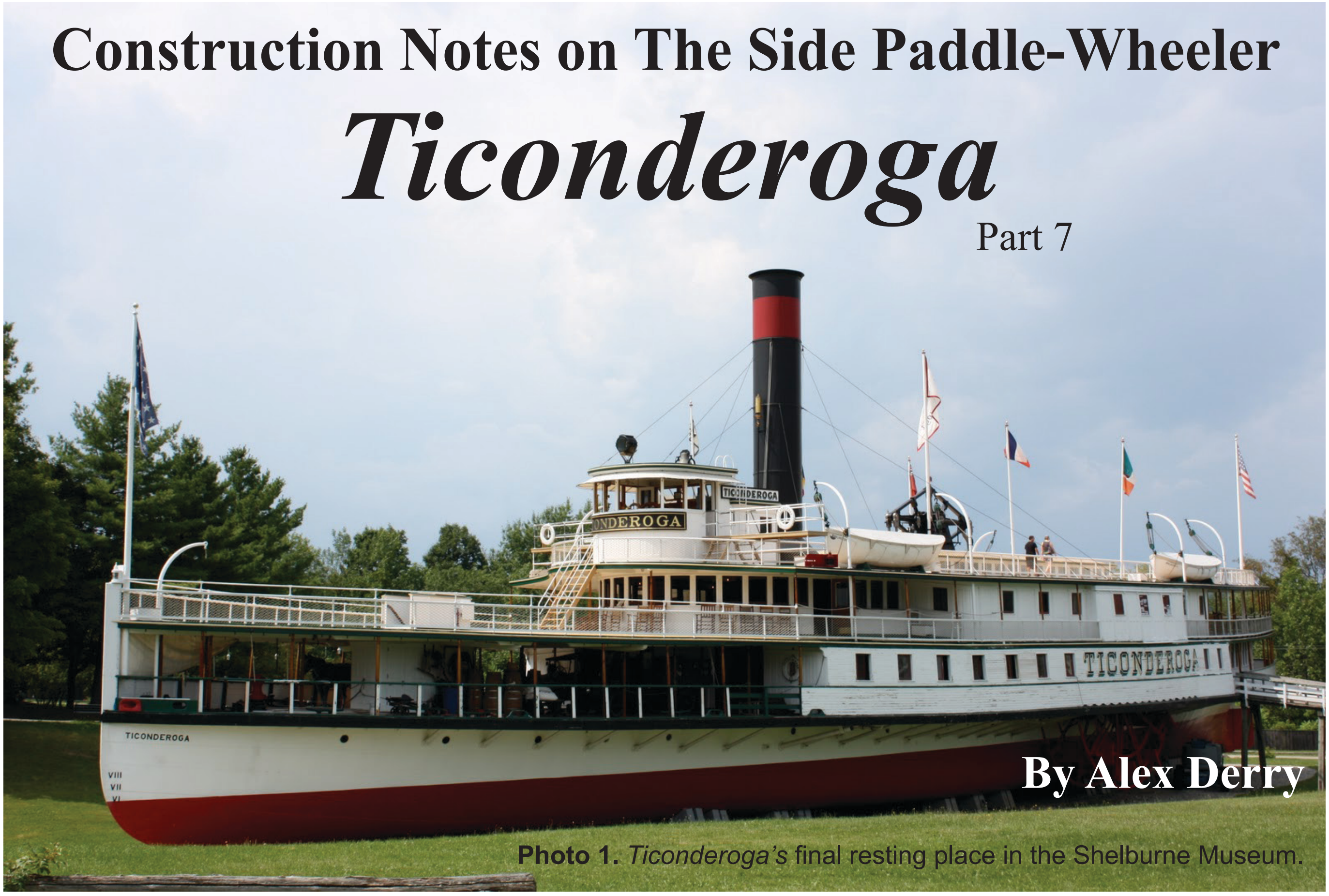
Construction Notes on The Side Paddle-Wheeler *Ticonderoga*

Part 7



By Alex Derry

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

Welcome back to Part 7 in which I will discuss the build of *Ticonderoga's* paddle-wheels. **Photo 193** shows the completed paddle-wheel ready for mounting onto the model. The actual paddle-wheels were 23' in diameter, had ten buckets per wheel and an all steel construction. They also had articulating buckets that in theory, would reduce unnecessary work as the entry and exit attitudes of the buckets would provide cleaner entrances and exits from the water. To accomplish this, each bucket required three sets of bearings. Two bearings, one on each side of the bucket, attached it to the mainframe that allowed the rotation of the assembly and one attached to the bucked bearing frame and then to the cam push rod. Each was made up of paired mounts that trapped the main frame between them. **Photo 194** shows this assembly. The third bearing was located on the outboard side of the paired bucket bearing mount also shown in **Photo 194**. Each of these had an extended length. The third bearing attached the push rod of the cam, to the outer most end of that mount. This provided the mechanical advantage of torque delivered by the push rods of the cam system as the engine caused the rotation of the wheel. The push rods were mounted onto a central hub that was fastened off-center from the main drive axle of the wheel to the frame of the hull. **Photo 193** shows the cam system and its off-center arrangement relative to the drive axel of the wheel. This caused the spokes to tug or push in a coordinated pattern on the extended outboard-bucket bearing mounts. The result was the controlled adjustment in the attitude of the bucket relative to the water's surface. This design had its advantages as it was more efficient and

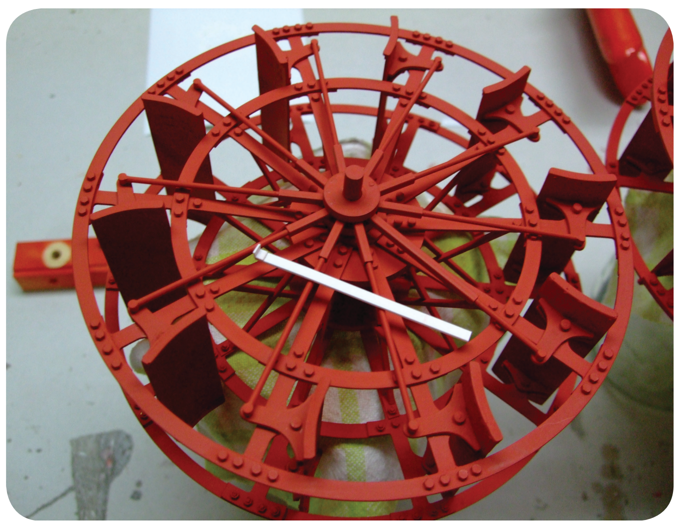


Photo 193. The finished paddle-wheel.

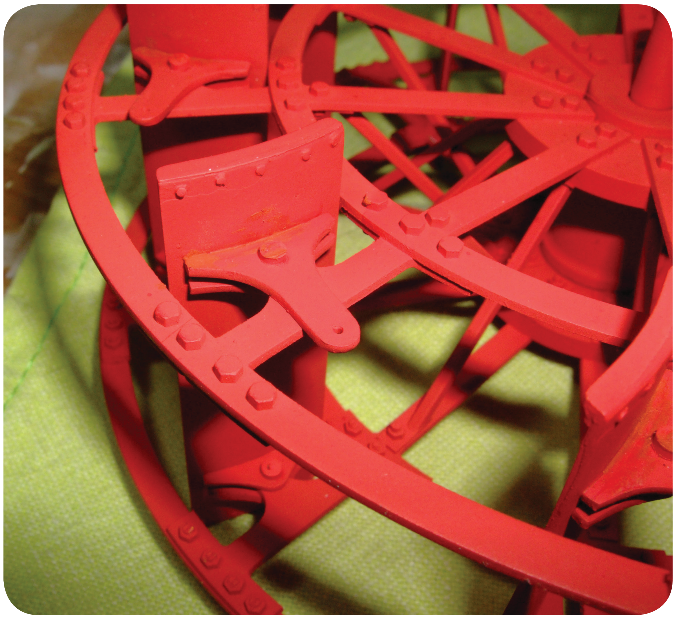


Photo 194. The arrangement of the bearings that allowed the bucket to rotate.

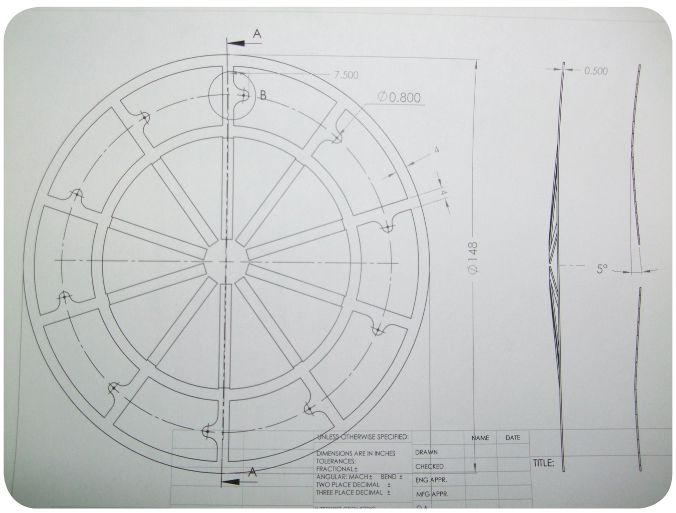


Photo 195. The drawing that came from the plan that was converted into programing.

Photo 196. The finished cut from brass and one of the wooden pie shapes used for the jig.

as a result, saved energy, however, the upkeep of the mechanism was far greater than that of a fixed paddle-wheel. I must conclude that the energetic advantages outweighed the labor disadvantages since they remained in service for the working life of *Ticonderoga*.

I began the process of building the wheels by creating a separate drawing of the main frame of the wheel. I had earlier experience in building paddle-wheels which turned out well but not totally to my satisfaction. As a result, I wanted to ensure that the mainframe was perfectly planar and symmetrical. I also wanted to use 1mm brass for this purpose since it scaled out to the thickness of the actual frame. I decided to explore having the main frames cut by water jet. The research showed me that it was possible, but I needed to develop a computer file that the cutter could use for the task. I didn't own the computer program required and found that it was an expensive investment so I found an obliging programmer who for a price, would provide what

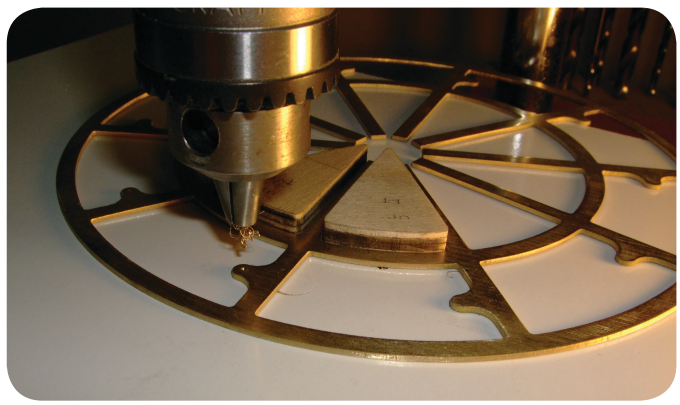


Photo 197. The arrangement of the jig that allowed me to cut the bearing holes in a consistent location.

was needed. The drawing in **Photo 195** was the image that came from the plans which was then imputed into a file that was used to do the cutting. An additional drawing of only the inner and outer ring of the wheel was also programmed for cutting. **Photo 196** shows the main frame that resulted. This brought together four mainframes and four sets of inner and outer rings. The edges turned out to be a bit rough but with some effort sanded smooth. I needed to cut the bearing holes in each spoke of the main frame and to do this I had to build a jig to consolidate the location for all ten sites for each. The pie-shaped wood piece shown in this photo was cut from a tracing of the inner shape between the spokes. **Photo 197** shows the arrangement of the jig. Each pie-shaped wood piece was secured to the base of the jig, and the base was fastened to the drill press stage. The bearing diameter was 1.0mm.

Photo 198. The first cut away of the inner ring in the process of freeing the spokes of the wheel.

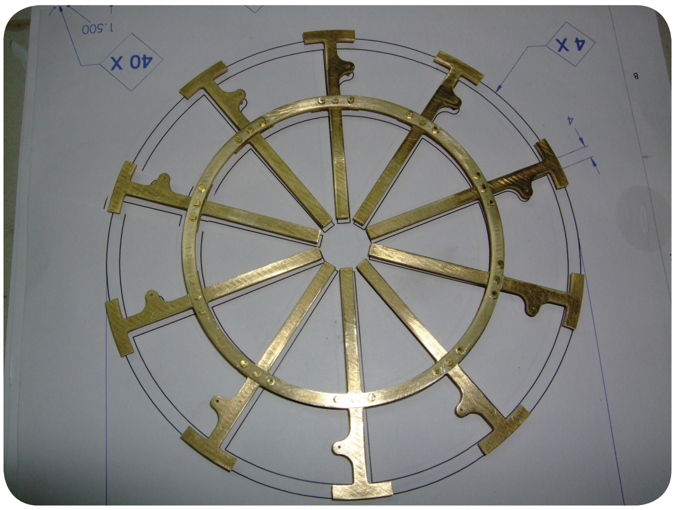


Photo 200. The inner ring has been attached, and the outer ring cuts have been completed.

The next step is shown in **Photo 198**. I used another jig to create the markings on the inner and outer rings shown in **Photo 198**. This jig was a paper pattern as is shown in **Photo 196** at the top. The main frame will eventually become the spokes of the wheel but getting there required an organized progression. **Photo 198** shows one of the cuts required to free the inner portion of the spoke. I cut the piece away while using my Micro-Mark table saw. It was important to ensure that the cut was, perpendicular to the inner ring's sides. This process though successful was challenging. **Photo 199** shows the next step. Each spoke junction at the inner ring needed to be drilled to accommodate bolts that would secure the ring to the spoke. All of the locations were drilled out before as is shown in the photo. Then the inner ring was fitted and held in place for its holes to be cut. To ensure that no movement occurred I inserted bolts into the finished holes from the top down. My source for

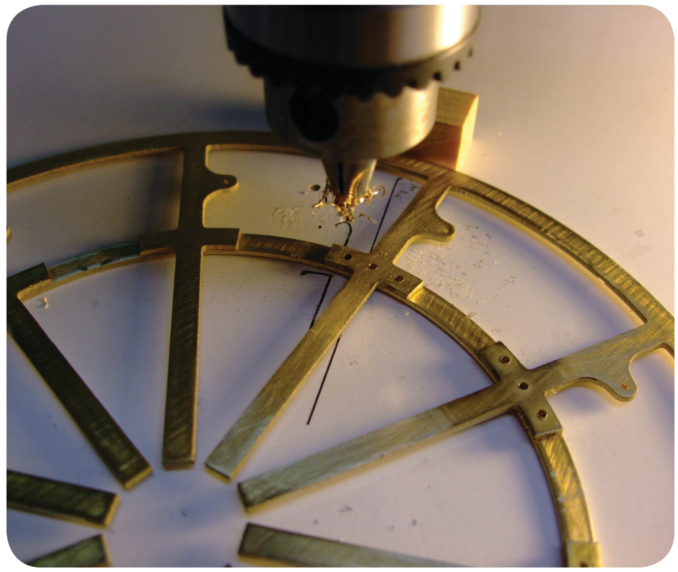


Photo 199. The spokes have been drilled to accept the bolt assembly. The inner ring was secured under the spokes and are being drilled for the bolt assembly.

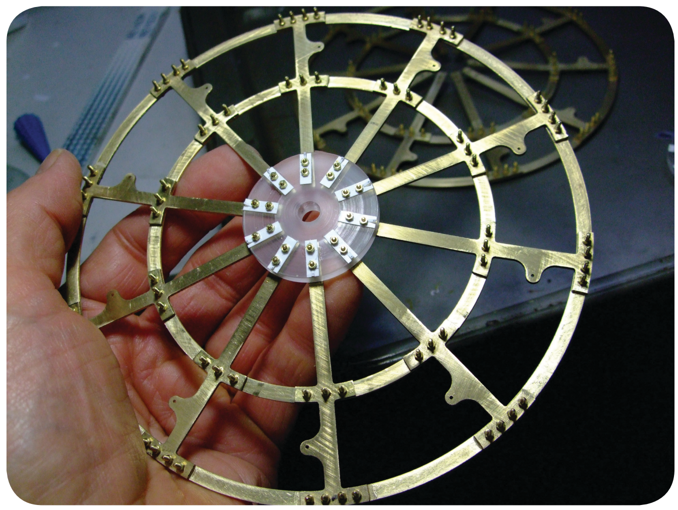


Photo 201. The outer ring has been fastened to the spokes.

the nuts and bolts was Hob-Bits located in Linn Creek Mo. **Photo 200** shows the completed inner ring attachment and the outer ring cuts have been done. The same process was used for the outer ring attachment. **Photo 201** shows the outer ring attached. The length of the bolts were next to be shortened and filed. Ninety bolts and nuts were required for each side of the wheel. It is important to note that the side of the main frame onto which the inner ring is attached must be reversed for the two sets of each wheel. This ensures that the bearing attachment locations on the spokes match in location on both sides.

In **Photo 201** one might notice that the spokes on the inside of the inner ring are bent to create a dish. **Photo 202** shows the jig that I used to ensure that

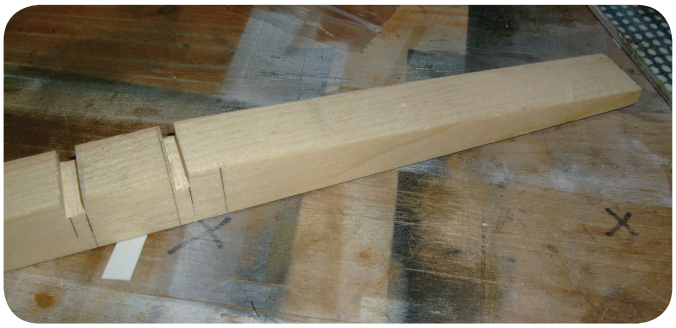


Photo 202. The jig created to govern the consistent bend of the spokes to establish the dish.

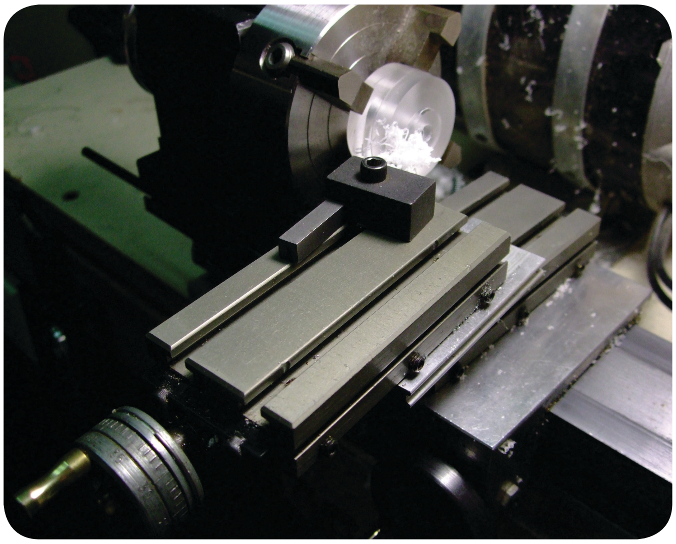


Photo 203. The cross-slide arrangement to cut the angle of the dish into the outer hub.

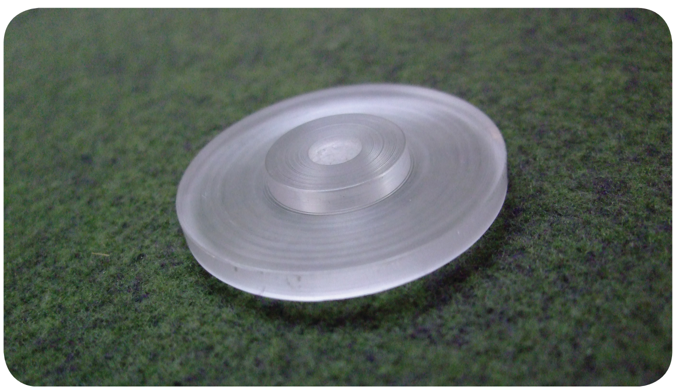


Photo 204. The finished hub. The raised center is there to accept the ends of the spokes.

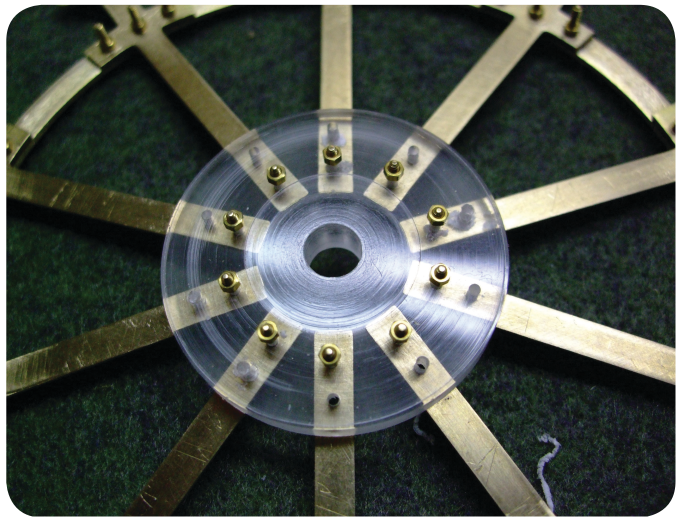


Photo 205. The outer hub has been mounted to the spokes and drilled to accept the bolt assemblies.

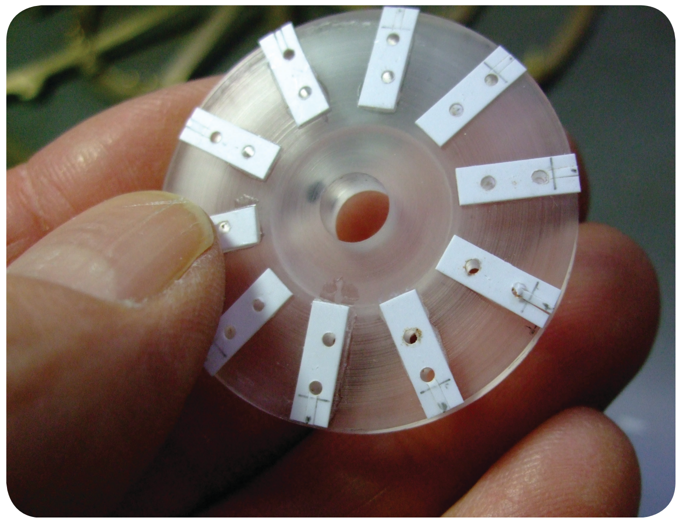


Photo 206. The addition of the mounts for the cross braces which will receive the inboard end of the cross brace.

each spoke was bent equally. The drawing showed in **Photo 195** illustrates the amount that the spokes needed to be bent and I used that to build the jig. The grooves accepted the rings while the spoke was bent down onto the beveled portion of the jig. **Photo 201** also shows one of the outer portions of the hub. The hub was cut on my lathe as is shown in **Photo 203**. Again the angle of the dish relative to the vertical side of the hub must be used to match that of the spokes. I used my cross-slide to set the angle for my cutter so that the hub formed a straight-sided concave surface. **Photo 204** shows the outside of the finished hub. The central raised portion accommodated the ends of the spokes. The hole cut for the drive shaft served as an alignment tool once the three portions of the hub were assembled. **Photo 205** shows one of the sides of the hub in place. The spoke bolt holes were cut before they were bent. These were then used to cut the bolt holes in the hub. The raised central portion of the hub helped to steady its position during this process as the spoke ends held it tightly during the drilling. The white colored mounts for the cross braces were attached to the inner side of the hub. These were attached at the bolt locations as is shown in **Photo 206**. Each mount has a small tongue onto which a cross brace will align. Once all of the hubs had been installed onto the wheel, the central

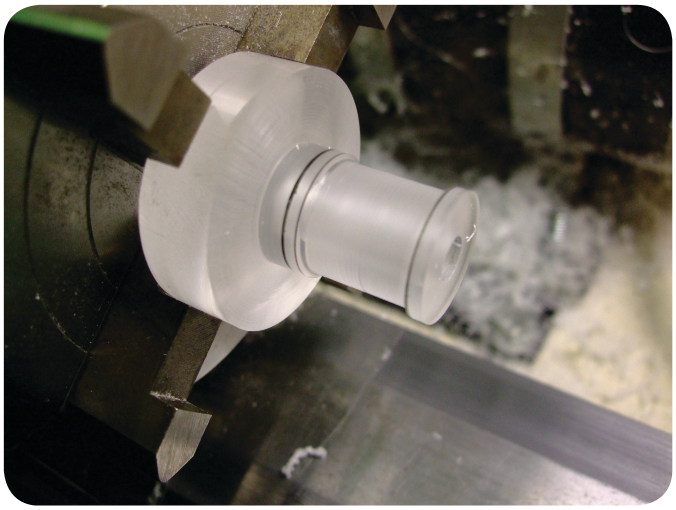


Photo 207. The central hub being cut.

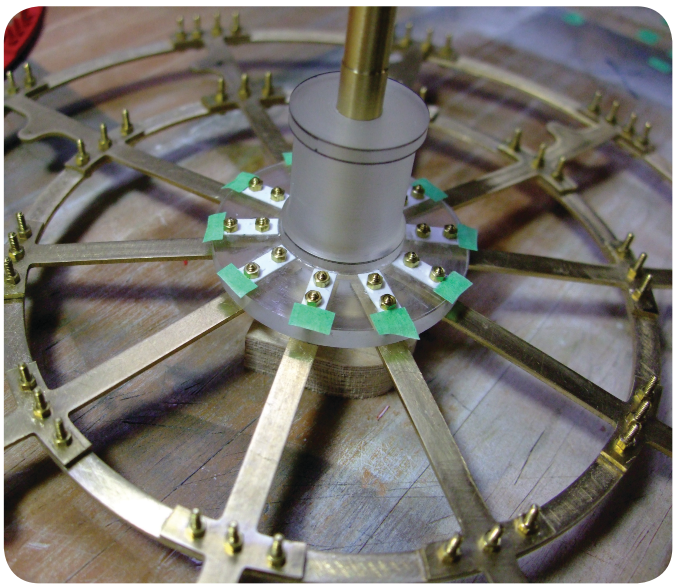


Photo 208. The central hub was aligned by the axel then glued into place.

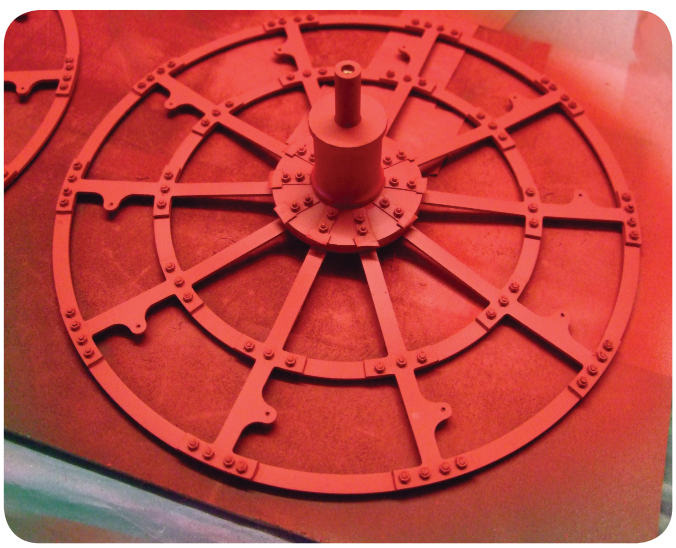


Photo 209. The inner portion of the wheel is painted with exception to the masked mounts for the cross braces.

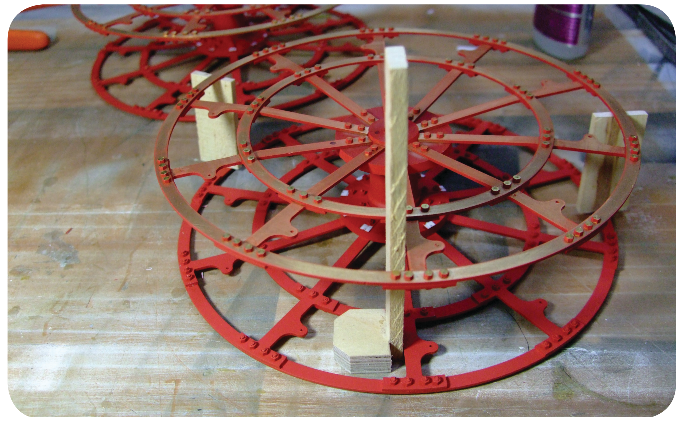


Photo 210. The final assembly method for alignment.

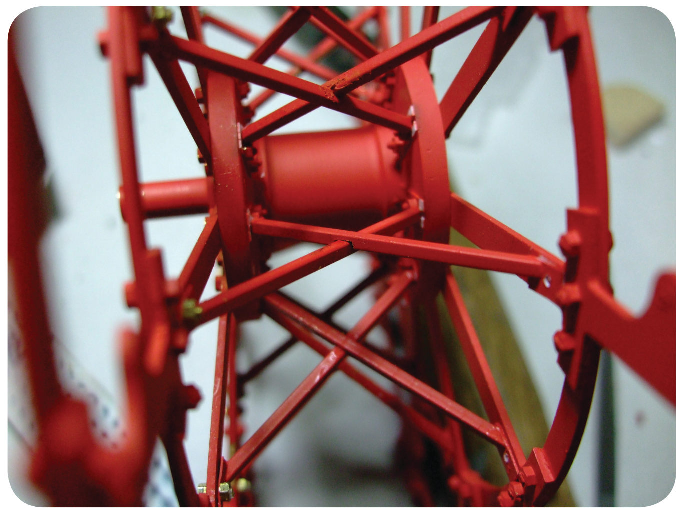


Photo 211. The arrangement of the cross braces.

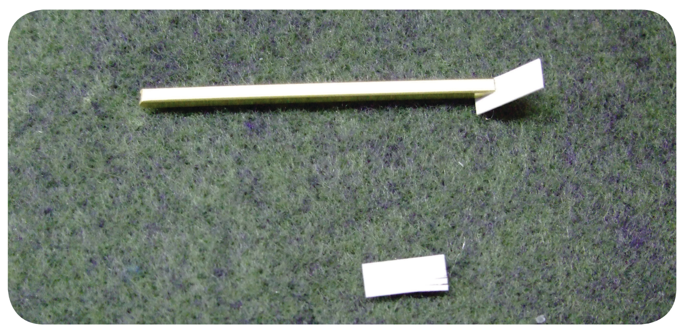


Photo 212. One of the braces showing the open and footed ends. The brace is angled at both ends.

joining hub was cut on the lathe. **Photo 207** shows this task in progress.

A word about Plexiglas as a building material is warranted here. My experience with this material in the lathe was excellent. Slower spin rates and sharp cutters prevented any melting. The resultant cuts were precise and smooth. For these purposes, it is an excellent material choice. The central portion of the hub was cut on the lathe as is shown in **Photo 207**. The measurements needed to be

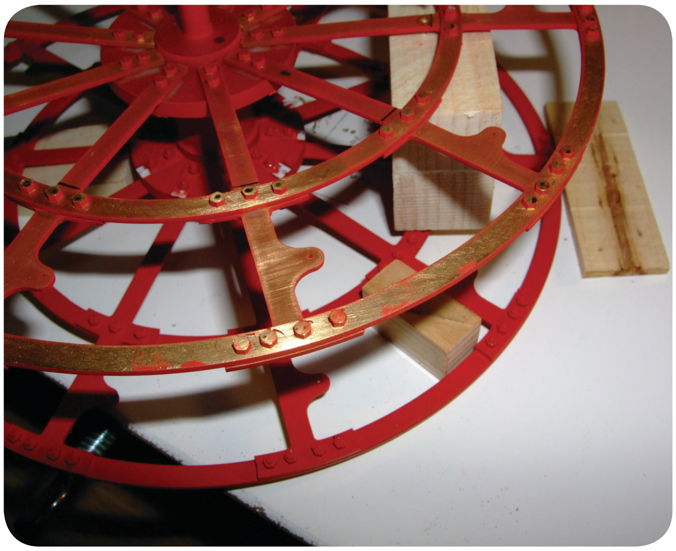


Photo 213. The blocks used to hold the wheel against the pressure of cutting the holes for the bolt assembly that will be used to attach the footed end of the brace to the spoke.

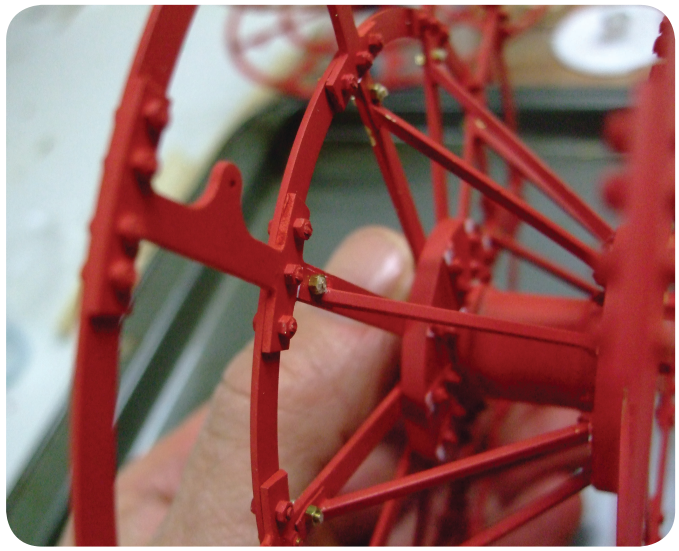
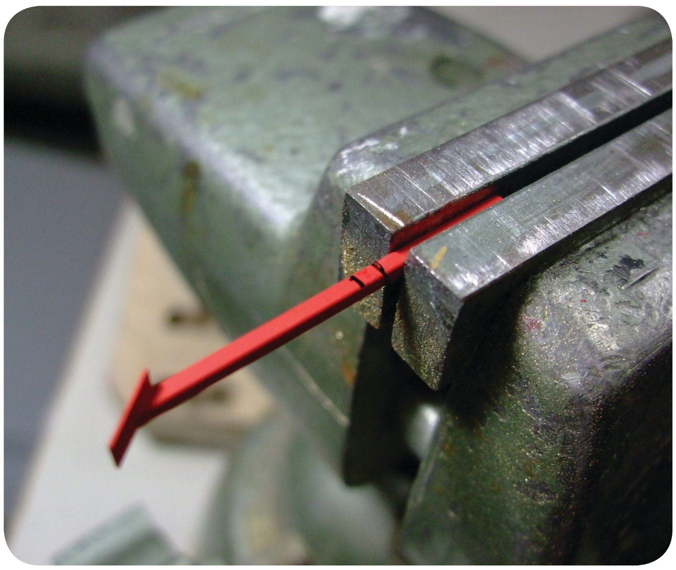
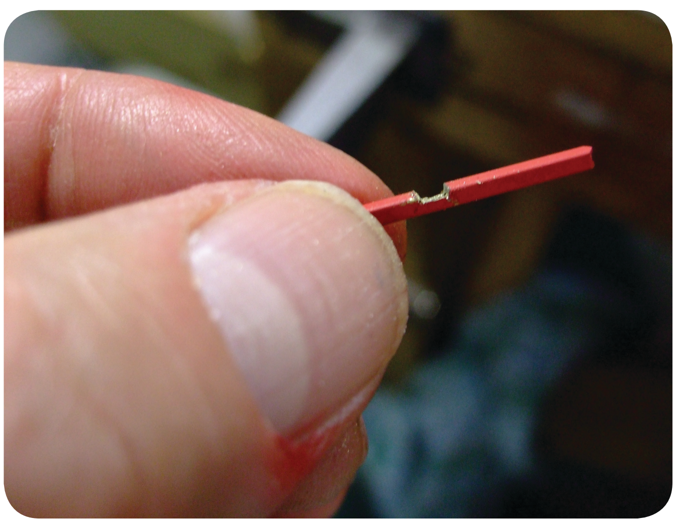


Photo 214. One side of braces has been attached.



Photos 215 (above) & 216 (below). The procedure used to adjust the clearance between paired cross braces.



done carefully to ensure that the dimensions were identical for both sets of hubs. The central hole of this portion of the hub served as an alignment tool when being installed as is seen in **Photo 208**. Note that the brace alignment mounts have been masked at this point. **Photo 209** shows the painted inner surface of the wheel. The final assembly is shown in **Photo 210**. I used Five Minute Epoxy at this stage since time was needed for the alignment of the two sides of the wheel. An upright right angle jig ensured that the alignment was perfected while blocks held the outer most rings at a consistent separation.

Next, I needed to install the cross braces. There were twenty of these, two opposing braces per spoke. The arrangement is shown in **Photo 211**. Each brace required two attachment points for which the correct angles needed to be set. **Photo 212** shows one of these braces. Note that one end is left open and cut on the needed angle while the other has a footing attached on the same angle. Discovering the appropriate length and angles took some effort and trials to get it right. The open end fits onto the hub using the established tongue mount while the footed end rests on the spoke just short of the inner ring's edge. See **Photo 211** to see this arrangement. It is also noticeable that at each of the footed ends of the brace there is a hole made to accept a bolt and nut assembly. These holes in the spokes were cut previously and then when the brace was attached the footing hole was cut through. **Photo 213** shows the blocks used to brace the inner ring while the brace hole was cut. **Photo 214** shows one side attached but not painted. Once I started the next side, I discovered that there was a space issue.

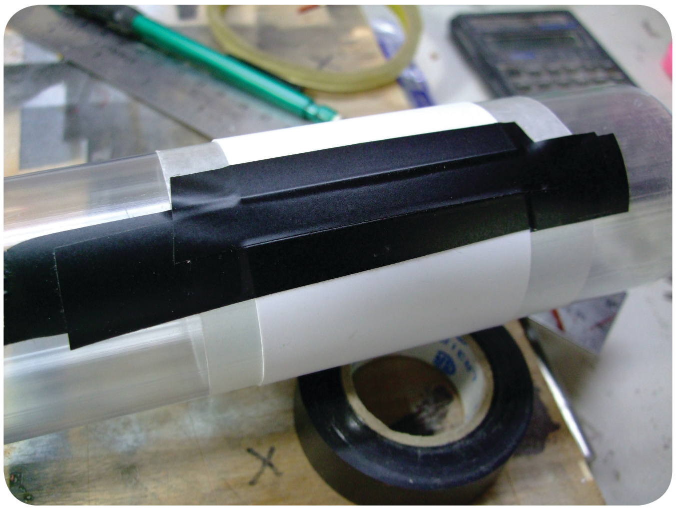


Photo 217. The styrene sheet lamination for the bucket curvature.

Photo 218. The mold of the master bucket.

Photo 219. One of the 20 duplicate buckets.

For them to pass by each other, I had to adjust the thickness of the brace. **Photos 215** and **216** show the adjustment procedure. The results are shown in **Photo 211**. Note that paint touch-ups are yet required to finish the assembly to this point. This then raises the nut and bolt total per side to 100!

The next stage of the build required that twenty buckets, plus eighty bearing mounts be built. I had anticipated these needs, so I had incorporated these tasks into my work on the frame of the wheels. I made a master of the bucket and the two types of bearing mounts and began casting them while other work was being done. The bucket for *Ticonderoga* was all steel and curved with reinforced outer and inner edges. Also, there needed to be evidence of the bearing mount's attachment to it. I started by using a large diameter Plexiglas tube on which to form the curved portion of the bucket. **Photo 217** shows the lamination process. The tube was covered by waxed paper then a layer of washed 0.25mm-thick Evergreen Styrene plain sheeting was then wrapped and secured there. Then a second smaller section of 0.25mm styrene was taped in place once thick Cyanoacrylate Glue was added. The set time for this glue is a bit more forgiving as there was a need to adjust the position of the laminate and its tape hold downs. Once the glue had set the laminate was removed, cut to the desired dimensions and then built up with the details of its construction. **Photo 218** shows the mold that the master produced and **Photo 219** shows one of the duplicates. Evergreen Angles were used for the sides and styrene dowels for simulating carriage bolts. The bearing mounts were also cast. Two different types were required as one of the mounts needed to be extended so that the cam bearing could be attached. Masters were built to fit to the curvature of the bucket, and then molds were made for duplication. Molding parts always help to speed up the process. However, not all results were satisfactory. The details on the bucket were at times not complete, so careful attention to moving air away from the trouble spots was necessary before closing the mold. There also is the need to "tidy" the duplicates before they can be used. I want to recommend Micro-Mark's molding products as they have provided the best results in my experience. Shop on line at www.micromark.com. They offer different formulas of resin which yield different strengths of castings so one can make duplicates of more delicate masters that will be of strength.

The next step was to attach the buckets to the wheel frame. **Photo 220** shows the jig that held the wheel frame while the elevated supports allowed the bucket to be positioned for the attachment of the bearing frames. A 1mm diameter styrene rod (Evergreen Scale Models Inc #211) was threaded through all of the frames to confirm the alignment of the four frames relative to the surface of the bucket. **Photo 221** shows the clamping tools used to hold the frames for gluing. Thin Cyanoacrylate was used since it can easily seep under the frames to establish a good bond. I needed to establish an attachment assembly for the bearings onto the frames. There needed to be a collar between the

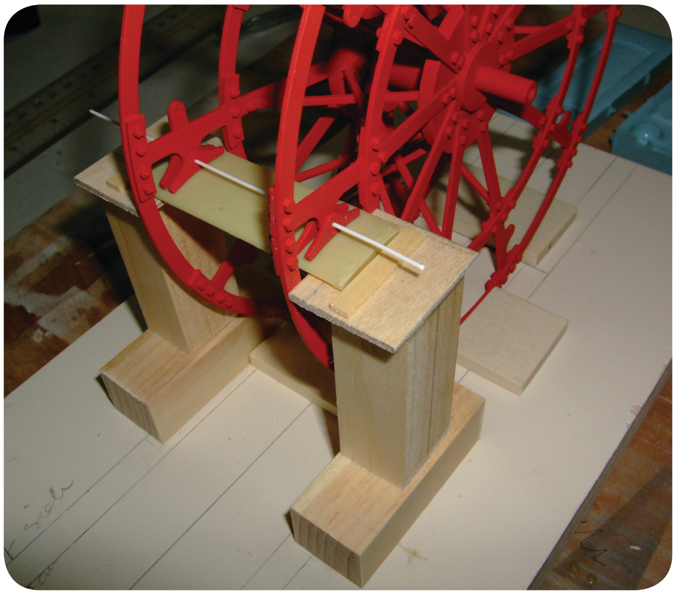


Photo 220. The jig built to align the wheel frame with the bucket for their attachment.

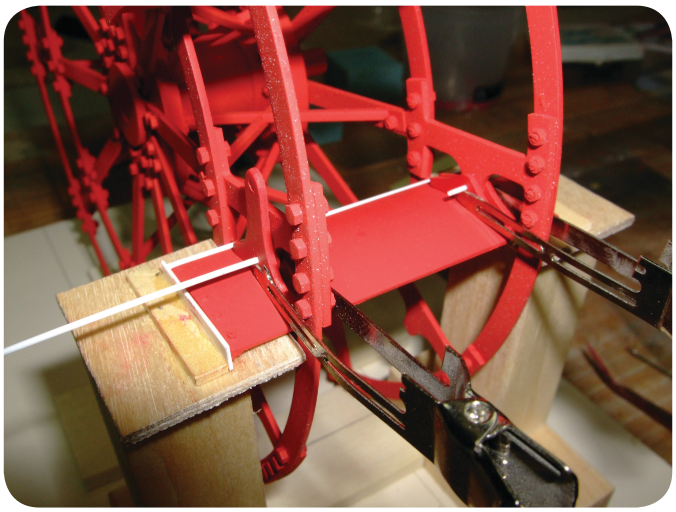


Photo 221. The clamping tools used to hold the frames while they are glued in place.

bolt and the frame that would provide a spacer. I used Evergreen Styrene part #223 for this purpose. This tubing has a 1.0mm-diameter inner hole which will accept the bearing rod. **Photo 222** shows the arrangement on my lathe for cutting the styrene tube to identical lengths. The white gage aligned to the cutter so that all I had to do was to bring it to the end of the tube to cut equal lengths. These collars were slid onto the dowels simulating the bearing, glued there, and then the excess styrene rod was trimmed. To finish the assembly I positioned façade hex nuts onto both sides of bearing frames on their collars. **Photo 223** shows them in position. These bolt assemblies are offered by Tichy Train Group part # 8080. Any quality model train store will have these in stock.

The final project to complete was the cam system that can be seen in **Photo 193**. **Photo 224** shows the drawing of this assembly. Sorry about the reverse orientation of the image, however, the main drive rod is shown at the top of the image. The main drive rod was attached to the cam hub to lock it in position. At this rod's extremity, it attached to the bucket bearing frame which then moves with the main frame of the wheel as it rotates due to the motion of the main drive axels. This then generates the rotation of the cam system. The other nine cam rods articulate on bearings within the cam hub as the cam system rotates. **Photo 225** shows the cam hub partially assembled. The aluminum hub was turned on my lathe and then placed into my machinist's turntable to be drilled for the bearings. **Photo 226** shows this process. I used square brass tubing for the inside portion of the cam rods. These also needed to be drilled to accept the bearing. **Photo 227** shows the jig used to ensure a consistent location was obtained for all of the cam rods. **Photos 228** and **229** show the bearings inserted before the main drive rod was fixed in place. **Photo 230** shows the bearing being attached to the outward end of the cam rod. I used brass tubing with a brass dowel insert for this purpose. The bearing was drilled to accept the dowel insert,

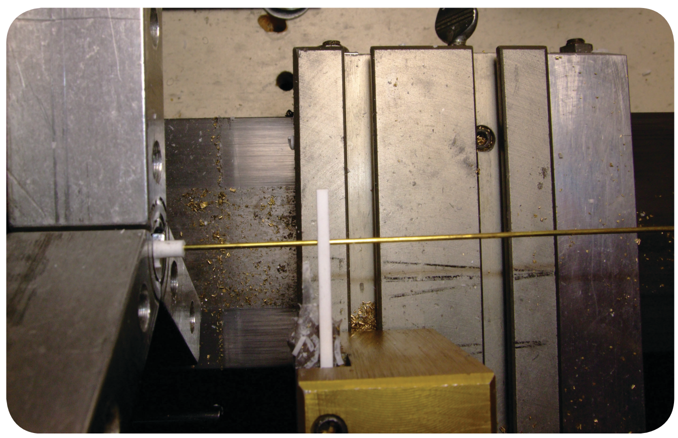


Photo 222. The arrangement of my lathe for cutting equal lengths of the bearing collars.

Photo 223. Façade bolt assemblies in place.

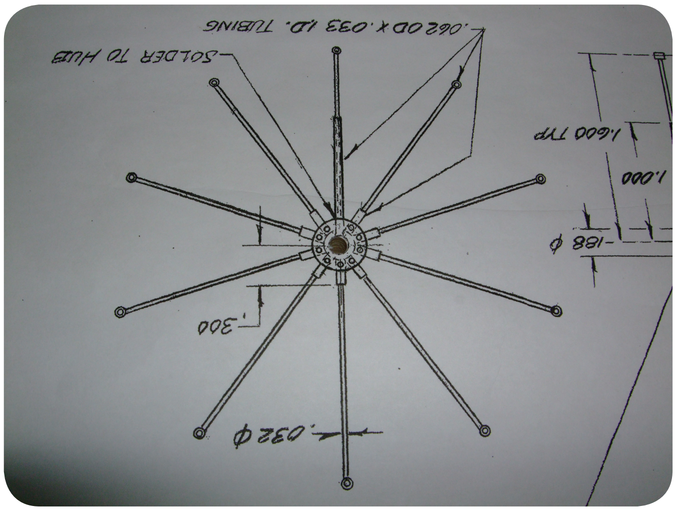


Photo 224. The plans for the cam hub assembly.

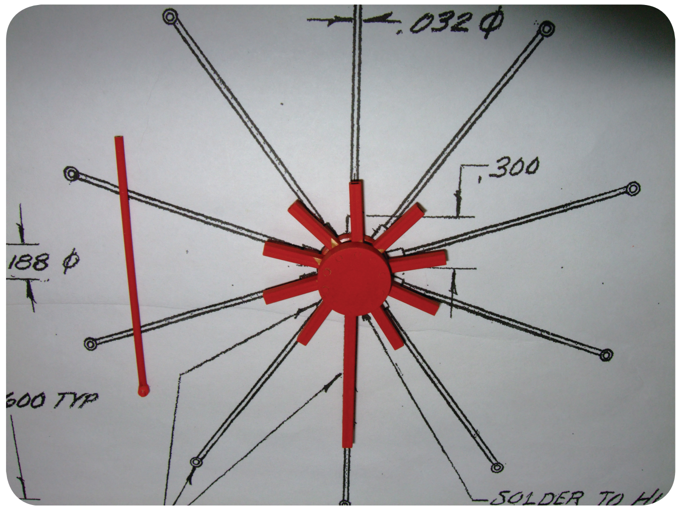


Photo 225. The partially finished cam hub.

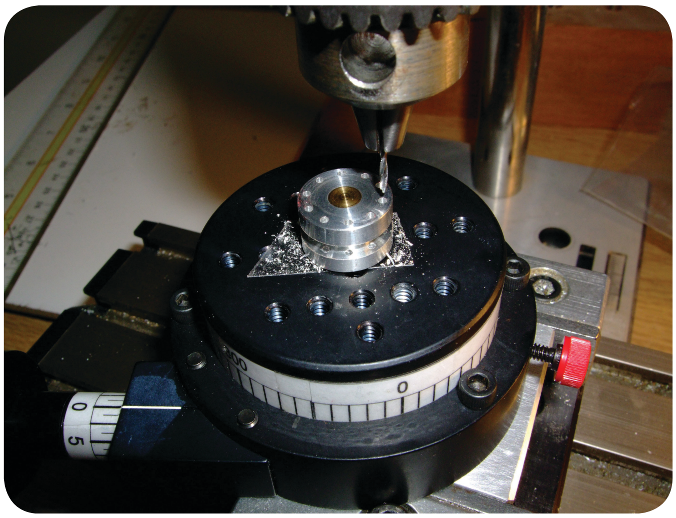


Photo 226. The bearing holes are cut using a machinist's turntable.

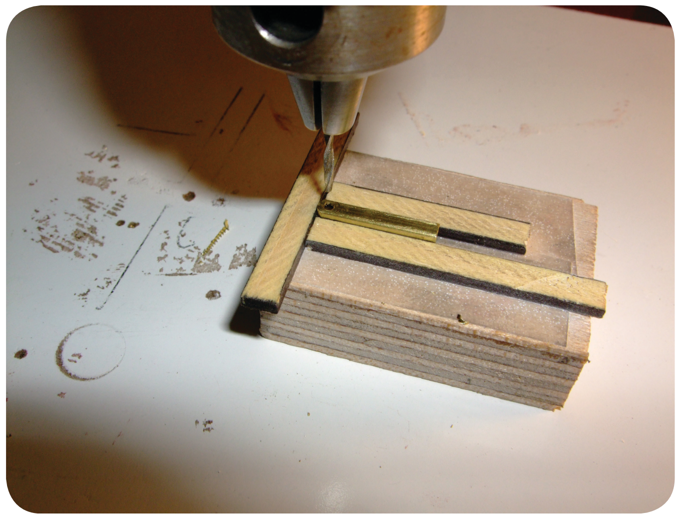


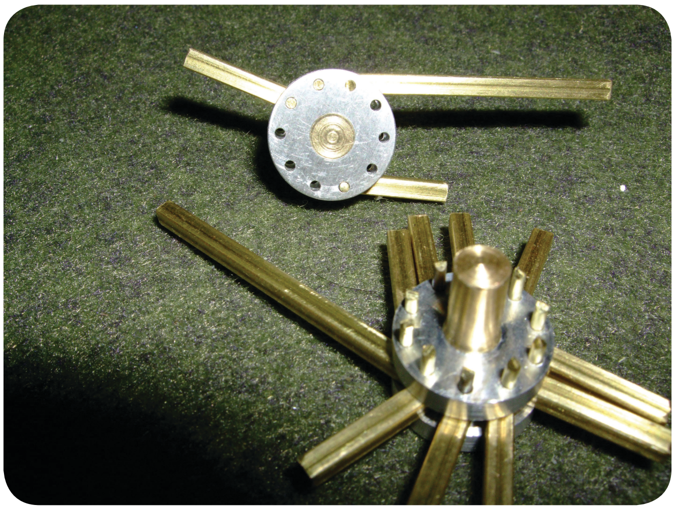
Photo 227. The jig used to drill the bearing hole for the inside portion of the cam rods.

and the assembly was glued in place. The finished cam assembly is shown in **Photo 231**. At this stage, the outer bearings were inserted into the extended end of the outboard bucket bearing frame. Paint touchups were done, and then the finished wheel was placed onto the model.

Photo 232 shows the finished paddle-wheel on the model. The enclosure was first laminated with simulated tongue in groove paneling before the paddle-wheel was installed. At this stage, the outboard wall needed to be added to enclose the paddle-wheel. **Photo 233** shows it in place. This wall needed to be tongue in groove construction and its length uninterrupted by a seam. To do this, I needed to special order Evergreen Scale Model V Groove sheets. Part number 14080 provided a sheet 60cm long and 30cm wide. This met my requirements for length, thickness, and the groove spacing. Three tasks remained to be done before it could be installed. The first was to cut the wall out. The difficulty here was that the ship has a slight curve to this shape and at the paddle-wheel site, there were ornate openings shown in **Photo 234** to be added. These were added at the base of the wall just above the rub rail. The second task was to locate and cut the openings for the seven windows. Again, since there was a curvature to the wall dimension, the windows needed to follow it while ensuring that the windows' side frames would orientate vertically. The third task involved engraving the locations of the butts of the planking for the tongue-in-groove as was discussed previously for the bulwark installations. Look closely, and you will see this in **Photo 234**.

A word here regarding window construction would be useful for some. I, like you, have struggled to perfect this demanding part of model building. The quality of windows and how they are often installed will determine the overall impression one has of any model. Uniformity in

Photos 228 (above) & 229 (below). The assembly of the inside portion of the cam rod to the hub. The drive rod hasn't been fixed in position at this point.



position and construction are critical elements to perfect. For this model, I built a pattern with which I could trace the openings onto the wall surface. (See **Photo 235**) Making these cuts is difficult and never results in a perfect opening. To mitigate this problem, I built the master of the window frame so that it could fit into the opening but also overlapped the edges of the opening. In **Photo 234** you can see some examples of these frames. This design does necessitate internal frames to complete the

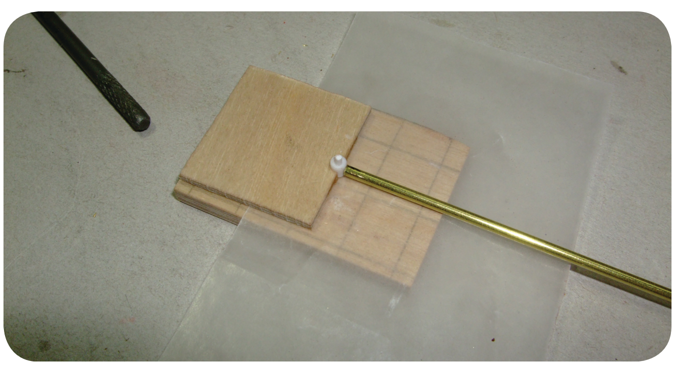


Photo 230. The bearing at the outside end of the cam rod is being attached.

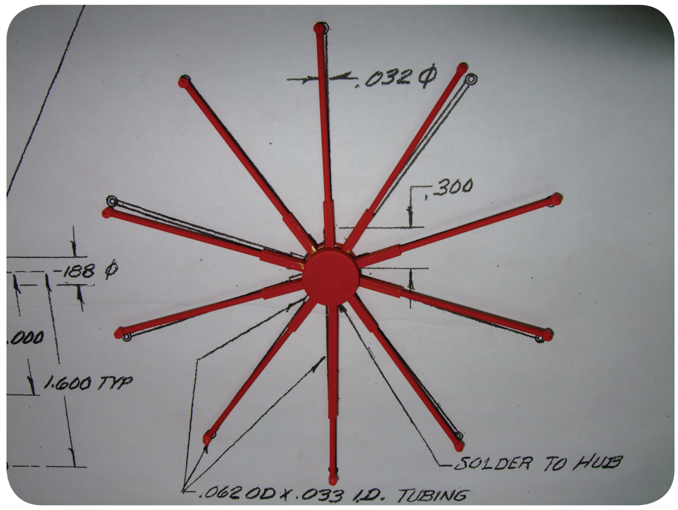


Photo 231. The finished cam assembly.

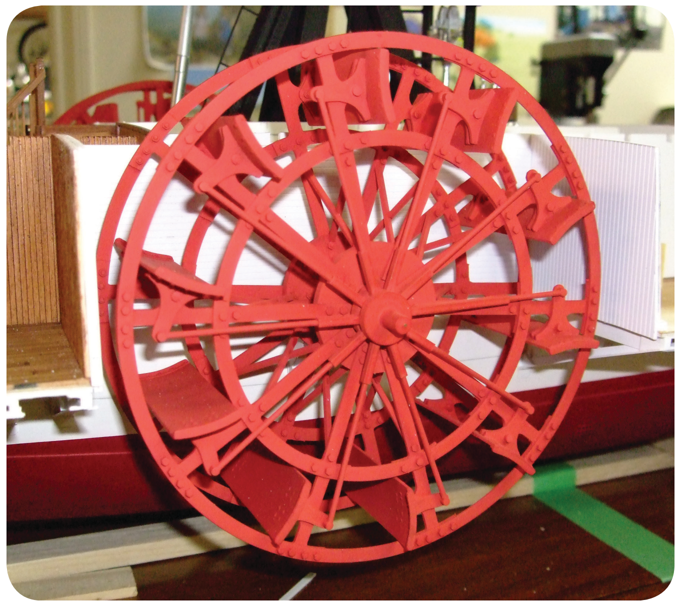


Photo 232. The paddle-wheel installed on the model.

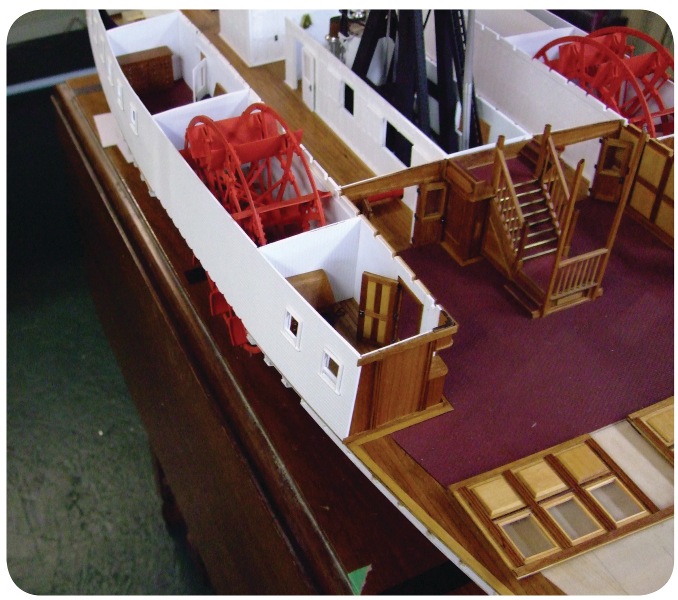


Photo 233. The outer wall has been installed.

Photo 234. The outer wall showing the details required.

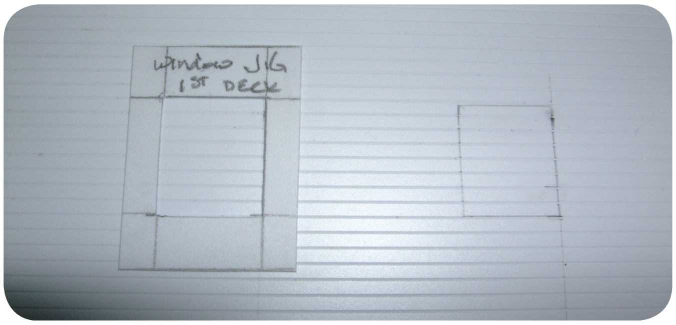


Photo 235. The pattern built to allow tracings to be placed on the wall.

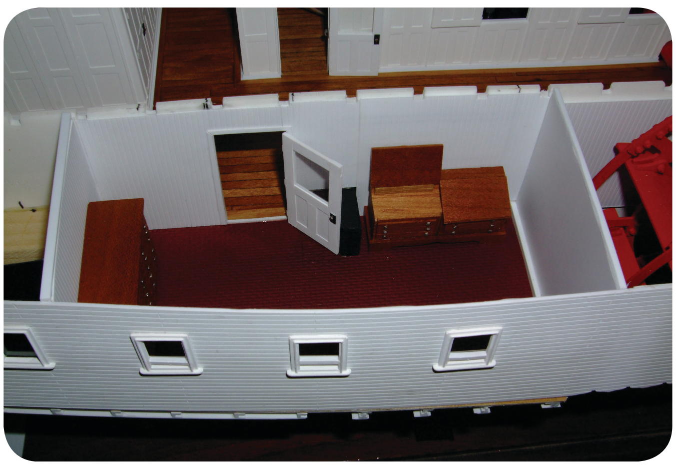


Photo 236. A furnished room which allows the observer to peer into the engine control room. Open windows and lighting allow the observer access to the inner space.

realism. I also opened some of the windows so that observers could look into the model unimpeded. These windows as are most in this ship, pocket windows. So they slide into the walls sideways or downwards. Glazing can be placed into the opening from the back as there is a ridge in the frame onto which it can rest. Micro-Mark sells glue called Liquid PSA. It is pressure sensitive glue that is designed to go on in a liquid form and then dries to a clear soft but sticky surface. So with care,

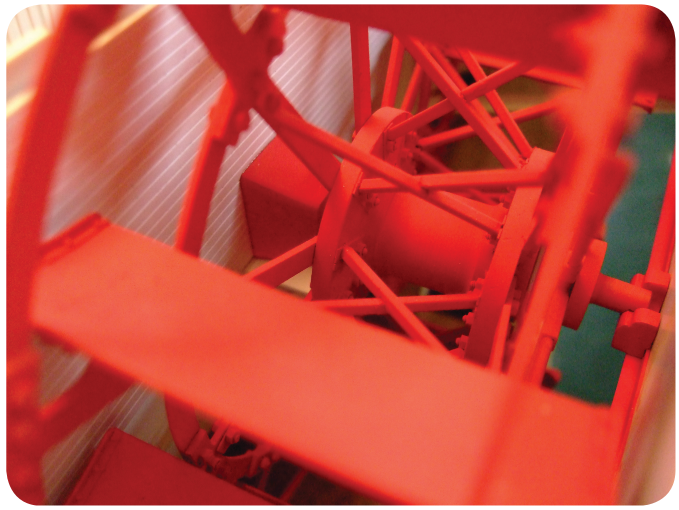
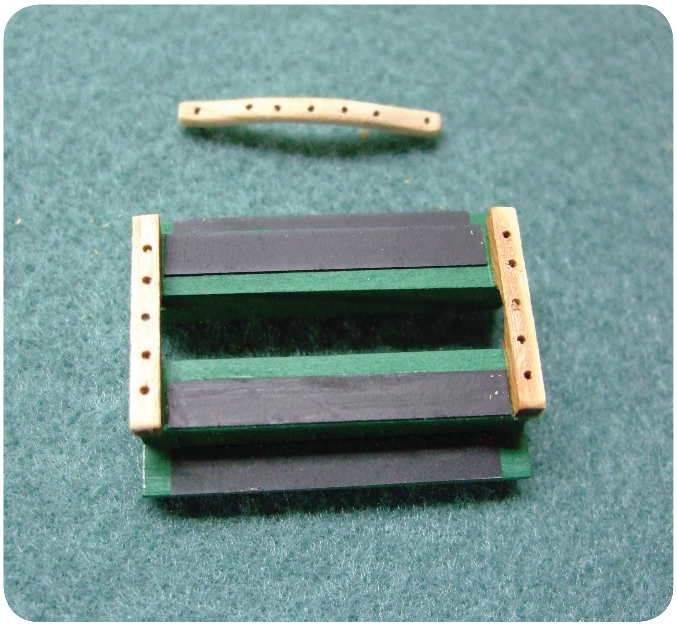


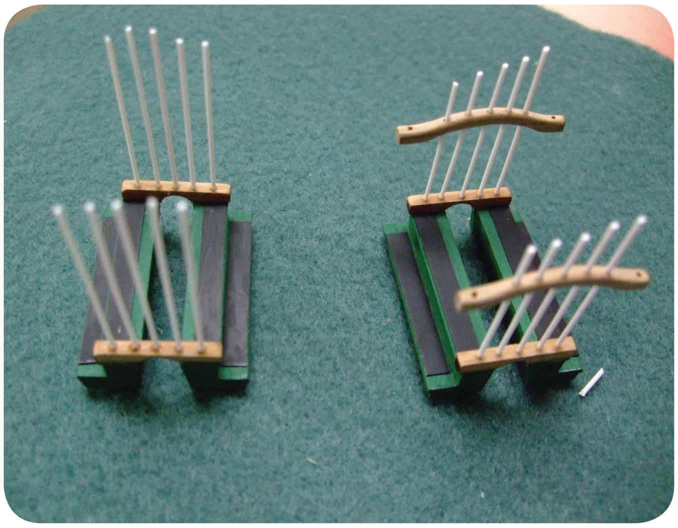
Photo 237. Two mounts were required to mount the paddle-wheel. One on the inboard side of the main driveshaft bearing and the other on the inside of the outer wall of the cam hub.

Photo 238. The main driveshaft housing passed through above the deck surface which presented an obstacle for passengers and crew. A staircase was built to solve this problem.

one can apply a small amount to the inner stopper edge of the frame so that later the glazing can be placed on it without showing any evidence of glue. There are seven windows on each wall of which some are open, but most are closed and shuttered. On *Ticonderoga*, internal shutters serve the role of curtains in most cases on this deck. I found shutters at my not so local model train store that served this purpose perfectly. **Photo 236** shows a workroom which I furnished and left three windows open. The doorway out of this room allows the viewer to look into the engine control room by peering into one of the external windows.

To mount the paddle-wheels onto the model I needed to build two mounting structures. One was a support bearing box on the inside wall of the





Photos 239, 240 & 241. The stages of construction of the stairs.

Photos 242, 243 & 244. Three rooms on this deck were furnished for the observer to peer into. Here are some of the detail included. Note the "painting" in the Captain's quarters. This is a miniaturized photo I took from *Ticonderago's* wheelhouse of a section of the museum's grounds.

paddle-wheel compartment. This served to support the main drive shaft and the weight of the paddle-wheel plus provide the bearing on which it ran. The other support was located on the inside of the outer wall on which rested the cam hub. Both of these can be seen in **Photo 237**. **Photo 238** shows the main drive shaft housing where it traveled across the inner deck to the engine enclosure. Stairs were built around this to allow one to step over it. The wooden structure shown in the Photo is the beginning stage in the construction. **Photos 239**, **240** and **241** show the progression of its build. Finally, as I have mentioned several rooms were furnished, given open windows and lighting so observers could peer into these spaces. **Photos 242**, **243** and **244** show some of the detail found in these spaces. This concludes the work on the first deck except for the rub rails and the lettering. Next time I will discuss the method for installing the lighting and the enclosure of the first deck with the addition of the next deck and its furniture plus, the installation of the rub rail. Until then enjoy your projects.

ADD REMOVED