A 3-1/2" Gauge, 1:16 Scale 2-6-6-6 Allegheny

by Chuck Balmer

HISTORY

Like most young boys of the 1950s, I was introduced to trains with the Christmas gift of a Lionel train set. When I was about 10 years old, my interest in live steam was triggered by an episode of *The Wonderful World of Disney* showing Walt's backyard railroad. The seed was planted, but actually building an engine was a pursuit that would have to wait.

In 1963, I was a junior in high school and interviewing at the University of Detroit's School of Electrical Engineering. While there, I decided to visit the Henry Ford Museum and saw the Chesapeake & Ohio's Allegheny locomotive for the first time. The image of this massive engine stuck with me.

I ended up going to the University of Dayton as an electrical engineering student. During my sophomore year, I was offered the opportunity to work part time as a technician at the UD Research Institute, helping build test equipment for research at Wright-Patterson Air Force Base. This job gave me my first exposure to using machine shop tools. I found it fascinating and took every opportunity to learn from the professional machinists in the Mechanical Engineering lab.

After graduation from college, I was putting together a small machine shop and electronics lab, and I wanted a project to help me improve my machining skills. Building a live steam locomotive seemed to be the perfect project, and it would fulfill a childhood dream. I chose to build a 1:16 scale, 3-1/2" gauge live steam model of a NYC 4-6-4 Hudson. The project took three years and was finished in 1971. The engine is still running today. Over the next six years, I built three more locomotives: an 0-4-0 switcher using the *Tich* casting set, an 0-6-0 vertical-boiler plantation engine using a Stuart twin launch engine, and an F7 diesel electric.

While on a business trip to Detroit in 1977, I again visited the Henry Ford Museum and was so impressed with the Allegheny locomotive that I decided it would be my next project. I purchased a set of about 100 blue prints, built a small foundry, and made a few wheel castings. This was a tumultuous time in my career. The demands of work, and the growth of my family, eventually put the project on hold for almost 30 years.

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In 2006, after being self-employed for 25 years as a consultant and manufacturer of electronic production test equipment, I decided to retire. My youngest son convinced me to resurrect the project, so for the next seven years my new full-time job was to build a 1:16 scale, 3-1/2" gauge live steam model of the 2-6-6-6 Allegheny locomotive. After about 14,000 hours, the locomotive described here was complete.

PREPARATION

Even though I had a large set of blue prints, I decided that I needed to get pictures of the real engine. I made plans to visit the museum to gather as much information as possible. My wife, son and I spent an entire weekend crawling over the locomotive, taking pictures, and getting measurements to fill in some of the gaps in the prints. In particular, we took many detailed pictures of the accessories, since I had little information about these. Some weeks later, my son went back and got some additional pictures of things we missed during our first visit.

Several months later, we went to the Lima Locomotive Works in Lima, Ohio, where the engines were built. We visited the Allen County Historical Museum and were able to get many more pictures and some actual hand-written engineering information.

During construction, we occasionally had to do additional research to understand how some parts were made or assembled.

PATTERNS

From the start of the project, I knew that I would have to make all of my own castings. Over a six-month period, I constructed about 60 patterns (**Photo 1**). Most were made out of pieces of scrap wood, and were designed for two-part sand molds. A couple of patterns were too complicated for two-part sand molds, so I had to make four and five-part plaster molds.

CASTINGS

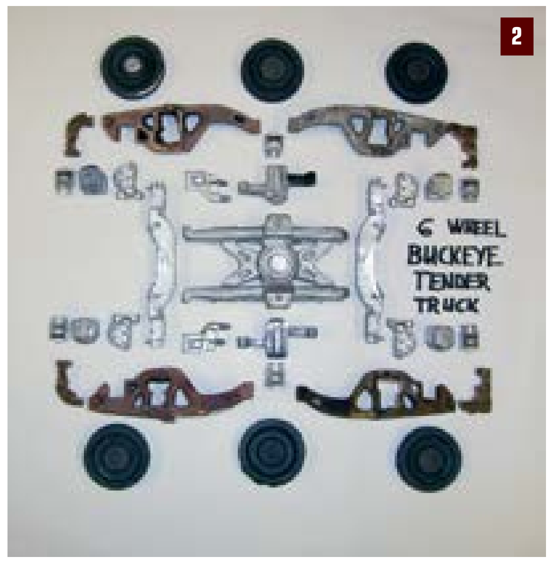
Over the next summer, my son and I poured over 100 castings (**Photos 2** thru **8**). All of the engine's twenty wheels and the tender's fourteen wheels were cast in iron. The parts that needed to be welded were cast in bronze, and the rest were cast in aluminum.

FRAME CONSTRUCTION

The side frames for both the front and rear engines were cut from 3/8" steel plate. They were bolted together using 3/8" thick spreaders and socket-head screws (**Photo 9**).

The top plate was formed from 1/8" thick steel plate and TIG-welded to the side frames. The rear engine's rear drawbar pocket and trailer-truck support were cast in bronze and silver-soldered to the side frames. The front of the rear engine has the main bearing box for the pivot of the front engine. The front of the front engine contains the pilot truck support and the buffer beam. This phase of the construction can be seen in **Photo 10**.

There was also a lot of detail built into the frames for the brake cylinders and



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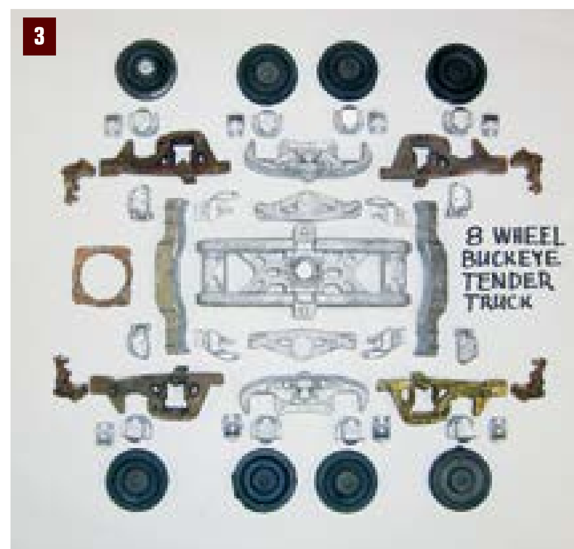

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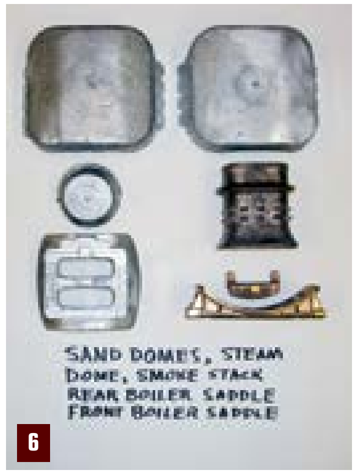

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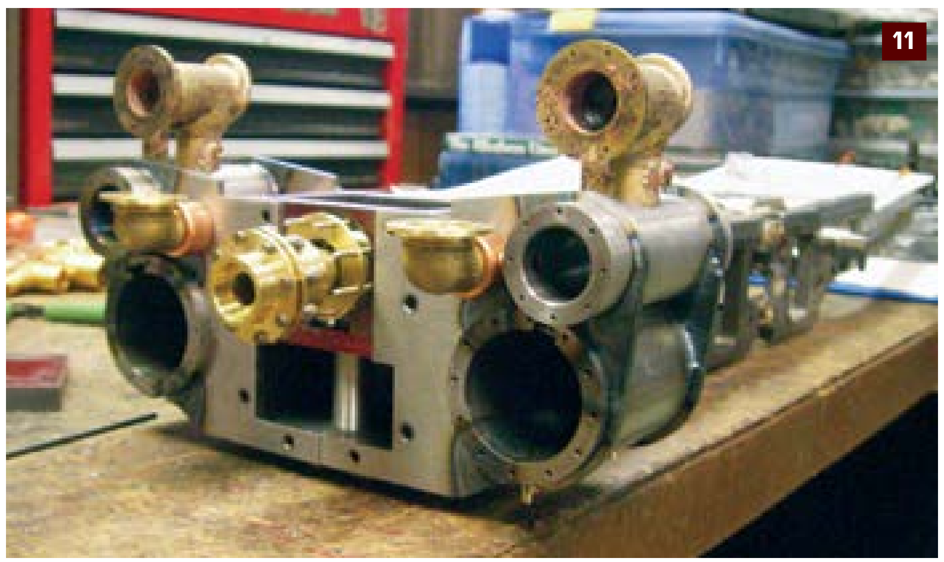
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brake supports. Provisions were also made for the pivoting steam connections between the front and rear engines (**Photo 11**).

The front engine's cylinder and pilot group is shown in **Photo 12**. Note the wooden valve gear support patterns in place to check clearance and spacing dimensions.

CYLINDER CONSTRUCTION

The side supports were cut from 1/8" steel plate. The cylinders and valve bodies were bored from steel bar stock. The port passages were drilled in both, and then they were TIG-welded to the side support frames (**Photo 13**).

The exhaust and steam passages were made from copper tube and silver-soldered in place. The steam and exhaust connecting pipes were made from modified brass fittings; again, these were silver-soldered in place (**Photo 14**).

The pistons, rods, end caps, and crossheads were made from bar stock. The pistons were fitted with brass rings, and the piston rods were sealed with *Teflon* O-rings.

The piston-valve spools were made from brass stock, and lapped to fit the steel valve port sleeves before being fitted with steel rings. The port sleeves were fitted with *Teflon* O-rings, to prevent any leakage between the steam and exhaust ports, before they were pressed into the valve bodies. The complete valve group is shown in **Photo 15**.

BOILER

The boiler was fabricated from a piece of 6-7/8" diameter copper pipe with 3/8" thick walls. In order to get the correct outside diameter, 1/8" had to be ma-


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chined off, reducing the wall thickness to 1/4". The diameter of the pipe was too large to fit over the cross slide of the lathe, so I could only machine about three inches of the pipe at a time until it would miss the cross slide. I could only cut about 0.005" at a time because of the large diameter. I would set up the lathe to begin a cut and set a timer. When the time expired, I would start a new cut. Each three-inch long section required 25 cuts to get down to the desired diameter. The entire process took a week, running eight hours a day (**Photo 16**). The copper shavings weighed 28 pounds and fetched $54 at the scrap yard.

The firebox sides and ends were made from 1/8" thick copper sheet, and the mud ring was made from 3/8" square copper rod (**Photo 17**). The corners were TIG-welded together so that they would not loosen while the firebox was being silver-soldered.

The front flue sheet, outer back sheet and sidewalls were also formed from 1/8" thick copper sheet (**Photo 18**). The boiler contains twenty small flues and four large flues to accommodate the superheaters. All of the flat surfaces were supported by 3/16" diameter stays.


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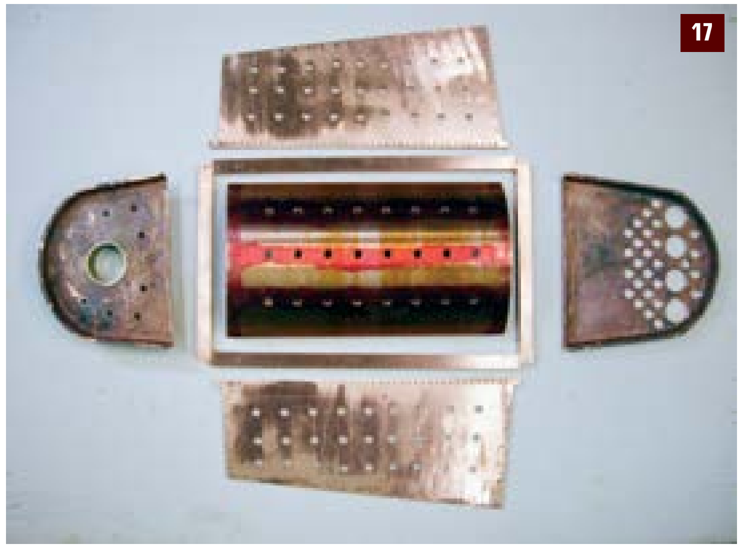
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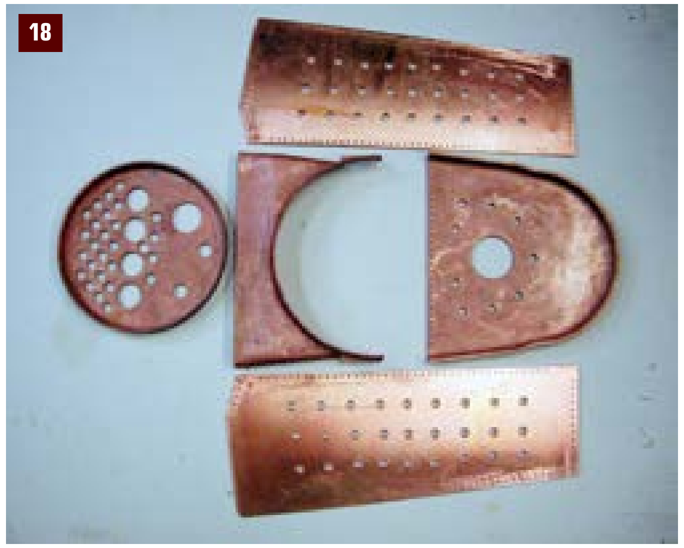
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The superheater assembly shown in **Photo 19** consists of four stainless steel outer tubes surrounding four smaller stainless steel inner tubes, all connected to the inlet and outlet manifolds. Saturated steam flows from the inlet manifold through the smaller inner tubes toward the firebox. It then flows back through the outer tubes, picking up additional heat from the flue gases, and is collected in the outlet manifold.

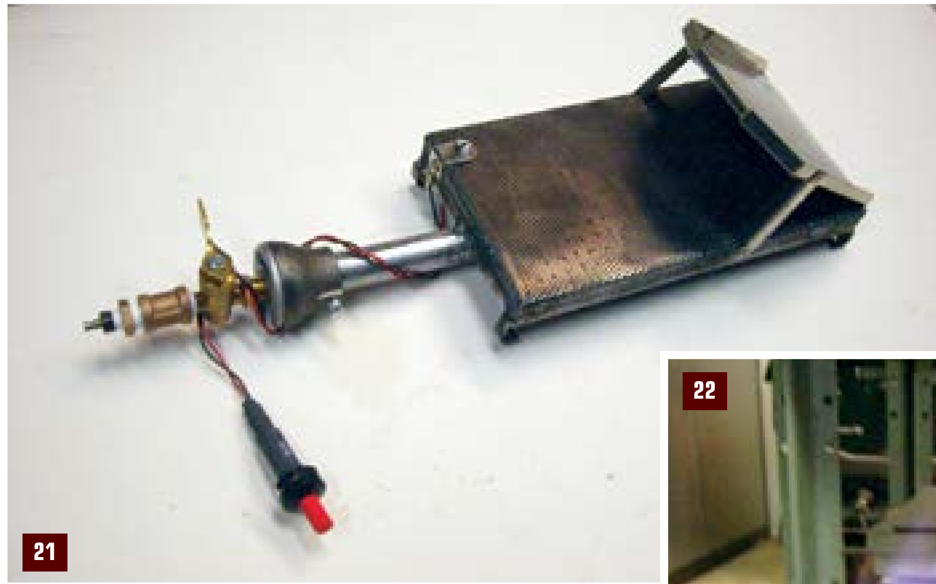
Once completed, the boiler was hydro-tested to 200 PSI (**Photo 20**).

BURNER

At the start of the project, I decided to fire the engine on gas. This decision was made for two reasons. First, it was going to be difficult to fire the engine with coal due to the length of the tender. Second, it was also going to be impossible to clean the flues because the front of the smoke box could not be removed without disconnecting all of the plumbing for the air compressors.

The burner was built using a commercial mixing tube with a fabricated plenum and arch designed to fit in the engine's firebox (**Photos 21** & **22**).

We already had an engineer's riding car outfitted with a propane cylinder and regulator for use with several other engines. The tender was outfitted with quick disconnect fittings: one for connection to the riding car, and one for connection to the engine's burner. The tender was also equipped with gas control valves for the pilot and main burner, both within easy reach of the engineer.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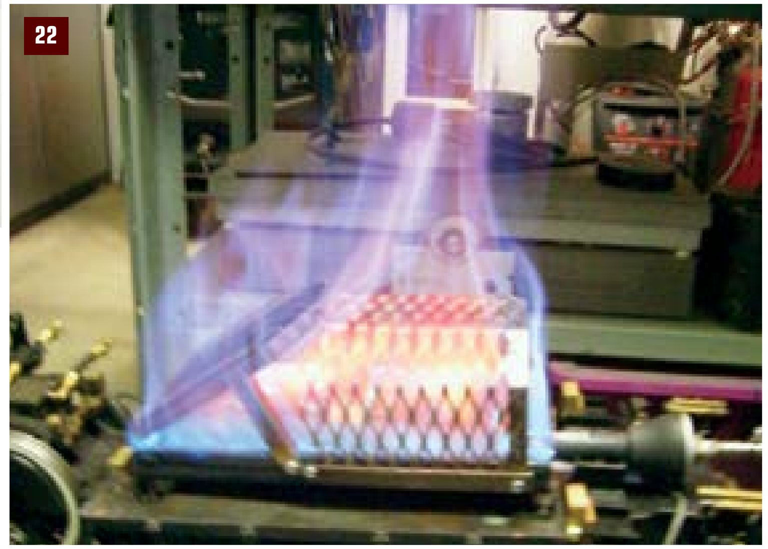
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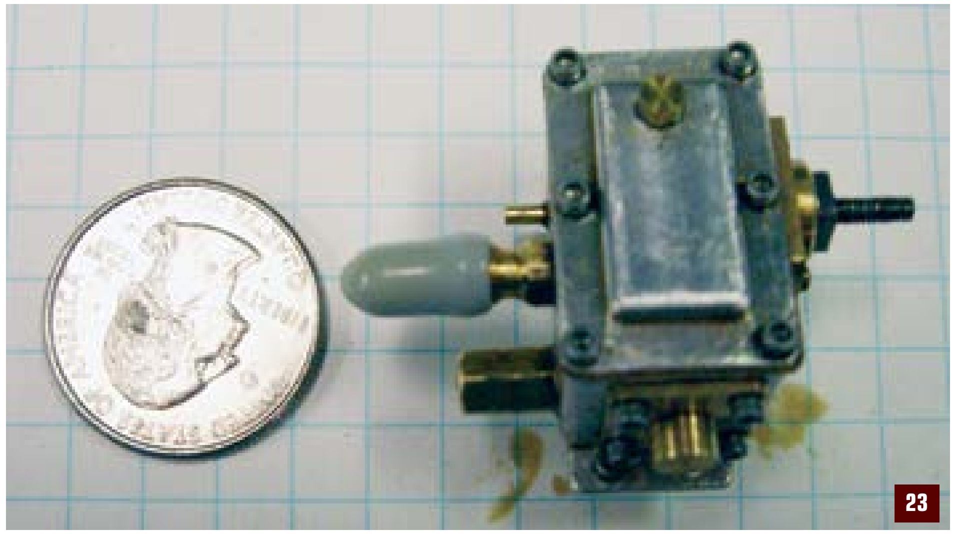
LUBRICATORS

The four mechanical lubricators on the full-size engine provided oil for the cylinders as well as some of the valve gear and chassis bearings. They were driven by the motion of the combination links.



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I decided the model's lubricators (**Photo 23**) would only provide oil to the cylinders. They were built with a reciprocating piston and ball check valves. Each piston was 1/8" in diameter with a 1/8" stroke. While the delivery volume of the pumps was more than necessary, I felt that excess lubrication was preferable to inadequate lubrication.

It was obvious that the oil storage volume in the lubricators would be inadequate for normal operation. I decided to make the sand domes into oil storage tanks. The rear dome supplies oil to the rear engine's lubricators, and the front dome supplies oil to the front engine's lubricators. Each dome can store about eight ounces of steam cylinder oil, which is more than enough for a full day of running.

WATER PUMPS

The full-size engine had only two water delivery systems. The primary system was an injector located under the right side of the cab that delivered cold water to the right side of the boiler. While tender water flows through the model's injector (**Photo 24**), it is not functional. The water leaves the injector and goes to the axle pump.

The second system was composed of a turbine-powered cold-water pump located under the left side of the cab. It supplied water from the tender to the feedwater heater located at the top front of the smokebox. A steam-powered reciprocating hot-water pump mounted on the front of the smokebox delivered warmed water from the feedwater heater to the left side of the boiler. The working model of the cold-water pump is shown in **Photos 25** & **26**.

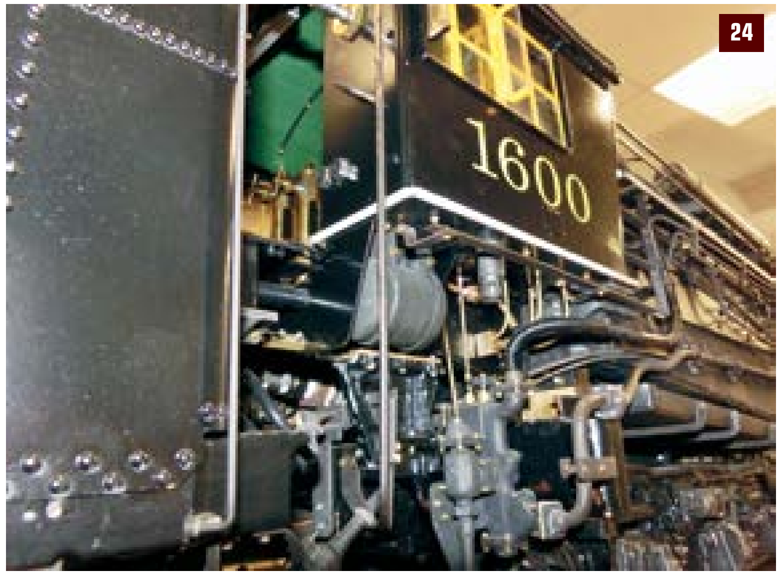

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Photo 27 shows the feedwater heater parts. Water is supplied by the cold-water pump through the smaller diameter tube shown on the right. The larger pipe on the right supplies engine exhaust steam to heat the water. The larger pipe on the left feeds warmed water to the hot-water pump mounted below on the front of the smokebox. The float valve assembly shown in the center regulates the water flow from the cold-water pump.

The parts of the hot-water pump are seen in **Photo 28**. The power piston and pilot valve are shown on the right. The double-acting water pump is on the left.

Our live steam club requires that a steam engine be fitted with a hand pump, not only for delivering water to the boiler, but also to be able to pump the boiler to 150% of normal operating pressure for an annual boiler inspection. The hand pump is located in the tender.

Since my Allegheny was fitted with a non-functioning injector, an axle pump was mounted to the rear engine's rear axle.

The functioning steam-powered cold and hot-water pump system is included to provide water when standing still. Since I had electrical power available in the tender, I also included an electric pump in the tender to assist in filling the boiler.

AIR SYSTEM

The two air compressors mounted on the front of the smokebox provide high-pressure air to operate the brakes, the power reverse, the drain cocks, and other accessories. While the compressors on my engine do work, their capacity is not sufficient to handle the engine's needs. **Photo 29** shows the parts for one of the steam-powered air compressors. In **Photo 30**, the compressors are mounted to the front of the smokebox.

An electric compressor located in the tender supplies air at 80 PSI for all of the engine's needs. You can see the air storage tank, the electric solenoid valves for the air brakes and the throttle control rod in **Photo 31**.

Looking at the tender from the other side, **Photo 32** shows the air compressor, the electric water pump, and the battery.

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ELECTRICAL SYSTEM AND CAB CONTROLS

The engine's electrical system consists of a headlight, marker lights, cab lights, electric bell ringer, a cab video camera, and a steam-powered turbine electric generator. Primary electrical power is provided by the 12 volt, 12 amp-hour battery located in the tender.

An operator control box is attached to the rear of the tender (**Photo 33**). It has a video monitor that shows the cab's pressure gauge and water level gauge. There are switches for the bell, lights, drain cocks and brakes. There is also an indicator for the battery charge level, and a low-water level indicator for the tender.

Photo 34 shows the cab interior. The two displacement lubricators on the left supply oil to the air compressors and the hot-water pump. The small gauge shows the air system's pressure.

THE FINSHED ENGINE

Photo 35 shows the Allegheny on its hydraulic lift stand at a model engineering show in Cincinnati, Ohio. The engine and tender weigh about 350 lbs.

Photo 36 is a left-side view of the tender showing the six- and eight-wheel Buckeye trucks.

Photo 37 is a view of the rear of the tender showing the connection for the control box. There is also a switch that operates the electric water pump, and the round knob is the control for the burner's gas valve.

Finally, **Photos 38** & **39** show the details of the locomotive's running gear.

This project was a labor of love. While it took seven years to complete, every day spent working on it was fun. Now that it is virtually complete, we are making sure that everything is operational and

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suitable for running at the club track. Even though there have been some issues with the throttle linkage, the engine appears to run well and follow the track without derailing. It is our plan to have any remaining bugs worked out for the 2017 summer running season. You can see a short YouTube video of one of our test runs at our backyard track at *youtu.be/6ASSNAjJ-rY.*

Photos by Jim Balmer.

READER'S PHOTO PAGE

Live Steam & Outdoor Railroading is happy to announce a new feature – **Reader's Photo Page**.

Send in your photo of any hobby related project, along with a detailed caption.

Those selected for publication will receive a three month subscription (or subscription extension) to *LSOR*, and two complimentary issues of the magazine with your photo.

Email your high resolution photo and caption to ***david@livesteam.net***. Submit as often as you like, but only one free subscription per person per year will be awarded. Be sure to include your full name and mailing address.

We will get the ball rolling with the example below.

Please share your work with our readers!

Here is one of my recently completed, 1.5" scale, steam-powered water pumps. They are based on the familiar VanBrocklin design. The first pumps that I built used the castings available from Friends Models. This pump was built entirely from bar stock. It features a condensate drain, and gaskets made with an inexpensive, computer-driven crafts cutter. It's an old design, but the pumps run great! *–David Brush*