STEAMING A MICRO STATIONARY ENGINE ● MAKING A MILLING ARBOUR

THE MAGAZINE FOR MODEL ENGINEERS

ENGINEERING in Miniature

DECEMBER 2020 | £4.50

Defeating Gremlins

Taking on an abandoned Simplex build

7¼-inch gauge pumps, valves and generators

UNTANGLING CHALLENGES OF BATTERY LOCOS WITH MULTIPLE MOTORS

NEW SERIES: INSIDE THE SHED – MAINTAINING MINIATURE LOCOS

CONTENTS

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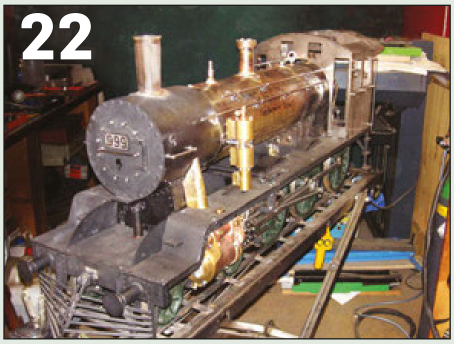

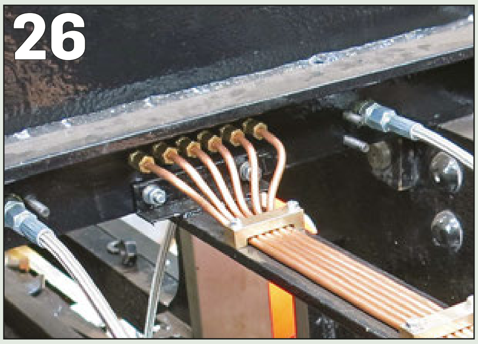

FRONT COVER

Stewart Hart looks very happy behind his clearly in-steam Martin Evans Simplex, but getting the loco to this stage after buying it as a part-built project proved a big challenge, as he begins describing in this issue.

Also this month, tech ed Harry Billmore begins a new series taking readers behind the shed door and describing mechanical engineering challenges at the Fairbourne Railway – ultimate model engineering!

EDITORIAL

Remote modelling again, but vital to stay in touch

Welcome to the December edition of EIM and I must start by offering you suitable wishes for the festive season, although if you buy each new issue as it is published, or even better subscribe, you will see the January edition well before the 25th!

It's more than possible and understandable that many readers won't feel quite as festive as usual this year – it's been a tough one and as I write these words the pressures appear to be ramping up again. Here in Wales we've been under a renewed lockdown for around 10 days and currently it seems that we will be coming out just a few days after England goes into a new four weeks of restrictions.

Difficult times indeed and it's important despite all the restrictions to try and stay in touch with friends in both the wider and the model engineering world, especially as many appreciate the social aspect, meeting up with like-minded friends that membership of a model engineering club provides. While physical meeting is again difficult thankfully these days technology provides a means to keep in touch with one another –I've heard of growing numbers of clubs setting up online gatherings by means of meeting tools such as Zoom, which are excellent initiatives.

On the subject of initiative I've said it before in the *Club News* pages but I keep on being impressed by the efforts being made by club newsletter editors – ensuring they keep publishing, even in times of no activity at the club itself, and in some cases even increasing frequency of publication to keep their members occupied.

We hope you enjoy the wide-ranging subject matter in this issue, which includes the start of a new regular series by tech ed Harry Billmore. Harry takes us inside the workshops of the Fairbourne Railway where he now works, maintaining six-inch scale model locos. While there's a degree of introduction in this initial episode, in coming months Harry will delve deeply into the various miniature mechanical engineering challenges he now faces on a daily basis, so it should be good!

Enjoy your EIM, and don't forget if your lockdown model engineering produces something of interest, write it up for your fellow readers! **Andrew Charman – Editor**

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Defeating the Gremlins

How many readers have been tempted to buy a part-complete loco project but been worried about what issues might be hidden within? Stewart took the plunge...

BY **STEWART HART** Part one of three

Gremlins are mischievous mythical creatures with a mechanical bent and an inclination to tinker with and dismantle machinery with disastrous results. The concept of Gremlins was popularised among airmen during the Second World War, with Gremlins being blamed for inexplicable accidents which sometimes occurred whilst flying.

I think we all have a touch of Gremlin blood in us, this is certainly true of model engineers – how many of you have the odd disaster hidden away under the bench or consigned to the scrap box? I think we all harbour a clan of Gremlins in our workshop.

After starting and abandoning a 3½-inch gauge locomotive, and developing an interest in stationary engines, I was looking for a quick way of getting a loco on the rails, when an opportunity arose to purchase a part-finished 5-inch gauge example of the Martin Evans Simplex design. At this point you should shout "Buyer beware!", but too late, I jumped in with both feet.

The workmanship on the engine looked a bit rough, but it was advertised as 90 per cent complete with just the plumbing requiring doing. It seemed to turn over smoothly enough and the Belpaire boiler, which is non-standard for a Simplex, had a certificate which was the main attraction as I reasoned that a commercially made boiler would cost more than I was paying, and with a little bit of effort and tidying I should be able to get the loco onto the track with a few months' work. Famous last words...

When I got the loco home I initially didn't do much with it as I was working on a stationary engine. After a couple of months with the other project finished I started to take a closer look at what I had bought. The more parts I stripped off the more I realised that a Gremlin clan had been hard at work – I was going to have to rework or remake many of the parts. If I was going to stand a chance of getting the loco on the track this would inevitably require time and cash, you live and learn.

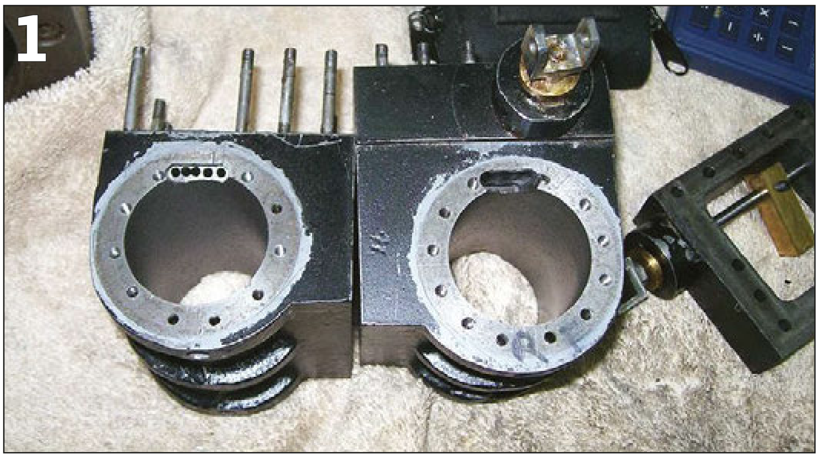
The Martin Evans 5-inch gauge Simplex 0-6-0 tank engine is a very popular freelance design, with a great many having been built. More than half a dozen are in regular use at my own club doing sterling work on public running days.

"At this point you should shout 'Buyer beware!', but too late, I jumped in with both feet..."

As well as the original Martin Evans series on building the loco in *Model Engineer* and his book, *Simplex 0-6-0 Tank* published by Model and Allied Publications there have also been articles on the later derivative the Super Simplex. Other articles and locomotive builds have also relied heavily on the Simplex design, including Terence Holland's *Fairlie Complex: A Beginner's Paradox*, that I found very useful. So rather than going over old ground on how to make each individual part, this short series will mainly deal with fault finding, how to re-work and correct defective parts. This hopefully may be of use for many readers as it is not uncommon for part-built locomotives to be passed around for final finishing, and I'm sure that many of them would not have come from the workshop of a expert builder, so mistakes and errors are bound to be encountered.

Many times during the rebuild I was reminded of the maintenance department during the 1960s and '70s at the factory where I spent all my working life. The department in that period was very well equipped with a wide range of machine tools both large and small, and was manned by some wonderfully skilled people, who took great pride in their work: there wasn't many jobs they couldn't tackle, or broken machines they couldn't fix.

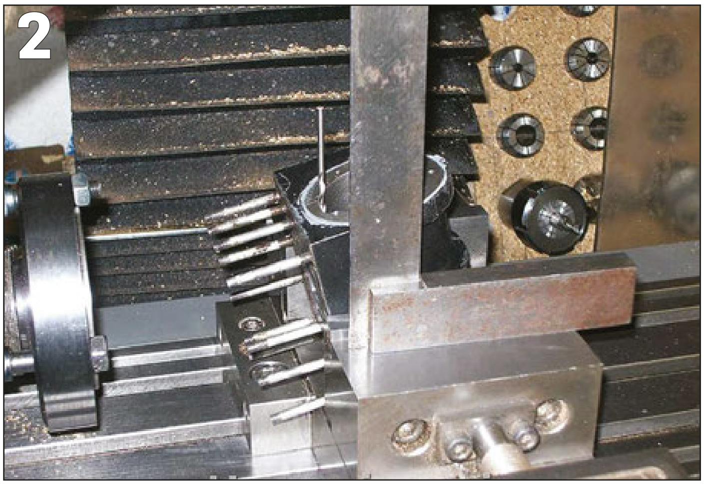
The factory in those days worked round the clock and the production machines were pushed hard, and



HEADING: The Simplex following what turned into a lot of work...

PHOTO 1: Incomplete steam ways in the cylinders.

All photos in this feature by the author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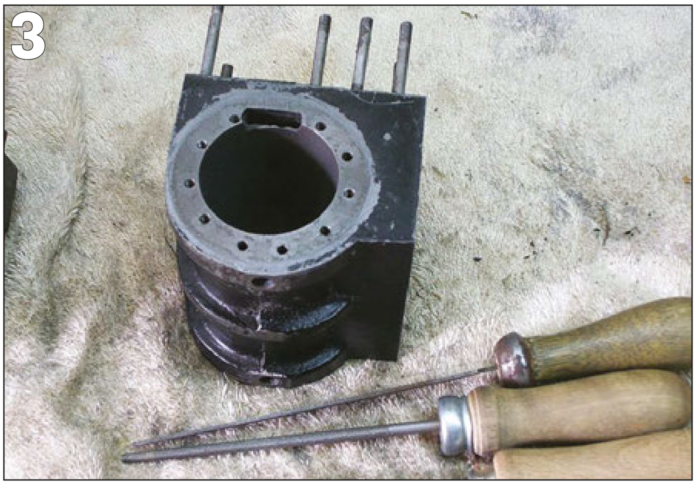
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when they broke down all the stops were pulled out to get them repaired and running again. That's the can-do attitude you must have when taking on this type of project, no matter what the problem there is always a way of fixing it, one way or the other.

After the preliminary strip-down and inspection of the engine and once over my initial bout of despondency over what I had discovered, I just rolled my sleeves up and got on with it. I decided that the best thing to do was strip the engine down to its bare bones, and make a list of the obvious things that required doing.

Sources of knowledge

Here it helps if you have some basic understanding about what features are critical to the functioning of a steam locomotive, and one way to gain this understanding is from books. There have been many books published on model locos but I think you will have to go a long way to beat the work of good old Curly Lawrence, 'LBSC' – I think the Gremlins who worked on this loco must have read one of Curly's books first otherwise how would they have known just how to get so many things wrong?

It also helps to be able to cross-reference other authors, just to get another viewpoint and emphasis. Don't just read the book from front to back then put it aside and say, "okay done that", you must read for understanding. The first-read through is just to get yourself familiar as to what's in the book, you then need to put it to one side for a few days, then go back to it and pick out sections, passages and the like that you didn't quite understand, and ask yourself "Why did he say it's important for so and so assembly to be square?" "Why does he describe the fit required to be tight/slack/running and such?" "Why is it important that all the parts are drilled at one setting?" By being proactive and questioning in this way you'll start to develop an understanding for the critical functional features that make a locomotive work.

Another great source of information is your local model engineering club. Here you can meet experienced builders who will be only too happy to help, you can join in the activities of the club and you will soon become accepted and able to start to ask questions or just listen in on conversations. That way you will learn from Professor Hindsight and Dr Ingenious about all sorts of tips and little improvements that you can take advantage of.

Finally we mustn't forget model engineering magazines (*I was beginning to wonder! Ed*) where you can find a host of articles both new and in the archives of practically every design of loco that has been built along with a host of relevant information to that design.

"The best thing to do was strip the engine down to its bare bones, and make a list of the obvious things that required doing..."

PHOTO 2: Lining up for drilling out the steam ways.

PHOTO 3: The cylinder once its steam ways had been duly reworked.

PHOTO 4: Marking out for cylinder cladding.

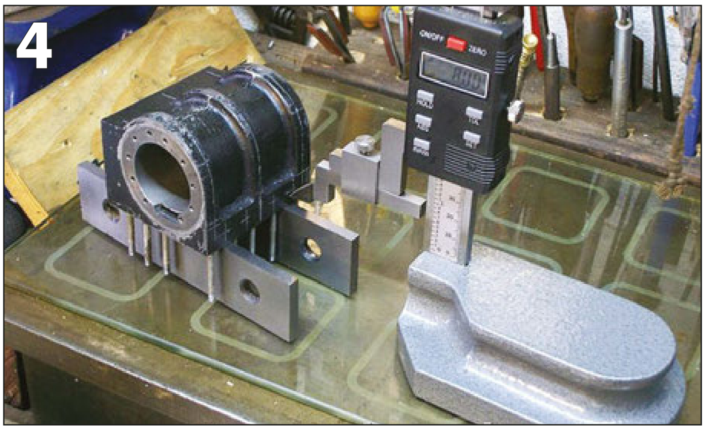
PHOTO 5: Drilling the cylinders for the cladding.

It wasn't long before I had a list of about a dozen obvious things that needed attention, and I was in no doubt that this list would grow before too long. I thought it would be better to start on something simple and straightforward then with a little bit of success under my belt, I hoped the project would take off and progress would accelerate.

Cylinder & Steam Chest

I made a start on correcting the cylinders and steam chest. I gave the bores the once over with a bore micrometer and found that on both cylinders they were correct to size and parallel with a good surface finish. The inlet ports were also accurately cut, and the centre of the bore was in the correct position. The only real problem was the steam passageways in one cylinder had been left just drilled, which would restrict the steam flow slightly (**Photo 1**). So I lined up the cylinder on the drill and opened out the holes slightly (**Photo 2-3**) and then with some swiss files joined the holes up to make a clear passageway to match the other cylinder.

The cylinders had not been clad so the next job was to mark them out and drill and tap for the cladding (**Photo 4-5**). A piece of wire was stretched around the cylinder to determine the length of cladding required, which was cut from a piece of brass sheet. Holes ▶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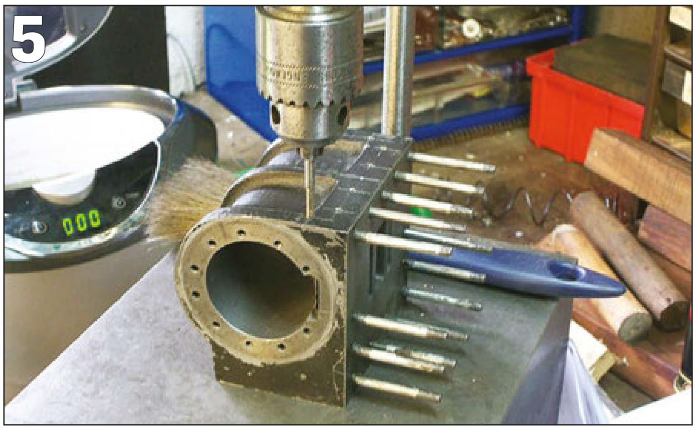
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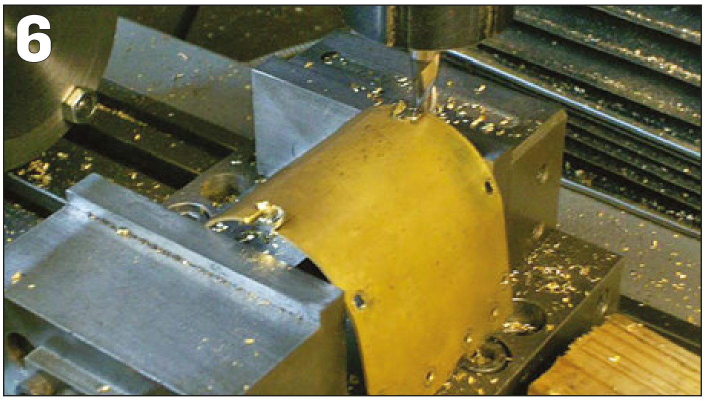
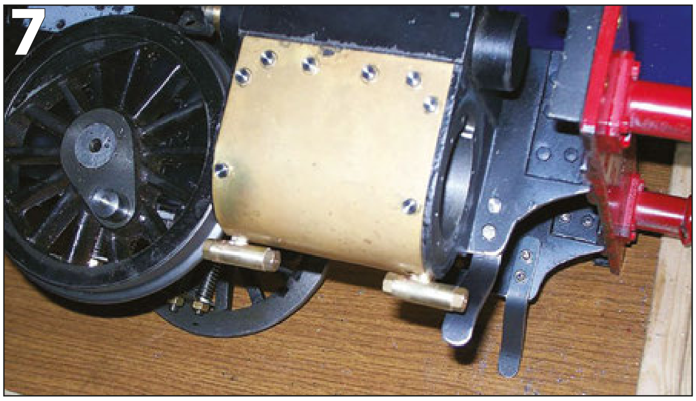




were drilled to match the cylinders and a cut out milled to accommodate the drain cocks (**Photo 6-7**).

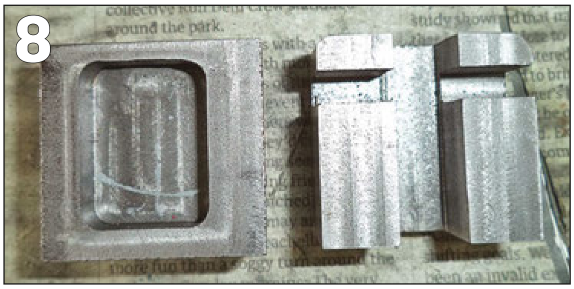
The Gremlins had not done a very neat job of drilling and tapping the cylinder for the covers and steam chest. There was not much I could do about that, the problem here was to do with visual appearance rather than function. I then checked the slide valves and discovered that the functional cavity in each was wrong by up to 3mm. With this amount of error there was no way that the engine would work, so there was nothing else I could do but make new slide valves (**Photo 8**).

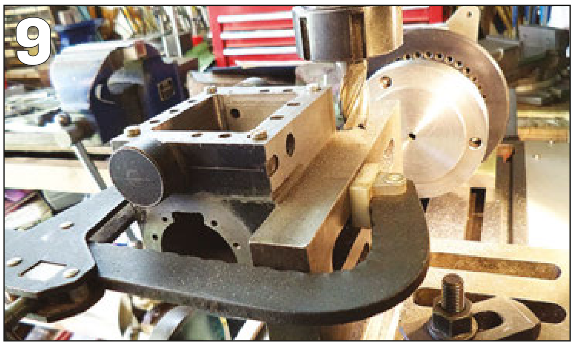
The pistons had also been badly fitted with Viton O-rings. The pistons themselves were undersized while the groove for the O-ring was oversize – these were replaced with new cast-iron pistons and rings.

The steam chests protruded over the back face of the cylinders – referring to the relevant drawing from the original Martin Evans design shows that they should sit inside the back face by 1⁄16-inch. The fact that they were protruding meant that the cylinders were not bolting down flat on the frames. To correct this error each cylinder and steam chest assembly was clamped up square on an angle plate and the back face of the steam chest skimmed down to take it below the cylinder face (**Photo 9**).

Not easy to spot on the drawing is how very specific it is about the position of the slide valve rod in the steam chest in relation to the cylinder. So with the assembly clamped square on an angle plate its position was checked using a digital height gauge. It was out of position by about 4mm (**Photo 10**) which would need some radical surgery to correct.

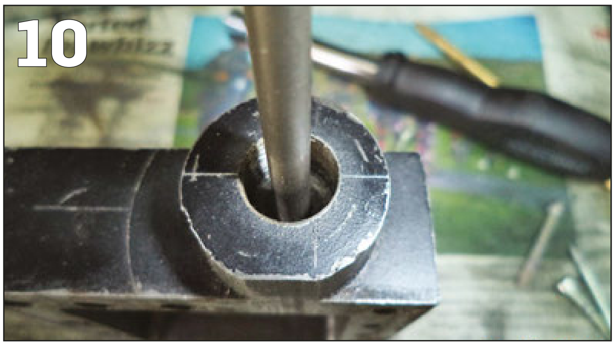
Using the newly machined face as a datum, the chest was set up square on the angle plate, and using the scribed lines and a pointer the mill lined up on the correct position and zeroed (**Photo 12**). The cast boss was then milled away, the mill brought back onto the zero position and using an end mill the hole position was corrected. An end mill will bore its own path in the correct position, whereas a drill will wander and want to follow the path of the incorrect hole.

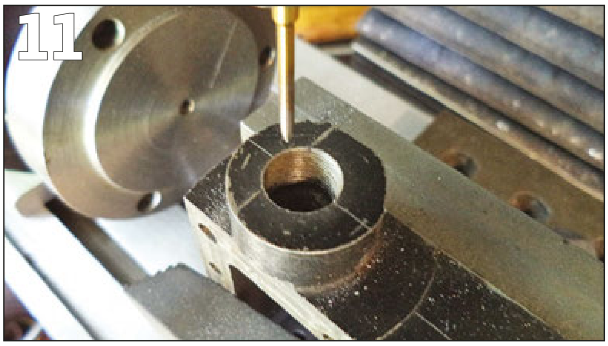




The hole was then opened out and tapped ½-inch x 32 ME (**Photo 13-14**).

A new boss was turned up from a piece of mild steel threaded ½-inch x 32 ME to match the chest, it was also drilled and tapped to take the valve





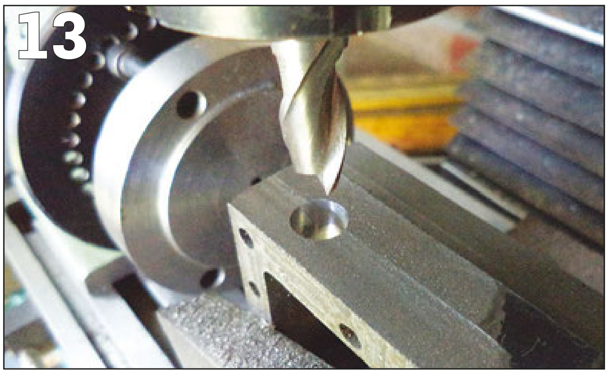


PHOTO 6: Machining the cladding on the mill.

PHOTO 7: Cladding fitted to the cylinders.

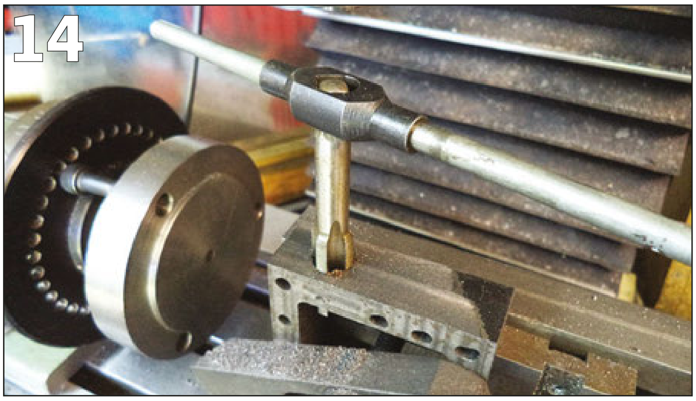
PHOTO 8: Newly made and correct slide valves.

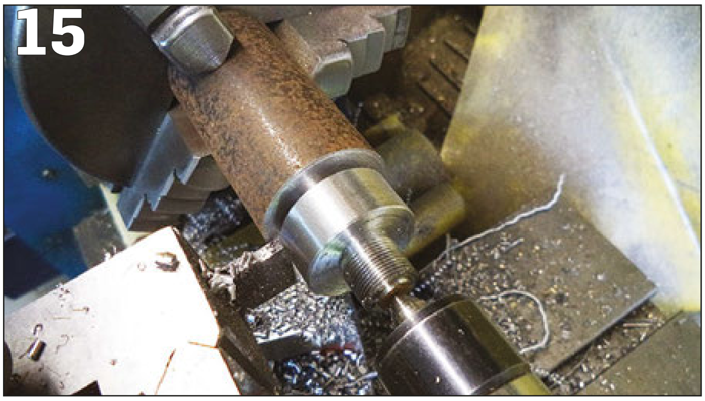
PHOTO 9: Skimming steam chest to correct fit.

PHOTO 10: Showing error of the valve rod position.

PHOTO 11: Locating correct position using a pointer.

PHOTO 12: Boss on steam chest removed.





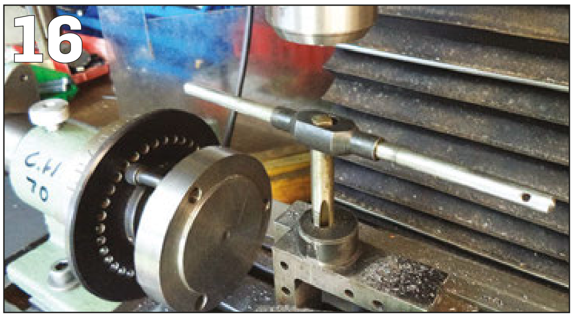


PHOTO 13: Boring valve rod inlet in correct position using end mill.

PHOTO 14: Tapping the inlet hole.

PHOTO 15: Turning a new screwed boss.

PHOTO 16: The rear boss drilled and tapped for plug.

PHOTO 17: New front boss being spotted through with a long-series centre drill.

PHOTO 18: The rear boss drilled using long-series drills to take tail of the valve rod.

PHOTO 19: Side of steam chest drilled for oiling point with screwed plug.

PHOTO 20: Machining up the automatic drain cocks.

rod and the stuffing nut (Photo 15). This was screwed home tight with some Thread Loc into the steam chest.

The rear boss that takes the tail of the valve rod was simply drilled out, tapped ½-inch x 32 ME and a screw plug fitted (Photo 16). The chest was then set up square back on the angle plate and the mill centred on the front boss. Then using a long-series centre drill through the front boss, the rear boss was centre drilled from the inside and drilled with a long-series drill to take the tail of the valve rod. A long-series centre drill was used to ensure correct alignment for the valve rod (Photo 17-18).

By hanging around the steaming bay at the club and asking questions and generally making a nuisance of yourself, you do tend to pick up little nuggets of information and tips. One that I picked up was to drill and tap into the side of the steam chest to take a small brass plug, so that at the end of a day's steaming when you are cleaning down, you simply unscrew the plug, squirt in a little oil and work the loco up and down the track a little so that the oil is taken down into the cylinders. This helps to prevent rust forming in the cast-iron cylinders and seizing up the pistons (Photo 19).

Auto drain cocks

The function of cylinder drain cocks is to drain away condensation that accumulates in the cylinders especially when starting from cold. This condensation can cause the pistons to create a hydraulic lock, that in extreme cases could strip the cylinder cover studs.

Piston-valve engines are particularly vulnerable to this trait, slide-valve ones less so as the valves are free to lift and so relieve the pressure. There are many manually operated drain cock systems about, but quite a few engines at the club are fitted with automatic cocks that seem to work well. They are quite simple to make and take the human effort required with manual drain cocks out of the loop.

I searched the available literature and questioned a few of the club members about the design of these automatic cocks – they are essentially ball clack valves. I was given some 'back-of-the-envelope sketches' which I converted into a drawing that I thought would suit my requirements.

There is some debate about just how these cocks work, my own theory is that being horizontal, when not under pressure the ball drops off the seat under gravity and some of the fluid drains into the cock. Under pressure this fluid holds the ball open and the fluid is expelled, when it's all gone the ball closes, but I'll stand correction on this. They are quite straightforward to make (Photo 20) and should pose no problems, and I can now say from experience that they work extremely well! EIM

■ Next time Stewart deals with the challenges posed by the chassis of his loco, which on first stripdown he discovered was "a sorry sight"....

Boxes and Trucks

Our series for newcomers to model engineering and steam locomotive mechanics focuses this month on some vital parts of the loco chassis.

BY **ANDREW CHARMAN**

Last time, in the September 2020 issue, we discussed locomotive frames and included the rectangular cut-outs in them, over which are mounted the horn blocks, in which the axleboxes run.

The axle box bearings of a steam loco are generally constructed in two halves to surround each axle. The top half is made of bronze or brass and lined with whitemetal – an alloy containing tin and lead and providing a softer surface to bear on the axle as it transfers the weight of the loco to it.

The bottom half is made of brass or cast iron and provides a bath to the lubricant for the axles.

It is essential to ensure that the axle box runs smoothly on the axle with no high spots which can cause it to overheat – a 'hot box' in railway terminology. Your editor is among many a heritage railway member who has spent hours on the tedious but vital role of removing slithers of extraneous metal from the bearing using a scraper.

Traditionally the axleboxes of the coupled wheels on a loco are sprung with leaf springs. Mounted under or over the axle box these consist of up to ten laminated strips of steel increasing in length to, on a large standard gauge locomotive, around three feet (1 metre) and allowing vertical movement of the axle box by approximately one to two inches (25-50mm).

More recent and narrow gauge locomotives have instead of leaf springs employed pairs of coil springs on their coupled wheels but these are more generally confined to the smaller uncoupled wheels in the leading or trailing trucks.

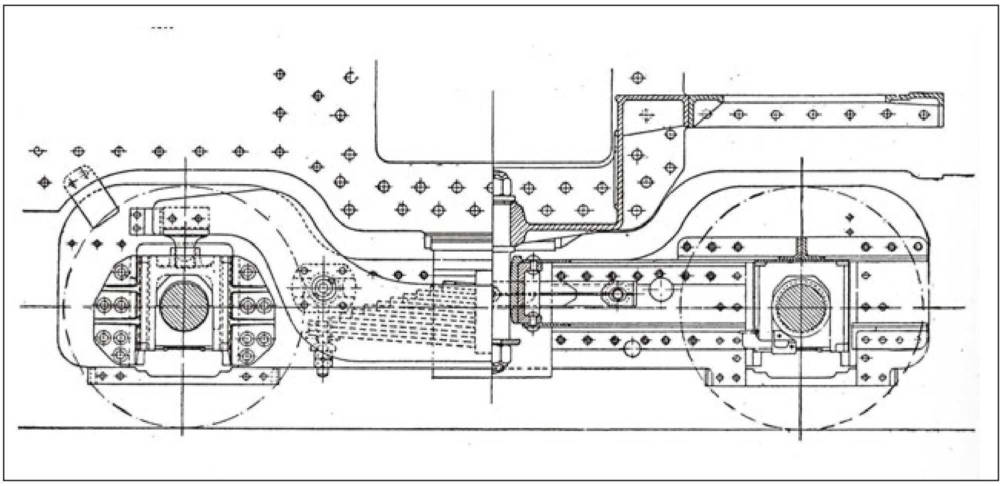
These trucks feature on all but the smallest locomotives – they are mounted ahead or behind the coupled wheels, and carry smaller wheels which are not coupled together and not driven. Their purpose is simply to spread the weight of the locomotive over a greater number of points, therefore reducing the weight pressure on the track.

The trucks are simply steel frames carrying two or four wheels and pivoting about a point on a stretcher mounted on the frames. They are independently sprung, with the wheels running in axleboxes just like in the larger coupled wheels.

ABOVE LEFT: Typical loco axle box – the bearing has a brass upper half and a base forming an oil bath.

ABOVE: Leaf spring mounted on top of a loco axle box.

BELOW: A diagram of a typical loco truck, in this case with two axles.



Simplest solution

Trucks were the simple solution to an issue of increasing weight that early loco designers addressed by simply adding more coupled wheels. The drawback was that the fixed wheelbase of the locomotive soon reached a point where it was too long to negotiate curves in the track.

Some locomotives have overcome this problem in the simplest way by fixing flangeless wheels to one of the coupled axles – the British Railways standard 9F class 2-10-0 has flangeless centre wheels and leading and trailing coupled wheels of reduced depth allowing more side play on curves.

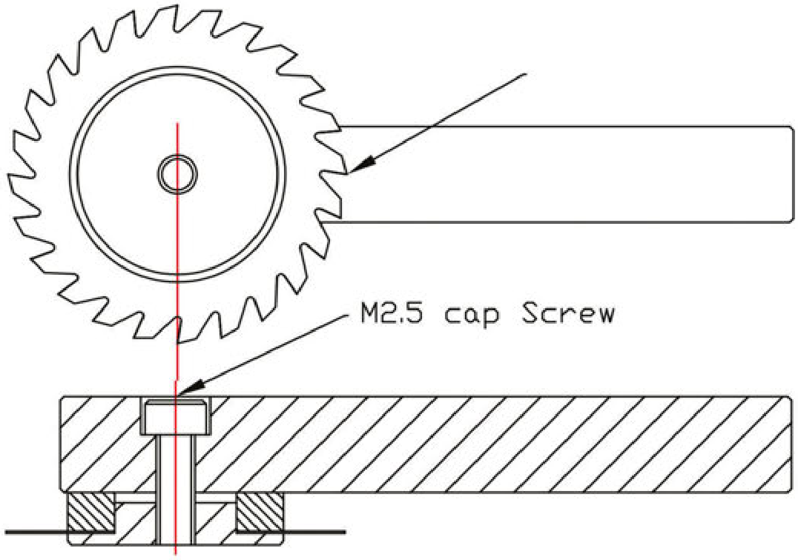
Popular on non-UK locomotives was the more complex solution of fitting articulated axles on the front and rear axles, a popular version being the Klein-Lindner in which the axle was separate to the wheels, having a ball at its centre which connected to a surround carrying the wheels. EIM

■ Next time: Stopping power – brakes.

Dot – a micro engine

Stewart completes and runs his tiny stationary engine construction project, particularly suited to those with limited model engineering space.

BY **STEWART HART** Part four of four



As I moved towards the completion of 'Dot', my stationary engine based on a design by noted US model engineer George Britnell and measuring just 2 inches (50mm) tall, I was amassing a nice collection of small parts that are easily lost, so to reduce the risk of this happening I started wiring the parts together (Photo 77). With the next parts things were starting to get seriously small...

Part 35: Valve Knuckle

I struggled to get any usable close-up pictures of the process in making this, something that I eventually put down to the lighting on my mill, so I'm afraid you're going to have to put up with the words and music. But this shouldn't be any real hardship as the process is similar to some of the other parts and involves, surprise surprise, the spin indexer.

The part is made from some ¼-inch square brass bar. Start by mounting the bar in the four-jaw self-centring chuck, facing off and drilling and tapping M1. Transfer the chuck over to the spin indexer and drill and tap the M1 cross hole, and with a 1mm slitting saw or slot drill slot the fork. It is better to do this machining before you reduce it down to 2.5mm square because the extra material will prevent the slotting process from springing the fork open, I learnt this the hard way...

With a nice sharp milling cutter and taking small cuts, reduce it down to a final 2.5mm square. Remove the bar from the chuck and before cutting it off radius the end with a Swiss file – job done.

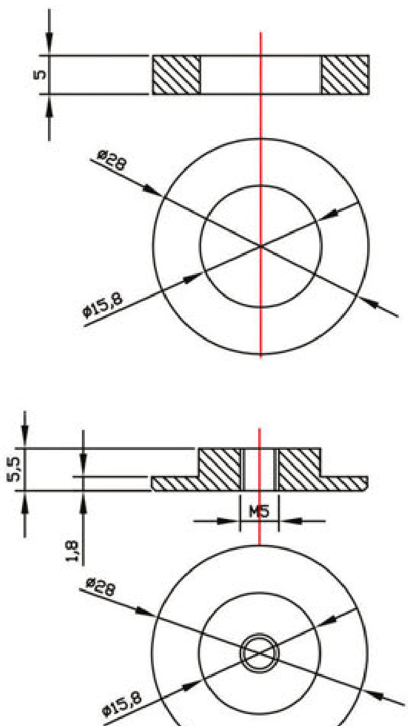
PHOTO 77: Small parts were wired together to prevent loss.

PHOTO 78: Parting off the spacers – note the use of a catch wire.

PHOTO 79: Components for the slitting saw-based parting tool.

PHOTO 80: Turning the screwed pins down to 1mm be means of a slender rod moving steady.

All photos and drawings in this feature by the author

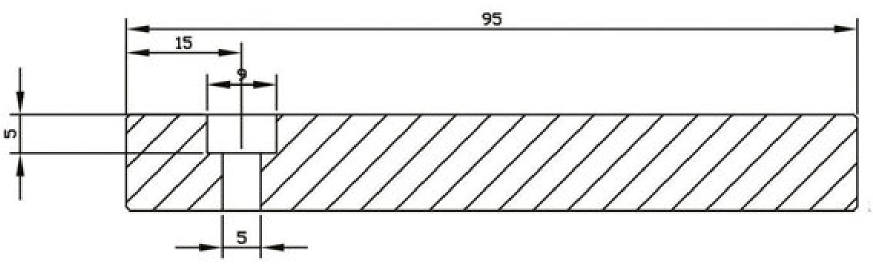


Parts 30-31: Spacers

These are real tiny components but they do an important job in keeping the parts of the reversing mechanism from fouling together. In the drawings I've called for two different lengths; two off at 2.0mm and two off at 0.25mm, but these are nominal sizes and are best adjusted to give optimum assembly.

The spacers are made from ¹⁄16-inch brass rod, just face and drill 1mm about 5mm deep, and part off to length. That sounds easy, but I found that with my thinnest ¹⁄16-inch parting blade the cutting forces just bent the bar, what was required was a thinner parting blade.

I then remembered seeing somewhere, a parting tool made from a slitting saw (Drawing Tool 3). The




77


78

parts are straightforward enough to make and shouldn't require any further descriptions – all that's required is a thin slitting saw. I used a 1⁄64-inch wide saw that had been reground a number of times and was getting to the end of its useful life (Photo 78-79).

To use the tool couldn't be simpler – just set one of the teeth on centre with a little bit of top rake, then to make the spacers first part off a small sliver, then advance the cross slide the desired spacer width plus the thickness of the saw. Use a small piece of wire in the hole to catch the part as it drops off – they are smaller than a grain of rice so if one drops into the machine tray it will be lost forever. Make plenty of spares as you will find the darn things have legs and just walk away into oblivion, and keep then threaded on a length of wire. You can watch a video of the tool in action at https://youtu.be/fnha5EygLP0

Part 15: Connecting rod pin Part 33-34: Reversing Mechanism pins

Next up were three screwed pins of similar construction, for the connecting rod and the reversing mechanism. Parts 33 and 34 are of identical design but of different lengths. Part 33 is used on the valve knuckle part 35, while two of the part 34 pins are used with the links part 23, with one being used on the bracket part 28. Drawing Part 32 shows the assembly and again the lengths are nominal, best optimised on assembly.

I made the pins from 2mm diameter stainless-steel bar and had quite a bit of difficulty: firstly with turning the 9mm long pins down to 1mm. Even though I was taking small cuts with a razor-sharp tool they just kept bending as I was getting close to the required size. The solution was to use a Slender Rod Turning Steady (see drawing on page 15). Again a video at https://youtu.be/yDrXDVB1ABI shows the steady in action.

It is quite simple to use, first you turn up a short length of bar to the target diameter, you then insert the bar into the guide bush and adjust the turning tool so that you just feel it dragging on the bar. Tighten the tool up, then with a good length of the 2mm bar sticking out of the chuck insert the end into the guide bush and turn down to the required length (Photo 80).

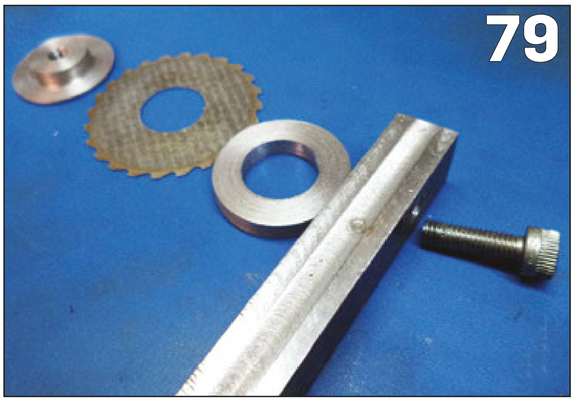
I also had troubles getting the die to cut, and parting the pins off, my slitting saw parting-off blade just kept breaking. Luckily I had plenty of teeth on the saw, but in the end I resorted to the good old mk1 junior hacksaw, and just cleaned the ends up with a file.

I first tried using a split die that I bought off the internet. When I received the die I was a little unhappy with its quality, the cutting edges were extremely thin, and looking at it under a glass I could see burrs, but I gave it a go anyway.

The first problem I found was actually locating the die on the bar, there was just too much clearance on the die holder, so in the end I resorted to locating the bar on the die and holder, holding it in place whilst advancing the guide bar with the tail stock. I then had difficulty in getting the die to cut, when I it did cut I ended up with a rough undersize thread, and in the end I broke the die.

I then priced up a UK-made M1 split die, I nearly had a heart attack when I discovered the price was more than £80. Finally I found a Dormer split die of dubious history on Ebay. This looked far better made, but the trouble here was that when I'd cut a reasonable length of thread it simply broke off, with the length of thread stuck in the die. This I had to cut out using a thin jeweller's saw, which didn't do the die any good. I think the problem here was that the die was just too blunt.

I then decided to try the die out of the set that I bought from Arc Euro (usual disclaimer) at one of the shows I had visited. It was an impulse buy, I didn't know what I would use the set for at the time, but they looked nice. The reason I hadn't first used a die out of this set was because they weren't split dies, they were more like die nuts, but wouldn't you know it they cut like a dream (Photo 81).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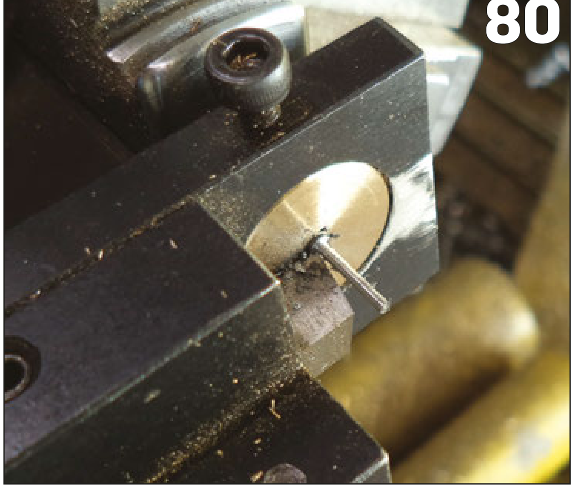
"Even though I was taking small cuts with a razor-sharp tool they just kept bending as I was getting close to the required size..."

Part 24-27, 35: Valve Assembly

The piston valve is simply assembled from 3mm discs with a spacer all parted off to the required length and assembled to the valve stem with an M3 screw. If you first loosely assemble the parts and then insert the loose assembly into the valve chest and tighten the screw, everything will automatically line up.

Making the Valve Stem, part 25 is just like making one of the screwed pins, its length is adjusted to centralise ▶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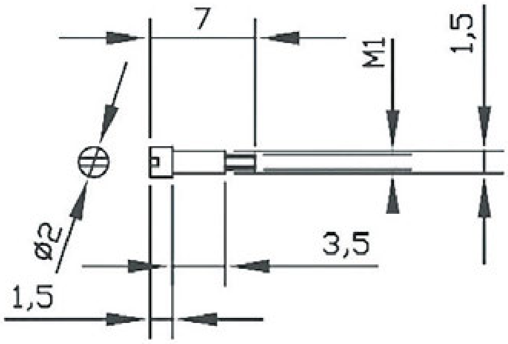
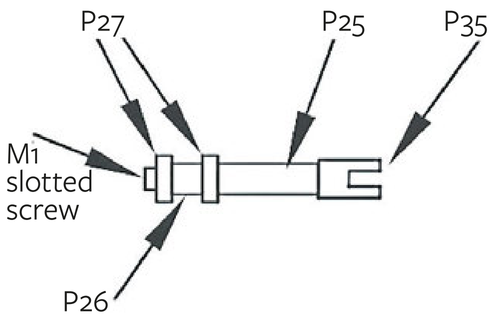
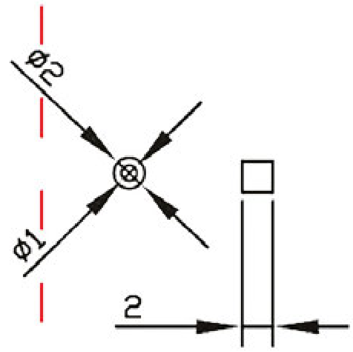
All component drawings reproduced approx TWICE full-size unless stated



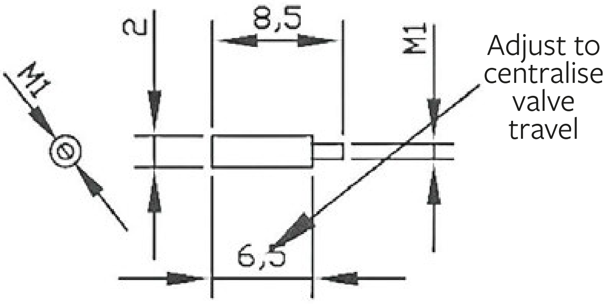
PART 15: CONNECTING ROD SCREW PIN
1 off: Silver Steel



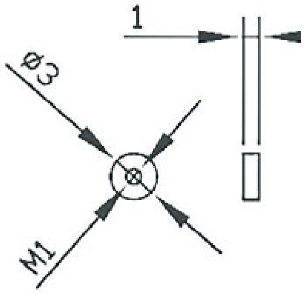
PART 24: VALVE ASSEMBLY
1 off



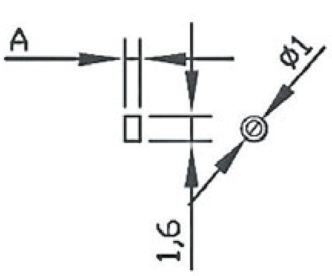
PART 26: VALVE SPACER
1 off, Brass



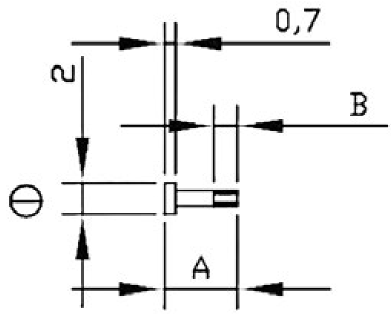
PART 25: VALVE STEM
1 off: Stainless Steel



PART 27: VALVE DISC
2 off: Brass



PART 30-31: REVERSING MECHANISM SPACERS
Brass
Part 30: A= 2.0, 2 off
Part 31: A = 0.25, 2 off



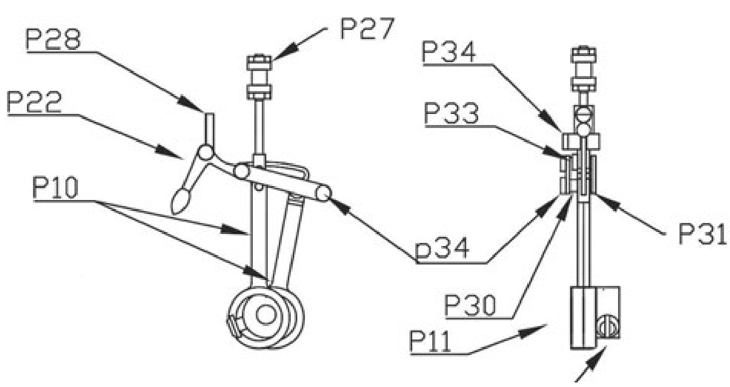
PART 33-34: REVERSING MECHANISM SCREWED PINS
Stainless Steel
Part 33: A= 3.5, B = 1.5, 1 off
Part 34: A = 9.0, B = 1.5, 3 off

the valve travel which I will explain shortly. The Valve Spacer, part 26 is made in the same way as the spacers for the reversing mechanism as are the Valve Discs, except the bar was turned down to be a close fit in the valve chest bore before the discs were parted off. (**Photo 82**).

You should have enough parts made now to assemble the engine. This is a bit fiddly, and parts are easily lost – I worked in a clean assembly area, the kitchen table, on a tea towel which helped stop parts bouncing to their oblivion on the floor if they were dropped.

To aid assembly a selection of tweezers and a lockable set of surgical-type forceps are recommended. I also had a lucky find at a high-street opticians when my boss was buying a new pair of sunglasses. You know how it goes; "How do you like these?", "Yes they are nice". "Well how about these?" "Yes they're okay," "And these?" "They're better," "They're the ones I came in with...". Amongst all this excitement I found the optician was selling a key ring with a screwdriver at one end and little socket at the other that turned out to be a perfect fit on the M1 nuts, and they threw it in free as my wife bought the sunglasses.

Assemble the engine slowly and methodically, pay particular attention



PART 32: REVERSING MECHANISM ASSEMBLY
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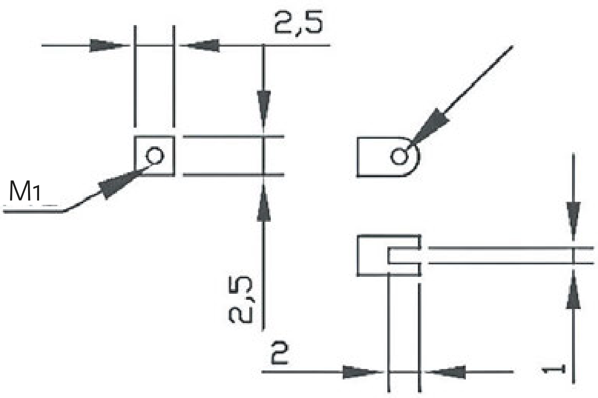
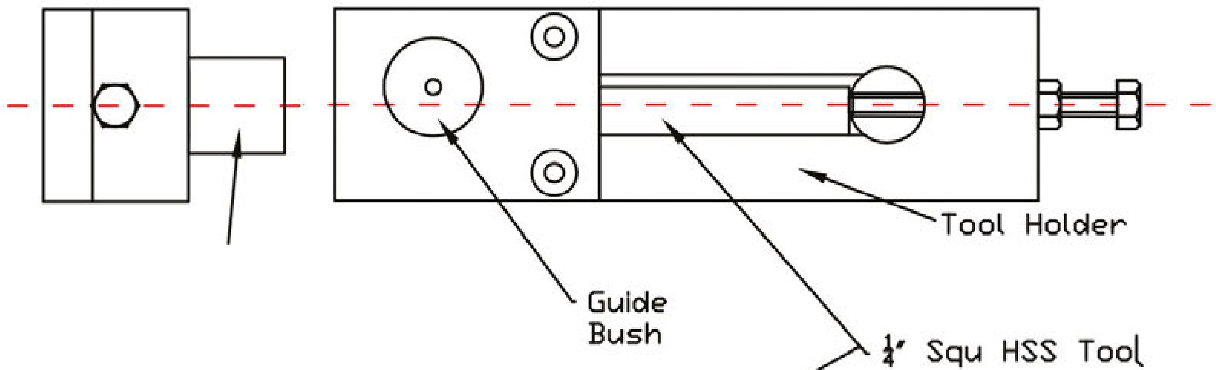


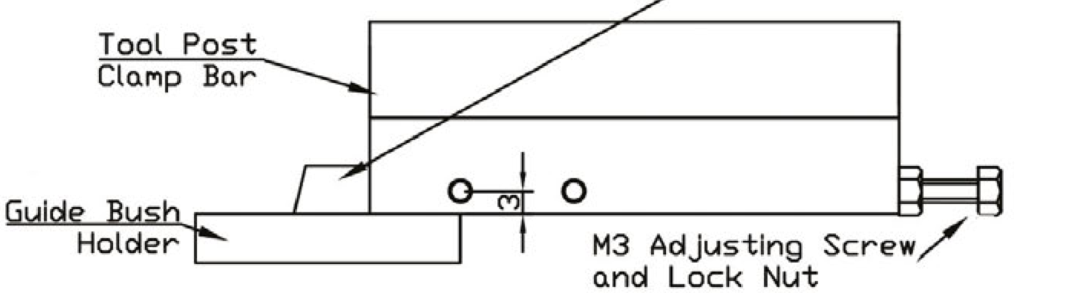
PART 35: VALVE KNUCKLE
1 off: Brass

SLENDER ROD TURNING STEADY

Reproduced approx full-size

Assemble with M3 cap screws, M3 countersunk cap screws and thread lock

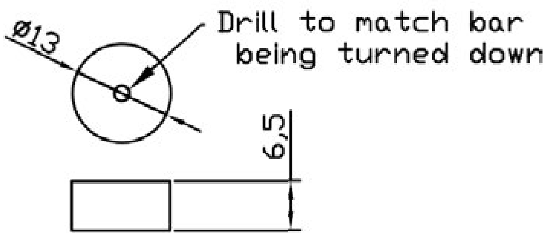




to any tightness, the engine has to be quite loose, and ensure that the reversing mechanism doesn't foul or catch – work on any places that do by adjusting the length of the spacers and by taking any high spots away with a Swiss file.

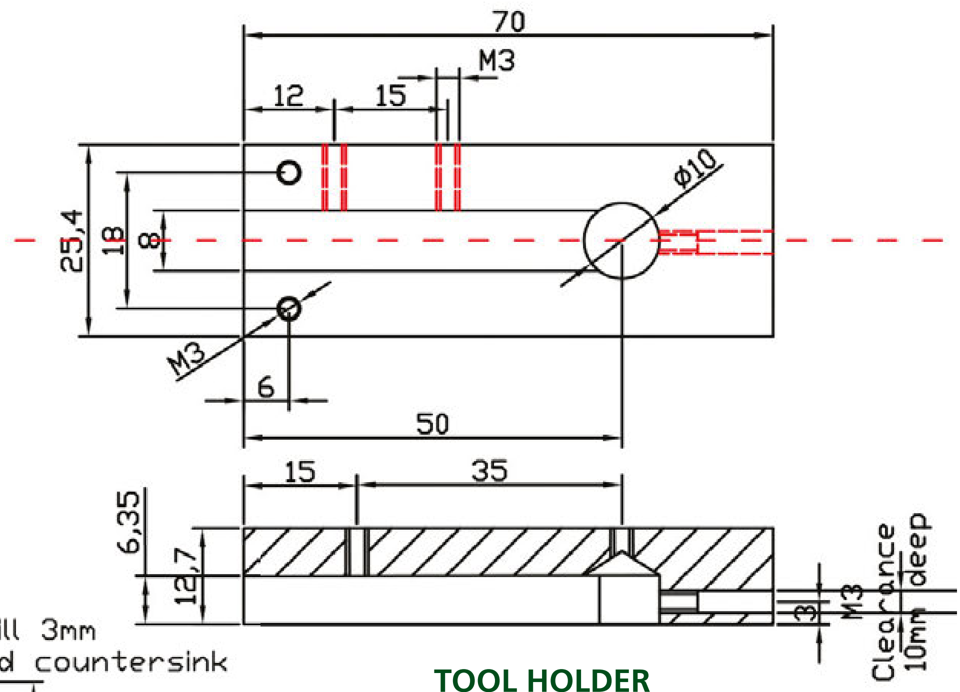
When you have the engine spinning freely, it's time to set the valve events. First centralise the valve by observing the movement through the inlet port – an eye glass may help in doing this. What you are looking for is the same amount of valve to be visible at top and bottom dead centre, adjustment is made by altering the length of the valve stem, part 25.

To set the valve move the reversing lever to the bottom, and slacken off ▶



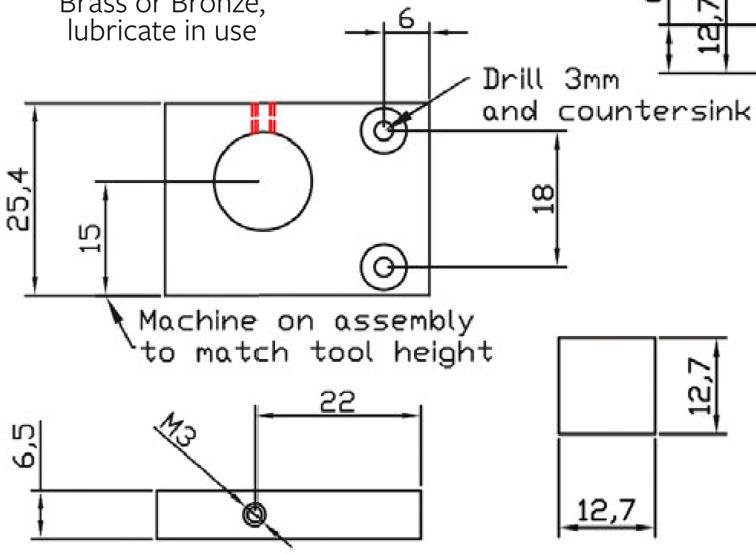
GUIDE BUSH

Brass or Bronze, lubricate in use



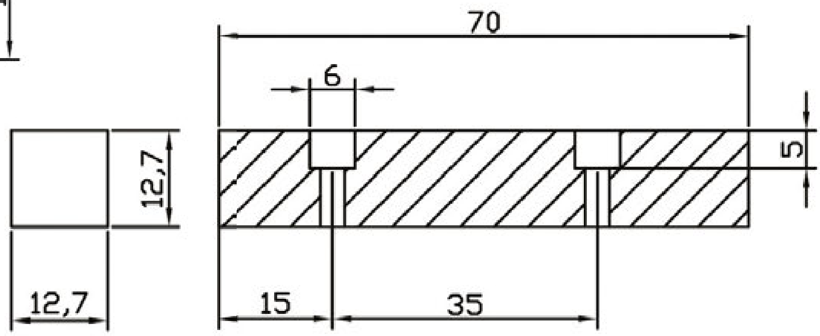
TOOL HOLDER

Mild Steel



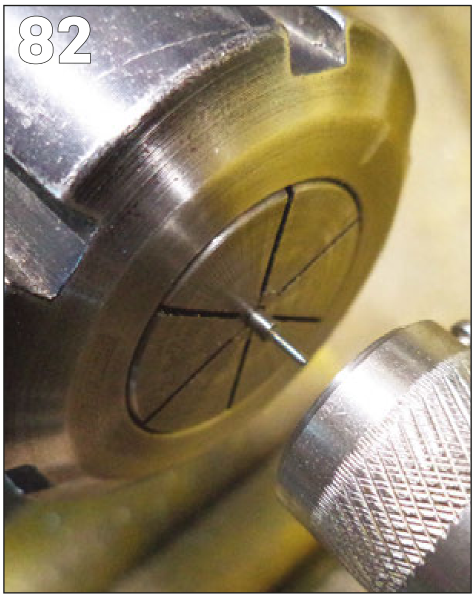
GUIDE BUSH HOLDER

Mild Steel



TOOL POST CLAMP BAR

Mild Steel



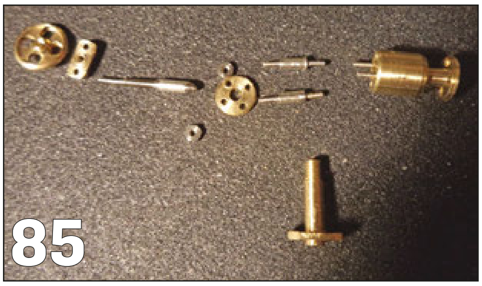


PHOTO 82: Cutting an M1 Thread.

PHOTO 83: Parts for the piston valve.

PHOTO 84: Silicon sealant stops nuts coming undone in use .

PHOTO 85: Stop valve parts.

PHOTO 86: Wooden base salvaged from 'Bog Oak'.

PHOTO 87: Machining the oak base on the mill.

PHOTO 88: Small but delightful – the finished engine .

"Mine will run at under 10psi with a rpm of about 400, at full pressure of 60psi it really buzzes along at more than 6000rpm..."

88

the eccentric. Rotate the engine to bottom dead centre then rotate the cam so it's just past the '20 minutes to' position, as shown in the reversing mechanism drawing Part 32. Tighten up the eccentric screw.

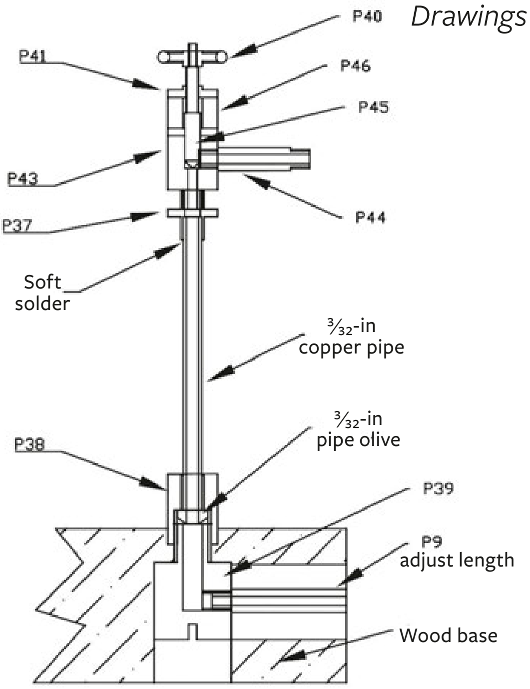
Give the engine a good oiling and connect it up to an air compressor and see what happens. With a bit of luck it should spring into life – you may have to give it a spin to encourage it. Mine will run at under 10psi with a rpm of about 400, at full pressure of 60psi it really buzzes along at more than 6000rpm, the video at https://youtu.be/Ih4R_ymxxwc shows it running.

I did find that the engine displayed an annoying tendency to cast off the M1 nuts. A friend suggested that I used silicon gasket sealer as a thread lock, being silicon it doesn't set hard making it easy to remove the nuts, and this worked like a dream (Photo 83).

Optional additions

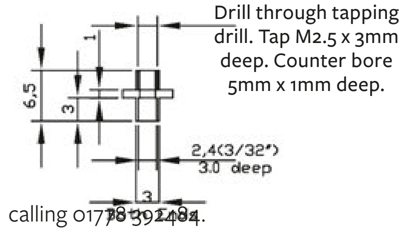
If you wish you don't have to take the project any further, but I always like to add a few little extra finishing touches as well as giving my models a paint job. So I made a little inlet valve and neatly piped the air in through a nice wooden base, this setup is

Drawings on this page reproduced approx full-size



PART 36: STOP VALVE AND BASE ASSEMBLY

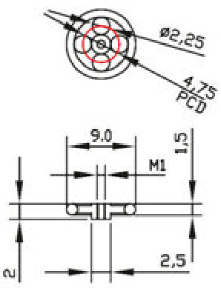
Optional addition – wooden base is approx 50 x 70 x20. Engine attached via base fixing plate, part 3 with M3 countersunk screw.



calling 01778 392484.

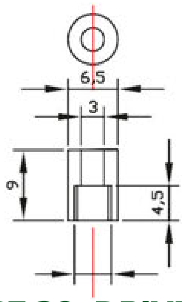
PART 37: UPPER CONNECTOR

1 off: Brass



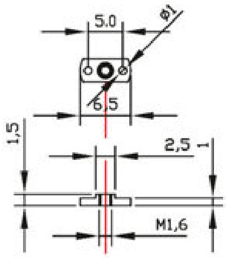
PART 40: WHEEL

1 off: Brass



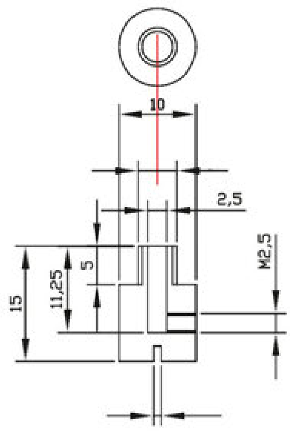
PART 38: DRIVE NUT

1 off: Brass



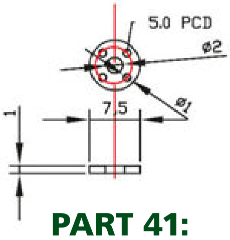
PART 41: VALVE STEM NUT

1 off: Brass



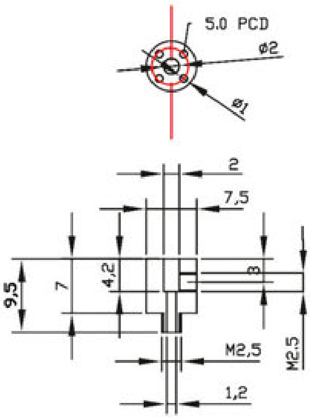
PART 39: LOWER CONNECTOR

1 off: Brass



PART 41: VALVE STEM NUT

1 off: Brass



PART 42: VALVE BODY

1 off: Brass

detailed in the Assembly Drawing Part 36 on this page.

The stop valve itself is similar to the valves that I have used on some of my other engines only a little smaller, because of this and the fact that I have covered most of the techniques to make this valve on other items in this build, I won't go into any detail how to make it (**Photo 85**). It is connected up to a 3/32-inch copper pipe with soft solder and an olive and a coupling nut at the bottom.

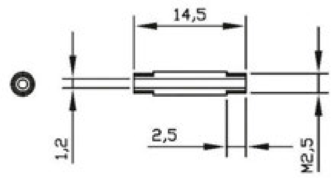
The wooden base was made from a bit of salvaged bog oak... (**Photo 86**) machined up in my mill (**Photo 87**) and the corners nicely radiused.

Before painting the engine I carefully went over the parts that would be coated, removing all sharp edges, and degreased them in an ultrasonic cleaner.

Using spray cans I gave them a puff of acid etch undercoat, followed by a couple of top coats of Vauxhall Burgundy (**Photo 88**).

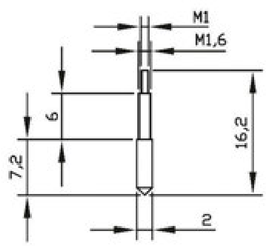
Well that's it completed, creating this little stationary engine has given me a great deal of satisfaction and pleasure, and along the way I have learnt a few things.

■ The three earlier episodes of this series appeared in the September to November 2020 issues of EIM. Digital back issues can be downloaded or printed versions ordered by going to www.world-of-railways.co.uk/store/back-issues/engineering-in-miniature or



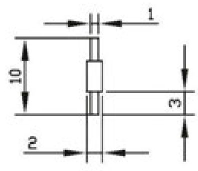
PART 44: FEED PIPE

1 off: Brass



PART 45: VALVE STEM

1 off: Brass



PART 46: DOUBLE-ENDED BOLT

1 off: Stainless Steel

Current Affairs

Peter continues his new series uncovering the mystery behind battery-electric loco wiring issues, looking this month at the potential multiple problems caused by multiple motors.

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

Many miniature battery-electric locomotives use multiple motors in order to provide tractive power. Jan-Eric Nyström in his electric loco construction series (**EIM**, June to Oct 2019), used two motors, one per bogie, and two separate controllers (one for each motor). Other locos, such as the class 08 in **Photo 3**, discussed later in this article, use multiple motors with a single controller.

The standard version of this class 08 employs three motors, one per wheel set, with all three motors being wired in parallel and the wheels being mechanically coupled (as on the prototype) by a coupling rod. This ensures that all three motors rotate at the same speed, irrespective of the 'sharing' of the load amongst the motors (more on this in a moment).

The particular class 08 shown in **Photo 3** has been re-wired (by its owner who is also an electronics engineer), as will be discussed in the next section, but started out life with a parallel-wired motor configuration.

There are a range of options in regard to the use of multiple motors and some of the more common configurations are:

1) Two (or more) motors wired in **parallel** (**Figure 6**), fed from a single controller, with all motors being mechanically coupled (for example via a chain or coupling rod)

2) Two (or more) motors wired in **series** (**Figure 7**), fed from a single controller, with all motors being mechanically coupled (such as via a chain or coupling rod)

3) Two motors running independently (for example on separate bogies), fed from separate controllers (see Jan Eric's series for an example of this)

4) Two motors, operating independently fed from the **same** controller (again, this can take the form of a series or parallel connection of the motors).

Equal effort

When multiple motors are used, one common problem exists: are all of the motors sharing the tractive effort equally (as we would wish) or is one (or more) taking a disproportionate share of the strain? If the latter is the case, then it is much more likely that the motor doing most of the work will burn out or, at least, fail somewhat earlier than it would otherwise have done. This is very unlikely to occur when a loco is only used to haul its driver around their local club circuit, but it can become a big issue when battery-electric locos are used for passenger hauling.

PHOTO 3: Typical club stalwart, a class 08 loco with series-wired motors.

FIGURE 6: This diagram shows parallel connection of motors.

All photos and diagrams by the author unless stated

With parallel-connected motors, each motor has, in effect, its own independent connection to the power source (controller) and can take as much power as it needs, subject to the limitations placed upon it by the controller (and, ultimately, the driver). It is relatively easy, therefore, for one motor to take a greater current than another motor, based upon the internal resistances, external frictions (such as of the bearings) and such, experienced by that motor relative to its brothers and sisters. Where multiple motors are mechanically-coupled together (such as by a chain or coupling rod) then the mechanical issues (for example bearing friction) are, in effect, shared by all of the motors approximately equally, since even if only one motor is working (or connected) it must move the bearings and such of all motors/wheel sets irrespective of the wheel set it is mechanically driving.

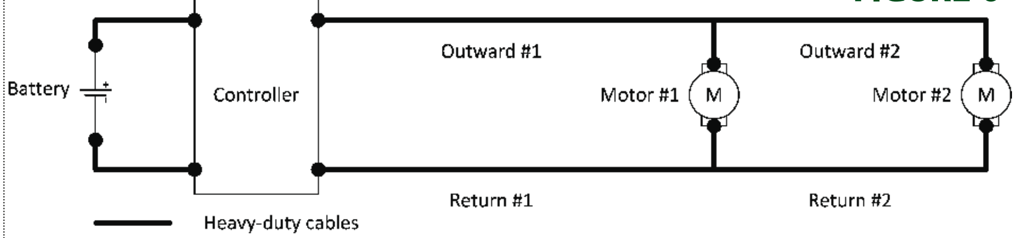
Any electrical issues are, however, not shared, even in this configuration. To understand this, consider the following example (**Figure 8**): a two-motor mechanically-coupled locomotive has one motor with negligible contact resistance at its terminals (Motor #1) and a second motor with a 0.1 ohm contact resistance at one of its terminals (Motor #2).

In this circuit, the total current from the controller, I_{total}, must equal the current drawn by the two motors (according to Kirchhoff's law, if you're interested). In other words:

$I_{total} = I_1 = I_2$ (Equation 1)

Ideally, the two motors should be

FIGURE 6



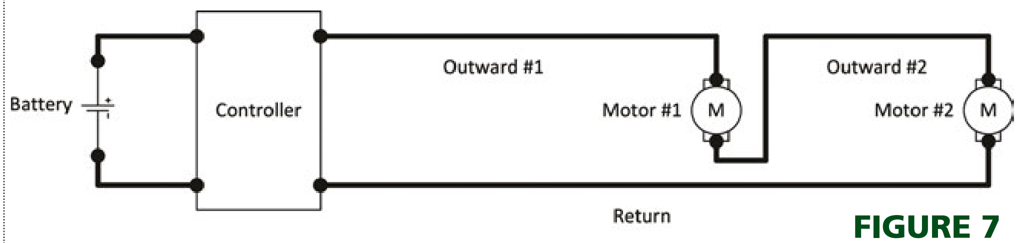


FIGURE 7

sharing the tractive load equally and hence should be drawing the same current, in other words;

$$I_{total} = I_1 = I_2 \quad \text{(Equation 2)}$$

However, if Motor #2 exhibits a contact resistance of 0.1 ohms, then it will have a smaller voltage across it than will Motor #1. This difference in voltage (and hence power developed by the motor) will increase the greater the current being fed to the motors and so will be most pronounced when the loco is pulling a heavy load (such as when passenger hauling) – hence the reason why simple loco + driver club running will rarely result in motor burn-out (at least due to this reason).

As an example, consider the motor used on a Sinclair C5 (for our younger readers, this was an electric 'car' released long before they were considered 'cool'). Loco builders have used these motors in their designs, although it seems that they are getting hard to source now. The motor is rated at ~30A of continuous current but has a DC resistance of only 0.1 ohms, so with a 12V supply, the peak current which could be drawn, with the motor stalled (i.e. as the loco sets off), is:

$$I_{peak} = V_{DC}/R_{DC} = 12/0.1 = 120A \quad \text{(Equation 3)}$$

This is around four times the continuous rated current and, quite obviously, would burn out the motor if sustained for any period (probably, at most, a few tens of seconds and possibly only a few seconds). The motor is reportedly capable of running off 24V, which would increase the peak current to 240A! (assuming that the controller was capable of delivering such a current, although many are).

It is easy to see, therefore, how an overloaded train can burn out a motor, particularly once the motor gets hot from doing a few laps of the track and therefore only needs a smaller temperature rise in order to melt the windings.

If two of these motors are used in the parallel configuration shown in Figure 6, and the voltage across the motors is 12V, then the total current drawn by both motors will be 60A. If the motors are operating perfectly and there is no contact resistance (or other differences between the motors), then:

$$I_{total} = I_1 = I_2 = 60 \quad \text{(Equation 4)}$$

And $I_1 = I_2$ (from Equation 2). Hence $I_1 = I_2 = 30$ amps.

The power provided by each motor is then:

$$P = VI = 12 \times 30 = 360W \quad \text{(Equation 5)}$$

And the total power from the two motors is then almost 1HP – which is absolutely fine for a small 0-4-0 loco on 7¼-inch gauge, for example.

"This would burn out the motor if sustained for any period, at most, a few tens of seconds and possibly only a few seconds..."

Now consider the situation shown in **Figure 8**. Equation 1 still applies, however I_1 and I_2 will no longer be equal, as we will see, so Equation 2 is no longer true. Let us assume that the load being pulled by the loco is such that, in a 'perfect' (such as in Figure 6) scenario, the motors require a voltage of 6V to get the train moving. Each motor will therefore (briefly) draw 60A as the train sets off and each provides 360W of power to the loco (assuming that the motors are 100 per cent efficient, for simplicity).

If the same 6V is applied in the case of Figure 8, Motor #1 will still see 6V across its terminals and hence will still draw 60A (I_1) at full load and produce 360W, as before.

The situation for Motor #2 is a little more complicated. The 6V output from the controller is now divided across the 0.1 ohm motor resistance and the 0.1 ohm contact resistance. The current through Motor #2's portion of the circuit (I_2) is then:

$$I_2 = V/R = 6/(0.1+0.1) = 30A \quad \text{(Equation 6)}$$

The voltage across Motor #2 is then:

$$V_{Motor2} = I_2 \times R_{Motor2} = 30 \times 0.1 = 3V \quad \text{(Equation 7)}$$

This is half the voltage across Motor #1 and the current through the motor, I2, is also half that through Motor #1. The power produced by Motor #2 is therefore only 3V x 30A = 90W, one quarter of that produced by Motor #1!

The total power provided by the loco is therefore only 360 + 90 = 450W, which is substantially lower than the original ~1HP. Result: the loco remains in the station with a cohort of restless passengers.

The driver will naturally compensate for the deficiency in power (quite possibly without realising it) by increasing the setting on his handheld speed regulator and hence increasing the output voltage from the controller. In order to return to the required 720W, he will need to increase the voltage to approximately 7.6V, with the resulting powers in Motor #1 and Motor #2 becoming:

$$P_{Motor1} = 578W$$
$$P_{Motor2} = 144W$$

Motor #1 is therefore providing over 60 per cent more power than it should need to, in order to get the train moving, whilst Motor #2 is having an easy time of it, providing less than 50 per cent of the power it should be. With this level of overload, Motor #1 is probably not going to last very long and don't forget that the assumed contact resistance of 0.1 ohms was just that, an assumption. It could easily be much higher, with Motor #1 taking an ever-greater share of the load as it increases.

A rather obvious conclusion could easily be overlooked at this point: the motor with the 'problem' (for example a corroded connector) is not the motor which is likely to burn out. It is the problem caused by Motor #2 which is forcing Motor #1 to take an unfair share of the load and hence it is this 'good' motor, paradoxically, which will fail, thus perpetuating the fault (since Motor #2 won't burn out and hence won't be replaced, leaving its corroded contact in-circuit ready to cause the replacement for Motor #1 to burn out prematurely, and so on).

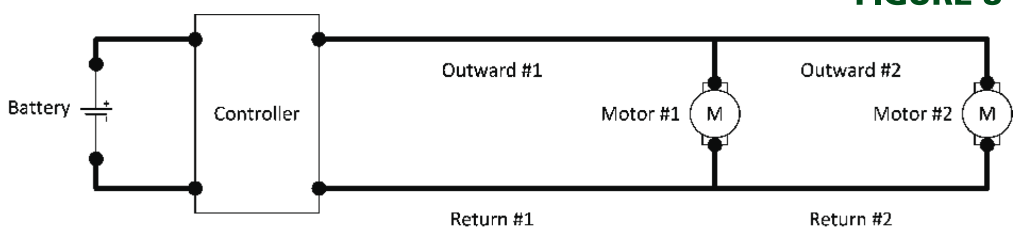
It is also worth looking at what happens at the (poor) contact itself. In the above example, it will dissipate the same power as will Motor #2, in other words 144W. This is quite a large figure and would easily, for example, de-solder a soldered connection (if that is how the motor wires are connected from the terminal to the internal wiring of the motor). Check the rating on your soldering iron, next time you get it out, it will almost certainly be a lot less than 144W!

If both motors' terminals or, more likely, the output terminal/connection on the controller itself, exhibit the kind of contact resistance just ▶

FIGURE 7: Motors connected in series.

FIGURE 8: This example configuration shows a parallel motor connection.

FIGURE 8



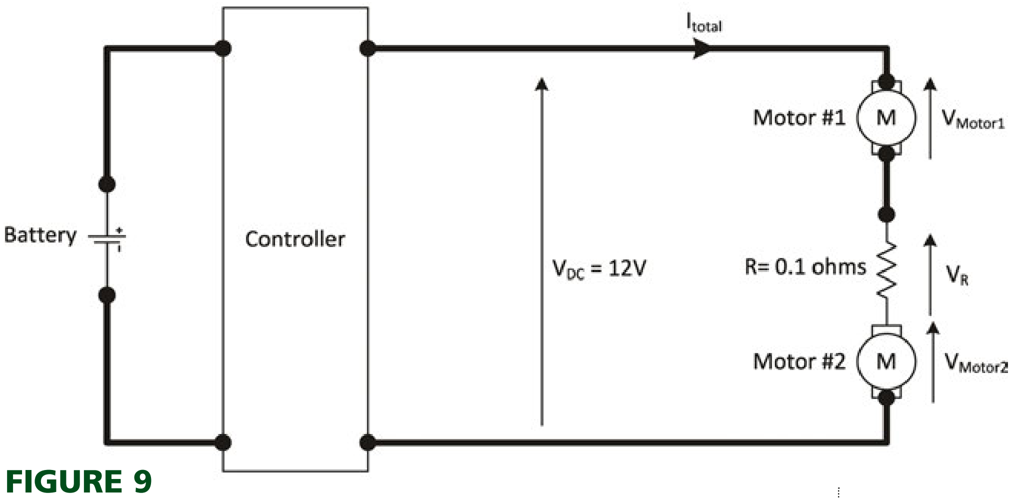


FIGURE 9

discussed (0.1 ohms) then this terminal will similarly dissipate a large amount of power. Even in 'steady state' (for example when running the train around the track), the controller could easily be providing 30A to the motors. With a 0.1 ohm contact resistance, some 90W will be dissipated in this connection – again, easily enough to de-solder it from the circuit board to which it is attached. This is what had started to happen in the first of the two sorry tales with which I opened this series last month.

Note that the above discussion largely deals with the case when starting a motor from standstill, which is often where a motor experiences the greatest strain (the other being nice challenging gradients). Once a motor begins to rotate, it generates a 'back emf' (as discussed earlier) and this slightly complicates the above picture. The same basic principles apply, however: contact resistance causes an imbalance in the power provided by each motor and hence one can become overloaded and burn out.

Brush with the law(s)..

… of physics. The above discussion has concentrated on the physical connections to the motors, controller and such. There is, however, another common source of increased resistance, namely that between the brushes on the motor and the commutator located on the armature.

These 'brushes' are commonly made from blocks of carbon and so are not actually 'brushes' in any real sense of the word (although they were in the early days of DC motors and the name stuck). They can become contaminated with dirt and/or oil/grease and this can increase the resistance between the brushes and the commutator to which they slip-connect. This increased resistance will result in the same issues as discussed above being apparent in the loco.

If the connectors have been cleaned thoroughly and problems persist, then the brushes may be the source of the problem. These may or may not be easy to service, depending upon the motor, but a squirt of switch-cleaner may help if the problem is grime or oxidation (of the copper contacts on the commutator). The brushes themselves may, of course, be worn, chipped or otherwise degraded and in need of replacement.

Moving to Plan B

Other than taking scrupulous care of the internal connections within a loco, is there another way to deal with the problem of unequal load-sharing by motors? The answer is yes, but with some heavy caveats. In theory, if the motors are connected in series (Figure 7), then they must have the same current flow through each of them, irrespective of the presence or absence of contact resistance on either or both of the motors.

Contact resistance is still an issue, as it will increase the current drawn from the controller and flowing through both motors (above that which would be needed if no contact resistance was present), however it will not lead to an imbalance in the power provided by each motor (just an overall reduction in the power from both motors).

In a series circuit, the voltage provided by the controller will be shared between the two motors, so a 24V controller/supply will only provide 12V to each motor. This can, of course, be taken into account at the design stage and 12V motors specified in the first place.

Note that this statement assumes that the motors are identical to each other and also that they have no contact resistance – any resistance will, however, reduce the voltage provided to each motor hence both will suffer a similar drop in output power (in other words one will not be disproportionately affected relative to the other, as was the case with a parallel connection). A poor contact on either motor will decrease the voltage provided to each motor and hence reduce the overall power output of the loco.

"The motor with the 'problem' (for example a corroded connector) is not the motor which is likely to burn out..."

This can be illustrated by means of the example shown in **Figure 9**, which is the series-connected equivalent of Figure 8 – the same motors, terminal contact resistance and such are assumed. The only change between this case and the parallel configuration described previously is that the available controller output voltage is assumed to have doubled (from 12V to 24V), to take account of the sharing of that voltage across the two motors.

Figure 9 shows the 'starting' situation, 12V being provided to be shared and, ideally, provide 6V across each motor (assuming no contact resistance). The presence of the 0.1 ohms of contact resistance will clearly change this, however, as we will see.

If the contact resistance is neglected, for the moment, then the 12V supply is shared equally between the two motors, with each seeing 6V across its terminals. The power provided by the (assumed stationary) motors is then:

$$P_{Motor1} = P_{Motor2} = V_{Motor}^2/R_{Motor} = 360W \quad \text{(Equation 8)}$$

This is as before, with the parallel arrangement. If we now re-introduce the terminal resistance, the situation changes somewhat. Since the terminal resistance and the motor resistances are the same in the scenario we have chosen, the available voltage (12V) is divided equally between the three resistances, hence each will experience 4V across its terminals. The power output from each motor is then:

$$P_{Motor1} = P_{Motor2} = V_{Motor}^2/R_{Motor} = 4^2/0.1 = 160W \quad \text{(Equation 9)}$$

This is less than half of the power produced by each motor when no terminal connection resistance was present. The current drawn from the controller, in this case, will be 40A.

As before, the driver will naturally compensate for this reduction in power and will increase the voltage to that required to get the train moving (720W total in our example). To do this, he will need to increase the voltage from 12V to 18V (quite a large jump) and doing so will lead to a substantial power dissipation in the terminal resistance (360W) – this is likely to cause damage to the terminal, connector or nearby wire (such as melting the insulation, perhaps) but probably won't damage the motor itself (unless it has a soldered connection to its terminal, which may de-solder).

"Having to turn the knob on the hand-held speed regulator far further would hopefully ring some alarm bells..."

It should also be obvious to the driver that he is having to turn the knob on the hand-held speed regulator far further than he would have had to do in the past and hopefully this would ring some alarm bells in a reasonably experienced driver's mind, thereby resulting in the loco being taken out of service before any major damage is done.

The current required from the controller, in this scenario, will increase to 60A. However as this is the same as that required for the parallel-connected motor circuit, when operating ideally, with no contact resistance, no damage to the controller will result.

So, just to state this clearly, in a series-connected motor circuit, even in the presence of an appreciable contact resistance, the same current flows through both motors as would do so in a perfect (no contact resistance) parallel motor configuration. In a series motor configuration, there is therefore no danger of the windings in the motor burning out, even in the presence of excess contact resistance to either or both motors. This is not to say that contact resistance will not cause problems (such as melted wiring, in extreme cases), however it should not lead to the premature burn-out of one or both motors.

Series solution?

The obvious conclusion, therefore, is to use lower-voltage (such as 12V) motors connected in series and a 24V controller, however there is a problem and it is a complex one: not all motors will work successfully when connected in series. The reasons behind this are complex and beyond the scope of a relatively simple(!) article in a model engineering magazine (if you've made it through this far, well done!).

In essence, some motors use 'brush timing' which is a method of improving the motor's performance characteristics by offsetting the brushes from their normal (neutral) position. This can affect the ability of current to flow through a combination of motors wired in series. This can result in the motors running okay with no load, but developing little torque when under load.

If you have an existing locomotive, then the simple answer is to try it. The worst that can happen is that it doesn't work very well. If you are designing or building a loco, then a discussion with the motor manufacturer would probably be wise before you go and spend out hundreds of pounds on motors which won't work in this way.

Having said the above, I have personally driven a series-connected loco dozens and possibly hundreds of times, specifically the Class 08 loco shown in Photo 3 (complete with a few 'professional' passengers from the Wye Valley Railway Society and a very young Matthew Kenington – who now writes regularly for this magazine). In all cases it was being used for passenger-hauling and it has never put a foot (or flange) wrong.

In the next part of this series, we will look at how the problems discussed above can be diagnosed, before they result in a failure, and also at a separate wiring problem, one of design/construction, which can result in the failure of the controller. EIM

FIGURE 9: An example configuration of a series motor connection

PHOTO 4: Passenger hauling can produce a strain on any battery loco's electronics. *Photo: Andrew Charman*

■ Part one of this series appeared in last month's issue of EIM. To download a digital back issue or order a printed version, go to www.world-of-railways.co.uk/engineering-in-miniature/store/back-issues/ or call 01778 392484.

End of the line in Scotland...

The last day of operation on any miniature railway is seldom a good thing but was particularly sad on 10th October, when Scotland's oldest miniature line, the 10¼-inch gauge Kerr's Miniature Railway ran its last trains – as reported in the October issue of EIM the line, which dates from 1935, has been beateen by falling passenger numbers.

Sjors van Dongen sent in these pictures from the line's Grand Finale event – the first at right shows all three available steam engines as well as 1935 steam outline 'Auld Reekie' on shed early in the morning.

The second below shows KMR resident 'Firefly' leading visiting engine 'The Empress' and former KMR resident 'Silver Jubilee', known locally as 'Big Bertha' into Hospitalfield Halt, the end of the line – all three engines were built by Bullock. Finally all three BR Class 25 outline diesel engines present were lined up for what Sjors tells us was the first time in the line's history. Sad times... EIM

WHAT IS AVAXHOME?

Building a Ten-Wheeler

This month Jan-Eric's 7¼-inch gauge loco build focuses on what he calls "fiddly stuff..."

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

The boiler of my ten-wheeler was built a long time ago, but the fittings are more recent additions. **Figure 34** shows the very simple smokebox throttle I've also used on my previous two engines; it is basically just a bullet-shaped plug made from stainless steel.

This plug fits into a PTFE (Teflon) washer press-fitted and secured in the steam pipe connector, **Photo 133**. The hole in this washer is somewhat smaller than the plug diameter. Since PTFE is soft (and even slightly softer at steam temperatures), this provides a good seal. I've newer had any problems with leaking throttles!

"Steam will exit through the smokestack, and not from any strange place under the cab or a running board..."

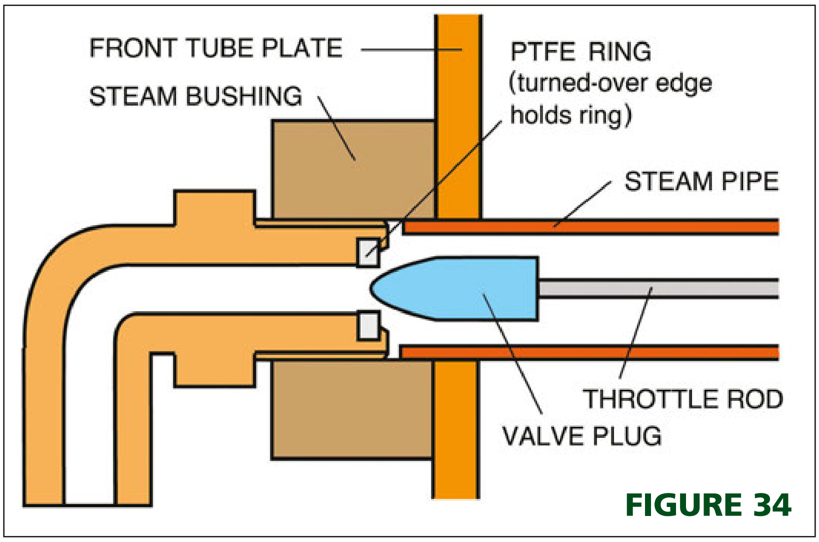


FIGURE 34

133

134

Photo 134 shows the steam tubes in the smokebox space. The throttle fitting is at top, from there the steam is led to a superheater manifold, with two concentric elements poking into the flues. This superheater was described in an earlier issue.

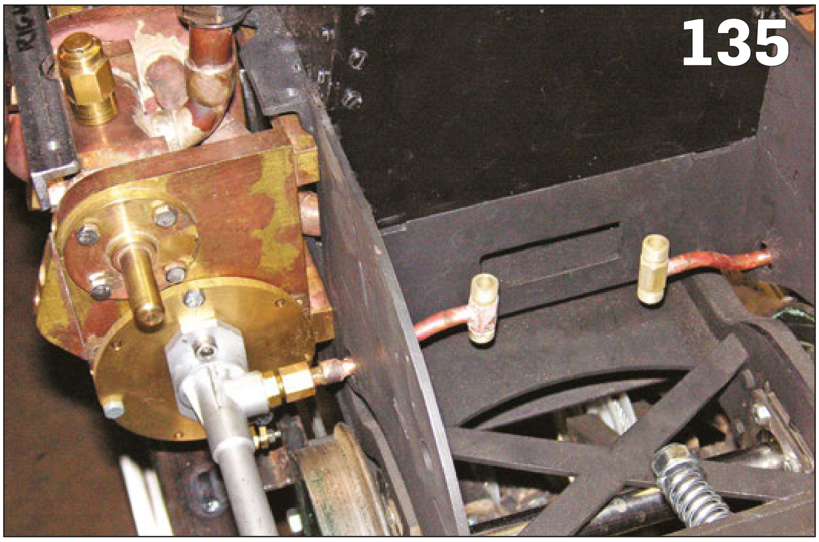
The superheated (or, more correctly, just dried) steam continues from the manifold to a T-splitter, from which it goes directly to the cylinder valves. All the tubing is 15mm outer diameter, 1mm wall thickness, and since the connectors (ordinary plumbing compression fittings) are also designed for this diameter, there are no restrictions to the steam flow.

At left in the picture, you can see the loco's steam whistle. It is connected to a 6mm tube that passes through one of the boiler's hollow stays, all the way to the backhead, where it is attached to the whistle valve. In this way, no condensate will form in the tube or in the whistle, so there won't be any gurgling sounds from the whistle due to drops of water.

Also, since the whistle is inside the smokebox, the steam will exit through the smokestack, and not from any strange place under the cab or a running board. Another hollow stay, seen at top right, will contain the tube for the blower, yet to be installed.

Simple but effective

The photo also shows the diamond-patterned running boards. They are made by attaching expanded aluminum mesh to the steel plates, using epoxy glue, and then painted matte black with rust primer. Simple, effective, and good looking! The mesh



135

FIGURE 34: A simple throttle valve.

PHOTO 133: Teflon (PTFE) ring is held in place by a few punch marks on the rim.

PHOTO 134: The tubing inside the smokebox.

PHOTO 135: Two valve chests inside the loco frame.

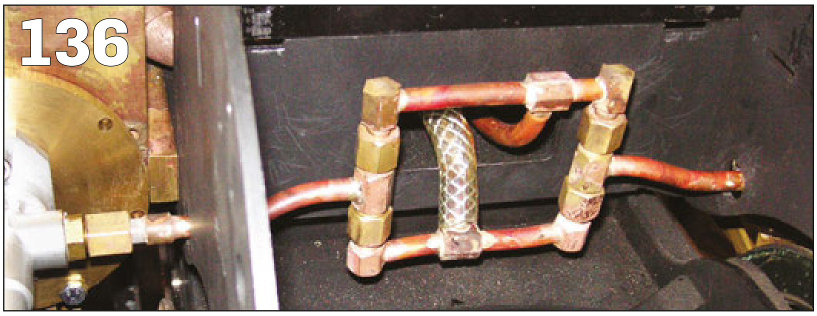
FIGURE 35: The working principle of the clacks.

PHOTO 136: The assembled and compact clack bodies.

PHOTO 137: Handrail stud screws into a tab welded to the boiler.

PHOTO 138: Handrails are attached to tabs on boiler.

All photos and diagrams by the author



came from a cheap fireplace spark guard, sacrificed for this purpose.

In Photo 135, the running boards are removed, and we can see a brass 'snifting valve' on top of the valve cylinder at top left. This snifting valve will allow air into the cylinder when the loco is coasting with the throttle closed – without it, combustion gases (and ash, if the loco is fired with coal or wood instead of propane) might be drawn into the cylinder, wreaking havoc with lubrication and causing excessive wear.

You can also see how the rather unusual and very compact feed water pumps are designed. The piston rod sheath, in which the piston rod moves back and forth, is 'isolated' from the cylinder with O-ring glands. Thus the piston rod can function as a pump ram. There is ample clearance between the rod and the inner surface of the sheath, so the water can flow freely back and forth.

The connection at the base of the sheath goes to a water-pump body. Both the left and right valve chests are seen in the photo. The clacks are of the common stainless-steel ball-valve type, and very compactly designed, incorporating both the suction as well as the delivery clacks in the same body. The quick sketch in Figure 35 shows the principle, and the parts needed.

Note that in order to avoid the clacks locking up, there must be a few nicks milled with a small bit in the 'ceiling' of the valve chambers – these nicks are marked with an asterisk. Without the nicks, it might be possible for the balls to be pressed up towards, and become stuck against the openings on top of the balls, preventing the water from entering or exiting the valve, causing a 'hydraulic lock-up'.

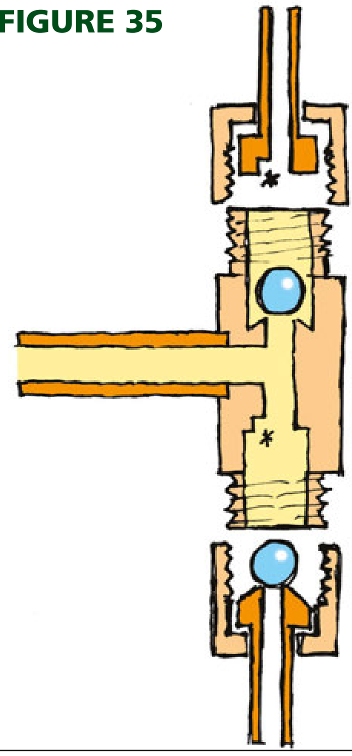
Photo 136 shows the assembled clacks. Note that the water enters the valve chest from below, supplied through a simple plastic hose. This is possible because the water is not under pressure at this point. The exit, under pressure, is from the top of the valve chest, through a silver-soldered copper tube.

Further details

The handrail studs are attached to the boiler with small tabs, Photo 137. By welding the tabs to the boiler only at the top edge, it was very easy to get them all to line up perfectly – by slightly lifting the lower edge of a tab away from the boiler, the angle could be precisely adjusted. In addition, the handrail was inserted during the welding, so that all the studs were lined up.

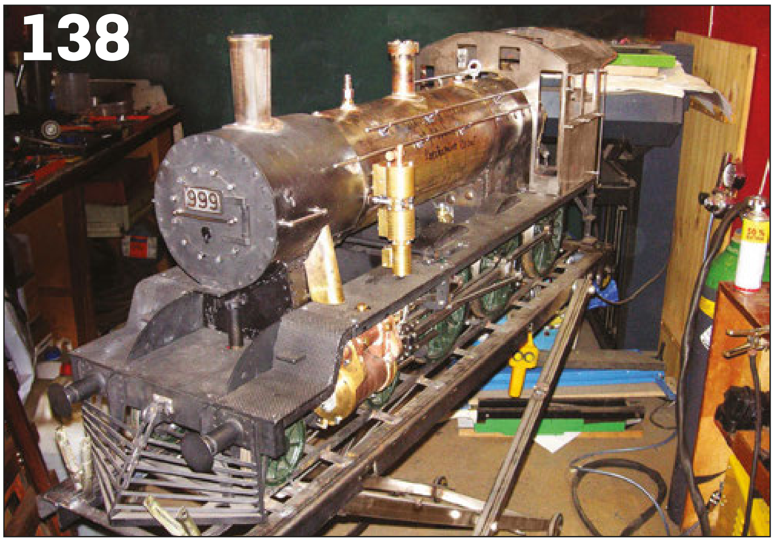
In Photo 138, all the handrails are in place. The tabs will be completely covered by the boiler lagging, so I didn't have to consider their appearance at all. Also tentatively installed in the photo is the still to be painted smoke stack as well as the lagging for the steam tubes from the smokebox to the cylinders, and the steam-powered water-and-air pump (the latter was described, with full drawings, in an earlier article).

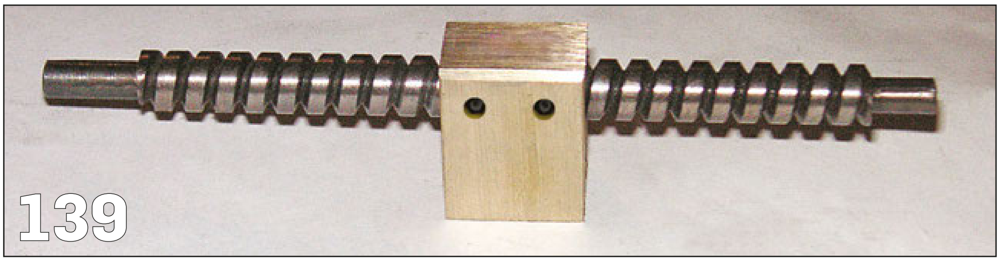
FIGURE 35



Since the original prototype has a screw reverser, I of course wanted my model to have one too. The construction of the reversing gear necessitated a left-hand screw and corresponding nut, and in order to get a prototype-like number of turns on the reverser, the thread pitch had to be very coarse. The only left-hand taps and dies I had in my workshop (6mm diameter, 1mm pitch) were not suitable at all. So, I had to think up a way of fabricating something – starting with an extra gear for the screwcutting gear train in the lathe.

Normally, a simple lathe like mine can only cut right-hand threads. But, by interspersing a single gear between the two last gears in the gear train that powers the feed screw, you can reverse its rotation. I made a small attachment to the gear 'banjo' to hold the extra gear, which can quickly be pivoted in and out of use. Now, I could run the ▶





lathe forwards, while the carriage was moved 'backwards', in other words to the right, by the lead screw. Choosing gears that provided a 4mm pitch, I could turn a screw coarse enough, Photo 139.

I could have made it as a double-start thread, too, but since that would have been even more fiddly, I decided not to. Since the diameter of the reversing screw is only 8mm, it would

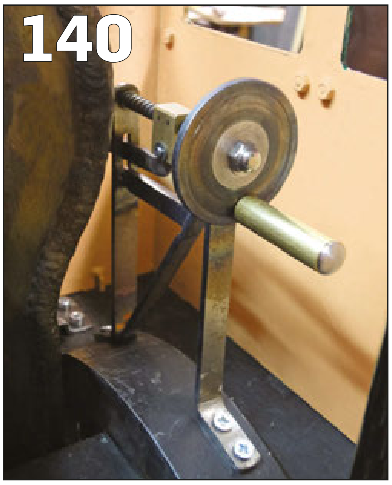


PHOTO 139: Reverser screw and its nut.

PHOTO 140: A very simple screw reverser.

PHOTO 141: A headlight incorporating a white LED lamp.

PHOTO 142: Two small motors found in a broken CD player.

PHOTO 143: Milling out a turbine rotor.

PHOTO 144: The parts for a simple turbo-generator.

FIGURE 36: A quick sketch of the turbo-generator.

PHOTO 145: Assembled but as-yet unpainted generator.

FIGURE 37: Schematics for a constant-current regulator.

have been a very fiddly task to cut an internal thread so precisely that there would be virtually no backlash in the screw-and-nut combination – not allowed in a reverser screw! So, I decided to experiment a bit...

Machining a brass block to suitable dimensions, and drilling and tapping four threaded holes in the block for four pointed grub screws, two on either side, spaced so that the screw points coincide with the thread, I got a 'nut' fitting the coarse reversing screw. It will be interesting to see how well this experimental nut will stand the wear and tear in the long run, but it has worked quite well for five years already – although not as smoothly as a proper, threaded nut.

Photo 140 shows the very simple construction of the reverser. As you can clearly see, I have not endeavoured to make it exactly per prototype, instead, according to my 'quick-and-dirty' philosophy.

Electricity from steam

The Ten-wheeler has a large headlight, shown in Photo 141, and also two other lights on the front buffer bar. Building these using white LED lamps (which should last for up to 10,000 hours if they are not overloaded) I didn't bother making the LEDs exchangeable – they are soldered in place and fixed with a few drops of epoxy glue. The reflectors are donated by inexpensive flashlights.

The turbo generator was an 'off-the-cuff' design, built in one weekend. The dynamo is a motor from an old, broken CD-player, which contained two identical small motors, Photo 142 (one turns the CD, the other moves the laser optics).

The motors had plastic gears pressed onto their axles, so it was an easy experiment to connect a multimeter to the little plug seen in the photo, and spin the motor with compressed air. It worked, the motor provided enough voltage and current to light several LEDs!

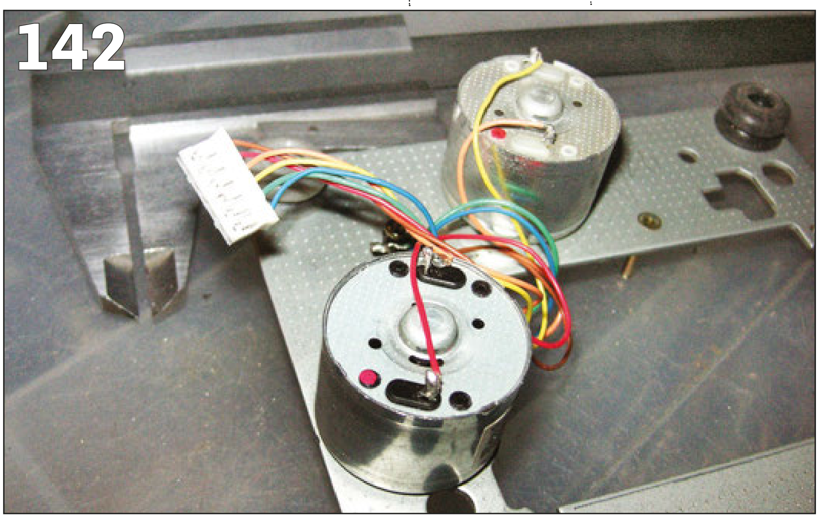
Most small DC motors can work 'in reverse' like this, generating electricity when spun. How efficient they are as generators, and what voltage and current can be expected from them, must be determined by experimenting. I got well over 100 milliamps at around 6 volts from these small motors. So, my next task was to build a turbine!

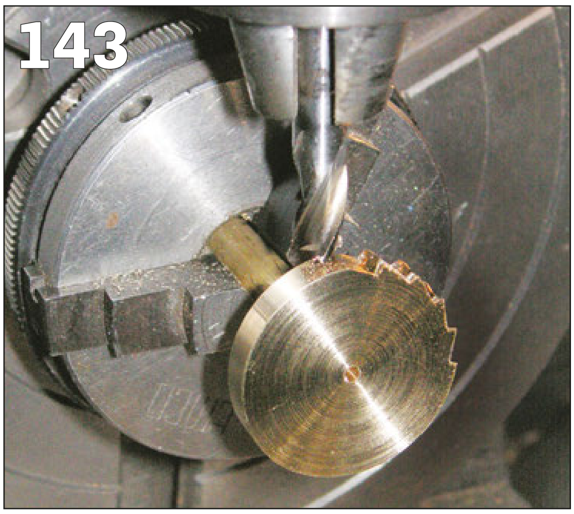
There have been many articles on how to build turbo-generators in hobby magazines, but I didn't use any published plans or drawings, I just 'ad-libbed' during building. A turbine wheel can be made in many different ways – I did it in perhaps the simplest way, milling it from a solid brass disk, about 4mm thick.

Photo 143 shows how – mounting the disk in a small chuck attached to my rotary table, I just cut notches in the periphery of the disk using a 6mm mill bit. Turning the rotary table 20 degrees between each cut, I got a turbine with 18 'blades', actually just notches with a curved inner edge.

All the parts for the turbine are shown in Photo 144, and the quick sketch in Figure 36 shows how they are assembled: A is the exhaust tube coming from the turbine enclosure B. The turbine C has a boss passing through the end plate D of the main body E.

The motor/dynamo H is pressed into a cover G, and its wires exit at O. The motor axle F exits through a piece of oiled felt N, which is prevented from being snagged by a Teflon washer M. A hollow Teflon axle L is pressed onto the motor axle, and into the turbine.





The end of the axle is steadied on a narrow brass cone **I**, attached with nuts to the end plate **J**. On the outside of the turbine casing there is a threaded fitting for the steam inlet, **K**, which is angled so that the steam jet impinges onto the curved surfaces of the turbine blades. Thanks to the little brass cone and the Teflon axle, the turbine is centred in the enclosure.

By adjusting the cone, and securing it in the correct position with the two nuts, the movement is smooth and without slop – very necessary, considering the speed with which the turbine will rotate!

Photo 145 shows the assembled turbo generator. The holes in the main body will allow any steam leaking through plate D to escape, while washer M and the oiled piece of felt N will protect the dynamo motor from steam.

"A turbine wheel can be made in many different ways – I did it in perhaps the simplest..."

String of lights

I connected the three white LEDs in parallel – even though parallel connection is not really recommended. However, it is possible, provided the LEDs are from the same batch, and in my case it was actually necessary, since the motor could not generate a high enough voltage for three LEDs connected in series (a white LED needs about 3 volts, so three in series would require 9 volts, while my generator provides only 6 volts.)

To prevent burn-out, the maximum current allowed is 30mA per LED, but due to inevitable small variations in their manufacturing, which are severely exacerbated when they are connected in parallel, I decided not to run them at full power, but feeding them only 20mA per LED instead. To do so, I connected a simple current-limiter in series with the lamps, using an easily obtainable regulator of the LM350 type.

The schematic in **Figure 37** shows how the regulator is connected. A resistor is needed to determine the maximum current. According to the formula, a value of 22 ohms will regulate the maximum current to a little under 60mA, or 20mA per LED, a safe value in my example.

Note that a LED is 'polarized', unlike an ordinary flashbulb lamp which can be connected either way; the LED's cathode lead is usually shorter and marked with a flat area on the round base. This lead must be connected to the generator's minus pole, in other words to ground.

The regulator also requires that the voltage is of correct polarity, otherwise it may be damaged (a DC dynamo will reverse the voltage if it spins the wrong way, so you need to check the polarity using a multimeter before connecting, with the generator rotating in the direction it will finally be running).

Thanks to the current regulator, the brightness of the LED lamps will be constant, as long as the generator rotates sufficiently fast to generate at least 4 volts at a 60mA load. Any excess power generated will be dissipated in the regulator, which will warm up a bit.

If the dynamo is very efficient and can provide a high voltage, it is of course important not to run the generator too fast – the ideal speed is only a little higher than that at which the LEDs reach a constant brightness. A simple adjustable steam valve can take care of this.

Next time, we provide the boiler with its water... EIM

■ Parts 1 to 10 of this series appeared in the February to November 2020 issues of EIM. Download digital back issues or order printed copies from www.world-of-railways.co.uk/store/back-issues/engineering-in-miniature or call 01778 392484.

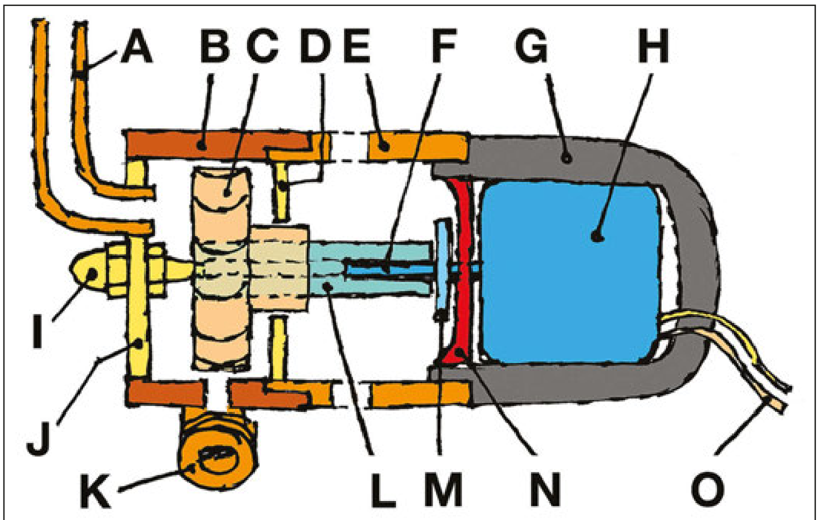


FIGURE 36

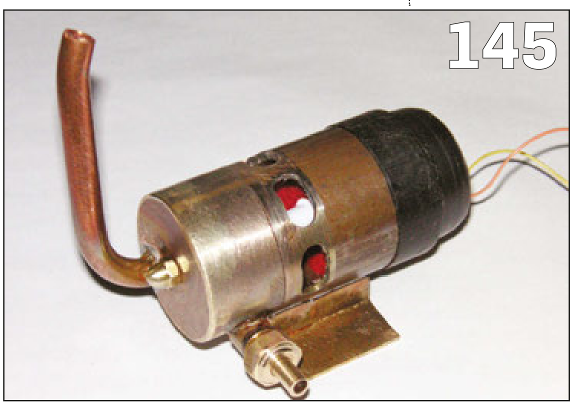
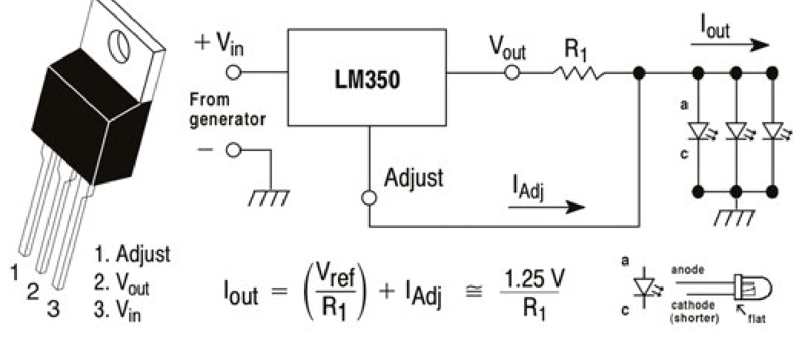


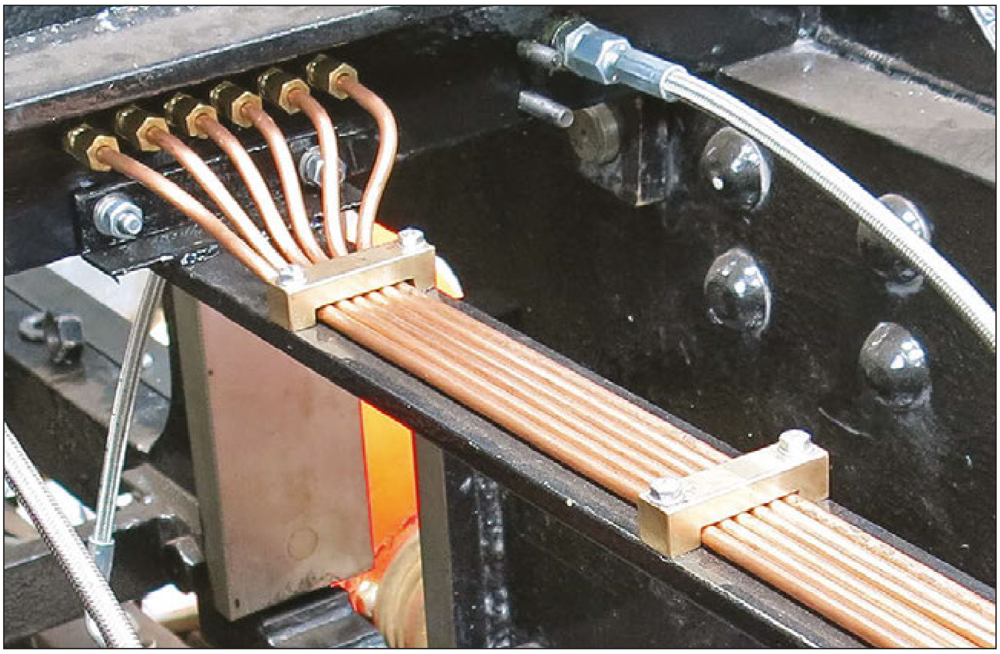
FIGURE 37



Bending copper pipe

Rich shares his thoughts and experiments on overcoming a common model engineering technique that is easy to get rather wrong...

BY **RICH WIGHTMAN**



HEADING: Well-curved pipes make all the difference whatever the size of loco – here on the Welshpool & Llanfair Light Railway. *Photo: Andrew Charman*

PHOTO 1: Set of spring-type pipe benders.

PHOTO 2: A 3/16-inch pipe being bent in a spring.

As the heading to this article suggests I'd like to show you my thoughts and the trials involved in successfully bending copper pipe. If you are a builder of steam or internal combustion engines (amongst other things) at some point you will have to bend copper pipe. Over the years I have tried many methods, some successful and some not so good, and relegated many unsuccessful attempts to the bin.

The pipe sizes I bend typically range from 1/16-inch to 3/8-inch in various gauges so I will concentrate on those sizes. Some of the smaller sizes, 1/16-inch to 1/8-inch can with care be bent by hand but the result is not always a neat finish and perhaps not the professional result one is looking for.

Way back when I first started model engineering the first pipe-bending kit I purchased was the spring type (**Photo 1**). These do work but do have their limitations. Creating a single bend is okay but once you get to three or more tight bends it is difficult to get the spring off.

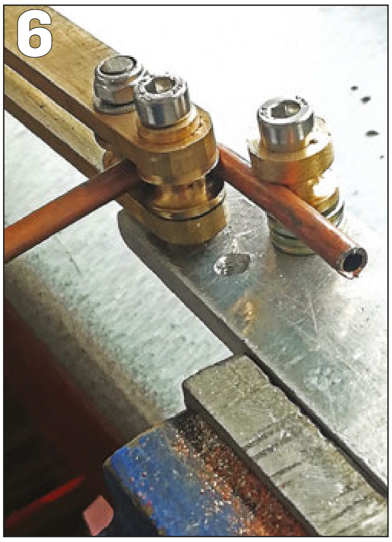
A second issue is that you can't solder nipples onto the pipe prior to bending and you should definitely not solder the nipples on with the spring still on the pipe! (don't ask me how I know..). You are of course still bending the pipe by hand, the spring (in theory) only prevents the pipe from collapsing.

Photo 2 shows a section of 3/16-inch pipe being bent with the spring method. **Photo 3** shows the result. It was not too bad but this was about as tight a radius as I could get.

The second tool I bought was one of these mini pipe benders (**Photo 4**). Once again they do work but only on pipes of 1/8-inch, 3/16-inch and 1/4-inch diameter . Really tight bends are not possible, the tightest bend has a radius of about 5/8-inch. **Photo 5** shows a bend in 3/16-inch pipe.

Looking for options

I wasn't overly impressed with the results of either the springs or the mini pipe bender so I did a bit of research. One idea I discovered was to fill the pipe with fine sand or salt, seal the ends of the pipe to prevent it running out and then proceed to make the bends. One then unseals the pipe and pours the sand or salt out.



This may work on larger-bore pipes but trying to get sand down a 1/8-inch diameter pipe isn't easy, trust me.

I understand there is a very low melting point metal that can be used to fill the pipe then melted out again afterwards, but this is not something I have tried. There are no photos of various methods that I tried basically because I had no success at all and at the end of the day I was still bending the pipe by hand.

A further method I tried was to fill the pipe with water, firstly sealing one end with a bit of Blu Tack and once the pipe was filled sealing the other end in the same way. The pipe was then put in the freezer for a few hours until the water had frozen solid then the bends made. After this one could either warm the pipe or wait for the water to thaw and run out.

This process works, that's about all I can say, but again you are still making the bends by hand and it is time-consuming waiting for the water to freeze.

The wheel method

During the course of my current loco build, 'Conway' a 3½-inch gauge 0-4-0, I needed to make a considerable number of pipes. Something better than the above-mentioned methods was needed so more research was carried out. There are some absolutely beautiful pipe benders out there that people have made complete with beautifully crafted wooden boxes to keep them in. But I'm more of a practical sort of bloke who just wants a bit of kit to work and is quite happy to keep it in a plastic ice-cream tub.

Having said that some good ideas were gleaned and a pipe bender duly constructed to bend 3/16-inch pipe (**Photo 6**). This worked okay but I found it rather difficult to reposition the pipe once the first bend had been made. Note also that the pipe is slightly crushed on the inner radius (**Photo 7**).

A Mark 2 version for larger pipe of 5/16-inch diameter (**Photo 8**) also worked okay but was still awkward in use and the same crushing of the pipe occurred (**Photo 9**).

At this point my good mate Julian who is building a Martin Evans Simplex loco was also having similar problems with pipe bending and came up with the idea illustrated in **Photo 10**, which is designed for 3/16-inch pipe. The handle is drilled 3/16-inch while the wheel part, which is silver soldered to the handle, has a 3/16-inch groove machined in it. This works fine (**Photo 11-12**).

PHOTO 3: The 3/16-inch pipe after being bent in the spring.

PHOTO 4: A mini pipe bender.

PHOTO 5: Bend in 3/16-inch pipe made with the bender.

PHOTO 6: Wheel bender for use with 3/16-inch pipe.

PHOTO 7: The 3/16-inch pipe bent using wheels – note slightly crushed inner radius.

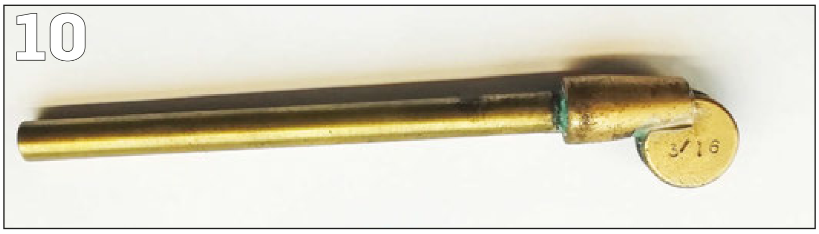
PHOTO 8: Wheel bender for 5/16-inch.

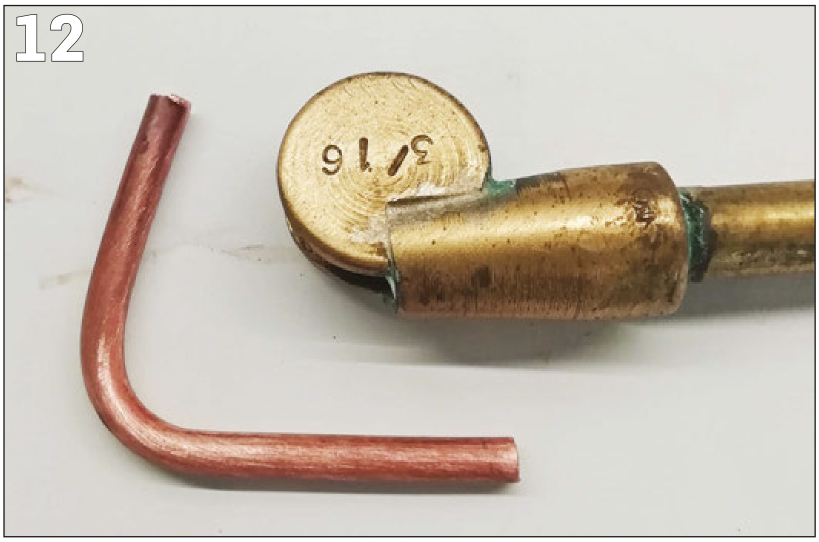
PHOTO 9: 5/16-inch pipe wheel bent, crushing on inner radius.

PHOTO 10: Fixed wheel bender for 3/16-inch pipe.

PHOTO 11: The fixed wheel bender in use.

PHOTO 12: 3/16-inch pipe bent using the fixed wheel bender.





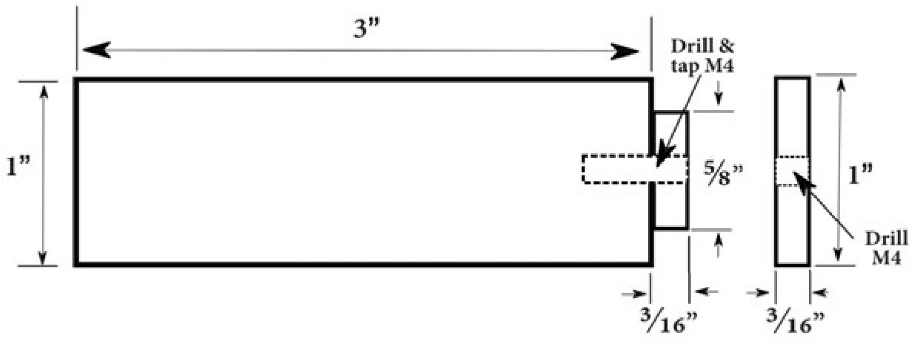


FIGURE 1

In trying all these bits of kit pipes were bent and fitted but I still wasn't 100 per cent happy with the results I was getting. I decided to give the problem one more go so I researched the subject again looking for something simple, quick to make and which above all would work.

When carrying out research on the internet one will find a link that leads to another link that leads to well, so on and so forth, until deep in the bowels of somewhere in the world I came across the following idea, about as simple as you can get and not difficult to make. Photo 13 shows a trio of pipe benders that I have made and I have to say they work absolutely perfectly every time.

Simple build

Construction couldn't be easier. The 3/32-inch and 1/8-inch bender is made from 9/16-inch round steel bar. The 3/32-inch end is the only end I didn't bother to use a separate washer, the small pipe being easily removed from the slot.

The 3/16-inch and 1/4-inch bender is made from 1'-inch round steel bar and the 5/16-inch and 3/8-inch bender is made from 1½-inch round aluminium bar.

I will describe the making of the 3/16-inch and 1/4-inch bender. Take a piece of round bar, something from the scrap box will do, steel, brass, aluminium, it doesn't matter which but it needs to be around an inch in diameter for pipes up to a 1/4-inch.

In the lathe centre drill and then drill tapping size for say M4. Part off a thick washer about 3/16-inch thick. Tap the body M4 and drill the washer part 4mm.

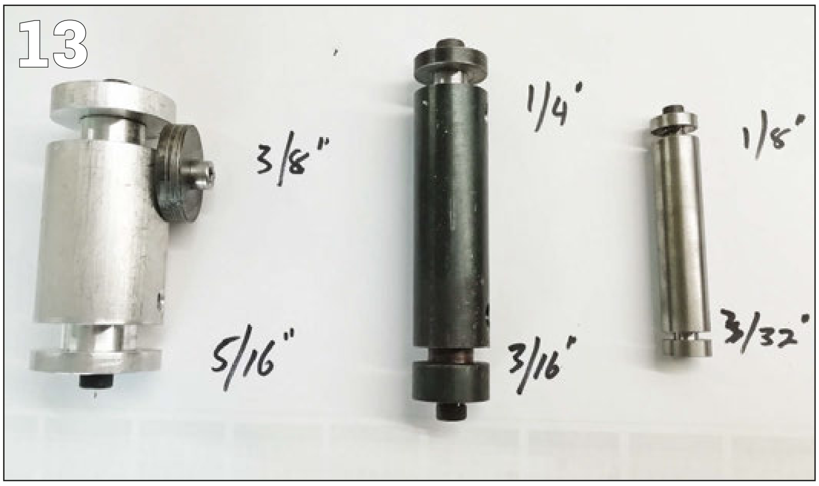
Turn a shoulder on the body part 3/16-inch wide and 3/16-inch deep. It doesn't matter if it is a little deeper but the width, 3/16-inch must be correct – Sketch 1 will give you an idea of what to aim for.

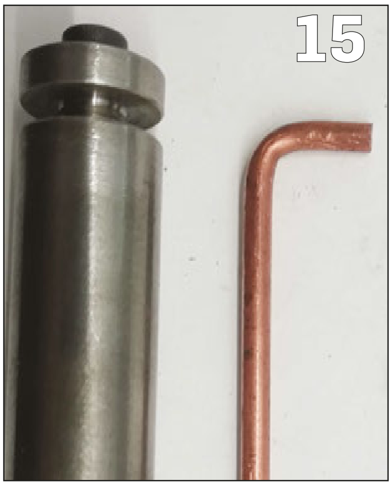
For larger pipes it makes life easier to drill and tap the side of the body and fit a thick washer that is large enough to cover the slot, this will hold the pipe in place. The same big washer can be used on both ends of the two larger benders, see Photo 13. That's all there is to it – machine the other end in a similar fashion but sized to take 1/4-inch pipe.

The tool can be hand-held or used in a vice. In use it helps if you anneal the pipe first then re anneal for each bend. To use the bender simply pull the pipe around the groove. The walls of the groove prevent the pipe from collapsing and going out of shape. To reposition the pipe for the next bend slacken the bolt/bolts a little, move the pipe and re-tighten the bolts.

Photos 14 to 17 show some sample bends in pipes of 3/32, 1/8, 3/16 and 1/4-inch diameter. As can be seen quite tight bends are achievable. If a bend of a particular radius is required it's a quick job to knock up another tool to the required radius.

The tool is cheap, easy to make, will last a lifetime and above all does the job. I hope readers will find this tip of use. EIM





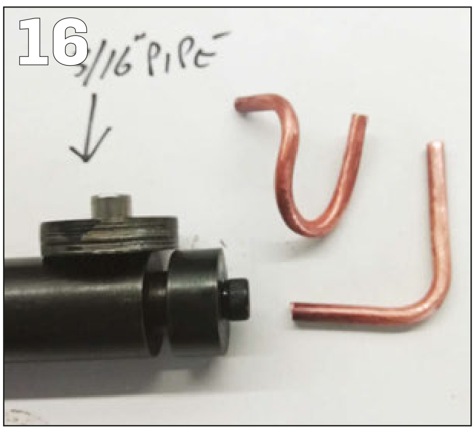


FIGURE 1: Drawing of the 3/16-inch end of a pipe bender.

PHOTO 13: A trio of home-made pipe benders.

PHOTO 14: A sample 'hairpin' bend formed in 3/32-inch pipe.

PHOTO 15: Similar process in larger 1/8-inch pipe section.

PHOTO 16: More complex bends in 3/16-inch pipe.

PHOTO 17: It works just as well in larger 1/4-inch pipe.

All photos and diagrams by author unless stated

Milling Arbour and Overarm Support

Graham provides us with another useful workshop addition – in his case for an Emco FB2 mill but easily adaptable to other machines.

BY **GRAHAM MEEK**

When carrying out any machining it is a Golden Rule to always reduce the overhang to an absolute minimum, this applies equally to the tool as to the workpiece. If this overhang is unavoidable then additional support will be needed.

When I had my first Emco FB2 milling machine about 30 years ago I was never satisfied with the finish when doing gear cutting, or using a large side and face cutter of about 75mm diameter with the standard Emco arbor. Among accessories on offer from Emco for this machine the largest side-and-face cutter is 50mm diameter – when mounted on the arbor and the diameter of the collars removed from the 50mm diameter one is left with a usable 12mm depth of cut.

This will suffice for most applications where you need to machine a slot of 6mm or wider but it is not so good if a slot 5mm wide is wanted. The diameter of the cutter is now only 35mm and the maximum usable depth of cut 4.5mm without the arbor spacers rubbing.

The diameter increase for slitting saws, but the maximum size available from Emco is only 63mm diameter by 0.8mm wide – fine for making a screwdriver slot in a component, or a split for a clamping ring such as the Depth Stop used on the Compact 5 lever-operated Tailstock Attachment in Chapter 3 of my *Projects for your Workshop Volume 1*, (TEE Publishing). The above suggests that the manufacturers are trying to restrict the size of tooling used with their Morse taper arbor accessory.

It may be of interest to mention at this point the bearing arrangement in the quill assembly of the FB2 mill, starting with the bearing nearest the bottom portion of the quill that we all see. This is a high precision needle-roller race matched to the spindle, which itself being the inner rolling member is hardened. A word of warning, never replace this bearing with a standard over-the-counter version from a bearing factors. Currently a standard commercial bearing costs around £12, the Super Precision is £60.

At the other end of the quill are two deep-groove ball-bearing races, both specially manufactured and selected. Should the reader ever take the spindle apart these bearings have a marking on the outer track and need to be replaced in the same order as they were removed. Also be aware of the left-hand thread retaining these to the spindle, as the position of the markings on the bearing slightly pre-loads the assembly to take out any axial play.

Another cause for concern among new owners is that with the spindle stationary there is a small amount of sideways play, detectable with a 'clock'. This disappears when the spindle is rotating, or as bearing manufacturers say, 'has become dynamic'.

What this means in reality is the rollers of the needle bearing start to climb over the film of oil that tends to fill up the quill over time after making its way in through the top bearings. What small radial clearance that once existed is now taken up by the oil.

Any reader thinking the oil is compressible should consider how a hydraulic actuator, or cylinder works. Oil under pressure is forced into the cylinder and it moves the ram. The movement of the actuator is not at all spongy, unless there is air in the system, so with the roller race in the quill the oil is being churned up at an enormous rate and under pressure. But this pressure will vary with the revolutions of the spindle, the oil being most effective at top revs and least effective at bottom speed.

Need for support

With this bearing arrangement in mind and the fact that I want this machine to last my lifetime, taking good care of the spindle would seem to be a good move. If one thinks about how far away from the spindle nose these cutters are mounted in comparison to the distance between the two quill bearing sets, the Golden Rule should be applied and some form of additional bearing support would be required if I was to use larger slitting saws or side and face cutters.

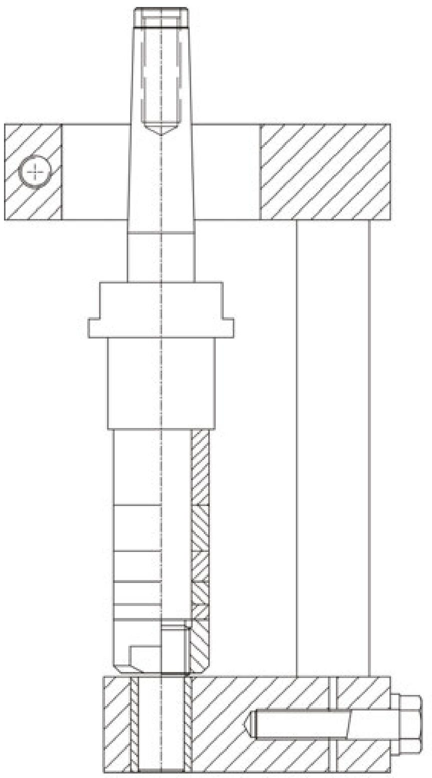
ABOVE AND BELOW: The completed milling arbour and overarm support – a useful addition to the workshop.

All photos and drawings in this feature by the author

Thus the design you see in the photographs evolved – further examples of the arbor and support in use can be seen in my article on the Myford Handwheel Dial, (**EIM** March-May 2007). I see no reason why this design cannot be adapted to fit the copies that exist of this machine but those with the Myford-type spindle nose will need to be made somewhat longer to accommodate this extra length.

The arbor and overarm shown was first made in 1986 and today the bearing shows no detectable signs of ▶

GENERAL ARRANGEMENT



wear. It was intended from the outset not to use cutters larger than 75mm diameter – if the reader has a stock of 80mm diameter cutters then the 60mm over-arm centres distance will need extending to something like 65mm. I would not consider cutters any larger than this being kind to the machine even with the additional support provided by the overarm.

There is an Achilles Heel in the FB2 in the form of a Tufnol gear, which takes the drive from the motor before it enters the milling head gearbox – these have been known to strip due to misuse and it was one of the reasons I designed the Spindle Lock shown in EIM in October 2012.

All drawings on these pages reproduced approx half full-size

As with the construction of the Slotting Attachment for the FB2 (EIM May/June 2008), it is a good idea to turn up a plug gauge from a short end of mild steel – the outside diameter turned to exactly the same size to that of the quill. The reader can fit this with a knurled detachable handle if wished, though a simple tapped hole for a bolt will suffice for a handle.

Clamp and support

The block that clamps around the quill and the detachable bearing support need to be worked on together as they will be machined as a pair when it comes to the holes, as all of these holes all need to be in line.

I made my attachment from aluminium as this was to hand and it has virtually the same damping characteristics as cast iron, plus it machines fairly easily. There is no reason why mild steel cannot be substituted. I would not recommend cast iron for the clamping block, but it could with advantage be used for the bearing support as it would not need an Oilite bush – this could then be used as a salvage scheme when wear finally does become a problem in a cast iron clamping block.

Cast iron could also be substituted for the Oilite bush in the aluminium version if desired, but where cast iron is used there will be a need to provide some means of oiling the bearing, either through a drilling or a spring-loaded oiler in conjunction with the oil gun. The Oilite bush on the other hand will absorb and retain oil for long periods, even so I always make a point of lubricating this bearing each time I mount the attachment.

It will be seen from the photos that all faces of the blocks are machined, these faces need to be flat and parallel to one another otherwise when the blocks are un-clamped after putting in the respective holes the initial care taken to get all the bores in line will have been wasted – the clamping forces will have distorted the blocks because they were not flat.

We therefore start by bringing the blocks to overall size and for now it is best if the bearing support block is left rectangular. Taking the clamping block and using coordinate location, centre drill, drill and ream 8mm diameter for the quill bore location. Before you un-clamp this part provide some form of stop(s) so that you can substitute the bearing support block in place of the clamping block.

Once the bearing support is in place, centre drill, drill 8mm diameter then tap the hole M8. This will allow the two blocks to be bolted together for the purpose of setting-up. But before this we need to put a filling in the sandwich in the form of an aluminium packing piece about 6 to 8mm thick – this needs to be 2mm shorter on length and width, but above all it needs to be fly-cut on both faces, and these faces need to be parallel to one another.

Using coordinates drill an 8mm hole where the spindle centre line will be, not forgetting that the material is shorter than the blocks otherwise your hole will be offset. The object of the exercise is to have the sandwich filling 1mm below the crust all round. Build up the sandwich using an M8 capscrew or hex headed bolt.

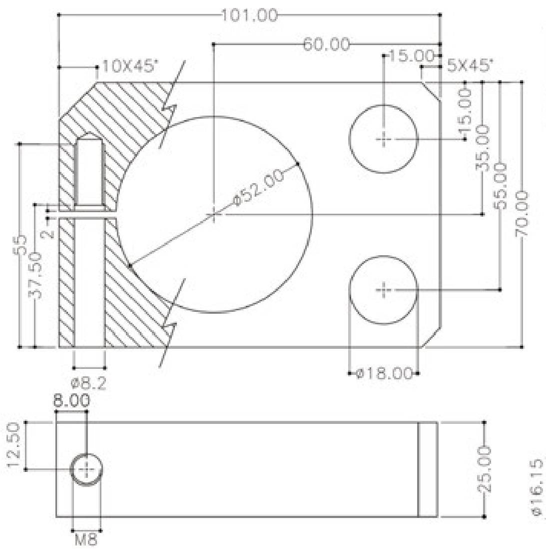
Before the assembly is fully tightened, place the assembly on the surface plate with the longest edge on the surface plate and the shorter edges urged against an angle plate or cube, then tighten the M8 fixing. If you do not have a surface plate, angle plate or cube, the table of the milling machine will double as the surface plate – a parallel of about 12mm thickness clamped to the table will provide an edge to urge the blocks against to keep them in line.

Returning the sandwich to the original set-up in the vice or on the machine table, it will now be possible to put in the support bar bores again using coordinates. If you do not have a reamer to do this, there are two alternatives. One is to bore the holes with a boring head (how I did mine).

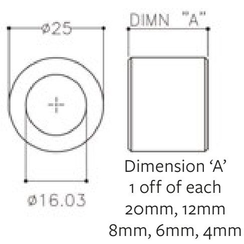
The second is to drill and ream the support bar locations 6mm diameter then transfer the work to the lathe, mounting the sandwich on the faceplate. Each bore would then need to be clocked to run true.

To ease setting-up the sandwich can be held roughly in position whilst the clamps are attached with a 6mm dowel held in the tailstock drill chuck. Never rely on this as an accurate means of location – if you do not believe me then put a clock in the bore afterwards. Nine times out of ten it won't be running spot on.

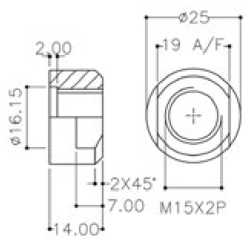
Once both 18mm bores have been completed two hollow location dowels are required, the length of which need to be slightly shorter than the overall height of the sandwich. They need to be a good fit in the 18mm bores, so that when the M8 fixing bolt from the quill location is removed they maintain alignment.



CLAMPING BLOCK



SPACERS



LOCKING COLLAR

You may be wondering why use hollow dowels? Well when mounted on the faceplate the hole through the dowel can be used to clamp through. When I did my own blocks I passed bolts through these hollow dowels with large washers either side and nuts. This made sure the blocks were firmly clamped together at all times.

It now remains for the quill bore to be machined in one block and the bearing bush bore in the other. When faced with a job of this nature it is always easier to put the smaller hole through both parts first, thereby avoiding having to measure the smaller bore through the larger, especially if no reamer is available. However in this case there is plenty of room due to the size of the Quill bore.

If the reader did decide to make the bearing block out of cast iron then this bore can be finished at 12mm diameter, as no bush will be needed. The larger Quill bore wants to be a nice easy slide fit on the plug gauge, but there is nothing to be gained from making this a really good snug fit as fitting the overarm will be a real pain when it really does not need to be.

When the bores are complete the sandwich can be dismantled. An allowance of 0.25mm (0.010-inch) on the overall length should be left on the bearing block, to be removed later when the radius is finally machined. This end face is best machined as it makes drilling the M8 tapped hole for the clamping bolt easier, plus it will also be easier to hold the block square whilst the 2mm wide slits are machined from either side.

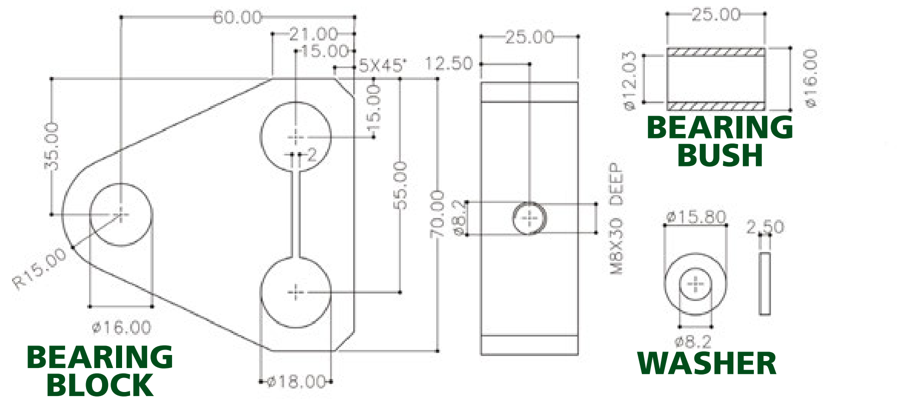
Before the block is removed from the vice it would be a good idea to machine the two 5mm by 45-degree chamfers, if the reader has a 45-degree inverted dovetail cutter. Otherwise it will be necessary to tilt the block over at 45 degrees each way to machine these with the side of an end-mill.

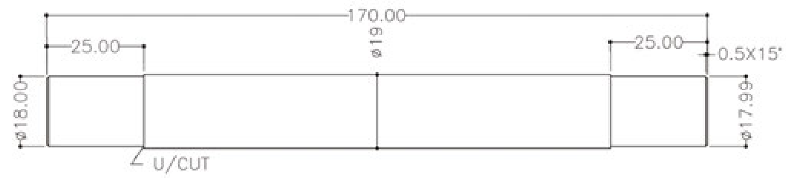
When the slits are completed, mark out the profile and remove the bulk of the material with a hacksaw, or on a bandsaw if you have one. Mount the block on the rotary table resting on the sandwich filling piece, this will ensure the table is protected. The filling piece may need to be shortened if you are using the Emco rotary table or something smaller. Try to get at least one hold-down bolt through one of the 18mm bores and a clamp on the opposite corner.

Clamping block

With the bearing block complete we can turn our attention to the clamping block, starting with the 45-degree chamfers – the smaller 5mm ones can be machined with an inverted 45-degree dovetail cutter but the larger 10mm one is best tackled with

“Aluminium has virtually the same damping characteristics as cast iron, plus it machines fairly easily...”





OVER ARMS

the side of an end-mill.

It is best to drill and tap the M8 clamping bolt hole prior to splitting and taking the 8.2mm diameter clearance hole about 1.5mm past the 2mm wide slit. This will make screwing in the bolt much easier.

The final operation is to machine the slit with a 2mm wide slitting saw, if you chose to make this part out of mild steel then when the saw gets to the end of the cut be on your guard. Depending on which way the grain of the material is running one of two things may happen. There could be a largish bang as the saw breaks through, and after opening your eyes again you may be very surprised to see that there is no damage.

What will have happened is that the material has sprung apart due to the locked-up stresses and the bore is well oversize. Don’t be alarmed, when the clamping bolt is inserted this will close up – under no circumstances tighten this down without the clamp being around the Quill. As the part may take on a permanent set in an undersize condition, believe me what you have now is a distinct advantage.

The other alternative is the opposite to the above, in that the block closes in on the slitting saw. This is not good, and the best way to avoid this is to machine the slit from one side approximately 75 per cent through the 25mm thickness. Then insert a piece of steel or brass 2mm thick in this slot; it needs to be a very good fit but you can get away with feeler blades provided they are kept away from the slitting saw.

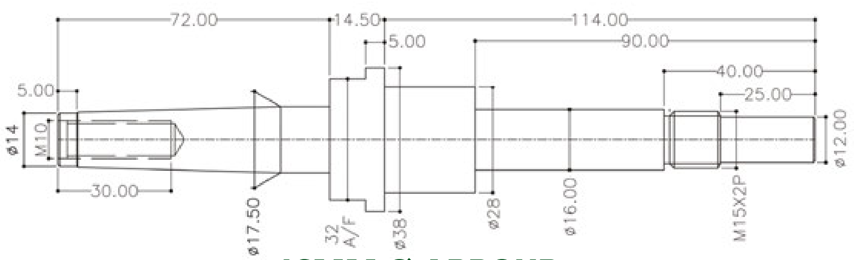
Now move the slitting saw to the other side of the block and continue cutting the slot, if it does choose to close in then it will now trap the insert or feeler blades rather than your slitting saw. However Sod’s Law dictates if you follow this latter course the former condition happens – trapping the slitting saw only ever happens when no preparations have been made for it to happen.

I made the two bars that form the over-arms from silver steel as this was to hand. The choice of ¾-inch or 19mm, even 20mm is up to the reader. Some might say why not use 18mm straight through and this is possible but bars from 19mm are substantially more rigid, due to the cross-sectional areas of the two different sizes of bar.

A centre is machined in each end after bringing the bars to overall length – a BS3 centre drill producing a cone about 4-5mm diameter is all that is needed and at the same setting the 18mm diameter locations can be roughed down to something like 18.30mm diameter by 25mm long.

The location diameters that go into the clamping block will benefit from a shallow undercut to ensure that the larger 19mm diameter section firmly abuts the clamping block. Lightly break the sharp corners with a ▶

“There could be a largish bang as the saw breaks through, and after opening your eyes again you may be very surprised to see that there is no damage...”



16MM Ø ARBOUR

0.025mm by 45-degree chamfer. However the 18mm diameters themselves benefit from a 0.5mm by 15-degree lead-in chamfer, especially on the bearing support end as this will aid assembly.

The bars are now mounted between centres and the location diameters brought to a nice snug fit in the clamping block – verging on a press fit is desirable. The opposite ends need to be a nice slide fit in the bearing block – I have dimensioned this at 17.99mm diameter to signify the lower limit to aim for. Too good a fit and you will be annoyed every time you have to cajole the clamping block onto the arms. Too slack a fit and excessive force will be needed to clamp the bearing support to the bars.

Black art

Now we come to the arbor, a big problem area for a home machinist. Why do I know this? Well I too used to fight shy of machining Morse tapers, like screw cutting and dovetails. When I first started out all the Morse tapers that I used were the sawn-off shanks of broken drills, until one day I said "No, I have to master this demon before I can call myself an engineer". The learning curve was not easy, but not much in life is. George Thomas wrote an excellent article on Tapers and Taper Turning in chapter 13 of his book *The Model Engineers Workshop Manual*. You will find that this helps no end.

For those who wish to buy an arbor it can be made from a suitable blank with a silver-steel shaft let into the boss section, by boring a really snug-fitting 16mm diameter hole at least 20mm deep. This is tapped M10 in both the Morse taper blank and the silver steel arbor about 15mm deep. The parts are then assembled using high-tensile studding or a sawn-off high-tensile set-bolt. This principle was used in the case of the composite head on my Retracting Screw Cutting tool (EIM June 2012).

There is however one word of caution required when choosing this route – even though the joint you have just made is inherently very strong it needs to be borne in mind that when tightening the locking collar the thread being tightened is 15mm diameter, that holding the arbor together only M10 plus Loctite with a shear strength of 22 N/mm^2. If used with care this joint should not fail, but overtighten and the joint could give up the ghost during a machining session. This approach will probably mean a longer arbor, that in turn will mean longer overarms.

ABOVE: The clamping block and its over arms – careful construction is essential to ensure the accuracy of results when machining.

BELOW: The clamping block, over arms and bearing block.

Taper turning

For those who wish to put the taper turning demon to bed, first equip yourself with a Morse taper socket to check the taper with. Using the milling machine spindle socket is fine but hardly convenient and if this taper should be bruised, it will give a false result when testing.

I have a reduction sleeve originally supplied to fit a lathe headstock socket – this is No 4 Morse on the outside, No 2 on the inside. This bush is open-ended and has no slot to take a tang from say a drill shank, a socket with this feature is of no real use. I have seen it advocated that the tang end can be cut off such a sleeve with an angle grinder to use this for gauging purposes. How exactly the remaining 'Gauge part' of this socket will remain true after being subjected to all that heat just escapes me.

The beauty of my socket is that when the taper is machined to the correct dimensions, the plain potion at the end is fully through the socket. The junction point where the taper and this plain diameter lies is in line with the end of the socket.

The second part of the kit is a dial test indicator, (DTI), that can be set somewhere near the centre-line of the lathe. This can measure the run-out of the taper blank over the given effective length of the taper when setting over the tailstock for instance, or if the topslide on your machine has sufficient travel to machine the taper. Then the clock can be used to clock an existing taper, say a precision-ground setting mandrel so that the angle is virtually spot on before starting.

When the taper is machined to about two-thirds the finished length, start testing this with the sleeve. Run a line of marker pen down the length of the taper, or a soft pencil, there's no need to completely cover it with micrometer blue. Put the sleeve on and gently twist back and forth while applying moderate axial pressure along the taper.

Remove the sleeve and see where the marker pen has been removed, this usually shows as bright rings. If the pen was removed all the way along the taper proceed with the machining, but continue to check from time to time.

If you need to make adjustments use a clock to measure exactly how much, and in which direction things were moved, be it the topslide or tailstock. Above all write this down, as it can always be returned to where it was beforehand, especially handy if the adjustment was made in the wrong direction. Too much adjustment can always be moved back by half of what it was moved initially.

There is another Golden Rule, and that is to make the first taper on a scrap piece of steel (it will always make a spigot mandrel blank). Then when the setup is correct, machine the actual part. Finish by turning up a few more blanks you will always have them to hand when you want one.

If you are turning between centres the 'dummy part' needs the centres to be exactly the same as the arbor otherwise the taper will change between components. This is no big deal; it just means a small adjustment, but you need to be mindful of this variation, which may come about through a simple oversight.

When you have mastered the black art of Morse Tapers, you have joined a select band of brothers and you will wonder why you fought shy of them for all those years, as they are not really such a big deal.

Making the arbour

The arbor is best made out of EN8 or silver steel if you can obtain this diameter, as these two materials offer the greatest durability, but mild steel could be used at a push. The part is first brought to overall length and centred at the same time. It is best to remove as much of the material as possible leaving about 0.5mm on all the diameters whilst leaving about 0.25mm to come off the lengths.

When the shaft is roughed-out, start the finish-machining process with the drawbar thread – this needs to be relieved for about 2mm deep at something like 10.25mm diameter in order to machine a 60-degree cone about 0.5mm long for turning the part between centres.

Whilst at this setting turn the plain portion at the end of the taper and at the junction point with what will be the taper I have found it best to chamfer the edge at 45 degrees right down to the diameter just turned. A square corner here can easily be damaged on insertion to the Morse taper socket – a chamfer does not.

I usually continue to finish the taper outright, this is then mounted in the Morse taper socket in the lathe mandrel and supported with a centre – for added security a drawbar can be used through the mandrel if desired.

Alternatively the part is mounted between centres to finish both the taper and the arbor portion. The 12mm diameter wants to be a running fit in the bearing support bush – a clearance of up to 0.03mm will ensure the two parts do not seize and that there is adequate space for an oil film.

Obviously if the fit is too loose the arbor will rattle around in the bearing and the support will not be doing as good a job as it could be. This will probably propagate chatter between the cutter and the workpiece.

I chose to use an M15 thread by 2mm pitch for the locking nut, M15 was chosen because it was below the arbor diameter. A truncated M16 thread could be substituted if preferred but either case the threads do need to be screw cut.

Any run-out, or out of squareness of this thread will distort the arbor and all the care taken turning the shaft will have been wasted. A cutter put onto such an arbor will have a distinct wobble as the locking collar nut will tend to distort the 12mm bearing, and the cutter will never cut true to size. Care in making both threads will be well rewarded, and as M15 is a non-standard thread both my threads had to be screw cut.

The arbor portion proper wants to be about 0.01mm maximum down on size which in this case is 16mm, but there is no reason why this arbor cannot be made 15.875, (⅝-inch), 19.05, (¾-inch), 22, or 25.4mm (1-inch). It goes without saying that all the respective diameters will need to be increased in proportion. I have always chosen to make stepped washers for those cutters which have bores larger than the arbor, the choice is therefore yours.

The locking collar nut needs little explanation other than the locking face and thread must be square to one another, and are best machined at one setting. It's a good idea to machine the 16.15mm diameter by 2mm deep thread relief at the same time thereby ensuring absolute concentricity.

Spacers

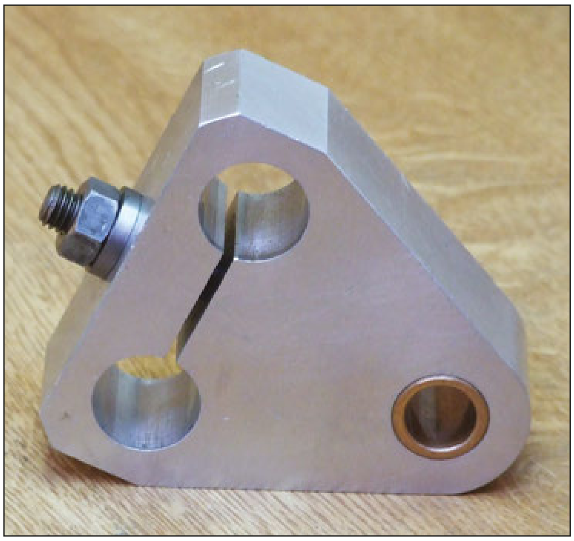
The spacers can be made from silver steel, or as in my case stainless steel, though mild steel can be used if preferred. These spacers need to be parallel over the faces, or once again the arbor will be distorted. It will not matter if the spacers are slightly over or undersize on length, parallelism is what counts.

It is advised that the bores and outside diameters have a 0.5mm by 45-degree chamfer. Once the part has been parted off oversize on length the longer parts can be mounted on a slightly tapered mandrel and both faces lightly machined with right and left-hand facing tools, the chamfer on the bore affording a run-out for the tool before it touches the mandrel.

The thinner spacers are best held in a split 'Pot Chuck' gripped in the lathe chuck, with the parted-off face outermost. This can then be lightly cleaned up. This type of holding device is used by watch and clock makers in the form of 'stepped collets', and there is no reason why this pot chuck cannot be initially machined before splitting to accept several diameters in the same way.

Any slight variations in thickness can usually be rectified with a few figures of eight on a piece of 400 grit Wet or Dry paper – I usually stick a piece down with double-sided tape onto a flat machined surface that I can grip in my vice. Or the part could be rubbed on an oilstone of suitable size again using the figure of eight to ensure even contact on the face.

All that remains to do is to machine a couple of thick mild steel washers – using standard commercial washers will probably lead to the aluminium distorting over time. A standard washer will probably also overhang the front edge of the clamping block and as well as being unsightly, is a potential sharp edge waiting to cut.



"Any run-out, or out of squareness of this thread will distort the arbor and all the care taken turning the shaft will have been wasted..."

ABOVE: A close-up of the bearing block.

BELOW: The 16mm diameter milling arbour complete with its spacers and locking collar.

The over-arms are assembled into the clamping block using Loctite 603, even if you have chosen a press fit and you have an arbor press I would still recommend the journals are smeared with Loctite as this assists the parts to slide together, with very little risk of pick-up in the aluminium. Also if the fit is not quite as good as intended the Loctite is there to take action.

When assembling parts with Loctite it is a good plan to have the bearing support gripping the outer ends of the overarms while the Loctite sets. I always allow a 24-hour setting time and I usually plan to assemble the parts one evening ready for my next shop visit the following evening. The bolts will benefit from some anti-seize grease or graphite grease to ensure they do not pick-up during use. You have the choice of M8 cap screws or hexagon headed bolts, I chose the latter as this is a standard Emco spanner size and is always to hand by the machine. EIM

■ Next time Graham describes methods of adding extra support to his overarm setup.

Behind the Shed Door

In the first of his new regular series, EIM's technical editor describes some of the mechanical challenges and solutions in his new role at the Fairbourne Miniature Railway.

BY **HARRY BILLMORE**

PHOTO 1: Entrance to Harry's new domain – 'Russell' peeks into the sunshine awaiting the boiler inspector.

PHOTO 2: The compact machine shop. Harry is working on the larger Colchester Master lathe – a smaller Myford, visible at left behind the pillar drill, has recently had to endure editor Charman for a few days. *Both photos: Andrew Charman*

PHOTO 3: The kind of challenges Harry discovered – the washout plug on Russell is neatly obscured by pipework.

I recently took up the position of the Engineer at the 12¼-inch gauge Fairbourne Miniature Railway – this came as a bit of a surprise as I hadn't quite intended on moving jobs in the middle of a pandemic as well as moving house from west Yorkshire to mid Wales. However for me it seemed to be the perfect role, which so far, it has turned out to be!

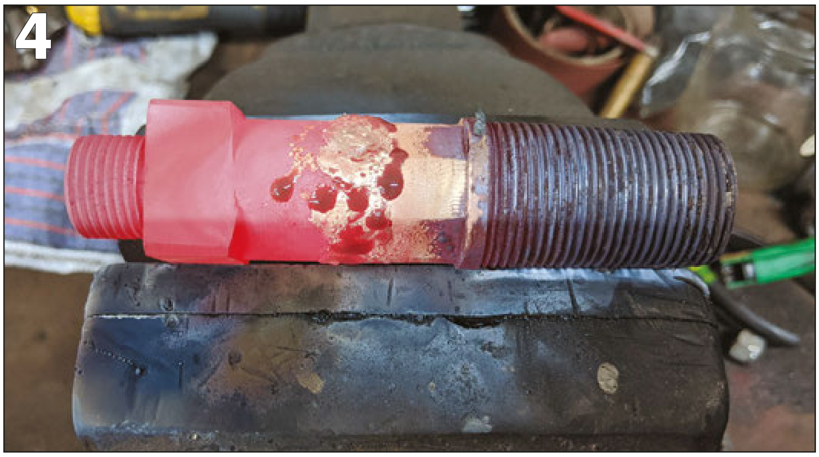
The previous engineer had left in January, but due to the pandemic, I did not start until September. With the railway itself having reopened on 14th July following lockdown, I was from the start of faced with an interesting backlog of the usual running repairs and failures. Thankfully the railway is well provided for in terms of stock, with four steam locomotives and nearly 20 carriages – of these one of the locos ('Beddgelert', built by David Curwen in 1979 as a half-size model of the 1878-built North Wales Narrow Gauge Railways Hunslet 0-6-4T of the same name) is out of service awaiting a major overhaul and boiler work, for which there is an appeal underway if any reader would like to help return her to use! (Details are on the railway's website at www.fairbournerailway.com).

The other three locos had started the season well, however an axlebox issue on 'Sherpa' (a half-size Darjeeling B-class 0-4-0ST built in 1978 by Milner Engineering) meant that the railway was down to two engines within a couple of weeks of starting to run.

Reliable fleet

Thankfully apart from routine brake adjustments, before my arrival there had been only a single failure in the season. This was the brake shaft snapping from the brake cross shaft on 'Yeo' (a half-size Lynton and Barnstaple Manning Wardle 2-6-2T, also built by Curwen in 1978), and the problem was quickly rectified by one of the fitters from the Talyllyn Railway just down the mid-Wales coast from Fairbourne.

The final loco on the roster is 'Russell', which emerged from the Milner workshops in 1979 as a scale model of a Leek and Manifold Kitson 2-6-4T. This had the distinct drawback of the cab being tiny, so within six years the loco was rebuilt at



Fairbourne as a representation of Russell from the Welsh Highland Heritage Railway, with a much roomier cab and larger tanks. This loco presented me with my first major task on arrival as the annual boiler ticket expired the week after I started.

I used that week to start figuring out how the railway worked and where everything was in the workshop – like many workshops, my own personal one included, it had got very cluttered over time, to the point where I was moving several things out of the way to access some of the machine tools. Thankfully it is a very well equipped facility, and once I had carried out a mega tidy up, I then had all the resources I need to do most jobs.

Plug problems

Once I started stripping Russell down to wash the boiler out ahead of its inspection, it soon became apparent that I would need to get quite creative with removing some of the foundation ring plugs The two front plugs that face outwards from the side of the outer wrapper were tight in the cut outs in the frames, while the right-hand side one had the injector pipework running directly in front of it. This one came out with a suitably modified spanner after removing the injector pipework.

The left-hand side one, which also has the blow-down valve screwed into it, was another matter entirely. I believe that the boiler has moved back slightly from when it was first fitted, as the corners of the plug fouled the opening and there was not enough room to get any sort of spanner in to turn the plug more than an eighth of a turn. I solved this problem by brazing a bronze hex fitting to the end of the plug to give me the purchase required to fit a socket on.

Doing this required overhead brazing, which I can definitely recommend avoiding if you possibly can! Once the plug was out, I then machined down the square, before brazing on an extension to a more easily accessible position.

PHOTO 4: The washout plug gained an extension brazed onto it before refitting in the boiler.

PHOTO 5: Extended washout plug in place with blowdown valve attached to it.

PHOTO 6: Russell's rear bogie removed merely to allow access to the locos ashpan.

PHOTO 7: With the successful cold test behind it and all the bits back on, Russell raises steam for the boiler inspector on the sector plate.

All photos by the author unless stated

Another of the issues with this engine in particular is the necessity to drop the rear bogie out to then allow the ashpan to be dropped. Once I had the ashpan out I then modified it a little to allow it to be refitted with the loco lifted a few inches, rather than having to pull the entire bogie out.

Also while the ashpan was out I took the oportunity to ease the damper so it fitted the opening in the pan a little more freely, this was to alleviate one of the gripes from loco crews who told me that the damper would not shut properly.

Thankfully Russell passed its annual exam with ease, with the cold exam being done in the morning and the in-steam exam the same afternoon once all the bits such as plugs and firebars had been put back.

Next on the list was a brake adjustment on Yeo. However once I was underneath the loco I realised the brake linkage was not optimised to provide easy adjustment, while the brake blocks themselves were nearly worn out.

I modified the linkage to provide a single point of adjustment for the brake system, while retaining the individual adjustment for each set of blocks for when a new set is put on. Unfortunately I had not found any ▶

PHOTO 8: A live centre used to hold tap true to hole while modifying Yeo's brake linkage.

PHOTO 9: The duly-modified brake link, now allowing single-point adjustment.

PHOTO 10: Brake link refitted under the loco.

PHOTO 11: 3D printed two-part pattern for new brake blocks, complete with locating holes.

PHOTO 12: Draft angle of 1.5 degrees, to allow pattern to be drawn from sand mould, visible here.

PHOTO 13: Intentional off-centre mounting of pattern on board to allow for pouring gates to be put into the sand.

locomotive brake blocks, or a pattern for them, in my tidy-up, and asking the members of staff that had been at the railway for some time, I learnt that the last of the brake blocks that were cast by John Ellerton, the man who had re-gauged the railway from 15 to 12¼-inch gauge back in 1985, had been used up.

Pattern of work

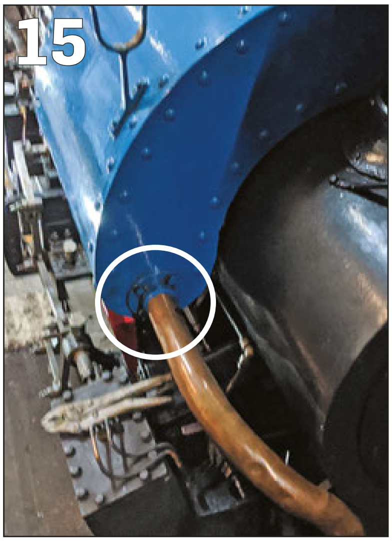
This therefore required a new pattern to be made, along with the core box to provide the space for the brake hangers (thus reducing machining time). Having had some success in the past with 3D-printed patterns, I spent some time designing the split pattern and core box, as well as a press for the core.

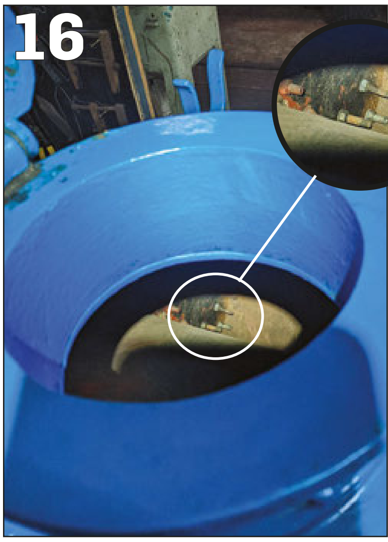
Included in this design is the angle of the wheel, the root radius of the flange and the 1.5-degree draft angle to allow the pattern to be drawn from the sand mould. I also put in locating divots for the pin holes that hold the blocks to the hangers.

If you look at the pictures attached, you will see that there are two 5mm holes through each half of the pattern, these are to locate them in relation to each other and the moulding board which then locates into the cope and drag boxes that the foundry use. You can also see the position of the core and how it is located in the mould.

Having designed and made the patterns, I then dropped them off at the foundry at Blists Hill Victorian Town, near Telford in Shropshire. The traditional-style foundry here carries out fantastic work and you can watch them in action, usually pouring the melt on a Wednesday afternoon.

What followed then was a repair to the handbrake linkage of one of the brake vans to allow it to return to traffic, before I made a start on the 10-year overhaul of Sherpa. This had been withdrawn from traffic in early August thanks to its axlebox issues, and the decision taken that since it was soon due for its 10-yearly overhaul, it wasn't worth dropping the wheel sets just for a couple of months of running.





During the stripdown of the loco, I discovered a few things that I am intending to modify as the loco goes back together. Chief among these are the nuts that hold the cosmetic saddle tank onto rather nice-looking copper pipes. I intend to fit blind top-hat bushes, or even rivnuts, here instead of the loose nuts that were on the loco – having to reach an arm all the way around a saddletank curve is really quite irritating and difficult.

One-piece body

Another modification to be made will be to install cut-outs in the cab floor, to allow the cab to be removed without having to take off the brake column and reverser stand as well. This is due to the cab, its roof, the coal bunker and cab floor all being one welded piece which is sandwiched between the frames and the brake column and reverser stand!

After some effort (and the occasional unprintable comment...) I had just managed to remove the boiler and strap it to the boiler trolley ready for retubing, before Yeo was back in the workshop with a badly leaking gland. At some point said gland had been over tightened and bent, so I set about straightening it. But unfortunately as soon as I had applied a little heat to straighten it on the bench, the top section fell off, exposing an old fault in the casting. Thankfully I had found a spare casting in the stores a few days before, so it was a simple turning job to make it fit.

Never dull

All of this work, alongside making improvements to the workshop air system, learning a new operating rulebook, looking back over repair books and trying to plan for an uncertain year next year (*as well as one a couple of days reminding a very rusty model engineering magazine editor how to use a lathe – Ed*) kept my first month at the Fairbourne Railway very full, but thoroughly enjoyable! As we now go into the winter, with no trains running, there's lots to be done, as I'll be describing in future issues. EIM

PHOTO 14: 'Sherpa' sits in one piece for the last time this winter...

PHOTO 15-16: Circles show less than helpful location of bolts that secure saddle tank to feed pipe.

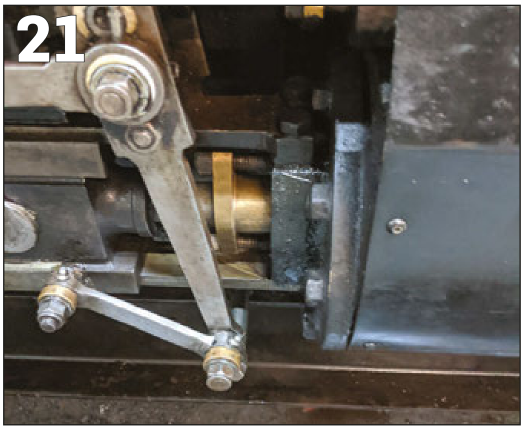
PHOTO 17: Success, after some choice words – Sherpa sits minus its platework.

PHOTO 18: One-piece body section stored on top of tender.

PHOTO 19: Boiler removed for retubing and bottom end ready for work.

PHOTO 20: Straightening that didn't quite work out...

PHOTO 21: Nice new gland fitted to Yeo.



International additions as miniatures show moves south

The pictures above and above right clearly illustrate that 'Brass Steel and Fire' will be of core interest to EIM readers, featuring a wide variety of model engineering examples including some very early locos. *Photos courtesy Science Museum*

'Fire Queen', (above), made in 1841 of a prototype built only a year earlier, is one of three models coming from the extensive Rahmi M. Koc museum in Istanbul (below). *Photos courtesy Rahmi M. Koc Museum*

Readers who missed the 'Brass, Steel and Fire' exhibition when it was held at the National Railway Museum in York between September last year and April this year (*including your Editor!*), now have a new opportunity to catch the display as it has moved to London – and added some interesting extras.

Brass, Steel and Fire tells the story of 100 years of model engineering, and features a host of miniature engines, including some of the oldest still in existence. As well as describing the models, the exhibition also highlights the stories of their builders.

Joining the exhibition for its opening at London's Science Museum are three British-made models that are part of the collection of the Rahmi M. Koç Museum in Istanbul, Turkey.

The three locos in question are of the broad gauge 2-2-2 'Fire King' built for the GWR, a South Eastern & Chatham E Class 4-4-0 model dating from 1905 and a Garden loco from 1845.

Bruno Cianci of the Rahmi M. Koç Museum tells EIM that the Garden loco was restored by Jonathon Minns at the Brighton & Hove Engineerium workshops and was acquired by the museum from Langfords Antiques in London. The Fire King, purchased from Christie's in London, is signed and dated by its builder Josiah Evans Haydock in 1841, only a year after its full-size inspiration was built. The SECR E Class locomotive was also purchased in the UK and its builder was a driver of the full-size engine.

Extensive exhibits

Bruno adds that the three locos represent just a small part of more than 16,000 items on display at the Turkish museum, which was founded in 1994 by the tycoon and philanthropist Rahmi M. Koç, CBE, born in Ankara in 1930. The museum was enlarged in 2001, after acquiring an adjacent venue on the shores of the Golden Horn, Istanbul's natural harbour.

Items on display include hundreds of items of railwayana, full-size locomotives, wagons and carriages (including one fine specimen presented to Sultan Abdul Aziz by Queen Victoria) that illustrate the passion of the Turkish magnate for steam and railway transportation. More information on the museum is online at www.rmr-museum.org.tr – we intend to feature the miniatures element of the museum in a forthcoming edition of EIM.

Brass Steel and Fire is scheduled to run at the Science museum until 3rd May 2021, so hopefully well beyond the current restrictions caused by Covid-19. Tickets must be pre booked and details are at https://www.sciencemuseum.org.uk/see-and-do/brass-steel-and-fire

Legacy enjoys 'oldest engine'

Legacy Vehicles Ltd has recently acquired and sold what the company believes is the oldest miniature road steam engine in the world.

The firm, based in Hadleigh, Suffolk and specialising in selling full-size and miniature road steam and other vintage vehicles, successfully bid for the 3-inch 'Heartbreaker', built in 1902, at auction in July. Road Steam managing director Tom Allen describes the freelance design as a "unique and somewhat remarkable miniature traction engine.

"We only know of a handful of pre-war miniature road steam engines to have survived," Tom told **EIM**. "Most were built by the toolmakers of steam engine manufacturers as display pieces or as a project for the firm's apprentices. Remarkably Heartbreaker was the work of a talented young wheelwright and carpenter, Mr George Long who was just 20 years old when he first completed the engine."

The engine was built in East Dereham, Norfolk and while a freelance design appears to have been influenced by steam tractors from the Burrell works which was just 25 miles up the road in Thetford.

"It stayed with Mr Long for more than 50 years and was extensively rebuilt in 1929," Tom added. "Local newspaper reports in 1937 and 1954 have helped piece together the history of this fascinating engine as they document the build, rebuild and its capabilities when in steam."

The engine passed on in 1955 to a new owner who purchased it as a present for his seven-year-old son. It's understood that the young boy went on to spend many happy years driving Heartbreaker around the family farm in the West Country.

Eventually, however, the engine fell into disrepair and was stored underneath the farmhouse stairs until 2015 when it was sent to be professionally restored.

The extensive restoration included a replacement boiler which was made to the 3-inch Burrell design but with a shortened barrel. To meet modern standards several fittings were also replaced. The original riveted boiler and fittings have survived and been kept with the engine.

"After we collected the engine from the auction it was clear some final fettling was needed before it could be steam tested and used – fettling turned into a couple of days in the workshop but nevertheless we were very happy with our purchase once the fire was lit and the engine was ticking over beautifully," Tom added.

Legacy Vehicles originally purchased Heartbreaker with the intention of adding it to the firm's private collection. "However we quickly realised it would end up on display in our office rather than be enjoyed at events. So the engine was put up for sale and within a matter of hours of it being on the website a deal had been agreed.

"We are not ones for keeping engines tucked away in the dark, so we were very pleased when the new and very enthusiastic owner told us all his plans to rally the engine in 2021."

So is this indeed the oldest miniature road engine? The evidence suggests so, unless **EIM** readers know different...

Garden Rail show postponed to May

Another month and another show falls victim to Covid, though thankfully the 2021 edition of the Midlands Garden Rail Show has not been cancelled, but rescheduled from its original March date.

The show, which focuses on those working in the smaller scenic garden scales, such as Gauges O and 1, 16mm and G-scales, will now be held on Saturday 22nd and Sunday 23rd May 2021, at its traditional venue of the Warwickshire Event Centre near Leamington Spa.

Organisers Meridienne Exhibitions told **EIM** that the decision was taken to reduce the potential impact of the pandemic on the event if it was to be held on its normal date.

"Hopefully by rescheduling the event to May next year restrictions may well be removed and allow the event to operate as normal," Meridienne added.

Readers are advised to keep an eye on the website www.midlandsgardenrailshow.co.uk for the latest information.

■ We've had an exclusively narrow gauge, and mostly Welsh selection of heritage railway Christmas cards arrive at the EIM office and they are worthy of highlighting here, much better than typical mass-market fare and the proceeds go to very good causes!

Take the Lynton & Barnstaple Railway card (**Photo 1**), featuring one of the last paintings of renowned rail artist Eric Leslie who sadly passed away in August. It shows a Manning Wardle 2-6-2T taking water at a wintry Chelfham station, and costs £2.50 plus post for a pack of five from www.lynton-rail.co.uk/shop

The 2020 Welshpool & Llanfair Light Railway card (**Photo 2**), is again by artist Jonathan Clay and depicts visiting ZB2 0-6-2T 'Zillertal'. Cards cost £4.75 for five, £7.75 for 12, £12.75 for 25, £16.50 for 36 and £21.00 for 50, from W&LLR Christmas Cards (EIM), 12 Maes Gwyn, Llanfair Caereinion, Powys SY21 0BD, cheques payable to W&L Sales. Cards can also be ordered from www.wllr.org.uk.

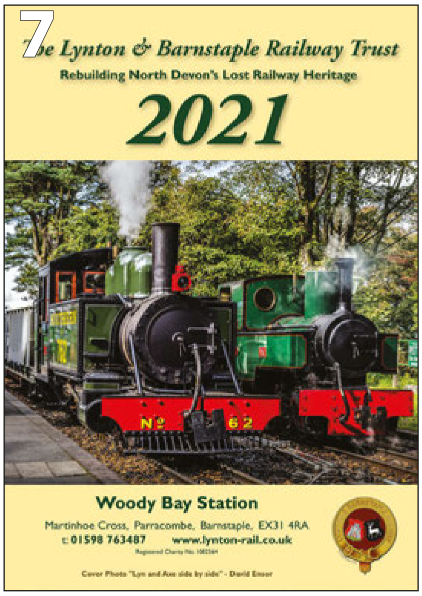
A photo of half-size Hunslet 0-6-4ST 'Beddgelert' at a snow-flecked Penrhyn Point features on the Fairbourne Railway card (**Photo 3**), available at three for £2.75 or 10 for £7.75, including postage from Fairbourne Railway, Beach Road, Fairbourne, Gwynedd LL38 2EX.

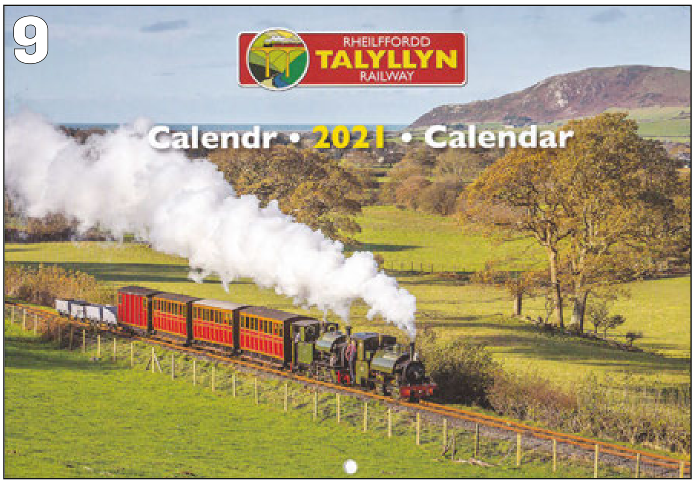
Two cards are available from the Ffestiniog & Welsh Highland Railways (**Photo 4-5**), both original paintings by Richard Marsh. They show a WHR Garratt at a wintry Caernarfon station, and Ffestiniog double-Fairlie 'David Lloyd-George' at Boston Lodge Halt. Packs of 10 cards, five of each cost £5.50 plus post from www.festrail.co.uk/shop

For something different, the Corris Railway card is also photo-based (**Photo 6**) a snowy scene of the mid-Wales line's woodland scenery. Cards cost £4 per pack of five plus £1 post from John A. Knight, 40 Fladgate Road, Leytonstone, London E11 1LY, cheques to Corris Railway.

Perhaps suitable for brightening up the workshop wall are a trio of calendars. The Lynton & Barnstaple Railway version (**Photo 7**) is vertical A4 format, the Ffestiniog & Welsh Highland (**Photo 8**) and Talyllyn (**Photo 9**) examples to horizontal folded A3. All feature quality scenes from the lines in question.

The L&B calendar costs £4.99 plus post from the same address as the line's Christmas card, similarly the FF&WHR calendar at a cost of £8.50 plus £3.60 post. The Talyllyn calendar is £7.50 plus £3.95 post, by phone using a credit card on 01654 711012, or through the TR's online shop that is accessible through the line's website at www.talyllyn.co.uk





Keeping things moving

Covid restrictions that are again increasing can't stop busy activities amongst club members.

COMPILED BY **ANDREW CHARMAN**

Welcome to the December club round-up, and sadly perusing the usual healthy selection of newsletters and journals received at **EIM** Towers there is a real feeling of *deja vous,* many reporting increasing activity at their clubs but of course all overtaken by events with the arrival of new lockdowns across the UK after they were published.

Still, we know what to expect now and we reckon a great many of our model engineers will take the opportunity to keep going on more projects, for their clubs or for themselves, and we look forward to seeing details of their progress.

A welcome newcomer to the publications sent to **EIM** this month is *Steaming Ahead*, newsletter of the Crowborough Miniature Railway run by the **Crowborough LS** in Sussex. What immediately took your editor's eye was the delightful picture that newsletter editor John Wood has kindly forwarded for use on this page. It's definitely worth sharing with a wider audience, summing up the sheer pleasures of the club scene – a bright sunny weekend, families strolling around a pond and a very rich variety of locomotives in the steaming bays ready for service. This timely picture reminds us what we will all be enjoying getting back to when the Covid menace is finally behind us.

Extension waiting

Reading *Steaming Ahead* the Crowborough club is working on the basis of a public reopening not being likely before Easter 2021 and sadly we reckon many other clubs will be thinking in similar terms. It's frustrating for the Sussex club as they have a recently completed track extension crying out for trains to be run on it. John also reports that membership of the club is strong, which is good to hear particularly in these troublesome times.

We mentioned last month the activities at the **Ryedale SME**'s track at Gilling in North Yorkshire and secretary and newsletter compiler Bill Putman has since sent us his rather splendid picture, reproduced at right. Fellow member Jed is using his 7¼-inch gauge Sweet Pea, apparently built from scrap during a Covid-enforced absence from work, to pull an impressive rake of 5-inch gauge freight stock. As Bill comments "the mile-wide smile on Jed's face says it all..."

ABOVE: Super shot from the Crowborough ME summing up what the hobby is all about, and what we have to look forward to. *Photo: Crowborough ME*

BELOW: Happy in his work, another superb shot from the Ryedale SME – look at all those wagons! *Photo: Bill Putman/ Ryedale SME*

Notable in the latest edition of the Ryedale newsletter is a story by member Colin Bainbridge, who years ago bought a 5-inch gauge Martin Evans 'Simplex' chassis from a certain auction website, but never got round to doing anything with it. Recently he took it out from under his bench with the intention of looking it over and then selling it on, at which point he realised just how poor an example it is – the list of faults runs to two pages! Definitely buyer beware, and rather pertinent in the month that **EIM** regular correspondent Stewart Hart starts describing his efforts to rescue a part-finished Simplex project.

Model engineering projects do not need to be large of course and the latest edition of *LeedsLines*, newsletter of the **Leeds SME**, illustrates a vision in brass, an almost complete Johnson 3P loco in Gauge 1 built by member Steve Russell.

One can sense a palpable air of frustration at the Leeds club, which has probably only been exemplified by the new lockdowns, as talks with the new owners of their former track site at Eggborough have been very constructive and a member has produced impressive plans for a new track. "I am sure that many members have itching spade fingers waiting to get stuck in," comments chairman Jack Salter.

Meanwhile Jack adds that Leeds members have clearly not been wasting the extra leisure time they

have had in 2020, a number of "inspirational" 'work on the table' write-ups received for the newsletter, other members returning to model railway layouts in various scales, others improving their workshops. "I know of one member in his late '70s who is building a new workshop using engineering bricks, as they last longer than common bricks – that is looking to the future, an example to us all," comments Jack. We certainly concur!

The front cover of the latest *Goodwin Park News*, newsletter from **Plymouth Miniature Steam** also features an excellent picture, of a young man at the controls of a steam engine, with a more experienced guiding hand sitting behind but letting him get on with it, and in the process planting the seed that hopefully will blossom into the next generation of model engineers.

ABOVE: Young member of the Plymouth MS Mackenzie earned himself a driving lesson by helping to pour concrete on a major improvement job at the club.

BELOW: The work at Plymouth kept member Bob and his digger busy. *Photos: Ian Jefferson, Plymouth MS*

Newsletter editor Dave Biss tells us that in fact the youngster, Mackenzie, is a new member to the club, and the driving lesson was his reward for earlier in the day assisting with a major concrete pour!

Thanks to the awarding of a major cash grant due to the Covid pandemic, the club has been able to advance what chairman Ian Jefferson, who took the photo, describes as "one of the most challenging repairs on the site."

The work involves replacing a bridge over car park access which has always been the subject of taxing gradients for the locos, steeply up on the approach with a severe drop off on the other side. A whole host of work, including removing an earth bank, has actually been made possible by the Covid shutdown, as club members have long thought what required doing was too much to accomplish in a 'normal' off season – 2020 has provided them with rather more time... We look forward to bringing you further news in these pages of progress on this project.

Don't fear the Tech

The latest newsletter from the **St Albans & District ME** highlights a feeling prevalent among many model engineers when lockdown began, a reluctance to use the online meeting tool Zoom, due to face-to-face meetings not being permitted.

"Now either through the necessity of keeping in touch with relatives or the desire to re-engage with the world outside our front door many of us have got to grips with it," reports chairman Mike Collins, adding; "It has turned out to be easy to use so has been adopted by the society as a means of allowing us to keep in touch with each other, keep the club business ticking over and having monthly talks."

The club now publishes a schedule of Zoom meetings on its website, and is asking for more members familiar with the technology to take up the new role of 'Zoom operator', hosting the meetings.

Mike does add, however, that the technology has heralded a new source of domestic conflict that can arise when more than one person in a house wants to use a shared computer for Zoom at the same time! Yup, the way of the world – we should not be scared of such technology, once tried you will find the benefits, principally in staying in touch, far outweigh any perceived challenges...

By the way one of the most fascinating features in the St Albans newsletter is a regular 'mystery object', consistently throwing up items that demonstrate just how wild and wacky engineering can be...

Always busy at the **Rugby ME** and a major recent project illustrated in the latest newsletter has been the installation of a new road crossing across both the ground-level and raised tracks.

Throughout October members have lifted sections of both lines, refurbished the ground-level track panel, created a new rubble bed with steel reinforcing mesh and poured the new concrete crossing.

A 'raised track' gang were equally active, working on refurbishing the line ahead of installing a swing-bridge section over the new concrete. Elsewhere tracklaying on the newly extended section of raised line has been completed, with by the end of the month only the two connections to the existing run and the swing bridge remaining to be completed. Let's hope that the new lockdowns do not cause too many delays to the Rugby club's extensive activities.

Chris Manning continues to do a quite amazing job at the **Chingford ME** with his fortnightly newsletters, which even with such frequent publication are quite extensive. Your editor was interested in the latest edition in a feature by member Ted Joliffe, describing a pipe and rod vice for small work. Apparently once marketed by the Footprint Organisation the design has been out of production for many years, a shame because it looks highly useful.

Ted bought his at a car boot sale and believes it dates from before the Second World War. He describes the tool in detail, complete with drawings and suggests how one could reproduce it for use in a home workshop.

All of which gives your editor a chance to remind all readers producing features such as this for their club magazines – useful tip items of this nature are worthy of wider circulation and we would always be interested in receiving such features for use in **EIM**!

A further edition of the Chingford newsletter includes the progress being made by a Walthamstow-based member on a 3½-inch gauge 'Virginia', immediately sparking memories for your editor who back in his youthful evening club days briefly planned to build this engine, but was put off by the sheer effort required to cut US-style bar frames from plate... Well, I knew even less in those days than I do today...

Keep smiling

We rather like the attitude of the latest **York ME** newsletter, which editor Roger Backhouse subtitles on the front cover 'Covid 19 chaos special issue'...

A message from chairman David Wood follows, which he starts with "The light at the end of the tunnel continues to burn brightly." He adds that the York committee can guarantee that the club is being looked after, is well maintained and will be available for use in the coming season. Can't say fairer than that, an excellent positive attitude to all that is being thrown at us at present.

David reports that a design for new storage and workshop facilities is being finalised and there are strong hopes for some concrete pouring early in the new year. And he adds that his most recent informal Saturday evening Zoom session attracted 17 visitors "who all appeared to enjoy the collective wit and banter." Another example of technology being put to proper use, and excellent to read.

THIS PAGE: Latest progress at the Rugby ME, installing a new road crossing across both its ground-level and raised tracks, and completing a significant extension tot he length of the latter. *Photos:* Rugby ME

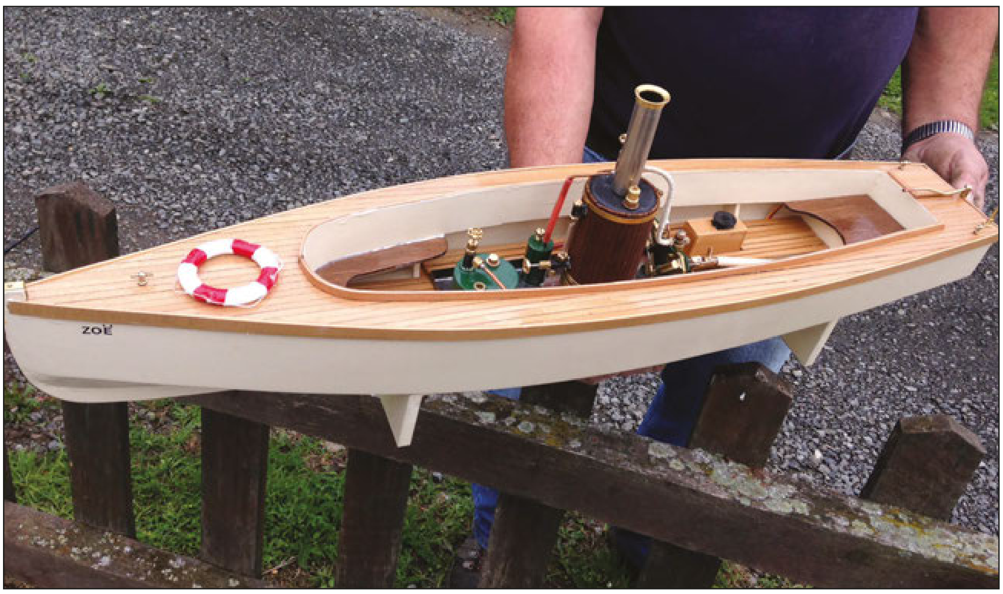
Full size follows model

Meanwhile readers may remember the piece in September's *Club News* reporting on the original LNER distance markers, restored and newly planted at the York club's track. Well according to the latest edition of *Rail* magazine it seems Network Rail has followed the York club's lead, installing a restored distance marker – on the platform at York station!

Also receiving grant aid to replace public running income lost to Covid is the **Southampton SME**, and as with all these grants the money comes with an important proviso that is quite challenging to meet – it must be spent in 2020! Southampton members have therefore tackled what they considered the most pressing issue, refurbishing the clubhouse, in particular stopping water getting in through the roof. New flooring, toilets and kitchen are also in the plans.

Aside from all this necessary work, and details of how members can stay Covid-safe while at the club, the Southampton newsletter also shows the variety of the club's members. One, Chris Harnett, describes adventures around Hampshire in the early 1980s with a full-size family-owned steam roller, while Roger Stewart-Hindley continues his reminiscences of a very full professional footplate career with British Railways, this time describing some hair-raising accidents that fortunately he was not involved in.

As I said in my editorial this month, club newsletters across the land have really come alive with such fascinating features during the period when members have not been able to meet up, keeping everyone in touch and providing them with highly interesting material to enjoy. The newsletter editors deserve credit for encouraging such contributions, and I look forward to describing more of them next month. EIM



■ Back in the July issue we carried a couple of pictures from **John Arrowsmith** of the attractive little vertical boiler and motion built by fellow Hereford SME member Phil Brown in a very short period, following a rush back from a holiday in France to get home before the first lockdown in March. Well John has now sent us a new picture showing the boat that Phil has since completed for the engine to power. Very fine it looks too – we wonder what Phil will produce during lockdown 2!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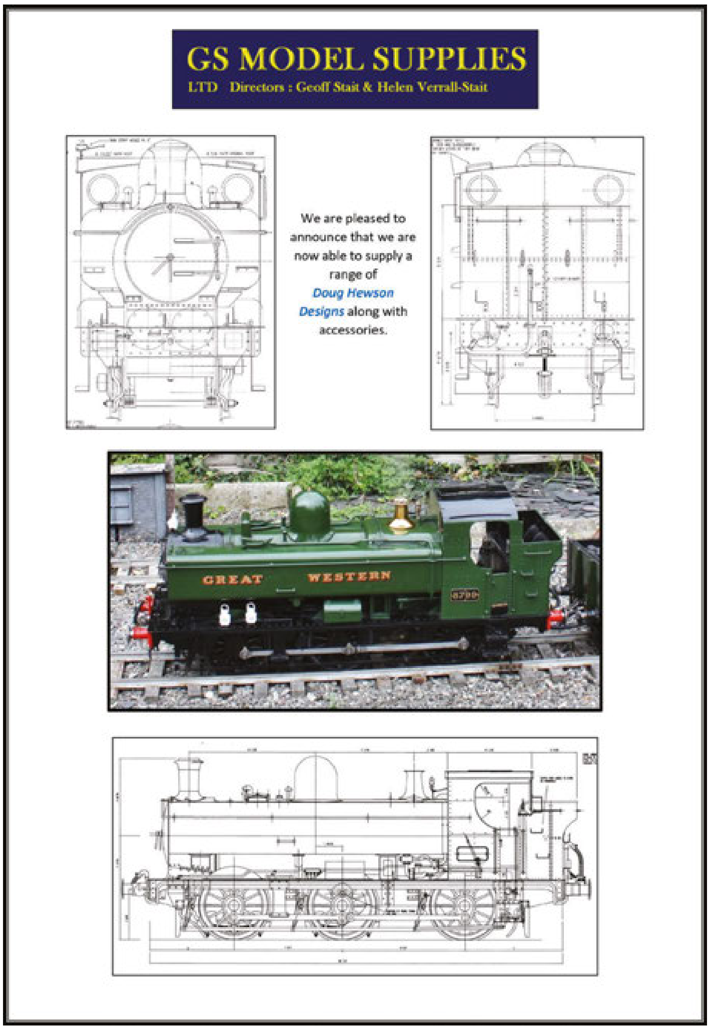
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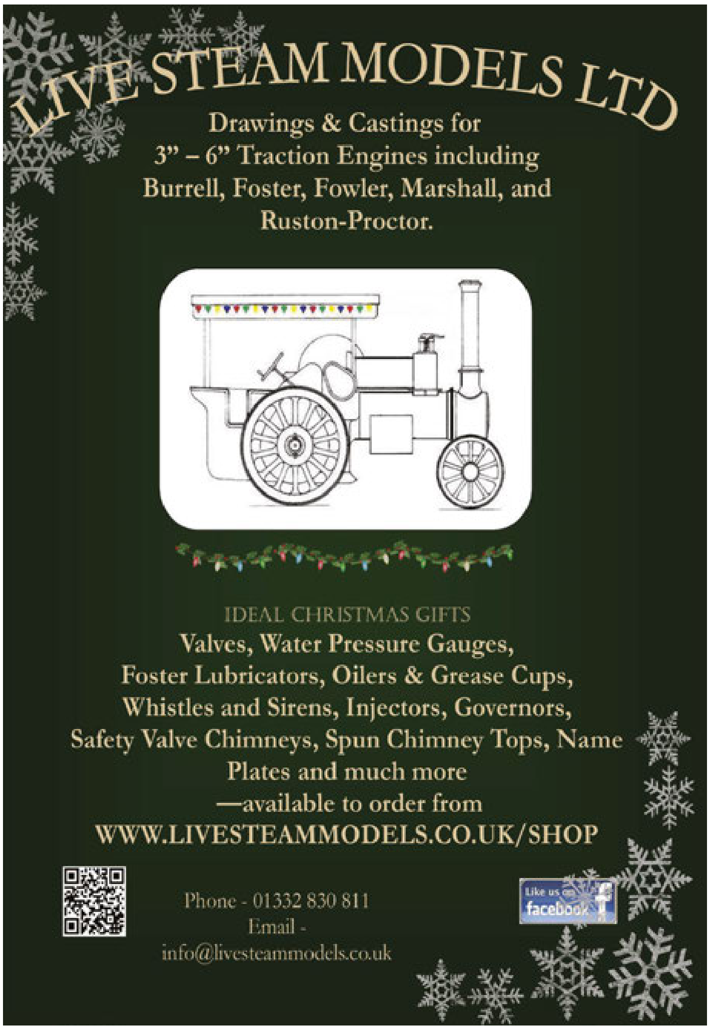
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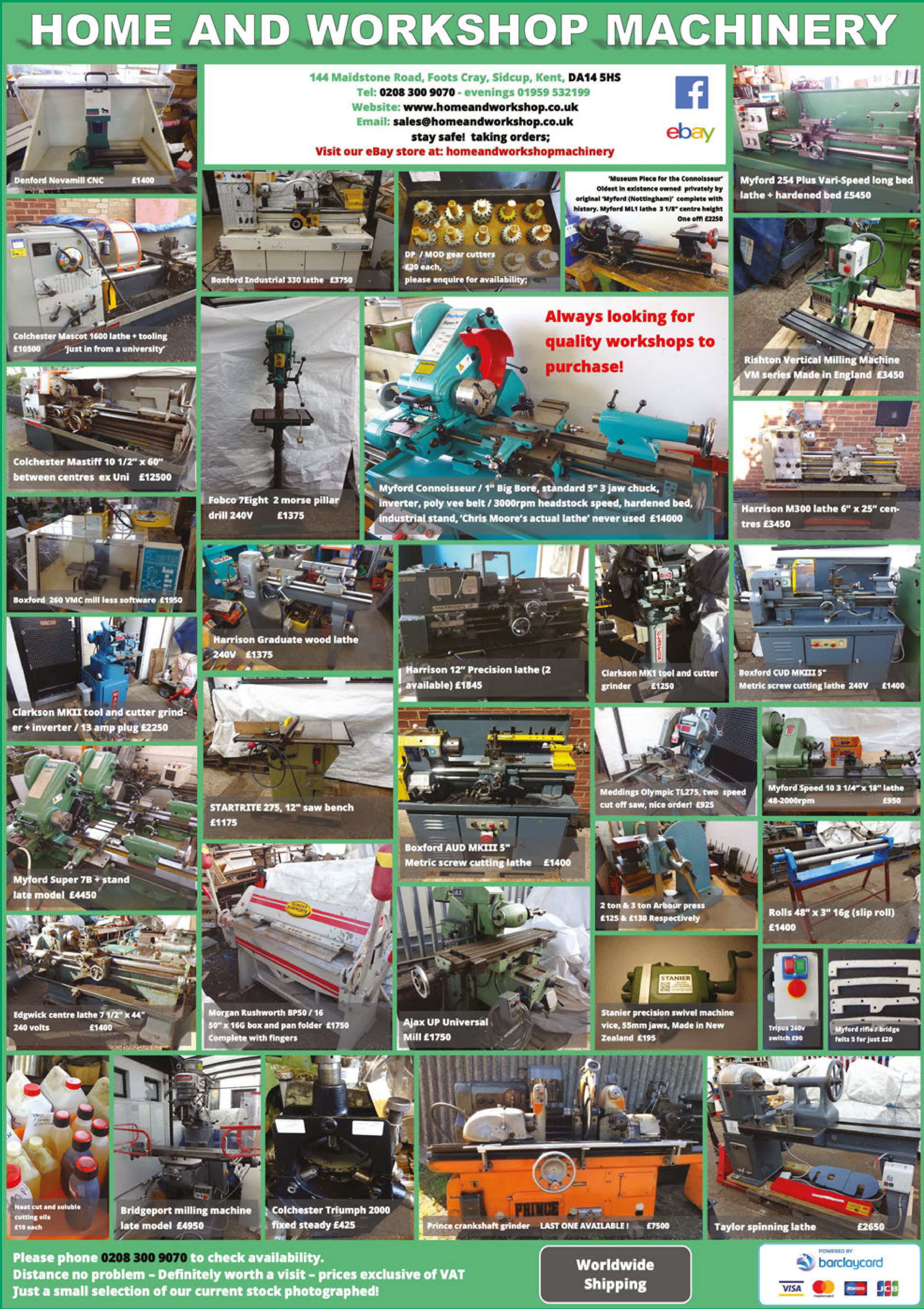

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