No. 163, September/October 2019 US $5.95
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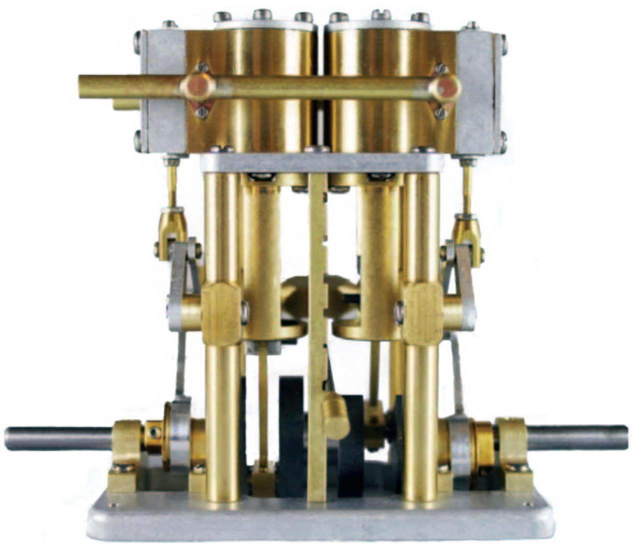
# STEAM IN THE GARDEN

# Aster-Accucraft Heavy Mikado Kit-Build Review

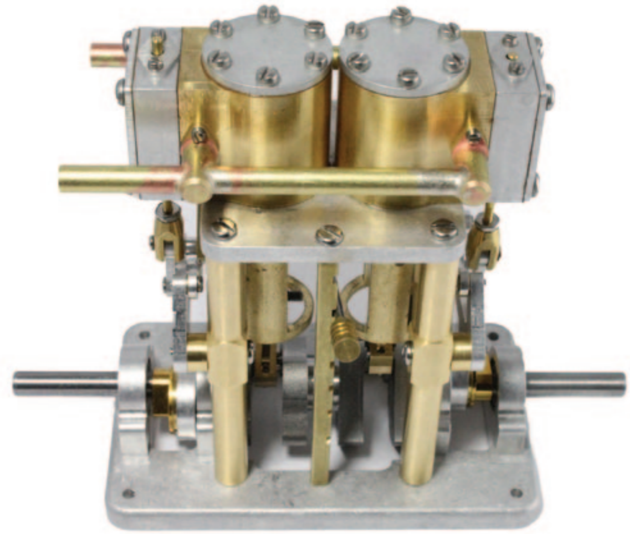
**Freelance Heisler Project - Part 4, Building the John Wilkes - Part 4, Detailed Back Heads... and lots more!**

# Fully Machined Steam Engine Kits



## TVR1A

Ready to assemble steam engine kit: $245
Fully Assembled and Tested: $350
Includes all hardware
Double acting, twin cylinder
Hackworth reversing gear
Includes full-color assembly manual
Dimensions:
Base: 3.000" x 1.844"
Crankshaft end-to-end: 4.344"
Height: 3.375"
Weight: 327 g



## TVR1ABB

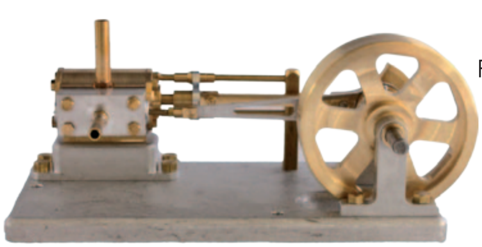
Ready to assemble steam engine kit: $295
Fully assembled and tested: $400
Includes all hardware
SAME AS TVR1A but with shielded ball bearings
Includes full-color assembly manual
Dimensions: Same as TVR1A
Weight: 323 g

## Flywheels for TVR1A / TVR1ABB

MFLY: $20
1 3/8" DIA
(Solid Marine)

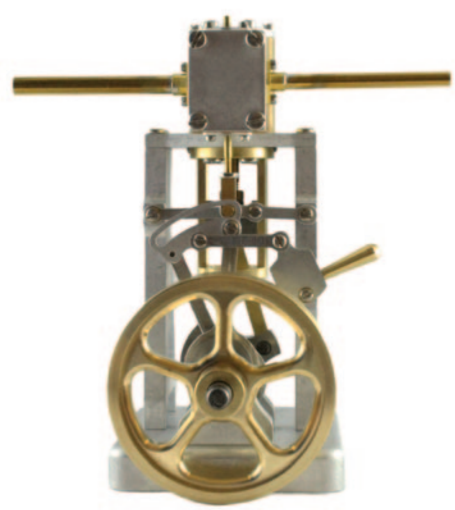
BFLY1: $25
1 3/4" DIA (5 Spoke)

BFLY2: $30
1 3/4" DIA (6 Spoke)



## HM1

Ready to assemble steam engine kit: $95
Fully Assembled and Tested: $145
Kit includes all hardware
.344" bore, .500" stroke
Double acting, single cylinder
Includes full-color assembly manual



## VR1A

Ready to assemble steam engine kit: $119
Fully Assembled and Tested: $175
Includes all hardware
1/2" bore, 1/2" stroke
Double acting, single cylinder
Reversing lever
Includes full-color assembly manual

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**Cover:** An Aster-Accucraft Heavy Mikado sits at the ready on Jim McDavid's railway. See Jim's review of this kit build. **Photo by Jim McDavid**

Vol. 29 No. 3; Issue No. 163; September/October 2019

# STEAM IN THE GARDEN

*Gather friends, while we inquire,*
*into trains, propelled by fire ...*


# Heavy Mikado Kit-Build Review

Text and Photos by Jim McDavid

Aster Hobby introduced the original USRA Light Mikado in 1999 as a basic model in unlettered black with very little detail and no axle or hand pumps. An axle pump, tender hand pump and some engine detail could be purchased separately. In 2000 they produced the engine in Southern Railway green with pumps and detail included. Both of these engines could be had in kit form or ready to run.

Recently the Aster/Accucraft partnership has chosen to re-issue the USRA Light Mikado and an all new Heavy Mikado in their quest to integrate Aster's kit-making techniques and materials into Accucraft's production prowess. The Light Mikado is available in four versions; black undecorated, New York Central, Union Pacific and Baltimore & Ohio. The Heavy Mikado is available in six liveries; undecorated black, Erie, CB&Q, Milwaukee Road, Southern Railway and Great Northern. Both the Light and Heavy Mikados are obtainable in kit form and ready to run.

The Heavy Mikado uses the same boiler, chassis and tender as the new Light Mikado but with a larger boiler shell and smokebox, a bigger cab and some different detail.

**USRA Heavy Mikado Specifications**

| | |
|---|---|
| **Scale/Gauge** | Gauge One (45mm) 1/32 |
| **Weight** | 15.65 lbs (7.1 kg) |
| **Length** | 30.5 in. (774mm) |
| **Width** | 4.2 in. (107mm) |
| **Height** | 6.5 in. (165mm) |
| **Wheel Arrangement** | 2-8-2 Mikado |
| **Driving Wheel** | 50mm Cast Iron |
| **Pilot wheel** | 26mm |
| **Trailing wheel** | 34mm |
| **Tender truck wheels** | 26mm |
| **Axle pump** | Bore 6mm / Stroke 5mm |
| **Cylinders** | Two cylinders 13mm X 20mm |
| **Valve gear** | Walschaert |
| **Boiler Type** | JVR Type B Smoke tube |
| **Water Capacity** | 400cc at 70% full |
| **Tender** | Hand pump Bore 11mm X 12mm stroke with Kingston valve |
| **Water tank V** | 500cc |
| **Fuel** | Alcohol |
| **Tender fuel Capacity** | 300cc at 80% full |
| **Minimum Radius** | 2 meters |

**MSRP**:
Light Mikado kit - $3,900 RTR $5,000
Heavy Mikado kit - $4,400 RTR $5,500

**History of the Prototype USRA Heavy Mikado**

In January 1918 the US government took control of the nation's railroads under the auspices of the United States Railroad Administration. Under the USRA a standardization program of locomotive design was begun. Twelve standard locomotive and three standard tender designs were proposed. Among them were Light and Heavy Mikados. The Heavy Mikados had larger cylinders, and a larger boiler with greater steam raising capacity than the Light Mikados. They also had a higher axle loading of 61,500 Lbs. and a total engine weight of 320,000 Lbs. The Heavy Mikados has 63-inch drivers and 27-inch X 32-inch cylinders. They produced 60,000 Lbs. tractive effort at a boiler pressure of 190 psi. The Heavy Mikados were assigned the standard intermediate tender with a water capacity of 10,000 gallons and a coal capacity of 16 tons. A total of 233 Heavy Mikados were manufactured while under control of the USRA. They went to an estimated twelve different railroads. Nine were assigned to the Great Northern as class O-3 road numbers 3200 to 3208, all built by Alco. The USRA Heavy Mikado design was very successful with an additional 724 copies of the design produced after the USRA relinquished control of the railroads.

*This information was gleaned from Uncle Sam's Locomotives by Eugene L. Huddleston. - J.McD.*

The new 2019 USRA Mikados have been improved and upgraded with:

- Cast-iron drivers
- Fully equalized driver suspension
- Stainless steel machined drive rods
- Axle pump with 20 percent greater capacity
- Sight glass blowdown
- Newly designed tender
- Tender water tank drain valve
- Increased alcohol capacity
- Removable alcohol tank
- Many new details

I have enjoyed assembling several Aster kits over the years, so I chose to purchase the USRA Heavy Mikado kit in the Great Northern Railway livery.

As is normal with these kits two booklets are included, one is assembly instructions which includes a list of all parts supplied by section and other is assembly illustrations (**Photo 1**). The booklets have corresponding section numbers, in the case of the Heavy Mikado they are 1 through 21. The parts for each assembly section are also bagged by section number. Generally the fixings – screws, nuts, washers, o-rings and such, are bagged by size or dimension and are pulled as you enter each section. Each assembly section is meant to be completed in order, however if you are so inclined it is perfectly acceptable to complete the tender sections first.

Before beginning the assembly of any of these kits a few essentials will be required:

- A flat surface – this is a must for frame assembly and lapping cylinder and valve parts.
- Metric measuring device
- A set of small magnetized screw drivers, both flat and Phillips
- A set of small metric wrenches
- A set of small metric nut drivers
- Small Allen wrenches- included with kit
- Small files
- Needle nose pliers
- Tweezers
- Scribe for aligning holes
- 1.4mm, 1.7mm, 2mm, 2.3mm, 2.6mm taps (mostly for cleaning paint from tapped holes)
- Pin vises for holding taps

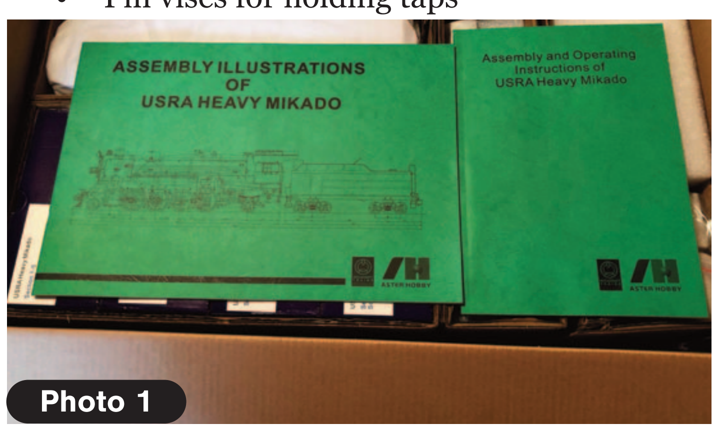



**Photo 1**

- Loctite 222
- Test rollers
- Small compressor

I also include a white terry cloth towel in my own list. After assembling the frames I do most other assemblies on top of this white towel. It is extremely good at catching small black screws and protects any finished parts from scratches.

## Kit Assembly Notes

**Section #1 Chassis** – Assemble the frames on a flat surface to insure they are square and level with no twisting. Clean all tapped holes with a tap, make sure chamfered surfaces are to the outside and use Loctite 222 on the screws (**Photo 2**).

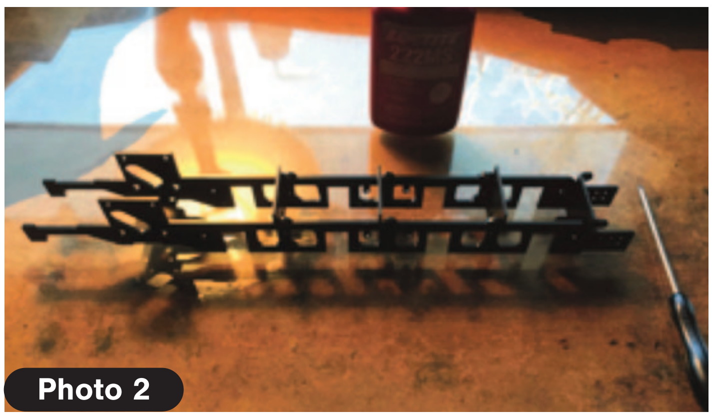


Photo 2

**Section #2 Drivers** – Make sure axle bearings slide smoothly. You may need to file some paint from the horn block cutouts (**Photo 3**).

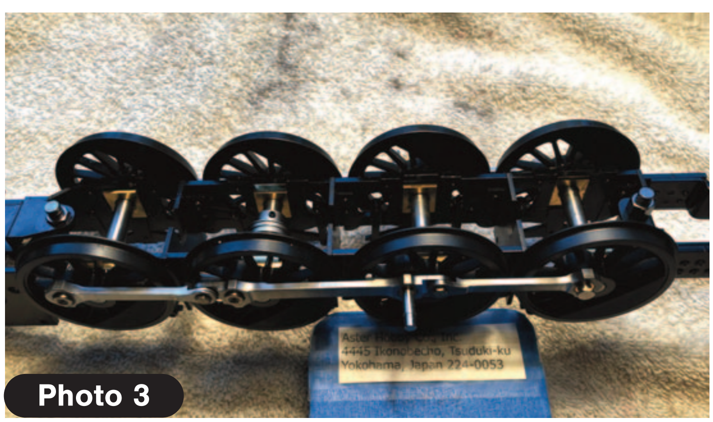


Photo 3

**Section #3 Cylinder blocks** – All mating surfaces should be lapped on a flat surface to remove scratches or any unevenness. The 3-4 valve chest mounting holes may not clear the 2.3mm studs. You may have to drill them out with a 3/32-inch or 2.4mm drill. Some minor filing may be necessary for smooth operation of the crosshead and valve spindle crosshead (**Photo 4**).

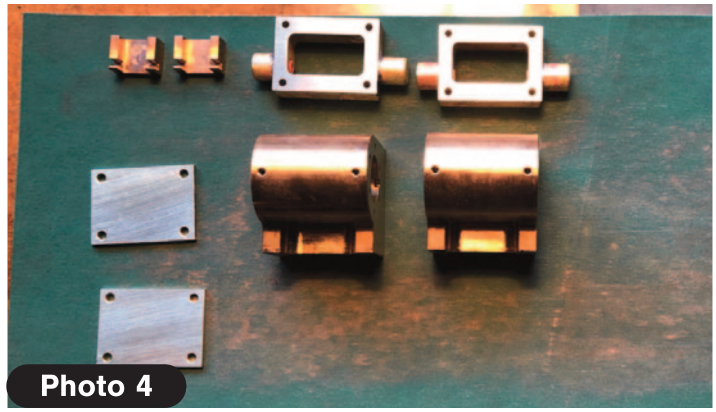


Photo 4

**Section #4 Cylinder block mounting** – You may have to slightly file the small ends of the main rods to fit inside of the crossheads.

**Section #5 Valve gear parts** – Make sure all valve gear parts function smoothly. For parts assembled with shoulder pins insert Loctite 222 into threaded holes with a toothpick to avoid getting locking compound in bushings (**Photo 5**).

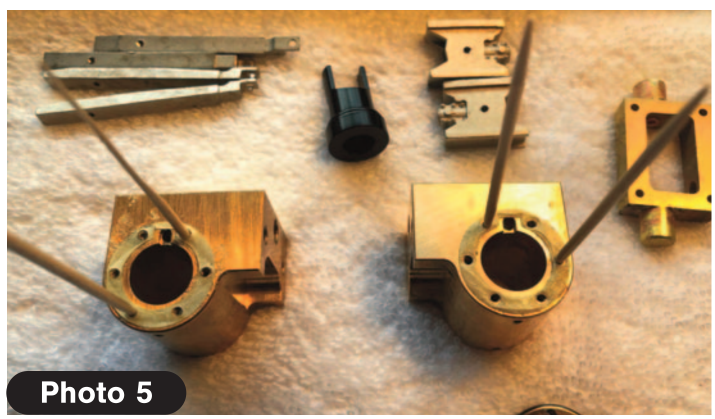


Photo 5

**Section #6 Valve setting** – Take your time with this section and make sure the valve setting for forward running is equal and correct. It is difficult to get the setting for both forward and reverse the same, so best to set forward perfect and fudge a little on the reverse setting. The engine will still run fine in reverse (**Photo 6**).

**Section #7 Chassis air test** – You will need a test roller stand and small air compressor. I chose to block off the lubricator feed with a small piece of

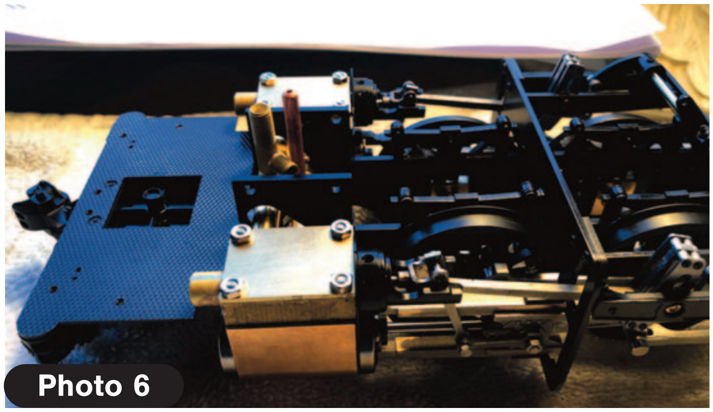


Photo 6

plastic inserted into the GN5 nut. If you use the lubricator tank and feed pipe to block your test air from escaping you will have to tighten the compression fittings on the feed tube. This will prevent you from adjusting the tubing length when you eventually mount the tank to the running board. If you took your time in the last setting there should be no problem here.

**Section #8 Axle pump** – In testing the pre-production model it was discovered that the axle pump eccentric strap was prone to laterally sliding off of the eccentric. This was caused by the addition of a 0.5mm Teflon strip which was meant to be an upgrade, as used on all the later Aster engines. However this brought the eccentric diameter up to the same height as the shoulder which is meant to keep the strap from sliding off. A new eccentric strap with a smaller inside diameter to match the eccentric minus the Teflon strip was designed and supplied, and all is well. To set the ball seats on pumps and check valves, I have for many years burnished them by using the proper size ball soldered to the end of a rod and rotated with a little toothpaste and downward pressure.

**Section #9 Boiler and boiler fittings (Photo 7)** – You will need a 6mm diameter rod approximately 2.75-inches long to properly align the sight glass fittings. This is critical to prevent breaking the glass while tightening the fittings. The sight glass will eventually have to line up with the 7-14 blow down valve when mounting the boiler to the chassis, so adhere to the 27mm dimension given for the distance from back of boiler to center of sight glass (**Photo 8**). The assemblers of the early delivered kits discovered a potential problem with the lower sight glass fitting, in that when mounting the boiler to the chassis as shown in in Section 13 there was minimal insertion of the 7-14 blowdown valve

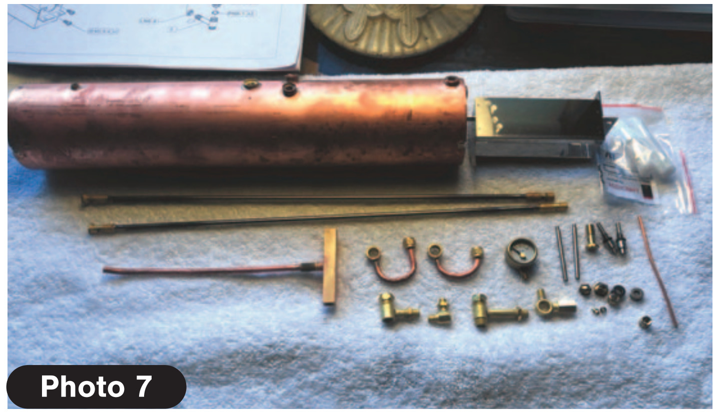


Photo 7

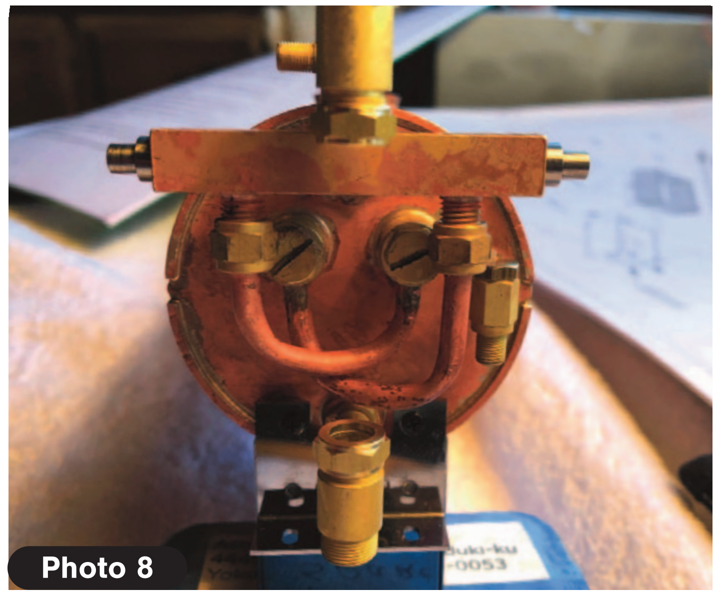


Photo 8

body into the lower sight fitting. This possibly could have prevented proper sealing of the O-ring. A new fitting was promptly designed and supplied by Aster/Accucraft.

**Sections #10 and #11 Boiler casing (Photo 9)** – You will need to make an adjustment to the two 10-18 dummy feed pipes as the last mounting insert does not line up with the square mounting opening in the boiler casing. There are several options to remedy this. You can file the opening in the casing

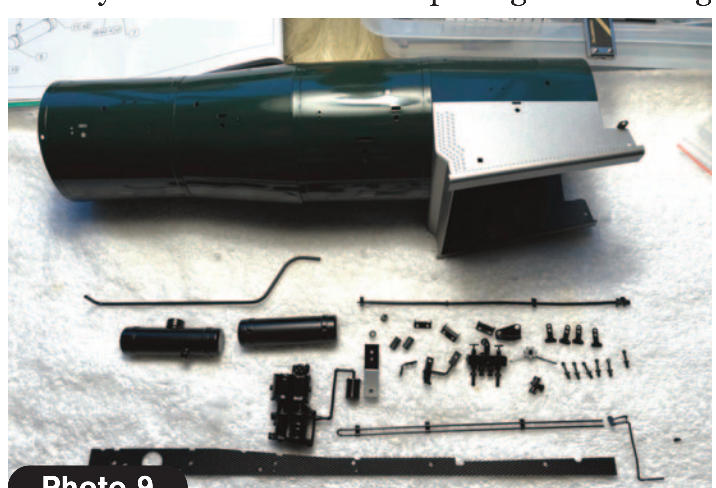


Photo 9

to fit the insert. The pipe itself will hide the larger opening. Or you can cut the pipe and add a dummy pipe coupling to lengthen the pipe so that the existing insert will fit the casing opening. This is the path that I chose. You could also file off the existing insert and make a new insert, sliding it on to the correct position to fit the casing opening.

**Section #12 Smokebox (Photo 10)** – Make sure the smokebox is well sealed with silicone and ceramic sheet. A little dab of JB Weld on the spread apart inserts which hold some parts to the smokebox before applying the ceramic sheet will prevent them from loosening in the future.


Photo 10

**Section #13 Mounting boiler (Photo 11)** – I found it beneficial to remove the 1-22 cab floor from the chassis and attach it to the boiler prior to lowering the boiler assembly to the frame. The cab floor 1-22 needs to be maneuvered around the dummy piping that is attached to the firebox. Before attaching the smokebox to the boiler shell it is a good idea to set the boiler assembly onto the frame and check the alignment of the steam supply pipe with the connection to the cylinders.

**Section #14 Reverser, smokebox door and handrails** – Use JB Weld to mount the number plates. I chose to make one piece handrails out of 0.039-inch piano wire. You may want to add lighting at this point.

**Section #15 Burner and trucks** – Put the wick material in the tubes a little long and cut to 12mm above the tube top.


Photo 11

**Section #16 Cab** – I added windows at this point using 0.020-inch clear plastic. You may want to reinforce 16-3 cab handrails. They are prone to bending when you handle the engine. I modified some spare handrail stanchions and glued them in the middle for support.

**Section #17 Tender trucks** – Use Loctite 222 on the 17-4 pins.

**Sections #18 and #19 Tender shell (Photo 12) and hand pump** – Make sure the tender water tank is well sealed.

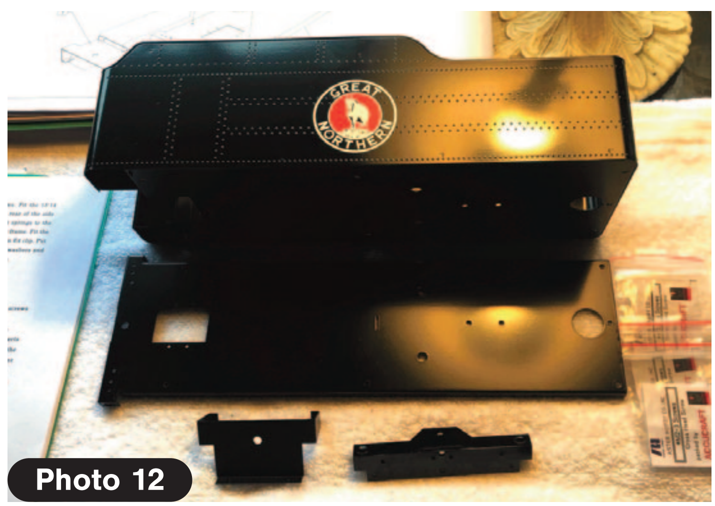
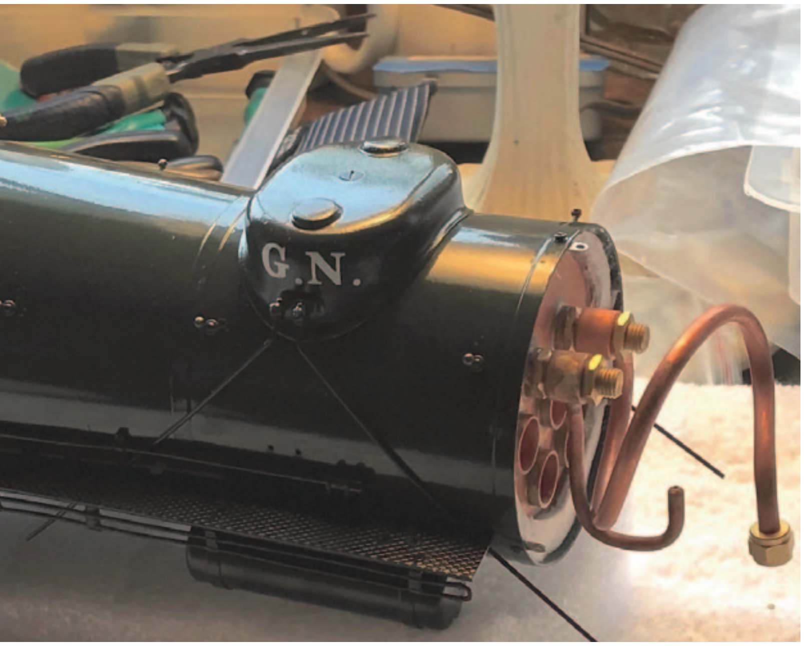


Photo 12

**Sections #20 and #21 Tender fittings** – Seal the rear bottom of forward tender compartment just in case of water spillage in the rear compartment.

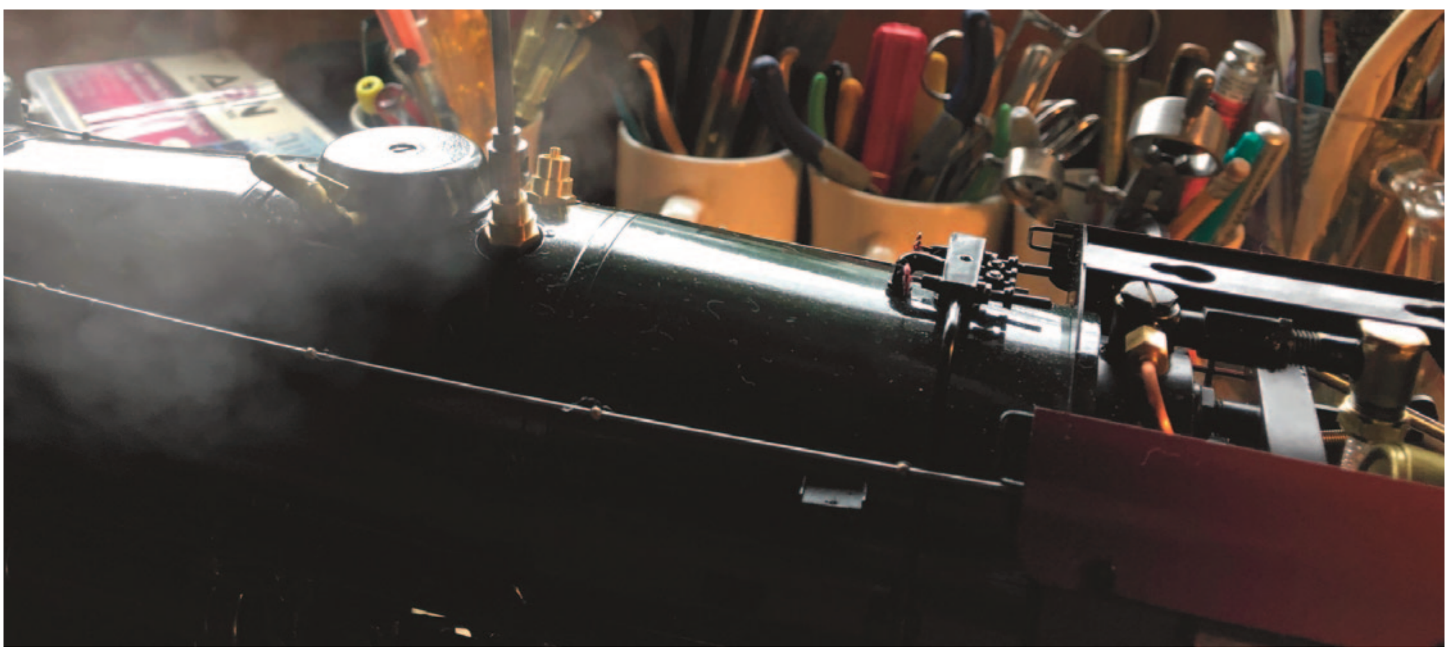



There are some significant upgrades and improvements on these new kits from the old ones which did cause a couple of engineering problems. Once they came to be known they were quickly corrected by Aster/Accucraft. The new equalized suspension on the driving wheels is a vast improvement on the sagging springs of the original Light Mikado. The sight glass blowdown is a blessing while running, and also when emptying the boiler after a run. I found the material and workmanship in the kit to be excellent. The new stainless steel machined main and side rods are the best that I have seen on an Aster kit in my memory. The JVR type B boiler is a great steam producer and can keep up with the engine's steam demand even when the by-pass valve is fully closed.

As far as the complexity of the kit assembly, I believe it to be one of the more straightforward recent kits that I have built. There are always a few head-scratching moments of course, for me mostly self-inflicted. This was an enjoyable kit to assemble, and I would highly recommend it to everyone, both beginners and veterans.

The performance is outstanding with significant stack talk as in the original, only limited by the adhesive weight on the drivers. I might add that this is a pretty handsome engine.

I am very happy with this purchase and look forward to many hours steaming with the Heavy Mike!



*The author's completed Heavy Mikado getting its first steam on the bench.*

# PRR E6 Update:


# Tuneup For The Accucraft Pennsy Atlantic

Text, Photos, and Drawings
by Steve Shyvers

Accucraft's live steam PRR E6 Atlantic locomotive looks good and features much fine detail. With 80 inch scale drivers, an overall appearance of power, and a 4-4-2 wheel arrangement the locomotive satisfies the need for 1/32 scale models of medium-sized North American steam motive power. After a year and a half of running the locomotive, I made modifications to the axle pump and boiler clack valve to improve their efficiencies, and to the burner wicks and blast nozzle to increase steam production. None of the changes are radical. All that was done was to apply some basic design guidelines that have been used in the miniature live steam hobby for a long time. The information presented here might be usefully applied to other small-scale live steam locomotives, whether commercially built or built from scratch.

Manufacturing tolerances and differences in assembly can affect individual model locomotive performance. Before assuming that your particular Accucraft PRR E6 needs any of the modifications discussed here you should first observe your locomotive under steam and watch how it performs. How many cars will it pull and what steam pressure will it maintain? Is the axle pump keeping the boiler full? Check the easy things first if you suspect a problem!

My alcohol-fired version of the E6 seemed to run well after making a number of small adjustments and modifications to improve the locomotive's "out of the box" set up and steaming performance. These changes were documented in *Steam in the Garden September/October 2017 Issue #151*. After running the E6 for a while, several things appeared to need sorting out. Although steam raised quickly to over 50 psig boiler pressure, the locomotive was unable to haul more than five or six cars without a steady decline in boiler pressure. Additionally, the axle pump performance became intermittent, which led to uncertainty about how much water was really in the boiler. The water gauge glass was no help. It would indicate sufficient water, the E6 would be steaming and going great guns down the track, and then suddenly the locomotive would slow to a stop and the gauge glass would show empty. Was the axle pump too small or was it intermittent? Was steam pressure dropping because the boiler was running out of water? Or was there another issue that prevented the E6 from steaming freely? I decided to keep running the E6 until I could isolate and characterize any faults with the water supply system and the

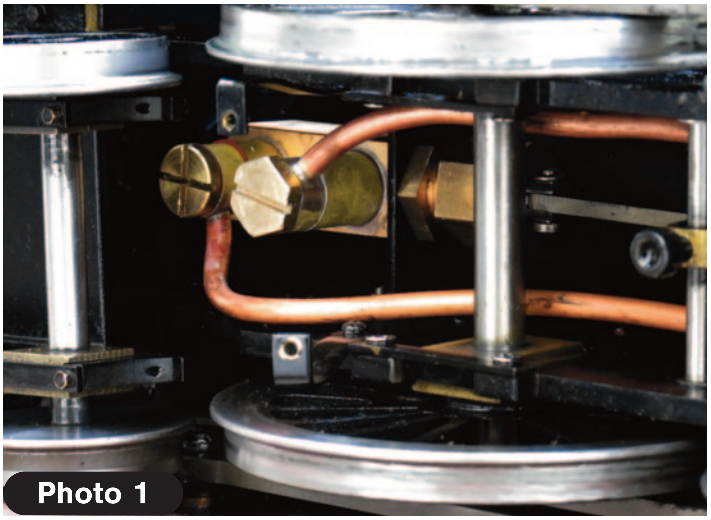


Photo 1

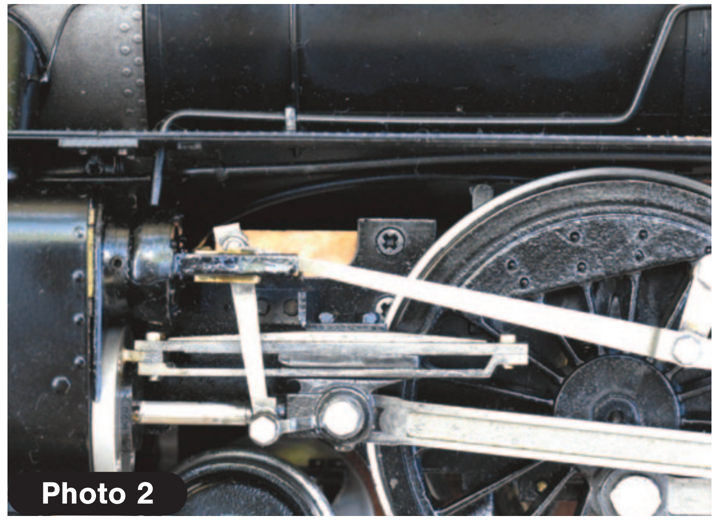


Photo 2

fuel/firing system. Testing proceeded with steaming on rollers as well as running the locomotive on my backyard test loop with a string of cars behind it.

**Axle Pump and Clack Valve**

Multiple steaming tests, both hauling cars and running on rollers, made it clear that the axle pump was intermittent. When the axle pump did work it would not pump sufficient water into the boiler to keep up with steam production. I decided to work on the axle pump and water delivery system first, since without a consistent supply of water to the boiler it would be difficult to judge the effectiveness of any modifications done to improve steam production. The E6 is a "thirsty" locomotive, and having to halt it every three or four minutes to add water to the boiler via the tender's hand pump would complicate steaming tests.

Ultimately the axle pump inlet and outlet valves, and the boiler clack valve, were reworked to improve their seals. Measurement of the axle pump ram diameter (5mm) and stroke length (6mm) showed that the pump capacity was small compared to the axle pumps used on some other similarly-sized live steam locomotives. This could explain the E6 axle pump's failure to keep up with steam production, but it would not explain the axle pump's intermittency. Because of the pump's small capacity I considered making a larger pump and installing it between the driving wheel axles. However I decided that if I could improve the existing pump's performance and reliability, then I would have a better idea about whether a larger pump was really needed, and how large it would need to be.

Problems with axle pump (and clack valve) performance can often be traced to the amount of ball "lift" in the pump valves and to the size and condition of the ball seats. These will affect both pump and clack valve efficiency and effectiveness. If a ball lift is too great then the valve fails to seal fast enough when the pump stroke (water flow) reverses direction. If the lift distance is very large then the ball might not seal at all. A ball seat that is too small, too large, or poorly formed can also prevent the ball from sealing properly, and the valve will leak.

The E6 axle pump is located above the pilot truck rear wheels and in front of the first driving wheel axle (**Photo 1**). An eccentric on the second axle acts through a bell crank to drive the axle pump ram. Visual inspection showed the bell crank, eccentric, and the intermediate linkages to be working properly. Checks of the piping from the tender hand pump to the axle pump, to the bypass valve and boiler clack, and finally back to the tender water tank via the bypass line showed no blockages or crimped tubing.

A small bracket, held in place between the main frames by four flat head screws, supports the E6 axle pump. Two of the screws are partially behind the left and right front driving wheels (**Photo 2**), and to remove them the "keepers" that hold the front driving wheel bearings in their frame slots must be removed in order to lower the front driving wheels. Pump removal also requires removing the pilot truck and driving wheel brake gear, and the copper water pipes to and from the axle pump must be disconnected at both ends and removed by "snaking" them past the driving axles, etcetera. Disconnecting the bell crank linkage from the

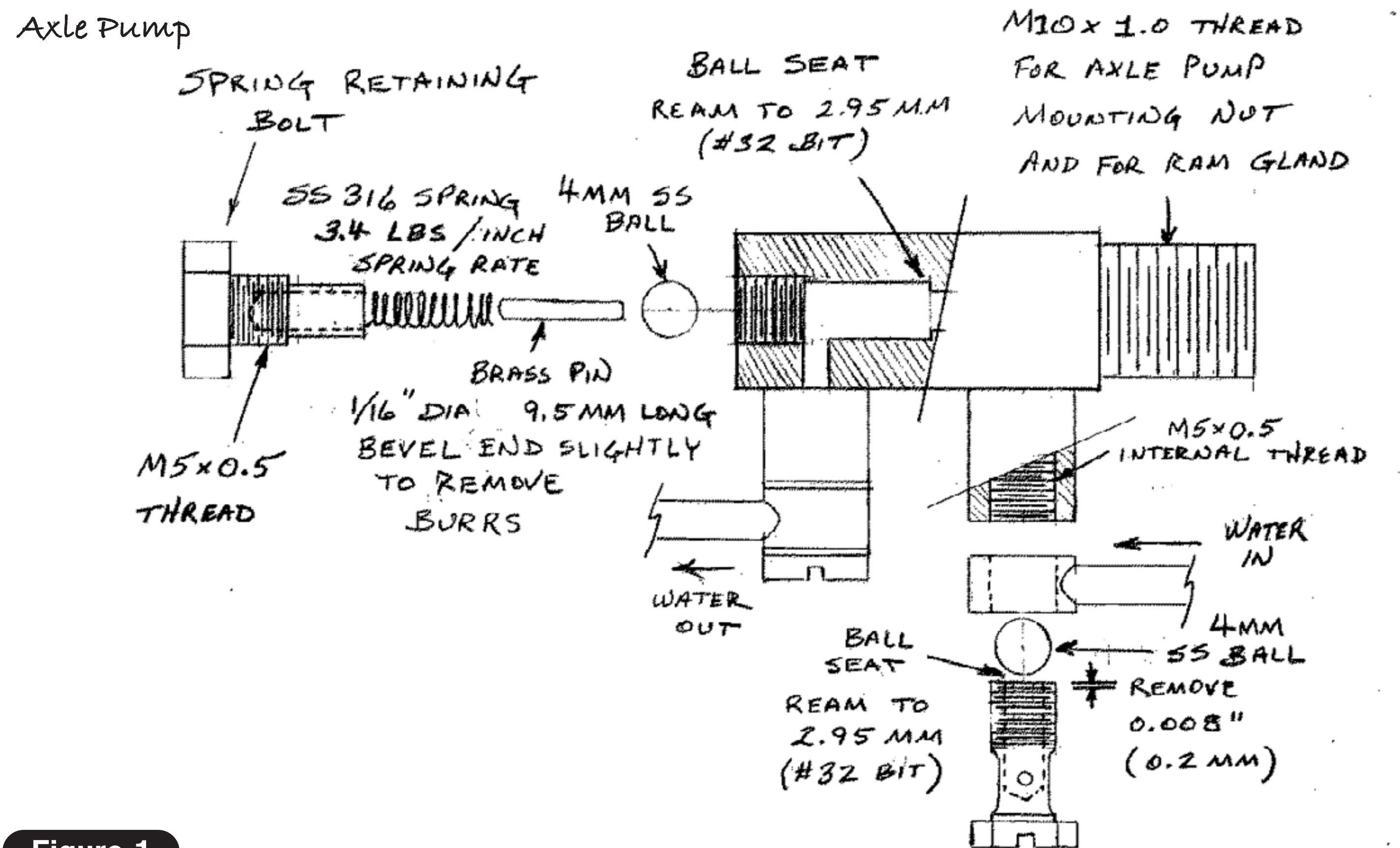



**Figure 1**

pump ram is easily done after the pump eccentric strap has been freed from the eccentric and the axle pump and its bracket have been partially lowered between the main frames.

The axle pump's configuration and connections are shown in **Figure 1**. The axle pump's stainless steel ram uses an O-ring seal set into a "piston ring" groove as well as an O-ring seal behind the ram gland nut. On my E6's axle pump the ram cylinder contained much oily residue that needed to be cleaned out. The O-ring behind the gland nut was very worn, and was replaced with a couple of wraps of 3/32-inch teflon valve-stem packing.

The axle pump inlet valve orientation is vertical, and its 4mm ball seals against a ball seat that is formed on the end of the water inlet banjo bolt. Careful measurement of the parts showed a full 1.25mm ball lift distance. For a mechanically-actuated pump, such as an axle pump, the recommended ball lift should be about one eighth of the ball diameter. Therefore with a 4mm ball the allowable lift distance should be only 0.5mm. I reduced the amount the ball could lift by substituting Loctite 592 sealant for the two fiber washers that seal the water inlet banjo fitting and then shortening the end of the banjo bolt by 0.2mm to ensure that the final ball lift was close 0.5mm. This is a straightforward job using a small end mill. An alternative to shortening the banjo bolt would be to eliminate only one of the fiber washers and to sand the thickness of the remaining fiber washer to a thickness of about 0.25mm.

The axle pump inlet valve ball seat diameter measured 2.8mm, which is equal to 70-percent of the 4mm ball diameter and very close to the ideal size for optimal sealing. (According to one reference I have read the seat diameter can be between 60 percent and 80 percent of the ball size.) To ensure that the seat was round I reamed it to 2.95mm using a #32 drill bit in a hand-held T-wrench. Work carefully and slowly so that the seat ends up circular. A proper reamer is a better tool for the job, and if a 3mm reamer is available, then by all means use it. The final step was to burnish the ball seat using scouring powder ("Bon Ami") and a homemade tool spun in the valve seat. The tool is made from an extra 4mm ball soldered to the end of a piece of K&S brass tubing.

The axle pump outlet valve is horizontal, and a return spring is used to hold the 4mm ball against its seat. As with the inlet valve, the ball seat was measured, enlarged from its initial 2.78mm diam-

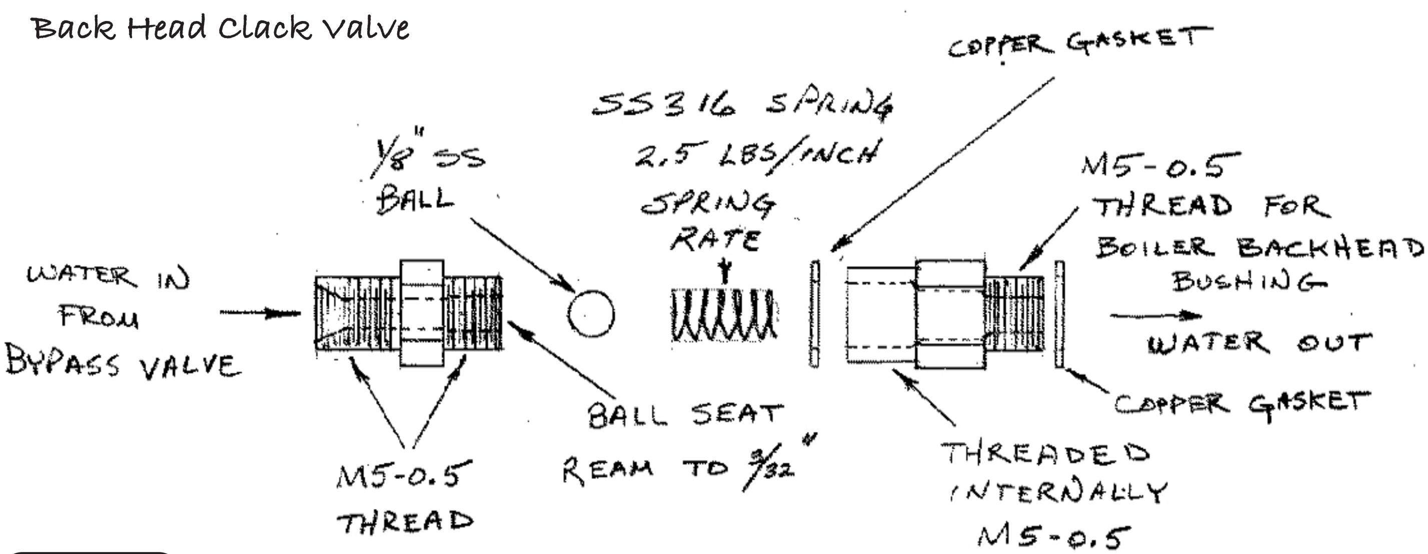



**Figure 2**

eter to 2.95mm using the #32 drill bit to ensure that the seat was round, and then burnished. The original outlet valve return spring was replaced with a "softer" and slightly longer 316 stainless steel spring (3.4 pounds per inch spring rate).

The installation of the softer spring was the result of what I call a "lung test." When pump valves (and clack valves, too) are oriented vertically, return springs are not typically used to close the valves. Instead gravity and the momentary reverse water flow is sufficient to drive the ball against its seat. In a horizontal ball check valve the ball return spring ensures that the ball is held against its seat, but any additional spring force that exceeds what gravity would provide in a vertical valve should be unnecessary. When the E6 axle pump's horizontal outlet valve was assembled using the original spring, I was unable to open the valve by blowing through it. Substituting the softer spring allowed the valve to open easily with minimal lung pressure, and close quickly when the air flow reversed. Hence the term "lung test."

Because of the axle pump's outlet valve configuration there is no "hard stop" to limit the ball lift to the recommended 0.5mm. Therefore a simple 1/16-inch diameter brass pin, 9.5mm long, was fabricated to fit concentrically within the return spring, which, in turn, fits into a deep recess in the spring retaining bolt. The ball hits the end of the pin after lifting approximately 0.5mm off the seat. Careful measurement of the ball chamber depth and the length of the spring retaining bolt is required to determine the correct pin length.

The E6 uses the same horizontal back head clack valve design that is used on other Accucraft live steam locomotives (**Figure 2**). On the E6 the clack valve is located on the boiler back head immediately to the right of the regulator (**Photo 3**). Instead of a ball a tiny 3mm diameter O-ring provides the seal (**Photo 4**). Inspection of my E6's clack valve

**Photo 3**

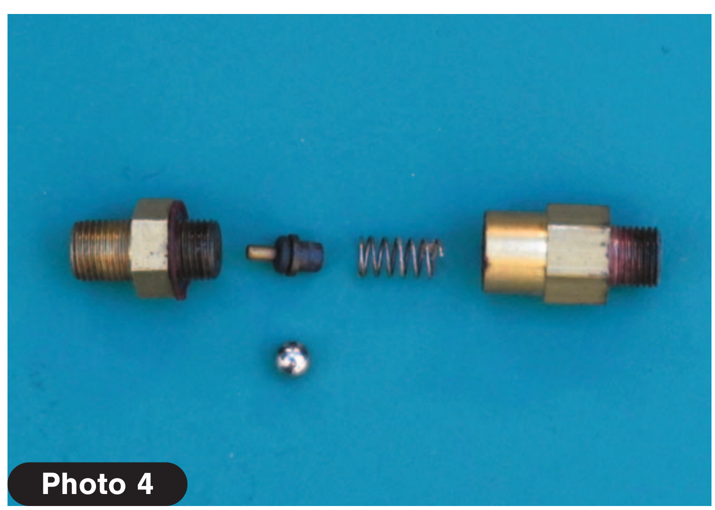


**Photo 4**

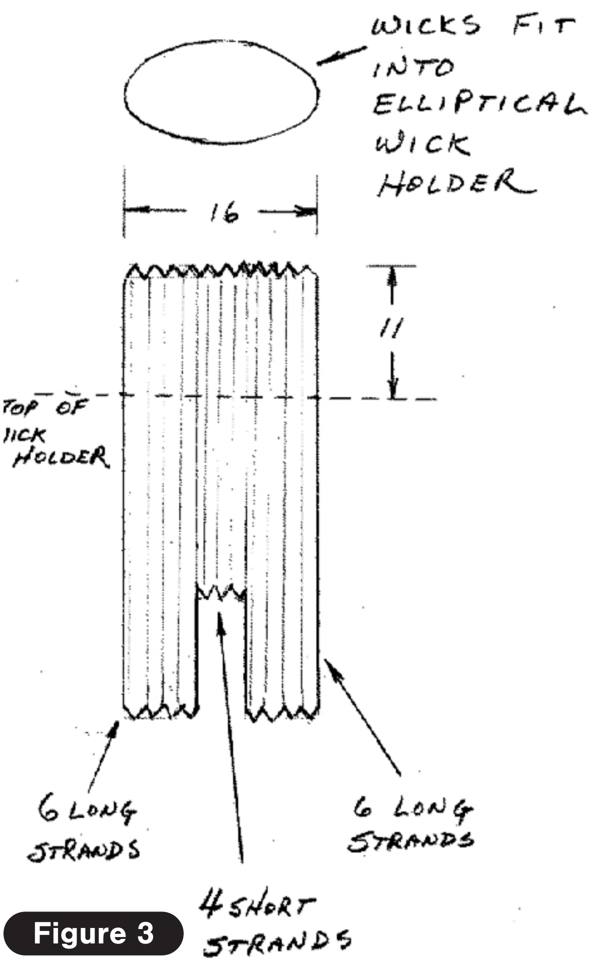
Photo 5

showed the O-ring to be damaged, and I decided to replace it with a one-eighth-inch diameter SS 316 ball (also shown in **Photo 4** for comparison). The valve seat diameter was enlarged to 3/32-inch using incrementally larger drill bits held in the T-wrench, and then burnished using a tool similar to the one used for the axle pump valves but with a one-eighth-inch ball. The clack valve's design prevents having a hard stop to restrict the amount of ball lift, so the length of the replacement spring was adjusted until the "lung test" showed that the clack was opening easily and closing quickly. Loctite 592 was used to reassemble and to re-install the clack after the parts, including the two copper gaskets, were cleaned of all old sealant.

After modifying the axle pump and clack valve the boiler is now kept supplied with water. More testing is needed, but the various test runs so far have shown that during a typical 30-minute run the axle pump will now keep up with boiler water consumption sufficiently so that no interventions with a hand pump are needed. With the axle pump able to maintain a proper water level in the boiler the water gauge is now a reliable and useful indicator of boiler water level.

### Alcohol Wicks

When first setting up my E6 no changes were made to the the factory-installed burner wicks. The wicks were removed from the wick holders and inspected, however. It was noted that the wick material must extend as far as possible down into the wick holders as possible because of the very shallow tender fuel sump, which causes only the bottom halves of the wicks, at most, to be immersed.




| | FRONT WICK | MIDDLE WICK | BACK WICK |
|---|---|---|---|
| LONG STRANDS | 35 mm | 38 mm | 38 mm |
| SHORT STRANDS | 25 mm | 28 mm | 28 mm |

Accucraft PRR E6
Wick Setup
Use Ceratex Ceramic Rope Strands
or
equivelent

Figure 3

Therefore I jammed the wicks as far as they would go into the wick holders. Difficulty of my E6 to maintain steam pressure when running, even with the alcohol tank and sump raised up to 0.25-inch higher, prompted an attempt to improve the wick setup. **Photo 5** shows the burner assembly, one of the original wicks, a new replacement wick, and a sample of the new wick material. The lower ends of the wicks are "forked" to fit around the fuel supply pipe, and the lower ends of the new wick have been made longer in order to extend as far as possible into in the alcohol. Note also that the front wick, and wick holder, are shorter than the other two, and that the wick holders are elliptical in cross-section. As with the original wicks, the new wicks are made of ceramic material. The new wicks use a rope-like product called "CeraTex" that is sold as gasket material for high-temperature applications. The CeraTex material is supplied in the form of three-strand twisted rope. I divided the CeraTex rope into individual strands, then cut and inserted them into the wick holders per the table in **Figure 3**. The number of strands shown for each wick seemed to achieve a reasonable wick packing density according to my experience with other alcohol-fired locomotives. Determining the optimal number of strands to use remains open to further experiment after more experience is gained steaming the E6 in different ambient temperatures.

The new wicks are more loosely packed than the original wicks, and definitely extend farther into the alcohol in the wick holders. Therefore the fire should be stronger with the new wicks than with old wicks. But even though the E6 could now maintain 50 psig boiler pressure for the duration of a 25 minute run hauling five or six cars, I had hoped that with so few cars to pull the boiler pressure would rise steadily, causing the safety valve to lift frequently. What to try next?

### Blast Pipe Modifications

My review of the E6 in Issue 151 of *SitG* stated that the locomotive's "front end" proportions seemed correct because the locomotive raised steam quickly and produced a strong steam exhaust "blast". I assumed that the locomotive would have no trouble maintaining steam, and therefore I never checked the blast pipe proportions and blower nozzle alignment. After repacking the burner wicks and raising the burner fuel level failed to improve the E6's loss of steam pressure when hauling longer consists, it was time to inspect the locomotive's front end.

The "prevailing wisdom" for alcohol-firing is that a strong blast pipe exhaust jet fans the fire, which makes it hotter, and therefore increases steam production. However experience with another alcohol-fired locomotive demonstrated that the opposite could be true as well. If the strong blast actually tries to pull the fire off the wicks then the result is a smaller fire and less effective heating of the boiler. The smaller flames might be hotter because of the increased draft, but they contact less of the firebox and flue heating surface. Alcohol flames do not produce a significant amount of radiant heat. Therefore surfaces that are not in direct contact with the alcohol flames get little benefit from the hotter fire. It is possible, too, that the stronger blast pulls the hot combustion gases into the smokebox too soon to effectively transfer their heat to the flue tubes and to the firebox walls. Once in the smokebox the hot combustion gases provide no benefit. Enlarging the blast nozzle internal diameter will generally reduce the velocity, and therefore the strength, of the exhaust blast.

After removing the E6's smokebox front (two screws) a 1:6 tapered template dropped down the chimney into the blast nozzle showed that the blast pipe height relative to the chimney top opening was close to ideal. Various numbered drills were used as gauges to measure the blast nozzle internal diameter (I.D.) to be approximately 0.073-inch. I have not measured the E6 piston diameter, but estimate that it is probably 13mm, in which case 0.073-inch would be about one seventh the piston diameter, which corresponds to one rule-of-thumb for calculating blast nozzle size. However the 0.073-inch diameter extended down into the blast pipe only 5/64-inch, below which the I.D. became only 0.052-inch for half the blast pipe's length. Below that the blast pipe I.D. Increased to 0.55-inch. This meant that the effective blast nozzle might be only 0.052-inch in diameter, which could develop a stronger exhaust blast than needed.

**Photo 6** shows the smokebox interior with the blower nozzle positioned behind and slightly to the left of the blast pipe. A bracket that clamped the blower nozzle to the blast pipe has been removed and discarded as unnecessary. **Photo 7** shows the blast pipe after removal from the smokebox, and

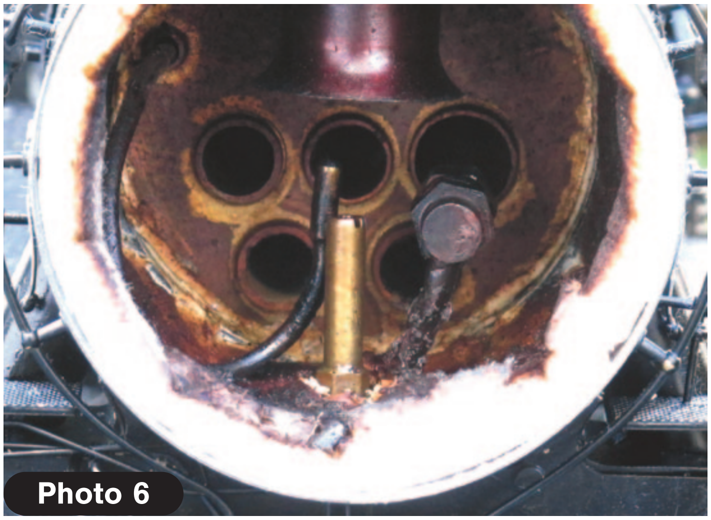


Photo 6

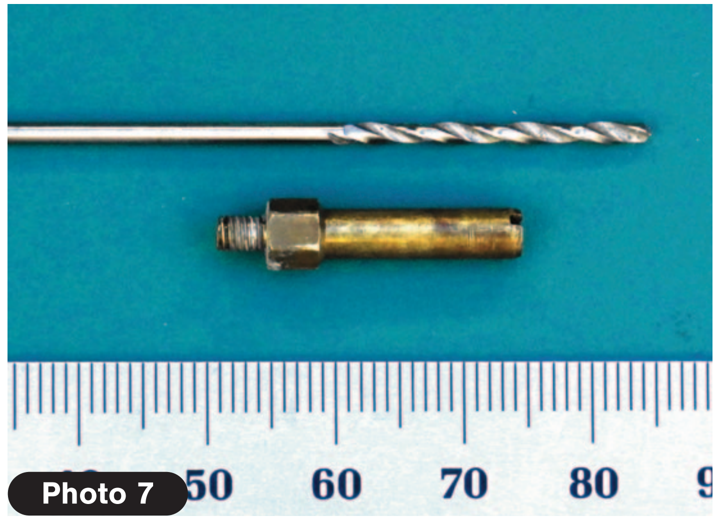



Photo 7

next to it a #50 drill bit (0.070-inch diameter) for scale. It can be seen that the blast pipe mounts using a small M3 thread at its base, which limits how much the blast pipe can be bored out. By using a small lathe  and incrementally larger drill bits I was able to increase the blast pipe bore to 0.070-inch. At this bore I.D. there is not a lot of metal left in the blast pipe mounting threads, but it should be okay as normally there is no side stress on the blast pipe and the delicate threads at the base.

Steaming performance increased dramatically after boring out the blast pipe internal diameter. In 60-degree Fahrenheit weather, nine freight cars were hauled at 60 scale mph with boiler pressure maintaining 50-plus psig, with periodic safety valve blow off, for the duration of the 25 minute run. A later test run with 11 cars behind the tender maintained 50-plus psig at 50 scale mph, and a final test in 50-degree F weather showed that the E6 could start 18 cars on dry track with no wheel slip and maintain 50 psig boiler pressure at 45 scale mph. All test runs were done with the valve gear notched up at 70 percent cutoff. Overall, a big improvement over the E6's original capability. More testing is planned when the weather returns to normal summertime steamup conditions.


*Summertime arrived and the updated E6 runs in tip-top-shape on the author's railway!*

Workshop Project

# Streamline Perfection


Text & Construction Photos by Bill Allen

**John Wilkes Series**
This five-part series includes:

- Part 1 - Chassis, Boiler, Ceramic Burner
- Part 2 - Boiler Wrapper, Nose Cone, Streamline Fairing
- Part 3 - Component Parts, Cab, Finishing Details
- ➡ Part 4 - Tender, Passenger Cars
- Part 5 - Interior & Paint

## TENDER

The tender is rather straightforward except for the paint job. The outer shell which is shown in **Photo 4-1** is constructed of brass sheeting bent and soldered together to form a water tight box. The sides are bent in to form the coal load opening and brass plates are screwed down behind it which will cover the fuel tank. The edges of the curved sides are covered with 1/16-inch copper tubing split and attached with JB Weld.

A hand water pump and the fuel tank are added (**Photo 4-2**) and copper tubing is routed to the underside. Looking at the underside in **Photo 4-3** you can see how the tubing is routed between the floor and the truck. The two outer tubes are the gas and high pressure feed water so they are brass compression fittings. The two inner ones are low pressure water return and tender warmer tubes, so they are just sealed to keep the bottom water tight.

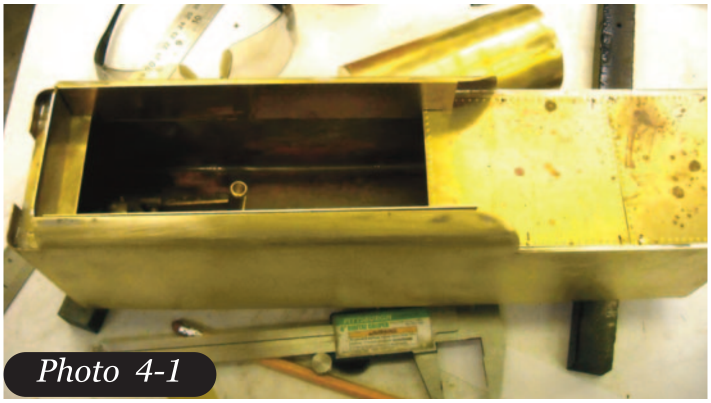


*Photo 4-1*

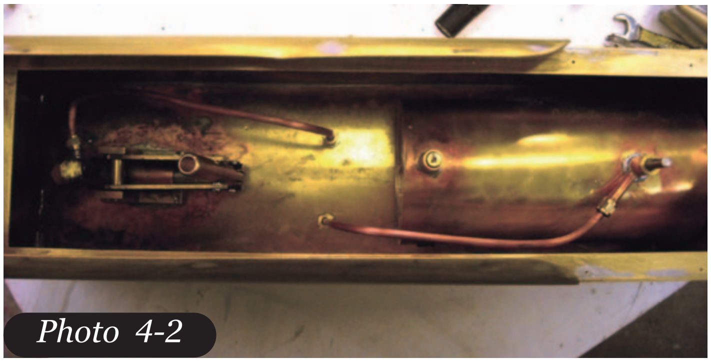


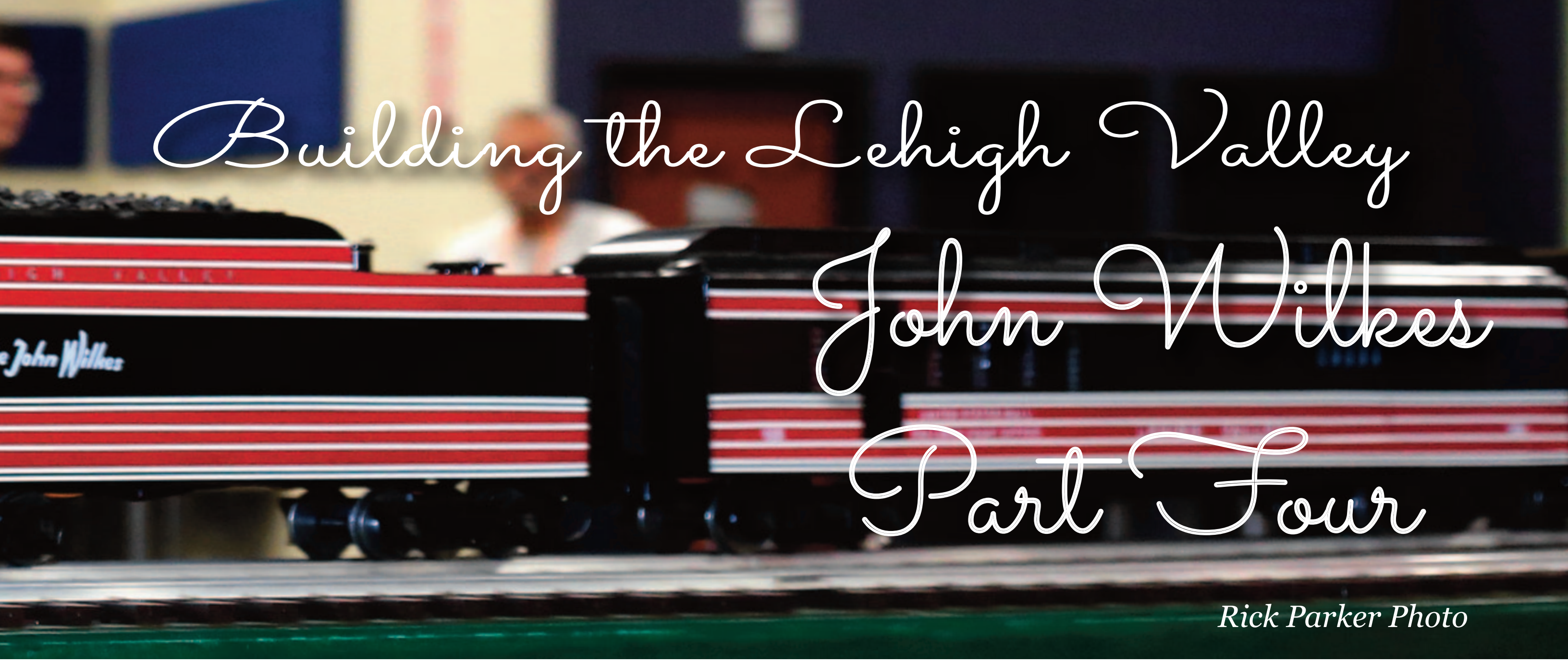
*Photo 4-2*

**Photo 4-4** shows the factory trucks supplied by Charles Bednarik mounted and the tubing routed under them.

## PASSENGER CARS

The passenger cars were of heavyweight design with three-axle trucks on the 80-foot coaches and two-axle trucks on the shorter ones. The clerestory roofs were designed for air conditioning and thus had vents and fans rather than windows. The book I received from Charles had detailed drawings of

# Building the Lehigh Valley John Wilkes Part Four




Rick Parker Photo

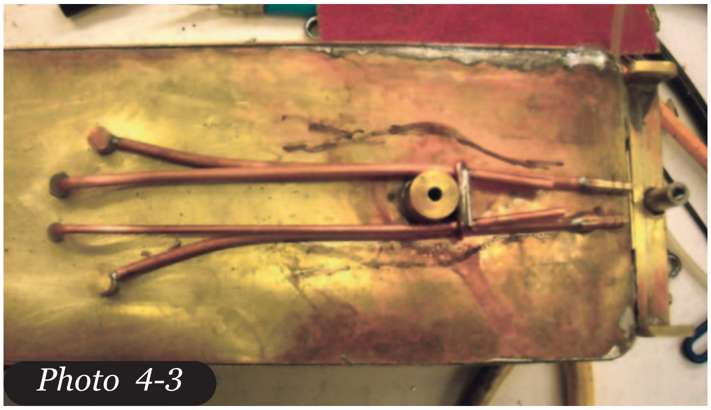


Photo 4-3

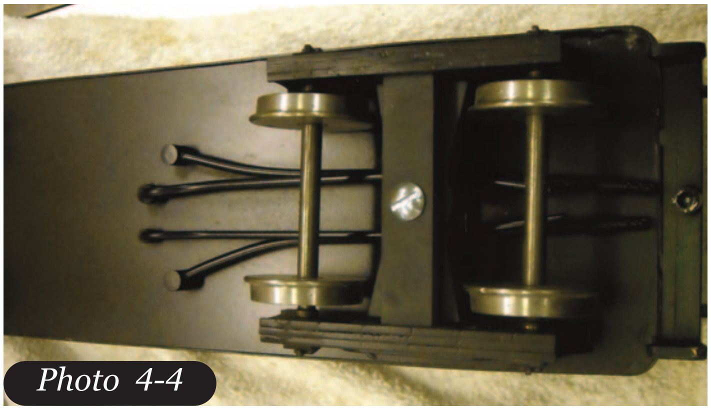


Photo 4-4

each car as well as dimensions (**Figure 4-1**). The John Wilkes shared the rails with its sister the Black Diamond, which had slightly different streamlining features and was assigned the only observation car. Since the observation car was so cool, we decided that the John Wilkes must have borrowed it from time to time so we made one for this build.

Modeling a clerestory roof is a challenge. The majority of those out there are plastic. Sculpting one in sheet metal would take forever but doing nine in several different sizes and shapes was not going to happen. I figured I could probably carve them out of wood but something that long and flat would tend to warp or twist, even with kiln dried hardwood. So I decided on medium density hardboard (MDF). It is a very stable material but it is also is very heavy. I was not too concerned about the weight as I knew the engine would have plenty of power. I first tried to carve it out of one thick piece but that didn't work. I decided on a wide piece for the roof structure with a narrower piece glued on top for the clerestory. I decided on half-inch material with short blocks glued on the ends of the clerestory where it bends down in the front. The ridge on the top side of the clerestory was cut

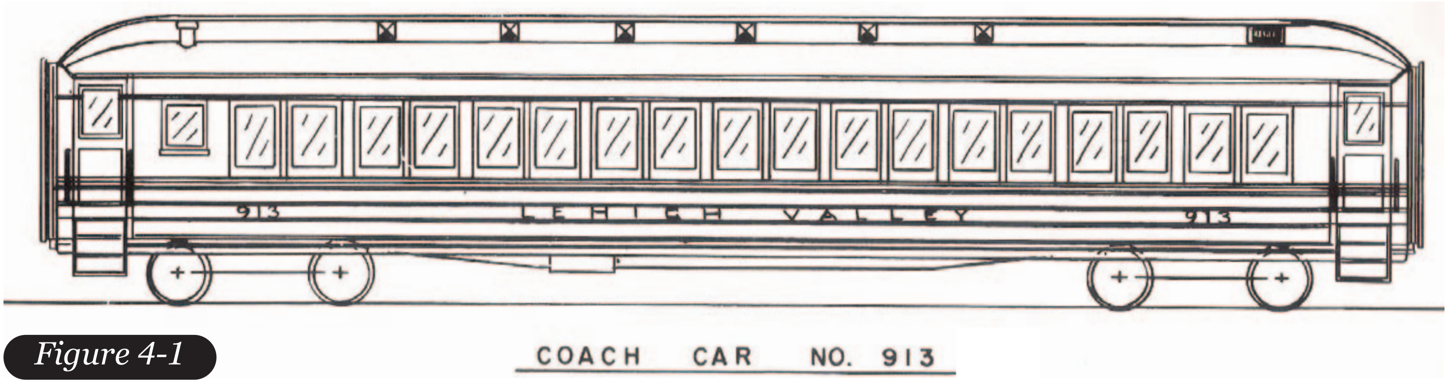



Figure 4-1

*Photo 4-5*

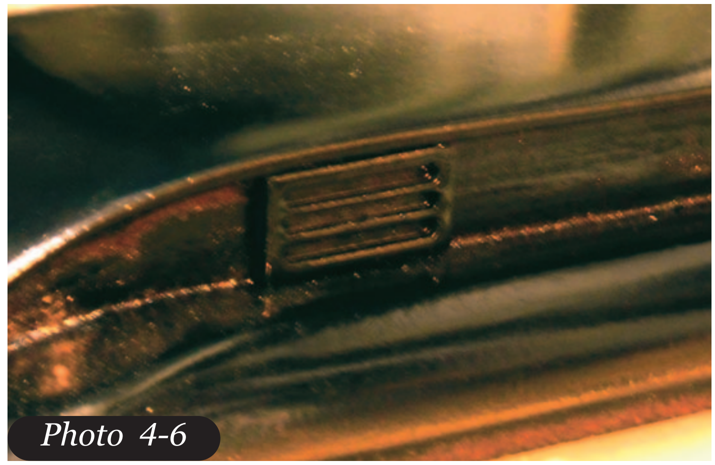


*Photo 4-6*

out with a router, as were the radii of the roof sides and ends. I only made six-inch lengths of my test pieces and was finally happy with the result (**Photo 4-5**).

The roof vents were of a simple design and were printed on the 3D printer (**Photo 4-6**).

The fans were printed on two pieces. **Photo 4-7** shows the two components below the combined result.

The car sides were water jet cut from 20 gauge Steel (**Photo 4-8**). They came out fairly clean with only a little sanding needed on the cut edges. Five tabs were cut out and bent over to attach the MDF floors with wood screws (**Photo 4-9**). The ends receive a dado groove (**Photo 4-10**) and are glued and clamped together (**Photo 4-11**).

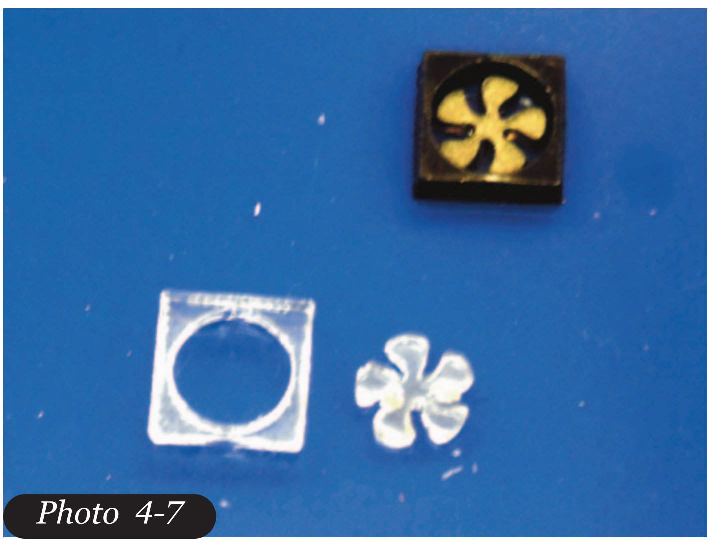


*Photo 4-7*

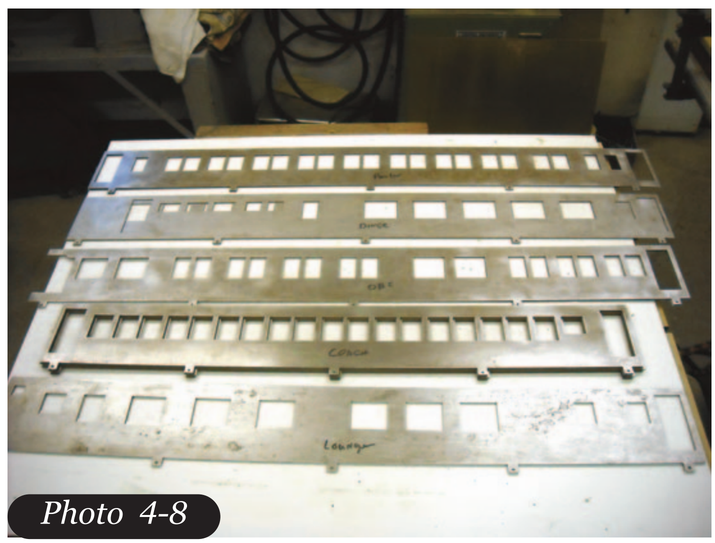


*Photo 4-8*

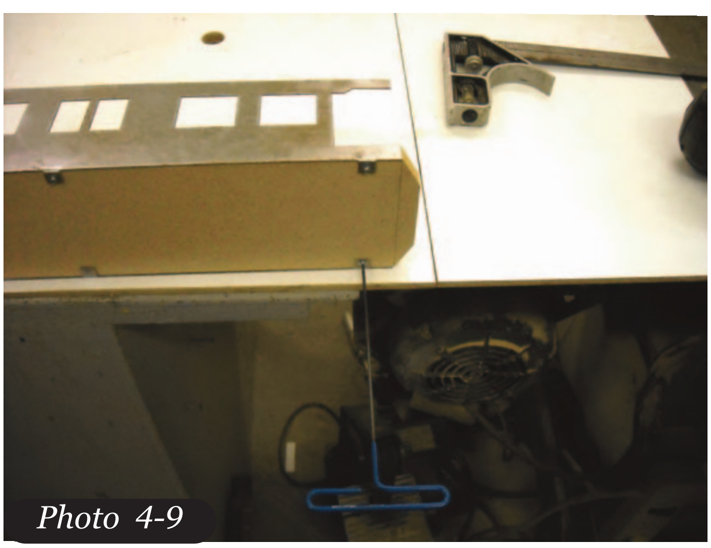


*Photo 4-9*

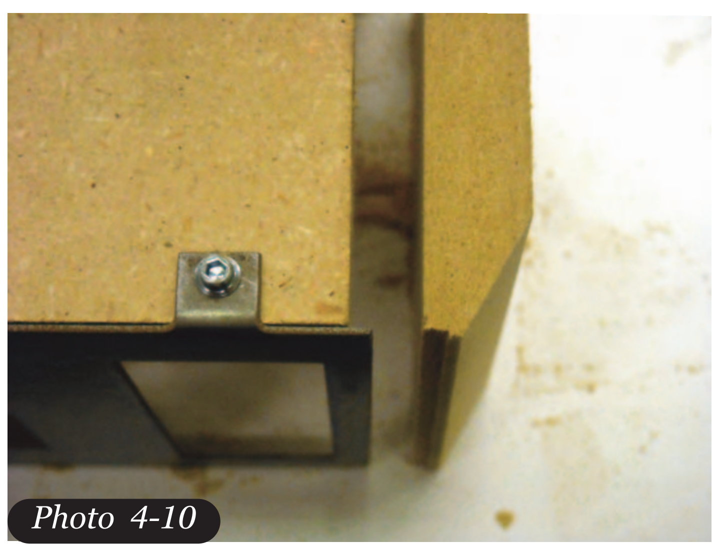


*Photo 4-10*

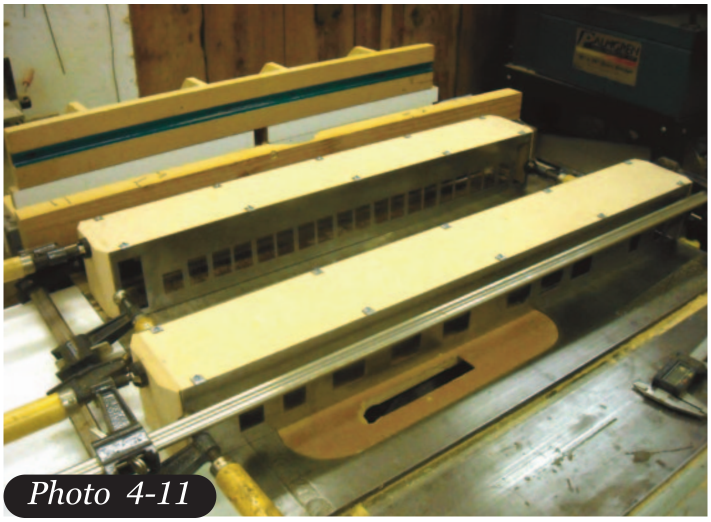


Photo 4-11

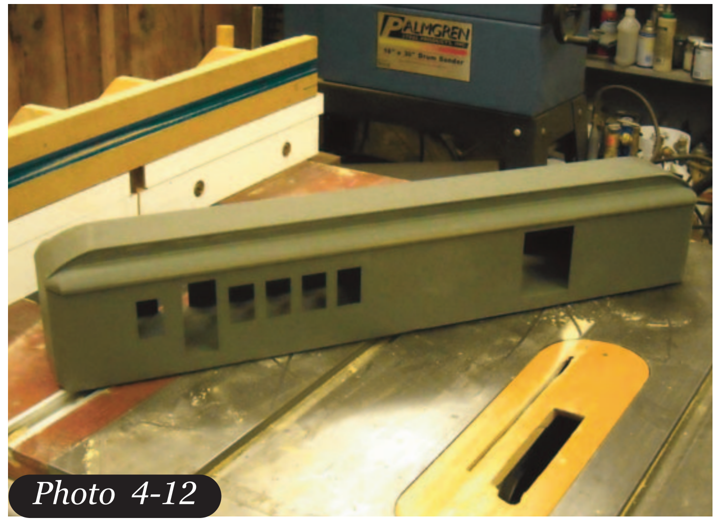


Photo 4-12

As the RPO car is the smallest and simplest, I completed it first to make sure I hadn't overlooked anything. (**Photo 4-12**).

The Lounge car roof had a different shape in that it was curved to the sides in the middle, but transformed into a clerestory at the ends. You can see in **Photo 4-13** where the ends were glued on. Because of the added weight of this roof design, I hollowed out the underside with a bull nose router (**Photo 4-14**).

The observation car floor was drilled out for the railing and the rear bulkhead, which was cut out on the mill, was fitted into a groove in the floor (**Photo 4-15**). The sides and roof are then added (**Photo 4-16**).

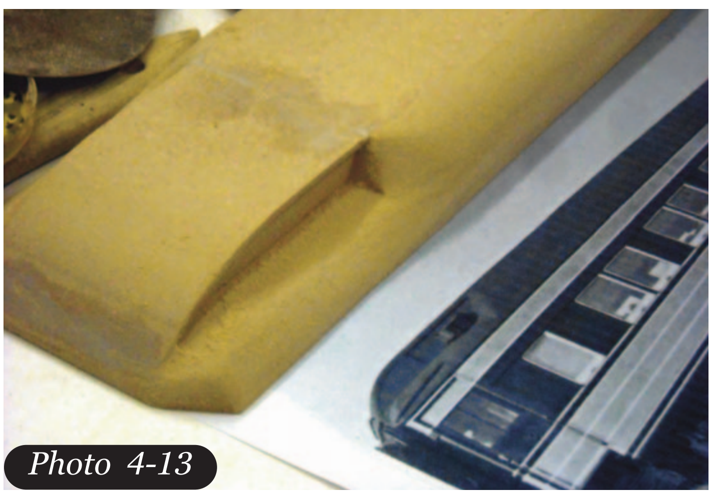


Photo 4-13


Photo 4-14

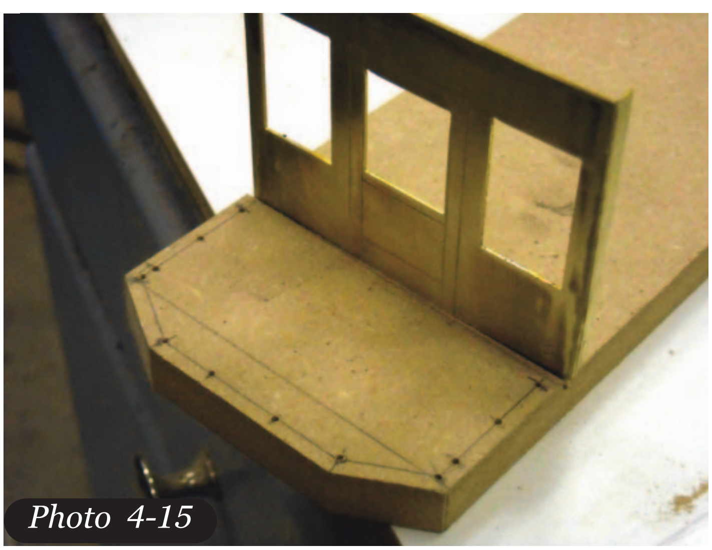


Photo 4-15

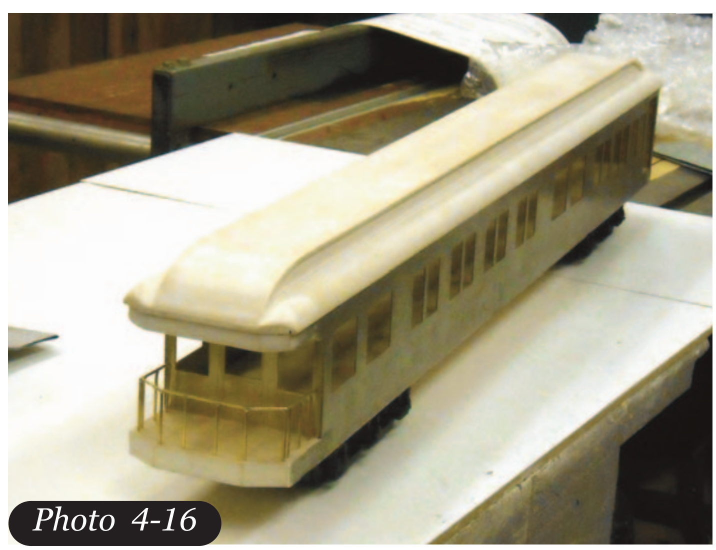


Photo 4-16

Window frames were laser cut and painted (**Photo 4-17**). The RPO got the first set to determine the fit (**Photo 4-18**). The RPO frames are black but the rest of the car frames are grey.

And finally the Observation car gets rear bullet lights made from brass rod turned on the lathe, and lenses also turned on the lathe from red acrylic rod. The lamps are LED's (**Photo 4-19**).

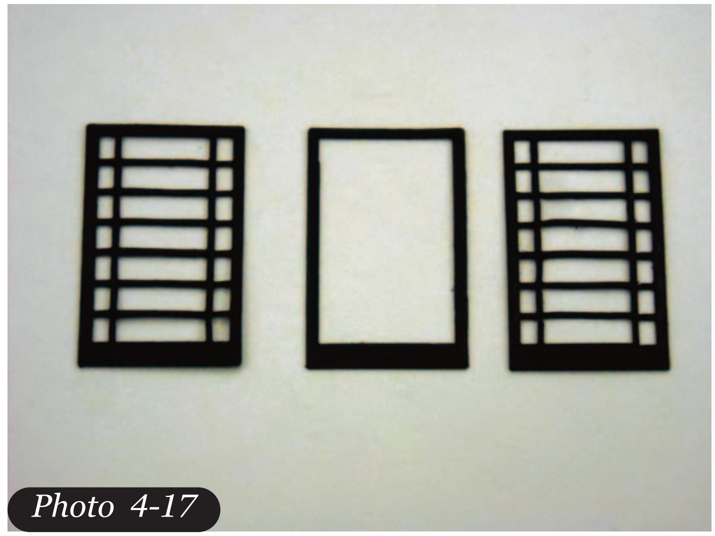


*Photo 4-17*

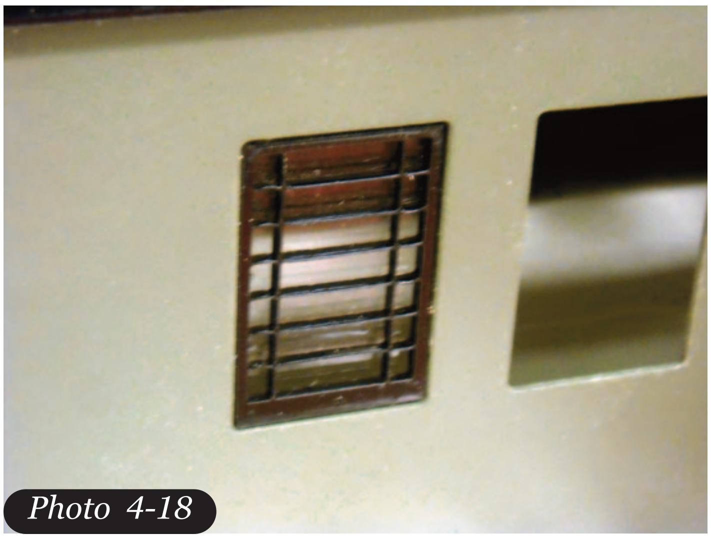


*Photo 4-18*

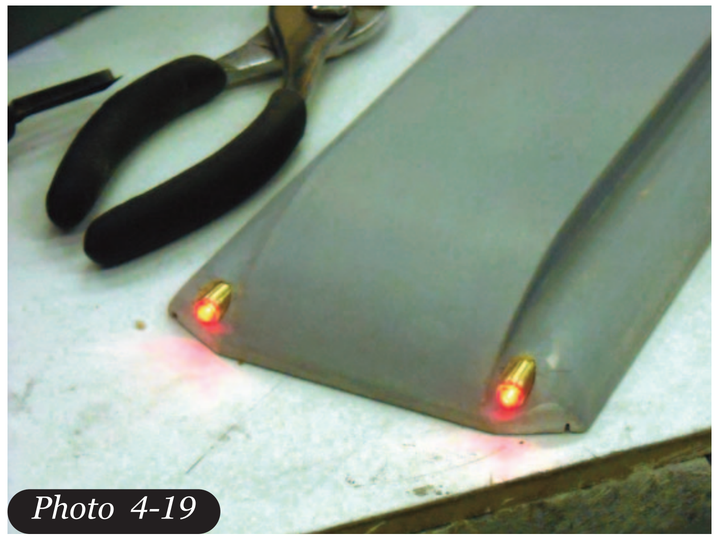


*Photo 4-19*

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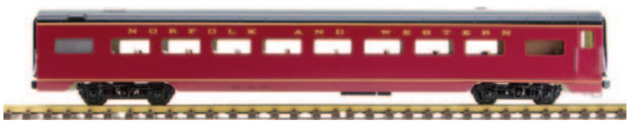
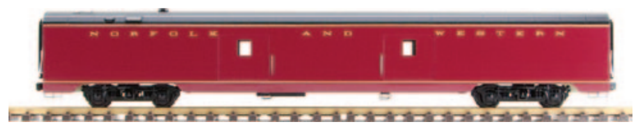
In the next installment we finish the cars with a classic interior and paint.

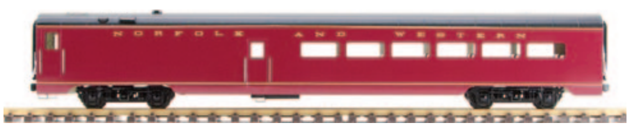
## NORFOLK & WESTERN 4-8-4 J-CLASS #611

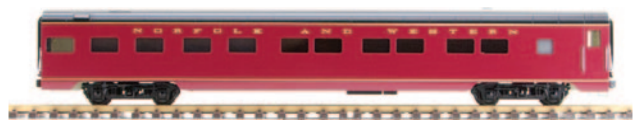

1:32 Scale, 45mm Gauge, Alcohol Fired
$5,950.00 Live Steam, $5,250.00 Electric

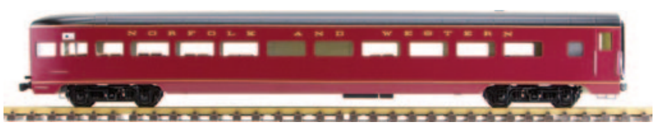
## SMOOTH SIDED MODERN PASSENGER CARS


Coach


Baggage Car


Diner Car


Pullman Sleeper Car


Observation Car

1:32 Scale, 45mm Gauge, Die-Cast Trucks, Metal Body
Available in Unlettered, Southern Pacific, Union Pacific, New York Central, Norfolk & Western, and Canadian Pacific
$340.00 / car, $2,040.00 / 6-car set

## SANDY RIVER & RANGELEY LAKES FORNEY #6 0-4-4

Engineering Sample Shown

1:13.7 (7/8ths) Scale, 45mm Gauge
Butane Ceramic Fired
$3,200.00 each

## 'DOLGOCH' 0-4-0T

Engineering Sample Shown

1:19 Scale, 45mm or 32mm Gauge
Butane Fired
Available in TR Green, Atlas Green, and TR Red
$1,600.00 each

Price is FOB Union City, California. Items subject to change in price, color, specification design and availability without notice.

ACCUCRAFT TRAINS
ELECTRIC & LIVE STEAM MODELS

# SOUTHERN PACIFIC P-8 CLASS 4-6-2


Engineering Sample Shown

1:32 Scale, 45mm Gauge
Alcohol Fired, Butane Ceramic Fired, Electric
Available in #2467 and #2472
$3,995.00 each, Delivery Fall 2019

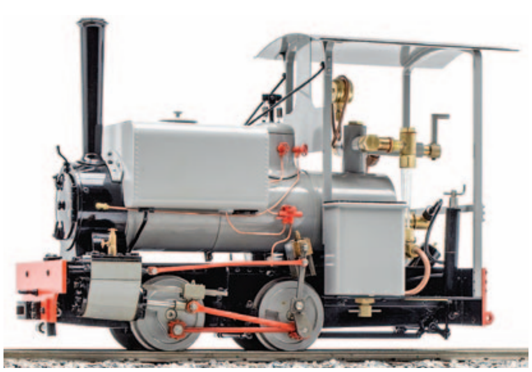
# ASTER BR 5MT 4-6-0

ASTER HOBBY


Engineering Sample Shown

1:32 Scale, 45mm Gauge, Alcohol Fired
Available in Green & Black "Camelot"
$3,500.00/KIT, $4,600.00/RTR

# KERR STUART WREN, LIVE STEAM

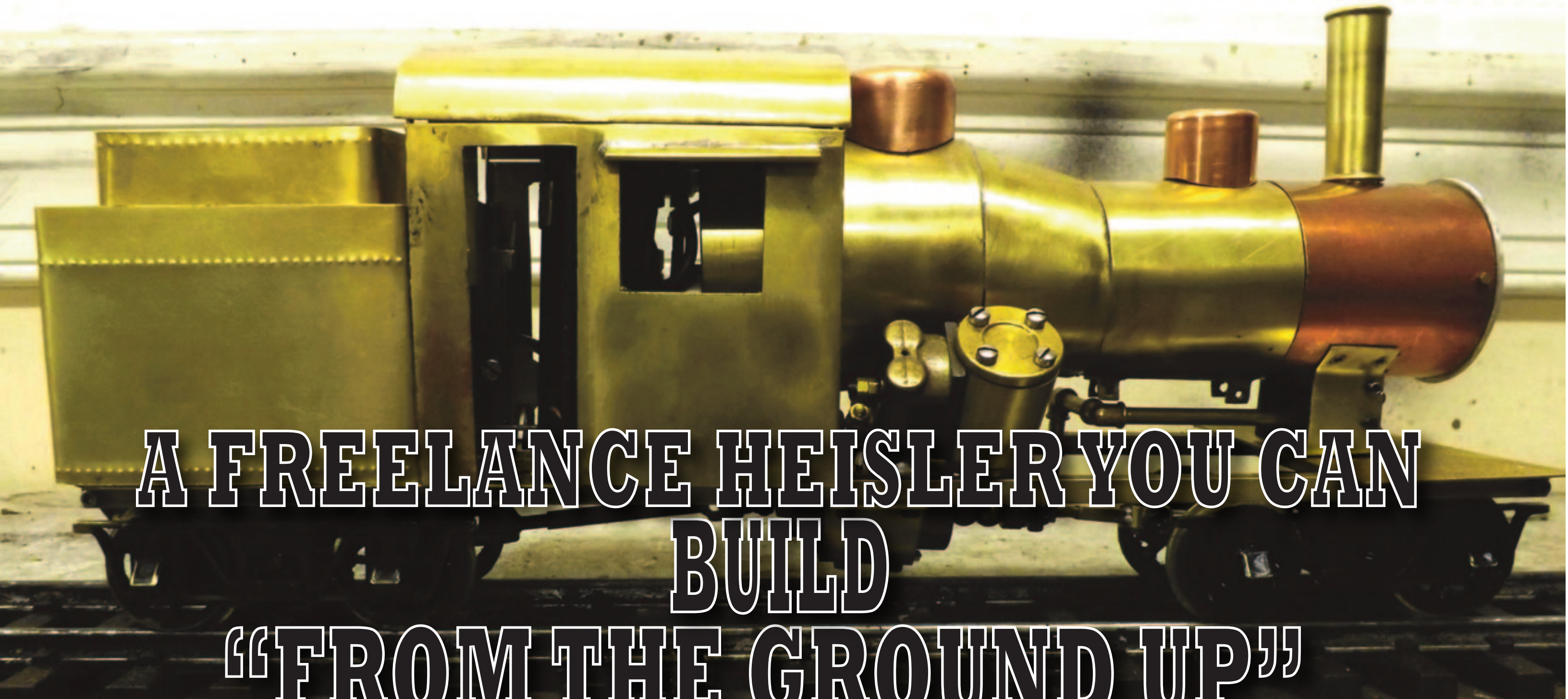


1:13.7 (7/8ths) Scale, 45mm Gauge
Butane Fired, In Stock
Available in Black, Blue, Green, Maroon, Grey
$1,775.00 each

# 3/4" MAXITRAK SENTINEL DG6 LORRY

3/4" Scale, Butane Fired, R/C Included
Available in Dark Blue w/ Red Lining,
Maroon w/ Yellow Lining, Green w/ Yellow Lining
$1,580.00 each

Price is FOB Union City, California. Items subject to change in price, color, specification design and availability without notice.



# A FREELANCE HEISLER YOU CAN BUILD "FROM THE GROUND UP"

# Part Four

Text, Drawings, and Photos
by Les Knoll, P.E.

**SMOKEBOX**

In this segment we will build the smokebox and smokebox base and fit them to the boiler. Just one step away from putting some steam into this little beast and making it go!

Before we start you will need to order the boiler from Roundhouse Engineering, because we will be doing a test fit with the smokebox before the final boiler mounting, which will be discussed in Part Five of this series. You can order Roundhouse components through The Train Department at *http://www.thetraindepartment.com* or phone them at 732-770-9625, or contact Roundhouse direct at
*http://www.roundhouse-eng.com*.

**Freelance Heisler Construction Series**

- Part 1 - Intro, trucks
- Part 1 Addendum - Machine-free trucks
- Part 2 - Building the frame
- Part 3 - Assembling, modifying and mounting the PM Research engine
- ➡ Part 4 - Smokebox
- Part 5 - Plumbing, Boiler modifications and steam testing
- Part 6 - Cab and bunker, misc details and wrap-up

**Ordering the Boiler**

The Roundhouse components used are from their HBK4 boiler kit. This is the same as used for their well-known and loved Lady Anne locomotive. When you order, specify their HBK4 kit *without the smokebox and safety valve*. You will get a manual operation throttle by default, which actually can work just fine for manual or single-channel R/C operations. Roundhouse will supply this kit without their standard smokebox and safety valve at a substantially reduced price, and even switch to whichever throttle, manual or R/C taper, you want. They are the most accommodating live steam merchants I have ever worked with. When I ordered the boiler kit for my West Side Heisler, which is a different one than is used here (It's for their "Billy'), I ordered some wrong parts for my project. When I called them to re-order, they said they would just exchange if I would send the originals back. Great people to work with.

**Where There's Smoke, There Isn't Necessarily Fire**

Smokeboxes most often require silver soldering operations to build them. This is because this is the hottest part of the locomotive and reaches temperatures that would melt common soft solders. Exhaust gasses vent directly from the gas burner into this area and there is no water jacket there to cool the area down as there is in the boiler itself. The smokebox on this Heisler locomotive consists entirely of bent and bolted parts, but looks pretty much the same as if it had been silver soldered together. You can build the entire smokebox without even getting warm! The only need for high temperature solder is for adding a number plate, and even this can be the 430-degree metalworking solder found at big box home improvement stores. The smokebox and base are two separate assemblies, bolted together when fitted up along with the boiler. This construction method has the added advantage that the base and smokebox proper can be disassembled from each other. This will come in handy in painting if you want a graphited smokebox with the base in another color. All assembly methods are prototype tested on three locomotives, one being my personal Heisler, and no parts have fallen off yet.

After having the smokebox tubing professionally cut, the Heisler smokebox was built entirely on the workbench with a moderate sized vise, a drill press, a rotary tool and a bench grinder to touch things up.

To lay out the smokebox base SB-1 (**Drawing 4-1**), the pattern is first laid out and cut to size. This can either be done by hand from the drawings, or better yet, transfer the full size pattern from the magazine to a piece of label paper such as Avery 15265 using a copier, similar to what was done to get the pattern for the cylinder gaskets. The label is then pasted onto a sheet of brass, using it as a guide to cut out the pattern (**Photo 4-1**). The bend lines on the pattern can are used as an aid in bending. There are also centers shown for all holes so they can be laid out with a center punch or center drill (**Photo 4-2**).

Note that in the pattern, there are four extended cuts that extend into the piece beyond where the bend lines stop. These are important because when bent, the bottom tabs and smokebox side mounting tabs must be flush with their adjacent sides after bending. The cut made into the adjoining surface is approximately equal to the thickness of the material plus a bending allowance. The outline of the pattern can be cut using a shears, but for the internal detail, it is best to use a rotary tool with a thin cutoff wheel. Do not try to go all the way through the metal in one cut, especially on the radius cut. Take successive cuts, maybe three or four, along the same cut line. The extended cuts, vital to bending the piece correctly, are easily made with the rotary tool.

All the holes in this part can be put in "in the flat" before bending. The only critical relationship is the 1.50-inch spacing between the two holes in the lower tabs. Since this is a "C" shaped piece, some adjustment can be made after bending to match the corresponding 1.50-inch mounting hole spacing in the mainframe front plate MF-8. The holes in the upper tabs, which are used to mount to the smokebox, have their locations transferred

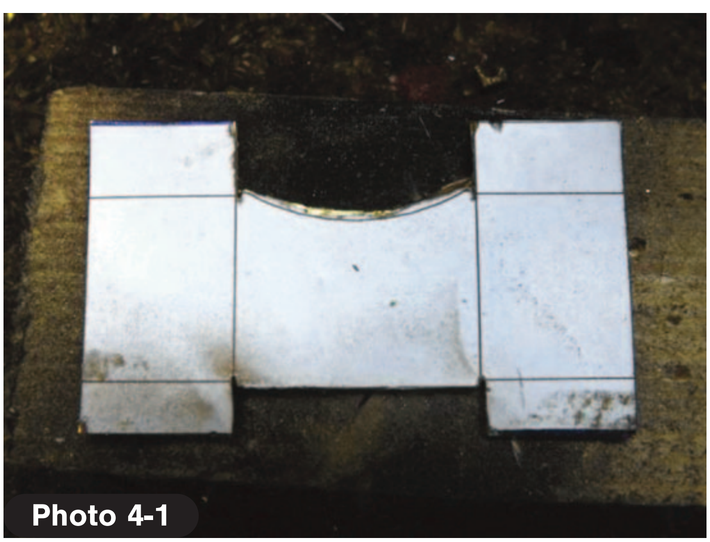


Photo 4-1

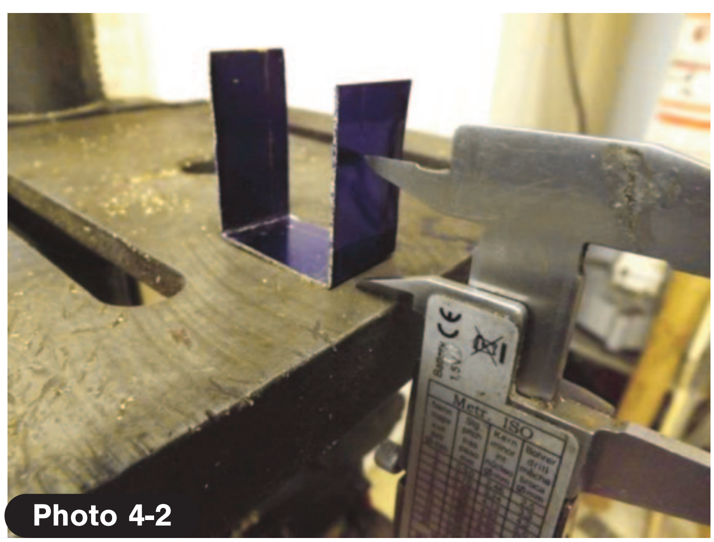


Photo 4-2

to the smokebox tube when the base is attached to the tube by drilling through the holes in the smokebox base tabs into the tube. When you first drill these four holes in the base, drill them only #50 (0.070-inch diameter). You will use these as locator holes later in the smokebox assembly. (**Photo 4-3**).

The smokebox itself is a straightforward assembly. The first part to be made is the smoke box tube (**Drawing 4-2**), which is Type "M" copper tubing saw cut 2.00 inches long. Only use Type "M" as it has the correct ID to fit the Roundhouse boiler. If you have no facility to cut this tube accurately, a local machine shop or metal supplier can do it for you. You might even be able to talk a plumber with a pipe cutter into doing it. Make sure to deburr both ends of the tube. You want as accurate a 2.00 inch length as possible because the smokebox wrapper, used to simulate rivets and other details, is made from a commercially available 0.016-inch x 2.00-inch strip, saving some cutting and insuring accurate edges. Some discrepancy can be made up by the installation of boiler bands later in the project.

The cross piece at the front of the smokebox (**Photo 4-4**), is a brass square which must fit the inside of the smokebox tube somewhat tightly. It is a good idea to cut this square oversize and use a grinder to bring the size down to fit, gently rounding both ends as you do. You can tap the 2-56 holes in the square ahead of time, but after the fitup with the grinder, put a slight 82 degree countersink in the holes and "chase" the threads again with a 2-56 tap. Two screws attach the cross piece at the 3:00 and 9:00 position. (The stack is assumed to be at the 12:00 position.) The holes for these screws will be drilled using holes in the smokebox wrapper as a guide. There will eventually be a center hole in the cross piece to mount the smokebox front. This will be located using the smokebox front itself as a guide.

A 0.016-inch x 2.00-inches strip is used as the smokebox wrapper (**Drawing 4-3**). It comes exactly 2.00-inches wide, so it is important your smokebox tube length matches it. This wrapper is embossed with "rivets" using the template provided in the drawings, and various mounting holes are drilled in it. Lay the brass strip on a piece of wood and, using the template copied from the drawings onto a sticky label (Avery 15265), "punch" in each individual rivet with an automatic spring loaded center punch. The desired rivet pattern will be on the opposite side. Determine the correct impact setting of your punch with a test piece of 0.016-inch brass for best rivet depth. A pilot hole is drilled for the smoke stack while the wrapper is still in the flat. When the wrapper is installed on the smokebox tube, the hole for the stack will be step drilled to within 1/16-inch of the required size, then opened up with a rotary tool and milling bit.

Bend the wrapper around the 2 1/8-inches outside diameter smokebox tube and transfer the four wrapper mounting hole locations from the wrapper to the tube and tap them 2-56. Now open up the holes in the wrapper to #41 (0.096-inch) and attach the wrapper to the tube with 2-56 hex bolts. Trim the excess bolt length inside the smoke box as some the rear bolts could interfere with the insertion of the boiler if not trimmed flush. The two boiler front crosspiece mounting holes can now be drilled through the smokebox tube using the existing holes in the wrapper as a guide. The cross piece is mounted with two 2-56 hex bolts.

**Photo 4-3**

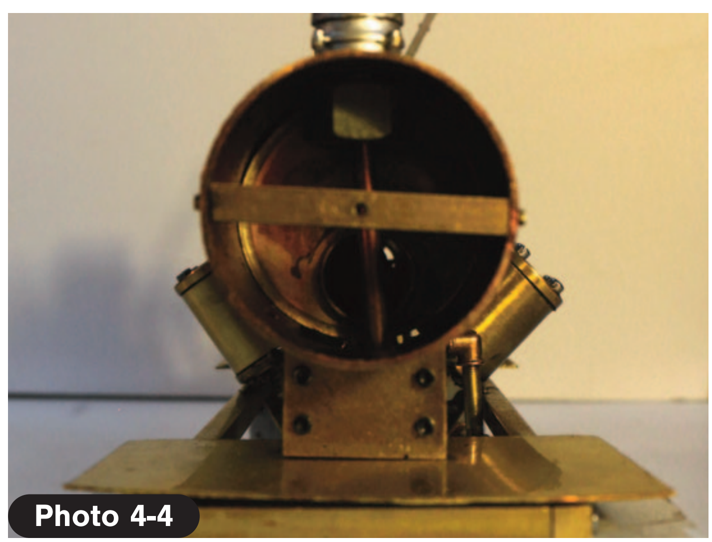


**Photo 4-4**

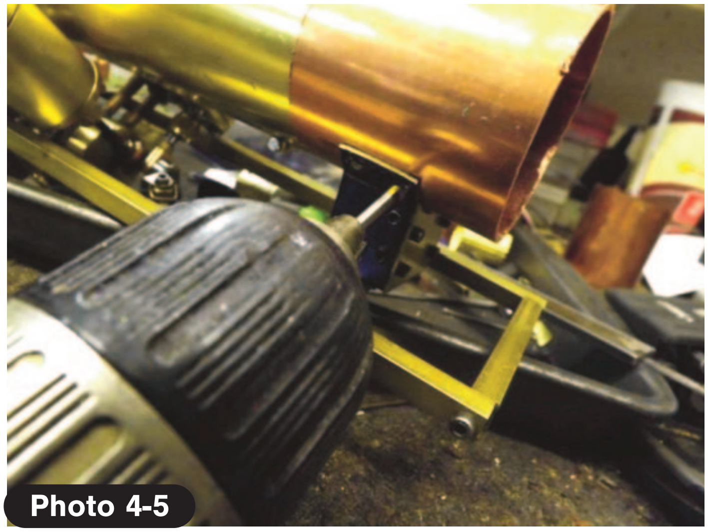


Photo 4-5

With the stack pilot holes in the wrapper and tube as a guide, step drill the smokebox hole at the top for the stack (**Drawing 4-4**). Start with 3/16-inches, then ¼-inches and eventually work up to 7/16-inches. The Trackside Details stack is intended for a ½-inches diameter hole, and the final enlargement is done with a rotary tool and milling cutter. The intent here is to try to obtain a "size-on-size" or slight interference fit so the stack is pressed into the smokebox. Before pressing the stack in, apply some JB Weld to the mounting surface. Use the long curing type, not the JB Quick. This stack is in here for keeps and will see some high temperatures, but JB Weld is up to the task. A number of my locomotives including my own Heisler project bear this out. When the stack is on place, wipe off the excess JB Weld so as to form a transition between smokebox and stack. Apply a generous amount on the inside between the end of the stack and the inner surface of the smokebox.

### Test Fitting the Boiler

Mount the smokebox base onto the mainframe with two 2-56 brass hex bolts. Insert the boiler with wrapper attached into the smokebox tube so that the wrapper contacts the tube, then mount the boiler at the rear using the boiler mount supplied by Roundhouse and the spacer MF-22 (hope you saved that from building the mainframe). Note that the mounting screw that came with the boiler is too short for this mounting application, the boiler sits up high in order to clear the Heisler engine. A longer 4-40 cap screw, BL-13, must be used, and the mounting hole in the boiler mount re-tapped 4-40 UNC to match.

With the boiler mounted front and rear, determine the exact position of the smokebox in relation to its base. With boiler and smokebox in position, the smokestack EXACTLY in the 12:00 position, and the bottom smokebox cutout to the REAR of the locomotive, transfer the four mounting hole locations in the smokebox base to the smokebox by drilling #50 (0.070-inch) holes through the base and smokebox (**Photo 4-5**). Remove the boiler, smokebox and base, tap the holes in the smokebox 2-56 and enlarge the holes in the base to #41 (0.096-inch). Mount the smokebox to the base using 2-56 hex bolts. Mount the smokebox and base back on the mainframe. Leave the boiler off of the assembly for now, it would just get in the way of the plumbing we'll be doing later in Part Five.

### Making the Smokebox Front

The smokebox front is made from a piece of copper sheet that first has its center punched, then the outside diameter scribed. I would HIGHLY recommend getting this part waterjet cut by Denver Waterjet, but it can be made by hand if need be. Cuts are made by various methods: saw, rotary tool cutoff wheel or other means, until a close approximation to a circle is obtained. First make four tangent cuts at 90 degrees close to the circular outline which gives a square, then split this, cutting at each of the four corners, creating an eight-sided shape approximating a circle. If you want you can split it again, creating a 16-sided shape.

At this point, the finishing can be done by grinding the edges to a circular shape by holding the part to the grinder and carefully guiding it until a circular shape is obtained. An alternative method is to solder a tube to the side of the plate that will be inside the smokebox, using the center punched hole as a guide. Before attaching, you will want to scribe the diameter of the tube into the part as a guide before you start soldering. The tube need only be a couple inches long, but should be square with the plate. Make sure the soldering job is extremely secure.

Chuck the tube with plate attached into a drill press and as the plate rotates, smooth the outer edge with a file or a rotary tool with a milling cutter. Take your time here, you don't want the tube joint to break off. I have made several of these for locomotives using both drill presses and lathes (same procedure with the lathe, except I used a cutting tool on the lathe, not a file or rotary tool) and have never broken off a tube. Just take it easy, don't lean into it.

Unsolder the tube from the front plate and grind off as much solder as possible. A sander could possibly take even more off after the grinder is through. Drill a #50 (0.070-inch) hole through the front plate. Sound like too much work? Call Denver Waterjet. They can make this part for you for around $10-$20.

Center the front plate on the front of the smokebox and transfer the location of the center hole in the front plate to the cross piece on the smokebox by starting a #50 (0.070-inch) hole into the cross piece, using the hole in the front plate as a guide. Remove the plate and finish drilling the hole and tapping it 2-56.

Detail the front plate using the Trackside Details boiler front and 0-80 hex heads as shown in the drawings (**Photos 4-6 & 4-7**). The front plate SB-3 will require drilling two holes in it to match the brass 'pins' that mount the hinges of the smokebox front casting SB-4. Since these are cast, their diameter and exact location can vary. Drill holes in the smokebox front plate to match these, trying to be size-on-size or the smallest bit undersized, so that the pins must be pressed into the smokebox front plate to securely mount the smokebox front brass detail. The center screw will hold everything in place anyway, but it would be nice not to have the smokebox front assembly fall apart every time it is removed.

Insert a brass 2-56 hex head screw through the Trackside Details boiler front and front plate and screw it into the cross piece at the front of the smokebox. If you wish to add a brass number plate to the front, this can be soldered to the 2-56 screw with high temperature solder such as the acid core metal working solder from Bernz-O-Matic, available at big box home improvement or hardware stores. I use a conventional flux with this solder when working with brass parts. This, like using JB Weld for the stack, is a somewhat unorthodox method of attaching parts in high heat areas as it digresses from the traditional silver solder, but both methods have been proven in running prototypes, although I admit I have not run boilers dry with parts attached this way. If you do that, you tempt fate anyway.

**Photo 4-6**

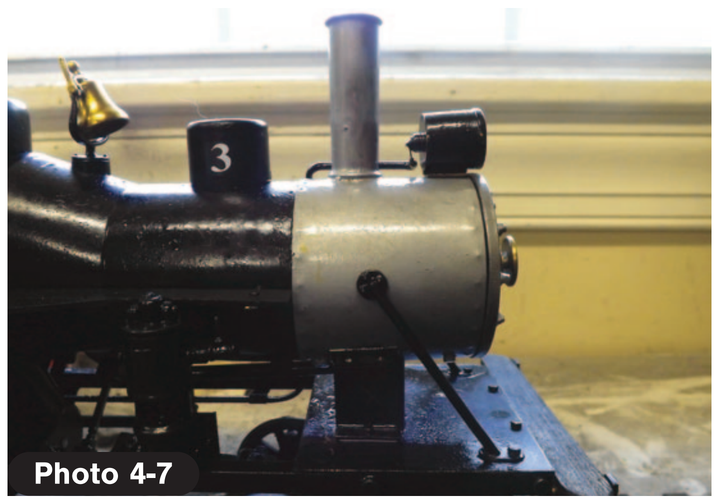
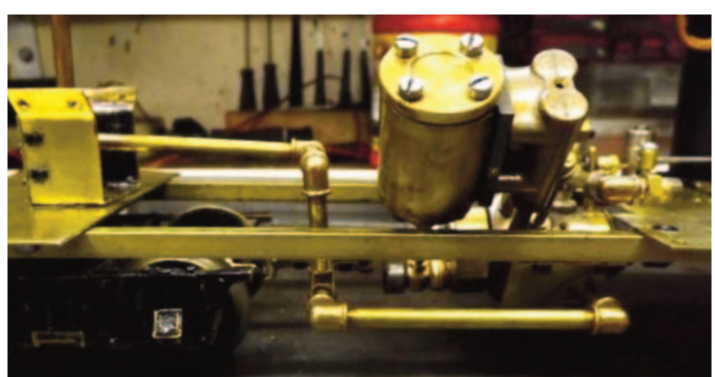



**Photo 4-7**

*Top: Front of the smokebox with the Trackside Details casting in place.*

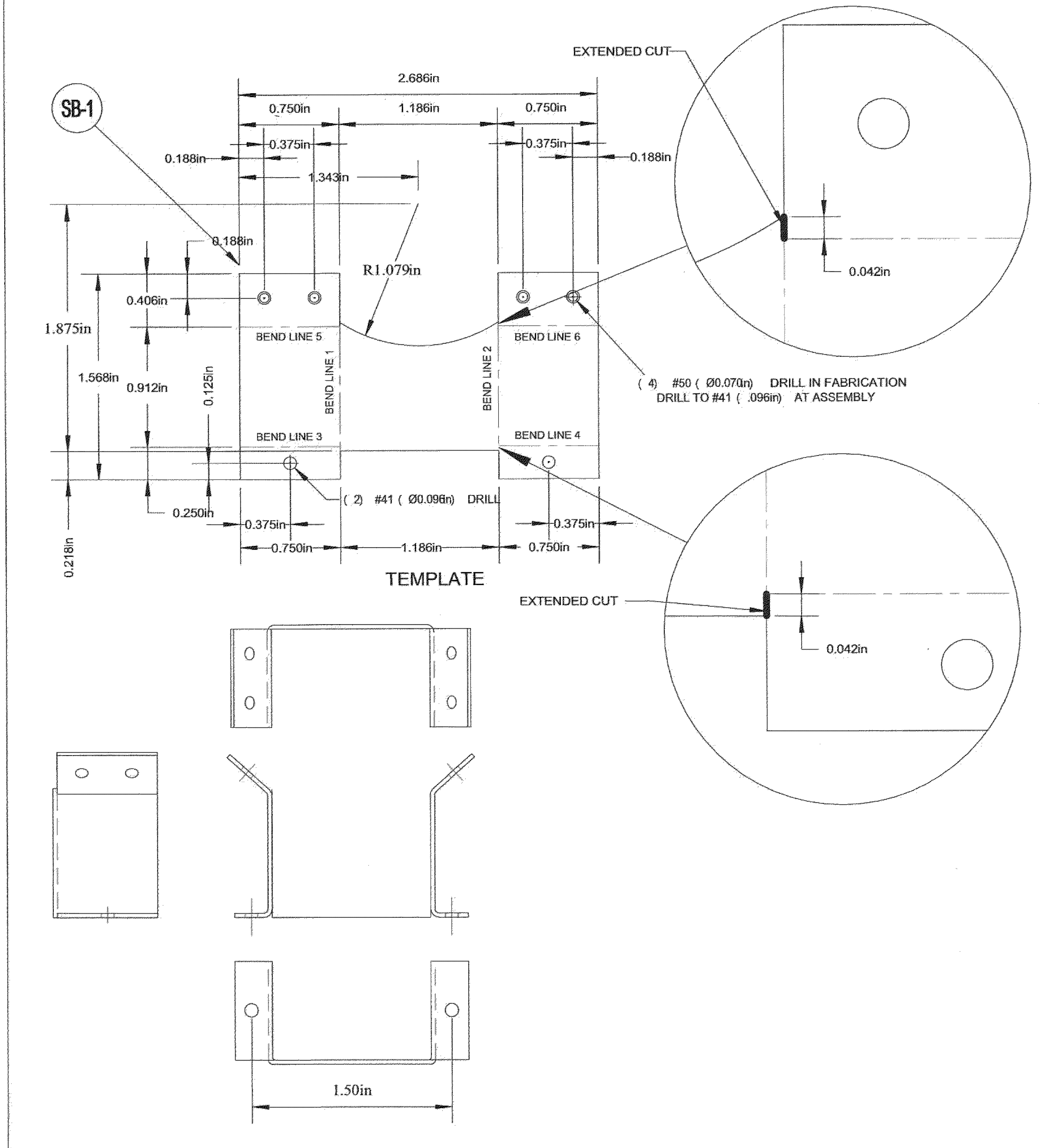
*Middle: Side view of the finished smokebox.*

Next, we'll tackle the underlying plumbing for the steam inlet and exhaust lines and get the boiler mounted in Part Five.



## SMOKEBOX DETAILS PAGE 1

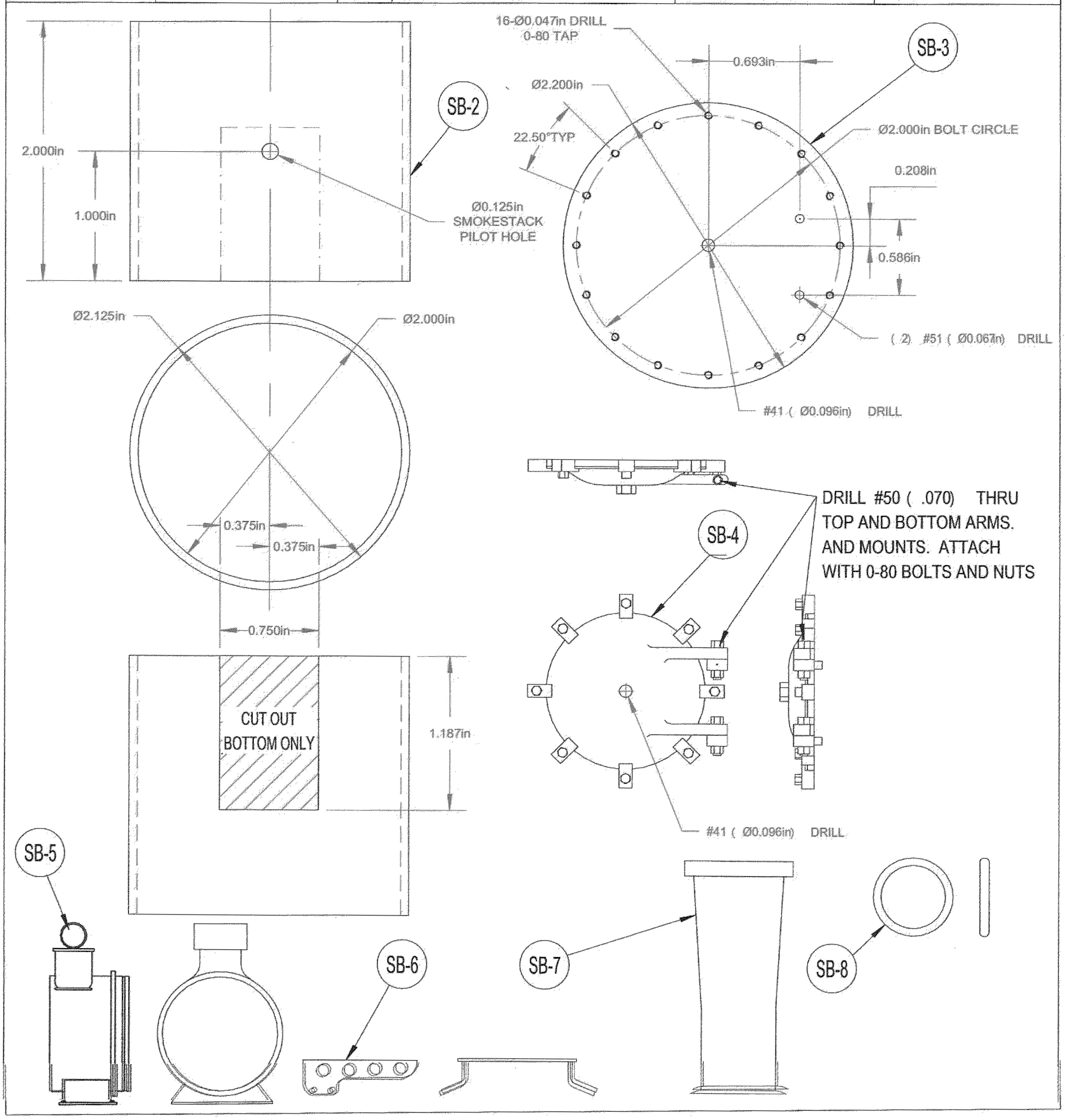
| PART NUMBER | REQUIRED | DESCRIPTION | VENDOR | VENDOR PART # |
|---|---|---|---|---|
| SB-1 | 1 | STRIP, BRASS, .032" x 2.00" | K & S | 8244 |




**Drawing 4-1**

## SMOKEBOX DETAILS PAGE 2

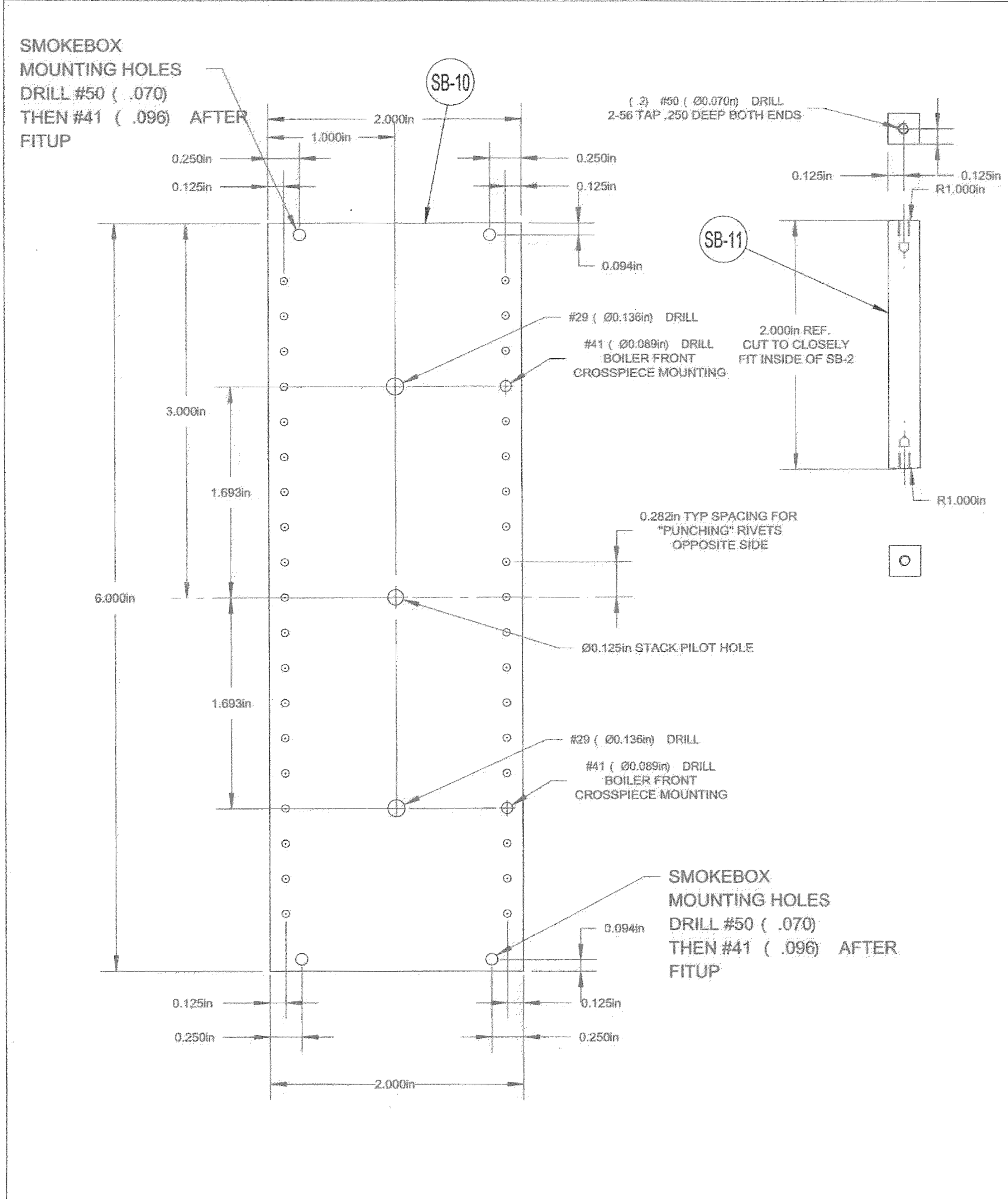
| PART NUMBER | REQUIRED | DESCRIPTION | VENDOR | VENDOR PART # |
|---|---|---|---|---|
| SB-2 | 1 | TUBE, COPPER, TYPE "M" 2.00" NOM. DIA. x 2.00" LG. | McMASTER CARR | 5175K139 ( 2 FT.) |
| SB-3 | 1 | SHEET, COPPER, .093" | McMASTER CARR | 8963K704 |
| SB-4 | 1 | SMOKEBOX FRONT | TRACKSIDE DETAILS | TD-185 |
| SB-5 | 1 | HEADLIGHT | TRACKSIDE DETAILS | TD-13 |
| SB-6 | 1 | HEADLIGHT BRACKET | TRACKSIDE DETAILS | TD-106 |
| SB-7 | 1 | STACK | TRACKSIDE DETAILS | TD-160 |
| SB-8 | 1 | NUMBER PLATE, 15.9 mm | TRACKSIDE DETAILS | TD-139 |
| SB-9 | 7 | SCREW, HEX HEAD 2-56 x .75 | MICRO FASTENERS | HBB0212 |



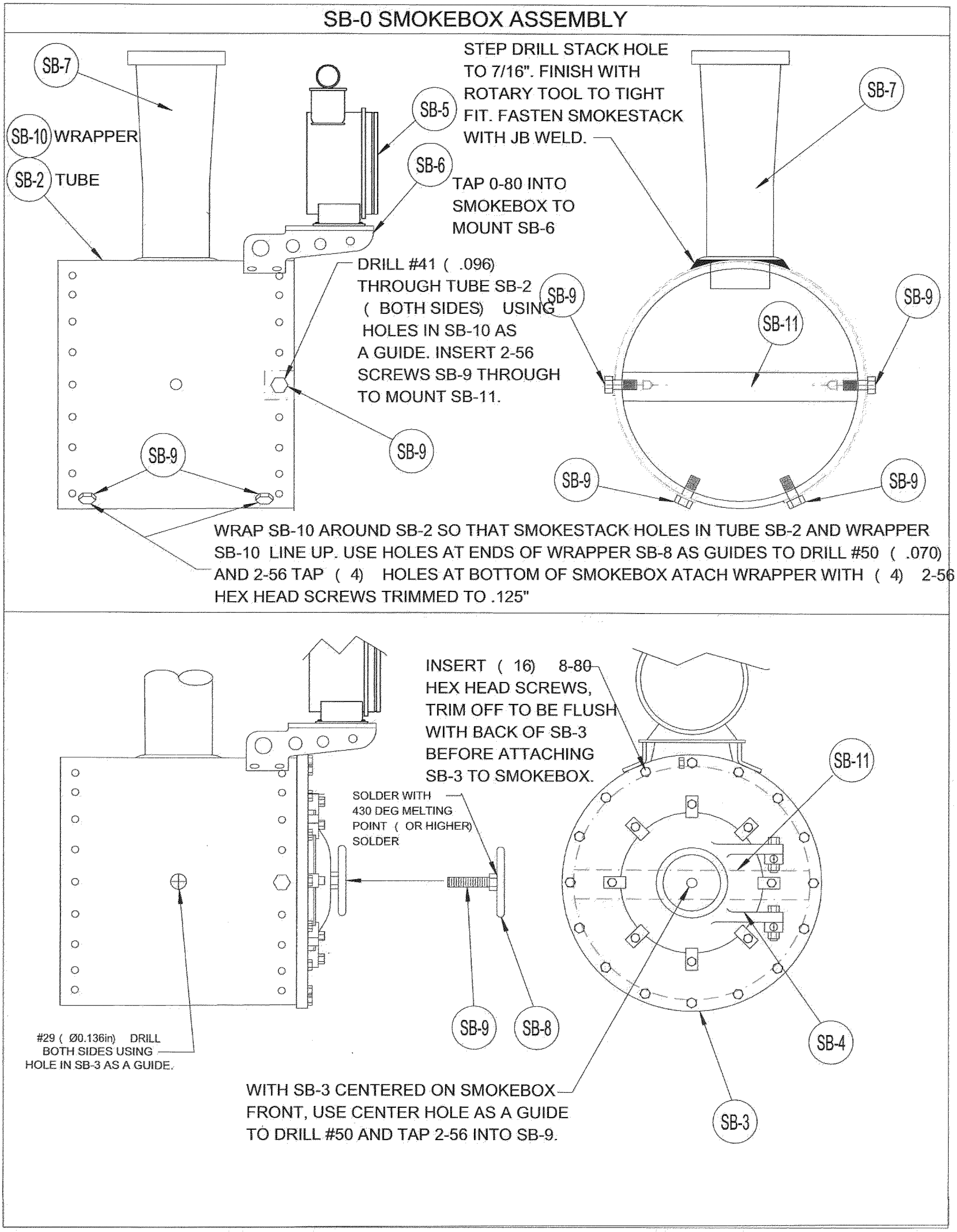

**Drawing 4-2**

## SMOKEBOX DETAILS PAGE 3

| PART NUMBER | REQUIRED | DESCRIPTION | VENDOR | VENDOR PART # |
|---|---|---|---|---|
| SB-10 | 1 | STRIP, BRASS, .016 x 2.00 | K& S | 8234 |
| SB-11 | 1 | 360 BRASS BAR, 1/4" x 1/4" | McMASTER CARR | 8954K13 |




**Drawing 4-3**


SB-0 SMOKEBOX ASSEMBLY
SB-7
SB-10 WRAPPER
SB-2 TUBE
SB-5
SB-6
STEP DRILL STACK HOLE TO 7/16". FINISH WITH ROTARY TOOL TO TIGHT FIT. FASTEN SMOKESTACK WITH JB WELD.
TAP 0-80 INTO SMOKEBOX TO MOUNT SB-6
DRILL #41 ( .096) THROUGH TUBE SB-2 ( BOTH SIDES) USING HOLES IN SB-10 AS A GUIDE. INSERT 2-56 SCREWS SB-9 THROUGH TO MOUNT SB-11.
SB-9
SB-11
WRAP SB-10 AROUND SB-2 SO THAT SMOKESTACK HOLES IN TUBE SB-2 AND WRAPPER SB-10 LINE UP. USE HOLES AT ENDS OF WRAPPER SB-8 AS GUIDES TO DRILL #50 ( .070) AND 2-56 TAP ( 4) HOLES AT BOTTOM OF SMOKEBOX ATACH WRAPPER WITH ( 4) 2-56 HEX HEAD SCREWS TRIMMED TO .125"
INSERT ( 16) 8-80 HEX HEAD SCREWS, TRIM OFF TO BE FLUSH WITH BACK OF SB-3 BEFORE ATTACHING SB-3 TO SMOKEBOX.
SOLDER WITH 430 DEG MELTING POINT ( OR HIGHER) SOLDER
#29 ( Ø0.136in) DRILL BOTH SIDES USING HOLE IN SB-3 AS A GUIDE.
SB-8
SB-4
SB-3
WITH SB-3 CENTERED ON SMOKEBOX FRONT, USE CENTER HOLE AS A GUIDE TO DRILL #50 AND TAP 2-56 INTO SB-9.

**Drawing 4-4**

# Scale Back Heads in small-scale live steam

## Part 1 - Inspiration and First Attempts

Text and Photos by Chris Tolhurst and Derek Pollard

*Steam in the Garden Issue No. 159 (Jan/Feb 2019)* included a special pictorial entitled "Authentic and Functional Back Heads." This featured some of the models with scale working cabs we have built in recent years. In the conclusion of the pictorial we promised further articles to go into more detail about the design principles behind these models. In this first part we will describe both our inspiration to start producing this level of detail and our first attempts, which taught us what worked and what did not.

### The Aster Pannier

Since the 1990s both of us have been committed to 1/32 Gauge One. By that time finescale models with detailed cabs had appeared in electrically powered models, but never in live steam. It was always our intention to start by taking a 1/32 commercial live steam model and rebuild it with a working, detailed, prototypical cab, before tackling the far more challenging prospect of a scratch built loco to that standard.

Examining production Gauge One models, it's soon apparent that some are easier than others to convert to a scale cab than others. Sometimes, by pure coincidence, the blower and regulator on the live steam model just happen to be more or less in the same position as the full size prototype. This applied to the first model to be worked on by either of us; Chris's Aster Pannier tank (**Photo 1**). In this case it was merely a question of replacing the non-scale levers on the blower and regulator, and fabricating a dummy backhead with scale fittings and gauges. There is no doubt that the cab interior looks much better than the original Aster cab, but the shortcomings of this approach are very apparent:

- With the dummy backhead added, the boiler intrudes into the cab too much
- The pressure gauge is way, way out of scale.
- There is a limit to how many controls can be

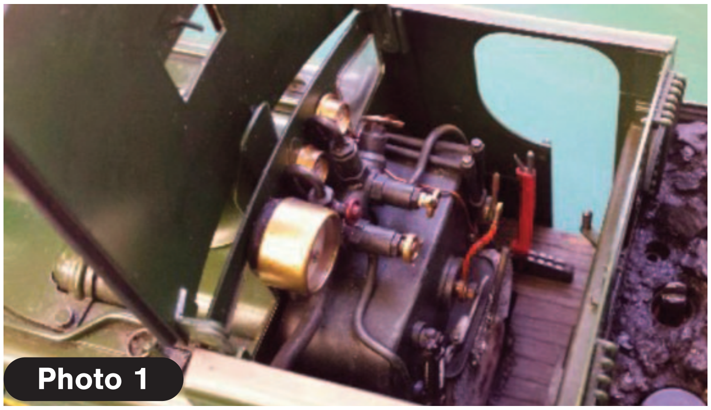


**Photo 1**

*An Aster Pannier Tank with a first attempt at a detailed backhead.*

implemented. The pannier was a simple model with no axle pump, so it used only two running controls which stick through the dummy back head.
- The water gauge (not visible in the picture) has been hidden on the left hand side of the boiler and is therefore difficult to read when running.

These four issues really are the main ones that have to be addressed if a completely scale working back head is required. Each prototype needs to be considered individually but in anything but the simplest back head (like the Aster Pannier) working valves need to be hidden in the cab or disguised as one of the controls on the full-size loco

### Boiler
Boilers in commercial models tend to intrude too far into the cab even without any cosmetic additions. The designers typically go for the biggest capacity possible to achieve a good run time and are not concerned about what the inside of the cab looks like. So it takes up more cab space than it should. There really is no other option here but to build a new, shorter boiler or shorten the original!

### Pressure gauge
Under normal circumstances an experienced driver knows what the boiler pressure is by judging a models performance, and interpreting the behavior of the safety valve(s). The most critical pressure level in an alcohol burner is that at which transfer from steam raising blower to internal blower is required, so viewing the gauge is only necessary intermittently. Hiding the pressure gauge in the cab is not difficult — it's just a question of repositioning it. For instance, it can be located:
- Under the cab floor with a sliding floor panel
- Behind an opening firebox door (**Photo 2**)
- In a cab crew locker or toolbox (which opens to reveal the gauge)

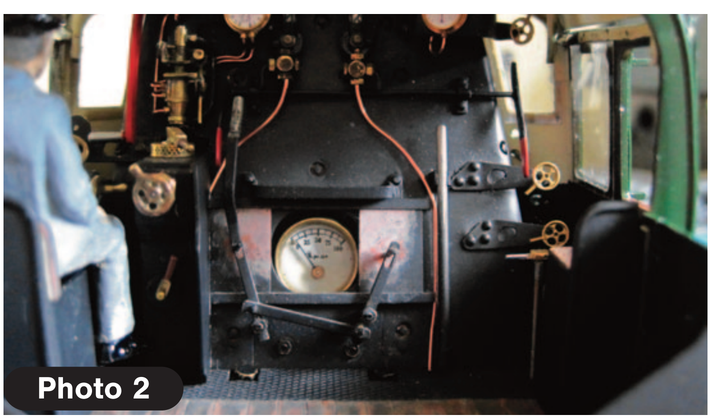


Photo 2

### Water gauge
Hiding a conventional water gauge is not really possible; making it inconspicuous makes it nigh on impossible to read when running the model.

Although it wasn't possible to use this on our first joint model (the Britannia), the ultimate solution is to use electronic water level detectors. These have become readily available in the last few years and are easy to install, particularly if building a new boiler. Our preference is for a two probe system, indicating "overfull" and "getting low". The problem with using LEDs is how to hide the unprototypical LED glow. The simplest solution is to put them with the pressure gauge in a location which can be covered up. Additionally we decided to use logic in the water level indications, such that nothing is lit when the boiler level is OK (hopefully most of the time). A red LED means that water level is low and a green indicates a boiler which is getting too full and may prime.

## Building the Accucraft (G1MRC) Britannia
The G1MRC Britannias produced by Accucraft in 2009 were an acceptable external likeness of the real thing although with significant inaccuracies. For us, the most glaring issue was the cab which was filled with the oversize boiler, chunky valves


Photo 3

Britannia - Builders Drawing

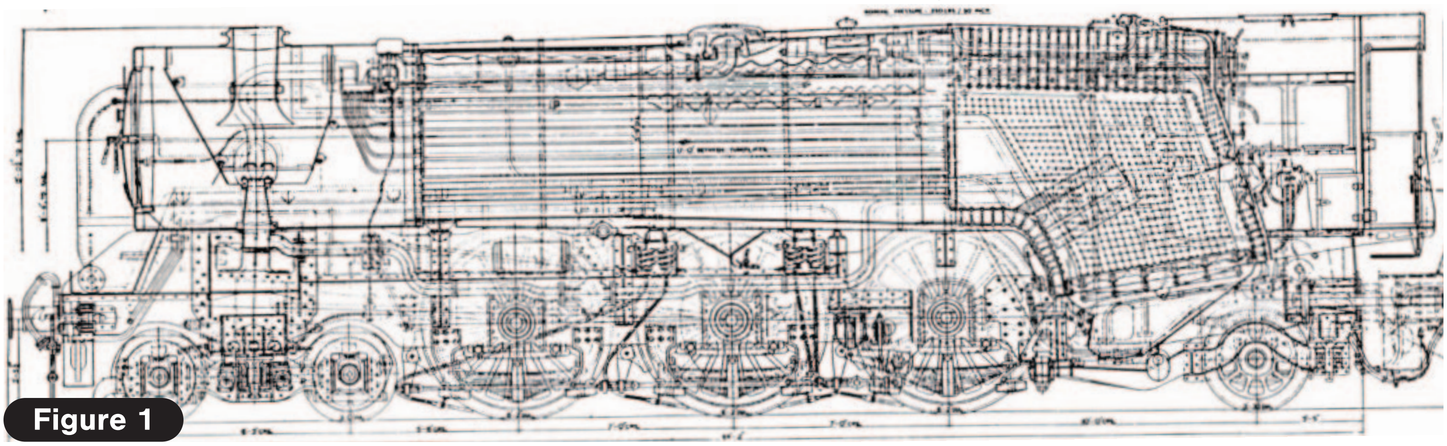


Figure 1

with chunky levers and lubricator reservoir (**Photo 3**). However they steamed superbly, ran well and were extremely powerful. This made them an ideal contender for a makeover. The work done on the exterior is not the subject of this article; suffice it to say that although we only used the frames, cylinders and platework of the original model, we were very pleased with the final result. The cab required the implementation of the four principles already described.

So where to start? First, buy two locos, one each, and take them to bits! Once builders drawings (**Figure 1**) were obtained we scaled them to exactly 1/32 scale, which enabled us to determine the dimensions of a new boiler and new valves, specifically to end up with the dummy back head in exactly the right place. At the same time we designed the cab layout which would allow for the following controls (**Figure 2**):

- Blower
- Regulator
- Axle pump by-pass
- Cylinder lubricator boost
- Water gauge drain

Each control was to be a fabricated miniature valve and disguised as one of the full-size cab controls. These valves were to be located either between dummy back head and boiler or in the driver's pedestal (which in the full size protects the driver from the heat of the fire). The complex steamways needed to achieve this were designed using CAD.

Britannia Back Head Working Valves and Steamways

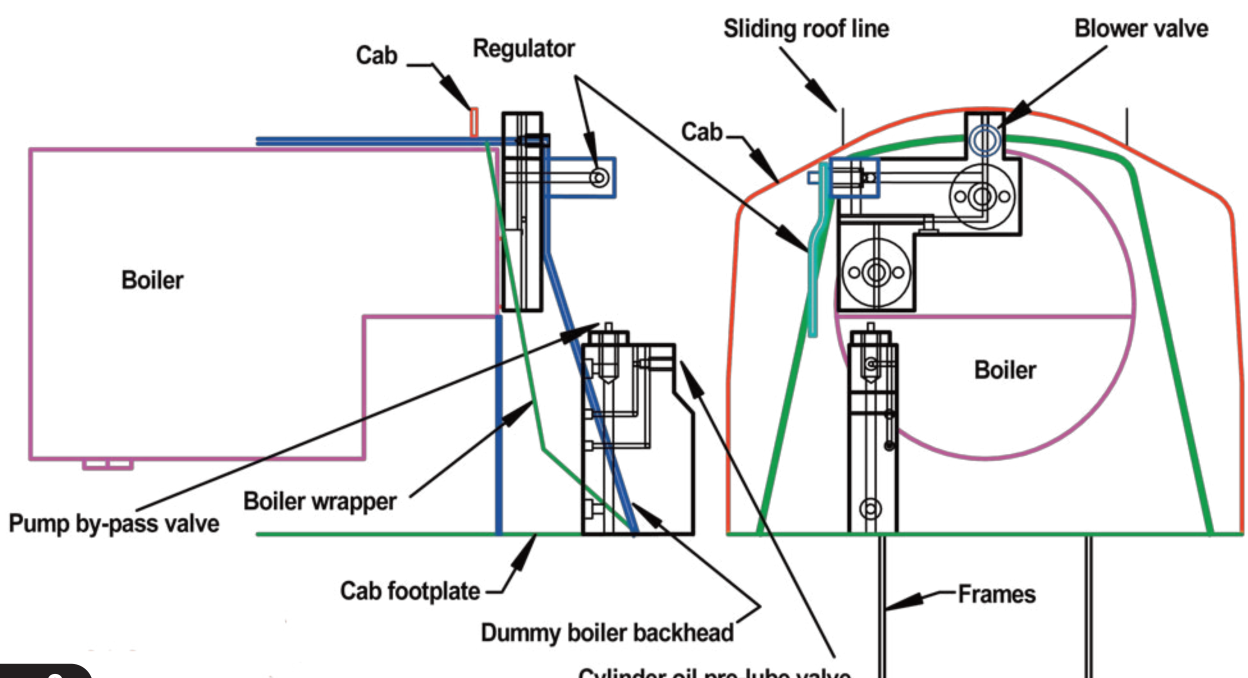



Figure 2

## Inspiration

Small-scale, museum quality models, correct in every detail, have been around for over a century (in museums)! But in general these have been static models which will never haul a scale train in earnest or see the outside of a glass case!

It was not really until the last quarter of the 20th Century that highly detailed working live-steam models with scale cabs became a reality.

In the early 1980's the authors were both active in 1/12 scale 5" gauge, (one of us as a professional engineer, the other as an enthusiastic amateur). A model engineer called Doug Hewson was something of a British 5" gauge guru and wrote in the UK's Model Engineer magazine on a regular basis. He advocated extreme accuracy and detail in all his designs including completely scale, working cabs for which he produced exquisite lost wax castings. Both of us were inspired by his writings. Even in the larger scales, in those days, that level of detail was rare and usually reserved for Medal Winners at Model Engineering Shows. Eventually we both got involved with the smaller, scenic scale of Gauge One (1/32 scale) and joined the Gauge One Association. But in the 1980s, most of the Gauge One models we saw at shows, on display or up for sale seemed rather coarse looking. One of us remembers asking a prominent builder back then, why the Gauge One live steam models on offer on his stand did not even have brake gear. "Oh, you can't put that level of detail on live steam models", he said, "it would just get broken off!"

As time went on, companies like Aster and Accucraft put paid to this myth and produced models with brake gear, sanding gear and a host of external detail previously unheard of in our scale. (And no, it didn't break off!) But for both of us authors, now committed Gauge Oners, all this external detail, progress as it was, was still counteracted and let down by overscale controls and gauges in the cab.

Then came something of a breakthrough. In 2007, we were looking at models on the member's display stand at the Gauge One Annual Meeting and saw the "Dee's", three beautiful Victorian locomotive models built jointly by John Werren, Rolf Engler and Erwin Herni, all with exquisite scale cabs with every cab fitting in lovely, sharp lost wax castings. They were stunning. We both agreed that that was the way we wanted to go in Gauge One!


*Above and Right:*
*Swiss "Dee" Cabs*
*photos by Jurg Gyger*

*Above: Three "Dee's"*
*photo by John Werren*

Photo 4

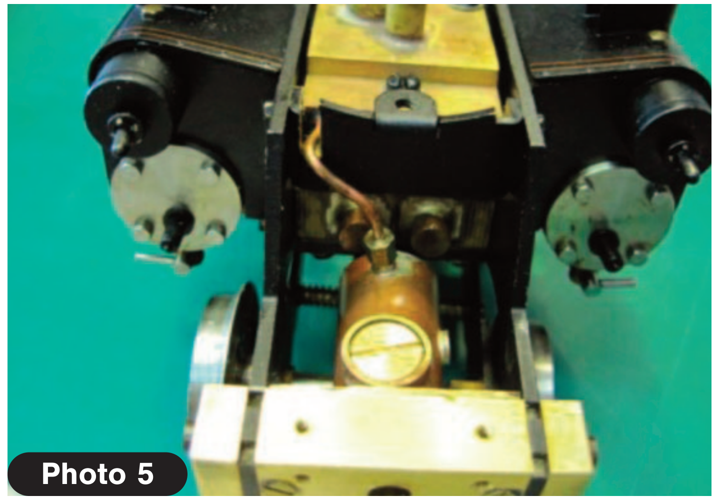


Photo 5

It turned out that to achieve the correct location of the back head we needed to build new boilers one inch shorter than the original one (**Photo 4**). We decided on an identical "C" type boiler design. Building new boilers meant we could place bushings in exactly the places we wanted.

The other major task here was to replace and resite the lubricator tank from the cab to between frames near the front buffer beam. (**Photo 5**).

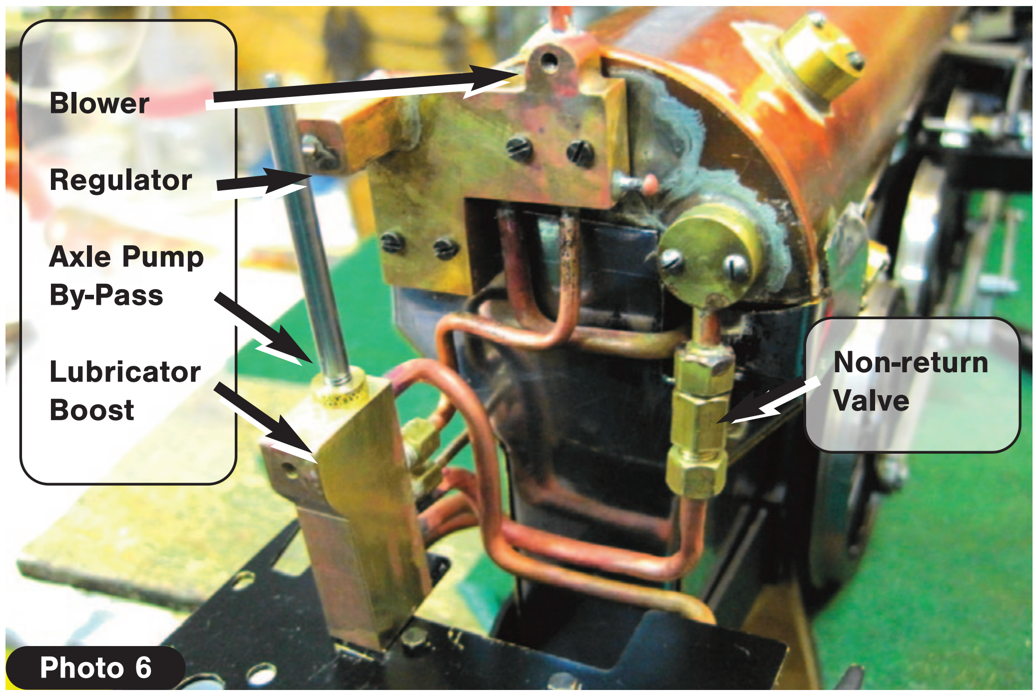



Photo 6

Much to our relief all the bushings on the new boilers lined up with the relevant cut-outs in the boiler cladding, so we could proceed to the next stage, which was fabricating and installing the two working valve "blocks." Each block was drilled and plugged according to the CAD design. If you look carefully at **Photo 6** you can see a plug which has yet to be removed. The back head valves are not very pretty but it doesn't really matter as these are covered up by the dummy back head.

Temporary valve spindles were turned in stainless Steel and then all functions could be tested on air. With a few minor glitches and adjustments everything was working perfectly.

Everything done from here in on was cosmetic, and the first thing to do was to produce the dummy back head structure. The full size Britannia's back head is not a simple one. It has two acute angles to the vertical and is trapezoidal and so a wooden former, (**Photo 7**), had to be made which copper sheet could be hammered around to get the correct profile. Once the firebox doors (fabricated) and the wash-out plugs (commercial castings) had been added, the dummy back head could be checked for fit around the driver's pedestal (**Photo 8**).

One of the most time-consuming parts of the process was undoubtedly providing the detailing parts for the cab. Wherever we could we used commercial castings or etches. At the time external detail castings for Britannias were available, but not cab details. Almost everything had to be fabricated and that takes time! For instance it took four hours to make two sets of firebox doors (**Photo 9**).

It's then just a question of working with photographs and drawings through each and every detail in the cab, then working out how to make an accurate facsimile in the most time-effective way.

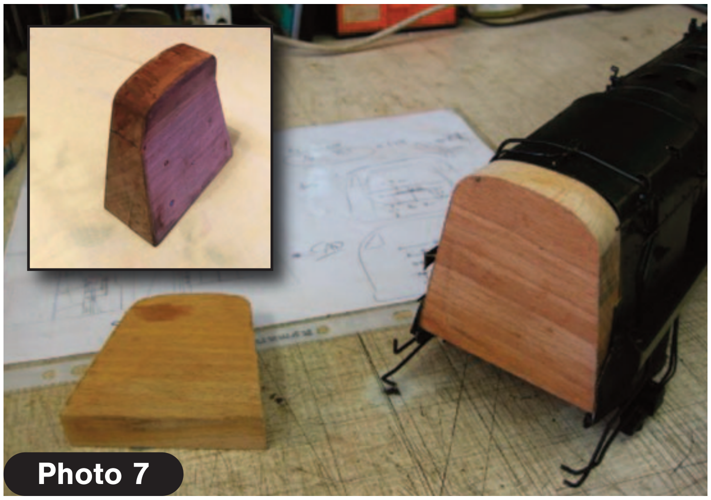


Photo 7

Photo 8

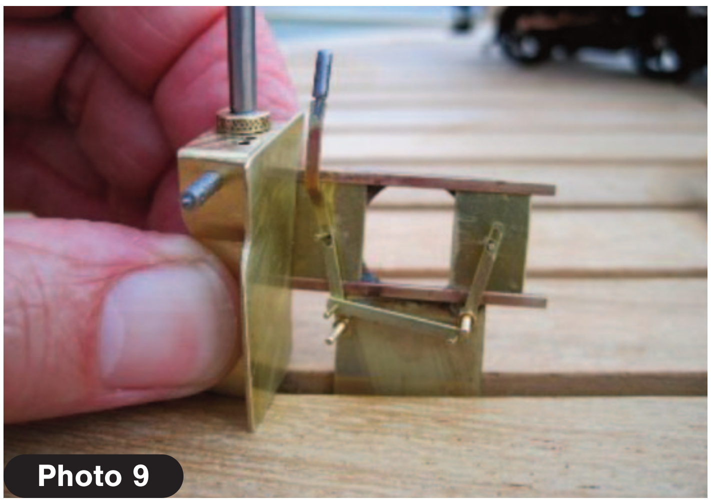


Photo 9

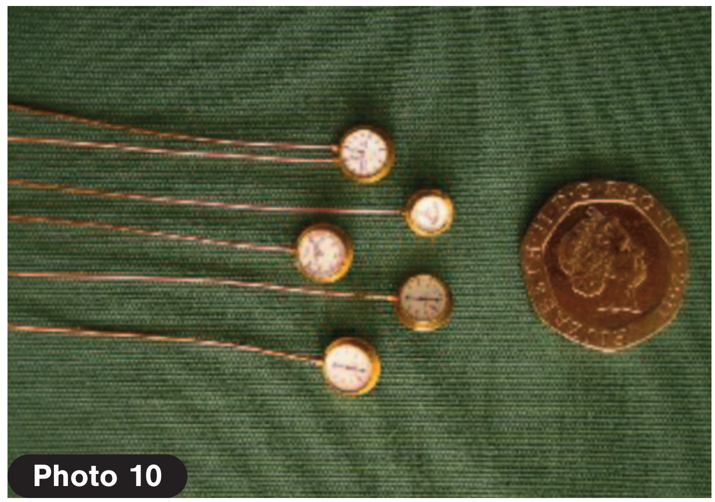


Photo 10

- Gauges - lathe turned and drilled for addition of fine pipework and 22BA nuts! (**Photo 10**)
- Dials - Photographs of real thing reduced onto gloss paper and punched out with a custom made, turned punch
- Gauge brackets and whistle lever bar - fabricated
- Valve wheels - castings which happened to be available and correct
- Vacuum brake unit and vac brake driver's control - fabricated
- Firebox door - fabricated (**Photo 11**)

Seats, lockers, flooring were then added to the loco cab, and details such as the firing iron tunnel, water level gauge and properly proportioned coal chute were added to the tender front. (**Photo 12 & 13**).

The dummy water gauge safety glasses were made from cut down acrylic rod (**Photo 14**), suitably polished and lined then backed with paper with a printed stripe. The unavoidable use of acrylic meant that the rear of the back head needed as much insulation as possible to prevent heat transfer from the alchohol burners and boiler to the plastic. Without that insulation they would not have lasted long!

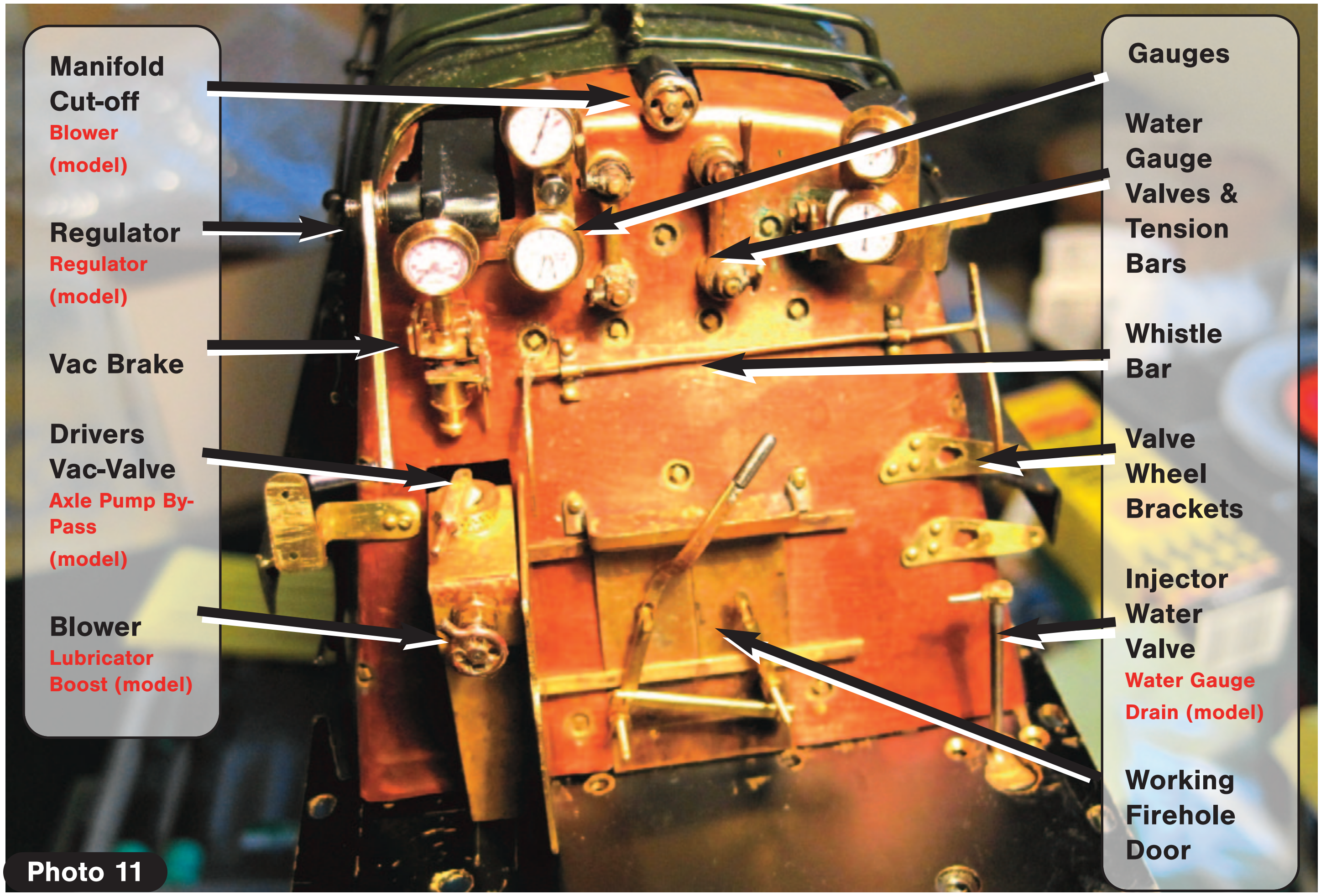
The cab floor used commercial, etched model chequerboard and scribed oak veneer, suitably weathered (**Photo 15**).

The crewmen were adapted from Preiser figures. (3D printed figures were not readily available back then.) They were positioned in the cab so that all controls were acccessible (**Photo 16**).

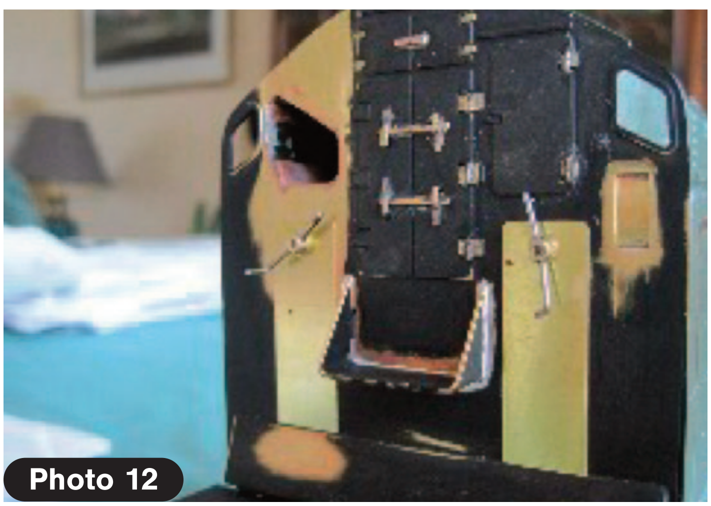
Because the Britannia cab is a fully enclosed one, it makes access to the scale controls in the cab less than ideal. The choice was to have a flip-up roof or a lift-off roof. Both have disadvantages but we decided that the necessity of a robust hinge with the flip up option would be too obtrusive visually. We went for the lift-off roof, but designed it to be as easy to remove and replace as possible.

### The Learning Curve

The amount of time and effort that went into building the Britannias was considerable, but it re-




*Detailed parts applied to new back head. Full-size functions in BLACK. Model functions in RED.*





sulted in two beautiful models that both of us are very proud of. But the main benefit was in what we learnt from the experience. The next model was going to be scratch built. So what lessons did we learn that we could take forward?

Using a conventional water gauge presents problems. By hiding it to one side of the back head, it inevitably becomes difficult to read and then only from one side!

- Use an electronic water gauge. Source : *fosworks.co.uk*
- Having the pressure gauge hidden (in our case behind the firebox door) does not present any usability problems.
- Continue hiding the gauge!
- Using conventional pipe connectors (unions and nuts) on so many valves makes access, stripping down and maintenance very difficult.

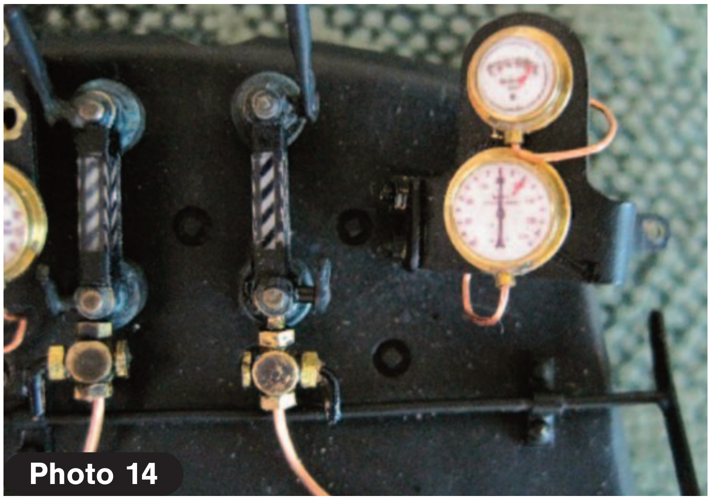


Photo 14

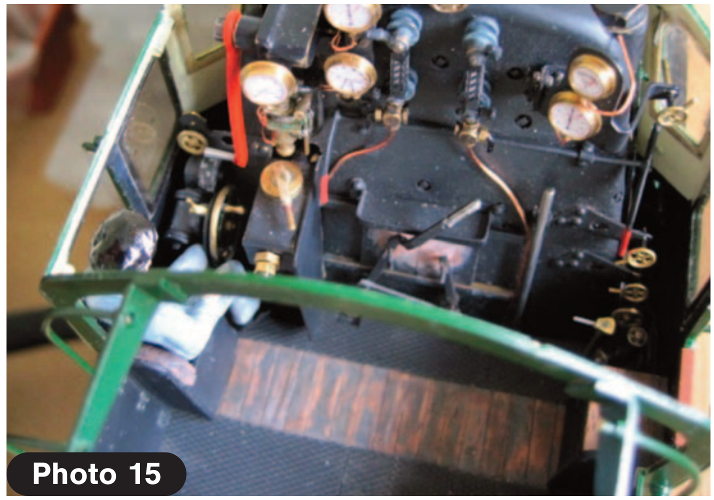


Photo 15

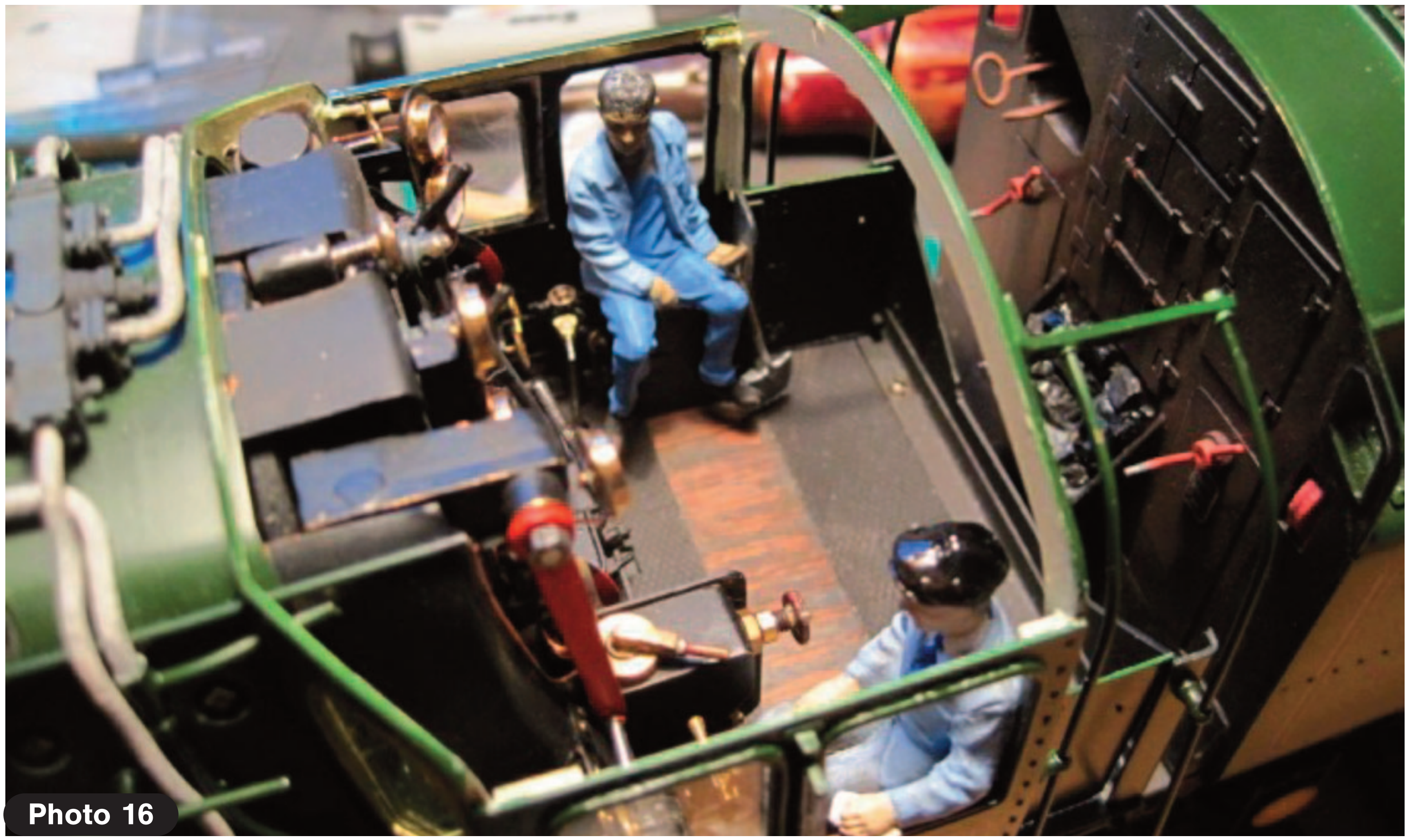


Photo 16

● Use pipe looms and O-ring based split manifolds.
● A fully enclosed cab is tricky for operation and doesn't do the work justice as it is difficult to see without the roof off. Choose an open cab locomotive for the next project.
● Getting to the non-return valve behind the dummy back head involves about an hour of deconstruction.
● Live steam is high maintenance. Access to components has to be easy. O-ring based split manifolds are the solution again.

In the next installment we will describe how these lessons were taken forward to the next models; a batch of twenty-five "King Arthur" Class locomotives.

# CONTRIBUTOR BIOS

The magazine couldn't exist if it were not for the dedicated individuals who take time from the hobby to chronicle their endeavors, interests, and joy of live steam. If you get a chance to meet any of our contributors at a steamup, please thank them for their contribution.

**Bill Allen -** Bill lives in Woodside, California and first became interested in live steam in 2008 when he saw Richard Murray's layout at a BAGRS open house. He proceeded to buy a Ruby, C16 and Forney before deciding to start building his own. He bought a mill and lathe and with the help of some BAGRS members learned to use them and was soon making chips. Since then he has completed 20 projects, some of which have been featured in Steam in the Garden, and currently has a multi part article running in Live Steam. All of his builds are one-of-a-kind, as he only builds those which have never been done before and probably will never be done again in G gauge live steam. Bill's prior hobby was building fine furniture and he uses some of those skills and tools in his engine building.

**Les Knoll -** Les started his railroading experience with a Lionel F7 freight set at Christmas at age 6. This grew to a tabletop layout in the family basement, later to be supplanted by a theater pipe organ and a rock band practice space in his teens. Later in life the HO/HOn3 bug bit, and the first incarnations of his Rivendell & Midland Railroad, one of the first JRR Tolkien-based railroads in the US, took shape. The R & M moved outdoors with his discovery of live steam in the early 90's, and after two purchased locomotives, five scratchbuilt live steamers followed, ranging from a 14-ton Shay to a 2-4-4-2 logging Mallet. The current Rivendell & Midland is in the back yard of Les's and wife Ruth's lake home in North Carolina. Les is a retired Forensic Engineer and a Registered Professional Mechanical Engineer.

**Jim McDavid -** Jim grew up in the 1950's with an intense curiosity for anything mechanical, especially trains, and has had a love affair with steam engines ever since. He has been part of the small scale live steam hobby for 30-plus years and is a founding member of Steam Events LLC which puts on the annual National Summer Steamup. Jim's machining skills have been honed building, modifying and repairing small scale steam engines and keeping a fleet of farm equipment in operating order. Jim currently reside in the small Sierra Nevada foothill town of West Point California.

**Derek Pollard -** Derek Pollard is a retired communications engineer with a lifelong passion for model railways, with many articles published in a range of journals. In his spare time he regularly drives full size trains on a heritage railway. He has been working with Chris Tolhurst for many years, both in prototype research and production support.

**Steve Shyvers -** Steve's interest in live steam started with a Wilesco steam engine back in the third grade, along with Lionel trains, and later HO. Soon thereafter radio and electronics took over, and a career in the semiconductor industry followed. Twenty years ago he discovered some of the pioneer small scale live steam internet sites. After seeing genuine little steam trains Steve was hooked! First rustic 1:20 stuff with chain drives, oscillators, and four-wheel cars. Steve converted Roundhouse locomotives to alcohol and coal firing. His interests today are centered in UK and US 1:32 scale. Recently retired, Steve lives in San Jose, California, and is a member of the Bay Area Garden Railway Society (BAGRS) live steamers.

**Chris Tolhurst -** Chris Tolhurst is a retired engineer living in Suffolk, England. For many years he ran TME, a manufacturing company specializing in small batches of detailed live steam miniatures. He has produced models in all scales from 1/32 Gauge One up to 1/4 scale traction engines. Most commercial production runs by TME have been in 16mm/ft but Chris's hobby is 1/32 Gauge One, and in retirement this will be the principle focus of future builds.

# THE CUPOLA VIEW

### Issue #160 Errata

I have to start out this issue "Cupola" with an errata to the March/April 2019 Issue #160 - Freelance Heisler Build by Les Knoll. An error was discovered while spending a shop day with Mike Moore working on the trucks for my own Heisler build. And yes, I'm woefully behind schedule with what I had hoped to accomplish by this time, but at least progress is being made.

*Errata: Page 35, [Drawing 2] , Bill of Materials, Part TF-5 should read:*

*TF-5 1 2 360 Brass Bar 1/4" x 3/4" McMaster Carr 8954K183*

The drawing is correct in showing that the bar is 3/4-inch wide and the hole placement is correct. It is just the Bill of Materials (BOM) that shows the wrong part number. Our apologies for not catching this sooner. I have uploaded a new file to the Plans Page at www.steamup.com, a full BOM listing by part source with this correction. The BOM list covers everything that has been published so far and includes Part 4 to get you prepared for that issue which will bring the boiler and plumbing into the locomotive.

Cheers, and Happy Steaming — *Scott*

*'Cupola view' is written by Editor Scott E. McDonald: you can contact him at sitgeditor@gmail.com or P.O. Box 1539, Lorton, VA 22199.*

## Special or Annual Meets

**Finger Lakes Live Steamers 50th Anniversary, Marengo, NY - August 1 - 4.** In addition to the Gauge One Garden Railway and the new elevated railway, Mike Moore will be providing his large Aikenback Track as well. Plenty of opportunity to run! Register for the event at http://*fingerlakeslivesteamers.org*

**Staver Locomotive Fall Steamup - September 19-22, 2019.** Staver Locomotive, Portland, Oregon. Visit *www.staverlocomotive.com* for latest information.

# TIMETABLE

**International Small Scale Steam Steamup. January 20-26, 2020**. 103 Live Oak Drive, Diamondhead, Mississippi. Visit *www.diamondhead.org* for more information.

**Fourth Annual Gathering of North American Members of the Association of 16mm Narrow Gauge Modellers - May 2020**. Hazlet, NJ.
Visit *www.northamerican16mmmodellers.org* for more information.

**National Summer Steamup 2020 - July 8-12, 2020**. McClellan Conference Center, McClellan, California. Visit *www.steam-events.org* for more information.

## Regular steamups

**Crescent City High Iron.** Steamups as necessary on an elevated backyard layout on Northern California's upper coast. Info: Don Cure, diamondd1947@msn.com.

**Greater Baton Rouge Model Railroad Club Open House and Gauge One Steamup.** Info: Ted Powell, (225) 236-2718 (cell), (225) 654-3615 (home), *powell876@hotmail.com.*

**On the Brink Live Steamers.** Wednesday, and occasional weekend, greater Sacramento, Calif., steamups on elevated live-steam tracks at two locations, as well as special events. Info: Paul Brink, (916) 935-1559, *paulbr@aol.com.*

**Puget Sound Garden Railway Society.** Two steamups per month, one at the Johnsons' on the second Saturday and a steamup at a member's track on the fourth Saturday.
Info: *http://psgrs.org/* or call Pete Comley at (253) 862-6748.

**Southern California Steamers.** Contact Jim Gabelich for dates, places and other pertinent information. (310) 373-3096. *jfgabelich@msn.com*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**by Joe Rothwell**

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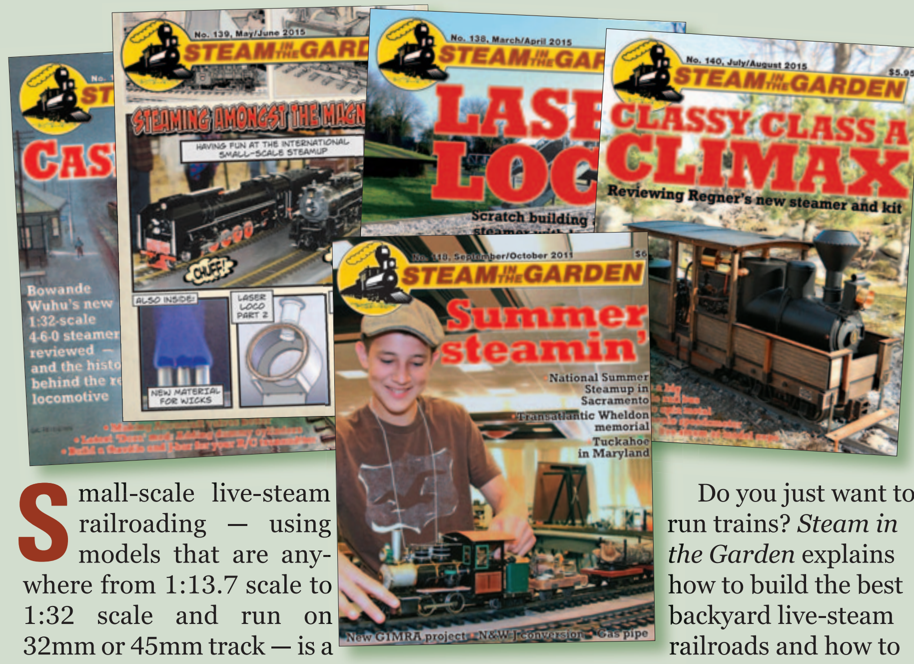


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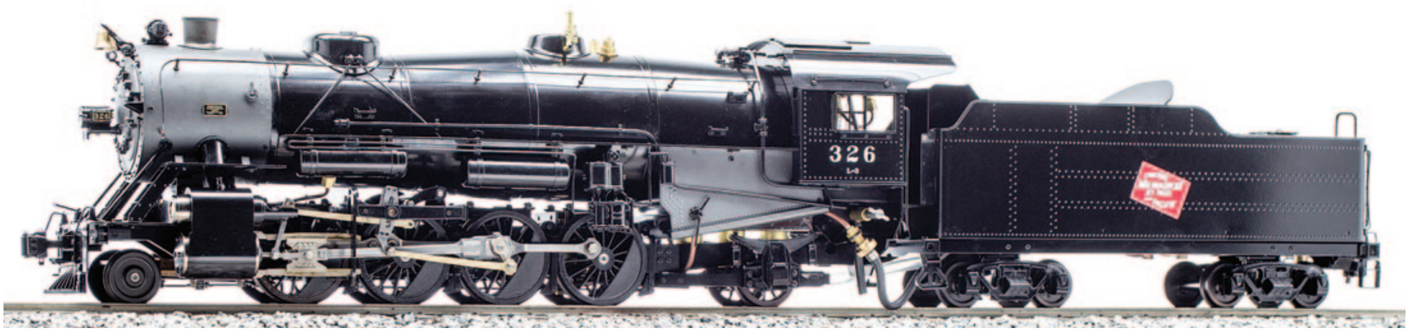


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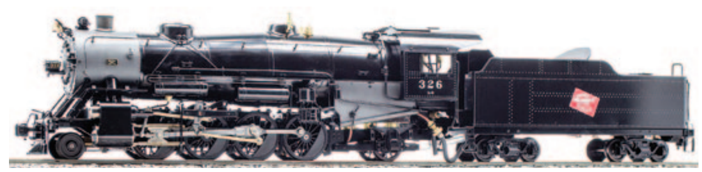


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