras mahogany. It has an interlocking grain that makes it more difficult to work with machine and handtools. African mahogany is usually cut into quarter sections before being milled. Quarter-sawing reveals a distinct ribbon-stripe pattern which is sometimes very pronounced (Photo 17-15). When the ribbon-stripe is pronounced, the wood is usually sliced into veneer. African mahogany is also pink to red in color and darkens with age.

Philippine mahogany, which is more commonly called lauan (pronounced LOO-AHN), is coarser and weaker than either Honduras or African mahogany. Its pores are much larger, making it a more difficult wood to finish nicely. Hollow-core doors used in house construction are commonly veneered with lauan. Though lauan also darkens with age and can be made to look fairly elegant by filling the pores, it is not a quality furniture wood like Honduras and African mahogany.

The high-quality mahogany available in the eighteenth and early nineteenth centuries was usually left unstained and unfilled. When mahogany came back in style in the late nineteenth century, and again in the 1940s with Duncan Phyfe reproductions, only the poorer-quality Honduras and African varieties were available. Furniture made of these mahoganies was almost always stained with dye stain, and the pores were almost always filled.

Both Honduras and African mahogany take all types of stain evenly. Before deciding to stain mahogany, however, remember that the wood will darken considerably within a couple of years. If you stain the wood to the color you want, you may find that it soon becomes darker than you want. Consequently, you might decide to stain the wood not quite as dark and let it darken naturally to the color you want.

Woodworkers today often finish mahogany without any stain or filling. They usually apply an oil/varnish blend or a wiping varnish. The wood darkens in time to a beautiful dark red, and both finishes can be kept thin enough so the pores don't take on a rounded-over, plastic appearance.

Personally, I like mahogany better with a rich brown dye stain, not too red (there being enough red in the wood already), the pores filled (at least on tabletops), and a lacquer finish rubbed to an even semi-gloss. This finish makes the lesser-quality Honduras or African mahogany resemble Cuban and Santo Domingan mahogany.

HARD MAPLE

Maple is an excellent wood for woodworking. It is strong and wear-resistant, and it works well. It makes very good flooring because it wears slowly, smoothly, and evenly without splintering. It is also the best wood for cutting boards because it is dense, fine-grained, and free of any odor or taste that might be imparted to food. Hard maple comes from the sugar maple tree, the same tree that produces the sap that is made into maple syrup. Unusual growth patterns in sugar maple result in the distinctive and attractive figures of curly and bird's-eye maple (Photo 17-19). Maple with a tightly curled figure is called fiddleback maple because it is often used for the backs of violins.

Maple is more difficult than most woods to finish. The problem is that most maple is uninteresting without stain. The exceptions are curly and bird's-eye maple, though these grain variations are also greatly enhanced with stain. To successfully stain maple, you must use a dye stain. Many woodworkers and finishers have been unhappy using pigment stains on maple.

The reason for the problem is the density of the wood. The pores in maple are not large enough to accept much pigment. So pigment stains don't have much effect, unless you build the pigment on top, which obscures the wood. This goes for curly and bird's-eye maple, as well. Though pigment stain highlights the curls and bird's eyes, it doesn't do so nearly as effectively as dye stain (Photo 5-3). With dye stain you can make maple any color you want and as dark as you want, without obscuring its figure. You can even make the wood black. (See "Ebonizing Wood" on page 83.)

When maple was used in the eighteenth and early nineteenth centuries, it was generally left unstained. As the wood aged, it took on a warm yellow-orange coloring and the figure mellowed. This is the look you see today in old maple furniture. You can imitate the coloring with a yellow-orange dye. But maple has a tendency to splotch when stained, and dye stain accentuates the figure. So, if you want to imitate the look of old maple, you will have the greatest success if you tone it using pigment, dye, or a combination of the two in the finish. This is what factories did on the maple furniture that was popular in the 1950s.

More recently, hand-made maple furniture has been left unstained, largely, I believe, because woodworkers haven't understood the results that could be achieved with dye. But unstained maple does have its own appeal.

I believe maple has much more character with a dye stain. I also like maple better with a film finish, though I don't object to maple finished with an oil/varnish blend. Film finishes bring out more of the wood's character because the thickness adds depth.

CHERRY

Cherry has been a popular furniture wood since the eighteenth century. It was often used as a native American substitute for imported mahogany. Cherry was sometimes stained to accelerate the darkening process, but it was usually left unstained to darken naturally. In the 1950s cherry became very popular in mass-produced furniture. Factories usually toned the cherry rather than stain it.

In recent years cherry has become one of the most popular woods used by woodworkers making one-of-a-kind furniture. It's popularity is so great that it is now among the most expensive domestic hardwoods. Cherry is popular for several reasons. Most important is its association with the warm, rust-red color found on older cherry furniture. Also, cherry is an easy wood to work. It has a pleasant scent when being machined, especially when contrasted with the smell of most other woods. And it has a familiar name which is associated with a tasty fruit (even though the cherry trees that produce the wood don't produce that fruit).

In spite of its popularity, cherry is a difficult wood to finish. Freshly milled cherry doesn't have the warm, even, rust-red coloring of old cherry. New cherry is usually pink to light reddish in color. But the color often has a slight grayish cast. Different boards vary in color, and the color often varies significantly even in the same board. In addition, the figure is far more pronounced in newly cut cherry than in old cherry. Since the look of old cherry takes many years to develop naturally, many woodworkers try to imitate it immediately by using stain.

The problem with this is that cherry doesn't stain well. It often splotches because of swirly grain. In this way cherry resembles pine and birch. In addition, even if you do achieve an even, rust-red color with stain, the effect will be only temporary. As the cherry goes through its natural darkening process, the stained color may become too dark. Therefore, it's usually best to choose your boards very carefully so they match well and contain little or no sapwood. Then, either use no stain at all, or use a stain that brings the color only part way to what will occur naturally over time. If the particular wood you're staining has a tendency to splotch, use a stain that doesn't penetrate.

If this solution is unacceptable to you, an alternative is to use maple, and dye-stain it to the color of aged cherry. Maple doesn't darken significantly, so the aged-cherry look will be both immediate and fairly permanent. The figure in maple is so close to that of cherry that it is often difficult to tell the two apart if color is not a factor.

Two good ways of coloring cherry are to stain it using a gel stain and to tone it by spraying on a lightly colored finish. Both of these methods reduce the possibility of splotching and even the contrast in figure, in addition to making the cherry darker.

Gel stain has a good track record as a stain for cherry. Gel stains were included with the cherry furniture kits sold by Bartley's, the popular mail-order company. Bartley's chose gel stain because it was easy to use, and they wanted the buyer to enjoy the finishing as much as gluing the furniture together. By chance, Bartley's had provided the perfect stain for cherry, and the company had success selling these kits because their customers got great results.

Toning requires that you have access to spray equipment, but applying a toner gives you great control over the coloring process. Use a dye toner when your primary goal is to make the wood darker without obscuring the figure. Use a pigment toner when your primary goal is to even the contrast in the figure. I find that it's usually best to use a combination of dye and pigment. But boards vary, so make your decisions as you proceed.

You will sometimes encounter the suggestion to use lye to make cherry look old. Lye darkens woods, such as cherry, oak, mahogany, and walnut, that contain tannic acid. It is sometimes possible to approximate the look of old cherry quite closely using lye. There are several problems, however, in addition to the obvious one that the cherry will darken on its own and may become too dark after several years.

Lye is very caustic and therefore dangerous to use. Be sure to protect your skin and your eyes if you do use it. Lye doesn't stop working on the wood just because the water has dried out of it. Consequently, you have to neutralize the lye with an acid or it will destroy the finish you apply. The best way to neutralize lye is with a 50/50 mixture of vinegar and water. Wash the wood liberally with this mixture. Then wash it with water alone.

Using any chemical to color wood is somewhat unpredictable. Using lye is no exception. In the case of lye, the color may come out uneven because different parts of the wood contain different amounts of tannic acid. In addition, if you get the color too dark, you can't lighten it easily as you can with stains. You can only bleach out all the color, including the natural color of the wood, using hydrogen peroxide. You can't remove just the lye.

Because of these problems, I don't recommend lye as a stain for cherry. I prefer to use gel stain or a toner. I also prefer a film finish on cherry rather than an oil/varnish blend, because a film finish provides more depth and richness. But many woodworkers like to use an oil/varnish blend, and I don't find the results this produces objectionable.

ASH, ELM, AND CHESTNUT

The grain structure of ash, elm, and chestnut is very similar to that of oak. Furniture manufacturers have often substituted these woods for oak or mixed these woods with oak. After staining, it takes a trained eye to identify which is which.

When you stain ash, elm, or chestnut with a pigment stain, the same problem occurs as with oak: The natural coarseness of the wood is made even more pronounced. But the problem is not as severe as with oak, because the latewood growth of these woods is not as dense. The latewood of ash, elm, and chestnut absorbs more pigment than the latewood of oak, so the overall coloring is more even. Nevertheless, the techniques for minimizing the coarse look of oak work well with ash, elm, and chestnut.

I like ash, elm, and chestnut finished in the same ways I suggest for oak: no stain, a dye stain, toned with pigment, or pickled; then a thin finish to leave the pores sharply defined.

SOFT MAPLE, GUM, AND POPLAR

Soft maple, gum, and poplar are relatively inexpensive hardwoods and are often used by factories for structural parts of tables, chests, and chairs that have a nicer veneer on the top or chair splat. The woods are usually dye-stained (when visible) to resemble the better-quality wood, and many people don't realize the difference.

There are two problems with finishing soft maple, gum, and poplar: their plain figure and their softness. The plain figure is usually uninteresting unless it is stained. You can use pigment or dye, but you'll be able to get much darker colors with dye. The softness usually requires that you apply a film finish rather than an oil/varnish blend to give the woods enough sheen to look nice.

I like these woods finished with a film finish. I use either pigment or dye, depending on how dark I want the wood to get.

AROMATIC RED CEDAR

Aromatic red cedar is commonly used in cedar chests because its odor repels moths. On the inside of a chest it's seldom, if ever, stained since it has beautiful natural color, and staining and finishing would seal in the odor that makes the wood effective. When it's on the outside of a chest, it's usually finished but not stained.

Problems occur when you finish any part of the inside of a cedar chest, whether the wood is cedar or not. The cedar's odor producing solvents build up enough inside the chest to soften most finishes, causing them to become sticky. To avoid the problem, leave all inside parts unfinished.

I think aromatic red cedar on the outside of a piece of furniture looks best when it's unstained and finished with a film finish.

BIRCH

Birch looks similar to maple and is sometimes mistaken for maple. Birch has the same characteristic of high density, so it is also difficult to stain with pigment stain. But birch usually has a more swirly grain, so it splotches more than maple. If the splotching is more than you can tolerate, build the color on top, using a toner, instead of trying to put it in the wood. If you use a dye in your finish, you'll get an even color without obscuring the wood.

Birch, along with maple, was often dye-stained red and used to imitate mahogany in furniture made at the turn of the twentieth century. I like to finish birch the same way I finish maple. If splotchiness will be a problem, I use maple instead.

OILY WOODS

Many woodworkers like to use colorful exotic hardwoods such as teak, rosewood, cocobolo, and ebony for decorative purposes, sometimes as accents to other woods, but also for whole pieces of furniture. It's rare that these hardwoods are stained; their natural beauty is the reason these expensive woods are used in the first place. But they are almost always finished, and the oil they naturally contain can cause problems.

The most common problem is that the finish sometimes takes a long time to cure. This can occur when you use oil, oil/varnish blend, or varnish. All of these finishes cure by absorbing oxygen, and the oil in these woods retards the absorption of oxygen.

The other problem occurs with lacquer, conversion finishes, and water base. The oil prevents these finishes from establishing a good bond with the wood.

You can prevent both problems by wiping the surface of the wood with a cloth dampened with a fast-evaporating solvent, such as naphtha or lacquer thinner. This cleans the oil off the wood surface. Apply the finish quickly after the solvent evaporates, so the oil doesn't have time to bleed back to the surface.

On objects made entirely from exotic woods, I use an oil/varnish blend or wiping varnish when I want the pores sharply defined. I build a thicker film finish when I want more protection. I sometimes use only wax when the object is decorative and won't be handled much. On objects where exotic woods are used as trim or decorative accent, I use whatever finish is appropriate for the object as a whole.

STRIPPERS

Removing the finish brings us full circle. I've taken you through all the steps involved in putting a finish on wood. Now I'm going to tell you how to take the finish off. No subject better illustrates the book's central theme. Despite the confusion and obscurities of myth and hype, finishes and finishing are understandable. So are strippers.

The advantage you have with strippers over every other product you use in finishing is that manufacturers are required by law to list all the principal ingredients. All dangerous solvents have to be listed, and strippers are composed almost entirely of dangerous solvents. So with strippers, you can know what you're getting and choose the best stripper for the job by reading the ingredients on the container. (See "Breaking the Code-An Overview of Strippers A, B")

There are only four primary solvents, or solvent groups, used in strippers, so the task of learning the names and how each works is not very difficult. The four solvents differ in effectiveness, price, and potential danger to your health. Pairs of these solvents or groups are sometimes combined, alkalis are sometimes added to increase the stripper strength, and one alkali (lye) is sometimes used alone. So you actually have more than the four primary categories of strippers to choose from. You should choose among the categories when choosing a stripper for strength, safety, or price. Within each category you should choose for ease of use and also for price. You won't notice any significant difference in solvent strength, speed of removal, or safety within each category.

STRIPPING SOLVENTS AND CHEMICALS

There are four solvents, or solvent groups, commonly used in strippers. These solvents or groups are sometimes used alone and sometimes combined with one of the other solvents. Since the names of the four solvents are long and sometimes difficult to remember, I'm including abbreviations:

- methylene chloride (MC)
- acetone, toluene, and methanol (ATM)
- N-methyl pyrrolidone (NMP)
- di-basic esters (DBE)

There are also a couple of very strong alkalis used for stripping sodium hydroxide (lye) and ammonium hydroxide (ammonia). Lye is often used alone. Ammonia is sometimes combined with one of the solvents to increase the stripper strength. Both of these chemicals darken many common hardwoods. Lye, which is used with water, also breaks down old glue and turns wood into pulp if left in contact long enough. So you should avoid using an alkali unless you need its strength.

Methylene Chloride (MC)

Methylene chloride has been the primary active ingredient used in most paint-and-varnish removers for the past three or four decades. It's the most effective stripping solvent available to the general public as well as to commercial stripping shops. It's also non-flammable. But methylene chloride is toxic and, unfortunately, it is a suspected carcinogen. (See "Stripper Safety") Exposure to methylene chloride may also trigger heart attacks in people with existing heart conditions. (Methylene chloride metabolizes into carbon monoxide in the blood stream, causing the heart to pump harder to get enough oxygen to the body. If you have a heart condition, don't use methylene-chloride strippers.)

You can buy methylene-chloride strippers in liquid or semipaste consistency and in three different formula strengths. The consistency of the stripper is important if you're working on vertical surfaces-liquid will run off, semi-paste will cling. The consistency has very little to do with the strength of the stripper.

The solvents in both liquid and semi-paste strippers of all three strengths evaporate very rapidly, so paraffin wax is almost always added to retard the evaporation. The wax rises to the top of the stripper, even on vertical surfaces, and forms a skin that holds the solvents in. If you disturb this wax skin, you allow the release of some of the solvents. (See "Using Strippers A, B, C")

Some methylene-chloride strippers in each of the formula strengths are made to be water-washable by the addition of a detergent to the formula. Water washing makes the stripper and the gunk it creates easier to remove from the wood, but it introduces water, which can raise the grain, remove water-soluble dye stains, and sometimes lift veneer and loosen joints.

The strength of methylene-chloride strippers depends primarily upon the formulation; there are three classes. All three contain a small percentage of methanol (methyl or "wood" alcohol) as an "activator" to increase the effectiveness of the methylene chloride.

- Methylene chloride and methanol.
- Methylene chloride and methanol strengthened with an alkali.
- Methylene chloride and methanol thinned with acetone and toluene (actually a combination of two categories: MC and ATM).

Methylene chloride/methanol strippers are the most common. These strippers are strong enough to rapidly remove all but the most solvent-resistant paints and finishes. They are less effective on epoxy, polyester, conversion, or baked-on coatings, but they eventually work. These strippers are also non-flammable and nonpolluting. (Methylene chloride, which makes up 75 to 85 percent of the formula, is non-flammable, and it's not considered an ozone depleter or smog producer by the Environmental Protection Agency [EPA].) The primary disadvantages are potential health hazards and cost. Methylene chloride is a moderately expensive solvent, so strippers made with high percentages of methylene chloride are also moderately expensive.

Alkali-fortified methylene chloride strippers are stronger than methylene chloride strippers because of the added alkali. The alkali is usually ammonium hydroxide (ammonia), and it's usually, but not always, listed on the container. (Acids, such as oxalic acid, are sometimes used in strippers sold to professional refinish shops but never in strippers sold to the general public, because the acid is unstable in the mixture.)

Alkali-fortified strippers are available in most paint, boat, and auto-body supply stores. They are often sold as “marine” strippers. The advantage of these strippers is their increased effectiveness on exceptionally tough coatings such as epoxy, polyester, conversion, and baked-on boat and car finishes. The drawbacks are their moderately high price, the health hazards associated with methylene chloride, and their tendency to stain hardwoods such as oak, mahogany, cherry, and walnut. The staining is caused by the ammonia, which reacts with the tannic acid contained naturally in these woods. (See "Using Oxalic Acid")

Methylone chloride/acetone, toluene, methanol (MC/ATM) strippers are the weakest of the three types that are based on methylene chloride. But they are strong enough to effectively strip almost all old finishes and paints. They are also the least expensive of the three MC types. The problem with adding ATM to methylene chloride is that it introduces solvents that are flammable and cause air pollution.

Sometimes methyl ethyl ketone (MEK) is substituted for the acetone, and xylene (xylol) for the toluene. These solvents, which evaporate a little more slowly than acetone and toluene, will be listed on the container.

Acetone, Toluene, and Methanol (ATM)

Acetone, toluene, and methanol are three of the basic ingredients in lacquer thinner. If you've ever put lacquer thinner on a finish, you're familiar with the damage this blend of solvents can cause. It will dissolve shellac, lacquer, and water base, and it will soften and sometimes wrinkle varnish. Manufacturers take advantage of this solvent strength to make non-methylene-chloride strippers.

There are two types:

- strippers that contain wax to retard evaporation, and usually contain thickeners to make them into a semi-paste
- refinishers that contain neither wax nor thickeners

ATM strippers are used in the same way as the three methylene chloride strippers. They work well on almost all old paints and finishes. ATM strippers are effective because the wax holds the solvents in contact with the coating long enough for them to penetrate. Their advantages are that they are cheap and perform well without the added health risks of methylene chloride. Their disadvantages are that they're highly flammable and airpolluting, and some brands contain an alkali that will stain many hardwoods.

ATM refinishers don't contain wax, so they evaporate very rapidly-before the solvents have time to penetrate and thoroughly soften or blister the finish. As a result, refinishers are ineffective on paints and all finishes except shellac, lacquer, and water base. Even on these finishes, refinishers are inefficient. The solvents evaporate so rapidly, you have to scrub the finish with steel wool to get it off. You can't just wipe off the finish as you can with strippers. This largely mechanical removal of the softened film is the procedure usually recommended by manufacturers.

The ineffectiveness of refinisher on old varnish (in spite of manufacturers' claims to the contrary) and on all the tough new finishes, together with the universal lack of instructions for identifying the type of finish you're stripping, is the most serious deficiency of this product. Many people become discouraged because of the great amount of effort they have to expend scratching off the finish with steel wool. In addition, considering that refinisher is simply lacquer thinner (you can use lacquer thinner, instead), many brands are unreasonably overpriced. On the other hand, because refinishers leave no wax residue on the wood to interfere with the new finish, there's no need to wash the wood with a solvent after stripping. You save a step.

H-Methyl Pyrrolidone (NMP)

N-methyl pyrrolidone is not as effective as methylene chloride for removing paints and finishes. Strippers based on NMP work at one-half to one-third the speed of strippers based on methylene chloride. NMP-based strippers are not effective on epoxy, polyester, or baked-on coatings.

NMP evaporates very slowly, so fumes don't build up in the air as quickly as with MC or ATM. As a result, NMP is less toxic to work with than MC or ATM, and it is not highly flammable. It is also not classified as an air pollutant by the EPA. Because the solvent evaporates so slowly, the stripper doesn't require the addition of wax to keep it in contact with the finish. There is, therefore, no wax that has to be removed after stripping. On the other hand, NMP is very expensive, so strippers based on NMP are expensive.

D'i-Basic Esters (DBE)

Di-basic esters are a combination of the esters of adipic acid, succinic acid, and glutaric acid. Sometimes you see these esters listed separately on the container. DBE is less effective than any of the other three solvents (MC, ATM, or NMP.). It's so inefficient on shellac and lacquer that overnight contact is usually needed to dissolve these finishes, despite manufacturer's claims to the contrary. (Most old furniture is finished with either shellac or lacquer.) But DBE is cheaper than NMP and fairly safe to use because of its very slow evaporation rate. (Working in a closed room may cause blurred vision, however, so be sure to work in an area with good cross ventilation.) Like NMP, DBE is not highly flammable, and its slow evaporation rate makes the addition of wax unnecessary.

Some versions of DBE strippers, such as Safest Stripper, Stryp Safer, and Easy-Off, use large amounts of water to thin the DBE. The inclusion of water causes many problems, including blistering of old veneer, warping of thin panels, and rust spots on wood when the stripper is used with steel wool. These problems are made worse because of the extended time DBE has to remain in contact with certain finishes to soften them.

N-Methyl Pyrrolidone/Di-Basic Ester (NMP/DBE)

Some manufacturers have combined NMP and DBE in one stripper. The NMP provides the greater solvent strength. The DBE reduces the price without losing too much strength. Other solvents and chemicals, such as gamma bulyrolactone, 2 propanone, 2 butanone, and formic acid, are sometimes added. These solvents and chemicals sometimes add a little strength to the stripper, but their primary purpose is to fill out the blend cheaply with something other than water.

NMP/DBE blends will strip most paints and finishes more slowly than NMP alone and faster than DBE alone. NMP/DBE blends are generally not highly flammable or air-polluting, and they are not highly toxic (because of slow evaporation). But some blends contain methanol, toluene, or xylene, which does make them toxic, air-polluting, and flammable. These solvents will be listed on the container.

Lye

Lye (sodium hydroxide or caustic soda) is probably the oldest chemical paint stripper. It is effective but dangerous to use and damaging to the wood. It's often used by commercial strippers, who dip furniture into a heated vat filled with lye and water. The lye removes the paint or finish, but it also dissolves glue and damages the wood. The wood's surface becomes soft and punky and requires heavy sanding to get through to good wood again. Much furniture has been ruined by being stripped with lye, and strip shops have received a bad reputation because of their often indiscriminate use of this chemical for stripping.

Lye is not all bad, however. It can be used sparingly to dissolve stubborn paint out of pores without doing too much damage to the wood. It can be used effectively to strip metal objects (except aluminum) without causing damage to the metal. It can be used to strip milk paint, a casein-based paint sometimes used in the eighteenth and nineteenth centuries that is particularly difficult to remove with other strippers. And it is a cheap, effective stripper for large surfaces of outdoor siding, masonry, and concrete, and on indoor plaster and softwood trim.

To make a lye stripper, dissolve about 1/4 pound of lye (available at paint stores) in a gallon of warm water. Don't use an aluminum or plastic container. Be sure to pour the lye into the water, not the other way around, because the sudden chemical reaction may boil over and burn you. The lye and water mixture will get hot from the chemical reaction, so don't hold the container.

Brush the dissolved lye onto the finish using a natural-bristle brush. Let the lye work just long enough to dissolve the finish but not damage the wood. After stripping the finish, you'll need to wash the wood with a 50/50 solution of vinegar and water to neutralize the lye. If you don't neutralize the lye, it may continue its chemical activity and slowly destroy the wood and the new finish you apply.

CHOOSING WHICH STRIPPER TO USE

How do you choose among all of these types of strippers? First decide whether you're willing to accept the health risks of using a methylene chloride-based stripper. If you are, choose the cheapest type that will do the job. The weakest formula class-methylene chloride and methanol reduced with acetone and toluene-is the cheapest and will strip most old paints and finishes.

Tougher finishes, such as polyurethane, will require strippers that are made with only methylene chloride and methanol. The toughest coatings, such as epoxy, polyester, conversion, and baked-on finishes, will require an alkali-fortified, methylene-chloride stripper-the strongest type of off-the-shelf stripper you can buy.

If you don't know what type of paint or finish you're stripping but you want to be relatively sure the stripper you use will work, use a methylene-chloride/methanol stripper. It will take off almost all coatings without staining the wood.

If you don't want to expose yourself to methylene chloride, use an ATM stripper. While not as strong as methylene-chloride strippers, ATM strippers will remove most old paints and finishes.

If you want to limit your exposure to toxic solvents as much as possible, and you are willing to pay more, use an NMP or NMP/DBE stripper. These strippers will work fairly rapidly and they don't contain wax that must be removed afterwards, so you save a step.

If you're willing to wait considerably longer for the stripper to work, and the project you're stripping won't be severely harmed by extended contact with water, you could use a DBE stripper.

If all else fails, use lye. Try to leave it in contact with the paint or finish just long enough to dissolve it but not harm the wood underneath. See A, B

SOURCES OF SUPPLY

Though local paint stores and home centers stock most of what you need to paint your house, few carry more than the basics for furniture finishing. Paint stores that cater to the professional finishing trade (this includes all Sherwin-Williams stores) carry lacquers and other finishes, and some types of stains. You will find quality spray equipment and the widest selection of supplies for rubbing out finishes at auto-body supply stores, which will be listed in the Yellow Pages of your telephone book. For other items that you can't find locally, you should turn to mail-order suppliers. Listed below are reliable suppliers who will send you a catalog on request. Many of these suppliers carry finishing materials from H. Behlen Bros., the consumer arm of Mohawk Finishing Products, which sells to professional finishers. Catalogs that carry a large number of Behlen products are marked with a (B). Many also carry a wide color selection of powder dyes from W D. Lockwood. These are marked with an (L). A few carry chemical stains. These are marked with a (C).

Constantine's
2050 Eastchester Rd.
Bronx, NY 10461

(212) 792-1600
(800) 223-8087
Wide assortment of finishing materials- (B)

Frog Tool Co.
700 West Jackson Blvd.
Chicago, IL 60661
(800) 648-1270
Wide assortment of finishing materials.

Furniture Care Supplies
5505 Peachtree Rd.
Chamblee, GA 30341
(404) 451-0676
HVLP spray equipment, lacquers, touch-up materials from Star Chemical Co., and other supplies for professionals and serious amateurs. (L)

Garrett Wade
161 Avenue of the Americas
New York, NY 10013
(212) 807-1155
(800) 221-2942
Wide assortment of finishing materials. (B)

Highland Hardware
1045 N. Highland Ave. NE
Atlanta, GA 30306
(404) 872-4466
(800) 241-6748
Specializes in HVLP spray equipment and
water-based stains and finishes.

Lee Valley Tools, Ltd.
1080 Morrison Dr.
Ottawa, Ontario, Canada K2H 8K7
(800) 461-5053 from USA
(800) 267-8767 from Canada
Wide assortment of finishing materials. (B) (L)

Liberon
P.O. Box 86
Mendocino, CA 95460
(707) 937-0375
(800) 245-5611
Wide assortment of finishing materials including finishes and touch-up supplies from Star Chemical Co. (L)

WD. Lockwood & Co., Inc. 81-83 Franklin St.
New York, NY 10013 (212) 966-4046
The largest supplier of water-, alcohol-, and Oil-Soluble powder dyes to the finishing trade.

Mohawk Finishing Products, Inc.
Rt. 30 North
Amsterdam, NY 12010
(518) 843-1380
(800) 545-0047
Major supplier of finishes and touch-up
supplies to the professional finishing trade.

Olde Mill Cabinet Shoppe RD 3, Box 547A
Camp Betty Washington Rd. York, PA 17402
(717) 75
Specializes in hard-to-get chemical stains, resins, and finishes including dewaxed orange shellac. (B) (L) (C)

The Sanding Catalog
P.O. Box 3737
Hickory, NC 28603
(800) 228-0000
Wide assortment of sanding machines and
sandpaper, including very fine grits.

Star Chemical Co., Inc. 360 Shore Dr.
Hinsdale, IL 60521
(708) 654-8650 (800) 323-5390
Major supplier of finishes and touch-up
supplies to the professional finishing trade.

Woodcraft Supply
210 Wood County Industrial Park P.O. Box 1686
Parkersburg, WV 26102
(800) 535-4482 (800) 225-1153
Wide assortment of finishing materials. (L)

Wood Finishing Enterprises
1729 N. 68th St.
Wauwatosa, WI 53213 (414) 774-1724
Specializes in hard-to-get chemical stains, resins, and finishes including dewaxed orange shellac. (L) (C)

The Woodworker's Store
21801 Industrial Blvd.
Rogers, MN 55374
(612) 428-2199
Wide assortment of finishing materials. (L)

Woodworker's Supply of New Mexico 5604 Alameda PI., NE
Albuquerque, NM 87113
(505) 821-0500 (800) 645-9292 Wide assortment of finishing materials. (B) (L)

Woodworking Supply Co.
13 Amy Elsey Dr.
Charleston, SC 29407
(803) 556-4538 Wide assortment of finishing materials.