the gap itself. Press the filler into the gap with a putty knife and scrape off the excess. The tape will protect the surrounding wood from getting stained with the filler. Peel off the tape right away.

You can either roll the glass out over the wet filler or let it dry and give it a light sanding to knock down any material above the strips.

Instead of epoxy and sanding dust you may also use water-based wood putties. These may come precolored, or you can add a little bit of artist's watercolors to match the tone of the surrounding wood.

Inspect the area around the boat, looking for sharp corners or other objects that may snag the glass. It doesn't take much to create a deformed spot in the glass by rubbing it across a rough drip of epoxy or a bit of wire. These snags aren't a catastrophe, but they do weaken the layup slightly and make it harder to get a smooth finish.

Cutting the Glass

Presumably sometime before you reached this point you decided exactly what layup you intend to use with your glass. For instance, you have chosen 6-ounce E-glass versus 4-ounce S glass; fiberglass on the inside or some exotic such as carbon fiber; one layer versus two, and so forth. Now you need to figure out exactly how you are going to put that material in its place.

Are you going to roll out one continuous piece of cloth, or will you piece it together, overlapping at the joints?

There are several considerations when making these decisions: ease, efficiency, speed, appearance, and strength. One piece of continuous, unbroken cloth is almost always going to be stronger and will look better than piecing several smaller pieces together. But putting smaller pieces together may use the cloth more efficiently. If the cloth is expensive, like carbon fiber, wasted cloth is not welcome. Fitting small pieces around complex shapes is often easier and quicker than trying to make a large piece conform against its will. Finally, some boats are just too big to cover with one piece.

I will generally try to cover large external areas with one piece for appearance's sake, but I am more willing to piece together several on the inside.

The easiest way to get the cloth the right size is to roll it out onto the boat and trim it in place. If you have a partner, have your partner stand at one end holding the end of the cloth while you hold the roll and walk down toward the other end, unrolling as you go. Try to hold the cloth up above the boat so that it doesn't snag on anything. Carefully check the alignment before draping the cloth down over the boat. Make sure you have enough length at both ends and that it will cover all the way from gunwale to gunwale.

On the outside of the boat, a large perimeter of excess cloth will help absorb excess resin dripping off the sides before it falls to the floor, but if you don't want to waste too much cloth as

Figure 9-6. *It does help to have an assistant when rolling out the fiberglass. Working alone it is easy to snag something, and even the pressure of rolling the cloth on the boat surface can distort the fabric a little bit. But with care and a pair of scissors in your pocket before you start, you should be able to handle the task alone. Note that the waxed paper is still in place between the deck and the hull.*

a resin trap, you can trim it a couple of inches below the edge.

On the inside of the boat, excess cloth will weigh down the top edge of fabric, causing it to pull away from the boat a bit. Make sure you have enough fabric to cover the whole inside before trimming, and then clip off the excess an inch or two above the top edge.

Use sharp scissors to trim the cloth. If you are going to use the trimmings, treat them gently as you cut them free and avoid letting them drop onto a dirty floor. Large pieces may be rolled back onto the original roll. Smaller scraps can be kept in a loose pile. Try not to fold or compress the scraps, as creases in the cloth can be hard to eliminate if you use the pieces later.

Figure 9-7. *The most efficient way to cut the cloth is to lay it across the boat, overlapping adjacent pieces by about 1 inch. This is not as desirable on the outside because the overlaps create bumps running across the boat, but on the inside it works very well with minimum waste of fabric.*

Figure 9-8. *A little fiberglass hanging below the boat absorbs drips and keeps them off the floor, but this can also waste some perfectly good cloth. I trim the edge several inches below the sheer/gunwale.*

Figure 9-9. *On the inside of this canoe I did not want any seams to disrupt the pattern of the carbon-Kevlar cloth, so I draped in the cloth in one piece and carefully trimmed near the stem. I initially left a little extra fabric around the stem area, and then cut it back to fit right up next to the stem. The top edge around the gunwale gets trimmed off about 1 inch above the edge.*

Figure 9-10. *After draping the glass onto the boat you will have small wrinkles and bubbles. You want to try to get the cloth as tight to the boat surface as possible before applying resin. Do not run your hand over the surface in an attempt to smooth the fabric. This will tend to cause creases and snags. Instead, use a chip brush to smooth the surface. Start in the middle and work out to the sides and ends.*

Smoothing the Cloth

A smooth coat of fiberglass starts with making sure the cloth lies smoothly on the boat when it is dry. While wetting out the cloth will help it conform, if you have big wrinkles in the dry cloth, you will probably have to struggle removing those wrinkles when it is saturated with epoxy.

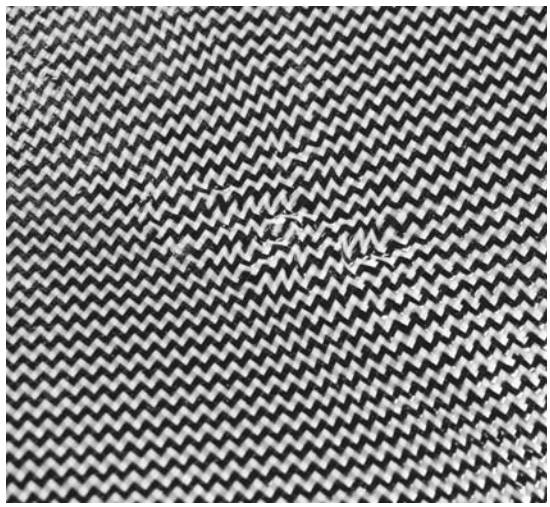

Figure 9-11. *All the fabrics used for reinforcing strip-built boats are subject to some distortion from rough handling, but a visible weave like this carbon-Kevlar hybrid cloth will show the pulls most distinctly. Try to align the cloth carefully on the boat so all parts can be smoothly covered with a minimum of tugging and pushing.*

If you have lightly sanded your seal coat or you did not do a seal coat, the glass will usually move fairly easily. Don't use the palm of your hand to smooth out the cloth. This just presses the fabric against the surface and increases the friction. The cloth will also stick to your hand a bit. As a result you will likely just create creases in the cloth. Instead, use a brush. The same chip brush you will later use for spreading epoxy will work well when dry. Any light brush with soft bristles will work. If you have an old drafting brush, that will work great. Starting in the middle of the boat, sweep down the length, pushing excess fabric off the edge and toward the ends.

On the inside of the boat, your natural inclination will be to use your hand to push the cloth down into the low spots. *Avoid this inclination.* It will cause snags as the fabric drags against the top edges. Instead, lift the edges of the cloth

up and let gravity drop the cloth down into the boat. In deep spots such as the ends of a canoe or kayak, you may need to help the cloth in with your hands, but again, lift the sides so the fabric does not drag over the edges of the boat and snag. Use a dry brush to smooth out any wrinkles, working from the middle toward the sides and ends of the boat.

Wetting Out the Cloth

Wetting out the cloth means pretty much what it sounds like. It means making the cloth wet, but in this case it means making it wet with epoxy. This is not brain surgery; it is just making fabric wet, something any baby can do from day one. However, there is a need to be a little more systematic than your average infant. We want the fiberglass (or whatever fabric we choose) to be completely saturated with epoxy, but ideally, the cloth should not contain any excess beyond the minimum required to fully saturate.

For reference, a good layup done by hand using the techniques described next will end up approximately 50% glass and 50% epoxy by weight. I don't expect you to weigh your materials, as that is not practical for most builders, but do understand from this that if you are leaving behind big areas with a lot of epoxy on them relative to the amount of fiberglass, you are using too much epoxy.

While you are wetting out the cloth you want to be doing one of three things at all times: making dry cloth wet, smoothing out the cloth, or removing excess resin. If you are fussing with your layup but not accomplishing one of these three things, you are at best wasting your time and at worst making the layup worse.

It is obvious when fiberglass cloth is saturated; what was white is now clear. When the fabric has the right amount of resin, it has a matte finish with the texture of the weave clearly evident. If the cloth is shiny, it has more resin than required. If it is a bit gray with flecks of white, the cloth is starved and needs a little more resin.

For most boats it is easiest to start wetting out the cloth in the center of the boat and move systematically out toward the ends, moving down both sides simultaneously. To limit the number of wrinkles, you want to move in a continuous front instead of working in unconnected patches. Dry patches surrounded by wet cloth tend to trap wrinkles, making it harder to get a smooth coat of glass. However, you don't need to get all the cloth thoroughly saturated in the first pass. It is often better to make a fairly quick initial pass over the whole boat, leaving the occasional partially wet-out spots, coming back later to touch up the spots you missed.

The epoxy I typically use allows me to work fairly slowly in a 65° to 70°F basement shop. A small batch can stay in the mixing pot for 10 to 15 minutes, and once it is spread in a thin layer it stays workable for up to 45 minutes. However, these times will vary with temperature. The same epoxy in 85° weather may only give you a few minutes of pot life and require quick work while spreading on the boat. The working time is also dependent on the epoxy formulation. Most epoxy manufacturers offer "fast" and "slow" mixes suitable for use in different temperatures to control how much time you have to work. Usually the jugs of epoxy will include information on pot life and working time.

Start working by mixing up small batches until you have a good feel for how quickly the epoxy starts curing. If you ever feel the cup of mixed epoxy start to heat up, throw that batch out. It will not soak into wood or fabric as it is supposed to. As you get more accustomed to the reaction rate of the epoxy you may want to mix up larger batches, but remember that the exothermic reaction of epoxy means that larger batches have a shorter pot life.

Dump and Spread

I generally try to slightly oversaturate the cloth initially, and then remove the excess resin later. With low-viscosity resins this allows air bubbles

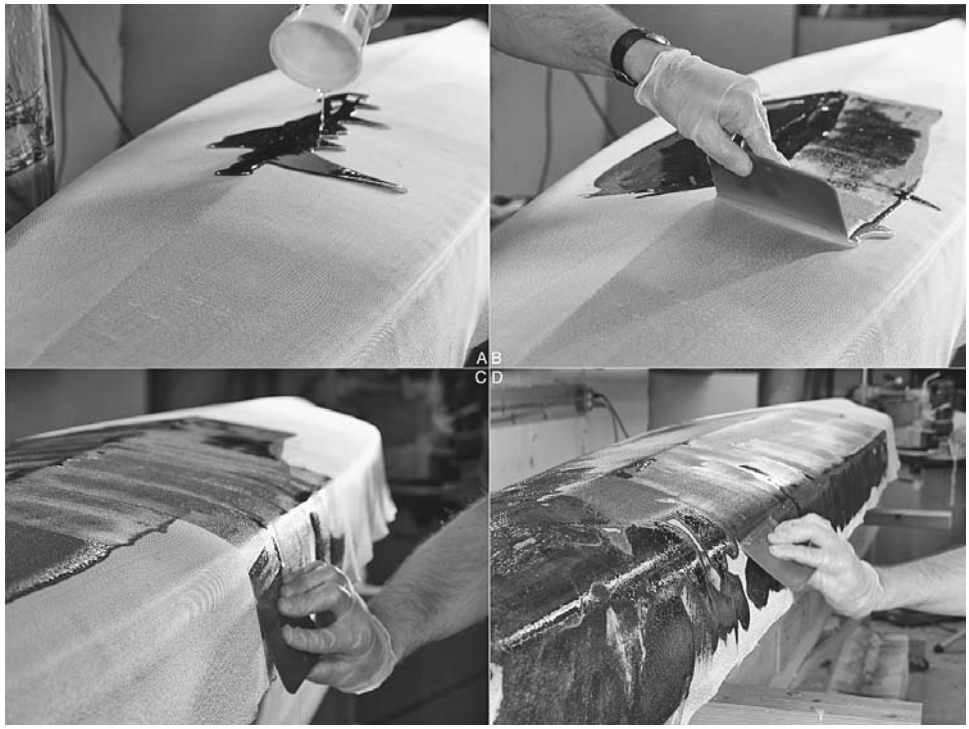

Figure 9-12. *When applying epoxy, start in the middle and move down to the sides and out toward the ends. This way you do not trap wrinkles between two wet-out regions. Dump the mix of resin near the middle (A), and then quickly spread the epoxy around with a squeegee (B). Hold the squeegee at about a 45-degree angle to move large amounts of resin over a distance. Do not use much pressure on the squeegee. Pull resin down over the side (C), decreasing the squeegee angle as you approach the edge to deposit it in place instead of dumping it on the floor. Spread the resin quickly even if it causes occasional dry spots in your first attempt. As you proceed, squeegee wet and shiny spots toward white spots (D), and dab on a little extra epoxy as needed. Don't try to pour epoxy onto sloping or vertical surfaces. When you can no longer make a pool of resin on a nearly level surface, use a brush to add resin where you need it.*

to rise to the surface where they can pop or get scraped off.

I start by mixing up a relatively small batch of epoxy resin (6 to 10 ounces), mixing it thoroughly. A deep mixing container allows you to mix easily without worrying about spilling any. This batch of resin is then dumped in a thick line about 12 inches long along the centerline of the boat near the middle of its length.

Move quickly so you don't just get a river flowing onto the floor. Use a squeegee to spread the puddle around. Pull the puddle a little bit lengthwise and then start pulling it toward the edges.

Use the edge of the squeegee to move the epoxy around. Hold it at about a 45-degree angle with the edge pressed against the cloth. Starting in a wet area, use moderate pressure,

Figure 9-13. *On the inside, start by dumping epoxy in a nice puddle in the middle of the boat, then pull resin up the sides with a squeegee.*

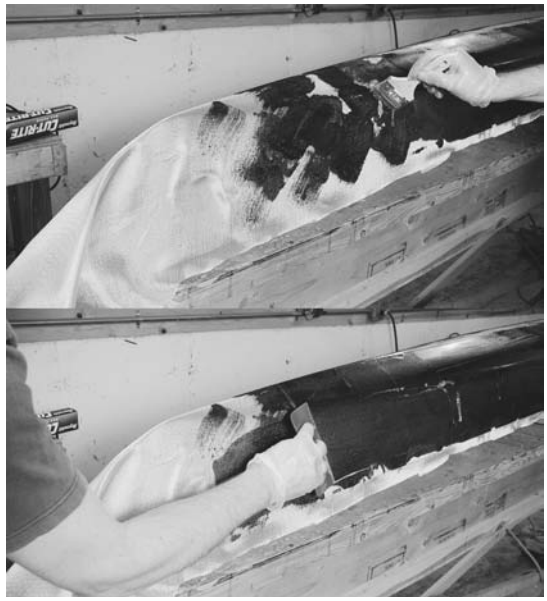

Figure 9-14. *The most common mistake with fiberglass and epoxy is to add too much epoxy, resulting in a heavy boat with little added strength. This is often because novice builders keep brushing on more epoxy until the fabric is clear, and continue hunting down white spots with a fresh brush full of epoxy when there is already plenty of resin available on the boat. Instead, brush a little epoxy at one edge of a dry spot and use the squeegee to spread it across the whole area.*

pulling the squeegee with the edge dragging behind. This will raise a bead of epoxy under the squeegee blade. When you get to a dry spot, tip the squeegee down so the face is sliding over the cloth, unloading the epoxy into dry cloth.

As you pull resin from the more level areas in the middle toward the more vertical sides, roll your wrist to maintain the squeegee at the same angle relative to the surface. Before you slide off the side, press the squeegee flat down onto the surface of the boat to unload the blob of resin onto the boat instead of onto the floor.

Listen to the cloth as you use your squeegee. When you are successfully moving epoxy, the squeegee will not make much noise. If you start hearing a dry scratching sound, you need to add more epoxy. Don't keep working the epoxy and cloth if you see that your efforts are not making any difference. Mix more epoxy and move on.

Add the new epoxy at the wet edge of the saturated cloth, using your squeegee to pull it into the dry areas. On flat level surfaces, dumping on more resin continues to work well. On the sides where gravity will just dump a puddle on the floor, use a wet brush to dab on more

resin. Do not keep brushing on more epoxy until the cloth is clear. This will apply much more resin than is required. Instead, dab on a few spots and then squeegee it around. See how far the resin goes and then dab on more as necessary. Attempting to wet out the whole boat with a wet brush is slow and will waste epoxy as it generally results in more epoxy on the boat than needed to wet out at the "ideal" 50-50 ratio of resin to cloth.

Again, try to get most of the boat wet out in one quick pass. Don't worry initially about the occasional unsaturated spot, so long as it is smooth and wrinkle-free. Come back later and dab on more epoxy as needed, squeegeeing as you go.

While doing the initial wet-out on the interior of the boat you will often get bubbles caused by bridging (see the Bridging section later in the chapter). Do not try taming every single one of these every time they pop up. Working in one place will often make a bridge pop up somewhere else. If you keep going back every time a little flaw appears, you will end up running around in circles. Instead, move deliberately down the length of the boat, dealing with egregious problems as they appear, but leaving the minor, recurring problems for the second pass. By moving quickly it will actually be easier to deal with problems because the epoxy will have less time to stiffen up and the fabric will still slide easily.

Moving Cloth

At some point in your fiberglassing career you are going to have to deal with places where the glass doesn't lay flat. This can happen for a variety of reasons, but they all really boil down to two different, but related problems: too much cloth or too little. Too much cloth is the most common, but generally the easiest to deal with. Not enough cloth in an area is less common, but can be perplexing to deal with.

With either situation, too much or too little cloth, the way to deal with it is to move cloth in or out of the problem area. By this I do not mean cut out a section or patch in a piece, although that is the last resort. Instead I am referring to sliding the fabric along the surface of the boat until you get the right amount of cloth where you need it.

Epoxy serves as a good lubricant for this process. Dry cloth can snag on small surface irregularities. Cloth that was wet out for a long time may start to get sticky. It is easier to work with fiberglass and epoxy if you work quickly and efficiently. Delaying in one place too long to resolve an issue can make it harder to deal with future issues; therefore, it is good practice to move along quickly, not spending time to get every spot perfect before moving on to the next. Work on getting the initial wet-out of the fabric done quickly and then come back to resolve minor issues later.

Fiberglass and other reinforcement fabrics move along the axes of threads in the weave. By applying pressure along the length of the threads, it is possible to move the fabric around to flatten wrinkles and fill in bubbles.

You can get the cloth to move by wiping or dabbing with a brush, scraping or wiping with a squeegee, or stroking and pushing with a gloved hand.

Wrinkles. Wrinkles occur when there is more cloth than can lie flat in one area. If the wrinkle makes a flap that folds over when you squeegee over it, there is no amount of pressing it and poking at it that will make it go away. You may be able to make it disappear temporarily by wiping over it with a squeegee, but chances are very good that it will pop right back up when you move on to another spot. Don't waste your time poking at the thing: you need to get to the root of the problem and remove the excess cloth to a place where it doesn't create a wrinkle.

To get rid of the wrinkle, you need to move the excess cloth out of the area to a place where the excess fabric can release itself. This means, off the edge of the part or into dry cloth. Wrinkles want to move in a direction perpendicular to the direction of the ridge. For example, if

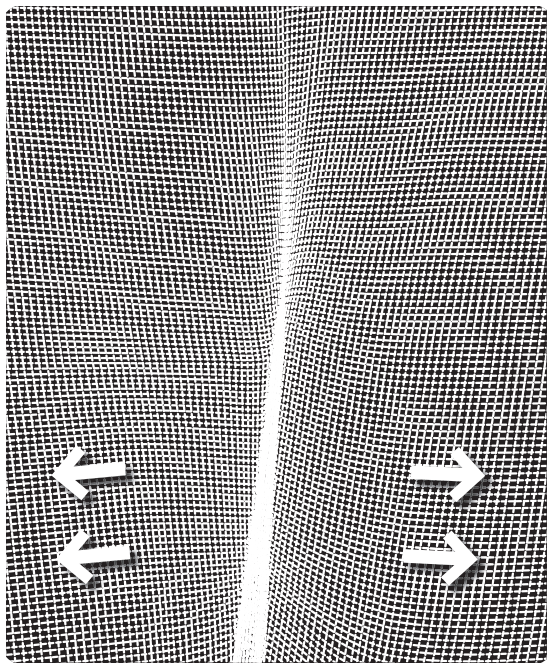

Figure 9-15. *Wrinkles occur when there is more glass on a region than there is area to contain it. They are removed by sliding the glass to a region where there is room, or off the boat. Observe the yarns of the cloth running across the wrinkle and note where they go. Look for the side of the wrinkle where the yarns run off the edge closest to the wrinkle. Use your squeegee or brush to pull the cloth away from the wrinkle toward the closest edge. You may also use your hands to pull on the cloth from the edge, pulling out the excess cloth.*

a wrinkle is vertical on the side of the boat, it needs to be pushed down the length of the boat.

Typically, wrinkles align themselves with the weave of the cloth and must be moved along the fibers. If you look carefully at the grain or fiber orientation of the cloth you can see where you need to go to eliminate the wrinkle. There are two places you can go: off the boat or into dry cloth. Follow the fibers that cross the wrinkle and determine whether the edge of the boat or dry cloth is the shortest distance.

You can either use your squeegee to carefully push the wrinkle along the grain of the cloth until it reaches that spot, or you can gently grab the cloth in that spot to pull the fibers and straighten out the bent fibers in the wrinkle.

Sometimes the wrinkle is a long distance from a potential escape point. A wrinkle across the back deck of a kayak behind the cockpit may be pulled out by gently tugging on the cloth back near the stern of the boat. As you pull, watch where the cloth moves, shifting from side to side until you find the strands of fiber that cross the wrinkle and gently pull it flat.

Excess fabric tends to accumulate in patches of dry cloth. For this reason try to wet out the cloth in a solid front without allowing intermittent patches of dry cloth between spots where it has been wet out.

If you have a wrinkle that does not seem to be moving well when you wipe the squeegee over it, you may be able to loosen up the cloth a bit by brushing on a little more epoxy as lubricant.

Bridging. On concave surfaces, pulling on the cloth will often lift the fibers off the surface. The result is a bridge where the fibers span the low spot creating a bubble under the cloth. In other words, the fibers are not long enough to fit down into the low spot. Feeding more cloth into the low spot eliminates bridges.

Since bridges usually appear in concave areas, you can expect to deal with them while glassing the inside of the boat. Bridges typically occur along the inside keel line, especially inside the deeply V-shaped areas at the bow and stern of some boats. They also show up on the inside along chine lines where there is a sharp corner that allows the fabric to lift up easily.

Like wrinkles, no amount of poking and prodding down the bridge will eliminate it. Painting on extra epoxy will appear to fill in the bubbles under them for a while, but usually the thick puddle of resin will eventually drain away, leaving a bubble and an excess of resin somewhere else. The solution is feeding more cloth into the bridge area.

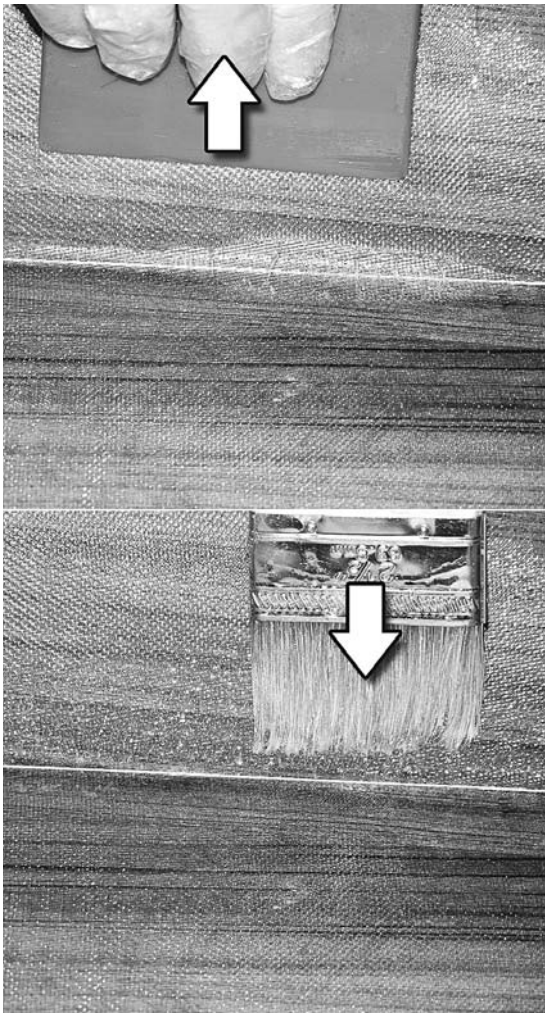

Figure 9-16. *While working on the inside of the boat you will often pull the glass in a manner that raises a bubble or bridge (top) between the glass and the strips. This is especially common in a chine or keel line where there is a sharp angle. Your instinct will be to put your squeegee in the middle of the bubble and push down, or get a big blob of epoxy on your brush and try to fill it in. Don't bother. That may make the bubble disappear briefly, but it will usually reappear. Instead, you need to feed fabric into the bridge so there is enough cloth to lie flat against the wood. Use your brush to gently push fabric down the side toward the bridge (bottom). Slowly feed fabric in until the bubble disappears.*

Like wrinkles, the extra fabric must feed in along the fibers that are creating the bridge, or those that cross perpendicularly over the low spot being bridged. This usually means pushing the fabric down the side of the boat into the low spot. A somewhat dry brush dabbed down the side is often enough to slide in a little extra cloth, thus nestling the fibers back down onto the surface. Sometime it just requires a little light squeegeeing. Another great tool is attached at the end of your wrist. Use a gloved hand to stroke the surface of the cloth to slide the fibers toward the bridge.

On boats with a sharp keel line as well as chines, bridges may occur in both areas at the same time. Attempts to lower the bridging in one often raises a bridge in the other. In this case, work from the center out to the sides.

Figure 9-17. *Most wrinkles need to be moved toward the ends of the boat. Depending on the shape of stem, you may need to trim the glass at the ends. While it is possible to wrap the trimmed glass around either side, I find it easier to let it come off straight and then trim it off later.*

Feed cloth in toward the centerline, and then push more down the side into the chine.

Snipping. There may be times when the contours of the boat are just more than the cloth can conform to. It is amazing how complex a surface the fabric will adapt to, but as a last resort you may need to cut a gore into the cloth or cut completely across a strip of fabric. Only do this if there is no way to slide the excess cloth out of a wrinkle or there is no more fabric to feed into a bridge.

With a wrinkle, the excess fabric ends up as two ends overlapping each other. Wet these flaps out, and smooth them down. Cutting a bridge of lifted glass creates a gap that needs a patch of fabric laid over the hole. Ideally any overlap should be at least 1 inch wide.

You can use scissors to cut fiberglass cloth even when the fabric is wet, although it may end up gluing your scissors together when the epoxy cures. You can also use a sharp utility knife to slice the cloth if you can cut against a surface that is not going to show.

Missed Spots

After the first pass, getting the fabric mostly wet out, you should start back in the middle looking for dry and starved areas where the cloth is white or grayish. The most common places to miss are right along the edge where epoxy from the middle didn't quite reach all the way. Dab on a small amount of epoxy and spread it over the area with the squeegee. Avoid using an aggressive brushing motion when applying the resin. The brush will tend to move the cloth, which can cause wrinkles or raise bridges. Instead, load up your brush, swat the inside of your mixing cup a few times to shake off the excess, and then press the brush onto the surface of the fabric without dragging it over the surface. Then use the squeegee to move the epoxy around to cover the rest of the dry spot.

If the cloth is fully saturated, there should be no reason to touch it with a loaded brush. Inspect the whole thing again to be sure everywhere is saturated, then step away from the boat.

Conforming to Shapes

Some shapes are so complicated that fiberglass cloth does not like to lie smooth. The cloth does not like to bend around sharp angles. Most cloth will not bend over a sharp 90-degree angle. And compound curves can confound most fiberglass. For the cloth to conform, the yarns must be flexible enough to bend, and they need the ability to move around relative to each other. This is where bias-cut cloth comes into use. Bias-cut cloth likes to distort.

Cut a piece of cloth with the weave running diagonally to the axis of the feature you need to cover. Because bias-cut cloth distorts easily, it must be handled gently. Carefully lay it into place, pushing it down gently, without stroking it. Use a fairly goopy brush to dab it down onto the surface. Stroking along the bias will tend to further distort the cloth, so do most of your work with dabbing motions that just push the cloth down onto the shape. Once the cloth starts to become secured in place with resin, you can start stroking the resin around with a light touch of the brush or with a squeegee.

Lightweight cloth is much better at conforming to complex shapes than thicker, heavier cloth. If you have a particularly complicated shape such as a kayak coaming, bias-cut 4-ounce cloth may be what you need. It is amazingly malleable and can conform to some complex shapes.

Scraping the Excess

At this point it is very likely the fabric is saturated with more epoxy than it really needs. It is time to scrape off the excess into a grunge cup. A grunge cup is typically a paper cup with a slit cut in the lip. A plastic cup will work, but they tend to rip as you use them. While it doesn't

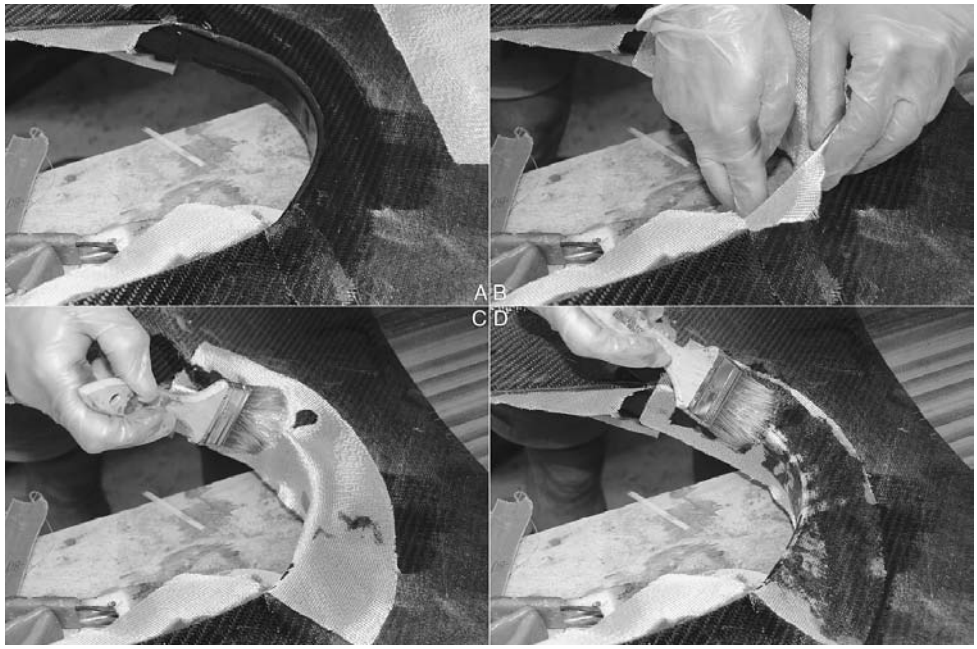

Figure 9-18. *Sharp corners may not allow a typical piece of glass to lie down smoothly. Cutting the cloth diagonally, on the bias, so the fibers run at a 45-degree angle over the corner reduces the stress on the glass, which allows the cloth to distort very easily. While this is good, the piece must be handled gently. First apply some resin to the destination area (A). Then carefully stick the cloth to that resin (B). Push the cloth down by dabbing (not stroking) with your brush (C). Keep dabbing with more resin to completely wet out the cloth (D).*

seem right that a paper cup is less likely to rip than a plastic one, that is the case. I use a pair of scissors, diagonal wire cutters, or a utility knife to cut a slit in the part of the paper cup at the seam where the paper is doubled up.

Again, starting in the middle of the boat and working toward the ends, use your squeegee to scrape the surface of the cloth to remove any resin in excess of the minimum required to wet out the fabric. Hold the squeegee at a 45-degree angle relative to the surface. Starting at the centerline, draw the squeegee toward the side of the boat. Use moderate pressure, just enough to press the cloth down onto the boat surface but not so much that you leave the fabric looking white or gray behind the squeegee. Pull all the way to the edge, rolling your wrist down over the side so the squeegee maintains a constant angle relative to the boat surface. Right at the edge, increase the angle to 90 degrees as you lift the small worm of epoxy you have created at the squeegee blade. Slide the blade through the slot in your grunge cup to clean the worm off the squeegee. Continue doing this for the whole surface of the boat.

On the inside this process will almost assuredly raise some bridges. To minimize this, use a fairly light touch so you are not dragging against the cloth too much. You can also start at the top edge and work down toward the middle. In boats with a distinct chine that is creating a lot of bridges, work on the bottom from chine to centerline and then work from the top edge down to the chine.

Do not use the epoxy in the grunge cup for wetting out more cloth. This epoxy will be full

Figure 9-19. *After wetting out the glass there are bound to be areas with excess resin as well as some with too little. Starting at the centerline, hold the squeegee at about a 45-degree angle. Pull the squeegee toward the edge, maintaining approximately the same angle as you roll down the side. Clean the epoxy off the squeegee by sliding the edge through a slot in a paper cup.*

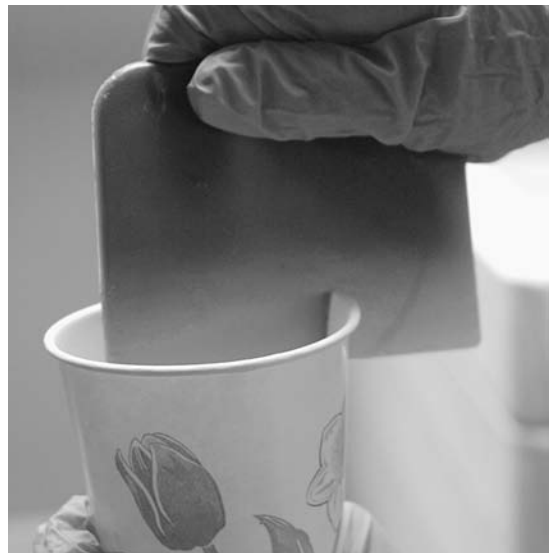

Figure 9-20. *Remove excess epoxy on your squeegee with a grunge cup. Cut a slit at the top edge of the cup. Drag the squeegee through the slot to scrape off the resin. A paper cup works better than plastic because it does not rip as easily. I cut the slit through the doubled-up area of the paper where it is a little stronger. Don't use the gunk you scrape into the cup for anything; just let it harden and discard it.*

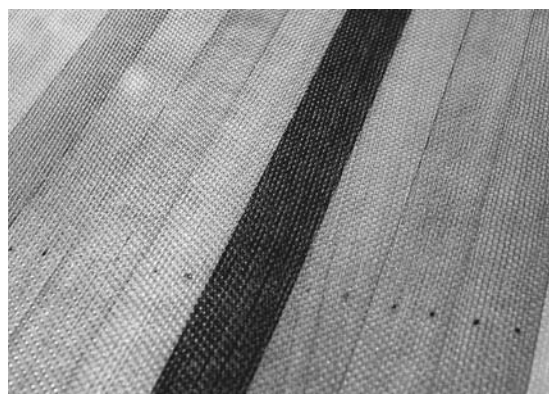

Figure 9-21. *After squeegeeing off the excess epoxy, the surface of the fabric should not be shiny. The weave texture should be clearly visible, but the fabric should be completely translucent, without white or gray spots.*

of tiny air bubbles that will tend to stay trapped in the resin, causing a cloudy finish.

Once again, when you are finished, go back and inspect your work. Look for unsaturated cloth that is white. Look at a low angle, with your eye down near boat level to look for dull, starved or shiny, overfilled areas. If you need to dab on a little bit more epoxy, do so, but don't start fussing. If the surface looks good, with a nice even matte finish that shows the weave texture pattern and the occasional shiny spot, step away from the boat. You have probably reached the point where further fussing and fretting will only make things worse.

With exotic fabrics, it will take a little more care to be sure the fabric is fully saturated. Since you don't have the obvious feedback of turning from white to clear, you will need to do a careful inspection under good light. Look for slight changes in color and variations in gloss. Saturated cloth will usually appear somewhat darker, but in some light starved, unsaturated cloth will not reflect as much light and will appear darker.

It is worthwhile to come back in an hour and inspect the layup. The wood may soak up some epoxy, thus starving the glass a little bit. If necessary add a little epoxy where the glass looks a little gray. You may see some starved spots at staple holes. You may be able to fill these up with a little epoxy now, although later fill coats should also do the job.

After glassing the outside you can remove the boat from the forms and start fairing the inside. Depending on my working pace, I will often apply one fill coat to the outside before starting the inside. This keeps crud from getting ground into the weave texture. The additional coat of epoxy provides some protection from workshop hazards as well.

Figure 9-22. *I use some V-blocks made of foam to hold the boat after I flip it over to work on the inside. You could also cover some blocks of wood with carpet scraps or make slings to support the boat.*

Additional Layers

Several options are available if you want to use more than one layer of fabric. You can lay down all your layers while dry and wet them all

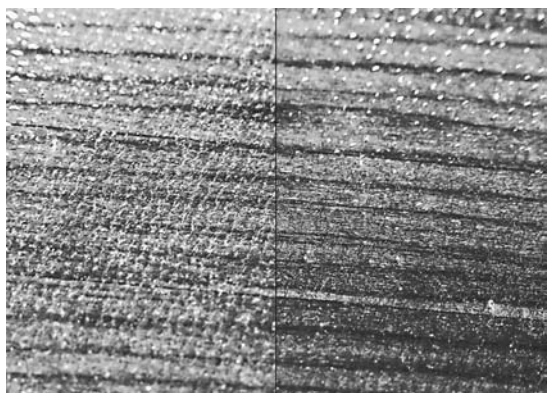

Figure 9-23. *The gaps between the yarns in the fiberglass cloth may trap tiny air bubbles as you work the epoxy. You can make these bubble rise up through the cloth and pop by carefully heating the area with a hair dryer or heat gun. This works particularly well when the boat is already sealed, either with an epoxy seal coat or a prior layer of cloth. On unsealed wood it can force air out of the wood, only making your problem worse. On the left, you can see the white spots around the weave. On the right, the weave is more transparent after heating with a heat gun.*

at once; you can wet out one layer at a time, adding new layers while the prior layers are still wet; or you can lay down each layer, wet it out, and let it cure before adding the next. Each method has its own benefits and disadvantages. Obviously, laying all the layers at once is the quickest; you don't ever need to wait on the epoxy, just add enough to saturate the cloth and you are good to go. With heavy cloth it can take a lot of epoxy to soak all the way through, and getting the fabric completely wet out can take some time. With opaque cloths like Kevlar or carbon fiber that are hard to determine if they are completely saturated, this could be a real problem. It would be very easy to have it look wet out on the surface only to find that it is not bonded to the wood at all. With fiberglass you can always see when you have completely saturated the cloth, but it is likely that there will be some small, persistent bubbles that are difficult to eliminate. The texture of the cloth creates some pockets between the layers where tiny bubble get trapped. Low-viscosity resin and warm but falling temperatures can minimize the issue, but it is hard to eliminate all the bubbles.

Wetting out one layer at a time may reduce how much air is trapped between the layers, but it still allows some bubbles to remain. If you are laying up large areas, you need to be careful draping the cloth down over the existing sticky resin. The cloth can stick where you don't want it. There really isn't much benefit to sequentially wetting out large expanses of cloth unless you are using a really heavyweight cloth that is hard to wet out, but for small reinforcement patches, it is typically the most practical technique. The small bubbles left in an otherwise good layup will not have a huge structural impact. Pinhead-size points of air trapped in the weave does not mean your boat is going to fall apart the first time you hit a rock. The main impact is cosmetic. The bubbles will make the layup a little less transparent, adding a slight fog to the finish. Even this is minor, especially over light-colored wood.

The best way to assure you don't have any trapped air between layers is to do each layer individually, and let it cure before applying the next layer. However, doing this is no guarantee of a perfect layup. It is still possible to have deep pits in the wet-out fabric that will be reluctant to fill up with resin. The best solution is to apply a light fill coat, enough to fill up the pits, and let it cure before adding the next layer.

If you let the initial layers cure long enough, you have the opportunity to use masking tape and a utility knife to get a clean, smooth edge on a subsequent, smaller layer of cloth.

If you are working quickly you should not need to do anything to prep the initial layers of cloth prior to adding an additional layer. As long as the epoxy is still "green" before adding a new layer, the layers should bond well. Try pressing your thumb into the epoxy. If you can make a noticeable dent, the epoxy is green and not fully cured and the next layer will chemically bond to it. You usually have a window of 24 to 72 hours depending on the formulation of epoxy and the temperature. If the epoxy is fully cured you should sand the surface to get a mechanical bond. A mechanical bond is not as strong as a chemical bond, but it is still very strong.

A light sanding with 80-grit sandpaper and then a good scrub with a green abrasive kitchen pad such as Scotch-Brite to remove any remaining glossy areas should be enough. If you have a greasy/waxy film of amine blush, use the abrasive pad with water to remove the blush and dull the surface at the same time. Wipe the wet surface dry with a clean rag.

Trimming Edges

Any extra cloth that extends beyond the edge of the boat can usually be trimmed off with a utility knife. The longer you wait after the epoxy has cured, the harder it will be to cut, but even quite hard resin may still allow you to cut the cloth. Hold the cutting edge of the blade right up against the edge of the boat so the cloth does not bend away from the blade. Use a smooth continuous motion to slice off the cloth. Avoid sawing at the cloth with your knife. If you feel

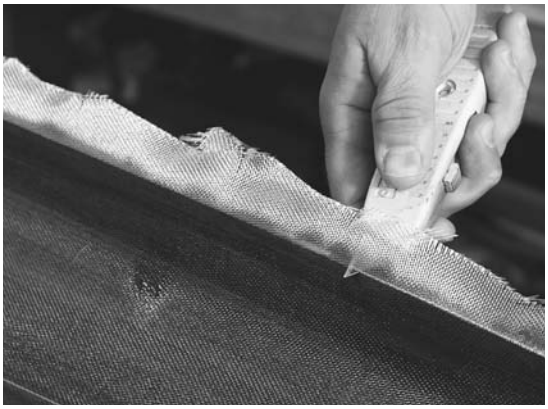

Figure 9-24. *Run the edge of a utility knife right up against the edge of the wood to get a very close trim. Cutting off a small amount of wood only means you are getting a smooth, flush trim.*

Figure 9-25. *You may get a bubble in the glass. This will most likely be along the gunwale/sheer. Usually you can just shave off the lifted glass by holding a knife tight against the surface. Try to get it as flush as possible, then sand the edge so it doesn't jut up. If the gap is under a gunwale or will get another layer of glass later on, wait until then and just cover it with the gunwale or lay the new layer of glass directly over the area. If this is not an option you may patch over it with an oversized scrap.*

you have to do this to make the cut, your blade is probably dull or you are not cutting close enough to the edge of the boat.

If you end up with air bubbles along the edge (which is often due to the weight of the excess glass sticking up beyond the edge) you can trim them off with a knife. Try to trim as flush to the surface as you can get. The area will often be covered with a gunwale on open boats or some seam tape on decked boats, so small gaps in the glass should not matter. Large gaps might require a patch of additional fiberglass.

These bubbles near the gunwale on the inside can happen because the weight of the excess cloth extending above the gunwales sags the cloth down a bit, lifting some of the cloth off the boat. You can reduce the chance of this happening by trimming the cloth off close (1 inch) to the gunwale after it has been fully wet out, then going back and inspecting to be sure everything is smoothed down.

Whenever you have a piece of cloth that ends somewhere on the boat surface, you are going to have to deal with the inevitably ragged, unraveled edge that results from working the cloth. Some cloth will have a selvaged edge, which allows for a fairly clean border, but even this will create a large bump. To avoid this issue, you can take advantage of the fact that epoxy takes a while to set up to full hardness. You can cut into the soft epoxy and glass without damaging the harder epoxy and glass below.

Start by outlining the area you want to glass with masking tape, placing the tape just outside the area of concern. Press the tape down securely along the inside edge so epoxy does not wick under. Wet out your glass normally, overlapping the tape slightly. Allow the epoxy to start setting up, then use a utility knife with a brand-new sharp blade. Lightly cut through the epoxy and glass, pressing lightly against the surface below. Cut just inside of the tape. As you cut, peel up the tape, removing the excess fabric. You will be left with a smooth, clean edge with no loose strands of glass hanging out.

Figure 9-26. *After the main body of the deck or hull has been covered with glass, you can come back and cover bits that were hard to deal with on the first go-round, such as transoms and stems. With this transom, I first applied a fill coat to the body of the hull, let that cure, then masked off the stern area before applying a layer of fiberglass to the transom.*

The longer you wait, the more pressure you will need to apply to the knife. If you allow the epoxy to set up fully, you may need to press quite hard, creating the potential that you scratch the surface below, leaving a permanent light line. If you start cutting too early, you will just distort the glass without cutting efficiently. Wait a while longer and try again. You may occasionally miss a fiber, which will pull at the glass a bit as you remove the excess. Just go back and cut the fiber with your knife. The pulled glass will usually heal itself, but you may need to press it down a bit with a gloved finger.

This technique is hard to do if the underlying fabric retains its full texture after squeegeeing off excess resin. You will generally want to apply at least one light fill coat so that there are no deep pits where fibers of the fabric can sink, making them hard to cut.

Fill Coats

You went through some effort to minimize how much epoxy you applied to the cloth, thus leaving the surface with the rough texture of the cloth. Since you don't want the finished boat to have this finish, you will want to fill the weave with more epoxy.

This can be done at various times after fiberglassing the boat. I like to start the process fairly soon after applying glass. The texture of the fabric can pick up dirt that is very hard to clean out, so generally I will apply one fill coat as soon as I can after glassing. You want the glassing coat of epoxy to at least be very sticky so the new coat does not reverse all the hard work you put in getting it firmly attached to the wood.

Figure 9-27. *The fill coat fills up the fabric texture (right) to create a smooth finish (left). There are several methods for doing this: some are quicker but open you up to making a mess; others are more controlled but time consuming. I brush on the epoxy using the same crisscross technique I use to apply varnish.*

As long as the epoxy is still green you should be able to apply the fill coat without sanding. The epoxy is green if you can make a mark in it with your thumbnail. Your time frame here is starting several hours after glassing to 72 hours. These times will depend on the epoxy you use and the temperature in your shop. If you end up going longer, you should scrub the surface with a kitchen pad to provide some mechanical bonding surface for the new coat of epoxy. This is only marginally effective given the texture of the fabric, so try to get the first fill coat on quickly. I will often apply a fill coat the next morning after glassing to be sure the epoxy is still green.

There are a variety of methods for applying a fill coat. Some are fast, but could be messy; some are neat but may take quite a bit of time. Which you use depends on your building style and temperament. You may also find that a system that works well for a slow-curing, low-viscosity resin is not as good for higher-viscosity, fast-curing epoxy.

I typically paint on a somewhat heavy coat of epoxy with a chip brush, using a crisscross brushing pattern. Working on about a 1-foot-wide area at a time, spread out a heavy brush load of epoxy on the surface using horizontal strokes (i.e., lengthwise on the boat). Next, even this out with vertical (athwartship) strokes, using moderate brush pressure. Finally, tip off the area with light horizontal strokes again, moving from dry toward the wet area. If you are careful to apply an even coat of uniform thickness you will not have drips or sags. Sags occur when there is an area of heavier liquid that attempts to level out. If the thickness is consistent it will tend to flow evenly, draining off the edge of the boat.

Figure 9-28. *Chip brushes are good because they are cheap; that, of course, means they tend to shed bristles. This is usually not a big deal when wetting out the fiberglass because you remove any shed bristles when you squeegee excess resin off the glass, and the bristles become nearly invisible in the epoxy, so any remaining are not offensive. But when you do the fill coats the shed bristles cause drips, sags, and other surface irregularities that are better to avoid. A little CA glue along the top of the ferrule will glue in most of the loose bristles.*

Figure 9-29. *Most of the bristles that are still loose after gluing can be removed by vigorously wiping the brush against tape wrapped around your hand with the sticky side out. You may find an occasional stray hair as you paint epoxy on the boat that you can lift off with the tip of your brush.*

For decked boats you will want to address the top and bottom of the boat in separate operations, masking between the deck and the hull as you do each. A line of masking tape just below the sheerline with the bottom edge folded up to shed drips will keep the other half smooth and clean until the epoxy sets up enough not to drool. Peel away the tape while the epoxy is still soft.

A more rushed method that could potentially turn into a real mess, but which works well for small boats, is the hot-coat method used by surfboard makers. This method involves dumping the epoxy in a big puddle on the bottom of the boat and then quickly spreading it around with a brush. As long as you spread it out evenly and don't mind some large drips on the floor, this technique can be a quick way to apply a fill coat.

This brush method takes some practice. Using a roller is more controlled. Roll on a thin, even coat, let it start to set up, and roll on a couple more coats. A short-nap roller will help push resin down into any pits or pinholes. Some people have good success squeegeeing on a thin coat—just enough to fill the low spots of the weave texture—then coming back and applying more using the brush or roller method.

The eventual goal with exterior fill coats is to be able to completely sand the boat without sanding into the fiberglass so the boat is very smooth. This usually does not happen with just one fill coat, but adding more epoxy directly over the first coat is usually not the most effective approach. Instead, start sanding the first coat a little until you start seeing signs of hitting the fiberglass. This usually looks like a slightly lighter weave pattern. When you see this weave pattern, stop sanding that area and move on. If you can sand to the point where there are no shiny, unsanded spots in the area without getting down to the weave, stop before you do hit the glass. Because epoxy takes a while to set up

Figure 9-30. *Mixing graphite powder into epoxy, creating a black paint, makes a low-friction surface that protects against scratches. Add about 10% to 15% powder by volume to the epoxy. Here I am applying it with a brush, but a roller also works well. The masking tape keeps the black stuff where I want it. Note that the finish will tend to make your clothes black if you rub against it.*

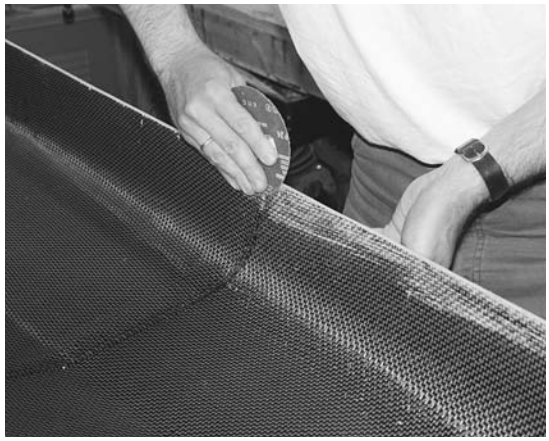

Figure 9-31. *Before joining the deck and hull, rough up the epoxy and fabric along the edge to assure a strong bond.*

hard, you will need to wait a little while before it is ready to be sanded. How long depends on the shop temperature and epoxy formulation, but 48 to 72 hours is usually the minimum.

Because the weave texture can telegraph through several coats of resin, I will often start sanding after the first coat, just to knock off the high spots. Use coarse (60- to 80-grit) sandpaper initially, being careful not to sand into the glass. You will find more information about this process in Chapter 10.

Some people like to add a coat of graphite enhanced epoxy as a low friction, protective finish. While this finish does not provide perfect protection against scratches, it does make it a little easier for the boat to drag across rough surfaces. It is not going to make a boat any faster going through the water, but it may help to make it faster dragging the boat down a beach. The material is added just like another fill coat. Add the graphite powder to premixed epoxy (about 1 or 2 parts of powder to 10 parts of epoxy) and mix it thoroughly. Apply the mix with a roller or brush as you would a fill coat.

Interior Fill Coat

With most boats, having a little bit of texture on the inside is not a bad thing; it will give your bottom or feet some traction so they don't slide around too much. You could go through all the effort of filling in the weave and then add some kind of nonskid surface to it, or you can take advantage of the fabric weave texture that is already there. You do want to add a little epoxy to the weave after the wet-out coat just to be sure that any remaining pinholes are filled. I will usually brush on small amounts of resin and then use a short-nap paint roller to spread it around in a thin, even coat. The nap of the roller should help get resin down into the texture.

You may decide you prefer a glassy smooth inner surface, in which case you can follow the directions for finishing the outside of the boat. If you are making a closed boat, you will need to sand the sheerline where the deck and hull will meet so there is a good surface for bonding.

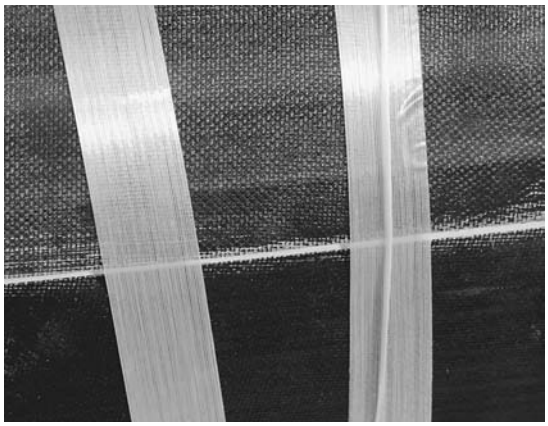

Figure 9-32. *Hold the deck to the hull with strips of strapping tape. The strip on the right has a wrinkle. This wrinkle will trap epoxy, creating a ripple that will require sanding. Try to avoid wrinkles.*

Figure 9-33. *Apply tape across the seam every 4 to 6 inches to be sure the seam does not pop while you are working on it. When the seam is aligned and secure, apply a strip of masking tape along the seam to keep the epoxy in. Burnish down the tape so there is no room for epoxy to collect.*

Seam Tape

Closed boats will need the deck attached to the hull. This is done on the inside of the seam with prewoven tape and on the outside of the seam with the same fiberglass as used everywhere else on the outside. After the edges of the deck and hull have been cleaned up, finish up the bevel to provide a tight joint. Secure the deck onto the hull with packing tape, being careful to get a tight, smooth seam. Avoid wrinkles in the tape as they will create rough spots in the epoxy used to glue the seam.

Unless you know some extraordinary small people, you will need a special tool to apply tape down the inside seam. A "brush-on-a-stick" is a unique combination of a brush and a stick. The stick should be about half the length of the boat. Cut the end of the stick at a 45-degree angle, and screw a chip brush onto the end. Cut off the brush handle. At the other end, stick a finish nail through the stick so the point sticks out the other side about 1 inch. Bend the point over so it lies flat against the stick.

Tip the boat on its side and secure it in place. Try to get the seam on the bottom so gravity will be working in your favor. Measure 1- to 2-inch wide tape out along the outside of the boat. I usually do each seam in two halves from about 12 inches back from the bow to the middle and from the middle back to about 12 inches from the stern, with 6 inches overlap in the middle.

Figure 9-34 *Unless you have really long arms, you will need a special tools to access the far reaches of the deck/hull seam—enter "brush-on-a-stick." Screw a chip brush to the end of a 1-inch by 1-inch by about 8-foot stick, and then saw off the brush handle.*

Lay the tape out flat on a worktable and presaturate it. Use your brush-on-a-stick to precoat the seam with epoxy.

Roll the tape up into a loose roll so you can pick it up easily, inspecting the roll to ensure it is fully saturated as you go. Starting at the middle of the boat, unroll the tape onto the seam. Keep the tape centered along the seam line. It will help to have a powerful flashlight to illuminate the interior. Some people use hiking headlamps. I use the rechargeable light that came with my cordless drill. Unroll the tape as far as you can reach with your hands, and then unroll back toward the middle for a foot or two. Then keep unrolling but going forward again. Keep unrolling back and forth until you get all the tape laid out in a neat Z-fold. You don't want any twists in the tape, just a smooth folded pile. The top layer should finish up with the loose end pointing toward the end of the boat.

Now using the nail end of the brush-on-a-stick, hold the stick with the folded end of the nail toward the deck. Spin the nail so it points up. Rotate the stick toward the deck until the nail points down. Lift the end of the tape so the nail pierces down through it about 1 inch back from the end, and then rotate the stick back up again. The tape should now be hooked on the nail on top of the stick and twisting down over the deck side of the stick.

Your goal when you extend the stick into the end of the boat is to rotate the stick toward the deck again such that the tape slips off the stick and drops on the seam. Sound tricky? Well, it really isn't that much fun, but if you mess up, just pull the tape back and try again.

Start by pushing the stick down toward the end. Keep the nail pointed up. Get some tension in the tape. If the tape starts to slide along the seam at the middle of the boat, hold onto it so you don't get too much length into the ends, making it impossible to release the tape. Get enough tension on the tape that it is lifted off the seam. Slowly lower the stick so the tape drapes gradually down the length of the seam. When the tape is aligned on the seam, rotate the stick toward the deck again so the nail points down. Look to see that the tape is not tangled on the end, and if it doesn't fall off give the stick a quick sharp push forward to release it from the nail.

Inspect your work. Check to be sure the tape is close to centered on the seam. If it favors one side or the other it is probably OK, and you may be able to tweak it a little as you brush it down later. If it is completely off to one side somewhere, you should probably pull the whole tape back and give it another go.

If it all looks good, flip your stick around and apply more resin with the brush end of the stick. By twisting the stick you can brush the tape a small distance to one side or another. Let the epoxy cure, flip the boat over, and do the other side.

After both sides are done, you can strip off the packing tape and clean up the outer seam. You can either run glass over the whole deck or hull across the seam and trim it off on the other side of the seam or mask off an inch on either side of the seam and apply bias-cut cloth across the seam.

If you are doing an open boat, be happy you don't have to do any of this, although some of these techniques may apply for installing small decks or breast hooks. When the glassing is done, you can proceed to finishing.

Chapter 10

Finishing

The finish of the boat is some form of ultraviolet protection. Epoxy is good stuff, but it does not hold up well to exposure to the sun. For most boats the finish will be some form of clear coat such as varnish with UV protective additives, but there is no reason why it couldn't be paint. This UV protection does not need to take the form of a mirror-smooth gleaming finish. You could really apply varnish at just about any time after finishing the epoxy and end up with a good protective coating that makes the boat look pretty good. How obsessive you want to get in creating a fine finish is really up to you.

The secret to a fine finish is in the preparation of the surface before applying any varnish. The more level and smooth you can make the surface, the better your finish will look. The technique to get a level surface is to sand the surface to knock down high spots and apply fill coats to raise up low spots. Once the surface is level, it is sanded with finer grits until the sanding scratches are fine enough that the varnish will fill them in.

The level to which you finish the boat may be different on the inside than the outside. A somewhat rough surface on the inside is nice for a small boat as it is less slippery. The outside is where most people will want to spend most of their effort.

Final Fill Coats

If you have not applied fill coats to start filling in the weave and it has been a while since you applied the fiberglass, you will want to clean the surface before doing so. This may be as simple as scrubbing the boat with a wet abrasive kitchen scrubby, but if it somehow got really dirty you might want to clean the surface with lacquer thinner before scrubbing with clean water.

There are lots of things that can cause issues with applying a coat of epoxy. If in doubt, the best thing to do is finish any cleaning with lots of plain water and a scrubbing pad. This is the least likely to cause problems. Sanding itself will not necessarily clean up contaminants, but instead may just spread them around more. If you somehow get oil or other gunk on the boat, you may want to use paint thinner or an appropriate solvent to clean it off, but then use some water with detergent, followed by clean water. Wipe everything off with clean rags so you aren't leaving dissolved contaminants to dry on the boat. Let the boat dry thoroughly before applying a fill coat or beginning sanding.

Sanding

The goal of sanding is to make the surface level and smooth. Supposedly when you did the previous fairing sanding, you created a smooth, even surface upon which you laid the glass. The sanding now is to reduce or eliminate any uneven spots caused by the fabric texture, edges of a glass layer, drips in the epoxy, or stray strands of fiberglass. You want to accomplish this without sanding into the fiberglass, because it is the fiberglass that provides the strength. Sanding into the fiberglass will cut the fibers, and these short fibers will not provide as much strength as long fibers. When you start cutting fibers it is time to add more epoxy.

Figure 10-1. *Epoxy takes a long time to fully cure even after it is hard to the touch. It continues to get harder as days and weeks proceed. This continued curing could cause the fabric texture to print through. To help reduce this effect and to harden the epoxy prior to sanding, I will often "cook" the boat out in the sun on a warm day. Even on a cool day, wrapping the boat in black plastic can make the boat quite warm. This accelerates the final cure.*

Figure 10-2. *A cabinet scraper does a good job of leveling small irregularities. It can be used with a lot of precision to knock down a small drip. Larger drips can be attacked with a rasp or paint scraper.*

While sanding will do most of the work of leveling the surface, big drips, nasty tangles of glass fibers, and other localized high spots are best addressed with a more aggressive tool. Rasps and scrapers make quick work of removing small high spots. Use a scraper for long ridges caused by runs and stray fibers, and a rasp for roundish hills or mountains caused by drips or tangles of fiberglass.

Run the scraper down the length of the ridge with the blade only on the ridge itself. Scrape down with several passes until the ridge is nearly level with the surrounding surface.

Be careful with the rasp, because while you are concentrating on one spot, another part of the tool may be cutting into a part of the boat you don't intend. I often wrap the end of my rasp with masking tape so it doesn't do its own thing while I'm looking elsewhere.

After you have removed the major high spots, go over the whole boat with the longboard fairing sander. I typically use quite coarse

Figure 10-3. *The fairing sander is an effective tool for leveling out any irregularities introduced in the fiberglassing and fill-coat stages of building.*

Figure 10-4. *Systematically sand the whole surface with 60-grit sandpaper. If you start sanding into the fiberglass, stop and move on. If you are unable to eliminate all the shiny spots before sanding into the glass, apply another fill coat. When you can achieve a smooth and even surface with 60-grit sandpaper, step up to finer grades of sandpaper through 220-grit.*

paper at this stage (40-grit) so the tool is very aggressive. If you are less confident, use a little bit finer grit (60 to 80), but not so fine that you get bored before you are done. Use long strokes along the length of the boat. At this point you are still just trying to knock down high spots that you didn't take care of with the rasp or scraper. You will start to notice some places where the long-board makes a lot of scratches and other places where it hardly does anything. Watch the scratched places for signs of hitting the fiberglass. You will notice lighter spots in the epoxy with a weave pattern. When you hit these spots, stop sanding that area.

If you can get fairly even scratches over the whole boat without hitting the fiberglass, you can move on to using the random orbit sander. If you are hitting glass surrounded by shiny areas, you will need to apply another fill coat. Get the surface pretty even before applying more epoxy. High spots will only cause new drips and sags. Clean off all the sanding dust, dull any remaining shiny spots with an abrasive kitchen scrubber, and clean the surface with clean water and wipe it dry.

Apply a fill coat as before, judging the thickness of the coat based on how smooth the surface is. If it is pretty smooth you won't need much thickness. After the fill coat has cured, start sanding with the long-board again as necessary.

Use the random orbit sander to create a smooth surface free of any fabric texture. Again, start with a coarse (60 to 80) sanding grit and a relatively stiff sanding pad. Hold the face of the sander flat against the surface and keep it mov-

Figure 10-5. *It is extremely easy to sand through sharp edges and feature lines. Avoid touching these corners with a power sander. You would likely go through the material before you can blink. Instead, keep the pad of the sander flat on the large surfaces, leaving the corners shiny until you are done with all the power sanding, then hand sand with fine sandpaper to lightly remove the gloss.*

Figure 10-6. *Where you have extra layers of glass, such as around the stem, you will need to feather in the edge of the glass. This will require sanding into the glass of the thicker layer and blending it down to the surface of the surrounding glass.*

ing. Be very careful around tight radius edges and feature lines. It is very easy to sand through the fiberglass on sharp corners. It is best to hand sand these areas. Work systematically down the length of the boat, working from centerline to sheerline, overlapping slightly onto previously sanded areas while moving onto new areas. Replace the sanding disks frequently. Sharp sandpaper does not require as much pressure, so it will more readily cut the tops off high spots without lowering already low spots.

The goal with the random orbit sander is to get an evenly sanded surface with no remaining shiny spots (again without sanding into the glass). The hardest shiny spots will be pits or divots down into the weave of the fiberglass. Sanding alone may not eliminate these pockmarks. When there are just a few remaining, a drop of epoxy or CA glue in the low spot will fill the hole. If there are extensive areas with little shiny spots and you can't sand anymore without removing glass, you will need to apply another fill coat.

Once you achieve a smooth surface, evenly sanded, without any shiny spots, you can start stepping up through finer sandpaper grits. Sand the surface until the scratches from the previous grit have been eliminated. If you end up sanding down to the fiberglass, roll on another light coat of epoxy. When you have reached about 180-grit sandpaper you are ready to proceed to varnishing. Finer sandpaper will make your first coat of varnish look better, but since you will be applying several coats and sanding between them, the appearance of the first coat is not that critical.

Varnishing and Painting

The traditional finish for boats is spar varnish. This was developed for boat spars that will be out in the weather as a coating to protect the wood from the weather. Typically, spar varnishes are a concoction of alkyd-modified tung oil and phenolic resins and solvents. When exposed to the air the solvents evaporate and

the resins react with the oxygen in the air to form a hard protective surface.

As I mentioned earlier, the finish is used to provide UV protection. While it does make the boat look nice, that is not really the reason for taking the time and effort to do it. You can make the bare epoxy look just like a quality coat of varnish, but after a year in the sun it would start to deteriorate, and after a few years the epoxy and fiberglass would start falling off. You can use the boat for a while before varnishing if you are really eager to try it out, but you will want to get some sort of UV protection on it eventually.

The UV protection need not be varnish; paint actually provides more protection than varnish, and if you paint the boat you can be a lot less careful on the woodwork, but it does require a smoother surface to appear blemish free. Paint can be applied in much the same way as varnish. Much of the UV protection of varnish is provided by the glossy surface simply reflecting the UV rays. While a matte or satin finish looks good and does provide some UV protection, it is not quite as effective. The downside of very high gloss is that it tends to highlight flaws in the surface. For surfaces where you don't want to put as much effort into getting a flawless finish, matte and satin finishes help camouflage minor drips and other textures.

In preparation for applying a finish you will need to get the surface clean. Vacuum off the sanding dust, then rinse it off with clean water, wiping off the excess water. I will often further clean the surface by wiping it down with paint thinner or mineral spirits, again wiping it dry afterward with a clean rag.

Most boats will require you to apply the varnish or paint in stages. There will always be some places where you can't reach. With a kayak or closed boat you will probably need to work on the deck and hull in separate operations; likewise, with a canoe or open boat, the inside and outside will need to be finished at different times. Because varnish and paint like to drip, it is worthwhile masking off the edge between the deck and hull or the gunwales.

Figure 10-7. *Mask off the lower edge of any area to be varnished to control any drips that may accumulate. Fold up the bottom edge of the tape to create a drip edge. Varnish the hull about 1 foot at a time, switching sides every 2 feet so you maintain a wet edge along the centerline. Remove the tape a minute or so after you have finished varnishing. Let the varnish dry, and then flip the boat over and repeat for the deck.*

Apply masking tape along a strip seam or along a gunwale where the slight ripple of the edge will be hard to see.

Dust will get in the finish. Learn to accept this. Unless you can afford a space dedicated to finishing that you can keep dust free, you will end up with some dust in the finish. People have been known to strip naked so as to avoid tracking contaminants into their varnishing space. I find this a little obsessive. If you are going to use the boat, it is going to get scratched; a few specks of dust should not be a worry. Remember that the varnish or paint is for UV protection and it will still do just fine at that with a little dust in the finish.

But since we are entitled our obsessions, we might as well try to minimize how much dust is in the finish. If you have the space, do your finish work somewhere other than where you do all your sanding. If you don't have this option, clean up as much of the dust in your workspace as you can and then let the air settle for a day or two. Some people wet the floor to keep the dust down.

Before starting to apply your finish, wipe the surface down with a tack rag. This is a piece of lint-free cloth impregnated with some sticky stuff that picks up those little bits of whatever it is that settles on your boat. A well-washed T-shirt wetted with mineral spirits does a pretty good job as well.

Figure 10-8. *Remove dust from the surface of the boat before varnishing by vacuuming, rinsing it with water, and then wiping with a tack cloth.*

Good light is the key to being sure you don't miss a spot. Bright lights should be set down low at each end of the boat so that when you put your eyes down near the surface and look toward the light you can easily see missed spots and the ripples of a sag or drip.

You want to pour your varnish into a separate container from the can it came in. Quart-size plastic food containers such as yogurt containers work well; just make sure they are clean. These containers let you pour a bit in the bottom of the container and have enough depth that you won't spill the varnish easily. You can also get excess finish off the brush by whapping it against the inside.

A smooth coat of finish is a function of getting the liquid onto the boat in an even layer. This means it needs to be laid down evenly but

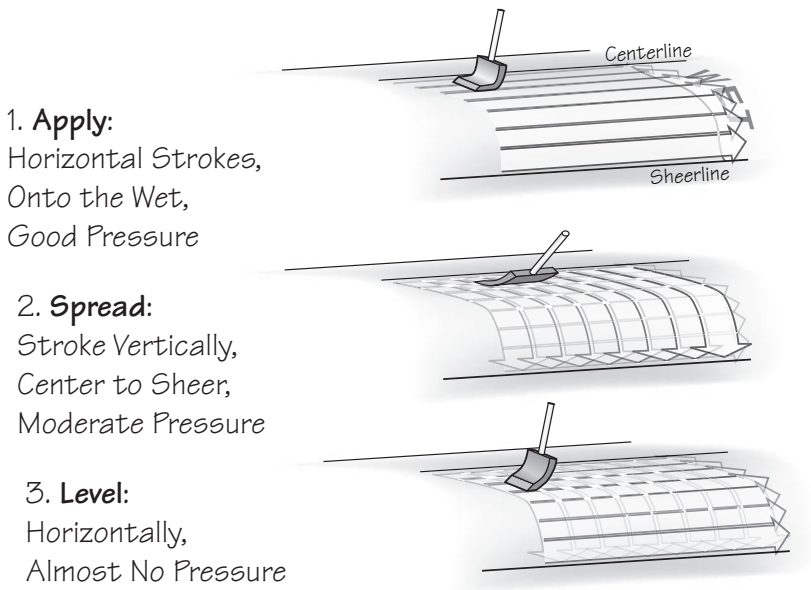

Figure 10-9. *A smooth finish starts with an even coat of varnish or epoxy. Work in small sections. Fill the brush with a somewhat heavy load of finish and apply it to the boat with heavy, horizontal strokes working from the centerline down to the gunwale or sheerline. Without getting more finish, spread out that layer evenly with moderate pressure and vertical strokes. Finally, level off the finish with very light, horizontal strokes. Inspect your work before moving to the next section.*

also quickly enough so that it has time to level out. If you move too slowly, the finish will be drying as you go, and any effort to apply more finish to an area that has had even 45 seconds to dry will result in a visible ripple. Experienced painters talk about a *wet edge*, which refers to the transition areas between where you have applied varnish and where you have not. At this transition, you want the finish to stay wet so that as you apply more finish it can blend in with the already coated area. Keeping this transition wet is called maintaining a wet edge.

The trick is to work fast enough that you maintain the wet edge, yet carefully enough that you apply a uniformly thick film of finish over the whole surface. Any spots with added thickness will tend to drip, run, or sag. It is possible to apply a relatively thick coat without any kind of drooling if you can maintain a consistent thickness—at the same time that you keep that wet edge. If that doesn't sound tricky enough, you also need to do it on both sides of the boat simultaneously to avoid a rough transition down the centerline. This requires that you be systematic. Don't just randomly slap the finish on everywhere until the boat is covered. You need to divide the boat up into manageable chunks, deal with those sections in a regimented manner, and then move on, confident that your system is working.

Applying the finish can be broken down into three steps: applying, spreading, and leveling. You apply the finish over the surface, spread it out evenly, and then tip it off to get it level. Break your boat down into imaginary sections running from centerline to sheerline. These sections should be small enough to cover with one brush full of paint or varnish. This will often be an area about 12 inches wide. If you used staples to hold the strips, they make a good guide to keep you organized as you work. (You knew there was a good reason for all those staples, didn't you?)

Apply the finish systematically. Work on one section at a time. Spread finish on the section with heavy horizontal strokes, applying sufficient finish to thoroughly soak the surface.

Figure 10-10. *Varnish provides UV protection for the epoxy. You want at least three coats to be sure there is enough coverage. Mask off areas where you do not want varnish. In this case I did not want to varnish over the graphite powder–epoxy bottom. The varnish will flow slightly down the side. A line of tape on the gunwale keeps this flow from creating drips along the edge. Get the upper side when you turn the boat over to varnish the inside.*

A few drips as you get the finish on the surface are OK.

Start by dipping the brush about 1 inch into your paint or varnish. Apply this in aggressive strokes moving horizontally, or back and forth along the length of the boat. Hold the brush at a 45- to 60-degree angle relative to the surface. Use enough pressure to squeeze finish out of the brush as you work over the area. If you don't quite get finish over the whole area with one brush full, dip it again, but only enough to cover the remaining area of your current section. You want the brush somewhat dry for the following steps.

After getting the material initially spread out, you want to even it out a bit. Use vertical strokes running up and down from sheer to centerline. Hold the brush at a 30- to 45-degree angle. This time use a little less pressure so you pick up excess finish where there is too much

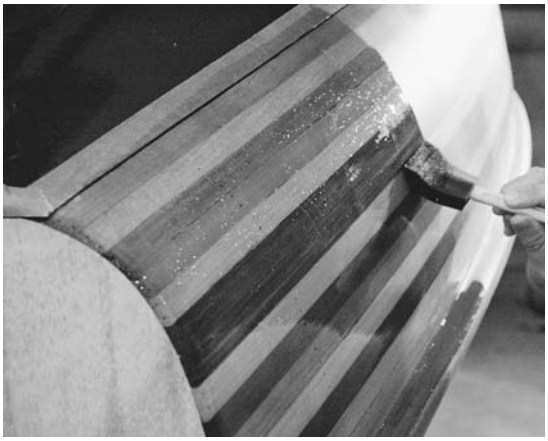

Figure 10-11. *After the varnish is on the section, even out the coat with vertical strokes. Use moderate pressure to pick up varnish from thick areas and move it to sparse areas. Do not redip the brush. Look for holidays where there is no varnish by putting your eye close to the surface and looking toward the light.*

Figure 10-12. *Finally, lightly tip off bubbles with quick, even strokes. Brush in one direction, from the drier side to the wetter. Lift up the brush while you are moving. Double-check for holidays as you work. As soon as you finish one section, move on to the next section. This is not a time to answer the phone or go eat cookies. Do the whole boat without stopping. When you are done, peel off the tape and leave the area so you don't stir up dust.*

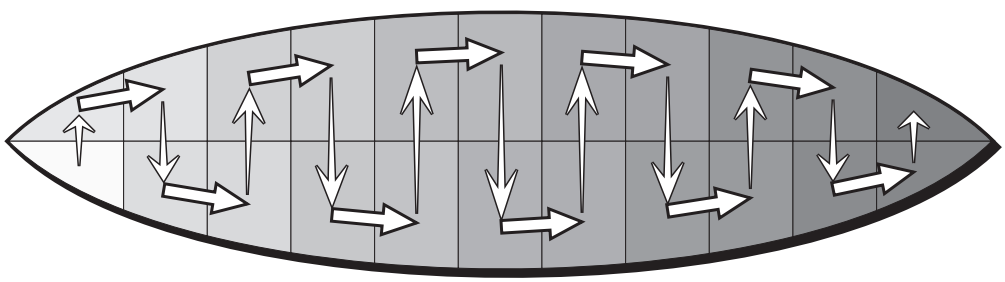

Figure 10-13. *Quick-drying varnish requires a wet edge to avoid lines between varnished sections. You must move fast and not get too far ahead of the drying varnish. Work in small (1-foot-long) sections and switch sides after every second section so you are never more than one section ahead of the other side.*

and lay it back down where you have missed spots. Get your eyes down near the boat so you can see the change in gloss. Look for dull spots and ripples, and brush them out as necessary.

All that working of the finish may have created some bubbles. Finally, tip off the surface with a light stroke. Hold the brush at a low angle and lightly drag it across the surface with horizontal strokes moving from the dry edge toward the wet. This will break any surface bubbles and lift up excess finish that could later drool down the side.

After another check to see that you didn't miss any spots, move to the other side of the boat and apply the finish to same band on that side. When you've finished that one section, move forward one section and repeat. Switch sides every two sections. The reason for all this running back and forth is to maintain that wet edge along the centerline. Varnish and paint start to dry the moment you brush it on the boat. When it dries enough, new coats spread on to it will not blend in well, but instead will leave brush marks on the surface. By constantly switching sides and working on relatively small areas you should be able apply a smooth coat with a minimum of visible brushstrokes.

As you move down from one 1-foot section to the next, look back to see if you have missed any spots in the previous section. Obviously, mistakes in paint will show more easily, but you need to look closely with clear varnish. You can carefully touch up this section because it should still be wet enough to blend in any new strokes, but if you go back farther to earlier mistakes, the new brushstrokes will probably fail to blend in. At this point you need to decide which is worse: a holiday without finish on it, or the ripple of a brushstroke. Honestly, I prefer a little bit uneven, but shiny surface over a dull one, so I'll touch up older holidays if I see them, but the best results will come from systematically applying a good coat on each section the first time.

When you have reached the far end of the boat, wait a minute or two and then peel off the masking tape at the bottom edge. If you peel too soon, the freshest finish may run beyond where you had the tape, making a drip. If you wait too long the finish will dry, leaving a sharp transition. Waiting a little bit can let the edge fade slightly as the finish continues to dry. Turn off the lights so you don't attract flies into the space, and leave the room until the finish is dry so you don't stir up any more dust.

In moderately warm weather most standard varnish and paints will dry in about half a day to the point where you can flip the boat over and do the other side. There are now varnishes available that allow you to apply multiple coats in one day without sanding between coats. With these you may apply several coats to the bottom one day, then flip the boat over and apply several on the other side.

Figure 10-14. *Between coats of varnish you can either wet sand by hand or use fine sandpaper in a power sander. This levels the surface and helps you see your new coat of varnish by dulling the surface.*

Even with regular paint or varnish you may reapply another coat within about 72 hours without sanding. This is good if you want to build up some finish thickness but aren't too worried about a flawless finish. After this dries you can always sand it smooth before applying a final pretty coat. Painting is complete when the finish is opaque; this may be after one or two coats.

There are several reasons to sand between coats. If the finish has dried for several days it will need to be scratched up for a new coat to stick. Sanding will also remove flaws so they don't get worse with the next coat. It is a lot easier to see where you have and have not applied

finish if the surface has been sanded. With it still shiny, new wet paint or varnish will look a lot like the previous dry surface.

Sanding with wet-or-dry 220-grit paper will create a smooth enough surface that the scratches generally will not show through the next coat of finish. Finer sandpaper such as 320- or 400-grit will not sand through thin coats as quickly but do not provide as much "tooth" for the next coat. If you are sanding a fairly recent coat of finish that has not reached full hardness, sanding with wet-or-dry sandpaper or fine abrasive sponges and water will help keep the abrasive from gumming up. Keep a bucket of warm water nearby and keep dipping the abrasive. You can also keep a hose or wet sponge handy to keep the surface wet. With all the water around, this is not the place to use electric power tools. Instead of your random orbit, you will want to sand by hand. Hand sanding is always a good idea around difficult contours and feature lines.

After about a week, most finishes can be sanded with dry paper, and if you have large areas to cover, a random orbit sander is a good choice. Because it is easy to burn right through the existing coats, a fine-grit paper may be a good idea, and if you have a variable-speed sander, now is the time to back off on the speed a bit. Use a soft backing pad and use a light hand on the sander.

The goal of the sanding is to just level off the surface. You want to knock off the *dust picks*, where dust has landed in the still-wet finish creating what appears to be a tiny bubble, and even out any brush marks. You do not want to sand off all the previous layers you worked so hard to apply. If the surface is already pretty smooth and all you want to do is prepare the surface for a new coat, you can use a kitchen abrasive pad to eliminate the gloss on the surface. When you are done, clean the surface and go back to the finishing step.

Repeat the sanding and varnishing process as many times as you have patience for. With paint you can stop when the finish is opaque. One coat of varnish is better than none. If it is already halfway through the summer and you just want to get your boat in the water before the season ends, put on one coat and get your boat out and use it. Come back in the fall and complete some more coats. Three coats is a good minimum, and there is really no upper limit beyond your tolerance for tedious sanding. More coats will look better and provide more protection, but there is a point of diminishing returns somewhere around six coats.

Varnish and Varnishing Alternatives

There are a lot of alternative clear coats available. The traditional spar varnish is nice because it is relatively affordable and fairly easy to deal with. It produces a warm amber tone that nicely complements the natural colors of most woods. While it is not the most durable and long-lasting finish available, it is relatively easy to refinish.

Polyurethanes are a variety of varnish that contains constituents that react with each other after the solvents have evaporated. Many polyurethanes and varnishes are actually hybrids containing both traditional varnish components and more modern polyurethane ingredients. Polyurethanes tend to be harder, more abrasion resistant, and more durable than varnish. Early polyurethanes were highly susceptible to UV degradation, but now there are marine polyurethanes that provide good UV protection.

Most polyurethanes can be applied just like varnish, although they seem to be slightly harder to apply smoothly with a brush. Polyurethanes may be clearer than varnish, but they may also have a slightly cool, bluish tint, which may look slightly "off" on some woods. The added durability of the finish is a nice feature, but generally polyurethanes cost more than traditional spar varnish. If you are using your boat a lot, polyurethane will still get scratched up, and for practical purposes an expensive scratch-resistant coating may not last much longer in regular use than a cheaper alternative before you want to refinish the boat. Due to the harder

properties of the finish, it can be a little harder to sand the surface prior to refinishing as well.

As you move up the cost spectrum you will find higher-priced polyurethane finishes that are tougher and more durable until you get into the two-part and three-part polyurethane and epoxy finishes. These finishes have a limited pot life because as soon as you mix the parts together, they start to react and are on their way to curing even before you start spreading them on the boat.

These finishes are quite appropriate for boats, and while some are formulated for brushing, spraying often provides the best results. If you are good at spraying finishes, you don't need me to tell you what is involved, and if you are not good at it, teaching spraying technique is a little beyond the scope of this book. For those who don't know how to spray finishes or don't have the equipment, you could do all the sanding on your boat and then bring it to an automotive body shop. A good automotive clear-coat that contains UV inhibitors will produce a beautiful finish on your boat.

If you go into a marine supply store, you will find a large selection of high-quality paints, most of which are suitable for applying to a strip-planked boat. Paints suitable for wood or fiberglass will adhere well to a properly prepared surface. There are primers that will help prepare the surface for a flawless finish. However, you can do well seeking out paints at the local home center. Any exterior enamel will work, and those intended for decks tend to be quite tough and will provide long-term service at a reasonable price. While they may not be as glossy as paints available from a marine supply store, you will avoid paying the premium associated with those stores.

Buffing Out the Finish

For those of us without a dust-free finishing room or access to professional paint equipment, a little dust in the finish should be a foregone conclusion. Even the guys who strip naked before going into the finishing room are going to end up with some dust settling on the finish. By far the easiest solution is to accept this and not perceive it as a problem. It is only cosmetic and will not affect the performance of the boat. After a year of hard use the presence of only a little dust on the finish will be a fond memory under all the scratches.

Figure 10-15. *You can get results almost as good as spraying by careful brushing followed by rubbing out and polishing the result. This* Night Heron *was sanded with 600- through 2,000-grit sandpaper and then buffed with polish.*

But, I have more than once succumbed to the unreasonable perfectionism of the desire for a flawless finish. If you really want to go for it, the solution is to rub out the finish. Fine sanding to remove the dust picks and buffing compounds to restore the gloss really can provide a spectacular finish. Standard spar varnish can be buffed, as can the harder modern finishes. It takes patience, but it isn't really that complicated.

The finish needs to be very hard before proceeding. After you have finished applying all your coats of finish, let the boat sit for a minimum of at least a week. A light sanding should produce a fine dust. The first step is to level the surface, sanding off all the dust picks and small ripples. This is achieved with superfine sandpapers available through automotive supply stores. Start with as fine sandpaper as will cut down the dust spots in a reasonable time (600- to 800-grit). Finer grits will take longer, but coarser will require stepping up through more grits. Like the previous sanding, any scratches will have to be removed with successively finer grits.

Use a wet-or-dry sandpaper and some form of sanding lubricant such as paraffin oil or water. Wrap the sandpaper around a stiff sanding block such as a block of wood or a firm felt block. Apply the lubricant to the boat surface and start rubbing. This will take some elbow grease. Keep rubbing until the surface blemishes are removed. You will need a clean dry cloth to wipe off the surface so you can gauge your progress. Keep switching out your sandpaper as it gets dull, and keep applying lubricant as the surface dries. Do this to the whole surface.

When you have leveled the surface it is time to step up to the next higher grit following a progression of 600, 800, 1,000, 1,200, 1,500, 2,000. With each level you will want to completely remove the scratches made by the previous level. It should go a little quicker after the initial leveling, as you don't need to remove as much material. Remember that you do not want to remove the varnish; you are only trying to polish it. If you do go through the varnish you will need to stop, revarnish, and start all over again.

After you are done with the extra-fine sandpapers, you should have a very nice-looking surface that is smooth and even but without much gloss. This actually looks very nice and could make a beautiful-looking finish; however, since much of the UV protection is provided by simple reflection, a higher gloss is desirable. An automotive buffer and buffing compounds will bring it up to the next level.

Apply the buffing compound to a small area and start working it around with a light touch and a lamb's-wool buffing wheel, spinning at a fairly slow rate. After the compound is distributed over the area, increase the pressure to help the buffing action. As the compound dries, decrease the pressure in order to bring out the shine.

When you have finished buffing, take a step back and look at and admire the boat. Put a polarizing filter on your camera and set the boat outside somewhere to get a nice picture. The boat will never look as good again. Do yourself a favor and get the first scratch early. This will save you a lot of care and worry as you try to baby the thing. Once the first scratch has christened the boat, it will be a lot easier to get the full pleasure of owning and using a boat you built yourself.

Part III

Boats You Can Build