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THE MAGAZINE FOR MODEL ENGINEERS

ENGINEERING in Miniature

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The Forgotten Gauge?

Could 9.5-inch, one of the oldest gauges, make a comeback?

Designing a boiler for a 7-inch Fowler wagon

ELECTRIFYING WAY OF RUST REMOVAL

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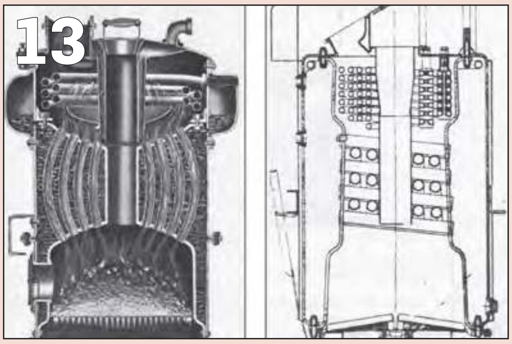
MAY 2019 Volume 40 Number 11

THE MAGAZINE FOR MODEL ENGINEERS
ENGINEERING in Miniature



FRONT COVER

No lack of atmosphere at the Downs Light Railway in November! We shine a light on the lesser-known 9½-inch gauge in this issue.
Photo: Andrew Charman

EDITORIAL

Opening up the digital archive – 171 issues...

Welcome to the May EIM – the year is flying by and I still can't get into my workshop! I have news this month, that might tempt you to take out a digital subscription...

From this month we are offering two alternative subscription methods for those reading their magazine digitally – the existing arrangement through Pocketmags now joined by a very different model through Exact Editions.

For £29.99 a year with Pocketmags you effectively buy a digital issue, which you can keep for as long as you wish. Exact Editions, however, is a bit like a members' club. You pay £8.99 a quarter, or £39.99 a year, for access to a password-protected online facility on which the issues can be read, and your access only lasts for as long as you hold a subscription – cancel it and your access is cancelled too.

So what's the advantage? Well on the Exact site you will find not only the current edition of EIM, but an archive going right back to the January 2005 edition. Yes, that's 171 issues to peruse so far, and growing every month.

The archive is fully searchable too, allowing you to find specific projects to aid your engineering. EIM Exact Digital Subscribers will be able to access the archive via the Exact Editions website or by downloading the 'Exactly' app via the Apple store or Google Play.

To repeat, Exact Editions is a membership scheme and once your subscription ends, so does your access to the EIM Archive. You can take out an EIM Exact Digital Subscription simply by calling 01778 392484.

We have plenty of interesting and in many cases quite different features planned for coming editions – for example in this issue we offer everything from highlighting an almost-lost miniature gauge to removing rust in the workshop by plugging in the electrics!

One of our regular features that is different this month is the Club News – instead of our usual round-up from across the clubs we highlight the recent Southern Federation AGM, both for some very interesting discussions during the AGM itself and the way in which the efforts of young engineers were highlighted, always guaranteed to score with EIM... Normal Club News resumes next month so keep sending those newsletters in!

Andrew Charman – Editor

The June issue of **Engineering in Miniature** publishes on 16th May.

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Published monthly by Warners Group Publications Plc,
The Maltings, West Street, Bourne, Lincolnshire PE10 9PH. .

Articles: The Editor is pleased to consider contributions for publication in Engineering in Miniature. Please contact us to discuss your work.

Engineering in Miniature – ISSN 0955 7644

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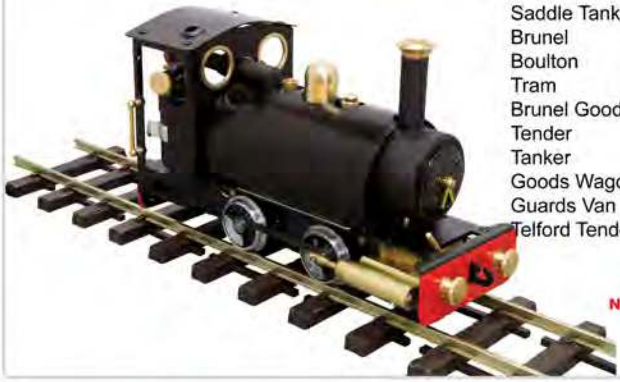

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Time for a 9.5-inch revival?

Telling the story of a model-engineering gauge once popular but today virtually unknown...

BY **ANDREW CHARMAN** with **MATT NUNN**

1

Today the gauges available to the aspiring miniature railway enthusiast are pretty cut and dried. Top of the list is of course 15-inch, effectively forming the border between miniature and narrow gauge and used by such major public lines as the Ravenglass & Eskdale and the Romney, Hythe & Dymchurch railways. Just below it we have 12¼-inch gauge, not so prolific with the prime line waving its flag being the Fairbourne in mid Wales.

All photos in this feature by Matt Nunn or from his collection unless stated.

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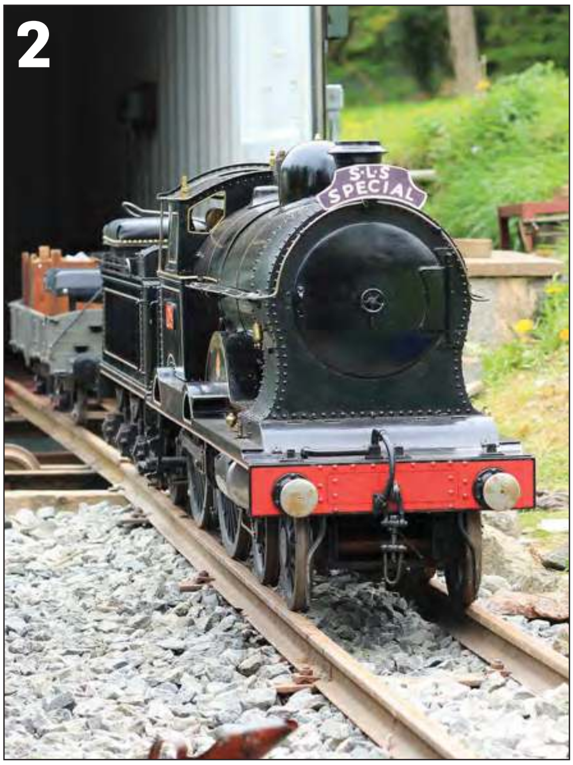


Popular for passenger-hauling lines in parks and such like is of course 10¼-inch gauge, with prime examples including the Audley End in Essex, the Kerrs in Scotland and the Rudyard Lake in Staffordshire. And then one moves down to the traditional model engineering gauges, 7¼, 5 and 3½-inch.

Once, however, there was another. Henry Greenly, designer of many of the 15-inch Romney engines and widely regarded as miniature steam royalty, wrote in his renowned work *Model Steam Locomotives*, originally published in 1922, that "The 9½-inch gauge engine is the largest size recommended for amateur construction. The gauge is a safe one and engines of this size are easy to handle. Speeds of up to 15 miles an hour can be obtained without trouble on a well-laid track."

It's quite possible that many of our readers have never heard of 9½-inch gauge, yet up until the Second World War it was a major miniature scale. Today, just one major public, and one significant private, line still flies the 9½-inch flag. So what happened?

To find out more EIM consulted Matt Nunn, one of the team operating the 9½-inch Lakeshore Railroad in South Shields and a historian of the gauge. And Matt pointed out that 9½-inch is a very old gauge, dating back to almost the start of the 20th century – one of the oldest extant locomotives is 'Orion', designed and largely built at the London North Western Railway works in Crewe in 1911, and today the only surviving operational Crewe-built Webb Compound, all of the full-size locos of the class having long been scrapped.

Why 9½-inch gauge? The reason is blindingly obvious once revealed. When modelling a standard-gauge prototype it effectively works out to ⅙th, or 2-inch, scale. The scale was promoted between the wars by manufacturers such as Bassett-Lowke as a choice for those affluent enough to build a large garden line but not to the extent of a 10¼-inch or 15-inch gauge estate railway. For the even less affuent, there was also in those days 4¾-inch gauge, or 1-inch scale, but that's another story.

Empire star

"The 9½-inch hit a peak in the 1930s and particularly during the British Empire Exhibition at Wembley in 1924. The Treasure Island Railway that was built for the exhibition achieved national fame from photos of King

George V and Queen Mary riding on it," Matt tells us.

He adds that remarkably, most of the equipment built for that Treasure Island Railway survives today amongst various owners – "remarkable for a temporary railway built for a single event."

By the 1930s 9½-inch gauge was fighting for its profile, with 7¼-inch becoming more popular, but then the larger size gained a major boost when in the 1940s the promotion of 'holidays at home' saw an explosion of lines laid down at seasides and other holiday venues, such as at Danson Park and Southsea. Many lines were built to the gauge, helped by a major exponent of 9½-inch dying and as a result eight locomotives all coming onto the market at once.

By the 1950s, however, the decline was beginning to set in. The old manufacturers who had promoted the gauge, such as Bassett-Lowke, were disappearing – public lines were being converted to the more prolific 10¼-inch gauge while the enthusiasts were increasingly turning to 7¼-inch which was now attracting much wider trade support.

Lost to a wider gauge

Matt reveals that the relationship between 9½-inch and 10¼-inch gauge has always been slightly nervous – the close similarity of the two gauges has resulted in many a 9½-inch loco being lost by regauging to the slightly wider and much more prolific 10¼-inch.

"The 10¼-inch has virtually filled the void where 9½-inch used to be. A lot of 10¼-inch exponents get on very well with us, but on the other hand in the early 2000s when I was first involved someone one day came up to me and said "your engines are worthless, we'll buy them off you when you are done, fix them and sell them on… So we tend to largely stay at arms length, only working with people who we know won't be regauging stock."

Locomotives that have been regauged include one of the original Atlantics that ran at Wembley, and 'Princess', a 4-6-2 Pacific that between 1964 and 1994 ran on a 9½-inch gauge line at Bressingham Steam Railway in Norfolk,. Currently the loco is being converted to 10¼-inch at the Bredgar & Wormshill Railway in Kent.

"The problem is a lot of 9½-inch gauge equipment is highly historic, dating from the 1930s," says Matt. "And it covers an immense expanse of history too, from an enlarged LBSC 'Invicta', to Heywood-type locos."

By 1960 no new equipment was being manufactured for 9½-inch and when it was opened in 1972 the ▶

PHOTO 1: Lakeshore scene – the line's home fleet and visiting narrow gauge prototype 'Nelly' at the station.

PHOTO 2: One of the oldest 91/2-inch gauge locos – 'Orion', built at Crewe in 1911, today cared for by the Stephenson Locomotive Society .

PHOTO 3: Early days at Lakeshore. Founders Jack Wakefield and Don Proudlock with the 1968-built 'Mountaineer' during the first season, 1972.

PHOTO 4: Also in 1972, a train ready to depart from what will become the station.

PHOTO 5: The Mayor drives the opening train in 1972.

PHOTO 6: Lakeshore stalwarts, the 1939-built Bell+Burgoyne 'Adiela' and Mountaineer, during the 45th anniversary Gala in 2017.

The variety of prototypes on the 9.5-inch...

PHOTO 7: Contrast in scales at the Downs Light Railway. Curwen-built 'Brock', the narrow gauge loco at right, is similar to 'Nellie', that is visiting the Lakeshore Railroad through 2019. *Photo: Andrew Charman*

PHOTO 8: 'George' is a Bell+Burgoyne engine built in 1939, seen at the Downs 90th Anniversary event.

PHOTO 9: This HSC Bullock 0-6-0 was built in 1936 for Vere Burgoyne. Just visible behind is a 2011-built petrol loco called 'Rockclimber.'

...and what's involved in looking after them

PHOTO 10: Maintenance on the Lakeshore, 'Adiela' undergoes a heavy rebuild during 2014.

PHOTO 11: Shrink-fitting new tyres to Mountaineer in 2015.

PHOTO 12: Lakeshore's Ryan Lamb profiles the new tyres.

Lakeshore Railroad was to date the last public railway built to the gauge.

"All the main figureheads of the gauge died off," Matt adds. "There were a few enthusiasts of the gauge meeting up in private, but when one particular proponent, a figurehead of 9½-inch went private he effectively took the gauge with him."

That's how matters remained until as recently as four years ago, the Lakeshore line ploughing a lonely furrow as the only extensively operating public 9½-inch line (there is another, the 200-yard long Hall Leys Railway built in 1948 in Matlock, but according to Matt these days run erratically using a diesel).

Anniversary action

The year of 2017 marked the Lakshore line's 45th anniversary, and plans for a celebration event saw Matt talking in detail with Tim Pennock at the one other major 9½-inch line extant in the UK. This is the private Downs Light Railway, the creation in 1924 of Geoffrey Hoyland, headmaster of The Downs preparatory school in Malvern, and originally laid to 7¼-inch gauge.

Hoyland saw operating and maintaining the railway, laid around the school's grounds, as broadening the minds of his pupils. He was a complete enthusiast, and when in 1937 he fell in love with 'Ranmore' a 9½-inch gauge model of an LBSCR Class D 0-4-2T and built in 1930, he simply bought it and set about regauging the entire Downs line to accommodate his purchase.

The Downs line has enjoyed a chequered history since, with good and bad times. It fell into a parlous state at one point but was rescued by the formation of a Trust in the 1980s spearheaded by narrow gauge railway historian James Boyd, himself a pupil at the school in the late 1920s.

Just as the Lakeshore line was planning its 45th anniversary in 2017, so the Downs was about to mark 90 years. With a third enthusiast, Ross Mangles, Matt and Tim set about reviving the 9½-inch scene. "We three re-ignited the gauge, put out invites to every single person we knew of involved in 9½-inch, owners of engines and such."

The result was the largest coming together of 9½-inch locomotives and their operators yet recorded. "We had a major gathering at the Downs that year – virtually an engine from every railway in the gauge and from several collections, well over 15 engines, with eight of them running."

Matt adds that the event proved the versatility of 9½-inch gauge stock. "Virtually none of these engines had ever been to another railway before but they all ran faultlessly with no problems. We disproved a long-held notion by some that 9½-inch locomotives are finescale creations that cannot run across various lines."

Future plans

Bouyed by this success the trio are working hard to revive 9½-inch gauge at every opportunity, with Matt very aware of a forthcoming special date. "We have one private railway to bring into the fold this year, and it is quite critical that we do so as we'd like that line to be involved with the 50th anniversary of the Lakeshore, coming up in 2022. The line in question has one engine that was once owned for a short period by the Lakeshore line.

"We are all working together now, we take an engine to the Downs bonfire night run each year and we've been doing trackwork at private lines."

Meanwhile the Downs and the Lakeshore will continue to keep the profile of 9½-inch in public consciousness. The Downs underwent a major rebuild which the Trustees at the school and others involved believe effectively saved the line, and is now focusing on raising funds for essential developments – in particular the building of a new engine shed, stock storage building, workshop and educational facility.

Public access to the Downs railway is only available at special open days and details of these can be found on the line's Facebook page, linked from its website at www.dlrtrust.btck.co.uk

The Lakeshore Railroad, meanwhile, is a very busy miniature line. "We run every weekend of the year, school holidays, on Christmas Eve and Boxing Day, and virtually daily from mid May until mid-September," Matt says.

"It's a very heavy life for our engines, and they are very traditionally built – remarkably they generally run with cast-iron instead of bronze axle bearings." Details of the Lakeshore Railroad, including the timetable, can be found at www.lakeshorerailroad.co.uk EIM

PHOTO 13: 'James Boyd', a 2-6-2 built by Milner Engineering for the Downs Light Railway in 1992, leads a quadruple header during the Lakeshore Railroad's 45th Anniversary gala.

PHOTO 14: That looks a very small hole... Heading for the New Road tunnel on the Downs Light Railway.

PHOTO 15: Matt Nunn at the controls of the 'Muizenburg Flyer', a well-travelled engine built originally in South Africa to 10¼-inch gauge.

PHOTO 16: Proper education! Youthful enthusiasm at the Downs Light Railway.
Downs photos by Andrew Charman

Measure for measure...

Harry relates how the use of a datum point can avoid expensive errors and more work...

BY **HARRY BILLMORE**

One of the first mistakes I made which required the remaking of a major component was on the first locomotive I built, when I laid out the frames.

Rather than picking a datum edge for the measurements to be taken from, I progressively worked my way along the frame, from hole to hole and edge to edge marking out what I thought was very accurately all the features of the frames.

This only came to light when I was trying to get the valve gear to fit and I couldn't work out why the valve rod wouldn't fit. It turned out that the compound errors of moving along the frames had caused the position of the motion bracket to be some 3⁄16-inch out of position.

On a small loco this is far too much to be easily got around and necessitated the re-manufacture of the frames and a fair bit of cursing.

Since then, I have always laid out everything from a datum point, whether that is one edge of the work piece or a certain edge of a feature. Then I double check my work with a point-to-point measurement.

Doing the measurements this way, elements such as horn guide holes end up both in precisely the right place and the right size!

This method can also work very well for keeping rows of rivets looking right – working from a datum point and then double checking the gaps leads to a very even and pleasing-to-the-eye row of rivets.

Photo by Megan Charman

■ Made an error and learnt from it? Tell fellow model engineers in these pages!

START HERE

Slipping into motion...

A simple form of valve gear that is strictly for model applications

BY **ANDREW CHARMAN**

Last month we described the basics of the motion – piston rods, crossheads, connecting and coupling rods. Now we begin the complex subject of the valve gear, controlling the action of the valves on the cylinders, and allowing steam to enter and exhaust the cylinders.

The various types of valve gear form a very complex subject that can fill a very thick book, but conversely the version described this month is very simple – the slip-eccentric gear. Today it is confined to model use though it did exist on earlier engines including Stephenson's Rocket.

The slip-eccentric gear uses a single rod, the **eccentric rod**, between each cylinder and the axle. This is propelled by the **eccentric** itself, a circular disc with the axle hole off centre to transfer the rotary motion of the axle to the back-and-forth motion needed to push the valve over the steam inlet and exhaust port openings in the cylinder.

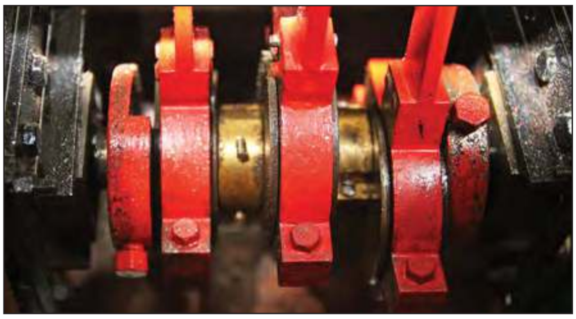
The eccentric is not fixed to the axle, but in a typical slip-eccentric design (there are variations) has a spigot mounted on it, again off centre. This engages in a collar that is firmly mounted to the axle – the **stop collar** looking like a disc but with 180 degrees of its circle at only half the thickness of the other. A good way of understanding this is to have a look at the July 2018 issue of EIM, in which the construction of Dougal's eccentrics is described and illustrated.

The stop collar rotates via the motion of the axle, the face of the thicker section engages the spigot and drives the eccentric. The direction the valves are driven, and therefore in which direction the loco moves, is determined by which of the two faces of the stop collar comes into contact with the spigot.

This is the basic drawback of the slip-eccentric gear. Starting the loco is achieved not by operating a reverse lever in the cab, but by physically giving the engine a slight push in the desired direction! Simple, but effective.

Next time we will look at Stephenson's Link motion – for which we will need a lot more space... EIM

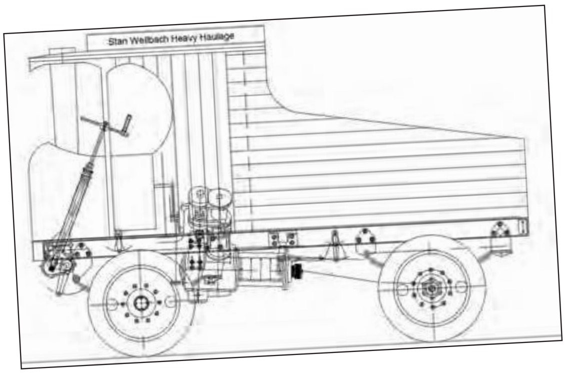
BELOW: Slip-eccentrics on 'Dougal'. On the outside are the stop collars (mating face visible on left-hand one), with the two eccentrics inside them.



Building a large-scale Fowler Steam Lorry

Martin details the complex design procedure of the boiler for his 7-inch scale wagon.

BY **MARTIN JOHNSON** Part Five of a series



The boiler is clearly the heart of a steam lorry, and for my 7-inch scale model I set myself a target of keeping the capacity within 500 Bar Litres, which means it can be tested under model engineering club rules. I also decided that the working pressure would be 11 Bar, very similar to the 160psi of my Burrell which I feel comfortable being near. It is important to remember that within the confines of a steam lorry cab, there is not much chance of rapid escape if a serious leak develops.

The comparison of the Fowler and Sentinel boilers, **Figure 4A/4B,** shows the Fowler unit had a large diameter jacket to provide steam space, which is good for ensuring dry steam and a slowly changing water level. However, a scale version would have been very expensive to construct and would not have left very much room for the driver and fireman, who remain obstinately over-scale.

I therefore opted for a parallel outside diameter and selected 18-inch nominal tube for the main barrel with a 15-inch tube for the firebox; this latter is not so readily available but is used on some 6-inch scale traction engine models for the main shell.

My initial design was for a unit with steam space around the smokebox. However, a calculation of water volume between top and bottom nuts of the water gauge divided by the peak evaporation rate showed that the water level would go from top to bottom in under two minutes; if a water feed problem develops, it is unlikely to be solved in under two minutes, so, I dispensed with the smokebox steam space, which gives a longer time to sort any water feed problem or drop the fire.

The next thing that is very apparent from Figures 4A & B is the difference in superheaters. The Fowler has 1.6 square metres, compared with the Sentinel at 2.2 square metres. In addition, the Sentinel uses two smaller steam pipes in parallel giving better heat transfer to the steam.

Given that a hot steam is essential for an undertype wagon to work well, and even more essential for a compound engine to work well, it seems to me that the Fowler was insufficiently superheated. Driving experiences that I have heard reveal that the Fowler only came 'on song' during a long run when the whole boiler had time to warm through thoroughly and achieve a sufficient amount of superheat.

Professor Bill Hall did tests on a 'Speedy' cylinder to determine the loss due to condensation in a steam engine cylinder. His results can be plotted as a graph of steam ratio (that is the actual steam used divided by the theoretical steam required) against superheat, as shown in **Figure 5**. This shows the steam consumption can be up to 2.5 times the theoretical demand if no superheat is employed.

For larger engines than Speedy and steam conditions other than around 5 Bar, the values on the graph will change, but the same pattern will be shown. Therefore, effective superheat is critical to getting good performance out of a small boiler, by reducing steam demand caused by condensation loss in the engine.

I have been studying methods of predicting boiler performance for the last few years and have developed a program for locomotive boiler analysis. This has been reported elsewhere and our editor has uploaded a summary along with the program to **EIM**'s model engineering forum – you will find it at; https://www.rmweb.co.uk/community/index.php?/topic/143493-eim-may-2019---martin-johnsons-7-inch-fowler-wagon-build-project/

I modified some of this work, which was aimed at conventional locomotive boilers, to deal with the vertical firetube units with smokebox coil superheaters as shown in Figure 4. I am indebted to a member of TractionTalkForum for passing me a set of tests on a Sentinel S6 steam lorry conducted during World War II in Germany. These included remarkably ▶

FIGURE 4: Comparison of the Fowler and Sentinel S6 9196 boilers. The Fowler in 4A has a grate are of 3.8 sq ft. The Sentinel (4B) has a 3.2 sq ft grate

All photos and diagrams in this feature by Martin Johnson

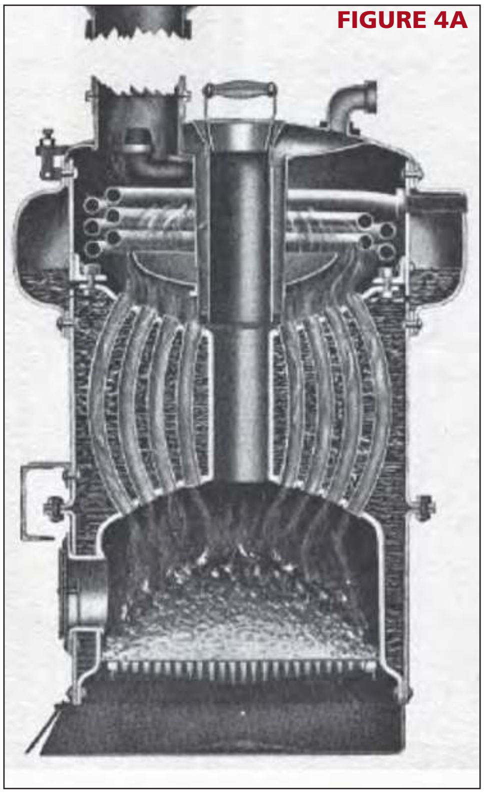


FIGURE 4A

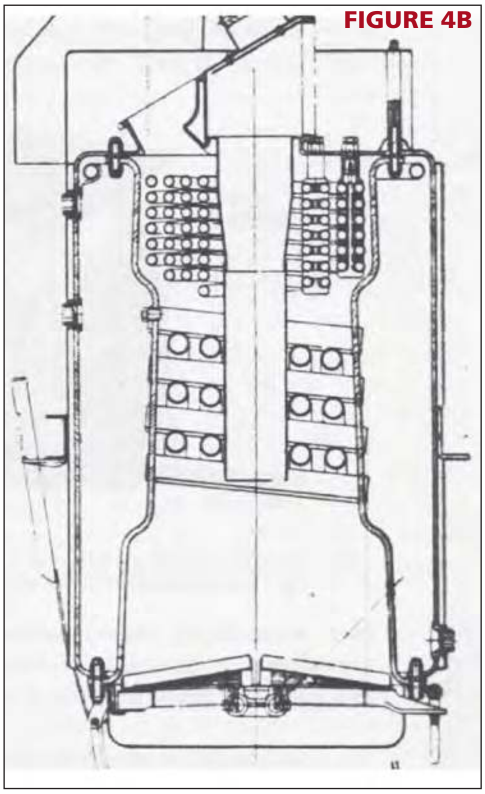


FIGURE 4B

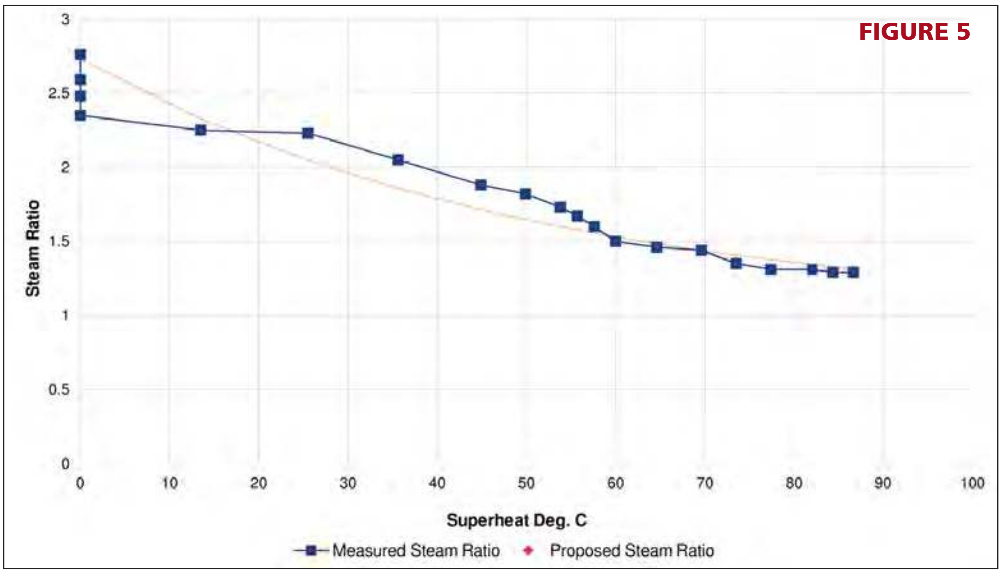


FIGURE 5: The steam ratio as measured by Bill Hall.

detailed tests of boiler performance, which allowed me to validate my coil superheater calculations.

I summarise in Table 2 some key test results and my predicted results. The table shows test results for the Sentinel in the left column, followed by predicted results for the Sentinel. These show that I was able to get good agreement except for boiler exit temperature. This may be because the German test results were taken at the chimney top and include the effect of exhaust steam, whereas my calculation refers to flue gas at the base of the chimney.

The next two columns show the Fowler performance and the model Fowler performance respectively. Note that all three predictions are made using the same calculation procedure that was validated against the Sentinel test results. This table reveals the key difference between a Fowler and a Sentinel boiler:

- The Sentinel boils a relatively low amount of water per pound of coal burnt (7.1lb/lb), but superheats it to a high temperature (470 degrees C) giving a superheat (steam temperature -saturation temperature at that pressure) of 289 degrees C.
- The Fowler boils more water per pound of coal (8.3lb/lb), but superheats it to a lower temperature (297 deg C) leaving only 117 deg C of superheat over saturation temperature.
- The Fowler will be slightly more efficient at converting coal energy to steam energy.
- The Sentinel gives the better performance as a vehicle (from various driver reports) since any undertype engine demands high superheat to work effectively.
- As an aside, the high steam temperatures also throw light on the habit of Sentinel engine inlet valves to stick after being worked hard. Note that most steam cylinder oils have a flash point around 290 deg C, so will degrade quickly at temperatures above that point. In the author's view this same effect may be responsible for the failure of the rail locomotive 'Tornado' on the Ebor Flyer in April last year.

The final column of the table shows the predicted performance of my boiler design The grate loading is a little lower than full size practice , and the air/coal ratio is a little higher; analysis of full-size and model locomotives has demonstrated this trend in practice.

I have incorporated twin parallel superheater coils, as in the later Sentinels. This gives a predicted steam temperature of 380 deg C, but by injecting the cylinder oil at four points adjacent to the piston valves, I am hoping that the oil will be subject to metal temperature, which is considerably lower than the full steam temperature. If I am wrong, it will be easier to remove superheater surface than to put more in!

"Not many people undertake the design of their own welded steel boiler,.."

Now Table 2 might suggest that I analysed the Sentinel and Fowler and then came directly to my proposed design – far from it! There were a whole load of variations investigated along the way such as:

- Longer/shorter firebox
- With/without a steam jacketed smokebox
- With spearhead superheaters instead of coil superheaters
- More/less superheater coils in various sizes of tube
- With various sizes and layouts of firetubes
- and in every case, the dimensions were adjusted to make full use of the 500 Bar Litre testing limit.

The net result of my labours is shown in Figure 6, showing a Sentinel-style superheater grafted onto a basic vertical firetube boiler.

Steel Boiler Design

Not many people undertake the design of their own welded steel boiler, but for those that may I hope the following notes may assist.

Once I had an outline design that seemed promising, I had to translate it into a pressure-vessel design that would satisfy the Pressure Equipment Directive. As a start I purchased drawings for the Steam Boat Association of Great Britain vertical firetube boiler No. 101. This has an 18-inch outer shell, but there the similarity ends – different firebox size, different tube size, no vertical stoke tube.

In addition, the SBAGB boiler design was from 2005 and things have moved on since then in terms of material specifications, need for detail on drawings and approval process. So while they were of some help, there was not much I could use from the SBAGB drawings.

The Model Engineering Liaison Group (MELG) code for examination and testing has some weasely words on Design Verification (Section 5). The usual starting point is 'Chat it over with your club boiler inspector', which revealed that designing from scratch was way out of the inspector's comfort zone. So I 'chatted it over with my boiler inspector's boiler inspector', which didn't really get me much further. Boiler inspection and boiler design are very different skills and I would suggest that very few club boiler inspectors could realistically undertake the design verification role for a large steel boiler – unless they happen to be chartered engineers with a professional background in pressure vessel design.

So I downloaded a copy of the *Pressure Equipment Directive*, and after a LOT of reading it transpired that I wanted to build a Class III vessel, for which 'Design Approval' would be needed from a 'Notified Body' (The PED Annex II, Table 5 refers – search for 'Pressure Equipment Directive' on the internet).

A Class III vessel includes most model boilers in excess of 200 bar litres, which would include many 4-inch scale traction engines and 7¼-inch gauge engines and larger. One assumes that the designers of these models have gone through the design verification procedure applicable at the time.

In practice the PED makes the following requirements:

1) The vessel must be designed to a recognised National or International standard. In my case the relevant standard is BS 2790, 1992 for which I suggest you Google 'BS 2790 free pdf'. BS 2790 is partly superseded by BS EN 12953, but for my work was still current. BS 2790, 1986 should (in theory) be used for locomotive-type boilers, but is now unobtainable.

However the 1992 version is used by default for locomotive type boilers.
2) The drawings, design calculations, operating instructions, risk assessments, hazard analysis, essential safety requirements checklist, nameplate details and material schedules must be reviewed and approved by a Notified Body. I used British Engineering Services (formerly known as Royal Sun Alliance), but others are available; check who your boiler builder deals with.
3) The construction and testing up to hydraulic test (and steam test if you are not using the MELG scheme) stage must be inspected by the Notified Body. The amount of testing is determined partly by the standard to which you are working and partly by the Notified Body. There seems to be some 'creative interpretation' of the requirements in BS 2790 for non-destructive weld inspection, since several well-known suppliers indicated that they do not normally undertake non-destructive testing on welds, and yet the standard specifies it.
4) When the Notified Body are happy with the construction, they will sign off the build and allow me to CE mark the boiler.
5) This level of engineering oversight by highly qualified engineers is expensive. A Notified Body will also charge extra if they need to see multiple revisions of your calculations and designs – in other words, carelessness costs!

The above means that the design calculations must be conducted according to BS 2790 and presented in a way which is clear. Fortunately, BS 2790 is written in a way which takes you through the process in a logical manner and for the benefit of those who might follow, I summarise it along with my own comments below:

"Suitable materials for a boiler must now have 'specified elevated temperature properties', and certification to show it, which excludes just any old mild steel..."

Materials

Material standards have changed since BS 2790 was written. In simple terms, suitable materials for a boiler must now have 'specified elevated temperature properties', and certification to show it, which excludes just any old mild steel.

The following are currently acceptable and are available. You should be able to find their relevant elevated-temperature properties in the appropriate standards, or try steel stockholder's websites for free data:
Shell tubes (including circular fireboxes and anything not a firetube): ASTM A106 Gr B or A333 Gr 6 or EN10216-2 P235GH or P265GH
Firetubes: BS 3059 - 1 Gr. 320
Flat Plate: BS 1501 Type 161 Grade 430B
Bar or plate for bushes, nozzles, brackets etc: Theoretically this should be BS EN 10028 – 2 Grade P235 GH but my boiler builder advised that this is very difficult to obtain in small quantities, so BS970 EN3B was used.

Design Criteria

Pressure: Always allow an extra 10 per cent on top, which is the stipulated over-pressure when blowing off. BS 2790 only allows for hydrostatic testing at 1.5 x design pressure but the MELG code for examination requires hydrostatic testing at 2 x working pressure. A vessel can be damaged by over stressing during testing, so I uprated the design pressure such that: Design Pressure = Working Pressure x 2 x 1.1/1.5
Temperature: There are a variety of formulae to calculate the temperature of various parts of the boiler. Most of these are straightforward except for the calculation of firebox wall and tubeplate temperature – the hottest parts. You need to have an estimate of heat input to the boiler and I have analysed a lot of IMLEC results and conclude that 40lb of coal/square foot of grate/hour is a reasonable firing rate for miniature boilers and 14,000 BThU/lb would be a reasonably safe calorific value for coal.
Calculating Plate & Tube Thickness: Section 3 of BS 2790 is crammed with equations to determine stress for a given geometry and location, which of course must be less than the design stress determined from the material properties. A potential trap for the unwary is that many surfaces in a boiler have two corrodable surfaces – usually water on one side and flue gas on the other – so you must take account of two corrosion allowances where appropriate.

BS 2790 requires a minimum space between firetubes of 12.5 mm + tube hole diameter/8. This is onerous for small boilers, because it limits the amount of heat-exchange surface that can be accommodated in a given shell. I found that there was virtually no thermal advantage in using smaller firetubes than 1-inch diameter, so opted for simplicity and ease of tube cleaning. I notice that my own 4-inch scale Burrell boiler and the SGAGB VFT 101 boilers have tube ligaments considerably less than the BS 2790 requirement, but I chose not to do battle with the Notified Body on this point.
Openings and Branches: Possibly not obvious to everybody , but you can't just put holes through a pressure vessel shell at random. There are calculations for the maximum un-reinforced hole you can have. For holes above that size, you have to investigate 'compensation', which is an extra thickness of metal to allow the stress to 'flow' around the hole. Particular areas to watch out for are inspection ports (also known as handholes or mud lids), domes, firebox doors & washout plugs.
Staying: I was saved the complexity of calculating stay sizes and pitches as mine is a circular firebox in a circular shell, so I cannot help here other than to say it looks potentially complicated, but it is covered in BS 2790.
Weld Details: Appendix B of BS 2790 runs to about 30 pages of diagrams of different weld features. Fortunately, many of them are not appropriate to small-scale boilers.

For branches on the shell, I used 'set on' branches as it can be very ▶

TABLE 2 **BOILER DESIGN** Working conditions selected	**SENTINEL S6 No. 9196 as tested by Henschel**	**SENTINEL S6 predicted results**	**FOWLER full-size design**	**FOWLER model design**
Grate loading (kg/m2/s)	0.0622	0.0622	0.0622	0.0549
Fuel Flow (Kg/S)	0.0186	0.0186	0.0221	0.0052
Air to coal ratio (Air/coal mass)		13.0	13.0	14.0
Dryness fraction of steam (%)		99.0	99.0	99.0
Boiler working pressure (Bar)		17.01	17.01	10.88
Pressure after regulator (Bar)		9.00	9.00	7.00
Max. temp in firebox (Deg C)		1505	1541	1359
Inlet temp to flues (Deg C)		1180	1186	1175
Ext temp from firetubes (Deg C)		910	795	783
Ext temp from boiler (Deg C)	380	587	618	552
Calculated evaporation rate (Kg/s)		1.326E-01	1.842E-01	3.768E-02
Evaporation rate/firing rate (ratio)	7.10	7.13	8.30	7.20
Energy in steam produced (kW)		423	516	111
Boiler efficiency (%)		68.08	69.98	63.26
Superheated steam temp (Deg C)	470	465	297	380
Superheat (Deg C)		289	117	217

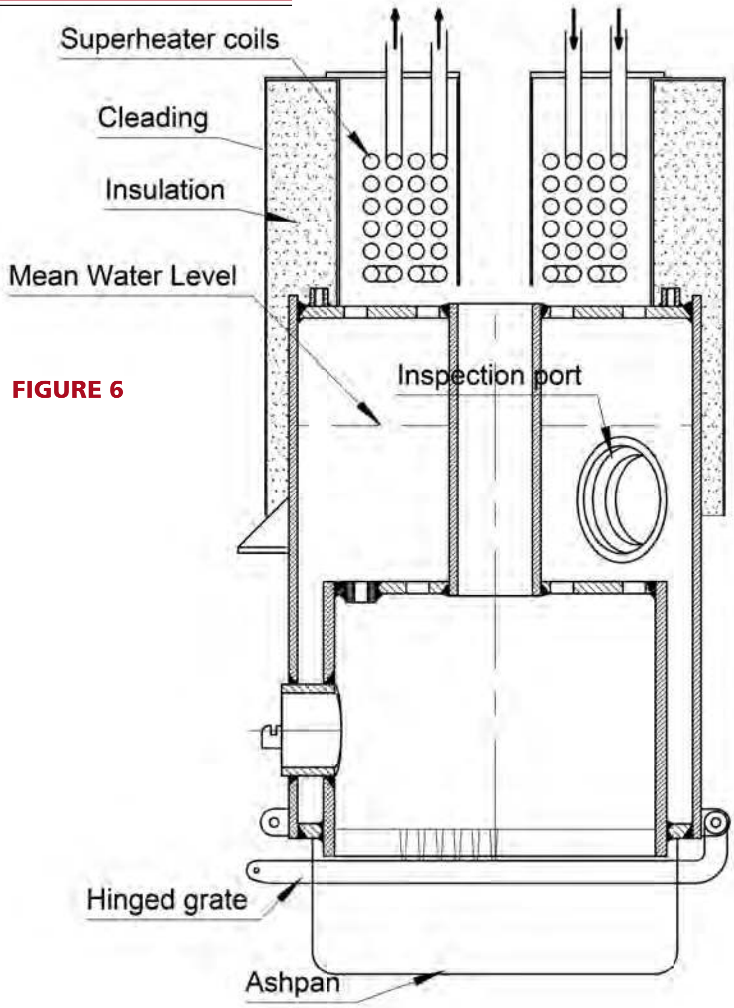
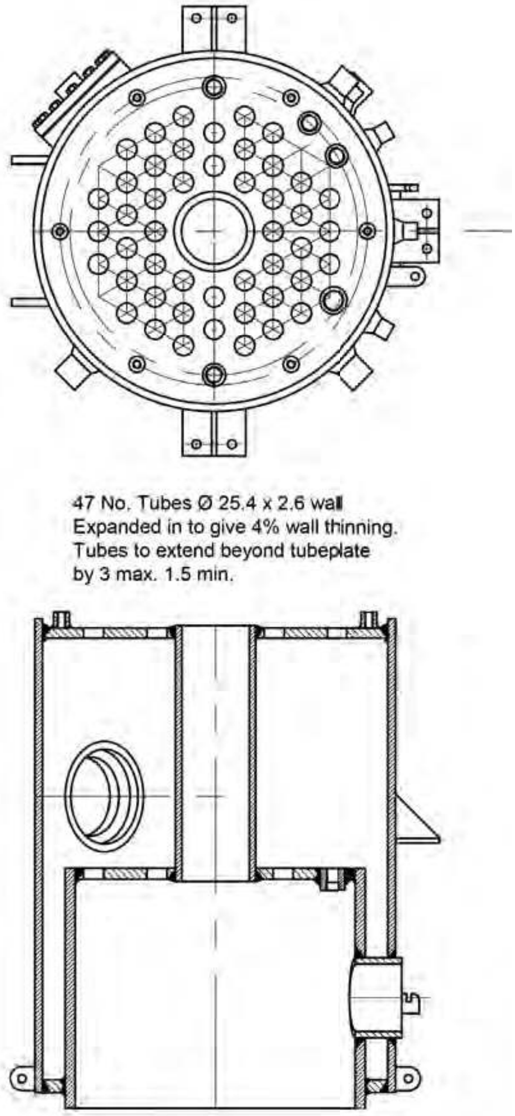


FIGURE 6

FIGURE 7



difficult to get access to the reverse side for preparation or welding. For branches on flat plates, I used 'set in' branches as access to the rear is easy at sub-assembly stage. On drawings, I specified each weld by reference to the relevant parts of BS 2790 as follows:

a) Branches & bushes on the barrel – BS 2790 Fig. B 12 a
b) Branches & bushes on plates – BS 2790 Fig. B 20 b
c) Flanged Inspection port frame to shell – BS 2790 Fig B28a & Fig B11 b3
d) Smokebox tubeplate to shell – BS 2790 Fig. B 3 b
e) Firebox tubeplate to firebox – BS 2790 Fig. B 4 b
f) Foundation ring to Inner Firebox – BS 2790 Fig. B 5 c
g) Foundation ring to shell – BS 2790 Fig. B 3 b
h) Inner and outer shell to clinker hole – BS 2790 B 11 b2 (similar to firebox door)

The above are what I specified for a vertical boiler; I hope they assist those designing other boilers, but may need some development to suit particular applications.

Brackets, supports, grate fixings, doors, hinges and such: ALL welds on a boiler – even those not subject to pressure – must be undertaken by a coded welder. So don't forget to specify all the various extra blobs needed to fix things onto the boiler or support the boiler on your drawings. Even the material for these twiddly bits must be specified.

Firetube fixing: Welding is an option, but I would not recommend it as steel tubes typically last around 10 years under 'hobby use', so will need replacing. I specified 'Expanded in to give 4% wall thinning. Tubes to extend beyond tubeplate by 3mm max.'

After spending considerable time acquainting myself with the intricacies of BS 2790 and translating it into engineering drawings I eventually had 10 sheets of drawings, 18 pages of calculations, two pages of essential safety requirements, four pages of instructions and four pages of risk assessment which all went off for approval. Figure 7 gives an indication of the style of boiler and general constructional details.

Approval was obtained without any great problems, the only points that needed changing were the material specifications and the Notified Body did concede that material selection is presently a rapidly changing topic.

And what next?

That brings progress right up to date. There is a waiting time of well over a year for the boiler, but I will not be idle. I have a lot of smaller bits to make such as reversing levers, handbrake levers, gear levers, control rods and connecting up the brake hydraulics. There is also a boiler-feed pump to construct, along with lubrication pumps for the engine.

There is quite a lot of design work to do, detailing the boiler equipment such as the grate, smokebox, superheater and chimney, and thinking about bodywork construction. I have some ideas on improving the design technique for draughting arrangements which will probably pick up where my work on boiler design has left off. It all helps to keep the grey matter going!

I hope that some of the techniques outlined in these articles will find use on your own project and if anyone feels inspired to tackle a 7-inch Fowler, I would be delighted to see the patterns and drawings getting some more use. With the editor's permission I shall check in again when I have some more progress to report. EIM

FIGURE 6: The layout of the boiler, superheater, the grate and ashpan.

FIGURE 7: Plan and section of the boiler pressure vessel.

"The Notified Body did concede that material selection is presently a rapidly changing topic..."

■ The first four parts of this project appeared in the September and October 2018, and the March and April 2019 editions of EIM and we will carry further features as the build progresses. You can also follow construction online at: www.flickr.com/photos/140734312@N06/sets/72157669955074511. The author can also be contacted via the editor.

Truing up brass or BMS angle

The latest in John's series of best practice techniques for newer model engineers.

BY **JOHN SMITH**

I learned the hard way – after riveting a length of brass angle to both sides of a side tank outer sheet – that commercially-available brass or BMS (bright mild steel) angle cannot be relied upon to be 'square', that is with legs at 90 degrees to each other. This means that using it to build 'square' structures is not possible; it has to be squared up first.

Putting it in the machine vice on the mill and machining one bolting face looks to be the obvious solution, but how can we be sure that the other bolting face is vertical in the vice? Figure 1, purposely exaggerated, illustrates the problem.

The solution is to hold the angle as shown in Photo 1. One leg of the angle is made truly flat by rubbing it on a piece of 400 grit Wet and Dry abrasive paper on the surface plate. The edge which sits on the parallel is also given a quick rub on the Wet and Dry to remove any burrs.

The flat side of the angle is then forced against the vertical rear machine-vice jaw by a length of silver-steel rod, the arrangement being facilitated by suitable parallels. Any size of angle can be accommodated (Photo 2). Very light cuts are taken, moving the head down, or the knee up, until the end mill cuts over the entire horizontal surface of the angle.

For many years, I used a Myford VM-B vertical mill, which I found to be a durable and sturdy machine, capable of quite heavy work. However, in common with many small mills, it features a spindle which cannot be adjusted left-and-right or fore-and-aft to ensure that it is absolutely at right angles to the table of the machine. Mine is a few minutes of arc out in both planes. This doesn't sound a lot, but every operation has to be approached in such a way as to minimise the effect of the inaccurate geometry on the workpiece.

If you have a mill with the same problem, you will know that an end mill will cut deeper in one spot, so you will need to make several passes over the angle at each setting or the head/knee to ensure that you achieve a true surface which is normal to the leg of angle held in the vice.

If your machine can be finely adjusted fore-and-aft and side-to-side to be perfectly at right angles to the table, no such contingency is needed; one or two passes over the angle at each setting of the head/knee with an appropriate end mill will produce a perfect result (Photo 3). EIM

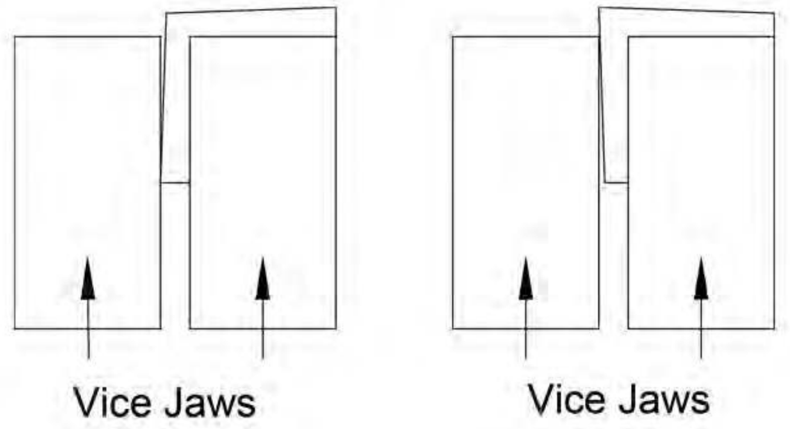
FIGURE 1: Exaggerated diagram that shows issues holding angle.

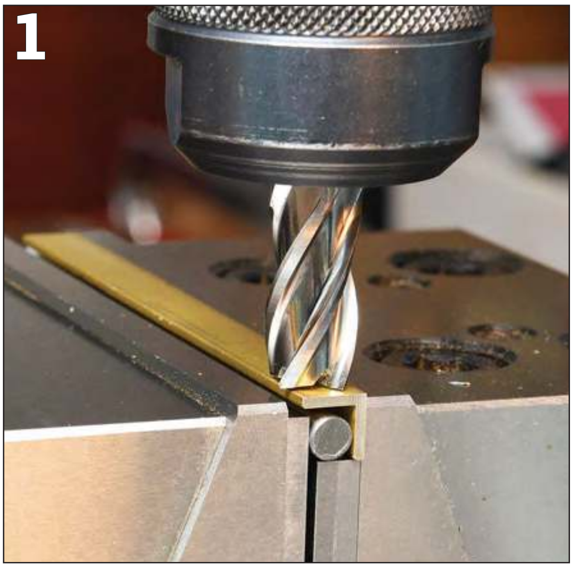
PHOTO 1: Method of holding angle to ensure one face is vertical.

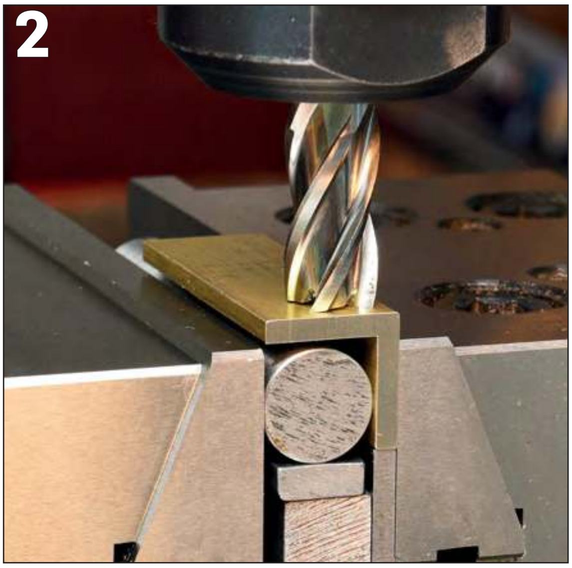
FIGURE 2: The method works for any size of angle.

FIGURE 3: Life is easier using a mill capable of fine adjustment.

FIGURE 1







Gas-fired vertical boiler for the EIM Steam Plant

Martin begins work on the firebox shell for the EIM Steam Plant project.

BY **MARTIN GEARING** – Part eight of a series

Firebox shell

Item B17 – 16SWG Brass – Refer to Drawing B15.

We begin by bringing the blank to size. Mark out a 245.5 x 45.5mm rectangle of 16swg brass (refer back to Drawing B14B if using metal from the Metal Pack), using a try square working against a guillotined edge to ensure both ends are square. Whilst probably not a brilliant finish, it will almost certainly be straight.

Cut out using a 32tpi hacksaw, taking care not to cross the marked lines. Using a file, clean up the guillotined edge checking with the steel rule to make sure that it remains straight.

There are many ways of bringing the sheet material to size and holding securely for drilling, and the method I'm suggesting is I think certain to prove successful, using commonly found equipment and materials.

Cut a piece of manufactured board 18mm or thicker to a size 250mm x 50mm, taking care that the 250 dimensions are straight and parallel. Hold in the middle of its length on suitable parallels so that it protrudes at least 5mm above the vice jaws. Clamp the rectangle of brass onto the board with four clamps, two at each end, making sure that the guillotined edge runs true to the board's length set against the fixed jaw. Arrange the clamps so as to allow a sharp milling cutter to pass unhindered the full length nearest to the fixed jaw.

Pass the work against the cutter's rotation along the length taking no more than 0.2mm depth of cut at a time until a continuous surface is produced. Reposition the clamps and skim one end until a continuous surface is produced. From these two surfaces, machine the blank to size (244.8 ± 0.1 x 45) taking light cuts **always feeding against** the cutter's rotation repositioning the clamps as necessary (Photo B66).

There are several acceptable methods for proceeding. The following method of clamping will use the accuracy and security inherent with a milling machine. It could be debated that it would be easier to use a drilling machine, but given the material, and the fact that to safely drill holes in soft thin sheet, the work would need to be clamped at each setting – any time-saving achieved becomes debatable.

Because there are 32 holes to be drilled and given the length of the workpiece, it will be a great help if the centres for the holes are marked out at this stage to catch any errors when indexing manually. Refer to the drawing B15 for the orientation of the datums. Scribe parallel lines from the long datum edge at 8, 17, 32 and 42.5mm. Place the stock of a try square against the long datum edge as you measure from the end datum edge and scribe 18 lines across the width at the relevant points only (otherwise it will look like you've marked out a mesh!). It also helps to mark at each intersection with a fine scriber where a hole has to be drilled (Photo B67).

PHOTO B66
Bringing the brass blank to finished size.

PHOTO B67
Once sized the blank is marked out.

All photos by Martin Gearing

Drilling Holes

Zero the spindle to the left-hand edge on the X axis and to the front edge on the Y axis. This will tally with the drawing. Referring to the table of coordinates below, move the spindle 8mm to the right on the Y axis. Centre drill at all the X-axis coordinates as

Firebox hole coordinates	Y 8	Y 17	Y 32	Y 42.25
X 4	Ø1.6		Ø1.6	
X 15.4		Ø9.5	Ø5.5	
X 32.4	Ø3.2			
X 40.4				Ø3.2
X 45.4		Ø9.5	Ø5.5	
X 75.4		Ø9.5	Ø5.5	
X 87.4	Ø1.6		Ø1.6	
X 105.4	Ø3.2	Ø9.5	Ø5.5	
X 122.4		Ø16		Ø3.2
X 139.4	Ø3.2	Ø9.5	Ø5.5	
X 157.4	Ø1.6		Ø1.6	
X 169.4		Ø9.5	Ø5.5	
X 199.4		Ø9.5	Ø5.5	
X 204.4				Ø3.2
X 212.4	Ø3.2			
X 229.4		Ø9.5	Ø5.5	
X 240.8	Ø1.6		Ø1.6	

listed. Move to 17mm, then 32 and lastly 42.25 on the Y axis and repeat at each listed X-axis coordinate setting until all 32 centres have been drilled (Photo B68).

Repeat the process but this time drilling at the relevant coordinates 1.6, 3.2, 5.5, 9.5 and 16mm diameter holes(Photo B69).

Remove and deburr all holes and edges on both sides of the rectangle. Scribe two lines from the long datum to contact the central 16mm hole tangentially (tangential = a straight line just touching the outside of a circle). Saw away the waste, cutting between the lines, and file the edges of the slot back to the line. Chamfer the straight edges of the slot.

As the rectangle will have to be bent to form a cylinder after drilling it should be annealed now. Heat the brass to a dull red and allow to cool to room temperature – remember to do this away from bright light as it is easy to overheat the brass.

Firebox Shell Former

Refer Drawing B15A – 1st stage.

A wooden former either from hardwood or multiple thicknesses of plywood glued together 76.2mm diameter x not less than 60mm thick is required initially to form and later to true the firebox after it has been silver soldered. Use the same procedure holding the blank against the chuck jaws with a running centre put through a 8mm washer to prevent it forcing too far into the wood as you did for previous formers.

Next step is to form the rectangular blank into a circular form. In a vice with soft jaws fitted, grip the blank against the former with about 15mm protruding to the right of the vice jaw. Starting as close to the former as you can, bring the end round against the former using the soft-faced hammer (Photo B70).

Move the blank so that about 80mm protrudes and repeat the process (Photo B71). Then turn the strip around and repeat these two stages on the other end.

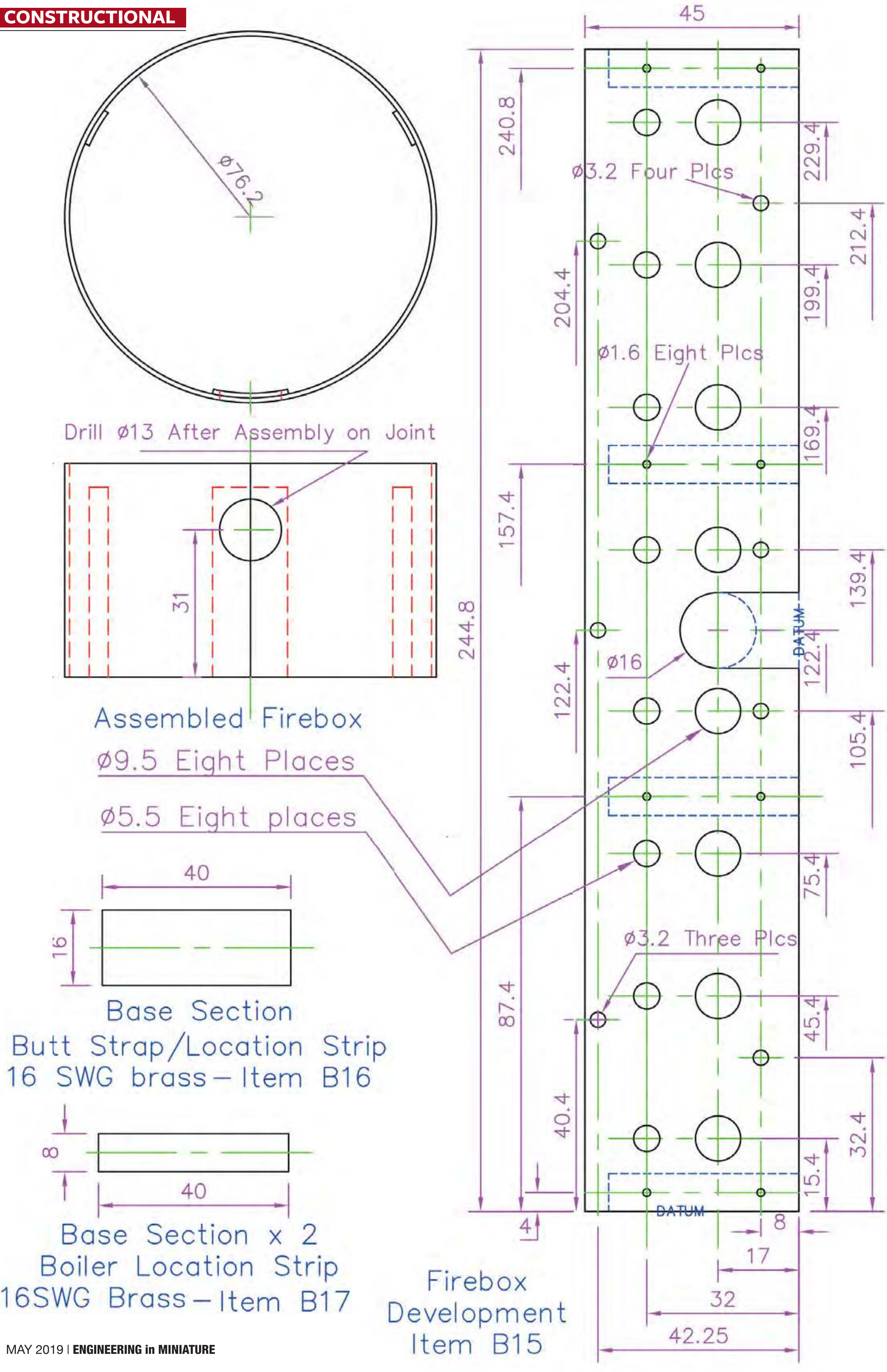
Using hand pressure, bring the two rounded ends together and clamp them together between the vice jaws, encouraging the strip to conform with gentle application of the soft-faced hammer (Photo B72).

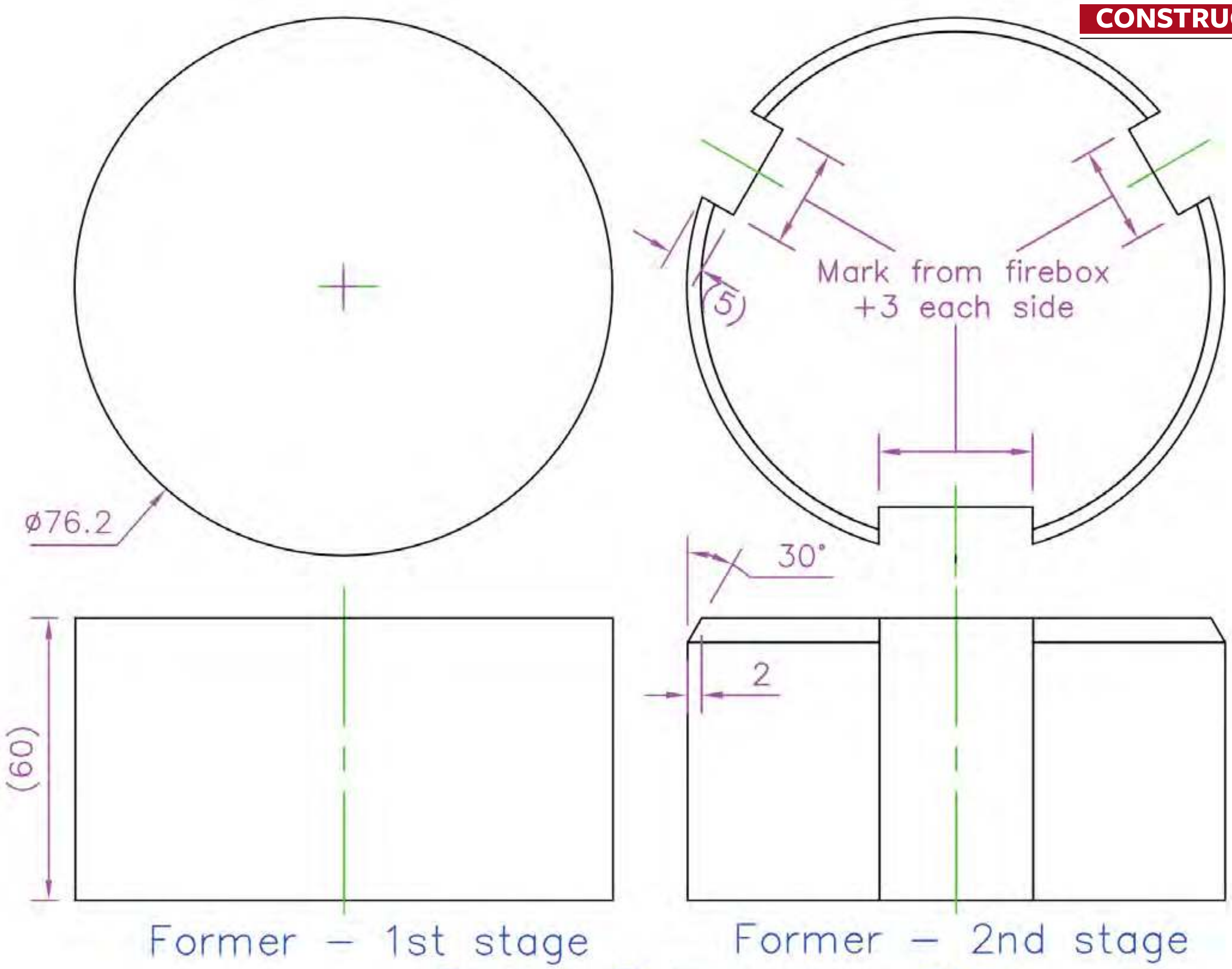
Pass a length of soft wire through holes drilled 45.4mm in from each ▶

PHOTO B68
All the marked hole positions are initially centre-drilled.

PHOTO B69
All drilling complete with holes to size.

PHOTO B70
First stage of the bending, around former using a soft-faced hammer.


ø76.2
Drill ø13 After Assembly on Joint
31
Assembled Firebox
ø9.5 Eight Places
ø5.5 Eight places
40
16
Base Section
Butt Strap/Location Strip
16 SWG brass – Item B16
8
40
Base Section x 2
Boiler Location Strip
16SWG Brass – Item B17
45
240.8
ø3.2 Four Plcs
229.4
212.4
204.4
199.4
ø1.6 Eight Plcs
169.4
157.4
244.8
139.4
DATUM
122.4
ø16
122.4
105.4
75.4
ø3.2 Three Plcs
87.4
45.4
40.4
32.4
15.4
DATUM
4
8
17
32
42.25
Firebox
Development
Item B15



Firebox Former–Item B15A

end and tighten until the two ends meet. Put to one side.

Further components

Firebox butt strap
Item B18 – 16swg brass.
Refer Drawing B16.

Mark out and cut a rectangle 16.5mm x 40.5mm of 16swg Brass. Bring the rectangle to size (16 x 40) using a file. Lightly scribe a centre line along the length of the rectangle, and with a triangular file mark across each end thickness where the centre line falls.

Boiler Supports
Item B19 x 2 – 16swg Brass - Refer Drawing B17.

Mark out and cut two rectangles 8.5mm x 40.5mm of 16swg brass. Bring each rectangle to size (8 x 40) using a file. Scribe heavily a centreline along the length. EIM

NEXT MONTH...
Martin assembles the firebox shell.

■ Parts 1 to 7 of this series appeared in the October 2018 to April 2019 issues of **EIM**. Digital back issues can be downloaded or printed versions ordered from www.world-of-railways.co.uk/engineering-in-miniature/store/back-issues/ or by telephoning 01778 392484.

PHOTO B71
The second stage of bending with the firebox adopting its final shape.

PHOTO B72
Bending completed, the two sides just about meeting up.

CNC-controlled Plasma Cutting in the Workshop

Concluding his two-part feature, Kustaa describes how be designed and built a table for a form of metal cutting seldom employed in the model engineering workshop.

BY KUSTAA NYHOLM

We begin this month by looking at the design of a CNC table. Plasma cutting is really best suited for cutting flat sheet metal so an XY controlled table is what is required with some Z control for better consumable life and ease of use. Of course various different configurations of table are used in industry such as a SCARA robot for '3D' cutting.

The plasma torch cuts a rail of about 1.5mm into 3mm steel at about 5000 mm/min. The flame is so powerful that (the lack of) cutting speed becomes a problem with thin materials. Hypertherm specifies 9000mm/min for 0.5mm thin steel. Cutting slower may cause flame outs as the arc will eat and blow away all the material!

My setup maxes out at about 300mm per second and an acceleration of about 250mm/sec^2. It would not hurt if I could crank up the acceleration as the width of the cut has some dependency on the speed (slower cuts wider) and rectangular pieces come out slightly, about 0.5 mm, barrel shaped.

The accuracy or repeatability of plasma cutting in my experience is about 0.5-1.0mm depending on the condition of the consumables, torch height consistency, cut speed and material/thickness.

As the accuracy of the cut is not going to be very high anyway and especially because the cutting action puts next to no forces on the workpiece the construction of the XYZ cutting table is not critical at all, I opted to make mine from parts at hand, not even bothering to do any drawings, mainly just eye-balling and bolting things together in a couple of spare-time weekends.

The most critical aspects of the construction and design, in addition to speed and acceleration, are that the table is flat and that the XY axis are parallel to the table and perpendicular to each other. To ensure the perpendicularity I made the Y axis adjustable while the table, really a sacrificial grille on top of a water bath, is also easily adjusted using shims.

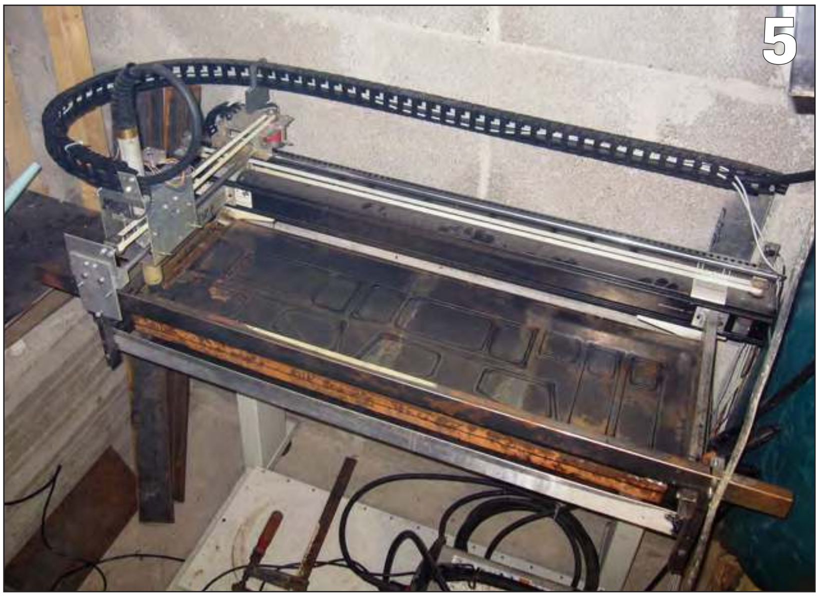


PHOTO 5: Kustaa's own impromptu CNC plasma cutter, the build of which he describes this month.

PHOTO 6: A further configuration, used on a wood-cutting CNC router.

All photos and diagrams by Kustaa Nyholm

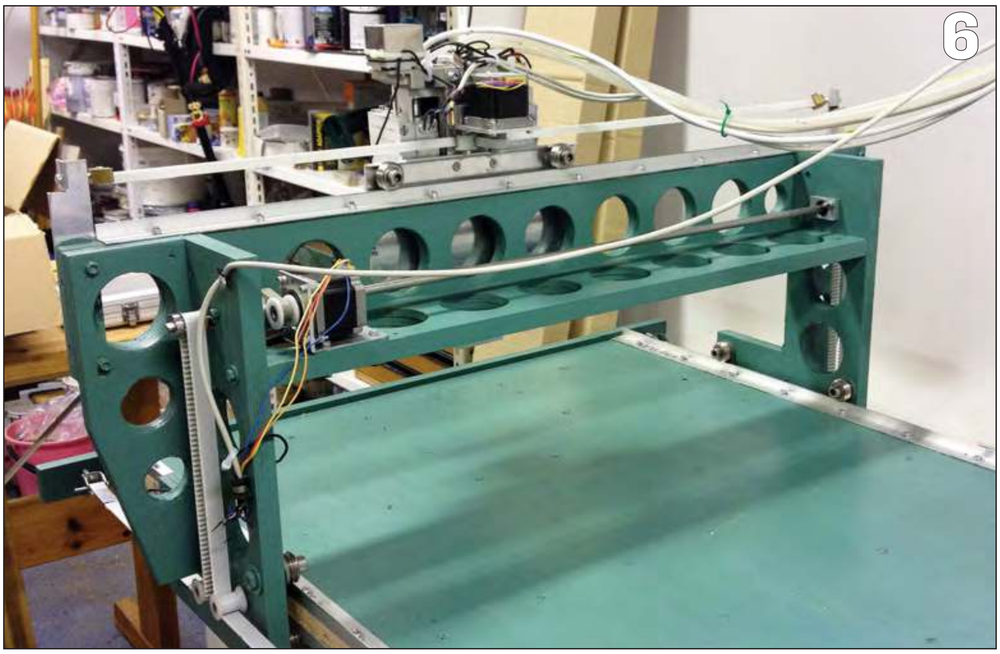
Drive Mechanism

There are a number of different drive configurations available ranging from exotic ones such as hexapods to straightforward lead-screw or belt-driven systems like I've used.

Lead screws are straightforward but long ones may prove to be problematic especially at speed and definitely more expensive than a simple direct belt or chain drive.

In Photo 5 you can see my configuration but I've also included another popular configuration in Photo 6 that I used in my wood-cutting CNC router. In both configurations the X-direction mechanism consists of two rails, one at the back and one at the front of the table. On these rails rides a 'bridge' on which carries the Y mechanism which in turn contains the Z mechanism.

The X-carriage rides on the two X-direction rails, and is driven from



the far end via a reinforced timing belt directly from a stepper motor. As this may not be very clear from the pictures I've included a schematic sketch of the arrangement in Figure 2.

This is by no means the only usable configuration, there is plenty of room for creativity here depending on what parts you have available.

Figure 3 illustrates an interesting XY movement configuration used in a Houston HiPlot plotter some 30 years ago which has the merit of having no electrical connections to the moving parts as both motors are in the non-moving frame of the system.

More importantly in this configuration, as the motors are mounted in the stationary frame of the table the moving mass is minimised which means higher acceleration and you can't have too much of that when you need to move the torch some nine metres per minute.

To give further food for thought Figure 4 illustrates how the HiPlot managed to off load even most of the Z-mechanism mass from the moving parts. Note that not all CNC-control systems have the kinematic control features in their software that more exotic mechanisms may require.

Guide Rails and Bearings

My rails are based on ½-inch OD roller bearings and some round bars I had at hand. Another good option for non-critical applications are V or W-groove wheels running on anodised aluminium L-stock. These wheels are not cheap at over $30 (approx £23) a piece and the rails at some $15 (£12) per foot if you buy the genuine stuff but cheap Far Eastern (I presume) versions can be found from the web at about $8 (£6) a piece and because they provide sideways guidance you can get by with three or four wheels per rail instead of the five or six required when standard roller bearings are used.

I've used the W-groove wheel with great success in my CNC wood-cutting router. Out of curiosity I got a quote for a lot of 100 W-groove rollers from China via Alibaba.com and they would have cost me only £4 a piece. Considering that a 3-axis machine requires about 16 it is not far-fetched to find a few friends to share them with or to offload them at eBay. If you look carefully you can see the W-groove wheels in Photo 6.

Stepper Motors

There is a lot to be said about stepper motors and driving them but I will save that for another article, noting only that in this makeshift cutter of mine the X/Y motors are NEMA 23 size 2 amp/phase and the Z-motor is 1 amp/phase NEMA17 – really just

"There is plenty of room for creativity here depending on what parts you have available..."

FIGURE 2

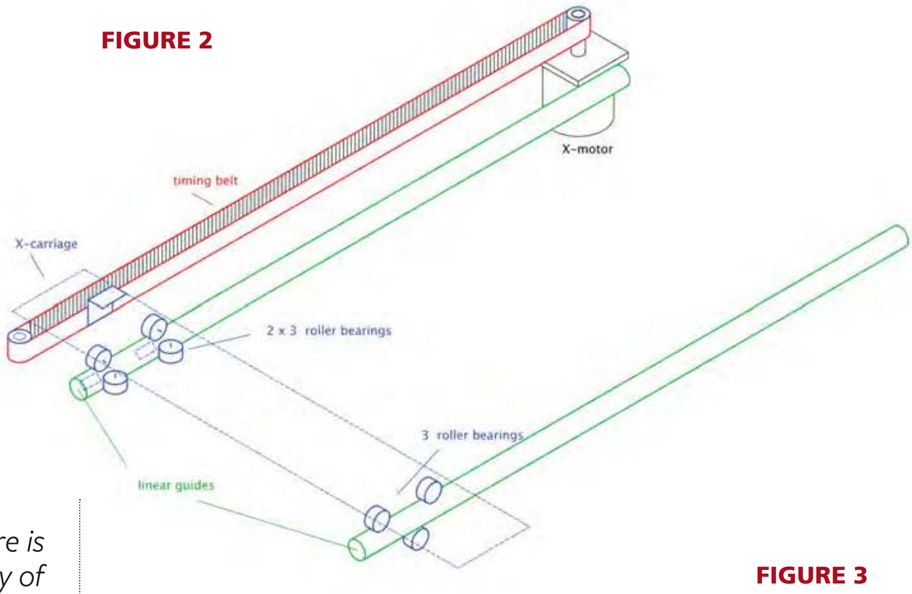


FIGURE 3

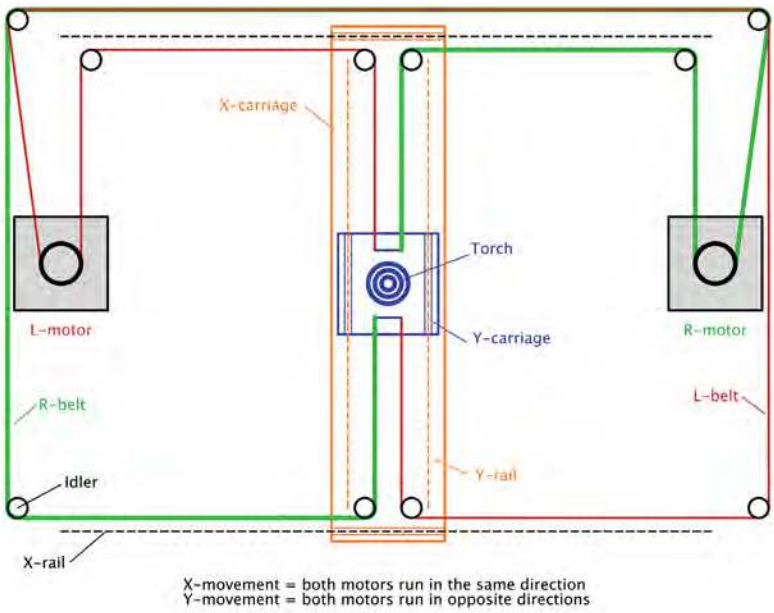


FIGURE 2: Schematic of the X-drive mechanism on Kustaa's CNC cutter.

FIGURE 3: Interesting XY movement configuration, used in a plotter of 30 years' vintage.

FIGURE 4: How the vintage plotter removed the Z-mechanism mass from the moving parts.

what I had at hand and they seem do the job just fine.

XY-Mechanism build

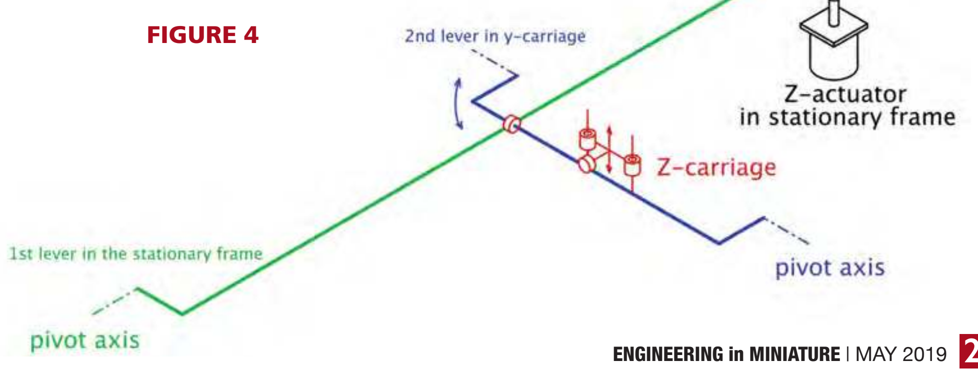
The basis for the design came from a Cadjet plotter that I had recovered from the skip at work. This provided the X-movement axis and confortable height support for the setup. I had hoped to use more of the plotter but in the end it donated only a nice, ground, 16mm axis and the sturdy extruded main frame with legs. Not even the slide bearings of the original Cadjet could be re-purposed.

The dimensions of the Cadjet also set the maximum width I can cut with my machine, which is slightly less than what I would have liked. It also restricted the Y-direction so that I cannot 'feed through' any material.

In practice I order steel pre-cut into 300mm x 1000mm sheets; that's not a bad way of working but in retrospect a slightly bigger machine would have made more sense. Oh well, this machine was really built for a particular project, my 2-4-0 live steam loco and the frames are too long to be cut at one go in the machine!

The Y-movement consists of two

FIGURE 4



parallel 10mm ground steel bars on which the Y-carriage rides. I don't think that ground bars are necessary but I happened to have them handy from a discarded X-ray machine so I used them. The back ends of the bars are attached to the X-carriage which rides on the afore mentioned original Cadjet rail. The front end of the Y-axis rides on rectangular section 'furniture quality' steel pipe.

The X and Y carriages ride on one of the rails on 12mm roller bearings that the X-ray machine also donated for this project. There are two times three or six roller bearings per rail, so arranged that four of them are fixed while the remaining two are spring loaded as illustrated in Figure 2.

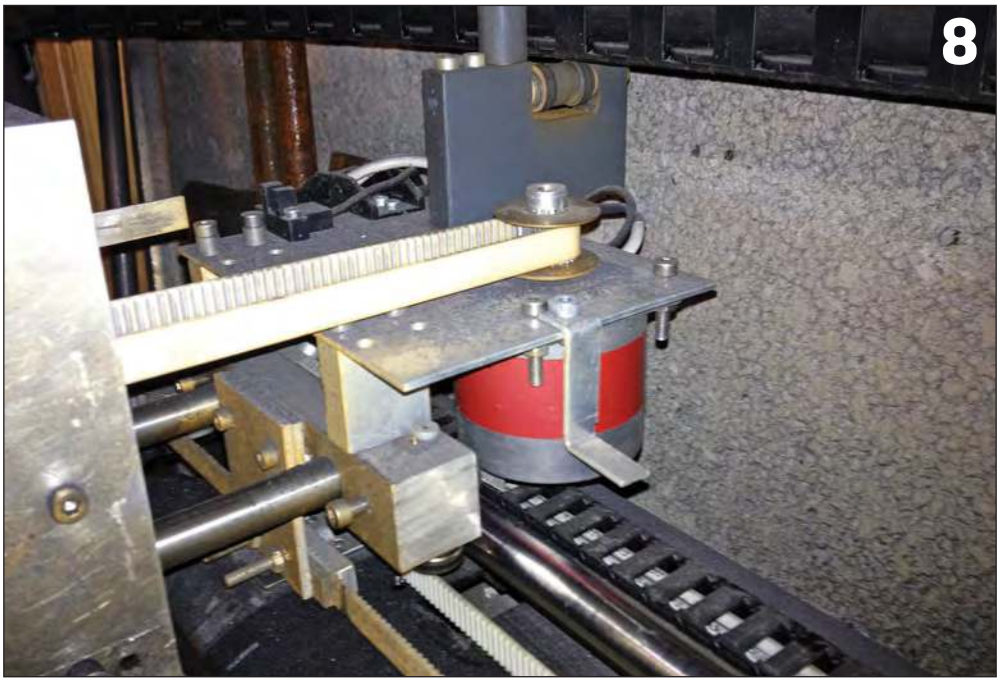
On the other rail the carriages are supported by two bearings on the top and one spring-loaded bearing below. In this way the system is not overdetermined. The two roller bearings (picture) that determine the orthogonality of the Y axis to the X axis were mounted on eccentric pieces so that I was able to fine-tune the orthogonality. On reflection it would have been enough to be able to adjust just one of the bearings!

Photo 7 gives a good view of the front X-rail (the square section tube on the right), the Y-rails (the horizontal round bars) and the Y-carriage that hosts the Z-carriage along with the torch. Photo 8 shows the same mechanism from the other side.

The drive system for the X and Y axis is via a toothed timing belt and pulley directly from the stepper motor axle. The drive is from one end of the carriage only. This sort of one-sided drive is not ideal as it subjects the carriages to a force that attempts to rotate them about their vertical axis causing the X and Y axis not to be perfectly orthogonal. But this is all in keeping with the simplicity of construction and the overall accuracy I expected/ demanded from this system.

PHOTO 7: Square section at right is front X-rail, carriage mounted on Y-rails above.

PHOTO 8: Mechanism as in photo 7 but viewed from other side.



The belt I used had a 2mm tooth modulus and 10mm width. The driving pulley had 18 teeth and was about 14mm in diameter. Given that the motors have 200 steps/rotation this works to about 14*pi/200 or 0.2mm/step which is a bit on the coarse side but again given the accuracy of the system it is okay.

By the way, roller bearings are not meant to be used as rollers as they rely on the surrounding mounting for strength but for light loads like this you can get away with them. Also stepper motors should not have radial loads applied to them but again for this type of light duty I was able to get away with my direct belt drive.

Z-Mechanism build

The Z-movement is based an two sliding sleeve bearings on a single 8mm axle and another 8mm axle parallel to it that prevents the Z-carriage from rotating via two roller bearings. The Z-axis drive is via a 1mm/r pitch lead-screw mounted directly to the stepper-motor axis. Because the motor is rigidly mounted the drive nut is mounted so that it can float and twist about the X/Y plane allowing for the imperfections of the lead screw and its coupling to the motor. All were provided by the courtesy of the donor x-ray machine.

The Z-mechanism is illustrated in Figure 5. A picture of the actual mechanism, taken along the Y-rails, is in Photo 9, as you can see from the accumulated iron dust this picture was taken much later than most of the other images.

The Z-movement requirement is small. Basically the difference in thickness between thinnest and thickest work piece plus the starting distance, in practice 25mm (1 inch), will be plenty.

The cut is started at 250 per cent nominal cut distance or about 3mm. However if you are willing to accept shorter consumable life you can use a constant distance and get rid of the Z movement altogether.

Cabling

The X-motor is stationary and thus cabling is a non issue. The Y-motor sits on the moving X-carriage and the motor and reference switch cables are brought to it via a small standard energy-transfer chain that bends in the vertical plane.

The torch cable, which is a heavy

12mm hose, and the stepper motor cable for the Z-motor are brought directly to the Y carriage via U-shaped energy-transfer chain that coils in the horizontal plane. This is a bit unorthodox but I wanted to keep the construction as simple as possible and reduce the weight of the moving parts as much as possible. The conventional way is to first bring the Y and Z cables to the X carriage using one chain and then the Z cables from there on using another.

The way I've used it puts a lot of sideways (vertical in this case) load on the chain, something it is not designed to carry, so I support it with a rubber band from the loop end to the ceiling.

I mounted optical reference sensors to each axis but I never use them. In practice I place the torch manually in the XY direction and eyeball it in place. In the Z-direction I jog the Z-axis via software so that I can just fit a feeler piece between the torch and the workpiece. Then I just zero the XY axis on the CNC software and set the Y axis to 3mm, load my G-code program and let the torch burn from there.

In retrospect, and I will do this the next time I need to take the Z-carriage apart, a dual-shafted stepper motor for the Z-direction would have been handy as I could have fitted a knob to the motor, allowing me to manually adjust the Z-axis. This would be faster and safer than using the jog controls.

Water bath

The workpiece, i.e. a steel plate, stands on a sacrificial grille on top of a water bath. The water bath stops the plasma jet and captures a lot of molten metal that the torch blows away, though some of it becomes airborne with the water mist. On YouTube I've seen underwater cutting with the same make and model of plasma torch but I've yet to try this myself.

The 6 kW flame heats the water quite a bit and it evaporates surprisingly fast... I'm now on my second bath as molten steel readily drops through 1mm thick aluminium. Fortunately when this happened the bath was empty enough to ensure that no water fell on the Hypertherm power supply that I foolishly kept under the bath!

The bath is formed from aluminium plate by folding up the sides and 'welding' (brazed really) the corners with Durafix. For those who do not know Durafix or similar products I recommend Googling up a video to see it in action. It really does what it says on the tin – with it you can easily solder aluminium.

The sacrificial grille is actually a doorfront unit I scavenged. Commercial units are typically made of thin shims of steel that are individually replaceable. Building this component is on my to-do list.

"I'm now on my second bath as molten steel readily drops through 1mm thick aluminium"

FIGURE 5

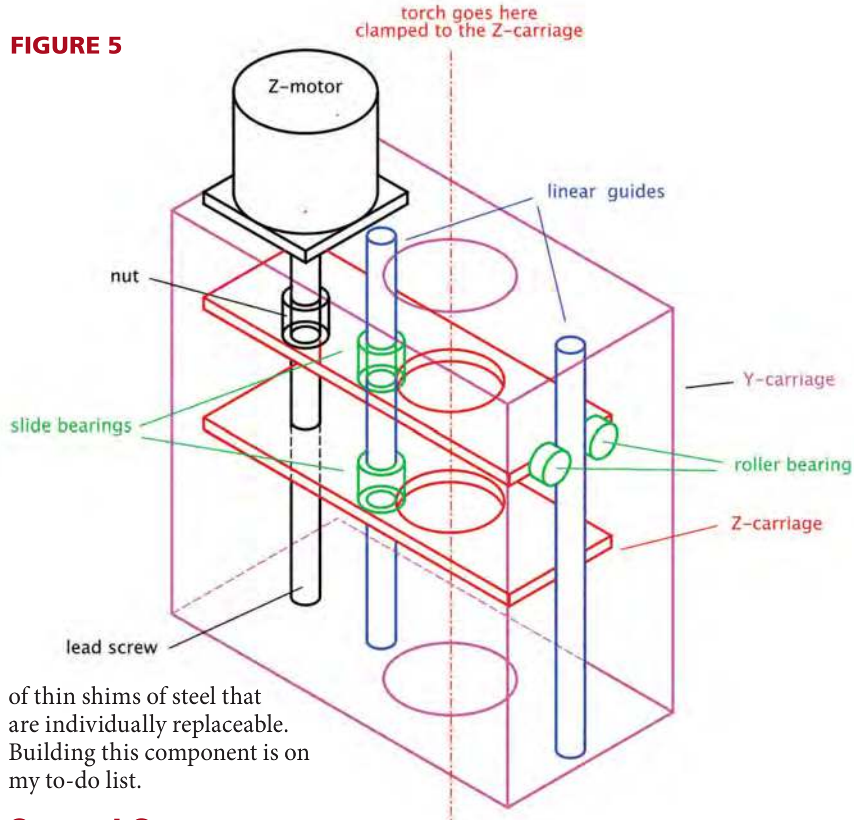


FIGURE 5: Schematic of Z- mechanism.

Control System

The control system is based on my own EazyCNC software and the companion TOAD4 stepper controller board, both of which have some unique features.

The EazyCNC software accepts standard G-code files and it runs on Windows, Mac OS X, Linux and Android. The last one particularly is very attractive as Android tables can be bought from supermarkets at below $100 and a touchscreen tablet with no ventilation is a good match with the dusty workshop environment.

EazyCNC is available for free on my website at: http://eazycnc.com

Because none of the popular operating systems (Windows, Linux, Mac OS) are designed for real-time control applications and because most computers, especially Macs and Androids, come without parallel ports EazyCNC 'out sources' the motor control to a micro-controller on the TOAD4 board with which it communicates via a USB connection.

In addition to the micro-controller that does the actual motor control timing the board contains four stepper motor drive chips and opto-isolated I/O signals to control a plasma torch or milling machine spindle. There is even a touch-probe input that can be used for such as automatic work piece alignment.

Unlike most other hobby systems which are put together from various

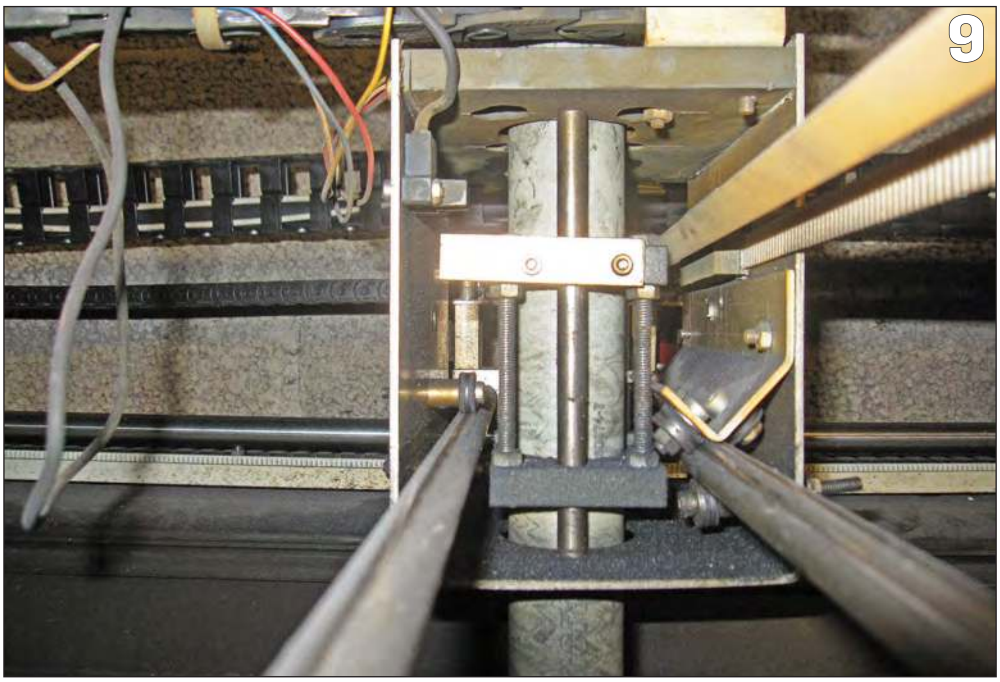
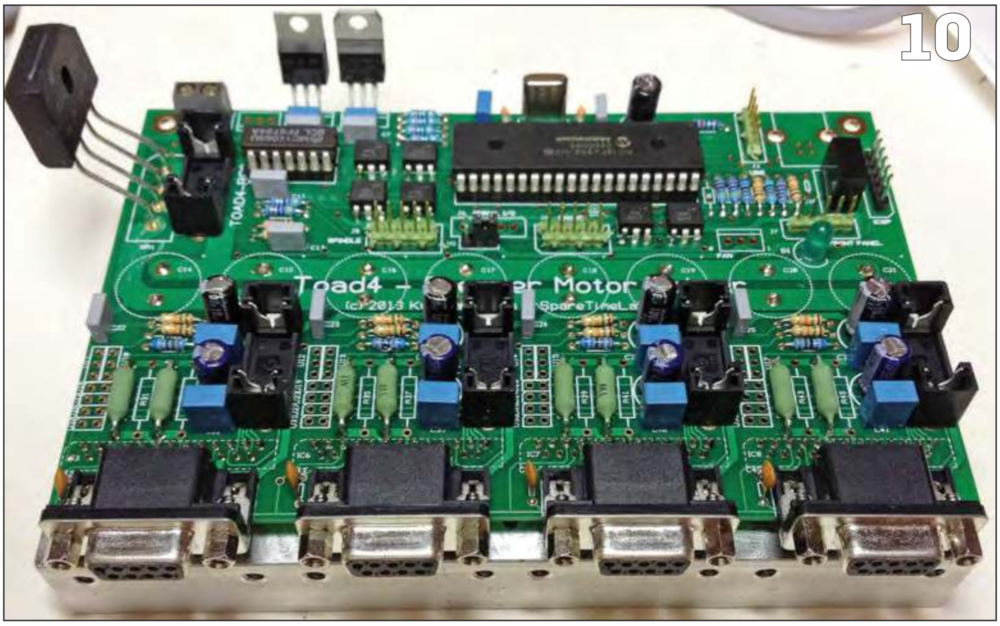


PHOTO 9: View of the Z-mechanism taken along the Y rails.



breakout boards, power supplies and stepper motor drivers TOAD4 is an all-in-one PCB solution cutting down the amount of wiring, improving reliability and reducing size and cost. See **Photo 10** for the all-in-one board that contains all the electronics to drive four steppers, including the power supply and torch-control I/O, just add the motors and a transformer.

As all the various parts of the system have been designed together in order to work together the system provides an almost out of the box plug-and-play experience, only some soldering is required.

TOAD4 is available in an easy-to-assemble kit form or as a PCB only. The PCB design uses all plate through components for easy DIY building.

The Budget

Before embarking on any adventure it is worth having a look at the budgetary cost. There follows a brief breakdown of the approximate costs – note that these are based on 'my approach'; you can easily spend several times more in each category if you just go and buy things off-the-shelf.

Plasma torch £200-£2500
Compressors £300
Computer £200-500
Control system £100-£200
Bearings £30-£40 per axis
Motors £20-£40 per axis

The plasma torch will obviously be the most expensive component.

Hindsight

These days I don't utilize the arc transfer signal from the plasma power supply to indicate start of cut, instead I've programmed a 700 msec delay between the torch-on signal and start of movement. This is not ideal as the delay will have to be a bit longer than necessary for the very first turn-on because of delays in the plasma system when the air valve opens. On subsequent cuts the delay could be shorter as the valve remains open for ten seconds after each cut. In practice, however, this has little consequence, you can just see that the first start of a cut is slightly different from the rest, if you know how to look for it.

I also don't utilize the arc voltage for torch-height control, instead I rely on having my workpiece flat and parallel to the XY axis, which is a bit of a problem, especially as cold-rolled plate tends to warp as the plasma cuts it. This must be the number one problem that brings my yield down, see **Photo 11**.

In the future I plan to add both the torch-height control and the arc-transfer signal to my system.

Cutting plasma produces a lot of fine metal dust that gets everywhere so in the long run I might have been better off with more effective protection of the guide rails and rollers, not to mention the motor and electronics. On the other hand I'm quite happy with the makeshift nature of this project... after all this was one of those 'make tools to make parts for the main project' – projects!

"As inconvenient as it is I wear a breathing mask, an arc-welding helmet and hearing protection when operating the machine..."

Lastly – Safety First

Even if I've saved it to last... The arc is bright and has ultraviolet light in it so proper eye protection is a must, just like when arc welding.

The arc is also extremely hot and sparks fly far and can set easily flammable materials on fire – a sponge I used to wipe off spilled water from the water bed caught fire!

The torch electrode is at over 130 volts DC so it can be dangerous but most nozzle designs are designed and required by law to prevent touching of the live electrode.

The burning metal emits hazardous vapours and the steaming water spreads a host of metal particles around the surroundings very effectively – most of the surfaces in the shop are covered with rust now, I even found some rust in the exit vents of my laptop, that does not spell good for the computer's life expectancy.

The torch/arc is also very noisy, not to mention the noisy compressors.

So as inconvenient as it is I wear a breathing mask, an arc-welding helmet and hearing protection when operating the machine. That must be the worst part of plasma cutting!

And finally remember that any kind of computer-controlled system is liable to go wrong at any time, so always disconnect the torch power-supply from the mains when changing consumables and install an emergency stop switch that will cut out the torch and movement. EIM

PHOTO 10: TOAD4 is an effective all-in-one control system for the CNC cutter.

PHOTO 11: Warping of the steel is a problem to overcome....

■ Part 1 of this feature appeared in the April 2019 issue of **EIM**. To download a digital back issue or order a printed copy go to www.world-of-railways.co.uk/engineering-in-miniature/store/back-issues/ or telephone 01778 392484.

Walschaerts motion – but it's very easy...

Bernard concludes his in-depth study of a propulsion system core to many railway locos.

BY **BERNARD FARGETTE** – Part Five of a series

We will see in this part and the next, the circular and Zeuner diagrams. These parts may seem a little tedious at first, but once the basis of these diagrams are understood; they allow us to follow easily the valve events during an out-and-return movement of the piston. These are primitively drawn for a valve moved by a single eccentric, but they are also valid for all valve gears whose movement of the valve can be simulated by an equivalent eccentric, as with the Walschaerts motion, or also the Stephenson link motion. It shall then be easy for you to know quantitatively the length of the different periods of a given motion, and also to know how the events vary if the key dimensions of the motion are altered.

A - Circular diagram

We have already seen that the elliptical diagram (Figures 5 and 13 in series parts 1 and 2), shows a lack of precision in the drawing of the ellipse. The circular diagram (called the Reech diagram in France and the Reuleaux diagram in Germany) eliminates this inaccuracy because the ellipse has been transformed into a circle. This allows a rule and compass construction and easier measurements of the different periods of a piston cycle. But how do we move from one to the other?

With a valve without lap (with no expansion of steam) such as in Figure 5 (Part 1), it suffices to expand the ordinate scale – that of the valve travel – or to reduce the abscissas – that of the piston stroke – so that the ellipse can turn into a circle.

In this case, it should be noted that the 90 degree angle corresponds to the angle between the abscissa and the perpendicular ordinates of the elliptical diagram, but also between main crank and eccentric.

On a valve with lap, such as in Figure 13 (Part 2), the transformation is not so easy. You must observe that the angle between the equivalent or true eccentric and main crank is greater (or less) than 90 degrees; it is therefore required to shift the axis carrying the displacement of the valve (the ordinate) by the angle of advance δ to find the correspondence between the two representations.

This circular diagram, Figure 33, corresponds to the displacement of a point **a**, which represents both the main crank and the equivalent or true eccentric, respectively projected on axes oriented according to the angle of advance **δ**. Assuming a constant speed of the engine, this point **a** moves at a constant speed on the circle, and the times set for each period are proportional to the angles scanned by this point **a**.

We can see, on this figure, that OS has the same length and angle **δ** of the equivalent or real eccentric.

This figure is similar, with a rotation and/or symmetry (direction of rotation of point **a**, slide or piston valve, sides of the piston), to circular diagrams which can be seen elsewhere.

We can follow on this diagram the sequence of the different periods;

bc: admission,
cd: expansion,
de: anticipated exhaust,
ef: exhaust
fb: compression

...in the same way as on an elliptical diagram.

In addition, we can quantify each period as a percentage of the displacement of the piston (projection **c'**, **d'**, **f'**... of **c**, **d**, **f**... on segment be), but also the angle **bOa** travelled by the wheel or crank for each period.

For example, let's determine with the next diagram (Figure 34) the percentage of admission (cut-off) in the current case in model engineering where half valve travel is equal to port + lap with, for instance ; port = 3 inches and lap = 2 inches.

To draw this circular diagram, plot a circle of centre **O** with a diameter **be** equal of the valve travel ;

Diameter = 2*(port+lap) = 2*(3+2) = 10 in

Plot the segment **bc** tangent to the half circle of radius R=lap=2 inches of centre **O**. The ratio (bc'/be)*100 gives the % cut-off which occurs here at 83.5% of the piston stroke.

In this geometrical figure, the determination of the ratio bc'/be allows us also to find easily the classic formula, but one which is valid only ▶

FIGURE 33

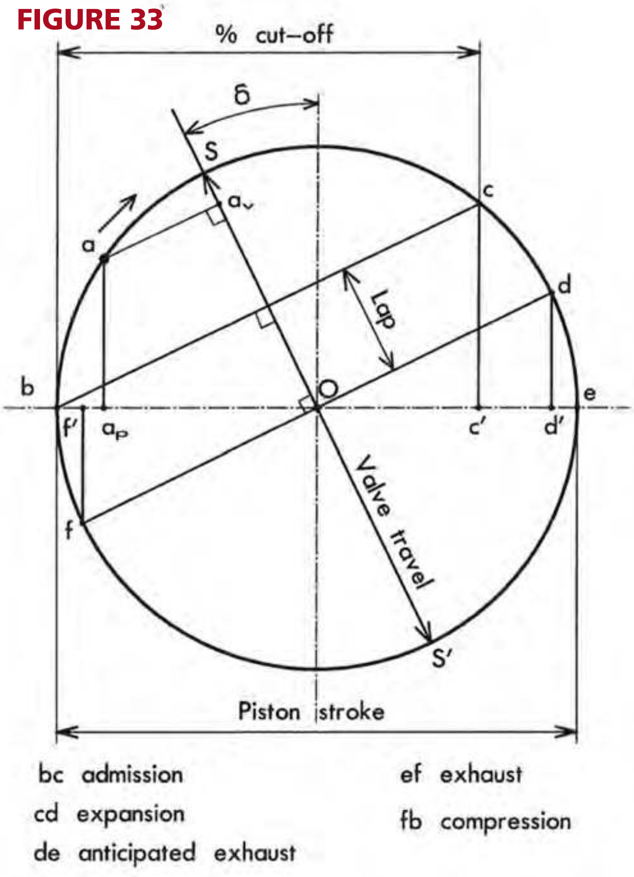


FIGURE 33: Circular diagram, slide valve with steam lap.

FIGURE 34: Graphical determination of the cut-off and the angle of advance δ (without lead).

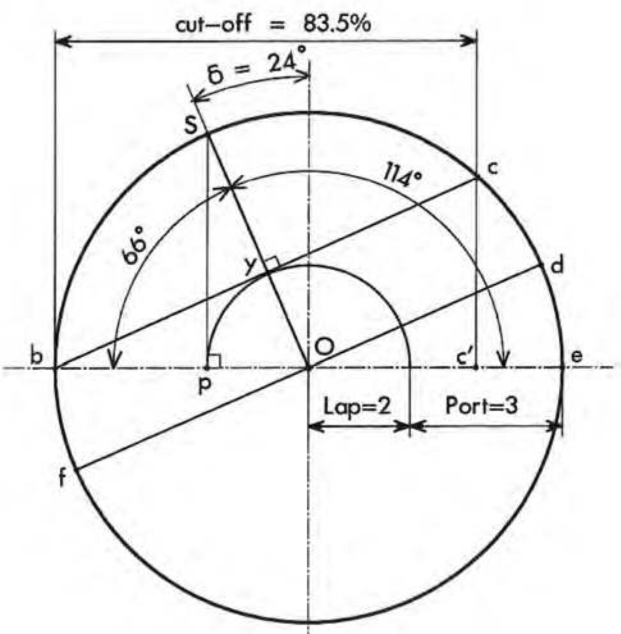


FIGURE 34

FIGURE 35

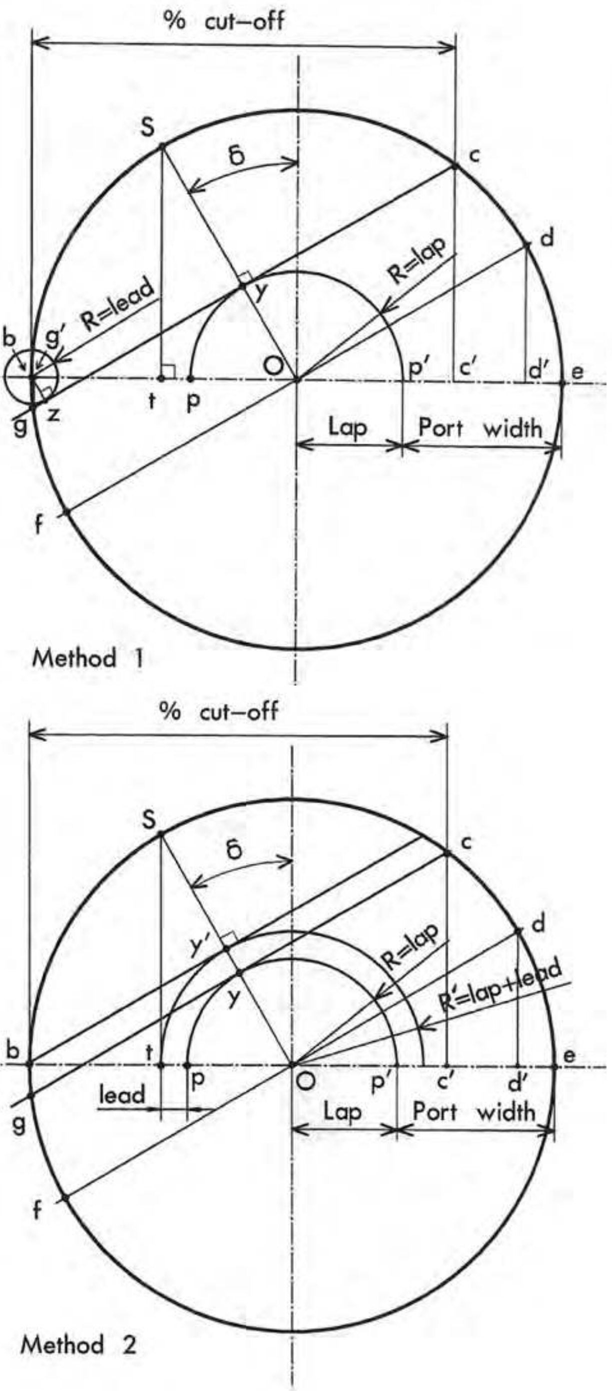
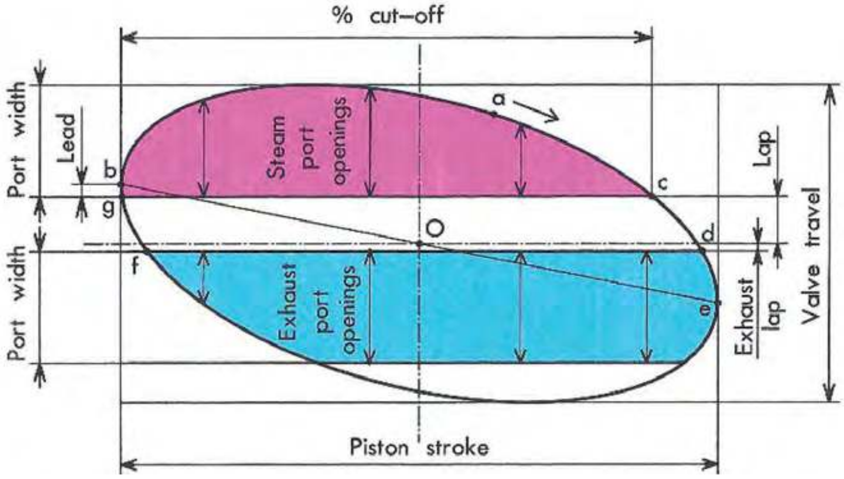


FIGURE 36



for a valve gear without lead and where half-valve travel = port + lap:

% cut-off = (1)

This diagram also makes it possible to obtain the angle of advance **δ** of the (equivalent or real) eccentric. For the data in figure 34 the angle of advance **δ** for the equivalent eccentric is 24°, so the setting angle **δ** is 90+24=114° for a slide valve and 90-24=66° for a piston valve.

But for a system with lead, how do we draw this diagram? Two answers are given in Figure 35;

Method 1; plot a half circle of radius R=lap centred in **O** and a circle of radius R=lead centred in **b**. The common tangent at **z** and **y** to these two circles cut the great circle in points **g** and **c**, beginning and end of the admission period. So with lead, there is a new period **gb** which is anticipated admission (pre-admission), and the compression period is now **fg**. In this drawing, the radius of R=lead is exaggerated for clarity. Even in this case, points g' and b are very close to each other.

"Some engineers propose a negative exhaust lap to decrease the period of compression but with an increasing of the 'anticipated exhaust'..."

Method 2; plot a half circle of radius R=lap and an other of radius R'=lap+lead, centred in **O**. Plot the tangent through point **b** at the half circle of radius R' and plot a parallel to this straight line, a tangent at the half circle of radius R=lap ; this is the segment **gc**.

So, the lead is known generally by model engineers as a dimension, but in a diagram, the result is an angle (gOb) or a time during which the steam fills the dead spaces and completes the compression period.

The complete elliptical and circular diagrams of a valve gear with lap, lead and exhaust lap, now become those of Figures 36 and 37, which allow us to know the various periods of the piston cycle .

On these diagrams, the length of the arrows represents the port openings at the inlet (up in red) and at the exhaust (down in blue) for each position of the crankpin (point **a**).

It can be seen that the anticipated admission **gb** and the anticipated exhaust **de** occur at a time when the angle of rotation of the wheel leads to a large displacement of the valve, but to a small displacement of the piston.

They therefore lead to apparently insignificant changes if one focuses only on the displacement of the piston in percentage of its stroke, but significant if one looks at the angles travelled by the axle and therefore the time granted to the steam to transfer from the cylinder ports and fill the dead spaces.

On these diagrams, we can easily examine the influence of the exhaust lap; it decreases the anticipated exhaust period **de**, increases the expansion period **cd**, but also the compression period **fg**... To the extent that some engineers propose a negative exhaust lap to decrease the period of compression but with an increasing of the 'anticipated exhaust!' Everything depends on the use of the engine; stationary engines with fixed or variable expansion, marine engines, traction engines, shunting, goods or high speed locomotives...

Shorter valve travel

Previously, we have always taken a valve travel equal to *port+lap*, in other words the valve fully opens the ports but no more. For our models, on admission, these ports are largely sufficient for the passage of high-pressure steam.

On the other hand, the exhaust port on the cylinder is generally made twice as wide as the steam ports, to permit a large volume of steam at lower pressure to pass through. However, before passing into this exhaust port, the steam must pass again through the steam admission ports.

Also D. Ashton recommends, at the admission, to open the ports only three quarters of their widths, but allowing the total opening of these ports for the exhaust. This solution has the advantage of reducing the valve travel and the disturbances caused by a long stroke (angularity effects) as the half valve travel is now equal to maximum port opening + lap.

Figure 38 shows the evolution of the circular diagram in this case. As we can see on this figure, that maximum port opening at admission is equal to **Sy** = ¾ port width, but at exhaust, the port opening stays at the maximum port width during a large travel of the piston.

In the calculation of the % cut-off with formulae (1), « port » is generally the port width, but in this special case, the « port » becomes maximum port opening for the admission of steam.

Circular diagram drawback

The circular diagram, however, has a

FIGURE 37

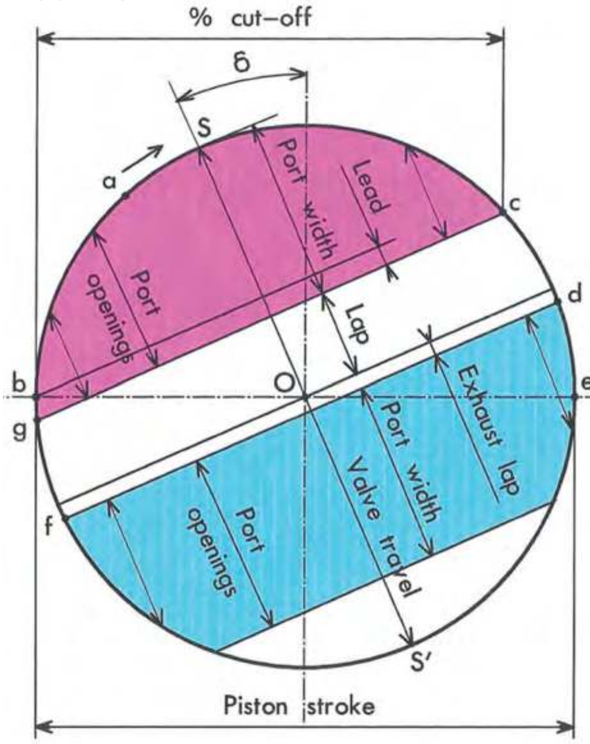


FIGURE 38

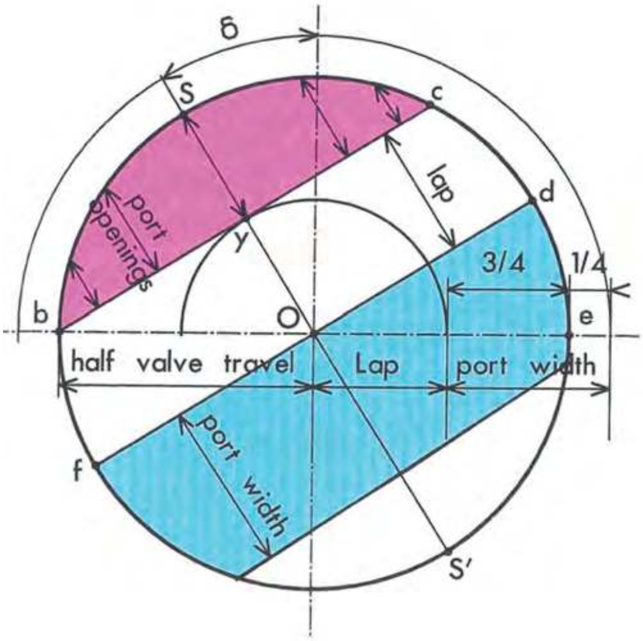


FIGURE 35: Examples of a graphical determination for a valve with lap and lead (methods 1 and 2).

FIGURE 36: Elliptical Diagram of a Walschaert motion with
- steam lap.
- exhaust lap.
- lead.

FIGURE 37: Circular diagram for a valve with:
- steam lap at admission.
- exhaust lap.
- Lead.

FIGURE 38: Circular diagram for the case that half valve travel < lap+port width

FIGURE 39: Circular diagram. The Pressure/Displacement diagram (at the bottom) is built directly for each position of the crankpin M in C, D, E.

All diagrams in this feature by Bernard Faguette

disadvantage; what happens when the driver of the locomotive notches up?
1) The total valve travel decreases (ports not fully open).

For example, if we want to keep the circle of diameter be ideal, it is necessary to expand the scale on the horizontal axis to bring the new valve travel to the diameter of this circle, the relative values of lap, lead (and eventually exhaust lap) are increased while that of the maximum port opening decreases.
2) The angle of advance is changed.

This leads to drawing a new sketch for each step of the notching up, as the drawing becomes quickly confused if we want to plot several different cases on the same diagram.

On the other hand, on the elliptical diagram, notching up leads simply to a progressive flattening of the ellipse, which then merges with the segment be at mid-gear.

Another version

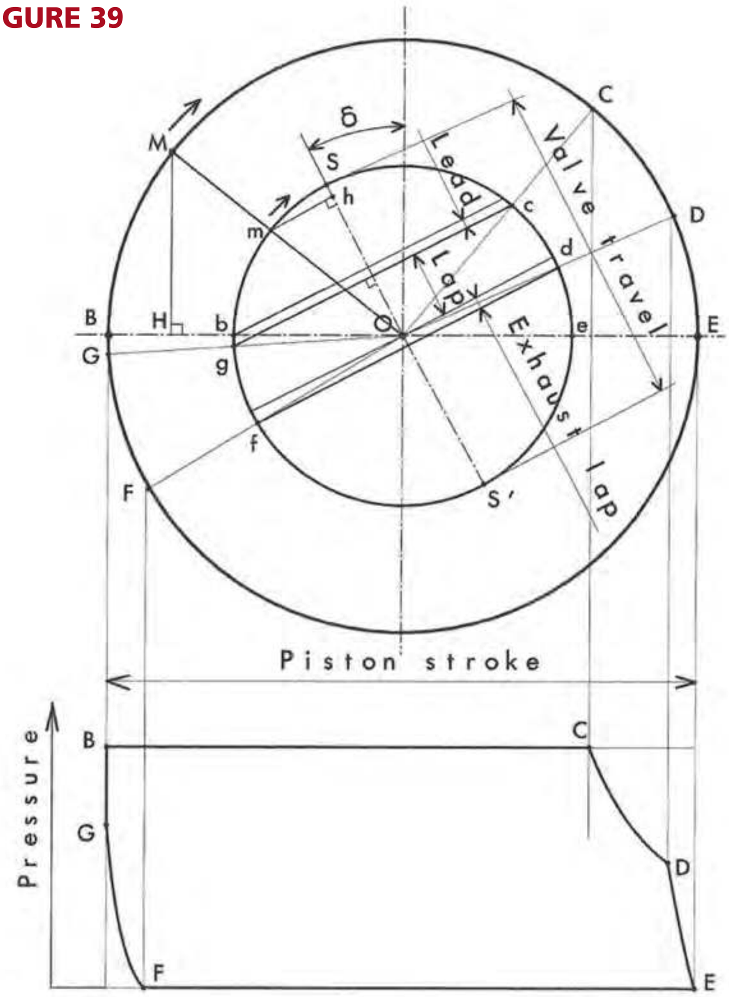
In a variation to the circular diagram (Figure 39), we can keep two circles of different radii, one for the path of main crank pin M (piston travel) and the other for the path of the eccentric centre. There is no expansion (or contraction) of scale, OM represents the position of the crank. and m, conjugate of M; it projects onto h on the axis SS'. This, for example, allows us to draw the pressure/displacement diagram directly to scale.

Connecting rod angularity

The circular diagram is only valid with the hypothesis of infinitely long rods (relative to the throw of the eccentric). However, methods allow us to take into account the angularity of the rods; these may be the subject of a later article, if the editor agrees. EIM

■ Previous parts of this series appeared in the June, August and October 2018, and the January 2019 editions of EIM.

FIGURE 39



To download a digital back issue or order a printed copy go to www.world-of-railways.co.uk/engineering-in-miniature/store/back-issues/ or call 01778 392484. EIM technical editor Harry Billmore contributed to the English translation of this feature.

Dougal – a 5-inch Barclay

Young Sussex engineer Andrew figures out the smokebox pipework on his entry-level locomotive construction project.

BY **ANDREW STRONGITHARM** – Part Thirteen of a series

Let me recap on the progress to date. I had a completed homemade boiler (which was gathering dust underneath my bed) and an air-tested chassis with running plates and brake gear made and fitted. It was now May 2011 and therefore time to begin marrying the two distinct halves together, especially as I had set myself the target of lighting the first fire before the end of the year.

I was already able to place the boiler on to the chassis, with the aid of a ¼-inch square mild steel bar welded between the insides of the frames, so I could start to work out where the holes needed to be drilled in the base of the smokebox. My smokebox was made as part of the boiler barrel and therefore all the holes had to be drilled and opened out to size with the rest of the boiler attached. The holes for the main steam pipe and blast pipe could then be marked accordingly on to the outside of the smokebox.

This was achieved by placing the boiler upside down on a Workmate with the jaws open at least two inches to allow the inner dome to sit between them. Next, using an engineer's square I checked to make sure the firebox sides were at right angles to the top of the Workmate. Then I checked the existing centre line which was scribed on the barrel during the construction of the boiler, by placing a large parallel vertically against the side of the smokebox before checking the distance to the centre line with a pair of dial calipers. I then repeated this process with the other side of the smokebox to make sure the centre line was correct.

I placed the boiler on the chassis and scribed the position of the port & saddle block on to the outside of the smokebox so that when the boiler was lifted off I could visually see where the casting sat underneath. I used the port & saddle block to measure the hole centres of the main steam pipe and blast pipe from the front edge of the casting. I then transferred these dimensions to the underside of the smokebox and used the scribe lines described above to ensure that the location of them was accurate.

Using a hand-held battery drill I initially opened out both holes to 4.8mm before checking the positioning of them and deciding if the hole centres required moving over with a file prior to opening up to their finished size. This was done in 0.1mm drill increments to 5⁄16-inch for the main steam pipe and ⅜-inch for the blast pipe (**Photo 1**).

I then continued with the manufacture of the blast pipe itself and developed my own design. Starting with a 2-inch length of ⅜-inch x 18 gauge copper tube, I cut ¾-inch worth of ⅜-inch x 32 tpi threads, part of which would screw into the port & saddle block beneath the smokebox.

The prototype 'Dougal' loco is a 2ft 6in gauge Barclay 0-4-0 built in 1946 for the Provan Gasworks in Glasgow and today resident on the Welshpool & Llanfair Light Railway in mid Wales.

A further ⅞-inch worth of ⅜-inch x 32 tpi threads were then cut on the other end of the tube which left a ⅜-inch length of plain section in the middle. Next, I turned up a 5⁄16-inch thick nut out of ½-inch hexagonal PB102 bronze and silver soldered this at the bottom of the longer length of threads which I had just cut. This nut would be used when winding the blast pipe in (or more importantly) out of the smokebox.

It is important to note that the hexagon on the blast pipe is located roughly halfway up and not at the bottom as this would conflict with the nut on the base of the main steam pipe that was positioned directly behind it, about which I shall describe later in this article.

Blower ring

Fabrication of the blower ring followed and I opted to make mine in

1

two halves with a groove in the middle for the steam. A ¾-inch diameter piece of PB102 bronze bar was used to create this and I began by inserting a ⅜-inch hole through the centre which would slide over the threads on the top of my blast pipe.

I then set up a small grooving tool in the lathe to machine the internal recess which would allow the steam to flow around the ring. This was ⅛-inch wide by 1⁄16-inch deep and positioned in the centre of the ring. Once this was complete, I parted off the first half 5⁄32-inch thick and repeated the steps above to create a second identical ring. That was the easy bit as I now had to silver solder the two halves together without filling up the groove that I had just bored out!

I held both rings together using an old engineer's clamp which I keep especially for rough jobs like this. The trick here was less is more and once up to temperature I carefully applied the smallest amount of solder possible.

For this job I used C4 silver solder, which as you may remember from my description of building the boiler, melts at a higher temperature than the normal Easi-Flo 2 silver solder. The reason for this was I now had to solder the steam supply fitting into the side and I didn't particularly want the blower ring to fall apart during this operation if I melted the first lot of solder!

I held the ring in the vertical slide on the Myford lathe, found the horizontal and vertical centre point and drilled a ⅛-inch hole until I broke through into the steam chamber in one side of the ring. The fitting was 3⁄16-inch x 40 tpi, drilled out 1⁄16-inch and I turned a ⅛-inch diameter stub at one end to push into the ⅛-inch hole in the blower ring to hold it steady during soldering.

Finally, I drilled two holes in the top face for a pair of blower jets. These were initially marked by holding the ring in the Myford lathe chuck and gently scribing a centre line across the face with a sharp-ended turning tool. This method relies on the fact that the tool holder is set at the correct centre height for the lathe.

I then scribed a 3⁄32-inch line to intersect the centre line described above using a pair of dial calipers and the outside edge of the ring as a guide. After centre punching the two points where the lines cross, I drilled them out undersize on the pillar drill before confirming their position and opening out to 1.8mm.

Replaceable jets

I then threaded the holes 8BA before turning a couple of stainless steel 'jets' which screw into these 8BA holes and contain a number 73 (24 thou') hole through the centre of them. The idea behind making separate 'jets' is so they can be easily taken out and cleaned if they become blocked and so that new 'jets' can be fitted if the holes need to be reduced in size.

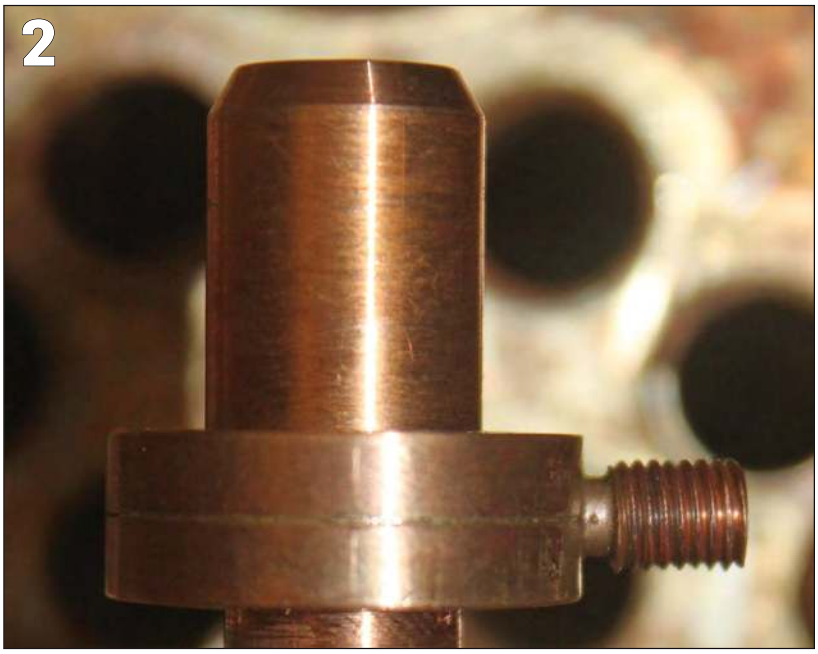
"I didn't particularly want the blower ring to fall apart during this operation if I melted the first lot of solder..."

PHOTO 1: The project so far – Dougal with its boiler temporarily mounted on the chassis to allow pipework calculations.

PHOTO 2: Blastpipe and blower ring after building.

PHOTO 3: Sorting out fitment in the smokebox – there is not a lot of space to play with....

Construction photos in this feature by Andrew Strongitharm



2

With the blower ring complete, the last part of the blast pipe assembly was the blast nozzle which was basically a 7⁄16-inch outside diameter x ⅜-inch long bronze cap. I drilled a 8mm hole x 5⁄16-inch deep in to one end of the nozzle before boring the hole out to 8.5mm to create a flat bottom. This was threaded ⅜-inch x 32 tpi and once I was happy with this, I continued the hole by another ¼-inch to a diameter of 7⁄32-inch. From my experience of running the completed model 7⁄32-inch provides an ample blast which draws the fire and makes pressure with ease.

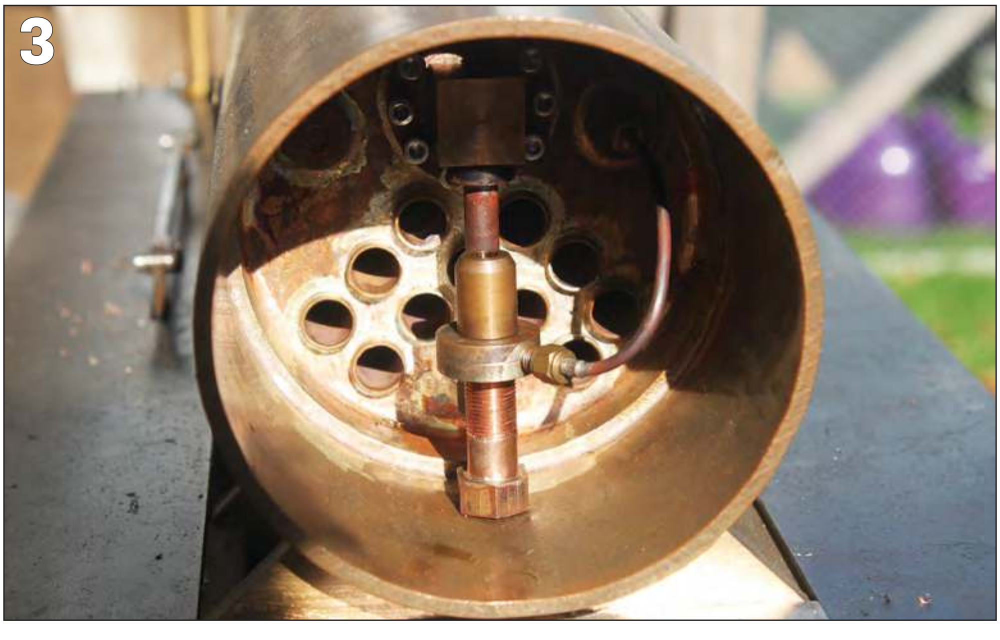
The blast nozzle screws down on the top of the blast pipe which in turn clamps the blower ring down that is directly beneath it. The blower ring is effectively sitting loose over the blast pipe threads and rests on top of the drive nut located about half way down. (Photo 2, 3 & 4)

Not a lot of room

I always knew that space would be tight in the 3¾-inch inside diameter smokebox and therefore some careful thought went into the design of the pipework and fittings.

One such problem was to work out how to fit the bolts in the regulator flange as the main steam pipe would obscure the two bolt holes at the bottom of the flange. The solution was to make a fitting which combined with a steam pipe that could be swung out of the way for the bolts to be done up before being pushed back in to position.

This fitting was silver soldered to the regulator bush flange and also incorporated the seating for the



3

regulator itself. The steam pipe has a flat olive at the bottom instead of a traditional conical one to allow the pipe to swing round over the steam chest fitting.

I began by boring out the centre of the front regulator flange blanking plate (used when the boiler underwent its first hydraulic test) to a diameter of ⅝-inch so that I was left with the divided holes around the circumference. I then turned a 3/16-inch step on to a piece of ¾-inch round bronze to a diameter of ⅝-inch to take the flange which I would later silver solder on.

Next, I drilled an 8.5mm hole to a depth of ½-inch and threaded this ⅜-inch x 32 tpi which forms the pivot for the steam pipe to swing. In order to seal the front of this fitting, I machined a counterbore to take an O-ring using a boring tool on the lathe to an inside diameter of 472 thou' by 60 thou' deep. I could now take the bronze out of the chuck, turn it round and start machining the other end.

I started by leaving a ½-inch length of ¾-inch diameter plain section which slides through the flange in the boiler before turning a further ½-inch length down to a diameter of 13mm to fit inside the 15mm regulator tube. Next, I machined a 70 thou' wide groove to take a silicone O-ring, which I used to seal the front of the regulator tube.

Finally, I drilled a ¼-inch hole in the centre until it broke through into the threads behind and following this I could silver solder the flange on to the finished fitting.

Steam pipe and fittings

I could now start on the manufacture of the steam pipe and its associated threaded fitting. For this I used a piece of ½-inch AF bronze which I began machining by turning a ⅜-inch length down to ⅜-inch diameter and I threaded this ⅜-inch x 32 tpi to screw in to the flanged fitting. I then drilled a ¼-inch hole through this to a depth of ¾-inch and having fitted the O-ring to the corresponding counter bore, I screwed this piece in to the boiler to establish which side of the hexagonal material to mount the down pipe on.

Following this I held the fitting in the vertical slide on the lathe and 7/16-inch in from the end I drilled a ¼-inch hole into the side which faced down towards the steam chest. I then opened this hole up to 8.7mm, being careful not to drill any further than the horizontal ¼-inch hole inside.

Before removing the fitting from the vice, I cut a few turns of a ⅜-inch x 40 tpi thread which was used to hold the down pipe in place during silver soldering. I then cut the same thread externally on the ⅜-inch diameter copper pipe that I was using as the down pipe and cut it to the right length.

The steam pipe was secured to the steam chest inlet by means of a pair of flat olives as a normal conical one would not allow the steam pipe to swing in and out. I used an off-cut of ½-inch AF bronze to make a ⅜-inch thick nut for the steam pipe which was drilled out ⅜-inch, counterbored to an internal diameter of 13/32-inch x ¼-inch deep and threaded internally 7/16-inch x32 tpi.

PHOTO 4: The completed blastpipe and blower arrangement.

"Some careful thought went into the design of the pipe work and fittings..."

I turned up what was effectively a thick bronze washer which I silver soldered on to the end of the down pipe with the aforementioned nut in place first. To aid the concentricity the washer was made deliberately oversize and I carefully held the copper pipe in the lathe chuck to true up the front and outside faces to end up 1/16-inch thick x 0.400-inch diameter. This formed the flat-ended fitting which would line up with a similar one on the base of the smokebox and the two would be sealed with the application of Loctite 574 flange sealant.

A more detailed explanation on how and why I made my pipe work olives in this way will appear in a subsequent article. EIM

FULL-SIZE DOUGAL UPDATE...

Readers following Andrew's build and perhaps considering or even embarking on their own Dougal project will be pleased to hear that following its adventures in Taiwan the full-size loco should be back in its display shed at Raven Square station on the Welshpool & Llanfair Light Railway by the time you read this. Before departing from the Pacific island on 13th March, Dougal performed one last starring role, in Taiwan's annual Lantern Festival with its very own Welsh dragon, funded by a group of supporters. The dragon is coming back to Wales with the loco, and readers wanting to see Dougal can check at www.wllr.org.uk to find out when the line is open. *Photo: Jyun Gang Guo/W&LLR*

Drawings in this series reproduced by kind permission of A J Reeves. Drawings, castings and material for this project are available from A J Reeves.

REEVES MODEL ENGINEERS 2000

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Previous Episodes of the build...

Introducing Dougal, **April 2018**; Building the boiler, **May 2018**; Frames, axleboxes, **June 2018**; Wheels, eccentrics, **July 2018**; Rods, boiler saddle, **August 2018;** Machining the steam chest, **September 2018;** Adding the eccentrics, **November 2018;** Machining cylinders, **December 2018;** Cylinder covers & slide bars, **January 2019;** finishing the motion, **February 2019.** First run on air, **March 2019;** Building the brakes, **April 2019.**

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Next Month...

"I've essentially tried two different types of regulator in Dougal with varying degrees of success ."

Rust is a four-letter word...

Peter and Matthew describe their experiments with electrolysis, a low-cost, environmentally-friendly remedy to remove the dreaded brown flake.

BY **PETER** and **MATTHEW KENINGTON**

My 13-year old son Matthew and I have recently acquired a 5-inch gauge GWR Manor chassis from the son of a deceased member of our model engineering club. With Matthew having completed an oscillating engine (made from bar stock) and a Stuart S50 (from castings), we felt ready to move on to something more ambitious and the completion of this model (with most of the work still to do) seems like an ideal next project. We are under no illusions that it will be quick or easy, but we are up for the challenge.

Our first problem is that of rust. The model is well engineered, but has been stored in a shed for a number of years and, as a result, has acquired a coating of rust on almost all of its exposed, ferrous, metalwork. Fortunately this is not too deep in most places, but nevertheless needs tackling before any further progress can be made. We have dealt with substantial amounts of rust previously, whilst restoring a Harrison lathe (**EIM**, March 2019), and used two different proprietary rust removers – a liquid bath for the parts which could be removed from the lathe and immersed, and a gel-based product for the areas which couldn't. Both worked, but were expensive and, in the case of the liquid bath, not very environmentally friendly when it came to disposal. The liquid-based product also poses a storage challenge until its efficacy is reduced to the point where disposal can be justified (many months in our case).

A further issue, notably with immersion-based solutions, is their effect on metals other than the (rusty) steel or iron. Many of the rusty parts on our loco chassis are also (irrevocably) attached to other, non-ferrous, parts (for example bronze or brass bushes) and these are already machined to the correct tolerances – the last thing we want to do is to remove the rust and a layer or two of our precious, machined, brass, necessitating its replacement (**Photo 1**). Quite a few proprietary solutions utilise acids of one form or another and these clearly have the potential to either etch the surface of brass or bronze directly or to set up a form of galvanic action, due to the dissimilar metals in the component to be cleaned, thereby ending up with the same result.

PHOTO 1: An example of a rusty component with integral brass features (part of the Stephenson valve gear for the Manor).

PHOTO 5: The same component after the electrolysis treatment and light sanding to remove black (formerly rusty) areas.

PHOTO 2: The tank, anodes and components, ready for the electrolyte.

All photos and diagram in this feature by Peter & Matthew Kenington

The Solution (literally...)

So what is the alternative to commercial rust-removing products (other than abrasives and household equivalents to commercial chemicals, such as citric acid)? The solution we tried was electrolysis – an option Matthew found and researched (credit where credit's due…). This utilises a number of common household/workshop items and soluble chemicals in order to produce an immersion-based rust removal system. We have experimented with it quite extensively, using steel, cast-iron, clean brass (as a control) and combined steel/brass and had excellent results (with the brass being unaffected, as desired). Even in cases where a purely abrasive method could be used (such as on locomotive wheels), electrochemistry has the edge; it is able to penetrate the tiny pits in the surface of the rusty material (even those invisible to the naked eye) and remove all traces of rust from the part (and thereby discourage its return).

The Recipe

The elements needed for an electrolysis system are as follows :

1) A large, watertight, container which can hold all of the parts to be cleaned when they are suspended from (one or more) cross-bars, together with a suitable anode (see below). For this, we used an old plastic packing crate left over from an office move decades ago – it is strong and sturdy and can hold plenty of parts (**Photo 2**).

2) A piece of scrap steel or iron to act as an anode in the electrolysis process. This can be virtually anything you have lying around and can, itself, be rusty, although the more rusty it is, the ▶

poorer the electrical interface between the anode and the electrolyte and the slower the rust-removal process will be (all other things being equal).

Note that any rust present on this anode will not be removed by the electrolysis process and, indeed, it is likely to suffer further corrosion during the process. Whilst it may be tempting to substitute a rust-inhibiting anode material (such as stainless steel, galvanized steel, copper, brass and the like), this should not be attempted.

In the case of stainless steel, the chromium present within the alloy may produce poisonous compounds of chromium and the resulting electrolyte will be illegal to dispose of down a domestic drain (thereby negating the 'environmentally-friendly' credentials of the process).

In the case of the other materials mentioned, there is a danger that they will electroplate the components being cleaned, with zinc (from galvanized steel) or copper and such. Note that aluminium may be corroded by the electrolyte itself and should be avoided both as an anode and in any part of the cathode (for example within a part to be cleaned).

Regarding the shape of the anode, there are certainly benefits in using a shaped anode which, as far as possible, surrounds the components to be cleaned (for example lining the tank). This can even include a portion covering the bottom of the tank and a mesh covering the top (note that all parts of the anode will need to be electrically connected together, but insulated from the parts/suspension wires and such).

The use of a shaped anode will make the rate of rust removal more even and potentially result in a much quicker process. A simple, but sub-optimal, alternative is to turn the parts, part-way through the process.

3) A conductive cross-bar from which to suspend the parts to be cleaned. Again, this can be anything you have lying around and it does not need to be made of steel or iron – copper, brass, aluminium and such are all fine – we used a piece of angle-iron. Note that it should be free from paint or any other insulating surface coating, at least at the connection points for the power source and the component-suspension wires.

4) Component-suspension wires. Again, these can be made from whatever conductive wire you have lying around – for example iron fencing wire, tinned copper wire (single-conductor is preferable) and such. We used 18swg (~1.2 mm) tinned copper wire.

Note that the thickness of this wire needs to be in keeping with the current you plan to use; putting 20 amps through something the thickness of fuse-wire will have predictable results. Note also that you will need some more of this wire for the anode. The wire for the anode will need to be rated for the full current you plan to use, whereas the wires for the components to be treated need only be rated for the current divided by the number of components being (individually) suspended.

In the case of Photo 2, for example, seven components are individually suspended and so each wire only needs to be rated at 1/7th of the total circuit current (with the total current being around 3A in our experiment).

5) A suitable quantity of washing soda crystals (sodium carbonate, sometimes labelled: 'sodium carbonate decahydrate' or 'anhydrous soda'). Note that this is **not** the same as sodium bicarbonate or bicarbonate of soda, also known as baking soda. Washing soda crystals are cheaply and widely available and are typically used for cleaning household drains. The variety we used was obtained from Wilko (£1.50 for 1.5kg) and we used roughly half of a packet in 40 litres of water (a whole 75p-worth!). As an approximate guide, 1.5 tablespoons of soda crystals per litre of water seems to work well, although this figure is not at all critical.

6) A power source. Again, this can take a variety of forms:

a) Car battery. This is perhaps the simplest option, but also potentially the most risky, due to the danger of an accidental short-circuit when setting things up. If you do opt to use a car battery, **it is essential** to incorporate a suitable fuse within the circuit (see Figure 1), say 20A.

b) Car battery charger. This is a much safer option, since these typically have a limited current

FIGURE 1

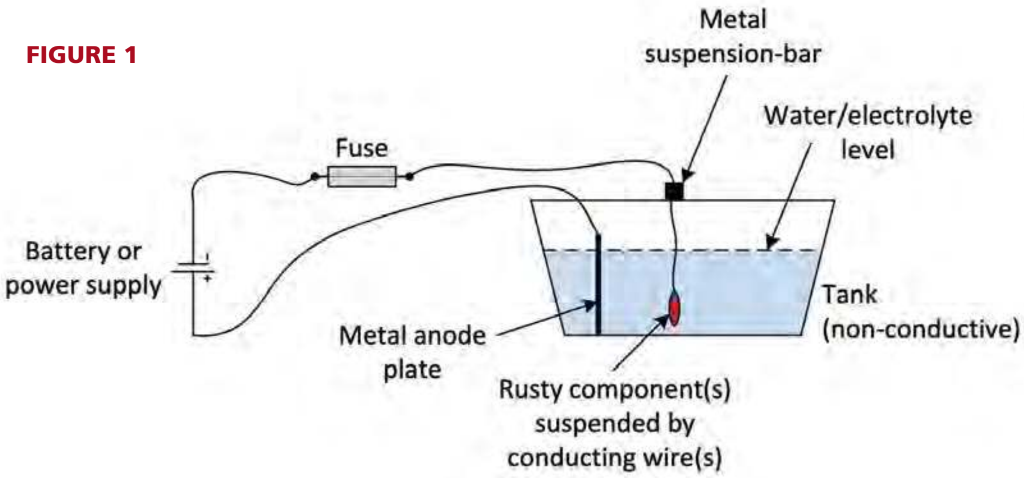

FIGURE 1: Electrolysis circuit (note the addition of a fuse if car battery used as power source).

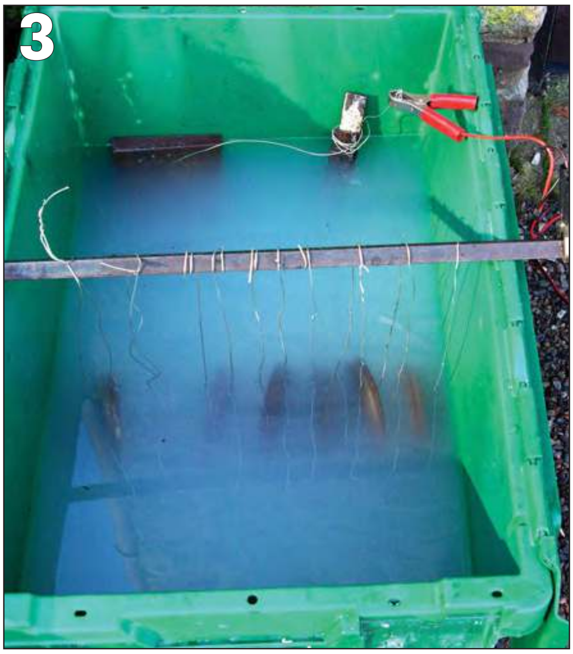

PHOTO 3: Tank, components and sodium carbonate solution.

PHOTO 4: Components moved closer to the anode.

capability in the order of 6A, meaning that an inadvertent short-circuit is potentially somewhat less spectacular than with a car battery. The problem with this option is that not all car battery chargers are suitable, since many modern chargers are 'intelligent' and will not provide any current unless presented with an at least partially charged battery (in other words, some voltage) at their terminals. If you have one lying around, it is probably worth a try (particularly if it is ancient and hence more likely to be 'dumb'!), but don't be surprised if it doesn't work successfully in this context. If you test its open-circuit voltage using a multimeter (set to say 20V DC), in other words its output voltage when only connected to the meter and nothing else, and it doesn't read between 12 and 15V, then it is probably 'intelligent' and will not be suitable.

c) 'Bench' power supply. These are widely available for use on electronics test benches or to power ham-radio equipment and I have a good selection lying around, so this was the obvious choice for us. They typically have a 'current-limit' feature, which prevents damage if accidentally short-circuited.

d) Computer power supply. These come in a wide variety of shapes and sizes, from laptop 'brick' supplies to 'frame' supplies, typically built into desktop machines. These have the advantage of being available very cheaply, particularly secondhand. What you are looking for is an output voltage of at least 12V at a current of at least 5A (to provide a little headroom) – they may have other outputs, for example 5V at many amps, but these can be ignored/remain disconnected and insulated.

Note that these supplies may not have a current-limit capability and hence are vulnerable to damage if accidentally short-circuited – again, a suitable fuse here would help.

The Science Bit...

Depending upon how the rust has formed, in other words what has formed it and over what time period, there are likely to be two forms of corrosion present:

1) The classic orange-red rust which is normally visible on the surface of a rusted object. This has the chemical formula Fe_2O_3 and is known as ferric oxide. It is this form of rust which causes flaking of the surface of the object, as it has a larger volume than the metal it is replacing (a bit like the process of water turning to ice in a crack in rock; the ice has a higher volume than the water from which it formed, thereby breaking apart the rock).

This is also the reason why rusted mechanical assemblies can seize up (as recently happened to me with a domestic boiler oil pump, but that's another story). This form of rust is also a fairly good electrical insulator, hence its detrimental impact on electrical connections and circuits (e.g. rusted battery terminals).

2) Beneath the outer layer of orange-red rust lies, typically, a darker layer of material with a grey (or even purple-grey) appearance. This layer is harder, being well-bonded to the underlying metal and is electrically conductive. It has the chemical formula Fe_3O_4 (magnetite) and can be referred to as 'black rust' (more on this later). Incidentally, this is the same material used in (now somewhat old-fashioned) magnetic recording tapes.

Since the formation of rust is an electrochemical process, it follows that it can be reversed using an electrochemical process: electrolysis. Whilst it is true that the process is reversible, it is not completely reversible: the process operates differently on the two forms of rust discussed above.

In the case of the 'black rust', some of this can be converted back to metal, whereas the orange-red rust will be converted to Fe_3O_4 and this will detach from the surface (since the orange-red rust is already, largely, detached as discussed above) and either be placed in suspension in the electrolyte or flow to, and collect on, the anode as a dark brown 'sludge' (mostly a mix of unconverted/loose red-orange rust and some detached black rust).

Some of the black rust remains on the surface of the part (along with some loose re-converted iron) and will need to be removed by the light application of a wire brush or similar, once the electrochemical processing is complete.

Toil and Trouble

First, the health and safety bit. Sodium carbonate, like all chemicals, should be handled with care, however it is not a highly-dangerous chemical (in the way that many commercial rust treatments are). In the concentrations we are discussing here, it is not a skin irritant (other than possibly if you have a skin condition, such as eczema) and is not poisonous if inhaled – it may induce coughing or a sore throat if sufficient sodium carbonate dust is inhaled, but this is very unlikely in the quantities we are discussing here. Bear in mind that this is a widely-available substance considered safe for use by the general public.

The main potential issue comes from splashes getting in the eyes – easily done if a part or anode is accidentally dropped in the solution; the simple message is: wear goggles. If it does get in the eyes, rinse with plenty of water and seek medical attention if eye irritation persists.

Note that the solution used here for electrolysis is around 20 times **less** concentrated than that typically recommended for drain cleaning, for example, and so the chances of any chemical-related health mishaps from this process are extremely remote!

The second 'health and safety' aspect concerns the gasses which are released during the electrolysis process (primarily hydrogen and oxygen). Again, these are not harmful ▶

PHOTO 6: Close-up view of the anodes, after a period of use.

PHOTO 7: Tender-wheel casting before processing

PHOTO 8: The same tender-wheel casting after processing.

in themselves (for example if inhaled), but clearly the mixture poses an explosion risk if kept in a very confined space and exposed to an ignition source. Again, it is best not to get too carried away here – hydrogen is a small molecule which disperses easily and is reasonably challenging to contain even if you deliberately set out to do so – but a prudent precaution would be to place the tank (but not necessarily the power source) outdoors. In our setup, we placed the tank outside a garage and the power supply inside, with the 12V DC leads fed under the door (Photo 3).

Note also the earlier discussion on the possible use of stainless steel for the anode – a definite no-no!

A little School Chemistry

Matthew hasn't actually covered electrolysis in his school chemistry yet, but still took to setting up the 'experiment' with gusto. He set up the tank, supporting conductor and two anodes (to better cover the area of the end of the tank, to equalise the distance from an anode to each component to be cleaned) as in Photo 2. We then added the wire and components, as shown, to the empty tank (thereby eliminating any danger of a dropped item causing splashes).

PHOTO 9: Firebox for a vertical boiler (before processing).

PHOTO 10: The same firebox after the electrolysis de-rusting process had been carried out on it.

Note that the components need to be free from oil/grease and such, to allow the electrolyte access to the rusty surface (although it is likely that any coating of that nature would inhibit rust formation in the first place).

We started with the components across the centre of the tank and adjusted the position once the 'experiment' was running (as will be discussed later). We then connected the power supply, which was turned off – if you are using a car battery then the final connections should not be made until the electrolyte is added and fully mixed and you have ensured that the anode(s) and component(s) are not touching.

The electrical connections are simple: the anode connects to the positive terminal of the power source and the rusty components connect to the negative terminal, thereby forming the cathode (see Figure 1).

We added the water so that it comfortably covered the components, carefully noting how much we had added (approximately 40 litres, in our case). Finally, we added the appropriate amount of sodium carbonate (60 tablespoons) and stirred with an old wooden spoon, until a uniformly-cloudy electrolyte solution was formed (Photo 3).

Once everything was in place, we turned on the power. With the rusty components at the position shown (halfway along the tank), the current drawn from the supply was approximately 1.5A, which is a good starting current to choose.

A few seconds after the power is turned on, bubbles should appear from each of the components, predominantly on the side of the component nearest to the anode. If they appear, then all is well. If not, check all connections and, with the components and anode raised to be clear of the solution, measure the DC voltage between the anode(s) and each component – it should read around 12V. If it doesn't, trace back from the component to its power supply connection and/or the anode to its respective power supply connection, to find where the 12V connection is lost. It is likely a bad connection exists and this can be identified and cleaned.

The rust-removal process can be speeded up by increasing the current through the circuit. The easiest way of regulating the current (either up or down) is to move the components relative to the anode. If the components are moved closer to the anode, then the current increases and the rust-removal process speeds up and vice-versa if the components are moved away from the anode. At the position shown in Photo 4, about quarter of the way along the tank (approx 15cm from the anode), the current increased to 3A; this was the current used in all of our experiments.

This in no way represents a limit and higher currents could be used, but bear in mind the potential for shorting the components to the anode when using a close-proximity of the two – a (starting) current in the range: 1-10A is probably about right (less for very small/delicate parts).

Note that in Photo 4, we added a G-clamp to discourage the positive wire/anode from slipping closer to or touching the parts and used a thicker cable (13A mains cable, with the earth core unused). The 'sludge' of removed rust can clearly be seen on the surface of the electrolyte.

Note also that it is not possible to 'over-clean' the components, for example by using a high current for a long time. Once the available rust has been removed, the process becomes inert and essentially the only downside is the waste of electricity.

The Results

We checked the components after one hour, and noted that much of the rust had gone, and then five hours after which all of the rust had gone. Note that the parts do not come up bright and shiny all over – in much the same way they don't with conventional chemical rust-removers. The rusty areas turn black and a little light sanding or wire-brushing is needed to obtain a shiny finish as in Photo 5. This photo doesn't really do the finish justice, due to bright reflections from the shinier parts of the surface making the surface imperfections into dark shadows! The black areas are the 'black rust' referred to earlier and should be fairly easy to remove.

This cleaning process, together with drying and then protecting the de-rusted part, needs to be undertaken immediately after the part is removed from the electrolyte. If the part is left for a period (even a few minutes), the rust will return surprisingly rapidly.

This happens because the rust which is close to the metal, and which is converted back to metal by the electrolysis process, is somewhat porous; it therefore has a high surface area exposed to the atmosphere and consequently is very prone to rusting. The residual black areas can be seen quite clearly in Photo 8, as this photo was taken immediately after drying the part and before any attempt at cleaning it – it will be discussed in more detail later.

The anode shows where the removed rust goes (as does the colour of the electrolyte) – Photo 6. Note that

this material is also easy to remove with the light application of a wire brush, allowing the anode to be re-used almost infinitely (although it will corrode). Cleaning the anode part-way through the process will also speed up rust-removal, as it aids the conductivity of the electrolytic circuit. Without cleaning, the current in our experiment dropped from around 3A at the start to under 1A after 24 hours.

The parts can be left in the electrolyte almost indefinitely, so long as the electrical circuit is operating, without fear that they will rust (despite the electrolyte being water-based). As soon as the circuit is turned off, however, the parts should be removed, dried and cleaned.

Once the parts have been cleaned and thoroughly dried, they should immediately be coated with oil (or an etch primer, if they are to be painted) in order to prevent them from regaining their coating of rust.

In the same batch, we processed a set of six cast-iron tender-wheel castings. The 'before' and 'after' results can be seen in Photo 7 and Photo 8. Note that in Photo 8 the only post-processing that has been undertaken is to dry the part; it has not been sanded or wire-brushed. The wheels underwent electrolysis for a little under five hours.

Some more examples of items processed include:

1) A firebox for a vertical boiler (intended for a stationary steam plant) shown before treatment in Photo 9 and after in Photo 10. This is a particularly interesting example, as the 'before' photo was actually taken after this item had been immersed in a bath of commercial rust-remover for some time (weeks!), albeit that this solution was somewhat 'spent'. Prior to its immersion in the commercial rust remover, this was a very rusty part indeed!

2) A steel template bar for checking the quartering on a set of driven loco wheels – Photo 11 (before) and Photo 12 (after)

3) An old woodworking plane – Photo 13 (before) and Photo 14 (after). Note the impact on the paint – see below for further discussion on this. Again, this item had spent a long time in the commercial rust remover, prior to processing by the electrolysis technique described here.

Top Brass

We also experimented with a piece of machined, scrap, brass, to see if it was affected by the electrolysis process (either in finish or size). Matthew carefully measured the internal diameter of the part, before inserting it into the electrolyte and running the system at a (starting) current of 3A for 48 hours (with the anode being cleaned after 24 hours as other parts were being processed in the same 'batch'). He then measured the part again afterwards – there was no measurable difference, showing that the part had not been affected by the electrolysis process.

"We checked the components after one hour, and noted that much of the rust had gone, and then five hours after which all of the rust had gone..."

Likewise, as can be seen in Photo 5, the steel and brass parts of the valve-gear component have not interacted in any way and neither is suffering from any etching away of the metal at the point where they join.

One word of caution is that the process may well affect paint already applied to parts being treated. We saw this when treating the woodworking plane (compare Photo 13 with Photo 14); its paintwork was already in a sorry state, but what remained was partially dissolved by the electrolyte and could be removed by gentle rubbing once out of the solution.

We have not conducted extensive testing on a wide variety of paint finishes, but it is probably best to assume that paintwork will be impacted to some degree. This is probably not a major issue in most circumstances (and may even be a benefit), since if the part is rusty enough to warrant treatment, it will generally require paint-stripping and re-coating anyway.

Finally, for those of you worried that this technique may be cheap in chemicals, but will cost a fortune in electricity, let me put your mind at rest. If we assume that the 12V power source used is 50 per cent efficient (most are now 80 – 90 per cent plus) and that we use a current of 3A for 72 hours (representing a really challenging bit of rust-removal), the energy consumed is around 5kWh, which equates to well under £1 in electricity charges, even on an expensive tariff!

This simple calculation assumes (pessimistically) that the current remains constant at 3A for the whole of the 72-hour period; as we have seen earlier, this is not the case and it would have dropped to well under 1A during this time, even if the anode is cleaned daily. This would bring the real electricity cost closer to 50p than £1.

In conclusion, electrolysis appears to be an excellent, low-cost and environmentally-friendly way of de-rusting both single-metal and multi-metal components. The electrolyte can be used many times and its time of disposal will be more a matter of when it becomes inconvenient to keep it (given that it costs a mere 75p to make some more) rather than when it is 'used-up'. It can be poured away down a domestic drain and even has the added benefit of cleaning the drain in the process! Perhaps it is time to dust-off that old lab coat? EIM

PHOTO 11: Steel template bar (before processing).

PHOTO 12: The bar after processing. Note that the small areas which look like rust, near to each end of the bar, are actually the brazing used to attach the (raised) end-caps to the main bar.

PHOTO 13: An old woodworking plane (before processing).

PHOTO 14: The same plane after processing. Note the 'side effect' of the removal of almost all of the paint!

Wilton ME & Hobbies show

At times we like to highlight the lesser-known model engineering exhibitions in EIM and Bill found an excellent example near Salisbury over the weekend of 23rd-24th March.

BY **BILL EDMONDSON**

PHOTO 1: An overview of the exhibition hall.

PHOTO 2: The impressive Bristol Mercury aero-engine built by Mike Tull.

PHOTO 3: The centre engine with organ engine atop, part of a 1950's built model of a set of Victorian gallopers.

PHOTO 4: An Armstrong hydraulic winding engine for the Allenheads lead mine. The builder was Derek Goddard.

PHOTO 5: This Armstrong hydraulic crane was on the Salisbury Model Engineers stand.

All photos: Bill Edmondson

This regional exhibition is held every two years; supported by a wide range of local traction engine owners, full size and miniature, plus local clubs and societies. All of the proceeds are given to charity.

The few photographs on this page hardly do justice to the enjoyment to be had at show, being simply of what displays particularly caught this reviewer's eye!

On display were several models of unusual prototypes, including two examples of how W G Armstrong employed hydraulic water power in the mid 1800's – Derek Goddard's detailed display included his model of a winding engine made for the Allenheads lead mine, while on the Salisbury MES stand was a model of Armstrong's hydraulic crane.

Mike Tull displayed his award-winning Bristol Mercury aero engine; this is certainly some high-end work!

Amongst several fairground ride models was one that has a venerable history, a set of gallopers made by Herbert Slack of Chapel en le Frith, begun during World War 2 and completed after nine years.

Exhibited at the London Model Engineering Exhibition in 1953, this model won the Duke of Edinburgh trophy. It is so pleasing to see it still being exhibited, ably looked after by Tom Langham.

Whoever booked the weather wins a medal – the Sunday in particular was bathed in sunshine and the traction engines looked splendid simmering outside. And to pinch an old Festiniog Railway saying – it was all JGF (Jolly good fun!).

Keep an eye out for the Wilton show in two years time' – it comes highly recommended. EIM

Grand day out at the AGM...

Peter and his son Matthew have fun enjoying the excellent facilities of the Wolverhampton SME whilst attending the Southern Federation AGM.

BY **PETER KENINGTON**

In the absence of EIM 'roving reporter' and fellow Hereford SME member John Arrowsmith, who was roving and no doubt will be reporting from another event elsewhere in the country, I have undertaken to fill his esteemed shoes and provide my views on the Southern Federation of Model Engineers' Annual General Meeting, which was hosted by the Wolverhampton Society of Model Engineers on Saturday 23rd March at their facility in Baggeridge Country Park, a few miles to the south of Wolverhampton.

This was the second Southern Federation AGM which Matthew and I have attended and not the dry and dull affair that might be imagined. Keeping a 13-year old entertained at an AGM is not easy; keeping five visiting and one local Young Engineer (age 13 plus) entertained for the day is a significant challenge but one that the Southern Federation and, in particular, Wolverhampton SME members rose to with commendable success.

Recognising that transacting the necessary business of an AGM is not something to set the pulse racing, the SFMES committee has taken steps to make the day more of an event and one designed to be as 'family-friendly' as possible. They have clearly succeeded in that aim, with both the Cardiff and Wolverhampton AGMs being classed as 'a good day out' in the Kenington household (both the junior and senior contingents thereof).

A Site Better than Most

Baggeridge Country Park includes both walking and cycling trails, a café, a children's adventure playground and a high-ropes adventure, in addition to the Wolverhampton SME's railway and clubhouse. The clubhouse itself is nothing short of magnificent, with a huge (and well equipped) workshop and similarly huge meeting room being its most impressive features.

The club track occupies a central location within the park and there are plans to extend it a (relatively) short distance to the clubhouse to aid in getting locomotives to the workshop as well as to provide a longer ride for the public.

'Hands-on' was the order of the day, beginning with us setting up our display in the large upstairs meeting room of the clubhouse ('club mansion' might be a more appropriate term!). We were then free to view and participate in the many displays and activities laid on by our hosts. The displays included static exhibits ranging from 5-inch gauge locomotives, through lorries and wagons to both small and (very) large traction engines (the largest being a 6-inch scale Garrett) and an

PHOTO 1: View of the raised track and about half of the ground-level track at Baggeridge Country Park, taken from the main meeting room in the clubhouse

PHOTO 2: Matthew tries his hand at casting for the first time; a very informative demonstration activity laid on by the host club.

PHOTO 3: Peter driving an LNER J39 loco on the raised track.

Photos by Peter and Matthew Kenington

PHOTO 4: Inspiring the next generation – from left Tom, James, Daniel and Matthew (all young engineers at Hereford SME) are captivated by an LNER J39.

interesting aero engine mounted on a gun carriage (yes, there is a prototype upon which this slightly unusual model is based). Meanwhile demonstrations were provided covering casting and gear-cutting.

Outside Chance

The weather on the day was cool but dry, nothing to deter the determined model enthusiast, particularly when there is a nice warm steam locomotive to sit behind. At least three locos ran on the ground-level track, all battery or petrol-powered, while a lovely 5-inch gauge LNER J39 ran on the raised track.

I was fortunate enough to be invited for a drive of this latter loco and it performed beautifully. I have not driven this particular class of locomotive before (one of Martin Evans' comparatively recent designs, although still almost 40 years old, or so Matthew informs me) and was very impressed with its power and ease of steaming. It also had the largest firebox of a 5-inch gauge loco based on a standard gauge prototype, that I have yet encountered – it was huge and required full-size firing techniques to maintain a healthy fire-bed.

Matthew was also invited to drive the loco and loved it just as much. It served as great inspiration for all of the Hereford Young Engineers who made the journey to the AGM.

Business as usual

The AGM itself proceeded smoothly, with no dissent from the floor on any aspects. Member societies can read the details in the minutes of the meeting (which will no doubt already be available on the SFMES website, www.SFMES.co.uk, by the time you read this) and I will only highlight a few aspects of debate and interest here.

There was an interesting discussion on whether or not to publish, or encourage the publication of, detailed, anonymised, reports of accidents at club tracks, together with lessons learnt, in the hope of avoiding similar incidents at other clubs. This is standard practice in, for example, aviation hobbies and allows participants to learn from the mistakes of others or allows inherent faults in equipment design to be identified (one of my other passions is hot-air ballooning and it is standard practice in the ballooning equivalent of the SFMES). There was a general feeling that this should be encouraged by the Southern Federation.

The new boiler testing code was

PHOTO 5: Daniel Bell and his model of a Foden Steam Wagon before the lining and transfers were added – it now has both.

also a topic discussed at some length, with many comments (around 150) having been received to date. Separate 'FAQs' have been published for the three parts of the boiler testing code, in an attempt to clarify some of the areas of ambiguity. These are available from the SFMES website or Walker Midgley Insurance Brokers.

One aspect which was highlighted was that of small boilers – if a boiler fits into more than one category (for example it is made of brass and also falls within one of the other categories: LO, LS or high-pressure), then which requirement takes precedence? Such topics will be addressed in a further revision of the code itself, in the fullness of time, with the FAQs list being intended to fill the void in the meantime.

An appeal was made for a volunteer to take on the role of newsletter editor and I'm sure that the Committee would be delighted to receive any expressions of interest. As an added incentive, it was emphasised that this role need not require travel to committee meetings.

Tony Wood from Walker Midgley gave his typically entertaining presentation on outstanding and new claims received or active during the last 12 months. Among the highlights was a reported arson of a portaloo at a club site although there were no reports of it being occupied at the time(!). Spark burns, especially those involving children, seem to result in extraordinarily large sums being paid out (to this, uninitiated, observer). The message here is that spark-arresters are clearly worth their weight in gold.

Tony finished by giving us a 'did you stay awake' quiz, with prizes of wine gums for all who managed to shout out a correct answer – mine mysteriously disappeared when Matthew spotted them later…

PHOTO 6: Matthew's display – an oscillating engine built from bar-stock, a Stuart S50 built from castings and a CAD model of his latest project: an own-design raised-level riding truck.

PHOTO 7: Zahra Webb's various radio-controlled models, all scratch-built in an upstairs-bedroom workshop (not hers, I hasten to add). The water-cannon on the fire-boat is reputedly very effective...


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PHOTO 8: SFMES Young Engineer winners. From left SFMES president Brent Hudson, Zahra Webb, Daniel Bell, Andy Clarke (Polly Model Engineering), Matthew Kenington and Tom Williams.

The Southern Federation Rally 2019 will be hosted by the Maidstone Model Engineering Society on 7th September.

Finally, the problem of commercially-interested parties (such as steam model dealers) setting up phantom 'clubs' was highlighted. Such 'clubs' have been established and been affiliating to the Southern Federation for the sole purpose of issuing boiler certificates for secondhand models which the commercial operation will then sell on. This is not within the spirit of the SFMES rules and these organisations should be hiring a professional boiler examiner to provide such certification. The SFMES plans to stamp-out this practice, and is currently looking at how to do so.

Awarding Experience

As many will know, Polly Model Engineering sponsors a 'Young Engineers' award each year, administered by the SFMES. This year featured an unprecedented (so far as I am aware) four winners, highlighting a wide range of modelling interests.

The overall winner was 15-year old Daniel Bell for his 4½-inch scale representation of a Foden steam wagon, based on parts from a mobility scooter. Prizes were also awarded to 13-year-old Matthew Kenington (proud dad moment here…) for his Stuart S50 built from castings, 18-year-old Tom Williams for his tailstock die-holder and centre-punch and an SFMES Special Award to 13-year-old Zahra Webb for her scratch-built freelance radio-controlled models. Daniel, Matthew and Tom are all members of Hereford SME's Young Engineers' Group and Zara is a member of Dr. Patrick Hendra's Eastleigh Young Engineers from Eastleigh Model Boat Club.

The happy winners all received trophies or certificates and prizes in the form of cash or Polly Model Engineering vouchers.

And finally...

The Southern Federation Committee, and members of the Wolverhampton SME, did an excellent job of turning what could have been a dry, dusty, AGM into an enjoyable, family-friendly, day out. Matthew and I both had a great time and I would like to thank the Wolverhampton Society for being such excellent hosts. And I'm not suffering from clubhouse envy at all, honest, no really, I'm not… (well, maybe just a little...). EIM

Chucking in a useful dodge to aid a tip...

Reading John Smith's article 'Turning perfect tapers on matching parts' in the March issue, I was alarmed where he advocates running the lathe in reverse to machine the taper on the piston rod.

This may be perfectly acceptable on larger industrial lathes, where the chuck is keyed to the spindle, but it must be done with extreme caution on a small lathe such as a Myford (which from the pictures John is clearly using) where the chuck is screwed on.

When running in reverse, a tool dig-in could easily cause the chuck to unscrew, with catastrophic results. No doubt John would say that he always makes sure the chuck is screwed on tight and only takes light cuts, and it may be that the small radius of a piston rod would produce insufficient torque to unscrew the chuck. However, the mandrel being machined in photo 3 is clearly pushing things to the limit!

A much safer plan is to use a left-handed tool, mounted upside-down, and to keep the lathe running in the normal direction.

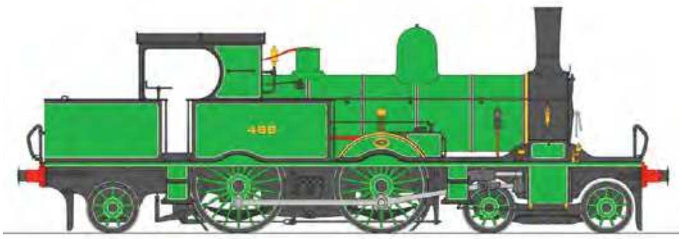
I would suggest that the only time when it is safe to run a Myford in reverse, is when using Myford collets, which do not require a separate chuck.

Ron Head

John Smith replies: Ron Head makes an excellent point which I had not even thought of! His assumption that I always screw the chuck on tight and take light cuts is quite right. I also tend to use modest speeds and never have my hand far from the clutch lever.

However Ron's clever dodge of using a left-handed tool, mounted upside down is undoubtedly a safer approach. Thanks for your letter, Ron. I've learned something today and that's the way it should be!

Model engineering query to have answered or point to make? Email or write to the address on page 3.



Accucraft adds Radial kit

Model engineers working at the smaller end of the hobby in Gauge 1 and seeking a rest from model building in the workshop could well be interested in the latest planned release from Accucraft UK, the well-known supplier of live-steam ready-to-run locomotives in Gauge 1, G and 16mm scales.

The newcomer is the William Adams' 415 Class 4-4-2T Radial locomotive, which started its life on London suburban services but due to its short coupled wheelbase proved particularly suited to sharply curved branch lines – as a result three survived on the Lyme Regis branch in Dorset until 1961 and one was subsequently preserved by the Bluebell Railway.

The model is 1:32 scale for 45mm gauge track, gas-fired with a single-flue boiler. It has a chassis constructed from stainless steel, with uninsulated wheels and a copper, boiler. Minimum radius curve capability is expected to be 4 feet 6 inches.

Due to new assembly facilities in Japan Accucraft promises improved build quality and finish on this model, and for the first time will be offering it in kit form alongside the traditional ready-to-run variant.

L&SWR, Southern and BR versions will be available from Accucraft while supplier Kent Garden Railways will exclusively market a version in East Kent Railway livery, Anticipated UK RRP is expected to be between £1950.00 and £1995.00 for the RTR version (depending on livery), and £1795.00 to £1850.00 for the kits.

Accucraft UK: 01981 241380, www.accucraft.uk.com

Chris Moore – Myford

■ Readers who use Myford machine tools will be saddened to hear of the passing of former owner of the company Chris Moore. Chris was the grandson of Cecil Moore who founded the Myford Engineering Company in 1934 and went on to produce the iconic ML7 and Super 7 lathes.

Chris was a familiar face to many a model engineer and a member of the Society of Model & Experimental Engineers (SMEE). While at the helm of Myford he was best known for introducing the popular Open Weekends at the factory, which proved popular gatherings for model engineers.

Chris's funeral was held on 8th April in Nottingham.

Coming next month in ENGINEERING in Miniature

THE MAGAZINE FOR MODEL ENGINEERS

- A new battery-electric diesel build project
- Searching at the NRM

...plus the EIM boiler, Dougal, advice for beginners and much more for model engineers...

June issue on sale 16th May

Contents correct at time of going to press but subject to change

MAY DIARY

EVERY SATURDAY
(Weather permitting)

South Lakeland MES public running, Lightburn Pk, Ulverston, pm

Sussex MLS public running, Beech Hurst, Haywards Heath, 2-5pm

EVERY SUNDAY
(Weather permitting)

Bournemouth SME public running, Littledown Pk, BH7 7DX, 11am-3.30pm

Canterbury SME (NZ) Public running from 1pm at Halswell Domain

Fylde SME Public running at Thornton Cleveleys from 1pm.

Grimsby & Cleethorpes MES public rides, Waltham Mill, DN37 0JZ, 12-4pm

Harrow & Wembley SME public rides, Roxbourne Park, Eastcote, 2.30-5pm

Kings Lynn & District SME, Lynnsport Miniature Railway, 11am-4pm

Kinver MES public running, Marsh Playing flds, High St, Kinver DY7 6ER.

Lancaster Morecambe ME public running, Cinderbarrow Railway, Tarn Ln, nr Yealand Redmayne, from 10am

Maidstone MES public running, Mote Pk, ME15 7SU, 2.30-5pm

Norwich SME public running, Eaton Pk, 1-5pm, NR4 7AU

North Wilts MES public rides, Coate Water Railway, Coate Water Country Park, Swindon, 11am-5pm

Portsmouth MES public running, Bransbury Pk, Portsmouth PO4 9JY, 2-5pm

Rochdale SME public running, Springfield Park, Bolton Road (A58), Rochdale, pm

Southport MES Public running at Victoria Park 11.30am – 4.30pm

Sussex MLS public running, Beech Hurst, Haywards Heath, 2-5pm

Urmston MES Public running in Abbotsfield Pk 11am – 3.30pm

Vale of Aylesbury MES Public rides, Quainton Rly Centre, from 12 noon.

West Huntspill MES public running, Memorial playing fields, 2-4.30pm

Wigan MES public rides, Haigh Woodland Pk, School Ln, Haigh, Wigan, PM

Wirral MES Public running, Royden Pk, Frankby, 1-3.30pm.

EVERY TUESDAY
(Weather permitting)

Romney Marsh MES Track meeting, Rolfe Ln, New Romney from 11am

Bromsgrove SME public running, Avoncroft Museum of Historic Buildings, B60 4JR 11.30-3pm

EVERY WEDNESDAY
(Weather permitting)

Bournemouth SME public running, Littledown Pk, BH7 7DX, 11am-3.30pm

Harrow & Wembley SME members meeting, Roxbourne Park, Eastcote, 2.30-10pm

Kings Lynn & District SME, Lynnsport Miniature Railway, 11am-4pm

1 Bradford MES meeting, 'Cromford & High Peak Railway', John Holroyd, Saltaire Methodist Church, 7.30pm

1 Bristol SMEE meeting, 'Why & How of boiler testing' by Bernard North, Begbrook Soc Clb, Frenchay Pk Rd, Bristol BS16 1HY, 7.30pm

1 Leeds SME meeting, 'P2 Prince of Wales Revisited' by Keith Crabtree, Eggborough Pwr Stn Sports & Leisure complex, DN14 0UZ, 7.30pm

2 South Lakeland MES meet, Pavilion, Lightburn Pk, Ulverston, 7.30pm

2 TIME meet, Pipers Inn, 70 Bath Rd (A39), Ashcott, Somerset TA7 9QL, 7pm

2 Wirral MES meeting, WI Hall, Thornton Hough, 7.45pm.

3 Portsmouth MES club driver instruction/training, Bransbury Pk, Portsmouth PO4 9JY, 6.30pm

3 Rochdale SME meeting, Springfield Park, Bolton Road (A58), 7pm

4 Ickenham SME public rides, Coach & Horses pub, Ickenham, UB10 8LJ, noon-5.30pm

4 North Wilts MES public rides, Coate Water Railway, Coate Water Country Park, Swindon, 11am-5pm

4 Southport MES Diesel Day, Victoria Pk, Rotten Row, PR8 2BZ, 10am-4pm

4 Tiverton MES Running day, Rackenford, contact Chris Catley, 01884 798370

4 York ME meet, film show, North Lane, YO24 2JE, from 7pm

5 Frimley Lodge MR public running, Frimley Lodge Pk, GU16 6HT, 11-4pm

5 Leeds SME public rides, Eggborough Pwr Stn, DN14 0UZ, from 10am

5 Plymouth MS public running, Goodwin Pk, PL6 6RE, 2-4.30pm

5 Welling MES public running, electricity station, close to Falconwood rail station, 2-5pm

5 Wimborne ME public running, from 11am Dorset BH21 3DA

5-6 Bedford MES public running, Summerfields' Railways, High Rd. Haynes MK45 3BH, 10.30am-3.45pm

5-6 Bristol SMEE public running, Ashton Court Railway, Bristol, BS8 3PX 7.30pm

6 Bracknell RS public running, Jocks Ln, Binfield Rd, RG12 2BH, 2-6.30pm

6 Bromsgrove SME public running, Avoncroft Museum of Historic Buildings, B60 4JR 11.30-3pm

6 Lancaster Morecambe ME public running, Cinderbarrow Railway, Tarn Ln, nr Yealand Redmayne, from 10am

6 Maidstone MES public running, Mote Pk, ME15 7SU, 2.30-5pm

6 Northampton SME Public Running, Delapre Pk, NN4 8AJ, 2-5pm

6 North Wilts MES public rides, Coate Water Railway, Coate Water Country Park, Swindon, 11am-5pm

6 Norwich SME EACH fundraising day, Eaton Pk, 1-5pm, NR4 7AU

6 Portsmouth MES public running, Bransbury Pk, PO4 9JY, 2-5pm

6 Stockholes Farm MR Open Day, Belton, DN9 1PH 11-5pm

6 Sussex MLS public running, Beech Hurst, Haywards Heath, 2-5pm

Wirral MES Public running, Royden Pk, Frankby, 1-3.30pm.

7 Canterbury SME (NZ) meeting, Halswell Domain, 7.30pm

8 Bournemouth DSME informal meet, Littledown Pk, BH7 7DX 7.30pm

8 Norwich SME meet, 'Mid Suffolk Light Railway', 1-5pm, NR4 7AU

8 Romney Marsh MES 50th Anniv Special, Romney Hythe & Dymchurch Rly, 12 noon

8 St Albans MES meet, 2003 Moscow air show by Chris Scriver, Christchurch Ctr,High Oaks, AL3 6DJ, 7.30pm

9 Cardiff MES meet, Members Projects, Heath Park

10 Tiverton MES meeting, Old Heathcoat comm Ctre, contact Chris Catley, 01884 798370. 7.30pm

10-12 Doncaster Model Engineering Exhibition, Doncaster Racecourse, 10am-5pm (4.30pm Sun)

11 Cardiff MES Steam-up & family day, Heath Park

11-12 Bromsgrove SME open day Sat, public running Sun, Avoncroft Museum of Historic Buildings, B60 4JR 11.30-3pm

12 Bracknell RS public running, Jocks Ln, Binfield Rd, RG12 2BH, 2-6.30pm

12 Bromsgrove SME public running, Avoncroft Museum of Historic Buildings, B60 4JR 11.30-3pm

12 Canterbury MES public running, Brett Quarry, Fordwich, 2-4pm

12 Harlington Loco Society public running, High St, UB3 5ET, 2-5pm

12 Hereford SME public running, Broomy Hill, HR4 0LJ, noon-4.30pm

12 Plymouth MS members day, Goodwin Pk, PL6 6RE, 12-4pm

12 St Albans MES club running, Puffing Field, WD4 9DA, 10am

13 Bedford MES talk 'Model Engineering Club Members Don't Get Dementia?' by David Powell, Summerfields' Miniature Railway MK45 3BH, 7.30pm. Contact meetings@bedfordmes.co.uk

13 Otago MES (NZ) general meeting, 1 John Wilson Drive, St Kilda, Dunedin, 7.30pm

15 Bristol SMEE meeting, Informal on-the-table night, Begbrook Soc Clb, Frenchay Pk Rd, BS16 1HY, 7.30pm

15 Grimsby & Cleethorpes MES meet, Waltham Mill, DN37 0JZ, 7.30pm

15 Leeds SME meet, Members' Hints & Tips, Eggborough Pwr Stn Sports & Leisure complex, DN14 0UZ, 7.30pm

16 Wirral MES AGM, WI Hall, Thornton Hough, 7.45pm.

17 Rochdale SME meeting, Castleton Comm Cntr, Rochdale OL11 3AF, 7pm

18 Leyland SME LNER theme day, Worden Pk, Worden Lane PR25 1DJ

18-19 Romney Marsh MES 50th Anniversary Wknd & Open Day, Rolfe Ln, New Romney

18-19 Wimborne ME Anything Goes Gala, public Sun only, from 11am Dorset BH21 3DA

19 Bristol SMEE Club Day, Ashton Court Railway, BS8 3PX 7.30pm

19 Bromsgrove SME public running, Avoncroft Museum of Historic Buildings, B60 4JR 11.30-3pm

19 Guildford MES Stoke Park Railway open day, Stoke Park, Guildford GU1 1TU, 2-5pm

19 Plymouth MS public running, Goodwin Pk, PL6 6RE, 2-4.30pm

19 Rugby MES Open Wknd, Onley Ln, CV22 5QD, 2-5pm

19 Tiverton MES Running day, Rackenford, contact Chris Catley, 01884 798370

19 Welling MES public running, electricity station, close to Falconwood rail station, Kent 2-5pm

19 York ME public running, North Lane, YO24 2JE, from 7pm

22 St Albans MES club running, Puffing Field, WD4 9DA, 1pm

25 Romney Marsh MES Track meet, Rolfe Ln, New Romney from 11am

25-26 Rugby MES Open Wknd, Onley Ln, CV22 5QD.

26 Harlington Loco Society charity day, High St, Harlington UB3 5ET, 2-5pm

26 Pimlico Light Railway public running, Pimlico, Brackley, NN13 5TN

26 Otago MES (NZ) running, 1 John Wilson Drive, St Kilda, Dunedin, 1.30pm

26-27 Bedford MES public running, Summerfields' Railways, High Rd. Haynes MK45 3BH, 10.30am-3.45pm

26-27 Bristol SMEE public running, Ashton Court Railway, BS8 3PX 7.30pm

26-27 Cardiff MES public running, Heath Park, 1pm-5pm

26-27 Hereford SME public running, Broomy Hill, HR4 0LJ, noon-4.30pm

27 Bracknell RS public running, Jocks Ln, Binfield Road, RG12 2BH, 2-6.30pm

27 Lancaster Morecambe ME public running, Cinderbarrow Railway, Tarn Ln, nr Yealand Redmayne, from 10am

27 Maidstone MES public running, Mote Pk, ME15 7SU, 2.30-5pm

27 Northampton SME Club run, Delapre Pk, Northampton, NN4 8AJ, from noon

27 North Wilts MES public rides, Coate Water Railway, Coate Water Country Park, Swindon, 11am-5pm

27 Portsmouth MES public running, Bransbury Pk, PO4 9JY, 2-5pm

27 Stockholes Fm MR Open Day, Belton, DN9 1PH 11-5pm

27 Sussex MLS public running, Beech Hurst, Haywards Heath, 2-5pm

27 Wirral MES Public running, Royden Pk, Frankby, 1-3.30pm.

27-30 Bromsgrove SME public running, Avoncroft Museum of Historic Buildings, B60 4JR 11.30-3pm

28 Wigan MES meeting, Ince Methodist Church, Manchester Road, Ince, Wigan, WN1 3HB 7pm

29 Bedford MES public running, Summerfields' Railways, High Rd. Haynes MK45 3BH, 10.30am-3.45pm

Details for inclusion in this diary must be received at the editorial office (see page 3) at least EIGHT weeks prior to publication. Please ensure that full information is given, including the full address of every event held. Whilst every possible care is taken in compiling this diary, we cannot accept responsibility for any errors or omissions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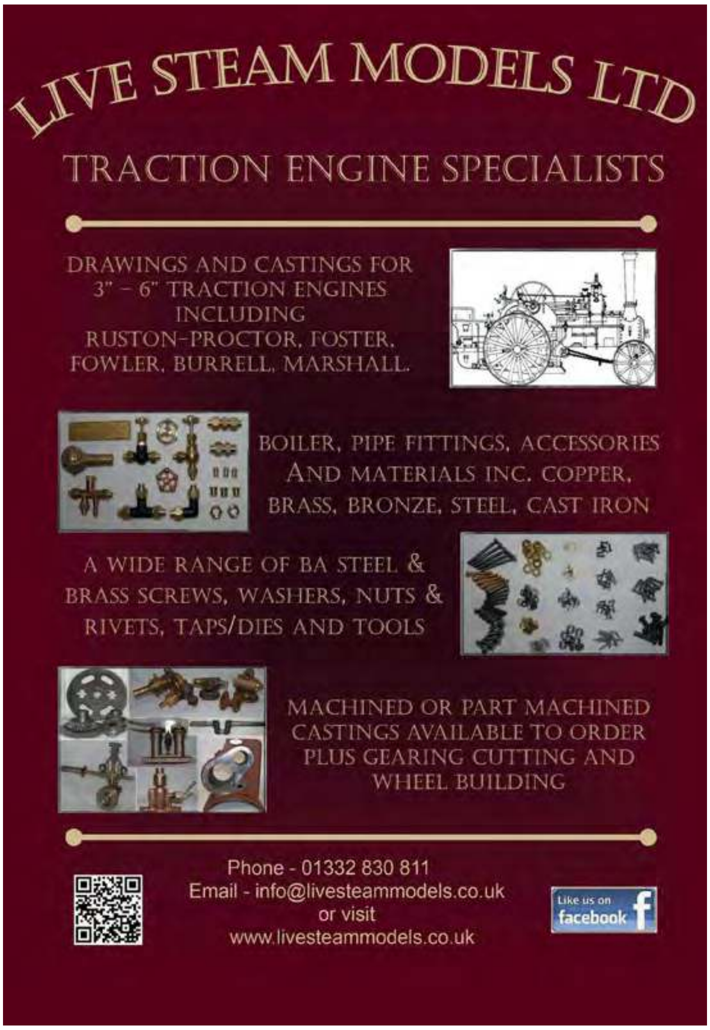
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7 1/4 INCH GAUGE GWR 41XX 0-4-0 "LADYSMITH"
A 7 1/4 inch gauge GWR 41XX 4-4-0 "Ladysmith", one of Dean's "Atbara" class of locomotives. Built by the late, legendary Great Western supremo Keith Wilson in 2004, the engine has been in regular club use. Mechanically it runs well, the superheated boiler steams freely, boiler feed by twin injectors. **£14,950**

1 1/2 INCH SCALE ALLCHIN "ROYAL CHESTER"
A finely made 1 1/2 inch scale Allchin traction engine to the "Royal Chester" design, unsteamed from new. Fit and finish of the motionwork is very good, it runs well on air. The model is nicely painted in the authentic Royal Chester Agricultural Show finish applied to the prototype engine; it remains in ex-works condition. **£4,750**

7 1/4 INCH GAUGE FORNEY 2-4-4
A 7 1/4 inch gauge Forney 2-4-4, a commercially produced engine supplied new by Maxitrak, still listed in their current range. The engine appears to have had little use, it's in super condition throughout. We've had it in steam recently - it runs well, notching up accurately in both directions. TIG-welded copper boiler. Complete with bolted steel transport/storage stand, fitted with castors. **£9,750**

7 1/4 INCH GAUGE LMS ROYAL SCOT 4-6-0 "LION"
A finely-made 7 1/4 inch gauge "Royal Scot", built to the Greenly design using Bassett Lowke castings. It ran at various locations before being sold at Christies in the early 1980s. Comprehensively overhauled at that time by Bishop-Ellis and fitted with new boiler, it was displayed, unsteamed, for the next thirty years. Recently recommissioned, it has been run less than a dozen times on the new boiler. **JUST ARRIVED**

5 INCH GAUGE "AJAX" FOR RESTORATION
A 5 inch gauge 0-6-0T locomotive - based loosely on an LNER J88 0-6-0T. The engine has had a hydraulic test here in the workshop, chassis rolls along freely, there has been some minor dismantling of fittings and pipework which are included. A good-looking, well proportioned locomotive. **£1,950**

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