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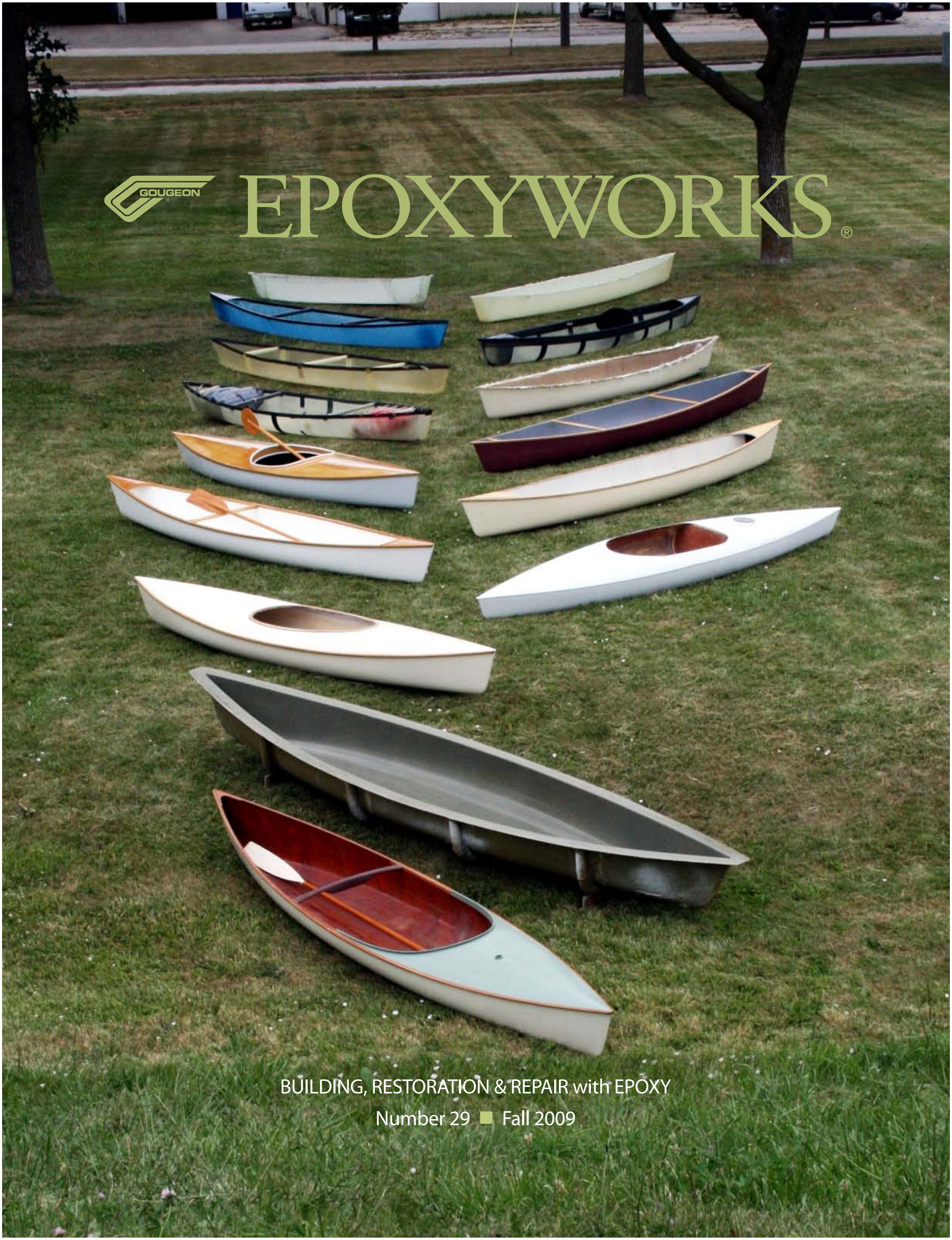

BUILDING, RESTORATION & REPAIR with EPOXY

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In this issue

EPOXYWORKS®

Editor / Designer Michael Barker

Managing Editor / Copy Editor Grace Ombry

Contact / Subscriptions Kristen Lore

Contributors Ken Filipiak, Greg Hatten, John R. Marples, Bruce Niederer, Grace Ombry, Ray Ordorica, Tom Pawlak, J. R. Watson and Julie VanMullekom.

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

Epoxyworks online epoxyworks.com

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The Gougeon 12.3 Canoe

By Tom Pawlak

The Gougeon 12.3 canoe represents several decades of experimentation by employees of Gougeon Brothers. Dozens have been built but no two are exactly alike. The evolution of the Gougeon 12.3 parallels our love of boating, passion for innovation and desire to build better boats—all of which contribute to the products we produce today.

It started 35 years ago with a personal project of Jim Gardiner, who was an employee of Gougeon Brothers at the time. He wanted to build the lightest solo canoe possible using wood and WEST SYSTEM® Epoxy. He based its lines on the popular Wee Lassie canoe designed by J. Henry Rushton back in the late1800s.

Jim planked his lapstrake canoe with ⅛" thick western red cedar veneer. The planks were lap-glued together and sealed with WEST SYSTEM Epoxy. He made the ribs with unidirectional carbon fiber tows. This 12' canoe weighed just 10 lb and drew lots of attention at the Small Craft Workshop in Mystic Seaport in the mid 1970s. It turned out to be a bit fragile for everyday use, but inspired another employee, Robert Monroe, to design a more robust version.

Robert wanted his canoe stronger. To accomplish this he chose to cold mold his hull using vacuum bagging. He incorporated three layers of diagonally laid 1/16"-thick western red cedar veneer. Robert modified the original Wee Lassie design by increasing the volume at the ends of the canoe. This was around the time Gougeon Brothers experimented to improve overall performance of sailboats by increasing the prismatic coefficient or curve of areas at the bow (both hot topics in the Gougeon break room during that time). Robert incorporated this feature into his canoe.

To vacuum bag a cold molded hull, he would need a mold to form the veneer against. He built his male mold out of strip planked pine and WEST SYSTEM Epoxy and sealed it with coats of epoxy so it would maintain vacuum without leaking. His hull was designed to be symmetrical; both ends of the canoe had the same shape. This allowed him to build the hull in halves off of the same half mold.

He built his mold a bit long and a bit wide to allow room for stapling veneers in place around the perimeter before covering the laminate with the vacuum bag. That way, after the hull half was removed from the mold he could trim away the stapled wood perimeter. He fit and glued together the molded halves to form the hull. Robert's finished canoe with a deck weighed about 25 lb.

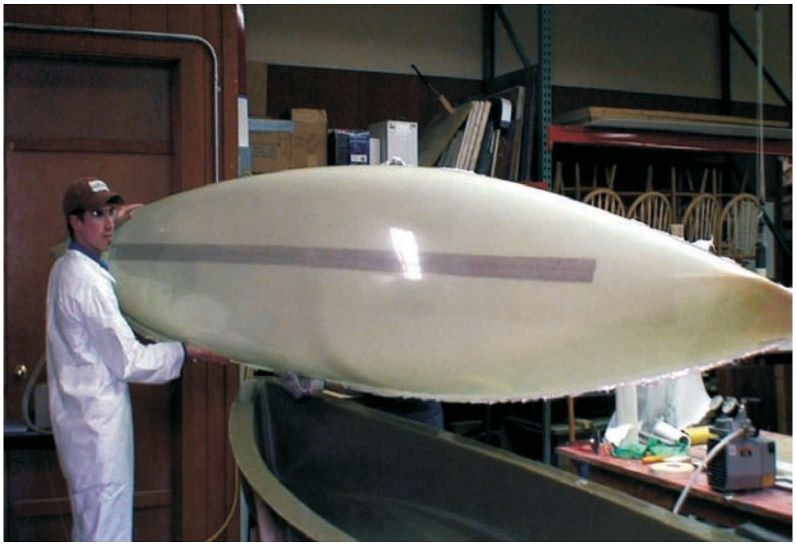
About 24 years ago I wanted to build a small canoe for my children, who were 8 and 10 years old. Robert offered me the use of his symmetrical half mold. He said I needed to laminate two halves off of it and glue them together to create a hull or if I wanted to make more hulls in the future, I should use the half mold as a plug to make two female molds. That way I could glue them together and create a one-piece female mold. With a full mold, hulls would be easier to build and result in a smooth exterior, eliminating the need to make two halves and the work of glassing the seams and fairing. I was familiar with building molds so I took his suggestion.

Because Robert's mold was made for vacuum bagging diagonal laid veneer, it was ¾" wider than the finished hull half along the centerline. I decided the extra ¾" per side would provide a wider and more stable boat for my kids. This produced a boat that was 1½"

Cover story

A small sampling of the Gougeon 12.3 canoe family. Robert Monroe's cold-molded canoe (foreground) came from a half-mold that eventually resulted in the mold (behind it) which, over the last 20 years, was used to produce nearly three dozen offspring that reflect a wide range of tastes and technologies.

The venerable canoe mold. The mold surface is epoxy/404 High-Density Filler/420 Aluminum Powder. It is backed by progressively heavier layers of glass, totaling ¼" thick.



Chad Sinicki removes his third hull from the mold. The hull, three layers of 737 Biaxial Fabric was the first one he vacuum bagged.

wider than Robert's original hull and about 4" longer. The result was extra buoyancy for paddling down Michigan's shallow rivers.

I built two canoes from this mold. The first was a fiberglass/Douglas fir veneer hybrid I vacuum bagged. I decked the ends and left the center open. About 15" from each end I added watertight bulkheads made of epoxy coated 4mm plywood. This provided enough buoyancy to keep the gunnels flush with the water even when the boat has a person aboard and was swamped.

The second boat employed the same fiberglass/Douglas fir veneer lay-up. I shortened the sides of the hull near the ends to produce a sheer that would be parallel to the waterline. This flat sheer line, decked over, gave the boat more of a kayak appearance. The deck ran the full length of the boat, making it much drier in rough water. The lower sheer near the ends allows it to handle wind better than the first canoe I built out of this mold. The decks were made in the hull mold by utilizing the bottom of the mold near the ends.

Alan Gurski installing layers of glass and carbon fiber tape into the mold for his resin infused version. He used two layers of 737 Biaxial Fabric, a thin foam core sandwiched between layers of 703 Unidirectional Carbon Tape followed by one more layer of 737.

Little mold becomes R&D tool

In the years that followed, we used the little mold to prove concepts for producing the Gougeon 32 (G32), the first production-built epoxy boat that had a polyester gelcoat applied in-mold. Long before the first G32 we used this mold to make experimental canoes. These incorporated polyester gelcoat and conversion coatings laminated over with epoxy, biaxial fiberglass fabric, end grain balsa and foam cores. All of these canoes were built using vacuum bagging techniques.

Before building the molds to produce the G32s, we experimented with different tooling gelcoats, fiberglass lay-ups and cores. Then we produced a master plug off of the little canoe mold. We used experimental resins and hardeners with different pigments and different thickeners in several locations along the length of the mold so we could see how well each of them buffed back after sanding. We also experimented with different epoxy formulations to see which provided the most stable surface with the least amount of print through when applying fiberglass.

Once the master plug was released from the canoe mold, sanded and polished to perfection, we made a high-quality production mold off of it with the resin/hardener and fiberglass combinations that produced the best results in the master plug. This new mold came off the master plug looking flawless. Based on what we learned with making the canoe tooling, we were confident we had the answers needed to produce the G32 tooling.

New mold plays ongoing R&D role

The new canoe mold came in very handy before and during the production of the G32. We used it to learn how to make molded parts without print through (that annoying fabric pattern you sometimes see in glossy gelcoats on fiberglass boats). Exposing the laminate to higher temperatures for several hours—after the epoxy had cured to a hard gel, and with the part still in the mold and under vacuum—eliminated print through. We used it to experiment with different cores. We learned that when vacuum bagging, care must be taken to not get too much resin in the fiberglass applied to the gelcoat, and that perforating, slicing or scoring a grid in the core eliminates air bubbles between the gelcoat, fiberglass and core.

The side benefit of these experiments was all the canoes that became available inexpensively to our employees.

Robert later used the mold to build a biodegradable canoe out of epoxy, balsa and hemp fabric. He learned that the hemp fabric was difficult to saturate with epoxy, but it did produce a light, efficient canoe. If you were to leave this canoe in the sun and weather without any paint or exterior varnish protection, UV light degradation would allow it disappear into the environment over a decade or two. Stored out of the sun and used several times a year the boat will remain intact for a lifetime.

More recently we've used the canoe mold to experiment with infusion resins. Five of our employees made beautiful fiberglass hulls reinforced with unidirectional carbon fiber ribs and keels. The boats are a bit eerie to paddle in because it's like paddling in a glass bottom boat except the whole bottom and sides are transparent.

Over the past 24 years employees have produced dozens of canoes from the molds. Some are made of sophisticated fabrics and foam cores, others are fiberglass and balsa cored that were vacuum bagged to produce strong and light craft. Others were made with a couple layers of biaxial fiberglass by hand lay-up with out vacuum bagging. Some boats received small decks while others were completely decked over with an opening just big enough for an occupant to slip into.

The canoe did not have a name until recently when an employee looking to build one inquired about where the mold came from. After hearing the story, he named the canoe the Gougeon 12.3 ■

Gurski's hull during the resin infusion process. with the resin flow front visible as it moves up the sides of the hull. Since the fabric, carbon and foam core were infused at the same, the hull was essentially "done" when it was popped from the mold, except for bulkheads, decks and a seat.

The latest generation of employees and canoe building technology. All three canoes were resin infused under vacuum.

Alan Gurski's finished canoe (left). Randy Zajac (center) used two layers of 737 Biaxial Fabric with 703 Unidirectional Carbon Tape reinforcing. John Thomas (right) used two layers of 737 with a 703 tape and foam keel. He added some blue quality control dye to tint the resin.

Building a Gougeon 12.3 has become a right of passage for new employees.

Turning a Gougeon 12.3 canoe into a Gougeon 12.3 kayak

By Tom Pawlak

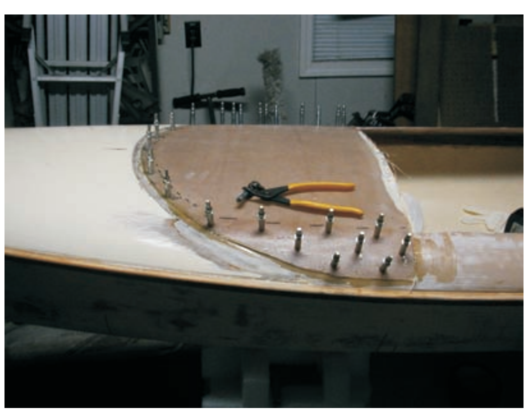
I recently modified the deck of my wife Mary's fiberglass canoe (one of dozens built from the Gougeon 12.3 mold) to make it more seaworthy and to facilitate a spray skirt. More like a kayak. Previously, the decks covered only the ends of the boat leaving the middle 40% wide open. I'm fairly pleased with how it turned out.

I'm thinking of making a quick mold off of the deck this winter so Gougeon employees can make the same deck for their boats if they wish. The original decks were made off of the bottom and near the ends of the mold that produced the hull. To extend these decks, I just made fiberglass parts off of the bottom of the boat, cut them to size, glued them in place, faired it all in and painted. I borrowed a bunch of Cleco clamps and the Cleco tool that installs and removes the clamps to temporarily hold the pieces in place while the glue hardened. What a great invention. The aluminum skinned aircraft builders use them to position panels before final assembly. Cleco clamps are available from www.eastwoodco.com.

The deck extensions were molded off of the bottom of the kayak in four separate panels. I mold released the bottom of the boat so I could use it as a male mold. From this, I made two 10"-wide × 7'-long fiberglass panels (one from each side of the boat) from the turn of the bilge area (at the water line) and centered along the length of the boat. These molded shapes became the deck along each side of the cockpit. Then I made a panel 3' in from each end that extended from the turn of the bilge on one side to the other. These panels were used to extend my original decks that were about 3½' long each. The panels were all glued together with lap joints of fiberglass and faired before being painted by brush with a one-part polyurethane paint. ■

Left—Plastic food wrap stretched over the bottom of the hull to create a non-stick mold surface from which four fiberglass deck parts were made.

Right—Gluing a fiberglass backer to the underside edge of the existing deck.



Left—A molded fiberglass deck extension is clamped in place using Cleco clamps.

Right—Close up of a Cleco clamp holding two panels together while the epoxy adhesive cures.

Left—Fiberglass panels, molded from the turn of the bilge area, became the deck along each side of the cockpit.

Right—With the four deck panels installed, the 4mm plywood, under-edge, coaming support is glued in place. The deck was then faired and painted.

The nearly finished kayak on a day trip to Rifle River Recreation Area in Lupton, Michigan, our favorite state park. (I still need to install the cockpit coaming that the spray skirt will attach to.) The weather was perfect. We only saw four other boats on the water. We paddled the perimeter of two lakes. Each had a family of loons in residence that helped make the day.

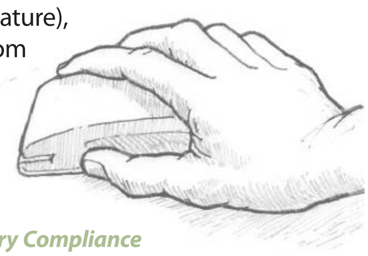
Safety Tip Dust from sanding or machining epoxy

Whether because of our impatient natures or desire to keep a project on schedule, we're often tempted to sand or machine epoxy as soon as it's hard. However, dust from machining or sanding epoxy that hasn't reached full cure can pose a serious health hazard. It may still contain tiny amounts of unreacted material which can become airborne in the form of a dust particle. If you must sand or machine epoxy before full cure, it's important to take special precautions.

We refer to epoxy which is hard but not yet fully cured as "green epoxy." You must protect yourself from inhaling green epoxy dust and prevent it from settling on unprotected skin. The unreacted material in these dust particles may cause an allergic respiratory reaction or severe respiratory irritation if inhaled. Allowing it to settle directly on unprotected skin (especially when the skin is sweaty, with open pores) can likewise cause allergic skin reactions.

You should filter the air in your workshop to remove the dust. If that's not practical, use body-covering clothing, even if it is lightweight, or applying a protective barrier cream to your skin. We always recommend wearing disposable gloves, even for dust. A dust mask can offer you effective respiratory protection. A tight fitting pair of safety glasses or a safety goggles helps prevent dust from getting into your eyes.

Once the epoxy has been allowed to cure for 10–14 days at room temperature, or if it has gone through post cure conditioning (elevated temperature), it becomes inert. Dust from fully cured epoxy poses no greater health concern than any other inert, respirable dust.



Glenn House
Product Safety & Regulatory Compliance

Kayak lessons learned

By Capt. J.R.Watson

Kayaks are versatile craft. I'm a lucky guy who has had decades of pleasure cruising, exploring, fishing and simply relaxing on many different streams and lakes throughout Michigan and Canada in my stripper. Comparing the investment dollar per pleasure derived, my kayak wins hands down over all the other water craft I've owned. In her wake I've been taught many lessons, albeit some the hard way. Here are a few I thought worth sharing.

Tying the craft to your car top.

Thirty years ago when my kayak was new and we were on our way out for her first trip, the boat blew off of the car while crossing a long, high bridge exposed to high winds. It didn't come completely off, just enough to beat against the side of the car until we stopped. Lucky for me there wasn't a lot of traffic; no one ran over the boat or ran into me or my car.

Lesson learned: In addition to taking your time, use stretchy line. Nylon is best. I still prefer line over straps and ratchets. I don't trust bungies or S hooks. Prior to tying down, I place 4"-wide strips of Dow Ethafoam® between the carrier crossbars and the boat. I tie to the forward and aft cross bars then cinch them to each other. The foam crushes slightly, the line stretches taut and when cinched, stays taut. All this stretching stores energy and keeps everything tight. In addition, I tie a line from bow and stern eyes to the car. Old cars had nice bumpers or a frame to tie to. Nowadays, you're tying to plastic ground effects. The key is that these ties connect the boat to the car whereas those over the boat hull only connect to the car top carrier. In addition, these lines on the end of the boat prevent it from canting when exposed to heavy winds over bridges or from passing trucks.

The kayak rides at anchor from the bow (1). Close up of the ring at anchor (2). To retrieve while seated in cockpit, I pull the ring aft and take in the anchor line and anchor (3).

1

2

3

Grab loops on the kayak

Grab loops, especially those positioned amidships (*above*), are useful on fast flowing streams. Grab loops provide a firm connection between you and the craft when you're launching or retrieving and the craft wants to take off downstream without you. I was on the main stream of the Au Sable River when taught that lesson. A simple rope loop or hoop is easy to grab and flexible.

Anchoring technique

I foresaw the hazards of anchoring from an amidship position thus came up with this scheme. I run a static line from my amidship eye, where my handle is attached, to my bow eye. On the static line is a metal ring with a line tied to it and led to the cockpit. Judging water depth, I calculate my anchor scope and make my rode fast to the ring. I lower my anchor, a lightweight Danforth® (a folding grapnel would probably work as well) along with the scope then allow all to run forward so the kayak rides at anchor from the bow. To retrieve while seated in cockpit, I pull the ring aft and take in the rode, or anchor line, and the anchor. ■

Drift boat building in the foyer

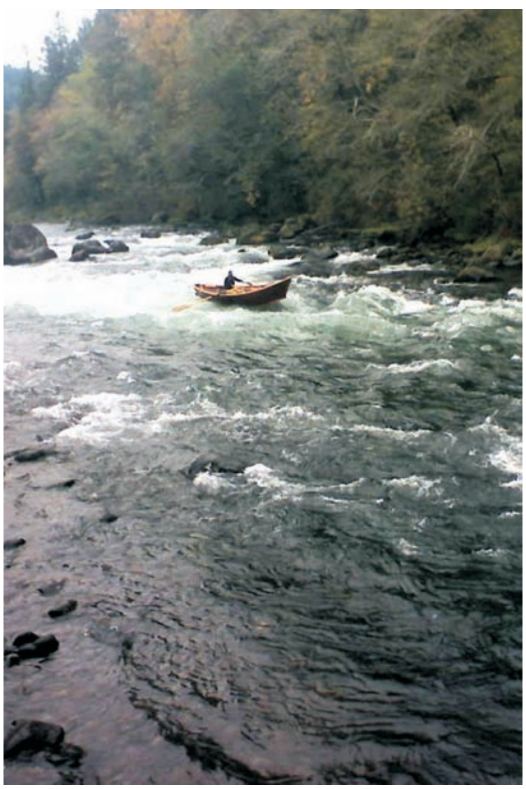
The wet winter months in Oregon are perfect for garage projects like boat building and car restoration. They are less than "ideal," however, if you want a perfect epoxy finish for your boat and your garage is unheated.

After failed attempts at space heaters and patience (waiting for a four day warm front in January), I had to improvise. My wife graciously let me move my boat building indoors to a perfect 72°F, dust-free, climate controlled environment. The WEST SYSTEM® Epoxy set up great in our front entry way and produced just the finish I was after for my 16' McKenzie Style Drift Boat.

Moving the shop indoors was not without precedence; the winter before, I restored an FJ40 Land Cruiser that required warming up parts in the kitchen before I could paint them.

I married a saint.

Greg Hatten—Eugene, Oregon ■



The McKenzie style drift boat is designed for maneuverability and is especially suited to get you down wild rivers (above) and not-so-wild rivers (right) to where the fish are.

Hull side panels (above) curing in the comfort of Hatten's warm and cozy foyer.

The drift boat is close to completion in the normal setting for boat building (left).

Project Brighter World

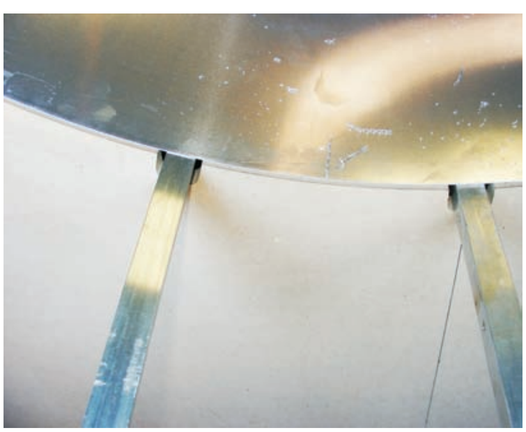
By John R. Marples

A Flettner rotor is designed to use something called the Magnus effect for propulsion. The Magnus effect is a force acting on a spinning body in a moving airstream that acts perpendicular to the direction of the airstream. It gives the pitched baseball its curve, the golf ball it slice.

In early 2007 Impossible Pictures of London, U.K. approached me to participate in a boat demonstration using a Flettner rotor powered trimaran. They were filming a demonstration for the Discovery Channel's Project Earth series. Our program would be called Brighter World. Two atmospheric scientists, John Latham and Stephen Salter, had devised the Albedo effect, a way of changing the reflectivity of clouds to deflect some of the sun's heat, cooling the oceans. It required a flotilla of vessels to seed clouds with small saltwater particles. Our trimaran would be a prototype for this type of vessel.

The scheme called for installing a couple of specially built rotors on a boat. We purchased a used Searunner 34 power trimaran (a boat I co-designed with Jim Brown in the 1970s) in Florida and trucked to our building site in Fort Pierce, on Florida's eastern coast. We chose the location for its access to tropical-colored water.

Tim Ziel installing the sheet metal mold surface on the mold framework. We replaced the Cleco fasteners with pop rivets after fitting.



The sheet metal pieces were butted together on each mold former.

We built two 4.5' diameter rotors. The forward (main) one was 27' long and the aft (mizzen) was 21' long. They were sized and positioned to center the lift in a similar place to the sail-powered version of the Searunner 34. A 48 DC electric motor (golf cart motor) powered each rotor from a bank of batteries wired through a speed controller. The controller throttle access was conveniently positioned in the cockpit for the helmsmen. Battery charging required a shore power plug-in at the dock.

Each rotor was a large, smooth cylinder, supported by ball and roller bearings. In addition, fences—8' diameter discs—were added to the cylinder about 3' apart to improve lift performance. Since the surface area of the fences and cylinder was quite large, we chose a foam/carbon fiber sandwich construction to keep the weight down. We made each cylinder in a cylinder mold in four longitudinal sections with joggle seams at the joints. Coring foam was beveled at the edges and omitted at the joints and bulkhead attachment areas. The 27'-long panels weighed about 25 lb and the 21'-long panel about 19 lb.

The rotors were supported on the boat by aluminum tube stub masts that went half way up the rotor to the mid bulkhead. A pin on the mast top supported a roller bearing, carrying the full weight of the rotor. Another larger ball bearing at the bottom maintained the rotor alignment on the mast and provided an attachment point for the cog belt drive system. We added major structural reinforcement to the boat deck, cabin top and flooring to support the weight and bending moment of the rotors. It was crudely done using multiple layers of plywood to resist the side loads created by the rotor lift.

The cylinder mold

Panel construction employed a metal surface, partial cylinder mold and vacuum bag layup. Cylindrical accuracy for the finished rotor was crucial since it was intended to operate at 400 rpm. (That equates to a surface speed of about 65 miles per hour.) Minor weight differences between panels could cause significant imbalances in the finished rotating structure, so we need the lay-up consistency to be as accurate as possible.

We chose MDF sheets and aluminum for the mold structure and surface to assure accuracy of the component parts. Using cutting fixtures, we made the MDF formers identical. The radius was rough cut and then trimmed with a router on a pivot arm. We assembled the sidewalls full length, keeping the lower edge perfectly straight. All formers were screw fastened to the sidewalls on 4' centers and registered with the lower edge. The upper corners of the radius cutout were sighted to check optical alignment of the formers. Then the aluminum square tube stringers were screw fastened into notches in the formers and adjusted to make sure the inside surface touched the radius. Small wood wedges were driven under the sidewall for adjustments to level the mold assembly. We tried to verify the alignment with a laser level, but it was not sufficiently accurate for our needs. Once the mold was adjusted, but before we installed the sheet metal surface, it was glued to the floor.

The mold surface was .040 aluminum sheets, 4' wide by 6' long. Each sheet was butted to its neighbor, with the butts centered on a mold former. The sheets were merely pressed against the formers and stringers, and pop-riveted to the top two stringers. Self-adhesive aluminum foil tape was used to cover the butt joints on the molding surface, rendering them air-tight. The foil tape was very thin and when burnished, was less than the thickness of a coat of paint. Sunlight reflections on the mold surface indicated it was very smooth and fair.

To prepare the mold for operation we mapped out the panel size on the mold surface and also marked off the vacuum seal locations. We also glued a strip of .040 aluminum sheet about 2" wide to the mold to create the joggle on one edge of the panel. Then we gave the molding surface five coats of mold release, hand rubbing each coat to insure a non-stick surface.

Panel layup

The panel construction consisted of 6 oz plain weave carbon fiber cloth on each side of ½"-thick H-80 Divinycel contour core foam. We started the layup with nylon release fabric against the mold, then used squeegees and roller to wet out carbon fiber cloth. The foam core was precut to dimension and coated with a light mixture of epoxy and 407 Low-Density Filler to fill the surface voids. We transferred the wet foam onto the carbon cloth and positioned it. That was followed by release fabric, baby blanket

A panel curing under vacuum. The panel was built of ½"-thick Divinycel foam between layers of 6 oz carbon fiber cloth laminated with West System® Epoxy.

The cured outer carbon skin with foam core.

Finished panels being prepped for final assembly. The first panel joint was held in place with Cleco fasteners onto a stringer after the sheet metal had been removed.

The middle bulkhead with main bearing attached. The eyebolts had cables connected to the lower bulkhead rim to carry the cylinder weight.

(quilt batting) and finally, the bag (4-mil poly film). The vacuum manifold was already in place and covered with masking tape. We pulled the tape off the manifold and the vacuum seal and attached the bag, with the pump running. Soon the bag was compressing all layers and the vacuum gauge normally showed about 23" of vacuum.

The rotor assembly

Each rotor was made from four panels longitudinally fastened with epoxy. To prep the individual panels we scuffed the bonding surfaces and trim the panels to exact size. We removed the sheet metal mold surface and fastened the panels for the first joint to one of the aluminum square tube stringers with Cleco fasteners. The mold formers and perfectly straight stringer accurately kept the cylinder shape while the epoxy cured. Next, the three ½" plywood bulkheads were positioned and epoxied in place, followed by a third panel. Next we added more ring frames and mechanical gear, then glued the last panel in place. All the longitudinal joints used Cleco fasteners to position and clamp the panels together during epoxy cure. They worked very well as long as they were oiled before use to prevent epoxy from clogging the moving parts.

Fences

Experimental work published by Thom in the 1930s showed a significant increase in lift created by the rotor if large discs were added. We duplicated his work on our rotors with 8' diameter discs added on 3' centers. Each disc had the same layup schedule as the rotors and was made on a special round table. A router on a pivot arm was used to trim the fences and maintain dimensional accuracy. With the rotors supported on a rotation fixture in the shop, the fences were positioned, wedged in place and adjusted to run true by slowly rotating the rotor. Once adjusted, they were glued in place with large epoxy fillets on both sides. We painted the assembly while it was still on the fixture.

Installation

A crane lifted the rotors into position and slowly them lowered onto the mast. We did this early in the morning before the wind came up. The rotors had to be threaded onto the mast perfectly vertically so that the bearing pin at the masthead would engage the bearing bore on the middle bulkhead, which was only 1½" diameter. The bearing pin had a machined "dunce cap" nut to help hit the target bore. It all worked very smoothly, thanks to the expertise of the crane operator.

All three bulkheads installed and a third panel added.

Ring frames and other mechanical gear installed before the forth panel was added.

Rotor roll-out. Pipe rollers make it easy to move the rotor into position for transport. It was then lifted onto a trailer by a crane.

The rotor is lifted by the eye-bolt in the top bulkhead. Note the "tilt-up fixture" to prevent damage to the fences.

The drive system

Each rotor was powered by a 10 hp, 48-volt electric motor with a speed controller and a bank of 6-volt batteries. The motors were mounted to the mast on clamp brackets of welded aluminum. A cog belt using pulleys to achieve the correct speed ratio spun the rotors at 400 rpm maximum. The system worked very well without any adjustment from the first run. The initial design called for the boat to be carpeted with photo-voltaic panels to charge the batteries, but we did not have the money or the time to install them.

Demonstration Day

We towed the boat about a mile offshore in light winds for the demonstration. At first, the boat bounced around in the light chop and swells, but as soon as the rotors started turning, the boat stabilized and became very smooth. We achieved 6 knots boat speed in 6 knots of wind at the best run of the day. Kevin, the "presenter" put aboard for the filming, was initially rather skeptical about the boat's potential. But by the day's end he ran out of superlatives to describe the performance. The whole crew was pleased with the show. The demonstration sailed with about 8 hours of powering time for a single charge on the batteries. Since the winds were light and the rotors only rotated to less than 200 rpm, we had over 12 hours of running time. ■

The rotors were lowered carefully over the stub masts. The mizzen rotor is being installed. The main rotor is already in place.

The 10 hp drive motor is clamped to a bracket on the mast. A cog belt drive system connects motor to rotor. It worked flawlessly.

Demonstration day. The boat performed very well, sailing at wind speed, even though it was about 30% heavier (due to the heavy batteries) than the normal sailing vessel design weight. The project was considered a tremendous success.

Alec Brainerd of Artisan Boatworks announced the launch of a full keel version of Herreshoff's Buzzards Bay 15, built for an owner in Newport, Rhode Island. Contact Artisan Boatworks, Rockport, Maine, 207-236-4231.

Readers' projects

Ted Clark of LaGrange, Indiana, built this Tigercat II. He stiffened the fiberglass hulls with aluminum trusses bonded to the insides of the hulls with epoxy/microballons and pop-rivets. A key design feature is the use of a single centerboard allowing very fast 180° reverse courses from a beam reach in about one hull length. The hollow boards are oriented strand board laminated with WEST SYSTEM® Epoxy and covered with fiberglass.

Patrick Ropp, former Gougeon tech advisor, now U.S. Coast Guard Commander living in Houma, Louisiana, sent a few pictures of his latest project. The stripper was built with WEST SYSTEM 105/207 and 6 oz cloth over western red cedar. He coated the outside, when the temperature was in the 90s, so the bubbles created from the roller flowed out just perfectly after his dad tipped it off behind him. He applied two coats of Cabot's satin spar varnish over two coats of Captains varnish on the inside of the canoe, "so as to keep the glare down whilst paddling on those sunny days."

Dave Pratt and Chuck Van Deventer from Sturgis, Michigan, decided to build two ice boats they could day sail with their wives. They found plans for a Nite, a side-by-side, two-seater ice boat. All component wood parts were built of basswood in Chuck's wood shop. The metal parts were fabricated in Dave's metal shop. Chuck's boat was finished in 2006, Dave's, a year later. Chuck and Dave belong to the Gull Lake Ice Yacht Club near Kalamazoo.

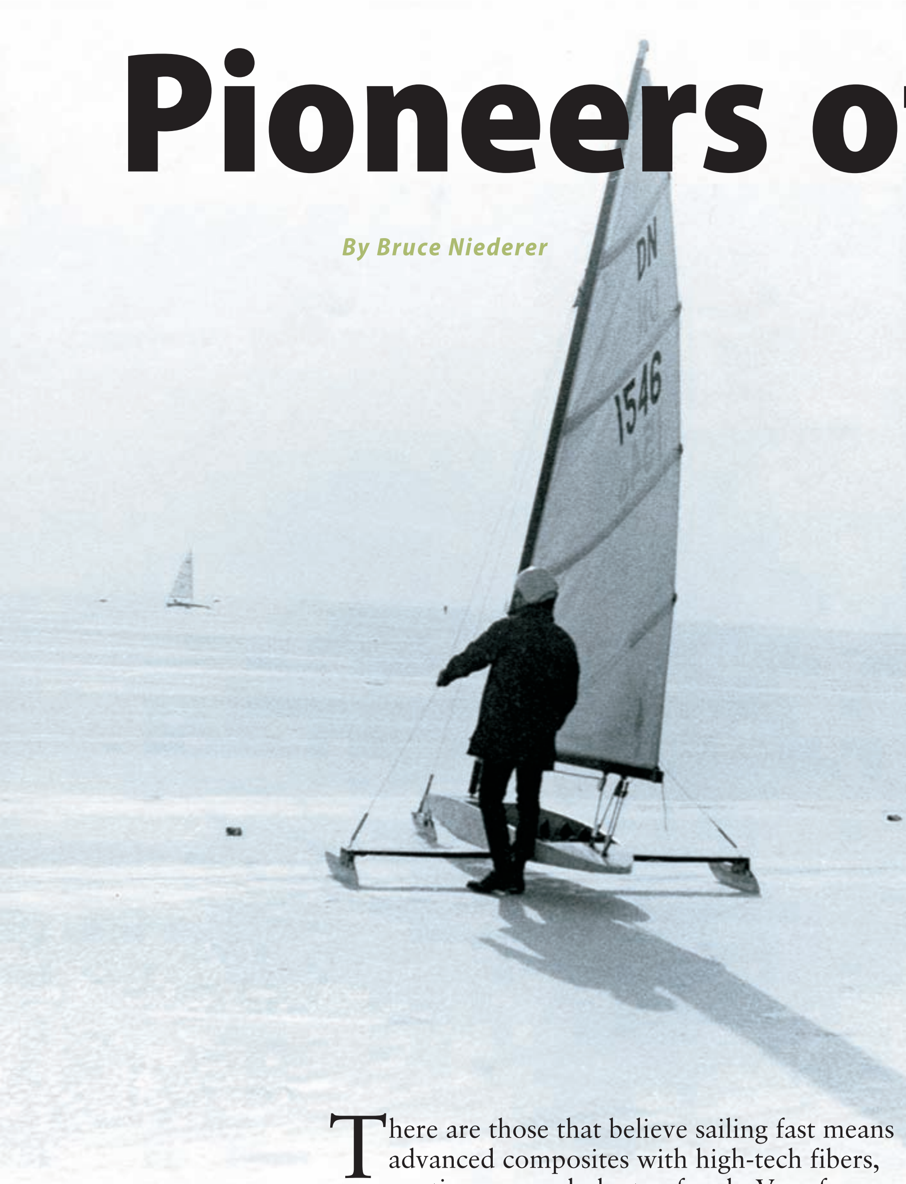
Russell Brown builds foils, boats and other composite projects. He designed this single outrigger motorboat for his friend Josh Sutherland. Although not completely finished when the photo was taken, it was "pretty well tested and didn't seem to have any really bad habits," says Brown. It is 24' long, and built fairly ruggedly. It uses a 20 hp Yamaha four stroke, and goes about 18 knots with three people aboard. Brown plans to start a business selling designs and kits for multiple types of small, fuel efficient motorboats. Russell, the son of legendary boat designer Jim Brown, lives in Port Townsend, Washington. Visit www.ptfoils.com.

Tom Watson sent this photo of the 15' cedar/epoxy canoe he built using West System® cloth and 105/207 epoxy. The hull is western red and white cedar, with ash gunwales and deck inserts made from a variety of woods including maple, teak and mahogany. One paddle is ash, the other spruce and cedar—both laminated with epoxy. Watson tells us, "it was a lot of fun to build, and your system was flawless." The design is the "15' Bob's Special" from Bear Mountain Boats.

Rich Jeric from Caseville, Michigan, built this runabout design from scratch. It was his first boat building project after retiring as a high school football coach.

Pioneers of Speed

By Bruce Niederer



There are those that believe sailing fast means advanced composites with high-tech fibers, exotic cores and plenty of cash. Very few think of wood when they think of fast, but before carbon fiber, before Kevlar™…there was wood.

I'm not talking about those great big lumbering tall ships or schooners. I'm talking about the pioneers of boatbuilding and fast sailboat racing. Men of vision who saw wood not just as planks and large hunks of trees to be bolted together, but as an engineering fiber. Men like Walter Greene, Jim Brown, James Wharram, Dick Newick, and the Gougeon Brothers: Joel, Meade and Jan.

Meade and Jan were first introduced to epoxy resins by Vic Carpenter, a boatbuilder who was one of the earliest users of epoxy as a structural adhesive to build boats. Vic built the Olin Stephens designed 36' *Yare* in 1963 using strip planked Honduras Mahogany. In 2008 it was the second oldest boat in the Bayview Mac race, the 46th Mac race for the boat with a second place finish in their class to add to their 11 firsts. Fast as it is, it is still basically a traditional style boat that employed epoxy adhesive in the build.

The wheels started turning. The Brothers enlisted the help of some friends who worked for Dow Chemical in formulating an epoxy adhesive that could be also used as a coating to take advantage of epoxy's excellent moisture resistance.

Soon the three brothers began using the newly formulated epoxy system to build improved DN iceboats. These rapidly began winning races due to the added stiffness and durability the epoxy provided the wooden structures. Everyone wanted one. By 1973, Gougeon Brothers Boatworks was the largest builder of iceboats in the country. In 1975 they sold the iceboat business to concentrate on selling epoxy and building larger custom boats. Joel focused on managing the fledgling epoxy business and didn't race nearly as much as his brothers. Through it all, Meade and Jan never stopped racing. Here's a quick list of Meade and Jan's winter sailing accomplishments in DNs:

Meade won the North American title in 1980 and again in 1997 when he was 58 years old. He is the oldest person ever to win the North American DN championship. His record still stands today.

Jan won his eighth North American DN championship in 2000. That's more than any other American sailor. He won four World DN championships won over the course of three decades. (1972, 1982, 1985 and 1991) and also won the Great Cup of Siberia Race in Russia in 1989.

Currently Meade and Jan are ranked 25th and 18th respectively in the Gold Fleet world standings of the IDNYRA (International DN Ice Yacht Racing Association). They vow to improve those positions this year.

2009 marks the 40th anniversary of Gougeon Brothers, Inc. Over the years an impressive number of fast boats emerged from the Gougeon Brothers boat shop including 14 production/custom water ballasted, trailerable, catamarans—the Gougeon 32 (G32).

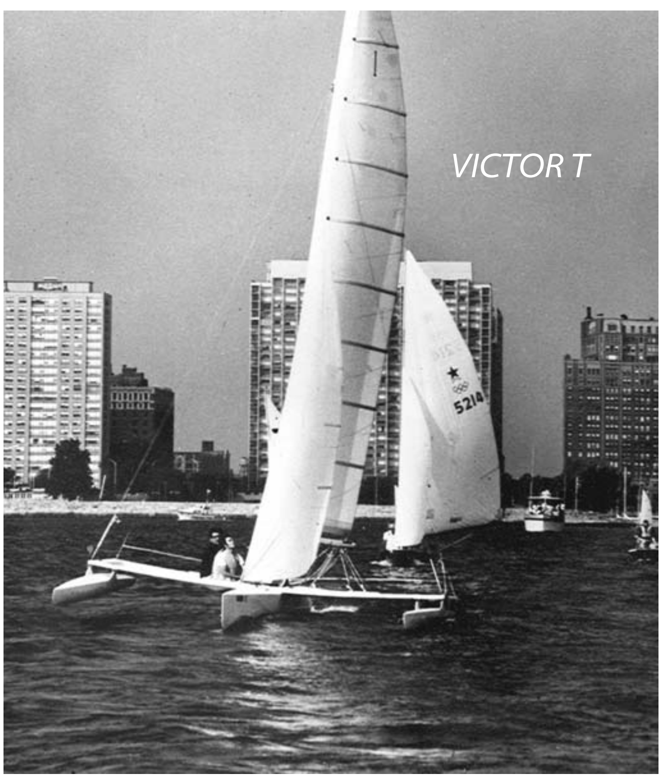
The original G32 promo footage is posted on our website at www.westsystem.com/ss/history/

I say the G32s were production/custom boats because they are all mostly the same, but like all things Gougeon, each build sparked ideas and innovations that found their way into the next build.

The Brothers built several high-profile racing sailboats that advanced and refined the construction techniques they developed while building iceboats and a series of experimental trimarans beginning in the late 1950s. Together they built an experimental 25' trimaran to IYRU Class C rules that marks the start of their early racing success at the 1963–1964 NAMSA Championships at Stamford, Conn. Building on this success and experience, Meade constructed *Victor T* in 1967–1968. He got the boat's weight down to 320 lb and it earned the distinction of being the lightest Class C competitor in the 1969 Nationals in Hamilton, Ontario. There, *Victor T* took home the win against a strong field of wingmast-powered catamarans.

Next came *Adagio*, launched in 1970 and believed to be the first all-bonded and sealed wooden structure built entirely without fasteners, using a unique building method which they called "developed plywood construction." She's a testament to the longevity of wood/epoxy construction, and to the competitiveness and seamanship of her only skipper. Meade has racked up a long and impressive string of trophies throughout the Great Lakes.

Meade first raced *Adagio* in the Bayview-Mac (Port Huron to Mackinac Island) race in 1996 and placed second behind another boat that many have come to know well



(and also built with WEST SYSTEM® Epoxy) Earth Voyager. The result of the long love affair between Meade and *Adagio* is an impressive race history on the Great Lakes which continues today.

Adagio's Port Huron-to-Mackinac race finishes: 1998 second, 1999 first, 2000 first, 2002 first, 2003 fifth, 2004 fifth, 2005 first, 2006 first, 2007 fifth, 2008 fifth, 2009 second.

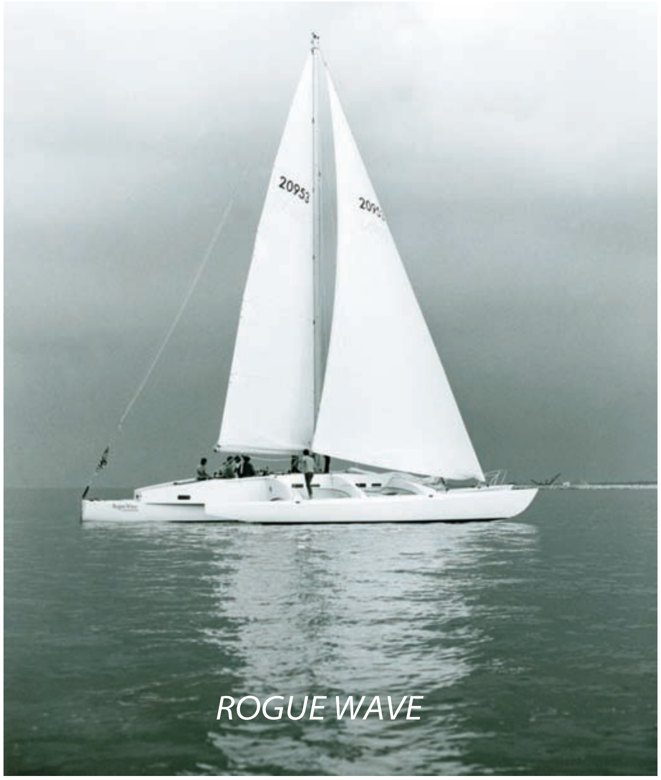
Adagio's Chicago-to-Mackinac finishes: 1998 first, 2000 first to finish, 2002 first to finish, 2006 first to finish, Reick Trophy, 2008.

In 1973 they built an Olympic class Tornado catamaran using vacuum-bagged, cold-molded construction. USA sailors David McFaull and Michael Rothwell sailed the boat in the 1976 Olympics and took the Silver medal behind the German team.

The Gougeon Brothers also began construction of *Golden Dazy* in 1973 for Dr. Gerry Murphy from the Bayview Yacht Club in Detroit. *Golden Dazy* generated a lot of press and won the 1975 Canada's Cup. She's still sailing today in upstate New York.

In the mid Seventies the Gougeon Brothers built Class C catamaran designed by the Hubbard Brothers. The boat was named *Patient Lady*.

I'm sure some of you will remember the fast monohull the Brothers built next: *Hot Flash*. This Gary Mull design was commissioned in 1976 by the Usnis brothers, also from the Bayview Yacht Club in Detroit.



In 1977 the Brothers began building *Rogue Wave*, a Dick Newick designed 60' trimaran for Phil Weld. He had planned to race it in the 1980 OSTAR, but never had the opportunity because of a rule change. Weld did win the 1980 OSTAR, setting a record for the race that year onboard the well known *Moxie,* designed by Newick to comply with the new rules. *Moxie* was built by multihulls guru Walter Greene, a user of WEST SYSTEM Epoxy who is also a good friend of Meade's.

At the Gougeon shop construction also started on *Flicka*, another plywood cruising trimaran. Jan spent four long days on the capsized *Flicka* in the Atlantic Ocean during a qualifier for the next OSTAR challenge. He had plenty of time to think about rightable trimaran designs before a passing freighter rescued him. *Flicka* had to be abandoned at sea.

In 1980 Jan designed and began to build *Splinter*, a developed plywood trimaran designed to be rightable after an offshore capsize. *Splinter* was the second boat, after *Adagio*, the Brothers launched with a wingmast. She is now owned and raced by Bob Struble (father of A-Cat and DN champ Matt Struble) in Saginaw Bay competes against *Adagio* and another noteworthy Gougeon built boat, *Ollie*.

Named after the Gougeons' grandmother, *Ollie* was started in 1984 using the developed plywood technology the Brothers had developed over the years. The design was trademarked as a Stressform™ 35 along with Stressform wing mast plans. *Ollie's* design advanced Jan's ideas for self righting.

Although Jan can be nostalgic for the boats he's built, particularly *Ollie*, he hears a different drummer than Meade. Jan is always thinking of the next boat, whether it's right around the corner or a few years out. A difference of even greater significance is Jan's appetite for solo sailing—and he's done plenty.

Jan raced *Splinter* in the single-handed Port Huron to Mac race beginning in 1981. He placed first that year and first again in both 1982 and 1983. In 1984 the weather forced most, if not all, of the multihulls off the water, including Jan's. Race records from the Eighties are hard to come by, and I thank Blair Arden of the Great Lakes Singlehanded Society for digging through his old records to help fill the blanks in. In one of the three races in 1981–1983 Jan set a new record for the fastest finish. Jan couldn't remember which year it was either, which is typical of Jan; once the race is over he's taking what he learned and applying it to the next race, the next boat design, the next build, the next challenge.

His record was short lived because in 1985 he broke his own record for the race in *Ollie* with a time of

26:09:00—a record that still stands. Weren't we all in awe of the fully crewed *Earth Voyager* completing the race in just under 25 hours a few years back? Jan and *Ollie* ran up a string of firsts from 1985 through 1991 and in 1989 he earned the Peter Fisher Award with his win. Jan also won the singlehanded SuperMac in 1987 with *Ollie*. That race ran from Port Huron to St. Joseph (just south of Benton Harbor, Michigan) setting another record that still stands today with a time of 77:40:00. The next finisher that year was the C&C 41 *C-Spray* with a time of 123:59:00—46 hours and 19 minutes after Jan. The loss prompted the skipper of *C-Spray* to retire the monohull from future singlehanded races!

In 1995 Jan raced his G32 *Pocket Rocket* in the single-handed classic to claim another first. In 1997 *Pocket Rocket* was the only multi entered so he scored another first. In 1998, this time with some competition, he finished second.

At times Jan and *Ollie* have taken some crew with them. 1995 marked the first time multihulls were allowed to race in the Port Huron to Mac race and *Ollie* finished third followed by Meade and crew on *Janet C*, a G32. In 1996 *Ollie* finished third behind *Adagio* and *Earth Voyager* and in 1998 *Ollie* finished eighth.

Ollie was sold to Tim Walli and Dave Sturm in 1998 and didn't race again that year, but in 1999 *Ollie* was back with the new owners and Jan as crew. She finished second behind Meade and *Adagio*. In 2000 *Ollie*, with Jan as crew again, suffered a fatigue failure in a stainless fitting and retired from the race. Jan has not raced on *Ollie* since.

The Brothers also built a couple of other noteworthy and well-known boats. The multihull *Slingshot* was launched in June of 1978. Commissioned by Georg and Carl Thomas, *Slingshot* was built to compete in the speed trials in Weymouth, England. *Slingshot* was 60' × 4.5' hull beam × 42' BOA and weighed in at 1,800 lb plus a crew of four. She could sail in both a proa configuration and a trimaran configuration. She recorded the second fastest speed 1979 at Weymouth behind the famous *Crossbow I* which recorded a speed of 31.8 knots—blistering fast in 1979. Jan reports that later that year in Florida they posted an unofficial speed of 40 knots. Racing the ditch in Texas City, Texas in 1980 with a crew of Jan, Mike Zutek, Ron Sherry, and Olaf and Peter Harken, they posted a speed of 38 knots. But alas, during a storm *Slingshot* came loose from her mooring and was dashed against the rocks and lost forever. All that remains of her is a section of the bow hanging in the Gougeon boatshop.

The last commissioned boat the Brothers built was *Adrenalin*. Started in 1984 and launched in 1987, she was a trimaran with articulating amas built to Formula 40 rules for Bill Piper of Ossineke, Michigan and intended to race in the European circuit. She shocked the sailboat racing community by placing a very close second in her first regatta on the Grand Prix circuit in 1988.

She raced for two seasons in Europe against the traditional big cats until, as Jan put it, "They couldn't stand being consistently beaten and changed the rule so the boat became illegal and only cats could race." Adrenalin was purchased by New Zealander Grant Beck in 2007 and is awaiting his attention to get back on the water.

Advancing age has not seemed to slow down either Meade or Jan. This year they sailed Meade's G32 *Janet C* in the 2009 Chicago/Mac race to commemorate the 40th anniversary of the company they started together. Being 70 and 64 years old, respectively, they will no doubt had the oldest average age in the race.

Janet C finished 3rd in the Chicago/Mac race and a week later, Meade, Jan and Butch Babcock finished 2nd in the Port Huron-to-Mac race on the 39-year-old *Adagio*. ■

Resurrection of the Dalotel DM 165

By Ray Ordorica

I've had a strong interest in airplanes since I was a kid. I had always built model airplanes, and went to air shows as often as possible. I loved the "warbirds," and built many models of them, and of other more-common aircraft. Of course, I had always wanted to fly, to become a pilot, but for many reasons I couldn't make that happen. During my college years my interest in aircraft waned, but after college I moved to Alaska, and of course, aircraft are part of the Alaskan lifestyle. I got rides in Super Cubs, Cessna 180s and the like, and naturally my interest in aircraft returned. However, the general-aviation world is a costly one, and as a photographer, I had precious little cash to spare. So I remained pretty much on the ground.

Ordorica built this model of the Me1990Dalotel in the late 1980s. Twenty years later he is restoring the real thing.

In the late 1980s I discovered radio-controlled (R/C) aircraft. I became seriously involved in that game, and built several models. Yet each seemed to be missing something. I decided to build an R/C model of the Dalotel DM 165, a French aerobatic aircraft that first flew in 1969 (also a key year for Gougeon Brothers, Inc.). The Dalotel was popular with modelers in the late 1980s because some guy won a tournament and made big money using an R/C model of it.

My model flew exceptionally well. It had it all, great performance and good looks. I enjoyed it immensely, but sold it when I left Alaska.

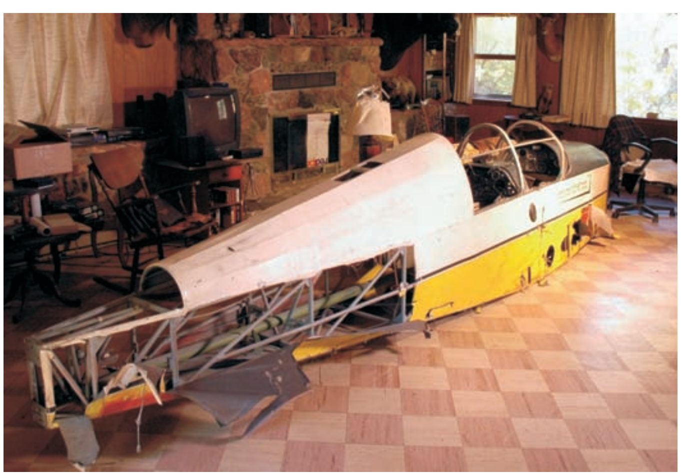
Twenty years passed, and it was time for me to build another R/C model of the Dalotel, which by now had become my favorite airplane of all time. This next Dalotel model was going to have all the details of the real one: retractable gear, scale cockpit, everything as close to the original as I could get. I went looking for plans and photos on the Internet...and then my life changed. I found a small ad offering the real Dalotel for sale, in England, in damaged condition from a forced landing.

After some serious soul-searching (I was not a pilot) I bought the one and only Dalotel DM 165, imported it from England, and began its restoration. My "model" was now full-size.

The Dalotel is the prototype for a series of aircraft that never happened, for many reasons. It is fully aerobatic, has tandem seats, and is powered by a 165 hp engine. Top speed is 190 mph with 150 mph cruise. The landing gear is retractable. Best of all, it's made largely of wood, and I happen to have a world-class woodworking shop called the Old Cranky Workshop, with sincere apologies to Norm Abram, grand master of PBS's New Yankee Workshop. The wings and tail surfaces have built-up spruce spars and plywood ribs, all covered with plywood, with fabric over that. The fuselage is steel tube, covered again with fabric.

When the airplane arrived here in Idaho in 2006, it was a mass of broken wood, shattered wings, a fuselage covered with torn and rotting fabric, and mildly damaged tail surfaces. The engine had no prop nor spinner, but otherwise was all there.

After nearly three years of digging through the bits and pieces of this airplane I have finally begun gluing it all back together. As I examined



The fuselage arrived in dismal condition, with torn and rotting fabric. Ordorica stored it and the engine in his living room.

Rather than repair the old rib, Ordicia built a new one with larger glue surfaces and added braces inside. Here it is being glued in a jig.

the parts I found many glue joints had failed from age, humidity, and the use of non-waterproof glue. My first job was to determine what to use to glue the new wood back into whatever bits of the old structures I could salvage. I considered resorcinol, the traditional glue for aircraft. It requires high clamping pressure, extremely close fitting, and several other considerations that must be met. These didn't mate well with the repair of old structures, I decided.

A good friend with 36 years of experience teaching aircraft technology suggested I use epoxy. My experiences with epoxy were sparse, but I had *The Gougeon Brothers on Boat Construction* in my library, and liked what I had read. I decided to use WEST SYSTEM® Epoxy on the Dalotel. After tentative beginnings with the clever 5:1 pump system, I found this epoxy very easy to use. I used it to re-glue broken parts in the stabilizer, install new rib sections, install new braces for the hinge mounts, and cover the stabilizer with thin plywood. The more I worked with WEST SYSTEM Epoxy, the easier it became.

As my experience with WEST SYSTEM continued, my confidence increased. When I wanted to stiffen the front wood edge of the Dalotel's new stabilizer, it was a fairly simple matter to lay thin fiberglass cloth onto the leading edge, wet it out with two coats of 105 Epoxy Resin® and 206 Slow Hardener®, fair it in with 410 Microlight Filler® and give the job a final very thin coat of neat epoxy, always using a squeegee to keep the parts as light as possible. I will do the same thing to the wooden leading edges of the wings.

I always make before-and-after gluing test pieces and break them to "prove" the bond. These are simply two or three small pieces of wood glued together in a manner that lets me insert them into a vise and load the joint until something lets go. I make one test assembly with the fresh mix of epoxy before applying it, and then make a second test assembly when I'm done with the serious gluing. In every test I've made, the wood has broken first, and no epoxy joint has failed. You really have to do something like this if you're betting your life on the quality of the bond.

After checking the rib's alignment, the author clamps and staples it in place before the epoxy sets.

The newly covered stabilizer is temporarily attached to the elevator to check the fit of balsa blocks epoxied to the ends of the former. Both parts have been rebuilt using WEST SYSTEM Epoxy.

After my success with the Dalotel's stabilizer I tackled the fin, one of the key parts on this aerobatic aircraft. The original glue joint around the fin's key bottom rib had failed completely. The plywood sides were hanging free. I made a new rib, thicker and better braced than the original. My final glue area is nearly twice that of the original, yet still light. With WEST SYSTEM Epoxy holding it together I have no fear of the glue joint failing.

Next up is the rudder, which I redesigned internally. Then I'll have to manufacture one wing in its entirety, including a wood box spar, plywood ribs, and plywood covering over that. With the use of WEST SYSTEM Epoxy, I'm sure it will all go smoothly, and I'm just as sure it'll stay together far better than the original.

Along the way, I tried to redesign the control panel to modernize it and replace the dated metric instruments. I could not do so because I didn't know what was needed. Therefore—entirely out of necessity, mind you—I obtained my private pilot's license, and then I found it was extremely easy to lay out the control panel. Now I knew exactly what was needed, and where it had to go.

Thanks to Gougeon Brothers and all the folks at WEST SYSTEM Epoxy for giving me the opportunity to tell a small part of this ongoing tale. ■

Testing, testing, 123

By Julie VanMullekom

Documenting destruction

By now most of you know that we are the manufactures of WEST SYSTEM® Epoxy. But you may not know what is involved in the manufacturing and more specifically, the formulating of WEST SYSTEM. It's not just slapping some chemicals together and then packaging it up into a pretty box. To date we have performed thousands of tests, generating thousands of test results. I spend large chunks of my days entering all of this data into our database and I am eternally amazed at all of the time, effort and testing that goes into making our products. Because of that, I am going to take you on a short but sweet journey into the world of Gougeon Brothers testing and I believe you too will be amazed. Please keep in mind that all of these tests, which are only a few of the many, are performed right here within our very own walls.

ABS Plastic to Ziricote The range of substrates that undergo adhesion testing.

This test determines how well our products adhere to all different types of substrates. Using a pneumatic tensile test instrument (PATTI meter) a load is increasingly applied to the surface of a substrate until a stud, fastened with epoxy, is pulled off. The force of this action yields the tensile strength in pounds per square inch. To date we have logged in 2,000+ adhesion tests.

60,000,000± The number of cycles our MTS test machine has generated performing annular shear testing.

This test helps us determine the epoxy formulation's fatigue resistance, allowing us to see which materials can best withstand the rigors of repeated stress caused by repetitive load cycles. The specimens tested consist of a 2.0" diameter epoxy annulus (cast in a cylindrical aluminum mold) around a central threaded ¾" × 3" steel rod. During each test, the load is repeated many thousands of times. After some number of cycles, the epoxy material either deforms or cracks until it can no longer sustain the steel post in its original position. The test is over when the post has been displaced downward one-tenth of an inch. This lets us rank epoxy formulations on the basis of how many cycles they can withstand at a standard peak load level, or on the basis of the magnitude of the peak load required to produce failure after a standard number of cycles.

Entire length of a professional football field The combined length of all the test cylinders we have tested in Compression.

Performed with the MTS test machine, this test determines the behavior of the epoxy under crushing loads. The specimins we crush in this test are approximately 1½" long cylinders of solid epoxy. The machine compresses them at various loads. We record the peak load required to cause epoxy failure.

40,000± The days of destruction our QUV Accelerated Weathering Test Machine has logged in, satisfactorily destroying over 300 test samples.

The QUV test machine produces cycles of UV light, condensation and temperature changes that mimic the environment but at an accelerated rate, it lets us foresee the level of environmental degradation that would take place over time. If you'd like to read more in depth about the QUV process see *Epoxyworks* 28 for a super article.

Much, much more! Other tests performed in-house: Chemical Resistance, Creep Rupture, Cure Profile, Hydromat Panel, Lap Shear, Moisture Exclusion, Moisture Uptake, Sandability, Specific Gravity, Tensile Strength, Viscosity and Wet Out.

I hope you enjoyed this behind the scenes tour of our test facility here at Gougeon Brothers, where we torture and break stuff to develop and maintain the excellence of our WEST SYSTEM product line. ■

805 & 806 Mixing Cup Graduations

You may have noticed some recent changes in the appearance of our 805 and 806 mixing cups. They now come with graduations on the side to make mixing larger quantities by volume faster. The diamond shaped indicators are easy to see and work great for 105 Resin-based epoxies, G5, G/flex, paint and more. Because the graduations are in 2 oz increments, the smallest amounts you can mix are 4 oz of G/flex or G/5, 12 oz of 105/205 or 206, and 8 oz of 105/207 or 209. It's a good idea to make a mark on the outside of the cup at the correct indicators for your mix ratio before you fill because the diamonds will disappear as liquid is added. —*Randy Zajac*

G/flex Saves the Race

By Grace Ombry

Robert Patenaude had ten miles left to reach the finish line in the Bermuda One-Two offshore race when a 30-ton whale hit *Perseverance*, his C&C 41, seriously damaging the rudder. Not content to drop out of the competition, he called on his racer friends to help him remove the 160 lb, 9'-long rudder from the boat while it was still in the water. He reasoned that if the contenders in the Puma or Vendee Globe races could make major repairs without dropping out of a race, he could too.

He took the rudder out in a slip at St. George's Dinghy & Sports Club and began making the repairs under a tent. The rudder post was bent backwards, so he cut a wedge off of the top of the aft end of the rudder and bolted the trailing edge of the rudder which was opened up by the hit. He then fixed cracks on both sides of the rudder with WEST SYSTEM® Epoxy and fiberglass cloth. Even after three days of drying time the foam core was still wet. He collected 12 of the sample G/flex 650-K Repair Kits (which we had donated for skipper's bags) from his fellow racers. G/flex is capable of bonding to wet surfaces. He added WEST SYSTEM 406 Colloidal Silica Filler to the G/flex, then used it to bond stainless steel bolts into the rudder.

The repaired rudder didn't look fancy, but it was strong. He tested it at 25 knots in 8' waves and it worked perfectly. He was back in the race in time for the leg that began June 18, 2009, and grateful to the friendly and generous racers who had donated their G/flex samples to him. He immediately emailed us, requesting that we replace their samples, and we were happy to do so.

Two weeks later, he sent us an update. With her repaired rudder, *Perseverance* had endured two squalls with winds up to 40 knots and 9'-10' waves, and in the Gulf Stream handled northeast winds of 20-30 knots, upwind, which meant a lot of stress on the boat and rudder. Yet *Perseverance* finished first in the race. ■

Some of the G/flex 650-K Repair Kits donated for skipper's bags.

Pulling the 160 lb, 9'-long rudder onto the dock after it was removed from the boat while it was still in the water.

The trailing edge of the rudder was opened up by a hit from a 30-ton whale.

Repairing cracks on the side of the rudder with WEST SYSTEM Epoxy and fiberglass cloth.

Far left—The C&C 41, *Perseverance* at anchor. After the repairs, she was still able to finish first in the Bermuda One-Two offshore race.

Dear Epoxyworks

I've long been a believer and user of WEST SYSTEM® since building my sailing dory back in 2000. I recently completed a project which you might have an interest in. Let me know your thoughts!

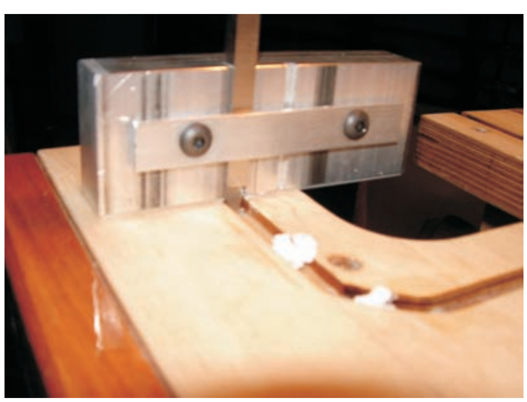
Thanks, Ken Filipiak

Building an ecosystem for salmon

By Ken Filipiak

Salmon growing up in a custom-built progressive ecosystem, ready for release.

Dry fitting the tanks in the shop. The tanks are built of 1"-thick, 16-ply birch-faced plywood.



A scraper designed to clean out excess epoxy from the groove that holds the "O" ring. The "O" ring seals the joint between the separate tanks.

The science teacher at the school where my wife works (West Ottawa Macatawa Bay School in Holland, Michigan) called me for help with his leaking aquarium which had flooded his classroom. This was no ordinary aquarium; it was one he had custom built to show a progressive ecosystem—a brook to a stream to a pond for raising salmon.

After reviewing what was there to work with, we decided to scrap the original tanks and build new ones. It was a good winter project we could complete in our shop and basement.

The science room counter top is 24' long and the assembled tank would span approximately 21'. The tank system needed to clear the overhead storage and be assembled between sinks and plumbing fittings. A riser system allows access under the tanks for clean up, and provides an air space to help keep things dry. The risers also let us place shims to level and align the tanks.

It was important to be able to keep the load (water, tank and seascape) off the bolts which would hold the tanks together, and maintain the pressure on the seal at the pass-through. The bolts, washers and nuts are stainless steel. Reinforced rubber washers are placed between the stainless steel washers and the epoxy coated tank to prevent marring.

We used 1"-thick high-grade (16 ply) birch faced plywood to construct four tanks. Each was 63" long, approximately 12" front to back and varying from 8" to 15" deep. There were cut-outs in the ends of the center tanks allowing the fish to pass-through to swim upstream against the re-circulating water pumped from the deep end back to the shallow tank. All the tanks were built to accommodate any lay-out the class may want by capping the pass-thru. They could also separate species by using a screen at the pass-thru as a barrier—this would allow a cascade of water for filtering.

Individual tanks were edge glued with WEST SYSTEM® 105 Epoxy Resin® and 205 Fast Hardener® thickened with 403 Microfibers. Stainless steel screws held the panels in position while the epoxy cured. Generous fillets were added in the corners of the panels to improve strength. The open end grain on the plywood panels were allowed to take in as much epoxy as they could to keep the exposed edges sealed. Then we gave the entire tank three to seven coats of epoxy to be sure there would be no unsealed surface where water might penetrate.

We paid special attention to the tank end panels. They had five bolt holes, and alternating tanks had an O-ring groove for sealing off against the proceeding tank. Before assembling the tank, we cut the O-ring groove with a router. The groove was sized for a ¼" O-ring stock and cut oversize to allow for epoxy build up to seal the exposed edge grain. The groove was cut at 9⁄32" wide and ¼" deep; the epoxy build up on the groove walls set up the proper compression for the O-ring seal. We made a scraper to help square the walls of the groove and control the depth after coating. The outer surfaces of the tank were sanded flat, this also helped set the depth of the O-ring groove and allowed the tanks to be bolted tightly together. The bolt holes were drilled oversized and given a generous coating of epoxy to seal exposed end grain. The holes were all located inside of the O-ring seal path to reduce the risk of leakage.

Tempered glass was required for the front panels. The glass was sealed in place with aquarium silicone seated in a groove around the facing of the tank and held in with epoxy coated hardwood retainers. The retainers were sanded just below flush and coated separately. This allowed for servicing the glass and silicone seal.

We asked a couple of the local businesses to help out with supplies and Glass Enterprise and Gentex Corporation stepped up. We appreciate their support to help make this project a success.

The tank has been in service since late February. The salmon were released the first week of June at a length to give them a good chance of making it to Lake Michigan from the local stream. We hope to see them back one day. ■

The bolt holes were all located inside of the O-ring seal path to reduce the risk of leakage. Holes were drilled oversized and given a generous coating of epoxy to seal exposed end grain.

Filipiak assembling and leveling the finished tanks. The tempered glass face was sealed in place with aquarium silicone seated in a groove around the facing of the tank and held in with epoxy coated hardwood retainers.

A pass-thru blocked by stones keeps the salmon from getting into the shallowest tank.

The finished assembled tank, an operating progressive ecosystem that flows from a brook to a stream to a pond.

Great Lakes Boat Building School partners with Van Dam

The Cederville 26.5, a re-designed version of Van Dam's custom 30' day cruiser is the project boat for the second year advanced boat building course. The course will include construction of the composite wood hull and the design and construction of the boat's interior.

The Great Lakes Boat Building School in Cedarville, Michigan is partnering with nationally known Van Dam Custom Boats of Boyne City, Michigan to develop the school's second-year advanced boat building course. The nine month full-time career program will run concurrently with the boat school's Basic Boat Building Course at their 12,000 square-foot facility in northern Michigan. As the project boat for the course, Steve Van Dam gave the school his plans for the Cederville 26.5, a re-designed version of Van Dam's custom 30' day cruiser. Students will build the composite wood hull, and design and construct the boat's interior including its twin berth cuddy cabin. They'll also install the engine, electrical and water systems.

The goal of the Great Lakes Boat Building School is to provide students the highest level of skill training to prepare them for jobs in the boat building and restoration industries. For more information about the programs offered at the Great Lakes Boat Building School, including summer workshops, visit www.greatlakesboatbuilding.org.

Van Dam Custom Boats has been in business since 1977 and is known throughout the U.S. building boats of exceptional quality and exquisite craftsmanship. For more information about Van Dam Custom boats, visit www.vandamboats.com. —*GO* ■

The Challenge Mountain (CM20) sailboat under construction (left and below). It is being built for a new sailing program for the disabled at the Challenge Mountain program in Boyne City.

Instructor Pat Mahon oversees construction of the jig for the combing of the electric-powered Zimmer utility launch.

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Information/contact

Contacts for WEST SYSTEM product and technical information

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

Phone 866-937-8797 or 989-684-7286
Fax 989-684-1287

Order Department

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

Europe, Africa, the Middle & Far East

WESSEX RESINS & ADHESIVES LTD
Cupernham House, Cupernham Lane
Romsey, England SO51 7LF

www.wessex-resins.com

Phone 44-1-794-521-111
Fax 44-1-794-517-779
E-mail: info@wessex-resins.com

Australia and the Far East

ATL COMPOSITES Pty. Ltd.
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Queensland, Australia

www.atlcomposites.com

Phone 61-755-63-1222
Fax 61-755-63-1585
E-mail: info@atlcomposites.com

New Zealand and the Far East

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17 Corbans Ave./Box 21-169
Henderson, Auckland, New Zealand

www.adhesivetechnologies.co.nz

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Fax 64-9-836-4849
enquires@adhesivetechnologies.co.nz

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Christopher Tully painting some of his critters.

Tile detail of a 8'×30' relief scene at the Richardson Nature Center, Bloomington, Minnesota. The relief is made of clay, epoxy and acrylics.

Artist Christopher Tully does two unusual things with epoxy in his work. He creates large clay relief scenes with lots of detail made up of many tiles. After they are bisque fired he brushes on epoxy and heats them with a torch so the epoxy penetrates deeply into the porous clay. This creates an extremely strong surface that still has great detail. He then applies a primer and paints it with acrylics and a clear coat. Another method he uses is to first apply fiberglass cloth to a carved panel then add details like plants or animals to the surface with a mixture of epoxy and powdered clay. He says he doesn't need to worry about shrinkage and the details are very strong so he just primes and paints it like any other piece.

Tully became a full-time sculptor after studying ceramics at the University of Minnesota, Duluth. His work can be found in galleries across the country. Today he works on larger more public pieces, which can be found in nature centers, hospitals and public libraries. To see more of Tully's artwork, visit www.christophertully.com.—*MB*

Upper half of a 30'-tall hippo, elephant, rhino sculpture made of foam, epoxy, fiberglass and steel for the Brookdale Public Library, Brooklyn Center Minnesota.

Mousetown, before fiberglass is applied. The 16'×4' foam, fiberglass and epoxy sculpture was commissioned by a private business.

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