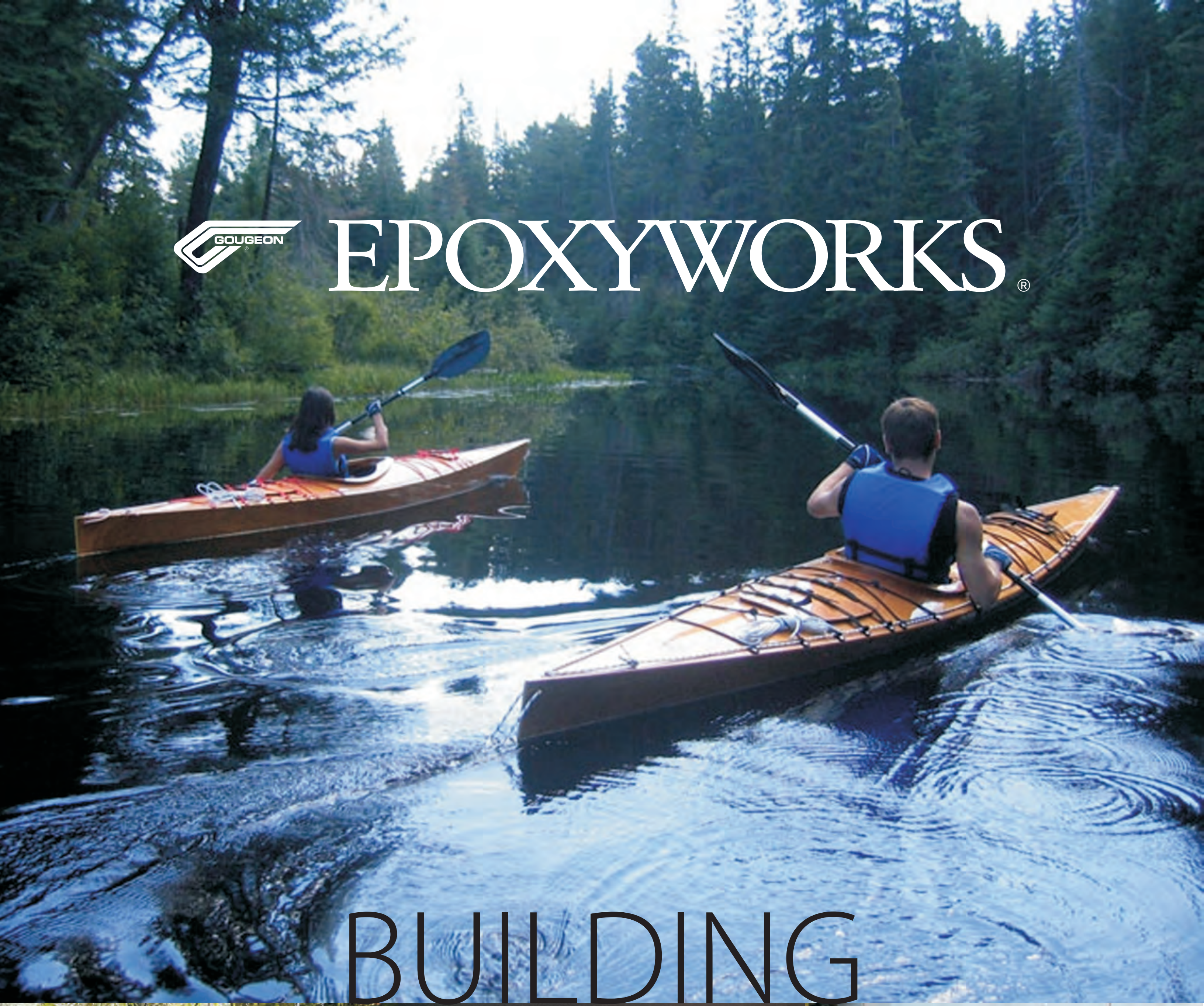

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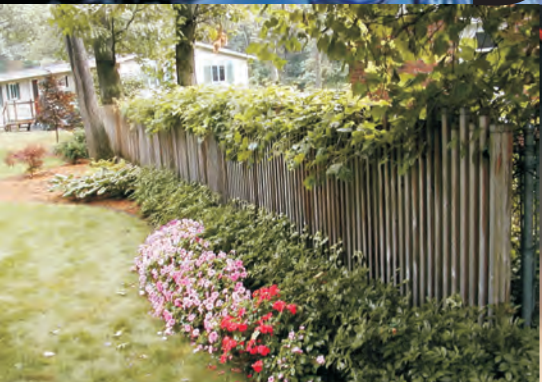
BUILDING



BUILDING, RESTORATION & REPAIR with EPOXY

Number 36 ■ Spring 2013

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Editor / Designer Michael Barker

Managing Editor / Copy Editor Grace Ombry

Contact / Subscriptions Darlene Auman

Contributors Kay Harley, Cris Jacobson, Brian Knight, Tom Pawlak and JR Watson.

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Mailing address Epoxyworks
P.O. Box 908
Bay City, MI 48707-0908

Email epoxyworks@gougeon.com

Epoxyworks online www.epoxyworks.com
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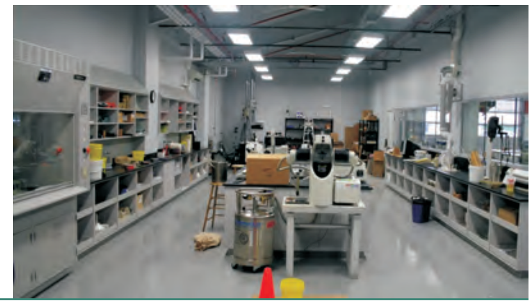
The Building Issue



For this issue we've dug through our *Epoxyworks* archive to put together a selection of all building articles. There are two reasons for doing this. For the last couple months we have been re-designing the PRO-SET Epoxy product line. This has taken an incredible amount of work by most everyone at Gougeon Brothers, especially those who write and produce *Epoxyworks*. In addition, since the beginning of the year, the chemists, lab technicians and technical staff, who are the main writers of articles, have been moving into their brand new quarters. Check out the new testing lab (right). More about that in the next issue.

The culture of Gougeon Brothers is building. This new addition, this test lab, every product we sell is geared toward the building of things. It is a company founded by builders. One of our founders, Jan Gougeon, passed away December 18, 2012 at the age of 67.

Few loved building things more than Jan Gougeon. Innovative boats and creative solutions flowed from him without the limitations of computers or drafting boards. We'll miss finding Jan in the boat shop dreaming up ingenious ways to go faster, building fantastic things—and always taking the time to share his love of building. His obituary is on page 12.—*MB*

Let's start off simple

An Easy-to-Build Clipboard

Epoxyworks 10
Winter 1998

By Tom Pawlak

Building a natural finish wood-strip canoe can be exciting and a bit daunting, particularly if it is your first clear finish canoe. You'll commit time and money to the project and your expectations may run high. Most people are happy with the results of their first strip composite project, but deep down they wish some aspect of it was a bit better.

This article suggests ways to overcome problems that can plague you as a first-time builder. You can eliminate pitfalls if you take time to build a simpler strip project before building a canoe. This is an approach woodshop teachers often take with their students.

Mail boxes, clip boards and canoe paddle blades can be built using the same technique as a canoe. This gives you a chance to practice and gain confidence, and you can learn from your mistakes on relatively inexpensive projects. A simple project like a wood strip clipboard can be fun to build, it's useful and can make a unique gift.

Whether you are building a clipboard or a canoe, a modern strip composite project usually includes these nine steps:

Step 1: Plan

Choose your materials and methods. Before starting your project, select your building materials, then research and decide exactly how you will accomplish each of the steps.

To make a clipboard, your materials include:

- ☐ 12 to 15 wood strips that are ¼"×¾"×14" long.
- ☐ A flat piece of wood that is at least 10"×14"× at least ½" thick.
- ☐ Plastic or wax paper sheet roughly 10"×15".
- ☐ WEST SYSTEM® 105 Epoxy Resin®, 207 Special Clear Hardener® and 406 Colloidal Silica filler.
- ☐ 2 pieces of 4 oz or 6 oz fiberglass cloth, one for each side of the clipboard.
- ☐ A staple gun with staples, or small brads to hold the strips in place during epoxy cure.
- ☐ A cabinet scraper, sand paper and hard pad sander.
- ☐ A nickel finish clipboard clip P/N 76190 or brass clipboard clip P/N 75838 is available from Rockler Woodworking and Hardware, 1-800-279-4441, www.rockler.com.

Before building your canoe, reading *Canoecraft* by Ted Moores and Marilyn Mohr is a good place to begin. Gil Gilpatrick's book, *Building a Strip Canoe* is another good choice. Both are easy for first-time builders to understand, yet thorough enough that many experienced builders use them for reference. I used both books in researching and building my first canoe.

You may have an idea of how you'd like the canoe to look, but are not sure what woods will create that look. You could experiment by making several clipboards using a variety of wood species. Once they're edge glued and coated with epoxy, the panel's color and tone will be evident. At this point, you can set aside any panels you don't like. Only panels that have the desired look need to be fiberglassed and finished.

Step 2: Select the wood

Experiment with color schemes and contrast. You can use a variety of wood species to create a colorful piece. Add 4 or 5 narrow strips of contrasting wood for a stunning accent. The photo on page 1 shows the accent strip effect.

Canoes are usually built with low-density woods like cedar, spruce or redwoods. Western red cedar and Atlantic white cedar are most popular, but some beautiful canoes are built with Sitka spruce and redwood.

Several years ago I purchased clear redwood from a local yard to build my canoe. I bought it because it came in 20' lengths, offered beautiful wood contrasts from light tan to dark reddish browns, was without knots and was affordable. The clear redwood grade includes heartwood and sapwood (dark and light) and is less expensive than clear/select redwood, which is all dark colored heartwood.

Step 3: Prepare the strips

We can experiment with edge treatments for the wood strips. Basic flat edges that will form butt joints should be sufficient for a clipboard, but the butted seams are more noticeable on curved parts of the hull. Bead and cove joints are used on canoes because the joints are less visible and the strips interlock and align better. See *Types and sources of strip plank material,* page 3.

Step 4: Create a mold

Because we're experimenting with flat panels, our mold can be a flat piece of plywood or a few pieces of straight 1"×1" wood strips, set apart to simulate mold frames. Cover the mold with plastic film to prevent epoxy from sticking to it.

Naturally a canoe mold is much more difficult. Don't skimp on the time or effort it takes to build a canoe mold. It's an important part of the process and flaws in the mold will show up in the finished canoe.

Step 5: Edge glue the wood strips

Coat both edges of each strip with epoxy, slightly thickened with 406 Colloidal Silica or a standard water-resistant glue. Place each strip tight against the previous strip. Staple or nail the strips to the plastic covered plywood mold using a single fastener at each end. Avoid driving the staples or nails in too deep because removing them later may damage the wood. You can avoid damage by stapling through strips of firm plastic or wood. Wipe or scrape away the excess glue before it cures. Allow it to cure overnight.

Again, we can use our test panels to experiment with different glues and determine which best meets our needs. Builders use a variety of adhesives to edge glue wood strips together on small projects like canoes. These include white and yellow carpenter glues, polyurethane adhesives, 5-minute epoxies and of course WEST SYSTEM epoxy. Although some of these adhesives are not marine grade glues, the builders have faith that the epoxy and fiberglass layers inside and out will keep the wood dry. As a strip plank project increases in scale and worth, builders almost exclusively edge glue with epoxy because they can't afford to take any chances.

Step 6: Prepare to fiberglass

We can use our flat panels to develop finishing skills for smoothing the wood surface. Even flat panels will have irregularities that you'll want to remove. Smooth the surface with cabinet scrapers, sanding blocks or modified vibrator sanders. If you are hand sanding, do it in the direction of the grain to avoid cross scratches in the wood. Use 80-grit sandpaper for rough shaping, and 120-grit for final sanding. Use a vacuum cleaner or bench brush to remove wood and epoxy dust.

Wipe the surface with lacquer thinner or water to expose any flaws and enhance wood color, contrast and tone. If you don't like the character of the wood, discard it and try again. I'll build two or more boards at the same time to increase the chance of getting a panel I like.

On curved surfaces like canoes, many strips edge glued together give the appearance of fluid curves, but in reality the shape is made of a series of narrow flat segments.

To prepare the canoe for fiberglass, you'll use sanders, cabinet scrapers and/or low angle block planes, to create one continuous smooth surface. Work them carefully. This can and should be time consuming, particularly if you plan to produce a flawlessly smooth hull.

You can modify tools to improve the outcome and make the job faster and easier. On a bench grinder, shape cabinet scrapers to match the desired shape of the hull. You can use several scrapers with slightly different shapes to scrape away the hard edges of the wood strips on different parts of the canoe.

You can modify a vibrator sander with plastic laminate between the sandpaper and backer pad to create a hard surface behind the sand paper. This allows the sandpaper to touch only the high spots. This trick works only on flat sections and on convex surfaces like the outside of the hull. Professionals usually combine these techniques to get the job done.

Step 7: Apply the fiberglass

For clear finished projects, seal-coat the surface with epoxy a day or two before fiberglassing. This step helps create a good clear finish. The seal-coat lets you see one more time, how the wood will look when fiberglassed. You'll be able to see any glue dribbles left over from the edge gluing, and can remove them before you apply the fiberglass. The seal-coat also reduces the chances of air escaping the wood to make bubbles in the curing epoxy, a process called outgassing. See *Fiberglassing a woodstrip hull*, *Epoxyworks 16* (visit epoxyworks.com).

Sand the seal-coat before you apply the fiberglass. Avoid sanding through it, because sanded-through spots may make irregularities in the finished surface.

To apply the fiberglass, carefully lay a dry piece of fiberglass cloth over the prepared surface. Smooth out wrinkles and air pockets. Apply epoxy using the clear finish techniques recommended in *Fiberglassing a woodstrip hull*, *Epoxyworks 16*. Remember to apply all of the fill coats on the same day if possible. You should apply each coat while the previous coat is still a bit tacky. This way you won't need to wash and sand between coats (as you will if you let the epoxy cure hard).

Apply fiberglass to the other side of the panel as soon as possible. This reduces the chance of the panel warping. If the unsealed wood on the opposite side picks up moisture or dries out, the panel will cup or bow. If this happens, add moisture or dry the affected side to correct the warp. Cure the epoxy for at least two days at 65°F or higher.

Most clear finish canoes are fiberglassed inside and out with a layer or two of 4 oz or 6 oz plain weave fiberglass cloth. You can experiment with fiberglass from different sources over the flat panels to determine what works best. If the fiberglass wets out clearly, it's probably suitable for your project. To avoid problems with fiberglass wrinkles, find a supplier who ships the fiberglass rolled on a tube, rather than folded.

Step 8: Finish the surface

Use stiff sanding blocks and modified vibrator sanders to smooth out any remaining surface flaws. Finish the surface by sanding it smooth with a Formica backed vibrator sander to create a smooth flat surface in preparation for varnish.

Repeat all of the surface preps to the other side of the panel. Trim the board to final size of 9½"×12½" allowing for a ½" radius on the corners. Break all edges with sand paper rounding them off slightly. Coat the edges with epoxy, allow to cure and sand smooth before varnishing.

Apply one or two coats of varnish to the flat panels to complete the process. Two or three coats are recommended for canoes.

Step 9: Install the hardware

Two different types of clipboard hardware are available. Conventional chrome hardware and a smaller, lower profile version in brass. Both are available at Rockler Woodworking and Hardware. Attach clipboard hardware with screws and T-nuts.

There is still quite a bit to install on a canoe after the hull is finished. the seats, shear clamps and decks finish the job and because the stressful part is over these can be more relaxing and enjoyable parts of the project.

If you decide to build a clipboard, remember to have fun and experiment with wood color and fastener technique. If you can perfect your building methods on small projects like this clipboard, you will be better prepared to take on larger projects. ■

A unique building method combining ingenuity and epoxy's versatility to create smooth, curved architectural surfaces

Building a Curved Wall

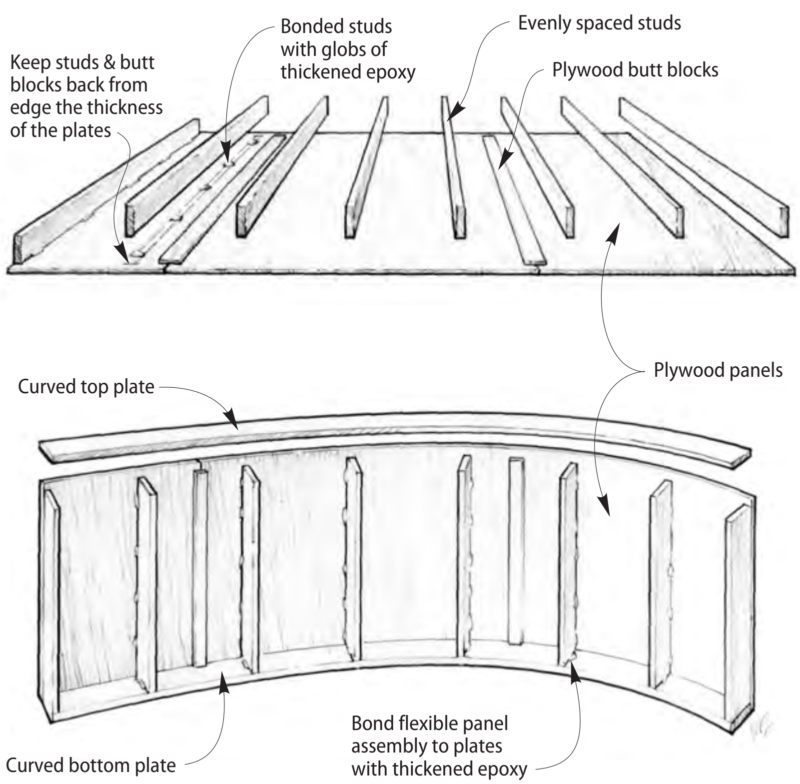
By Brian Knight

Epoxyworks 13
Spring 1999

A while back, as I was waiting in the reception lobby of a major American corporation, I had the chance to admire the curved reception desk and other oak furniture in the room. However, when I examined the reception desk more closely, I could see facets in the oak veneer instead of a nice, smooth curve. I immediately realized that the cabinet builders had sawn closely spaced saw kerfs in the back of the panel so they could bend it to shape. I thought there must be a better way.

The following is a description of "the better way"—the methods of building expert Jon Staudacher, to create curved walls and curved face cabinets. Jon's boat and airplane building background, coupled with the unique properties of WEST SYSTEM® epoxy, have combined to create very elegant solutions to difficult construction problems.

Building a curved wall with no "kinks" is rarely successful, but Jon's method turns the job into a no-brainer. No special skills are required, very few, if any, fasteners are needed and the time spent building the wall is shorter than using conventional methods.



The basics

The wall consists of thin plywood glued to standard 2"× studs (or 1"× if the wall is not load bearing). The plywood is easily bent into smooth, fair curves and the studs provide rigidity. The trick to this process lies in *not* trying to fasten the plywood to the standing studs. With the conventional method, you almost always have a flat spot at any butt joints and it is tough work trying to force the plywood against the studs, especially if the curve is concave. With Jon's method, the studs are bonded to the plywood before the plywood is bent into position. No fasteners are necessary to attach the studs to the plywood.

Layout the wall

You need a large, flat surface on which to build the wall (the subfloor). Draw a line where the bottom plate will sit on the floor full-size and in the proper location. Measure the length of the wall. (You could calculate the length of the wall, but it is usually more efficient and accurate to draw the wall and take measurements from the full scale drawing.)

Bond the plywood together

Once you have determined the length of the wall, lay enough plywood sheets on the subfloor, butted long edge to long edge, to make the wall. The thickness of the plywood is determined by the radius of the curve you are building. Thin plywood like 3mm for tightly curved walls, heavier plywood for more gently curved surfaces. Apply a butt block strip over each seam in the plywood. This is one area where you may need to use a staple or two. Wet epoxy is slippery and the butt block will slide around unless you tack it in place. Use the same plywood to make the butt block as used to make the wall. The block should be a minimum of a couple inches wide—enough surface area to keep the joint from breaking when you bend the plywood while making the curve in the wall.

Add the studs

Now you have this great big piece of plywood laying on the floor. It is 8' high and may be many sheets of plywood wide. The next step is to lay out the stud location on the plywood. Studs are typically set at 16" centers, so mark the centers of the studs at the top and bottom edges of the plywood. Arrange the stud layout marks so they miss the butt strips. Cut the studs three inches shorter than the wall height. (An 8' high wall will have studs that are 93" long.) This leaves space for a 1½" plate at the bottom and top of the wall. If the wall is not load bearing, use 1"×4" stock for the studs and if the wall has to support a load (or if the building inspector requires it) use 2"×4" stock for the studs. You do not need to worry too much about bent or bowed studs. As long as the plywood is on a flat surface, the epoxy will take care of any gaps between the stud and the plywood.

Use epoxy like you would use nails—a glob every foot or so to attach the stud to the plywood. Mark the full length of the studs so you can place epoxy where the stud is in the middle of the panel. Mix a batch of resin and hardener. Every foot or so, brush a thin coating of the epoxy mixture on the plywood and on the stud. Then thicken the epoxy with 403 Microfiber filler to a peanut butter consistency and put a good sized glob where you have pre-coated with the original mixture. Locating the stud on its layout marks, squish it into the globs of epoxy carefully. You may want to hold the stud in place, with duct tape, bricks or anything else you have available, until the epoxy cures. You do not need strong clamp pressure—that is the feature of epoxy that makes this whole idea work. As long as epoxy bridges between the face of the stud and the plywood the epoxy will bond them together.

While the epoxy globs are curing, you can saw out the bottom and top plates. These plates will define the shape of the wall, so lay them out carefully and saw them accurately. Make each of the plates from two layers of ¾"plywood. It is a good idea to stack the plywood four layers thick and cut all four pieces at once. Bond two pieces together to make each plate, and off-set any joints you have to make. Use 1¼" drywall screws to clamp the plates together until the epoxy cures.

Bond the panel to the plates

You now have a big, flat wall with studs bonded to it and a couple of curved plywood plates that define the shape of the wall. All that remains is to put the two parts together. Depending on how much room you have, you can assemble the wall in the horizontal position or stand up the big panel and assemble the wall in the vertical position. Either way, all you do is clamp the plywood panel to the curved plate. Mix some epoxy and bond ends of the studs to the bottom plate using the same method as you did to bond the studs to the plywood. Pre-coat small areas where the stud meets the plate, and apply a good sized glob of thickened epoxy so it is in contact with both the stud and the plate. You can be as neat or sloppy with this operation as you want. Just be sure you have a couple of large globs holding the two pieces together.

When all the epoxy has cured, move the wall to its final location (previously drawn on the floor) and fasten it in place with nails or screws. Apply drywall or whatever finish you want to the plywood surface and the open sides of the studs and you will have built a very fair, smooth curved wall.

Curved cabinet doors

Building curved cabinet doors is a variation on the theme described above, only on a lighter scale. There are no fancy molds or presses to build. Jon used the plywood shelves on the back of the door to define the shape of the door and glued the plywood to it—no fasteners are involved. ■

Above—Detail of the back of the wall showing 1"× 4" studs, two" plywood plates and a plywood butt block. Keep the butt block 1½" shorter than the plywood panel on each end, so it will clear the top and bottom plate.

Left—A semicircular shower enclosure ready for installation. Many of the curved walls for John's house were built off-site in his shop. When the house is at the proper stage of construction, the preassembled walls will be brought in and quickly installed.

In midwinter, we purchased a portable barbecue and would, by summer, need some kind of table to support it. The table was to be located in an old English garden setting. We wanted a compact, all-weather structure that could be permanently affixed just off the edge of a patio, blend into the surroundings, complement a nearby picnic table, conceal a 20 lb LP gas container, and outlast a long succession of barbecue grills.

Our table design was completed by early spring. Recently retired Gougeon technical advisor, Brian Knight, agreed to build it as an example of high-quality, all weather construction using treated lumber and WEST SYSTEM® epoxy. —Grant Urband

Building a Barbeque Grill Table

By Brian Knight

The wood selected for this project was pressure treated 4"×4", 2"×4", 5/4"×6", and ½" Medium Density Overlay (MDO) plywood. The solid wood was Copper Azol treated lumber—one of the lumber treatments approved as a replacement for CCA which was banned recently. MDO plywood has a phenolic paper applied to both surfaces of fir plywood. It is used for surfaces that will be painted, such as signs. The phenolic covering provides a nice, flat, stable surface for paint. Epoxy adheres very well to the phenolic covering without any surface preparation, so glue joints are easy.

I let the treated wood dry in my heated shop for a week or so before beginning work on the project. Treated wood is usually very wet when purchased, and I wanted to get the moisture content down to a manageable level. The problem with trying to glue-up wet wood is not so much the adhesion of the glue, but the shrinkage that occurs as the wood dries. The 4"×4" lumber was left over from another project and had been in my shop for a year of so. It was pretty dry, but it had split a little as it dried. I filled the splits with thickened epoxy and sanded each surface and rounded the edges before it was assembled to the box.

Epoxyworks 24
Fall 2006

Assembling the wood flat panels

The necessary 5/4" wood pieces that would make up the flat panels of the box were cut slightly oversize and trimmed to exact size after gluing them together. I examined growth rings at the ends of each board and organized them so when the panel was glued together, the growth rings alternated—one up and the next one down, etc. This helped to keep the panel flat.

A combination of plate joining biscuits and epoxy was used to assemble the panels. All the 5/4"×6" lumber panels were glued-up using biscuits, which were located about 4" apart. To glue the biscuits in place, I used a slightly thickened mixture of WEST SYSTEM epoxy and 406 Colloidal Silica Filler. The wood biscuits don't swell when using epoxy so the clamps have to remain in place longer

Figure 1—Alternating bar clamps and clamps at the end of the panel to keep it flat while the epoxy cures.

Figure 2—Assembling the LPG box.


1


2

Figure 3—The inside of the LPG box showing the epoxy/Colloidal Silica fillets that add additional surface area to reinforce the joints.

Figure 4—The almost-completed stand showing the MDO apron as well as the supporting 2×4's and 4×4's.

than with water-based glue. While this slows the construction process somewhat, the completed product will hold up to exterior use much better.

When clamping these panels, I alternated the bar clamps with one on top of the panel, the next below the panel and so on *(Figure 1)*. Also note the clamps at the end of each panel. These were used to clamp a straight scrap of wood to the bottom of each panel. This scrap held the panel flat while the epoxy cured. The scraps of wood had poly plastic stapled to them so they wouldn't stick to the bottom of the panel.

When all the flat panels were complete, I assemble them to make the box that would hold the LPG tank *(Figure 2)*. Fillets on the inside corners added extra surface area to each joint *(Figure 3)*. The fillet material was WEST SYSTEM 105/205 thickened with 406 Colloidal Silica to peanut butter consistency. This combination produces a high-strength fillet.

The plywood apron

The print showed an apron with sides sloped at 37° *(Figure 4)*. To make this assembly, the wood strips making up the apron had to have a compound miter. The blade tilt was set to 34° and the miter gauge was set to an angle of 31.5°. The corner joints were tacked together using a few brads and each inside corner was filleted. ■

Brian finished the table later this spring. After I added screened vent holes and applied three coats of paint, we placed the table on duty in our garden, confident of many years of service.

The table came out true to its design and was constructed better than one could have hoped. Thanks Brian!

Figure 5—The finished parts of the table after painting, before installation.

Figure 6—The table was secured in the earth with four 30"×4"×4" METPOST™ fence supports. The back-reaching legs, held down by the clamping collars of the fence supports, produced stability for the forward extended table top.

The "Lost Foam" Method of Composite Fabrication

"Lost foam" composite fabrication uses Styrofoam™ as a male mold, over which composite materials are applied. The Styrofoam is then dissolved out of the cured part with acetone or lacquer thinner, leaving a hollowed out shell. (Other types of foam may not dissolve, so use styrenated foam exclusively for this process.) It is used to produce custom (one-off) parts with a molded interior cavity. Since the mold is destroyed after the part is built, this version of the lost foam method is not a production process. With this method, any shape that can be carved or molded out of Styrofoam can be turned into a fiberglass/epoxy composite. For example, this method can be used to fabricate air scoops and intake plenums for combustion engines, masthead fittings, and various types of nozzles or plumbing applications.

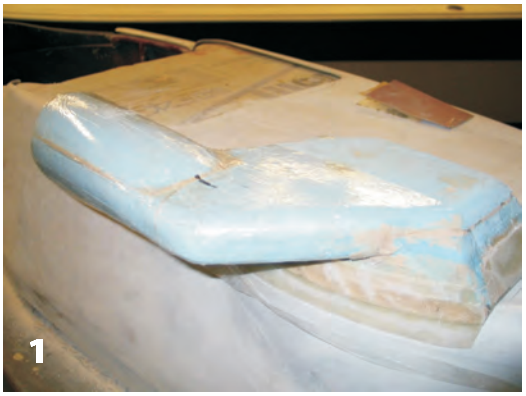
Brian Knight and J.R. Watson recently built small composite parts that required a specific hollow space. Both used the lost foam method to build the parts. These articles demonstrate two different approaches to a problem and how the method can be modified to suit individual needs.

1 Fabricating an Air Scoop

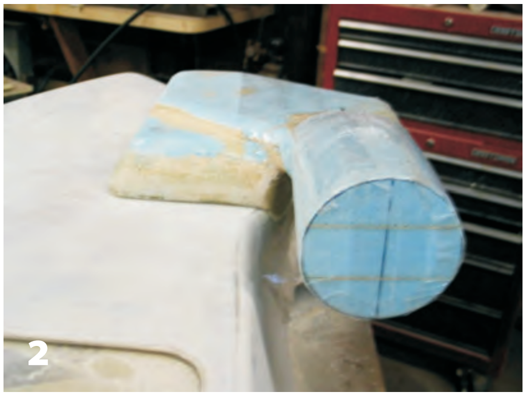
By Brian L. Knight

Epoxyworks 23
Spring 2006

I used lost foam construction to fabricate a fiberglass air scoop for my son's Formula Continental C race car. Our project started because a modification to the shape of the race car body necessitated the construction of a new air scoop. The air scoop is bolted to the car body so if either the air scoop or the body is damaged (a very likely scenario), the repair will be simpler. To fabricate the scoop, I made a Styrofoam male mold, surrounded the mold with fiberglass, and then dissolved the Styrofoam to leave a hollow part. I used Styrofoam to build the male mold for several reasons. It is readily available at most lumberyards, it is easy to shape with files and sandpaper, and it is easy to dissolve with lacquer thinner.



1—Viewed from behind, the finished Styrofoam mold carved to fit in place on the body where it will be installed.



2—The air scoop mold viewed from the front. The mold is in the process of being covered with clear packaging tape to prevent epoxy from bonding and to provide a smooth interior surface in the finished part.

Carve/shape a Styrofoam blank

The blank was built up of several layers of foam and then carved to shape. To build the blank, I used WEST SYSTEM® epoxy because it does not chemically attack the foam. However, the hard glue lines at each layer of foam can cause difficulties when shaping the part. Styrofoam has a density of about 2 pounds per cubic foot—very low. Unless the density of the glue line approximates the foam, the shaping process will remove foam much more quickly than the glue lines. This leaves unacceptable ridges at each joint in the foam. So to make shaping easier, I used epoxy thickened with 410 Microlight™ to glue the layers of Styrofoam together. Microlight has a very low density and does not make hard glue lines that other fillers might.

I used Surform™ tools, coarse files, and sandpaper to shape the mold. I made no attempt to get a good surface finish on the mold—I just concerned myself with the overall fairness. Since fiberglass will not conform to sharp corners, I used fillets of 410 Microlight on all inside corners.

I used clear packaging tape as a mold release *(Photos 1 and 2)*. One thing to pay attention to—epoxy does not adhere to the shiny side of the tape, but it will lock itself into wrinkles and gaps in the tape. So, do a neat job of applying the tape to avoid difficulty removing the tape from the cured part.

Apply the fabric

I applied a couple of layers of wet-out fiberglass cloth to the bottom of the foam and wrapped it up the sides a few inches. Then I allowed this to cure.

The next step involved sanding the cured edge of the fiberglass where the first application ended. There were lots of sharp "hairs" sticking up as well as several wrinkles in the glass. I carefully sanded this area smooth, taking care not to gouge into the Styrofoam immediately adjacent to the cured glass.

Then I applied several layers of fiberglass to the remainder of the part. These overlapped the previously applied cloth *(Photos 3 and 4)*.

When all the epoxy had cured, I sanded enough so that I could handle the part safely without getting cut on sharp edges and then cut a hole through the bottom fiberglass skin. This hole was sized to allow the carburetor and air cleaner to fit inside the air scoop. The hole also provided access to the inside of the scoop to make the job of removing the foam easier.

Dissolve the foam and clean up the inside

Lacquer thinner will effectively dissolve Styrofoam. Poured slowly over the foam, the lacquer thinner reduces the foam to a viscous blue liquid. When the lacquer thinner evaporates from the liquid, it leaves a small, hard plastic residue. For the air scoop, I used about a cup of lacquer thinner.

After dissolving the foam, reach in and remove the epoxy "ribs" that are left. The ribs are the epoxy layers (which are not attacked by the solvent) used to laminate the layers of foam. They need to be removed by hand.

The tape will generally remain with the part and will peel off after the foam is destroyed. This will also allow the removal of the fillets that are left after the foam is dissolved.

Finish the scoop

I wanted the air cleaner to fit precisely to the top of the car body. To accomplish this, I applied clear packaging tape to the body, applied a layer of 410 Microlight to the tape, and placed the air scoop in the putty. The 410 did not stick to the tape; it stuck to the bottom of the air scoop. This made a perfect fit between the two parts. Then I removed the tape from the body.

Because this part was built on a male mold, it required considerable fairing. I used epoxy thickened with 410 Microlight to make an easily sanded fairing compound. This was applied with a plastic spreader and allowed to cure. Lots of hand and block sanding later, the part was almost ready for paint *(Photos 5 and 6)*. To seal the sanded 410, I applied one last seal coat of neat epoxy.

The term **lost foam** is also used in metal casting. Similar to the lost wax method, the foam or wax is an exact pattern of the finished part within a sand or plaster mold, which is displaced by molten metal.

In lost foam composite fabrication, the foam is a core or male mold over which the finished part is built.

3—The fiberglass has cured over the Styrofoam mold before it is trimmed and sanded.

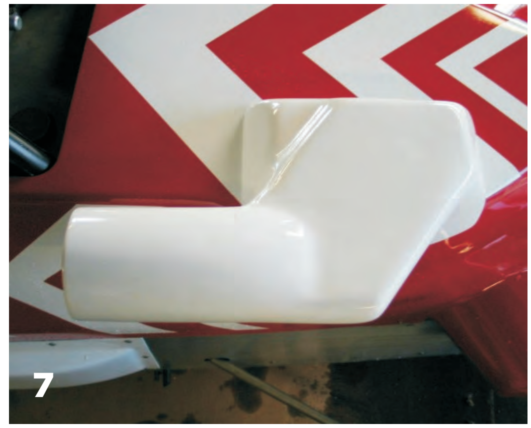
4—The cured part and mold from below before the foam was dissolved with lacquer thinner.

5—The cleaned up part after cleaning out the interior and fairing the exterior with epoxy/410 Microlight Filler.

410 fairing compound was also used to make a body-conforming base for the air scoop.

6—The finished air scoop viewed from the front. The lost foam method of composite fabrication was ideally suited for the scoop's aerodynamic shape.

7—Viewed from the top, the finished air scoop with two coats of white automotive paint and one clear coat.



After a final wet sanding of the seal coat, I sprayed several heavy applications of lacquer primer on the part. This was wet sanded and two coats of Omni™ automotive paint were applied. One more wet sanding followed by a coat of Omni Clear finished the job *(Photos 6 and 7)*. ■

2

Building a Masthead Fitting

By J.R.Watson

The masthead fitting had several design requirements:

- It must fit within an existing spar size and shape.
- It must have sufficient wall thickness to bear expected forces.
- It must house the sheave and provide adequate room to internally route the halyard.
- It must offer an attachment point for the topping lift.

Here's another use of the lost foam method to produce a custom part with a molded interior cavity. In this case, the part was a mast head fitting to hold an internal sheave and provide a route for the halyard to pass. This method can be adapted to a variety of other applications, as demonstrated in the previous article.

Making the foam mold

The first step was to make a full-size drawing of the fitting to use as a reference for manufacturing *(Photo 1)*. Using the drawing, I fashioned Styrofoam to represent the fitting's internal void. I bonded pieces of foam together to produce a billet of sufficient size, using the bond lines for a centerline to aid in measurements. (By using more layers of foam, you could use the additional glue lines each side of the centerline to produce contour lines for additional shaping guides.)

From the drawing, I made templates of the two side views. I taped them to the foam billet so I could rough-out the mold on a band saw *(Photo 2)*. Then I rounded over and smoothed the corners with sandpaper *(Photo 3)*. I bonded the sculpted foam blank to a temporary base to facilitate handling and applied paste wax to the mold to fill the porosity of the foam. This was done to produce a smoother surface and promote release of laminate later on.

Applying the fabric

Next, I applied a ⅛" thick layer of WEST SYSTEM® 105/205 epoxy (thickened to a grease-like consistency with 406 Colloidal Silica and 423 Graphite Power) over the entire part.

I wet out strips of woven graphite fiber reinforcement and pressed them into the thickened mixture until I achieved an estimated thickness of ¼". (Any more than this could have resulted in excessive exothermic temperatures.) While the laminate was still wet, I covered it with plastic (a freezer bag) and wrapped it with self amalgamated tape. This consolidated the laminate, extruding excess resin out the bottom. Reducing resin content to around 45% resin/55% fiber improves mechanical properties. Then I allowed it to cure.

I removed the cured part from the temporary base and dug out the foam with a carving chisel, hand-held rotary tool (Dremel™), file, and knife. As I approached the wax-covered exterior surface of the mold (now the interior surface of the masthead fitting), the foam fell off, revealing and replicating the sculpted surface.

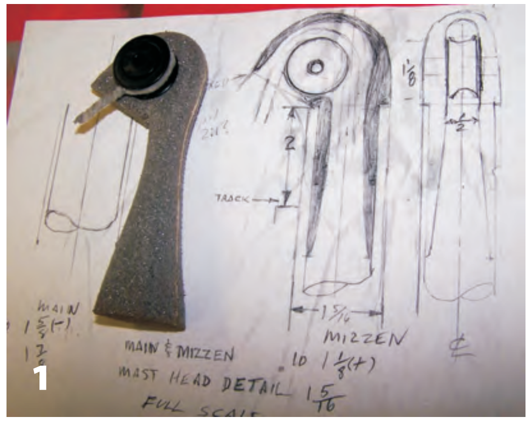
Then, I applied additional layers of fabric. I first applied another thickened epoxy/406/423 layer, which helped span minute surface irregularities. I used braided reinforcing material for these layers, taking care to overlap and align successive layers. Tape was produced by cutting braided sleeve material. With braid, fiber orientation can be adjusted simply by compressing or tensioning the material. I used templates made from the drawing to aid in establishing the finished shape/size. Round templates produced from paper towel core made for accurate sizing of round sections. After achieving the shape I wanted, I allowed the final layers of fabric to cure.

I located the sheave axle hole by measuring off the drawing with calipers. I first drilled undersize to check for accuracy with the real part and then drilled to axle size. You can make the topping lift of various materials; in this instance, I stitched nylon line together and wrapped it with thread for flexibility and light weight. I bonded the fiber part of the line to the crown of the fitting and covered it with fairing compound and a layer of braided tape *(Photo 4)*.

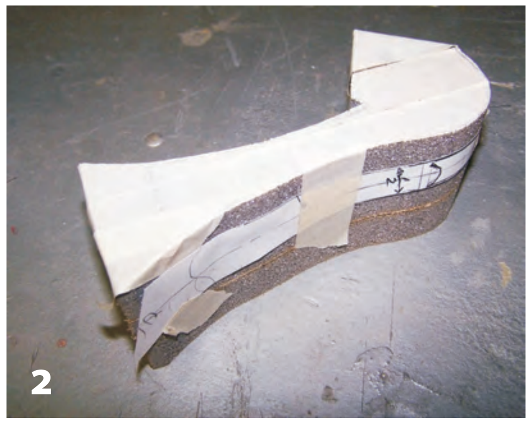
A tip for mounting the fitting to the mast

To prevent obstructing the passage with adhesive when the fitting is installed into the top of the mast, I inserted a common balloon covered with a thin layer of Vaseline™ down into the cavity. I inflated it after the fitting was inserted into the masthead, thereby pressing any invading excess adhesive against the spar and out of the way of the halyard. The balloon also exerted sufficient force to prevent any minute movement from the fitting's intended location until cure-up was achieved. The Vaseline made it easy to remove the deflated balloon after everything had cured.

Final blending and touch-up was done after cure-up, and a cover of carbon fiber braided sock was applied as further reinforcement. After a final coating and sanding, the fitting was primed and painted. ■



1—Make a full-size drawing of the part to make templates and use as a reference for manufacturing.



2—Make templates of the two side views and tape them to the foam billet. Use a band saw to cut out the rough shape of the mold.

3—Then round over and smooth the corners with sandpaper.

4—The nearly finished fitting with a duplicate of the foam mold. After the inside was cleaned out, additional fabric was applied to achieve the final exterior shape. The outside was faired and shaped before the topping lift and sheave were installed.

Jan C. Gougeon

August 7, 1945 - December 18, 2012

A visionary, ingenious, a great innovator who could see beyond boundaries, one of a few people to have really changed the boatbuilding game in his lifelong quest for speed. This is how boatbuilders and designers, sailors and iceboaters recall Jan Gougeon. A natural engineer, Jan became an accomplished boat designer and builder who was always thinking about his next boat. His vibrant boyish enthusiasm lit up the room. Jan was a fierce competitor who shared tips and technology openly, offering astute and encouraging advice to novice and veteran sailors and builders alike. His work with epoxy and lightweight composites expanded wooden boatbuilding to another generation. Jan believed the faster you make others, the faster you will be.

Accidents and setbacks never defeated him but offered new problems to solve. Jan spent most of his time trying out new designs, materials or construction approaches in the Gougeon Brothers Bay City boat shop. After a terrible iceboating accident in the early 70's, a friend asked Jan what he would do if he could never walk again. "I'd still come to the boat shop every day so I would build a platform with casters so...I could work." Jan was working in the shop until a few days before his death on Tuesday, December 18, 2012, at age 67.

Jan Gougeon in one of his favorite places, the boat shop, building the masthead dirigible for *Strings* in early 2012.

Born August 7, 1945, the youngest of four children, Jan spent his boyhood on Wenona Beach, and the Saginaw Bay of Lake Huron shaped his life. He loved to build and take things apart and was pretty good at anything mechanical. Born cross-eyed with visual impairments that weren't corrected until his early teens, Jan never did well in school, and he lost his father at age10. Through sailing, Jan found something he excelled at and mentors to learn from. At 14, he started an informal apprenticeship with master boatbuilder Victor Carpenter, which continued after graduation from high school. Then Jan was drafted into the U. S. Army and served in Vietnam, earning the rank of Sergeant E-5.

Returning to Bay City in 1969, Jan and his brothers Meade and Joel founded Gougeon Brothers, Inc. Excited by the emerging potential of wood/epoxy technology, they built iceboats, multihulls, and custom wooden boats. They pioneered bonding wood together with no fasteners and developed techniques for metal-to-wood bonds that solved major structural problems. They also found great success in formulating and marketing WEST SYSTEM® Epoxies for boat construction and repair.

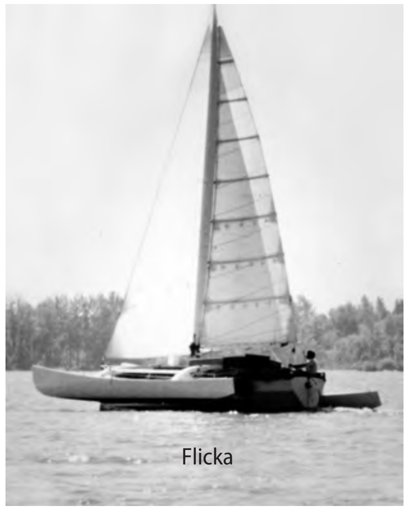
Racing multihulls and iceboats was Jan's passion. He particularly loved sailing solo. Jan's first sailboat race was in 1957 at age 11, and he competed in Chicago Yacht Club Race to Mackinaw aboard the newly launched Strings in July 2012. In 1980, during qualification trials for the OSTAR challenge, Jan's trimaran *Flicka* capsized in the Atlantic Ocean. After four long days floating in *Flicka's* disabled hull, Jan was rescued by a passing freighter. While upside down, he started designing his next boat, *Splinter*. It was self-rescuing, as was every boat he designed since. Jan placed first in the single-handed Port Huron to Mackinac race in 1981, 1982, and 1983 aboard *Splinter*. Racing his trimaran *Ollie*, he won the singlehanded Supermac in 1987 and the Great Lakes Singlehanded Society Peter Fisher Memorial Award in 1989. Jan also finished the 300-mile Florida Everglades Challenge in 2011.

Jan excelled as a DN iceboat racer. He won the DN Iceboat World Gold Cup Championships in 1975, 1982, 1985, and 1991. After dominating the DN Worlds on Barnegat Bay with a new hull design, Jan went home and made a detailed set of plans so anyone could build the boat. These are still the official plans of the DN class. Winning the DN Great Cup of Siberia Race in Russia in 1989 was Jan's "ultimate iceboat trip. Can you imagine. Here I am in Russia—in Russia—to race iceboats." Typically, he shared all he could with the local sailors about modern construction techniques and left his tools and spare parts for them to use. Jan also won eight DN North American Championships, initially in 1971 and 1972 and most recently in 2000.

As well as racing, Jan loved cruising, often in the North Channel. He was also a licensed pilot.

Jan's quest for speed guided his life. His legacy is the innovation, hard work, technical prowess, and enthusiasm he shared with so many.—*Kay Harley*


Wee Three


Flicka


Splinter


Ollie

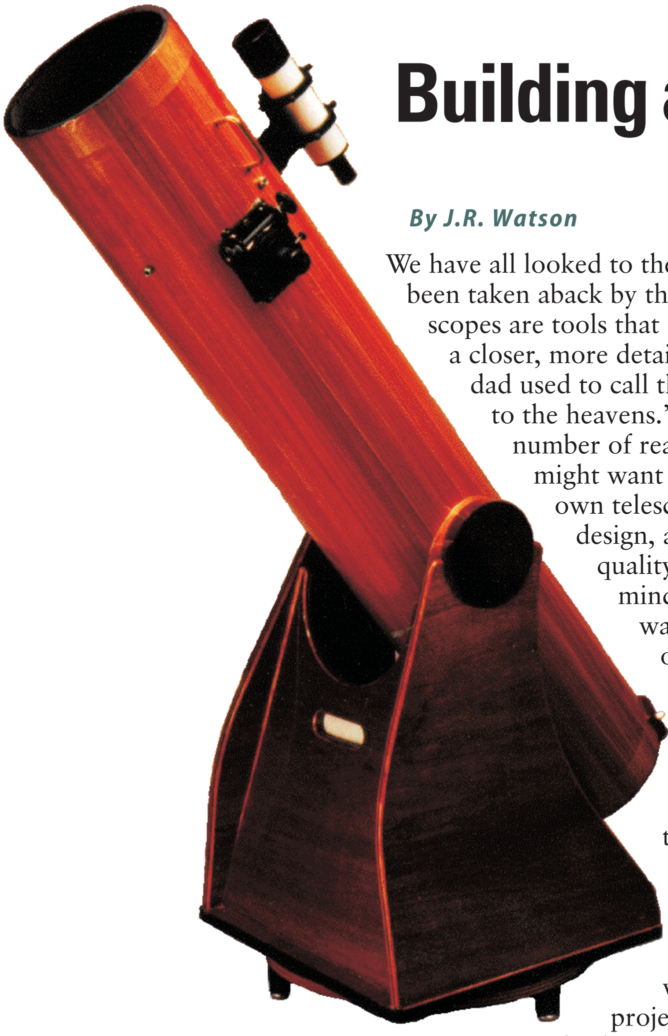
Over his lifetime, Jan Gougeon designed and built numerous multihulls including *Wee Three*, *Flicka*, *Splinter*, *Ollie* and the Gougeon 32s including *Pocket Rocket*. In 2012, he launched his groundbreaking 40' multihull, *Strings*, a boat that he had been working on for over 10 years. Jan was also a key builder on the multihulls *Adagio*, *Rogue Wave*, *Slingshot* and *Adrenalin*, as well as several monohulls including the 1975 Canada's Cup winner, *Golden Dazy*. ■


Pocket Rocket


Magic Carpet


Strings

Building a Ladder to the Heavens



By J.R. Watson

A portable, easy to build, cedar strip reflecting telescope.

Number 10
Winter 1998

We have all looked to the night sky and been taken aback by the view. Telescopes are tools that allow us to get a closer, more detailed view. My dad used to call them "a ladder to the heavens." There are a number of reasons why you might want to build your own telescope: Custom design, aesthetics and quality come to mind. There is always the element of satisfaction in creating your own. I chose to build this particular telescope to observe the heavens and reel in some astounding views. This project is not as difficult to construct as it sounds. The configuration and components are straight forward.

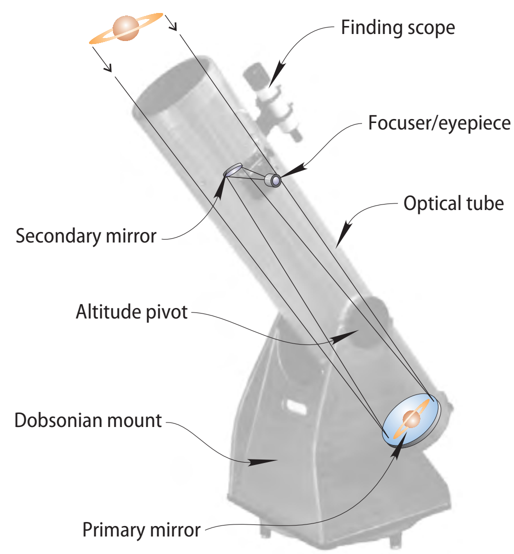
You won't save money building a telescope like this one. You could buy a fine telescope similar to the one I've built, for the cost of the building materials and components. If you built the components yourself, you might save money. However, you'd have to grind your own mirror—a project in its own right and beyond the scope of this article. Building this instrument may give you enjoyment, and the completed telescope will give you, your family and friends a life time of viewing pleasure.

My goals for this project

I wanted to build a high quality, portable and aesthetically pleasing telescope. I didn't want building it to consume too much time. I was willing to work at it part time for a few months, make some of the parts, buy others and assemble them all.

The main parts of a telescope are the optical components, for viewing, and the base, for holding the scope steady and allowing adjustments. I chose a Newtonian type of reflecting telescope, named for its inventor, English physicist Sir Isaac Newton.

The optical components; the primary mirror, secondary mirror and focusing mount are attached to the optical tube. Light enters the hollow, open-ended optical tube and is reflected off a large, curved primary mirror at the tube's base up to a smaller flat secondary mirror near the front end of the tube. It's reflected again out of the tube into the eyepiece in the focuser. The tube's interior is baffled to reduce stray light.



The tube rests in a simple and efficient base, designed by the U.S. telescope builder John Dobson. The Dobsonian mount permits precise movement toward the objects you wish to view. Its drawback is that it doesn't allow tracking for photography.

Because the scope is portable, the less it weighs, the better. I decided to make the optical tube out of cedar. The simple cylinder shape makes it perfect for strip-planked construction. And because it is encapsulated in epoxy, it is dimensionally stable and resists weathering, although I'd never leave it out in the rain. This kind of scope is relatively inexpensive and doesn't call for exotic manufacturing steps, so a home-builder can make one.

Laying it out

I laid out the telescope, full-size, on a piece of plywood (boatbuilders call this lofting). For the optical component, I wanted the biggest aperture practical for a portable scope, to gather more light and allow me to view fainter objects in the night sky. I decided on an 8" diameter, f6 primary mirror. This choice drove all of the telescope dimensions. I began with the primary mirror, and its 48" focal length. The focuser and secondary mirror I had chosen, determined the distance from the face of the primary mirror to the center of the secondary mirror. I added a few extra inches and made the optical tube 56" overall. The extra length helps reduce stray light and prevent dew on the secondary mirror. The added length does make the scope more cumbersome, but I feel it's worth the tradeoff.

At the location of the secondary mirror, I drew a cross section of the tube. A mirror this size requires an optical tube with a 10" inside diameter. I determined the number of wooden strips required to build the tube and the bevel angle for the strip edges. Adding the thickness of the strips to the inside diameter gave me the mold frame dimensions.

Building the optical tube mold

The mold in this project serves two functions. It is first used to build the optical tube halves, and later becomes part of the storage case. The optical tube is simply a hollow, open-ended cylinder. It would be built in two halves then glued together. I made three female mold stations of ¾"-thick plywood to support a half of the optical tube. The tube's wall thickness is ⅜" so the inside mold surface diameter is 10¾". I made the stations identical by screwing them together and making all the cuts at the same time. I made the mold frames 2" larger than the optical tube on the sides and bottom. Then I separated and glued the three stations to a piece of ¼"-thick plywood that would become the bottom of the storage case. I placed one in the middle (see illustration) and the others about 6" from each end of the optical tube. To keep the form flat, I temporarily screwed it to my flat workbench. I used this form for many alignment steps and as the foundation for the telescope's storage and transport cabinet.

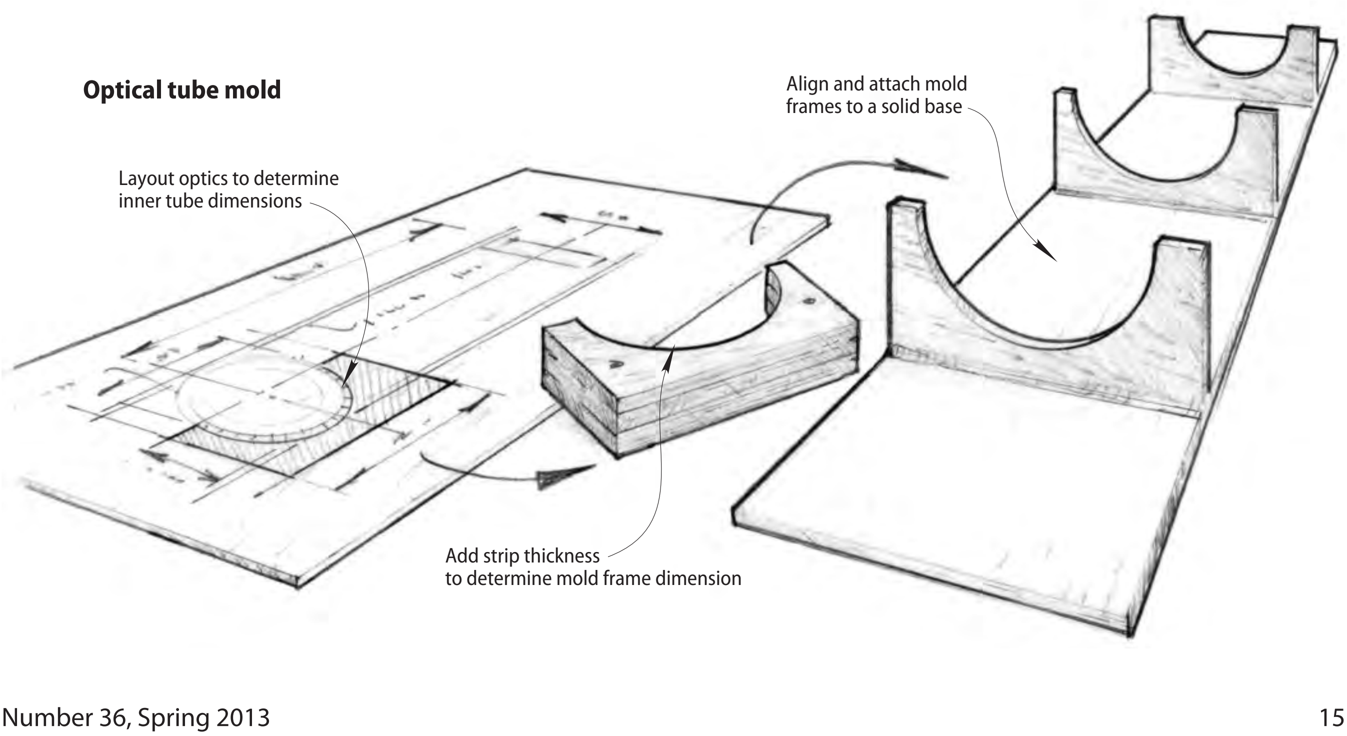
Making the optical tube

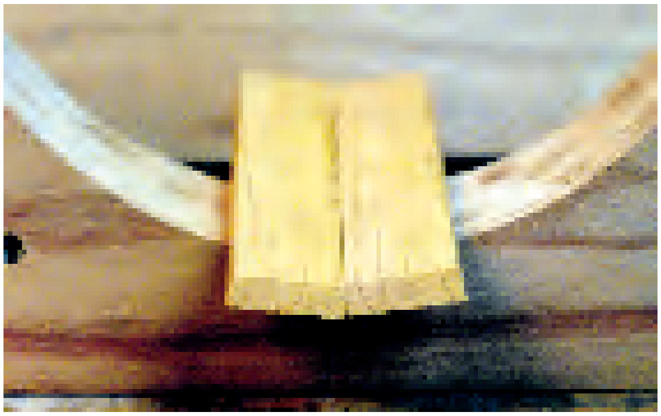
To build the optical tube, I needed a dimensionally stable wood that would plane, sand and bond well. I chose western red cedar. Redwood would have been another good choice. Mahogany would have looked very nice but added some weight.

I ripped the strips from a flat sawn 2"×10"×6' planks, so I ended up with quarter sawn strips ⅜" thick×1⅝" wide. The strips are 16" longer than the finished telescope tube. I cut enough strips to allow for 20% reject after examining for grain flaws, and bought extra stock for the altitude bearing pads (discussed later). I selected my strips for the tube, numbered them and flipped every other strip end for end to limit dimensional change and counter the grain runout.

I made the stations identical by screwing them together and making all the cuts at the same time. Then I separated and glued the three stations to a piece of ¼"-thick plywood that would become the bottom of the storage case.

Optical tube mold





Test strips in the mold, showing the bevel angle on each strip. The bevel angle was established by lofting and the strips were ripped the proper angle on a table saw.

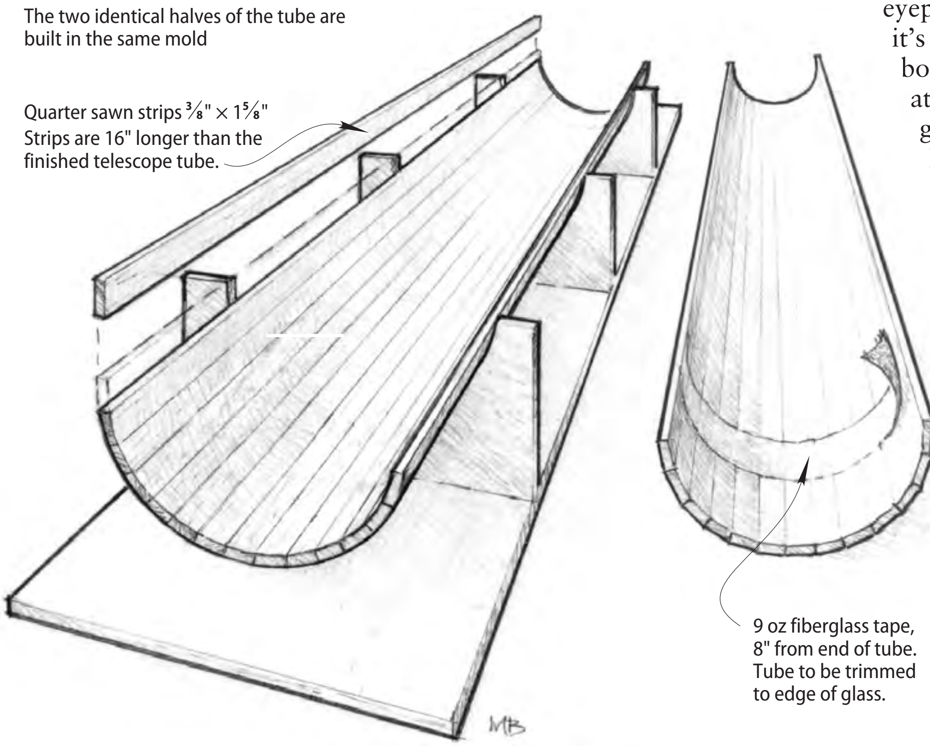
Wooden strips across the top of the mold frames, forced the end strips down and all the strips together against the frames, like an upside-down arch.

I beveled the strip edges to the angle I'd established by lofting (*left*). You can rip the strips at an angle on the table saw or shape them with a plane as I had done. An easy method is to attach a bevel guide block to the plane's base. Building one half at a time, I dry-laid all of the strips for the first half into the mold frames. I trimmed the two end strips flush with the top of the mold frames, then numbered and removed the strips.

To prevent the strips from adhering to the mold frames, I covered the frames with polyethylene plastic. One by one, I coated the edges of the strips and laid them in order into the female mold frames. I used epoxy mixed with 407 Low-Density Filler so that it would sand at a similar rate to the wood.

Optical tube lay-up

The two identical halves of the tube are built in the same mold



I stapled wooden strips across the top of the mold frames, forcing the end strips down. The pressure forced the strips together and against the frames, like an upside-down arch. I was able to clamp all of the strips at the same time without putting holes through the strips. I made sure all of the strips were aligned, scraped off the excess and allowed the epoxy to cure.

Before removing the tube half from the mold, I bonded 6"-wide, 9 oz glass tape 8" from the ends on the inside of the tube to prevent cracks. The next day, I removed the tube from the mold and repeated the process to make the other half of the optical tube.

Baffling

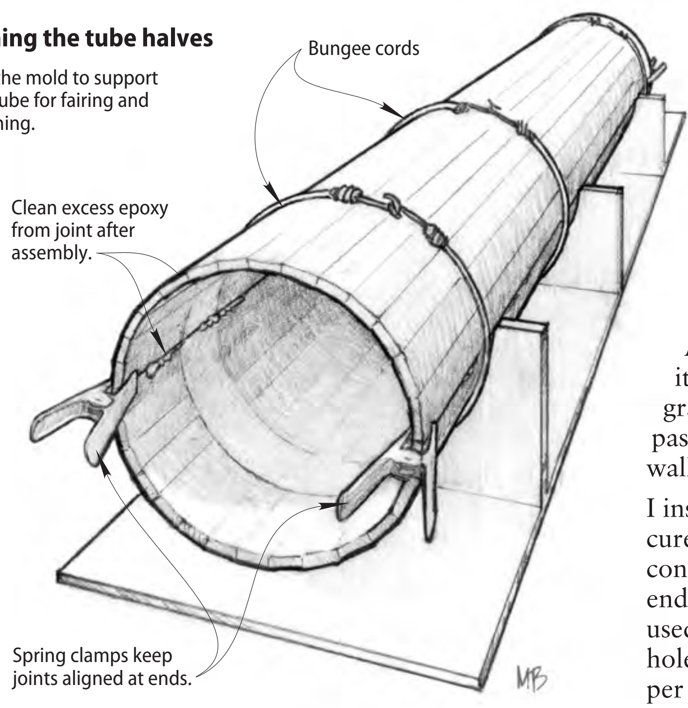
Baffling is the texturing of the inside surface of the optical tube to ensure that the only light that reaches the eyepiece is the direct light from the object it's focused on. To make the baffling, I bought fine sand (the kind used to create terrain on scale train sets). The grains are consistent in size and color. I coated inside the tube halves with epoxy, then sprinkled the sand onto it before it had gelled. After it cured, I spray painted the surface flat black. It was easy to accomplish this while the optical tube was still in halves.

The textured surface absorbs 90% more light than a smooth surface painted flat black. Its drawback is that it's difficult to keep clean, and dust is light colored. It's easy to wipe clean a smooth, flat black tube, whereas you must vacuum or periodically repaint a textured tube. This is time consuming, because you must remove the mirrors or mask them to protect them from paint.

Joining and finishing

Next, I carefully aligned and joined the two halves. I held them together with three bungee cords that exerted moderate pressure around the tube. Spring clamps at the ends kept the joints aligned. When the epoxy cured, I used flat black paint to touch up the slight adhesive squeeze-out on the inside.

Joining the tube halves



Using the mold to support the tube, I lightly planed the faceted exterior round, then I sanded it with a flexible sanding block that conformed to the round shape. (*Flexible sanding blocks are described in Epoxyworks 5*.) I began with 40-grit sandpaper, then used 60-grit. As the finish became smoother, I padded the mold stations with a soft cloth to prevent marring the wood. I then returned to sanding with 80-grit, then 120-grit, until the surface was smooth and fair.

I applied a layer of 6"-wide, 9 oz. glass tape around the tube, 8" from the ends, just as I did on the inside of the tube. When the epoxy cured, I cut off the ends of the tube at the edge of the fiberglass tape to the finished 56" length.

I applied three coats of WEST SYSTEM® 105 Resin® and 207 Special Clear Hardener™. To make it easier to apply the epoxy, I supported the tube with a piece of pipe through the tube and hung it from my shop ceiling. After each coat cured completely, I sanded it lightly with 220-grit sandpaper before applying the next coat. The final coat was left unsanded. Because the telescope will be used mostly for night viewing, and not exposed to UV, epoxy will be the final finish. When the final coat cured, I was ready to the install the optical components and altitude bearings.

Optical components

I selected an Aster Systems™ crayford low-profile focuser. The crayford mechanism is smooth and precise. Its low-profile allows me to use a smaller secondary mirror. Since light must pass the secondary mirror it before it reaches the primary mirror, a smaller secondary mirror obstructs less light and offers a brighter view of the night sky. With my 8", f6 primary mirror, I can use a secondary mirror 1.52" in diameter.

I marked the location of the secondary mirror and focuser using my full-sized layout. The crayford focuser is heavy, so I located it on the side in line with the altitude pivot to maintain balance as elevation is increased. I tend to favor my right eye, so I mounted the focuser on the left side of the optical tube to move me away from the base. The focuser mount came with a template that I used to layout the hole.

After I'd cut and shaped the focus mount hole, I wet its perimeter with epoxy to seal the exposed end grain. Next, I reamed the hole so the fasteners could pass through them without cutting threads in the hole walls.

I installed the mirrors in a specific order. To begin, I secured the holder for the secondary mirror. This holder consists of four thin vanes with bolts attached to the ends. The bolts pass through holes in the optical tube. I used my hole finder tool (*Epoxyworks 9*) to locate the holes for the bolts. I wrapped a wide piece of heavy paper around the optical tube to mark the holes so they were all square to each other and perpendicular to the centerline of the optical tube. I then mounted the secondary mirror.

For the primary mirror, I selected an aluminum mirror support made by University Optics, Inc. It allows air to circulate around the mirror, so it can quickly reach the ambient temperature. It is fully adjustable and lightweight.

To temporarily locate the primary mirror support, I backed the mounting bolts against the inside of the optical tube walls. This held the mirror in place until I'd completed the basic collimating or aligning of the mirrors. To make this alignment, I focused on a distant object with the tube stabilized in the mold stations. I used a diagnostic collimating eyepiece in the focuser to align the primary mirror with the secondary mirror. Once the primary mirror was in position, I used my handy hole finder to transfer the exact location of the support arms to the outside of the optical tube. Then I drilled the mounting bolt holes and mounted the mirror.

A telescope this size deserves a larger aperture finding scope, which rides piggy back on the primary telescope. I purchased an Orion 8×50 achromatic (two-element finder telescope). I located the scope's base on center on top of the optical tube. The finding scope slips into a dovetail on the base and is easily detachable for storage.

The altitude pivot spacers fashioned from cedar strips.

The finished altitude pivots with a mahogany bearing surface.

Altitude pivots

The altitude pivots are short, 6" diameter cylinders, glued to the tube at the fore and aft balance point. They protrude from the sides of the optical tube and rest in a yoke in the Dosonian mount.

I used scrap cedar strips from the optical tube to fabricate two altitude pivot spacers (*above left*). I scribed the pieces to the outside of the finished tube, sawed and laminated them together. After they cured, I cut them into 6"-diameter circles. Next, I cut 6"-diameter disks from 1"-thick mahogany and bonded them to the spacers to extend the pivots (*above right*). The mahogany portion of the pivot would rest on the mount's bearings.

With all of the optical components installed, I hung the optical tube by a rope to locate the balance point. The center of the pivots was located precisely at this balance point, in line with each other on opposite sides of the optical tube. I used the top edges of the mold stations as a reference to align the pins, then bonded them to the sides of the tube.

Dobsonian mount

The mount holds the telescope steady and allows for smooth vertical and lateral movements. The mount has two parts, the rocker box and the ground board. The optical tube's pivots rest on Teflon™ bearing pads in the yoke of the rocker box. The low-friction pads permit smooth, precise tilting, or rocking of the optical tube. The precise balance of the telescope lets you freeze the location, or adjust it with a slight nudge. This lets you easily follow an object as the Earth rotates. A pin on the bottom of the rocker box passes through an Oil-lite™ bushing in the center of the ground board. The weight of the rocker box and optical tube rests on low-friction bearing pads between it and the ground board.

The mount is constructed of ¾"-thick marine plywood glued and screwed together. Bonding will result in a more rigid and stable base. I attached a tray for eyepieces and filters to the supporting end piece on the rocker box. The bearing surface of the rocker box is covered with plastic laminate. I spaced three Teflon bearing pads on the top of the ground board 120° apart and located them directly over the three legs for maximum stability. The ground board is round, its diameter is the same as the width of the rocker box so you don't stumble over the ground board in the dark.

After using the scope a few times I discovered a couple improvements I'd like to make. As I observed objects more directly overhead, leverage for lateral adjustments of the scope is greatly reduced. I'll be adding a lever, like a boat's tiller, to the side of the rocker box to improve control and allow me to more easily steer through the heavens.

When switching to a focuser with a different weight, the balance point shifts slightly forward. To compensate for this, I'll apply an adhesive-backed magnetic strip to the back end of the optical tube. Then I will be able to add or subtract steel washers to precisely balance the telescope regardless of which accessory is attached.

Transport/storage case

I fabricated the telescope's storage and transport cabinet around the mold I'd used to build the optical tube. The sides attach to sides of the three mold frames and the edge of the ¼" plywood bottom. I set wooden fillets on the inside corners between the stations. I built a 6" tall lid and attached it with brass hinges. I glued felt padding to the three mold surfaces (now bunks) to protect the optical tube. Inside, I fashioned separate compartments for eyepieces, finder scope, sky charts and accessories, then varnished the interior.

Conclusion

I'm not an astronomer, but this instrument makes me feel like one. I look into the sky and see more than what I thought were just stars. What I thought were stars are whole galaxies, greater than the Milky Way. What I thought was one star is actually two, revolving around each other. What was a white smudge in the dark sky is a collection of millions of stars. They fill the view through my telescope. An asteroid streaks through the view before my eyes; the sky is as alive with action as the sea.

You could buy a fine f6, 8" Dobsonian telescope, ready to use, for about $500 (1998 price). For the dollar, it's worth it. I spent many extra dollars on some premium items that drive the price up, but improve the view. I could have made it for less money, but I didn't take on this custom project to save money. I completed the project in approximately 150 hours. It was a pleasure to build and more fun to use. I plan to have it around for more than a lifetime.

Sources

Optics

University Optics, P.O. Box 1205, Ann Arbor, MI 48106, 734-665-3575—mirrors, cells, eyepieces

Orion Telescope and Binocular, P.O. Box 1815, Santa Cruz, CA 95061, 800-447-1001—mirrors, cells, eyepieces

Roger Tuthill Inc., 1255 Toms River Rd, Jackson, NJ 08527, 732-657-5314—filters, eyepieces

Starry Messenger, P.O. Box 4823-P, Ithaca, NY 14852, 201-992-6865—used equipment

Books

Build Your Own Telescope, Richard Berry, Willmann-Bell, Inc., P.O. Box 35025, Richmond, VA 23235, www.willbell.com.

Material list

- ☐ Western red cedar and plywood
- ☐ WEST SYSTEM epoxy, 1½ Group A with 206 Slow and 207 Special Coating Hardener
- ☐ Miscellaneous items (Teflon, plastic laminate, screws)
- ☐ Secondary mirror
- ☐ Secondary mirror support
- ☐ Primary mirror
- ☐ Primary mirror support
- ☐ Focuser
- ☐ Eyepieces
- ☐ Finder scope
- ☐ Finder scope bracket
- ☐ Collimator ■

How to Make a Solar Filter

The sun is magnificent to view through a telescope—*but only with a filter*. Building a solar filter for a telescope is pretty straight forward.

To build one for my telescope, I sawed two 1"-wide rings from ¼"-thick plywood. The inside diameter of the rings matches the outside diameter of my telescope's optical tube (10¾"). I bonded the two larger rings together with an identically-sized ring of foam between them. The laminated ring slides over the tube.

I cut a third plywood ring with an inside diameter that matched the inside diameter of the optical tube (10"). I laid a piece of solar filter material over the foam/plywood laminated ring. I placed the smaller plywood ring over the filter material, and bolted the rings together with the filter between them. I glued felt to the inside of the rings. For viewing, I slip the filter over the open end of the optical tube. The friction of the felt holds the filter in place.

I purchased an aluminum-coated Mylar solar filter material called SOLAR SKREEN® from Roger Tuthill Inc., 1255 Toms River Rd, Jackson, NJ 08527, 732-657-5314.—*J.R. Watson*

WARNING! Never view the sun through a telescope without a filter. It can instantly result in permanent blindness.

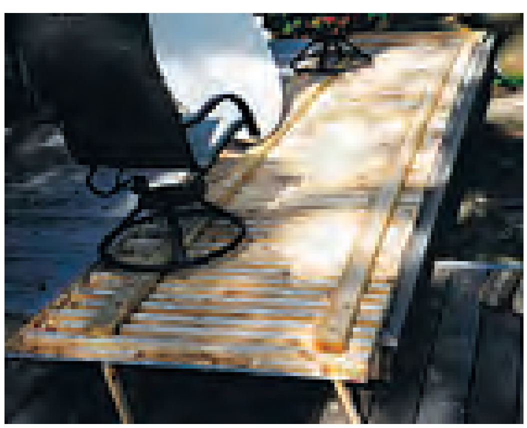
Fence & Gate Construction

By Brian Knight

The finished fence, of rot resistant cedar, is built by gluing pieces together instead of nailing.

I built a jig to assemble the fence sections so I could be sure the spindles were consistently spaced and quickly aligned.

Number 14
Fall 1999



I set the 2×4's in place and weighted them down until the epoxy cured. No screws were necessary to anchor the 2x4's to the spindles

Rot is one of the major disadvantages of a wooden fence. Wherever there is a fastener—nail, staple or screw—there is a potential site for rot to begin. Water gets around each fastener and soaks into the wood. When the temperature and the moisture content are right, rot invades these areas. To make a fence that would not rot quickly, I used a rot resistant wood and eliminated fasteners, gluing pieces together instead of nailing. Not only was the process fast—I could assemble 42' of fence a day—but warps and twists in the fence material were easily dealt with.

Our local lumberyard stocks construction grade cedar 2×4 and 2×6. I bought a stack of each and began by machining the spindles—240 of them—at my shop. I ripped them so they had a cross section of 1½" square. Next I cut them to length, cut a chamfer on one end, and sawed a shallow dado as an accent feature.

Starting with a jig

To build the fence, I needed a method of quickly aligning the spindles so they were parallel, had consistent spacing, and had good alignment along the top. To accomplish this, I built a jig to assemble the fence sections. The jig consisted of two sheets of Oriented Strand Board (OSB) with a series of spacers screwed to each sheet. I made the spacers with scrap stock left over from making the spindles and spaced them 1½" apart—the same dimension as the spindles. The two sheets of OSB were placed end to end so I could build 16' sections of fence.

Once I had all the spacers installed, it was easy to lay the spindles between the spacers and at the same time align the bottom edge of each spindle flush with the edge of the OSB. This automatically aligned the height of each spindle. The good side of the spindles was placed face down on the jig.

Using the 2×4's for stringers, I laid them across the spindles and marked their location on each spindle. I moved the 2×4's out of the way, mixed some WEST SYSTEM® 105/206 with 403 Microfiber to a mayonnaise consistency, and put a glob of the thickened epoxy where the 2×4's crossed each spindle. When I had the globs of epoxy in place, I set the 2×4's in place and weighted them down until the epoxy cured. No screws were necessary to anchor the 2×4's to the spindles.

I used the "cake decorator" technique to apply the thickened epoxy to the spindles. I mixed the resin, hardener and filler to the appropriate consistency and dumped it into a Ziploc™ plastic bag. I sealed the top of the bag, snipped a corner off the bottom and squeezed the material onto the spindles. The amount deposited is controlled by the size of the cut corner.

When the epoxy had set, I lifted the fence section from the jig and carried it over to the 4×4 posts that were already in place. I mortised the posts to accept the 2×4 stringers and glued the posts and 16' section together. Then back to the fixture to build another section. Because the temperature was very warm and the epoxy cured quickly, I was able to build several sections a day.

Epoxy for gate construction

Epoxy can also be used to avoid stresses often associated with gate construction. If nailed, screwed or bolted together, the gate pictured would only last a year or two. The stress on the fasteners would begin to crush the adjacent wood fiber and elongate the hole. Eventually, the fasteners would begin to wobble in their holes and make the problem even worse. To avoid the problem, this gate was glued together. The large surface area in each joint distributes the loads and alleviates the point loads that are the downfall of metal fasteners in relatively soft wood.

The boards that form the starburst pattern provide the strength to keep the gate from sagging. The long boards in the starburst are being pulled lengthwise, wood's strongest direction. The shorter boards are being compressed, but, because they are short, they are not as easily bent as longer boards would be. The large gusset in the upper hinge corner of the gate distributes all the stresses over a large area.

Once it was properly engineered, building the gate was easy. It is a sandwich consisting of two rectangular layers, one on each side of the starburst pattern. One layer of the outer rectangle was cut and laid out on the floor. The starburst truss parts were laid on top of the rectangle and bonded to it. WEST SYSTEM Epoxy was applied to both surfaces using the two step bonding procedure and the process repeated to bond the top rectangle. A little light clamping pressure was applied to the joints until the epoxy cured.

To complete the assembly, hinges and a latch mechanism were installed. Because the weight and leverage of the entire gate were concentrated at the hinge fasteners, these were good candidates for hardware bonding. As we pointed out in the last *Epoxyworks (Number 13)*, wetting the fastener pilot hole with epoxy doubles the pull-out strength of the wood. Drilling an oversize hole and casting epoxy around the fastener will, at a minimum, triple the pull-out strength.

Side loaded fasteners also benefit from being installed in an oversize, epoxy-filled hole. Epoxy around the hinge bolts better distributes the loads placed on them into the wood, and, as a bonus, the epoxy annulus keeps water out of the fastener holes. ■

Epoxy distributes stresses over a larger area than standard fasteners, making a gate design like this possible.

Follow up—After five years of Michigan summers and winters, Brian attested in an article in Epoxyworks 21, that there was no rot in the fence nor had any of the spindles fallen off. There was no finish on the wood so it weathered to a dirty silver color. One additional trick he used was to apply a stripe of epoxy around the fence posts about a foot wide at ground level. This is where fence posts rot and break because this is the point where the post is continuously in contact with moist soil and also has oxygen available. Above this stripe, the wood is able to dry out and does not rot. Below this stripe, the wood stays wet, but there is not enough oxygen to support the growth of the rot fungus so the wood cannot rot there either. The epoxy reduced the oxygen and moisture at the spot where is was most likely to rot. And five years later, no rot was evident.—*Ed.*

Building a Pair of Chesapeake 16 Sea Kayaks

By Chris Jacobson

Paddling the south shore of Ontario's Lake of Two Rivers and into Pog Lake.

It all began when we went camping in Algonquin Park in 2005. We rented a couple of plastic kayaks and the kids loved it. We came home with the intention of buying a couple of kayaks but while on the internet we saw these stitch and glue mak'em yourself boats. I purchased the books "The New Kayak Shop" and "Kayaks You Can Build." Both are available at Chapters or Amazon.com. We decided this was something we could do. We also discovered www.clcboats.com which would prove to be a tremendous source of encouragement during the project. We made a day trip to Toronto to purchase plans for a Chesapeake Light Craft 16 and some marine-grade plywood. The books have some great suggestions for worktables. We made a 17' one from some ¾" plywood and some stands from scrap 2×4's from a recent renovation.

Number 27
Fall 2008

What follows is the the step-by-step story of the construction of these kayaks—from basement worktable in September 2005 through launching in July 2006.

1

1 Scarfing the hull panels

After ripping two 4'×8' sheets of 4 mm marine plywood into eight 11" blanks on the table saw, I scarfed the strips together to make full length panels. I used clear packing tape on both sides of the scarf joints to prevent the epoxy from oozing out onto the panels.

2 Gluing the shear clamp

You can't have too many clamps for this job. We did one side at a time.

3 Stitching the hull

We made up some forms to hold the kayak at a comfortable height. The panels stitched together like a charm. We used 20-gauge copper wire from Home Depot. You can find it in 50-meter rolls in the picture hanging department. The kids cut it into 3" pieces. We spaced our stitches every 4".

2

3

4

5

4 Checking for twist

We made up some stands and clamped the kayak to the worktable. We then checked for any twists in the hull.

5 Taping the seams

We applied masking tape to keep the epoxy glue neat at the seams. We made various rounded plastic tools to apply the epoxy fillets. It's not a bad job once you get the hang of it. Kind of like applying drywall compound only more expensive and permanent. One tip though—after making your fillets, wait a couple of hours before applying the 3" tape and wetting it out with clear epoxy—makes for an easier, less frustrating job.

6

6 Laying the cloth

The outside of the hull gets a layer of 6 oz fiberglass fabric.

7

7 First coat of epoxy

We brushed on then squeegeed the first coat of epoxy. We used WEST SYSTEM 207 Special Clear Hardener™ for a nice bright finish. Mom is tipping out any runs with a dry brush. We'll add three or four more coats over the next few days. One of the books suggested using cardboard orange juice cans for the grunge while squeegeeing—great idea.

8

8 Foot brace details

We made these fully adjustable foot braces from ¼" oak with an epoxy coating. They are easily adjusted by the paddler while sitting in the cockpit. The hardware is all stainless steel and they are fully detachable with no through-hull fasteners. The front bolt keeps the brace on track and the back wing bolt tightens down after adjustment is made. The deck beam was clamped in place and fillets applied—again, no through-hull fasteners for this either. The foot braces have proven to be extremely rugged.

Hey! I thought I was going to be on the cover.

Annie's getting a little impatient with this epoxy business. It's been a few days since she's been on her walk. The kayak has its fifth and final coat of epoxy.

9 Fiberglassing the deck

We covered the decks with 4 oz fiberglass and clear epoxy. Mom mixed the epoxy and I applied it. It's a good team job.

10 Got clamps?

You can see we used lots of clamps for this job. Once the ooze was cleaned up, I removed the masking tape from the spacer stack. It received a coat of clear epoxy when we glassed over the coaming rim with 4 oz cloth. It might sound strange, but I found shaping the coaming enjoyable. It did not take long with a spoke shave and sandpaper and the result, with epoxy and varnish, was like a piece of fine furniture.

11 Hatch openings

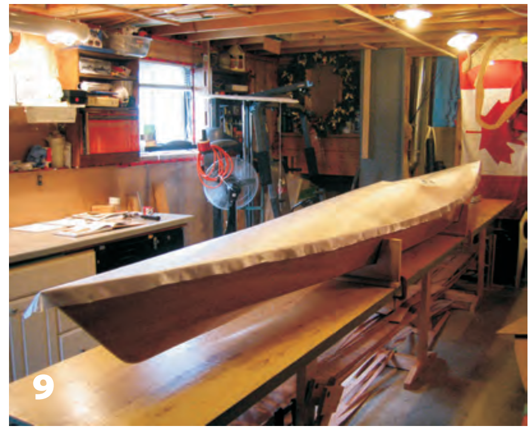
I applied some wide masking tape to the deck and strung a center line. I then traced the hatch openings from the templates we made earlier. I carefully cut the openings out with a sabre saw. You can see our digital scale on the floor. I periodically weighed the kayaks to monitor the weight progression. In the end they came in at 42 lb each.

12 Making hatch covers

The hatch covers were cut from 4mm marine plywood. The frames were router cut from poplar. Not a great wood, but it will be encapsulated with epoxy.

After sanding the kayaks, we applied five coats of Z-Spar Captain's varnish with an epoxy roller and tipped out the bubbles with a foam brush for a coffee-table finish.

We started this project in September 2005 and pushed the kayaks out of the basement and carried them to a reservoir down the street for sea trails on July 22, 2006. ■



Taking a break on Canisbay Lake in Algonquin Park, August 2006. We paddled the entire shoreline of the lake before moving on to Smoke Lake the next day. The kids leisurely paddled the kayaks. My wife and I busted our asses trying to keep up in a rented 15' fiberglass canoe.

For information about WEST SYSTEM® products or technical information for a building or repair project, Gougeon Brothers offers a range of detailed publications that can help you get started. These publications are available at your local WEST SYSTEM dealer or by contacting Gougeon Brothers. They are also available free at www.westsystem.com.

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000-425 ***Other Uses–Suggestions for Household Repair***—Repairs and restoration in an architectural environment. Many useful tips for solving problems around your house and shop with epoxy.

Also included are the current price list and stocking dealer directory.

How-to publications

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*Available as a free downloadable PDF at www.westsystem.com/ss/use-guides.

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North and South America

GOUGEON BROTHERS, INC.
P.O. Box 908
Bay City, MI 48707

www.westsystem.com

Phone 866-937-8797 or 989-684-7286
Fax 989-684-1374

Technical Services/Health & Safety

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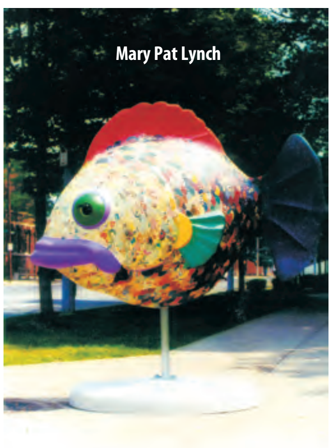
John White

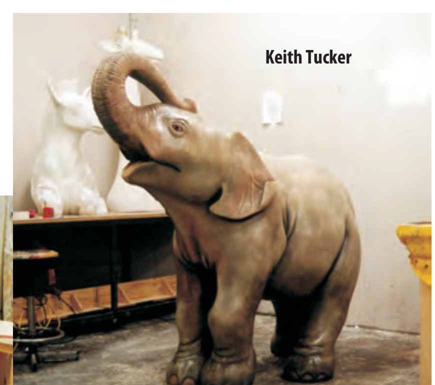

Dave Drimmer


Mary Pat Lynch

WEST SYSTEM® Epoxy users represent a great variety of interests. Over the years we have used the back cover to highlight some of the more creative and interesting uses for epoxy. Here are a few past projects that demonstrate the diversity and ingenuity of our readers.


Claudia Toutain-Dorbc


Bill Boudreau


Keith Tucker


Curt LaCross

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