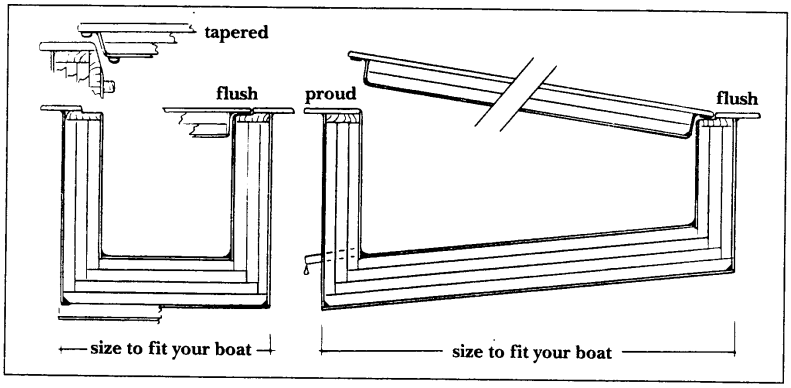
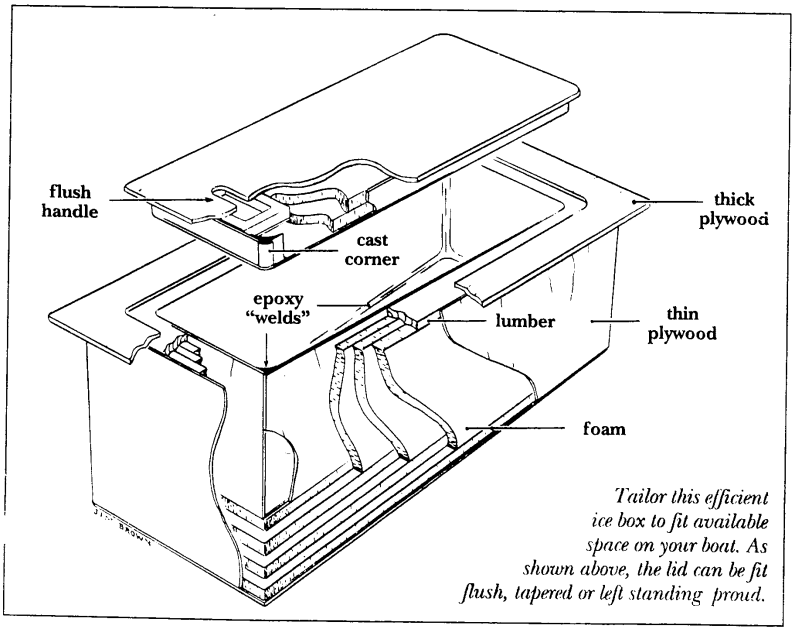
# BUILDING A PROPER ICEBOX

## *Liquid joinery keeps it cool*

Text, photos, and drawings by Jim Brown



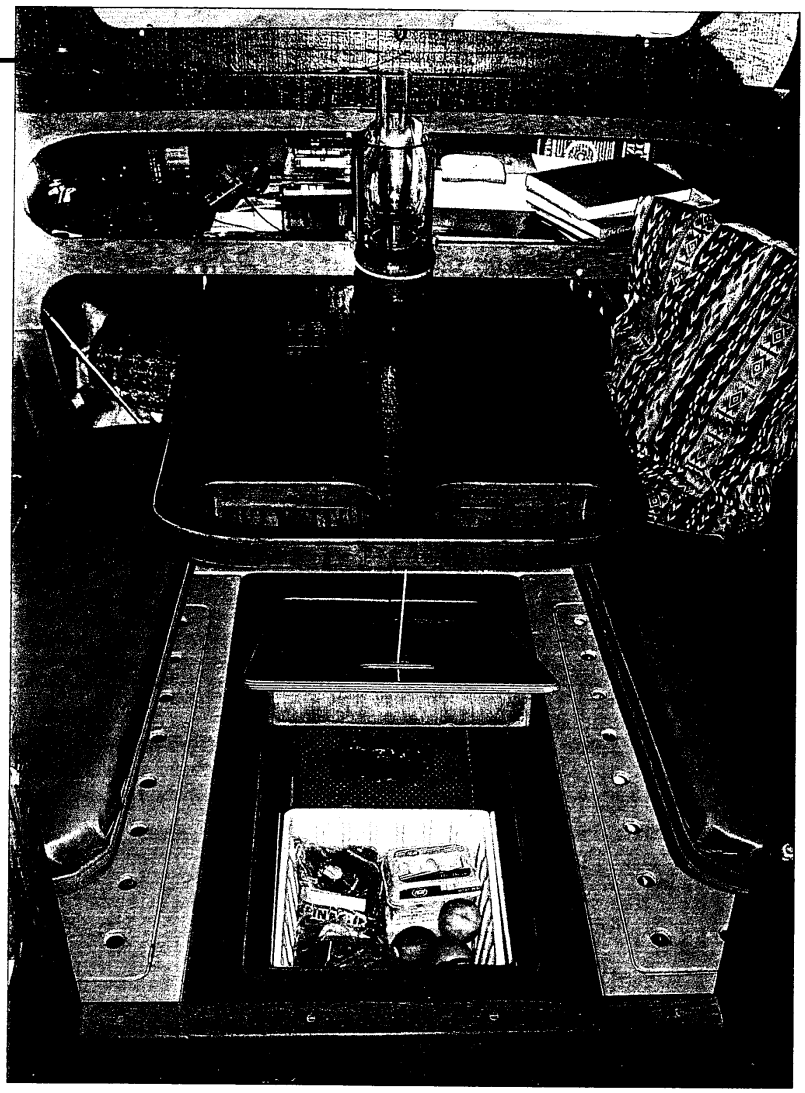




*Tailor this efficient ice box to fit available space on your boat. As shown above, the lid can be fit flush, tapered or left standing proud.*

In some boatshops, epoxy mixed with nonstructural thickeners, like fumed silica, is known generically as *duokei* (pronounced to rhyme with "cookie"). Whereas, epoxy mixed with reinforcing fibers, such as wood flour or synthetic flock, is called *schmutz* (this word rhymes with the apparent plural of foot, i.e., "foots"). If the epoxy is mixed with both thickeners and fibers, which is often the case, it becomes, logically, *duokeischmutz*. (Yes, it rhymes with "cookiefoots.") The two roots often are used singly and interchangeably.

As we shall see, the concoctions bearing these names can be mixed to a spreading consistency like that of mayonnaise or even peanut butter. With a tool such as a tongue depressor or a rubber cake spatula, the stuff can be sculpted into concavities, where it forms something akin to a bead of weld, but with some "beads" having a radius as large as that of a baseball or even a dinner plate. This technique, which can join wooden components together astonishingly well, is sometimes called "liquid joinery."

What can you do with this technique? Well, you can build amazingly complicated artifacts just by hanging the pieces together with tacks and masking tape, and then coming along later to "weld" them together with duokeischmutz. And, rest assured that this material is capable of bonding disparate, highly stressed components



*A wood/epoxy icebox made with liquid joinery, installed beneath the sole in the author's 31′ trimaran. The ice shown is what remained of the first 10-lb block after six summer days in Maine waters.*

into organic, monocoque structures. It has been used for years to build very modern wooden boats, including sprawling multihulls, in sizes commonly exceeding 60′ in length, and t' method is embodied in vessels ι ıfied for passenger carrying by the United States Coast Guard.

However, there's an easier place to begin learning how to sling duokei than at real ships; for instance, at an icebox. And an icebox, in a boat, is a good place to test the long-term effectiveness of liquid joinery, because in wooden boats, the icebox is the first place the surveyor looks for problems. Iceboxes in wooden boats have been responsible for many a big yard bill. Even the modern, nondraining, built-in refrigerator/freezer can be a threat to wooden boats; who knows what's going on behind all that insulation? However, by using the techniques of liquid joinery, you can build a wood/epoxy icebox, or even a refrigerator/freezer, into your boat, and it can be non-rotting, non-sweating, self-contained, separate from the hull, and removable. Even if you don't have a boat, or one that's deserving of a fixed fridge, you can build an elegant replacement for the usual weekender's cooler—only yours will probably keep i· 'or a week instead of a weekend—a . you can explore the myriad uses for liquid joinery in the process.

You wouldn't want to build this icebox, or any other wood/epoxy structure, out of just plain boards. For this construction, the wood prefers to be laminated. Especially, it prefers to be cross-laminated—like plywood. The joints between components, such as the corner joints in the plywood walls of this icebox, are not necessarily attached to each other in the usual manner—that is, with the likes of end-lap joints, mortises and tenons, dovetails, glue strips, or mechanical fastenings. Instead—and here's where the joinery solidifies—they are all "welded" together with coved fillets of home-grown epoxy putty. Ultimately, every surface either is coated with epoxy or is fiberglass/epoxy sheathed, and all glue joints are made with epoxy. Here's a woodworking system that really keeps wood dry!

Sloppy or loose-fitting joints in woodwork, when filled with duokeischmutz, can be stronger and more dimensionally stable than close-fitting joints, especially if the close fit is combined with sufficient clamping pressure to squeeze most of the epoxy out of the joint. You don't have to purposely perform sloppy woodwork to use liquid joinery, but you can get away with it. Even with tight-fitting joints, we usually wet the end-grain of the pieces with a preliminary swipe of straight resin-hardener mixture (no fillers or fibers) and come along a while later with a cream-thick batch of duokeischmutz used as the real glue. The fibers in this glue mix actually hold the two wooden surfaces apart, minutely, thus providing a reservoir of epoxy between so that there's plenty left even after penetration; this makes for a good, juicy joint. Fiber-reinforced epoxy is that rare kind of adhesive that

spans gaps well, and because no real pressure is required to make it stick like crazy, we use just enough pressure on joints to obtain proper squigment, as evidenced by a bit of squeezed-out schmutz all around.

To build an icebox, we're not going all the way with this discipline; but even an icebox is sufficiently involved to tax your skills and judgment. It utilizes lots more wood/epoxy know-how than the obvious corner fillets, and it utilizes other joining liquids besides epoxy, such as contact cement, squirt-can foam, and marine caulk... sometimes all on the same piece of wood! In short, I found this project to fully illustrate the potential of liquid joinery.

Want to try it? I'll include a step-by-step description of building the simple icebox illustrated; but first, you have to design *your* box. Draw it out to scale, because there are several detailed considerations:

The usual minimum inside volume for week-long cruising is about 3 cubic feet, but our space limitations dictated a volume of only 2 cubic feet. Be your own designer. My box had to fit into a void in my old 31′ trimaran. We have used an Igloo on our boat for 18 years, and it kept ice adequately for week-ending (the time frame for which it was designed), but it was annoyingly inefficient for longer cruises. However, it contained two plastic trays that my wife found useful for organizing storage and keeping things dry. Therefore, I was challenged to design the box to fit within existing outside dimensions, and to accommodate the trays inside—and to accommodate at least the minimum thickness of urethane-foam insulation needed to keep ice for about a week. In my box, this turned out to be: 4″ on the bottom, 3″ on the sides, and 2″ on top. These are minimums. Large boxes for use in the tropics, and refrigerator/freezers, need much more insulation; 8″ on the bottom is used sometimes.

Any reasonable shape can be matched with the method described, but be sure to provide clearance for ventilation all around the box (1″ minimum recommended).

Will your box have a door or a lid? Will it fit flush or have a lipped face? Top-opening lids are by far the most efficient for saving ice, but if you use top-opening you must decide whether your lid will stand proud of the counter top or nest flush. Proud ones interrupt counter space, but flush ones collect dirt and spills. My box actually fits under the sole in the dinette. It is usually covered with carpet, and thus the lid must fit flush and have a flush handle. Allow for gasket thickness to achieve a flush lid. A simple icebox can do well with a weather-stripping-type gasket, but refrigerator/freezers want a hollow "B"- or "D"-section vinyl gasket, sometimes available from a large appliance-repair shop. Adhesive backing, provided on some weather-stripping-type gasket materials, sticks more permanently to epoxied surfaces if the epoxy is lightly sanded and pre-coated with contact cement. The point is, you need the gasket ahead of time in order to allow for its thickness when building the box and when buying the hinges and latch.

Whether you have a door or a lid, it must be built to plug the opening, and the tighter the clearance between this lid/plug and its recess, the less space there is for air to circulate around the closure. (Hereafter, I'll call

the thick outer part of the lid the "cover," and the box-like inner part the "plug.") To avoid binding, the plug and the recess into which it fits should be tapered; the smaller the plug, the more taper is required. My lid is long, and swings up from the end; thus, very little taper was needed. But a fully tapered recess and plug can be built with the method illustrated; just schmutz the angled faces together. For freezers, a double-landing closure is desirable, with a gasket at each landing to create a dead-air space between. Furthermore, in real seagoing boats, lids, just like doors, should be secured with a hinge and even a latch, so that they cannot come adrift in heavy weather.

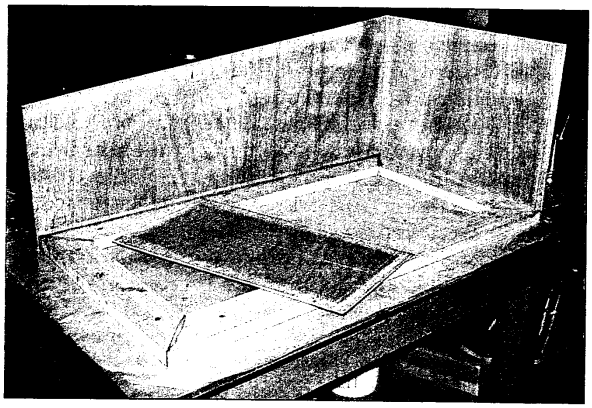
Boatbuilder Gordon Swift suggests that you not install a drain. He says that even if the meltwater is collected in a tank, thus preventing fresh water from entering the bilge, the drain fitting itself always sweats, providing a regular supply of rot-causing moisture to the area where it drips. Instead, Swifty installs a little bilge pump with which to occasionally evacuate the meltwater into the sink. Whatever your choice, meltwater must be removed, or the ice won't last nearly as long. If you use a drain, be sure it is easy to clean and inspect, and that there is a "gooseneck" or low spot in the line where water can collect. This prevents cold air from escaping through the drain; otherwise it will siphon warm air in past the gasket and drastically shorten the life of your ice.

The box should be easily removed intact, either laterally or vertically, for inspection behind it. Furthermore, the opening's face, like the counter top or the cabinet front, should be integral with the box. This allows the walls of the box to permanently support the opening's face, so the lid or door can have a dimensionally stable sash, a tight seat on the gasket, and no binding of the closure.

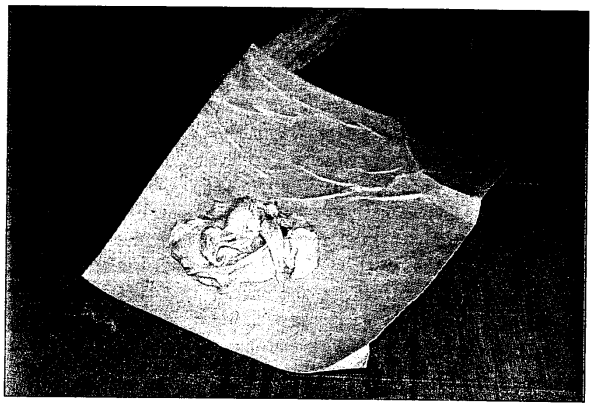
If you're building just a simple, portable cooler (as mine nearly is), many of these complications do not apply. But even a cooler will make good use of liquid joinery. The design of your box may influence the assembly steps below, but you can use my box, and the above design considerations, as a general guide.

With its double-wall construction, a wooden icebox can get heavy, so I used very light plywood—3mm (about ⅛″), three-ply okoume—for both inner and outer walls of the box, and the lid's plug. Heavier plywood—say, ¼″ thick—would be suitable for a larger box, or on the outer bottom of a portable box. If Douglas fir plywood is used, all visible surfaces, inside and out, should be fiberglass sheathed. For the opening's face and the lid's cover, I used ½″-thick, seven-ply okoume plywood. Most counter tops would be heavier—say, ¾″ plywood. Whatever you use for the opening's face, and for the outer lid itself, be sure it is very stable and flat. For the lumber frame around the opening, I used a nice, straight piece of ¾″ mahogany. My material came from Harbor Sales in Baltimore, Maryland.

For epoxy resin, I used the Gougeon WEST SYSTEM products, with the fast hardener. The controversy still rages over which resin is best, but for an "inside job" like this, where workroom conditions can be controlled and where many small batches



*Erecting the initial walls of the box by gluing them to the frame for the opening, which is glued to the counter top or cabinet front.*



*Duokeischmutz mixed to peanut-butter consistency for sculpting, and scooped onto heavy scrap paper, which is ready for rolling into a "pastry-decorating" cone.*

will be mixed for the myriad, separate operations, the Gougeon stuff has the advantage of being faster curing than, say, System Three resin, especially when spread in thin films for coating. If there are no other jobs waiting to be done while a batch is curing, the faster resin helps hustle the job along. But I often use System Three resin, too, for jobs where temperature and humidity are more difficult to control, and where the structure is likely to get knocked around.

For this project I used the "Wood Flour" filler offered by System Three, simply because it was available, and it's inexpensive. I mixed the Wood Flour about half-and-half by volume with Cab-O-Sil, which is the common fumed-silica thickening agent. When the dry powders are stirred into the resin at about two-to-one by volume, the matrix forms a fairly smooth and creamy schmutz, about like Skippy peanut butter, and gives a good color match with okoume or Douglas fir plywood. But duokei doesn't have to match; the often-available, all-white, plastic fillers, or the red microballoons, will produce contrasting "welds," which are quite pleasing if neatly done. Unless you're building an airplane, where "high-crush" filler components are specified, you can usually be your own Julia Child when concocting this stuff. Just be sure to mix the resin and hardener thoroughly first, scraping the sides and bottom of the container, and then add whatever recipe of schmutz you prefer. And, don't dally with it; as soon as you combine the resin and hardener, every second of working time counts for a better, more efficient job.

For insulation, your local building-supply store will likely carry the polycyanurate (urethane) foam used to insulate homes. It usually comes faced with foil on both sides. That's what you want; it's the best refrigeration foam for the money. Buy 1"-thick sheets. Don't use polystyrene foam, or the denser urethane foams designed for structural boatbuilding.

You'll also need "squirt-can foam," the household insulation available from building-supply stores (be certain to get the "non-expanding" type). I also used about a quart of contact cement, and a big tube of marine caulk like 3M 5200 or Sikaflex 241. You may also employ some five-minute epoxy, or even a hot-glue gun, for making "spot welds." Use anything, even props and string and gravity, to hold your components together until you can come along with the schmutz.

For tools, you'll need the usual epoxy supplies, of course, like rubber gloves, dust masks, respirator, plastic squeegees, disposable brushes, and the solvent to clean them. Don't just throw brushes away; a used brush is far preferable to a new one because the loose hairs have already come out of it, or been glued into the head by previous batches of epoxy, so save your used brushes in a covered container of acetone. Paint rollers, however, may as well be disposed of because it takes so much solvent to clean them, and all but "solvent-resistant" roller covers fall apart when cleaned.

You'll need the usual assortment of hand and power tools, including sanders. Your box may require special fastenings, like non-ferrous screws and nails.

I'll describe building this box by the numbers:

**1.** Don't start cutting yet! Instead, see Step 13, and then start coating. That's right, pre-coat all the wood with epoxy and allow it to cure—both sides of your full 4 x 8′ sheets of plywood, and all sides of your milled lumber. If you plan to leave your box with a clear finish, pre-coating avoids color discontinuities, but mostly it saves time and trouble later by ensuring that the material is sealed from the start. Combine the resin with the hardener, following the manufacturer's specified proportions exactly; we'll call this "neat resin" from here on, because it has no schmutz in it. For pre-coating, apply just enough neat resin to wet the surface; spread it with a nearly dry roller, or scrape it almost dry with the squeegee. This thin application penetrates the surface just as much as a thick coating. When cured, it raises the grain. Indeed, it raises every microscopic sliver on the wood's surface, which facilitates a light sanding and stabilizes the substrate for subsequent coatings of anything. A "dry" coat like this also minimizes the formation of bubbles during the initial, and subsequent, coatings. Mahogany, in particular, seems prone to exuding gas from within the wood, inflating myriad tiny bubbles in resin coatings. To avoid this troublesome phenomenon, begin with a very dry coating. Do not coat the wood and then set it in the sun to cure. If anything, warm the wood in

the sun, and take it into the shade for coating, so that it will be cooling—not ating up—during the cure.

**2.** Now you can cut. Size all the box material into rough, oversized pieces per plan for your box; leave about an inch all around for final cutting. Include all the side walls and end walls of the double box, the sides and bottom of the lid's plug, the opening's face, and the lid's cover.

**3.** Stack all similar-sized pieces, clamp them together, and run one edge of the stacks over the jointer. If you don't have a jointer, saw or plane at least one straight edge on all your pieces. This gives you something to "square" from, and it simplifies the layout for final cutting of the other edges.

**4.** Cut the opening for the door or lid. A pocket cut by sabersaw can be utilized for making a flush lid.

**5.** Cut and glue-fasten, permanently, a flat frame to the inner face of the opening. For boxes with flush lids, this frame should extend into the opening by the width of the gasket's landing (about 1¼"), and the frame must now be shimmed away from the , or the frame rabbeted, to allow for the thickness of the gasket. In any case, the width of this frame should equal the thickness of the insulation in the side walls of your box—that is, the inside separation between the inner and outer walls. Mix a batch of epoxy and schmutz powder for making internal glue joints between rigid pieces of wood. Again, follow the specified proportions of resin and hardener (more hardener does not make the stuff harden faster). Then add your duokeischmutz—about half of the neat resin's volume. When all is thoroughly stirred, you want a gluing mix about the consistency of heavy cream. This will reduce sagging and fill gaps. So, go ahead, glue on the frame.

**6.** Attach the side walls and end walls of the box to the frame, permanently, with your same sort of epoxy-glue mixture. I decided to erect my outer walls first, and then build the rest of the box from the inside. Depending on the shape of your box, and the size of the opening, you may wish to reverse the procedure by erecting the inner walls first and building outward from them. If so, be sure to fiberglass-sheathe the inside of the walls before assembly, as in Step 19. In attaching these side walls to your frame, just the slightest mechanical fastening will suffice; use very small ring nails, or even steel staples if you plan to pull them out after the cure. Remember that liquid joinery does not require pressure, just a reasonable fit and a juicy joint.

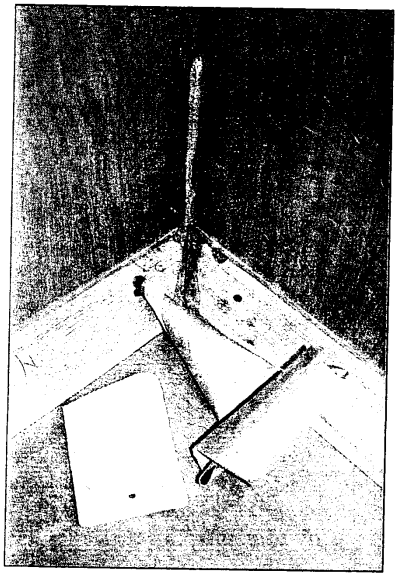
**7.** You're almost ready for some real schmutz-slinging, but first, use masking tape to bring the corners of your box into the desired alignment. (In a larger box, this alignment of components can be done with "spot-welds" of five-minute epoxy or dabs from a modeler's hot-glue gun.) The arrangement of the overlaps, and the size of the gaps between, are not particularly important. Remember, you're soon going to join them all together with something liquid, resulting in a perfect "cast fit" at the joints. For now, cover the entire outside of the joints with masking tape.

**8.** Now's the time to ready your sculpting tools. For my box, I wanted a fillet radius slightly larger than the nickel-sized one produced by the usual sculpting tool, which is a wooden tongue depressor. So, I cut a plastic squeegee, as illustrated, with a radius the same as that of a quarter. Note that the sides of the squeegee are cut at an angle slightly less than 90°, to allow you to tilt the squeegee, and that the sides are wide enough to clean up the mess on both sides of the fillet. A little experimentation, and you'll be crafting your own schmutzers for specific jobs.

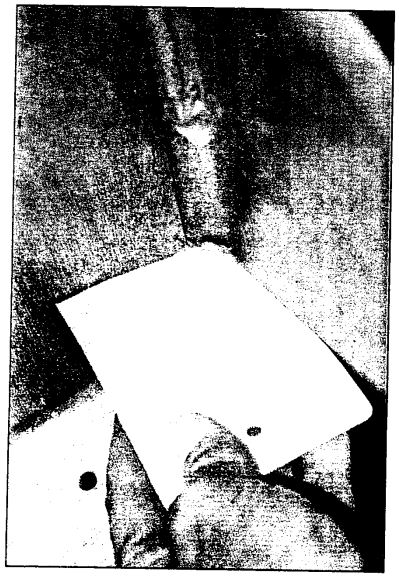
**9.** Pre-wet the inside corners with a little neat epoxy, wetting the end-grain of the plywood by pushing the resin with a brush through the joints against the masking tape outside.

**10.** Mix a big batch of duokeischmutz to peanut-butter consistency, thick enough so that only egg-sized globs will fall from the mixing stick. A batch about the volume of a stick of butter is large enough for starters. Remember, stir the resin-hardener mix thoroughly first, scraping the walls and bottom of the container before adding the fillers. You'll need a big container and a stout stick—and a dust mask on your face, to prevent you from breathing the fibers.

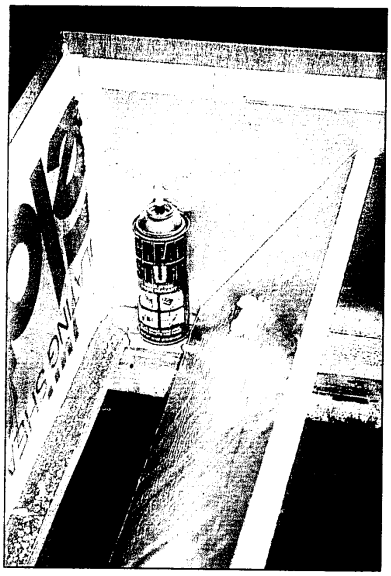
**11.** Working quickly, scoop the mix out of the container onto a piece of kraft paper about twice the size of a



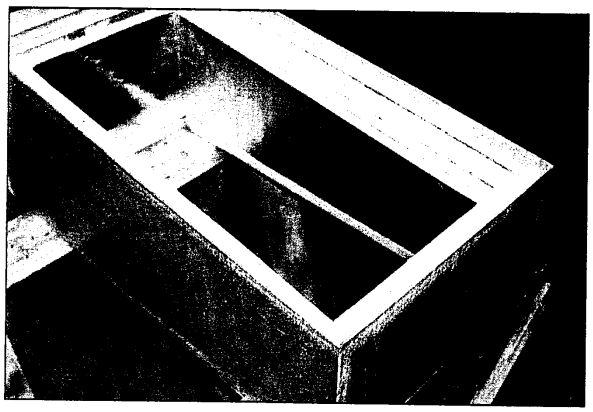
*The "pastry" cone and initial "welding" results.*



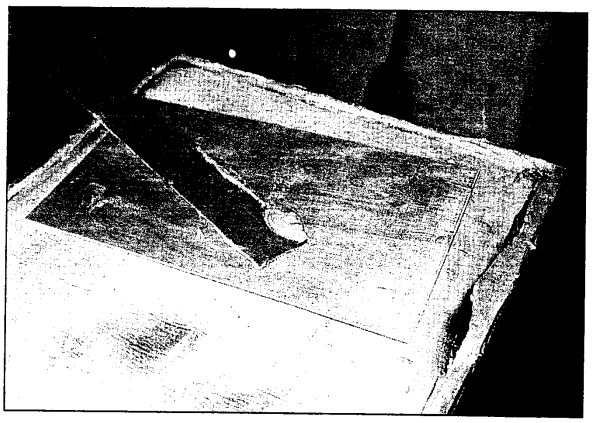
*Sculpting the duokei into coved fillets with a custom-cut plastic squeegee.*



*Layers of foam board (left) are installed with contact cement against the walls of the box. Squirt-can foam (non-expanding type) is used to fill air spaces at the corners.*



*The foam board has staggered end-lap joints, ready to receive bottom foam. Foil is removed at the joints.*



*"Blind duokei" technique involves chamfering the outer edges of the foam (right) to create a small void, which is filled proud with epoxy putty, transferred from a palette of scrap plywoood.*

letterhead (like a split-open manila envelope). Roll the paper into a cone, and double over its top, as if you were going to decorate a cake by squirting frosting from the nozzle of the cone. Then, squirt the schmutz into all the inside corners of your box. The important thing is to get the stuff out of the cone as soon as possible; otherwise it will heat up in there and harden before you're finished. Once duokeischmutz is extruded into those relatively small beads, however, it doesn't insulate itself as much—it can stay cooler, extending your working time. But if it starts to heat up in the cone, discard it without hesitation and concentrate on the step below. You can mix another batch if it is needed to complete the job. Be certain to squirt enough schmutz into the corners. Experience, and the size of the radius desired, will determine how much to apply. If you apply too much, the sculpting tool will remove any excess. Have a palette of scrap plywood handy for collecting the excess from the squeegee. The stuff can be re-used if you spread it out thin on the palette to keep it cool.

**12.** Now, sculpt! Notice how your best fillets are made in one swipe with the filleting tool. That requires applying about the right amount of material in the first place. When it comes to compound or complex cavities, where the bead of weld branches out in two or three directions, don't begin your stroke quite at the apex of such corners; leave enough duokei there so that you can come back after the long strokes are made, and simply drive your sculpting tool around the corner with very light pressure. Any messy ridges left at the sides of your radius can be scraped up with "chisel sticks," which are scraps of thin wood or veneer whose ends have been sanded to a chisel shape. Make a handful of them before you start.

**13.** This should really be Step 1, but to avoid confusing the initial steps, it seems to fit better here. Yet, it is critical: Always get everything ready before mixing epoxy: containers, mixing sticks, gloves, brushes, squeegees, rollers, hand cleaner, brush-cleaning solvent, paper towels, chisel sticks.... Keep your workbench neat, and provide in advance for the disposal of waste material. Mixed epoxy left in a container can heat up during cure, possibly even catching fire. Dump waste in a metal container expressly for the purpose, located where the noxious vapors exuded by hot duokei will disperse outside the shop.

**14.** So now the first walls of your box, except for the bottom, are erected and "welded" together. After the fillets cure, no further structure is necessary inside these joints. If you're building a portable cooler, you may want to apply fiberglass tape to the exterior edges and corners later. For applying the 'glass, see Steps 20 and 31.

**15.** When the fillets of my outer box were cured, I cut and dry-fitted the foam insulation inside it. Of course, your box may be coming along the other way, from inside out. If so, this may require more use of the "blind duokei" technique, as described in Step 17. In any case, by buying 1″-thick foam sheets and using it in multiples, you can graduate thickness as necessary. Stagger the end-lap joints. During this dry-fitting step, scribe the pieces of foam board where they protrude beyond the next layer, to denote

areas where the foil facing is to be removed. Mark all dry-fitted foam for ·r relocation. Remove the foam ..om the box, and skin off the foil by running the foam edgewise through a table saw. I was not able to devise any way to peel the foil off efficiently, so I sawed it off, and depended on the squirt-can foam to fill any air spaces in the joints. Where necessary, chamfer the edges on your foam boards in way of fillets.

**16.** Re-install the foam, permanently, using two kinds of adhesive as follows: Apply contact cement to the large, flat areas, and squirt-can foam in all the corners. Apply the contact cement to both surfaces to be bonded (between all mating surfaces of foil-to-foil and foil-to-box), and allow it to dry. Then run a fat bead of squirt-foam around the edges of the box where each foam piece will go. Install the foam boards by locating them with extreme care, for once the contact cement touches itself, there is no chance of adjusting the foam's position. It is critical that the squirt-foam be the non-expanding type; even this will swell slightly during cure (which t an hour or so), easily filling all the air spaces at the joints. The full-blown expanding type could distort, and maybe even burst, your box.

**17.** Now, here's an application for so-called "blind duokei." With all the foam in place, including the bottom-most or outermost layer, install the outer plywood bottom with contact cement and "blind" fillets. How? Just chamfer the outer edges of the last layer of bottom foam to produce a small void all around, and fill the void proud with duokeischmutz. Lay the bottom on (cut slightly oversized), and weight it or tape it down during cure. Presto! A "blind" fillet/joint. With this technique, you can build practically anything!

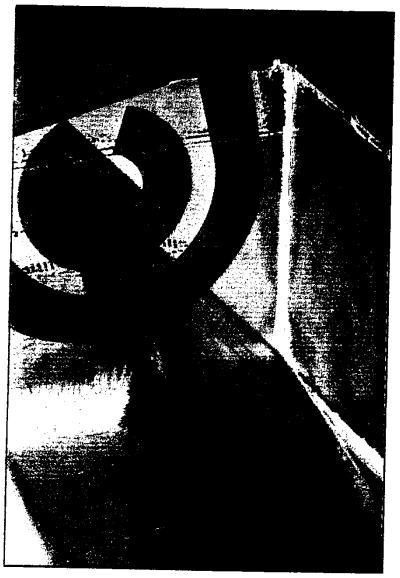
**18.** Now, you've got the outer box built. When it's cured, you can clean up the edges with a sander, and/or run the router around it to bullnose all the edges, and apply an initial coat of neat resin to these raw areas. Turn the box over, and prepare to install the inner walls. Note how rigid and lightweight it is.

**19.** Because my box was built from the outside inward, now was my time to dry-fit the plywood walls of the inner box. I fit the sides first, then the bottom, so that the bottom could be used to press the sides outward against the foam.

**20.** Then I removed these inner walls, and sheathed them with fiberglass while they were outside the box. In this type of operation, don't pre-cut the fiberglass cloth to match each panel; it'll move around on you during wetting-out with epoxy. Instead, lay out all the panels over polyfilm and sheathe them all at once with an oversize piece of fiberglass cloth. This process we call "gang sheathing." Six-ounce cloth is sufficient, but you may wish to put two or three (extra-large) layers on the inside bottom panel, to resist jabs with the ice pick. Lay the cloth over the dry panels, and apply the neat epoxy directly to the dry cloth with a roller or squeegee. (You can even wet through the two or three layers of fiberglass on the bottom panel all at once.) Make this first application fairly dry—just enough resin to turn the cloth transparent—no white spots. When this first application is done, the surface should not look wet or glossy anywhere; rather, it should look like honey soaked into hot toast. Too much resin, in this bonding application, will cause the fiberglass to float above the wood and leave lumps, so work lean. When this bonding application is cured just "cheese-hard" (don't wait overnight if you can help it), apply a second coating of epoxy, and this time flow on plenty. You're working on a horizontal surface here, which is the best reason for not trying to fiberglass the inner walls of the box after assembly, when it has vertical surfaces. You can really flow the resin onto a horizontal surface, which saves applying several thin coats, plus saving you the drudgery of sanding out the inevitable sags associated with vertical surfaces. You don't want puddles on the flat, but the epoxy should completely bury the weave of the cloth. When the final coat is cured cheese-hard, trim the edges with a knife, separating the panels.

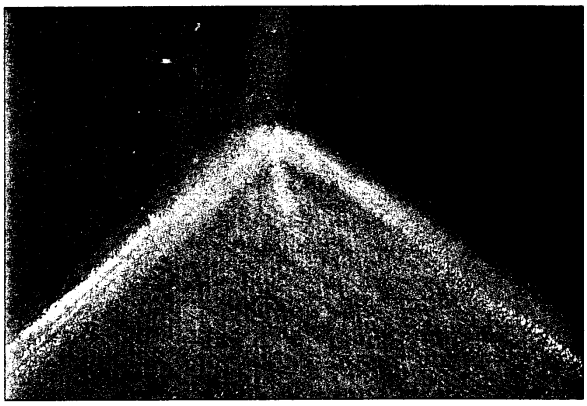
**21.** Wash these fiberglassed panels with water. Notice that the glossy surface is covered with a slightly greasy film. This film is called "sweat-out." It is evidence of the epoxy's hardener attempting to react with water vapor in the air—the more humid and cold the day, the more sweat-out. Sweat-out can

*The outer plywood bottom has been schmutzed into "blind duokei" and held with tape until cured. All outer corners are bullnosed later, and fiberglass-sheathed if desired.*

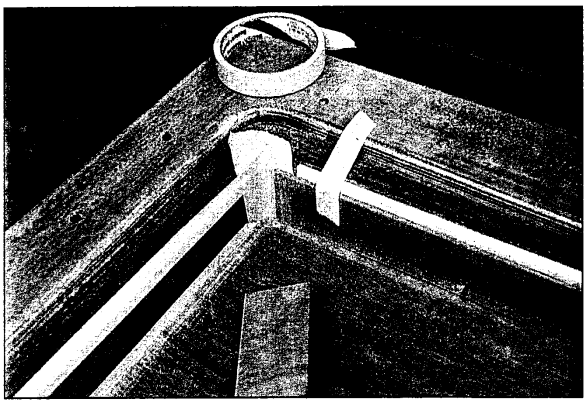


*Pre-fiberglassed inner box walls are installed using contact cement on the wide flats, marine caulk behind the corners, and epoxy glue at the upper edge-to-frame joints, each adhesive having a different purpose.*

*Corners of the inner box after filleting.*



*Making the lid's plug over tape shims for clearance.*



inhibit the bond between successive coatings (especially if the initial coat is cured hard), and it can weaken the "weld" in the corners of your box. So, wipe it off with a wet rag. That's all, just water. It'll jump right off onto the rag. Because you'd like to avoid wetting the end-grain of these pieces, a few passes with a damp rag will suffice, if it is wrung out in a bucket of water between passes. When your glossy surfaces are dry, notice that they are no longer "greasy." That's good; but, just to make sure, you should sand off the gloss from these inside walls with 120-grit sandpaper. If you don't wash first, the "grease" could clog your sandpaper.

**22.** If you have built from the outside inward, you're ready to install the inner walls of the box. For good practice, we'll use three, or even four kinds of adhesive. Use contact cement on the big flats (to hold the inner walls against the insulation foam), use squirt-foam (to fill any large dead-air spaces in the sheet foam), use epoxy glue around the frame (to structurally bond the box walls to the frame around the opening), and use marine caulk behind the corners (to fill and seal any small air spaces there). Note that all three of these liquid joiners serve a different purpose, and the only mechanical fastenings used are masking tape and maybe a few small nails or staples around the frame; and they can be removed later. Any gaps in the vertical corners were simply schmutzed into oblivion by the final, inside fillets.

**23.** Here, in the actual service area of the box, is maybe the place to get fussy with your final fillets. If you want, you can wait until they get "Jell-O hard," and wipe them with a sopping, acetone-soaked rag. They'll come out super smooth, and needing not one swipe of sandpaper. After everything is cured, you can round the upper corners at the frame and apply the initial coat of resin to this raw joint.

**24.** Install accessories such as runners for trays or shelves, and maybe a drain. This can be just a nipple of plastic pipe, sanded, and bonded in with duokei to extend outside enough for attaching a drain hose to a meltwater tank—such as a collapsible plastic jug.

**25.** Apply another thin coat of neat resin to all the raw joints, allow it to cure, and give everything a light sanding. Repeat as necessary. Don't sand through to raw wood. Get at least two full coats on everything, three on end-grain plywood.

**26.** Now you can apply a final, thin coat of neat resin everywhere, inside and out. But, watch out for those vertical surfaces! Just the lightest coating of resin is in order, perhaps thickened with a little Cab-O-Sil at about one tenth the resin's volume, or else the stuff will sag like crazy, leaving you to sand and re-coat. I think there's nothing like a roller for spreading coatings thinly and evenly. A paintbrush, if used to apply resin, seems always to produce sags and brushmarks, but a dry brush can be used to "tip off" the stipple of a rolled coating, if you wish; make vertical strokes.

No, you're not finished. The lid, or door, is a box in itself, and it has to be fitted into its opening with a minimum of air space created around the plug. As mentioned earlier, a tapered recess and a tapered plug are required in most installations, but their construction is similar to what's been described so far—just stick them together with that old devil, duokei. The techniques of liquid joinery permit the plug to really fit its recess. Here, with the numbers continuing, is how to "cast" your plug with wood/epoxy:

**27.** Erect a shore or platform inside the box on which to drop the lower, inner surface of the plug.

**28.** Apply at least two layers of masking tape to the sides and corners of the recess, where the plug's side walls will engage the recess. Smear paste wax on the surface tape, especially in the corners.

**29.** Using more masking tape, fit the plug's side walls in place against the recess. If the plug is tapered, these pieces must stand proud of the gasket's landing by the thickness of the compressed gasket, or about two-thirds of its relaxed thickness. Note that these plug pieces must end short of the corners, in order to allow room for the corner radii that you made inside the box (they are now lurking beneath the waxed masking tape).

**30.** When you're sure the above conditions are met, go ahead and fillet all the plug's concavities, actually casting the corners of the plug with duokeischmutz against the waxed tape.

**31.** If you're worried about these large corner castings, you can apply

small fiberglass patches, cut round to about the size of a plum, against their inside surfaces. Note how the round patches will contort to complex shapes; they can be applied even while the casting schmutz is still wet. Round patches, several layers of them in staggered sizes, can also be used to reinforce the outside corners of a portable box.

**32.** When the epoxy has cured, separate the plug's box from its recess, just to be sure it isn't stuck. Then, return it to its position in the recess, and fill it with foam board. To avoid distorting the shape of the plug, these pieces want to be sized to fall in place of their own weight; be sure this foam exerts absolutely no pressure against the side walls of the plug. Then, install the foam with contact cement. No squirt-foam should be used here, however. Marine caulk is OK, but don't use anything that could swell and cause your lid to stick.

**33.** Attach the thick cover (the actual lid or door) to the plug's foam with contact cement. If the cover is flush like mine, extreme care must be used in locating the cover on the plug, with shims fitted into the kerf all around the cover to assure clearance everywhere. Remove the assembled lid, and apply *small* schmutz fillets at the plug-to-cover joint. Shape the assembly, making sure it will fit into the recess without binding, all before the double masking tape is removed.

**34.** After removing the tape, proceed through final coating of the lid or door, and install the gasket and hardware. Does the closure stick anywhere? Is the gasket squeezed all around? If not, fix it now or forever lose your ice.

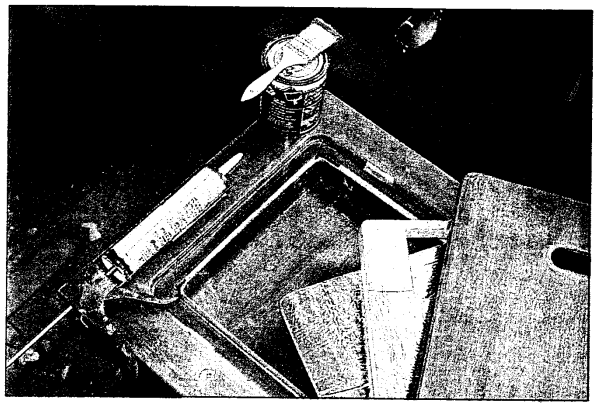
**35.** Well, you're close to buying your first ice block, but first you've got to get this unit installed in the boat and hooked up to the drain—if you have either. And, maybe now's the time to decide if you want to paint the box. The clear, new epoxy finish is attractive, but it will dull with use, and coolers exposed to the sun must be painted white, at least on top. Otherwise, you'll broil your ice and frizzle your epoxy; neither one lasts in ultraviolet light. As for the insides, maybe it would be nice to be able see where mildew is growing, eh? We use two-part epoxy primers, over freshly sanded resin coatings, and any kind of topcoat over that.

There are other things to say about the wonders of liquid joinery. It's messy and fabulous. Also, it can be dangerous to handle; you must learn to work clean with this stuff to avoid exposure to potentially dangerous materials. Solvents are the worst. The fabulous part of liquid joinery will be evident from even your initial projects. It makes things that are almost rot-proof, and wonderfully strong and lightweight.

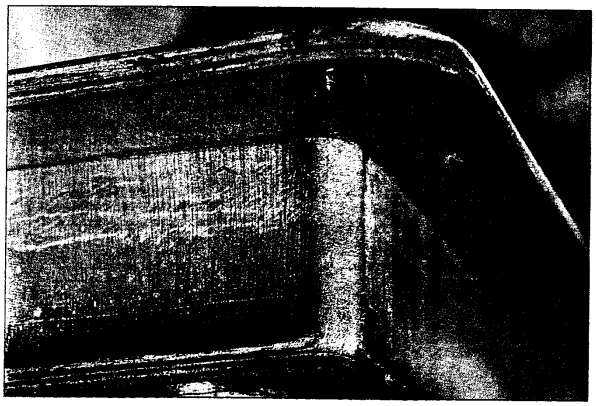
There are lots of things to say about refrigeration systems afloat, too. A real fridge on a boat can be troublesome and expensive and, like liquid joinery, fabulous. There are relatively new technologies available, such as the engine-driven Sea Frost system offered by C.F. Horton & Co., Inc., of Dover, New Hampshire, and the solid-state, thermoelectric process offered by the Cool Corporation of Minneapolis, Minnesota.

Whether you just decide to buy ice, or opt for the Freon frenzy, the right place to start is with a good box, and duokei will do it. Have a cold one!

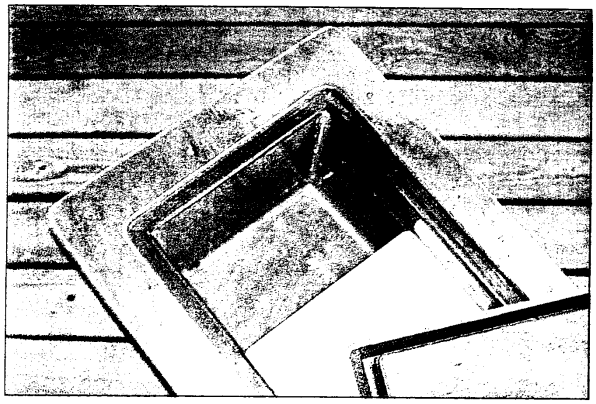
*Multihull pioneer Jim Brown designs, builds, and writes about boats.*



*The lid's plug ready to receive insulation, and the outer cover with flush handle.*



*The lid's plug with "cast" corners, before filleting against the underside of the cover.*



*The completed project, with an interior plastic tray on runners, and a gasketed, flush-fitting lid.*