**Installing New Deadwood and Ballast**
**11/22/2012**

After soaking in water for 4 months, the keel plank finally swelled to its maximum dimension. More specifically, the athwartship spacing of the keel-bolt holes stopped increasing and stayed stable for the last 3 weeks. At this point, I removed the water bath and decided to seal the keel plank so that it would not loose the moisture that was just added. More to the point … I don't want the keel-bolt-hole spacing to shrink again! But what to use as a sealant?

As I describe under Moisture & Adhesives in Boatbuilding , epoxy is one of the best coatings for limiting the loss (or gain) of moisture from wood; however, epoxy is expensive and difficult to remove, if that becomes necessary. The traditional coating for limiting moisture loss is red lead, but it is almost twice as expensive as epoxy and not nearly as effective. It so happens that Primocon primer from Interlux is about as effective as epoxy (in limiting moisture loss) at about 2/3 the cost. It's also a single part paint that requires no sanding between coats. It can be easily planed, scraped, or sanded. Now Interlux markets this product as a metal primer, so they will not recommend Primocon for this application. In fact, they specifically say that it should only be used below the waterline under antifoulant paint. None the less, the limited experiments that I've done (along with the recommendation from one professional boatyard) favors Primocon. It can also be over-coated with bilge paint to form a very durable surface. Below are some pics of the keel plank and other parts of the backbone that have been coated with Primocon. The top surface of the keel plank has been top-coated with Pettit EZ bilge.

At this point, I'm confident that the keel plank is well above the fiber saturation point, so that some moisture loss will not result in dimensional changes. Also, with most of the keel plank coated with Primocon, moisture loss should be very slow. So it's time to install the new deadwood and ballast.

The question is what to install first? If I install the deadwood first and the front of the deadwood interferes with the ballast, I'll have to remove the ballast, trim the deadwood and try the ballast again. Given the potential difficulty with inserting 12 rigid keel bolts into 4.5" of keel plank, and then having to do this multiple times, I decided to install the ballast first and then fit the deadwood to the ballast.

To install the deadwood after the ballast meant that I had to remove the two keel bolts that penetrate the deadwood. As the pic below shows, there are actually 4 keel bolts that penetrate the deadwood (where the ballast is sloped); however, the 2 longer aft-most bolts go completely through the ballast and were removed when the ballast was removed from the boat. What you're seeing in the picture are sections of all-thread that are used to temporarily hold the blocking in place.


The two shorter bolts (the ones still in the sloped section of the ballast in the pic above) do not pass completely thorough the ballast. Instead pockets called galleries are cast into the side of the ballast to provide access to nuts at the end of the bolts. One of these galleries is shown below.

These galleries are plugged with lead blocks, made of softer lead than the ballast proper (no antimony), so they can be melted away with an oxy-acetylene torch. As you can see in the pic, I got a little carried away with the torch and melted a bit of the keel. Oh well that's what filler is for!

After removing the nuts, I was able to remove the two bolts with an improvised puller.

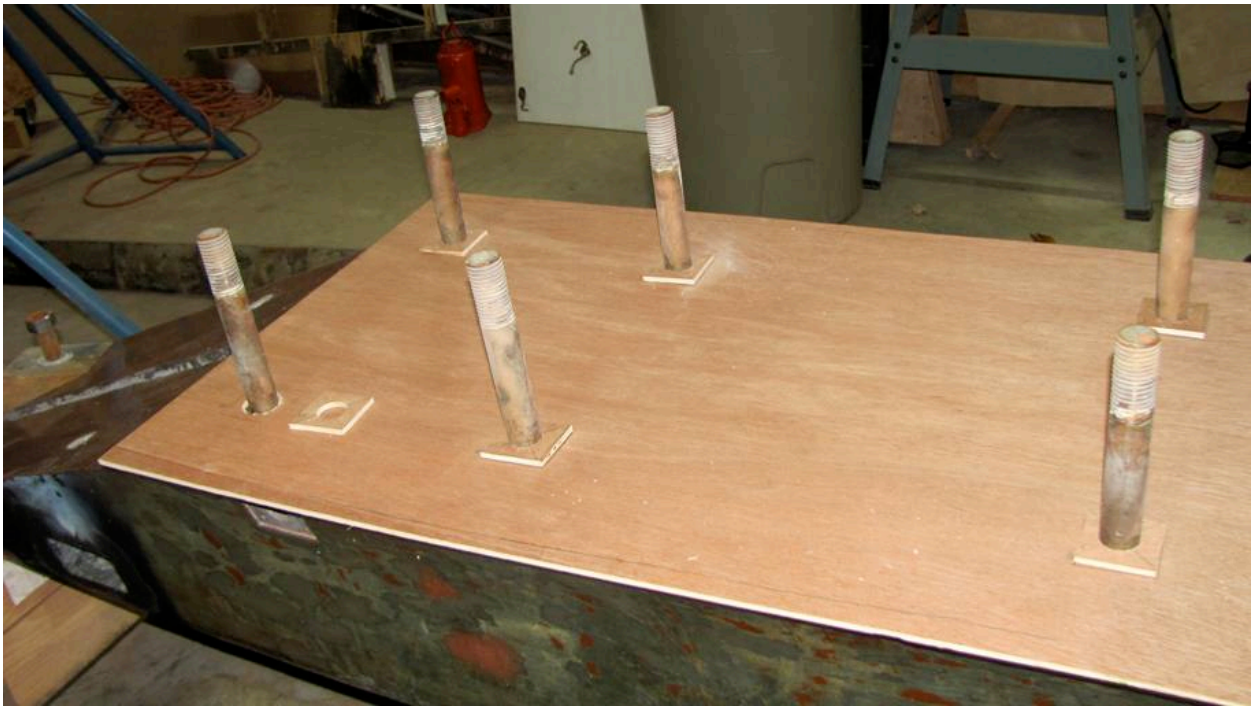
One of the problems working alone on a project of this magnitude is that you forget some of what you learned months ago. In this case, I forgot that the copper centerboard liner must be attached to the deadwood with wood screws, many of which are covered by the ballast! So the deadwood has to be installed before the ballast, so that you have access to these screws! So I removed two keel bolts unnecessarily.

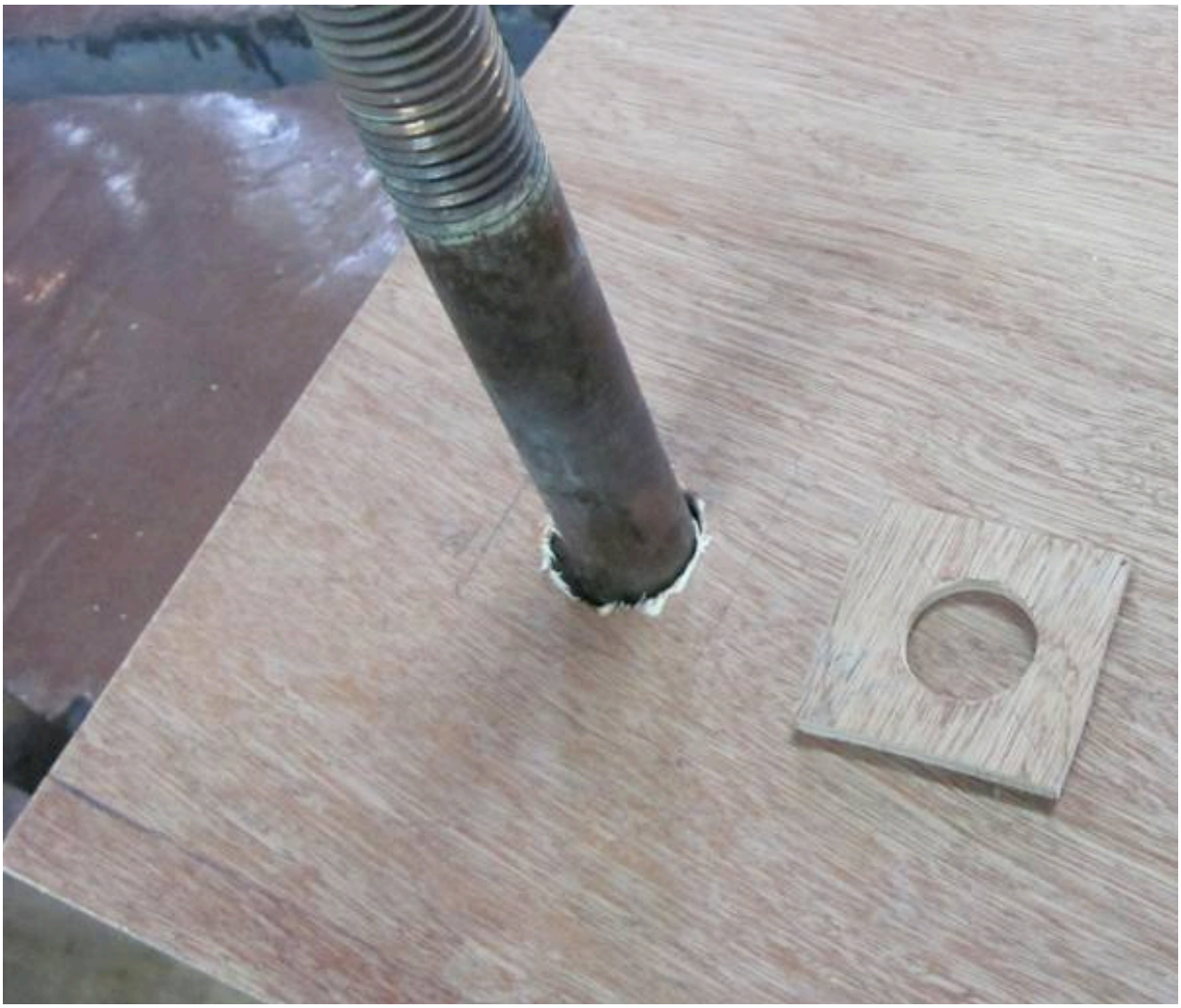
In any case, it's on to installing the deadwood. Referring to my commentary on 1/6/2012, you'll see that I tried to install the deadwood at that time. But after drilling for the keel-bolt holes I realized that the keel plank had shrunk. So now the first thing to do is to position the deadwood and see if the bolt holes line up. The holes seemed to line up, although I couldn't check that the 4 forward-most holes in the deadwood matched the corresponding holes in the ballast. Determined to make progress, I decided to move forward, so I …

- Fabricated the remaining T-neck bolts for attaching the deadwood to the keel plank. I had made about half of them earlier.
- Applied traditional bedding compound to the top of the deadwood that would be in contact with the bottom of the keel plank. The top of the deadwood was previously coated with 6 coats of epoxy and the bottom of the keel plank was coated with Primocon, so bedding seemed to be the right sealant.
- Positioned the two deadwood halves under the keel, clamping the halves together until bolts could be installed. Positioning of the deadwood is determined by the copper centerboard liner, so there is very little room for adjustment.
- With the two halves clamped together and in position, I chased a ½" drill bit through the holes, just be sure that the bolts would fit.
- I then counterbored the holes from below to recessed the heads of the bolts – later to be bunged.
- Starting with the two pairs of shorter bolts that terminate at the top of the keel plank, I coated the underside of the heads with 3M5200 and tapped the bolts home. I then secured them temporarily with nuts and washers to allow the sealant set. Eventually, these bolts will attach to the centerboard trunk.
- The 3 pairs of bolts aft are much longer (up to 26"), penetrating wood floors or the stern knee. These bolts went in a bit harder, but with firm blows with a heavy hammer (wood block between bolt head and hammer), they eventually seated properly.
- Next I bolted the two halves together (3 bolts aft of the centerboard liner), with 3M5200 under heads and nuts/washers. These will also later be bunged.
- Finally, I fastened the centerboard liner to the deadwood.

Now it's time for the ballast!

In preparation for the move, a sheet of Irish felt was cut to fit the top of the ballast. The Irish felt, which is impregnated with pine tar, provides a seal between the lead and the keel plank. Cutting the felt to size required a fixture, which is described in the sequence of pics below.





First, the rough dimensions of the keel bolt pattern is transferred to a sheet of Luan underlayment. Oversize holes are drilled at each bolt location. The pattern is then place on top of the ballast. Small square taps, with accurate holes drilled in them, are then slipped over the bolts and there outlines traced on the pattern. The pattern is then removed and the tabs are hot-melt glued in place. The resulting pattern accurately represents the bolt-hole pattern.

The pattern is then placed on the felt and a silver marker is use to trace the hole diameters. A drill with a spade bit cuts the holes to the correct size. The felt is then positioned on the ballast and trimmed to outside dimension. Once trimmed to size, the felt was removed until the ballast was ready to be raised into position.

After the felt is cut, the next step is to rearrange the blocking under the boat so that there is room for the ballast to be rolled into place. Fortunately, with the ballast gone and the interior stripped, the poppets can (at least temporarily) support the weight of the hull. Next I rent a set of Hillman

rollers, which are designed to move heavy equipment. Then with the help of a neighbor and a roller under each corner of the blocking, we easily roll the ballast into place.

Next, bottle jacks are used to raise the ballast just below the keel plank. This is done incrementally adding blocking fore and aft to support the ballast if a jack should fail.

Much of the success with this procedure can be attributed to the attention paid to a number of details:

- The top of each keel bolt was chamfered with a pneumatic die grinder.
- The threaded area of each bolt was wrapped with Teflon tape to prevent the threads from catching in the hole.
- Each bolt was liberally coated with lithium grease and each hole was coated as well. A conical brush from a big box store help to spread the grease inside the hole. I then used a spare bolt to test each hole for friction. With sufficient grease, the bolt could be moved in and out of the hole by hand.
- The hull was made level, fore and aft and athwart ship.
- The distance from the top of the ballast to the bottom of the keel was adjusted to be the same at 3 corners.
- Finally, the ballast was positioned so that each bolt was centered under its corresponding hole.

Moving 5800 lbs. ¼" or less in any direction was no small feat. Hillman rollers are designed to roll in one direction at a time. You can change the direction, but this requires some effort. We tried levers and block & tackles to control the amount of movement, but these proved to be unsatisfactory. Ultimately, we had to call it a day and return the rollers (they cost $75/day).

After some thought and helpful ideas from neighbors, a solution emerged. The key was to establish controlled incremental movement both longitudinally and athwart ship. The control of longitudinal movement was discovered accidentally.

In the picture above, the pipe rollers are arranged for fore/aft motion. A steel plate is inserted between rollers and wood blocking. Rotating the pipes 90 degrees provides the desired lateral motion.

The idea is to lift the ballast at its center of gravity just high enough to take weight off the blocking (which is still bolted to the ballast). A pry bar between the steel plate and the floor can then shift the ballast as needed.

The single jack at the center of gravity provides another benefit. When the blocking is unweighted, the ballast is effectively balancing on the jack. In this meta-stable state, one can

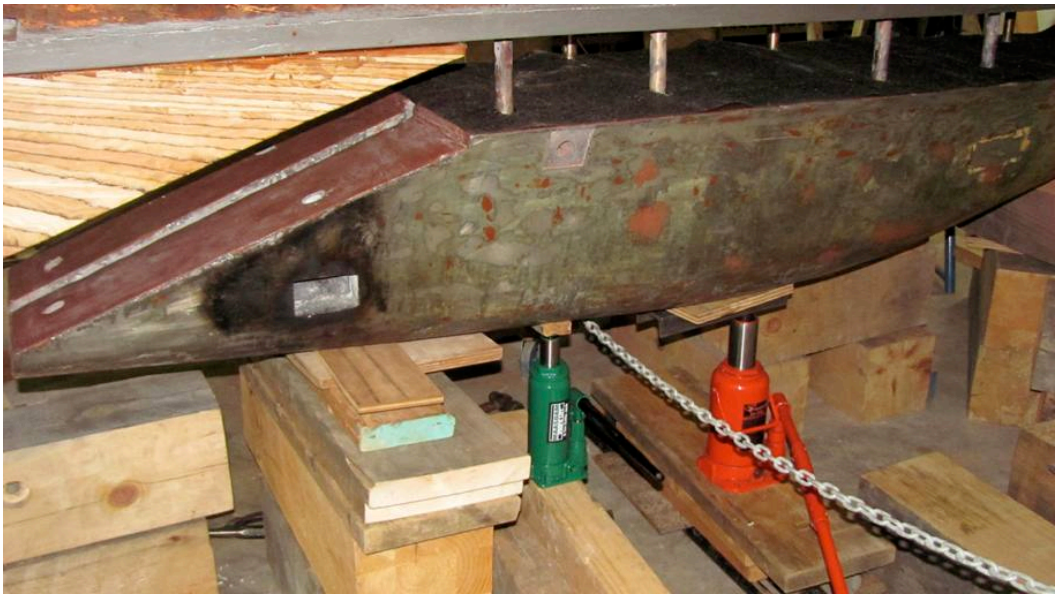
make small position adjustments by rocking the ballast slightly by hand. Since the blocking provides a very wide base, the degree of rocking is very limited, so safety is maintained.

Once the ballast was in proper position under the keel, it was time to check the fit between deadwood and ballast. At this point, the ballast was 7” below the keel. So a template was made to transfer the shape of the ballast up 7”. So if the shape of the deadwood is correct, the template should just fit in the space between ballast and deadwood. After making some adjustments to the deadwood, the template fit. (Because the top of the ballast is not perfectly flat, I found it better to cut the template in half vertically, and fit the front half and back half independently.) It’s now time to raise the ballast.

First, the felt was installed and the bottom of the keel plank was coated with pine tar. No tar was used between felt and the top of the ballast, because the top of the ballast was previously coated with epoxy.

After applying the tar, the ballast was raised so that all the bolts engaged in their respective holes.

At this point we discovered that a single jack was insufficient – one or more bolts would bind in their holes. This is actually quite easy to determine. One can watch the bolts as the jack is raised and see if they are moving in the holes. Also, if the bolts are binding, the hull begins to lift and the poppets become unloaded. Through experimentation I learned that by adding a jack forward and one aft, provided the necessary control to lift the ballast in place.



Little by little the ballast moves upward …

After several hours of jacking and blocking (1/4” at a time), the ballast is finally home!

At this point it's important to mention that not everything proceeded as smoothly as described above. In particular …

- Although the template idea for adjusting the fit of the deadwood was a good one, I was careless with my measurements. Specifically, the ballast was about 1/8" too far aft and I neglected to account for the thickness of the felt. These errors combined to produce about 1/16 – 1/8" gap between the deadwood and ballast.

The same pic reveals another problem with the fit. At the top of the deadwood forward, the deadwood does not make contact with the keel plank. I'm not sure what happened here, since the

rest of the deadwood lies tight against the keel. Maybe I planed too much from that corner. Whatever the problem, it's systematic since the other half of the deadwood has a similar problem.

Of course these mistakes can be filled, but it is none the less very disheartening. I have very high expectations and try very hard to do things correctly; however, my lack of experience means that every step is a learning process and thus errors are inevitable.

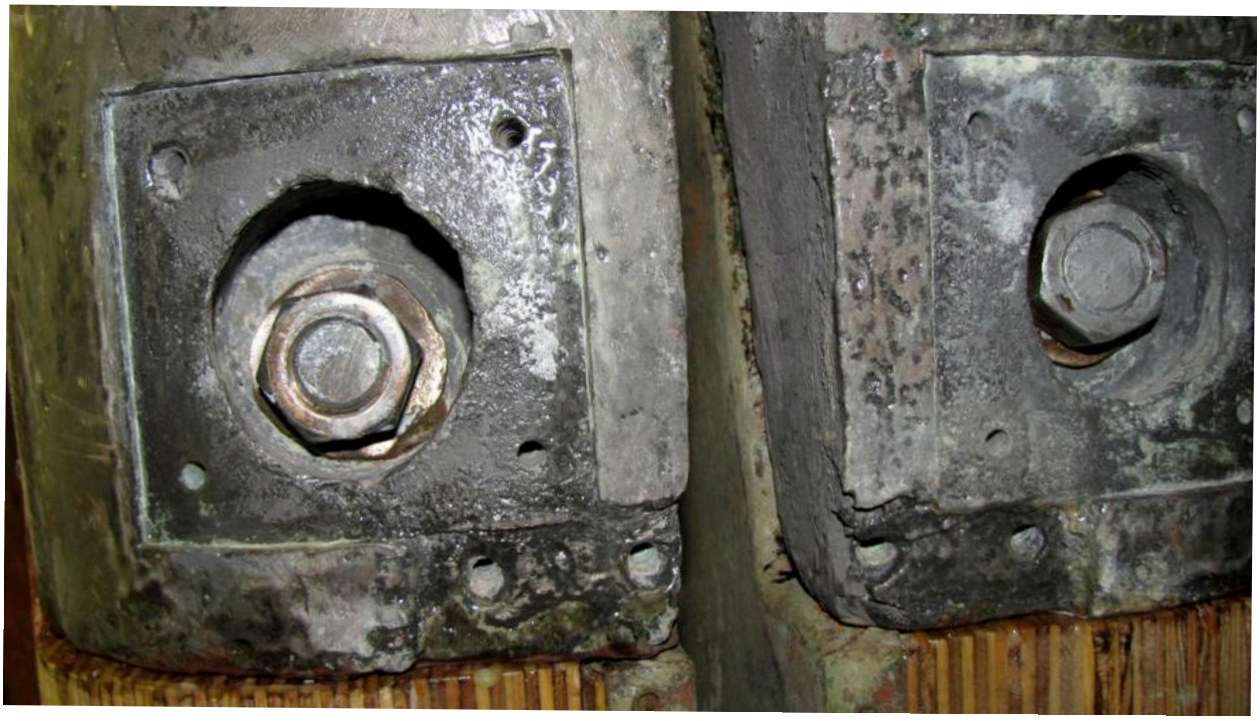
When drilling for the deadwood bolts, I positioned the deadwood below the keel plank and using the holes in the keel plank as guides, extended the holes into and through the deadwood. Unfortunately, the longest drill available was 24" and several of the holes were a few inches deeper than that. So I had to drill as deeply as I could with the deadwood in place, and then remove the deadwood and finish the holes off the boat. This in itself was not a problem, if I had only remembered to do it! Alas no! Here is what happened … After starting the holes (back in January), I realized that I better check that the forward most 4 holes lined up with the keel bolts in the ballast. Of course they didn't because the keel had dried out, so I decided not to finish the holes until I swelled the keel, in case I would have to plug the holes and re-drill.

So months later, when I got back to installing the deadwood, I forgot that I didn't finish drilling the 4 deeper holes. So after covering the top of the deadwood with bedding compound, positioning the deadwood under the keel, and installing the forward most bolts, I attempt to install the aft-most bolts only to find no holes!

After a lengthy Internet search, I found what is called an "installer's drill bit." This is a bit that has a short drill section (about 4") but a very long shank having a much smaller diameter. This drill is not appropriate for drilling long straight holes – it would probably lead off too much, but for drilling the last couple of inches, it worked great, and it cost about half of what my 24" drill cost.

After completing the long holes and counterboring them to recess the bolt heads, I decided to chase these holes with my 24" drill bit from both ends, just to clean up the holes. Unfortunately, the bit bound up in a hole half way through and the bit broke. Fortunately, I was able to drive the broken bit out of the hole, but I was left with two 12" drills (there goes $130!). In the future, I hope to remember to reduce the torque setting on my drill.

One other problem associated with drilling for the deadwood bolts, is shown in the pic below.



The pic shows the aft end of the ballast, where two deadwood bolts connect to the ballast. For whatever reason the bolt holes in the deadwood did not line up precisely with the holes in the ballast. (Since these were the longest holes in the deadwood, I suspect that the drill lead off some.) The misalignment was not much, but upon chasing the holes with the drill bit, some lead was removed, resulting in the nuts not in the center of there pockets. The shift wasn't much, but enough so that for the nut to the left in the picture, you can't get a socket on the nut (the right one is ok). This could be a nuisance if one ever needs to remove this bolt!

One final issue …

In the pic below, notice that the left half (starboard side of the boat) of the deadwood does not fit the centerboard liner as well as the right half. This caused the deadwood to shift outboard slightly. I suspect that the problem might be due to the keel plank swelling. This would reduce the space between bottom of the keel plank and the flange of the centerboard liner. If I had noticed this earlier, I could have trimmed the deadwood a bit where it mates to the liner. I'll just have to live with it now, however.