

The Craft of Scratch Building

This is an edited version of The Craft of Scratchbuilding, published in the Gauge O Guild Gazette, Vol. 16, No. 10 (Winter 2006)



The 700 class was one of my earlier models, but I still managed to include the connecting rods, crossheads, slidebars, and working inside valve gear. Detail like that, which is quite visible under the high-pitched boiler, is a must for me. The wheels are Slater's, but I had to modify them because the crank throw on this loco is unusually small.

Back in 1960, Cyril Freezer wrote “The construction of locomotives and rolling stock entirely from basic components is rightly regarded as the pinnacle of the railway modeller’s craft.” That was at a time when, in 7mm scale, kits were all but non-existent. Even in 4mm, which was by far the most popular scale, locomotive kits were largely limited to cast white metal offerings, mainly body kits designed to drop on to which ever Triang or Hornby chassis had the right number of wheels. Never mind that the wheel diameter and spacing were not always what they should be, the kit maker had adjusted the footplate up or down and moved the splashers a few millimetres to suit. And the castings were not always great quality either. The boiler was often not quite round, and there was usually a need to fill the gaps between components that did not quite fit together, once they had been soldered or glued. The point about it all was that if you wanted an accurate model, or anything outside the limited ranges of models available, or worked in just about any scale except 4mm, you had to scratch build. And looking back, it is apparent that there was a wide range of standards in the results. The best were as good as they have ever been, before or since, but the skills of people like Beeston and Miller are given to only a few, and if you look back in the model railway magazines of the time, it is obvious that many people were making do with what are, by today’s standards, mediocre models.

Fast forward twenty or so years and the arrival of chemical etching changed everything. It is not always realized the extent to which our hobby has benefited from this technology, which came about to meet the needs not of railway modellers, but of much larger markets, notably consumer electronics and computers. As with most innovations, it was initially expensive and unusual, but costs quickly dropped and the ease of access increased. Today it is very easy (if you have the skills) to design a sheet of etched components using a CAD program, send the electronic file to an etcher, and receive the result, without anyone committing anything to paper (except the bill, of course!). Small wonder, then, that our hobby has taken full advantage of this technology.

And so now, as has frequently been observed, we have kits for most of the British prototypes you are ever likely to want, unless you are interested in railways before about 1880 or the most obscure companies, and even then you will probably not be completely lacking. You may even have a choice of kits for any given prototype, perhaps ranging in price, quality, detail, and ease of construction. That means that most modellers can today put together a very decent layout with a representative selection of locos and rolling stock, built to a high

standard of detail and accuracy, without ever having to contemplate scratch building. So is it fair to regard it still as “the pinnacle of the railway modeller’s craft”, or do we now relegate it to the status of coracle making, or wattle-and-daub building, quaint crafts whose time has passed?

If you are still with me, it will not by now surprise you to know that I scratch build locomotives, and usually get a lot of pleasure and satisfaction from doing so. But, the nagging little voice in my head demands from time to time, why scratch build with all the time and toil that it involves, when there are so many models that can be built from the kits available? Even if I restrict myself to what are generally recognized as the best of the trade offerings, there are still a lot to choose from, and I can aim at a very high standard, knowing that if I fall short it will not be the fault of the kit.



Clyde. Intended to be a quick construction, it still seemed to be glacially slow compared with what some people achieve.

To quote another voice from the past, the late David Jenkinson once asked himself the same “why scratch build?” question. His answer was “because I have to”. As most readers will know, David spent many years constructing a series of layouts that were most carefully located in time and space, in which the most important factor was the overall impression that is gained by a combination of the correct locos and rolling stock, believable scenery and detailing, and prototype operation. His conclusion then was that he could not achieve his aim without some scratch building. A 100% reliance on kits would compromise his vision too much and the result would not, in the final analysis, be satisfactory.

Unfortunately I cannot even advance that as an explanation. In my own approach to the hobby, I concentrate on loco building these days. Partly that is a matter of time available. I still have a day job, and I have become very parsimonious with what time I get in the workshop, preferring to spend time on what I most enjoy. I have no ambitions to build a layout of my own. But my locos are certainly not showcase models, they are designed to run and haul the sort of trains that their prototypes would. Those I keep for myself, if I can watch them pulling a train on a friend’s layout or test track from time to time, that is enough for me. Shunting layouts and timetables both leave me cold, but good luck to those who enjoy them, I have nothing against them in principle. Sitting in the garden on a summer’s day, watching the trains go by, with good company and a glass of something decent in hand, is satisfaction enough.

Since I have been connected in some way or other with the Gauge O Guild’s annual modelling competition for a number of years now, I have been interested to see how many scratch built models have been entered as opposed to the number of kit built models. Scratch

built efforts are definitely in the minority. I cannot put a number to it or say whether it is increasing or decreasing, but I do know that sometimes one of the judges' easier tasks is awarding the trophy for non-kit built locos, because often there are not many to choose from. That is not to say that the standards are not high, indeed there have been some very impressive models over the years, but it is certainly a minority interest.

Speaking of standards, it is tempting to argue that if you are not prepared to set yourself high standards, there is little point in scratch building. If you think you cannot make your dimensions accurate and achieve a high level of detail, or are not prepared to invest the time it would take to do so, should you be scratch building at all? Accuracy is necessary in the chassis dimensions anyway if the model is to work properly, but actually it applies to all parts of the model. If the cylinders are 2mm shorter than they should be, that does not affect the running of the model (as long as it is not live steam, which is something else again), but to anyone familiar with the class, it might look all wrong. If you are not prepared to work to the necessary standards of accuracy and detail, the argument goes, you are better off sticking to kits where the manufacturer has done the work of designing the kit and including all of the necessary fittings, thereby saving yourself a lot of time and anguish.

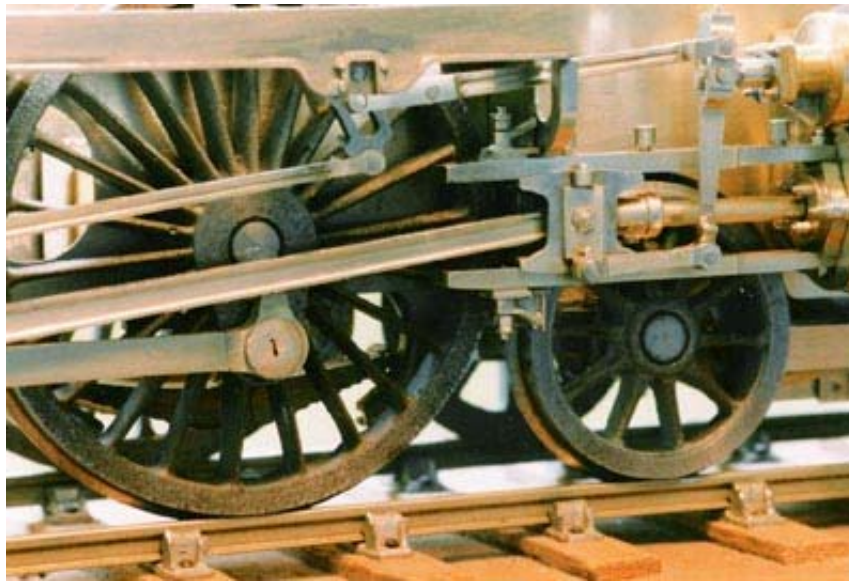
That argument, in my view, overlooks two things. First, if your heart is set on a particular model and nobody makes a kit, you may decide to build something that pleases you, even if it will not win any prizes. That is your decision and it is not up to anyone else to judge whether you are right or wrong. Second, we all have to start somewhere. In scratch building, the best and probably the only way to make real progress is through experience. Over the years I have read lots of articles about various aspects of scratch building. I have also talked and listened a lot and enjoyed it all. But I learn more from an hour in the workshop than ten hours doing all of that. That was true when I started and it is just as true today. I still have my very first scratch built loco, I just don't show it to anyone! Actually, there are some parts of it that I am still quite pleased with, but overall the effect is far short of what I can achieve today. Of course, that is how it should be, and visible evidence of progress in one's work is always cheering.



The Adams T6 is still my favourite. Unfortunately the historians of the South Western Circle have expressed doubts about whether No. 682 ever carried Adams livery, so at some point it will probably have to be renumbered. It too has full inside valve gear. In this case it can hardly be seen, but it is nice to know it is there. The same can be said of a lot of the detail between and under the frames. Sometimes I just don't know when to stop. On a much more visible level, the AGH wheels set it off so well.

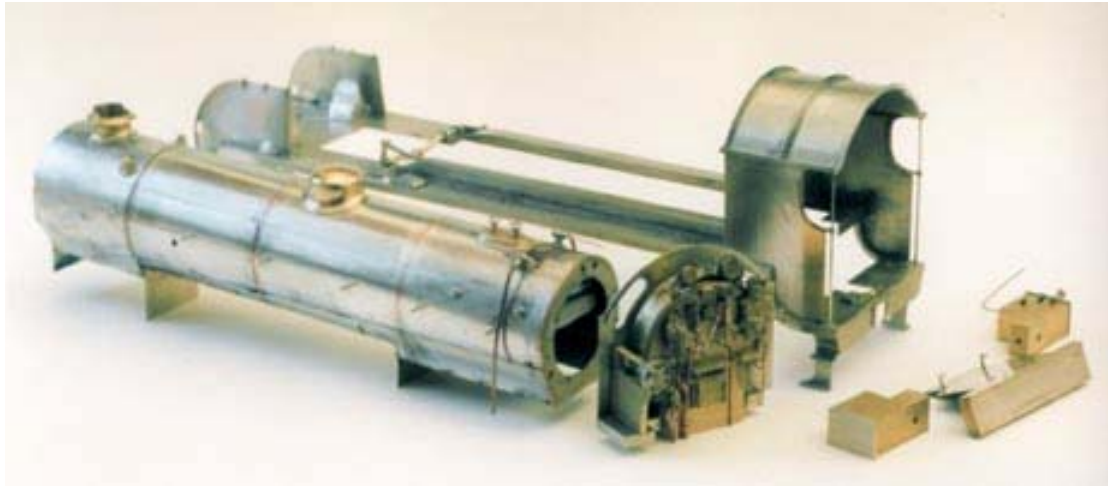
Notwithstanding my remarks about the availability of kits, scratch building does give me the freedom to make anything I like, without restriction. The Beattie 2-4-0 *Clyde* and the Adams 4-4-0 that are illustrated here are examples of this. The Beattie prototype was built in 1859 and withdrawn in 1883. The entire class comprised only seven locos, and the few photos that are available suggest that they were all different in detail, which was not uncommon at that time. Commercially it is not a very attractive prospect for a kit manufacturer. On the other hand, it is precisely those features that made it attractive for me to model, and indeed, the fact that it is a rarely modelled prototype has gained it more attention than probably any other loco I have built.

The Adams loco came about for different reasons. Late in his career, Adams built four 4-4-0 classes, differing only in detail. To my eye, they were among the most attractive LSWR or Southern locos ever built, particularly when newly finished in their Adams livery (Drummond was soon to vandalize them with his changes, but that is another story). A sole survivor of one of the classes, the T3, is preserved, and there is a kit available of this class. So I did the not-so-obvious thing of building a T6 instead. The main difference between that and the T3 is that the T6 had larger driving wheels, which required a continuously-curving splasher over the wheels. The finish of brass beading is a wonderful touch. The T3 wheels were smaller and the space between them was that much larger, and that class has a straight section between the wheels. It is only a small detail, but it makes such a difference to the appearance. I have only ever seen one other T6 modelled in 7mm (there are probably others), but quite a few T3s.



The valve gear of King Arthur. I was particularly pleased with the three-dimensional effect, and the rods really look like they can transmit the forces involved in pulling away from Waterloo with a fully loaded summer Saturday special! The crank pin, by the way, is a temporary one used during construction, and was eventually replaced with the real thing.

I suppose I should here attempt to destroy the myth that it requires the workshop facilities of Crewe and Swindon combined, arcane skills, and a lifetime of experience to scratch build locomotives. My earlier locos, such as the 700 Class and *Clyde*, were built entirely by the time-honoured manner. Frames and body parts were marked out on nickel silver sheet of the appropriate thickness, and cut out by hand with a piercing saw. For multiple components, two or more sheets were soldered together and cut out as one. In both cases I used Slater's wheels, and I can say with certainty that the only time a lathe was essential was to turn the chimney, dome, safety valve cover, and other fittings of *Clyde*. For the 700 Class, the necessary castings are available from our "bits and pieces" suppliers.



The body construction of King Arthur, showing how it comes apart into several subassemblies. I use nickel silver for most construction. In this model I experimented with tinplate for the curved components. It is much easier to roll to shape than nickel silver, but it gave me a lot of trouble with rusting. The culprit was the liquid flux used in soldering.

However, it is undeniably a slow way of doing things, and while you do need a modicum of patience to succeed in our hobby whatever your approach, I am not especially endowed in that department. So gradually I started acquiring specialized tools, not because they were essential, but because they helped the process along. In doing so, I learned new skills and devised new ways of doing things, and that is all part of the fun. And so now my workshop is full (I mean full!) with two lathes, two milling machines, both of which can double up as high-speed drilling machines, and a general-purpose drill.

So what was that about the workshop resources of Crewe? And what does this all mean to the average modeller (if such a beast actually exists) working on the kitchen table, balancing hobby expenditure with all the usual financial commitments of mortgage, family, and so on? Bear with me a bit longer while I explain.

I did not rush out and buy all these tools at once, and I would not recommend such a thing to anyone, no matter how affluent. They were acquired one at a time over a long period. I purchased my first lathe, a Sherline, which comes from the USA and is roughly the size of the more familiar Unimat, about ten years ago, and learned a lot from using it. That learning included an understanding of what I could and could not do with it. I have gradually added to the collection since. In every case it was something to overcome a limitation that I discovered I was up against. The larger lathe is a Myford, which is really a model engineer's tool but is immensely useful for turning things like AGH driving wheels and large boiler fittings, for which the Sherline proved not really heavy and powerful enough. But the smaller lathe is still used extensively for the fine stuff.

None of these tools cost more than £600, and most of them were considerably less than that. The Myford was the most expensive, acquired second hand, but these lathes were built to last and this one came to me in excellent condition. Some were inevitably misused, but many were cherished by their model engineer owners and perform today as well as they did when new.

If you think about it, the cost of such a tool is about the price, or perhaps even less than the price, you will pay for a top-of-the-range kit if you include a motor and gearbox from ABC and wheels from AGH, and considerably less than the price of having someone build it for you. Now I have friends in the Guild who will happily pay that sort of money for a Duchess or an A1, and why not? We all have our own ways of enjoying this hobby.

I am not a trained toolmaker or anything like that, though I sometimes wish I were! I had a brief exposure to lathe work and milling many years ago, but I am mostly self-taught. As they say, an ounce of practice is worth a ton of theory, and a willingness to try things out, more than once if necessary to get it right, is essential.



The pantograph milling machine.

Frames and other plate work are now cut out using a pantograph milling machine. Many modellers heard about these clever devices from the articles that Tony Reynolds has written in the *Model Railway Journal* (numbers 53, 74, and 116), although Tony has been very careful to credit the original idea to Ron Spiers, some years previously. Briefly, it works like this. A large-scale pattern of the component required is made in some easily-worked material such as styrene sheet. This is mounted on the copy table of the machine, and the pattern is traced by hand using a stylus that is connected through the pantograph mechanism to a milling cutter, which cuts out the actual part to the correct size in sheet metal. In that way the marking out and hand-sawing operations are avoided and multiple identical parts can be made quickly. If the pattern is made to a large scale, any errors in the dimensions are reduced in the pantograph and very accurate parts can be cut. If the pattern is five times size, for example, which is quite feasible for smaller components, an error of 0.5mm in the pattern becomes just 0.1 mm in the finished component.

Funnily enough, those articles were not my first exposure to such a machine, but when I first read them, they did remind me that, many years ago as a young student engineer, I watched a complex turbine blade being cut from a ten times size pattern on a three-dimensional version of such a machine (mine only handles two dimensions but that is sufficient for cutting out plate work). Nowadays that sort of thing is done much more quickly and efficiently using CNC machine tools. And that is also why pantograph mills are no longer made, as far as I know. Industry no longer has need of them. But for the same reason they are often available second hand at low cost, which is how I came by mine.

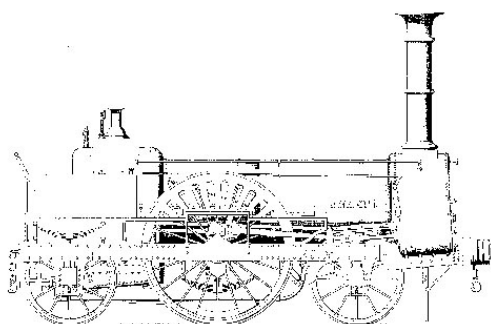
All of the plate work for my *King Arthur* was done in that way. With a sharp cutter, the parts are quickly produced and the cut edges require only a light dressing with a file to produce the square, sharp corners and edges that look so good, but are also that much more difficult to achieve with etched components. A further benefit is the ability to cut each part in the most appropriate thickness of material. Frames, stretchers, and the like are cut from 0.7mm material, which is near enough scale thickness for most prototypes. Body parts are usually cut from 0.3 or 0.4mm plate. This is actually over-scale, but anything less than that is too flimsy to handle, so where the edge shows I taper the edge with a file, which only takes a moment. In an etched kit, commercial considerations usually restrict the kit maker to one or two thicknesses, and thicker parts have to be built up in multiple layers.

The pantograph mill is also useful for fretting out other components such as the valve gear parts that I mentioned earlier, although these then needed further operations to cut the forked ends and get the full three-dimensional effect. The order of the machining operations and the set-ups for each have to be carefully planned, and if that is not your sort of thing, then this approach is probably not for you, but I find it is all part of the challenge. In fact I think that making the valve gear was the most satisfying part of that particular project, and the result is components with a visual “solidity” that is difficult to achieve by building up from layers of etchings.

That brings me on to another of the pleasures of scratch building: the challenge of planning the model and how it will go together. Most British steam locos followed a similar pattern, with an obvious division between the chassis and body at the footplate. Yes, I know that was not how the real thing was built, but that is conventionally and conveniently how we model them. It gets a little more complicated with the likes of BR standards where the footplate was raised to be part way up the boiler, but a similar division can usually be adopted, with the motor poking up into the firebox.

Beyond that, I like to divide the body into major subassemblies such as the cab and boiler (the backhead and cab fittings is usually a subassembly also), for ease of construction and painting. For the chassis, various parts can be dismantled in order to get at the works. On outside cylinder engines, the cylinder head, slidebars, valve gear and motion bracket are normally a separate assembly screwed to the frame and slotted into the cylinder body, which is itself screwed separately to the frame. Planning all of these things is something that keeps me interested in the project.

Less conventional engines pose more interesting problems. I am showing here a drawing of a current project, which is a double frame 2-2-2 engine dating from 1847. If you look closely, you will see some interesting features, particularly at the smokebox end. The smokebox and the cylinders have a wrapper that goes over everything, but to complicate matters, the cylinders slope relative to the smokebox so that the whole thing becomes a complex, three-dimensional shape. The front of the smokebox is partly flat and partly sloping, while the interface between the smokebox backplate, the boiler, and the cylinders is very complicated. In the model, there is no way in which the smokebox can be split from the cylinders, as it would be in the classic chassis-body division, without a great deal of trouble. Instead this all has to be made as a complete unit.



*The LSWR 2-2-2 from 1847,
currently under construction.*

Consider also that the slidebars are attached to the cylinder head at one end, and to a curved bracket, itself bridging and attached to the inner and outer frames, at the other end. All of which also makes it very difficult to split the firebox-cylinder assembly from the frames. Conceivably and with some ingenuity the inner frames, together with the wheels, gearbox, and motor, could be made to drop away from this lot, but that brings with it the problem of how to divide the inside valve gear. This is not shown in the drawing, but it is visible and needs to be modelled (at least, that was my judgement). The valve gear is driven from eccentrics on the driving axle and attached to the frames with various brackets, and so the four eccentrics would have to be split every time the inner frames were separated from the rest of the model.

My solution, after much thought, was to attach the smokebox assembly permanently to both the inside and the outside frames. Access to the motor and gearbox will be by removing the boiler and firebox (the motor occupies the firebox), leaving the driving wheels, connecting rods, and valve gear intact. A major overhaul, such as to replace the gearbox (I think that is the modeller's equivalent of re-tubing the boiler) will still be a big job, I just hope it is not needed too often, like more than once in a lifetime!

At least, that is the theory at present. I have often found that as I get into the building, other ideas surface, and so the end result might be different, and who knows, a more convenient solution might emerge.

Yes, it all takes time if a good standard is to be achieved, undoubtedly longer than producing a similar model from a decent kit, although possibly not longer than compensating for the inadequacies of a less than decent kit. I am not completely averse to building kits or lacking in experience of doing so, so I am aware of the time factor. Scratch building everything is certainly not the way to build up a loco stud to rival Nine Elms in its heyday. But, I would argue, that is not really the point. The time factor, whether elapsed time or hours spent actually modelling, is not something to be ignored completely, but is far less important than the pleasure it gives. And in the final analysis, that is the only real criterion.



Various bits and pieces for the LSWR 2-2-2, mostly cut on the pantograph mill. To the right of the picture are some of the casting masters, assembly jigs, and riveting templates. The odd-shaped pieces at the bottom centre are spacers for the complex smokebox assembly. Yes, there are parts here for two locos. There are no commercial wheels available that have the correct spoke profile, or the symmetric centre of the driving wheel, so they will have to be specially made. Castings will be made from these masters, and then turned tyres added.