

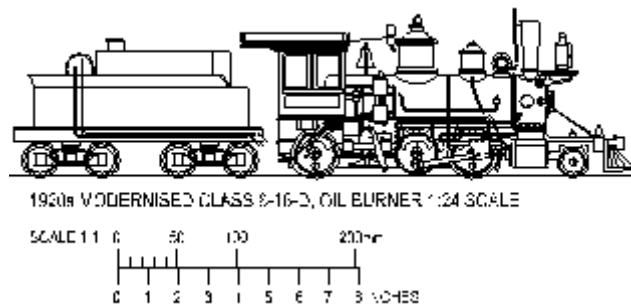
# Masters-2001

## Build a Baldwin 8-16-D 2-6-0

**A Locomotive Adventure**  
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**Melbourne, Australia**  
**Color Photography by the Author**

### Chapter 4 - All About Boilers

#### Background - Construction - Detail



*....and now things get really interesting....*

Chaps - Welcome back. This week we turn our odd looking 2-6-0 chassis into something resembling a locomotive. We'll construct the boiler, domes, stack headlight and sideboards/cab floor. The work in this chapter is of an easy nature but takes time and care none the less.

Your loco will start to have personality from here on. Don't ignore it, something wonderful is transpiring. It's time you began talking to your locomotive. This is a valid part in the process of bringing a model to life, talk to it and listen to what its trying to tell you. Listen to the sounds it makes when it runs, look carefully at its lines. If at any time you get the feeling the model project is just not going well; parts just wont stick, wont go on straight, or stay together, and the paint just wants to do things other than what you intend, this, above anything else, is a pretty clear indication that the model is trying to tell you something! Maybe you should stop for a while.

It is true, models, particularly model locomotives have a personality; sometimes they run well, other times for no reason at all, they refuse to run (I suspect that why we call them 'she'!!). It begs the question: does a model Locomotive have a soul? The answer is YES, the model has the soul of its maker...it's a part of you. Your vision, feeling, and passions are tied up in every curve, color and connection in the model. This is also why it's so easy to look at a particular model and know who built it. The models may be representations of 1:1 prototypes, but the models themselves have their own very distinctive character, the character is yours. And at the end of this class, this will be demonstrated when everyone's models, all built from the same instructions will look utterly different and man what a delight that is. Talk to your locomotive, talk and listen. Once again this Chapter is divided in three parts:

## **Background:**

This week we talk all about boilers, their evolution and basic form. We'll also look at some of the construction methods used in boiler making. We'll look into the origins of the sand dome, headlight, and other boiler fittings typical of early American motive power. We'll also display the great array of smoke stacks devised for steam locomotives.

## **Construction:**

This week we construct a boiler for our 2-6-0 model. The boiler will be fully equipped with steam and sand domes, stack, headlight and mounting and boiler sideboards or side walks. The emphasis this week in model making is 'strength' the model will be STRONG!! Once again direct any difficulties you may encounter to the '[Model Making](#)' forum here at myLargescale.com.

## **Detail:**

For the brave at heart, we'll add some minor details to the boiler. Up to you if you wish to carry out this additional work. The work is not difficult, just a bit fragile.

*...all I ask is a steam locomotive...and a star to guide her by.....*

# **Background**

## **Of Mice and Boilers**

### **The energy plant of locomotion:**

#### **The Industrial Revolution**

The term industrial revolution evokes images of factories, steam powered wheels spinning endlessly and lives turned into numbers, sure there is some truth in that, as mechanization flooded through Europe and the US from the early 1800s. Mechanization was not in itself the 'revolution', rather just a means to an end. If I remember my college lecturer's description of the term 'Industrial Revolution' while undertaking a totally cool subject called 'Industrial Revolution & Society', the term meant 'Increase in productivity per unit land, labor and Capital'. Wow how things haven't changed!! What brought the whole industrial thing into being was a change in the system of land ownership in England and France in the early 1700s. The traditional Feudal system in society broke down and with it the role of the land owners and peasants changed. The first productivity changes were to be developed in farming and later textiles. Early industry had been rural based, usually near streams or rivers, where the power of flowing water would provide the necessary torque for the machinery. The first steam engines of Newcomen and later Watt were to aid in the mechanization of these early factories and in-turn severed the need for factories to be near rivers, giving rise to the ugly polluted metropolis!!

#### **Boiling the Kettle**

I won't delve into the earliest experiments in steam power we're talking ancient Greece and a weird spinning steam jet powered orb. No lets move onto the piston and cylinder type thing, back to 1712 and the inventor of the piston steam engine, Mr. Thomas Newcomen (1663 - 1729). As mentioned in Chapter 2, Newcomen began building steam powered pumping engines for the

deep coal mines of Northern England and Cornwall. The engines were very large, filling an entire building. Hmmm, that's what they said about computers once. The machine comprised a single large vertical piston & cylinder, propelling an overhead beam up and down, which in-turn pumped the water up a shaft. Steam was only used to move the piston in one direction, while the return stroke was provided for by a large weight placed on the beam.

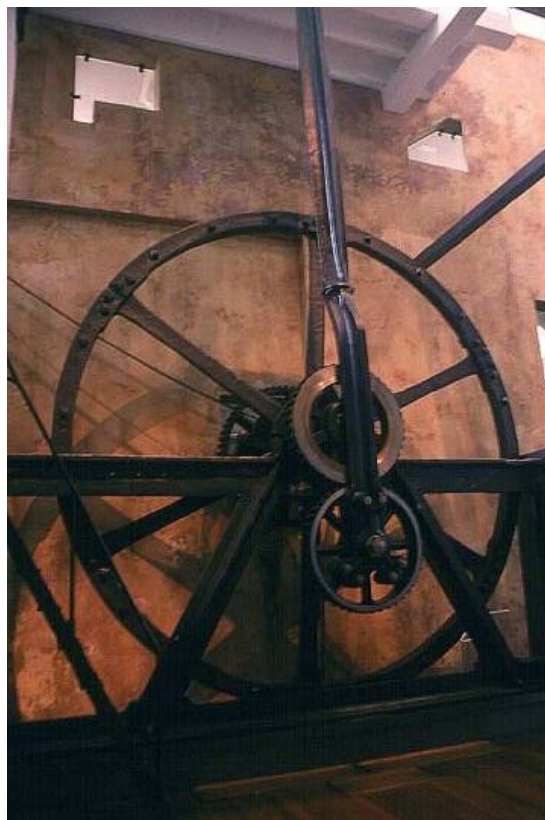
The biggest issue to point out about the Newcomen engine, along with the new approved version of the machine as later patented by James Watt, was that these engines were an 'atmospheric' type. They did not use the expanding power of steam to push a piston, rather used the drop in pressure in condensing steam to create a vacuum with the power to 'suck' the piston along its path. Steam was generated in a large dome topped boiler that looked like a giant kettle. The kettle sat on a brick base where a raging fire was maintained below. The boiler only had the task of turning water to steam, there was no real pressure in the boiler. The steam produced was exactly like what comes out of a boiling kettle...a real saturated 'wet' steam. When this steam was admitted to the cylinder, upon cooling and re-condensing back to water, there would be a drop in pressure relative to atmospheric pressure outside the cylinder. This vacuum would pull the piston down, or rather the normal atmospheric pressure on the other side of the piston would push the piston down....and boy did it take time to condense that steam and make the engine move!! Usually the engine would only make 4 cycles per minute. To condense the steam within the cylinder, Newcomen had a jacket of cold water circulate around the outside of the cylinder. This would keep the cylinder cool and cause the inward steam to condense quickly.

One day a Newcomen steam engine was found to be working at high revs, nine cycles per minute. What could be causing that?? A full check of the workings revealed the jacket of cold water around the cylinder was leaking into the cylinder causing the steam to condense all the more rapidly. The leaky cylinder concept was immediately introduced on all new machines!!

As mentioned in chapter 2, James Watt with his Partner Boulton, developed the Newcomen concepts improving the machine substantially, including improved efficiency, speed, and converting vertical motion to circular motion via the invention of an early wheel crank, termed the 'Sun and Planet' Motion. It was also during the Watt era that the engine became a fully 'reciprocating' type, where steam was used to move the piston both up and down. The boiler was still the big kettle concept, operating at a pressure just above normal atmospheric pressure.



*An early Boulton & Watt Steam engine. The big wheel is the first form of steam powered circular motion and also acted as a 'fly wheel'  
London Science Museum, UK.*



*The Watt wheel crank...the 'Sun & Planet' motion.  
PowerHouse Museum, Sydney, Australia.*

It was the invention of circular motion that demonstrated the possibility of steam power beyond being a pumping machine. The low pressure boiler and the atmospheric engine had been the power plant for most of the industrialized nations of the 1700s.

## **More Efficient Than Horses**

Richard Trevithick had been raised in the mines of Cornwall, and had watched the slow workings of the Watt engines every day. Trevithick would make his breakthrough in steam technology in 1800....but it wasn't due to his dislike for the inefficient Watt engines.

Change had hit England in many forms, the most obvious was the industrial movement. Another was more subtle. The famous French Emperor, Napoleon had been a bad boy, yes indeed he had. His small size had given rise to some very large military campaigns and conquest. His trouble making covered much of Europe, the Mediterranean, Egypt and ultimately right up against the wooden walls of Britain. Napoleon would one day be credited in having invented 'Egyptology' for his passion and interest in Ancient Egypt during his Egyptian campaigns of the late 1700s. He would also be unwittingly responsible for Trevithick's experiments with high pressure boilers.

Napoleon's battles had placed a strain on Britain, with much of the country's resources being put into the war effort. Like any good war, some of the best inventions are devised during conflict, some to ease the burden and some to fight a better war. With the Napoleonic wars, came a severe shortage in Horses for Mother England and France. This was accompanied by a shortage in horse fodder, which lead to a substantial rise in the cost of feed....and thus a rise in the cost of maintaining the limited number of horses left to service the country. It was to replace the horse that Trevithick began his work. His desire was simply to build a machine that could work more efficiently than horses and cost less to maintain.

Trevithick's high pressure steam theory was something new. You've probably heard by now that its darn near impossible to get a hot cup of Tea while ascending Mt Everest. The problem is that water boils at a much lower temperature at high altitude and thus the water has already boiled off before it's even hot. The real issue is that the boiling point of water is lower in a low pressure environment as found at high altitude.

Conversely, the boiling point of water rises in a high pressure environment, and that's where the advantages of high pressure boilers begin. More energy is expended in heating the water to boiling point in a high pressure boiler, but that energy is in some ways captured in the steam produced. When this high pressure steam is released back into normal atmospheric pressure, it undergoes a massive and instantaneous expansion. As the steam expands and cools, it begins to condense only to vaporize again as various boiling points are met in the descending temperature gradient. The expanding power of steam from a high pressure boiler was Trevithick's innovation. This was a kinetic power like nothing ever seen and would be used to push the pistons in Trevithick's early engines.

His first boilers were made from riveted plates of wrought iron and were coupled with steam cylinders powered by expanding steam. Running at pressures as high as 145 lbs/sq. inch, they were many times smaller than the Watt Machines and many times faster. The Trevithick engines were immediately put into service for the mines and other industry. This made Watt very nervous. His low pressure engines were old, and he'd pushed the technology as far as it was possible to go, it was curtains for the low pressure steam engine.

Watt's machines had played a large role in the economy of the nation, and its not unexpected that he was a man with considerable political and social influence. In his fading years Watt was to use his influence to try and have high pressure boilers prohibited by law on the grounds that they were too dangerous. Numerous court battles were to be fought, but Watt would lose every time. In a society where industrial accidents were commonplace and deaths were expected, 'incidents' involving high pressure boilers were not out of line.

On one occasion in 1803, a boy tending a Trevithick engine in Greenwich went off fishing, leaving the engine to a laborer untrained in its use. The engine began to race as boiler pressure increased. These early Trevithick boilers had a manual pressure relief valve. If the pressure got to a certain level, the guy would open the valve and dissipate some of that pressure. On this occasion the laborer decided to stop the engine's motion and in doing so, brought about an accelerated increase in boiler pressure. The boiler exploded killing the laborer and fueling another Watt inspired court battle. The court found in favor of Trevithick, but insisted better safety measures be installed. The automatic safety valve was devised and thicker metal plating would be used.

On another occasion a boy tending the Trevithick pumping engine was frustrated by the engine's persistent scream, while the automatic safety valve was blowing off steam. He loaded the valve with weight to stop the screech. The boiler very quickly exploded killing the attendant and sending Watt and Trevithick straight back into court. Again Watt lost.

Had Watt's influence succeeded in having high pressure boilers prohibited, the development of the steam locomotive would have been set back at least 20 years. Watt had provided much to the development of the steam engine, we should not forget that, and if nothing else his continual court battles with Trevithick had brought about safety standards for the operation of high pressure boilers. That in itself was a worthy effort.

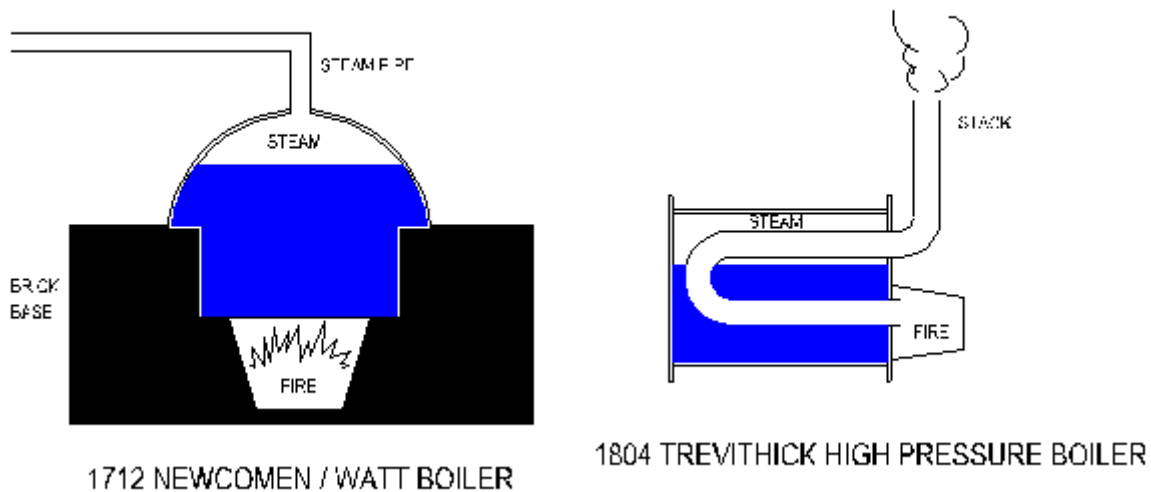


*This lousy photograph depicts an early Trevithick pumping engine with high pressure boiler. This is probably the only surviving Trevithick boiler in the world today. Exciting isn't it!!  
London Science Museum, UK.*



In 1803, Trevithick would place his high pressure boiler on wheels and build the world's first steam locomotive. His 2nd engine would go to work at the collieries, but proved too heavy for the rails. A 3rd engine was developed and run for public display in Northern London on the site of today's Euston Station. Sadly he was unable to successfully prove his locomotives to be more efficient than horses, he left for South America to pursue other engineering challenges. He was to be found penniless in the 1820s by Robert Stephenson who assisted in bringing Trevithick home. Trevithick's last Patent, in 1832 was for the use of super heated steam, a system that would become standard in locomotive design from around 1900. He died in 1833.

The Trevithick boiler was simple in design. Basically a horizontal barrel of water. A firebox was provided as an integral part of a long 'U' shaped flue that ran horizontally through the boiler, with the stack and firebox both located at the same end of the boiler on opposite ends on the 'U' flue. This basic boiler design would remain unchanged until the 1820s. The fireboxes were found either external to the boiler, or within the boiler simply as a widening to the flue

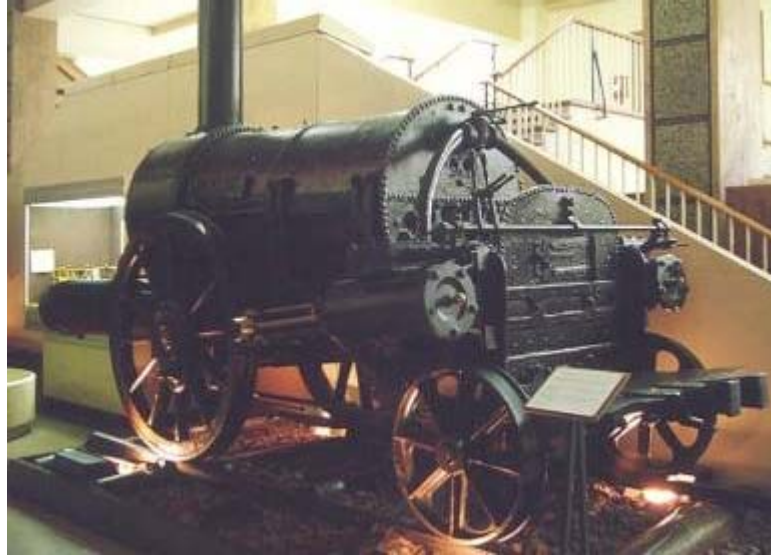


*The early Newcomen Low Pressure boiler and the Trevithick High Pressure boiler. Note the 'U' shaped flue in the Trevithick boiler was actually entirely horizontal, with the stack horizontally next to the firebox, my picture is only diagrammatic.*

## The First Multi-tubular Boiler

The Trevithick boiler had essentially one flue running through the tank of water. The flue acts as a heating element. The efficiency of the boiler is a measure of the ability of the hot metal surface area of the flue to heat the water around it. It was for the purpose of increased heating efficiency that Frenchman Marc Seguin patented the concept of a 'multi-tubular boiler' in 1827. This was a boiler design where the firebox was linked to the smoke stack via many small flues, each acting as a heating element in water. Conceptually it figures that if the same volume of hot gases can be moved through many smaller flues instead of one large one, there would be an increased metal surface area to heat the water within the boiler. The concept was sound, but difficulties were experienced in making the boiler steam. The boiler just wouldn't breathe. George Stephenson would come up with the same invention at the same time in England and his was the first used on a locomotive. George found some success with the boiler but only when the boiler had a fan forced draft pumped through it, via a unique fan tender that looked like a giant vacuum cleaner on

wheels. In 1829 Robert Stephenson would make the Multi-tubular boiler concept work with the introduction of the 'blast pipe'. He applied this type of boiler to the famous 'Rocket'.



*The Rocket, 1829- First Successful use of unaided Multi-tubular boiler with blast pipe. Note the top of the firebox is missing and you can see the ends of the flues at the rear flue sheet. Also note this locomotive received a full smoke box in 1830 as seen in this photo. The original smoke box was a small semi-circular unit, with the blast pipe fitted within the stack. With the new smoke box the blast pipe was moved to sit within the smoke box.  
London Science Museum, UK.*

The rocket had a unique feature in its smoke stack, the very first use of a blast pipe. This was a small nozzle placed within the stack that discharged the spent steam from the cylinders. The nozzle forced the exhausted steam into a vertical jet. With every chuff from the cylinders, the blast pipe within the stack would produce a movement of air up the stack and create a vacuum below. This vacuum would effectively pull the air through the boiler from the firebox grate right to the stack....no fans needed. The faster the loco ran, the more it chuffed and the greater the draft generated through the boiler...heating the water at a more rapid rate and sustaining the loco's speed.

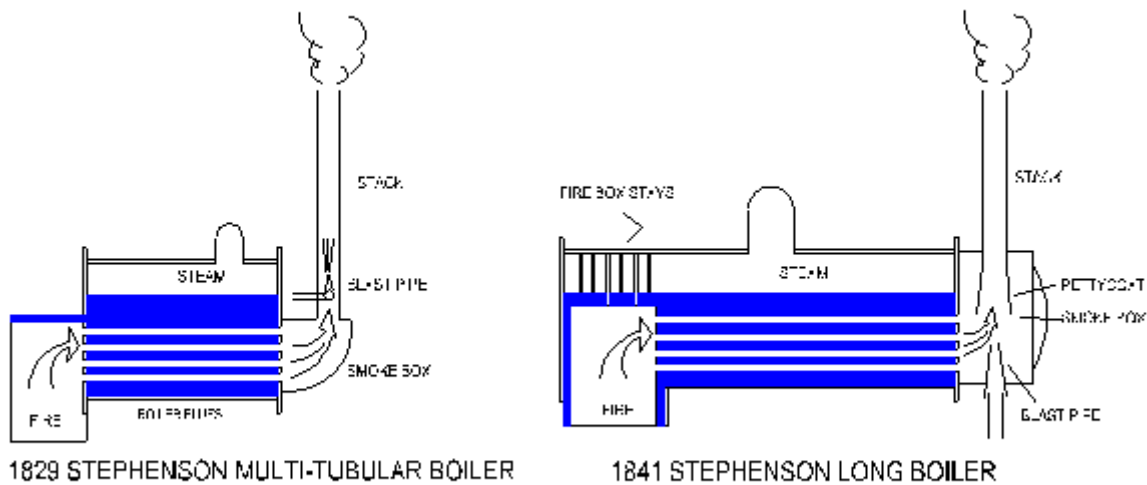
The Multi-tubular boiler would become standard on all the Robert Stephenson locomotives. The effect of the blast pipe would be improved when Robert pioneered the first full 'smoke box' on a new locomotive called 'Phoenix' in 1830. In 1832 Robert would patent the 'Petticoat' blast pipe where a cone was added between the blast pipe and stack, focusing the exhausted steam, increasing the vacuum in the smoke box and increasing the efficiency of the draft through the boiler.

### **Stephenson's Flamin' Locomotives**

In the late 1830s Robert Stephenson would watch one of his 'Rocket' style locomotives whizz by at speed and be astonished to see flames leaping out of the smoke stack...the front of the smoke box was also glowing red hot. Flames coming out of the stack can only mean one thing...wasted heat energy up the spout. Upon investigation Robert would learn that the action of the smoke box, blast pipe, and petticoat were altogether too efficient. That was coupled with some uncertain wind dynamics under the chassis that could direct air up into the firebox grate and make the fire burn hotter. Robert pondered the problem, back off on the air flow?? Or make the boiler longer?? Given the height of the smoke stack was the length of the boiler again, and the fire was burning all the way through the boiler, up the stack and into the sky, there was the potential to build a



boiler at least twice the length of the 'Rocket' boiler, and use those lengthy flames to boil water within the boiler itself. In 1841 Stephenson would patent the 'long boiler' The design elements of the long boiler would remain a constant in all boiler design to follow. Our Baldwin 8-16-D has a boiler of a design consistent with the Stephenson 'long boiler'.



*The Stephenson 1829 'Rocket' Boiler and the Long Boiler.*

## Firebox Stays

During the evolution of the Trevithick boiler to the 'long boiler' the firebox evolved from just an extension of the stack flue to a full suspended firebox with bottom grate within the boiler shell. Stephenson had known the top of the firebox or 'crown sheet' was a very hot element and a worthy heating element if submerged in water. Water over the crown sheet also had an advantage in cooling the firebox metal and allowing the firebox to burn hotter without disintegrating the metal casing. The 'Rocket' of 1829 was the first locomotive to have a firebox fitted with a thin water jacket over the top and sides. With the long boiler he went a step further, fully submerging the firebox within the boiler. Suspending the firebox within the pressure vessel of the boiler was some trick. The boiler pressure pushes hard against the firebox walls and if it weren't for the firebox 'stays' the firebox would pop out like a cork out of a Champagne bottle. The stays were originally an array of metal rods spaced at close centers that rigidly suspended the firebox in place.

Most engine shop crews will tell you firebox stays are a pain in the backside!! With all the expansion and contraction and movement going on in a boiler, the rigid stays tend to break and break often, putting a loco out of action until repaired. If too many break, there is the potential for boiler failure, leaks or even an explosion. From about the time of our 1870s 2-6-0 through to the early 1900s, American locomotives used a unique 'hollow' stay concept. These were hollow rods holding the firebox in place. On the firebox end the rods were sealed. Where the stays reached the outer boiler shell, the hollow rods were open. If at any time a firebox stay was cracked or broken, boiler water would be forced through the broken hollow rod to the outer boiler shell. The crew could then instantly see a stay failure when water was seen squirting out of a hollow stay.

By the 1920s flexible stays replaced the old rigid stays. These were a ball and socket type stay or a pin jointed type, that allowed the boiler to flex relative to the firebox without the stays breaking. Regardless of the types of stays used, those delightful rivets we always see around the exposed bottom of a firebox on our models are the boiler stays.



*This is a photo looking from within the boiler, viewing back toward the rear flue sheet and firebox. You can see the arched shaped firebox slung within the boiler shell. Note the firebox stays holding the firebox in place, rigid stays to the sides, flexible pin jointed stays around the top.. Also note the boiler flues cut off as this old 1920s boiler once used on a 30" gauge Baldwin outside frame 2-6-2, awaits scrapping.  
Puffing Billy Railway, Australia.*



*In this view of the 1920s boiler, you can clearly see the rigid stays to the side of the firebox and the flexible pin-jointed stays around the top, crown sheet of the firebox.  
Puffing Billy Railway, Australia.*

## **Safety Valves and Boiler Explosions!**

Trevithick's early boilers had manual relief valves to enable the engine crew to lower the boiler pressure. As noted there were explosions and one could ask why Trevithick didn't think to add an automatic safety valve of some kind. Perhaps it was because he didn't believe the boiler could attain sufficient boiler pressure to blow. The greater the pressure within the boiler, the harder it becomes to turn water into steam, as the water boiling point continues to rise. I suspect there would come a point where the boiler was incapable of heating water to boiling point....I guess that point was well after the boiler had already exploded!!

Early automatic safety valves were a simple system of lever and weight. As the pressure in the boiler rose, the pressure would push against the weighted valve, lifting the weight only when the max operating pressure was attained, and allowing steam to escape.

The first spring loaded safety valve wasn't introduced until 1862 (James Fenton, UK), only a handful of years before our 2-6-0.

Most locomotives had a minimum of 2 safety valves, usually both were rated to blow off steam at slightly different pressures. Thus one valve would begin to blow and if the pressure continued to increase, the 2nd valve would then open. It's a sad fact of large scale model railroading that all together too many models are made with only one safety valve, this is not accurate modeling. On the larger standard gauge locos of the 20th century, as many as 3 or 4 safety valves would be used.

Boiler explosions in the early 1800s were not uncommon. The reasons for the failures were often structural failures or mis-handling of the boiler by the crew. It may come as a surprise but on occasion explosions occurred even during the big steam days of post WWII. There is the story of a D&RGW standard gauge Mallet that blew in post war years. The loco disappeared in a cloud of steam...when the steam cleared there was no sign of the loco!! The boiler had shot off into the sky and the two drive wheel units continued to run on for a mile or so. Interesting to note there were 4 people on the foot plate that day, including the crew and a rail enthusiast photographer. We'll never know, but its possible through all the excitement and discussions in the cab, someone didn't see the boiler water level dropping to dangerous levels, exposing the firebox crown sheet. That is a whole bunch of bad news.

If the water level within the boiler drops below the top of the firebox crown sheet, the metal is left exposed with no cooling water. The crown sheet rapidly begins to glow red hot, then white hot and will disintegrate, causing a massive explosion through the firebox top. In 1826 Sir Goldsworthy Gurney (1793-1875, UK) invented the soft metal plug to protect the firebox crown sheet....basically if the crown sheet was left exposed, and began to heat up, the plug would melt allowing the steam in the boiler to blow through the hole and damp the fire down before the crown sheet heated any further. Naturally the loco would be out of action until the plug was replaced and the crew responsible would be looking for a new job. The plug concept could protect a boiler to some extent but was no guarantee. Remember the RGS rotary snow plough blew one day when the attendant let the boiler water level drop.

Boiler explosions are not like a balloon bursting. A boiler explosion is extremely violent. A lot of heat is required to turn water to steam under pressure, if there is a small rupture in the boiler shell (crown sheet or otherwise), the boiler pressure will drop rapidly and when it does, all that un-boiled water will suddenly be at boiling point again. The water within the boiler instantly vaporizes and expands with the dropping boiler pressure and BAM!! It tears the whole boiler apart. No don't get involved with exploding boilers, they are really no fun at all!!

Boilers are pressure tested to twice the operating pressure using cold water. If the boiler fails under the pressure test, there is a water leak. That's all, no explosion, this demonstrates the difference between an explosion caused by rapidly expanding steam, and a failure caused by pumping too much pressure into a vessel.

The water level is foremost in the fireman's mind when tending a loco. Care is taken to keep the crown sheet submerged in water, even when the loco is running up and down grades, a condition which can leave the crown sheet exposed when all the water sloshes down to the far end of the boiler. On the other hand care is taken not to overfill the boiler or the steam capacity of the loco drops and with it comes a loss of potential efficiency. It's a careful balance between efficiency and death!!

## **Boilers, Early American Locomotives and Shot Gun Barrels**

Sometimes legends or folk tales tell of heroic actions that prove to be the literal misinterpretation of the written facts of the day. I'll give an example of an unrelated but cool story.

In 1509 a German fella by the name of Martin Luther posted a list of church reforms on the door of the Schloss Kirche in Wittenberg, eastern Germany. The list would be called the '95 thesis' and covered a whole bunch of things he believed wrong with the Catholic Church. Such things as giving money to the church in exchange for a written 'get into heaven free card'. Naturally his remarks made the church very angry and Luther was lucky to escape the town with his life.

For a time Luther would be hidden by a friend in a large mountain top castle in south eastern Germany called the 'Wartburg'. It was here in hidden isolation that Luther began his work in creating the 'Lutheran' church. In a small room he wrote his manuscripts with a quill and ink, translating the Bible into common German for all to read. One day, as legend has it, Luther saw the Devil coming through the stone wall before him. Luther grabbed his ink well and threw it at the approaching apparition, the ink well smashed onto the wall leaving a big ink stain, and the Devil vanished.

For centuries after, as the Lutheran followers would visit the castle and Luther's room, the owners of the Castle would continue to stain the wall with new ink to keep the legend alive. The owners were only just able to stain the wall at a faster rate than the speed in which the tourists would remove the ink (and wall) as a souvenir!!

Today, its believed by many that Luther never actually threw any ink at any wall. The legend is merely a literal misinterpretation of Luther's use of the ink and quill to WRITE the religious manuscripts which drove the devil away. Ah legends.

One of the United States' earliest Railroads was the Baltimore & Ohio, the famous B&O. In 1830, the railroad had to make a decision regarding motive power. To use steam power or horse? Which was more efficient? Which cost less to run? which pulled more etc?

Legend has it that US industrialist and inventor, Peter Cooper, hearing the railroad's desire to test steam power, built a small locomotive. The loco had a geared chassis, almost identical to William Hadley's Puffing Billy of 1813. The boiler however was something new. It was the first vertical boiler, comprising a vertical cylinder with firebox at the base, multi-flued boiler unit midway up and smoke box at the top. There was a genuine logic to Cooper's boiler design. Heat rises and a vertical multi-tubular boiler could 'breathe' using this rising heat energy. It is said that Peter used the barrels of shot guns for the boiler flues in this tiny loco!! At that time the B&O had very tight curves and Peter Cooper used the vertical boiler on this loco because it proved to be a successful way to put a larger/taller boiler on a loco of very short wheel base. The little loco would later earn the nick-name 'Tom Thumb'.





*Peter Cooper's Tom Thumb -1830(replica).  
B&O Museum Mt Clare, Baltimore*

On Aug 30 1830 the B&O held a great locomotive trial, similar to that held at Rainhill in 1829 for the Liverpool & Manchester railway. They would have horses compete with the steam locomotive to see which would be best for the railroad. Peter Cooper's Tom Thumb was entered and allegedly raced against a horse for a distance of 23km. The loco was hauling a wagon filled with B&O directors. The fan belt broke on the loco and the horse won (don't broken fan belts always ruin your day!!). But the pulling capability of the loco won the directors over into making the B&O a steam railroad. Actually the whole Tom Thumb vs the Horse story is a lot more dramatic than my account!!

The interesting thing is that no mention of a race was ever documented prior to 1868, when Benjamin Latrobe spoke about the great Tom Thumb Vs the Horse race in a speech. There however had been locomotive trials which were documented in the Baltimore Gazette in 1830. Once again the legend is bigger than truth. Similar to the tests at Rainhill, the locomotives would have been tested for speed, power and costs on an individual basis on those 23 miles of track. Horses would have also been tested, but not in a one-on-one race!! It wouldn't have been a fair race anyway, the horse would have easily out-run the tiny geared steam loco. The Tom Thumb legend was created though a misinterpretation of the horse vs. steam trials. There is one ounce of truth in the story, there had indeed been a 'locomotive'!!

I believe Peter Cooper only ever built the one loco, but the success of the design and the vertical boiler principle would have lasting effect on the US. All of the B&O locos for the first 7 years were to have vertical boilers and would become known as the 'Grasshopper' type, being a mix of William Hadley rocking beam steam power and the Cooper Boiler. The Grasshoppers were outdated by William Norris' B&O #13 'One armed Billy' 4-2-0 'Lafayette', Built in 1837.(Refer chapter 3).



*A typical early B&O Grasshopper loco - 1832. The main power of the B&O for the first 7 years  
B&O Museum Mt Clare. Baltimore.*

The vertical boiler would be used throughout the US on all kinds of steam equipment, from logging winches, to shipping plant to Class A Climax locos. Vertical boilers were still being made well into the 20th Century.



*Typical Steam winch, as used in lumber, shipping, ski resorts and all kinds of applications, note the Cooper Vertical  
Boiler,  
Photo Taken at San Francisco Maritime Museum.*

## Curious US Boiler Fittings

### The Headlight

The locomotive headlight was a uniquely US concept. Probably in line with the greater distances traveled than those of the UK lines, night travel was inevitable, and the desire for the engineer to see in the dark, out in the wilds was desirable.

The first 'headlight' was a flat car pushed in front of the loco, used on the South Carolina Railroad in 1831. The flat car had a raging fire placed on top, made from burning rope knots. During the 1840s candle and whale oil were burned in reflector lamps mounted to the locomotive. Isaac Dripps of John Bull fame is credited with having invented the oil headlight that could withstand the vibration and elements. The Dripps headlight was used on the John Bull and was a blue print for the oil headlights used through the 19th century, including the Class 40 2-6-0 of the D&RG and our mogul of the Nevada County.



*Dripps' early oil headlight, John Bull, Smithsonian Institution.*

You will notice most, if not all Builder's photos of locos, rolled out of the factories in the 1870s and 1880s show locos without headlights. There is usually just the headlight bracket. The reason is that the art of headlight making had become a specialized trade. The headlights were made by separate contractors directly for the Railroad, thus the Baldwin, Cooke, Mason, Brooks locos were built and delivered without headlights. The headlights were then fitted in the roads' own shops.



*The typical Oil Box Headlight and mounting bracket of Baldwin's 1870s. The headlights were made by a specialist contractor to the Railroad.*

The electric headlight was introduced in 1881.

### **The Bell**

Also an American concept, I don't know the origins but the bell became standard on US locos after 1835, when the State of Massachusetts passed a law requiring this as a warning device.

### **The Whistle**

Originally invented by Adrian Stephens at Dowlais Works, Wales, UK in 1832-1833. First fitted to a locomotive in 1835. It spread to the US in 1836.

Funny but the first two US whistle fittings to locomotives were carried out by George Washington Whistler in 1836 in Massachusetts, get it? Whistler!! When the first loco entered service on the Long Island RR, the whistle was reported to make 'a shrill, wild, unearthly sound, like drawing a saw flat across an iron bar.'

The other locomotive, running in Delaware, at 35-40 mph was said to 'give an awful notice of the approach at any point'



Rogers of Patterson NJ fitted a whistle to his first locomotive in 1837, a 4-2-0 called 'Sandusky'. During its initial trips on the Hudson River RR, the loco ran short of steam due to the unprecedented use of the whistle!!

## **The Sand Dome**

This is a cool tidbit!! The use of sand to gain rail traction was first tested in the US in 1836 following a grass hopper plague in Pennsylvania. The sand was sprinkled on the rails to prevent the engines slipping on the squashed insects!!

Robert Stephenson began fitting sand boxes to his locomotives from 1841. From that time, various sand boxes and domes were fitted to locomotives which enabled the crew to deposit sand on the rails at any time from the cab. Sand became useful in gaining the added traction in departing a depot, stopping and gaining traction on wet, slimy rails and on grades.

The sand dome was hugely successful in the US, while Britain and much of Europe preferred sand boxes mounted to the side boards or on the chassis sides.

The classic 'Fluted' domes of early American locomotives are a symbol of the Industrial Art Period of loco design. While stylistically ornate, they were also the result of form following function. The domes used a simple construction system that concealed the joints between dissimilar components. The top and base of the dome were cast iron, the center parts fabricated from rolled iron, sometimes with brass cladding.



*The sand dome of V&T #13 'Empire', 1873, Baldwin 2-6-0, made from cast iron and iron tubing.  
Cal State RR Museum, Sacramento.*





*The sand dome of V&T #12, Genoa, 1873, Baldwin 4-4-0, made from cast iron with brass cladding.  
Cal State RR Museum, Sacramento*

The exact profiles of the cast dome tops were different to each locomotive company, and the dome forms became styles particular to that company. It is usually possible to discern a Baldwin locomotive from a Rogers, Danforth, Brooks or Mason just by the style of the domes.

### **A Note About Smoke Stacks**

In the 1800s, there were a huge array of spark arresting smoke stacks. In most cases, the chief engineers to US railroads were responsible for designing their own version of the spark arresting stack, which is in part why there are so many types that do the same work.

The big issue from a design stand point was:

1. Collect the burning cinders before they set fire to the landscape
2. Design the spark collector in such a way that it did not hamper the air flow through the boiler and stack, reducing the engine's steaming efficiency.

It is for this reason that the spark arresting stacks can become so large. There was the need to open the stack over a wide area, filled with screens and baffles, which collectively would have a real 'open' flue area equal to the required stack opening size to make the loco steam. Naturally the more the screens were clogged with soot, the worse the loco performed. The term 'balloon' stack is used to describe these large stacks, but that's a generic name used to describe a whole host of styles, such as 'Radley Hunter' (a personal favorite), Congdon (the famous stack of the South park), SPC, Diamond stack, Ridgeway, cabbage stack, Sunflower, pan cake, Pacific type, Nesmith and so forth. I should also mention that a large spark arresting smoke stack does not mean the loco was a wood burner. In fact the opposite was often true. Many of these fancy stacks were designed to catch coal cinders. In the 1890s onward, the small smoke boxes began to extend forward, becoming longer barrels and in doing so, the forward end of the smoke boxes on coal fired locos became the cinder collector. The large stacks were then replaced with short stove pipe types and capped stacks, as most of the larger cinders never left the smoke box. You will

notice early extended smoke boxes had cinder clean-out hatches on the sides to enable easy cinder clean out.

**Coming to you from the Cat Walk of Smoke Stacks...**

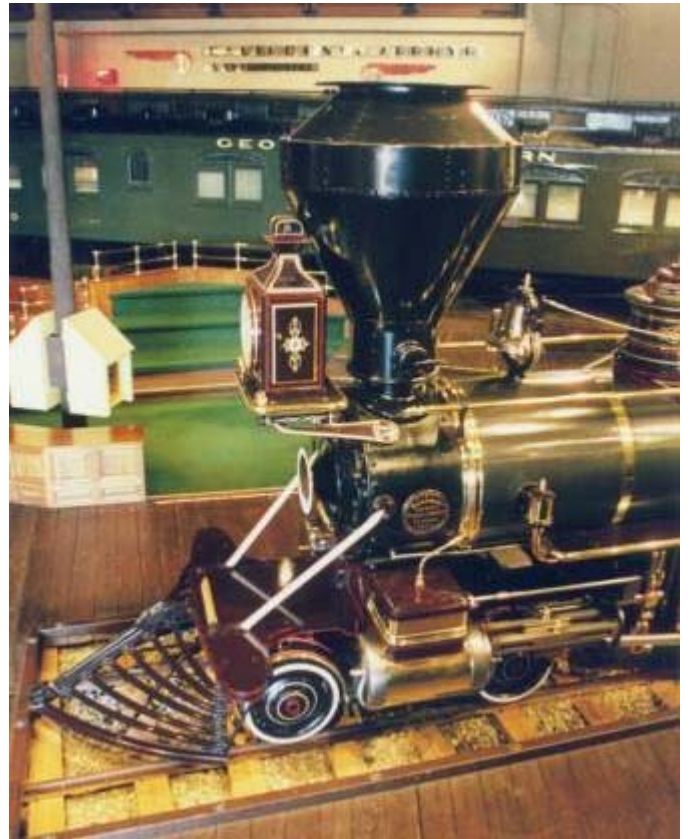
## **Specstackular 2001**

...and now Ladies and Gentlemen, coming to you from Danforth Cook & Co...  
The W&A RR 'Texas'....aahahaahaha!!



Those clean shapely lines will knock out any RR fan...

Next we have the Radley Hunter, proudly worn by Sonoma....



..and isn't Sonoma just gorgeous...

Next we have a visit from the Chief of South Park Design and a fashion label of note, Mr. Congdon of 1884....



..and the C-16 is feeling right at home wearing this stack, Thank you Mr. Congdon.

Ah...and a favorite of the Classical era, timeless and a fashion for any occasion...the Pacific Stack...horrrraahhh!!



And its Genoa wearing a Striking 1904 look...thank you Genoa...

Next we have a very cute pair...the Conical stacks for the wood era.



The William Mason of Mt Clare....and...

...The Tahoe, currently making a fashion statement at Strasburg, Penn.



She proudly demonstrates the stack most often worn by the V&T before oil.



No show could be complete without the coal dust buster, the Diamond stack....



Proudly demonstrated on a Camel Back,  
The Diamond stack is the ultimate  
accessory that can match any design.

Dim the lights please....and for a touch of class, catching  
the coal from a straight stack...the work of Mr.  
Ridgeway and known as the C&S Bear Trap...the  
Ridgeway stack....



...and the Ridgeway is resurrected for use on the  
Durango & Silverton...proudly accompanied by the  
Author!!



...hush now...quiet in the hall...coming to you live from the West Coast, the cleaner of Wood sparks, the most bulbous of stacks, the Cabbage style from the patch, and the most gog danged hardest to Fabricate....THE CABBAGE STACKS....Aahahahshshdha!!



From the gates of Mt Rainier National Park, WA, the Heisler is just a natural with this stack.



...and Argent Lbr Co #5 is feeling particularly gorgeous wearing the Cabbage stack at Nevada City.