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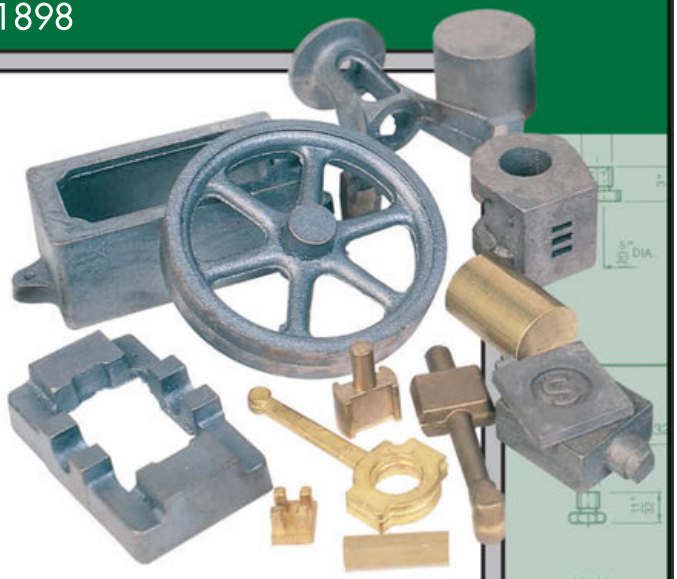

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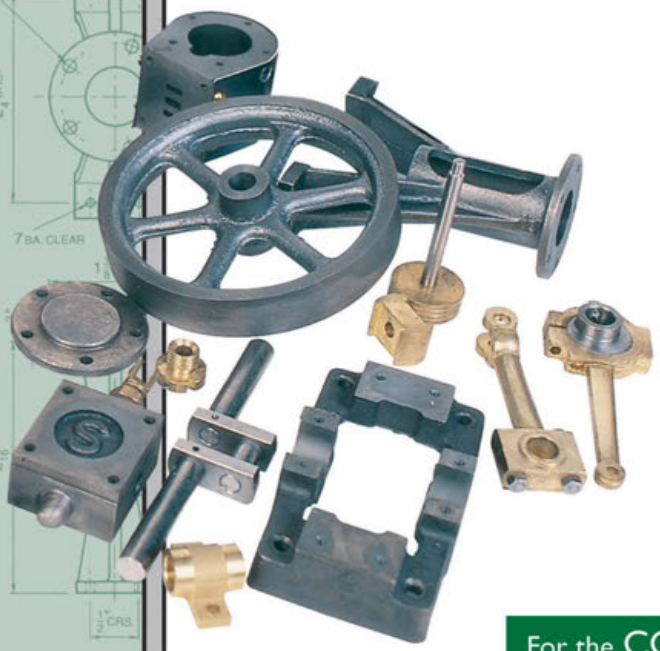

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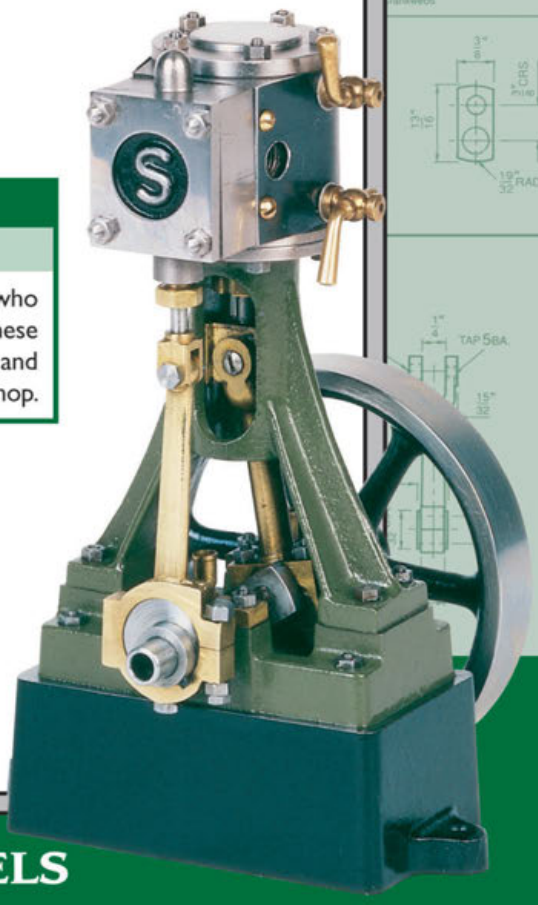

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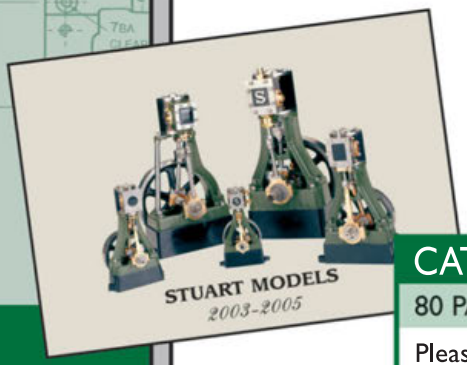

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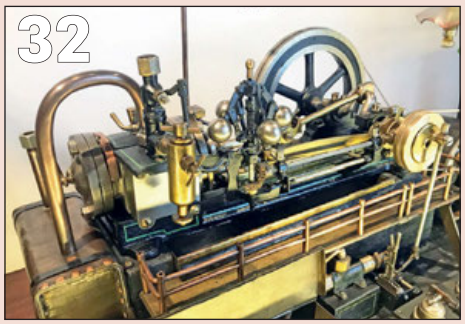

FRONT COVER

Anyone can build a live-steam engine, and to prove it in this issue young model engineer Matthew Kenington begins describing a simple oscillator, which he made aged 12 before going on to bigger things. Never built an engine before? Why not start with this one?

Photo: Peter Kenington

EDITORIAL

Locked-down family? Let them into your workshop...

Welcome to the February EIM and I write these words less than 24 hours after the Prime Minister announced yet another England-wide full lockdown, incidentally joining those of us living in Wales who have been locked down since before Christmas! As a result I've decided to take up much of this column with the information box we offered during the first lockdown nearly a year ago, explaining how you can still get hold of EIM without going out of the house. We wouldn't want you to miss your monthly read...

Especially as we have so much new and interesting material to offer you in the coming months. I've been delighted with submissions arriving at EIM towers in recent days, from a new traction engine construction series to kit refurbishment and a host of clever workshop techniques – all to come as the year winds on.

Typical is this month's cover feature, a new short series by young Matthew Kenington showing just how easy it is to build your first engine. Matthew built his aged just 12, so if you have a bored youngster in the house facing a lockdown diet of shooting things on a computer screen, why not take them into your workshop?

Andrew Charman – Editor

The March issue of **Engineering in Miniature** publishes on 18th February.

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A first model engine for first-time model engineers

In this new series Matthew seeks to inspire other novices by describing his first project in model engineering – built when he was just 12 years old.

BY **MATTHEW KENINGTON** Part one of a short series

This project is based upon an idea for an oscillating engine taken from US-based model engineering supplier 'The Little Machine Shop', with modifications made by myself. This was my first project as a model engineer, and I learnt a huge amount from what is ostensibly a very simple design.

I would thoroughly recommend this engine as a beginner's project – most of the basic techniques upon which more advanced model engineering is based can be learnt from this simple design: basic turning, threading and tapping, simple milling operations and even finishing and polishing. In my case, I took advantage of my dad's CNC milling machine to engrave the 'M' on the cylinder cap and lettering on the plaque on the base (Photo 1), however this is not strictly necessary!

PHOTO 1: The completed oscillating engine – a simple but effective first project.

FIGURE 1: The general arrangement of the oscillating engine, with the parts list.

All photos and diagrams in this series by the author

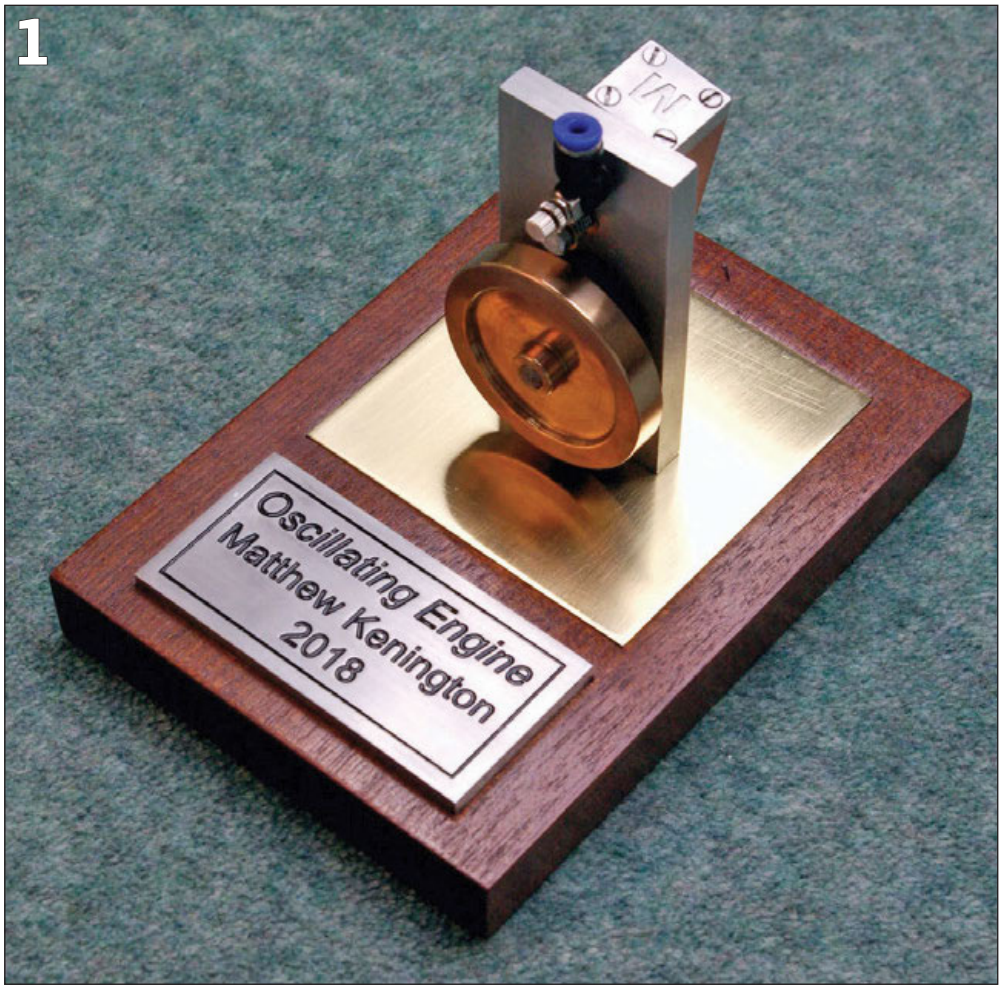
For the basic machining, I used the CNC mill as, in effect, a manual machine with a DRO (digital read-out), and also used a basic manual mill in the workshop at Hereford SME. If, at the tender age of 12, I could do this, then so can you (in my case, with much help and advice from the infinitely-patient members at Hereford SME's 'Young Engineers' club and my dad, all of which is very gratefully acknowledged).

Whilst I made many mistakes along the way, I didn't quite fulfil fellow Hereford member and EIM contributor John Arrowsmith's maxim that "every model engineer makes two models: the one they finish and the other which ends up in the scrap bin." This was a hugely rewarding project and I had a real sense of achievement when the engine ran, first-time.

The finished model won (joint) second prize in the Midlands Model Engineering Exhibition 2018 (Junior Engineers' category), which was a great boost to my confidence as a novice model engineer.

As this is a project aimed at the absolute beginner, I plan to go into more detail on materials and construction than is typically the case in most projects presented in these pages. I try to assume little or no knowledge of how to use a lathe and a mill – these skills are no longer taught in most schools (including mine) and many new model engineers will not have gone through an apprenticeship in which they were taught these things.

My aim is for you to learn along with me, hopefully avoiding the pitfalls which I encountered. If you are a member of a local model engineering club, don't be afraid to ask for help. Persevere and you'll soon find out who is willing to assist (and has the time). If you are not a member of a club, I recommend joining one straight away – there is a wealth of experience waiting there to help a keen novice, in my experience.

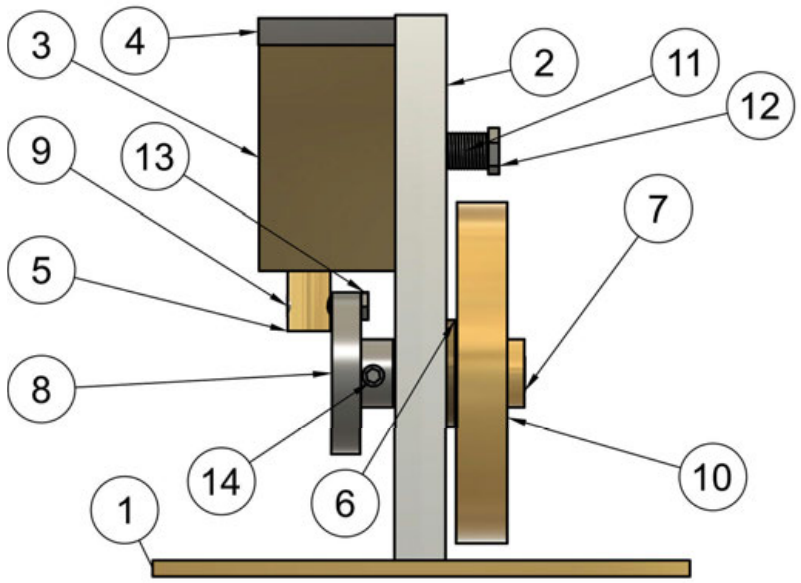


Basic design

So, what are we going to build? Figure 1 shows the general arrangement of an oscillating engine. It is not designed to look like an 'old fashioned' steam engine and is not based upon any form of full-size prototype – indeed, it looks quite 'modern'. It consists of a mere 14 parts (plus a few off-the-shelf machine screws), the final four of which require little or no work.

So only 10 parts to build; "how hard can it be?" you ask yourself. The answer is: 'quite challenging' if you've never done anything like it before (as I hadn't before embarking upon it). You will learn a huge amount and gain a great deal of confidence in building this little project, and will experience a small glow of satisfaction in seeing it run. You will need to practice many of the basic milling and turning skills needed in producing much more ambitious models and can use this as a springboard onto greater things.

FIGURE 1



Item	Qty	Description
1	1	Base
2	1	Upright
3	1	Cylinder
4	1	Cylinder Cover
5	1	Piston
6	1	Bush
7	1	Flywheel Shaft
8	1	Crank
9	1	Crank Pin
10	1	Flywheel
11	1	Spring
12	1	Bolt
13	1	Nut
14	1	Grub Screw

From this I moved on to a Stuart S50 mill engine (www.stuartmodels.com/item/17/stuart-s50-unmachined) and then a riding truck (which has featured in these pages a few times) and I am now working on a 5-inch gauge GWR Manor 4-6-0 tender locomotive – at each step I have learnt a huge amount and gained both confidence and skills. And it all started with this humble little oscillating engine…

Materials

All of the materials used in this project, including un-machined bar, rod and plate stock were 'to hand' (in other words not purchased for the project but sourced from an 'off-cuts' cupboard), with bolts, the spring and such also being from stock – hole sizes and threads were tapped to suit what was available, and the drawings made to suit the materials – the opposite of normal practice!

Some of the materials chosen were not ideal, but serve to illustrate how forgiving the design is, while they also allowed this novice engineer to learn about a wide range of metals in a single, very simple, project.

The materials used for the major components (along with suggested, more appropriate, alternatives) were:

Main base: a magnificent piece of solid mahogany given to me as a birthday present by a friend, specifically for this project. It was a beautiful wood to work and looks fantastic – but is expensive! Any suitable piece of wood would, of course, suffice, however you will spend many hours, days and weeks on this project, so why not treat yourself to something which will greatly enhance the look of the finished item?

Base plate: brass sheet (3mm thick) – this was a good choice and looks right,

"Most of the basic techniques upon which more advanced model engineering is based can be learnt from this simple design..."

"I was told it was phosphor bronze when it was handed to me and didn't realise it wasn't until too late..."

although aluminium could be used as a cheaper alternative (for example with a 'brushed' finish – easy to achieve with a coarse-ish grade of sandpaper on a sanding block).

Upright support: aluminium (10mm plate) – a good choice and inexpensive. It also provides an interesting colour contrast to the base plate and the flywheel. It is easy to work, won't rust and is strong enough for the job. It will wear/scratch more quickly and easily than other options (such as mild or stainless steel), but you probably won't be running this engine on a daily basis, so it's unlikely to be a big concern.

Flywheel: phosphor bronze – what a lovely material, both in appearance and to work. I was asked what I wanted for Christmas last year, from my grandad (who is largely restricted to buying online); after pondering for a minute, I wondered out-loud if Amazon stocked phosphor bronze (they don't, sadly). Unfortunately, it is rather expensive (around twice the price of brass), so brass or steel would be good alternatives – we will discuss later in the series about how to stop the latter from rusting. Aluminium is probably a bit too light to maintain the required angular momentum to ensure smooth operation of the finished engine.

Cylinder: copper – yes, I can hear the experienced readers saying this wasn't a great choice, but in my defence, I was told it was phosphor bronze when it was handed to me and didn't realise it wasn't until too late (after I'd completed a few machining operations). Copper has a tendency to 'grip', particularly when encountering small drill bits and taps, which can then easily break in-situ. It also wears quite easily – not ideal for use in a cylinder then (although this one probably won't get enough use to make this a major concern). Aluminium would be better (and cheaper) if the engine will not be run very often (as it will wear quickly, like copper); cast iron would be a better, low-cost, alternative, with other options being brass or phosphor bronze (which I would love to have used…).

Cylinder cap: aluminium – this provided a nice visual contrast to the copper of the cylinder, but brass would have been another good choice.

Piston: brass – a good choice; easy to machine accurately and not too expensive for the small piece of material needed for the piston. It is also not too bad when it comes to wearing, in normal circumstances (such as when used with a cast-iron cylinder). In my case, however, the copper cylinder will wear in preference to the brass piston, which is, of course, the wrong way around. It is much easier to machine a replacement piston than a replacement cylinder!

Crank: mild steel – this is hard-wearing and provides good practice in machining a harder material.

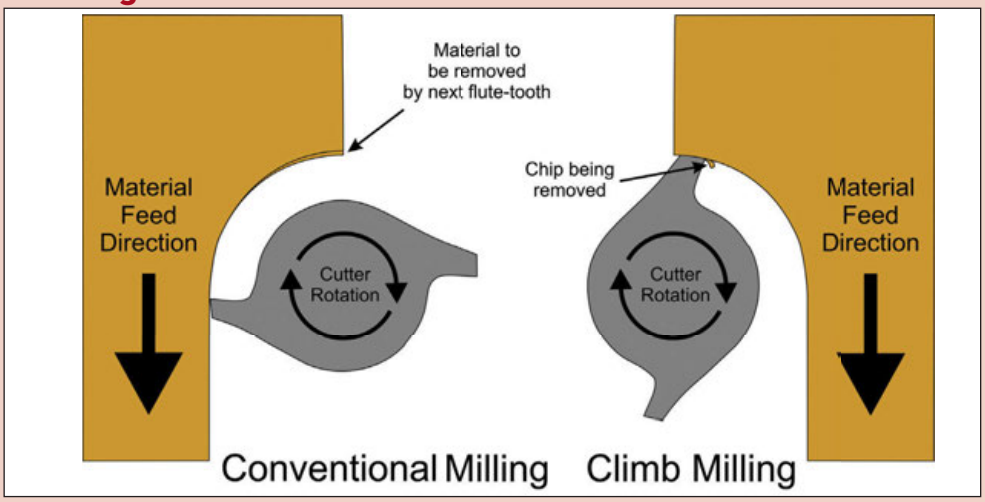
The materials used for the various shafts, bushes and the like will be discussed at the appropriate points in the text.

Before you start

As this article is being written, we are in the middle of the Covid pandemic. There is one benefit of this: I don't have to explain what 'PPE' stands for. PPE is not just for care workers – it is just as important in the workshop, although the forms it takes are a little different. As a bare minimum, you will need:

1) A good set of goggles – the kind that attach limpet-like to your forehead and cheeks. Don't go for the cheapest – these will steam-up,

Climbing the walls...



■ At this point, we should probably discuss 'climb' vs 'conventional' milling. The main description of milling the base plate did not say in which direction to move the table when taking the cut, for example 'start with the cutter to the left of the workpiece and move the table from right-to-left to take the cut', or vice-versa. This matters, as we will see.

We need to have a basic understanding of the concepts of 'climb milling' and 'conventional milling' in order to decide which direction is best. In conventional milling, the cutter (which rotates clockwise) is moved such that the cutting edge of a flute encounters the workpiece in the opposite direction to that in which the cutter is moving, relative to the workpiece (left side in the diagram above).

In climb milling, the cutter is moved such that the cutting edge of a flute encounters the workpiece in the same direction as that in which the cutter is moving, relative to the workpiece (right side in the diagram).

So, why does this matter? After all, the cutter will cut successfully in either direction of travel for the workpiece. The answer lies in the load put on the tool (and hence the feed-rate which can safely be used), together with tool life and, perhaps more importantly for model engineers, the finish obtained.

Most model engineers are not time-constrained in the way that a production facility would be – if a lower feed-rate needs to be used and the job consequently takes a little longer, this is not usually a problem (unless you're an impatient teenager, of course...). Tool life is also of less concern to us, since we are not attempting to turn a profit from our endeavours. The finish obtained, however, is another matter and worth getting right.

With conventional milling, the chip thickness starts at zero, gradually increasing to the full 'feed-per-tooth' of the chosen feed-rate. At the start of the cut, as the tooth engages the metal of the workpiece, the cut is very light (left side in the diagram, where the 'sliver' to be cut can be seen to build from a zero-depth starting point).

As discussed above, we want the tool to engage with the workpiece and cut into it (I like to think of it like a wood-chisel engaging with a piece of wood), not skim over the surface and abrade it away (imagine using a wood-chisel to wear away a piece of wood without cutting into it!).

However, the lightness of the start of the cut, with conventional milling, means that this 'skimming' does happen, at least to begin with, until sufficient pressure has built up and the tooth suddenly penetrates and starts to cut.

This has two consequences: it deforms the material, possibly resulting in some work-hardening, and dulls/wears the tool. This constant sliding, followed by sudden biting, as each tooth tries to engage with the workpiece results in a poor surface finish.

The skimming action also generates heat – much more so than the correct cutting/slicing action does. And finally, the chips are thrown-up in front of the cutter, where they can build up unless continuously removed by flood-coolant or a vacuum system. If the cutter is forced to cut both the chips and the workpiece, this also leads to a poorer finish.

With climb milling, by contrast, each tooth is able to engage the material at the full feed-per-tooth rate intended by the chosen feed-rate, with the chip thickness starting at this value and gradually decreasing as the cutter rotates. The chips are flung out behind the cutter, hence being less likely to impede the next cut-rotation. There is also no skimming or rubbing action, which is likely to improve tool life.

So, it's a 'slam dunk' for climb milling, as our American cousins would say? Not quite. The sudden, full-tooth, engagement of the tool with climb milling means that the machine needs to be quite rigid and have minimal backlash for its benefits (in terms of finish quality) to be fully realised. With old, worn, or small/low-rigidity machines, conventional milling may yield better results.

The answer is to experiment – try milling one side using conventional milling and the other using climb milling and compare the results. Listen to the sounds the cutter makes – louder 'graunching' noises mean that the cutter is less happy.

On my dad's machine, the difference between the two is quite obvious in the difference in the sounds made. This is a 'learning' project after all and you will learn something about your machine while carrying out this exercise.

scratch easily and the elastic will give out on their journey from the front doormat to the workshop.

2) A good set of ear-defenders – again, don't scrimp on these. The more you spend, the more comfortable they will be, particularly considering you will be wearing them for hours!

Some safety glasses can also come in handy – they don't mist up like goggles, but offer less protection.

Gloves, however, should not be worn anywhere near fast-rotating machinery (as a general rule) – they can get caught and drag their wearer in with them.

Likewise, avoid loose clothing, jewellery and long hair (tie it back, get it permed, maybe a Mohican? – anything to keep it out of the way). And with all that sorted, now we can start construction.

Base plate

The base plate is a simple place to begin your project. Whilst the dimensions of this component are not at all critical, I used this as a practice piece to learn basic milling skills and so tried to stick to the drawings as accurately as I could.

The first step is to mark the sheet material to approximately the correct dimensions (Figure 2) using a scribe, steel rule and engineers' square. Then cut it with a hacksaw – aim for a few millimetres too large so the milling cutter always has something to cut away, even if your saw cutting isn't perfectly straight (mine wasn't!).

The four edges of the sheet can then be milled to achieve the correct dimensions and a perfectly rectangular base plate. I used a manual milling machine with appropriate locking of the unused axes for this purpose – this was a novelty to me, as the axes do not need locking off on my dad's CNC mill, even when used in 'manual' mode. What does 'locking-off' mean, I hear you ask? This is the process of securing one or more the three axes (usually two) in order to prevent them from moving whilst cutting in a different axis. The axes are usually defined as X (the mill table moving from left to right), Y (the mill table moving backwards and forwards) and Z, (the column or 'quill' moving up and down).

To mill a straight side, say parallel to the front of the bed of the mill, the plate is clamped to the bed, including suitable spacers (see Photo 2) and the quill set to an appropriate depth such that it will cut very slightly below the depth of the plate material, i.e. it will just-to-say cut into the sacrificial spacing material (in Photo 2 this spacing material is some mild-steel – the grooves made by the milling

cutter, for both X and Y axes during this operation, can just be seen toward the front and far side immediately outside of the plate). The quill can then be locked at this depth – there will be a lever or hand-wheel on the column somewhere to do this.

To perform a cut on the X axis (parallel to the front of the bed, say), the Y axis should be set to take off a small sliver (say 1mm, if your sawing left more than this as spare material), for example set such that the edge of the milling cutter sits around 1mm inside the area of the plate. It is better to take off too little material than too much – you can always do a second, third, fourth… pass.

Once the Y axis has been set, it should be locked – how you do this will vary from machine to machine, but there will be a lever or clamping wheel somewhere to do it.

The only axis which can now move is the X-axis. The handwheel for this axis can be gradually turned and the cutter passed along the edge of the material. You will get a feel for how quickly to move the bed – too fast and the machine will 'complain' (become noisy!) and the finish will be poor, too slow and you'll miss tea-break.

The ideal speed will produce noticeable 'chips' or longer shavings (depending upon the material), without 'complaining' unduly. If you are getting a fine dust, instead of chips, you are probably going too slowly – the cutter needs to cut the metal (producing chips), not wear it away (producing dust).

Once you have completed a pass, have a look at the finish – it should be beautiful along the cut-side, probably with a burr on the top surface of the plate (always beware of burrs, they can be sharp...). If it isn't a beautiful finish, it may be that your cutting tool is blunt, your clamping is inadequate (if the plate rattles up and down), you went too fast, or your machine lacks rigidity (likely if you have only a small, low-cost, machine). The solutions to the first three issues are obvious (sharp, tight and slow, respectively). In the latter case, taking very gentle cuts is the solution – use 0.5mm cuts instead of 1mm, say, or maybe even less. You'll get there, it'll just take longer.

Repeat this process for the far side of the plate and then for the left and right sides, adjusting the clamping accordingly (see below) and locking off the X-axis, then moving the Y axis. In so doing, you should be able to mill the plate to exactly the right dimensions (checking with a digital calliper – these are not expensive to buy and quicker than learning how to use a vernier-based version! – I am a teenager, after all...).

"If you make a mistake and it ends up a bit smaller than it should be, it will still be usable..."

FIGURE 2 – Reproduced 75% full-size

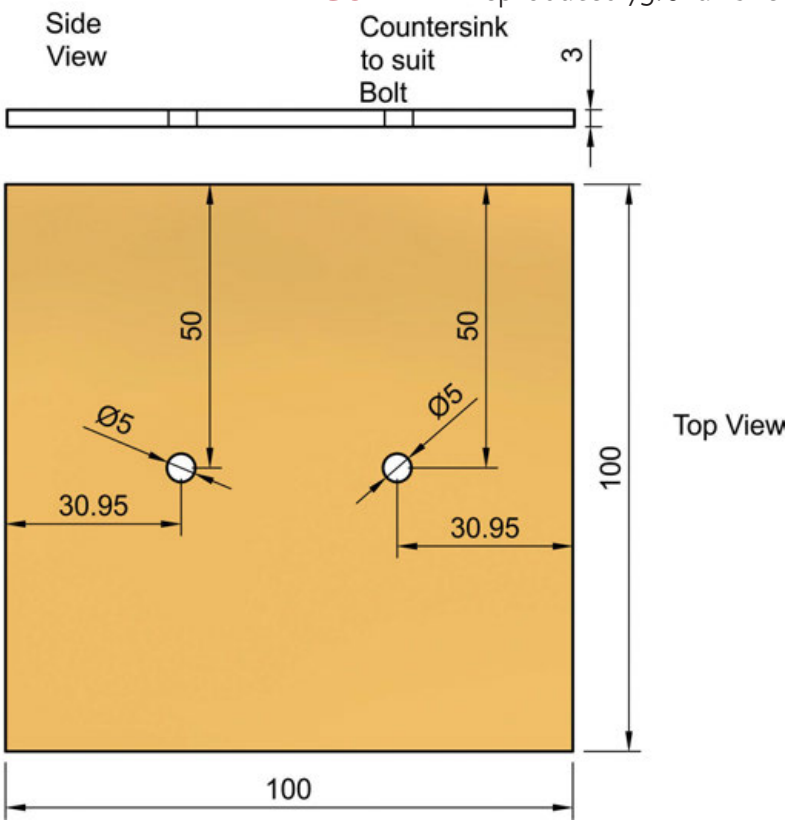


FIGURE 2: Dimensions of the base plate (in mm).

PHOTO 2: Setting up the manual mill ready for drilling with a Slocomb centre-drill bit.

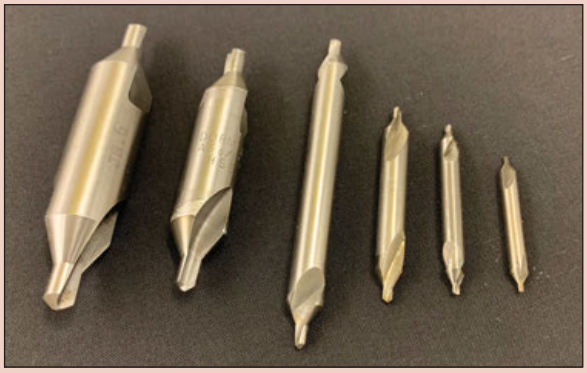
As stated earlier, the dimensions and 'squareness' of this plate are not at all critical, however it is a great part to practice on – if you make a mistake and it ends up a bit smaller than it should be, it will still be usable; this may not be true of some of the other parts to come and at all times the famous scrap bin will await, hungry to devour your embarrassment!

A difficult part of this first milling operation lies in how to clamp the material. The best way is to use a sacrificial piece of steel plate (ideally) or wood underneath the workpiece (brass plate), to stop it from resonating when being cut by the milling cutter and to allow the cutter to penetrate to the full depth of the plate, without any chance of damaging the machine bed – the use of a piece of steel plate can be seen in Photo 4.

The (brass and steel) plates can be clamped at two ends (as shown) whilst the two free edges are milled. The clamps can then either be moved to the freshly-milled edges (if the bed is large enough to accommodate this), one at a time to preserve the position of the plate, or the plate can be rotated, and an edge-finder used to ensure that the newly-machined edges are set parallel to the mill axis.

Note the use of a soft metal (aluminium) between the clamps and the brass, to try and minimise scratching/bruising of the brass, by the clamps.

Centre drills



It is worth taking a moment, here, to discuss centre drills, also known as Slocombe drills as they were first patented by the Slocombe company of America. I had not encountered these before working on this project and they are a terrific invention.

They are short, stubby and above all, stiff. This means that they won't 'wander' as much when attempting to start a hole, even if there is no indent (such as made by a centre-punch) in order to guide them to the right place. Indeed, they are so stiff that they are likely to 'ignore' such an indent, even if one is present!

The narrower section is small enough to start the hole and the wider section is then intended to form a tapered guide (countersink) into which a conventional drill's tip will locate precisely. In this way, a deep hole may be drilled in a precise location, with ease.

The diameter of the milling cutter is not critical – ensure it is large enough not to break easily in novice hands (say 10mm plus) and the rotational speed should be in the mid hundreds of rpm (slower for larger cutters, faster for smaller ones).

It is a good idea to experiment with a bit of the brass you have just sawn off, before committing to the wanted piece – you are aiming for the cutter to produce some nice 'chips', when advanced at a comfortable speed (say 0.25cm/sec) and not dust, which would indicate the rotational speed is too high for the feed-rate used. As mentioned the cutter is designed to cut the material not to wear it away, which in the process will prematurely wear the cutter.

Have a play and find what works with your mill. Smaller, less rigid, mills will need to take lighter cuts, perhaps using a smaller tool and a slower feed rate; larger, more rigid, mills will obviously be more capable (and more forgiving!). The mill I used could probably be said to fall midway between these two extremes.

Once the edges have been milled, emery cloth can be used to remove the sharp edges/burr and sharp corners – say, 120 grit. For a novice, emery cloth is much more forgiving than emery paper (which tears easily on corners). Try not to score the surface of the plate unduly with the emery – it will only need more polishing later!

The position of the two attachment holes for the upright support can then be marked using a square, ruler and scribe. Again, this is not too critical, but any skew or poor centralisation of the holes will jar, visually, when the model is complete.

Alternatively, use an edge-finder in the mill to locate the edges of the plate and from these, move to the hole positions – this is easy if you have a DRO on your mill. If you don't, invest in one quickly – they make life so much easier! Don't forget to subtract the radius of the edge finder (the clue is in the name – it finds the edge of the finder on the workpiece so the quill is offset from the edge by the radius of the end of the finder), or move and zero the DRO, to take account of it.

Centre-drill each hole with a suitable centre drill (Photo 2 – note that I wore goggles for the actual drilling operation!). Almost anything under 5mm should do in this (non-critical) case. Go deep enough that the main body of the centre drill creates a countersink in the plate for the through-hole twist drill to engage with. Next, drill the 5mm clearance holes for the M5 countersunk-head bolts which will ultimately support the upright.

If you don't plan to use a wooden main base (relying upon this brass base plate alone for stability), use a countersinking bit to countersink the holes to match the diameter of the heads of the bolts. If you do plan to use a wooden base (as shown in Photo 1) then this operation can be reserved for that component.

Note that a centre-drill is not the same as a countersink bit – the angles are different (the former needing 118 degrees to match the tip of a conventional drill, the latter needing 90 degrees, typically, to match a countersunk screw-head, although 82 degrees and 100 degrees are also used).

"It is likely that the surface of the plate is scratched or scored to some extent and this needs to be removed..."

Cleaning and polishing

Once the basic machining is complete, it is time to make the piece look good. It is likely that the surface of the plate is scratched or scored to some extent and this needs to be removed. I didn't do a perfect job of this, as can be seen in Photo 1! In my defence, my dad says I have the attention span of a gnat and polishing is not the most fascinating task to a 12 year-old… (as I was at the time).

The technique I used was to pick a starting grade of emery cloth based upon the depth of the scratches (in my case, the scratches were quite deep as it was a 'scrap' piece of brass). The deeper the scratches, the coarser the required starting grade of paper. I started with 80 grit and then moved to 120 grit and eventually to 240 grit before resorting to metal polish (Autosol being recommended by a friend and mentor, which worked very well). A more discerning (and patient) model engineer would probably have used a lot more time and finer steps in the sequence of emery papers.

In all cases I used a large sanding block (approx. 150 x 100mm) to maintain an even surface. Note that very deep scoring could have been removed at the milling stage, using a face cutter (Photo 3) to skim off a fraction of a millimetre at a time (say, 0.1mm), until the scoring had been removed. This would also have made the subsequent sanding/polishing quicker and simpler, as I could have dispensed with the use of the coarser grits. Material-holding would have been more of a challenge and the fly-cutting would best have been performed prior to cutting the brass plate to size – the areas being clamped and hence remaining un-cut by the

PHOTO 3: A typical face cutter/mill.

PHOTO 4: Assembled base, base plate and nameplate.

PHOTO 5: Underside of the wooden base, showing the countersunk bolt-holes.

fly-cutter would then, ideally, have been removed in the sawing process.

The final step was to apply a metal lacquer to the finished plate. I used Rustins – this is a specialist clear varnish for use on metals and gives a lovely finish, showing through the polished brass almost as if the lacquer was not there. It also saves a lot of future effort with Brasso or Autosol, as the base plate, at least, will never tarnish. Clearly this only works on non-rubbing surfaces (the flywheel being another possibility here, along with three sides of the cylinder), but it is certainly worth doing.

The assembled base, the base plate and nameplate (a bit of indulgent CNC milling on another piece of the 10mm aluminium of the type used for the upright) are shown in **Photo 4**, with the underside, including the counter-sunk bolt-holes, in **Photo 5**. Once assembled, this side can be covered with some felt. The more observant of you will notice that I didn't quite get one of the holes in the right place in Photo 5 – this is not visible, once assembled, and so is not an issue. It's all part of the learning, or so I was told when I spotted the original error...

The recesses in the wooden base were made using a wood-router bit (⅛-inch) in the mill, running at 5600 rpm – not many mills are capable of such speeds, but a lower speed can be used with a suitably slow feed-rate. A small wood chisel was then used to square-off the corners of the recesses.

I could have used a larger router bit, followed by the ⅛-inch tool (for the corners), but then I would have had to do a tool-change and re-set the depth and such. At least with a single tool, whilst it may be a bit slow, the depth is guaranteed to be constant across the whole area (no chance of setting the depth slightly wrongly, following a tool-change). EIM

■ Next month Matthew tackles the flywheel and its components.

"It's all part of the learning, I was told when I spotted the original error..."

Measuring on the edge...

Edge-finders are really handy, and surprisingly inexpensive, measuring tools. They are an astonishingly accurate means of finding the edge of a workpiece, allowing an accurate amount of material to be removed and the correct size of part realised.

There are two main types: mechanical 'wobbler' style finders (upper picture) and electronic alternatives (lower picture). Both work very well and I still use both (although our electronic version is a relatively recent acquisition). Note that some mechanical types are 'double-ended' and offer different diameters or styles of end-piece on each end, as can be seen in the picture.

The mechanical versions consist of a precision ground shaft, to hold in a mill chuck, and a precise-diameter end section, attached to the shaft with a spring. When the edge finder is rotated (a few hundred rpm is fine) and touches the edge of a workpiece, the end section first aligns with the shaft and then, as the mill table is moved beyond this point, it deviates sidewards, perpendicularly to the axis of the table movement.

For example, if the table is moved in the X (left-right) direction whilst the finder is touching an edge we want to find, orientated in the Y direction (front-back), then the end-section of the finder will deviate in the Y direction. The aim is to adjust the X axis of the mill (in this example) such that the end of the edge-finder deviates and then (by reversing the X travel) just pops back into alignment with the shaft. At this point, the finder is right on the edge of the workpiece.

The edge of the workpiece itself is then obtained by subtracting the radius of the end of the edge-finder from the current DRO or hand-wheel reading. So, for example, if a 10mm diameter edge-finder is used, then 5mm must be subtracted (or added, depending upon the direction) from the DRO reading, in order to obtain the quill centre location of the edge of the piece.

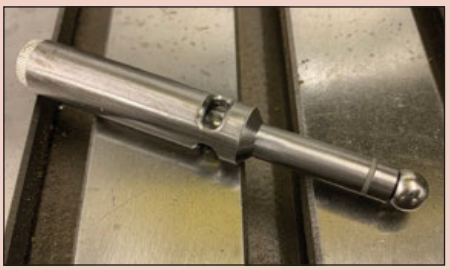
I normally then retract the quill and move it to the edge (i.e. move it 5mm in the appropriate direction) and then zero the DRO in that axis (X, in this example). I can then insert my tool (e.g. an endmill) and, knowing its diameter, move it to the appropriate position to take the cut I need.

The electronic versions are slightly different. They utilise a precision ball-bearing which is attached to an indent in the bottom of the shaft with a spring. This ball bearing will be, say, 10mm in diameter, to a very high degree of accuracy.

The edge-finder can be mounted in the chuck of the mill (which does not need to be rotating for this type of edge-finder) and moved to an edge of the workpiece. When it touches the edge, a 'beep' sounds and a light illuminates in the shaft of the finder.

The aim is to move the relevant axis until this 'beep' first sounds – at this point, the centre of the quill is then the radius of the ball (5mm, say) from the edge of the workpiece. Again, the quill can then be moved this additional 5mm (with the finder clear of the workpiece) and the DRO set to zero in the relevant axis.

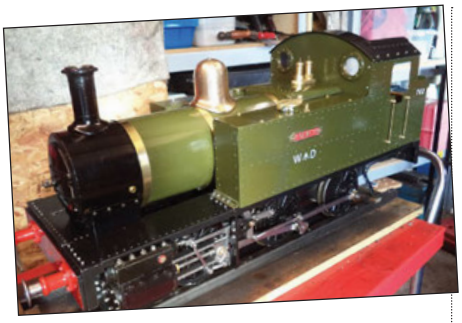
The electronic version is slightly quicker to use, in my view, but needs to be kept very clean, especially the ball-seat, in order to retain its accuracy.



Defeating the Gremlins

Stewart concludes his tale of successfully restoring a somewhat basket-case Martin Evans Simplex project that he bought on a whim without realising just how bad it was...

BY **STEWART HART** Part Three of Three



My Simplex rebuild was progressing towards its conclusion, following a great deal of work, especially to the cylinders and bottom end, not exactly expected when I had bought the unfinished project. Next on the list was the motion.

The motion works and coupling rods had been extensively butchered, no doubt in an attempt to correct the effects caused by the out-of-square frame, the wrongly positioned valve rod in the steam chest, and the error in the crank throws. I decided to cut my losses and for my own satisfaction, to remake all of the motion work.

Here I took a bit of a flyer and ordered a set of laser-cut parts from a local firm that I found in the Yellow Pages – I simply took in a set of drawing showing what I wanted and the price was reasonable, so I just left them to it. A few weeks later I got a phone call to come and collect the parts, and I was extremely delighted with the result (Photo 55).

I had no problem with the finish machining, my only regret was that I missed a trick in that I should have got the firm to laser-cut out the motion plate and bracket at the same time – doing this would have saved me the job of milling them out myself.

PHOTO 55: Laser-cut motion works and coupling rods.

PHOTO 56: Nicely made expansion link.

PHOTO 57: New guide Block fitted to expansion link.

PHOTO 58: New fabricated motion plate.

PHOTO 59: Plenty of scrap parts left behind.

PHOTO 60: New linkage trial fitted to cylinders...

PHOTO 61: ...and to frame.

All photos in this feature by the author

I also ordered a set of new cast cylinder covers from one of the hobby's suppliers – the slide bars for the crosshead are mounted on the front covers, and as I was planning to replace the slide bars and make a new one-piece crosshead I thought it would be easier to start with new covers rather than try and make the old cover fit my new parts.

As I was remaking these parts I thought I might as well change all the threads from BA to M3, I'm a great fan of metric threads purely on availability and cost grounds. I was able to purchase M3 nyloc nuts that I will fit at a later date when I've got the loco through its shakedown trials, this should help prevent bits coming loose and dropping off, improving reliability. I reckon a metal detectorist going round any miniature railway track would find enough BA nuts and bolts to set up a business.

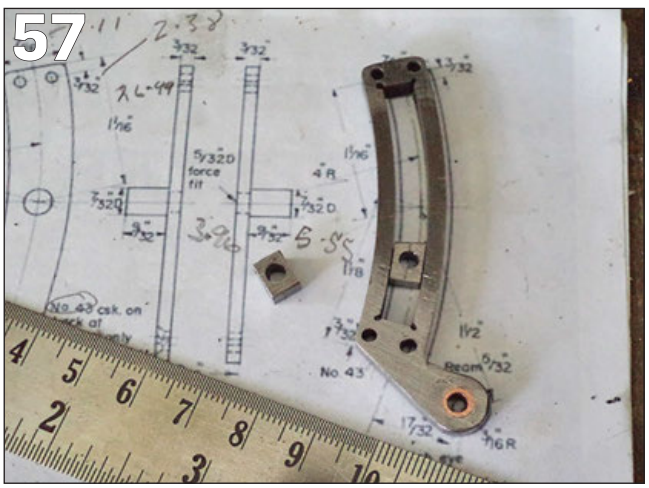
Not all of the motion work was replaced. The expansion links were very nicely made (Photo 56), it looked to me as though they had been wire eroded. The die blocks however had been badly fitted so they were replaced (Photo 57), and a new motion plate fabricated (Photo 58). I ended up with a lot of scrap parts! (Photo 59).

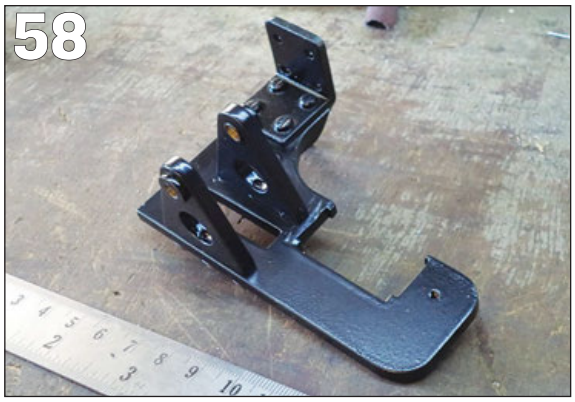
One bit of mischief I did discover whilst renewing the motion works was that if you make the parts are per the drawing with nice sharp corners in the forks and slots, everything will just lock up. After trial fitting (Photo 60-61) my first attempt to turn everything over resulting in my bending the combination lever. I asked one of the club members who had built a Simplex that runs very well about this and he said "yes that happened to me also!"

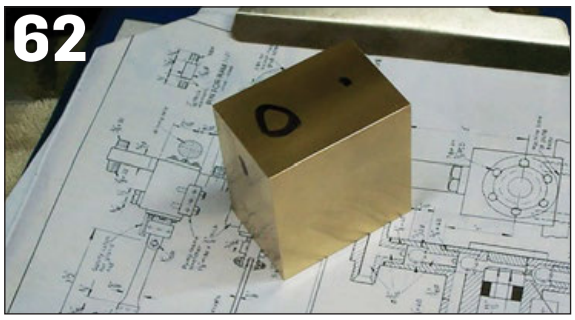
I was able to straighten the link so no real harm was done, and I then set to work with Swiss files putting nice big radiuses on all the sharp corners to correct the mischief.

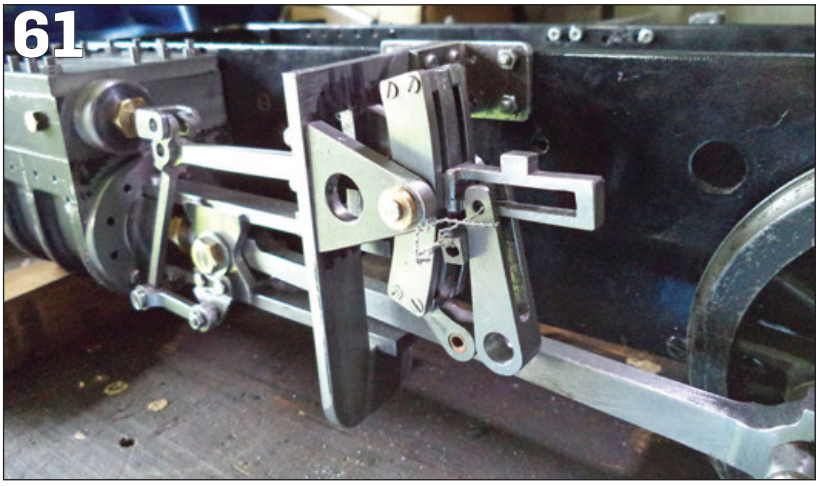
Axle Pump

The purchased project engine had no axle pump fitted. I did a little research









on the subject and decided to build an axle pump to the Super Simplex design – this design followed on from a suggestion by a Mr Anderson, a reader of *Model Engineer*, as the original Simplex pump reportedly suffered from a number of faults.

This design is a balanced double-acting pump with large passages and feed and suction pipes that reduce the power loss. It also mounts clear of the way shaft.

I made the pump body from a chunk of brass obtained from the local scrapyard (Photo 62). The manufacture and fitting of the pump was straightforward and should pose no problems to the experienced builder (Photo 63-64).

PHOTO 62: Scrapyard-sourced hunk of brass for axle pump body.

PHOTO 63: Parts of the axle pump.

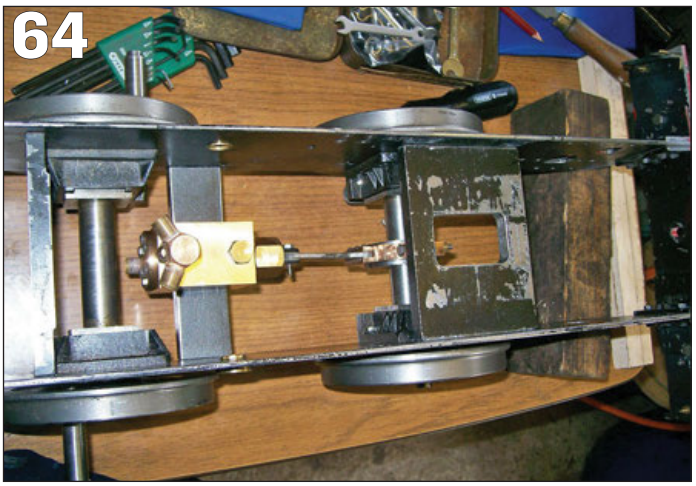
PHOTO 64: Location of axle pump on frames.

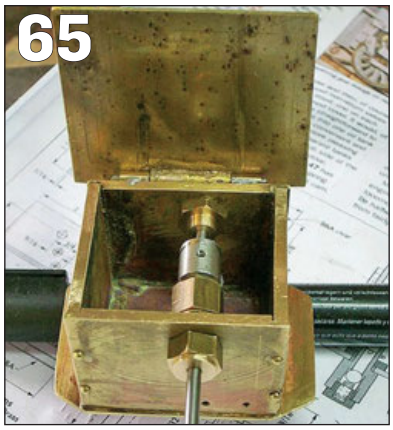
Lubricator

Lubricators for working model steam engines are something I find very satisfying to build. I've made quite a few in my time, but initially I was puzzled; Simplex designer Martin Evans merely refers to drawing LO44 in his original *Model Engineer* article and book, and I couldn't find this drawing. Fortunately Terence Holland's article 'Fairlie Complex' in another edition, dealing with various steam valves, came to my rescue. He explains that LO44 is a drawing of a generic lubricator which is available commercially, and very conveniently his article included a drawing for an alternative design that I could adapt to my use.

I fabricated quite a large tank for the lubricator with the capacity to hold enough oil for a couple of hours running, and inserted a single pump to Terry's design, with a commercial roller ratchet (Photo 65).

I can say that it works very well – in fact too well, the poor old driver got covered in specks of hot oil that just would not wash out. The solution was to halve the stroke of the pump ▶





and to extend the crank arm to slow down the delivery rate: so banishing the wash day blues

Smokebox

One key functional feature of the smokebox is to be air-tight, so that the flow of exhaust gas through the chimney forms a partial vacuum in the smokebox that draws air through the fire grate, getting the fire good and hot.

The Gremlins had, however, made the smokebox of the Simplex far from air tight – you could see the gaps at the riveted joints between the tube and smokebox door ring and the boiler ring.

I thought about trying to seal the gap with high-temperature silicon sealant, but I decided instead to make a new smokebox using the salvaged door ring, with a new rolled brass tube bought from one of our suppliers. For the boiler ring I was lucky to drop on a brass disc at the scrap yard (Photo 66) that I could turn a new ring out of and fill my non-ferrous scrap bucket up with swarf (Photo 67). The two rings were silver soldered to the rolled tube and the smoke and steam pipe holes machined, and the smoke pipe silver soldered in place.

"I had broken the spell and each time I took her out after I was slowly gaining in confidence – too much confidence in fact. I got my licence endorsed by the club chairman for speeding..."

Smokebox Door

The face of the smokebox door was left as cast – needless to say it wasn't flat and wouldn't make an air-tight seal. So it was chucked in the three-jaw so that it was running as true as possible and skimmed flat.

I was also unhappy with the very flimsy door hinge, which was made from a thin piece of brass coiled over to form the hinge. So a new more substantial hinge was made.

A number of club members told me to make the door a sloppy fit on the hinge pin, so that it would pull up flat on the door ring and form a seal. The fact that more than one mentioned this would suggest that making it a too tight a fit is a common mistake for people to make (Photo 68).

Steam and exhaust pipes

There was nothing basically wrong with the pipes as fitted – they were more or less to the Martin Evans design, but I must admit I couldn't resist the temptation of a little tinker. I much preferred the Y-shape exhaust pipe as used on the Super Simplex as this would direct the flow of exhausted steam more gently in the direction I wanted.

From a local plumber's merchant I bought a couple of copper elbows for the steam pipe (Photo 69), while for the exhaust pipe I again visited the local scrap yard to rummage through a skip of copper water pipe, until I found a few with bends that looked about right (Photo 70). These were sectioned and fitted together and silver soldered into brass bushes to produce the Y-shaped pipe. They were screwed into the steam chest and cylinder using screw couplings and sealed with high-temperature silicon sealant (Photo 71).

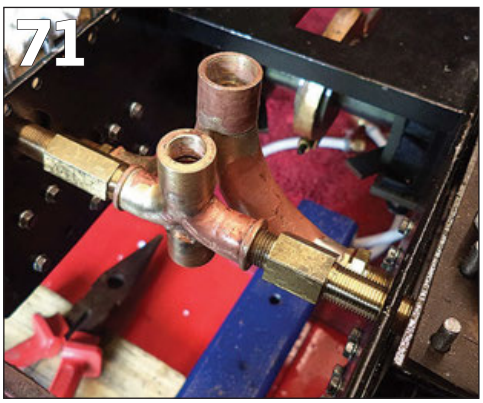
Running boards

I deviated from the Martin Evans one-piece design of running boards, the main drawback being that should you wish to get to the slide valve to carry out maintenance or adjustments, you have to remove the side tanks in order to take off the running board.

I made a two-part running board which was screwed to an angled bracket bolted to the main frame with the same bolts that hold the motion plate. This allows the front of the running board to be removed to gain access to the slide valves (Photo 72).

I carried out one further addition to the basic design of the loco, again at the suggestion of a club member. As drawn the bunker water tank has no convenient way of draining the water out of it, this can only be done by uncoupling the pipe work. So I added a 5/16-inch x 32 ME bush into the base of the tank to take a drain plug.

For my own satisfaction I carried out a fair bit of tidying-up work on the side tanks and made a new spectacle plate and roof. With that completed all that was required was the pipe



work and fittings that I bought from one of our suppliers, and to give the loco a paint job to the best of my abilities. When it comes to paint I'm not very competent, I think it's due to lack of patience. But the engine doesn't look too bad in the dark and covered with authentic running grime. As a finishing touch I gave her a name that I thought fitting 'Gremlin' (Photo 73).

Steam testing

My adventures weren't over however, neither was the mischief, but this time the Gremlins were all from the MacHart clan: I still had to get the loco running. When it came to steaming a loco I was at this time a complete novice, even though I'd watched the process many times I'd never done it for myself.

The boiler passed the hydraulic test at 1½ times working-pressure with no problem, but the steam test was a different kettle of fish, with the problems all down to me. I must have made every mistake in the book, thankfully I was well supervised so no harm was done, but it wasn't until the fourth attempt that the loco easily passed, and I was able to nervously take it onto the club track.

I managed four laps before a pin fell out of the linkage, the second time onto the track I managed half a lap, this time I was convinced there was no water getting to the boiler so I panicked and dropped the fire. The third attempt was similarly abandoned, and only at the fourth attempt did I decide that most of the problems were likely due to my nerves and ignorance.

So once Gremlin was in steam again I handed her over to one of the club's experienced drivers, who took her for a spin round the track. After about four laps he handed her over to me and gave me a bit of schooling and encouragement (thanks John).

This time I managed six laps before the same pin fell out: those Gremlins were having fun. But I had broken the spell and each time I took her out after I was slowly gaining in confidence. Too much confidence in fact – I got my licence endorsed by the club chairman for speeding, but I chased out the teething problems. You can see a video of my efforts at: https://youtu.be/vTLHo9wU7Ag

PHOTO 65: Lubricator to Terrence Holland design with large capacity tank.

PHOTO 66: Brass disc for smokebox boiler ring.

PHOTO 67: Trying boiler for fit on ring.

PHOTO 68: New sloppy-fitting door hinge fitted.

PHOTO 69: Parts for exhaust pipe.

PHOTO 70: Scrapyard-found parts for steam pipe.

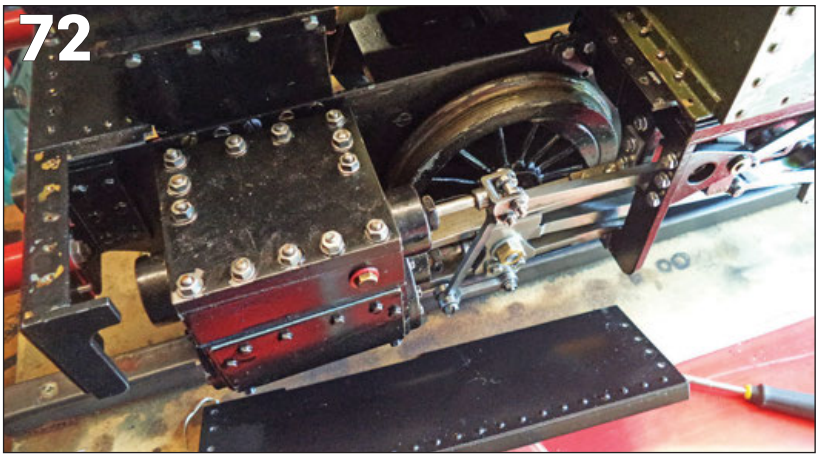
PHOTO 71: Pipes silver soldered and connected to cylinder and steam chest.

PHOTO 72: Front part of running board removed for easy access.

PHOTO 73: An appropriate nameplate.

PHOTO 74: A train load of grandchildren.

■ Part one and two of this series were published in the December and January issues – to download a digital back issue or order a printed version, go to www.world-of-railways.co.uk/store/back-issues/engineering-in-miniature or order by phone on 01778 392484.



Conclusion

As a way of quickly getting onto the track buying this loco was a complete failure – it took me the best part of three years to get on the track, I did build a few stationary engines in that time as well. But it did cost me a fair bit of time and cash that I wasn't planning on spending – I suppose I could have cut my losses and moved it on, but that's not my way.

I was unlucky and careless to have bought a locomotive that was deficient in so many ways, my wife summing the situation up nicely when she said; "you bought a good boiler with a load of defective parts".

Getting Gremlin sorted has been frustrating at times, finding out what the problems were wasn't all that straightforward – finding the error with the crank-pin pitch for example took me about two months. I just didn't think that anyone could get something so fundamentally wrong, I ended up chasing my tail and it wasn't until I went right back to checking the basics that I found the fault.

Now that it's all sorted, however, I have the satisfaction of knowing that I've rescued a basket case from the scrap heap and defeated the Gremlins. I've had hours of enjoyment driving Gremlin on the South Cheshire Model Engineering Society's track, hauling passengers at club public running days and birthday parties (Photo 74). At family trackside picnics the loco has become a firm family favourite with my grandchildren, my youngest grandson claims that Gremlin is the most famous loco in the world and he insists on giving him a polish when he visits (Photo 75). EIM

A Hard Cell...

Having revealed much of the mystery and potential pitfalls concerning battery loco electrics over the past three issues, Peter now considers the other essential element – the battery.

BY **PETER KENINGTON** Part Four of a short series

The battery, particularly in a battery-electric loco, is an area in which there is a lot of 'received wisdom', strong opinions and hearsay. Hopefully this discussion will focus on the science and the views of battery manufacturers, rather than on what 'Fred who used to own a caravan and never had any trouble with his batteries' would advocate. 'Fred' may be right, but he's probably not an authoritative source.

In my case, I have spent decades dealing with all types of batteries in mobile communications applications, both hand-held and back-up batteries for fixed wireless equipment. I even specified a battery (and, indeed the whole of the electrical and communications) system for a round-the-world ballooning attempt (which was ultimately successful), although the budget for that project was somewhat larger than that of your average model engineer. The batteries had to last reliably for 21 days, with loads as diverse as a satellite phone and a microwave oven and cost in excess of £20,000 at the time.

"I even specified a battery system for a round-the-world ballooning attempt, although the budget for that project was somewhat larger than that of your average model engineer..."

A Loco on Acid

In model engineering, the answer to every battery-related requirement is 'lead acid', or so it would seem. Lead acid batteries are used to power locos (obviously) but also steam-raising blowers, sound-effects generators, lights and the like (I have often seen separate batteries used for such accessories, even on battery-electric locos). Are they always the right choice? Not necessarily.

Putting aside the issue of providing tractive power, which we will return to in some detail below, there is a strong argument that lead acid batteries are not the best option for the other applications listed. For example, I use a (home-made) battery pack consisting of NiMH (Nickel-Metal Hydride) cells to run a steam-raising blower. It has the advantage of being far smaller and lighter than a lead-acid 'gel' battery (**Photo 10**) of a similar capacity (although the battery in this photo is of a somewhat larger capacity than usually required).

My battery pack will last (in terms of its service lifetime) far longer than will a lead-acid equivalent, while it won't suffer from sulphating or other deleterious chemical effects and retains 85 per cent of its charge after one year sat on the shelf – so long as you pick a 'Hybrio' or 'Recyko' or similar low self-discharge type.

This type of battery is available from Amazon for about £1.50 each (for Amazon's own 'basic' brand) and you will need 10 for a 12-volt battery pack, as each cell is nominally 1.2V.

Although 2.6Ah versions are available, it is generally better value to go for a slightly lower (i.e. further from the 'cutting edge') capacity rating, such as 2Ah or 2.2Ah (2000mAh or 2200mAh respectively). This is a not-dissimilar capacity to the 'smaller' sizes of lead-acid battery currently used by model engineers for steam-raising and is much less than half the size and about one-third of the weight. Such a pack will run a blower for many steam-raisings without needing a recharge – how many will depend upon the blower size/power and your fire-laying skills!

An 'internal' picture of the pack I use is shown in **Photo 11**, with the completed battery, including a fuse and connectors for my blower being shown in **Photo 12**. A fuse is advisable, since NiMH cells are capable of high currents if shorted out (although not as high as the current which would flow from a lead-acid battery, if shorted).

The connectors shown are chosen to minimise any risks of a short (shrouded 4mm 'banana' connectors, if you want to look them up). This complete battery pack will comfortably fit in a trouser pocket and is easily light enough to be transported that way, if desired.

Moving On

So why not use NiMH for traction purposes as well? This is a topic I keep re-visiting, as it has a lot of attractions and is not a completely daft idea, especially for smaller 5-inch gauge locos. **Photo 13** shows a 'typical' lead acid gel battery of the type used in many 5-inch gauge locos – a pair of these has been used in the 5-inch gauge 'baby Deltic' loco, shown in this month's heading shot. I have driven this loco a number of times, although its particular battery was purchased for other – work-related – purposes.

The Deltic battery is rated at 40Ah – could this be replaced by a battery made up of NiMH cells? The answer is

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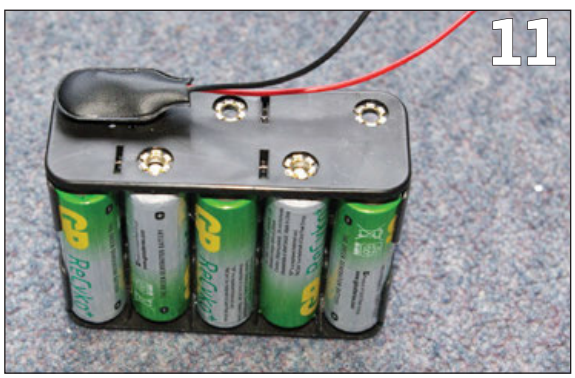
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"possibly", but at a price (although this price has reduced markedly since I last considered this option). NiMH cells are widely available in the popular 'D' size and have a typical capacity rating of 10Ah at this size. Note, however, that there are many cheap NiMH D cells which are in fact AA cells placed in a D-sized battery case, so be careful to check that your 'bargain' really is what it seems!

To realise a 40Ah, 12V battery would require 40 cells. Leaving aside the logistical challenge of wiring all of the cells together (in a combination of series and parallel and noting that balancing resistances would be needed for the parallel aspects), the cost would be fairly high. Again, taking Amazon's 'basics' range, at about £5 per cell, this would work out at about £200, excluding the battery housings required.

A better solution would be to use 'tagged' cells (which can be soldered together), however these are typically much more expensive, as they are primarily used in industrial systems.

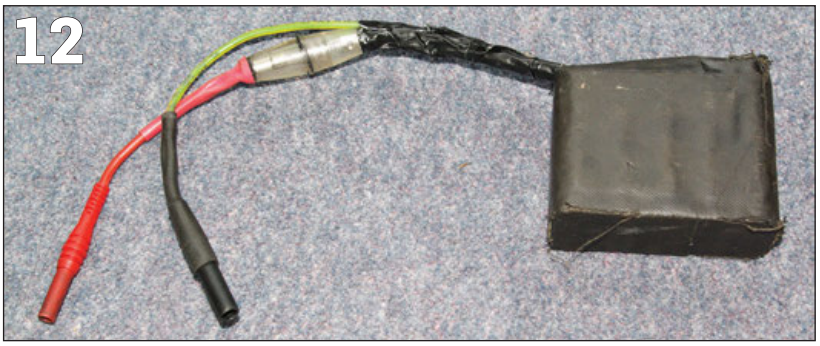
The equivalent lead-acid 'gel' battery is, perhaps, a third of this price (relative to an untagged NiMH solution). So, the answer is probably 'not yet', but the time may come when it is worth considering, although lithium-based options may overtake NiMH (in price and certainly in performance) before that option ever becomes economic.

Lithium-based solutions are 'getting there' in terms of affordability for use in our locos. The main reason for this is their expanding use in 'off-grid' solar power systems and solar energy storage in domestic premises – higher volumes result in lower pricing. In contrast, the battery packs used in electric cars are much larger and, whilst they are drivers (no pun intended) for the technology in general, probably won't feature in our locos due to their sheer size.

Currently, taking our 12V, 40Ah example, lithium-based batteries cost around the £250-£300 mark new, however I have spotted a few 'little-used' examples on ebay for about £100 (for 60Ah, in a recent example). The latter are getting to the point of being 'tempting' for our use.

The main thing to check is the peak and continuous discharge current ratings – we need a high current to get our locos moving and the battery must be capable of providing this without damage or a shortening of the battery's life. Having said that, examples with >80A (for < 3 mins) and 70A (continuous) seem to be widely available. Perhaps, in the not-too-distant future, such batteries will replace or trusty lead-acid bricks, but I'm not sure we're quite there yet.

"We need a high current to get our locos moving and the battery must be capable of providing this without damage or a shortening of the battery's life..."



Acid Trip

For the present, it seems, we're stuck with lead-acid for traction purposes, so which is the best option and how do we look after these expensive and vulnerable components?

Firstly, the options:

1) 'Wet' lead acid. This is the traditional type of lead-acid cell (dating back to the mid-19th century) which uses a liquid electrolyte with all of the associated problems of spillage, but the advantage of being able to be 'topped-up' if overcharging leads to 'gassing' of the electrolyte.

Accidental spillage is possibly the biggest single disadvantage with these batteries, particularly if there is a serious derailment or 'passenger leaning over' type of accident. Even transporting such batteries in the boot of a car is fraught. A friend of mine was doing this and in 'normal' driving (though he was a bit of a boy-racer in those days!) tipped the battery onto its side. His boot proceeded to rust away at an alarming rate and he eventually had to scrap the car.

2) 'Gel' batteries. These were invented in the 1950s and became popular in the 1970s. Essentially, the liquid electrolyte of the standard lead-acid battery is replaced with a gel electrolyte, meaning that spillages are no longer a problem and the batteries can cope with more 'abuse' in terms of shaking or tipping. They are 'sealed-for-life' and maintenance-free.

Gel batteries are generally more suited to static applications (in the sense of charge/discharge operation), such as uninterruptible power supplies, although as noted above, many model engineers use them to power steam-raising blowers as they are small and easily transported (safely). They are not generally suited to high-discharge or 'deep cycle' use.

3) AGM (absorbent glass mat) shown in Photo 13. This is a development of the wet lead acid battery, popular in the 1980s (although it was invented in the 1970s) due to its reduced weight and improved reliability.

The acid electrolyte is absorbed by a very fine fibreglass mat, resulting in the same 'spill-proof' benefit as gel batteries and indeed, both technologies share many of the same advantages. AGM batteries are generally better suited to 'deep discharge' and traction applications than are gel batteries, however.

AGM batteries are less susceptible to sulfation than are 'wet' batteries and can be stored for longer periods before their charge needs to be topped-up. They also cope better with low temperatures, being much less likely to freeze. Their two main advantages are, however, an ability to take a charge at a rate up to five times faster than a 'wet' battery, together with the aforementioned deep-cycle capability. AGM batteries can be regularly discharged by 80 per cent of their nominal capacity whilst enjoying the same service life as a 'wet' battery ▶

HEADING: 'Baby Deltic' using a pair of batteries of the type shown in Photo 13.

PHOTO 10: Smaller lead-acid 'gel' battery of the type often used to power steam-raising blowers and the like.

PHOTO 11: Internal view of a NiMH battery pack designed to replace the smaller types of lead-acid battery.

PHOTO 12: A complete (and well-used!) 12V NiMH battery pack.

PHOTO 13: A lead-acid AGM battery.

All photos in this feature by the author

discharged to only 50 per cent.

The main disadvantage with AGM batteries, when compared to a gel battery, is that they suffer a gradual decline in performance over their service lifetime, whereas a gel battery will continue to maintain a high capacity until close to the end of its service life.

4) 'Deep discharge' leisure batteries (**Photo 14**). This type of battery is more a classification than a technology, as it can be based upon 'wet', gel (less so) or AGM chemistries. It is designed to cope with deeper discharges than is a conventional battery, although 'deep' may only be 50 per cent if a long service-life is to be achieved. It may or may not be suited to the high-current demands placed upon a battery by our traction needs – see below.

5) 'Traction' batteries. Again, this is a classification rather than a technology, although these tend to be either 'wet' or AGM-based, since gel technology is less well suited to the high discharge rates inherent in traction applications. They are mostly employed in electric wheelchairs and golf buggies, in addition to model locomotives, of course. Note that the battery shown in Photo 13 is a good example of a 'deep discharge' AGM battery which is also designed to meet the requirements of traction applications.

Deep Thought

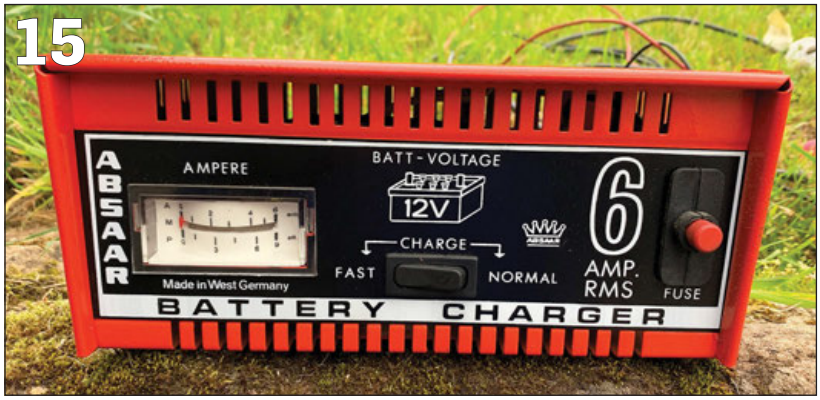
So, what is the difference between a 'deep discharge' battery and a 'traction' battery? Are they both different names for the same thing?

There are probably exceptions out there (I can see **EIM**'s letters page filling up in the coming months...), however in general all traction batteries will be capable of 'deep discharge' use, even if such discharges are not as a result of traction applications, whereas not all 'deep discharge' batteries are suitable for traction use unless they are specified for such applications.

Why the difference? Deep-discharge batteries are often used in caravans and other applications where the battery is not necessarily 'topped-up' (with charge) on a regular basis – unlike a car, for example, where the battery is quickly topped-up after being used to start the engine.

These batteries are designed to be more tolerant of such 'abuse' than 'normal' lead acid batteries, although even in this case, it is recommended that they are re-charged after dropping to 50 per cent of their stated capacity, to ensure a long battery life at near full capacity.

Note that the same is true of traction batteries and our practice, as model engineers, which is often to continue passenger-hauling until the batteries are completely exhausted, will be drastically reducing their service lives! Most hand-controllers fitted to these locos have LED bargraphs to show the state of charge of the battery – we need to pay more attention to these when running…



"Our practice as model engineers, which is often to continue passenger-hauling until the batteries are completely exhausted, will be drastically reducing their service lives..."

PHOTO 14A: 'Deep discharge' lead acid battery.

PHOTO 14B: Top view of the deep discharge lead acid battery.

PHOTO 15: Older style of 'dumb' car battery charger.

Charging

Charging and chargers is another potentially-controversial subject, as again there are a wide range of opinions on the 'right' way to do it. There are also a range of chargers (and prices) and views as to what is and isn't worthwhile. I'll nail my colours to the mast here, however and state that, given the high cost of new traction batteries, a good charger is one area in which it is certainly worth investing. There are three broad options when it comes to chargers.

Photo 15 shows a traditional 'dumb' battery charger. This simply provides a (nominally) constant-voltage (typically) to the battery, at a charge current which shouldn't over-stress the size of battery for which it is designed.

As a general rule of thumb, a battery should not be charged at a current greater than C/10, where C is the capacity of the battery in ampere-hours, with a gentler charge rate being C/20 (but taking twice as long).

This type of charger has no means of detecting that the battery is fully charged and there is therefore a danger that the battery can be inadvertently overcharged. In particular, if the state of charge of the battery is unknown (and hasn't been checked with a voltmeter, prior to commencing charging), then it may be left on charge for too long (overcharged) or for an insufficient time (undercharging, leading to sulphating, which will be discussed further below).

A rough guide to a battery's state of charge may be obtained by measuring its terminal voltage and comparing this to the values given in **Table 2** (and note that the voltage reading should obviously be taken with the charger and any load disconnected!).

Photo 16 shows a low-cost, simple, 'automatic' charger (purchased from a motor accessories shop). Almost all chargers available these days claim to be 'automatic', however there are varying degrees as to what constitutes 'automatic'. In the case of Photo 16, it simply means that the charger will reduce to a trickle-charge when the battery has reached capacity (as judged by the charger – this will be

discussed further below).

This type of charger is fine for occasional use, topping up a car battery, for example – I use it for a small tractor battery. But it is not ideal for use with deep-cycle or traction batteries and is, in any event, too small for most larger batteries of this type.

The charger shown in **Photo 17** is more sophisticated and is better suited to AGM batteries (of the size/type shown in Photo 13) than is a basic 'dumb' charger or a simpler form of 'automatic' charger.

Photo 18 shows an even more sophisticated charger, in terms of its ability to adjust the charging current throughout the charging cycle (including 'pulsing' current into the battery at certain points in the cycle). This example has a broad capability, being able to charge both 12V and 24V batteries at a range of charge rates/(maximum) currents.

Most sophisticated chargers are (at least) 'three-stage' – Stage 1, lasting for about four hours is a constant-current charging cycle; stage 2, lasting about six hours, is constant-voltage cycle at about 2.4V/cell (= 14.4V for a nominally 12V battery); and stage 3 is a 'float charge' at about 2.25V/cell (= 13.5V for a nominally 12V battery) for the remaining time.

These charge rates/times are a compromise and should, ideally, be adjusted with the ambient temperature of the room in which the battery resides whilst being charged – a higher temperature (say, 30 deg C) will require a slightly lower float-charge voltage and vice-versa for a lower temperature. The better chargers will measure the terminal voltage and thereby assess the state of charge of the battery, at the commencement of charging, and then begin charging at the appropriate point in the above charging cycle.

Charging a lead-acid battery is always a compromise – too low a charge level (i.e. <100 per cent) and the battery wants to sulphate on the negative plate, too high a charge level (in other words continuing charging when the battery is at 100 per cent) leads to grid corrosion on the positive plate. In short, you can't win and the best you can do is to try not to lose too badly!

Some recommended actions:

1) Keep lead acid batteries at, or close to, 100 per cent charge when stored. Note that this advice will change if we ever move to Lithium-polymer or other types of cell, where a partial 'storage' charge is recommended. Automatic chargers for this type of battery even have this facility built-in, for example chargers designed for radio-controlled model batteries.

2) If the battery voltage falls to 12.4V or less, charge immediately, in order to avoid long-term damage and an associated reduced capacity.

3) Grease the battery terminals regularly (particularly conventional, round, clamp-on style terminals) in order to prevent corrosion.

4) Consider 'resting' (and charging) a loco during part of a public running day. Giving the loco (or just its batteries) a rest/charge for an hour or two 'over lunch' will significantly reduce the depth of the discharge experienced by the battery and help to preserve its life. This may not always be practicable, of course, although substituting an 'old' set of batteries for that hour or two may make it feasible.

5) Give the battery a top-up charge, say once/month, when in storage (over winter, for example). There are conflicting views on this, but most manufacturers recommend this kind of top-up rather than leaving batteries on a 'trickle-charge' (also known as a 'float charge') for long periods. In the latter case, the excess energy (once 100 per cent charge has been reached) has to go somewhere and this will take the form of heating of the battery.

Note that some chargers may simply turn off (or turn off their output, at least) when a full charge has been achieved and may not maintain a trickle charge.

6) A new deep-cycle battery may have a capacity which is only 70 per cent or so of its rated capacity. The battery can be brought to full capacity by applying a gentle load for the first five cycles – this is known as 'formatting' the battery and can be achieved as follows:

a) Calculate the C/20 rate for the battery, where C is the stated capacity. For a 100Ah battery, the rate will be 5A.

b) Calculate the load resistance needed to achieve (roughly) this discharge rate using:

R = V/I =12/5 = 2.4 ohms

Anything close to this figure will do – err on the high-side, if necessary.

c) Calculate the power which will be dissipated in this load using:

P = V*I =12*5 = 60W

d) Source (or make, using resistance wire) a suitable wire-wound resistance (~2.4 ohms rated at >>60W)

e) Install the resistance and allow the battery to discharge for 10-15 hours (but no more)

f) Remove the resistance (which will be hot!) and recharge the battery.

g) Repeat four more times.

Alternately, run the loco around the track, with a very light load (driver + riding truck only) and gentle acceleration, until the battery voltage reads around 12.4V (~50 per cent discharged) and repeat four times. This option is more time-consuming but more fun!

As a final option, there are (sophisticated and expensive) chargers available which will discharge and then charge a battery, although most of these are designed around the needs of the radio-control community and, whilst they will charge/discharge lead acid batteries, may be restricted to 10V maximum, rendering them of limited value to the model engineer. ▶

TABLE 2

Voltage Reading	State of Charge (% of full capacity)
>12.7V	100%
12.5V	75%
12.4V	50%
12.2V	25%
<12V	Discharged

PHOTO 16: A low-cost 'automatic' battery charger.

TABLE 2: Judging the state of charge of a lead-acid battery unit.

PHOTO 17: A simple intelligent battery charger which is intended for 'gel' batteries (such as that shown in Photo 13).

7) Keep your battery warm! Just as you don't like being cold over winter, nor does your battery. The electrolyte can freeze, particularly at low states of charge.

The optimum storage temperature is often quoted as 15 deg C. This is, perhaps, where the diverging views regarding top-up vs trickle-charging stem from – if the battery is stored in a cold environment, the warmth added by 'over-charging' may be beneficial, whereas in a warmer environment, this could lead to loss of electrolyte ('gassing').

A battery will lose approximately one per cent of its stated capacity for every 1 deg C reduction in temperature. **This also applies to charging**. If a 100Ah battery is charged at an ambient temperature of 5 deg C, its capacity will reduce to approximately 80Ah. The battery will be 'fully-charged', however it simply won't be able to accept as much charge at this lower temperature.

8) Keep your battery cool! References to Goldilocks' porridge are apt here – batteries should be not too hot but not too cold. The optimum operating temperature is 25 deg C.

As a rule of thumb, every eight-degree rise in operating temperature will cut the battery's service life in half. Fortunately, we don't get many days of 33 deg C heat in the UK, but this is an issue in some overseas countries. Note, however, that a poorly-ventilated loco body could result in the batteries reaching a temperature well above ambient.

9) Take care when charging indoors. Lead acid batteries release both hydrogen and hydrogen sulphide gasses when being charged. We all did the experiment in school chemistry demonstrating what happens if we introduce a spark into a mixture of hydrogen and air...

In practice, this is probably only a significant issue in a very small, draught-proof, workshop or if many large batteries are being charged simultaneously (hydrogen only becomes explosive at a concentration of 4 per cent in air) – good practice would be to open the door and wait a few minutes before turning on the lights (or anything else).

Hydrogen sulphide, despite also featuring in most childhoods (in 'stink bombs'), is poisonous and again it should be ensured that any room in which batteries are charged is well ventilated prior to human occupation.

PHOTO 18: 'Intelligent' battery charger.

PHOTO 19: Current-limited power supply.

■ Next month Peter will address some of the queries readers have raised since the start of this series, the first three parts of which were published in the November 2020 to January 2021 issues of EIM – to download a digital back issue or order a printed version, go to www.world-of-railways.co.uk/store/back-issues/engineering-in-miniature or order by phone on 01778 392484.

Is it terminal?

A common problem experienced with lead acid batteries is that of reading 'fully charged' and an attached charger insisting that it cannot put any more charge into the battery, yet when the battery is used, it either fails to function at all or does so for only a short period, before being 'flat'. Why is this?

Battery chargers judge whether a battery is fully charged based upon the voltage they sense across the battery's terminals. Thus, if a battery exhibits the correct voltage, then (so far as its charger is concerned) it must be fully-charged. However, charge is not the same as voltage (it is measured in Coulombs, for a start, and not volts…). If a battery has reached the end of its useful life, its ability to store charge is drastically reduced – it will be capable of sustaining a voltage level commensurate with a 'full charge' but without actually storing much energy.

As soon as a significant load is placed upon the battery, the voltage collapses due to the internal resistance of the (or a) cell being high or the charge quickly disappears due to their being very little of it stored within the battery chemistry. This is often the result of sulfation (the formation of lead-sulphate crystals on the negative plate, which impede the operation of the cell) or a lack of electrolyte, or another similar cause – essentially anything which prevents the correct chemical operation of the battery.

Sulfation occurs when a lead acid battery does not experience a full charge. The battery must be charged for long enough to achieve a full charge and (ideally) not given a quick boost to cope with the next day's (or hour's) running. On a busy running weekend, it may not always be possible to accommodate a full 14-16 hours of charging time between the end of one day's running and the start of the next; regular partial charging of this nature will shorten the life of the battery, although partial charging within the running day (as discussed above) is better than deeply-discharging the battery, which might well be the result of not performing a 'top-up' charge.

Recovery Position

It is sometimes possible to revive (or partially revive) a sulphated battery, depending upon how long it has been in that condition, although a standard battery charger will typically not be capable of performing this revival (it will continue to insist that the battery is 'fully charged'). What is required is a means of intentionally over-charging the battery, for a carefully-controlled period of time, before returning to a normal charging (or maintaining) cycle.

If action is taken early, reversible sulfation may be reversed by overcharging an already 'fully-charged' battery. This over-charging should take the form of applying a regulated current of approximately 200mA, using a current-limited source (discussed below). For a 12V battery, this means allowing the terminal voltage to rise to between about 15 and 16V for about 24 hours. This is the reason why a conventional charger will not be of use here, as it will not permit the terminal voltage to rise this high, since it would ordinarily cause damage to the battery, shortening its life.

Increasing the battery temperature (up to 50 deg C) during the over-charging process will further help in dissolving the lead sulphate crystals. This may not be easy to achieve in a typical workshop/garage!

If the battery has been left in a low state of charge for many weeks or months, then the reversible sulfation becomes permanent sulfation and typically the battery is beyond restoration. The use of high-current

pulsing and other means of dislodging the sulphate crystals have been proposed, however forcing high currents through a sealed, corrosive, chemical-filled, environment is probably not a wise move and it would be better to crack open the piggy bank and invest in some replacement batteries.

Over-supply

To realise the over-charging discussed above, some form of current-limiting power supply is needed. Being an electronics engineer, I am well-provided in this area (Photo 19), but others may not be so fortunate. What is needed is a supply capable of at least 15V and with a current limiting ability which can be set to 200mA or so.

Suitable supplies are available new for about £30, or less for a secondhand example. This is under half the cost of even a relatively small new battery and it can also be used to charge that nice new NiMH battery pack you've just made for your blower – set to 16V @ 200mA for 14-16 hours, from flat, or less (time) if partially-charged. Try searching for 'bench power supply' and select one with variable voltage and current controls.

Photo 19 shows a dual-output power supply, with the left-hand half set to the required voltage (16V) and current (200mA) – note that the excessive number of decimal points in the current display is this particular supply's way of showing that the current indicated is that 'set' by the controls and not the actual output current at the time (which would be zero, in this case, as it is unconnected). When a load is connected and the supply's output switch turned-on, the meter will read the actual current being provided by the supply.

The Appliance of Science

Hopefully you now have a fairly scientific basis upon which to judge if 'Fred' was right when he told you that all batteries should face East when charging and the third day after the new moon was the optimum one on which to undertake such activities.

It is an area in which it is easy for misinformation or half-truths to proliferate – who religiously checks their battery capacity, makes a note of its usage, the conditions and 'mistakes' (such as over-charging, running flat and the like) it experiences in operation, together with its purchase date, to then compare with the next (replacement) battery and its characteristics? I've yet to meet anyone who has – we're all too busy enjoying our hobby and providing fun for hundreds of passengers each season, although perhaps not this year... EIM

Going nuts...

Roger solves a problem we have all encountered...

BY **ROGER VANE**

I recently had to devise a way of fitting nuts onto some inaccessible 6BA studs, and thought that other readers might find the technique helpful, hence this short article.

Having timed my 5-inch gauge Adams T6 4-4-0, I had the tedious job of permanently fitting the steam chest covers. For testing the chassis on air I had attached the gaskets and covers, only fitting nuts in the four positions shown as they were reasonably accessible (Photo 1).

The problem then was how to fit the remaining nuts to the studs – the top row wasn't a problem, neither were the upper ones on the sides. The bottom row really presented a problem though due to limited access – the gap between the ends of the studs is only 7/16-inch, and the bottom row is 1¾-inch from the top of the steam chest.

I could turn the nuts with a spanner when they were fitted to the studs, but how was I to fit the nuts onto the studs in the first place? I was 'going nuts'.

Well, one option was to remove the bogie stretcher, which I was reluctant to do. So, I looked at various other options for presenting the nuts to the ends of the studs in such a way that I could then use a spanner to transfer the nuts to the studs and then tighten them.

My first thought was to use a magnet – no chance here as the magnet tried to attach itself to everything in the vicinity. The next attempt was to use double-sided tape on the end of a piece of mild steel flat – but the nut fell off due to insufficient contact between nut and tape.

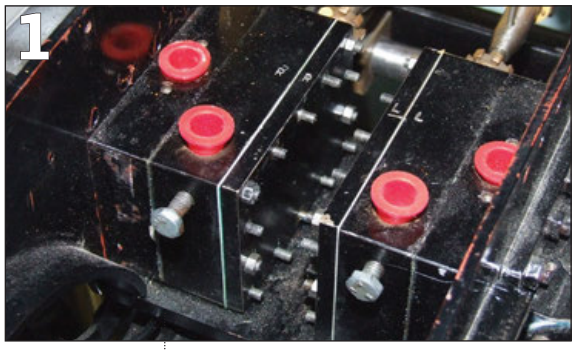


PHOTO 1: The problem – the bottom row of studs was totally inaccessible..

PHOTO 2: The holder, showing a nut partially fitted.

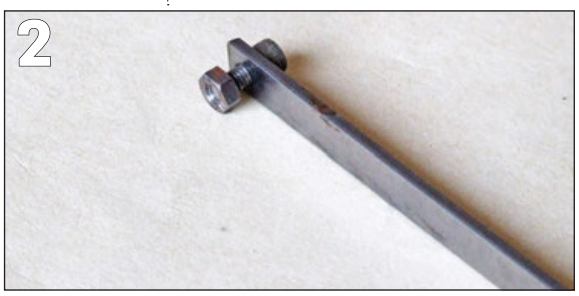
PHOTO 3: The holder in use - transferring the nut to the end of the stud.

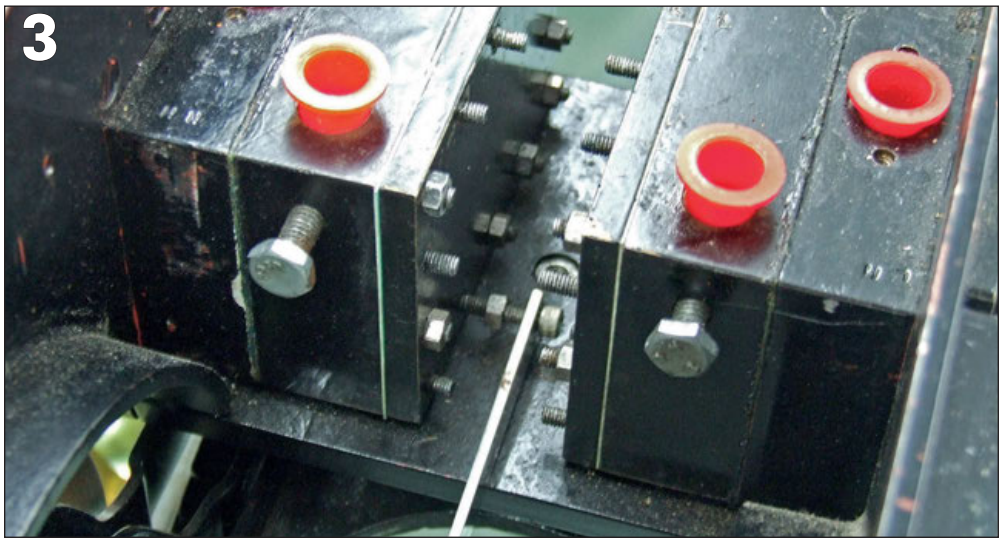
Photos by the author

I then wound several turns of tape around the steel – this was better as it increased the contact due to a cushioning effect, but it still wasn't very satisfactory.

The final solution is shown in Photo 2. I drilled and tapped a 6BA hole at the end of a length of mild steel flat, and then fitted a short 6BA screw. I simply wound the nut onto this screw for a couple of turns and then presented this to the end of the stud as in Photo 3.

Now I could wind the nut onto the end of the stud, transferring it from the holder onto the stud and then do it up completely. The result was that the nuts were easily and quickly fitted with no problems and no dismantling of the loco to gain access. Success! EIM





A new Loco Lift Table

Replacing the lift table at a busy passenger-hauling club track is not a simple process and requires careful and safe design, as Rugby ME chairman Aubyn relates.

BY **AUBYN MEE**

A note from the Author

As this lift table project is a piece of safety critical equipment, it needs to be said that this feature has been written in good faith, and that neither I or the Rugby MES are accountable for omissions in design, working practice or issues arising outside of our control. Our view is that this is merely an informative share of our lift table for guidance and ideas.

The Rugby ME Society's original lift table was installed at the club in 2005 and was a converted lift table trolley that was commercially available with a 500kg Safe Working Load (SWL).

It was originally a twin scissor pack enabling it to lift to around 1200mm from the ground, but this was found to be insufficient in capacity to lift many of the club's 7¼-inch gauge locos at the time,. So we removed one of the scissors to double the capacity but in the process also reduced the lifting height by half. This lift served us well for many years and was moved to its current position (Photo 1) in 2010.

Unfortunately, in recent years with the expansion of the society's track and the ever-larger size of locos that visit us, this old table was suffering from wear and tear, and the lift ram seal was starting to pass oil and cause concern, so the decision was taken to replace it.

I had become in recent years an Engineer Surveyor in the lift and crane industry, and I wanted something that was robust, easy to service, and had a good SWL capacity that could cope with the large locos that are around now. I mainly required something fit for purpose and that would meet the current Lifting Operations and Lifting Equipment Regulations (LOLER) statutory requirements. LOLER is in place to ensure that all lifting equipment is used in a safe manner. Any business or organisation whose employees operate lifting equipment on the job are required to comply to these regulations, which come under the Health and Safety at Work Act.

Quoting from the introduction to HS2020, *Managing health and safety at passenger-carrying miniature railways*; "Private clubs and operations run by volunteers may not fall under the Health and Safety at Work Act 1974 (HSW Act) and the regulations made under it, but they still have a duty of care to protect the public, their members and visitors. Failure to do so may result in civil action. In general, the same health and safety standards should be applied to voluntary workers as they would to employees exposed to the same risks". It would be very prudent for all model engineering clubs/societies to adhere to the LOLER regulations regarding all their lifting equipment.

In my role I unfortunately see a good number of lift tables that are not fit for purpose for what they are currently being used for, or have been incorrectly modified. I also know that there are a lot of lifting tables within the model engineering world that we rely on to safely lift and lower our expensive locomotives. These should all be inspected on a yearly basis, preferably by an independent competent person, to ensure they continue to be safe.

If the lift has been manufactured locally or modified heavily from its original design, then it will need to have a certified load test with a 110 per cent load of the SWL it is stated to lift. Failure to do this leaves clubs/

ABOVE: The Rugby club's 71/4-inch gauge Romulus 'Dr John', the rebuild of which was recently documented in our pages, on the new lifting table.

PHOTO 1: The previous lifting table, which was reaching the end of its useful life.

All photos in this feature by the author

people wide open to prosecution if something were to go wrong.

Anyone visiting a club has the right to ask to see the load test certificate and current thorough examination certificate for a lift table, should they be concerned whether it is suitable. There should also be maintenance and inspection records for the table readily available for perusal if requested.

With there not being anything available commercially at a reasonable price that the club could afford, I decided to make my own. I had the benefit that I could look at all the many different lift tables that I inspect and then copy all the best bits to then design my own.

Most tables that are long enough for our locomotives are also just as wide, which we do not need. I also wanted to install a traverser, as I know unloading and loading from a fixed position can be a stressful exercise requiring the manoeuvring of vehicles and/or trailers, especially in the dark at the end of a long running day.

People who know me also know I always tend to over-engineer the things I make, as I would rather err on the side of caution when building safety-critical components – The members of the club use the term Aubynized! I would recommend that this is a good course of action to take with locally made equipment.

So, I came up with a design based on the larger commercially available scissor lifts and I copied the ram position and lowered starting angle to provided the best mechanical advantage, as the most power is needed at the initial lift point. I also looked at different diameter and length rams to see what would best fit our requirements.

I tried to position the ram upper pivot assembly as far away from the centre scissor pivot point to give the maximum mechanical advantage, as the closer you go to the centre pivot the less advantage you have and the more power you need – this also induces a lot more mechanical stress which needs to be minimised.

"In my role I unfortunately see a good number of lift tables that are not fit for purpose for what they are currently being used for..."

PHOTO 2: Most of the components for the new table were machined at home.

PHOTO 3: Work begins on site with the removal of the old table...

PHOTO 4: ...and the installation in new concrete of the rails for the new traverser.

The traverser rails were made from C-section 80 x 45mm UPN steel channel set into the concrete, with about 15mm protruding from the surface. This was used so that a retaining hook could be fixed under the lip at both ends of the table to prevent any uncontrolled tipping if an excessive load were applied on the overhang. It also prevents the table coming off the rails.

I priced the materials up for a lifting capacity of 2 tonnes, plus getting the table load tested, producing a total cost of around £2300, including re-using the hydraulic pump from the old lift table. This worked out at £1350 for the steel, £350 for the two hydraulic rams, £100 for a foot brake, £90 for hoses, fittings, and paint, and £410 for the load test and certification.

The materials used were as follows; the base chassis is constructed from 120 x 120 x 10mm equal angle. The end plates that support the wheel bearings are made out of 20mm plate and the main scissor arms are out of 120 x 60 x 6mm wall rectangular hollow section.

The top table was made from a combination of 120 x 120 x 10mm equal angle plus 80 x 45mm UPN channel and a 6mm thick top plate. All pivot pins were made from 1¼-inch Diameter EN8. and the four scissor rollers were produced from 80mm diameter bar.

I then spent a fair amount of time in my workshop at home machining all the bushes, pins, and rollers, all provided with grease ways and nipples to aid the servicing (**Photo 2**). I also machined all the small items that I could take home, such as the pivot plates, and the lift ram brackets, all ready to commence the on-site construction of the table.

The removal of the old table (**Photo 3**) and the installation of the traverser rails (**Photo 4**) commenced in May 2020, and then in June once the concrete had hardened, I started the lift table construction, taking a week's holiday from work.

If anyone is wanting to take on a construction like this, I would strongly advise that you find a professional-standard welder with a powerful machine to carry out this critical work. Most of this job was done with over 200 amps to ensure the best weld penetration.

I find that pictures explain the construction much better than I can so please turn the page...

▶

PHOTO 5: The rolling chassis being put together on site.

PHOTO 6: Guide rollers were fitted to the traverser.

PHOTO 7: Construction of the inner scissor mechanism.

PHOTO 8: Pivot bushes for the outer scissor legs being welded into place.

PHOTO 9: Next up, installation of the lift rams.

PHOTO 10: This view shows the upper lift ram pivot point.

PHOTO 11: The scissor pack in its lowered position.

PHOTO 12: Frame for the left table under construction.

PHOTO 13: Plate welded in place on top of the lift table frame.

PHOTO 14: Guide rails installed on top of table.

PHOTO 15: Next step, thorough painting of the components to ensure they survive outside.

PHOTO 16: Lock ensures traverser can be secured in position before moving stock

PHOTO 17: Important event – the day of the load test in August,

PHOTO 18: The table was loaded with 2200kg – this includes the 10 per cent overload of 200kg against its planned rating.

PHOTO 19: A successful and duly certified lift.

PHOTO 20: Table marked up with its SWL (Safe Working Load) and an identity number.

PHOTO 21: The control box uses a hydraulic lever for raising and lowering.

PHOTO 22: The 3-phase hydraulic pump motor was sourced from an old vehicle lift.

PHOTO 23: Final essential element – the test certificate!

PHOTO 24: Another view of Dr John on the table, descending to its lower position.

The finished lift table measures up at 3500mm long, 700mm wide, a lowered height of 380mm and a raised height of 1325mm, with 1450mm of sideways movement.

The whole project, including ripping out the old table and preparing the site, to making the new lift table, took about 120 hours of my time, but I am pleased with the result which should serve the club safely for many years to come. EIM

■ Once Covid restrictions come to an end and public running days are able to recommence, EIM readers will be able to see the new table at the Rugby ME's extensive Rainsbrook Valley Railway, at Only Lane, Rugby, Warwickshire, CV22 5QD. For details of future running days see the website at https://rugbymes.co.uk/ or the club's Facebook page.

Behind the Shed Door

This month our resident Fairbourne Miniature Railway engineer does some track work before returning to a diet of detecting and solving technical challenges in the workshop.

BY **HARRY BILLMORE**

November on the mid-Wales coast started with a spot of 12¼-inch gauge trackwork. Kev, the person in charge of the permanent way asked me to help fabricate a set of points to go in between the sector plate at the end of the platform and the carriage shed road at Fairbourne. This is a vital point as every carriage and every loco used during an operating day passes over it, which is why Kev decided to take it out at the start of the winter maintenance period, so if there were any issues they could be fixed before the next running season.

My part of building the point was to make the frog, and then finish welding everything down to its tie-plates for final assembly. I used a jim crow to bend a rail to the correct radius over the length of the frog before cutting the section out of the middle I was going to use. This is because the jim crow leaves a straight section at the end of each bend so you can never get a smooth curve along the full length of the rail – an issue when you are dealing with lengths that are short enough to make a frog.

Way of the welder

After bending the curved rail, I then used the rail saw to rough out the shape I needed. I wanted the nose of the frog fully supported in the middle of the web of the rail, and the straight section starting a few inches back from the nose of the frog. This would reduce any potential issues with trying to weld up to a fine point and then having that weld take the hammer blow of every wheel over it.

Once most of the material had been removed, I set the frog up on the mill and using a carbide-tipped face mill, tidied up and trued up the mating faces before putting a large weld prep onto all the faces to be welded to ensure they were clean.

You can see in Photo 1 after it had been tacked up and checked in position, this was done several times to get the angle spot on – handily we had the existing point to lay the components we were making on top of to ensure they fitted correctly.

I then welded the frog up and ground the running surfaces back (Photo 2) before giving it to Kev so he could finish laying out the point. Once everything was in place I then welded ▶

ABOVE: Perks of the job – testing Yeo's valve timing in the Autumnal sun and superb surroundings...

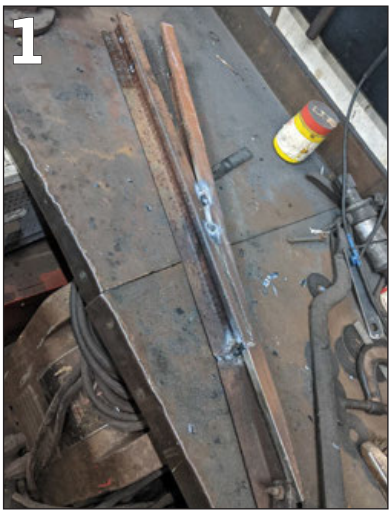


PHOTO 1: Point frog part welded – note shapes described in text.

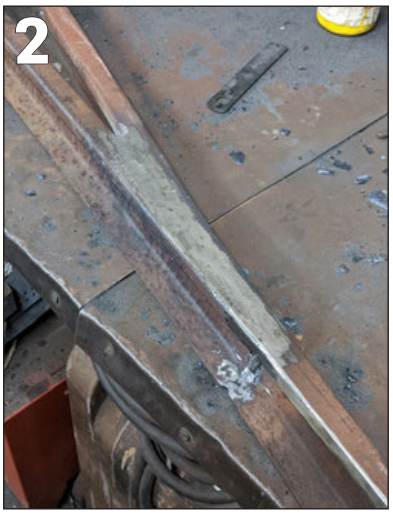


PHOTO 2: Frog welded up and dressed back, still to have final shape ground on nose of curved rail.

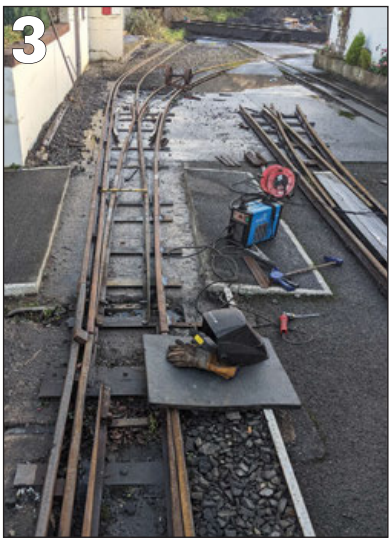
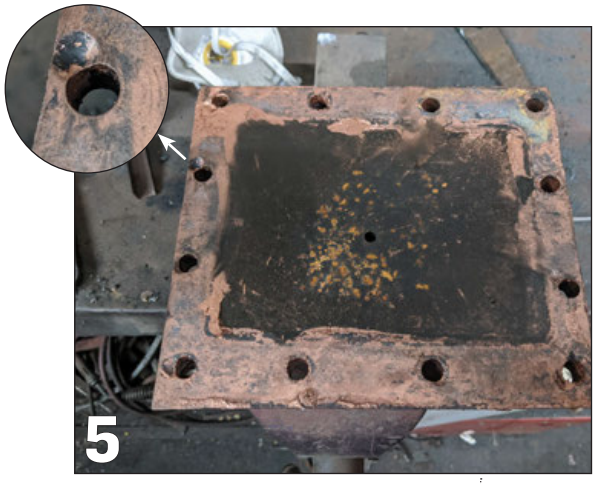


PHOTO 3: Welding up new point in place, starting from straight fixed rail at left and working across – replaced point at right.

PHOTO 4: Pins made by our editor welded onto point into lean-to side of carriage shed.



it all down to the steel sleepers, these are just flat bar as the point sits directly on top of a concrete pad.

I started by welding the straight rail in place along its length (Photo 3), then worked across the point to the farthest curved rail, setting the gauge as I went – this ensures that everything is to gauge where it needs to be and that it all fits onto the existing trackwork.

While I had the welder out, I also finished off the point rodding for the cariage shed lean-to pointwork (Photo 4), the bushes and pins having been machined previously by your Editor.

Missing the spot

Back in the workshop I discovered one of the reasons for the steam chest on our Lynton & Barnstaple 2-6-2T 'Yeo' leaking. At some point in the past, the holes in the steam chest cover had been miss spot drilled, leaving very little surface area for the gasket to seal on (Photo 5).

There are several potential ways of remedying this. I could fill the divots with a two-part product such as JB Weld (which I have had excellent results with in the past). I could fit a filler plate on the bottom of the steam chest lid, machine the lid down until the spot marks are gone or the option I chose, braze up the spots and machine the bottom of the lid back true.

This involved cleaning the lid back carefully to remove as much steam oil residue as possible, before using an oxy-acetylene welding torch and flux-coated brazing rod to fill the spots. This is quite difficult as the spots are frequently on the edge of holes or on the edge of the cover itself so care needed to be taken not to overheat the cover to prevent the braze just slipping through the hole.

After it had cooled down, I set the cover in the four-jaw chuck on the lathe (Photo 6), trued to the existing flat face as close as possible before taking as little material off as needed to get back to a flat surface.

When machining shallow braze like this, it is important to take small cuts, as with an interrupted cut you can snag the braze with enough force to peel it off the base material if it has not taken fully.

Once I had a flat face, I set the cover up on top of the vice in the mill and machined out the holes to size (Photo 7-8). I used an end mill for this, as a twist drill would run the risk of the drill snapping as the brass engages into one of the drill flutes like a screw, or ripping the braze out in a similar way to taking too large a cut on the lathe.

The final task on Yeo was to set the valve timing. My favoured method is to put the loco in mid gear, roll it a turn in either direction and then move the valve on one side to approximately the correct spot. With Walschaerts motion you should normally be able to see the inlet ports just open at each end of the travel due to the lap and lead in the valve gear, and you can then use feeler gauges to set the valve precisely in the middle of the travel.

Most of the valve gear on Yeo, however, is worn and the valve doesn't travel far enough to be able to do this, so measuring from the edge of the port to the inside edge of the steam chest it takes longer but you end up in the same place.

Then putting the reverser into full forward, you do another full rotation and note down the valve openings, then put it into full back gear and do the same. Unless the valve gear is absolutely perfect, there will be a discrepancy, so you then have to balance the valve movement as best you can.

Once this is complete, you then repeat the procedure on the other side. Once again unless everything is perfect and new, there will be a difference side to side and you won't be able to get them to perfectly match. In the case of Yeo, it is a combination of wear and a difference in the lengths of the drop links side to side.

I set the valves as close to even in both directions as possible since the engine works uphill in both directions with no turntables. If you have the same issues on a loco you know will not be required to work hard in reverse, you can set it up with a forward bias to produce better valve events in forward gear.

The timing work was finished just before Kev finished making all of the components for the new point but before he had removed the old one which allowed me to test the loco on a run down the line in glorious autumnal light, seen in the heading photo. A significant improvement was noted all round, although there is much work to be done to improve the steaming qualities of the loco. A close look at the drafting in the front end is high on the list of improvements, but this won't be until later in the spring once we have three working steam locos again.

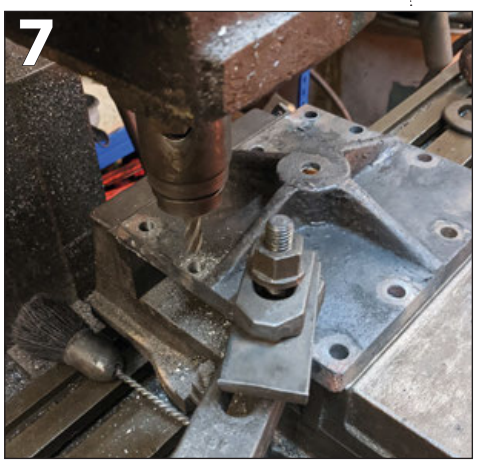
PHOTO 5: Missed spot drilling on valve chest cover – clearly visible in inset.

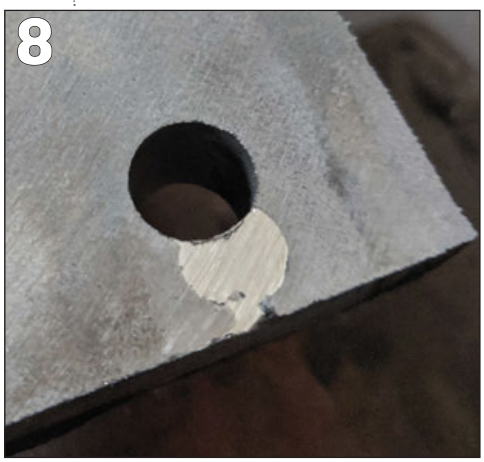
PHOTO 6: After brazing, steam chest cover set up in the lathe to turn back flat.

PHOTO 7: Using end mill to machine holes back to round.

PHOTO 8: Close-up of cover after braze repair.

All photos in this feature by the author





Fine finish

While I had been working away on Yeo and the new point, one of our volunteers, Andrew, had been busy repainting and lining out 'Russell', which, while looking like a miniature version of the 2ft gauge 'Russell' 2-6-2T running on the Welsh Highland Heritage Railway, didn't start out life that way.

Our loco was built as a representation of one of the Kitson 2-6-4Ts on the Leek and Manifold Railway, closed in 1934, hence the four-wheel bogie at the rear and the chimney shape among a few other

clues. But it was quickly discovered that the cab was far too small to spend the day in, so the loco was rebuilt into its current form. All of this is leading up to the decision on the lining – we took cues from the Welsh Highland Russell, but didn't directly copy it (Photo 9). Andrew's superb lining especially has lifted the look of the engine a lot!

Last month I mentioned the bodywork restoration of carriage 17 by Peter, now it was time for the underside. Two freshly rebuilt bogies were put under the vehicle, and to aid with cornering and to prevent flange wear I added a pair of Vesconite rubbing strips to the underside of the cross bearer on the carriage frame (Photo 10).

Previously the bogie top rubbed on the entire width of the cross bearer with grease being added occasionally to lubricate the steel on steel joint. The issues with this was that the grease would be squeezed out almost immediately due to the weight of the carriage with people in, only leaving a slight smear, which was then pushed out as the carriage went around a corner and the bogie pivoted.

Once this lubrication reduces, it increases the side load on the wheel flange as it is forced to overcome the friction between the bogie bolster and the cross member before the bogie will turn. In extreme cases this can lead to the flange being forced to climb the outside rail and then derail.

Grease nipples fitted to the cross members was not a sufficient solution as the carriage needed lifting to allow the grease to enter the space between the cross member and the bolster. This meant a trip into the workshop to use the lifting equipment.

With the new vesconite bearers, the rubbing surface area is considerably reduced and the material used is self lubricating. So it will last a long time with occasional greasing.

Root of the problem

Alongside the improved bolster bearers, I have also been carefully measuring the wheel sets that had previously been machined before I arrived at the railway.

In Photos 11a and 11b, the calipers are set to gauge with one jaw on the start of the root radius of one wheel, and you can see that the other jaw sits halfway down the root radius of the other wheel. This is not ideal – all the time the wheelset is running on true to gauge track, the root radius on both wheels will be taking all of the load and the guidance of the main cones of the wheels is completely negated. As a result the root radius wears prematurely, which is then exacerbated on every corner – the only time when the root radius should come into contact with the rail.

You can also see in photo 11b a slight error in machining one of the wheels, meaning the root radius is almost entirely gone already. Time constraints do not currently allow re machining so these wheel sets will be fitted but then closely monitored.

Once no 17 was back in the carriage shed, work on the 10-year overhaul of our Darjeeling 0-4-0ST 'Sherpa' could continue. The motion was carefully stripped down and inspected and there was no serious wear on any of it (Photo 12), so it will be refitted as it is, with a re-bushing pencilled in for about five years' time.

I had noticed that the left-hand cylinder was showing signs of moving against the frames so this needed removing and the issue sorting. With one side showing signs of moving the likelihood of the other moving in the near future is quite high so I took that ▶

PHOTO 9: 'Russell' on the traverser after repainting and lining out.

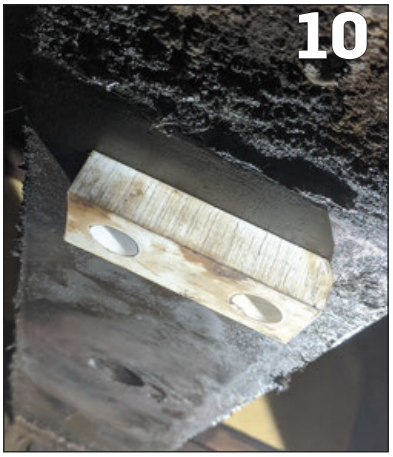
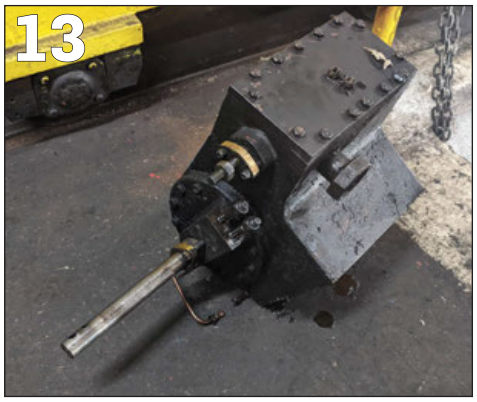


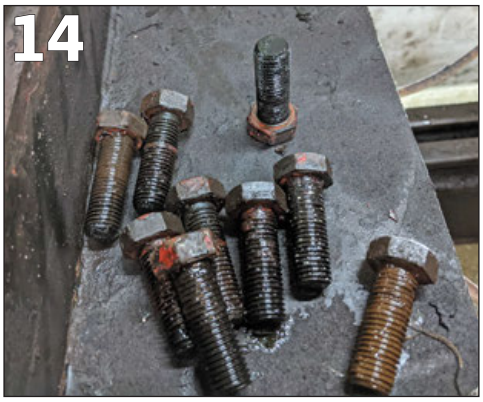
PHOTO 10: Vesconite bearer installed on crossmember of carriage.

PHOTO 11A: One side of wheel set – resting point of caliper set to gauge, halfway up root radius of flange, compared to...

PHOTO 11B: ...other side, where point is on main cone of wheel. Slight machining error has also reduced root radius.

PHOTO 12: Motion of loco 'Sherpa' has been carefully stacked on shelving for later refitting.





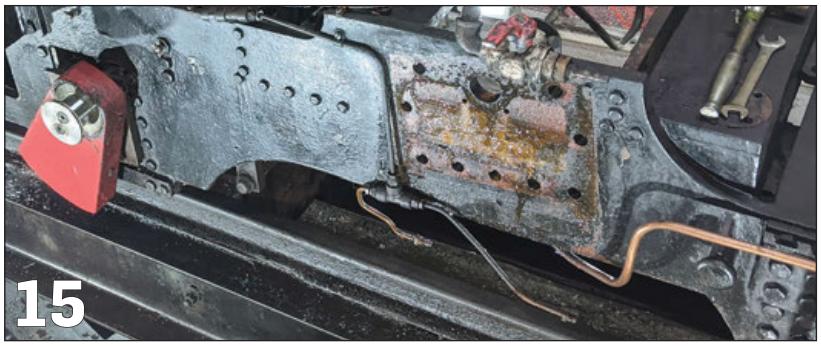


PHOTO 13: Sherpa's left-hand cylinder after removal.

PHOTO 14: Lack of fitted bolts helped cylinder move on frame.

PHOTO 15: Rusty marks where cylinder exhaust has leaked into cavity.

PHOTO 16: Wheel set after removal from Sherpa's frames.

PHOTO 17A-B: Slightly odd wear marks on horns and guides.

PHOTO 18A-C: Nuts had to be welded onto axlebox keep bolts to remove them. Top view shows second attempt after first weld failed.

one off as well (Photo 13). To my surprise, the bolts holding the cylinders on (Photo 14) were not fitted (specifically machined to precisely match their holes) – the most obvious cause of the cylinder moving...

Another interesting discovery was that the cavity in the back of the cylinder was full of wet rust, steam oil and other gunge. This is due to the exhaust port on the cylinder bearing directly onto the frames (Photo 15) and then the exhaust pipework on the inside sealing onto the inside edge of the frames, allowing exhaust steam to fill the space behind the cylinders.

To prevent this from happening again, I will be brazing exhaust stubs onto the cylinders and opening up the holes in the frames to allow them to poke through with a screw-on flange between the frames.

Once all the components were off the frames, I then lifted them off the wheel sets (Photo 16) and put the latter onto a stand for easy access. I had a good look at the horn guides.

There are some strange wear marks (Photo 17a-b) but they are not terribly worn with only the inside faces that take the side load requiring a little refinishing work.

The axleboxes are a somewhat different story – the keeps are held on by a pair of countersunk screws through the horn bearing faces of the axlebox into tapped holes in the keeps. I managed to get two of these out using allen keys but the others stripped out as I tried to remove them. To remedy this I had to resort to very carefully welding nuts onto the top of the heads (Photo 18a-c) and then removing them with a spanner. When I refit these, there will be a plate across the bottom of the boxes and they will be bolted from underneath, this will allow for regular inspection and maintenance of both the bearing surfaces of the axle and the oiling pad.

Oil on water

A surprise I had on removing the wheel sets was that the axleboxes were full of water. While a reasonable cooling medium, water is not known for its lubrication properties. On taking the keeps off, I was also surprised to discover the lubrication supply to the axle was a small amount of horsehair sat in a bedraggled ball in the bottom of the keep (Photo 19), in other words, completely useless.

Thus it was no surprise that the bronze axlebox bearings were worn badly, vertically and horizontally and barrel shaped due to the movement of the axles (Photo 20). You can see in the pictures how bad they are.

I suspect the only thing saving the bearings from total overheating and failure was the journals having a good round hardened surface, a hangover from when the loco ran on roller bearings. This is still not perfect due to the water sat in the axles having caused a small amount of pitting to the journal surfaces. I am intending to

tidy them up with emery paper, but the axleboxes will require complete re-machining, along with white-metalling the horn bearing surfaces.

At this point I had a call from the Talyllyn Railway, with whom we share a boiler inspector, saying that they were having him visit in a couple of weeks if we had anything that needed looking at. This brought forward the plans for Sherpa's boiler, saving the inspector a long extra trip to the mid Wales coast.

The first thing to do was to finish stripping the boiler, so I removed the ashpan, fusible plug, the adaptors in the backhead for the gauge frames and then tried to remove the washout plug in the bottom of the barrel. This proved to be a three-hour job as it had rusted in so badly.

Tubular hell

Once all the external fittings were removed, I took the J-pipe and regulator off, which required making a special tool to unscrew the long pipe from the elbow in the bottom of the dome. I could then set about removing the tubes from the boiler.

First I ground the tube ends in the firebox flush with the tubeplate, before turning up a mandrel to fit snugly in the tube end so I could start driving the tubes out. But I only got the first tube out about 10 inches (Photo 21) before I could not drive it any further due to the amount of scale built up on the tubes.

So I had to use the oxy-acetelyne cutting equipment to cut lengths of a few inches long out of each tube (Photo 22), then knocking them in from both ends before feeding the tubes out of the j-pipe hole in the front tubeplate (Photo 23).

Photo 24 shows the build up of scale and silt around the tubes, this one is from the bottom row of tubes at the firebox end and you can see that the scale is still damp. I believe this is due to it having been sat with scale and silt to above the bottom row of tubes where the barrel meets the throatplate.

I think that this is due to there being no washout plugs in the front tubeplate to facilitate washing along the bottom of the barrel, so sediment and scale could build up there easily without being washed away. The solution will be to put a pair of washout plugs in the tubeplate either side of the bottom row of tubes (which the boiler inspector agreed to, but more of that next month!).

I'm not the only one busy at Fairbourne over the winter. For example Peter, our ever dedicated volunteer in the carriage workshop had also been busy. What started out as a quick adjustment to seating in one of our carriages to standardise the cushions we use, turned into a fairly major rebuild with the discovery of some rot in a couple of the panels (Photo 25). Peter took the opportunity to replace those and repaint the carriage as well. As you will read repeatedly through these writings, we could not run the railway without the happy band of volunteers willing to turn their hands to just about anything and I am most appreciative to be working with them. EIM

PHOTO 19: Sad remains of horsehair trimming that did nothing to lubricate axles.

PHOTO 20: Close-up shows barreling wear to axlebox.

PHOTO 21: Detubing boiler – first tube refused to move any further.

PHOTO 22: Tubes cut into sections to allow them to be driven in from either end.

PHOTO 23: Pile of redundant tube sections.

PHOTO 24: Cross section of bottom-row tube near firebox, showing damp scale and silt build-up.

PHOTO 25: Carriage that entered shops for quick job that turned into new panels and complete re-paint.

Automata in Istanbul

A fascinating model built in the UK but that has passed its centenary in Turkey.

BY **BRUNO CIANCI**

Among many anniversaries that occurred in 2020, and for which celebrations were restricted by the various effects of the Covid-19, one that may have passed many by was the centenary of an unusual piece of model engineering, just one exhibit amongst a huge collection in Turkey.

With more than 16,000 items on display, all related to the history of industry and transport, the Rahmi M. Koç Museum is among the most visited attractions of Istanbul. Founded in 1994 by its namesake industrialist, the Museum is the result of efforts spanning many decades.

These efforts began the day the tycoon at the wheel of Koç Holding (Turkey's largest industrial and services group) decided, after visiting the Henry Ford Museum in Dearborn, to reunite under one single roof his own large collection, in a similar way the Fords had done in Michigan. Somehow, it all started with a Märklin toy train brought by Mr. Vehbi Koç (1901-1996) for his son Rahmi, when the latter was a child.

Some 60 years later, in 1994, the Rahmi M. Koç museum opened the doors of the 'Lengerhane' ('House of anchors') in the district of Hasköy. Then in 2001 the museum increased in size dramatically, thanks to the acquisition of a nearby abandoned dockyard (called the 'Tersane') that resulted in the museum gaining an overall surface area of 27,000 square meters (290,000 square feet).

"Built by an amateur model-maker named F G Webb, the workshop was displayed in a shop window located in the town centre of Swindon..."

All photos in this feature by the author

Today, besides the one in Istanbul, two further Rahmi M. Koç Museums have been established, one in Ankara and the other in Ayvalik, but that is another story....

Even though most of the fortune of Rahmi M. Koç, CBE (born in Ankara in 1930) comes from the automotive and home appliance business – as evidenced by the presence of myriad cars, other road vehicles and white goods within the museum – his biggest passion has always been steam, anything related to this magical vapour arising from heated water a regular companion in his daily life. The number of full-scale portable and traction steam engines, of steam tugs and boats, steam models and miniatures Rahmi M. Koç owns runs into very high figures.

Centenarian model

Among the items in the museum one attracting special attention over the past year has been an unusual model steam-powered workshop, celebrating its centenary in 2020. Originally built by an amateur model-maker named F G Webb, the workshop was displayed in a shop window located in the town centre of Swindon in the UK.

Many years later the model was sold at auction, and later purchased from a third party in the summer of 1998 by Richard Foster, an advisor to Rahmi M. Koç since the inception of his first museum.

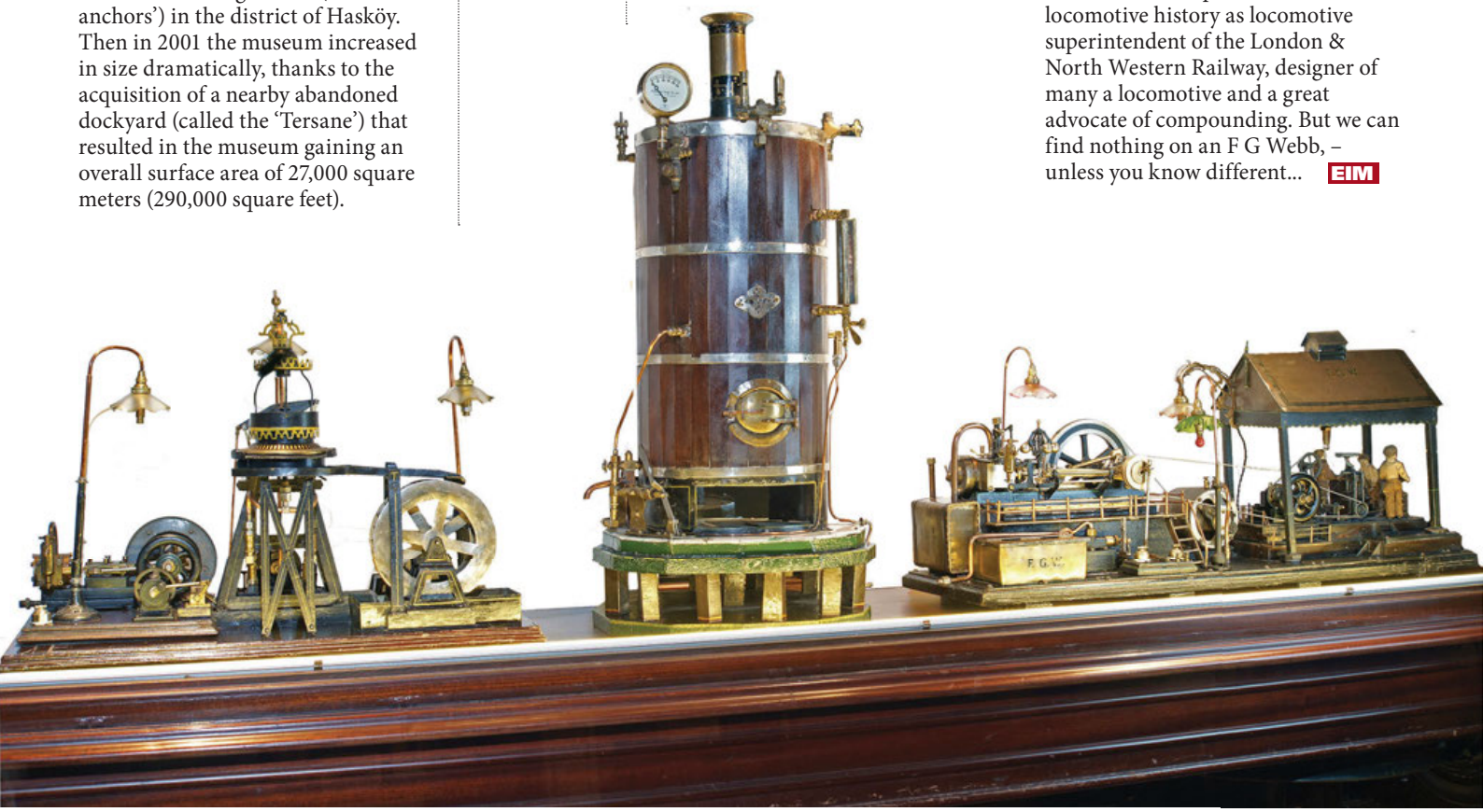
This curious display is powered by a vertical multi-tube coal-fired boiler, which supplies steam to two single-cylinder horizontal steam engines.

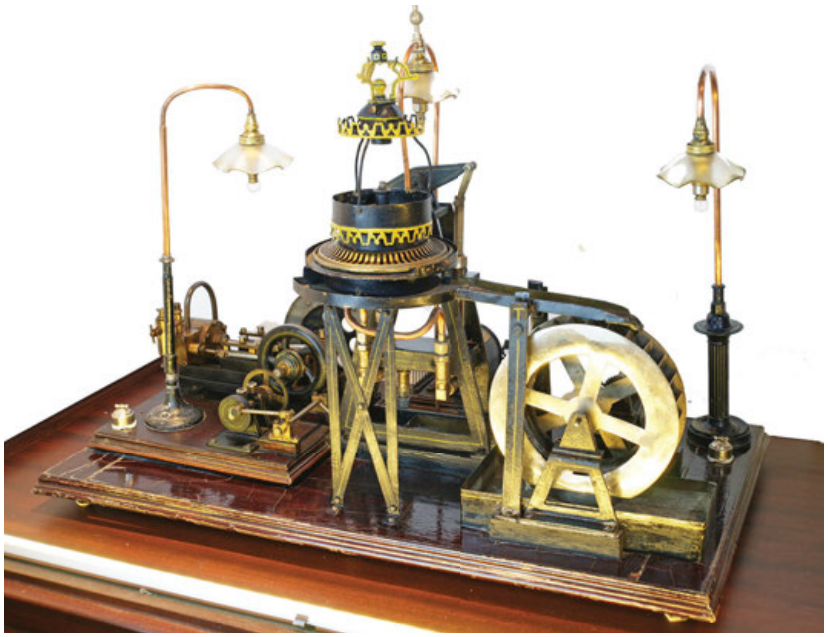
One is coupled to a dynamo generating electricity to power the lights and operate the workshop automata which consists of a saw bench, blacksmith's bellows, pillar drill and figures that move as if operating the machines.

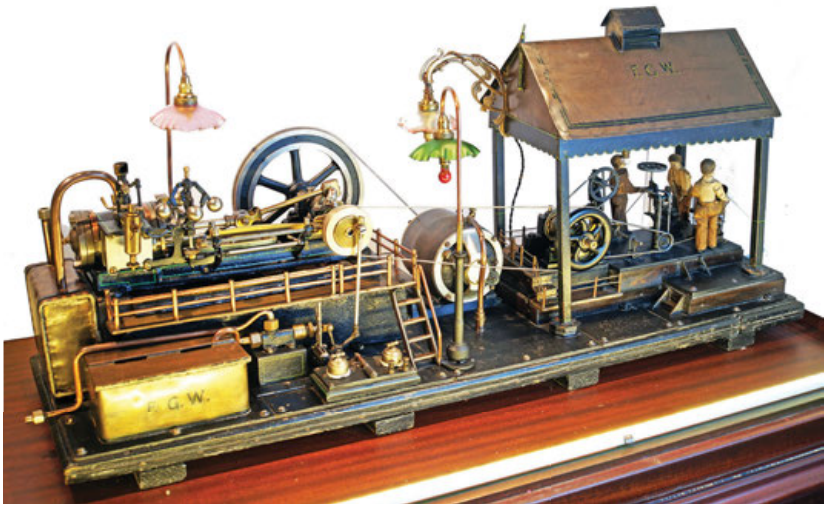
The second smaller engine drives a further dynamo and a water pump to lift water, which then cascades into a holding tank to power an overshot water wheel.

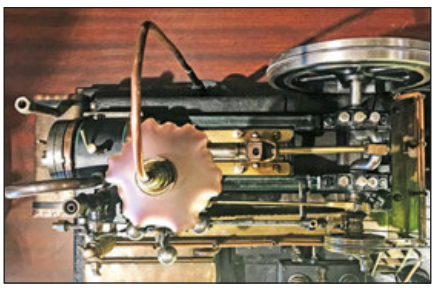
It is doubtful that this fascinating model ever ran while on display in the shop, but it is a real beauty to look at.

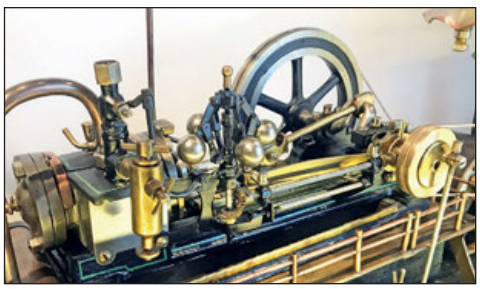
***Andrew Charman** adds:* Can any reader throw any more light on the mysterious model engineer F G Webb? Of course F W Webb, Francis William, has his place in UK locomotive history as locomotive superintendent of the London & North Western Railway, designer of many a locomotive and a great advocate of compounding. But we can find nothing on an F G Webb, – unless you know different... EIM

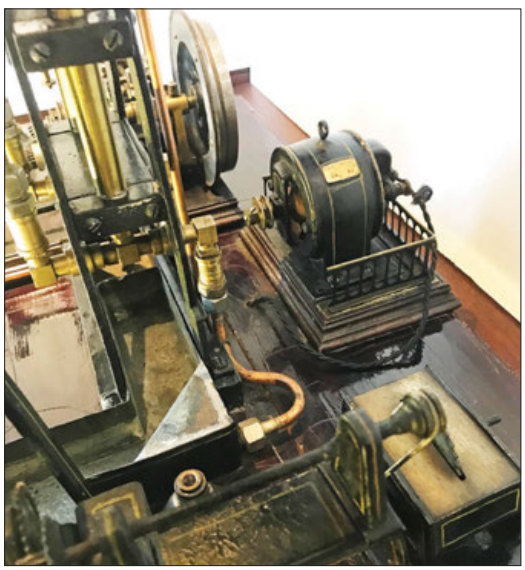


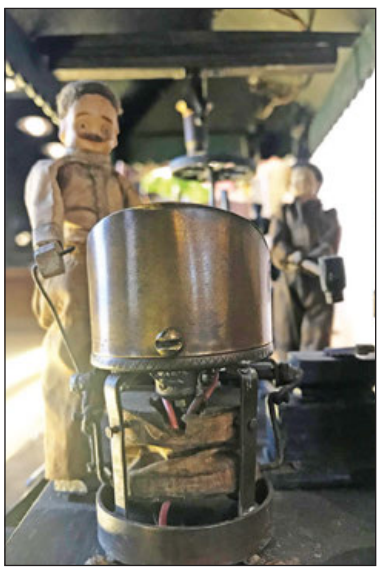












■ As can be seen in the picture above, extricating the model from its case is not an easy process! The Rahmi M. Koç Museum houses a great deal to fascinate the average EIM reader, and as detailed in our December issue has recently loaned items to display at the 'Brass Steel & Fire' exhibition currently on at London's Science Museum.

Once Covid relents to a degree that we can all travel freely again readers wanting to visit the museum in Istanbul will find more information online at www.rmk-museum.org.tr

Building a Ten-Wheeler

Jan-Eric's 7¼-inch gauge loco project progresses to another vital area this month – ensuring the brakes come on when they are supposed to...

BY **JAN-ERIC NYSTRÖM** Part Thirteen of a series

Of the 99 Hv-class Ten-Wheelers used in Finland during the steam era, only five have been spared the scrapper's torch. By the 1970s one of them, road no. 680, was on display outside the Museum of Technology in Helsinki. Photo 155 is from a 35mm transparency I shot sometime in the mid 1980s.

At that time, the engine was already in very bad shape – all the brass fittings, such as the road number and builder's plates were gone, the headlights and some of the windows were vandalized, and rust had started chewing away at the steel. Later, the engine was transported to the 'Steam Locomotive Park' in Haapamäki, where it still resides today, together with 13 other classes of Finnish steam locomotives – some of them still today awaiting restoration.

While modelling this prototype (albeit a later version with a longer, two-bogie, four-axle tender), I have closely studied photos in books and magazines, and of course my own photos of the immaculately preserved Ten-Wheeler no. 555 at the Finnish Railway Museum. In addition, I have obtained copies of the original works drawings, and I also bought an old

PHOTO 155: This Ten-Wheeler was in pretty bad shape in the 1980s...

FIGURE 40: Intricate brake rigging required in order to provide equal braking force on all six wheels.

PHOTO 156: Brake lever and ratchet in loco's cab.

All photos and diagrams in this feature by the author

book, published in Helsinki in 1945 – its title translates to *Steam Locomotives and their Care*.

The book contains many explanations and diagrams about different parts of locos, including this particular engine. The Ten-Wheeler's brake system is explained in detail – Figure 40, from the book, shows the linkage inside the loco frame in the top half of the drawing, and in the lower half how the braking force is distributed to all six wheels.

In the original, the brakes were actuated by a piston in a compressed-air cylinder (pink in the drawing), but I have designed a simplified, completely mechanical system for my model. The brake lever and its ratchet, Photo 156, indicated at A in the simplified, bottom half of the diagram, take the place of the air cylinder.

In order to get the motion in the correct direction, I had to introduce an extra lever into the linkage, only schematically indicated at B in Figure 40 – it is further forward in the engine, and actually pulls the blue link, as indicated by the thick black arrow and asterisk.

By using a pulling force, the link rod won't buckle. This moves the top of the blue brake link forward, also rotating it clockwise. Since this link lever is not pivoted around any fixed point (the lever is held only loosely, by a 'hanger', yellow in the middle of the drawing above the diagram), the braking force is applied to two short links, affecting the orange and red levers in the directions of the arrows.

The red lever has different lengths of its 'arms', and its fulcrum is connected to a fixed point (purple) on the smokebox saddle, in the front of the engine. Thus, due to the different leverage, one third of the total braking force is applied to the first pair of brake shoes (indicated by the rightmost green point in the diagram).

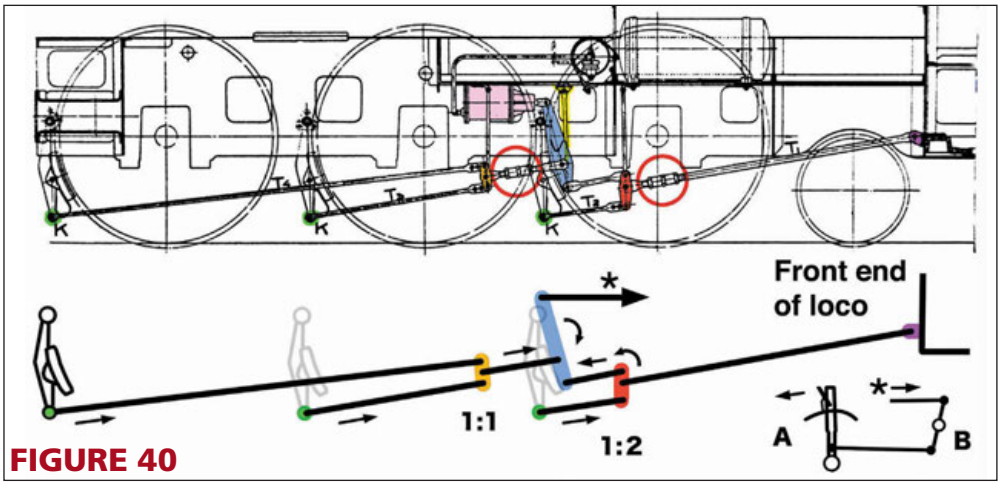


FIGURE 40

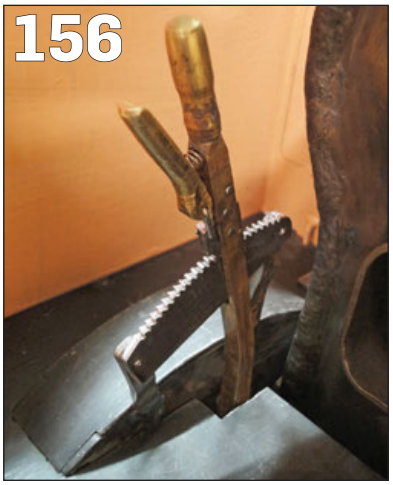


FIGURE 41

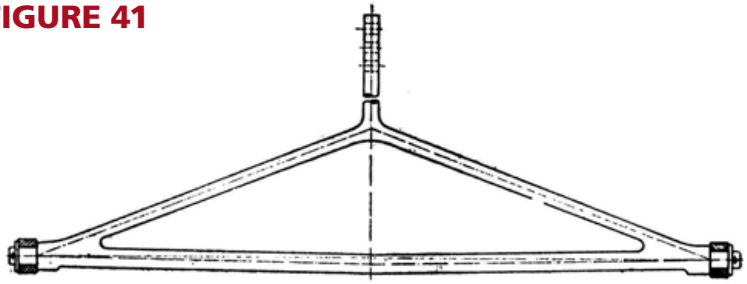


Photo hints

Photo 159 was taken from an interesting angle; the camera lens was exactly at axle height. That would be a little under one metre above ground in full size – imagine crouching down a bit, and you'd see a view like this!

A small, pocket-sized digital camera is ideal for shooting pictures of miniature models; a larger SLR camera has much less 'depth-of-field', which would cause both the foreground and the background to be severely out of focus.

If you want to take similar pictures, be sure to set the camera lens to its widest zoom position, and move in as close as possible – this enhances the perspective. Shoot in available light only – using the camera flash would completely destroy the picture, causing an overexposed foreground with severe reflections and shadows, and an almost black background.

To avoid blurred shots, use a tripod or some other means to support the camera if the exposure time is much longer than 1/30th of a second!

If you take your pictures outside, avoid direct sunlight (it is almost as bad as flash, causing totally black shadows) – stay in 'bright shade', instead!

These shoes press against the front-most drive wheels.

The other two thirds of the force pull on the orange lever, and since this has equal 'arms', the force is evenly divided between the brake shoes on the middle and rear driving axles of the locomotive. In this way, each and every axle gets exactly one third of the total braking force.

Note the circled turnbuckles in the drawing – thanks to them, the length of the linkages can be adjusted so that all the levers assume their correct position, and the links won't hang loose, requiring too large a movement of the brake lever.

On my ⅛th scale model, I have made the turnbuckles of 10mm hex brass rod, with M6 threads, right-handed on one end, left-handed on the other. In this way, rotating the turnbuckle 'in place' enables me to lengthen or shorten the links, not having to disassemble the clevis attachment on either end of the link – this would be necessary if you only used right-hand threads. Brass locknuts (right and left-threaded) on each side of each turnbuckle locks it in place.

Shoes and hangers

The brake hangers, each carrying a pivoting brake shoe, are attached to short studs fixed to the frame, as shown in Photo 157. The hangers are secured in place with clip rings.

Also visible in this photo are the steps to the cab, made from laser-cut 3mm hot-rolled steel, as are more than 300 other parts for this engine. The step pieces were TIG-welded together, and pieces of expanded metal mesh were glued to the steps, to simulate the non-slip 'diamond plate' on the full-size prototype.

The lower end of the brake hangers on either side of the engine are connected in pairs to three triangular braces – Figure 41 shows the original works drawing of such a brace. The triangular shape resists bending much better than just a straight bar. Nylock-type locknuts on all bolts and threaded studs ensure that the hangers and brake shoes will stay in place.

Photo 158 shows the rear of the engine – all three triangular braces are visible under the frame. Note also the oval hole in the buffer bar; here, the coupler to the tender will be attached. The white plastic hose hanging down and sticking out at the right-hand side will connect to the tender's water hose with a quick-release coupling.

PHOTO 157: Brake hanger behind the cab steps.

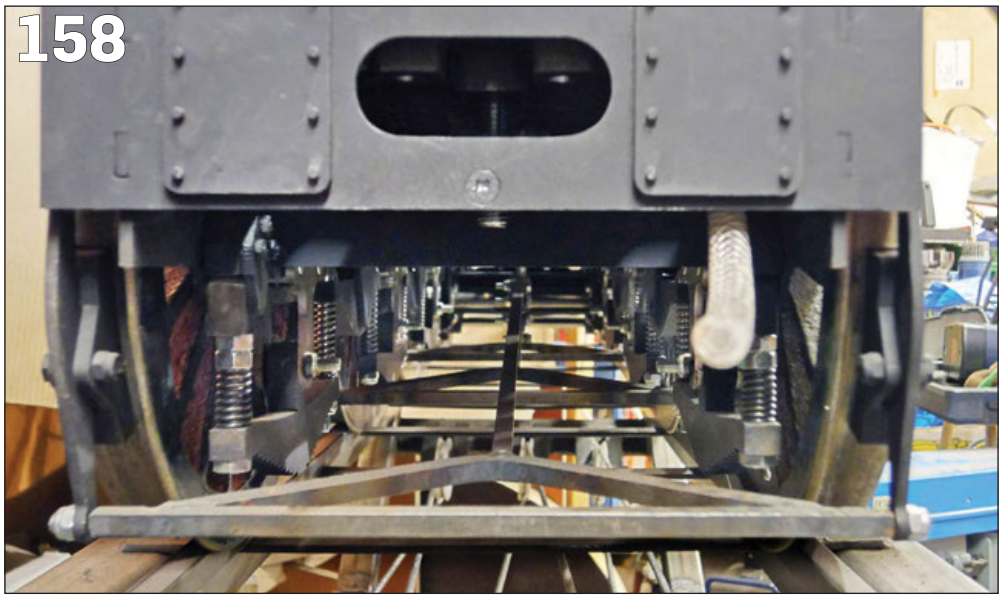
FIGURE 41: Triangular shape resists bending forces much better than straight bar.

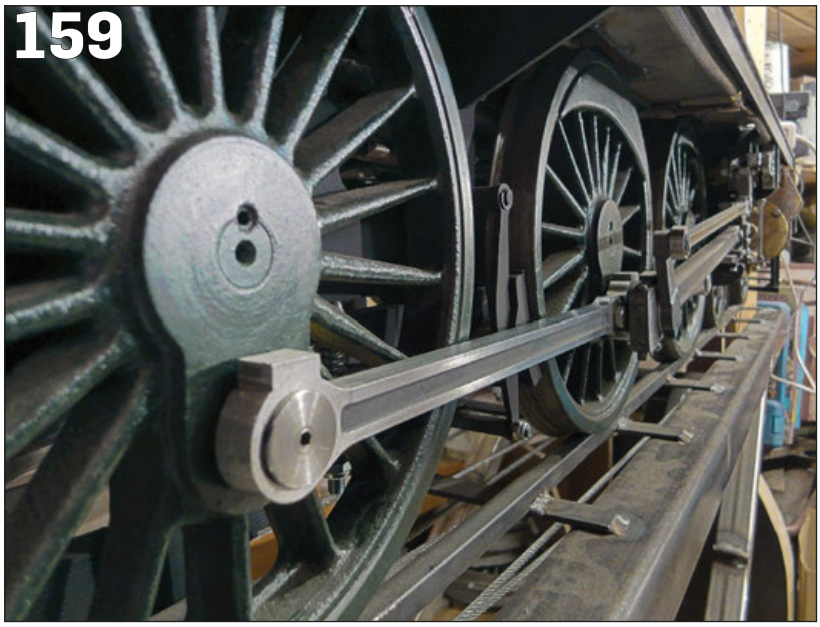
PHOTO 158: Brake rigging and equalization mounted under loco's frame.

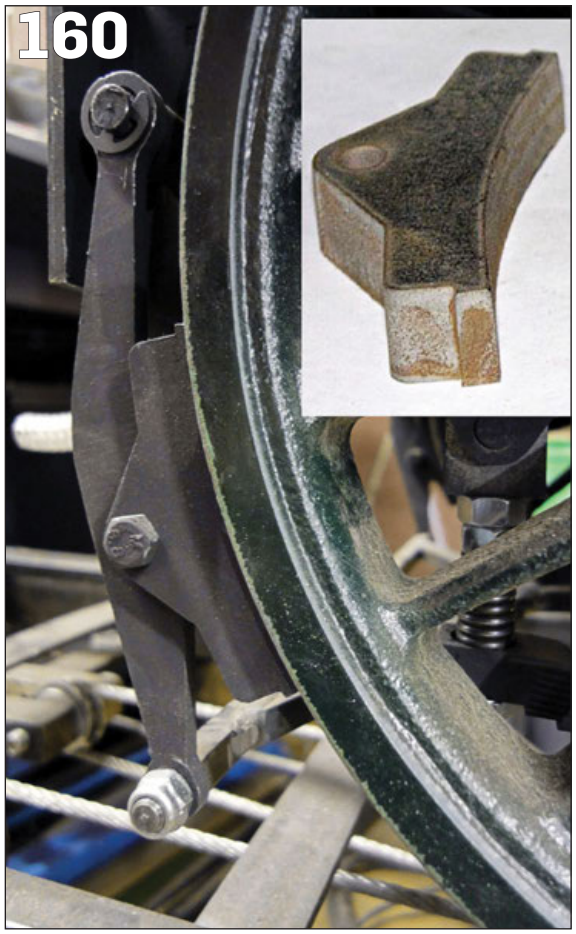
Also seen in Photo 158, in the shadows under the frame, is the equalization system, consisting of levers and springs. The full-size original engine had leaf springs, but I have 'faked'" these, making them of solid, water-jet-cut 10mm steel plate.

Instead of the leaves, I have used coil springs at both ends of the fakes. They do act in the same way, as parts of the equalization system, which is an important feature in any but the very simplest miniature engines. Thanks to equalization, the wheels will stay securely on the track even if there is a dip or other unevenness in the rail.

For this reason, the coupling rods ▶







for any engine with more than two coupled axles must also have flexible knuckle joints, so that the wheels can move vertically, in order to conform to the shape of the rails. Photo 159 shows this joint, at the middle wheel, half hidden behind the eccentric crank and the big end of the main rod.

You can also see one of the brake hangers, between the driving wheels, and the feedwater hose, suspended under the running board, top right. Also note how the wheels are 'keyed' to their axles by a grub screw in a threaded hole halfway in both the axle and the wheel hub.

In Photo 160 you can see a close-up of one brake hanger and its brake shoe; the latter is very simply made from a water-jet cut piece of 10mm thick cold-rolled steel, seen in the inset. Since the water-jet cutting causes a slight slant to the cut edges, these shoes fit perfectly against the slightly conical rim of the wheels without any machining!

In order to prepare a brake shoe, I only had to mill a groove for the brake hanger, which is laser-cut from 3mm hot-rolled steel. All the holes in these parts were 'drilled' by laser or water-jet, slightly undersize. Enlarging them with the correct-size drill was a breeze, and they were certain to be exactly in the right position, as determined by the CAD drawing.

Tender braking

The tender has its own braking mechanism, slightly different from the loco's rigging, since the brake shoes reside not behind, but between the wheels on each of the two-axle bogies, (Photo 161). Just as on the loco, triangular braces connect the left- and right-hand pairs of brake shoes together. Links and turnbuckles carry the braking force from the combined hand- and foot-brake.

In order to avoid having the brake shoes scraping against the wheels during running, I have installed two springs, bent from flat spring steel, to the underside of each bogie bolster. They can be seen above and below the turnbuckle. They pull on the triangular braces, lifting the brake shoes away from the wheels.

PHOTO 159: Interesting wide-angle perspective of driving wheels.

PHOTO 160: Brake hanger and shoe.

PHOTO 161: One tender bogie with its brake rigging.

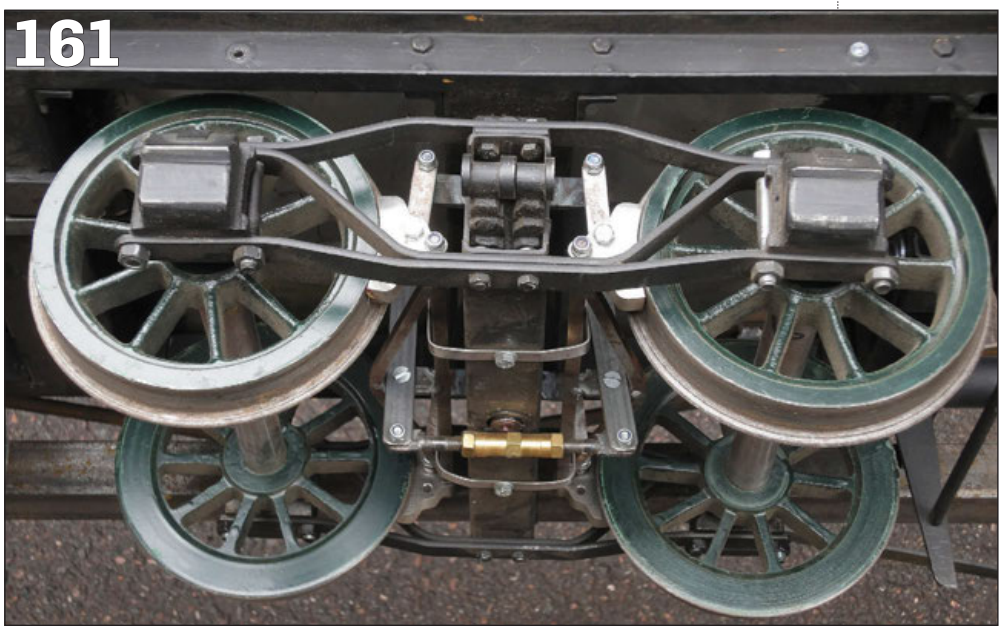


Photo 162 shows the design of the braking mechanism. As mentioned in an earlier article, there is a 6mm steel axle with a simple foot pedal attached to it, seen at upper left in the photo. The pedal is simply made, from a bent piece of flat iron, welded to the axle.

Another piece of flat iron, also welded to the axle, holds a large, rectangular nut made from cold-rolled steel, visible at left of the brass bearing block. The hand brake is operated via this nut – turning the brake crank on top of the tender pulls the nut upwards. This also happens when the foot pedal is pressed.

The rising nut turns the brake axle, which is prevented from flexing by the flat-iron 'hook', seen attached to the buffer bar at mid-left. A clevis welded to the axle, above the hook, transfers the braking force to a link, made from a twisted piece of hot-rolled steel, leading to the rest of the brake linkage.

This linkage is somewhat similar to that in the engine, but it is a bit more convoluted – since the tender bogies need to pivot around their king pins, the linkage must accommodate the movement.

Starting from the left in Photo

163, the twisted link seen in the previous photo passes under the first wheel axle, then under the bolster of the bogie, emerging to the right of the second axle. It pulls on the short, triple-link system seen in the middle of the tender frame. There, the force is evenly divided to both bogies.

Two additional links on each side transfer the force to the triangular braces holding the brake shoes for the bogie's inner wheels, while a turnbuckle and a final link on each bogie affect the outer braces, pushing their brake shoes against the outer wheels. These links are partly hidden behind the turnbuckles, and can best be seen in Photos 161 and 162.

Whew! Quite a complicated linkage is needed in order to transfer the force equally to all eight wheels – but then, it is just as important to be able to stop a train, as to run it! EIM

■ Next month Jan-Eric focuses on the Ten Wheeler's cab. Parts 1 to 12 of this series appeared in the February 2020 to January 2021 issues of EIM. Digital back issues can be downloaded or printed versions ordered by going to www.world-of-railways.co.uk/engineering-in-miniature/store/back-issues/ or calling 01778 392484.

PHOTO 162: Simple hand- and foot-brake system at front end of tender.

PHOTO 163: The entire brake rigging mechanism – ten links and two turnbuckles.

The Liverpool & Manchester Railway – an operating history

By **Anthony Dawson**

General railway histories may interest may an EIM reader despite seldom containing much technical detail about the locomotives and stock used, especially those of the early lines, and this new book on the first major passenger line in the UK follows the trend. Those looking for engineering details of the 'Rocket' and her successors will find what they need in excellent volumes published elsewhere.

However your editor, who admits to an interest in the earliest lines surpassed only by his passion for narrow gauge and miniature railways, did discover that this book is much more than a typical chronological railway history. Instead it delves into the day-to-day minutiae of the Liverpool and Manchester Railway – how the line was operated.

When one thinks about this, everything about railway life that students of this form of transport would become familiar with, from ticket types and classes of carriages to rates for carrying goods and other livestock, creating timetables, signalling, policing... all had to be created by the pioneers who operated this first railway.

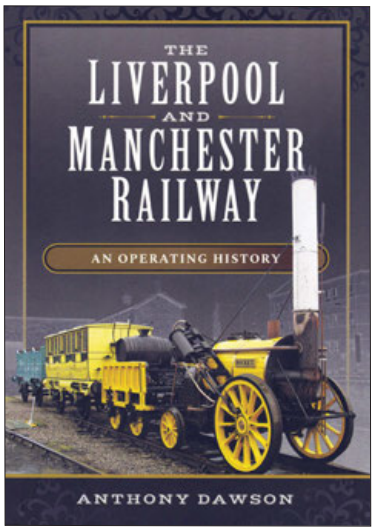
The author has clearly undertaken extensive research to present what is both an interesting and informative portrait of what life was actually like on the L&M, and certainly this reviewer learnt much that he was unaware of.

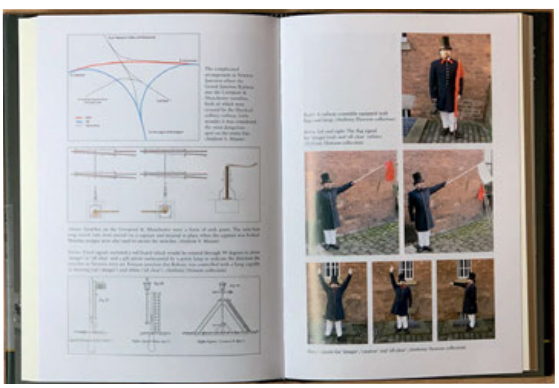
The book is divided into four sections, Passenger Business, Carrying the Goods, Time Working & Timetables and Rules & Regulations. Each includes several chapters presenting a very full picture, and written in such a way that is informative while never becoming dry.

The detail is impressive, down to prices of various classes of ticket between individual stations, the workings an early trainspotter might have witnessed on an average day and their scheduled times, and even a sobering list of fatalities, mostly it seems caused by passengers not realising that jumping out of or in front of a moving train was likely to lead to serious injury...

Imagery is restricted to a colour plate section in the centre (few photographers were around in the early 19th century!) but the period images are well reproduced if a little small, and the selection includes diagrams of track switches and two pages of flag signals demonstrated by a modern re-enactor in period 'Railway Constable' garb.

The book also scores on its collection of extensive notes and its bibliography, which while described as 'select' includes a good number of entries including a dozen sources that are highlighted for their technical content. ***AC***





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Loco lubrication made easy

In the August 2020 issue of EIM on page 8 Jan-Eric Nyström speaks about "good lubrication" he obtains with oil cups on the steam chests of his Ten-Wheeler.

I wonder if he could supply a short description of these oil cups (drawings with the most important dimensions).

Thank you in advance.

Hubert De Houck

***Jan-Eric** replies:* Hello Hubert, thanks for your query. The oil cups are simplicity itself, see the quick sketch at right.

The dimensions are based on the cups I have on my 1:8th scale 4-4-0. Measurements are definitely not critical, you can make the cups larger or smaller, but the effective lubrication time will vary accordingly.

For the centre tube I've used 2mm outside diameter thin-wall brass tube available in most hobby shops. For 1:12th or smaller scales, the tube can be a little smaller, since less oil is needed.

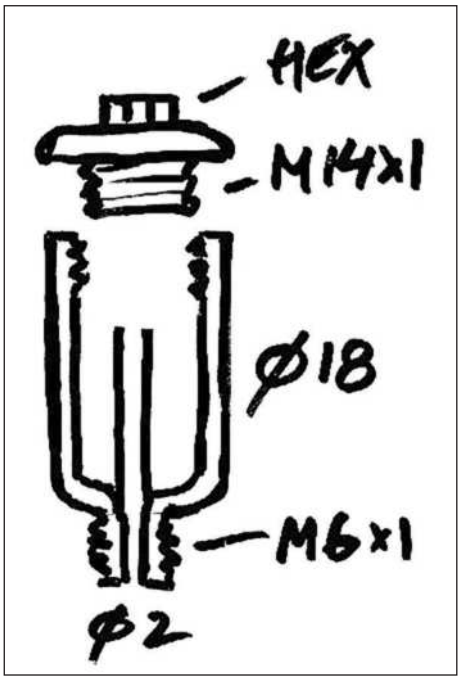
The principle of working is by 'displacement' – when you open the throttle, some steam will find its way up from the steam chest through the thin tube, into the top space of the cup.

There it will condense to water, which being heavier than the oil will sink to the bottom of the cup, displacing the oil upwards so that when the steam pressure drops, a small amount of oil will run down the tube and into the steam chest.

The cup needs to be emptied of the collected water every now and then. You can either unscrew the entire cup, then the lid, and pour the water out. Or you can open just the lid and use any syringe-like appliance to remove the water – I have a small ear-washing bulb dedicated to this task.

Replenish the oil (leaving a bit of space for the steam), screw on the lid and you are again ready to go.

I have hard-soldered a brass nut to the lid – this makes it easy to open and close with a spanner. I use a small O-ring to make the lid steam tight.



Tanks for the advice...

I am building a 5-inch gauge Martin Evans Simplex 0-6-0 and have completed the motion to produce a running chassis. I have purchased the Model Engineers Laser kit for the bodywork side tanks, cab, roof, and spectacle plate.

One of our club members advised me to reinforce the side tanks with what I believe to be the standard method of construction using ¼-inch brass angle secured with 8BA countersunk screws.

Fingers crossed I now have two watertight side tanks but cannot find any further information regarding the securing of the kit to the loco. Perhaps or the side tanks, spectacle plate and rear plate are fitted as a completed structure to the running boards?

My dilemma has coincided with Stewart Hart's Simplex rebuild series in EIM. Would it please be possible to seek his advice to my questions either directly or indirectly?

Peter Brown

***Stewart Hart** replies:* I understand the advice needed about fitting the side tanks and spectacle plate.

The tanks should have brass angle plate running down the inside of the cab, and a short length of angle at the front of the tank – you fit the tank to the running board by these brass angle with 8BA or M2 screws. I actually filled in the door space with a dummy door just to stiffen up the assembly.

The spectacle plate is fixed to the cab side again with brass angle – make sure the spectacle plate has a good ⅛-inch clearance above the boiler cladding to allow the boiler to expand without scraping its paint off on the spectacle plate.

The back plate also screws to the back of the cab, again via brass angle. I put in a good deep cut-out in this back plate to make it easy to shovel the coal in – some guys at our club don't have a back plate at all on their locos for this reason.

At some point in the future once you've got the Simplex running you should consider making a water/coal tank – it makes driving so much easier and you'll have a cold water supply to the injector that will save you a lot of trouble (see picture).

I made my wagon from a part-finished tender that I bought at a club auction – it's not supposed to be any particular wagon type, I just adapted it to do the job I wanted. Most of my club's Simplex drivers use a water/coal wagon of some sort.

The editor adds: Peter, who made the original query, adds that he has subsequently been told of another method of securing the tanks to the running boards, which involves drilling and securing through the tanks and running boards, making them water-tight at the same time with two brass nuts and bolts into each side tank. He adds that no doubt there will be other solutions too!

Lockdown help

In the October 2020 edition you published an article on my model of the steam-powered tug 'St. Cruiser', my lockdown project. I did manage to sail the model and its performance was good, a few teething problems to sort out not least being able to handle a model of this size and weight.

The gas attenuator is lazy – it shuts off okay but the pressure drops far too low before the burners come up to full power again.

Looking around for my next lockdown project I have been refurbishing a 15cc Kiwi mk2 that my father made in 1963. It has taken me three months to overcome its stubbornness to run but I succeeded in the end. I am now building it into a test rig prior to building a model for it (*this will soon appear in* EIM – *Ed*).

I am thinking of making a semi-scale model of an early diesel/petrol shunting engine in 3½-inch gauge but despite many hours searching the internet and several enquiries to museums I cannot find any outline drawings to design the model around. Can you and/or your readers help?

Also I would like to have a go at a simple hydraulic clutch and wonder if any body else has ever made one?

Stuart Rothwell

The editor replies: If anyone has any suggestions for Stuart send them to the address below and we will pass them on.

Model engineering subject to raise or question to ask? Send your letters to the editor at 12 Maes Gwyn, Llanfair Caereinion, Powys, SY21 0BD or by email to andrew.charman@warnersgroup.co.uk

All change at Model Engineers Laser

Model Engineers Laser, which over the past decade and a half has established a reputation for providing laser-cut versions of the parts that many find tedious to make for their projects, has new owners as of 1st January. Rugby ME stalwart and regular EIM contributor Ed Parrott and his wife Holly have acquired the business on the long-planned retirement of company founder Malcolm High.

First started as an alternative to hacksawing out metal for loco frames, the company is now a major resource offering parts for designs ranging from O gauge to 10¼-inch gauge. Malcolm and Ed have taken a moment to explain the changes to EIM.

Malcolm High writes: "I started Model Engineers Laser some 15 years ago when I first retired – just a one day a week thing to keep me occupied. Well there are now more than 22,500 parts on the database and I have sent more than 425,000 parts to places as far away as Tasmania. I guess I needed Mr A Penguin building a Simplex to get any further. I have had help from a number of fellow model engineers who have been kind enough to allow me to make their drawings and parts available to others; for this I am very grateful.

The time has come for me to hand over the reins to younger blood and I am extremely pleased that Ed Parrott and his wife Holly have agreed to take the business over. I always believed it needed to be a model engineer with the right skills to take the business to another level. When 1500 parts arrive on the back of a pickup you have to have some idea what the different shapes are. You need to have some idea of what you are looking at.

Ed and Holly will be attending shows, when this is possible, of course. I have always enjoyed shows – they are a good time to meet like-minded souls but you have to know what you are talking about, and Ed and Holly do.

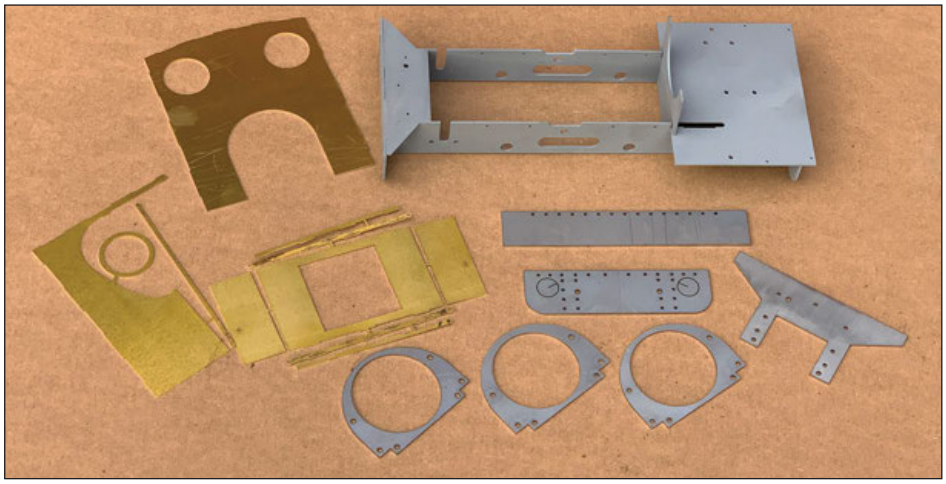
Fast and accurate

Laser cutting offers, for many model engineers, a fast and accurate way to progress and finish a project. Its popularity within the hobby has increased dramatically.

I would like to think I have provided a speedy, reliable and friendly service over the last 15 years and I am sure Ed and Holly will continue in the same vein, with many exciting innovations to come, and I wish them all the best. Thank you for your support over the years – please give the same support to the new owners of Model Engineers Laser."

Ed Parrott writes: I've been a customer of Malcolm's for nearly 10 years, and it's fair to say that both mine and my local Model Engineering Society's models feature extensive use of laser-cut parts that have been produced by Model Engineers Laser.

When Malcolm first mentioned retiring, the thought went through my head very quickly that it would be a great opportunity to take on the amazing range of products he offers, and to further develop the various projects that I have been involved with.



We plan to continue things as they are including offering all the same parts that are currently available, and the bespoke service offer. The only changes that we hope you will notice is that of a new logo, new (ish) faces, and the new bank account and VAT number.

New products

This said, we do have lots of exciting new products planned to complement the current range available, the first of which will be a kit for a 16mm scale narrow gauge diesel, of variable gauge to suit both 32mm and 45mm modellers. The prototype is at an advanced stage and we hope to launch the finished kit at the National Garden Railway Show at Peterborough in June, Covid-19 permitting.

Other plans to tease you include a 10mm scale kit to suit Gauge 1 modellers, possibly to be matched with a 1/32 version and a number of sundry items to suit other scales.

To keep up to date with our new products, which shows we are going to, and general other news, you can follow the Facebook page that has been created, just search for 'Model Engineers Laser'.

It's going to be a hard act to follow, and Holly and I are delighted to be able to take over the business. As with all new ventures, we are finding our feet and learning very quickly Malcolm's best practices, to ensure that we can continue to provide the same fantastic service and great quality you all expect."

TOP: Typical of Model Engineers Laser's vast range, these parts for the EIM editor's 7/8ths scale Hunslet build.

ABOVE: Ed Parrott sent us this pic of some last-minute customer service training, demonstrating that the company has passed on to a younger generation...

Model Engineers Laser
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E-mail: sales@modelengineerslaser.co.uk
Tel: 07927 087172

Bexhill battery locos join AP

It is definitely the month for new ownership amongst the trade... Andy Pennock of AP Model Engineering has been in touch to let us know he has purchased the rights to all of the range marketed by Model Engineering Products Bexhill, which formerly owned by the late Robin Neighbour.

MEP Bexhill produced a range of 5-inch gauge battery diesel-outline loco kits, ranging from the simple class 08 British Railways shunter to the large class 37 and 58 bogie locos, and also offered various detail castings.

The purchase includes the name products and designs and these are slowly being re-introduced, still under the Model engineering Bexhill name. They will complement the existing AP Model Engineering range of 5-inch and 7¼-inch gauge battery locos and rolling stock, and extensive line-up which are offered either in kit form or ready to run.

Further details can be obtained from the website at www.apmodelengineering.co.uk, by phone on 01287 678204 or email – apmodelengineering@gmail.com

No cramping of the style....

In the UK and across the globe, club members continue to defy the pandemic...

COMPILED BY **ANDREW CHARMAN**

"If you cannot get the right thickness sheet in copper, stainless steel may be the answer..."

Welcome to the February *Club News* pages and I'm running out of superlatives to describe the ever-declining situation we continue to find ourselves in –the news seems to get worse as each month arrives, and running trains for happy visitors to a club track is a prospect seemingly moving ever further into the distance...

In the midst of such gloom, however, club publications continue to impress with their positive outlook and the picture above brought a smile to my face – it was worthy of a nice big reproduction here. It was taken by Jim Clark, editor of *Steam Lines,* the newsletter of the **Northern Districts ME** in Perth, Australia, and another club publication your editor is enjoying for the first time.

How often does one see a 7¼-inch gauge Crampton locomotive, let alone a pair double-heading, as here? Ron Collins and Lindsay Lockhart were enjoying exercising their locos at the 'Sandgropers 2020' meeting, held in Bunbury, south of Perth, on 7th November. Jim reports that while the event was scaled down and more informal in the current environment, there was a good turnout of members from various clubs, a host of interesting locos on the track and five traction engines in steam to boot – all of which sounds encouraging.

Okay, I can hear the big question on the lips of several readers, and yes, I did ask Steve Reeves, who sent me the Perth newsletter; what is a sandgroper? He tells me that it is an insect about three inches long related to the cricket family.

"Each state of Australia has nicknames for its people – for example Queenslanders are known as banana benders, Western Australians are known as Sandgropers," Steve adds, which neatly explains why the name was adopted for the two-day annual model engineering festival. So now you know!

Cold front

The weather in Jim's two pictures looks sunny and warm and of course 'down under' they are now into their summer, making me somewhat jealous with temperatures in mid Wales having plummeted in the couple of days before this was written. I asked tech ed Harry how his first day

ABOVE LEFT: This pair of 7¼-inch Crampton locos certainly made an impressive sight at Sandgropers 2020, held in Western Australia in November. What's a sandgroper? Read the text...

LEFT: The Australian event certainly offered variety.

Photos: Jim Clark, Northern Districts ME

back at work in the Fairbourne Railway workshop following the Christmas break had been, and he replied "Cold, the heating has broken..." In the very next breath he asked whether I was going to join him for any swarf making in the coming week! He didn't exactly sell it to me, though he did promise that the heating was set to be fixed in very quick order...

Continuing the international theme, a comment made by Errol Koch, editor of the *Workbench* newsletter of the **Durban SME** in South Africa, caught my eye, accompanying a picture Errol had taken of **Rand SME** member Luke Ronne test-running his newly completed locomotive 'Ballerat', pictured at right.

Apparently this is a lockdown project, built during the Covid crisis, and includes castings that Luke makes himself. Errol adds that the loco has a stainless steel boiler, built in a mere two weeks by Luke. "This appears to be a future path with regard to small locos – if you cannot get the right thickness sheet in copper, stainless steel may be the answer," Errol says. What do **EIM** readers think? Are we likely to see more stainless steel boilers, and if so would some of those who have gone down this route like to discuss the challenges of construction? Your thoughts welcome to the editorial address on page 3...

Staying on the subject of boilers (the linkage this month is unusually efficient for this particular correspondent!), the front cover of the winter edition of *Goodwin Park News*, the newsletter of **Plymouth MS**, certainly arrests the eye. It shows the tubeplate and tubes in the barrel of a partially completed steel boiler, and inside the newsletter we discover this is for a 7¼-inch gauge Black Five 4-6-0 – Plymouth member Tom Pawley was inspired to start building the loco when he spied the start of a constructional series in *Model Engineer* – in 1967!

Never give up

This really has been the epitome of a long-term project – Tom got as far as making the frames and acquiring various castings before he met his future wife "and loco building came to an abrupt halt..."

The components were packed into a crate and spent the next 40 years following the couple through various house moves, until in 2011 they returned to Cornwall "after a one-year sailing trip that lasted for 10," (*great phrase!*) and settled in a new house with a proper workshop.

Since then Tom has been making steady progress and thinks there is even a chance the loco might run in the next year. And if it does he wants to then build a 7¼-inch gauge single-wheeler! The morale of this tale? It's never too late to return to a stalled project (*Does that mean I'll eventually build the 'Minnie traction engine', the parts for which have been travelling in a box with me through various house moves since 1980?*).

From time to time model engineering club news pops up in the mainstream media, but sadly seldom for good reasons. Such was the case in early December when *Kent Online* reported that following what was not the first incident of vandalism at its Mote Park track, the **Maidstone ME** was being forced to crowdfund in a bid to pay for a new clubhouse roof.

It seems that vandals jumping on top of the glassfibre roof caused some £10,000 worth of damage, allowing water to leak into the clubhouse. With no prospect of bringing in any revenue due to public running days not being possible in the Covid environment, the only option was to appeal to the public.

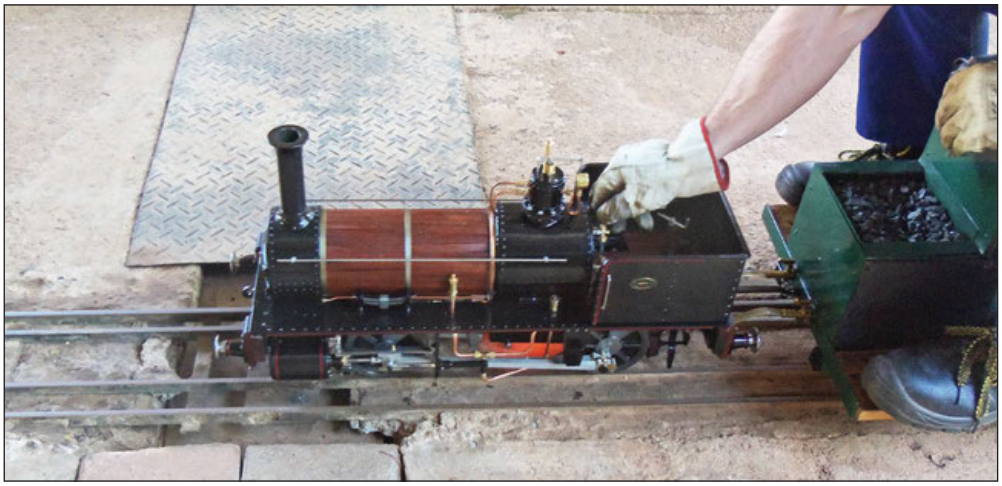
Target smashed

The story has a good end, however – the club set a target of £5,000, half the repair costs, from the appeal, and when **EIM** checked the site the total raised stood at just over £9,100. If you want to contribute you can go to uk.gofundme.com and searching for Maidstone MES.

Also culled from the internet is some further good news, that the **Saffron Walden & District SME** appears to have found a new home. Readers may recall us reporting back in September 2019 how the club had been obliged to abandon its home of some 30 years at Audley End House, adjacent to the 15-inch gauge Audley End Railway, after the house owners decided to develop the 15-inch gauge line and add a new cafe.

Following the move some of the club's equipment relocated to the North Weald & District Miniature Railway in Harlow, but it's now being reported that a home for the club has been found at the Great Easton Railway, a private 7¼-inch gauge line in Dunmow, Essex. Facilities include a workshop and there are apparently plans to add a 5-inch gauge line to the 7¼. Perhaps a SW&DSME member would like to bring us up to date?

I hesitate to mention the B word – yes, Brexit, but it seems our departure from the European Union will have a bit of an effect on our activities, and will almost immediately show up on boiler tests. The latest edition of the **Southern Federation of MES** newsletter reports that in future certified UK-made pressure vessels will be marked with a 'UKCA' mark instead of the previous EU CE mark. From 1st January 2022 the European mark will be the only one valid in Europe, the UK one the only one valid in the UK... What it



ABOVE: The stainless steel boiler of this new loco in Durban, South Africa is a talking point. *Photo: Errol Koch, Durban SME*

BELOW: The cover of the latest Plymouth newsletter includes a boiler picture showing that you should never give up on a project... .

does mean is that if you plan to take your loco abroad, or sell it abroad, you could run into problems. Yes, I know, I can hear you saying "chance would be a fine thing..."

You do find some gems of information in club newsletters. In his latest editorial **Bristol SME** newsletter editor Richard Lunn describes progress with his 6-inch scale Burrell traction engine, including finally obtaining a high-pressure injector "that works". Richard adds as almost a throwaway comment that a problem with valve timing traction engines is that if you set the correct timing while the engine is cold, as the boiler gets hot it moves the cylinder away from the crankshaft and changes things! I'd never thought of that but once written down it seems blindingly obvious...

Well done the **Bradford ME**, which sent us its December newsletter on the same day as the club would normally have been holding its annual exhibition. Of course Covid put paid to any plans in that area, but members were not to be denied, and so they set up a 'virtual exhibition' online.

There are some 20 items in all, varying from several locos including a 7¼-inch gauge quarry Hunslet and a 5-inch gauge Crampton (it's that type again...), to a trio of clocks, stationary engines, a steam wagon and even a Manx tram! And the good news is that all **EIM** readers can enjoy the descriptions – just go to www.bradfordmes.uk/?p=4207

ABOVE AND LEFT: Not content with spearheading construction of a new swing bridge for the raised track, Rugby chairman Aubyn Mee has also been testing out a new jig to add a radii to the rails and prevent excessive wear. *Photos: Rugby ME*

Sadly I think we will be doing a lot of our model engineering interaction virtually for a good while yet, with opportunities for proper get-togethers a long way off. Literally as we closed these pages we heard rumours that the Doncaster National show, normally held in May, could be about to not happen for a second year in 2021. We hasten to add that we had not confirmed these rumours as we closed for press, but sadly we would not be at all surprised if they were true...

Welcome support

In fact considering the circumstances we have been living with for some time now, from perusing the various newsletters it's remarkable just how much so many clubs have achieved in 2020. It is abundantly clear, from the number and the variety of the articles appearing in many of the publications, that most club members have been making the best use of the time that has been given to them, and producing things in their workshops!

It's also both pleasing and some relief that many clubs appear to be navigating the unprecedented situation very well in terms of finances. A good example is the **Chingford ME** which reports in its latest newsletter that despite the major curtailment of public running in 2020 due to the Covid issues, the club goes into 2021 in a much better financial position than was feared earlier in the year.

This positive outlook is put down to the hard work of the committee and the membership, and the great support of the public, showing clearly that our miniature railways across the country are greatly appreciated by those who in a normal year come for their weekend train rides.

Of course the **Rugby ME** must be counted among the high achievers over the past year, and not just for the design, construction and installation of the impressive new loco lift table that features in this issue.

Not a bridge too far

The December issue of the Rugby newsletter includes the annual round-up and shows that as ever much has been done at this most busy of clubs. The work continues, including the building of a swing-bridge for the newly extended raised track, and not content with producing the lift table chairman Aubyn Mee has been spearheading the work on both the swing bridge and a girder bridge designed to connect one end of the raised extension to the existing line.

Even in the latest edition of the newsletter Aubyn is pictured working with a fellow member on a rail-borne jig to put a small radii on the steel rails recently laid on the raised track extension. These radii are essential to prevent excessive wear on rolling stock wheels and the jig will cut the job of adding said radii from days to a few hours – Aubyn is certainly leading his club from the front!

Meanwhile fellow Rugby member, **EIM** correspondent and now business entrepreneur (see page 39) Ed Parrott, has been leading a group trying to restore the club's 'Criccieth Castle' diesel loco, this greatly delayed by the Covid-enforced shutdowns and shieldings, plus budgets frozen due to the lack of revenue from cancelled public running sessions.

However a way was found to complete the work with the aim, as Ed describes it, of giving the membership a "Christmas present" of the loco running before Christmas. This was achieved, at 5pm on 19th December when the loco tentatively moved a few yards up and down the workshop, as can be seen on this video clip; https://youtu.be/Llve7V8B_D0

And finally it has to be said that at the end of the year the content of club newsletters does include some pretty light-hearted stuff, which no doubt we all particularly appreciate this year though some of the jokes we could not possibly repeat!

Christmas quizzes are also popular, and seldom involve model engineering subjects! Bristol SME, for example, set members a series of questions based on local landmarks, while your editor admits to being totally floored by the Christmas quiz provided by **High Wycombe ME** member Linda Richardson in the December edition of the club's *Criterion* newsletter. Every one of the 24 posers was about – cheese! The only one I was able to answer correctly was Wallace & Gromit's official cheese, and to be honest I prefer a good cheddar or a Red Leicester to a Wensleydale... **EIM**

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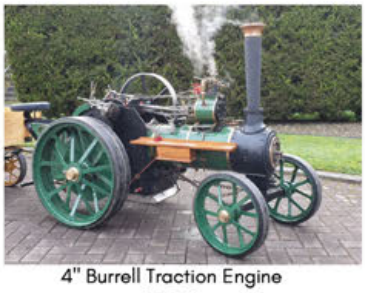

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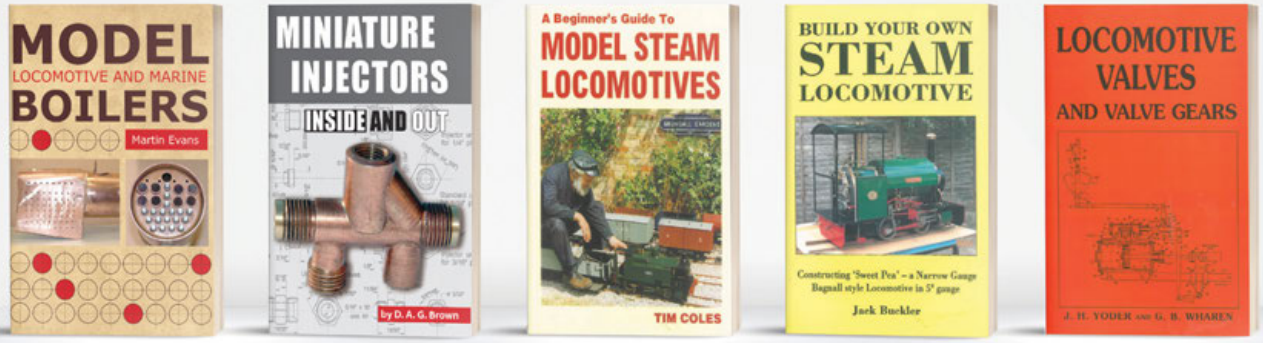

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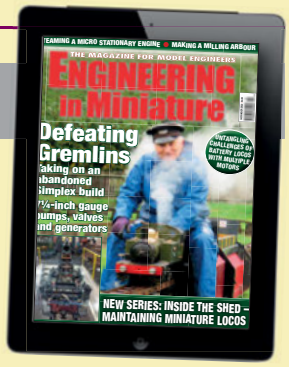

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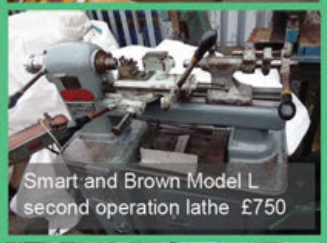
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