Construction Notes on The Side Paddle-Wheeler

Ticonderoga

Part 3

By Alex Derry

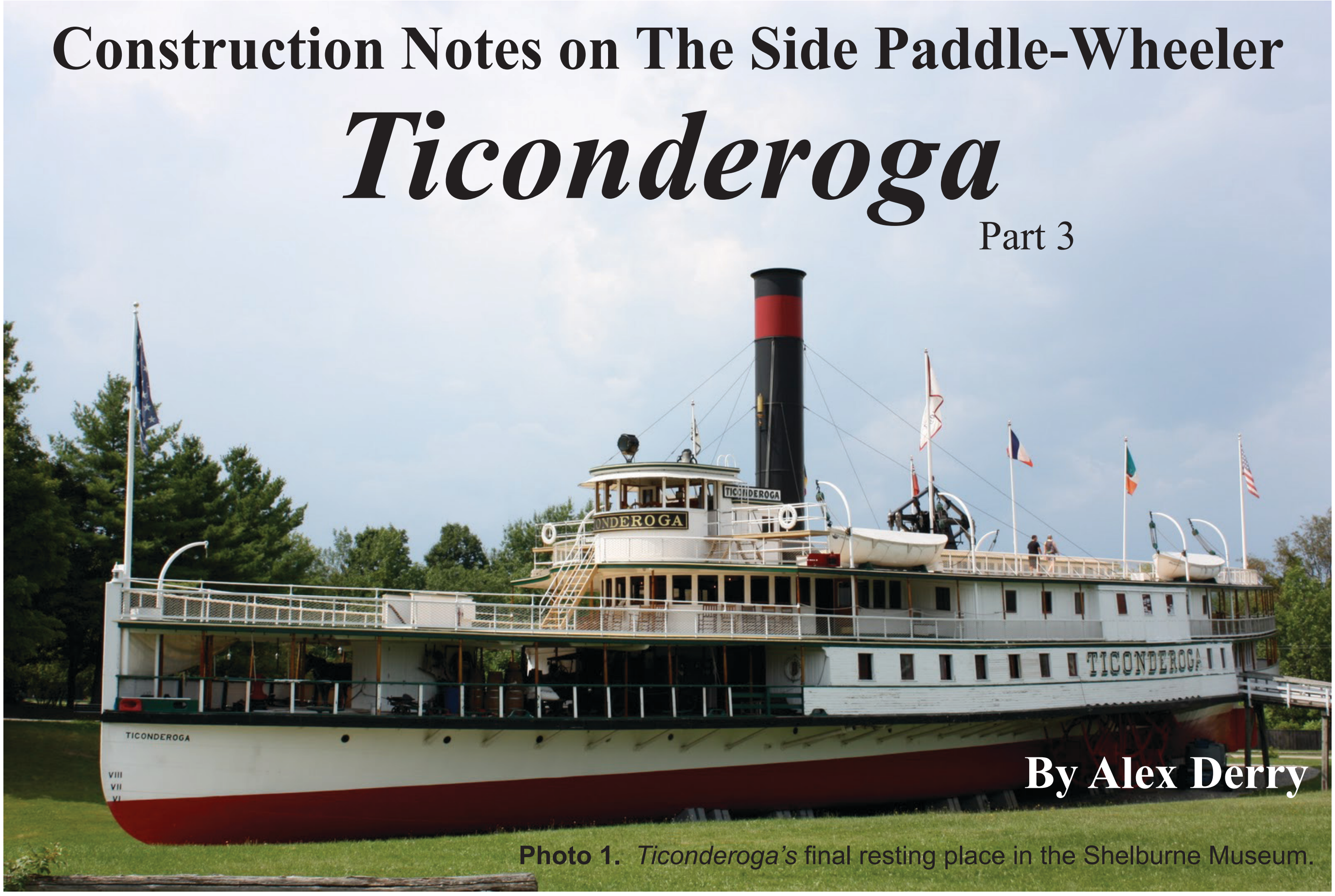

Photo 1. *Ticonderoga's* final resting place in the Shelburne Museum.

Welcome back, in Part 2 the plating and then the second layer of the first deck construction were discussed. The hull beam of a side paddle-wheeler is slim in comparison to that of the first deck since the paddle-wheels need to be allowed access to the water yet to increase the functional deck surface area, it also requires the deck to be built around the paddle-wheels. The first deck served three main purposes. In the forward third, cargo was stored along with the ground tackle. The middle third housed the upper portion of the engine and its control room. This area also gave access to the paddle-wheels for maintenance and repairs. Interior outboard panels could be removed to give unencumbered access to them. Storage and work related rooms were located in the outboard spaces. I chose to detail the bursar's office, the Captain's quarters and a workroom in detail. These will be viewed and discussed in Part 4. In the abaft third, was the dining salon including a walkway that ran around the outer edge of this deck. The salon was located here since the galley was down one flight of steps. If one looks into the forward area of the dining salon, they will see the banisters and railings for the broad staircase leading down into the galley. All of this usable space was made possible by extending the deck outward and building around the paddle-wheels. As you saw, there was an elaborate series of support structures required to make all this possible. Lots of work went into these and so at that time; I wanted to take a break and begin the building of the walking-beam steam engine, a break that would last for 600 building hours. **Photo 24** shows the top most portion of the actual engine. It is called a "walking-beam" because the action of the beam is one of a

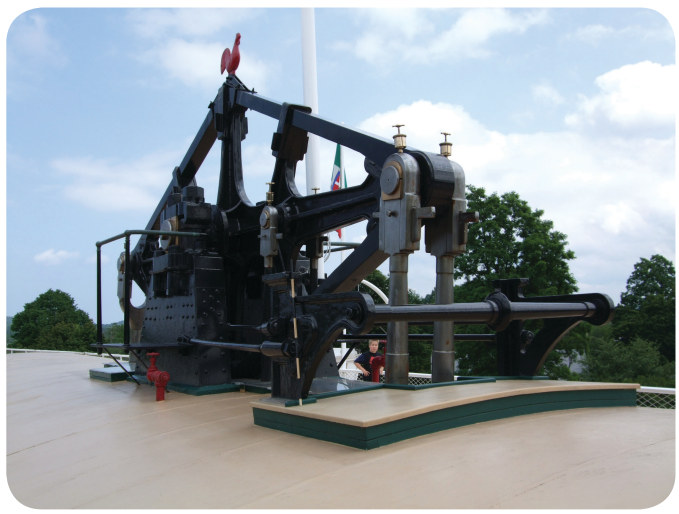

Photo 24. The actual upper frame of the walking beam engine.

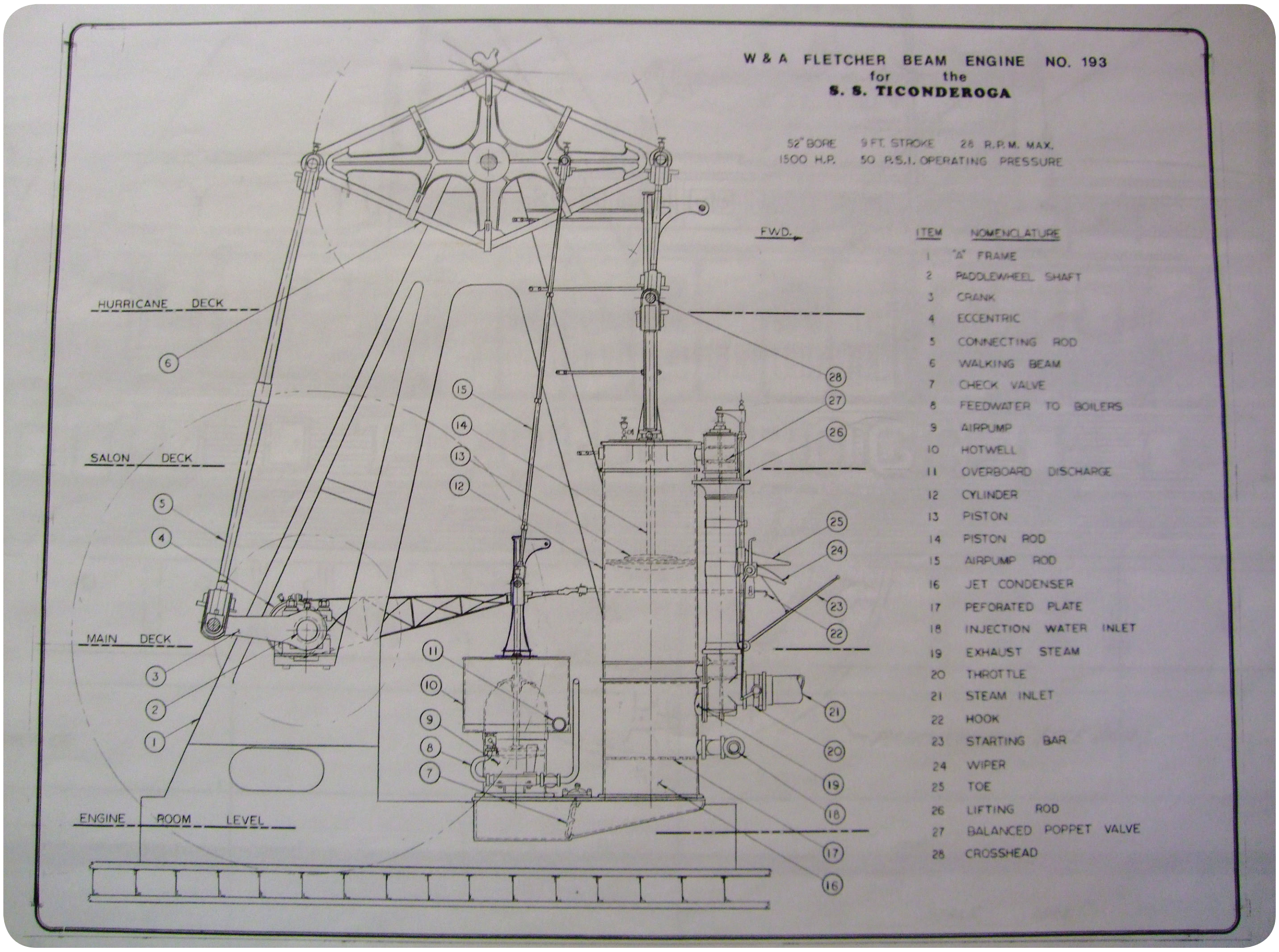

Photo 25. One of the many 1/48 scale drawings used to build the model.

rocker rotating around the center bearing actuated by the motion of the piston's connecting rod on the forward end of the walking-beam. The combination of the rocking motion and the forward motion generated gives the impression of a walking gate.

It was fortunate that Chip Stulen had excellent drawings of the engine and even better in a scale of 1/48. **Photo 25** shows one of these drawings. The finished model engine stood 10.5" tall. **Photo 26** shows the completed engine. As is seen in the drawing, the main frame of the engine was comprised of an "A" frame. There were two of them mounted to a base. The "A" frames were angled inward to form the mount onto which the walking beam central bearing was mounted. **Photo 27** shows one of the incomplete frames. It is a "box construction" held together by way too many dome-headed rivets. I say this because of the time spent on simulating them. Each rivet location needed to be drilled and countersunk. I used pinheads for this purpose which taught me some little-known facts about them. One, not all pinheads in a package are identical in size or shape. Second,

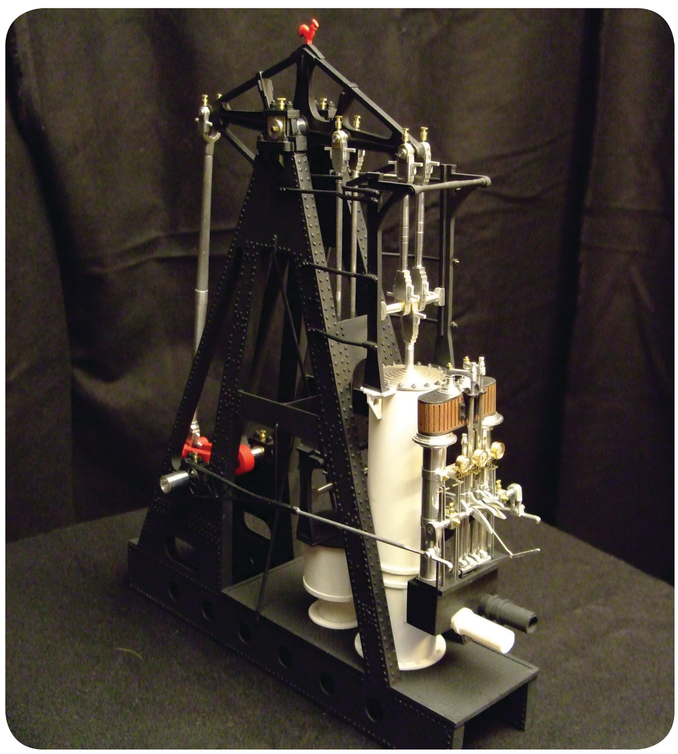

Photo 26. The finished engine which is 10.5" tall.

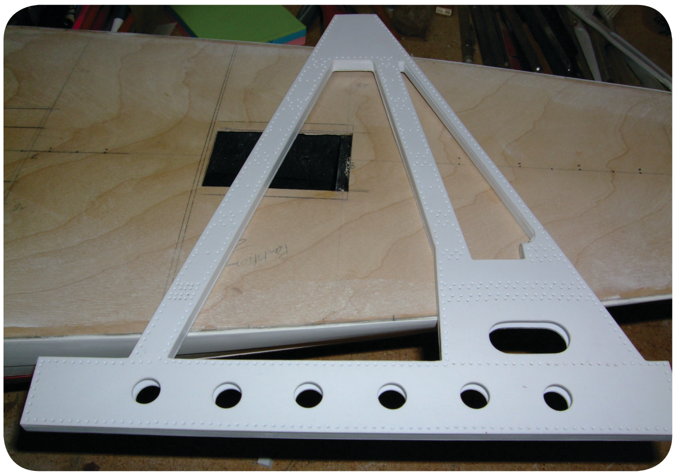

Photo 27. One of the “box construction” “A” frames.

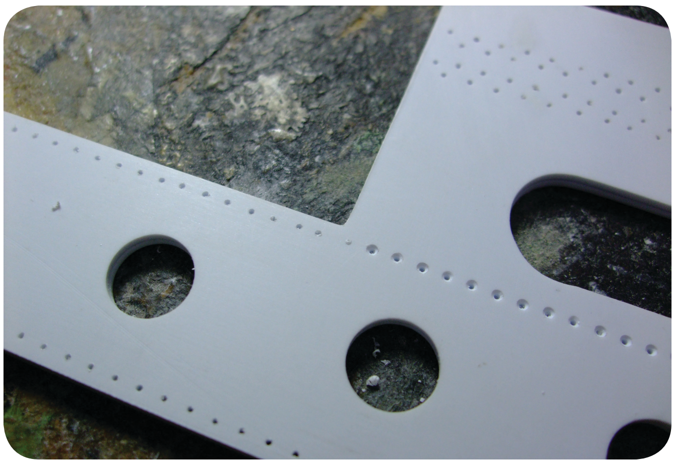

Photo 28. A section of the “A” frame preparation showing the locator holes and the countersinking.

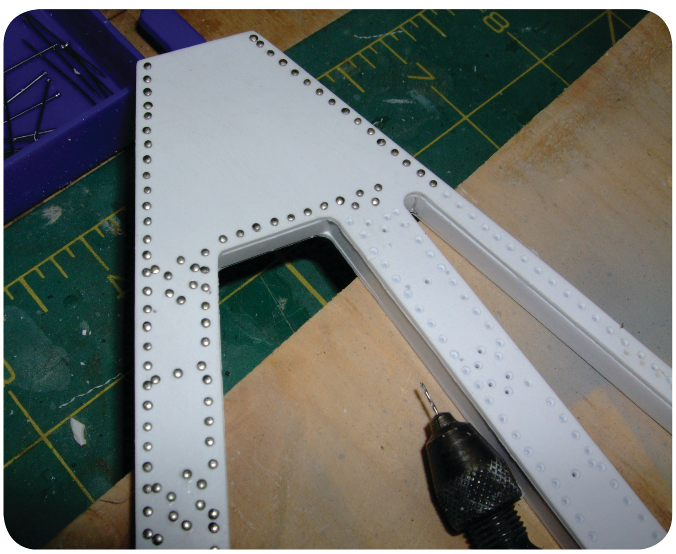

Photo 29. The rivets in place on the “A” frame.

the underside of the pinhead is not flat, and so, each location had to be countersunk. There are more than 200 pinheads per side and each “A” frame needed to be done on both sides plus their edges of the “box construction.” Model builders are known

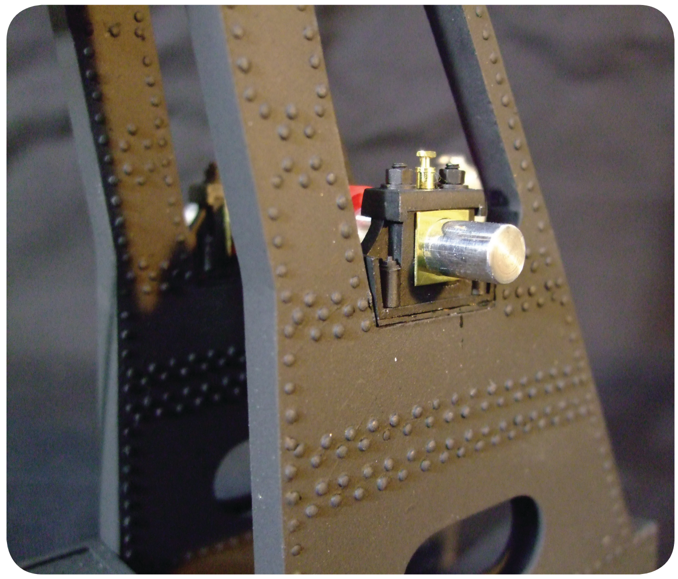

Photo 30. The painted frame showing the results.

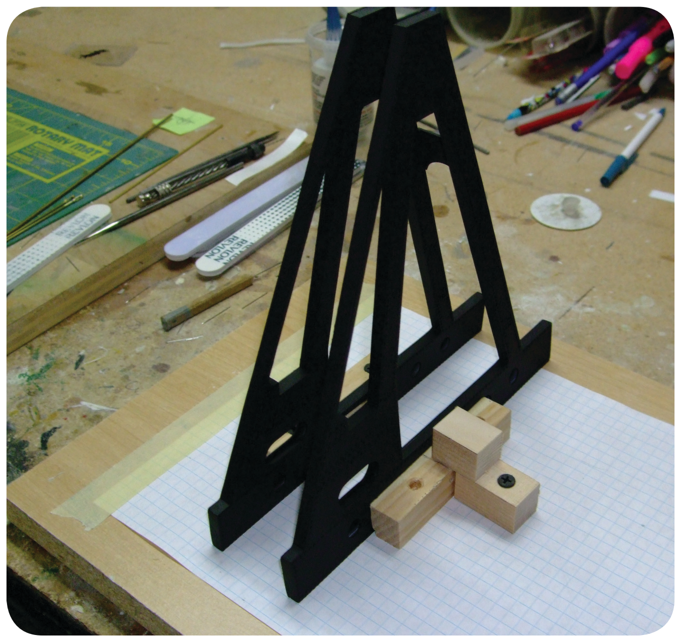

Photo 31. The frames needed to be held by a jig, at the correct angle during the addition of the cross members.

to frequent types of stores to obtain the necessary materials for their projects, and so once again I had to rely on my local fabric store. I chose a particular size of pin of which I bought more than thirty-six dollars worth in the end. I had to sort through each box to separate out the acceptable ones. About 40% of them were suitable. My repeated visits to the store did raise some eyebrows as I depleted their inventory to record levels. **Photos 28** and **29** show both the preparation for the rivets and some in place.

The frames were painted with Polyscale’s Steam Engine Black once they were fully riveted. It is worth noting here that the actual paint was not flat

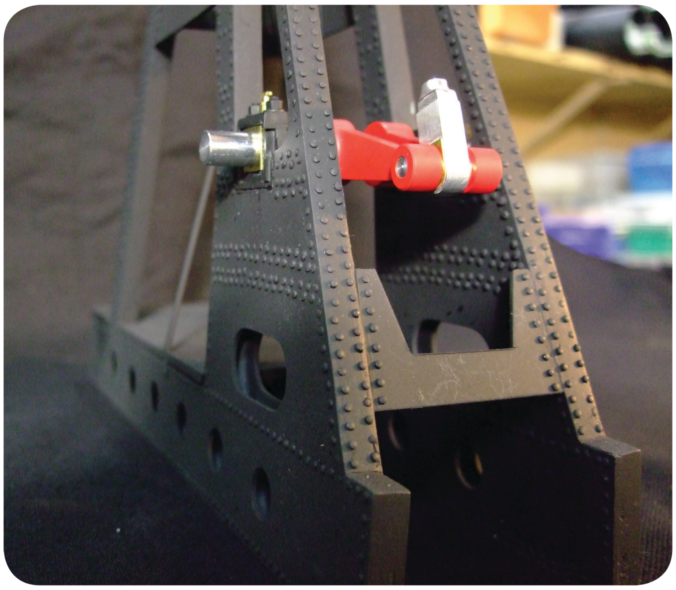

Photo 32. This is one of the cross members required and the deck at its base.

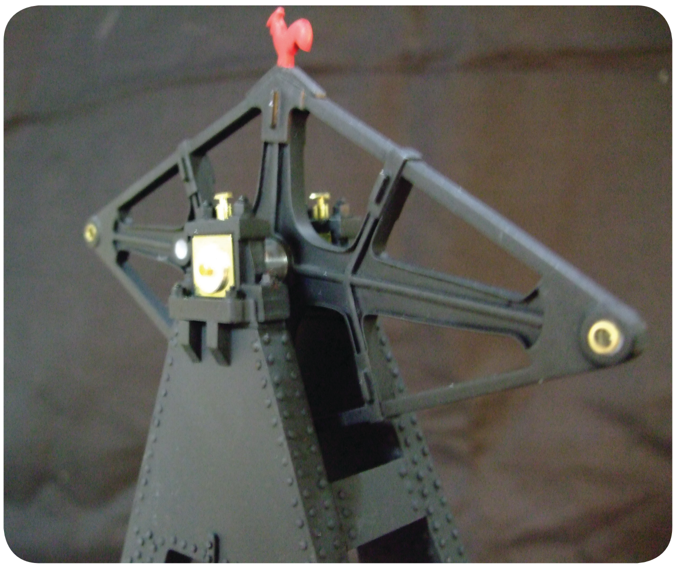

Photo 33. The walking beam assembly.

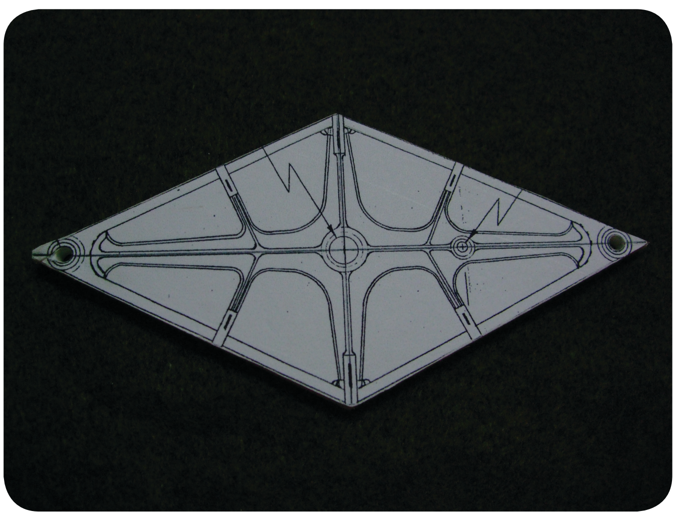

Photo 34. The drawing used to construct the diamond shaped walking beam.

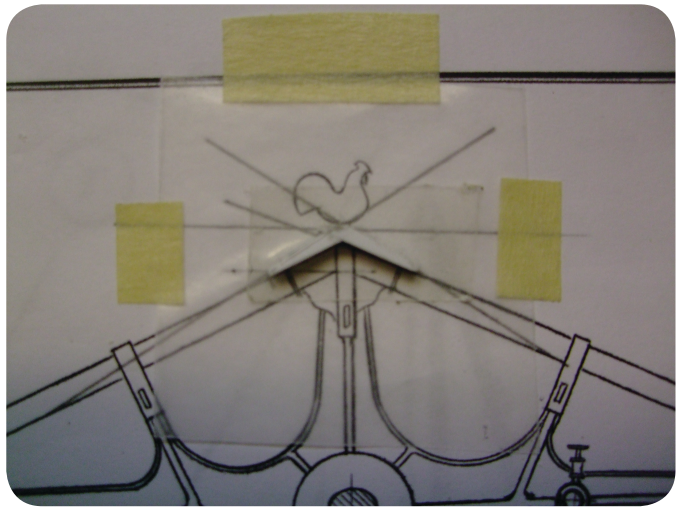

Photo 35. Extensions were drawn onto the beam diagram to help determine the angle sizes to be used for the frame pieces.

since it would be easier to keep clean in a coal fuel environment, however when modeling anything one must represent what the ship would look like from a distance. The distance tends to diminish the luster of paint. **Photo 30** shows some of the painted frame. The frames were then placed into jigs shown in **Photo 31**, which held them in place at the correct angles while cross members were added to permanently arrange them. **Photo 32** shows one of these cross members which, needed, even more, rivets! There were several points requiring these cross members plus a deck was added to the base as can be seen in **Photo 32**.

At this point, I needed to build the diamond shaped frame shown in **Photo 33**. The frame has four bearing locations. One located centrally upon which it rocked, one at each end opposite to each other and a fourth found more inboard on the forward midline. **Photo 34** shows a copy of the drawing that I used for this purpose. The outer frame needed to be built first. I used Evergreen styrene to form these pieces. It was critical that the angles required, and the lengths of sides are precise. **Photo 35** shows the extensions drawn to measure the top and bottom angle. From these drawings, the four sides of the diamond frame were cut and assembled. **Photo 36** shows this frame backed on one side, by 0.25 mm styrene sheet. This acted as a solid base onto which the frame could be assembled using thin cyanoacrylate glue. Later the center portion was cut out leaving the support portion on the one side of the frame. A gusset was attached at the two outside corners to act as the framework where the outer bearings would be mounted.
Each bearing location was provided by laying the drawing shown in **Photo 34**, onto the frame and

Photo 36. A thin 0.25mm sheet of styrene was glued to one side of the frame to ensure that the frame held together.

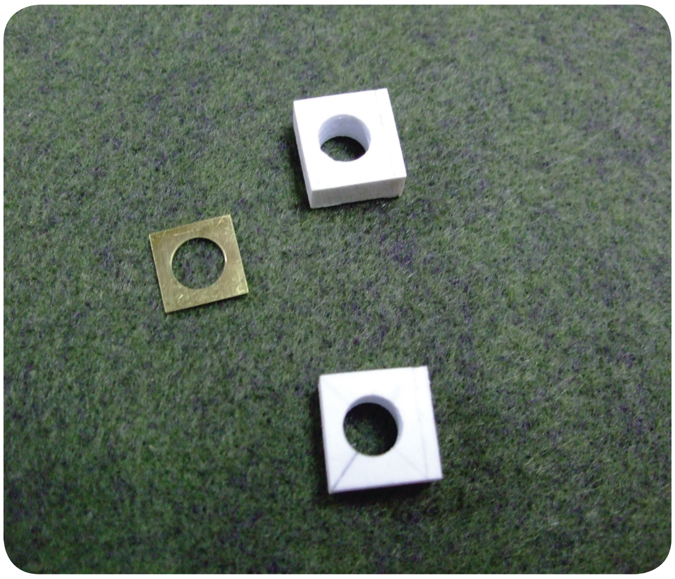

Photo 37. The parts for the bearing construction.

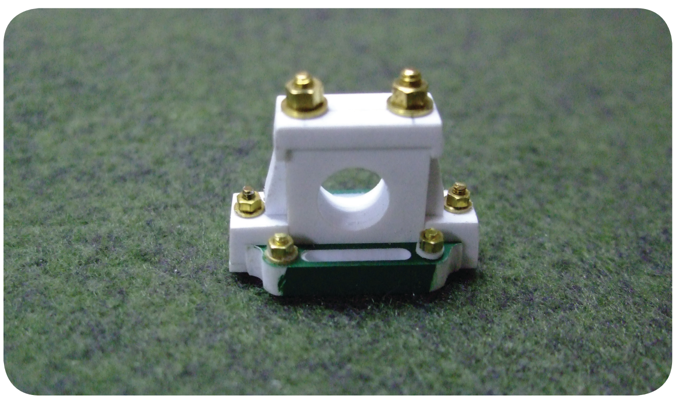

Photo 38. The unpainted finished bearing.

then center drilled for each bearing. The center webbing was cut from styrene using the drawing shown in **Photo 34** and finished with styrene to represent the various types of reinforcements as is seen in **Photo 33**.

The main bearings for the walking beam and the main bearings for the main crank and drive shaft for the paddle-wheels were made from Evergreen Scale

Photo 39. The painted bearings and brass insert used to simulate the brass bearing inserts.

Photo 40. The two bearings for the main drive shaft and crank being tested for sizing before the brass insert was added.

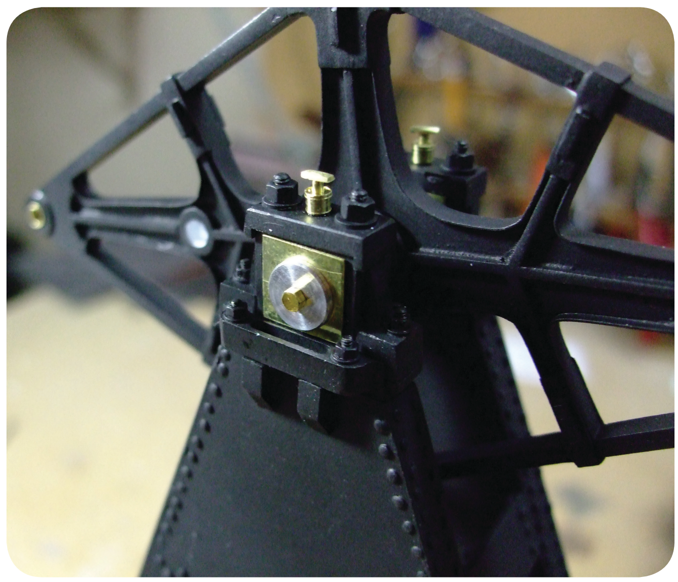

Photo 41. The installed bearing for the walking beam with the brass oil reservoir included.

Models polystyrene products. **Photos 37 - 39** shows the stages of construction for these main bearings. Specifically, **Photo 38** shows the end product for the walking beam bearing before painting. The bolts and threaded shafts were purchased from Micro Fasteners of Lebanon N.J. The bearings also needed brass inserts to simulate the actual two-piece brass bearing. **Photos 37** and **39** show the parts before assembly. The configuration of each

Photo 42 - 44. The two halves of the main crank built from styrene. The bearing for the main connecting rod ready for assembly. The assembly ready to be mounted in the “A” frame.

bearing pair differed according to the mounting space. **Photo 40** shows the main crank bearing pair before the brass insert was installed. **Photo 41** shows the bearing mounted on the “A” frame holding the walking beam assembly. Note the brass oil lubricant reservoir mounted above the bearing. The oil was distributed by gravity which, demanded constant monitoring to avoid running out. Each of the bearings involved required a constant source of lubricant.

The main crank was built of styrene as two separate identical halves as is shown in **Photo 42**. The larger end housed the drive shaft for the paddle-wheels. The smaller end held the axel onto which the bearing for the main connecting rod ran which is shown in **Photo 43**. This bearing was made out of Aluminum on my milling machine. **Photos 44** and **45** show the assembly in place on the “A” frame. Note that the drive shaft does not pass through the main crank.

The main connecting rod needed to reach 6" to the abaft end of the walking beam bearing from the main crank bearing. This dimension created a problem for me since my lathe bed is at its limits since I needed to use a cross slide to cut a double taper on the connecting rod. The taper is shown in **Photo 46**. I used aluminum rod as my stock and found that unlike good quality brass the metal does not cut as fluidly. The texture of this metal was sticky which caused vibration at the cutter edge resulting in an unsatisfactory result. Through trial and error, I discovered that a lighter touch and higher turn rates allowed a satisfactory cut. Another issue with the required double cut and the length involved was the flex of the stock away from the cutting edge. Having a follower rest included on the cross slide to prevent the flex caused space limitations so I decided to divide the connecting rod in half so that I could avoid this problem. The other advantage was that I could cut the taper so that the narrowest portion would be close to the headstock. This strategy allowed the deepest cutting closer to the mounted end of the stock which, avoided flex

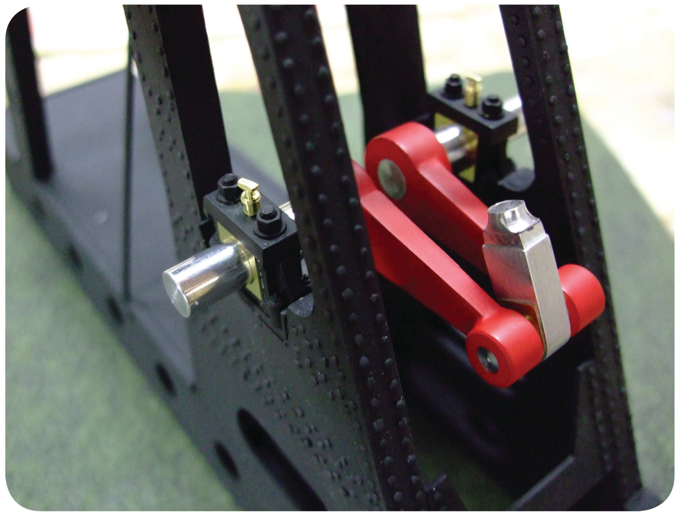

Photo 45. The assembly mounted and ready for the next step.

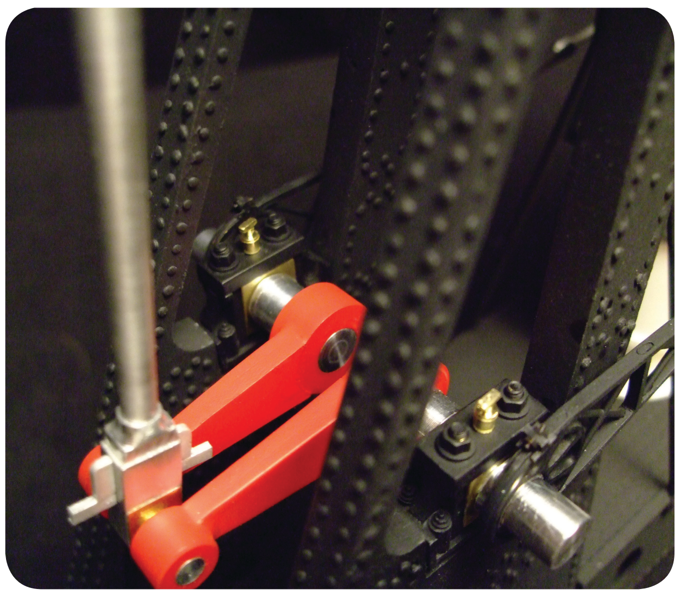

Photo 46. The connecting rod attachment to its bearing at the crank.

Photo 47. The “U” shaped top bearing for the main connecting rod.

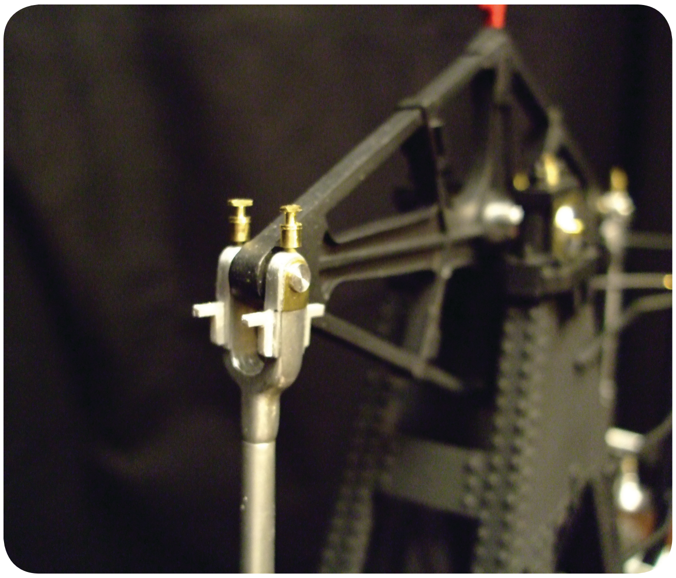

Photo 48. The final assembly of the top bearing including the two brass lubrication reservoirs.

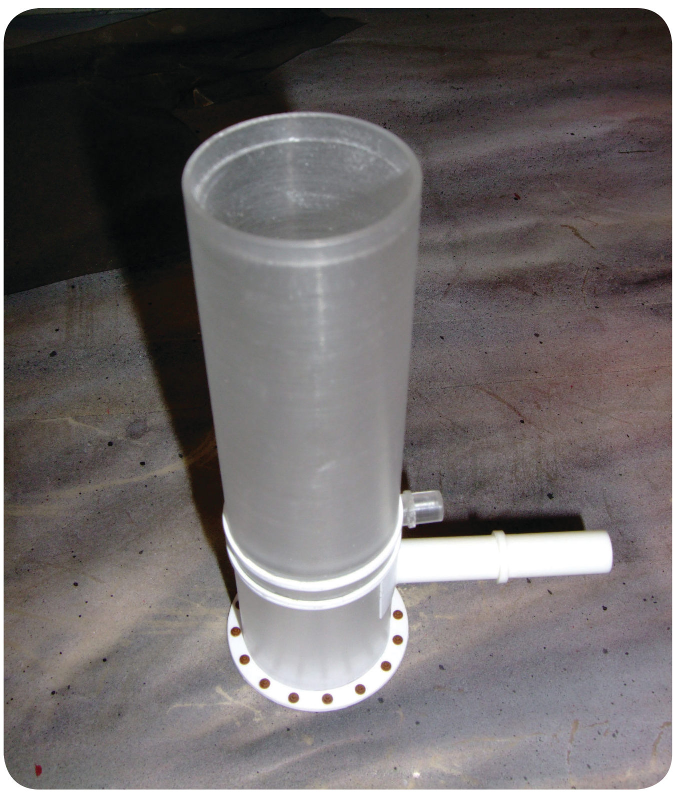

Photo 49. The cylinder assembly before paint.

issues. The draw back was the requirement that the two sides be assembled seamlessly. At the very center of the rod there is a section of straight sides where I was able to create the insert joint. Thin cyanoacrylate glue created a strong unobtrusive bond. Also, each end of the rod needed to fit perfectly into the bearing ends. This part of the cut needed to be straight, so the standard slide was used to finish the cut. **Photo 46** shows the connecting rod’s attachment to its bearing at the crank. The finished upper bearing shown in **Photo 47**, was built from rectangular aluminum stock. Its “U” shape was cut on my milling device. The inside dimension needed to be precise to ensure it cleared the bearing insert in the walking beam structure without excess space. Brass laminations were added to simulate the bearings. The attachment for the connecting rod on this bearing started out as a centered hole cut into the rectangular stock aluminum which was reduced by the milling process to enough material to allow it to be filed into a round shape matching the diameter of the connecting rod. **Photo 48** shows the top bearing installed on the walking beam with two brass lubrication reservoirs included.

The business end of the engine is a cylinder with a 9' stroke and a 53" bore for a three-ton piston assembly. Steam at a pressure of 50 pounds per square inch causes the movement of this piston. **Photo 49** shows the beginnings of the build of this part of the engine. I sourced a clear plexiglass tube of the correct diameter. Into which I inserted the steam inlet pipe. This is the white tube found in the lower portion of the cylinder. The smaller clear tube above is included in the delivery of live steam controlled by the valve system. There is a mounting flange at the bottom with cosmetic nuts attached carefully at equal intervals.

The top of this cylinder was built from stock aluminum mounted into a four-jaw headstock and center drilled to accept the diameter of the cylinder connecting rod. **Photo 50** shows the beginning of the stepped cutting for the top of the cylinder. The dimension of this part needed to be precisely cut to the outside dimension of the cylinder tube with a 1/16" overlap. This part then was parted from the square stock and then placed into a self-centering three jaw headstock bottom side out. There needed to be a cut made to recess the depth of the top to allow it to seat within the cylinder. A machinist’s turntable shown in **Photo 51** was used to locate the bolt pattern on the outer edge of this part. Two-sided tape and a center dowel of the correct diameter were used to hold the top during the process of locating the cosmetic nuts once again were sourced from Tichy Train Group. The unfinished result is shown in **Photo 52**. The bolts were later painted with Stainless Steel Polyscale to simulate metal finish.

At this stage, the composite "A" frame has been built with the base ready for the installation of the working parts of the engine. Into the frame have been installed the main bearings for the walking beam and the main crank. The walking beam and the main crank have been connected up by the two-piece connecting rod, and finally, the cylinder has been made ready. At this time I needed to build the machinery responsible for the coordination of steam pressure with the motion of the piston and drive train. This included the crosshead which guides the piston connecting rod and links its motion to the forward end of the walking beam. To see this one needs to refer to **Photo 26**. Four bearings were needed, two for the connection to the crosshead and two for the link to the walking beam. A fifth bearing was needed to link the piston connecting rod to the crosshead. A closer look at this assembly can be seen in **Photo 53**. The crosshead assembly slid up and down while simple bearings at each end ran on rails mounted on parallel support structures. These supports were mounted at there bottom to platforms attached to the sides of the cylinder. Also, at the top of these supports were reinforcements designed to guard against deflection. As can be seen in **Photo 53** a single substantive rod ran between mounts on the support structure. This completed the connection between the piston's motion with the walking beam and then the main crank. **Photos 54** and **55** show the parts required for the crosshead assembly.

The next step was to build the portion of the engine that coordinated the delivery of steam pressure and the release of exhaust steam. Once again, refer to **Photo 26** where you will see the whole engine. To coordinate the delivery of pressurized steam to the cylinder and to exhaust it required two separate valves. These valves are located inside the wooden steam chest mounted on top of the two large steam pipes. The valves needed to be forced open at the appropriate times to coordinate with the position of the piston. **Photo 56** shows the external portions of these valves that are linked to push rods that force them up and down which in turn open and close the valves. The timing of these movements is controlled by a camshaft. **Photo 57** shows the finished assembly. The camshaft is mounted to the two steam pipes by two bearings, and a third is mounted on the

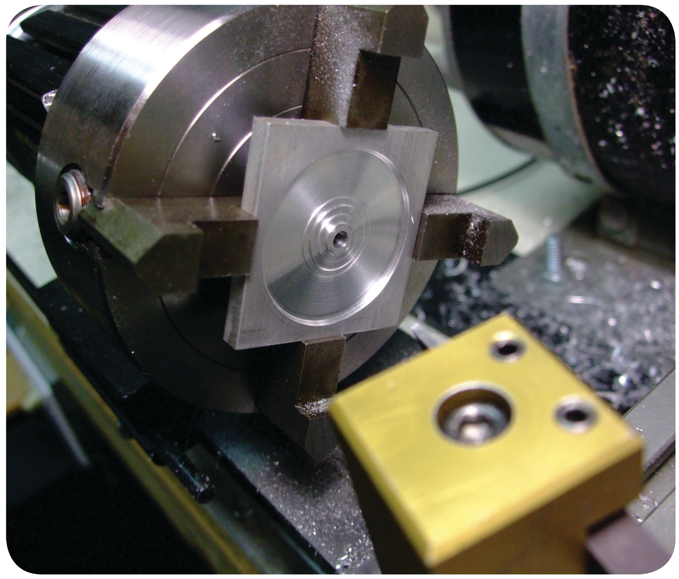

Photo 50. The cylinder top mounted in a four-jaw headstock in the process of cutting the stepped surface.

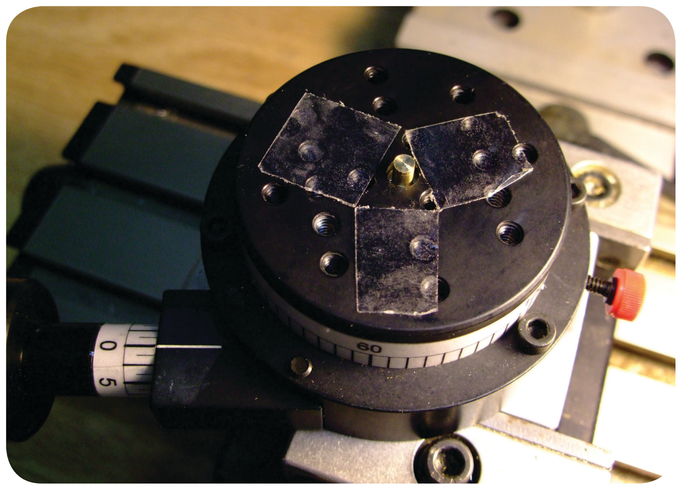

Photo 51. The machinist's turntable was used to locate the positions for the cosmetic nuts.

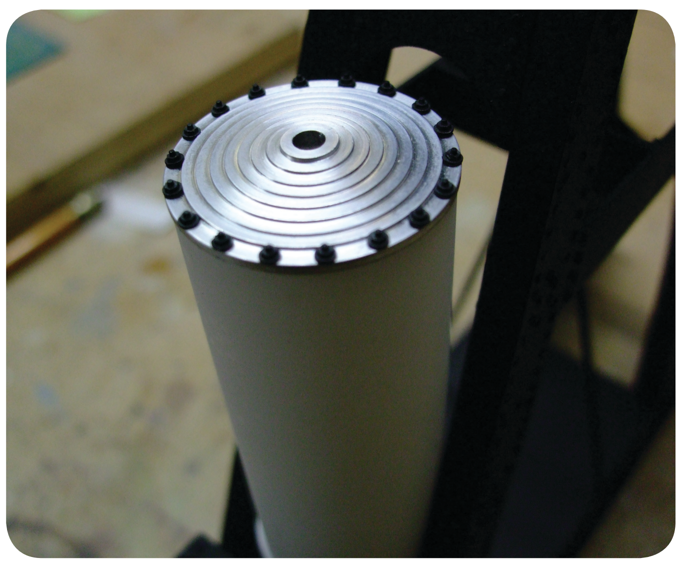

Photo 52. The unfinished assembly for the top of the cylinder.

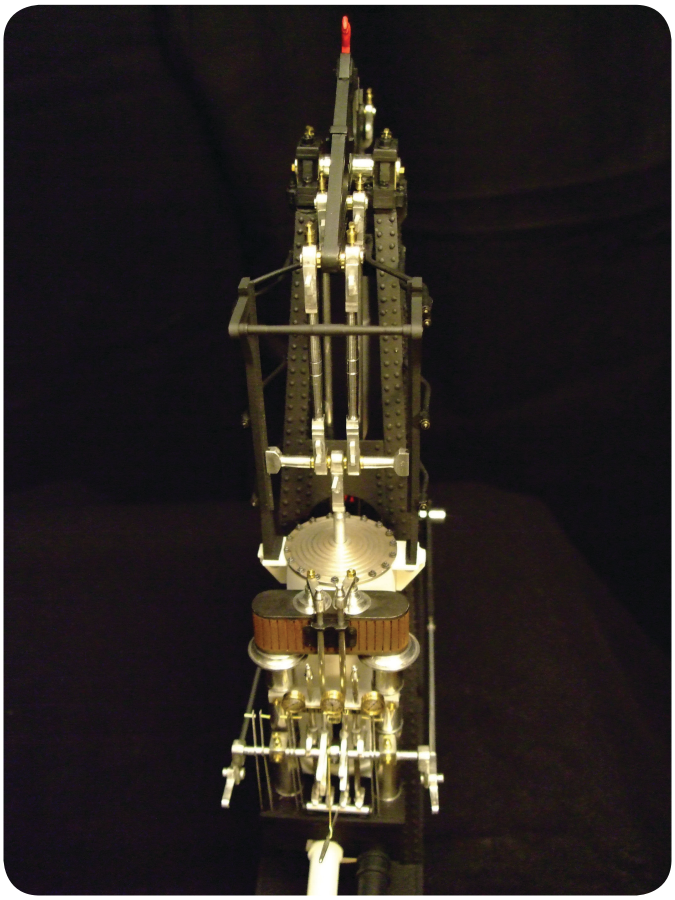

Photo 53. A closer look at the crosshead assembly linking the cylinder to the drive train.

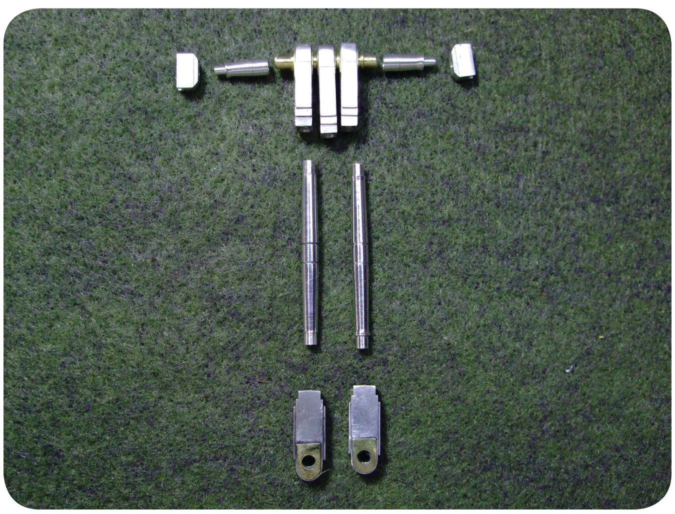

Photo 54. The metal parts required to build the crosshead assembly.

cylinder's surface which allow it rotate. The strange shaped curved objects are cam lobes and pushrod lobes which when the cam rotates in alternating directions, causes them to move against each other to create the up and downward motion of the push rods that open and close the valves. These parts were built from aluminum stock. There are six control handles which are mounted to the cam shaft and a 7th at the base of the assembly. At the

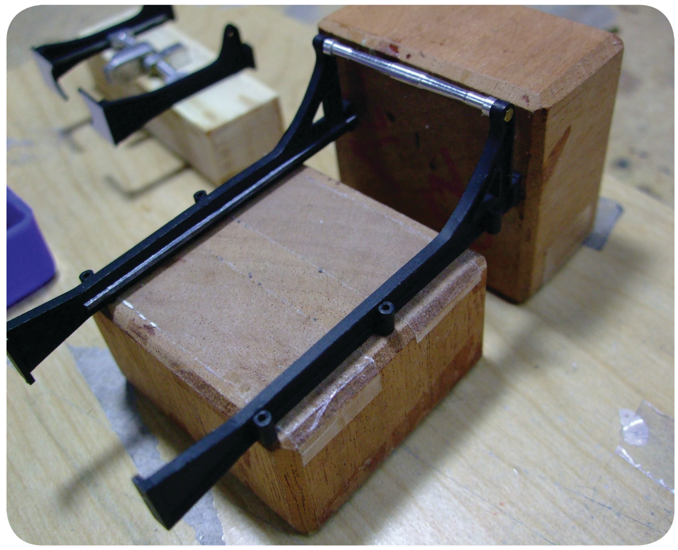

Photo 55. The support structure on which ran the two outer bearings of the crosshead assembly.

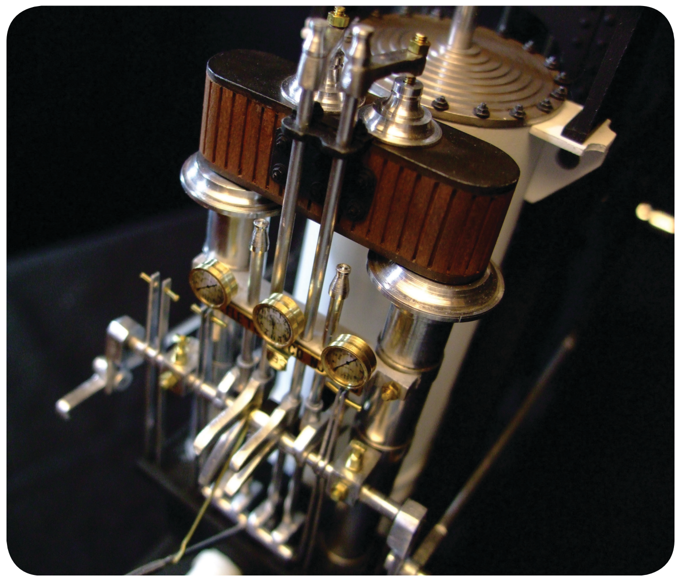

Photo 56. External portions of the valves.

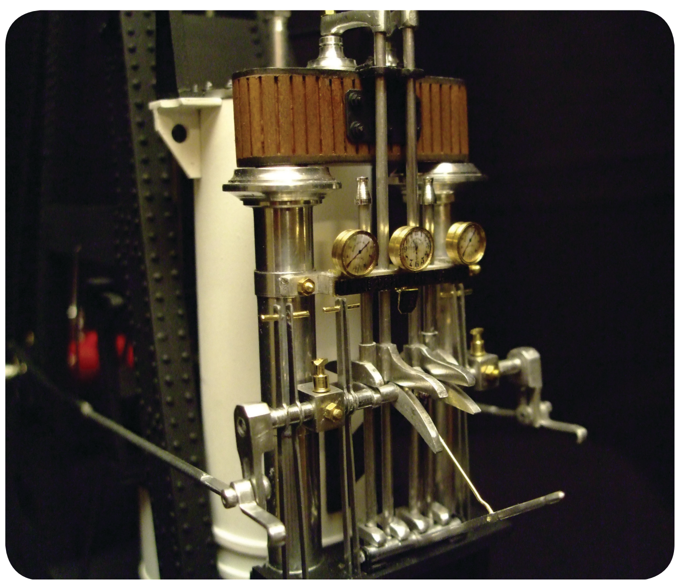

Photo 57. The finished assembly.

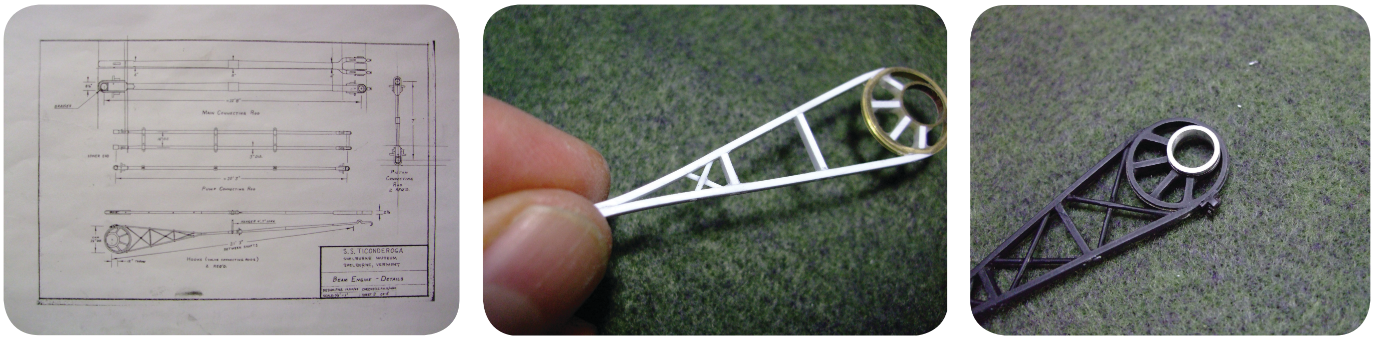

Photo 58 - 60. The eccentric bearing constructed from brass and Evergreen styrene stock with an aluminum off-center mounting ring.

ends of the camshaft, there are sliding bearings housed in attachments to the camshaft shown in **Photo 57**. Resting on these bearings is a rod that has been flattened and shaped to hook onto this sliding bearing. This connection is the heart of the coordination of the valve system with the position of the piston. **Photos 58 - 60** shows another strangely shaped assembly. This is what is called an eccentric bearing. It was constructed from brass and Evergreen styrene stock with an aluminum off-center mounting ring shown in **Photos 58 - 60**. The outside ring is the bearing comprising of two parts. The inner half is part of the aluminum mounting ring structure. The outer half slides over the inner ring half. This means that the offset mounting ring will rotate with the drive shaft. As the driveshaft rotates the position of the outer bearing will also rotate. If one looks at the end of the driveshaft the whole eccentric bearing would appear to wobble as it turns. The result of this is the movement back and forth of the whole mechanism about the horizontal plane. The push rod attached to the eccentric bearing transmits this horizontal motion to the cam shaft by resting on the sliding bearing found on the end of the camshaft shown in **Photos 57** and **61**. There is also a nut and bolt tensioning mechanism on the out side of the assembly shown in **Photo 60**. This is used to adjust the position of the off center mounting about the bearing that runs at the outside edge of the assembly. **Photo 46** shows the position of this assembly on the drive shaft. The adjustability of the eccentric bearing allows the engineer to time the release of the pressurized steam and exhaust because the rotation of the crank and the position of the off-center bearing causes the push rod to move forward and back as the crank rotates. The back and forward motion then cause the camshaft to alternately rotate which lifts and lowers the valve push rods via the interaction of the lobes. The crank is linked to the position of the piston within the cylinder via the walking beam, and so the eccentric bearing push rod then can time the opening of the correct valve at the appropriate time via the cam shaft rotation.

Finally, the hotwell needed to be included in the build. This can be seen in **Photo 61**. It is located behind the main cylinder. It is a cylinder and piston apparatus which needed to be attached to the walking beam. **Photos 61** and **62** show the lower part of the assembly. It has a crosshead which needed the same bearing set up as the main piston.

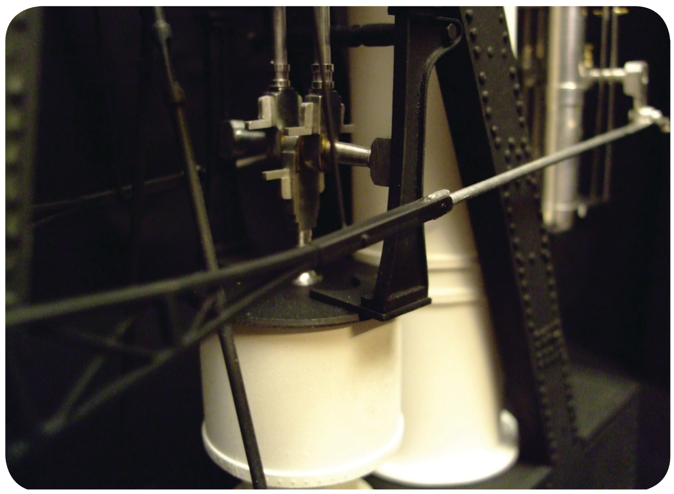

Photo 61. Closeup of the hotwell which is located behind the main cylinder.

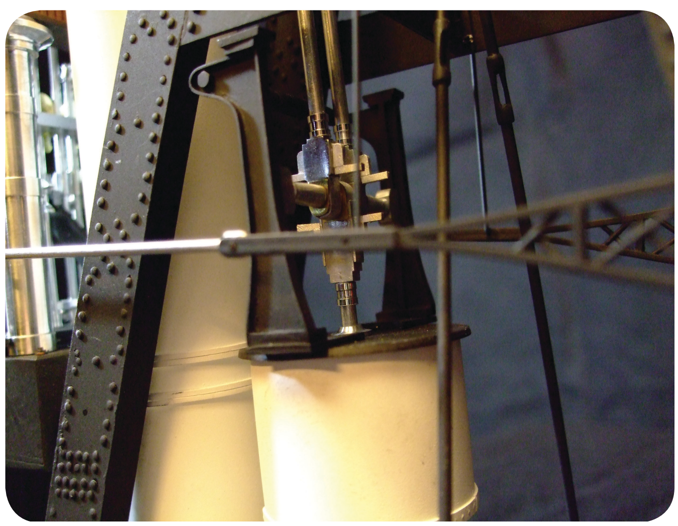

Photo 62. The lower part of the hotwell.

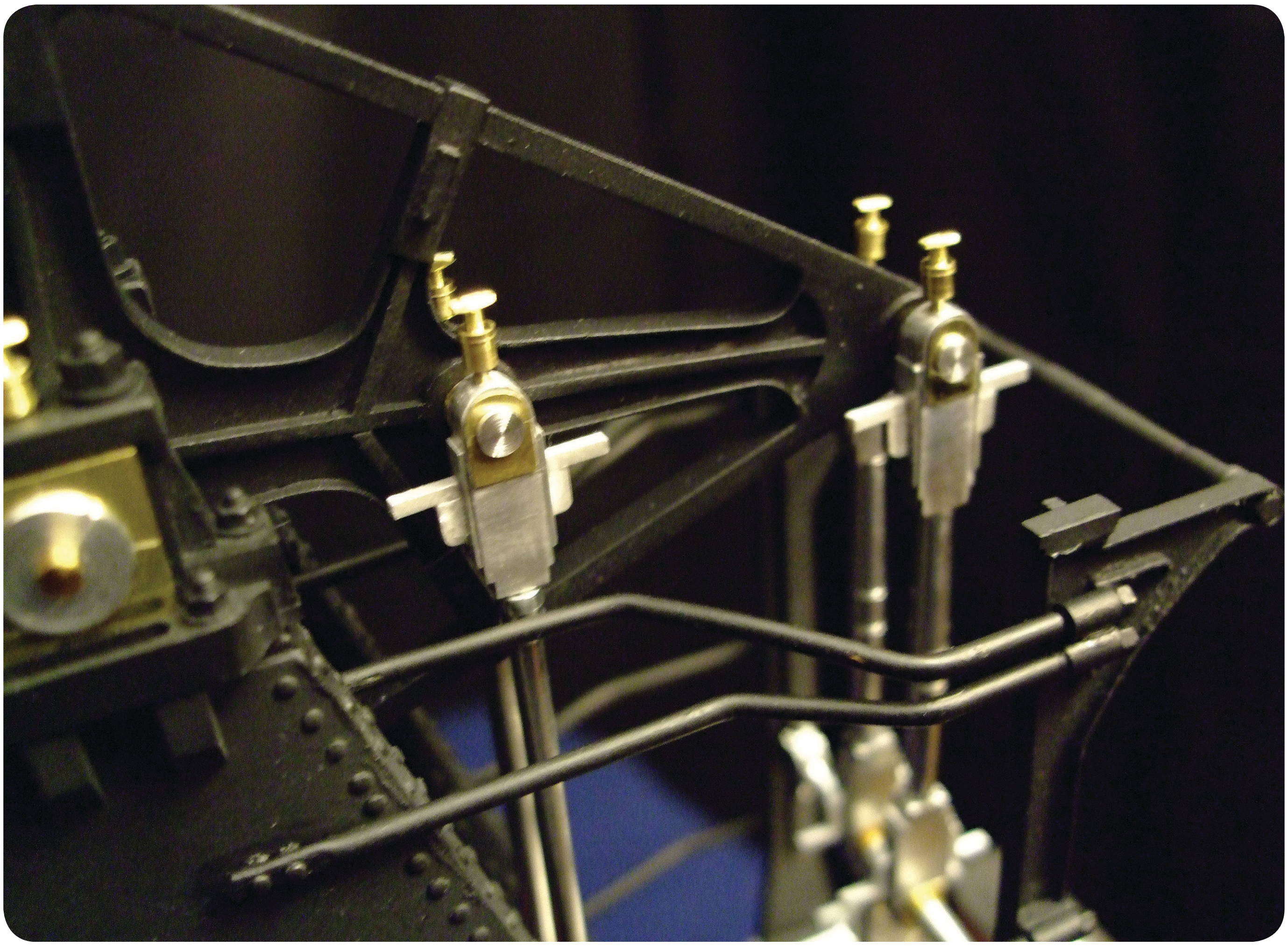

Photo 63. Closeup of the bearings and the bracing used to stabilize the upper portion of the crosshead for the piston.

Up at the walking beam, there was the need for two bearings as well. **Photo 63** shows these bearings. The hotwell could then be coordinated with the motion of the piston. Its function involved pumping air and water.

Once the hot well was installed, I needed to include some bracing used to further stabilize the upper portion of the crosshead for the piston as is shown in **Photo 63**. The nuts and bolts were obtained form Micro Fasteners of Lebanon N.J. I could have continued to build in more detail. However, it was my intention that the engine be installed on the model, so I decided to not include the extreme detail. Some have questioned why I would go to all of this effort when the engine was destined to reside within the model. My answer to this is that I believe that a true historic replica of any vessel requires that the interior be included. There are practicalities that limit what need be done, for instance, areas that are not visible through openings provided by the exterior doors, windows, gangways, etc. aren't required to be modeled. Built up interiors involve lots more work for the builder but results in a much more satisfying model. At the risk of repeating myself, it is the element of adventure that is offered to the observer of my models since a glance through an open door or window reveals the complexity found within any ship. Lighting the interior is a necessity to allow the observer the opportunity to see the detail. This added challenge will be discussed in subsequent parts to this series. Building the engine was very challenging and rewarding and did provide a respite from the repetitive work I did installing the details for the first deck. The engine at this point was placed in a display case to protect it form harm and of course the dust. Next time, I will be continuing with the work on the first deck interior which will involve simulating raised paneling for all of the walls of the various spaces found there and the planking of the decks. Until then enjoy your projects.