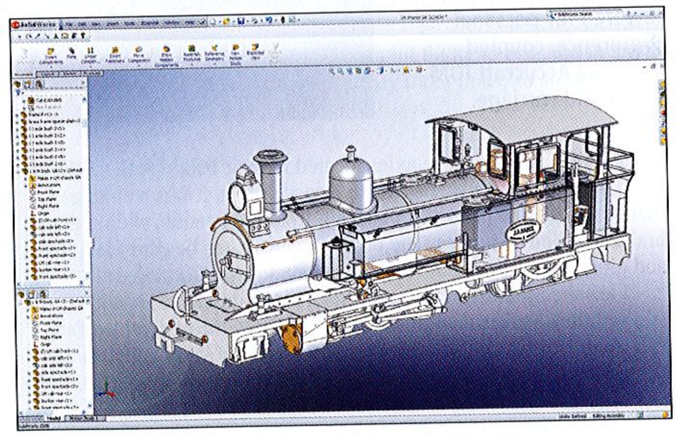
Birth of a locomotive

Roundhouse boss **Roger Loxley** reveals how his locos come to life...



Photos by author except where credited.

Heading: Leek & Manifold *ER Calthrop* posing on the Longlands & Western Railway. Photo: GardenRail staff

Centre: A Solidworks rendered picture of *J B Earle*. The finished 3D computer model is 'rendered' to give a lifelike representation.

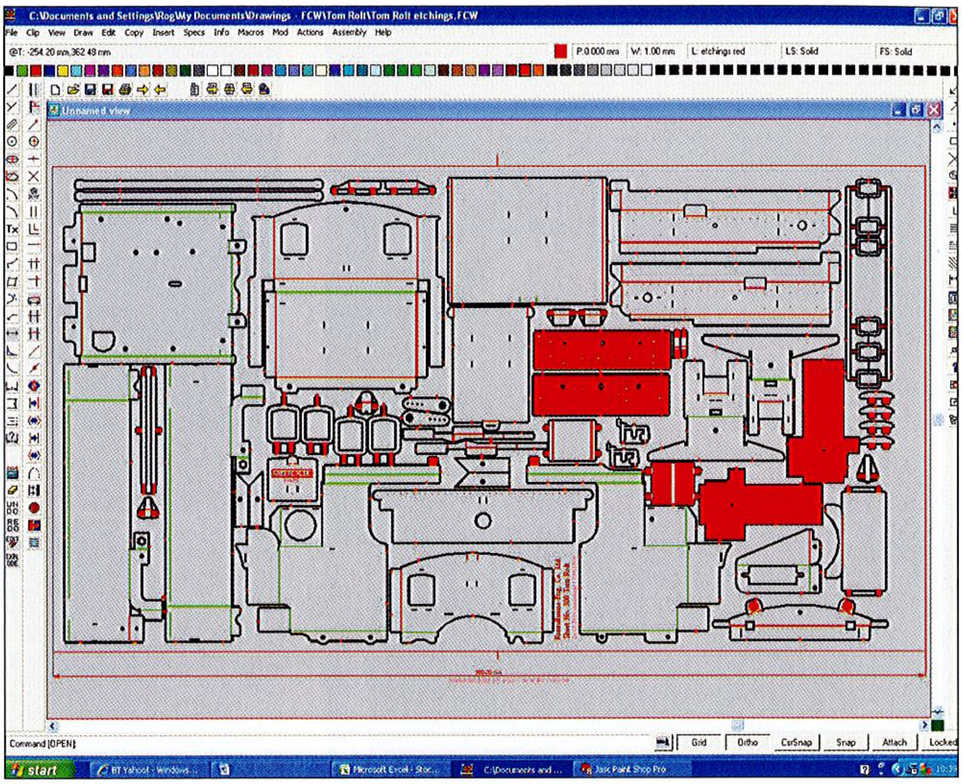
Above: The Solidworks design rendered picture with bits ghosted out. The initial design is created on computer as a 3D virtual model.

The question often asked is, how long does it take to design a new model? For Roundhouse, I guess the average gestation period for a new steam locomotive is around six months. Of course this varies with the complexity of the model and some of the simpler 'freelance' designs can take less time. However, as the general trend now is for more accurate and detailed models of full-size locomotives, six months is about the norm from concept to production. So, just what goes on during the months preceding the 'grand launch' and what chain of events has led up to the moment when the gleaming new model is placed on it's plinth to make it's debut on the exhibition stand?

Well, the initial hurdle to get over is what the new locomotive should actually be! We are constantly on the lookout for suitable subjects for miniaturization and we do try to keep a shortlist of possible candidates from which to pick – but it can still be a very difficult decision to make at the time. There are literally thousands of different locomotives that have existed since steam was first used as a means of moving loads from A to B and, at first glance, it would seem an easy task to choose just one. Unfortunately, this is not the case. From a manufacturer's point of view, the model has to sell well in order that we stay in business and therefore, whilst some obscure Patagonian geared tank loco may be the ultimate steam purchase for some, it is perhaps obvious that it may not be a good choice commercially. Let me say straight away that we have nothing against Patagonia, or indeed geared locomotives, and merely use this example as an illustration.

There are a number of criteria that will determine a suitable subject at any given time;

Aesthetics; Words such as 'pretty' or 'ugly' are often used when



Above: A 'Tom Rolt' at Longlands station... Photo: GardenRail staff

Right: ...and again as etchings on 2D CAD. The etching artwork is first created in 2D CAD and all parts 'nested' for a particular sheet size.

talking about locomotives and, though it's not always easy to quantify just what constitutes either end of the visual scale of attractiveness, a locomotive usually has to look 'good', and be 'well proportioned' (in the eyes of the prospective purchaser) in order to succeed. Whilst some 'ugly' engines will certainly sell, a 'pretty' one may well sell more. This, I should say, is a bit of a grey area for, as the saying goes, beauty is in the eye of the beholder.

Size; Large engines are impressive but then don't fit everyone's railway, whilst small engines can be very difficult to squeeze all of the necessary components in to. We will usually prepare a set (top, side and end elevations) of general arrangement drawings, which are actual size for 1:19 scale, and then check that the model would be physically capable of housing all the 'non-scale' items. By this I mean things such as control levers, gas firing and radio control equipment that are required for the model to operate.

Cost The selling price of a model is directly proportionate to its complexity of manufacture. Sometimes, what appears a rather plain and unimpressive-looking engine can actually be quite difficult and labour intensive to produce. Conversely, a large and impressive-looking loco, for example the new Leek & Manifold model, can be quite straightforward from a production point of view, making its selling price far more attractive.

Familiarity: Locomotives that still exist today and can be seen running on the many preserved railways or even as static exhibits in museums, will often be popular simply because people are familiar with them.

We ask ourselves several questions, and the answers give clues we look for to help point the way. Is any particular railway 'in vogue' at the moment? Have there been any new items of rolling stock produced by other manufacturers? Have any new books been published about a particular railway?

Customer feedback is also considered and can be helpful, but has to be used with care because it can be misleading. Ask 100 people what new model they would like to see and you will probably get a list of 80 or 90 different suggestions, as everyone has their own particular favourite. Even if one name keeps cropping up, it really doesn't mean that if we do produce this engine, those who suggested it will actually put their hand in their pocket and buy one.

Whilst on the subject of customer feedback, it is just as difficult to decipher operational preferences because, almost as a general rule, it is mainly those people who dislike a certain aspect of a model, who will make this known to us – and their views may not reflect the opinion of the majority. I would like to illustrate this by providing a couple of notable examples.

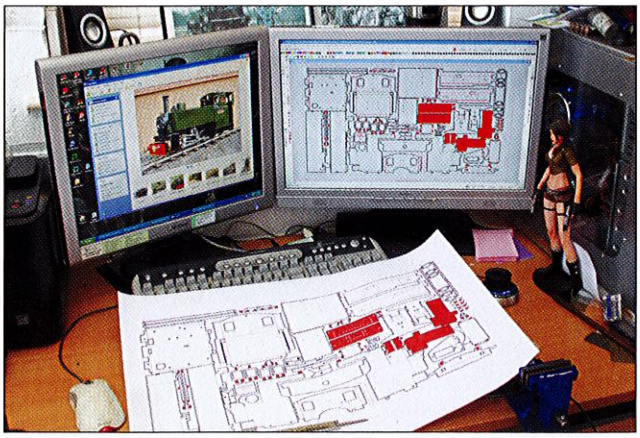
Many years ago, we replaced the brass lubricator cap with a black plastic one, following a significant number of comments about hot brass burning fingers. Well we thought this was an excellent idea that solved the problem and looked good as well. Wrong – we were then inundated with requests for replacement brass caps to replace the 'cheap and nasty looking' plastic!

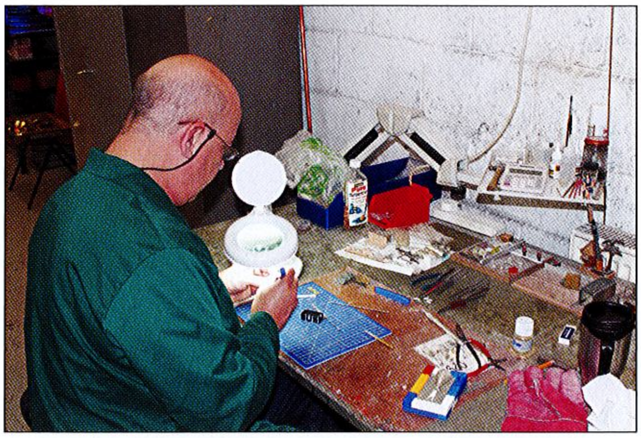
Inside the Cab

Staying with the lubricator, many people will remember that all of our early models had them located in the cab doorway where they were easily accessible for draining and filling. Mainly as a result of customer feedback complaining that this looked rather unsightly, later models have them inside the cab out of sight. Nowadays the most common comment about lubricators is that they would be easier to service if they weren't tucked away inside the loco – so I'm afraid that we just can't win in many cases. The bottom line here is that whatever is produced and however it's designed, no locomotive feature will please everyone.

So, having mulled all of this over, and looked at countless photographs and drawings, we will come up with a suitable candidate. The next step is to gather as much information as possible in the form of photos, reference books, drawings, Internet websites, or indeed, whatever we can find. Field trips can also be extremely useful if we are looking at an existing locomotive – as was the case with 'Criccieth Castle', 'Taliesin' and the Vale of Rheidol models. An hour spent with a digital camera produces hundreds of shots from angles that would never occur to the average railway photographer. With Taliesin for instance, we were actually able to inspect the full-size engine while in pieces at Boston Lodge.

Once we think we have enough information, it's then up to the design department to create a three-dimensional scale model using computer software, generally referred to as 3D CAD (Computer Aided Design). We use a design program called Solidworks, which enables us to build a model, complete with every last nut and bolt, without actually cutting a single piece of metal. This can be rotated, sectioned, exploded, magnified, looked inside and generally manipulated in a multitude of ways, so that the shape and fit of all parts can be checked from every possible angle, prior to





any production. This computer software also allows us to animate any moving parts to check correct interaction and, finally, using clever texture rendering, gives us photo-realistic pictures of the finished thing.

The Scale Question

If I may add here just a few notes on the subject of scale before we go any further.

To begin with, let me state that Roundhouse models are designed and built for hard work on your garden railway and are not intended to sit on a shelf looking pretty. Normal viewing distance is several feet and they are going to be running past, and sometimes hitting, overhanging shrubs and rocks, therefore fine detail is omitted on the basis that it will not normally be seen and can very easily be damaged. We do however try to incorporate all the obvious features and the less delicate detail that appears on the full-size locomotive we are reproducing in miniature, to try and capture the character of the engine.

All of the models of British locomotives Roundhouse produces are built to 1:19 scale and, as far as is practical, are kept as close to scale size as possible with regard to overall shape and size. It is not possible however, to build exact scale models and maintain the same level of performance, durability and practicality that our models are renowned for, so certain parts are deliberately made oversize. Having said that, Roundhouse has come in for some unjustified criticism in recent years regarding alleged 'over-scale' models. This criticism is often based on looks rather than actual measurement.

Freelance designs, such as 'Lady Anne', 'Katie', or 'Millie', are actually full-size locomotives in their own right. They are built to operate within the 'loading gauge' of the typical narrow gauge garden railway, whether on 45 or 32mm tracks and are therefore neither over nor underscale. I use the word typical for, unlike our friends who model standard gauge railways, there can never be a universally accepted loading gauge or set of standards for our garden narrow gauge railways as it covers anything that runs on track over 15in gauge but under 4ft 8½in. This means that in real life, you could actually have a tiny quarry Hunslet engine running alongside a massive NGG16 Garratt. If you then add in to the equation all the different track gauges in use around the world and the fact that the average garden railway operator wants to have a 2ft 6in gauge W&LLR 'Countess' running on his line as well as a 1ft 11½in gauge Penrhyn 'Blanche' and it all gets very messy. Obviously, some compromise is inevitable.

Precisely Cut Parts

Getting back to the computer, every individual part of a model is created 'virtually' and assembled exactly as it will be in the real world then, with a few clicks of the mouse, each part can be turned into an engineering drawing, for our machine shop or pattern maker, or into a DXF file for other processes.

The 'other processes' are either laser cutting or photo-etching. Laser cutting is used to produce all the flat steel parts. Items such as main frames, buffer beams, pony truck and bogie frames and other structural brackets are normally made from 1.6mm mild steel and motion or valve gear parts are made from 1.5mm stainless steel. The relevant parts are picked from the 3D CAD creation and saved as DXF computer files. They are then sent as attachments by e-mail to a company elsewhere in the country, that specializes in laser cutting. The files are loaded into their laser-cutting machines and, a little while later, a parcel arrives at the Roundhouse factory with a couple of sets of precisely cut parts ready for us to build the first prototype.

The superstructure components are made from brass sheet that has all the profiles, surface detail and fold lines photo-etched into it. To produce the etching artwork, the folded up and shaped components in the 3D CAD model are 'flattened out' by the program, and exported as individual DXF files which are then imported into a separate 2D CAD program. Any fold lines and surface detail are added, then, all the separate parts are nested onto a template, which corresponds to the size of brass sheet to be used. Dozens of little tabs are added that hold all the parts into the sheet and eventually, a three-colour artwork 'master' is created.

This is printed out on a large format printer at high resolution and thoroughly checked for errors. The artwork is then sent to the photo-etchers who, from this, photographically produce the two-piece tooling they require to carry out the brass etching process.

There is usually a little wait for the sample etches to arrive, so, work continues on the prototype chassis. This first build is normally left unpainted as minor alterations and adjustments

Facing page left: The etching artwork is printed out full size and checked for errors. Lara Croft is not officially on the Roundhouse staff books but is provided solely to keep the designer happy.

Faacing page right: Pattern making. Patterns for all castings are made in a variety of materials.

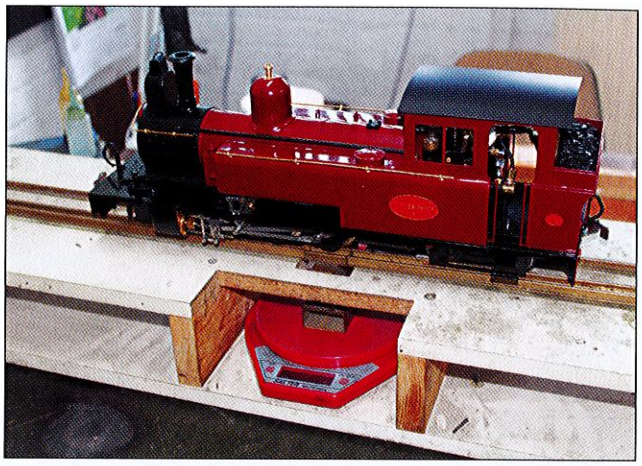
Facing page lower left: CNC machining in the machine shop. A bit different to early days at Roundhouse.

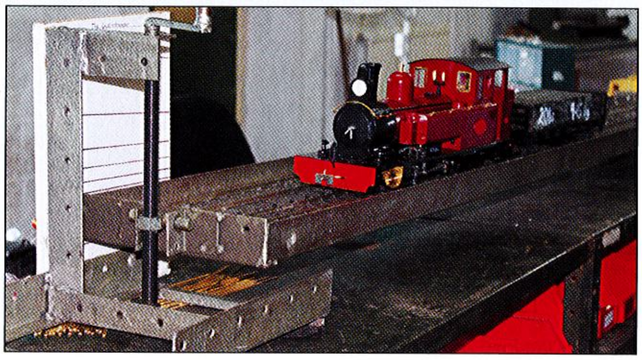
Facing page lower right: Mould making. Preparing a mould pot to vulcanise a production mould.

Above: Gas analyser. The exhaust gas is checked for CO (carbon monoxide) levels to establish the efficiency of the gas system.

Above right: Axle load weighing. The weight distribution is checked on the finished prototype during testing.

Right: Incline test. Haulage capacity on inclines is also checked during initial testing.





can, if necessary, be more easily made. Any new machined parts are only made in small quantities at this stage, just enough to allow the writing and proving of the CNC programs required. As practically all machined parts are made in house, we have much more flexibility for alterations and improvements before production quantities are made. Once the chassis is assembled, it is left running on air for a few days while the boiler and gas tank are built, again just a couple of each.

Thorough testing is essential throughout this first build as the slightest change from what is known to work well can have negative results and so the boiler and gas system are added as soon as possible so that we have a working chassis/boiler. This can now be run on the test tracks, under varying conditions, for as long as it takes to sort out any steaming or running problems.

Several weeks later, the sample etchings arrive and the first set is removed from the fret and formed. All of the etch parts are hand formed to shape and soldered together into their assemblies and carefully checked for fit. Any adjustments that need to be made are noted so that the artwork can be amended. Also, any special tooling needed for forming is noted so that this can be made prior to production.

Now we have a complete set of bodywork, the patterns for any castings can be made. There are three types of casting used on the models, brass for the smaller fragile items, whitemetal for the more bulky cosmetic items and zinc where heat is involved. All the brass castings are outsourced to a specialist foundry and so we make all the patterns for these, normally in metal, and send them to the foundry for them to produce both moulds and castings. We have our own casting and pattern-making department and cast both whitemetal and zinc.

Patterns, or masters, can be made from any material for the whitemetal or zinc castings as they go through a two-stage process to produce the final item. Normally, one master is hand made for each different casting, with a small shrinkage allowance added. The shrinkage allowance is simply a set percentage added to all dimensions because castings shrink slightly so will come out smaller than the original master.

Depending on the material from which the master is made, either a vulcanized or RTV rubber mould is produced. Vulcanizing is a process that requires a metal master because it involves heating the mould up to 150 degrees Celsius before applying a pressure of five to ten tons until it cures. RTV (Room Temperature Vulcanizing) rubber, on the other hand, uses rubber in a liquid form that vulcanizes chemically. As no heat or pressure is involved, masters can be made from softer materials such as plastic or wood.

Heat and Pressure

Once these master moulds are ready, a series of castings are made in whitemetal (the number depending on size) and then these 'first generation' castings are carefully checked with only the best selected for the next stage. Enough 'first generation' castings are needed to fill a 9in diameter mould for the centrifugal casting process that provides us with the production items. The parts are arranged in a circle around a central pouring cavity so anything from around a dozen small items to two or three large ones are fitted in, with a separate mould made for each different part. These final production moulds are heat and pressure vulcanized and the whole process takes about three hours for each mould.

Now the finished castings can be fitted to our prototype bodywork to check that everything fits correctly. Finally, all of this is assembled onto the chassis boiler and we have a complete, but unpainted, locomotive. It all sounds very straightforward, but all of this can take several months. Small adjustments to panels, and sub assemblies to get the fit just right, can be very time consuming and, if a casting isn't quite right, then any alterations mean repeating the mould-making process all over again.

The fully assembled model can now undergo thorough testing for all aspects of operation. This will include weight distribution, correct driving wheel and pony truck springing (where fitted), lighting and stability of gas system, steam generation, access to controls, radio control performance, haulage capacity and a host of other aspects.

We have a number of tools that we have developed over the years to assist in these processes. Weight distribution can be far from ideal because things such as gas tanks and radio control equipment have to go where they will fit best and this can often result in an uneven weight distribution that plays havoc with traction. Simply by adding a little weight to one side or one end to

Above: A radio-controlled 'Taliesin' backing slowly on to a train. Photo: GardenRail staff

Above left: We all know this is what it is all about! Driving one's own steam train out in the garden. Photo: GardenRail staff

Left: Roundhouse freelance locomotives lend themselves to a bit of 'doctoring' by the purchaser. Here a much-loved and carefully tended 'Carrie' ambles along with a short goods train... This locomotive has a working whistle on the spectacle plate and draincocks worked from the cab. Photo: GardenRail staff

even out the load on the drivers, can turn a model that just sits there slipping with a 5lbs load into a monster hauler capable of 30lbs.

On sprung chassis, or models that have pony trucks or bogies, getting spring rates correct is also important and sprung trucks can be used to 'push' weight from one end to another instead of adding extra weight. None of this is easy by guesswork so we use an axle weighbridge, which tells us just where the weight is and just what effect changing spring rates or adding weight has.

On the track, the effects of this 'balancing' are checked with test weights and on an adjustable track which we call the 'inclinometer'. This is a length of straight track, which can be adjusted for different gradients from level to a maximum of 1:10.

Carbon Monoxide

The gas system is one we have developed over many years and works extremely well if set up correctly. Any change in parameters however, even something as simple as changing the size of a smokebox or a chimney diameter, can upset the balance and has to be carefully checked. One tool that assists us greatly in this is the gas analyser which tests the level of Carbon Monoxide (CO) in the emissions and is a very good indicator of the efficiency (or otherwise) of the burning process.

It is very important that all aspects of the model are checked and tested throughout the prototyping process – not only to ensure that all the components fit and work correctly, but also to make sure that assembly is as simple as possible. Hopefully, all of this was carefully considered at the design stage and we won't suddenly find that some critical part or screw is actually inaccessible, although it does occasionally happen. That's the whole reason for building a prototype however, and by the end of the exercise, any mistakes or improvements have all been documented.

Once happy with the running and operation of the prototype, a demonstration model is then built from the second set of trial laser-cut and etched parts if no major changes are needed. If changes are required the demo model will be built from a freshly ordered amended set of parts. This demonstrator is fully painted and finished just as the production models will be, and is the one we will photograph for publicity and put on display in the showroom and at exhibitions.

I must mention here, the thorny subject of livery. Many of the locomotives we now model appeared in a variety of unique liveries during their life and we do try our best to offer a close match to at least some of these. This is very problematic however and will often create great debate between the 'great and the good' in the modelling world, who all feel very strongly that they know precisely what the colour should look like. In reality, paint changes colour over time and each time an engine was re-painted, it would be a slightly different mix of the 'same' colour.

No samples exist of many liveries and even the official descriptions could be vague and contradictory so, what may look correct to one person's eye will appear completely wrong to someone else. The bottom line is that it is almost impossible to faithfully re-create the exact shade that an engine appeared in at any given date so we do our best based on available information.

Forming Corner Radiuses

Any special tooling required for the forming of laser-cut or photo-etched parts is made now. This is all done in house using various heat-treatable steels so that the finished tools can be hardened as required. This can be quite time consuming if there are a number of new parts. The etched-brass parts are much thinner and softer, so we can also take advantage of a combination of steel and hard rubber tooling for forming corner radiuses on tanks and cabs.

That's not quite the end because finally, the loco assembly team, here at the factory, has to learn how to build the new model. Now, over the past 29 years we have evolved a relatively uniform system and similar (if not quite common) parts are used on most of our designs. Every new model. however, is subtly different in the order and method of assembly. Our normal procedure is to go through the entire process just prior to the first production batch with the loco head builder, and decide on a logical and practical order of assembly. Then, as the first batch actually commences, he passes all this information on to the building team and we are up and running. GR

GardenRail Resource

Roundhouse Engineering Co Ltd, Units 6-7, Churchill Business Park, Churchill Road, Wheatley, Doncaster DN1 2TF Tel: 01302 328035 Fax: 01302 761312 email: sales@roundhouse-eng.com Web: roundhouse-eng.com

*Please mention **GardenRail** when contacting suppliers*