Centerboard Removal
(3/29/2011)

I've determined that proper inspection and repair of the keel and deadwood requires that I remove the centerboard. This turns out to be a substantial undertaking. First, I must raise the boat high enough so that the board can be removed from below. On delivery, the boat was set on blocks 16" off the floor. Since the board is 28" deep, I will need an additional 16" of blocking. Next, I must remove the pin acting as the centerboard pivot. Then, finally, lower the board to the floor where a cradle will be waiting to hold it (the board weighs about 500 lbs). Raising a 9 ton boat without a proper hoist is a scary proposition. A boat with a lead ballast keel, such as this one, has much of its weight concentrated in the lead keel. So wood timbers are used to support the weight and a series of screw jacks called poppets are used to balance the boat.

To lift the boat, the strategy is to use bottle jacks to raise the boat slightly and simultaneously tighten all the poppets to keep the boat balanced. It's very important not to rely on the poppets to support much weight, otherwise the hull could be damaged. Of equal importance is keeping the boat balanced and on stable blocking so that it doesn't fall off of the blocks. The process is deceptively simple but one careless mistake can lead to disastrous consequences! I offer the following advice:

- Use two bottle jacks. One (heavy duty) under the lead ballast and a smaller one under the keel aft. The big jack should be positioned as close to the boat's center of gravity as possible.
- For the ballast, use a bottle jack that is significantly oversized for the job. I used a 20 ton jack for a 9 ton boat. You want the base to be very stable with enough safety margin to insure a seal doesn't rupture at an inopportune time.

- Use hefty blocking arranged as a crib; i.e., two block north/south or top of two block east/west, etc. I used 8" square White Pine 24" long.
- Lift a little at a time. I would make about 6 pumps on the jack (1/8" lift) and then go around to tighten all the poppets. I used a plumb bob from the stern to check that the boat was level. After a few cycles of this, I could add a 1/2" piece of plywood to the blocking.
- Use redundant blocking. I used 4 sets of blocks - three under the ballast and one aft. Actually, if your lifting near the boat's center of gravity, very little load is aft. You can easily support the boat aft with the poppets. I used the blocking aft for piece of mind. For the three under the ballast, I used one as close to the jack as possible, one near the back end of the ballast and the other near the front. Since the boat is typically not perfectly level fore/aft during the lift, one of the three blocks is always very close to the ballast. So, if the jack fails, the boat won't have far to fall.
- Use a block of hardwood to protect the ballast and a steel plate between the jack and the hardwood to distribute the load on the wood.
- As the lift progresses, the bottle jack will reach the limit of its travel. So you will have to put the jack on blocking. Be very careful that the jack is on a stable platform (don't ask how I know this!).
- You might also have to relocate poppets. Be sure that you have enough so that no one poppet is support too much load. Be sure they are chained together port/starboard. I use four on each side plus one supporting the stem. That would be a minimum.
- After completing the lift, I was faced with a dilemma - all this blocking was in the way of the centerboard slot. So I had to reposition the blocking, which took some finagling. The final arrangement is shown below with the centerboard partially lowered.

With the boat at the required height, it's time to remove the centerboard pivot pin. The pin passes completely through the ballast keel. Each end is covered by a small bronze plate that is attached to the ballast with 4 screws. (see the link “Centerboard Preliminary" for a pic). I wasn't sure how to remove the plates, but Stephen Olson (marine surveyor who I meet through the WoodenBoat forum) suggested just cutting a notch in the lead with a chisel and pry them out with a screwdriver. Simple and it worked just fine.

According to the original plans, the pin was to be a bronze bolt with a nut to keep it in place. Alas the builder decided to use a bronze rod instead. I don't know if the rod was originally an interference fit, but it certainly is now! No pounding with a hammer and drift will budge this rod. It's about 20" long and has been in salt water for 50 years! I could never bore it out freehand, and I can't see how to press it out without laying the ballast on its side. So the only option is to try to pull it out. Frankly, I'm skeptical!

The starboard end of the pin is dimpled in the center where presumably it was hammered in place, so the plan is to pull from that end. Here is a picture of it.

I marked the center of the pin and used a center drill to start a hole. I followed this with a 1/4" hole 2" deep to act as a pilot hole for a 1/2" - 20 tap drill. Of course, the goal is to drill these holes down the centerline of the pin. Good luck with that! The only reference that I had was the end of the pin on the other side of the boat. I did my best to transfer this location to the starboard side, but it was very rough. After tapping the hole, I installed the my make-shift puller.

I estimate that it took about 20-30 ft-lbs of torque to move the pin. I was surprised/elated. I expected much more. Well, my elation was short lived. What I removed was just a 2" long plug covering the end of the real pin! Well, maybe this isn't so bad after all? Maybe both ends have a plug the the actual pin is a slip fit. So I moved to the other side, drilled, tapped, and started pulling.

Unfortunately, 30 ft-lbs did nothing! Now I'm wondering how much torque that this system will take before I either strip the threads or shear the pin. I'm using a grade 8 9/16" bolt, so the bolt itself is not likely to be the first thing to fail. I've tapped deep enough so that almost 1.5" of threads are engage, so I don't think the treads will strip. After some rough calculations, I estimate that I can apply almost 300 ft-lbs of torque. So I put a 3 ft pipe on a 1/2" drive breaker bar and lean into it. At about 200-250 ft-lbs (estimated) and pin starts to move! After a couple of evenings, I've moved it about 1". It's going to be a long process.

End of February

I now have about 2.5" of pin showing. So I'm making slow progress. It's difficult to see what I'm doing since the puller hides the end of the pin and the bolt. So my approach is to keep cranking until I feel added resistance (threads bottom out in the pin). Then tear down the set up, add another 1" hard wood shim, reposition the puller, and start again. This seemed to work well until one time I was cranking a bit too fast and the bolt reached the end of its threads. This was brought to my attention by a loud bang, followed by a shower of puller parts and shims, as the bolt sheared off.

The bolt parted flush with the end of the pin. So removing it will be no simple task. As I see it, I've got two options: Cut the bronze pin off behind the bolt, then re-drill and tap the pin or try to remove the bolt with a screw extractor. If I cut the pin behind the bolt, very little of the pin will extend beyond the lead keel. This makes it difficult to drill and tap a straight hole. When I drilled

the pin initially, I had this same problem, which resulted in the bolt not being parallel to the axis of the pin. I believe this contributed to the eventual bolt failure - where pulling resulted in tensile and flexure stresses. So my plan is to remove the bolt (if I can), so that I can use the protruding pin as a guide for re-drilling the hole parallel to the axis of the pin.

It took an entire afternoon to drill a hole in the center of the bolt to fit a very large screw extractor. Then it took quite a bit of force on the end of a 13" adjustable wrench to get the bolt to move. This was a bit of a surprise. Before the bolt broke, it was relatively easy to remove it. I suspect, now, that the threads must have been stretched, for there was considerable resistance the whole way out.

With the bolt removed, I considered my options. I didn't want to reuse the existing threads, even though they seemed ok after I chased them with a tap. I would just have the same problem with bolt misalignment. I ultimately decided to enlarge (and straighten) the exiting hole to 5/8". My rough calculations indicated that the bronze would fail before a 5/8" Grade-8 bolt. If that happens, I'll just have to re-drill the bronze, not first having to remove a broken bolt. With the protruding pin as a reference, I was able to (freehand) drill and tap a much straighter hole.

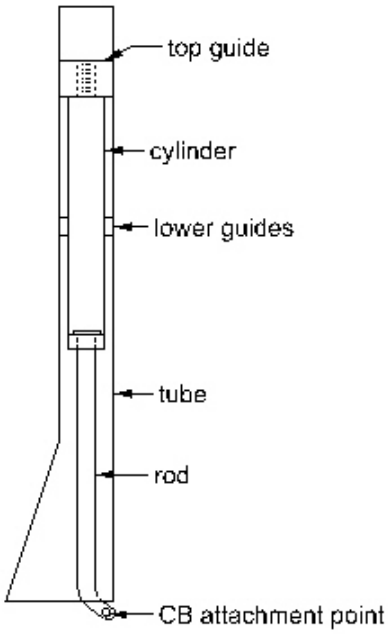
After modifying my puller to accept a 5/8"-18 bolt, I started cranking again. Now I took the time to measure the amount of pin travel (by measuring the pin depth on the other side of the boat) to be sure that I didn't bottom-out the threads again. After about 4" of travel, I noticed that the torque required had dropped to maybe 100 ft-lbs. At about 9", the pin cleared the centerboard hole and shortly after that the torque was down to about 50 ft-lbs. Progress was much faster now. At this low torque, I could use a ratchet and not have to worry about the treads bottoming out. Eventually, I was able to remove the puller and extract the last 4" by hand.

I suspect that the pin was originally a slip fit (and seems to have been coated with anti-seize), but the weight of the centerboard and years of corrosion led to the difficult removal. The pin shows slight wear due to contact with the centerboard - maybe 1/16". The next step is to remove the centerboard!

End of March

With the centerboard pivot pin removed, removing the centerboard involves lowering the board below the bottom of the keel and detaching the lifting mechanism (or vise versa). To clarify the problem, it's helpful to understand how the centerboard lifting mechanism works. Refer to the drawing below.

The lifting mechanism is housed in a bronze tube that is bolted to the top of the centerboard trunk (not shown). Inside this tube is a hollow bronze cylinder that moves up and down inside the tube. A top guide and a set of lower guides keep the cylinder centered in the tube. The top guide is treaded to accept a long threaded rod and provides the lifting force. Attached to the bottom of the cylinder is a solid bronze rod that connects to the centerboard with a pin at the attachment point. This rod is not rigidly attached to the cylinder. Rather, the rod is inserted into a hole in the bottom of the cylinder. The end of the rod is equipped with a large washer that prevents the rod from exiting the cylinder. In case of a grounding, the centerboard is free to move upward, the rod moving up inside the cylinder, without damaging the lifting mechanism.



A picture of the bottom of the tube and the top of the centerboard trunk is shown below. As you can see from this pic, the solid rod of the lifting mechanism is attached to the top edge of the

centerboard, but access to this attachment point is inaccessible due to the presence of the centerboard trunk.

To gain access to the attachment point, I first tried to disassemble the rod from the lifting mechanism. With the rod free, I could lower the board sufficiently to access the attachment point below the keel. I attached a chain hoist to the tube and attempted to lift the tube off of the cylinder. Unfortantely the cylinder cannot be removed from below - the lower guides will not go below the flair in the tube, due to weld penetration during the construction of the flair.

Next,I tried lowering the board below the keel using the existing lifting mechanism. Unfortunately, this exceeded the normal travel of the lifting mechanism. Once I reached the lower limit, the board would not move any further. At the time, I thought that the rod was binding in the centerboard slot. Ultimately, I think is was the board itself that was binding, due the considerable about of dirt accumulated in the trunk over the years.

Finally, I decided to remove the centerboard trunk, lifting it enough to access the attachment point. This was a major undertaking. As you can see from the pic below, the centerboard trunk is a substantial bronze weldment - integrating the trunk itself with 18 bronze floors.

Each of the floors is bolted to a frame with 5 carriage bolts. Removing these carriage bolts was an adventure. First of all, to prevent the nuts from coming loose, the original builders peened-over the ends for the bolts. So I was forced to grind off the ends of the bolts to free the nuts. Of course, gaining access to the ends of the bolts was no picnic - butt blocks, through-hull fittings, bulkheads in the way. I ended up removing one bulkhead completely.

Even after grinding the bolts, some of the nuts would not spin freely. As you know, carriage bolts have a square shoulder, which buries into the wood allowing you to tighten the nuts without a backup wrench or screwdriver. Unfortunately, some of the bolts were now loose in the frames and would spin when I tried to remove the nuts. So in many cases, I had to grind a slot in the bolt head to fit a screwdriver.

In some extreme cases, I had to insert a hacksaw blade between frame and floor and saw the bolt in two.

Once the carriage bolts were free, it was time to remove the fasteners holding the trunk to the keel. Below is a example of a typical bay between two floors. Three lag bolts fasten the trunk to the keel and two threaded rods come up through the keel at the base of the floor. In addition, some bays have a ballast keel bolt (with washer and nut) that clamps to the floor.

Even with all the bolts removed, I was not able to lift the trunk with a chain hoist; however, after some work with a putty knife and careful prying at one end, I was able to break it loose. It appears that thin canvas in white lead paste was used as a sealer. After that, the chain hoist did the rest. I raised the trunk just enough to access the centerboard-lift attachment point and put some wood blocks under it.

This pic shows the attachment point. The pin you see is just a slip fit kept in place by the sides of the centerboard trunk. I was able to push it out with a long drift. Of course the centerboard was supported below with blocking before I removed the pin! Afterwards, I used a bottle jack and a series of different height blocking to slowly lower the board. One would think that the board, weighing about 500 pounds, would slide down easily, but it actually took some prying downward (pry bar between the centerboard and the bottom of the trunk) to get the board to move. Once the pivot hole was exposed below, I was able to insert a shaft an pry downwards on it to finally free the board from the trunk.

I built a pair of dollies to hold the centerboard.

This pic shows the dollies at work. Note also the block and tackle arrangement. This was to keep the centerboard from sliding aft out of control while lowing the board. Also note the bottle jack/ C-clamp arrangement at the front of the board, which allowed me to lower the board close to the ground.

This pic shows the attachment point with the rod/pin removed.

To prevent raising/lowering the centerboard from wearing away the ballast keel, two large bronze washers were inserted at the pivot point. The following pic shows these washers and the pivot pin.

With the board removed, I could detach the lift mechanism from the centerboard trunk and remove the cylinder from the tube through the top of the tube.

Subsequently, I had the tube stripped of the chrome plating and then I applied filler and painted the tube with white enamel.