

Experiences with Early Locomotives and their Replicas

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For the last few years I have worked as a Consultant on Early Railway Technology with Dr Michael Bailey. I shall tell how I got into this job and how our approach has been different to that of other practitioners. I hope also to show that engineering can be fun.

My interest in steam engines started at an early age with a Mamod model, and I know that many engineers had similar engines. I was fortunate to be sent to Oundle School in Northamptonshire. Our curriculum included the usual Latin and French, physics and chemistry, but also we had extensive workshops where we spent one week of each term. We had a pattern shop where we made the patterns from which we made moulds in the foundry. We then finished our own castings in the machine shop and fitting shop. We also learned machine drawing and applied mechanics. Though I am by no means a skilled craftsman or draughtsman, my appreciation of manufacturing was a great help throughout my career. I read engineering at Manchester University and then gained a master's degree by research into the thermodynamics of turbocharged engines. After a short while in industry I went to Manchester Business School where I

specialised in accounting and finance, not as much fun as engineering, but perhaps the most useful thing I ever did.

I then went into our family firm which manufactured its own lines of fittings and equipment to make branch connections into pipes carrying gas, oil or water under pressure.¹ I headed the drawing office and technical department for a while. Our contract engineering division manufactured machines or parts to customers' drawings, for example, rolling mill plant, de-canning machines and transport flasks for the nuclear fuel industry.

My interest in model engineering grew and I also became interested in industrial history. In about 1970 I attended a WEA course in industrial history. This was run by a youthful dynamic chap by the name of Richard Hills. Though my main interest was in stationary engines, I also collected model trains. I did not foresee that years later I would be involved with building models at a scale of 12 inches to the foot.

One day I went down to the Museum of Science and Industry in Manchester at its new site on Liverpool Road. I was astounded by the wonderful mill engines. I filled in a form to join the Friends of the Museum. A few days later I received a letter asking me if I would join a group of volunteers who were going to build a replica of Stephenson's 1830 *Planet*. The *Planet* class of locomotives was the 'production model' that followed on from the more famous *Rocket* and provided most of the motive power on the Liverpool and Manchester Railway. At the first meeting of the group the chairman asked if anyone knew anything about *Planets*. I eagerly put my

¹ E. Peart & Co Ltd of Hyde, Cheshire.

hand up and said that I had just read an article in The Newcomen Society Transactions about *Planets*. “That was the article I wrote” said the chairman, Michael Bailey.

Michael had done much research but had found no set of drawings. The design was further researched, valve gear was understood, specifications were written to meet modern standards but original appearance, drawings were made, components were manufactured or bought from outside, the locomotive erected, brakes fitted and concealed... A paper has been written and a video made about building the *Planet* replica.² After six years work the great day came for its first public steaming. *Planet* was hidden behind a screen with steam up. Copious quantities of oil were put in the valve chests to overcome the newness. A great crowd had gathered. The signal for *Planet* to appear was given. The day was damp and as *Planet* set off from the station the wheels spun on the wet rails, oil and soot were blasted out of the chimney. What goes up must go down again, and it came down onto the Lord Mayor, The Lady Mayoress and the invited guests.

Planet ran at the museum at weekends, but we thought that it ought to be let loose on a decent length of track. We therefore took the train to the Great Central Railway at Loughborough. We devised a programme of tests and we started off in high hopes. We soon found that fast continuous running was very different to the slow short trips at the museum. We had to learn to fire it and drive it properly. Faults showed up under the higher loads. Check valves leaked, pieces of the valve gear broke, and several times we came to a grinding halt. We

² *Learning through Replication, the Planet Locomotive Project*, Michael R Bailey, *Transactions of the Newcomen Society*, Vol 68, London, 1997

had made the wheel bearings too tight and they seized. Changing a wheel on a car is one thing, taking the wheels off a loco is another. We managed to jack it up, remove the bearings, machine them out, re-assemble everything and be running next day. Later we took the train to the East Lancashire Railway at Bury to continue the tests. One test was to see how heavy a load we could do a hill start with. Others tests were to measure water and fuel consumption with various loads at various speeds. We measured speed with an adapted cycle speedometer. Water consumption was measured by counting the number of pump strokes and coal consumption by counting the number of shovel-fulls. We deduced many interesting facts, there is not space to go into them here. Running resumed at the Museum at weekends but we soon ran into another problem. The axles broke due to a stress raiser. We had shrunk the axles into the wheels using liquid nitrogen. To make sure that the back-to-back dimension was correct we had put shoulders on the axles. We had left a generous radius in the corner, but not generous enough. We learned a lot through building *Planet*, mainly that, in spite of modern materials, computers, education and so on, the original builders knew a lot more than we did. Our mistakes made us very embarrassed and humbled.

The publicity surrounding *Planet* attracted enquires from other museums and Michael and I set up a consultancy to deal with these. By this time I had sold our family company and had set up as a management consultant. I could devote time to the new business. Michael had read transport studies at university and his M.A. was by dissertation on the early history of Robert Stephenson & Co. He had worked for British Rail and as a transport consultant around the world.

He is always very thorough and extremely knowledgeable about the early railway industry. He disbelieves anything unless it is from a prime source. The work we did was part documentary research and part industrial archaeology, archaeology being defined as the methodical examination and recording of artefacts. We took to this our experience of the real world and so our approach was very different to that of many academics.

Our first job was to advise on the history and conservation of two locomotives in Canada. The oldest, *Samson*, was built by Timothy Hackworth in County Durham in 1838 and had worked on a coalmine in Nova Scotia.³ When the cladding was stripped off many interesting features were revealed. We not only counted all the rivets, but noted the different sizes and styles of head. Every hole, rivet, bolt or stud was put there at great labour and for a purpose. Our job was to find what that purpose was. We were detectives trying to deduce sequences of events. When the smokebox was taken off we found the remains of studs. They had held the original chimney. It had had to be removed because its weight swaying about caused a tear in the boiler front plate. We were ecstatic when the name of the maker of the boiler plate was revealed, Low Moor, the premier ironworks in the UK at that time. The loco had been modified in service and we were able to deduce what it had originally looked like. We recommended that the museum did not reverse any of the modifications made in service, but that they conserve it in the state that it was at the end of its working life.

³ *Learning through Restoration; The Samson Project*, Michael R Bailey & John P Glithero, in *Early Railways*, Guy & Rees, eds, Newcomen Society, London, 2001.

A job that we did in the U. K. was on a loco called *Braddyll*.⁴ It also was reputed to have been built by Timothy Hackworth in 1838, but for the South Hetton Colliery owned by a Colonel Braddyll. It was outside The Timothy Hackworth Museum in County Durham and in a very bad state. It had been converted to a snow plough in 1874. In 1917 it was found abandoned behind a slag heap. Again we drew out what it looked like when built and we made recommendations as to how it should be conserved. We were then asked to do the conservation work ourselves! The loco was in such bad condition that it was unsafe to move. We designed a support to take the weight off the springs and we put steel joists under the rails that the loco stood on. It was then craned into the museum by the Territorial Army. We blast cleaned it with a soft material and many interesting features were revealed, the firebox showing several repairs and strengthenings, for example. I was particularly excited to find the original fitter's scribe lines and pop marks on the valve gear eccentrics. We could also deduce that attempts were made to make the loco go better by adjusting the valve timing. The original keys were replaced by stepped keys to reposition the eccentrics. No improvement was found and the eccentrics were returned to their original positions. The original keys had been lost and so the lugs were sawn off the stepped keys.

We were working under it one day when I said to Michael "Timothy Hackworth did not build this loco".

⁴ *Learning through Conservation: the Braddyll Locomotive Project*, Michael R Bailey & John P Glithero, in *Industrial Collections: Care and Conservation*, Dollery & Henderson, eds, Council of Museums in Wales/UK Institute for Conservation, Cardiff, 1999.

“How do you know that?”

“I just get a feeling that the hands that built *Samson* were not the hands that built this loco.”

I then tried to rationalise my feeling. It was in the detail that the differences were. The horns on *Braddyll* were fabricated but those on *Samson* were cast, the bearing blocks were of different shapes, there were collars on the axles etc. In our final report to the Timothy Hackworth Museum we said that we were unable to confirm the Timothy Hackworth had built it. Much later further research showed that the loco had been called *Nelson* and was used on the Hartlepool Dock & Railway Company’s line, and might have been built by Fossick & Hackworth, that Hackworth being Timothy’s brother.⁵ The remains of the locomotive were conserved and painted and it has now been taken into the National Railway Museum’s collection.

Another adventure we had was a study tour of the eastern parts of The United States. We saw every pre-1850 locomotive or replica there, except one. The replica of the *Best Friend of Charleston* amused me. The builders of the replica had not understood the valve gear and did not know that the original would go backwards. They steamed it forwards on their four mile track, but they reversed it back using a Ford V8 petrol engine hidden in the tender!

Our most prestigious job was an archaeological survey of *Rocket*.⁶ We were actually allowed to pull the Stephenson’s original *Rocket* apart! The National Railway Museum’s

⁵ *Turning a Blind Eye to Braddyll*, Michael R Bailey & John P Glithero, in *Early Railways 4*, Newcomen Society, London, 2009.

working replica is an excellent piece of work and is what most people think that the original looked like. We were able to show that there were a number of significant errors. Our principal method of work was to spend each Monday working on the locomotive. Michael would spend the rest of the week researching in various archives whilst I would draw up what we had done using CAD. We mainly used conventional means of examining the loco, the Mark 1 eyeball being the principle tool. For screw threads, we made moulds with dental putty and scanned their sections into a computer.

There are various holes in the boiler and from them we were able to deduce a sequence of modifications. Originally there was a safety valve at the front where the brass dome is normally portrayed. There was little cover over the firebox crown. A dome was fitted in place of the safety valve so the water level was raised. The eccentrics again were of great interest. Before a fitter dismantled the valve gear for maintenance, he would put his own marks on so that he could put the parts back in the right places. He would not have been able to see that under the dirt there were marks made by several previous fitters. In some cases we found four sets of marks! Some parts of the valve gear had the number 16 punched on. There was only one *Rocket*. These must have been spares for a *Planet*!

I did an interesting experiment on the design. I familiarised myself with the books that Robert Stephenson would have

⁶ *The Engineering and History of Rocket*, Michael R Bailey & John P Glithero, The Science Museum, 2000.

The Stephenson's Rocket, Michael R Bailey & John P Glithero, The Science Museum, 2002.

read. Using that information only, I worked through the design calculations, starting from the trial stipulations and ending with the cylinder size. It was spooky to come up with the same answer!

Seeing a locomotive in a museum is interesting, riding on one at full speed is quite another thing! We and a colleague Peter Davidson were involved in making a *Timewatch* programme for the BBC.⁷ *The Rocket and Its Rivals* was a restaging of the Rainhill Trials. In 1829 the Directors of the Liverpool and Manchester Railway had wanted to establish if loco-motive engines could meet the needs for traction on their new railway. Two of the locomotives broke down in the original trial. By using replica locomotives, the BBC wanted to find out if those locomotives might have won.

Playing trains at full size, locomotives rushing up and down... All our birthdays and Christmases rolled in to one! When *Rocket* was on the line it simply flew. The film crew could not keep up with it. I was very interested in the making of the programme. The location facilities were quite extensive, catering van, dining tent, generator, ablutions, security, first aid, camera vans, workshop van, gofer's bicycle, helicopter, camera hoist etc.

But what actually happened in the re-trial? *Sans Pareil* would not steam at first. The grate had to be re-arranged. The suspension collapsed and had to be mended. *Novelty* would only go about half a mile before running out of steam. The replica blower was inadequate. A leaf blower powered by a petrol generator had to be hidden on the loco. *Rocket* wiped

⁷ *The Rocket and Its Rivals*, BBC4 2002.

the floor with the opposition. This was due to the original *Rocket*'s good design, a well built and well maintained replica, and a superb professional crew.

We took the opportunity to carry on our own research into locomotive performance.⁸ A satellite tracking system fitted to each locomotive gave us its position, speed and acceleration at any time. We plotted numerous graphs and it was quite clear that that *Rocket* in 1829 and its Replica in 2002 were miles ahead of the others, the close result in the TV programme only being possible by using inconsistent data.

A project that we have been involved in is the building of a replica of *Odin*, the first locomotive to run in Denmark.⁹ It was a Sharp single built in 1844 on Oxford Street, Manchester. The original drawings no longer existed and so our task was to provide the National Railway Museum of Denmark with a set of drawings and description. The build is well underway.

Another television programme that we were involved with was *The Re-Inventors* presented by Dick Strawbridge.¹⁰ The objective was to build a standard gauge locomotive in three days using easily available bits and pieces. The structure was made from bicycle frames and timber. The working cylinders were made from hand pumps for inflating airbeds etc. The valves were quarter turn ball valves operated by tappets. Instead of steam from a boiler as the working fluid, carbon

⁸ *Analysis of Locomotive Performance*, John P Glithero & Peter Davidson, in *Early Railways 3*, Michael R Bailey, ed, Newcomen Society, London, 2006.

⁹ *Odin Project*, Michael R Bailey & John P Glithero, Danish Railway Museum, 2004.

¹⁰ *The Re-Inventors*, UK-History Channel xxxx

dioxide was supplied from cylinders, ingenious, and it nearly worked. The problems were quite predictable. The demand for the carbon dioxide was so great that the cylinder cooled so much that little would evaporate. The pressure regulator was then turned up. When the cylinder warmed up the increased pressure blew the end off the cylinder etc. I am not sure that I would put this job on my CV.

The last job that we undertook was a survey of *CN40*, the oldest mainline locomotive in Canada.¹¹ It had been made in Portland, Maine in 1872 for the Grand Trunk Railway of Canada. The following year it was rebuilt after being in a major crash. It was rebuilt again in 1890 and had a major overhaul 1900. It was sold to a logging railway in 1903 and smaller wheels were fitted. It was rebuilt again in 1925 and retired in 1947. It was rescued and restored in 1950. It worked for about 10 years on the Museum Train before being put into store.

We were asked to report on what the locomotive originally looked like and how much was original. The latter task was relatively easy as most of the parts were numbered. We found the original works number on only one part and that was a link in the valve gear. Most of the rest had been replaced in its working life.

It was interesting to reflect on how American design had evolved to cope with the particular conditions. The distances in North America were so great that well laid track as in The UK was not affordable. The three point suspension system was developed to cope with the poor track.

¹¹ Canadian National Railways CN40, Survey Report for Canada Science and Technology Museum, Michael R Bailey & John P Glithero, 2008.

We learned a lot during these jobs, in particular we appreciate even more how inventive and resourceful our engineering ancestors were. It is relatively easy for us to analyse their work because we have seen the answers. They did not even know what the questions were. We have seen many ingenious solutions to problems. We have learned from their mistakes as well as from our mistakes. The sad thing is that it is now too late to put these lessons into practice as I am no longer actively involved in industry. We have however, tried to pass on our knowledge by publishing our work.

Appendix- Photographs & Drawing









