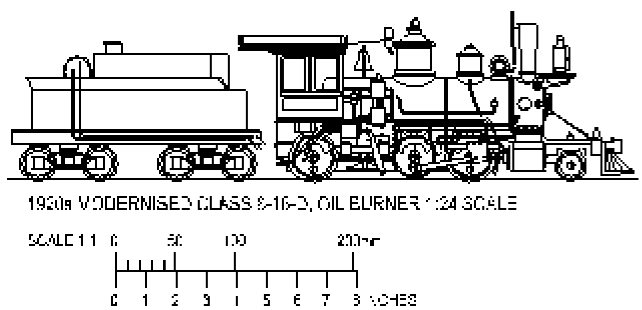
Masters-2001

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

A Locomotive Adventure
By David Fletcher
Melbourne, Australia
Color Photography by the Author

Chapter 2 - Chassis Construction

Background - Construction - Detail



....and the game is afoot....

Welcome back. Now the fun really begins. It is time to build your very own Baldwin 8-16-D 2-6-0 Each chapter of the 2-6-0 construction will cover a different sub-assembly of the locomotive, and each chapter will be broken into 3 parts, background, construction and detail.

Background is my favorite part, it's a lengthy waffle about the hows, whys and origins of the locomotive design, as appropriate to the 2-6-0 sub-assembly we're working on. You can ignore this part if you like, as it has no real bearing on the model construction, merely a bit of background to prototype methodology. If you do read it however, you will be able to impress friends and acquaintances by spouting obscure pieces of locomotive wisdom at dinner parties and conferences.

Construction is the most important part of the chapter and deals with the building of the model itself. This part is the instruction book for the 2-6-0 model.

Detail covers the finishing of the locomotive sub-assembly, and is the rivet counter material. The info in this part of the chapter brings the model up to high detail level, the length to which you go is up to you. My intention here is to make the detail of the model as close to prototype or prototype methodology as possible. This may at times mean very fiddly, tiny parts which may break off or get lost after one run!! Depending on what you're used to in terms of detail, you may choose to not apply everything noted in the 'detail' section and you will still have a very fine model. No one will be shot down for opting for the more robust, less detailed version of the model.

Background (Ex loco Scientia)

From the locomotive- Knowledge

The Origins of the Locomotive Chassis

The Fathers of the Steam Engine

Speak to the average history teacher, and you will learn that James Watt is regarded as the 'Father' of the steam engine. NOT TRUE. While Mr. Watt has a place in the evolution of steam engine design, it is fairer to say the steam engine had many fathers, each helping to refine certain elements of the design. There were many engineers involved, but the most notable are:

Thomas Newcomen (1663-1729)
James Watt (1736-1819)
Richard Trevithick (1771-1833)
George Stephenson (1781-1848)
and Son Robert Stephenson (1803-1859)

British engineers all!!

As we work though our li'l 2-6-0, you will see the role these gentlemen played in the design of the locomotive elements we are modeling.

Now if you visit the Deutsche Museum, Munchen Germany, you'll leave believing the Germans invented everything!! Visit the London Science Museum and the Brits invented everything…and go to Moscow…well enough said!! Funny thing about human kind is that in many cases important inventions were dreamed up in tandem, often nations apart. In the case of the steam locomotive, you will learn that the Brits did invent the basic principles, but here's the rub: It was the Americans who made it work and made railroading safe.

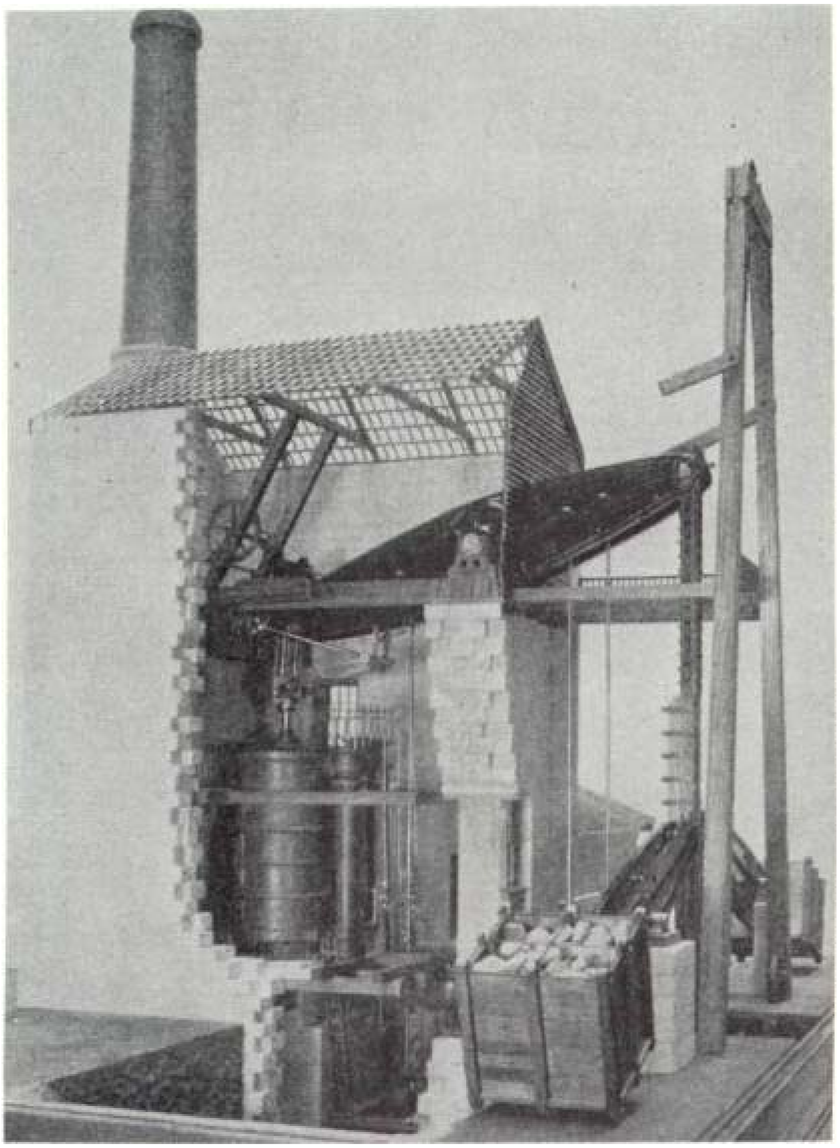
The Steam Piston and Side Rod

The need to convert the power of steam into a usable form of Kinetic energy had engineers stumped for years. Dating to the time of Ancient Greece, the energy in steam power was known, but this power was little more than a toy.

It may come as a surprise but the very first advance in steam engine design, that enabled the development of steam power and brought about the industrial revolution was the development of the 'steam cylinder' and 'coupling rod'. I wish I could go back to the early 1700s and put money into shares for locomotive cylinders and side rods!! We still have them in our car engines today!! The 'cylinder' and 'rod' were the conversion mechanism that enabled the power of steam to be converted into motion.

It was Thomas Newcomen who goes down in history as the first man to have made a successful application of steam to a piston and cylinder, and the translation of that power to a mechanism via a connecting rod. This engine dated to around 1712. This type of engine was developed to pump water from the lower levels of the coal mines of Northern England. I'll go into this engine a bit more when we talk about boilers in a couple of chapters from now.

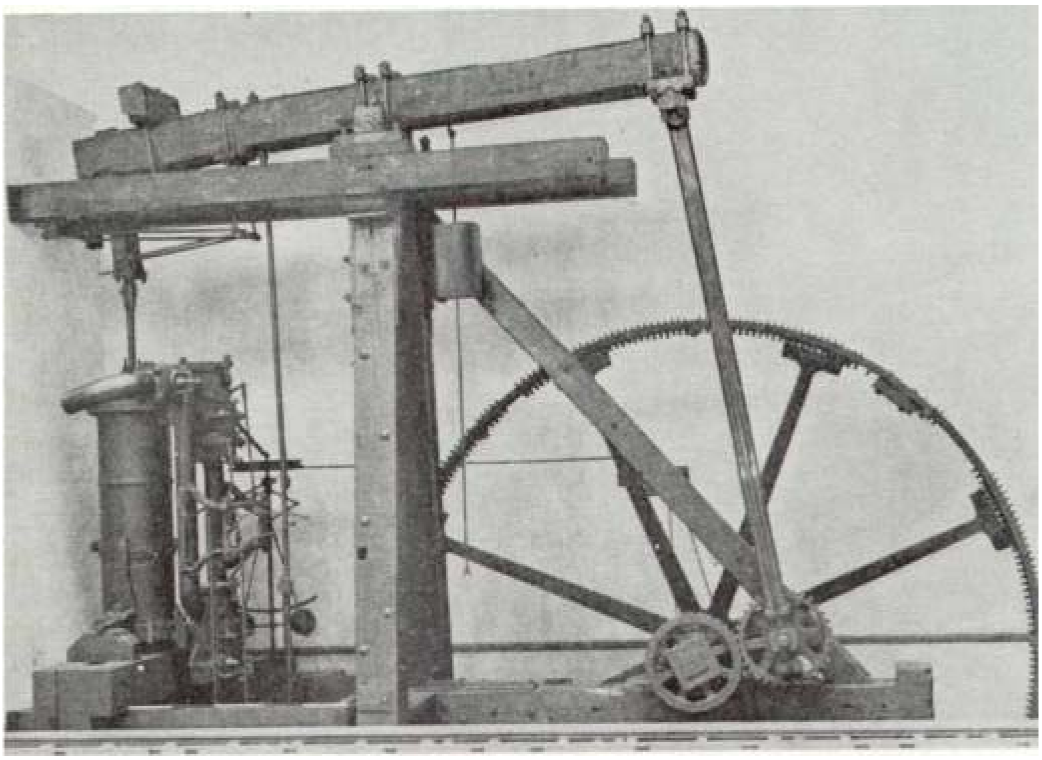
In the context of locomotive chassis design, Thomas Newcomen invented the locomotive cylinders and side rods!! The Newcomen engines were enormous contraptions, with a vertical cylinder powering a giant overhead beam. The piston would make the beam rock up and down, which in turn, connected to the water pump on the other end of the beam. The Newcomen engine looked a lot like a modern oil pumping device one might find in Texas or California. The engines were so large, the big overhead beam often protruded beyond the walls of the engine house. Visit Wales or northern England today, and you will still find the ruins of old Newcomen pump houses, with the large openings in the walls to let the beam pass. The Newcomen engines converted steam power directly to vertical motion.



Model of the Newcomen steam pumping engine - note the giant overhead beam protruding through the walls of the engine house.

Steam Power to Circular Motion

James Watt's involvement in the steam engine was more a role of refinement. Being an engineer, he was asked to repair a working model of a Newcomen engine for a British museum. Taking the model home to study it, he realized a number of inefficiencies in the engine and set about improving the machine. This would lead him to set up the world's largest steam engine company of that era with his friend Matthew Boulton. The list of improvements were many, but in particular, it was during the Boulton and Watt era, that the engine rod would be used turn steam power into circular motion for the first time. Watt's patent for the conversion of steam power to circular motion, was called the 'Sun and Planet' motion. Today we know the 'Sun & Planet' motion simply as the locomotive wheel crank. The Sun and Planet motion was rather a complex design for something so simple, rather than the rod coupling directly onto the wheel crank, the rod moved the drive wheel in a circular motion by meshing the teeth of a fixed cog on the end of the rod with another cog at the wheel hub. The wheel hub being the 'Sun' and the side rod cog being the 'planet' orbiting the 'sun' What a contraption for a wheel crank!! The Boulton & Watt engines would reduce in size as efficiencies were developed, enabling the engines to work faster, while maintaining the same power as the Newcomen engine.



A very typical Boulton & Watt steam engine with the 'Sun & Planet' wheel crank motion.

Note also in this picture the complex arrangement of levers along side the cylinder to the left, this is a very early valve gear. The vertical rod, coupled 1/3 of the way down the overhead beam, at the cylinder end is the valve rod that, while rising and falling with the beam motion, would lift and lower the levers at the cylinder side and this all came from the creative mind of a child!! Read on...

The First Valve Gear

…..was made from string. The fathers of the steam engine all failed to see the good that an automatic valve gear could do, they just didn't think of it. Unlike a modern automotive engine, the steam engine was always double acting, and steam was used to power the piston both directions in the cylinder. The Newcomen steam engine was a slow affair. It didn't use the power of expanding steam to move pistons, rather used the drop in atmospheric pressure associated with condensing steam. The pistons were 'sucked' back and forth, via the condensing steam from a tea kettle type low pressure boiler. For many years these engines pumped back and forth with the aid of an engine man, who stood by the machine. The engine would pump back and forth as many as 4 strokes per minute. Sloooow.. and at the end of every stroke, the engine man would pull 4 levers to change the flow of steam to the opposite end of the cylinder and enable the engine stroke in the opposite direction. You can imagine this task was poorly paid and VERY BORING!!

So it came to be that a young boy, named Humphrey Potter (Not Harry!!), was detailed for such a chore. Well kids will be kids, and he rather wanted to go off fishing, so he observed the motion of the giant beam working overhead, powered by the steam piston and realized the up and down beam motion was directly proportional to the engine stroke. Using lengths of rope, Humphrey tied the 4 valve levers to the giant overhead beam in the exact location where the beam's vertical motion matched the amount of vertical play required to move the valve handles. At the end of each stroke the beam would reach the end of its travel, pull the string, move the valve handles and automatically apply steam to the cylinder in the reverse direction. For the very first time, the engine was working itself!! And young Humphrey went off fishing for the day to come home later to learn he'd been fired or rather, had become one of the first 'redundancies' of the industrial age. The engineers were quick to apply this new technology to their engines, and so the first automatic valve gear was invented (see picture above.)

The First Steam Locomotive

The Newcomen and Watt steam engines were very large units. The whole steam engine filled a building, with the boiler often in a completely separate building. There was no way these large machines could ever be made compact enough to be mount on a frame and propel themselves as a vehicle.

Then there came a radical change in thinking, the atmospheric steam engines that 'sucked' the pistons were about to become history when a young fella by the name of Richard Trevithick began experimenting which high pressure boilers. When high pressure steam is released to normal atmospheric pressure, there comes an instant and powerful expansion. Overnight this new principle in engineering theory transformed the pumping engines for the mines. The Trevithick engines were many times smaller than the Watt engines, and could run 20 to 60 times faster. Even as early as 1802, Trevithick was building boilers with pressures as high as 145 lb, as compared to the Watt boiler pressure of 5 lb. We'll talk more about this when we build our locomotive boiler. Needless to say James Watt, with an exclusive Patent on the low pressure 'Atmospheric engine' did everything in his power to stop Trevithick's experiments, and declare high pressure technology too dangerous to use. Had Watt succeeded, the steam locomotive would have been delayed by up to 20 years. Watt knew the truth, his Patent was based on dead-end technology, he had gone as far as the system would allow. Think on it, all this happened nearly 200 years ago. It didn't take long for Trevithick to realize his steam engines were small enough to be mounted into a carriage and power the whole thing as a portable unit. In 1804, the world's first true steam locomotive self-propelled itself along rails for a Welsh mine, hauling 10 tons of ore, and 5 wagons loaded with 70 men, all at 5 mph!! In 1808, Trevithick built a similar locomotive for public demonstration and ran the 0-4-0 on a circle of track at the site of today's Euston Station in northern London. The locomotive had smooth flangeless wheels, and pounded down 'L' shaped rail. The rail broke, the locomotive overturned, and the first public steam Railway came to an end. So too did Trevithick's experiments into steam locomotives. While the Trevithick pumping engines had revolutionized the coal mines, Trevithick was just unable to prove a steam locomotive was cheaper and more efficient than horses. Almost broke, Trevithick began work on other, non steam related engineering projects.

The First Locomotive Chassis with Flanged Wheels

While Trevithick had proven a smooth wheeled locomotive could attain enough traction on smooth rail to be practical, the engineers who followed didn't follow that lead. The locomotives to follow between 1808 and 1813 all used various rack and pinion wheel systems and even cable type locomotion to wind a locomotive along a track. It was commonly thought that a smooth wheeled locomotive would have insufficient grip to even pull itself along smooth rails.
William Hedley's 1813 'Puffing Billy' began a new era. The locomotive was designed by Hedley and built by Timothy Hackworth, as an 0-4-0 with twin cylinders. The wheels were turned by a series of cogs connecting to the main rod crank. The locomotive also had the first flanged wheels to run on smooth rail.

William Hedley's 'Puffing Billy', 1813, Today this is the oldest steam locomotive in existence, London Science Museum.

The first smooth flanged wheels on a steam locomotive - 1813 William Hedley's 'Puffing Billy' London Science Museum.

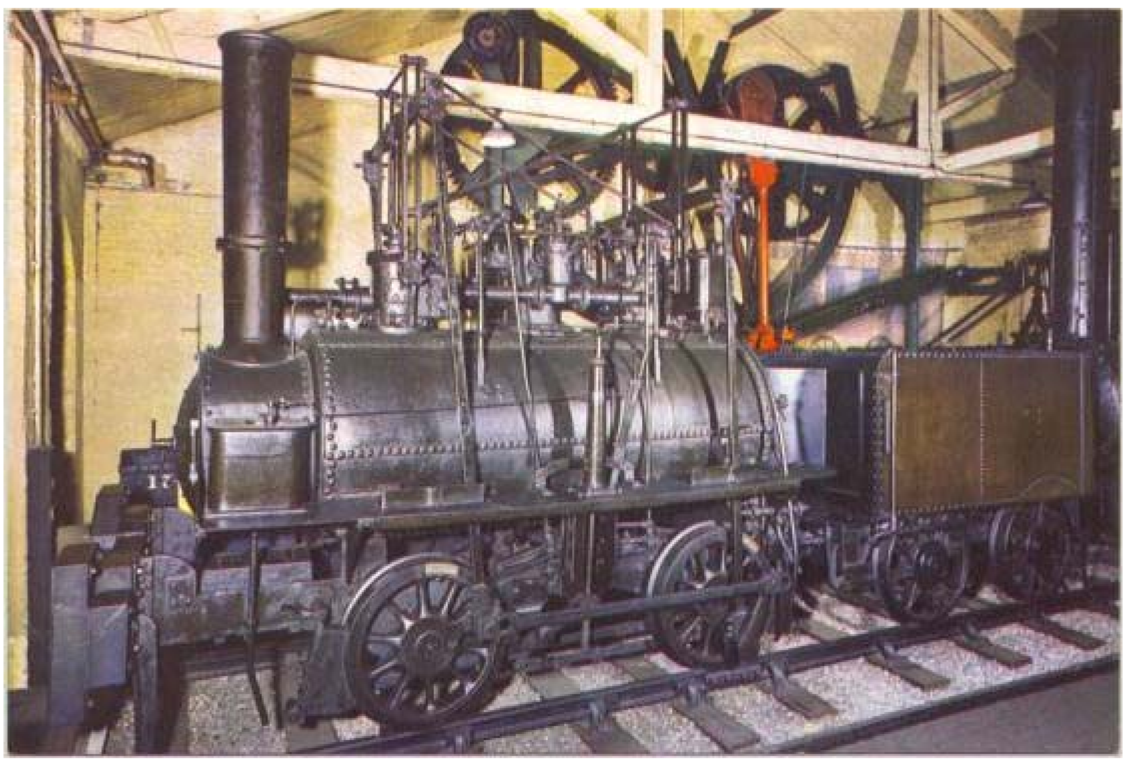
Puffing Billy was to prove a reliable work horse, and remained in service for 50 years.

The London Science Museum today is a hallowed place for the steam enthusiast. For there is no other place where one can see the origins of the steam locomotive in one room. On one side of the hall is the only surviving example of a Trevithick Boiler. About 15 feet from that exhibit you will find William Hedley and Hackworth's 1813 'Puffing Billy' in almost perfect condition, unaltered from its 1813 beginnings apart from the scars of time, and 10 feet from that is something entirely more important.

The Steam Locomotive and Reliability

George Stephenson is often incorrectly credited as being the 'inventor' of the steam locomotive. George was indeed one of Britain's great engineers. George did what Trevithick was unable to do - prove that steam locomotives could be more efficient than horses. By systematically hacking at the edges of locomotive design, George proved the basic concepts that made a locomotive reliable and worthy of development. Read a statistics book on the design of locomotive components and in every second paragraph you'll learn George was first to dream it up.

George was first to power driving wheels on a locomotive by rods, previously the rods powered internal gearing, which then powered the wheels. George invented the 'Loose Eccentric Valve Gear' which would evolve into the 'Stephenson Valve Gear' many years later. George was the first to couple multiple driving wheels together by using side rods.



A typical George Stephenson 0-4-0 locomotive, featuring side rod coupled driving wheels and direct main rod connection to the wheels. This two cylinder locomotive was built in 1822 as one of five similar locomotives used on the Hetton Colliery in County Durham. It speaks volumes for the George Stephenson design - Reliability. This locomotive was in service for 86 years, retiring in 1908, 4 years after the K-27s began life in the D&RG? Locomotive photographed at the National Railway Museum, York, UK. (I don't believe this locomotive is displayed there anymore). However, it is often said that George's best invention was to have his son Robert!!

The Rocket. A Revolution in Locomotive Design.

In a basement hall of the London Science Museum, sits a rusty, weather beaten, dilapidated 0-2-2 called 'Rocket'. It rests among the locomotives of later generation, almost a toy, and I'm sure many visit the hall, photograph the big polished 1923 GWR Castle Class 4-6-0, and not even notice this li'l 0-2-2. But should you visit this museum someday, pay your respects to the curious looking older locomotives there and in particular the 0-2-2 called 'Rocket'. There is not a Railway museum anywhere in the world that has an exhibit of more importance for there is not a single locomotive that is more significant to the history of the steam locomotive. The Rocket was not 'evolution' it was 'revolution'. In 1829 when her firebox was lit for the first time, she was so utterly different to contemporary locomotive design, she must have looked like something from another planet.

Robert Stephenson's Rocket, 1829. London Science Museum

We will come back to 'Rocket' though the chapters of this MasterClass, because many of the design features of our lil 2-6-0, along with every steam locomotive ever built since 1829 can be attributed to 'Rocket'.

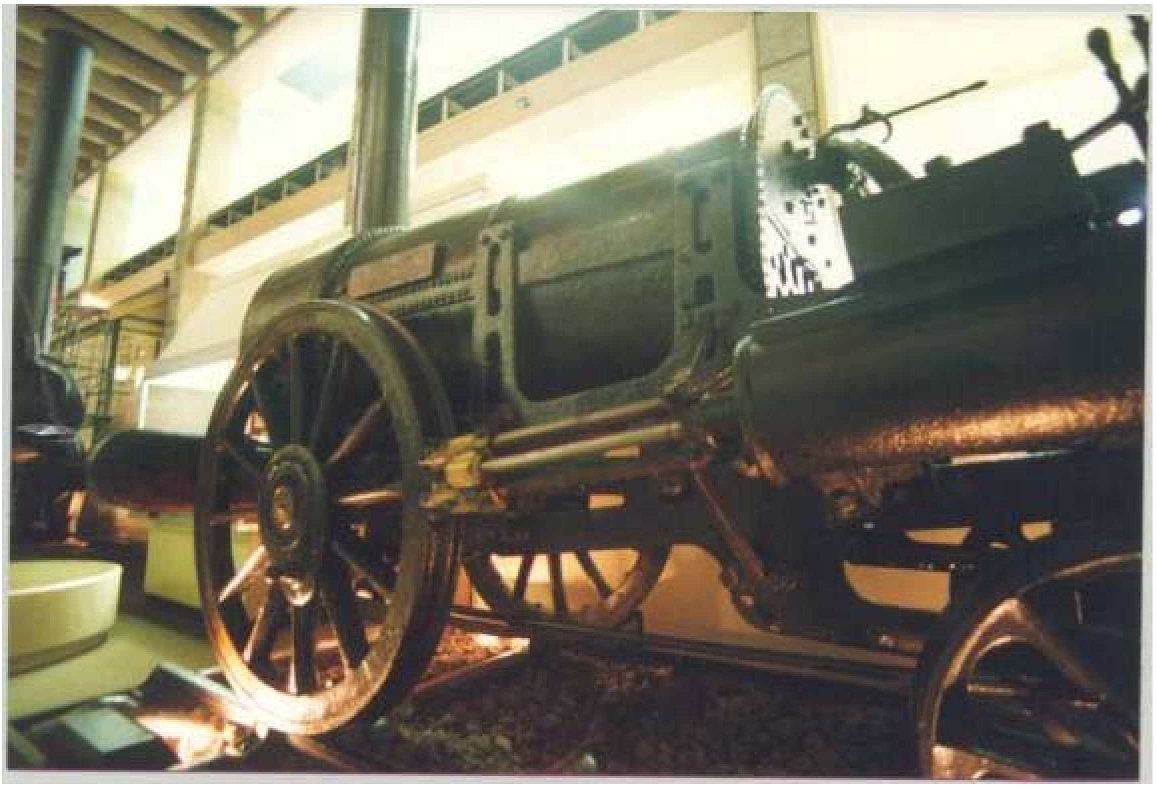
She was the work of George and his son, Robert Stephenson of Newcastle Upon Tyne. Prior to 1829, George had built a reputable engineering company, building steam locomotives, pumping engines and general engineering work, such as bridges and tunnels. His steam locomotives followed practices of pistons propelling overhead beams, which in turn propelled the side rods to turn the wheels. Locomotives of this time were contraptions of rocking beams, rods and wires. 5mph was the type of speed you could expect. While George had proven the reliability of the steam locomotive in industrial applications, no public railway had yet considered steam a viable option.

Railways were still unsure if the steam locomotive was a practical alternative to horses. In 1829 everything changed. The Liverpool and Manchester railway was setting up its 70 mile line between the two cities, and was calling for engineers to tender for the role of 'Chief Engineer' It was an unusual tender in the form of a locomotive competition to be held at Rainhill. The competition had two purposes, to test the reliability of steam power for this new line, and to appoint the engineering firm to be responsible for the line, should steam power prove to be more reliable than horses.

Strangely there were only 4 entries, but it wouldn't have mattered if there had been many more, the 'Rocket' won the trials at Rainhill on that October day in 1829, and steam locomotive design would never be the same again. The list of revolutionary features on this locomotive was extensive, and we shall note them as we come to them. In the context of locomotive chassis design, the Rocket had the successful application of direct coupling of the piston to the drive wheels, transferring power directly from the crosshead to the wheels. During the Rainhill trials, the Rocket averaged 29.1mph over the 1 3/4 mile test track.

The main rod, linking the crosshead to the wheel crank, reduced pounding on the rail head and more directly applied steam power to the wheel motion. The result was more speed, torque and less moving parts.

Speed and the steam locomotive were not words used in the same sentence. In fact during the days prior to 1829 it was commonly thought that any human riding a machine that could sustain a speed of 30mph or more, would probably have their face peel off in a most grotesque way. I should also mention here, when the Liverpool and Manchester railway opened for business a year later, 'Rocket' accidentally knocked over a pedestrian. The guy acquired the dubious distinction of being the world's first railway fatality, however this is only part of the story. The poor fella was rushed to hospital on the footplate of the 'Northumbrian', a similar 'Rocket' type loco, at the unprecedented speed of 36mph...a world land speed record. The guy did not survive the trip, but his face didn't peel off either.



Direct coupling of piston the drive wheel via the main rod and first locomotive chassis bar frame Rocket 1829. London Science Museum.

If you read the general history book, you will read that George Stephenson invented the 'Rocket'. There is no question that the locomotive was founded on Trevithick and Stephenson principles, but it was in reality one of Robert Stephenson's first steam locomotive projects. Fresh blood to a profession oft brings fresh ideas, so it was when 26 year old Robert took on the 'Rocket' project. Several of the Rocket's design features had been tested in a some form between 1828 and 1829, by Robert Stephenson on other locomotives, but Rocket was the first to have them all in one integrated package.

The most basic new design features were:

- Multi-tubular boiler
- Early 'smoke box' -first locomotive to use a draft system and blast pipe.
- Water jacket around firebox
- Direct coupling of pistons to wheel cranks
- First chassis 'bar frame'

Late in life, Robert Stephenson could reflect with pride on having been central to one of the largest steam locomotive factories of its time, and had taken the locomotive from a curiosity to a reliable machine. He had also exported locomotives to every continent in the world. There are few countries anywhere that can't say one of their first locomotives was a Robert Stephenson product. Yet sitting in a junk yard in the 1850s Robert was to find the remains of his 1829 'Rocket'. Nothing had given him more pride than winning the Rainhill trails so he bought the rusting relic from the yard owner with the intent of restoring her to the glory days. Robert died in 1859 and the rocket remains to this day unrestored. Do visit the Rocket someday.

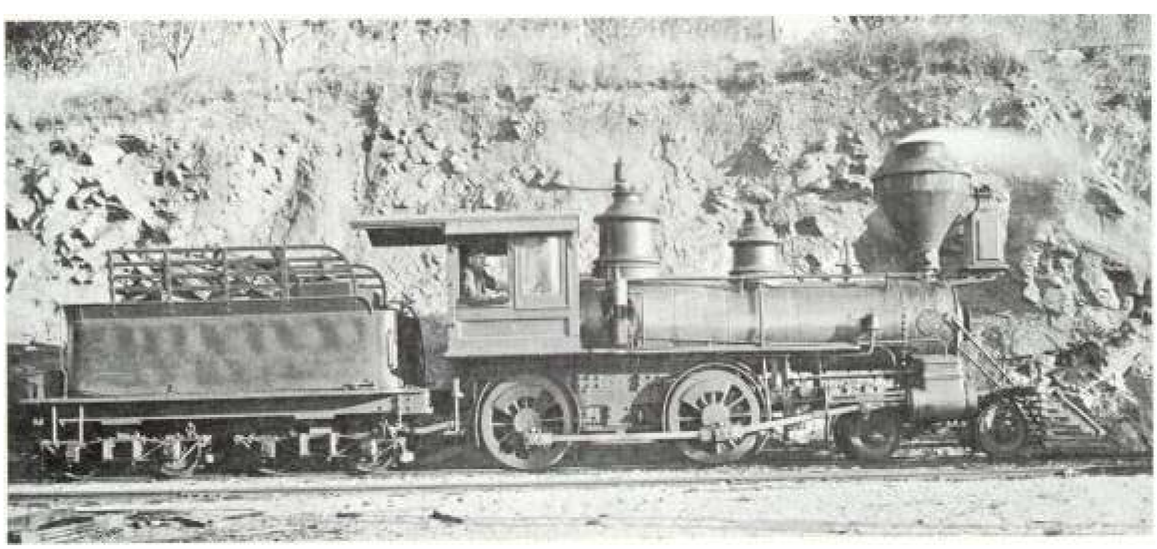
The Mogul 2-6-0

The 2-6-0 wheel arrangement has its origins buried in obscurity, no-one can be sure when the first loco really had this 2-6-0 wheel arrangement. What is certain is that the 2-6-0 gained recognition in the US. The first recognized 2-6-0 locomotive was built by James Millholland for the Philadelphia & Reading RR in 1850. The loco called "Pawnee" was a rigid framed loco, with the pilot wheels fixed to the frame. The famous pivoting pilot truck was still some years away.

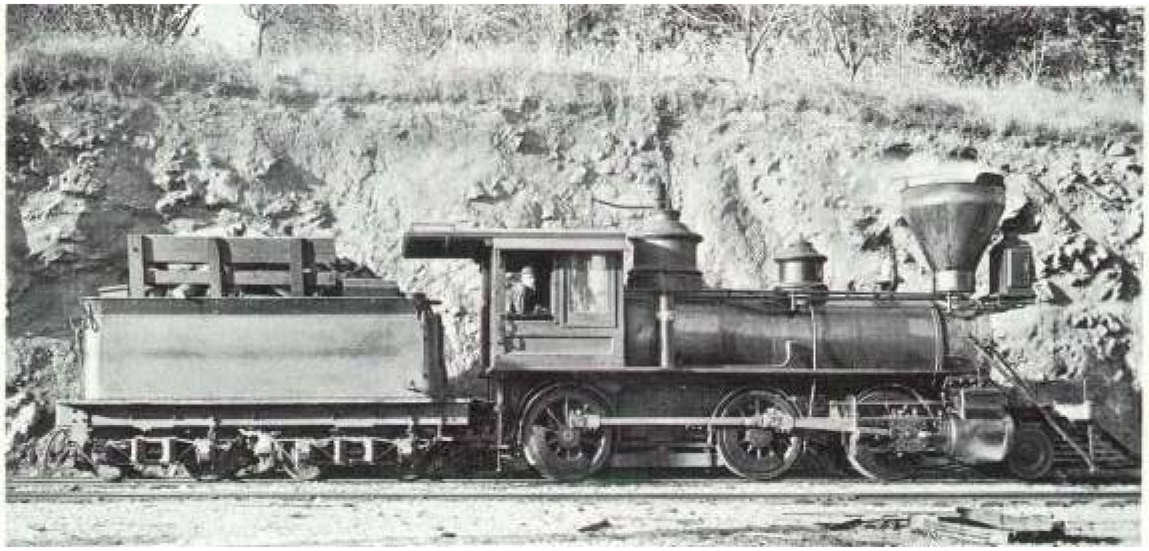
The 2-6-0 that we know so well, came about following the invention of the pivoting two-wheeled 'Bissell' truck in 1858. The first 2-6-0s with the pivoting pilot truck, to be known as the 'Mogul', were built by the Baldwin Locomotive Works, Philadelphia in 1860 for the Louisville & Nashville RR. By 1871, the 'Mogul' name was used in Baldwin advertisements for this type of loco. I don't know why or where the name really came from, although there are plenty of stories.

The Uneven Baldwin Style 2-6-0 Wheel Base Design

The 2-6-0 came about as a direct result of attempts to bring about more power in locomotive design. For more than 20 years the Classic 'American Standard' 4-4-0 had ruled the rails. Their equalized suspension allowed them to run on even the most irregular trackwork. It had long been known that the 4-4-0 was nearing it's maximum power output, and many were said to be underpowered for the growing demands placed on them. Engineers had tried in vain to add more driving wheels to the 4-4-0 to increase the power output, but the added wheels could never be successfully integrated into the equalized suspension system. By the 1860s, trackwork had improved greatly and Baldwin experimented with a type of hybrid or modified equalized suspension system. They took a standard equalized 4-4-0 loco, removed the 4 wheel pilot truck, and replaced it with the Bissell 2 wheel truck and added a 3rd driver set behind the cylinders...the result was a 2-6-0 with the uneven driver spacing. Now the 4 rear drivers were still equalized to the 4-4-0 design, while the lead pair of drivers had its own independent suspension. While this system was not as efficient as the straight 4-4-0 deign, over improved trackwork, the gains in motive power output, outweighed the lost of suspension efficiency. During the 1870s and early 1880s, the Baldwin 2-6-0 and 4-6-0 designs all had this uneven drive wheel setout as a result of the modified 4-4-0 principle.

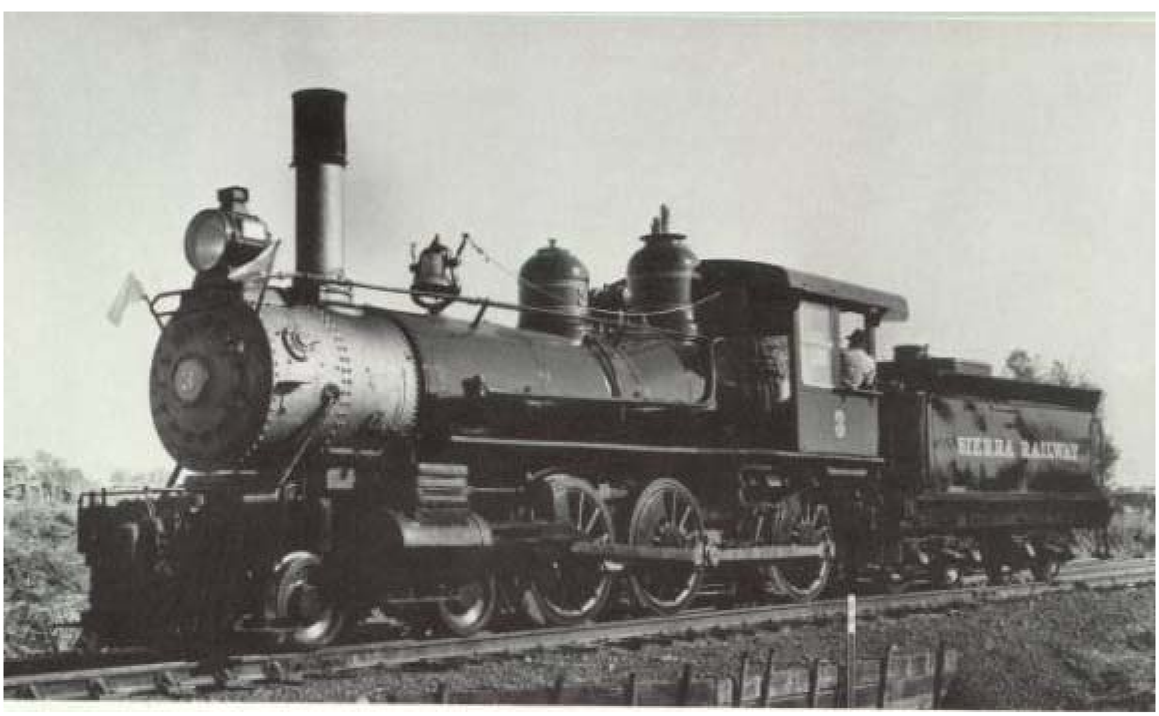


The typical Baldwin 4-4-0 of the 1870s



The early Baldwin Mogul 2-6-0 - a modified 4-4-0.

The 2nd reason for this uneven wheel spacing, which was also the reason for the 4-4-0 wheel spacing, was the need to maximize the grate area of the firebox. The larger the grate area, the better the firebox could breath and hence increase the efficiency of the boiler. The 4-4-0 design was perfect, it enabled an unobstructed space between the lead and rear driver set to hang a large firebox with suitable grate area. When the 2-6-0s were developed, the grate area was maintained by spacing the middle and last drivers apart, which meant pushing the lead and middle drivers together. The design similarities between the 4-4-0, 4-6-0 and 2-6-0 of this era enabled Baldwin to offer these 3 types of locomotive from the same standard 4-4-0 plan. The superstructures of the locos shared common parts. Many manufacturers of this era designed in like fashion and the uneven wheel spacing would be seen in many locomotive types. A classic survivor is the 1891 Rogers 4-6-0 #3, preserved at the Jamestown roundhouse of the Sierra RR California.



The 1891 Rogers 4-6-0 - Note the uneven spacing of the drive wheels.

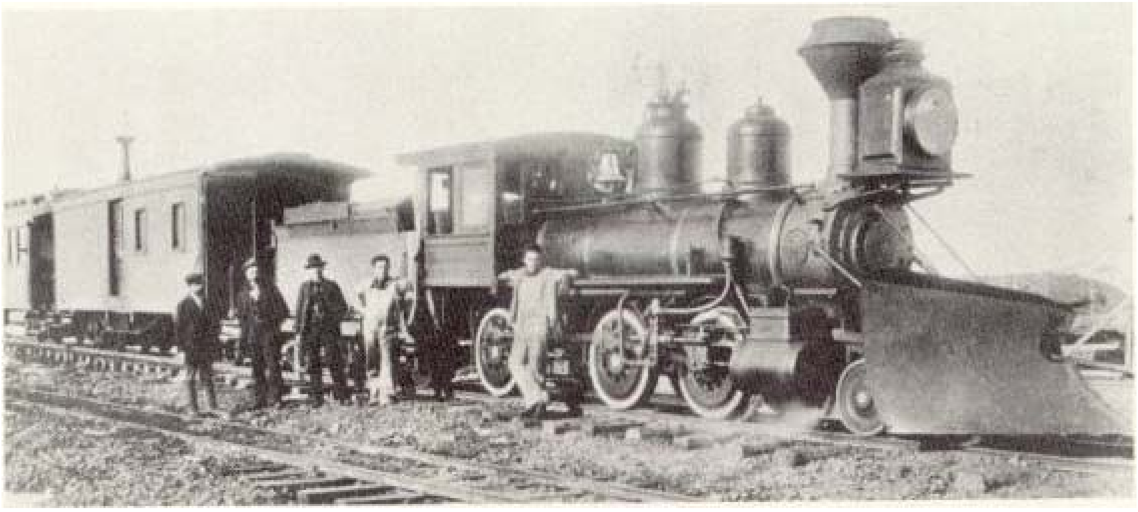
Even as late as 1890, the uneven wheel spacing was still prevalent. Like it or lump it, the uneven wheel spacing is one of the charms of early Mogul design.

The Clinchfield 4-6-0,1882, B&O Museum, Mt Clare, Baltimore.

The D&RG Class 47 4-6-0 (T-12), Baldwin 1883, Colorado Springs.

In a short number of years as locomotives grew in size, the 2-6-0 wheel spacing became more regular. The grate area and firebox rode above the frames, with varying success. The famous early Brooks Moguls of the Denver South Park and Pacific RR, 1878, which had more evenly spaced wheels, gained the nick-name 'Cold Water Brooks' for their poor steaming capability, due in part to a constrained firebox grate area.

As a finishing note to this 'background' section, I'll share yet another example of our cute lil straight boilered 1875 2-6-0. This example is our typical Baldwin loco, as seen on Canadian rails. The large snow plow adds another feature worth considering in your models, and also note the post 1890 rounded domes, signs of this locomotive having been upgraded at some point....stylish...damn stylish!!



Construction

Chassis Construction -Pt1.

May the winds favor your route, for you are about to embark on your locomotive construction.

This first week of construction will be fairly limited. I do not want to over complicate, or confuse this part of the chassis construction. I will keep the work in this chapter as simple and straight forward as possible. Everything you do during this chapter effects the successful outcome of the loco. The work in this chapter effects how well your locomotive will run. There will be no detailing in this chapter, no rivets, or styrene to cut and paste....all that comes in the next chapter. This chapter builds a solid and reliable base for a model. 'Build on the rock!!'. Take your time with the work in this chapter, do a lot of testing, run the block, tweak it, make it as smooth as possible to run. By not giving you more work to do this week, hopefully you'll confine your excitement to making the loco run better.

With every chapter in the Construction of the 2-6-0, I suggest you read the chapter in its entirely first, fully acquaint yourself with what's required. If you have any questions..any at all, please ask. Use the 'Model Making' forum at Mylargescale.com and I will answer your questions. Others will also be able to answer by outlining what worked best for them...share your problems and ideas.

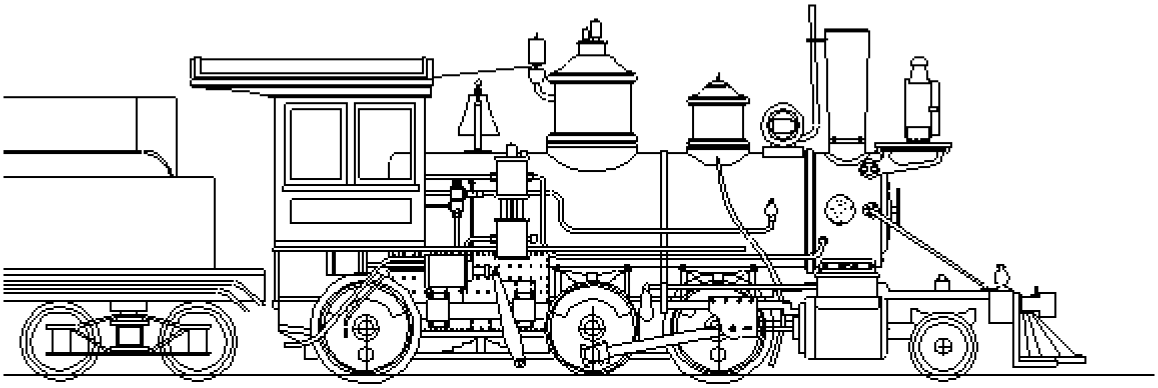
In this chapter we will:

1. Trim the Aristo C-16 frames and modify the detailing
2. Cut the Aristo C-16 chassis frame to fit lower over the 8 wheel drive block
3. Disassemble the Aristo C-16, 8 wheel block and turn it into a 6 wheel drive block for 2-6-0 application
4. Check the Aristo C-16 block for performance and improve the areas of deficiency.

Updated Locomotive Drawings

These two drawings are updated and are enlarged as far as this page will allow. Print this page and using a photocopier, enlarge the drawings to full size, follow the scale bar provided. (Editor's note, we're trying to get a PDF file so you can just print it off actual size. I have one on my wall and it's fantastic.)

Use these drawings to help set out the parts and details such as domes etc. The same setouts are appropriate to all era versions, so I have only included one 1:24 version and one 1:20.3 version here. When we get to tender construction, I'll provide a close up of the tender too.

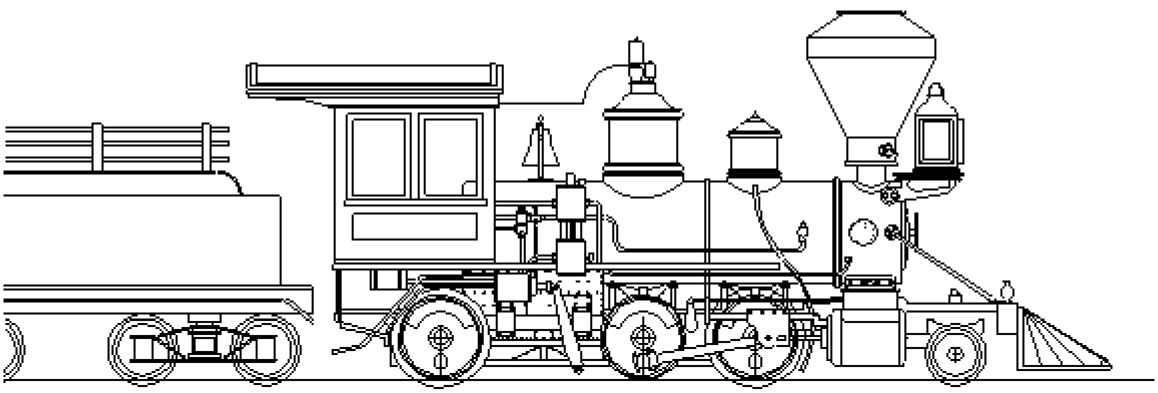


1920s MODERNISED CLASS 8-16-D, 1:24 SCALE

SCALE 1:1 0 50 100 200mm

0 1 2 3 4 5 6 7 8 INCHES

1:24 scale version



FREELANCE OLD TIMER, 1:20.3 SCALE

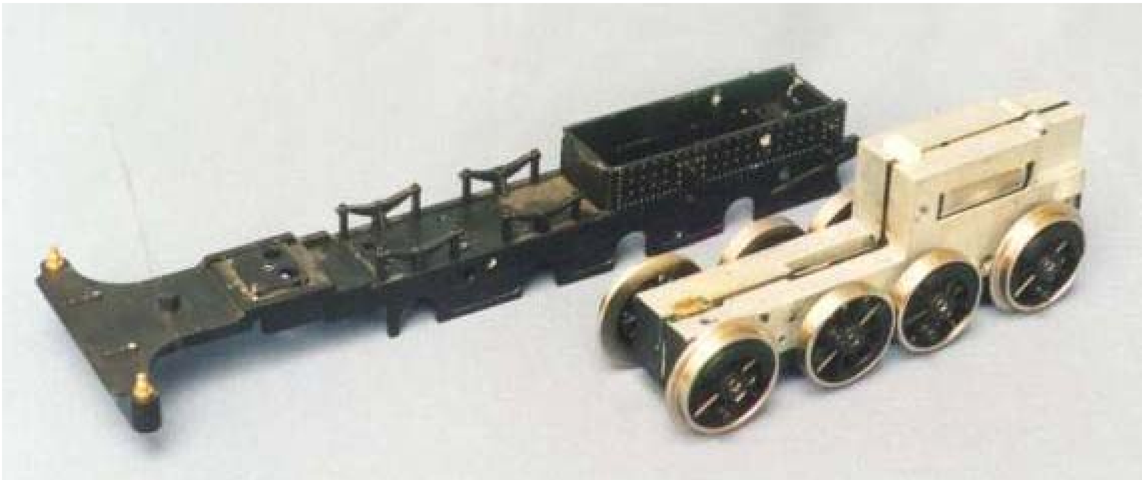
SCALE 1:1 0 50 100 200mm

0 1 2 3 4 5 6 7 8 INCHES

1:20.3 version

Trimming the Aristo C-16 Frames and Modify the Detailing

Here's where you get to use your razor saw, at last!! The two C-16 parts you'll be using in this chapter are these:



The C-16 plastic chassis frame (black) - The 8 wheel drive block (silver)

Pick up your C-16 plastic frames, feel the frames, be one with the frames!! Worship the frames!! You're about to cut a piece of Classic Delton locomotive history!!

Removing Unwanted Details from the C-16 Frame

Look at the diagrams below and note the extent of firebox rivets that are required. The 2-6-0 has a firebox that ends at the backhead line, near the front wall of the cab, while the C-16 backhead is near the rear end of the cab. The rivet detailing we require is forward of the 4th driver location, while the C-16 firebox rivets extend all the way back to the rear end of the frame. Using your modeling knife, slice the unwanted rivets off, gliding the blade along the side of the firebox, using the firebox surface as a guide. Once the unwanted domed rivet tops are sliced off, use fine sand paper to smooth over any remaining image of the rivets in that location.

There is also a stylish 'patch' on the side of the firebox between the 3rd and 4th drivers. This patch with rivet detail is one of the boiler/chassis clamps of the prototype. We will be making our own boiler/chassis clamps appropriate to a 2-6-0, so this C-16 version will have to be sliced off in the same manner as the rivets above. Carefully slice the 'patch' off using the knife, guiding the blade along the surface of the firebox. Use fine sand paper to smoothen.

Next we have to shorten the rear end of the chassis. Since this masterclass covers 1:24 and 1:20.3 scale versions, I have engineered the two versions to share as many parts as possible. I have designed the 1:20.3 version to have a boiler identical in length to the 1:24 version. Given the cab on the 20.3 version is quite a bit larger than the 24th scale version, it follows that the 20.3 version will require a longer chassis frame to support the added cab length. Thus the plastic chassis frames will need to be cut at different lengths depending on the chosen scale.

The 1:24 Scale Version

Mark out a perfect vertical line near the rear end of the frame on both sides, 93mm to the rear of the firebox front wall. Using your razor saw cut vertically downward, following that line. There is a horizontal brace between the frames you will need to cut though. Cut right though the brace, leaving most of it still attached to the wanted end of the chassis. Once the unwanted end of the chassis is removed, chamfer the bottom edges of the frames as shown on the diagram. This chassis length is arranged such that the rear wall of the cab will fall 2mm behind the frame end.

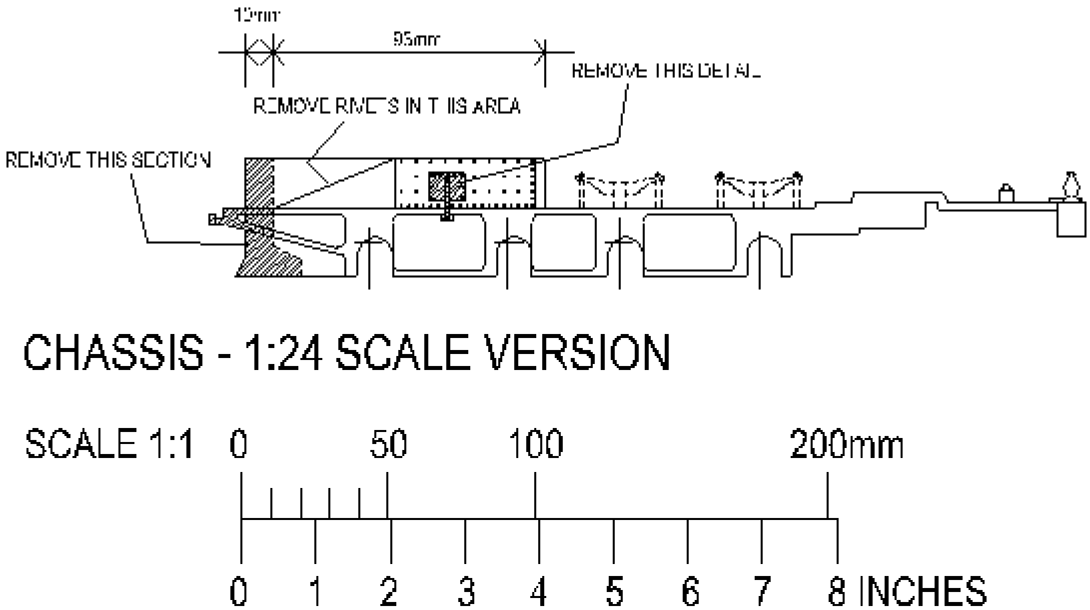


Diagram indicating extent of existing firebox rivets and clamp detail to be sliced off (repeat both sides) and extent of rear frame to be removed for 1:24 scale version.

The 1:20.3 Scale Version

The existing C-16 frame length is almost perfectly the correct length for the 20.3 version, and as such we only need remove the bars protrubing past the end of the main frame. Cut these off using the razor saw as indicated on the diagram. Remove the lower ash-pan sides as indicated. Our 2-6-0 does not have a firebox extending that far back, so there will be no ash-pan to see there.

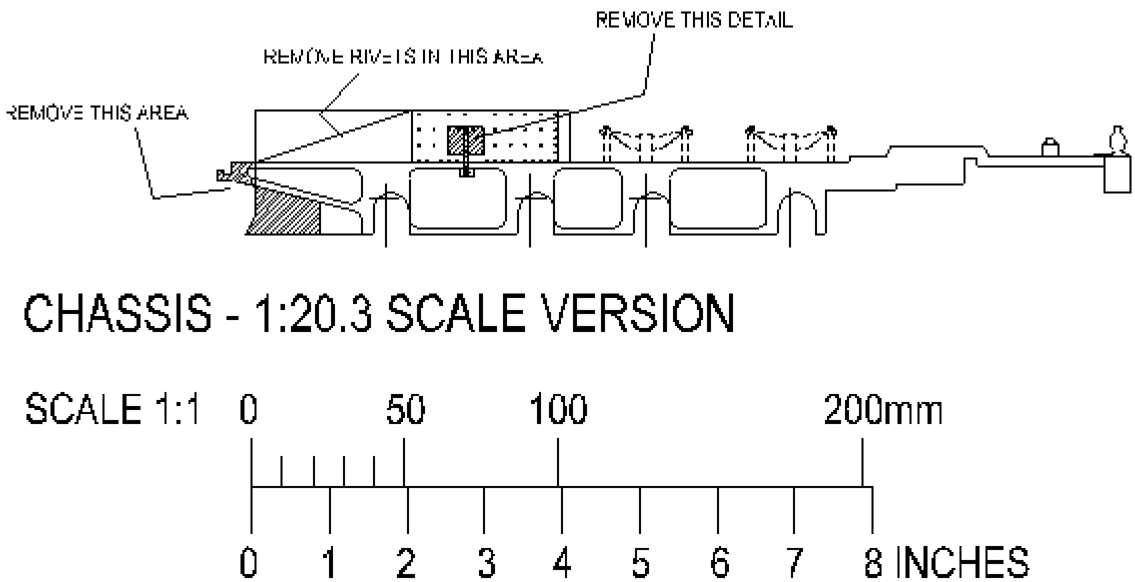
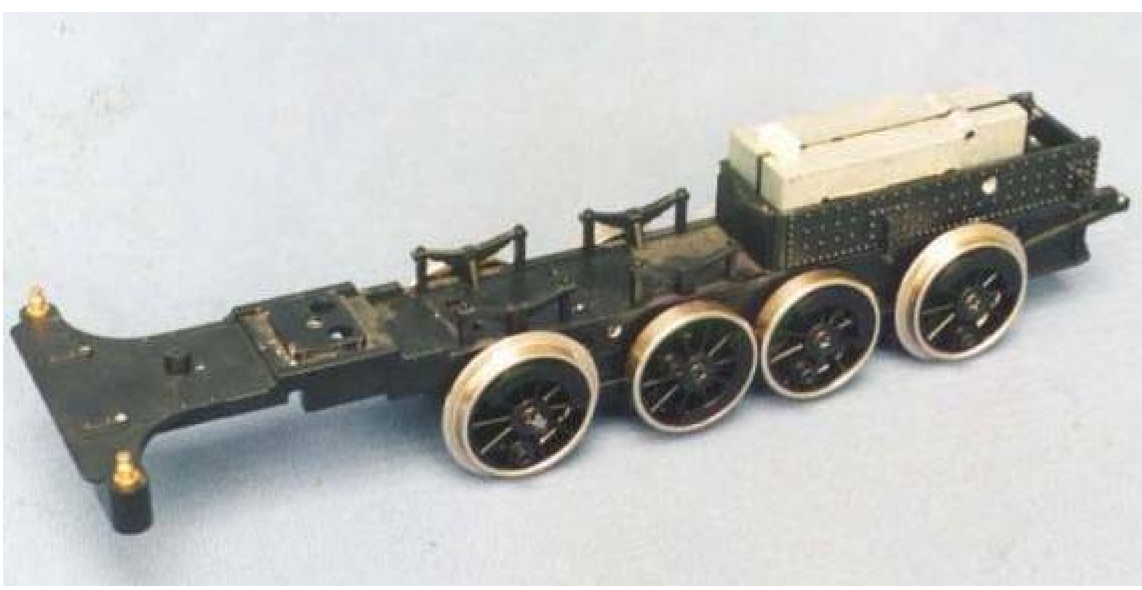


Diagram indicating extent of existing firebox rivets and clamp detail to be sliced off (repeat both sides) and extent of rear frame end to be removed for 1:20.3 version.

Fitting the Aristo 8 Wheel Block into the frames.



The block inserted into the frames.

The Aristo C-16 frame sits snug over the 8 wheel block. Go ahead and fit the block into the plastic frames.

The taller 'rear' part of the block fits into the raised 'firebox' end of the plastic frames. Push the block all the way into the frames from below as far as you can make it go. The black spray painted line near the bottom of the metal block should align nicely with the bottom edge of the plastic frames...you will notice in this position the metal block is a full 6mm lower than the bottom of the frames. This is the bit we have to correct. Now in this position, without change, the loco will ride too high. In many loco bashes it would be possible to use the Aristo frames and block without change, but for out lil 2-6-0, the loco will end up 6mm too tall. It doesn't sound much, but it really mucks up the looks of the loco. So lets not squirm out of it, lets lower the frames and get the whole chassis nicely setout so the model looks correct from the outset.

Lowering the frames is a simple procedure, but done wrong could be a disaster, again, it's a good thing we do this first. If you muck it up, go ahead and get another frame before proceeding with the rest of the model. Take your time with this, cut carefully, work at it a bit at a time, at times the chassis will become fragile so take care.

The work carried out in this chapter is perfectly appropriate for other models that may use the Aristo C-16 chassis, in fact, if you want your Aristo C-16, 2-8-0 to look right, with all the correct rod motion and low slung appearance, use these instructions to lower your C-16 as well.

George Schreyer also covers much of the C-16 lowering info in his fabulous web site. Go and check it out, the more you read about the work required in doing this modification, the better.

Here is George's C-16 site, go to 'Lowering the C-16'
http://www.trainweb.org/girr/tips/tips5/c-16_tips.html#inside

Lowering the Frames

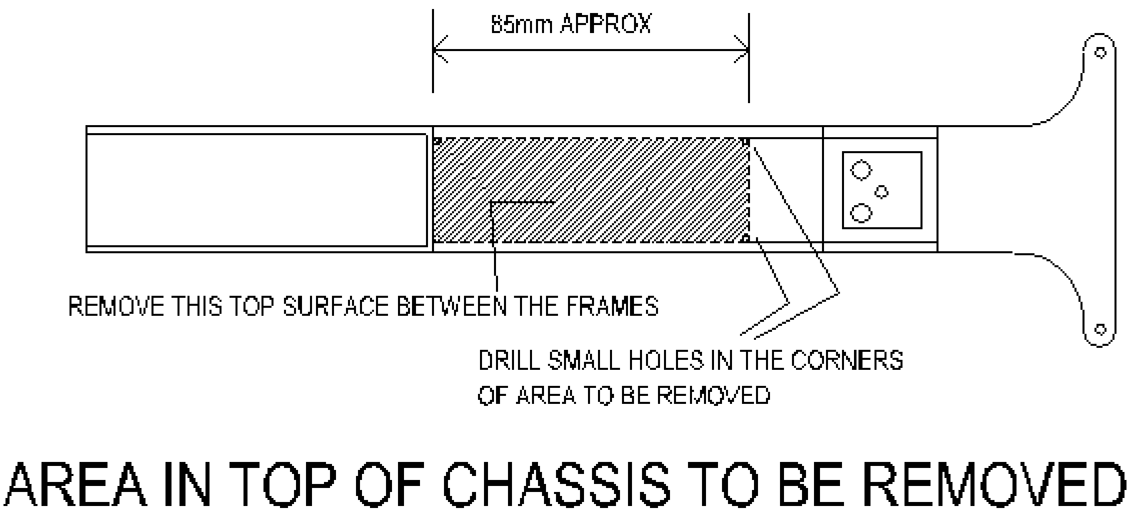
Step 1

Very carefully cut the 4 leaf spring units off the chassis, from the top the forward end of the chassis. Cut them off clean and flush with the chassis top, we'll be re-using these springs, so don't damage them. Carefully cut them off at the base using a modeling knife, using flat top surface of the chassis as a guide.

Step 2

Insert the 8 wheel block again into the frames, take a note of where the forward end of the block rests relative to the frame top....we need to cut out the whole top of the frame from the front of the block, back to the forward wall of the firebox. You will notice the forward end of the block is exactly 85mm from the front wall of the firebox. When this rectangle of plastic area is removed from the top of the frames, it will allow of the top of the block to pop up through the top of the frames enabling us to 'lower' the frames further down over the block.
Drill 4 small holes (1.5mm dia) in the corners of the area to be cut. We will often drill very small holes at the ends of lines to be cut. We do this as a guide to know where to cut to and from, and also to stop splitting of the plastic beyond the cutting area. A nice round hole will prevent future cut lines continuing to split further than you intended. You will see the area to be removed is 3mm inside the outer edge of the frames, and there is a nice recess to locate the cutting line. Drill the first two holes right in front of the firebox wall, nested next to the 3mm outer frame lines.

Drill the other two holes directly in front of the forward end of the block, and again nested next to the 3mm frame molding on top.



Plastic rectangle in top of chassis to be removed.

Now cut the area between the 4 drilled holes with a modeling knife. Carefully score along the edges of the 3mm molding on the top of the frames, each pass, cut deeper until you cut vertically though the 2mm thick plastic on top. Cut also between the two drilled holes at the front wall of the firebox and between the drilled holes at the forward end of the frames. It will take 5 or 6 passes with a sharp modeling knife to cut though the plastic. Don't rush it, be precise.

When the top is removed, carefully flush the inside face of the chassis frames, such that the cut edge is perfectly smooth and flush with the inside face of the frame..thus allowing the block to glide though.

Step 3

We have to decide how far to lower the frames over the block. This is governed by the height of the wheel bearing arches in the frame and also the amount of plastic at the base of the front firebox wall.

To make the perfect height, we need to lower the frame a full 6mm. This will put the bottom face of the block in line with the bottom edge of the frames. It will also, by default, put the cylinder centerline and piston crosshead exactly in line with the wheel hubs. However, I have a **Caution and Warning** here, at the full 6mm lowered position, the exposed Stephenson valve crank can bind with the 2nd driver, the piston rod can bind with the cross head guides and the tip of the Aristo long wood pilot can drag too low to the rail head and get caught in switches. It's a touch and go scenario. The real solution is to move the whole block rearward 2mm as well. That pushes the block away from the Stephenson valve crank, and allows the piston rod a lesser up and down angle, thus missing the cross head guide. This also happens to be the location of the wheels on the original Delton C-16. Some of you have done this full lowering and rearward push of the C-16 block previously and I don't mind you going ahead and doing that here if you wish.

The drawings of the loco provided show the wheels in the frame, lowered the full 6mm and pushed 2mm rearward.

For this Masterclass, however, I'll agree on a minor compromise. We'll lower the chassis only 5mm....1mm shy of the full amount...whoa you say, big deal!! This will avoid the binding of the main rods, and valve crank, and will also lift the pilot tip out of trouble later on. Here's another tip of wisdom!! Some of these early NG locos were so small, their cylinders nearly dragged on the ground. Take a good look as some of these early locos, and you will discover the piston center line was sometimes a tad above wheel center line, just enough to raise the cylinders out of harms way, but not enough to compromise the piston stroke or power angles, this is the chassis height we'll be aiming for with our 2-6-0.

OK that being decided, the next step is to remove a full 5mm from the front firebox wall...remember to measure the 5mm from the inside face of the chassis...or about 3mm above the top face of the chassis in front of the firebox wall. Carefully cut out this small rectangle of plastic...its kinda hard getting the knife in where you want, take it a bit at a time.

Step 4

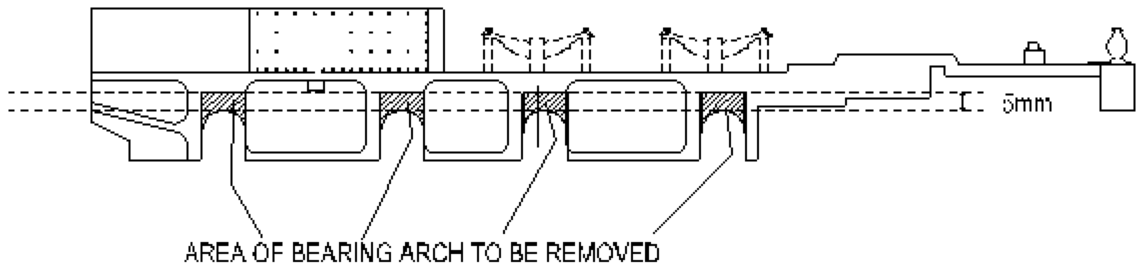
Next we need to increase the height of the wheel bearing arches, to enable the block to slide further into the frames. There is an **easy** and **hard** way to do this!! The chassis after steps 1 & 2 is already weakened with so much plastic removed. The work to enlarge the 8 bearing arches will put some stress on the. The **easy** way places minimal stress on the frame, but is visually less desirable. The **hard** way requires much sanding and filing with greater stress on the frame. The frame could break while carrying out this work. Should the frame break, it will be hard to repair as there is very little plastic area left to patch the frame.

Now it could seem more logical to enlarge the bearing arches prior to steps 1 and 2 above, thus work with a stronger frame in the first place. A reasonable thought, however, the act of removing the top of the chassis after the bearing arches are enlarged will definitely place more stress on the frame and the frame is likely to break right in front of the lead wheel bearing snapping the whole front end, from pilot to boiler saddle, right off!! You must choose the **easy** or **hard** way!!

The easy way.

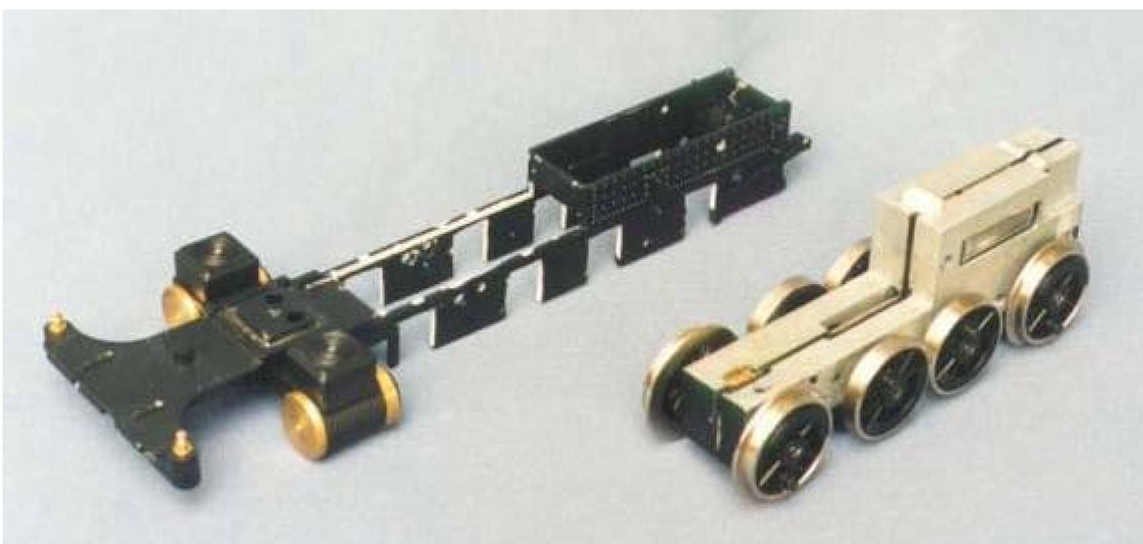
Mark out a horizontal line 5mm above the bearing arches. Measure from the top tip of the arches. Use a pencil to mark, and mark one side of the chassis at a time. Then use your modeling knife to score a line above of each bearing arch to the full width of each arch. Again drill a small hole at the end of the score line to prevent further splitting along that 5mm line.
Next, using the existing vertical lines of the arches as guide, cut a perfectly vertical line from the chassis base to the scored line, using a razor saw or 'jeweler's saw'. **DO NOT CUT PAST YOUR SCORED LINE.** You can stop sawing just shy of your scored line is you wish. Using your knife score along the horizontal line again a couple of times. Using long nose pliers, bend the wheel arch inward, it will fold at the scored line, 5mm above the arch. Bend the wheel arch in and out a couple of time and the fold line will crack and plastic break free. You should have a perfect rectangle in the wheel arch area now with the top of this rectangle exactly 5mm above where the bearing arch used to be. Repeat this for each of the 8 bearing arches. We will do all 8 wheels, even though our loco will be a 2-6-0. The reason is that the cast metal bearing area of the block

will punch though the frame in all 8 bearing arches, even when no 3rd driving wheel set is used. We will clad over this exposed bearing in Chapter 3.



BEARING ARCH EXTENSION

Area of bearing arches to be removed on both sides.



Here is the finished work of step 1, 2 and 3.. The top of the frame is cut out, and a 5mm patch at the lower edge of the front firebox wall is removed .and there are 8 rectangular bearing arches. If you insert the block into the frame, the block should slide right in, until exactly 1mm of metal block is left protruding below the bottom edge of the frame.

Here is the block inserted into the frame.

Directly behind the 3rd driver bearing on the frame is a small hole. This is the screw hole used to screw the frame to the block. Measure a point exactly 5mm above this hole and drill a new hole to the same diameter. When the block is inserted, the frame will be screwed to the block though this new hole. If you look hard at the 8 wheel block, you will notice a very similar 'tapped' hole in the block directly in front of the 2nd driver. This is also a frame fixing point. Aristo found this fixing point redundant because of the snug fit of the block in the frame. They only used the rear fixing holes. Because the front end of our frame is so much weaker than before, you might like to drill a hole in the frame to correspond with the forward block fixing holes and fix the frame to the block in all 4 points. This will add much strength to the frame.

For the concerned masses....the frame does appear to flex altogether too much at the front, and you might think it would break right off after the loco's first head-on crash. I must point out, the frame gains much strength when the boiler is mounted to the frame...it becomes rock solid in fact. Just be careful handling the weakened frame until the boiler is mounted.

The Hard Way!!

The hard way is a finer way of doing the above. Instead of scoring a line 5mm above each bearing arch and sawing up to that line, to cut out a rectangle, we use a round metal file to grind the bearing arch to a height 5mm above the existing position. Basically we copy the existing shape of the arch to a new location 5mm above the old. The outcome is the same, however, more care is required. Should you peer though the spokes of the driving wheels, the hard way provides a cleaner finish.

Step 5

Using solvent glue, re-attach the 4 leaf spring units cut off in step 1. Glue them directly to the top edge of the frame, exactly center of the wheel bearings. You will need to cut off the rear plastic support on each spring to make the rear of the spring flat, such that the metal block will slide past these units without snagging them on the way though.

Conclusion

We now have a fully lowered 0-8-0 chassis, ready for detailing and conversion to 2-6-0. We shall detail the chassis in the next chapter. For now however, drop the block back out of the modified frames and we'll proceed to work on the block itself.

Turning the Aristo 8 Wheel Block into a 6 Wheel Block

Take a look at the block design. It is an 8 wheel affair, with the 1st and 4th driver driven via worm gears on a long drive shaft. The drive shaft is turned by a reduction gear at the rear end of the block, connecting the motor to the drive shaft. The 2nd and 3rd driver sets are free wheeling, power supplied only via the side rods. The whole block is made up of two cast metal halves, separated by a 2mm thick plastic insulating panel. The two block halves carry the +ve and -ve supply between the wheels and the motor. As such the whole metal block is electrified. The wheel axles are split with a plastic central insulator in the form of a plastic gear wheel. Notice all 4 axles have a central insulating gear wheel, even the 2nd and 3rd axles which are not driven. (you've won a couple of spare gears for future use in the event of any gear stripping!!).

This type of split axle design is becoming more and more popular among the American manufacturers. The advantage is a much more continuous and robust electrical connection between wheels and motor. No more burned out elec wipers or contacts, as the whole chassis is the 'wiper'. The disadvantage is that the split axles, with wheels screwed on from the outside hubs, have a tendency to be bent, causing wobbly wheel syndrome or even a 'buckled' wheel effect. The best manufacturing system is one which enables the workers to either put the parts together 100% correctly, or have the parts not fit together at all. This type of design results in quality products every time. The split axle/block design has too many variables, too many fixing points, and too much latitude to enable straight axles and wheels on every model. Thus I've yet to see an Aristo C-16 block that does not have 'buckled' wheels. Also the split axle system employed on the Spectrum models, such as the 4-4-0 and 2-6-0 suffer from the same problem. Look hard at the wheel hubs on such models and you'll see they almost rotate in an eccentric motion relative to the true axle center point. It's a shame these models don't run as smooth as they could, but the upside is greater reliability. As a side note, LGB's early chassis block design were not unlike this type of design, with sandwich blocks and wheels screwed on from the hub. Since the mid 80s, this design was phased out, and smoother running models have followed. I'm not making an editorial here, just providing some explanation as to why many of these split axle models, don't always seem to run as smooth as they should.

So now to working with the Aristo 8 wheel block. The first thing to do here is power up your 8 wheel block. Make sure the main side rods are attached, so that all 8 wheels are powered. Place the block onto a 2ft length of rail, and apply power to the rails. Next create a metal contact between the 1st and 2nd...as well as the 3rd the 4th, pin in the plug on top of the block. This should complete the circuit and enable the wheels to turn under track power. A better way is to try and obtain the female end of the 4 pin plug and wire the pins together as noted. Hold the block to stop it running away and watch the wheels turning from above. You'll be initially surprised at how 'wobbly' the wheels appear to be. Yes, nearly all 8 of the wheels appear 'buckled', causing the block to waddle, rock n' roll and bounce from side to side...not a good basis for a nice loco. Don't worry we will fix that. Look hard at the 2nd and 3rd driver sets (the blind ones). The object here is to note which of the 2nd and 3rd driver sets are least buckled!!. You will shortly be removing the 3rd driver set altogether, creating the uneven spaced 2-6-0 wheel setout by default. All I'm suggesting is that when the block is taken apart, you may want to switch the 2nd and 3rd driver sets, such that the better of the two axles occupies the 2nd driver location on the finished model helping to smooth the rough ride of the chassis.

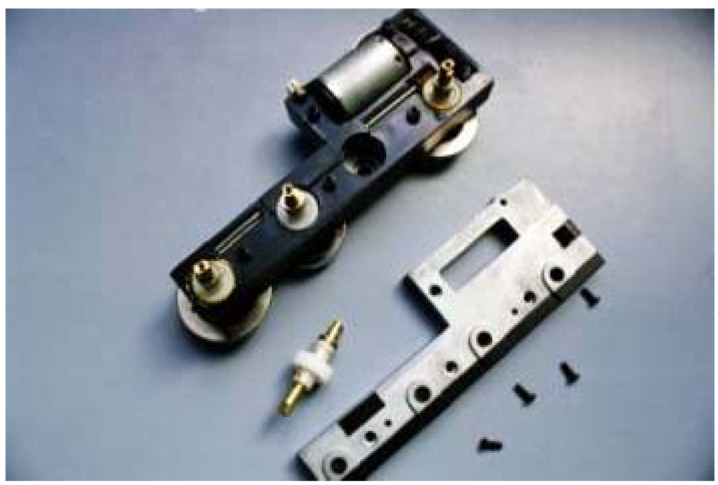
The 4 pin plug on top of the block.

1. Remove the side rods and store away.
2. Remove the Philips head screws to both wheel hubs on the 3rd axle
3. Remove the hub screws to the remaining 3 wheels on the fireman's side only. (no need to unscrew the wheels on the other side)

4. Using a flat screw driver, very carefully pry the 4 wheels off the axles on the fireman's' side and 3rd driver only on the engineers side. Use the screw driver to lever the wheels off from the rear. There is a metal circlip on the rear of the wheels, which screw onto the rear of the drivers, and slide onto the axles. These metal circlips are the power connection between the metal wheel tires and brass axles. Be sure not to damage these circlips. Use the screwdriver to push to the circlips up off the axles, while working the wheel off the axle by hand. Store the 5 wheels away.

The metal circlip on the rear of the wheels...do not damage this!!

5. Remove the 4 black screws holding the two halves of the block together, unscrew on the fireman's side only. Lift the fireman's half of the block off the remainder of the block. The block is now in half.



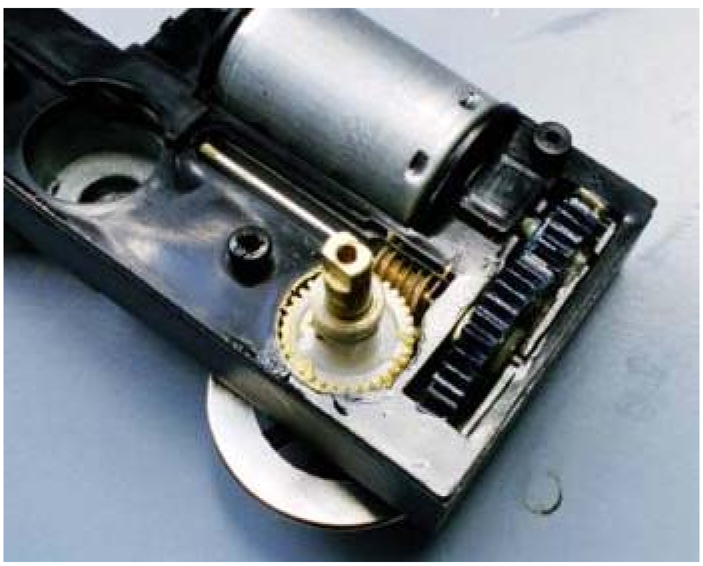
6. Lift out the 3rd axle completely. Remove the nylon bearings in the 3rd axle bearing holes in both block halves. We don't want these lil bearings floating freely around the inside of the block causing damage in future. Swap the 2nd and 3rd driver axles around at this point if you find the 3rd wheel set was a smoother runner than the 2nd.


The two nylon and two brass bearings removed with the 3rd axle.

This is all we do to turn the 8 wheel block into a 6 wheel block at this time. Before we reassemble the block and reinstate the wheels, we'll examine the function of the gears.

Check the block for performance and improve the areas of deficiency

1. Check the amount of lateral slop in the reduction gear at the rear of the block. You want the reduction gear to run freely about its axis, not bang from side to side. If there the gear can move from side to side too far, the block will have grinding noises as the gears mesh improperly. You can add a nylon washer to space the gear and stop it sliding side to side. This will also quiet the block down somewhat. If this cog is firm, then you're 100% AOK.


Reduction gear is the larger of the two black cogs at the rear here.

2. Next using a flat screw driver, check the amount of lateral play in the worm drive and shaft over the 1st driver. When the loco goes from forward to reverse, you do not want this worm drive slipping from side to side over the axle gear. Again grinding noises will occur. The worm drive is held in place by the drive shaft running though the central insulating plastic right behind the lead drive wheel set. If the shaft is loosely held in this mounting, the worm will have too much lateral play over the lead axle gear. You may want to pack the plastic mounting at the drive shaft bearing, to hold the shaft more firmly. Use some of your .5mm styrene sheeting, cut slithers and pack them into the shaft

bearing area...do not make the bearing so tight that the shaft doesn't want to turn!! This will now make the block run smoother and quieter.

Insert a slither of styrene to pack the worm shaft (hidden in the block aft of the worm). Stop that worm gear from being able to slide side to side over the axle gear.

3. Grease the reduction gears at the back of the block and the worm gears too. After we re-assemble this block, you will not be wanting to go back in there to grease it again for some years.
4. Re-assemble the two block halves and re-insert the screws to hold the halves together.
5. Apply power to the motor again by connecting the wires directly to metal block halves. Check how smoothly the reduction gears and worm drive shaft run, watch for lateral play. The cogs and gears should run true, no lateral slop.
6. Carefully press the 3 wanted drivers back onto the axles on the fireman's side. Make sure all the wheel cranks are facing the same way on both sides on the block, and make sure the cranks are 90 deg relative to each other on the same axle. If the 1st and last (3rd) driver cranks are not angled the same way, you will need to take the block apart again, and move the lead axle around a little, disengaging the gear from the worm, until the cranks are directionally matched with the rear driver set.

At this point you'll have a 6 wheel block with wheels fitted to the 1st, 2nd, and 4th bearing holes in the block. The 3rd bearing hole is left exposed.

The re-assembled block, now an 0-6-0!!

Next place the block back on the rails and apply power again. Hold the block down and watch the rhythm of the wobbly wheels!! This is our next target.

Finishing Up

7. Check the metal flanged and blind wheel tires. In most cases these metal tires are just pressed onto the plastic drivers. They slip off easily and they can also very easily slide out of 'plumb' relative to the wheel centers. Press the tires firmly onto the wheel centers from the rear of the wheels, get those flanges parallel to the wheel face...no wobbly flanges!! Apply a bit of force to the rear of the metal tires, really PRESS them onto the plastic centers. You can hold these tires in position with a drop or two of CA glue (super glue) if you wish...make darn sure you're not gluing them out of plum!!

8. Once you're happy the tires are true relative to the plastic wheel centers, we next target the fixing of the wheels to the axles. Check the running of the block again, holding it against the rails. Take note of which wheels seem 'buckled'. Take out the philips head hub screw on these 'suspect' wheels and pry the wheels part way off the axles. Check the rear bearing point, where the rear wheel hub rests against the brass axles. Look for brass flash and plastic dags that could prevent the wheels from pressing onto the axles properly. Clean the rear hub areas and press the wheels back on very firmly. Screw the philips head screws back in real tight. Check the performance of the block again. If the wheels are still 'buckled' the problem is in the axle not being straight. ie the axle is a 'V' shape with a bend where the insulating gear wheel is fixed at the center of the axle.

9. The insulating gear has some flexibility in it. Very slowly run the wheels again, and watch where the wheel's inside surface wobbles close to and away from (high point) the block sides. Make a note of where the 'high' point is, use the wheel crank as a guide to locate this 'high' point. Next hold the block in your hands and using your fingers apply a small amount of force on the driver 'high' point, bending it back toward the block and hopefully evening out the 'buckle' in the wheel. Do this over several tries, turn the wheels slowly by applying track power and watch for the wobbles in the wheels, then try and bend the wheels back straight where the wobble is most noticeable. You can and will get this block to run without wobbly wheels!!

Conclusion

Many folks have had experience with these Aristo C-16 blocks. If there are any further ideas you have tried that work to improve the performance of the block, particularly addressing the gear noise and wobbly wheel syndrome, please be sure to raise them in the Chapter 2 Support Forum under 'Model Making'. Everything helps. The Block is a sound design in principle, and will run forever, even with wobbly wheels, but the quality is pretty broad with these units; some are really dreadful, others are near perfect.

One final point to note; All the blocks have gear noise at first. It's a high pitched kind of whine, which tends to squeal when you apply weight on the drivers or hold it back with the wheels turning. As long as the whine is smooth and not mixed with 'grinding' sounds, you will see the noise subside with age. After 10-20 hrs running time, the whine all but disappears, and you are left with a smooth running, very powerful block.

There is no Detail section for this chapter. That comes in the next chapter. Also the chassis will be painted in the next chapter, so don't get carried away with the spray cans just yet, the chassis might look kinda messy right now, but It'll look great after its detailed and painted in the next chapter.

Next chapter - detailing the chassis, and a little background to the Equalized Suspension system and the 'American' 4-4-0. See you in about a week to 10 days.

Good luck dear engine builders,
David Fletcher
June 2001