Schwimmer Construction Notes

By Matteo Spadafora

Schwimmer built between 2023-12 and 2024-05. Mainly based on Casavant examples; also incorporates changes made by Blair through experience. Associated blueprints and graphics are located in the same directory as this tutorial. Drill press used for drilling where feasible. All marking is to be done on inside faces of wood where possible.

NOTE: Pre-milled hardwood (Home Depot) was used in 2023-12, resulting in thicknesses of ¾" where blueprints indicated 1". To follow blueprints exactly, purchase five-quarter thickness wood (1 ¼") and mill to 1" thickness.

The hardwood thickness used should be large enough to prevent wood splitting when tee nuts are driven into spring rails; thickness should also be greater than the width of pantograph spring mounting plates for adequate support. Test with a tee nut and mounting plate before commencing. Thickness should be greater than the widest of the above two objects.

Materials:

- ✓ 4' x 8' cabinet-grade plywood board, domestic maple, veneer core (from Craftsmen Hardwoods, Drayton)
- ✓ 1" x 7" x 8' solid maple board for spring rails (from Home Depot) [milled thickness was actually ¾"… too short]
- ✓ Hot hide glue, Titebond (or equivalent wood glue), Weld-Bond glue as needed
- ✓ 5/16"-18 threaded rod, 6-foot & some matching nuts for spring rails
- ✓ 4 x 5/16" flat washers (or same diameter as above threaded rod)
- ✓ 4 x 5/16" split washers (or same as rod above)
- ✓ 4 tee nuts (hammer-in) for the above diameter and threading
- ✓ 9 x OSI part # 7990-00 ball joints
- ✓ 1 x OSI part # 7993-00 linear ball joint
- ✓ 3-foot length of threaded rod matching the diameter and threading of the non-linear ball joints [1/4"-28 used], plus some matching nuts
- ✓ 4 x OSI part # 2220.00 pantograph spring assembly (or fewer assemblies, depending on number of springs to be installed – see step 26)
- ✓ #12 bolt flat washers, 9/16" OD & ¼" ID, roughly 1/32" thickness [enough to place inside each screw countersink]
- ✓ 1' by 1' aluminum plate, can use from 1/8" up to ¼" thickness [3/16" used; Casavant uses ¼"]
- ✓ ¾" by 6' black steel pipe (Home Depot) [¾" inner diameter used 2023-12; blueprints indicate ¾" outer diameter]

- ✓ ¾” wide by 1/8” thick, ~2’ long cold rolled steel flat bar for roller arms [¼” thickness used 2024-01]
- ✓ Small sample of *lignum vitae* wood (oily for bearings), use thickness such as ¼”, surface area large enough to drill at least 8 plugs: multiple plugs will be stacked as necessary to fill plug holes (A&M Wood Specialty)
- ✓ #6 x ¾” pan-head wood screws (several required; enough to fasten all pantograph springs)
- ✓ #12 x 2 ½” wood screws (or other screws with non-threaded shank >=1”; four required)
- ✓ Aluminum angle iron, 1” by 1”, 3” length
- ✓ Felt strip, ¼” thick, same approximate width as thickness of hardwood used, ~2’ long
- ✓ Hardwood dowel stock, 7/8” by 48”, or 1/8” larger than inner diameter of roller pipe (Home Hardware)
- ✓ Neoprene foam, closed cell, ¼” thick, large enough to cover aluminum valve plate [open cell, 3/16” thickness used 2024-02; from Rubberline Supply]
- ✓ Varsol (or similar mineral spirits)
- ✓ Black matte spray can paint (Rustoleum or similar brand)
- ✓ #12 wood screws, 1” and 1½” lengths
- ✓ Brass rod, ~ 9/64” diameter, 1’ length
- ✓ #12 x ¾” round head wood screws
- ✓ ¼-28 lock nuts (nylon) for ball joints
- ✓ ¼” lock washers

Directions:

1. Rip plywood to size.
    a. Use strong, high-quality, cabinet-grade plywood. Birch, maple or poplar ply is ideal (Maple used 2023-11). 10+ ply Baltic birch is too heavy; can use domestic plywood with 4-5 plies.
    b. Use Casavant “Calcul. de la Table” graph to determine required square inch area based on number & pitch of ranks on the chest, then consult Casavant blueprint for measurements of the inner plate.
    c. Cut a board to the outer dimensions of the schwimmer. Then, mark dimensions of inner plate and cut out a hole with table saw blade, turning blade off while still in the cut, and stopping early enough to account for the arc of the blade so as not to overshoot correct dimensions on bottom side.
    d. Finish remaining sections of cuts with handsaw.
    e. Mark “INSIDE” on the worse looking sides of the inner plate and outer frame. Mark an “X” in the same spot on both pieces to indicate proper orientation.
2. Tidy up corners and edges.

a. Use a tape roll or similar rounded object to draw the outlines of rounded corners on the inner plate. Cut out the corners with band or scroll saw, backing out and cutting again as necessary.
b. Use spindle sander (or belt sander) to tidy up corners.
c. Use router with round-over bit to slightly round the edges on the inner plate and outer frame for only the sides that will become the INSIDE. [To prevent rubbercloth from being sliced on sharp edges.] Adjust router on scrap wood first.

3. Drill hole for intake valve.
    a. Use Casavant calculations graph to determine hole size based on inner plate area. Round to the nearest half-inch. Graph also provides dimensions for tremolo hole; Casavant used a pneumatic tremulant mounted on the schwimmer. [4 ½" hole was calculated in 2023-12, but 4 1/8" hole was drilled since this was the closest bit size available].
    b. Mark centre (widthwise and lengthwise) of larger rectangular panel on the outer frame. Centre of hole will be at the intersection of the centre lines drawn.
    c. Cut hole with hole saw. Start hole from one side until bit protrudes, then finish from other side.
4. Drill and countersink screw holes for mounting.
    a. Pass marking gauge around outer edges of frame on the inside face, with the width determined by the thickness of the wood into which screws will enter on the chest. Mark line at approx. the centre of the chest wall thickness, but slightly closer to the inside of the wall so screws cannot protrude.
    b. Follow approximate measurements on "Screwing Chest Bottoms". Mark hatches on the etched line at the locations of each screw hole. [Err on the side of closer screws; over 12" spacing too large.]
    c. Using a clearance-size drill bit for a #12 screw, drill holes with inside facing up.
    d. *If desired, use a router to extend the holes on one narrow end to the edge, creating U-shaped slots. This helps keep frame in place when removing schwimmer from chest without help.*
    e. Switch to a clearance-size bit with appropriately sized, Forstner-style countersink attached for the diameter of a #12 screw head (not pan head screws). Use scrap piece of the same wood to test and set drill press stop for the proper countersink depth (6 mm).
    f. Drill each countersink to the stop.
5. Drill holes for spring rail mounts in outer frame.
    a. Two holes on each long side of the outer frame are required for mounting spring rails. Use marking gauge to mark lines on the long sides of inside of frame. Mark closer to the inner plate than the outer edge, otherwise rail mount may not clear chest wall once mounted (see "Schwimmer Spring Rail" blueprint"). [1" from inner edge used 2023-12].

    b. On the etched line, mark a hatch on the centre between ends of the inner plate hole, then the centres between this centre line and the outsides (making quarters).
    c. Drill one hole on each of the centres-of-the-centres hatches (the first and third hatches).
        i. Find the clearance width for the threaded rod being used for spring rails off of a chart, then use the closest-sized brad-point brill bit available (slightly larger if not exact). [5/16 – 18 threads, 11/32" brad-point bit used 2023-12].
6. Sand outside-facing (visible) surfaces and edges of inner plate and outer frame.
    a. Clamp boards in place where possible.
    b. Sand edges that will be visible from final mounting position with coarse sandpaper [60 grit on random orbital sander used 2023-12]. Edges only need to be sanded until roughness and burrs are eliminated, paying attention not to sand on an angle.
    c. Sand outside visible surfaces sparingly with finer grit [150 grit]. Do not over-sand to avoid "polishing" the plywood and decreasing the effectiveness of poly coat later on. Erase any pencil marks.
    d. Soften all corners quickly with sanding block and fine grit sandpaper, held at a 45-degree angle.
    e. If necessary, sand interior of intake valve hole with spindle sander.
    f. Deburr screw countersinks with sandpaper wrapped around a circular object.
7. Apply Wipe-on Poly to visible surfaces and edges.
    a. Tape over surfaces on both pieces that will receive glue to protect them from poly.
    b. Apply Wipe-on Poly [Minwax used 2023-12] to visible surfaces and edges using a folded cloth rag. Use poly generously. Edges will soak up poly much more than faces and will require more passes to absorb a thick enough coat.
    c. Coat countersinks by rubbing rag around inside.
    d. Once all required surfaces have been coated, inspect every surface for dryness/uneven coats and apply more poly as necessary until an even coat is present everywhere.
    e. Allow to dry for up to a day. Longer is better, but surfaces can be worked with in under an hour if needed.
8. Glue rubbercloth strips to inner plate.
    a. Use marking gauge to mark a line on the inside faces of both plate and frame, all the way around the edges to be glued. [Blueprint says ½" from edge; ¾" from edge used with ¾" plywood in 2023-12]. This serves as a guide for how far rubbercloth will extend.
    b. Position the inner plate centred inside the outer frame. Lay a scrap strip of rubbercloth across the gap between the pieces with one end aligned with an

etched line from above step. Press strip down into gap to create purse. Ideal purse is when cloth sits mostly bottomed out in the gap, but does not touch and extend across the whole bottom and sides of gap. When satisfied, cut strip at the other etched line. This is the template from which to cut the appropriate width of rubbercloth strips.

c. Cut four rubbercloth strips as wide as the template scrap strip above [3" stated on blueprint; 3 ¼" used 2023-12]. The lengths should be as long as the straight (pre-corner) segments of each side of the inner plate, plus a slight overlap onto the corner at each end.
d. Note: Glue will be placed on the black side of the rubbercloth, NOT the white side as usual, since the black side faces out for cosmetics.
e. Use white pencil crayon to mark roughly (by eye) the same gluing width as marked on the wood before so that glue can be kept neat on the cloth. Mark this thickness on both ends of the black side.
f. Centre rubbercloth strip in front of the side of inner plate to which it will attach. IMPORTANT: Leave ~2" of each end of the strips unglued so that leather corner pieces can be attached later.
g. Glue the strip in sections: coat a section on the wood with glue, coat same length on the rubbercloth with glue, then lay strip onto wood and rub joint together. Glue the remaining sections as above.
h. Use hot rag to tidy up excess glue.
i. Glue the rest of the sides as above. Allow to dry for a day.

9. Glue rubbercloth strips to outer frame.
    a. Cut out spacer sticks (table saw) from scrap wood that fit the gaps between inner plate and outer frame for all four sides so that the plate can be kept centred.
    b. Insert spacers into gaps for the opposite dimension to that being glued to keep plate centred (ex. Insert spacers on short sides of rectangle if planning to glue on a long side). Spacers may need to be run on jointer if too thick to fit.
    c. Raise outer frame on blocks to reduce purse in rubbercloth so it can be glued more easily without bunching up.
    d. Glue strip in sections, aligning edge with marking gauge line made previously. Strips may have to be held down for few seconds until set. Clean up excess glue with hot rag.
    e. Allow glue joint to set (10-15 minutes), then slide plate over to prepare to glue other strip in the same dimension (ex. The other long side or short side). Glue as above.
    f. Remove set of spacers currently inserted, insert spacers for other dimension, and glue remaining strips.
    g. Leave frame in raised position to dry while proceeding to next step.
10. Make and prepare leather corner pieces.

a. Use the thickest possible leather available (black bellows/gusset leather).
b. Cut out a square template from a piece of scrap paper to the approximate size of what would cover one corner by eye.
c. Dry fit the template to test. Template should be laid underneath the ends of the rubbercloth strips. Leather should protrude past the outer edge of strips on the frame by ¼"; on inner plate it should glue onto the corner of the wood. Leather should have enough purse that strips continue their natural contours around the corner (no bunching of leather). [120mm square used 2023-12]
d. Once appropriate size is determined (remake template if necessary), use template to trace four squares onto leather with permanent marker and cut out with scissors.
e. Use the lid of a small jar or similar round object to round 2 opposing corners on each square. Cut around lid with scalpel.
f. Skive edges on a glass sheet with scalpel. Which side of the leather to skive depends on side being glued: for good presentation, best to glue on shiny side so it faces out. For better adhesion, best to glue on fuzzy side. [Glued on fuzzy side in 2023-12]. *Skive on side receiving glue.*

11. Attach leather corners to schwimmer.
    a. Use scissors to round corners of ends of rubbercloth strips freehand (for cosmetics).
    b. Place leather in position, over corner and under rubbercloth strips, with ¼" protrusion past strip edges on frame and mark locations of corners of square with pencil (as a guide for placement).
    c. Coat wood (only outer frame portion currently) and leather that will contact this wood and press into marked position. Clean excess with hot rag.
    d. Dry fit bottom corner onto inner plate and ensure purse is correct, then mark position of leather on plate. Apply glue to plate and leather and press into place.
    e. Ensure that any wood on frame and plate meant to attach to rubbercloth strips (that was not glued before) receives glue now to form a complete airtight seal. Coat rubbercloth strips and leather underneath them with glue and attach strips to leather.
    f. Rub strips and leather together from underneath joint as well as from the top. Clean excess with hot rag, but NOT on fuzzy sides of leather.
    g. Repeat marking and gluing process for remaining three corners.
    h. After all corner gluing is complete, check to see that no saw cuts extend past leather corners both on outside and inside of frame. If present, fill saw cut crevices with hot glue to prevent wind leaks.
12. Construct spring rail components.
    a. Refer to blueprint "Schwimmer Spring Rail & Side View" for visuals.

b. Use hardwood with strength like maple; otherwise poplar is acceptable. [Maple used 2023-12].
c. There are 2 sets of rails:
    i. 2 of 1" by 2" with notches cut out for threaded rod bottom
    ii. 2 of 1" by 1¼" with tee nuts to anchor threaded rod top [in 2023-12, used ¾" thickness instead of 1", 1½" width for tee nut rails instead of 1¼"]
d. Rip lengths for each respective width (2 of first rail, 2 of second rail). Leave lengths longer than the distance between the holes in the outer frame previously drilled for the rails, so they can be fine-tuned later (the lengths of both sets of rails are equal).
e. Measure and decide on appropriate length for the rails. Rails need to extend a little bit past the holes on either side of frame [21 ¼" used in 2023-12]. Mark slightly longer [~1/8"] than desired length and cut first piece to length on mitre saw. Mark other three pieces from this piece.
f. Since cuts through hard woods like maple create burn marks, use the extra 1/8" to make a light shaving cut that removes any burn marks (just glaze over the end of the wood with blade).
g. Chamfer long edges of all rails on jointer adjusted for a shallow cut, passing corners over blade at 45-degree angle. Take care not to change the angle during jointing.
h. Chamfer end edges with block plane (hold plane at 45 degrees to wood edge, hold plane at 45 degrees clockwise for the attack). *Only chamfer edges that will not make contact/join with other pieces of the schwimmer.*
i. Mark dimensions for notches on 1" by 2" rails (see blueprint). Draw lines with a square and then cut freehand with band saw. **Notches must be wide enough to accommodate washer, split washer and nut diameter. Test before cutting and widen beyond blueprint suggestion, if necessary.**
j. Soften newly cut edges with sandpaper.
k. Ensure any residue from labels on wood is thoroughly removed to ensure poly coating absorbs properly, then sand end grains with sandpaper. Quickly sand all surfaces if desired.

13. Construct outside spring rail supports.
    a. Rip a piece of solid wood (maple or poplar) to the width of the supports (see Spring Rail blueprint). [2 ½" used 2023-12. Thickness of maple was ¾", but blueprint shows 7/8"].
    b. Cut resulting strip into four pieces each 4" long. Use first piece as a marking guide for remaining pieces. If desired, mark an extra 1/8" and shave it off with a light cut following each main cut to prevent burn marks.

c. Use to-scale blueprint to mark hatches where the angled cuts begin and end on each support and complete the lines with a straight edge (or use measurements from blueprint for tapered bottom width and height).
d. Cut angled cuts with a band saw freehand (carefully), or use mitre saw set to proper angle [used band saw 2023-12].
e. Use belt sander to clean up burn marks or correct curved cuts. Sand with the belt running into the wood and away from the sander. Move the piece side to side gently while sanding.
f. Chamfer edges that will not contact any other components (i.e. chamfer vertical and angled sides, not top or bottom edges that will touch the frame and the outer rails, respectively).
    i. Use sanding block, block plane or a belt sander. If using a belt sander, quickly and carefully align the edge to be chamfered over the belt at 45 degrees, then drag it across the belt for a split second on an angle. [Belt sander used 2023-12; quickest but most prone to error].
g. On the bottom (smallest) ends of all supports, use a straight edge to mark an "X" from corner to corner to show where the centre is (holes for threaded rod will be drilled there).

14. Construct inside spring rail spacer blocks.
    a. Review spring rail blueprint. Spacer blocks are located between inside spring rails and frame. Sections with diagonal crossed lines indicate placement of felt as a stop for the inner plate.
    b. Blueprint measurements show each block as 1 1/16" W (matching width of rail) by ¾" H by 7/8" D (same as support wood thickness). In 2023-12, measurements used were: ~1 ½" W (accounting for ¾" spring rail plus ½" overhang on each side for strength) by ¾" H by ¾" D. Depth must be big enough to accommodate hole for threaded rod.
    c. If possible, cut spacer blocks with grain direction facing up/down instead of left/right (wood does not swell/shrink with the grain, but across it). Rip widths on band saw and then cut to length freehand. Use first piece as marking guide for remainder.
    d. Mark diagonal "X" with straight edge similarly to rail supports to mark centre of top of each spacer for a hole.
15. Drill holes through spring rail supports and spacer blocks.
    a. On a flat surface, place supports against each other in pairs in a "T-shape" (perpendicular) with the bottoms flat on the surface. Clamp the pairs together and leave the clamps on while drilling to keep pieces square.
    b. Using the same diameter brad-point drill bit as earlier [11/32"], drill as far as reasonably possible down the centre of the supports with drill press, backing out

occasionally to exhaust sawdust. Set stop on drill press to bottom out before chuck makes contact with wood.

c. Finish holes with same bit in handheld drill. Drill bit may need to be loaded closer to the outside of the chuck than usual to be able to reach all the way through the supports; use common sense.
d. Drill holes through spacer blocks at marked centre location using same drill bit on press.

16. Drill holes in inner & outer spring rails.
    a. *From this point forward, keep all spring rail parts together with the set of drilled mounting holes they are designated to. This ensures that any variations in placement of holes are accounted for on an individual rail basis and no misalignment occurs.*
    b. Lay frame assembly on workbench with one set of spring rail mount holes hanging over the edge of bench.
    c. Use pencil to mark crosshairs extending out from the centre of each mount hole on the frame. Existing marking gauge lines can be traced over.
    d. Place an inner spring rail (non-notched) over the first pair of holes and, using crosshairs, align it so that it is centred both horizontally and vertically (i.e. there is the same amount of overlap on the outside edge of the holes on both sides). Centring by eye is sufficient.
    e. Once satisfied, clamp rail to frame at both ends and use threaded rod clearance brad-point drill bit [11/32”] tip to go through both holes and mark locations.
        i. Repeat process with other inside spring rail and next pair of mount holes.
        ii. Alternate method [used 2023-12] is to hold rail in place by hand and mark only one hole, drill it, and insert threaded rod through while marking second hole. This is not ideal because each hole may not be exactly on marking gauge line, resulting in possible misalignment.
    f. Use brad-point bit to drill holes on drill press.
    g. Remove bit from drill press. Align and square inner rail over outer (notched) rail *for the same side* and then press bit through the holes in the inner rail to mark position on the outer rail.
        i. Repeat for other set of rails.
    h. Set drill press stop so that brad point just exits through bottom of notch. Drill from top of outer rails first, then flip upside down and finish holes through.
    i. Test alignment of holes for inner and outer rails by inserting threaded rod into one end and drill bit into other to see if they fit smoothly. Enlarge any problem holes slightly with a larger drill bit if issues arise.
17. Apply poly coating to outside-facing spring rail pieces.
    a. Only apply poly to outside (notched) spring rail pieces.
    b. Erase any pencil marks that will be visible before applying.

c. Apply Wipe-on Poly with cloth as described for plywood earlier. Pay special attention to end grains that absorb more poly than normal.

18. Prepare aluminum plate for valve.
    a. Determine valve diameter: 10mm more than wood hole diameter already drilled in frame.
    b. Hammer location for centre of circle with a punch on aluminum sheet.
    c. Set a compass to the radius of circle being cut and scratch circumference into aluminum with point of compass.
    d. Drill hole through the punched mark in the centre; this will accept the linear ball joint.
        i. The size of hole drilled depends on the diameter & threading of bolt on the ball joint as well as whether a threaded tap or clearance hole is desired. *Choose tap or clearance drill bit accordingly.* [Tap diameter used 2023-12].
    e. Use a wide countersink bit to lightly glaze both openings of the hole on high speed to make it easier to insert bolt later.
19. Cut aluminum valve.
    a. It is ideal to use a band saw with metal-cutting blade for the task. Using hole saw is not recommended (could result in seizing).
    b. Cut along line, then back out and make a new cut, continuing to follow curve until circle is formed. [Blair cut on home band saw in 2023-12].
    c. It is possible to use jigsaw and clamp aluminum to a bench, but this is more tedious and requires frequent undoing and attaching of clamps.
    d. Clean up edges on spindle sander.
20. Tap aluminum valve hole.
    a. Use tapping set. Load starter (not full bottoming) bit into chuck for the proper diameter of threaded rod used [1/4”-20 used 2023-12].
        i. Starter bits are tapered and easier to turn. Bottoming bits are flat and difficult to start.
    b. Hold bit straight and steady, especially at beginning. Turn bit several turns until it begins to “grip” the metal.
    c. Turn bit 1-2 turns, then backturn until a release is felt; this is the shards of aluminum releasing from threads in bit to prevent jamming. Repeat this pattern until the entire tapered part of the bit has gone through the hole and only the full-diameter shank remains.
    d. Remove tap bit and check for proper threading of rod.
21. Drill *lignum vitae* bearing plugs.
    a. Use plug drill bit in drill press [blueprint “Schwimmer Plan Side View” states 11/32” diameter, “Oily Wood for Bearings” blueprint states 5/8” diameter; ¾” diameter used 2024-01].

b. Drill plugs slowly on low speed (~700 rpm), releasing bit often to prevent heat from building up, which can cause wood to swell beyond the correct diameter to fit in bored holes.

22. Construct roller support blocks with bearings.
    a. See blueprint "Schwimmer Plan Side View". Use same solid wood as used for spring rails.
    b. Cut four pieces of wood to the dimensions shown on blueprint (65mm x 105mm). *IMPORTANT Correction: Blueprint shows height of blocks as 100mm, but actual to-scale measurement on paper is 105mm. If not correct, hole drilled will cross over edge of wood.*
        i. Pay attention to grain direction. Grain in cut pieces must run in the vertical direction, where swelling must not occur.
    c. Draw lines in the centre (vertically) of each piece, then mark hole location on centre line as per blueprint (90mm from bottom).
    d. Drill holes using Forstner bit the same diameter as the *lignum vitae* plugs [¾"]. Drill holes with stop set so that only the point of the drill bit protrudes from the other side.
    e. Clean rims of *lignum vitae* plugs by applying a coat of acetone with a brush to temporarily strip the oil for gluing. Once dry (quick), use wood glue (Titebond) and coat inside of bearing hole as well as rim of plugs with glue. Press into place.
        i. If using more than one layer of *lignum vitae*, place a layer of glue between each piece as well.
    f. Set block plane to a shallow cut position (takes some trial and error) so that light shavings come off on each pass. Pass plane repeatedly over the protruding plug end until it is flush with the block. Observe proper grain direction to prevent tear-out.
    g. Lightly sand all surfaces. Use block plane to chamfer all edges that do not contact a surface.
    h. When glue is dry, apply poly coating to support blocks.
23. Enlarge inside spring rail holes to accept tee nut sleeves & install tee nuts.
    a. Find twist (non-brad point) drill bit the same size as (or slightly larger than) the diameter of the sleeve that accepts the threaded rod in a tee nut. Drill the tops only of the four holes in the inside spring rails with the drill press stop set *slightly deeper* than the total depth of a tee nut sitting flush as it would when fully hammered into wood.
    b. Hammer tee nuts into holes. Ensure all nails are over solid wood. If wood looks at risk of splitting (nut nails too close to edges), use grinder to grind off two opposing nails flush with the rest of the nut while holding nut securely in pliers. Only two nails will suffice to hold tee nuts in place.
24. Cut threaded rod into lengths.

a. Cut threaded rod to hold spring rails into four equal lengths. Each length should be long enough to protrude through all components of the spring rails with some excess above/below for good measure [9”-10” used 2024-01].
b. Clamp rod in a vise or similar device and cut using hacksaw.
c. Round off cut edges on angle grinder at 45 degrees to chamfer ends of the rods for easier threading, rolling each rod while holding it at 45 degrees to the grinder wheel.

25. Dry fit spring rails.
    a. Line up all spring rail parts in place and push threaded rods through. Check that all components align properly for both sets of rails.
    b. If a threaded rod does not fit smoothly through all components, start with a bare rod and assemble by adding the components one by one until the point of resistance is found.
        i. Use file or rasp to file the wood at the point of resistance slightly so that rod passes smoothly.
    c. Disassemble parts and remove threaded rods, keeping each set of parts together.
26. Prepare pantograph spring upper mounting plates.
    a. Using a straight edge, draw two light pencil lines across the schwimmer plate between each pair of threaded rod through-holes. Lines should be centred with the centres of the holes on either side.
    b. *Important: Decide on the number of pantograph springs to be used. Number used depends on size of inner plate and wind pressure desired and is determined through trial and error after connecting wind to the schwimmer. Initially, estimate the number needed based on the size of the plate and mount them.*
        i. Ex. If three or four springs are mounted initially, but while testing it is determined that the pressure is too high and the springs cannot be loosened enough to lower it, one or more springs will need to be removed (vice-versa for two springs that cannot be tightened enough).
        ii. [Four springs were used in 2024-01 without testing; an educated guess was made that springs could be loosened enough to produce desired pressure.]
    c. Based on number of springs being used, see mounting positions below:
        i. 2 springs: Mount one spring under each spring rail, centred on the schwimmer plate.
        ii. 3 springs: Mount one spring under one spring rail (centred) and two springs under the other spring rail (both an equal distance from the side of the plate; choose a distance that makes spacing look balanced).
        iii. 4 springs: Mount two springs under each spring rail. Make the distance from the outer edges of all springs to the edge of the plate equal. [1 ½” from edge of plate used in 2024-01.]

    d. Place the desired number of upper spring mounting plates on each penciled line (in the spring kit, upper & lower plates are longer than the side plates, which are used later). Mark hatches for the desired distance in from the edge of the schwimmer plate for all mounting plates [1 ½”].
    e. Position each mounting plate so that it is both the correct distance from the edge and is centred on the long pencil line drawn earlier (look through screw holes).
    f. Holding the plate in position with one hand, use a hammer and punch or awl to mark screw hole locations. Repeat for other three plates.
27. Install pantograph spring upper mounting plates.
    a. Drill pilot holes appropriate for screw size (#6 wood screw) with handheld drill. Use tape on bit to indicate depth of hole (estimate by holding screw next to wood beforehand). Use assistant to tell if drill is straight before drilling.
    b. Install screws to attach each mounting plate.
28. Prepare pantograph spring lower mounting plates.
    a. Lower spring mounting plates attach to outside spring rails. Upper and lower plates must be aligned with each other, or else springs will be crooked.
    b. To ensure proper alignment of plates, slide an outer spring rail onto a set of threaded rods with the side that will attach to the lower mounting plates facing the already-attached upper plates. Insert threaded rods into their holes and slide the spring rail down so that it touches the upper mounts.
    c. Mark the outer edges of each upper plate onto the rail above it so that the widths of each plate will be clear on the spring rail. Remove the rods and rail and use square to extend the marks into lines. Repeat for the other spring rail.
    d. Use straight edge to draw a line on the spring rail between the threaded rod holes, centred on the holes (similarly to earlier). [Instead, lower plates centred on spring rail and hole locations eyeballed in 2024-01.]
    e. Mark screw holes with hammer and punch, holding each plate in place firmly.
29. Install pantograph spring lower mounting plates.
    a. Drill pilot holes appropriate for screw size (#6 wood screw) on drill press. Set bit stop to depth of hole (estimated beforehand).
    b. Install screws to attach each lower mounting plate.
30. Mount spring rail assemblies.
    a. Install threaded rods and slide components onto rods in their respective locations.
    b. Tighten the spring rails together (inside & outside). Ensure top of threaded rods are flush with tops of tee nuts, then tighten from outside end with the following order of fasteners: flat washer closest to wood, then split washer (acts as lock), then nut. Tighten nuts with pliers.
31. Assemble pantograph springs.
    a. *See OSI spring assembly blueprint, which should be provided with parts kit, for specific instructions.*

b. Install panel positioning pins (small, black cylindrical pins) into holes that run horizontally through upper and lower mounting plates (two per plate).
    i. Pins require a lot of force to be driven through. Get each pin through one hole first. Before crossing through second hole, look through it from the other side and ensure that pin is aligned with hole. Use a hammer and very hard strikes until pin exits through the other side. Repeat for other pins.
c. Remove nuts from all eyehooks. Thread one eyehook through the centre hole in each side plate (side plates appear similar to upper & lower plates but are shorter), towards the fatter side of the plate. Place a flat washer (included) on the outside of the plate, then a wing nut (only a few threads tight for now). Repeat for all eyehooks and side plates.
d. Hook each coil spring onto two eyehook assemblies.
e. Install spring panels. See blueprint for a visual depiction.
    i. *Important: Panels have bevelled edges. Blueprint will indicate the proper directions that the bevels must face.*
    ii. Install a lower panel first. Panels simply sit against trenches in mounting plates. Next, install the adjacent upper panel. One end of each panel will sit in a side plate, and the other end will sit in its respective upper or lower plate.
    iii. Install the other lower panel.
    iv. Install the final upper panel, placing its base in the side plate first, then using hands to gently force the other end into the remaining mounting plate. Spring should now be under compression and standing on its own.
f. Use a light mallet to tap the panels sideways as necessary so that they are centred between the positioning pins.
g. Place small pieces of cork (or similar padding material) between the schwimmer plate and the inner spring rails underneath each spring to temporarily support the plate until felt is glued onto the inner rails.

32. Install felt liners on inner spring rails.
    a. Cut four strips (or same amount as the number of springs installed) of ¼” felt, each 4” long.
    b. Use a felt/leather glue (Weld-Bond) to fasten the strips to the inner spring rails, aligned with the spring positions (i.e. as a replacement for the corks).
        i. Mark locations for strips with a pencil so they line up centred above each spring.
        ii. Use finger to apply glue to both wood rail and felt, then press felt onto rail.
33. Prepare and cut steel roller pipe.
    a. If steel pipe has threaded ends, cut threads off of one end first.
        i. Clamp pipe in a vise securely.

ii. Use your thumbnail of one hand as a surface to guide a hacksaw blade while making initial backstrokes at the location of the cut. Once a groove is made, begin cutting in both directions. Ask an assistant to check the saw is square before proceeding.
iii. Use both hands to move saw: one hand on the end of the handle and the other gripping the front of it. Add weight to the cut to finish faster, but not excessive weight.
iv. Once complete, use a coarse file to deburr all edges, then give a light chamfer to the outer edge.

b. To cut main (long) roller, position roller support blocks standing on the inside surface of the frame in their approximate positions.
   i. On one side, the block must not go past the large valve opening, since it will be controlling it. Locate the block in between the edge of the frame (not too close to edge or you will meet the chest wall) and the valve hole.
   ii. On the other side, the block must also be clear of the edge, but should not be resting on top of rubbercloth. Placing it lined up with the edge of the rubbercloth is acceptable.
   iii. The two blocks should line up across from each other, and must be to one side of the lengthwise centre of the frame, or else the arms cannot pivot to reach the objects they connect to.
   iv. *(Measurements taken after construction):*
      1. *Non-valve end: block positioned ½" from chest wall when mounted*
      2. *Valve end: block positioned 1 1/8" from chest wall*
      3. *Widthwise: blocks positioned 4" from front chest wall*
c. With blocks positioned, slide one block over laterally (maintaining correct spacing from edge). Align the end of the roller pipe flush against one block, then lay it straight past the other block and observe where the pipe will need to be cut so that it will contact the other block's inner face flush. Mark cut location with masking tape and indicate which side of tape to cut on.
d. Cut pipe with hacksaw using method described above.
e. Repeat process to cut the short roller. Position support blocks close to the middle of the schwimmer. Blocks must be far in from the edge enough not to interfere with the mounting of the schwimmer.

34. Cut aluminum angle iron brackets.
   a. Four pieces 3" long are required. Draw cut lines on all sides using square.
   b. Cut using band saw.
   c. Use 45-degree (triangle) square to mark two diagonal lines on each 3" piece, one on each side extending from the bottom corner towards the middle of the top of the face of the aluminum that will stand vertically (this creates a "trapezoid" looking shape on one leg for cosmetics).

    d. Cut on the lines with band saw. Clean up burrs with file.

35. Drive dowels into ends of roller pipes.
    a. Clamp one pipe onto a bench using a scrap piece of wood with a V-wedge cut inside, which cradles the pipe to keep it stable.
    b. On a belt sander, hold the dowel end a few inches over the belt at a very slight angle and roll the dowel while sanding, aiming to create a slight taper.
    c. Draw a line on the dowel 1 ½" from the end. Have an assistant hold a steel anvil against the back end of the pipe while using a hammer to pound the dowel in from the front.
        i. Dowel should enter into the pipe by at least 1 ½". If the line is not reached, remove the dowel, sand gently to increase the taper, then re-insert.
    d. Cut dowel flush to pipe end using hacksaw.
    e. Repeat for the remaining three pipe openings.
36. Mark and drill centre holes in roller pipe ends.
    a. The more precise the hole locations, the better. [Holes were marked by hand in 2024-02.]
    b. Use a pencil to draw an "X" on a pipe end, then mark the centre with an awl to the best possible using eyes.
        i. Repeat for remaining three ends.
    c. Drilling holes on drill press is preferable, but the long roller pipe will not fit on drill press.
        i. Based on the screws to be used [#12 x 2 ½" in 2024-02], choose a drill bit suitable for a hardwood pilot hole [1/8" used 2024-02]. Drill holes as deep as the threads protrude on the shank of the screw.
        ii. For short pipe, lower drill press stage and have an assistant hold base steady while you hold and drill at the top (use level if desired). Repeat for other end.
        iii. For long pipe, place on flat surface and clamp down. Ask an assistant to indicate whether drill is straight in the horizontal axis, while you drill the hole and pay attention to vertical position with a handheld drill. Repeat for other end.
37. Insert and trim screws for pipe ends.
    a. Rub screw threads with candle wax before driving in.
    b. Clamp pipe. Drive screws into pipe ends until no threads are exposed.
    c. Use hacksaw to cut off screw heads so all that remains is a pin protruding from dowel. Soften sharp edges with file as necessary.
38. Drill holes to accept pipe end pins into roller support blocks.
    a. Mark centres of *lignum vitae* plugs by eye.

b. Set drill press stop so that bit stops at 5/8 to ¾ the depth of the wood thickness. Use a drill bit the same (or closest possible) diameter as the pipe end pins. Use verniers to find diameter of pin, then fit drill bit to same measurement [3/16" used 2024-02].
c. Drill holes, then dry fit pins into blocks. Pins should move freely in holes, but not be loose enough to rattle (no resistance but snugly fitting).
d. If resistance occurs, use number inch bits and find drill bit with diameter closest to the original drill bit used. Drill to enlarge hole.

39. Glue neoprene foam to aluminum valve plate.
    a. Cut a rough square of neoprene slightly larger than the diameter of the plate. Neoprene stops aluminum from ringing while moving in the schwimmer and contacts plywood to prevent knocking.
    b. Use an awl or pointed object to scratch the surface of the plate to be glued to aid with glue adhesion.
    c. Punch a 1" diameter hole at the centre of the foam pad using an arch punch to create clearance for a nut to be able to thread onto the ball bearing bolt and sit flush against the plate.
    d. Coat plate and neoprene with Weld-Bond glue and press together, ensuring centre holes of both materials are aligned.
    e. Allow to dry for several days. Once dry, use scalpel to trim excess neoprene from circumference of plate.
40. Shorten short roller support blocks.
    a. Arrange all blocks and rollers in position on frame, then turn short pipe blocks sitting on side.
    b. Use small identical objects (ex. Paintbrushes) stacked underneath the sideways blocks on either side to raise the blocks until the short roller sits half way between the schwimmer plate and the long roller (by eye).
    c. Measure the height from the base of the plate to the centre of the *lignum vitae* bearing pinhole.
    d. Remove short roller from blocks. Mark above height on the blocks vertically, starting from the pinhole going downward.
    e. Cut off excess wood from base on both blocks. On a mitre saw, lightly glaze the wood on the waste side with the blade running to see where the blade cuts, then inch the marked line closer to the blade until the blade cuts exactly on the line.
41. Cut roller arms.
    a. Use ¼" steel flat bar. Blueprints have differing instructions regarding arm length. "Phelps, Erie PA" blueprint suggests 6" arm length from roller to centre of hole. "Schwimmer Side View" suggests 125mm (5") from centre of roller to centre of hole. [Blair's judgment: cut arms to 6" flush.]

b. Mark cut line on flat bar. Clamp in vise and cut using hacksaw. Use first bar cutting to mark length for remaining arms.

42. Drill holes in roller arms.
    a. Blueprints differ in suggested hole positions. If using one particular blueprint, remain consistent. [Blair's suggestion: centre of hole ½" from end.]
    b. Mark centre of hole at centre of arm with centre punch [done by eye]. Repeat for remaining arms.
    c. Drill holes with clearance-diameter bit for the thread size used on the bearings that will be attached to arms [OSI bearing thread: ¼-28; bit size G (letter inch drill bit set).] Use lower speed on drill press.
43. Grind round C-curves into ends of arms.
    a. The ends of the arms opposite the holes must be curved inwards to fit with the contour of the roller pipes to which they will be welded.
    b. Use angle grinder with coarse wheel. Wear gloves and/or long sleeves to protect against hot flying sparks. Hold arm flat horizontally and press into corner of wheel, moving arm side to side to form curve.
    c. Test continually until fit is approximately the same arc as the roller (some variation will be filled in by welding). If curve surface is uneven, arm will not sit flush (turn arm upside down and grind off bumps as needed).
44. Mark arm welding locations on roller pipes.
    a. Fit support blocks onto roller pins and arrange rollers and blocks in their positions.
    b. Position angle iron brackets in place (L-shape facing edge of plate for long roller and facing inside for short roller).
        i. [Blueprints were not followed for angle iron or arm positions, though the measurements exist. Brackets were arbitrarily placed for long roller at 4" and for the short roller at 3" relative to plate edge.]
            1. *Front bracket for short roller needed to be moved eventually, but keep spacing of pairs equal as a rule.*
        ii. Important: Take measurements for the placements of the arms for both rollers at once (taking both rollers' positions into account), or else the arms of one roller may fall in the path of the other roller.
    c. Ask an assistant to hold an arm in place against the roller and wrap a line of masking tape around the pipe on either side of the arm to indicate location. Repeat for remaining arms.
45. Bring roller pipes and arms to welding shop to be attached.
    a. Instruct welder to weld all arms to rollers in the same plane.
46. Clean roller surfaces of oil residue.
    a. Remove all tape and other materials from the pipe surfaces of the rollers.
    b. Wipe all surfaces of both rollers (pipe & arms) with a rag soaked in Varsol.

    c. Allow Varsol to dry. (Do not leave oily rag crumpled up).
47. Paint roller assemblies.
    a. Use black spray can paint outdoors when wind is calm.
    b. Wrap roller end pins in masking tape. Hold roller in the air and coat all surfaces of roller pipes, arms, and ends with paint (use paint sparingly; if paint runs down the roller surface, too much was applied).
    c. Run a wire through one of the arm holes to be able to hang it in the air, then finish painting on remaining surfaces.
    d. Hang rollers by wires to allow paint to dry. Remove tape from end pins when dry.
48. Drill holes in angle iron brackets.
    a. Find a piece of scrap wood or a tool that is approximately half the width of the angle iron to use as a jig for placing the holes.
    b. Place jig on angle iron and use it to mark the locations for two screw holes on the bottom (non-chamfered) faces of the angle iron brackets. Centre the holes on the middle of the face and inset the holes an equal amount from each end. Go over pencil marks with a centre punch.
    c. Mark one hole on each of the chamfered faces of the angle iron brackets for the threaded rod ball joint connectors, centred in both axes. Mark hole locations with centre punch.
    d. Drill the screw holes with a clearance bit for a #12 screw [15/64”]. Drill the threaded rod holes with a clearance bit for a National Fine (1/4-28) threaded rod [letter G bit].
49. Cut new threads in linear ball joint.
    a. Linear ball joint (OSI part # 7993-00) comes with National Coarse (1/4-20) threads but National Fine (1/4-28) threading is required.
    b. Follow instructions above used for aluminum tap and re-cut threads with a tapping set. Cut threads as closely to the bottom of the socket as possible.
50. Shorten roller end pins.
    a. Assemble both rollers into support blocks and observe the gaps between the end of the rollers and the blocks. Gaps should be ~1/8”.
    b. If gaps are wider, clamp rollers and use hacksaw to shorten pins. Deburr once cuts are complete.
51. Begin assembly of rollers and ball joints for long roller.
    a. With schwimmer on work surface, position roller support blocks and two angle iron brackets in their rough positions and insert rollers into blocks. Move the support blocks back or forth until the roller arm for the aluminum valve sits over (or close to) the centre of the valve hole, but keep in mind the clearance of the blocks from the edges so as not to collide with the chest walls once mounted.

b. Use ¼-28 lock nuts and install one ball joint through the arm hole over the valve. Which side of the arm the joint should be on depends on which side results in better alignment over the centre of the valve.
c. Place the valve over its hole and line up the female ends of the linear and regular ball joints. Determine the length of ¼-28 threaded rod that needs to be cut to thread fully into both sockets while leaving ~¼" of visible rod between.
    i. Cut length of rod required using hacksaw and deburr both ends.
d. Connect both ball joints with rod so that rod is fully bottomed out in both joints. Valve should now hang from arm.
e. For the arm at the other end of the roller, attach ball joints through the hole in the arm and through the hole in an angle iron piece. Cut a length of threaded rod similarly to the above to connect the two joints.
    i. When connecting the joints with the rod, adjust the length of the rod visible until the ball joints stand completely vertically from plywood to arm. The arm may need to be at an angle above the horizontal to accomplish this.

52. Adjust position of aluminum valve relative to schwimmer plate travel.
    a. Ask an assistant for help if necessary.
    b. Press down on the sprung schwimmer plate, keeping a finger on the connected angle iron so that it moves with the schwimmer plate. Watch the movement of the valve.
        i. The valve should seal firmly against the hole at the same time as the plywood of the schwimmer plate becomes flush with plywood of the outer frame. It should not contact the wood before the plate is flush, and also should not leave the valve hole open after the plate is flush.
        ii. Loosen or tighten the valve ball joints & threaded rod until the above occurs. Make sure to evenly apply pressure to both sides of the schwimmer plate when moving it to simulate actual operation.
53. Fasten first angle iron bracket to schwimmer.
    a. Ensure that the two ball joints are still positioned vertically with respect to the arm and the schwimmer plate. Check that this is the case from all aspects (up/down as well as left/right).
    b. For the widthwise dimension of the schwimmer, align a large square along an outer edge and then draw a line on the width of the plate, in line with where an edge of the angle iron is already positioned. This will ensure the angle iron is fastened square.
    c. Align the edge of the angle iron on the line, then slide it back or forth on the line as needed so that the ball joints are vertical in the lengthwise dimension as well (left/right vs. up/down).

    d. Use an awl to mark screw hole positions. Drill screw holes to half the depth of the plywood with battery drill (mark bit with tape for stop). Use a #12 pilot bit [11/64”].
    e. Fasten angle iron using #12 x 1” screws. *If using round head screws, decrease the length of the screws as needed to avoid puncturing through the other side of the plywood.*

54. Assemble second angle iron bracket & ball joints to arm.
    a. Connect ball joints with lock nuts, cut threaded rod length and adjust until vertical, as done for first angle iron bracket.
    b. Draw line with square and check for centering, then mark and drill holes and fasten angle iron with screws.
55. Test operation of valve and check alignment of valve.
    a. Valve should now move with schwimmer plate and seat against the plywood as the plate becomes flush.
    b. Valve should be centred over hole. If it is not, use a large lever (e.g. long adjustable wrench with hole in the end), slide hole over arm, and bend arm slightly to correct alignment.
56. Attach roller support blocks to outer frame.
    a. Pencil around the bases of each support block to mark their outlines.
    b. Disconnect each arm linkage to allow the roller to be removed. Set aside.
    c. Use a pencil and awl to mark two holes an equal distance from the ends of each block outline.
    d. Clamp a scrap piece of wood underneath each set of holes to prevent bust-out. Use a battery drill with a #12 clearance bit to drill the marked holes.
    e. Remove the clamps, reconnect the roller arm linkages and place blocks in back in their positions. Use clamps to clamp each block to the schwimmer frame.
    f. With an assistant, turn and hold the schwimmer on its side. Use a countersink bit to create countersink for each hole (if having trouble, repeat this step later). Drill into the blocks through the holes from underneath with a #12 pilot bit. Drill deep enough to accept 1 ½” screws. Fasten blocks with #12 x 1 ½” screws
        i. If clamps block access to certain holes, prepare and fasten one screw, then remove clamp and fasten the other.
57. Create brass rod pins for valve guides.
    a. Return schwimmer to normal orientation.
    b. Using a hacksaw and vise, cut four 2 ½”-long brass rod lengths.
    c. At the bench grinder, chamfer one end of each pin, and then grind the other end to a nail point.
        i. Dip end into a jar of water between each pass to prevent hot temperatures in the metal.

    d. Mark each pin at a specific length from one end [2” used 2024-03] so that each pin can be pounded into the wood by the same amount.

58. Install brass pin guides.
    a. Have an assistant press down on the schwimmer plate while you observe the aluminum valve. On the crosshairs already drawn on the plywood of the outer frame from a previous step, mark an equal distance from the edge of the valve on all four sides that allows for some clearance (~1/8”), but still keeps the valve in place to seal properly.
        i. Remember that the marked lines represent the edges of each pin, not the centres. This must be taken into account when marking with awl in the next step.
    b. Mark drilling locations with awl. Drill pilot holes for half the height of the plywood with a drill bit slightly smaller than the diameter of the pins [7/64” bit for 9/64” pins in 2024-03].
        i. *Test with two opposite pins (half-drilled), lightly hammering in the pins, for proper alignment before drilling the rest of the holes.*
    c. Install pins with hammer. If pins appear angled, use hammer to tap and bend them back to vertical.
    d. Test operation of valve and see that it seals over entire hole properly.

59. Prepare and mark locations for short roller support blocks.
    a. Position short roller and support blocks widthwise on schwimmer frame. Locate blocks close to the middle in the long direction, and centred in the short direction (being mindful of avoiding a collision with chest walls later).
    b. Place angle iron brackets next to the ends of roller arms. Angle irons should be located as closely as possible to the centre of the schwimmer plate (in the long direction). Measure and mark a line at the centre of the schwimmer plate using a square, then line up the centres of the angle iron brackets on the line.
    c. Assemble the two ball joint/rod assemblies required as done for the long roller, then attach them loosely to the arms and angle iron brackets. To determine the final locations of the support blocks in the long direction, raise the arms so that their tops align with the top of the long roller pipe, then ensure the angle iron brackets are centred on the line drawn previously. The blocks will need to move back or forth to a location where the above two conditions are true.
        i. Note that the ball joint assemblies will be on an angle from the vertical to achieve this arrangement.
    d. Measure from one end of the frame to the same edge on both blocks and mark this length to ensure both blocks are aligned [22” from valve end (widthwise) in 2024-04].
    e. Pencil around the outlines of the bases of each block to mark locations.
    f. Remove ball joints and angle iron brackets from schwimmer and set aside.

60. Fasten short roller support blocks to frame.
    a. Follow instructions in step 56 to attach blocks to schwimmer frame.
61. Cut two threaded rod lengths (1/4-28 thread) to the same length as used to couple ball joints previously and deburr edges on bench grinder.
62. Fasten remaining angle iron brackets.
    a. Place the remaining two angle iron brackets on the schwimmer plate and align them with the short roller arms.
    b. Connect two pairs of ball joints with the threaded rod lengths and then attach ball joints to roller arms at one end and angle irons at the other. Secure with lock nuts.
    c. Keeping the angle iron brackets aligned with the roller arms so that the ball joint straight lengths stay "vertical" (do not tilt to one side), slide both angle irons back or forth together until the height of the tips of the roller arms are in line (or slightly higher than) the top of the main shaft of the long roller.
    d. Align the angle iron brackets with themselves in the widthwise direction of the schwimmer plate. The alignment for these brackets can be done by eye.
    e. Mark hole locations with an awl, then drill #12 pilot holes and fasten angle iron brackets to schwimmer with screws (preferably round-head; watch length to avoid puncturing through).
63. If not already secured, fasten ¼-20 lock nut and lock washer to the bottom of the valve plate on the ball joint threaded rod.
64. If installing tremulant, mount motor and weight wheel assemblies so that the weight(s) are as close to the centre of the schwimmer plate (in both dimensions) as possible. Mark locations with a square if desired and then secure using round-head screws.
65. Mount schwimmer to windchest and attach wind line. With wind on, calibrate the pantograph springs so that each spring is deformed the same amount (this ensures approximately the same pressure at each spring). Adjust springs together to change wind pressures to new values.