WoodenBoat One-Off Wood & Canvas Canoe

When European-Americans decided to replicate the native bark canoe in the later part of the nineteenth century, they faithfully reproduced some aspects of the craft while using a construction method which was decidedly different. Not only did they replace the highly prized bark of the paper birch with cotton canvas, they inverted the construction process. Whereas the natives started with a roll of bark and built the canoe from the outside in, the Europeans started with the ribs and built the canoe from the inside out. At least that is the process we now know was used.

What we think of now as the "traditional" method of building wood and canvas canoes on a solid form with metal straps beneath each rib (to facilitate clench-nailing the thin planking to the ribs), was almost certainly not the first approach. While it is possible some folks tried using canvas in the same way the native's used the bark, because of the differences in materials, as well as differences in boat-building heritage, alternate methods of construction were developed. When I first started building wood and canvas canoes in the 1970's I may have replicated some of the European/American's process. I tried different methods including an approach much like the one detailed here, before I, too, settled on the solid form with metal straps beneath the ribs. This solid form made construction of a wood and canvas canoe, if not easy, at least relatively straight-forward. There were limitations to the solid form however - once a form was built, for instance, it was very difficult to make significant changes. While the native could build a canoe any length and any width he wanted, with varying amounts of rocker, those of us following the solid form method were pretty much stuck with the size and shape we had.

Later in the 1990's, a customer asked me to replicate a canoe that he had, one he especially liked and one I doubted would have much mass appeal, I decided to dabble once more in an "open-form" wood and canvas canoe construction. In the years since, I have come to appreciate this method as a way of developing new models and have felt it offers a favorable alternative for those wishing to build only one or two of a certain kind of canoe. It holds special appeal, I think for those contemplating a larger canoe (because the solid form would be especially cumbersome), or those with a lifestyle that perhaps has begun to resemble the semi-nomadic natives and they simply don't want to cart around or store a heavy solid canoe form.

This "open form" method differs from the solid-form method primarily in that the form consists of station molds not completely covered with stripping, as in the solid form, but instead has ribbands spaced several inches apart. The ribs are then bent over these ribbands. The obvious limitation of this method is that there is no metal band to help clench the tacks holding the planking to the ribs, so, instead, a hand-held iron is employed. There is a potential problem also in that the thin cedar ribs, common in this type of canoe construction, could be easily crimped when bent over ribbands spaced at intervals. My first attempts at avoiding the crimping may have resembled bark canoe-building methods by pre-bending the ribs "above" the form before bringing the ribs into contact with the ribbands. This actually worked fairly well, though it demanded a certain

amount of skill and took more time. Later I stumbled on a solution from modern science - a flexible plastic strip that can be slipped under the rib to be bent and is used like a temporary form spanning the ribband spacing. The next hurdle was developing a way to readily remove the ribbands as the boat was being built to make it easier to clench-nail the planking to the ribs. Again, I have found plastics in the solution – electrical cable ties prove to be an easy way to cinch the ribband to the form and are also readily snipped when the time comes to remove it.

The process of building the open form begins the same as for a solid form. Plywood stations cut to the cross section of the hull at the station intervals are mounted on a level building platform. When doing demonstrations out of the shop I use two 2x6's ripped so they have at least one straight edge to make the platform. I prefer a building platform for canoes to be 16" wide and so cut pieces of 2x4" to 16" lengths and mount them onto the 2x6's at the station lines and attach the plywood station molds to the 2x4's. With a symmetrical canoe I will place the center station in the middle of the platform and measure the station intervals from the center of the ¾" thick plywood stations.

I mention a symmetrical canoe scenario only because that is the norm for traditional canoe designs. The design I am describing in this article, however, is not symmetrical. This is a canoe with a transom. You could call this a square stern canoe but with a 42 inch beam and a 30 inch side transom, in my mind it is a "sportboat" similar to the Grumman sportboat I knew as a boy. Whatever you call it, it is anything but symmetrical and so the station molds are all mounted to one side of the station lines, either on the side towards the closest end of the boat if you want to bevel the stations or on the side toward the center of the boat if you don't. Another difference between this boat and the average canoe is that it has a slight "V" bottom. To hold the "V" in the bottom a keelson or structural member inside the boat is planned to a rolling bevel reflecting the angle of the "V". A sportboat could be built with an arched bottom and no keelson would be required, though, given the forces on a boat that may be driven by a motor, I think the keelson is good idea in any event.

When building my forms I like to add a piece I call the "keel-backer" which is fitted into slots cut in each station mold. This is usually gotten from a 1x4 and can be marked with the station lines, which is helpful when aligning the stations. From the plans you can pick up the depth of the keel-backer at each station and by plotting these depths you will define the rocker to the boat. Using a fairing batten you can check the fairness of these points and saw out the rocker. This is helpful in settling any arguments that may arise when the station molds are set. A plywood mould I call the stem backer is used to define the bow in this boat or the bow and stern in a symmetrical canoe. I attach this to the second station in from the end of the canoe. The last station is made from two pieces that are screwed to the sides of this stem-backer. I usually use 2x stock of fairly clear pine or spruce for this. These last stations should be mounted to the side of the station line toward the end of the boat and are beveled to match the changing angle of the boat and serve as a landing for the ribbands. I will normally screw the ribbands to these stations. In this boat I screwed the ribbands to these last stations and also to the piece I call the transom-backer in the stern. All other ribband connections will be covered by ribs and

therefore need to be fastened in a way the fastener can be easily removed without disturbing the rib.

Looking for the best method to connect the ribbands to the stations took a circuitous course. I began using the plastic electrical ties, but found they were not strong enough to pull the ribbands into the twists needed toward the ends of the canoe. Where the electrical ties broke I switched to steel wire. It did its job, though was quite tedious and, as I discovered in a class at WoodenBoat School, could result in some minor nicks and cuts: we nearly emptied the first aid kit of the Band-Aids. It was on the drive home from that class that I realized I could side-step the problem by rounding the corners of the ribbands. If the ribbands were round in cross section there would be no need to twist them and the plastic ties would be strong enough throughout. When using ¾" thick ribbands I have chosen to drill a hole large enough for the tie to pass through, whereas when I have used 9/16" thick ribbands I have simply rasped a cut diagonally across the ribband at each station so that the electrical tie would fit into the cut and be looped through a hole in the station and cinched up and thus not be proud of the ribband and interfere with the ribs.

For ribbands to build this sportboat I chose white ash. It is strong and also flexible and somewhat readily available. If you can't find ash in the lengths you need I would suggest gluing sections with a 10 to 1 scarf joint to make up the length. In lieu of ash, of course oak would work and probably a variety of other woods. It is important to have a ribband at the turn of the bilge. This is probably the most defining line in the hull, so I start by running a ribband along the line of the centers to the bilge radius at each station. I then divide up the area on the center station so that there is a ribband at least every four inches. You can simply attach a ribband at this center station and then run it out to the ends and mark where it intersects each station. This way your ribbands will follow a flowing line. In some areas the ribbands may bunch together and in other areas they may be further apart. Bunching is not a problem and greater spacing is fine if it is in an area where the curve of the station is very relaxed.

When setting up the form it is important to keep the stations in proper alignment and check that all parts of the boat form fair curves. The inwales are clamped to an inwale-backer which was first screwed to each station mold at the sheer line. This, of course should describe a fair curve. If it doesn't spend the time necessary to correct it and keep in mind that when changing one thing you maybe changing several others. You definitely want to end up with inwales on both sides that match in height. Careful work should yield accurate results. It is also important to see that the stem-backer not develop a twist. This piece is held in position at the second-to-last station and is also screwed to the building platform. This leaves the edge where the actual stem is to go free to twist or curve. The bilge ribbands can do a good job of keeping these pieces in alignment. I have also found that pieces of plywood can be braced against the second-to-last station and, run at an angle up the stem backer and screwed to it, can help keep this piece on course. Again, working carefully will pay off in keeping the form in proper shape.

With the form set up you can begin attaching the inwales, stems, and in the case of this sportboat; the transom. The stem will be notched to accommodate the ribs. Ribs can

usually be bent to within a foot of the bow end of the boat. Beyond that ribs cut in half can be installed, tucked into the side of the stem, after the boat is off the form. The ribs for this type of boat are wide and thin. I recommend 2 ¼" width and 5/16" thick. The thickness can vary. I will use thinner ribs, down to ¼" for solo canoes and in the ends of the tandem canoes and may use up to 3/8" thick ribs in the center of larger freight canoes. Normally the ribs are made from northern white cedar (Thuja occidentalis). This is a tree that grows with the paper birch (*Betula papyrifera*) and was a favorite for bark canoes and remains the favorite for wood and canvas builders as well. Other species have been used successfully, however. Whatever wood is used, the ribs bend best if steamed. Since steaming will drive the moisture out of the wood, you can even use green lumber for this. If not green, then air-dried is best and I have found it important to soak the stock beforehand. I soak the ribs in water for several days. This will make them supple and it helps them to hold their shape once bent. An alternative is to boil the ribs. This does prevent the moisture from being driven out and can yield good results as well. I would go with whatever method best fits your situation.

The ribs are bent over the form and nailed to the inwales on each side. This is the same as with a solid form. The difference here, as opposed to the continuous curve offered by the solid form, we are bending over the strip of 1/8" polycarbonate plastic. This will offer a *temporary* continuous curve for us to bend against. Once the rib is bent the strip of plastic can be slid out from under the rib and the rib can be put into place gently over the ribbands. Normally a 2x2 strongback is attached to the form so that the ribs can be slid beneath it and held tight to the form at the keel line. This strongback can easily be attached to the keel-backer with some utility screws. With this method a gap must be left between the strongback and the form to allow not only the rib to pass, but also the plastic strip. This means that once the plastic strip is removed the strongback will not hold the rib tight to the form. An easy solution is to use construction shims to force the rib tight. In building this sportboat, since it has a keelson already installed, no strongback is necessary; the ribs are nailed tight to the keelson. Also, in this boat, with the shallow "V" bottom, the ribs are to be nailed to both faces of the shallow "V" which has been planed into the keelson, so the ribs define the "V" shape. A technique I use here is the same as where the ribs are bent over the stems and involves lining the pencil-drawn center line on the outside face of the rib directly over the apex of the "V". This allows the outer fibers of the wood to partially break at the pencil line encouraging the rib to fold at the center rather than attempt a bend, which keeps the "V" bottom sharp, as the design intends.

Getting the ribs to take the shape of the form is vital to keeping the boat true to its design. I find well soaked ribs and hot steam are a great help. Holding the ribs in place is also important. I often use wooden toggles that can be screwed into a ribband and hold two adjacent ribs tight to the form. I use the same toggles on the solid forms. It is important in either case that these props keeping the ribs in place remain in place until the ribs are dry and set. It is perhaps more critical in the open form process since the ribbands must be removed or at least moved for the planking process to begin. Near disaster was narrowly diverted when trying to demonstrate this method during a particularly humid week on the coast of Maine. In order to proceed with the planking the day after the ribs were bent involved drying them with heat lamps and a wood stove on a 70 degree day. Fortunately,

building this sportboat in Minnesota during winter insured that the ribs were set the following morning.

Before starting to plank the canoe I always leave the ribband at the bilge on the form and normally remove the rest, but still timid from the experience in Maine I chose to only remove the first three ribbands in the bottom of the boat. Because this is a square-stern boat I was able to pull the ribbands that I wanted to remove out the rear without releasing the clamps holding the inwales. Normally, in a double-ended canoe I will release the inwale entirely. When doing this great care must be taken to return it to the original position after the ribbands are removed. Locator marks can be made in the inwale and inwale backer and the inwales can be snugged back in contact with the cross palls at the sheer line.

I left the transom off the form until these ribbands could be removed and then clamped it to the transom-backer so that the planking could be nailed to it as it was being installed. I waited until it was clamped in place to finish planing the rolling angle at the transom edge using the bent ribs as a guide. The first plank runs straight down the keel line and in this boat can be nailed through each rib into the keelson as well as being clench-nailed to the ribs. The three inch wide planking receives three fasteners per rib in a pattern that allows the fasteners to be spread out on the rib so as to narrow the distance between fasteners from rib to rib. Care should be taken to not get too close to the rib edge to prevent splitting out the rib or sending the clench nail through the beveled edge of the rib. The fasteners on the edge of the planking should be close enough to the edge that the head is within an 1/8" of the planking edge. This will help prevent curling and keep the edge tight to the rib even after it has been water-soaked from use.

The clench nails used are sharp-pointed cut brass nails, about ¾" long with a dome-shaped head. This head allows the nail to be countersunk when clenched so that the hull can be sanded smooth on the outside. I have found automotive dollies make the best clenching irons for this purpose. A thin iron which I bought from an auto body supply house varies in thickness from ½" to ¾" with a slight crown to one surface works well in flat areas of the boat and an iron called a Martin Wedge, which tapers quite thin on one end and has a large curved end that offers a grip on the other end works well throughout the boat, though because of its higher crown is a bit problematic in the flat areas. A canoe clenching iron can also be used, though is not quite as versatile. The iron is slid under the rib where the nail is to be driven and, when held tight to the rib, will clench the tack, turning the tip around into a "U" shape and sending it back toward the head. This is a fairly primitive, yet effective way to join two pieces of wood. Both of the automotive dollies are thin enough to be slid between the ribs and the station molds and can clench the nails in these hard-to-reach places as well. It might be some of the nails cannot be clenched or clenched well because of the form. In these few cases it is best to just wait and install them after the canoe is off the form.

I find that when using ribs 2 ¼" wide spaced on 4" centers there is just enough room to slide my hand through and hold an iron to reach the nail being driven at the farthest edge of the plank. Unfortunately I chose to make the ribs for this sportboat 2 3/8" wide. While

you wouldn't think making them just an 1/8" wider would make much difference, it did. I banged and scared myself up trying to squeeze my hand through the rib spacing in the bottom of the boat. My helper suggested putting on a leather glove and this helped a lot. It was still a bit of a struggle but at least didn't hurt as much. Some of these far-edge nails I just left out and it was no big deal to put them in when the boat was off the form, so my self-mutilation was really for naught.

The thin cedar planking for the wood and canvas canoes can be easily shaped and each course is planed to meet the preceding course. The first course goes on straight down the keel line and is fastened to the stems with ½" ring shank nails. In this sport boat it is also fastened to the keelson through the ribs at the centerline of the boat. Normally, in my canoes, the next three courses of planking on each side of a canoe are run full-length. In this sportboat I ran the next four courses full length. At this point it is necessary to start making up for the difference in width at the center of the canoe from the ends. In all my canoe models I run three courses of planks at the bilge which fair into one course that parallels the last full length plank coming from the stem. From then on it differs a bit from model to model, but I try to have a course at the center of the boat fair into another course coming from the stem and make this intersection at a rib thus avoiding planks which are planed into little points that might not even land on a rib. In the sportboat things were laying out a bit differently so I just had to wing it. I only used two bilge planks and these ran fairly thin all the way to the transom and faired into one course from the stem. From there I filled in with planks fairing into other planks at ribs as best I could. In these areas you will need at least some planking that will taper a great deal. This is an ideal situation to use up material with some wane on an edge or other defects that would not be used elsewhere, so before starting the planking process I try to plan ahead sorting out which planks to use where.

Most of my planking stock is eight feet long. This is what is available. I can occasionally locate a log or two that can be gotten out longer, though often it is only clear for six to eight feet anyway. It really isn't a problem to use these shorter lengths, and it offers some advantages. I just try to scatter the joints out as much as possible, especially avoiding joints on the same rib. The joint, per se, doesn't weaken the structure, but the typical six nails used at a joint may weaken a rib and cause it to split. You might want to pre-drill these holes right through the planking and the rib.

Whether building on a solid form or this one-off open form it is best not to plank the canoe all the way to the gunwale while it is on the form. For one thing you will be on your knees trying to get the perfect fit and crawling along as you go. Taking the canoe off the form and turning it right-side-up puts your work at a more convenient height and there is the additional advantage of being able to see exactly what needs to be taken off a plank to fit. Using spring clamps, you may attach the plank in place and simply trace along the upper edge of the previous plank to determine the shape of the new plank. Continue installing planks until the entire canoe is covered up to the sheer line. Let these last courses run above the inwale and do not nail them to the inwale at this time. The planking can be trimmed lower than the sheer lines to allow a rabbeted outwale to cover the edge of the planking and canvas. To make this cut in the planking, first run a scribing

jig which has a hole for a pencil putting the point ¼" below along the top of the inwale making a pencil line where the planking can be cut. It can be scored with a sharp knife until cut through. Once cut, pilot holes can be drilled for bronze ring nails to attach the planking to the inwale. Because of the number of fasteners into the inwale I nail the planking only at every other rib (the other ribs will get the screws to attach the outwale).

At this point in the process you will have something that looks remarkably like a boat – though not a completed one. There is still plenty of work to be done. Before covering with canvas all the clench nails need to be checked or reclenched to insure they are tight and the nail heads are countersunk below the surface (this is also a necessary step when building on a solid form). You may need to add nails which were hard to place when the boat was on the form and replace nails that didn't properly clench (nails which have just simply folded over are not well-clinched). When this is done the hammer blossoms can be swelled out with hot water and the hull sanded smooth. I use an 8 inch diameter pad on a disc sander. Any bumps or ridges on the hull will be transmitted through the canvas so care is advised in sanding. I have found working a large 40 grit sanding belt across the grain is the best way to smooth these out the bilges, and a straight sanding board will flatten areas in the bottom and sides of the boat.

I used a #8 duck on this sportboat which is stouter than the #10 duck I normally use on canoes. The heavier canvas will take on more filler. This boat drank up close to two gallons of the linseed oil-based filler which I rubbed out smooth by hand. Linseed oil stays flexible for many years making this filler ideal for this use. It also takes quite awhile to fully cure – approximately three weeks at room temperature – before it can be scuff sanded, primed and painted. In the meantime the filler was stable enough in a few days that I could work on the inside, sanding the top face of the ribs and installing the seat risers and spray rail. I mounted these opposite each other and screwed them to each other, through the ribs. It is more common to first attach the seat riser before canvassing and then screw the spray rail on in a different location, but I liked the idea of sandwiching the ribs between the two so the screw heads are countersunk into hardwood rather than the cedar planking or ribs.

Normally I paint the outside before installing outwales, leaving the canvas hanging down as a mask to the ribs and inwales, but in this boat I chose to trim the canvas and install the outwales first and then mask them off for painting. Either way is acceptable. Also, while the canoes are rarely fitted with keels, this boat, which might be used with a motor will definitely benefit from having one. I felt it necessary to bring the keel out level in the stern as is done in most rowing boats, creating a small skeg which makes up for the rocker in the stern. Here I decided to fit a triangular piece in the stern, screwing it into the keelson and then mounted a continuous keel covering this triangular skeg and tapered it into the stem at the bow.

With outwales fastened, the ribs can be sanded flush to the gunwales. The exposed corners are rounded with a router and by hand sanding. Seats are screwed into the seat riser and knees installed to the inwale. Once the boat is varnished and painted a brass stem band is installed to the stem and oar locks mounted.

Now for the hard part: waiting for ice to go out of the lakes to give her a try.