The *Firefly* Project: an update

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Introduction
The March 1984 issue of BAS *Journal* contained the proposals of a group then recently formed, the *Firefly Trust*, to build a replica of an 1840 Great Western Railway passenger locomotive. The history of the selected class of locomotive, and the trust's hopes and programme. were outlined by the chairman of the group, John Mosse.

These notes are presented as an update on the original scheme and a record of progress to date, together with details of changes and modifications to the original proposal which have been brought about by changing circumstances in the.,seemingly lengthy, intervening period.

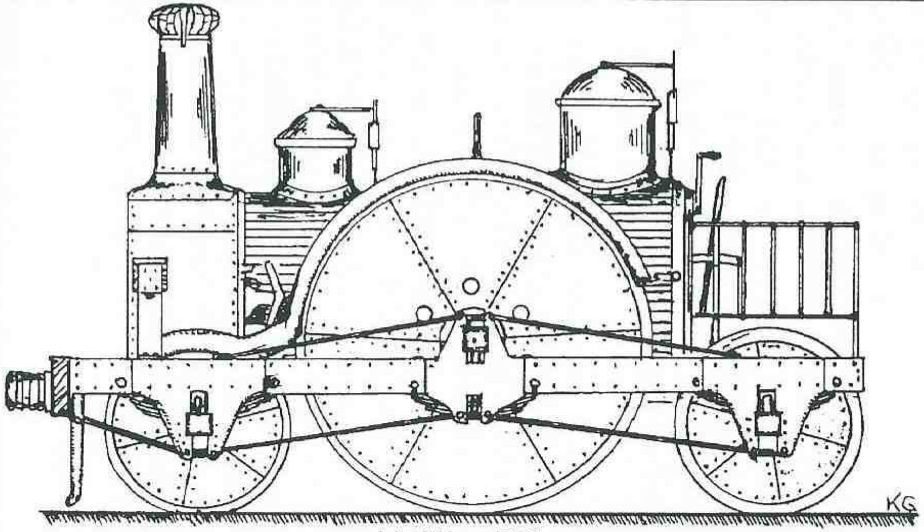
Historical background
The first locomotives of the Great Western Railway, built to specifications issued to manufacturers by LK. Brunel have, over the years, been described by most railway writers as freaks! The great engineer, having convinced the directors of the company of the benefits of a 7 foot gauge for their new railway, then had to specify the motive power to suit. Correct in his idea of the potential for speed, power and comfort for such a wide rail setting, he was completely adrift in his ideas for a locomotive design.

The locomotive of the period, the late 1830s, had reached a surprisingly developed stage in the thirty or forty years from the success of Richard Trevithick in 1804. Such was the interest and the demand for the new-fangled replacement for the horse, that not only was there a quickly spreading requirement in this country, but a thriving export business was also in being. The first locomotive manufactory in the world, that of the father-and-son firm of Stephenson, had such a full order book that it was sub-contracting to other companies, all exporting to Europe and America, as well as satisfying demand in Britain.

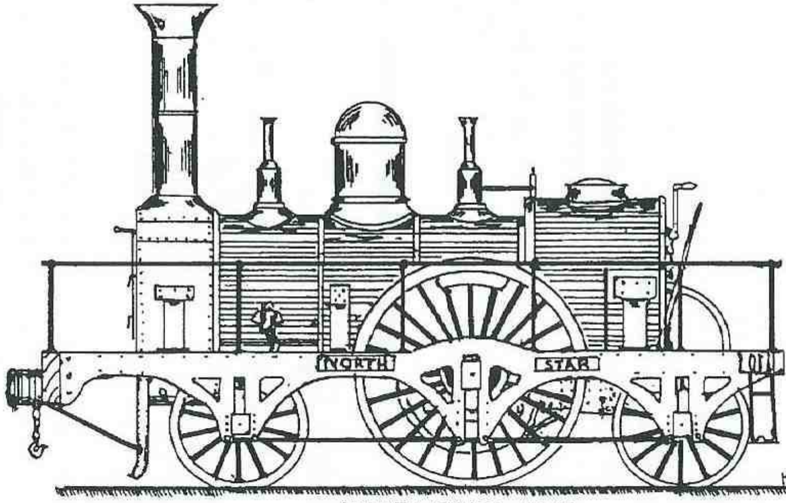
Into this existing world of locomotive building strode Brunel with his far-seeing, but technically impossible, specification for his locomotives. Without going into too much technical detail, his requirement of a weight limit of ten tons and a piston speed of 240 feet per minute for 30 miles per hour left the manufacturers with a king-sized headache. The huge locomotives which were not only possible, but which were actually required, to fit the 7-foot rail gauge were far and away much bigger than anything previously made. This situation brought yet another problem.

The rail-gauge requirements varied according to the orders placed. Although most were to the then accepted gauge of4 feet 8½ inches (which we have to this day) there were variations up to about 5 feet 6 inches, and thus all the workshop facilities had to suit the different sizes. As an example of the engineering problems inherent in Brunel’s specification, two makers' designs included driving wheels of 10 feet diameter! Whilst a large lathe existed in which the wheels could be turned, it was too close to the stone wall of the workshop. In a recorded reminiscence the writer described how, as a young apprentice, he had to hand chip, with hammer and chisel, a curved groove in the wall so that the huge wheel could be machined.

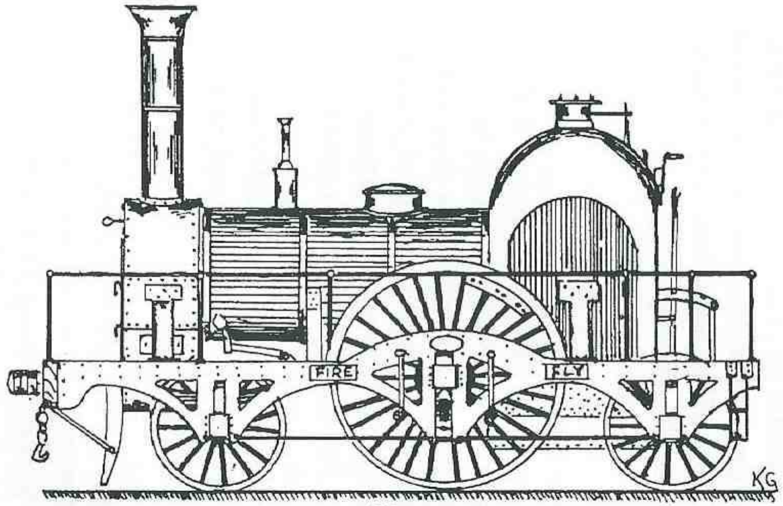
Delivery was also a major problem, and this applied to all locomotives. At this time there was, in any case, no national network of railways of any kind, and certainly not of 7-foot gauge. Thus. having ordered your locomotive from your chosen supplier, you then



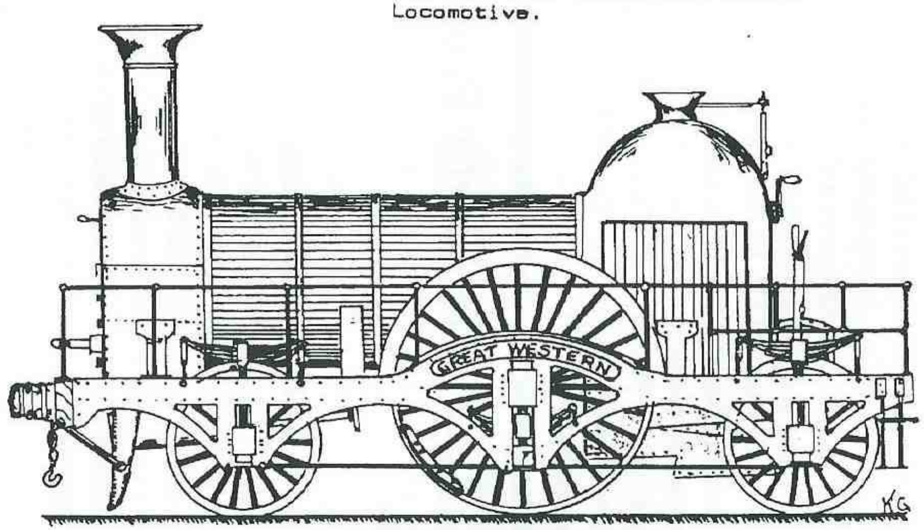
C1/18 'AJAX' 1838.
Another design to Brunels specification.
10 feet dimeter Iron Plate driving wheels.



C1/19 'NORTH STAR' 1840.
Not to Brunels specification
and the 1st.'successful'G.W.R.
Locomotive.



C1/20 'FIRE FLY' 1840.
A Daniel Gooch design based on
'NORTH STAR'



C1/21 'GREAT WESTERN' 1846.
A larger version of 'FIRE FLY',built
at Swindon for the continuing 'gauge
war',and proving the success of the
broad gauge designs.

Early Great Western locomotives. These are all drawn to the same scale by the author to show relative sizes had to have it delivered virtually in kit form. Transport of the period was by horse-drawn wagon over very rough roads, by coastal shipping, then by river or canal barge, then maybe again by road. The purchaser was then stuck with what he had ordered. There was no easy way of sending it back, except by the way it had arrived.

Therefore, in an engineering world in which there were no milling machines, large metal planers, twist drills (with no milling machines there could be no drills, and it took so long to drill a hole with a drill of the period that most holes were hot-punched by the blacksmith), no steam hammers, no special steel lathe tools, and no grindstones as we know them today (they were actually cut from solid rock the achievements in engineering, mostly done by hand, are incredible.

I have found it very strange that I, and other interested writers, have discovered no trace of correspondence or references to Brunel from the manufacturers of his locomotives complaining or commenting on his impossible specification. The several manufacturers just appear to have struggled on as best they could, one producing a geared locomotive which, through the gearing, gave an equivalent diameter driving wheel of 18 feet!

The opening date of the first length of track, the inauguration of the Great Western Railway, was fast approaching, and Brunel was now waiting for delivery of some very weird, and ineffective locomotives which would wheeze and puff and have great difficulty moving themselves, let alone a passenger train on the widely spaced rails. He needed a locomotive man to take the burden of motive power from his shoulders, shoulders which to date had carried every aspect of establishing a viable railway, complete, and to a hitherto unheard of track gauge.

The appointment was filled by twenty-year-old Daniel Gooch, who, hearing of Brunel's requirements, wrote what has become probably the most famous 'CV' in railway history, extolling his 'vast experience' of the steam locomotive and its manufacture. He had had seven different jobs interspersed with bouts of illness, no apprenticeship, starting work in a foundry as a moulder, and having a period as a salesman for a firm of locomotive manufacturers which never really got off the ground. I think the kindest comment one could make on his CV was that he was a little economical with the truth. However, his application was accepted and Brunel travelled north himself to interview Gooch, liked what he saw, and duly appointed him.

Gooch's first job was to visit the manufacturers. ostensibly to check on what progress they had made, but increasingly he realised what a mass of problems were in store for when the locomotives were delivered. During his visits he was shown a locomotive built for the New Orleans Railroad, but proprietors of the railroad had not been able to pay for it, so that it had been left on the builders‘ (Stephensons’) hands. Recognising that it had been built to the standards of the day, and not to Brunel's suspect specification, Gooch recommended its purchase after suitable alterations to fit the broad gauge of the Great Western. The alterations duly carried out, it was purchased by the GWR, and the first successful locomotive was delivered to Maidenhead as the usual 'DIY' package.

The system was inaugurated on time, but the directors apparently went around Brunel to Gooch, knowing of the general failure of the first, specified, locomotives and asked him to design for them locomotives which worked! How much of the design for the new locomotives was actually Gooch’s work is open to speculation as he now had Archie Sturrock (from the East Foundry, Dundee) and Thomas Crompton on his team, both to become famous engineers in their own right at a later date.

Whilst the design team worked to produce the new design, the building of the locomotives would still have to be contracted out; the major works at Swindon, later to be the hub of the Great Western construction network, did not exist and the site itself was just another vista of fields in an agricultural area located in a valiey below an insignificant village up on the hill. Such was the confidence in the new locomotive design that sixty-two were ordered from seven different companies, literally straight off the drawing board. Sets of templates were also issued to ensure a certain uniformity of construction. but standardisation as we know it today did not exist. You lost a nut at your peril, as each company had its own standard thread, similar. but not identical, to the others.

Thus was born the *Firefly* class of locomotives, which carried the bulk of the Great Westerns passenger traffic for about thirty years, the class being based, with slight modification. on the successful design of the New Orleans purchase, now named *North Star*. From *Firefly* sprang *Great Western*, a bigger and better design. Originally a 2-2-2 wheel arrangement, the increased weight of Great Western caused front axle breakages, so an extra pair of wheels was added at the front, giving a 2-2-2-2 format, the four front wheels being non-swivelling. Thus the broad gauge classic design for *Iron Duke* and the famous *Lord of the Isles* evolved and remained in service until the demise of the broad gauge in l892, but all were bigger and more powerful versions of “Firefly” which itself had been based on “North Star”.

Every one of the *Firefly* class, some converted to more mundane tank locomotives toward the end of their working lives, had gone by that fateful date in 1892 when broad gauge died. *North Star* and *Lord of the Isles* lived on until 1908 when G.J. Churchward decided that their space was more valuable than their company, and had them cut up for scrap, an early example of industrial archaeological vandalism! Preserved, today they would have been priceless.

The *Firefly* project: the 1981 concept

The original project to build a replica *Firefly* locomotive was conceived by John Mosse (who became chairman of the group) during his work on the restoration of the Brunel buildings at Temple Meads Station in Bristol. Having assembled a team of railway and other interested engineers, he began research into the feasibility of such a project. Support was obtained from The Newcomen Society, BIAS, the Great Western Society. the Broad Gauge Model Railway Society, the Brunel Society, the Science Museum and the Brunel Engineering Trust.

The trust hoped to commence construction in 1985, and to set up a drawing office in Swindon to prepare specifications for the work. It was their intention to build a seven-eighths scale version to conform to the British Rail loading gauge, with changeable wheels to allow broad or standard gauge running, the latter being ‘*an essential feature if the project is to pay its way by means of passenger receipts*’. It was also hoped to run the locomotive with replica broad gauge carriages on the line from Temple Meads to Wapping Wharf, discussions having been opened to this end with Bristol City Council. Trains out of Paddington and Bristol were also envisaged, subject to talks with British Rail.

The first requirements were to be recruitment of members. and to raise sufficient funds to cover all operations; in the meantime designing would commence, and a search continue for a suitable building for use as a workshop.

The *Firefly* project: from 1981 to 1999

Fund raising and membership recruitment started immediately, but the design programme proved more of a problem. The original *Firefly* had been built by Jones. Turner & Evans of Newton-le-Willows, and the several manufacturers, whilst adhering to the general concept, had introduced slight variations of their own. Therefore, when research turned up a drawing of a *Firefly* class locomotive, it was not of the original *Firefly*, but of *Tiger*. by a different maker.

A further complication was the difference between modern day regulations governing construction of any passenger vehicle and the almost non-existence of such regulations when the originals were built. Materials had also changed beyond recognition, and engineering techniques had advanced beyond what would have been dreamed of by the original makers. Steel. so common now in all sorts of alloyed forms and huge quantities, only existed in *Firefly's* day for small tools and knives.

The Bessemer process for producing steel in quantity was still a quarter-century in the future. No longer can a steam boiler be made of comparatively thin wrought-iron plates, but of much thicker steel to strict formulae. So the changes were acknowledged and then had to be built into the replica, which, from quite early in the design process, was to be full size, not to seven-eighths scale as originally proposed. Three major problems were that the enthusiasts included engineering technical management staff who had long ago left their tools behind, so who would actually build the locomotive when the technical design work was completed, where would it be built, and how would it be financed? A further complication was with what tools would it be built? The only tools existing were in the personal possession of the enthusiasts, tucked away in garages and garden sheds.

Another major problem to raise its head was that of recruiting suitable members and of retaining them. This can be explained with an example: if an existing locomotive is to be refurbished, anyone can come along and, under supervision, can be given some spanners and be told to strip down a component for, say, examination. This person need not be an engineer. Building a locomotive from scratch is vastly different. All components, everything, has to be *made* before anything can be done with it, thus people who came along to the building area found that they could do nothing, and so the quest was on for engineers.

In the meantime. a successful request to the Bristol authorities led to the use of a building, but five years had now elapsed. taken up by design and financing efforts. The support of a friendly bank manager interested in railways and the completion of the first designs combined to enable a start to be made on the frame. Modern techniques were to play, and still play, a major part in construction; oxy-cut plate and modern drilling facilities had the frame soon under way. The Youth Opportunities programme assisted by financing some young lads who were a help in the workshop.

The frame is of steel plate, as opposed to the original wrought iron, and, following the period technique of sandwiching wood between the frame plates, thick marine plywood was substituted for the oak of the original designs.

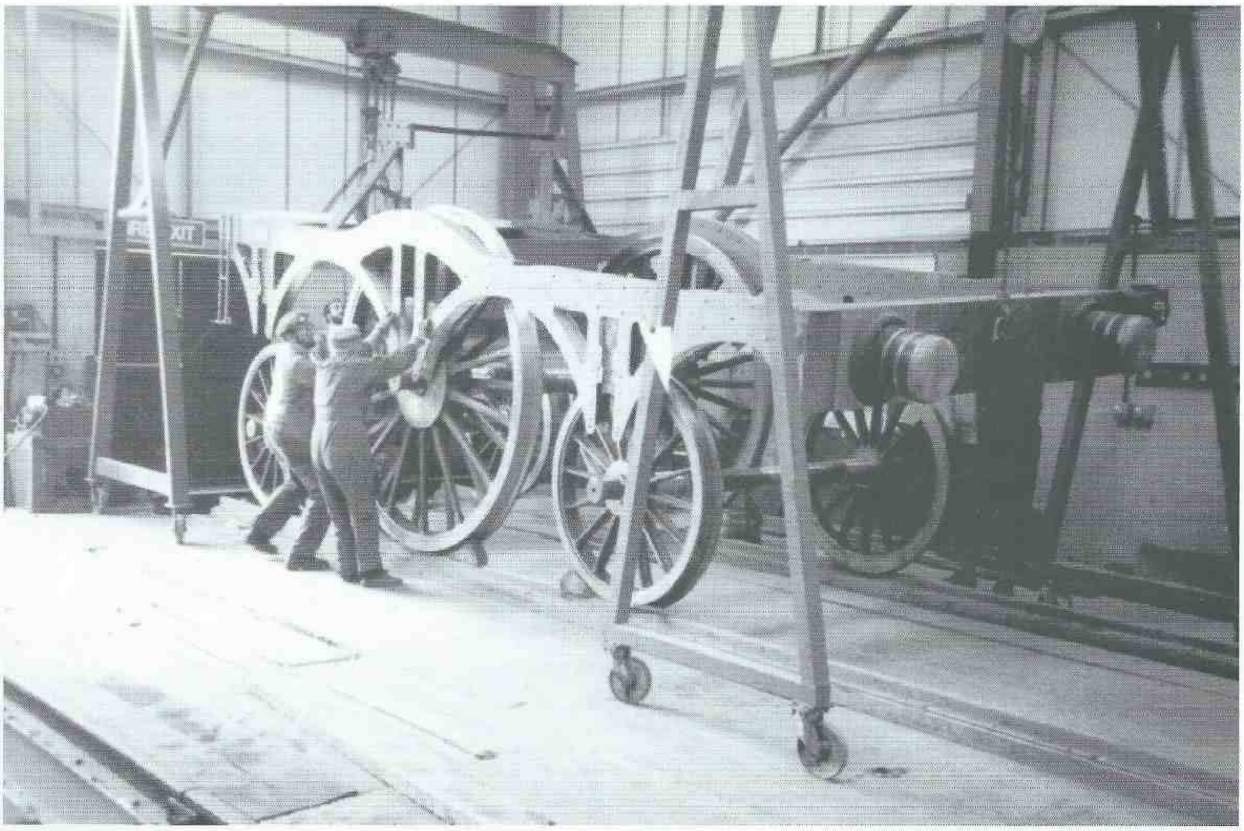
About a year into the practical construction programme the well-known saying of Rabbie Burns was brought home to us: '*the best laid schemes...* '! Within a matter of weeks the Bristol authorities wanted their building back, the government stopped the Youth Opportunities programme, and a change of bank manager stopped the finance. The project was then left high and dry with no workshop, no money and a depleted practical construction staff.

As a consequence of a positive effort by the chairman, John Mosse (always the driving force behind the project), he received a welcome offer from the Great Western Society at Didcot to locate the project in the Society's workshop, with use of all facilities. The project will be forever indebted to the Society for this great offer. The partly-completed frame was loaded onto a lorry, together with whatever tools and equipment had by then been purchased or obtained by gift, and driven to the new location at Didcot.

Whilst this excellent location and its facilities could not be bettered, it brought about another very serious problem. The very few engineer volunteers who had been doing the practical work along with John Mosse found they could not, or would not, travel to Didcot. The manning level dropped almost to zero.

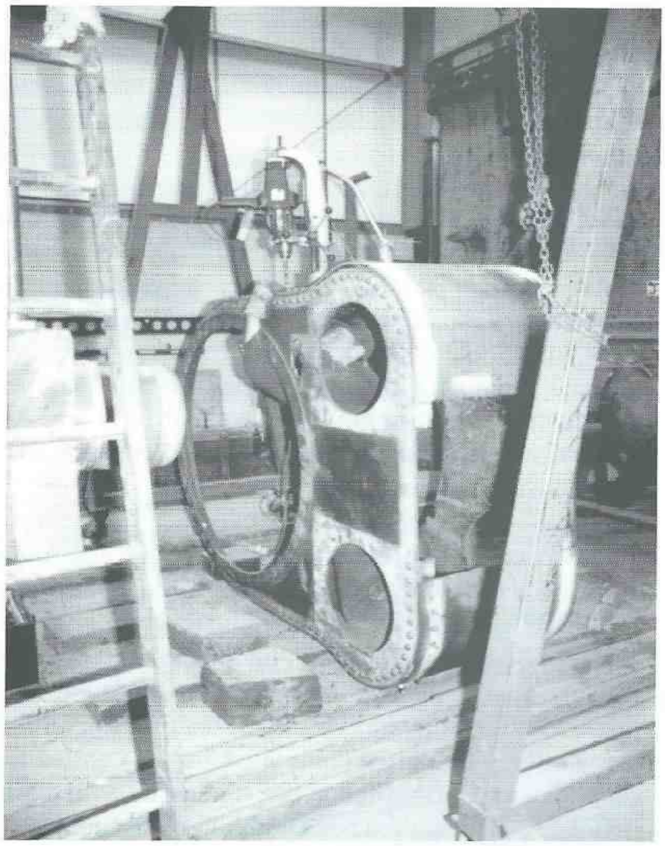
It was at about this time that a member of the Great Western Society who visited Didcot on the odd occasion, steam days and the like, saw the frame under assembly. Now retired, and an ex- Swindon apprentice from the steam days, his interest was rekindled and a new member joined the group. The chairman was, at that time, literally working alone on the project, enthusiasm in no way dimmed by lack of assistance. But, as explained earlier, the newcomer could see that there was nothing he could do as there was only one set of tools and much awaiting making before it could be fitted. One facet of the construction which would be required, he realised, would be a vast array of castings in steel, iron and the yellow metals, so he asked if the group included a pattrn-maker. It did not, so he volunteered to start the ball rolling if the chairman would suggest a first requirement. Just as a start, the name plates were suggested, so that some progress could be seen to be made.

During this time a firm had been contacted and patterns made for the cast steel wheels. These have angled spokes from the edges of the central boss to a line on the wheel rim, and were at this time being cast. Pattern making is a great expense, and with wheel patterns of seven feet diameter for the driving wheels and four feet diameter for the carrying wheels (fortunately the six tender wheels were of the carrying wheel type) a large chunk of the existing finance had been taken up. The main crank axle, casting the wheels and getting the wheel tyres rolled in Belgium almost reduced the scheme to bankruptcy.



The author near camera assisting with wheel positioning under the frame

The wheels were eventually machined at Stotherts of Bath, and the tyres machined for heating and then shrinking onto the turned wheel rims. Incidentally, the original wheels would have been made of wrought iron, shaped and smith welded in sections by a highly skilled group of smiths. Electric or gas welding did not exist at this time, so all 'welding' was done using a coke fire. What a task to undertake! Wheel assembly was supervised at Stotherts by the chairman, who photographed the process. The photographic record has continued as building has progressed.

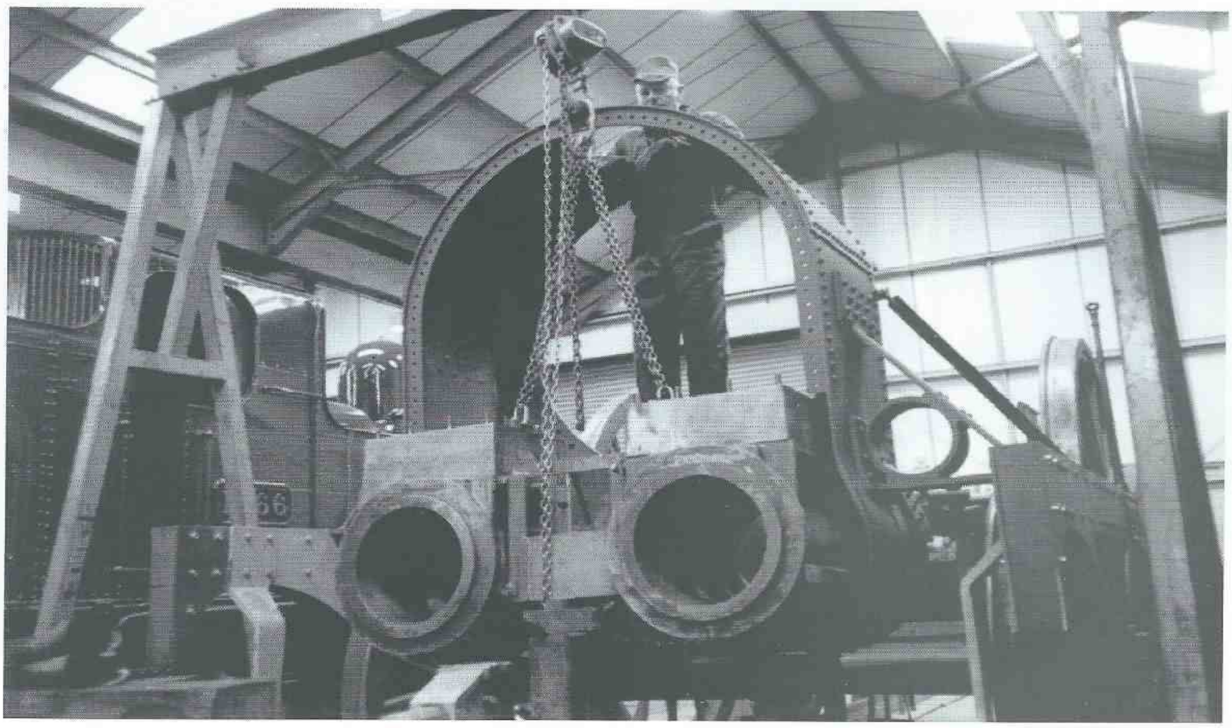


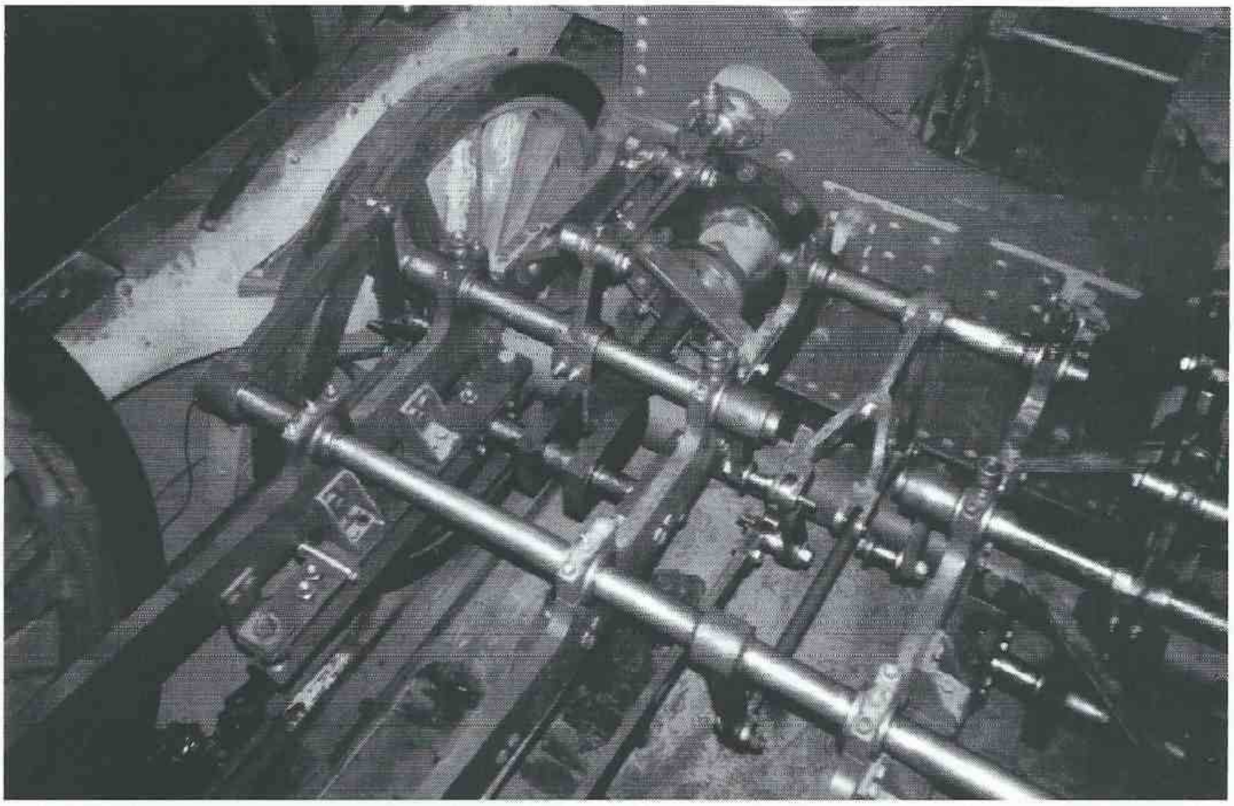
John Mosse gilding the smoke box

Once the wheels and axles were under way the next requirement was for axle-boxes, the bearings in which the axles rim. There were no drawings, so from measurements taken, and from experience, a full-size model axle-box in wood was made for examination and discussion. The design was approved, so patterns were made and the boxes cast and machined at Didcot. The name plates were also cast and machined ready for fitting, and the wheels mounted. When the boxes were fitted it meant that the frame could be moved, and as a publicity gesture the great railway artist, Terence Cuneo, was invited to perform a 'naming' ceremony, duly covered by newspaper and television reporters.

The next pattern requirement was for the cylinders, the biggest pattern job to be tackled. When the patterns were completed, some time was to elapse before the funds were available to get the cylinders cast and machined, and during this time they were displayed in Swindon Railway Museum in the hopes that a sponsor could be attracted. Eventually cast and machined, the completed cylinders, two in number,

Positioning the cylinders





Assembly of the valve operating gear

weigh in the region of half a ton each. During this time also the chairman was constructing the smoke box, literally by himself, and with the chimney mounted the locomotive was now recognisable, although still a long way from completion.

During this period several requests were received from various interested groups and organisations for a talk about the *Firefly*. At one such talk to a large group of retired and/or redundant railway staff when Swindon works closed, a positive enquiry enabled two more names to be added to *Firefly's* construction team, one of the volunteers also being an ex-Swindon steam apprentice.

The design of the locomotive, typical of the period, included decorative, turned metal pillars and hand rails along the side of the frame, and these were sponsored and supplied by the engineering faculty of a northern university. Another feature of the period was that the driving, or crank, axle had no fewer then six axle-boxes, two of which were positioned in the outer 'sandwich' flame, whilst four more were required for the four inner frames. Thus patterns were again required, and all the boxes were cast in phosphor bronze, a heavy duty bearing metal, and very costly.

Various plating jobs were undertaken, and a start was made on the design of the valve operating gear and connecting rods and other items which all come under the general locomotive term of 'the motion'. Much time and thought were given to this aspect of construction, and acquisition of the component parts and material was undertaken by the chairman, who placed all orders for material and subsequent machining operations.

Whilst one team member was occupied in making patterns (in his home workshop) for all manner of valves, bearings and various boiler fittings, some of which have been cast, machined and now await fitting, the chairman and the two later recruits assembled the components of the motion as they became available. Later on two further members brought the actual manufacturing team to six, painting and polishing the components before or after assembly.

It was decided that a start on the tender would be advantageous, as progressing the complete locomotive would then be of greater interest. The procedure followed that for the locomotive. The frame, wheels (cast at the same time as the locomotive wheels and stored at Didcot) and axle-boxes gave a 'running' frame on which the water tank and the coal space are mounted. Again, all components were ordered and processed by the chairman. A pattern was made and the bearings cast for the axle-boxes, following a much cheaper fabricated steel design of axle-box with a separate phosphor bronze bearing, the team working at Didcot progressing both tender and locomotive together.

A major worry over the years, and it is surprising how time flies by, was the financing of the biggest single expense of the whole project, the boiler. Eventually a sponsor was found to a sum which could be used to place a positive order, but before this event a request was received for the loan and transportation of *Firefly* to Exeter for the celebration of the opening of the Bristol & Exeter railway 150 years ago.

As there was no boiler, to make a more realistic silhouette the college building and engineering faculties combined to make a dummy boiler, which was duly delivered to Didcot and fitted. A great disappointment to all was the fact that the sponsor for transportation backed out at the last minute, and the project itself could not justify the expense (even if such had been available) so *Firefly* remained at Didcot. A further boost to finances occurred in 1998 when the project benefited from a bequest in the will of an engineer.

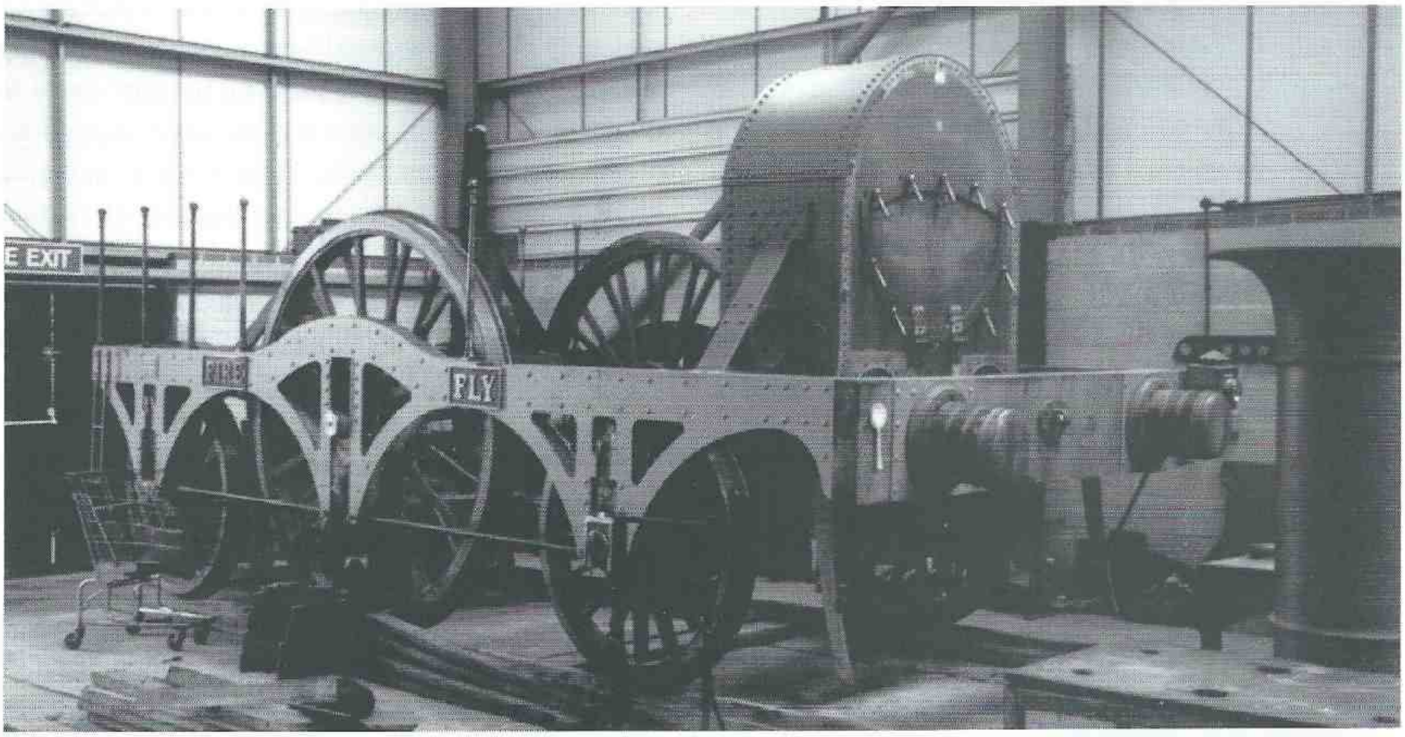
Although it appeared that everything could now go forward there was a further major stumbling block. It had been the intention to follow in the footsteps of Brunel and issue a specification to a selected boiler-making firm and allow then to design and construct the boiler. It was not to be. The insurance company totally rejected the idea, and insisted that the boiler be completely designed by the project, even to the extent of such detail as specifying the weld used in construction, with all material strengths, weld strengths and calculations.

The boiler proposed was all steel, welded instead of riveted in the well tried and trusted tradition of former Great Western construction. The design itself could not follow the original *Firefly* in any case. Not only had materials changed (the originals being wrought iron and no longer acceptable), but the original period technique of using the boiler as the main ‘frame’ and hanging all the motion and bearings from subsidiary under-flames attached between the smoke box and the fire box was also not acceptable practice. The boiler would be a separate modern concept, and additional cross members attached to the outer frames would support the four inner frames, the latter cut to profile and installed.

Whilst the boiler problem was being sorted out, discussion with the insurers continued and a working drawing materialised through the stalwart efforts and determination of one of the founder-members of the group. Whilst the boiler design progressed, the working team went ahead with the tender brake gear. Original concepts again could not be followed. The single side-brake arrangement on the tender, applied by a hand-operated screw, had to be augmented by a modern vacuum brake system.

Work was under way on assembly when the project suffered a great loss. After a full working day at Didcot, the chairman, John Mosse, died suddenly during the night. John had been the founding inspiration and driving influence from the start of the project; he was responsible for finance and construction, ordering components and materials, dealing with publicity and liaison with the many firms involved with supply. The determination of the working team to continue the project is highlighted by the fact that work continued at Didcot from the date of John's passing in October 1998. A new active board has been formed to continue the requirements so ably undertaken by John Mosse alone. It is sad that he did not live to see the completion of a project to which he gave so much, but 1999 will see continued progress with a project so far advanced.

Completion will be a fitting memorial to the man who started it all, and we hope that the new century will see a locomotive of an earlier century operating in steam.



Firefly with nameplates and smoke box in position

Smoke box and chimney backed by the dummy boiler and fire box