THE ORIGINAL MAGAZINE FOR MODEL ENGINEERS

Vol. 229 No. 4695 • 15 - 28 July 2022

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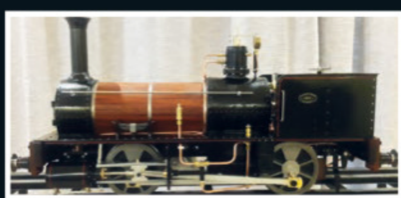

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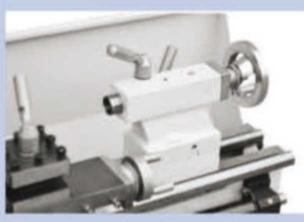

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IN THIS ISSUE

Vol. 229 No. 4695 15 - 28 July 2022

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ON THE COVER...

Six inch Burrell showman's engine **General Gough** *on the Whissendine Steam Rally lunchtime pub run.*

This issue was published on July 15, 2022.
The next will be on sale on July 29, 2022.

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The LNER A3

The world famous **"Flying Scotsman"** is probably the name that most readily comes to mind out of the 78 A3's that saw service on Britain's railways.

All locomotives received double chimneys by 1960 and subsequently most were fitted with German style "trough" smoke deflectors following complaints from drivers in respect to poor visibility. 4472 was the first steam locomotive to be officially recorded at 100 mph. The A3's saw service over most parts of the LNER system. The final locomotive, 60052 was withdrawn in 1966. Before the war the A3's were painted in LNER green livery, but carried unlined black 1939-45. They were re-painted in LNER green following the war. A majority of locomotives then carried BR blue livery before all were re-painted in BR brunswick green with orange/black lining. Early, or later, lion crests were carried according to period.

Overall length approx 74"

"Took delivery this morning of 46225 Duchess of Gloucester and wow what a magnificent locomotive she is. Please pass on to the factory my thanks to them all for their efforts. I must go and look at her again, happiness and on a cloud of steam!"

A C - Wiltshire

The Model

This coal-fired model features three cylinders and outside Walschaerts valve gear. The copper boiler is silver soldered and hydraulically tested to twice working pressure, CE and UKCA marked. The body casing is assembled using etched brass sheet.

This development of this model has been supervised by our award winning professional engineer Mike Pavie and the batch is being built by the same manufacturer who supplied our much acclaimed Coronation Class locomotive.

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- Silver soldered copper boiler
- Reverser
- Working drain cocks
- Stainless steel motion
- Safety valves
- 3 cylinders
- Boiler feed by axle pump, injector, hand pump
- Bronze cylinders with stainless steel pistons and valves
- Sprung axle boxes with needle roller bearings
- Piston valves
- Mechanical lubricator
- Outside Walschaerts valve gear
- Multi-element superheater
- Etched brass bodywork
- Choice of liveries
- Choice of nameplate
- Fully painted and lined
- Ready-to-run

Approx Dimensions:

- Length 74"
  Width 9.5"
  Height 14"
- Weight 105 kg

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Model Tram Exhibition

Saturday 20th and Sunday 21st August 2022 sees the return of the ever popular Model Tram, Trolleybus and Railway Exhibition at the National Tramway Museum, Crich Tramway Village, Crich, Derbyshire.

A total of 10 layouts will be present at the Exhibition and two examples include:

Whiteleaf Tramway

Belgium had a very extensive tramway system of this type and the Buckinghamshire Garden Railway Society members are running Belgium Vicinal rolling stock, all of which is scratchbuilt. This is the largest assembly of Belgium G scale Vicinal rolling stock to be seen in the UK. The layout portrays an electric tramway that runs through the streets and then sets off through the countryside to serve surrounding villages. As not all sections of a tramway would be equipped with overhead wire, steam and diesel traction come in from outlying areas. This type of operation handles both passenger and goods traffic, which was very common on tramways across Europe.

The layout is built to G Scale. The track gauge is 45mm and represents the metre gauge tracks of Europe.

Camwell's View

The layout shows a section of street track somewhere on the Bristol Road, Birmingham in 1952 with various types of Corporation trams operating along the route. The diorama assumes the famous photographer W.A. Camwell was the manager or working at the Municipal Bank on the right-hand end of the layout and, at the other end, we have a photographer's shop W.S. Eades, another famous tram photographer.

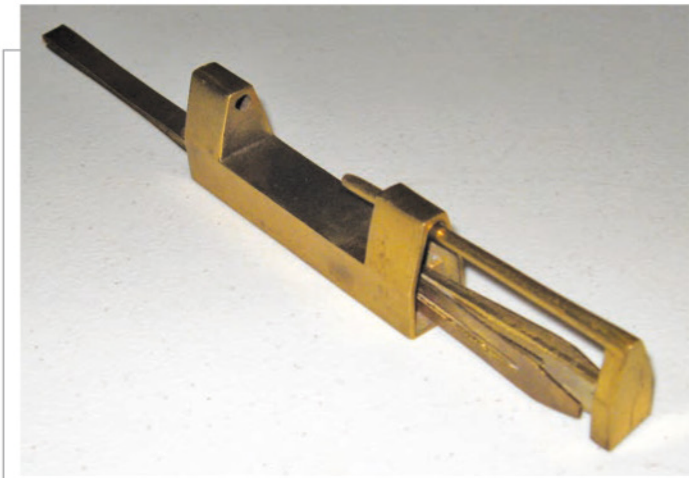
Organiser, John Huddlestone said:

'We are delighted to present this Model Tram, Trolleybus and Railway exhibition again, which is popular with both exhibitors and visitors.'

Marketing manager, Amanda Blair, said:

'The Model Exhibition is a fantastic addition to our life size trams, which will also be running. There is no additional cost for the exhibition, which will be included in normal entry prices. You can find prices and opening dates on our website: www.tramway.co.uk'

Normal museum entry charges apply and opening times are 10am to 5.30pm (last admissions 4pm) both days. For details visit the website or telephone 01773 854321.



Oddity

Here's something to puzzle over while as you soak up the sunshine, sipping your Sangria.

Patrick Williams has sent me a picture of a strange looking tool and wonders if anyone can identify it. Patrick writes: 'From the widow of Larry, a model engineer friend in America, I have been sent the enclosed picture of an oddity, which she would like to have identified.

'Overall length is 100 mm, 35 mm high and 20 mm wide at the base. It appears to be a brass casting which has been machined and the end cap fits with no visible joint. There are no markings.

'Larry spent much of his life as an artist and had specialized in "Found Objects Art", which is where the artist takes all kinds of oddments and assembles them into a picture of sorts. This was an oddity from his collection, which he had not got around to including in a picture.'

The editor awaits your opinions!

Stan Bray

I am sorry to have to report the death of Stan Bray, who died on the 18th of June at the age of 97.

Stan was a major contributor to *Model Engineer*, first technical editor of *Engineering in Miniature* and founder editor of our sister magazine *Model Engineer's Workshop*.

We celebrate his life on page 171.

Brian Baker reports from a very popular event in the 7¼ inch gauge calendar.

Tom Parham, Maidstone club member, came for a day visit last year, obviously enjoyed his time with us, and returned with family and Mum and Dad, Martin and Sue, this year as well as bringing this fine Stirling Single, with which he was first on the track for the week.

Parklands Railway Week 2022

We knew that the ending of Covid rules would likely increase the number of visitors to this year's Parklands Railway Week, at Hemsby in Norfolk. It has always taken place starting on the weekend of the late May Bank Holiday, continuing to the following Friday, but this year Royal Events moved the Monday Holiday to a Thursday and we were given an extra holiday on the Friday. We decided to stick to our original dates, so all our thoughts based on previous numbers attending were of little use. We need not have worried because in the event attendance was larger than we thought possible with some 41 locomotives attending during the week, with some locomotives we had seen before but many new attendees.

The weather always plays a big part in these events and the Tuesday weather was not as good as it might have been, with some heavy showers, but on most days we had plenty of sunshine.

It has been a great assistance to us, as a relatively small group, in running the event that some people come to help run the railway and that fact, coupled with the experienced catering team running 'Café De Parklands', helped the whole week run very smoothly. Our bacon rolls are popular, as well as becoming very well known, coupled with excellent home-made cakes consumed by one and all. We decided to allow late running on one evening and this was well enjoyed, as

Parklands member Andy Briggs about to have his first run of the week, with his 'Holmside' locomotive, a regular performer.

The Upchurch family have been regular visitors and here Rick is starting off with his Maxitrak Pearl*, whilst in the background Dad Eric's Crewe Works 18 inch gauge shunter awaits preparation.*

Another of the Chelmsford trio was this fine Edward Thomas *driven by Kevin Church (picture by John Dalton).*

This 0-4-0 0-4-0 Garrett, a newcomer to the track, was built by Andy Haresnape, on a day visit from Chelmsford Club.

All the way from Edinburgh was Paul Hicks, with LNER 3401 Bantam Cock, *which he very kindly let me drive, while he took the photograph.*

It's not all locomotives at Parklands. John Dalton brought this beautifully made Burrell roller in 4 inch scale from Chelmsford Club to help smooth out and tidy the field and he could often be seen trundling on the site access roads.

Mick and Chris Jones brought two locomotives to us this year; this good-looking SR Schools class 901 Winchester *was one, and yes, it does have three cylinders.*

This GWR Collett 0-6-0 No. 2260, here with a mixed goods train, was the 'Jones' second entry and both locomotives performed faultlessly for the whole week.

Bob Whitfield is a member of the 7¼ Inch Gauge Society management team and this year his Denver & Rio Grande 2-8-0 Old Rube *did much of our passenger hauling.*

Our catering team had a very special visitor this Jubilee year to thank them for their efforts in supplying a great range of refreshments to all attendees.

Being prepared for steaming is this finely detailed (but unnumbered) GWR 14XX class 0-4-2 tank owned by Matt Gunner.

The Reeves 'Hercules' design is an 0-4-0 design, to continental loading gauge, which has been built in many variants. Here is a long wheel based 0-6-0 on passenger duties.

Tom Hubble brought this GWR 0-6-0 pannier tank No. 5403 with two lovely matching coaches to join the week.

The Bulleid Q1 class were built in 1942 to fulfil an urgent need for more goods locomotives and were based on the Maunsell Q class. Some may call them ugly but they performed well and lasted to the end of steam on the Southern Region. This model of No. C1 (under BR it became 33001), like the original, performed well all week, the driver spending many happy hours trundling round the track with long freight trains.

was the fish and chip supper that went with it.

The few locomotive breakdowns were quickly and easily fixed which meant that all the participants had plenty of time to run a fine selection of locomotives and stock. Unusually, everyone liked our coal - I never heard one complaint about it all week. Everyone enjoyed themselves with lots of spirited running, shunting and passenger hauling. Speaking personally, I think the best part about events like Parklands Week is the chance to chat in a relaxed atmosphere.

Rather than mention each engine I have gone with 'one picture saves a thousand words' and attach a selection for your attention.

Finally, my thanks to all those who attended and particularly those whose tireless work made this a great week, as well as a splendid 70th Jubilee weekend. We are already well booked for next year so if you have a 7¼ inch gauge locomotive do think about joining us on this delightful railway.

ME

We have for a long time been great supporters of the 7¼ Inch Society Proficiency Scheme. It is very pleasing to see past Silver award winners such as George Witheridge, now a Railtrack signalling apprentice, taking new candidate Rio Kent for a training drive on the 08.

Britannia Class 7 Locomotive in 5 Inch Gauge

PART 13 - PAINTING AND DETAILING

A Modelworks Rebuild

Norm Norton takes a renewed look at this popular, kit-built BR Standard Pacific.

Continued from p.37
M.E. 4693, 17 June 2022

Oliver Cromwell *on the GCR, Loughborough in 2014.*

What is the correct colour and where does it go?

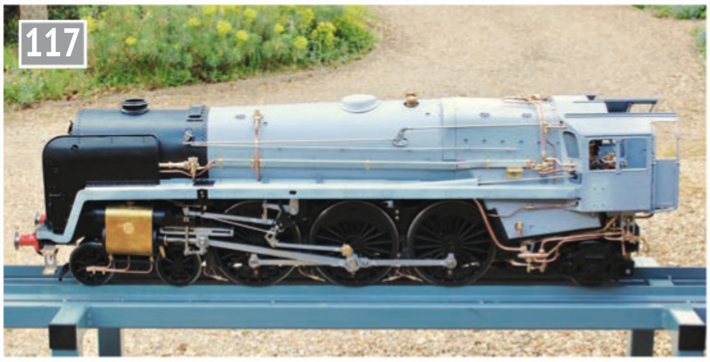
The colours of the locomotive, and where the various colours go, should be defined by the prototypical engine - but straightaway we have problems. There were few colour photographs, even in the 1960s, and often we are reliant on what others have written or drawn since then to give us their thoughts. Although we have no idea of its colour, black and white **photo 116** shows us that this engine, appearing here from the workshop, was most definitely shiny and not satin or matt finished. *Oliver Cromwell* is shown here outside Crewe works in February 1967, ready for official photographs after being the last steam locomotive rebuilt there.

BR Standard Class 7 express engines were painted in a colour described by BR as 'BR Loco Green'. I have been helped in understanding much of the story by Bob Shephard. According to Phoenix Paints this green colour changed slightly in 1954 and from then on BR used sample panels to match to. There was never a BS paint standard, just the reference panels that Bob Shephard later obtained as he was a supplier. In magazines and books I have seen the colour often described as 'BR Dark Green', or 'Bronze Green', or 'Brunswick Green'; all of these descriptions are wrong. BS381 224 Deep Bronze Green and BS381 227 Deep Brunswick Green are most certainly not the same colours as BR Loco Green post 1954. We can therefore say that Phoenix have got the shade right and I know that Craftmaster BR Green is near identical to that because I have sprayed test panels for comparison, along with the various BS381 railway greens to confirm that they are wrong.

Many people will no doubt rely on Phoenix Paints' excellent Livery Data Sheet to judge what colour goes

116

Oliver Cromwell *at Crewe depot in 1967 after its last BR repaint. The staging is set for the arrival of dignitaries and official photographs. I have the original of this print thanks to an* M.E. *reader getting in contact.*



The locomotive awaits its painting but it has to be stripped down and the boiler lifted. There is a lot of work to come before it is finished in its painted state.

The tender tank still in bare brass as it has only recently been finished. The chassis was earlier painted black.

where and we can see many model engines finished with black paint to the top of the running plates (side platforms) and also the top of the rear tender around the water filler and dome. Many of the small Hornby and 00 gauge models are similarly finished. But here I have my doubts as to whether this is always right. If you look at 70013, *Oliver Cromwell* and 70000 *Britannia* today those top surfaces are green. Obviously, back in BR days, after a month's steaming and a few pairs of boots running about, they were as good as black anyway! Some BR sheds no doubt painted them black, but was this practice for every repaint after overhaul? I have chosen to paint this engine as *Oliver Cromwell* is today with green top surfaces, and very likely as it was in 1967 after leaving Crewe (there is photographic evidence of the running plate tops in green at Bressingham, where it went after 1967).

The painting process

This article does not try and tell you how to set about painting. The best advice I can give is to suggest that you get hold of the book, *How (Not) to Paint a Locomotive* by Christopher Vine. There have also been some good articles here in previous issues of *Model Engineer* and I have rarely read anything that I disagreed with. But I will tell you briefly what I did and what works for me, and some of you who have previously had a go might find some ideas of interest.

It is a daunting process to strip the engine (**photo 117**) down to its component parts and place all these in labelled trays. I had previously painted the frames and wheels, so all the chassis could be left intact. This is something that many builders will do. Fortunately, the tender tank lifts off in not too many parts and, again, the chassis had been painted earlier (**photo 118**).

I have previously spray painted motorcycle parts and other jobs. I started in the days of cellulose paint, which is now virtually unobtainable. The automotive trade then used what are known as 2K paints and we can buy these from various trade outlets. Now there is a move to water based paints and we can expect to see those in the hobby trade one day. Meanwhile, the traditional enamel based paints, used from the earliest times, are widely available and can be brush or spray applied. They just take longer to dry.

A word about 2K paints: they are a two-product mix with a hardener stirred in and will be useable for a few hours but they contain iso-cyanates and you **must** have adequate ventilation and use personal breathing equipment. I wear a one-piece Tyvek cat.111 500 Xpert overall, a Gerson 9000E series respirator with G03E cartridges, latex gloves and goggles over my glasses for when there is bounce-back from a large surface. The Tyvek plastic overall and hood also help stop you from shedding dust particles all over the work. 2K gloss and satin black is easy to spray, dries very quickly, is hard wearing and thermally stable for use on a smokebox. You can do the same job with enamel paints and I still wear exactly the same protection, but you now will not be able to handle any painted surface for a few days, depending on temperature and air movement.

I worked in a laboratory many years ago so a fume cupboard is a natural 'home' for me (**photo 119**). If it is sited at the dirty end of the workshop it can also pull out grinding dust and welding fumes. The Ventaxia fan must be 10 inches diameter and it needs a frame to hold a glass fibre matting sheet to remove paint particles, or the fan blades and shutters will soon be clogged.

For paint spraying some fume extraction is essential. This is a fume cupboard that anyone can build in a reasonably sized workshop. Sited in a corner, wooden framing on top of a cupboard, perspex hung on screws to make the windows and a large 10 inch Ventaxia fan at the top. Items for painting hang by wires from bars above, with fishing line swivels added to enable rotation.

Spray gun or airbrush?

I have had a few spray guns and the cheap 'touch-up' type with a plastic reservoir above can work adequately. The important bit is the nozzle jet size and matched needle. Touch-up guns might have 0.8mm nozzles while a larger 1.3mm nozzle will do for a motorcycle large petrol tank, or perhaps car wing. A Graco Finex gun can be fitted with 1.0mm or 0.6mm nozzles and that smaller size would be right for a tender or boiler. I have used cheap airbrushes and they are good only for small fittings of around 5-10 cm and might just do for an engine cab. However, my eyes have been opened following the purchase of a more expensive Passche series VL airbrush kit (**photo 120**). The two-stage trigger gives better control (down for air and back for more paint) and a range of nozzle+needle sizes means it can pretty much do the job

>>

of a 0.6mm touch-up gun. I say 'pretty much' because the air brush does not have a fan pattern air adjustment. To get down one side of the Britannia boiler, for example, the Paasche No. 5 nozzle took eight passes, whereas a fan pattern gun might have been four or five passes. With a bit of care aligning those passes, the Paasche coped with the job. The No. 3 nozzle was good for things like the tender front and side platforms, the No. 1 for all the tiny items.

The whole painting process took a couple of months of steady work (**photos 121** and **122**). Some of the etch priming was done as parts were made but this can cause problems as, after time, you will have to rub it down if you want subsequent gloss coats to adhere. Etch primers that come in just one tin will soon go off and you may be better using two-pack etch primers. The automotive trade 2K etch primer is excellent for steel, being a very thin, grey coat that can take enamel gloss directly on top. For all the brass I used Paragon Paints 2-Pack chromate etch primer. It is now frowned upon because of the chromium content but it is a thin, yellow, transparent paint and you can see the brass or copper change colour underneath as the acid does its job. It is also stable to 200 degrees C so ideal as the primer under a smokebox black.

It is important to try and keep rivet detail by not applying too much paint. Undercoat paint is designed to be thick and cover defects for rubbing down, but there are very few places on a screw head and rivet covered engine where you would attempt any rubbing down between coats. For this reason you have to try and put the layers on perfectly each time.

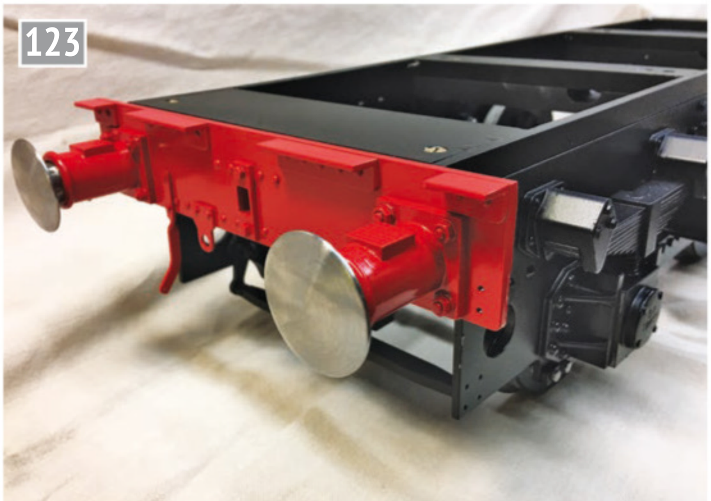
The frames and chassis parts are in 2K satin black (**photo 123**), as is the smokebox. All other black parts like the tender coal space, tender front, cab roof, backhead, smoke deflectors and front platform are in 2K gloss black. I personally feel that using the gloss gives the model a 'lift' and a look of reality. I just use one or two passes of 2K acid etch primer and 2K black goes on top of this; two coats of black fifteen minutes or so apart. Two coats is the ideal, but in places I have got four coats of the 2K because of errors and I just got away with the screw head detail. A perfectionist will put it all in paint stripper and start again. I'm sorry but I am a realist!

On the boiler cleading and tender I used the etch primer, then one thin enamel green undercoat (as there had been repairs or the touching up of defects with cellulose stopper), then just two coats of Craftmaster BR Green applied 15 minutes apart (**photo 124**). For an air brush the paint is thinned +30% so you are applying a very thin liquid that will easily sag and run. However, you must fully wet each coat and I have a spotlight reflecting off the surface to see more easily that

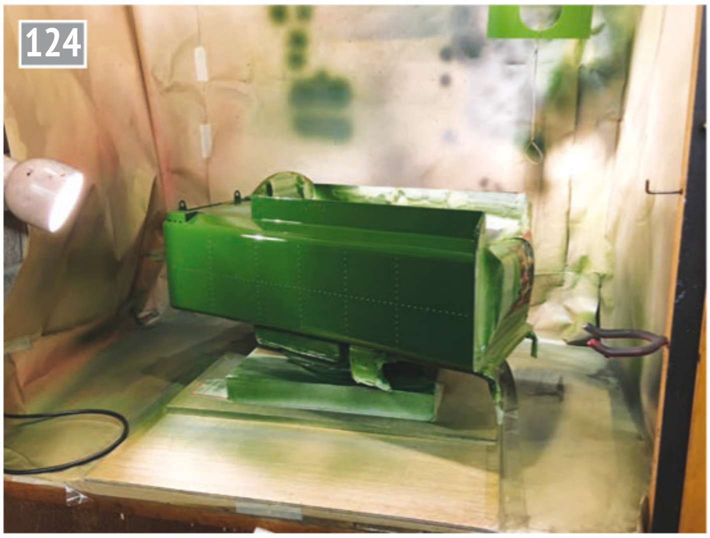
The 'upmarket' airbrush that did all the spraying. A Paasche VL Series with 'double-action' trigger, optional 90ml paint bottle and a range of nozzle+needle pairs.

The reality of painting – lots of parts to be cleaned and then hung on wires or arranged on jigs for spraying.

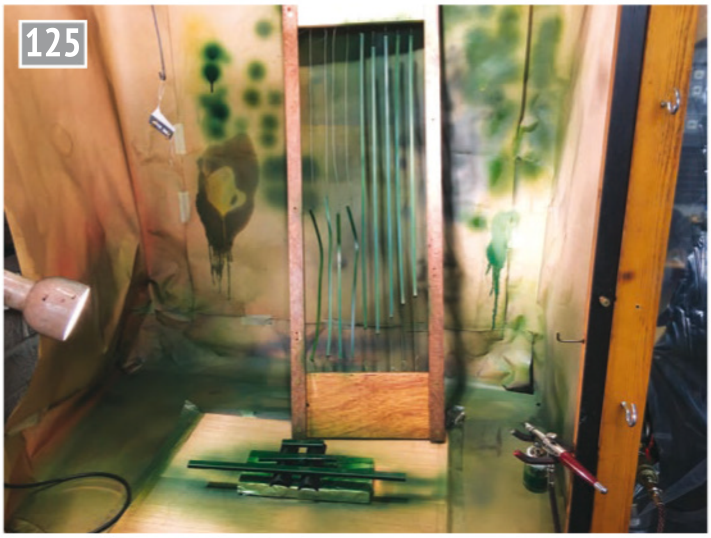
An alternative to painting small parts. 'Black-It' solutions give a smart appearance to steel, but it is not a corrosion protector.



The tender chassis has been painted with automotive 2K satin black, as have the locomotive frames. The red is a simple signal red enamel.

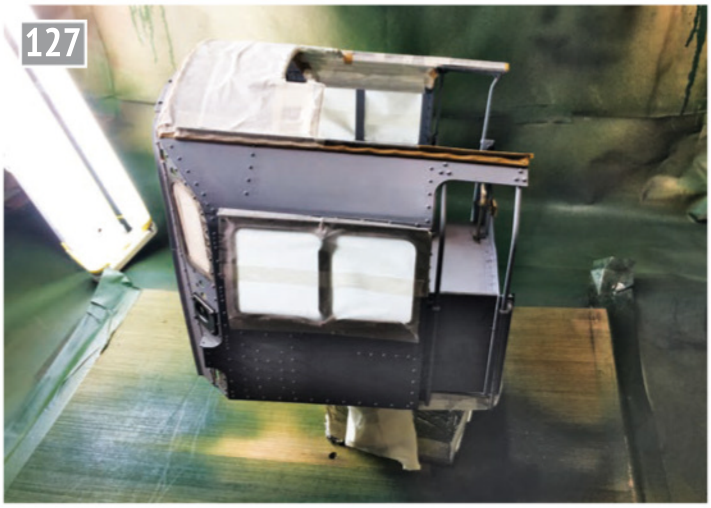


The tender is supported on a turntable to enable spraying of all sides while the fumes are carried up and out by the extraction fan. The close spotlight allows you to see a reflection while spraying so that just enough paint is applied to fully wet the surface.



The boiler bands are held in a wooden frame with wires pulling them straight. After priming, and spraying green, the transfers were applied while still in the frame. Finally a lacquer coat was sprayed before taking them off.

That is a big and heavy boiler. It was lifted by an engine crane onto a welded cradle that sits on a ball bearing, which is bolted to the red metal cabinet. The cabinet has castors underneath. The edges of the workshop have been covered with clear PVC sheet making, in effect, a bigger spray cabinet.



The cab sits on a simple support block. The tricky part was all the successive applications of masking tape for a satin black underside, gloss black roof, green sides and off-white interior ceiling.

wet shine appear (**photos 125, 126** and **127**). I used perhaps 600-700ml of the gloss green for the whole locomotive.

I did have a problem with paint on some lower cab rivets just starting to sag and agonised for a day or two about dropping it all in paint stripper and starting again, but common sense came to the fore and I made myself leave it alone - it is going to be a working engine!

Transfers

As well as some metal panels to practise and test your spraying, it is helpful to make panels with rivets and screw heads added. Then you can see when there is too much paint around the rivets and adjust your amount sprayed. These panels also help with practice for applying transfers and testing the application of a final coat of varnish (lacquer). I used Fox transfers as their quality and range is excellent. I know that many people will use a lining pen and paint, and I admire their objectives, but Fox can provide a nice set of BR Standard orange/black/orange lines in straights and curves. I doubt that I could fully replicate the orange/black/orange lines with a lining pen. The only time I struggled with the transfers was when I cut out many thin orange lines from the sets to let me line the

The 'transfer softening' products just do not work for the sizes of rivets.

Each transfer has to be marked for the rivet position and then a hole cut with a small 1.5mm punch.

>>

valance of the running plates. The orange lines came out of the water on their paper fine, but as soon as I slid them off onto the valance it was like pushing microscopic spaghetti into straight lines. Next time, I will use a lining pen for that job only!

> I did have a problem with paint on some lower cab rivets just starting to sag and agonised for a day or two about dropping it all in paint stripper and starting again, but common sense came to the fore and I made myself leave it alone - it is going to be a working engine!

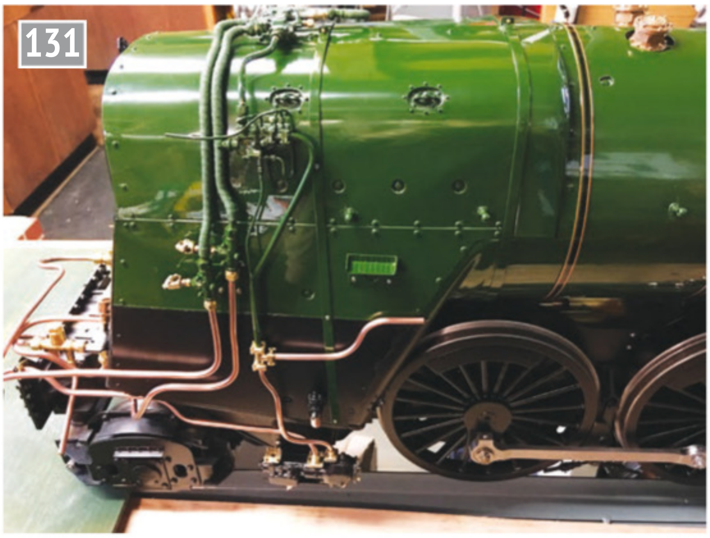
I tried some of the commercial 'transfer softening and affixing' solutions that are sold. I found that you could soften the transfer, and indeed almost cause it to fall apart, but the softening was insufficient to help the transfer lie properly over $\frac{3}{64}$ inch rivet heads, never mind anything larger (**photo 128**). I guess the solutions are intended for plastic Airfix kits. The answer was to position the transfer where you wanted it and gently press the head with a small tool (rounded end of posh Staedtler pencil). The indent could then be seen under the transfer and a 1.5mm diameter punch used (**photo 129**). The bare heads were touched up with mixed enamel paints after a day (**photo 130**).

The sides of the tender, sides of the cab, boiler bands and all the boiler and firebox cleading were sprayed with two coats of Craftmaster clear varnish (thinned +30%). The first was kept light to just seal the transfers, and the second coat applied 30 minutes later much fuller and wetter (**photos 131**).

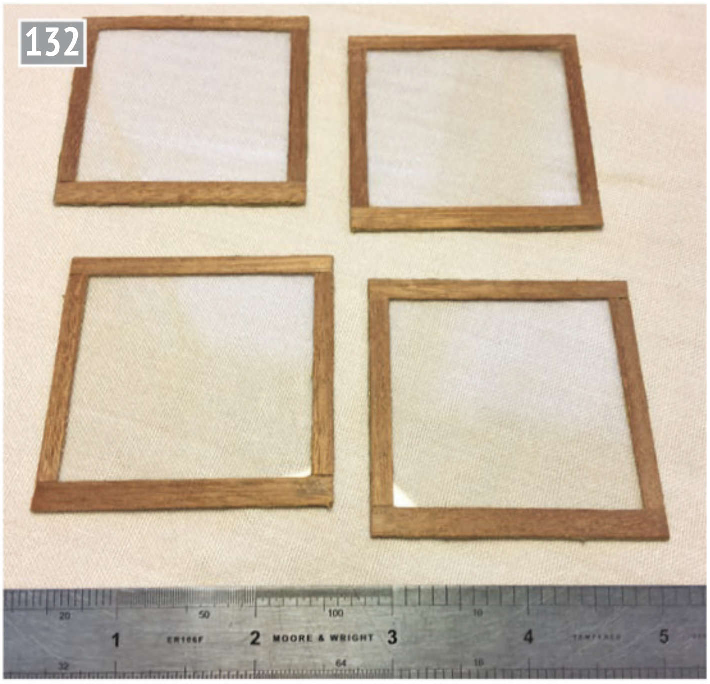
The numerals on the cab sides are the scaled down BR Standard 9 inch numbers but the Britannia should have 8 inch high numbers. Fox also do these but I realised my error too late. **Photographs 132** and **133** show the cab window detail and the captions briefly describe the construction.

●To be continued.

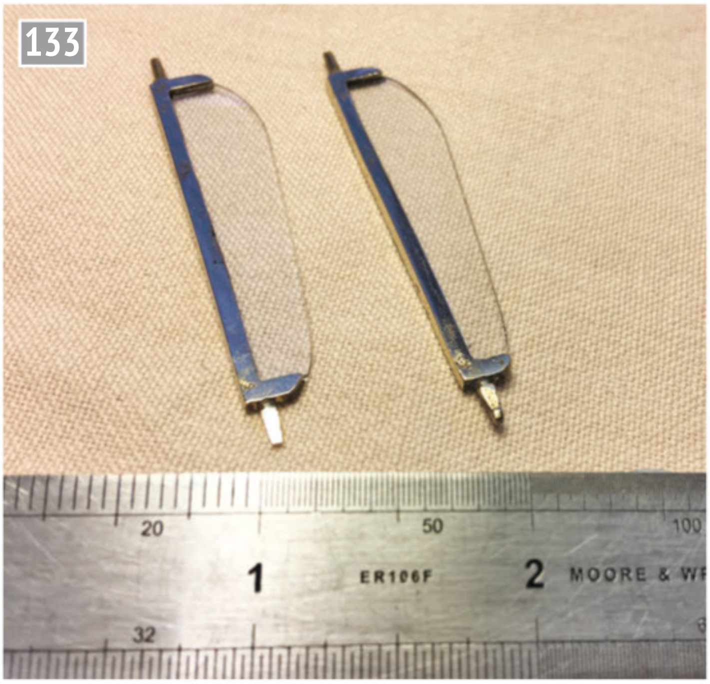
The tender emblem also had all its rivet holes cut with the 1.5mm punch. Then the artwork was touched up with enamel paints and very small brushes.



Once painted and lacquered the boiler could be craned back onto the frames. Then all the detail painted parts could be added.



The cab side windows are cut from 1mm thick glass. Mahogany laminate was sliced into strips and fixed with petroleum based contact adhesive.



The small cab-side wind deflectors are fitted with 1mm thick glass. After cutting, the curved shape is smoothed under soapy water with 180 grit wet and dry paper.

Rewinding a Two Speed Motor PART 1

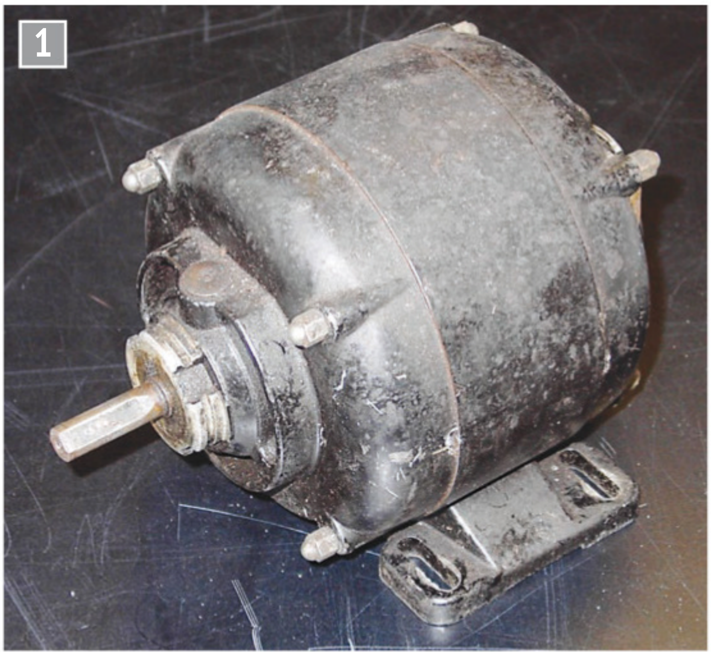
Graham Astbury learns a lot about single-phase induction motors and describes 'The long and winding road that leads to a 2-speed single-phase motor'.

Introduction

I had always felt that the large gap between direct drive and back gear on my lathe needed something doing about it and I contemplated the idea of having a two-speed motor instead of the single-speed motor that I had. Myford used to do this on one of their lathes, so there is a precedent for such things. When I moved house, I needed to build a new workshop and mount my 1934-built lathe on some suitable machinery mounts. Whilst making the mounts, I became somewhat irritated by the large gap between bottom direct speed and top back-gear speed, so I looked into what could be done. I could have built a second counter-shaft to provide a direct drive or a 2:1 reduction that would have filled the gaps exactly but, as this would involve new belts, bearings, supporting framework and a method of tensioning three belts instead of two, I looked at alternatives. I did have a three-phase 4-pole 1425 rpm motor of the same frame size as my existing ¼ hp lathe motor (which was similar to that in **photo 1**) but the three-phase motor was 415 volt star wound and so could not be fitted with a simple single-phase solid state variable speed drive as these require a delta connected 240/415 dual voltage motor. I did contemplate poking about inside to find the star point to convert it into a delta connected motor but the star point was so well hidden that I could not find it and I didn't want to risk cutting through a winding of a perfectly good motor to try and find it so I was back to the start again.

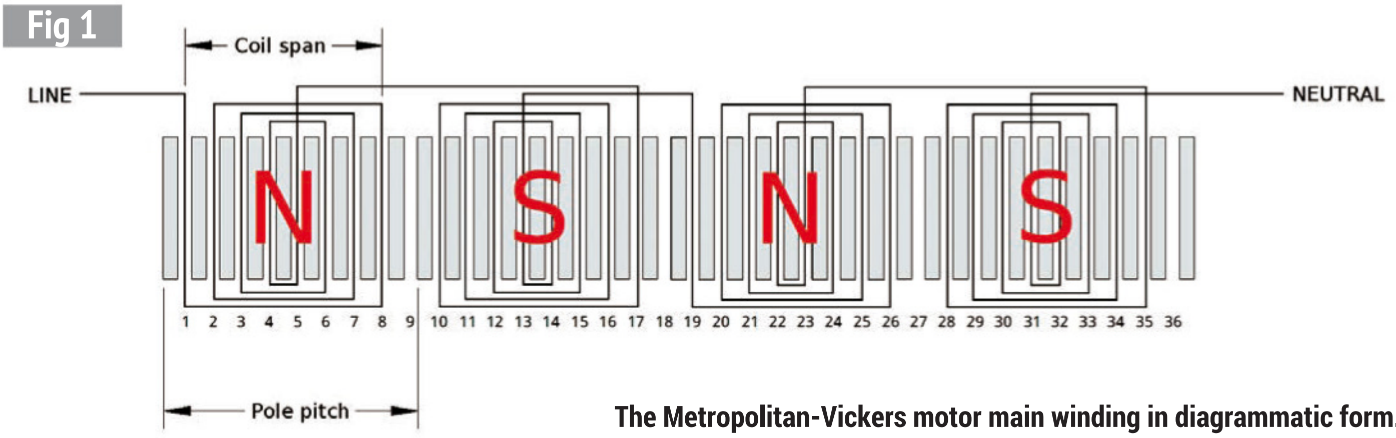
I searched the internet with little luck – all the two-speed motors I could find were too large and three-phase. Enquiries at a local motor rewinding firm revealed that whilst they could rewind my 415 volt three-phase motor as a two-speed motor, I might be better buying a new lathe as that would be cheaper... Even this would then give me a problem as I didn't have a three-phase supply available. I knew that it was possible to make a two-speed single-phase motor as I had one that I had salvaged from an

Nomenclature	
a	Pole face area, mm^2
Ac	Electrical loading, Ampere turns/mm
B	Magnetic flux per pole, Webers
C	Capacitance, Farads
Co	Output coefficient, Joules/m^3
$\cos\varphi$	Power factor – where φ is the phase angle between the voltage and the current
D	Stator bore, mm
E	Supply voltage, Volts
f	Supply frequency, Hertz
H	Magnetic flux density, Teslas
I	Current, Amps
Im	Magnetizing current, Amps
K	Temperature difference, Kelvins
L	Stator length, mm
lg	Air gap length, mm
N	Number of turns per pole
n	Number of turns per phase
p	Number of poles
P_{in}	Power input, Watts
P_{out}	Power output, Watts
S	Synchronous speed, rpm
V	Voltage (rms)
Z	Impedance, Ohms
η	Efficiency (Greek letter eta)
Ω	Ohms (Greek letter Omega)



The Metropolitan-Vickers motor similar to the existing lathe motor.

Fig 1



The Metropolitan-Vickers motor main winding in diagrammatic form.

old washing machine. This was a permanent split-phase capacitor motor which ran at 2-pole and 16-pole speeds (measured offload speeds of 2937 rpm spinning and 368 rpm washing). I had saved this as a 'might come in useful one day' item so all I needed to do was wind the right number of turns of the correct diameter wire into the appropriate slots – easy! The only problem was to decide on the number of turns and which slots to put the turns in. It is fairly obvious that once you have decided on the number of turns for each slot, the size of the slot would limit the diameter of the wire that could be fitted.

As a warning, what follows could be described as 'technical waffle' which I know will not appeal to some readers but I am sure that there will be at least *one* reader who will like it and at least one other who will disagree with what I have written and write to the editor to tell me how I should have done it. If you are an electrical engineer, particularly a designer of induction motors, please stop reading at this point and read something else!

Important disclaimer

If anyone is contemplating using this article as a basis for rewinding their own motor, all the information in this article is given in good faith but ultimately you are responsible for your own safety. As the use of the information contained within this article is beyond the control of both the author and the publishers, neither can accept any responsibility whatsoever for any death, injury or loss, whether financial or otherwise, which may occur as a result of using the information contained in this article. If you are not *absolutely* sure, then consult a qualified electrician. Electricity at these voltages is usually lethal if you touch anything which is live. Please do not take any risks – your widow will not thank you for it! So if you are in any doubt – don't do it.

The rather empirical way that I 'designed' the motor was to try to obtain a *working* motor – and not necessarily one that has the best performance, efficiency or power factor. All I needed was a motor that worked. There will be alternative ways of achieving the desired result and there will be motor designers 'out there' who will be shaking their heads in disbelief at what I am doing but as far as I am concerned, I am merely relating the progress that I made to produce a result that I wanted!

The theory

I started off by looking for any books on motors previously published in the model engineering press and the book by Alfred Avery (**ref 1**) seemed like a good starting point. However, I was somewhat disappointed with this as it contained a lot of descriptions of extremely obsolete motor types and it only gave a little guidance on the calculation of new windings for a motor if I needed to change the voltage, frequency or motor speed. It did not give any advice on two-speed motors. To be fair, it was published in 1946 and things have moved on just a bit since then – even though my motor was made only twenty years later.

Next, I searched the Internet to try to find out the information on winding two-speed motors in an easily assimilated form. This proved disappointing as it mostly referred to much larger motors or how to wire up existing two-speed motors, not how to rewind them. I identified and obtained a copy of the 'Bible' on small electric motors by Yeadon and Yeadon (**ref 2**). If you are really academic, you can wade your way through almost a thousand pages which go through the entire design process of a motor to whatever specification you require. However, as I had an existing motor I was stuck with what I had and I had to assume that the original motor designer had specified all the factors correctly to get the best possible performance out of the motor. Since I didn't have any of the design characteristics available, such as the magnetic properties of the stator and rotor laminations, or the diameter and number of rotor bars, I had to make a lot of assumptions as to the original design.

Induction motors

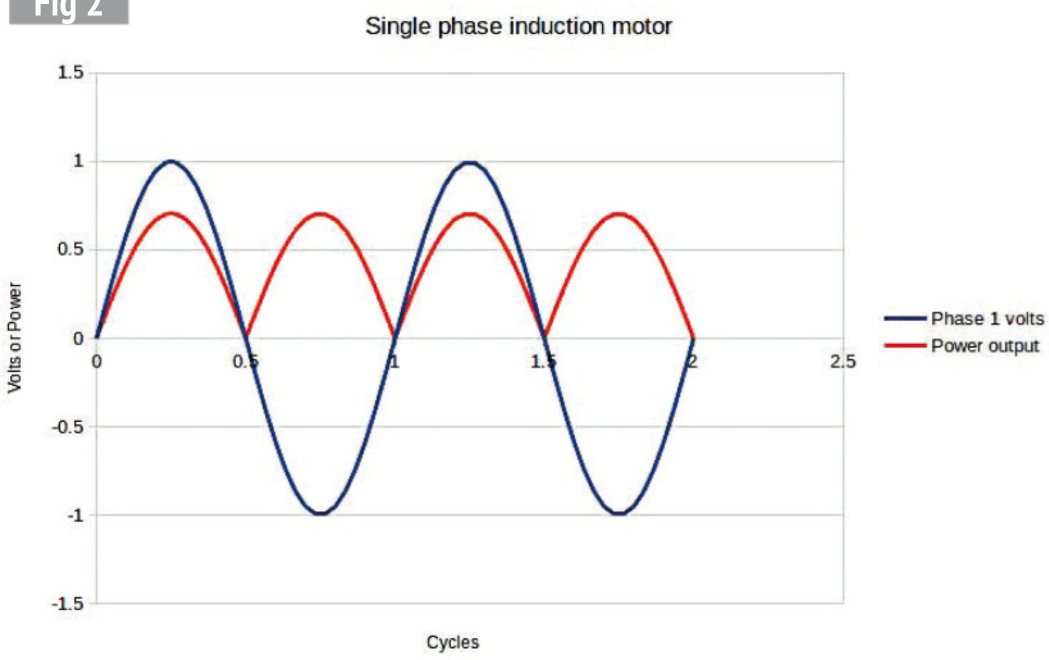
Alternating current induction motors always have pairs of poles and the speed of the motor is fixed as a multiple of the number of poles and the supply frequency. The nominal speed, called the synchronous speed, is determined by the equation (Oh no! not an equation!): $S = 120\ f\ /\ p$ where S is the speed in rpm, f is the frequency of the supply and p is the number of poles. Hence a 4-pole motor in the UK, where the frequency of the supply is 50 Hz, would have a synchronous speed of 120 x 50 / 4 = 1500. In the Americas, where the frequency is 60 Hz, the synchronous speed would be 1800 rpm. The synchronous speed is the speed at which the motor would run if there were no losses at all. Since in the real world there will be losses, particularly under full load, the *actual* speed would be more like 1425 rpm. This difference is known as 'slip' and in the case of the motor in photo 1 is (1500 - 1425) x 100 / 1500 = 5%. For single-phase motors, the slip is usually between 5 and 10%.

Single-phase induction motors

Typical small single-phase motors of the type I had on the lathe already are wound with a 'main' winding and a 'starting' winding. The main winding is connected to the single-phase supply and this produces an alternating magnetic field inside the motor. It is rather like a single cylinder steam engine – it is not self-starting but, once running, it will continue to run. If the motor stator in photo 1 is visualised as being 'straightened out' or unrolled, it has 36 slots with the main windings arranged as in **fig 1**. Whilst this seems a little complicated, it is not as difficult as it appears. The supply comes to the winding from the left and the first winding is wound anti-clockwise and, for the purposes of explanation, it can be assumed that this forms a 'north' pole. In fact, when the motor is running, the pole alternates between 'north' and 'south' at the supply frequency but it is easier to visualise if the supply is 'frozen' at a moment in time. The second coil from the left is wound in the opposite direction and so produces a 'south' pole. The other two poles are similar. Note that the coil is wound using eight adjacent slots - so the coil span is the number of slots embraced by the coil and in this case is eight slots. The pole pitch is the number of slots divided by the number of poles equal to 36 slots over four poles which is nine slots per pole.

As the supply to the motor is single phase, only an alternating magnetic field is produced when power is applied and the motor will not revolve. This is akin to the single cylinder steam engine – once given a push, the motor will start and run. The magnetic field and hence power output will vary between zero and full twice per cycle, as in **fig 2**. In order to start the motor, there is a second set of *starting windings* wound between the main coils as in **fig 3**. In this figure, the actual coils are not shown connected up – just the outline of how they are fitted into the stator. These coils are also wound clockwise and anticlockwise as in the main winding. Note that the starting winding only uses four slots, but actually embraces nine slots, so the coil pitch for the starting winding is nine slots. If the current in this starting winding is not in phase with the current in the main winding, there is a phase shift and the combined magnetic field from the two windings will rotate within the stator. This is effectively a two-phase supply. The magnetic flux passes from each 'north' pole through the rotor and back to the adjacent 'south' pole and this flux will rotate within the stator. If the phase difference is exactly 90 degrees, then the magnetic field will rotate and also will be uniform in magnitude as in **fig 4**. If it is shifted only 45 degrees the magnetic field will still rotate, but will vary in magnitude at twice the supply frequency, as in **fig 5**.

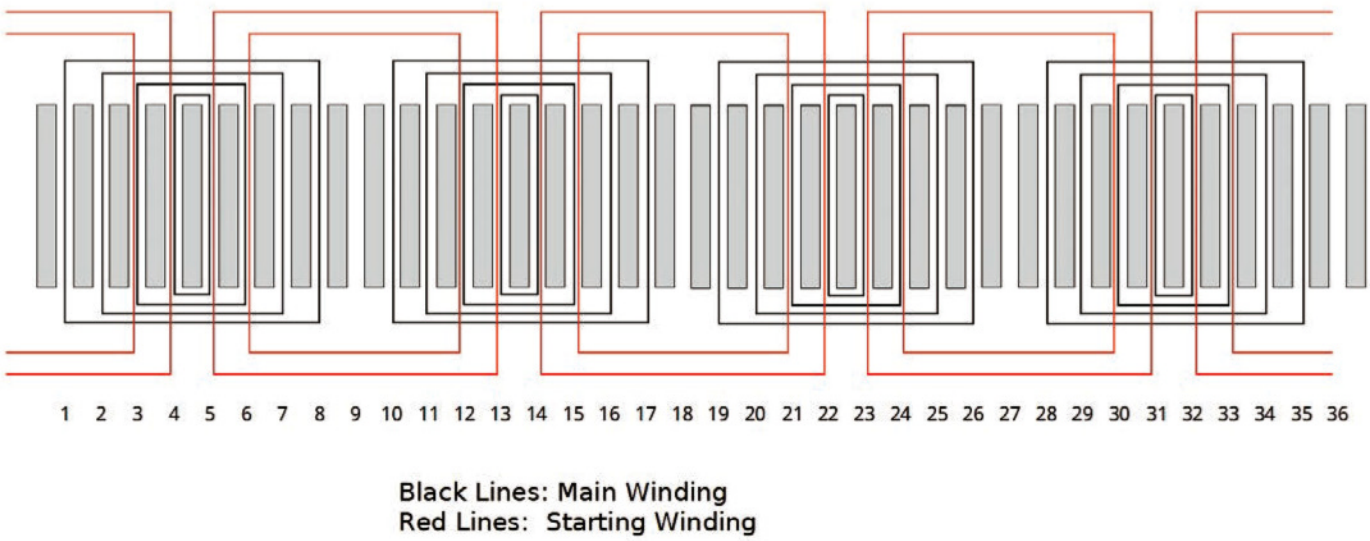
Fig 2



A single phase motor showing the pulsating nature of the power.

Fig 3

The Metropolitan-Vickers motor with main and starting windings in diagrammatic form.

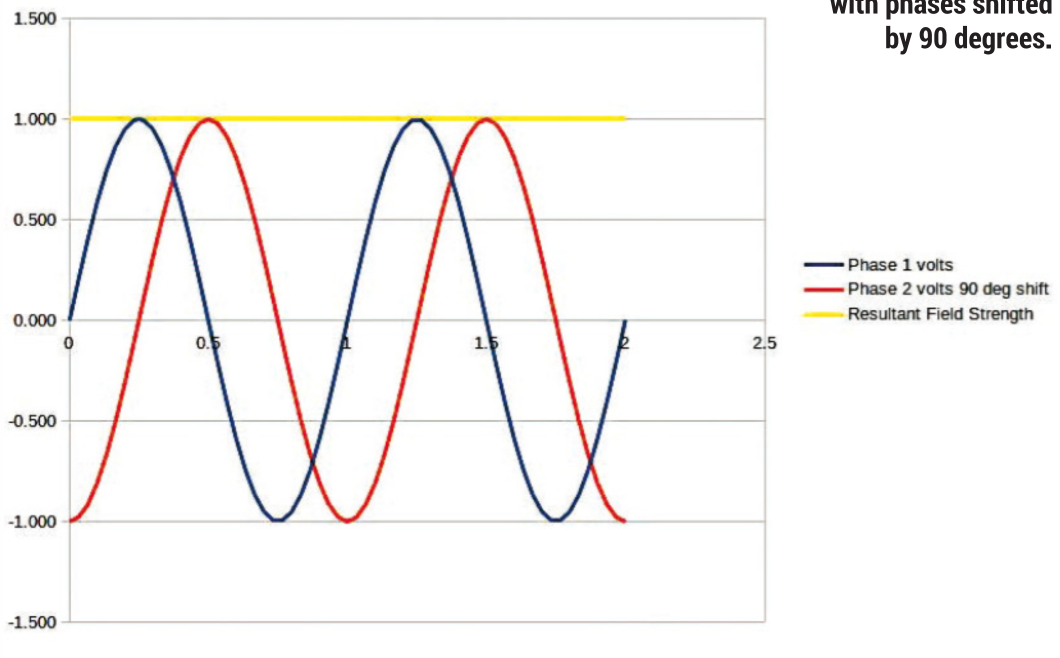


This flux moving around the rotor will now induce a rotating magnetic field in the rotor - hence the term 'induction motor' - in a similar fashion to the primary (main windings) and the secondary (the rotor bars) windings in a transformer. The rotating magnetic field within the rotor generates a current in the bars embedded in the rotor which in turn generates a force on the rotor, making the rotor begin to rotate. These rotor bars are usually die-cast in aluminium into the rotor and are short-circuited at each end by the casting which also forms a cooling fan at each end of the rotor laminations, visible in **photo 2**. When the motor is stalled, the current induced is very high, as each rotor bar acts like a 'shorted turn' in a transformer. As there is a high current, there is a corresponding high force produced which will turn the rotor so it will to try to keep up with the rotating magnetic field. Once it is up to speed, the rotor will continue to rotate even if the starting winding is disconnected. This is done using the centrifugal switch which has weights which fly out as the speed rises. These weights are visible in photo 2, held in by the springs.

There are two ways of making the current in the starting winding differ in phase from the main winding. The way that was used in my motor in photo 1 was to make the starting winding have typically the same number of turns as the main winding but of much thinner wire than the main winding. This presents a lower inductance but higher resistance than the main winding, so the current will be out of phase with the current in the main winding. As the starting winding has much thinner wire (typically six gauges thinner than the main winding), it can only be in circuit for a few seconds before it overheats and ends up looking like the blackened winding in **photo 3**. Also, in photo 3, visible in the end-bell, are the contacts for the starting switch and the pads which are pressed down by the black ring in photo 2 to connect the starting winding to the supply.

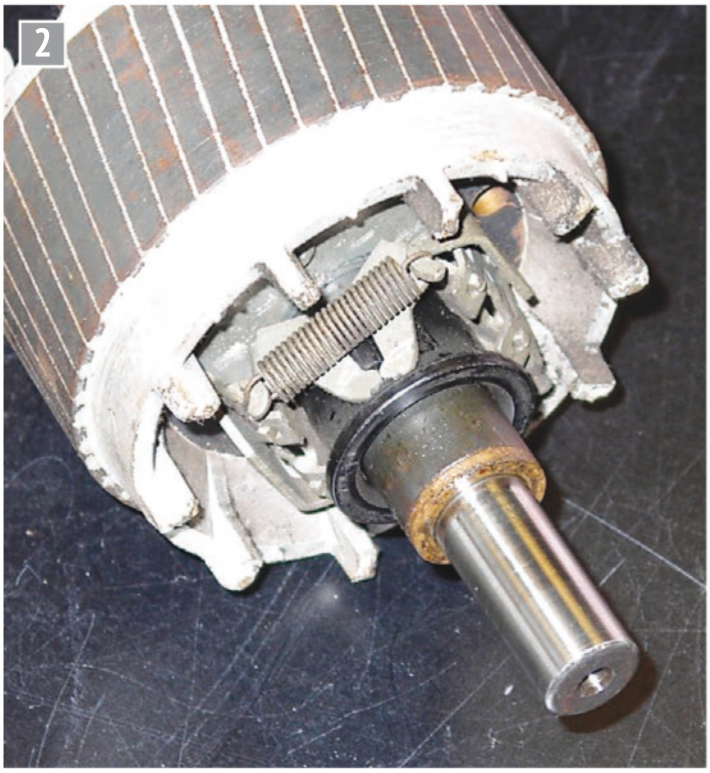
As the motor runs up to speed and the starting winding is disconnected, the motor acts as an induction motor and will continue to run despite the magnetic field merely pulsating in the stator, providing the supply is maintained. Once it stops, it needs the starting winding to re-start. Because the magnetic

Fig 4



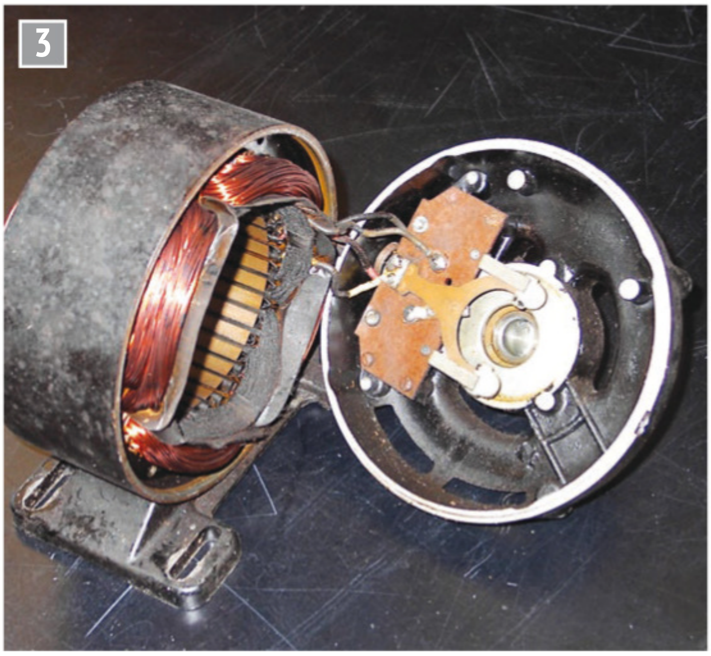
A two-phase motor with phases shifted by 90 degrees.

2



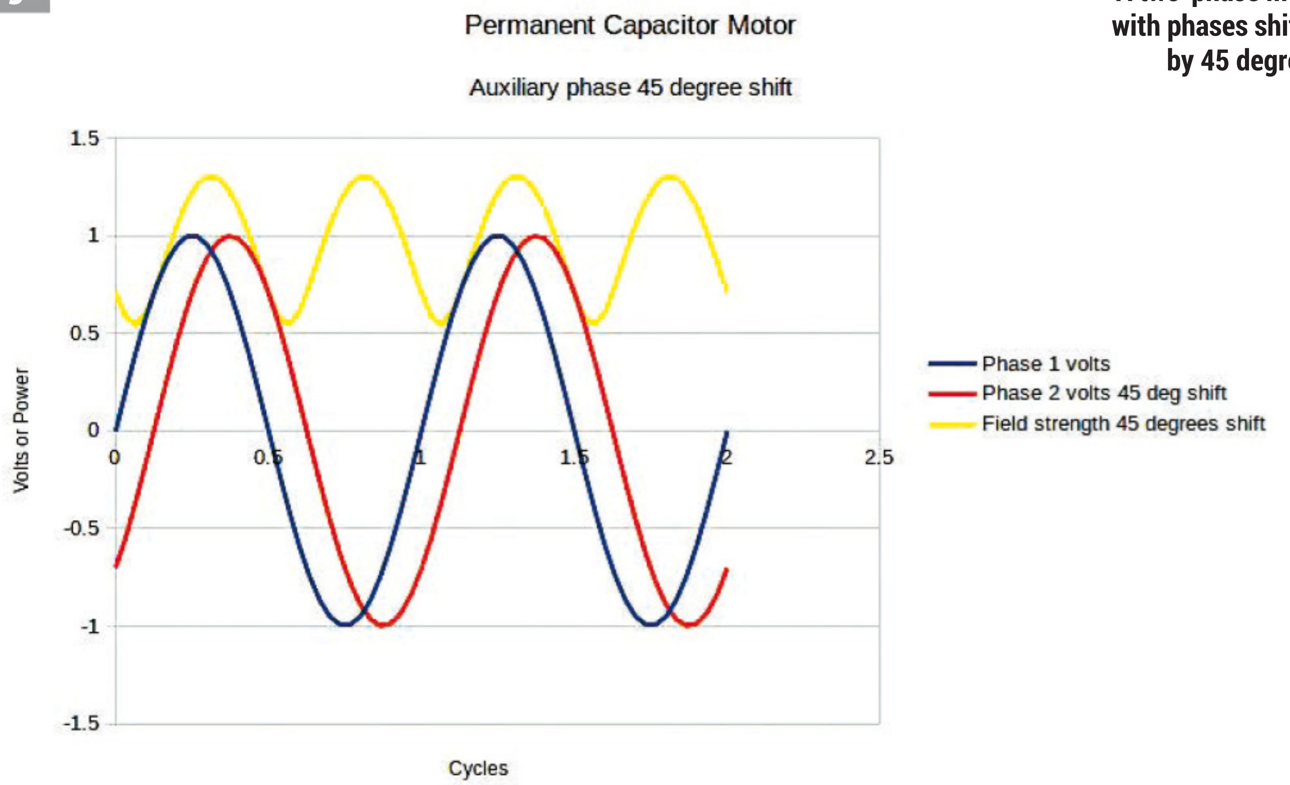
The rotor with its die-cast fans and the centrifugal switch.

3



The motor with its burnt-out starter winding and starter switch in the end bell.

Fig 5



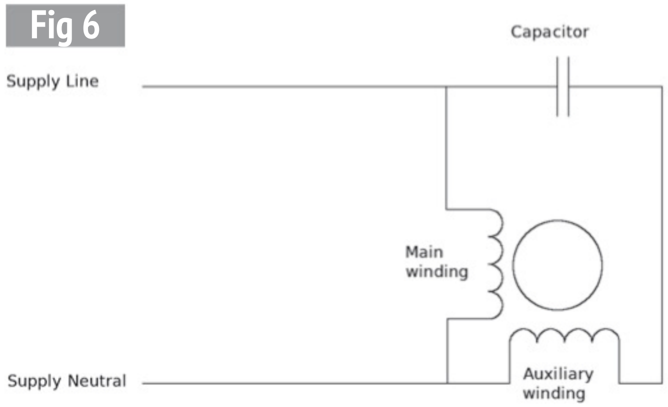
A two-phase motor with phases shifted by 45 degrees.

field pulsates and does not rotate, there is a tendency for the rotor to be accelerated as the magnetic field reaches a peak, and decelerated due to the load as the magnetic field decreases, producing angular vibration and noise. This can be minimised by spreading the turns of the winding in a sinusoidal fashion so there are more turns on the outer part of the coil than the inner part, rather than all the slots having the same number of turns. This is detailed by Appleman (**ref 3**) and it means that there are more turns in the slots at the sides of the coil than in the centre. In figure 3, the outer turns go down slots 1 and 8 and the fewer turns on the inner part of the coil go down slots 4 and 5. An additional advantage of the sinusoidal winding is that it also allows the fewer turns of the starting winding to be wound in the same central slots of the pole as the fewer main coil turns. I found this out when stripped out the old windings of the Metropolitan-Vickers motor in photo 1 in preparation for a rewind. This feature of a sinusoidal winding for single-phase motors was unknown to me until I started rewinding motors.

An alternative to using a higher-resistance lower-inductance winding is to use a capacitor which shifts the phase by 90 degrees. This gives the best starting torque. However, if the starting winding is made of the same number of turns and wire diameter as the main winding, the capacitor can be left in circuit permanently and the starting winding is then known as an 'auxiliary' winding. This, along with the main winding, produces a rotating magnetic field and does make for a better motor for a single-phase supply, as effectively the auxiliary winding becomes a second phase and the motor can be described as a 2-phase motor. This type of motor is called a permanent capacitor motor and is self-starting without the need for a starting switch. The circuit diagram for such a motor is shown in **fig 6**, and it is described very well by Bailey (**ref 4**) and Specht (**ref 5**).

●To be continued.

Fig 6



Wiring diagram for a two-phase permanent capacitor motor.

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4. Bailey, Benjamin F., *The Condenser Motor*, Trans. Am. Inst. Elec. Eng., **48**, No.2, 596-606, (1929).
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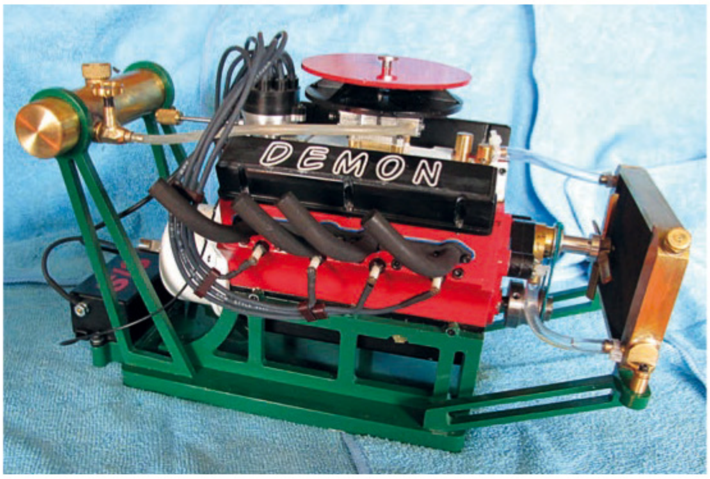
The *Little Demon* Supercharged V8 PART 9

Mick Knights describes the construction of a supercharged V8 internal combustion engine.

Continued from p.99
M.E. 4694, 1 July 2022

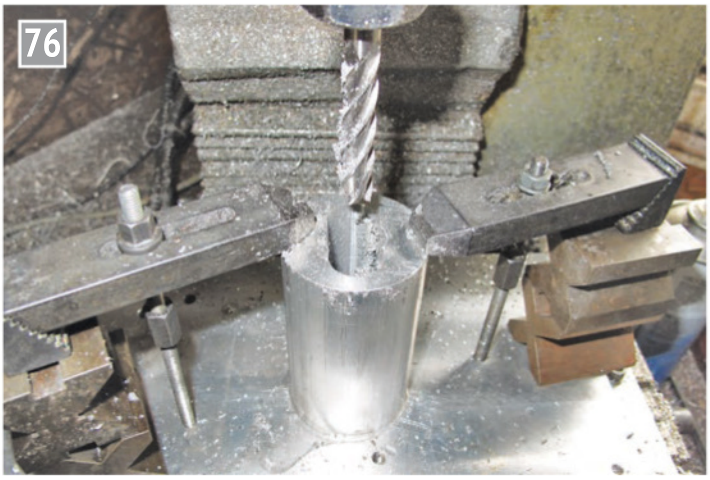


Air scoop

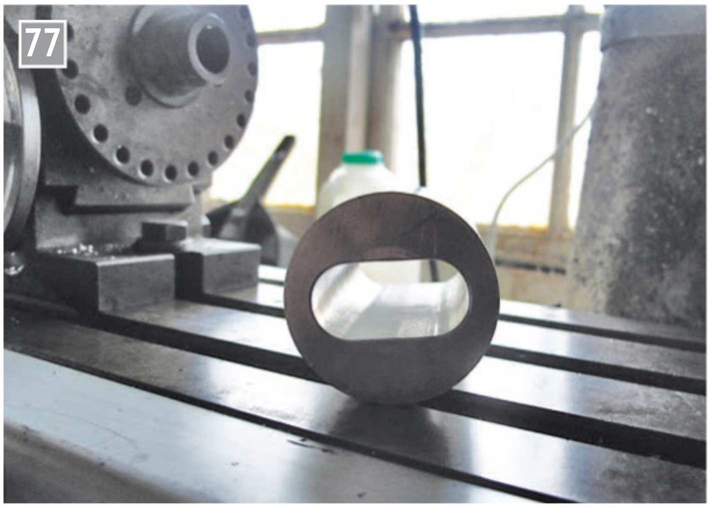
The air scoop was fabricated in two parts - the main scoop body and the end block - as it would be extremely difficult to produce the oblong channel with a flat bottom to the depth required. Producing the scoop in two parts will allow the oblong channel to be milled from both ends. First operation is to rough drill the channel end radii right through with a suitable drill (**photo 74**). Using two round plugs the scoop can be set square against a DTI ready for the machining of the channel, this operation will be repeated on the other end of the scoop (**photo 75**). **Photo 76** shows the machining to half distance of the air scoop channel, while **photo 77** shows the finished channel having been machined from both ends. Once the two flat faces had been machined, the underside being machined 0.062 inch deeper to allow for the larger form of the scoop mouth, an end block was produced with a male spigot to match the air

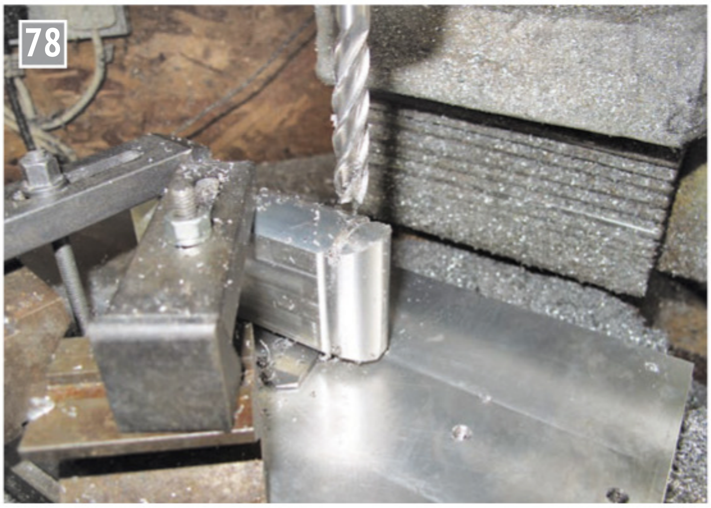
Drilling the channel end radii.

Setting the scoop square for machining the channel.

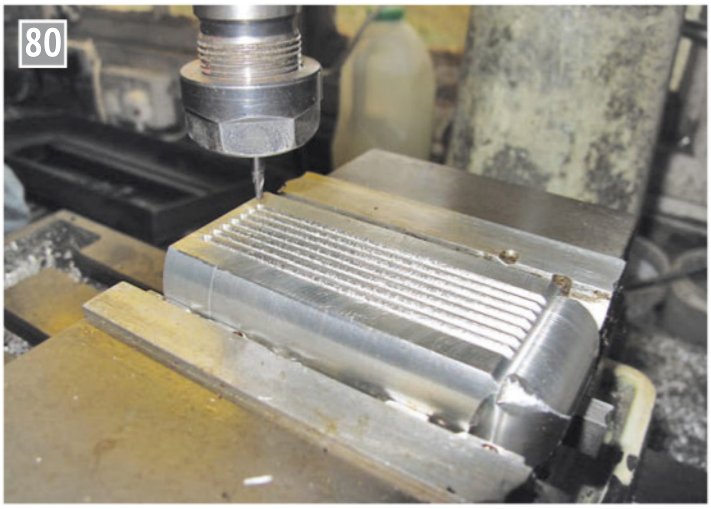


Machining out the sides of the channel.


The finished channel.


Milling a male spigot to match the channel.


Milling out the carburettor location bores.


Machining the grooves onto the top face.


The work is transferred to the dividing head.


Generating the outside form of the scoop.

scoop channel and the two were bonded together. Once cured the rear radial form was roughly generated. The final profile will be achieved by the time honoured process of filing using my age old method of, if it looks right then it probably is (**photo 78**).

Next operation was to produce the carburettor location bores on the underside of the scoop (**photo 79**). The top face grooves were also machined using a 3mm diameter solid carbide ball nose cutter (**photo 80**). A quick word on the supplier I use for solid carbide cutters: it's APT Cutters - their service is first class and the prices of their economy range of cutters, which is the only grade the hobby machinist should require, beats most HHS cutters of a similar size and of course they last considerably longer, while orders received before 4.00pm are usually next day delivery.

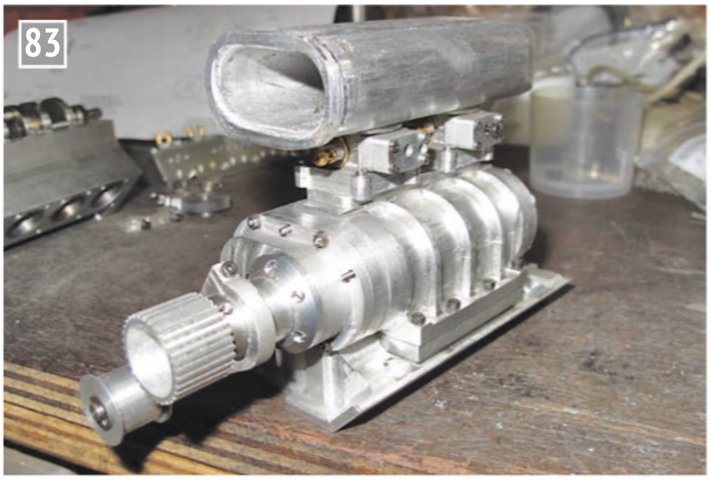
To machine the radial form of the scoop body a special milling fixture was produced with a male spigot to locate the mouth of the scoop. The fixture was first set in the four jaw chuck in the lathe to achieve the offset required to generate the 0.500 inch radius, then the set-up was transferred to the dividing head (**photo 81**). Using the 3mm diameter solid carbide ball nose cutter the form was gradually generated by rotating the crank handle and advancing the cutter in one millimetre increments (**photo 82**). With the first side rifled smooth, the second side was set in the fixture and the second radial form successfully generated. With all the machining marks riffled smooth prior to final polishing, the scoop was fitted to the carburettors (**photo 83**). Before finishing the air scoop I had obviously started the first complete assembly of the supercharger and the fitting of the rotors, so now let's cover the fitting of the blower rotors.

First the mounting plate for the carburettors was screwed on to the top face of the blower body followed by the rear bearing plate (**photo 84**). In order to establish where any high spots or pinch points where the rotors might be binding, all the surfaces of the rotors were coated with marker pen. With the rotors mounted inside the blower body, the front bearing plate (**photo 85**) was fitted. The drive gears were secured to the rotor drive shafts with M3 grub screws locating on two milled flats on the rotor spindles. The exact position of the flats is obtained by lightly tightening the grub screws against the rotor shaft to leave a circular indentation - where the grub screw bites is where a small flat can be milled or filed (**photo 86**). As the rotors were a little tight on the first assembly, rotation was achieved by holding the main drive shaft in the chuck and holding the blower body with one hand while the lathe spindle was rotated by the other. If any real resistance is experienced the rotors would need checking and relieving before another attempt (**photo 87**). The high spots on the rotors required gentle riffling to ease the pinch points. The whole process took several hours to achieve smooth rotor rotation. **Photograph 88** shows the finished rotors ready for assembly.

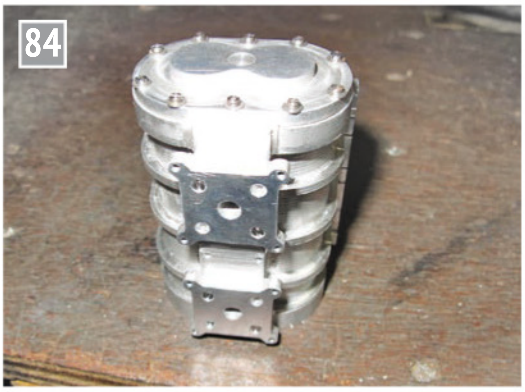
To check all the other blower components didn't inhibit smooth rotation of the rotors, the gear cover plate was fitted and tightened down and rotation checked. A few thou' was faced off the drive gear hubs at this stage.

Next component was the nose, which has a bronze bush to support the drive belt sprocket and so smooth rotation has to be checked again and any adjustments carried out. The drive belt tensioner is clamped to the nose (**photo 89**). Finally, the drive belt sprocket is secured with an M3 grub screw against two more flats milled on the drive shaft.

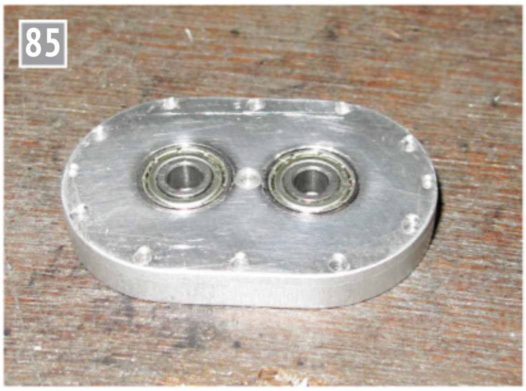
● To be continued.



The scoop fitted to the carburettors.

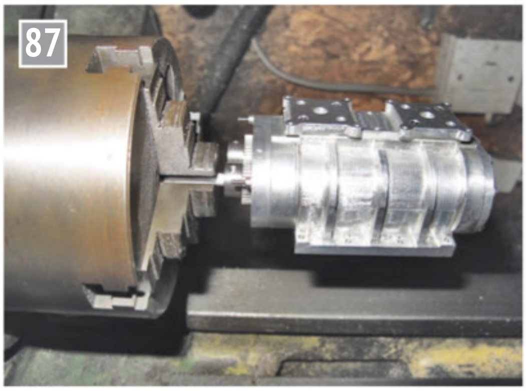


Mounting and bearing plates attached to the blower.



Front bearing plate with bearings.

Rotor spindles are installed and gears fitted.



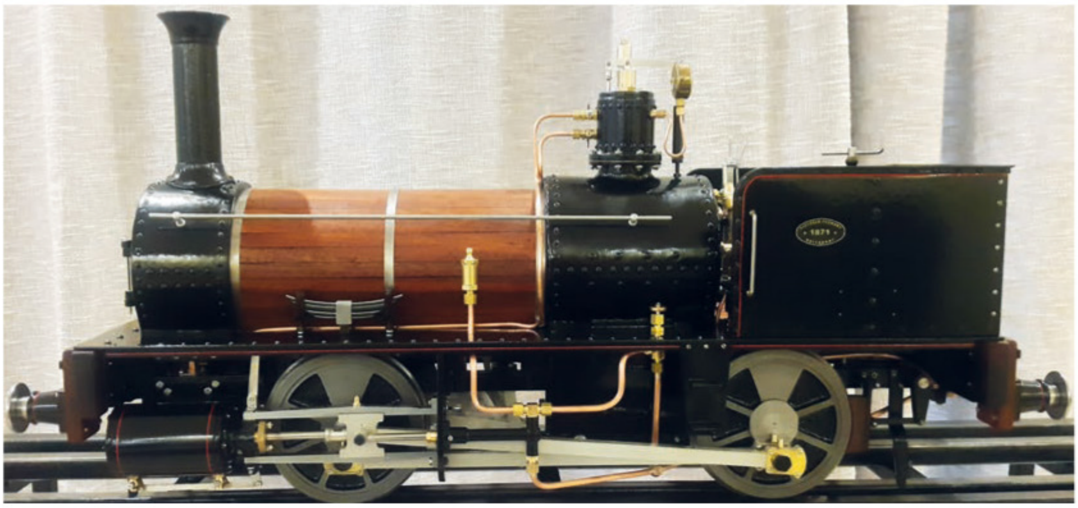
Checking for tight spots on the rotors.

Rotors with high spots removed.

Drive belt tensioner attached to the nose.

Luker describes a simple but authentic small locomotive.

Continued from p.28 M.E. 4693, 17 June 2022



Ballaarat PART 14

A 5 Inch Gauge 0-4-0 Aussie Locomotive

The boiler clacks

Many builders battle with getting boiler clacks (**fig 27**) to seal properly, with most of the problems traced back to a poorly seated ball on a non-round hole. Even with a keenly sharpened drill you will most certainly get a clover hole. To prevent this predicament, a similar approach to the snifting valve is followed, but this is one of the few times I'll repeat the methodology to emphasise the machining steps. Starting with the part most likely to give issues (the coupling with the ball seat), start with the ball seat side; centre drill and drill with a smaller drill through full depth. Machine and thread the outside then flip the component around and machine the other side to drawing with the threaded part held in a tapped mandrel. Concentricity won't be perfect, but this isn't an issue on the pipe coupling side. Run a toolmaker's reamer from the back end through to the seating surface. Most of my toolmaker's reamers are just the back end of a drill that has been ground 60 degrees to the midpoint of the drill and polished with a little 600 grit sandpaper. The shank will be completely in the hole before it gets to the seating surface, therefore the hole will end up perfectly round and any concentricity issues will be taken up by the flexibility of the drill and the tailstock. Finally the 60 degree CSK is machined with a home-made silver steel tool from the tailstock.

The part is then removed from the threaded mandrel and the seated surface is very lightly de-burred with some steel wool (outside the workshop away from any machines!). Nine out of ten times the ball seats perfectly and this is tested by the normal, very scientific 'tongue testing method'. Just a quick recap: this is the method of 'suck and seal' using your tongue and see if it holds a vacuum. If it doesn't then a light tap with a piece of brass on a scrap ball normally puts things right.

The clack body is a simple lathe turning exercise. Some builders swear by removing the thread past the top and bottom ends, but I've never bothered and haven't seen any ill effects. I generally mill the end of the Tee-piece going into the boiler with an end mill to get a clean soldered joint, typically held in place with an M3 screw smothered in a little Tipp-ex for soldering.

The cap is machined with a forming tool to suit your own preference. The geometry I used matched one of the later clacks fitted to the prototype. In the manufacturer's yard it didn't look like there was any clack fitted; just a small elbow. The builders probably assumed the crosshead pump would seal adequately, but this doesn't work, neither in full scale nor for a model. At some point this became clear and the elbow was changed for a rather large, bulky clack, which is what I matched in the model.

The amount of ball lift required will determine the length of the threaded part of the top cap and this will be different for the pump and the injector. When the bottom assembly is completed with the ball fitted, this dimension can be measured and the top cap machined. A little advice on machining the cap: after making the forming tool (actually two formers are needed; one for the ball and the other for the tapered

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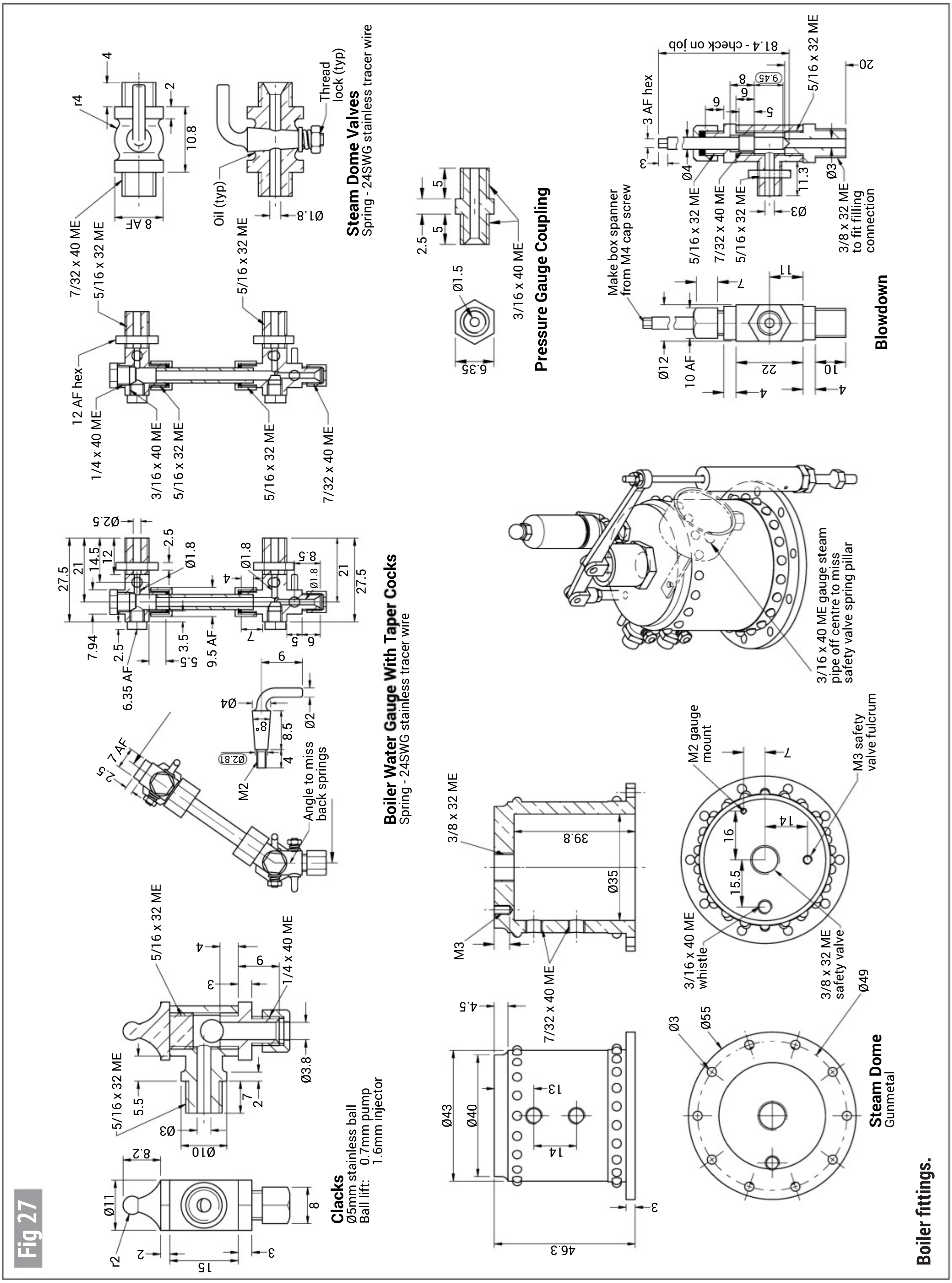


Fig 27
Clacks
Ø5mm stainless ball
Ball lift: 0.7mm pump
1.6mm injector
Boiler Water Gauge With Taper Cocks
Spring - 24SWG stainless tracer wire
Angle to miss back springs
Steam Dome Valves
Spring - 24SWG stainless tracer wire
Thread lock (typ)
Oil (typ)
Pressure Gauge Coupling
Steam Dome
Gunmetal
M2 gauge mount
M3 safety valve fulcrum
3/16 x 40 ME whistle
3/8 x 32 ME safety valve
3/16 x 40 ME gauge steam pipe off centre to miss safety valve spring pillar
Blowdown
Make box spanner from M4 cap screw
3/8 x 32 ME to fit filling connection
81.4 - check on job
Boiler fittings.

section) do a couple of tests on some scrap brass to check that you're happy with the form. I machined the threaded part first and flipped the component (held in a threaded mandrel) to finish with the forming tools. I did not just plunge - I doubt this would work. I rough machined the general profile with a roughing cutter then used the forming tools to finish the profile.

The water gauge

The water gauge is designed to match the prototype gauge, which used a taper cock arrangement for the top and bottom glass valves and for the blow-down. Tricky construction to say the least! These taper cocks have not received much favour in the model engineering fraternity. I have seen taper cock arrangements with compression glands to prevent leakage, but this seemed like extra work, and space was somewhat limited. In the end I did a little experimentation on materials, taper angles, holes sizes and manufacturing methods which helped in making a steam taper cock that had no leakage on my model and functioned rather well. All the steam valves are made using this method so repeatability throughout makes machining a little easier and quicker once you get the hang of it. Other than the design considerations there are two fundamental manufacturing tolerances that need to be perfect. Firstly, the taper needs to be identical for the spindle and the hole, and secondly, the taper spindle needs to tighten on the taper itself and not the nut or washer at the end. The machining of these tapers and tapered holes is identical to that of the taper cocks described in Part 8 (*M.E.* 4683, 28 January) so I won't go through that again.

After machining the taper (**photo 111**) it can be parted off - or cut with a hacksaw if you're not yet confident with parting - and pushed into a taper mandrel for facing and drilling (**photo 112**). The mandrel needs to be short enough so the back end of the taper spindle is accessible to tap out. If the taper spindle spins when drilling then your matching tapers are out and the valve will not seat properly. A push of the thumb into the mandrel should be enough to face and drill the hole.

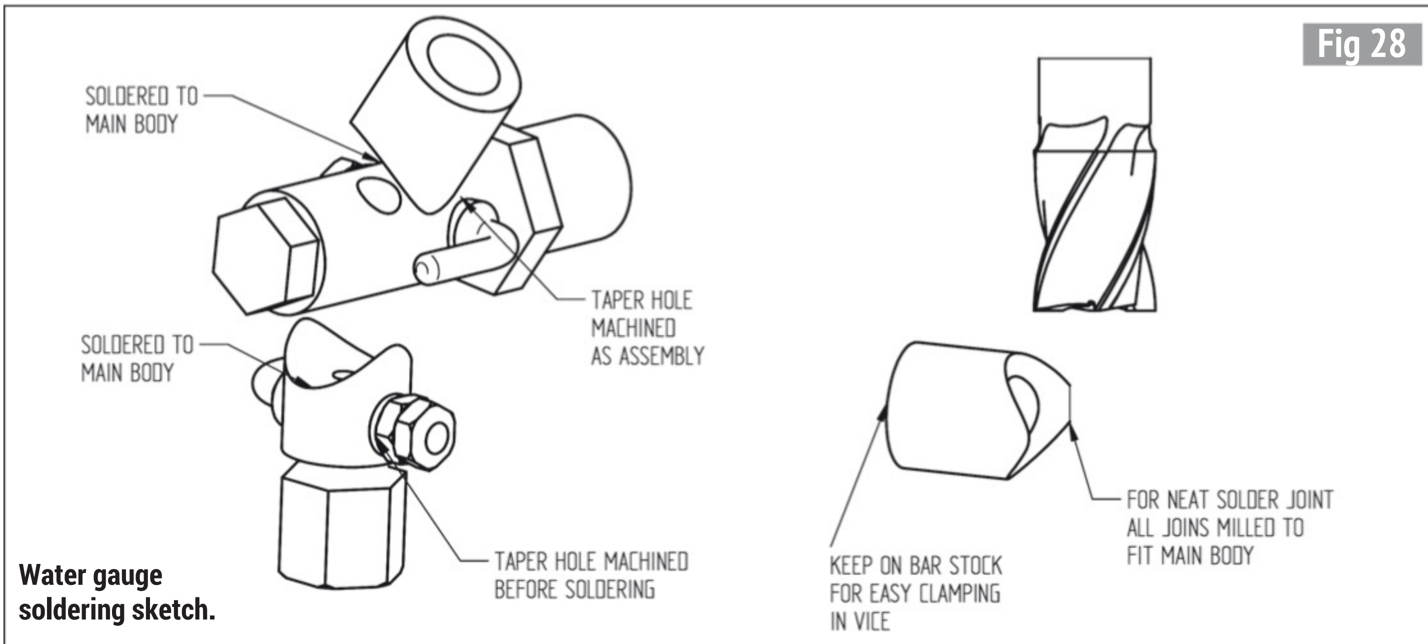
With the hole drilled a piece of stainless steel rod can be fitted and silver soldered in place (**photo 113**). For this operation it's a good idea to hold the spindle in another mandrel to protect the taper surface from oxidation and to hold it upright when soldering. Using this same mandrel the handle is bent into the desired position, cut and the end rounded with a fine file (**photo 114**). All told, you will need six of these taper spindles for the various steam valves.

The body component of the sight glass requires mostly lathe turning and is relatively simple. The soldering and final match machining operations, however, may catch you out a little. For all my valves - or any component, for that matter - with two similar cylinders that need to be soldered, I machine the end of the soldering component to match the mating body, i.e. the end of the Tee-piece will have a milled

Machining the taper spindle.

Drilling the hole for soldering the handle.

The handle soldered and bent.



Water gauge soldering sketch.

half round. This neatens up the joint considerably and makes soldering a little easier (**photo 115** and **fig 28**). My standard practice of placing a locating dowel (screw or bolt) through the hole to align the component with a little Tipp-ex makes sure the holes line up nicely.

Most of the holes through the stainless steel spindle need to be drilled after the components have been soldered with the exception of the sight glass drain spindle. This needs to be done before soldering to the main body. All match drilled spindles need the same treatment as described in Part 8 and they will not be interchangeable after drilling is completed (**photo 116**). Fair warning: when drilling through the brass into the stainless spindle, the two different materials need to be drilled differently and a careful hand is needed when you hit the stainless to prevent the drill from breaking. Likewise, don't overdo the drilling through the stainless, otherwise the drill will jam and break when you punch through into the brass. I normally pilot the holes in the brass before soldering, but I do not drill straight though. Starting the drilling directly on the stainless through a pre-drilled hole will cause drift due to the curved surface that the end of the drill starts on.

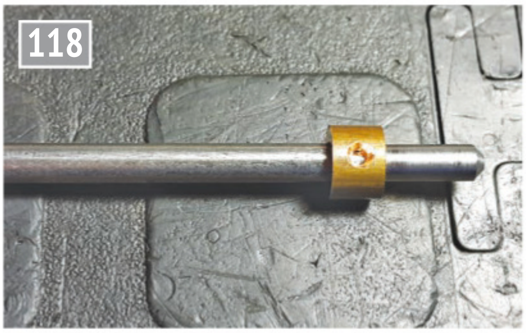
When assembling the water gauge to the boiler make sure to line up the glass holes properly by slipping a drill or piece of ground bar stock down the holes before tightening the back locking nuts (**photo 117**). These nuts shouldn't be messed with when the glass is fitted!

Some taper spindles ready for fitment and cross drilling.

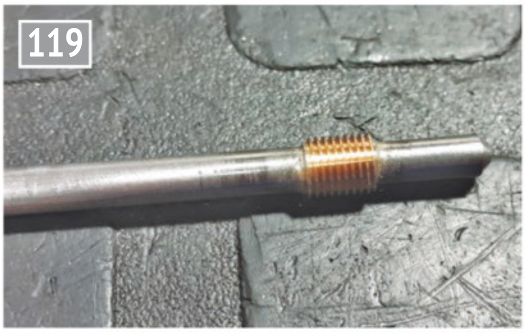
Machining the neat soldered joint.

Cross drilling the spindle in the assembly.

Lining up the boiler sight glass.



Blowdown valve spindle solder hack.



Blowdown valve spindle machined.

Blowdown valve

The blowdown is conveniently located under the footplate with the shaft extending through the floorboards for easy blowdown and filling the boiler. All my locomotive blowdowns have a common ⅜ inch fitting at the end, so I only need to make up one filling line, and I never bring the wrong line on a steam day. The same connections are used throughout for all my locomotives, from the smallest 3½ to my larger 7¼ inch gauge.

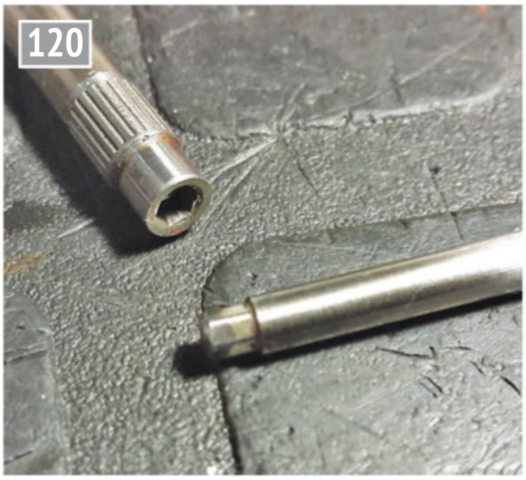
I've drawn the valve body with a separate coupling on which the spindle seats, which is technically more correct than making this all one component. To be honest, I did combine this coupling and the body with no ill effects; it just means when the seat has been skimmed a few times to fix any leaks the whole body will need to be scrapped (melted, in my case, so no real issues here).

The shaft for the blowdown is designed not to screw out totally, which would be bad while on steam. This configuration requires the threaded part of the shaft to be larger than the rest. Machining a solid stainless bar is laborious, so a simple hack was necessary to cut down machine time and wastage. In the end a PhBronze tube soldered to a stainless steel rod did the trick (**photo 118**). A hole was drilled in the centre to feed the solder making sure it filled the capillary gap properly. Machining the thread is then a simple lathe turning operation on a much more forgiving material (**photo 119**). The rest of the valve is simple lathe work.

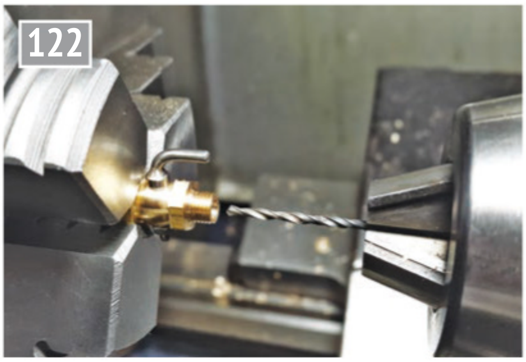
To be honest, I did combine this coupling and the body with no ill effects; it just means when the seat has been skimmed a few times to fix any leaks the whole body will need to be scrapped (melted, in my case, so no real issues here).

With the valve fitted and the footplate and floorboards in place the correct height of the end shaft can be checked and cut to size. Finally, the end is faced, drilled and a piece of Allen key soldered in the hole. The blowdown box-spanner is made from a capscrew (**photo 120**).

Common steam valve body.



Blowdown valve spindle and box spanner.



Drilling through the spindle.

Steam valves

The steam valves match the tiny valves used on the large prototype, all fixed to the steam dome; no turret was used. The valves are incredibly quick and easy to make, provided you work accurately with the taper. The body of the valve is made using a forming tool (**photo 121**) with all other operations typical lathe turning, drilling and tapping operations. Again, as with all the taper valves, do not drill the steam hole straight through. This needs to be drilled with the taper spindle fitted in the open position (**photo 122**).

Steam dome

The steam dome was a gunmetal casting using a 3D printed pattern. I made the bore slightly undersize to clean up the inside for uniform clearance around the regulator. Then the rest of the casting required only minor cleaning on the lathe. The only tricky bit is facing the top surface flat for the safety valve and whistle. A mandrel was machined with an easy fit transitioning to a 1 degree taper for machining the dome. The dome should be pushed to at least two thirds of the taper mandrel for safe machining. The top can then be faced and the safety valve hole drilled plumb centre.

The drilling jig used for the boiler flange was used to drill the matching dome flange. The front and back was marked and all holes drilled to line up with the centreline of the boiler. Alignment here is important; skew valves and lines are very distracting when driving.

The coupling for the pressure gauge should be positioned to miss the safety valve spring casing set as high as practical. The arm holding the pressure gauge will need to be long enough to clear the coupling. I never dimensioned any of this because it is largely dependent on the specific gauge used. The prototype had a rather large gauge fitted in the manufacturer's yard (not sure what machine they ripped that off for the first steaming) but subsequent photos suggest that machine never got it back and it stayed on the locomotive.

The two holes in the front of the steam dome are for the blower and injector. It doesn't really matter which is which, but before drilling the bottom hole make sure there is enough clearance to screw the taper steam valves home. Depending on how tight the spindle handle is bent they might clash which would mean the spindle would have to be removed to assemble it to the dome. On my locomotive the valves cleared so there shouldn't be any issues.

●To be continued.

An Engineer's Day Out

The Tolson Memorial Museum - Huddersfield

Roger Backhouse visits a Yorkshire museum of local history.

This time a visit to Huddersfield for the Tolson Museum, an unpretentious but interesting council run local history collection for Kirklees. There are fascinating exhibits in the transport gallery with displays about local textile manufacturing and mining.

Yorkshire winding engine displayed outside

A *Model Engineer* reader helped save a steam engine from the Fieldhouse Brickworks near Huddersfield in the early 1950s (**photo 1**). As with many Yorkshire brickworks, coal and fire clay were extracted from the Coal Measures. (During the 1960s and 1970s my uncle, Edmund Sykes managed similar brickworks near Ainley Top between Elland and Huddersfield.) Quarrying and a tunnel into the hillside brought out fireclay with coal almost a by-product. The works made house bricks and firebricks though the market for the latter dwindled along with the demise of British Railways' steam locomotives.

1

The Fieldhouse winding engine, an unusual design from around 1850, preserved thanks to the initiative of Model Engineer *reader, Bill Stocks.*

2

The unusual layout of the Fieldhouse engine resembles a table engine laid horizontal.

Fieldhouse Works of the Leeds Fireclay Company Colliery was established in 1850 and worked until the 1930s. Originally there was a coal pit shaft with a steam engine and Science Museum experts considered that the engine was from around 1850 and almost certainly the original. William B. Stocks was gathering information about Huddersfield's railways, tramways and canals and wrote to *Model Engineer* to suggest its preservation. He believed it to be the second oldest horizontal engine to be saved and wrote about its preservation. (*The Fieldhouse Steam Engine; Model Engineer*, Vol 111, No. 2785. 7 October 1954 - pp416-418.)

With the site about to be cleared, the owners asked if he could find a permanent home for the engine. Having seen a table engine once displayed at the Festival of Britain, Mr. Stocks was inspired to suggest its preservation and prepared a watercolour showing how the Fieldhouse engine could be protected from the weather.

Huddersfield Council were sympathetic and with the help of Messrs Thomas Broadbent and Sons the engine was removed and restored in their workshops before being re-erected on the present site outside the museum, making a generous gift to the town. (Broadbent Engineering is a locally based engineering firm now specialising in industrial centrifuges.)

Unfortunately the maker's name is not known. The engine has unusual features including an odd placing of the cylinder in relation to the crankshaft, working almost like a table engine but horizontally (**photo 2**).

An 8 foot diameter flywheel has a false rim bolted to its circumference to increase its weight; the flywheel made a lorry load in itself when it came to re-erection! The pulley boss is split to facilitate cooling during casting. Without facilities to machine such a large flywheel, early engineers used a method known as 'staking' to secure the wheel to the shaft. With four flats on the shaft the wheel is secured by four taper keys bedding on the flats. These keys were adjusted to make the wheel run true.

The valve gear to the connecting rod has a decidedly odd bend on one side to clear the exhaust pipe. William Stocks observed that there appeared to be no way to reverse the engine and surmised that gravity might have been used to lower kibbles or small wheeled cars down the shaft. He noted that valves were worked through a drop lever with two projecting pegs and the eccentric rod assembly terminates in a handle which allows it to be engaged with either of these pegs, rather like an early locomotive gab valve gear. There was no sign of a governor (**photo 3**).

When the pit shaft closed the engine was used to haul standard gauge wagons up an inclined siding from the works to the junction with the Leeds and Huddersfield main line.

Re-erection posed quite a few problems as the bedplate

Crank end of the Fieldhouse engine. The maker is unknown.

Display of roadmaker and surveyor at work. The surveyor's wheel was an easy way to measure distance on new turnpike roads.

and cylinder assembly weighed 35cwt alone. With the help of William Stocks and others, the Broadbent team managed the job. The engine remains outside the Tolson Museum with a four poster canopy above and iron railings around. Though not the best displayed engine, at least it was preserved.

Upstairs galleries

Parts of the museum are devoted to local textiles manufacture with examples of historic textile machinery. Huddersfield is still noted for fine suitings, but textile production here goes back to the 17th Century and even before. Many local villages have early weavers' houses, built with large, top floor windows to illuminate hand weaving. There is also a model of a coal mine showing the geological conditions and displays about social history, for Huddersfield was once a radical centre. Unfortunately on my visit it wasn't possible to take photographs here, but displays are well worth seeing and may be subject of a further article.

Transport gallery

The transport gallery is excellent for a small museum. Huddersfield was a noted engineering centre with several famous firms. Starting with a section on road building, the gallery follows the principal developments (**photo 4**) except for canals. Horse drawn vehicles include a fire engine, and bicycles include a magnificent Starley Brothers of Coventry 'tandem tricycle' made around 1884 (**photo 5**). Another revolutionary design was the Dursley-Pedersen designed by the brilliant Danish inventor Mikael Pedersen in 1893. Like the Starkey trike, this was a well made luxury item with a cleverly designed frame to reduce stresses and a comfortable hammock type seat. Many were built (**photo 6**).

The railways came to Huddersfield quite early, with lines going west to Manchester, through the Standedge tunnel, and south to Barnsley and Sheffield. Both are undervalued scenic railways and deserve a ride (if you can cope with Northern Trains' reluctance to print timetables!). The

This 'tandem tricycle' by Starley Brothers of Coventry was a real luxury item when introduced around 1884.

Another luxury bicycle designed by the innovative Danish engineer, Mikael Pedersen in 1893. He came to Gloucestershire to make milk separators but also designed the remarkably comfortable 'Dursley Pedersen' bicycle (right). This model was built around 1910-11.

»

This carving by a 16 year old apprentice graced the original Berry Brow station.

The Lancashire and Yorkshire Railway built many of these 2-4-2 tank engines. Introduced in 1889, some lasted until the 1950s.

Classic LNER B17/4 Huddersfield Town *was appropriately named after the local team. Both models were made by Geoffrey Cocking.*

Yorkshire factory owners spent in style. The elegant steam yacht, Venetia *was built at Leith for F. W. Sykes in 1904. It was later sold to the US Navy and used on anti submarine duties.*

gallery has a curious carving once erected at Berry Brow station on the Penistone route (**photo 7**). Made by a 16 year old apprentice sculptor, it has an accurate depiction of a Lancashire and Yorkshire 0-4-4 tank engine. This was Lancashire & Yorkshire territory and there's a good model of one of their characteristic 2-4-2 tank engines (**photo 8**). LNER class B17/4 named after the local team, *Huddersfield Town* is commemorated by a good model of the 4-6-0 with a nameplate nearby (**photo 9**). Both were made by Geoffrey Cocking of Honley.

Local industrialists liked to flaunt their wealth and how better than with a steam yacht? Huddersfield's F. W. Sykes owned the *Venetia*, built at Leith in 1904, represented by a fine model. She was sold to the U. S. Navy and used as a patrol boat (**photo 10**).

There's a sectioned example of the famous Panther M100 Redwing motorcycle engine built by the Cleckheaton firm of Phelon and Moore. The inclined cylinder forms part of the frame but is difficult to photograph.

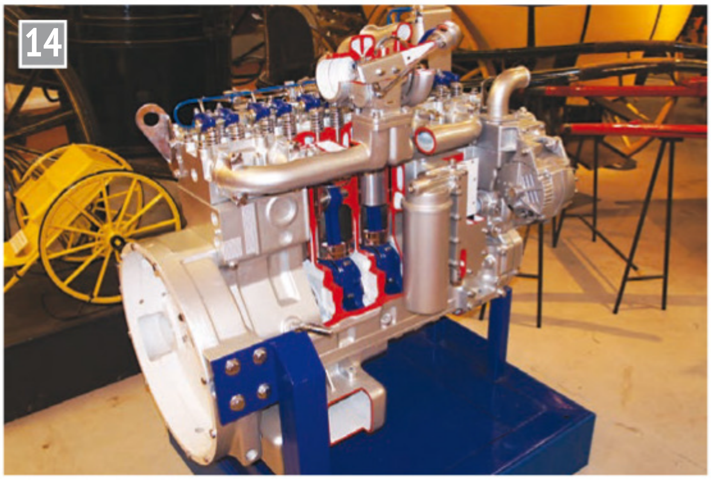
For contrast, the French designed De Dion-Bouton engine of 1902 is also sectioned. This was a highly successful, early auto engine, even used in an airship (**photo 11**).

Huddersfield had other automotive companies. Karrier made commercial motors from 1904 but after

De Dion Bouton engine; one of many imported from France.

The Vulcan had a two stroke engine of 3888cc generating 25 hp. This car was brought back from South Africa to be restored by David Brown apprentices. It is on loan to the Tolson museum.

The original 'Red Tractor' - David Brown Cropmaster tractor model VAK1C. Nearly 60,000 were made, in different variants, between 1947 and 1954.



Cummins Turbo Technologies Ltd. (formerly Holset Engineering) made components for this Series C engine used in a Dennis fire engine. It was sectioned by John Bywater helped by his brother, Peter and David Charlesworth. A six cylinder engine of 8.3 litres capacity.

a takeover by the Rootes group, production moved to Luton in 1935. David Brown began as pattern makers in 1860 but then specialised in gears, which they still make. One of their early cars was the unusual valveless two stroke, *Vulcan.* Ralph Lucas of Blackheath designed it in 1901 but from 1911 to 1914 cars were built by David Brown. The museum example was brought back from South Africa and beautifully restored by apprentices (**photo 12**). David Brown also made tractors (**photo 13**) and the DB6 sports car. More recently the firm made engineering components for other makers including parts for Cummins engines There is a sectioned example of a Cummins Series C engine made in 1994, stripped down (**photo 14**) and displayed with the Holset turbocharger and air compressor made locally (**photo 15**).

For contrast the museum has what is claimed to be Britain's rarest production car. Electrical engineers, Longbottom and Sykes joined with their accountant, Mr. Dyson to set up their LSD firm in 1919. They bought in engines and made lightweight cycle cars with a limited production run, hence their rarity (**photo 16**)

Reaching the Tolson Museum

Parking is available nearby in Ravensknowle Park, or take the number 232 bus route from Huddersfield Bus Station to Wakefield. On a clear day, continue to cross Emley Moor for fantastic views across Yorkshire including Britain's highest free standing TV mast which stands 329m (1080 feet) high.

The museum is in Ravensknowle Park and the winding engine is visible all year round. Kirklees Museums suffered severely after 2010, however, when the Government cut funding to the Council by some 40% so opening is limited. Long term plans to move the museum to Huddersfield town centre may lead to more restricted displays, although it's expected the Fieldhouse engine will remain *in situ*.

Other engineering attractions

Huddersfield's magnificent railway station has a Grecian style colonnade front. The National Coal Mining Museum at Caphouse Colliery is *en route* to Wakefield. Take the 232 bus to the Reindeer Inn, Overton, and walk a short distance to reach the museum. Like the Tolson, admission is free.

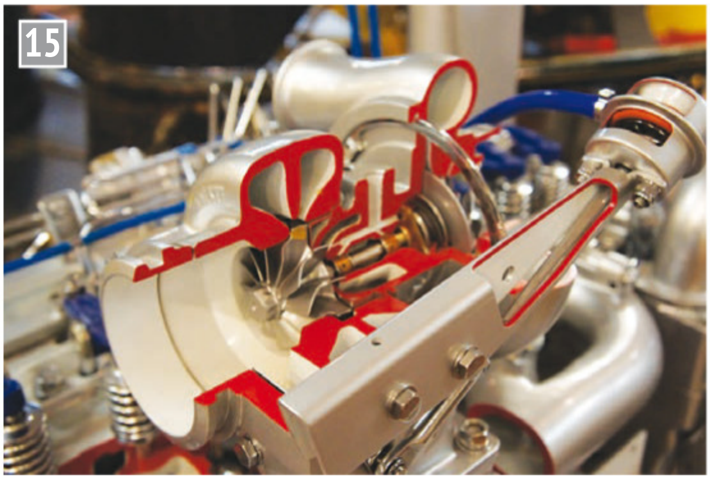
Huddersfield Model Engineers have tracks at their Highfields base and a track in Greenhead Park operated on Saturdays from March to December, Pennine weather permitting.

Contact details

Tolson Memorial Museum, Ravensknowle Park, Wakefield Road, Moldgreen, Huddersfield, HD5 8DJ
Tel. 01484 223240.
W. https://www.kirklees.gov.uk/beta/museums-and-galleries/tolson-museum.aspx

Opening hours

From April to August and during school holidays the museum is open Tuesday to Thursday, Saturday and Sunday from 12.00 to 4.00 (which, sadly, is not long enough for a museum of this quality). ME

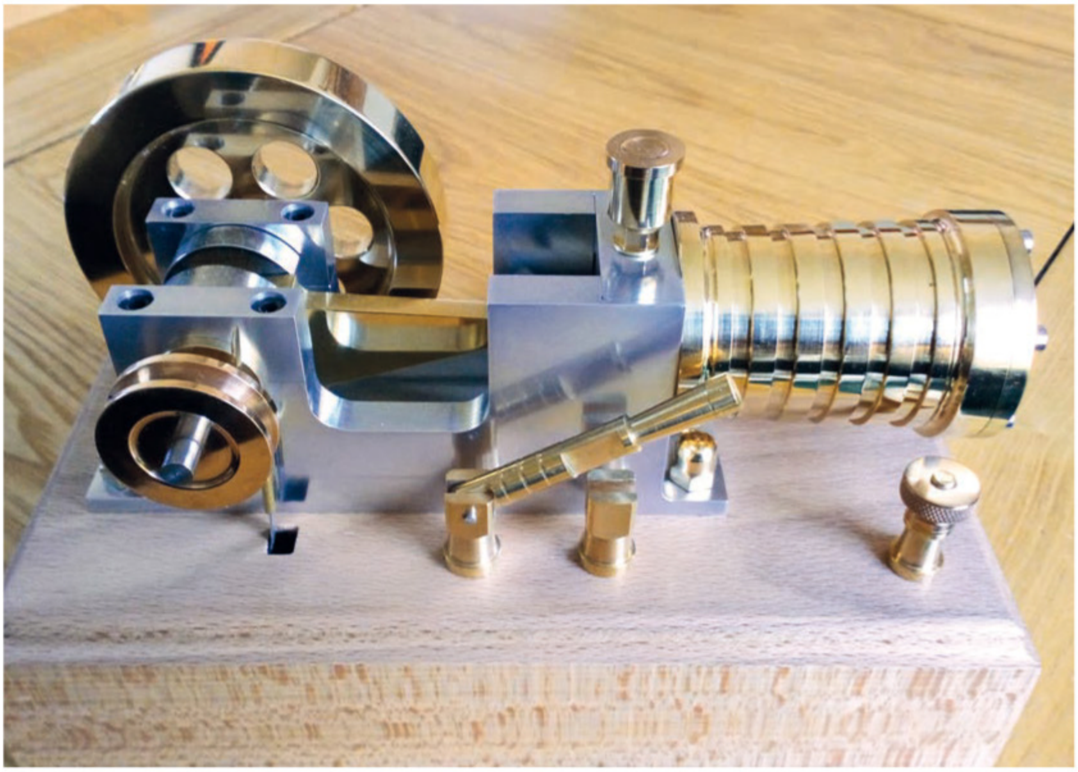


Turbocharger made in Huddersfield, part of the sectioned engine.

The very rare LSD cycle car produced from 1919 for a few years.

Tony Swinfield constructs an electrically driven horizontal engine.

Continued from p.88
M.E. 4694, 1 July 2022



The coil engine.

PART 5

Making a Solenoid Engine

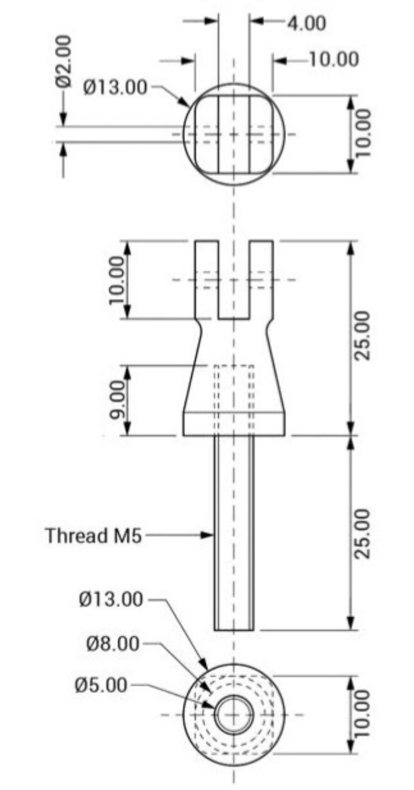
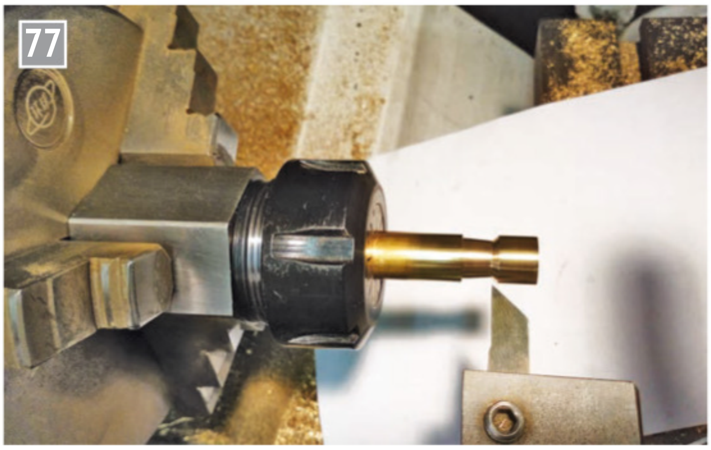


Fig 15 **Post for the switch.**
2 off

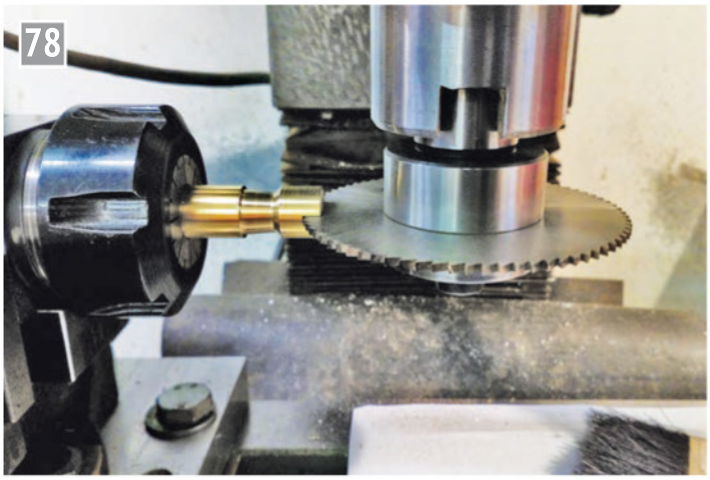
The switch contact

Note, this switch isolates the battery and must be in the closed position before the engine will work. There are three parts, two posts and one arm, all made in brass (**fig 15**) and the posts are 13mm diameter x 25mm long.

First hold the brass bar in the lathe, face the end and turn the outside shape. This is done to both ends of the bar because two are required. Next it is fitted in the square collet block and mounted in the mill vice for the slot to be machined. I first centred the 3mm wide slitting saw by eye and cut to a depth of 10mm (**photo 77** and **78**). The block was then turned 180 degrees in the mill vice and another cut taken; this ensures that the slot is in the centre of the bar. I then measured the width



Shaping the switch contact.



Cutting the slot in the contact.

Cutting the contact in the arm.

of the slot by using drills and the difference between that and 4mm was halved and the height of the slitting saw raised by that amount. Again, a cut was taken, the block turned 180 deg and another cut taken. By doing it this way you should end up with a 4mm slot in the centre of the bar.

While it is still set up in the vice, a fly cutter is used to form the square end. First, lower the cutter on the bar, set the readout to zero, then lower it by 1.5mm and take a cut. Rotate the block 90 degrees and do the same until the square is formed, again while still in the block. The 2mm hole is drilled and reamed, as shown in the drawing, in one post, for the pivot pin. The two posts are returned to the lathe and parted off, then faced, brought to size then centre drilled, then drilled 4.2mm and tapped M5 to a depth of 9mm. A 40mm long M5 machine screw is screwed in using Loctite and the head sawn off to leave it 25mm long.

This part can alternatively be made from one piece of brass 50mm long, turning down one end 5mm diameter x 25mm long and threading it M5.

The switch arm

This is 8mm diameter x 60mm long and made of brass (**fig 16**). Most of it is simple turning and marking out for the milling of the flat parts.

This again is fitted in the square collet block and held in the mill vice. I then used a 10mm diameter cutter to form the flat parts. The end of the bar was supported when milling the flats (**photo 79**) and only light cuts were taken, to a depth of just under 2mm, The block was then turned 180 degrees for the other side. Note that if the slot in the post is wider than 4mm then the width of the flat needs to be adjusted. A file was used for the final fit, creating a slight wedge shape, which ensures a good electrical contact.

The pivot hole in the end flat is drilled and reamed 2mm diameter, centrally on the length and width of the flat.

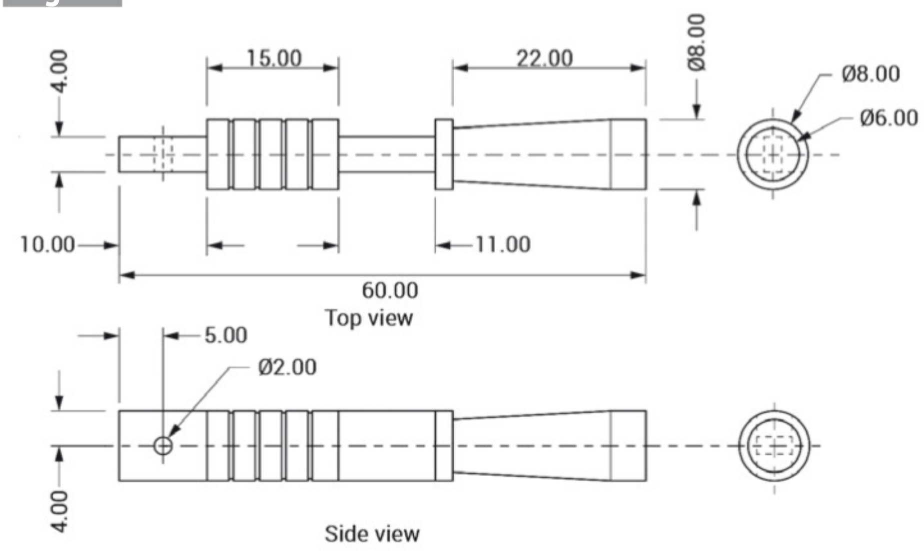
This part had to be made again because after milling the arm it was found to be a sloppy fit in the post. One for the scrap box - note to myself, be more careful.

The battery posts are not really needed as the battery is inside the wooden base but I liked them so I made and fitted them. The making of them is much the same as the switch posts and I have included the drawings for them (**fig 17** and **18**), should you choose to make them.

Acorn nuts

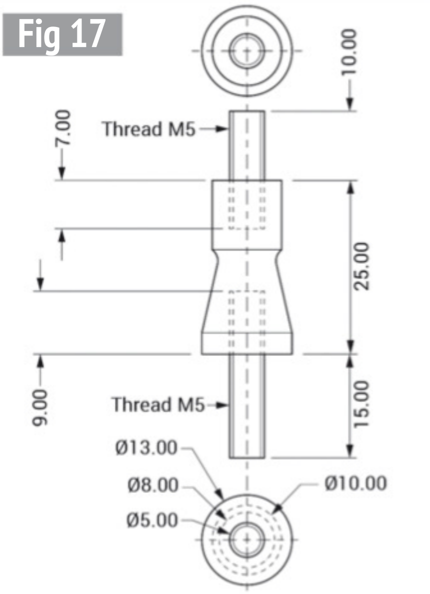
I used 10mm a/f hexagon brass bar for these. Mount it in the lathe, face the end leaving 5mm of hexagon then turn down 10mm long x 9mm diameter. Centre drill then drill and tap M5 x 9mm deep and part off 14mm long, I then mounted them on a threaded mandrel and used a form tool ground to the finished shape to form the top (**photo 80**).

Fig 16



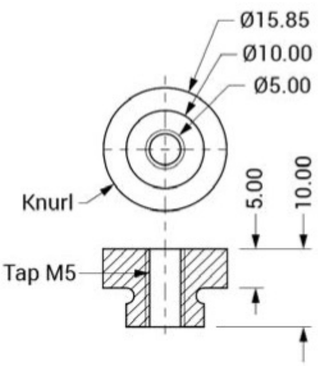
Switch arm.

Fig 17

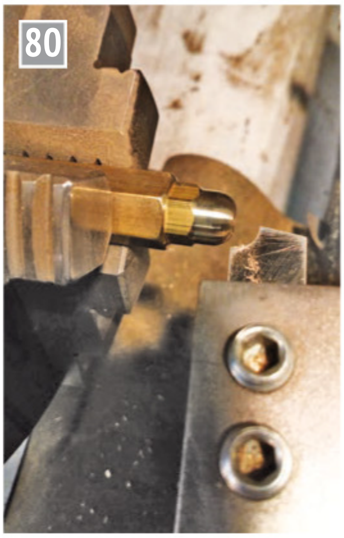


Battery post.
2 off

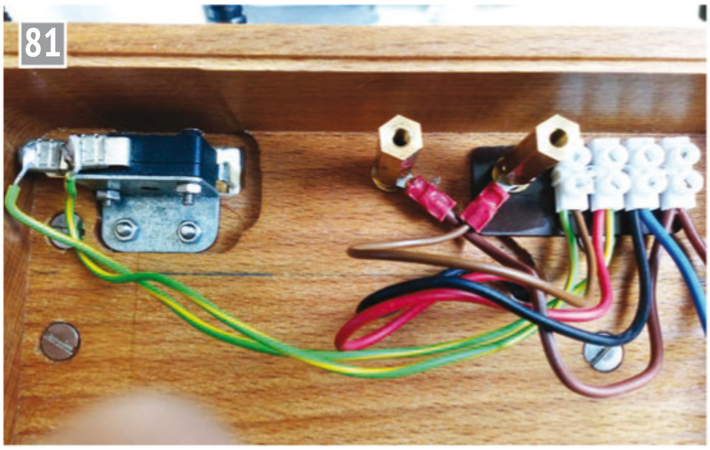
Fig 18



Battery post nut.
2 off



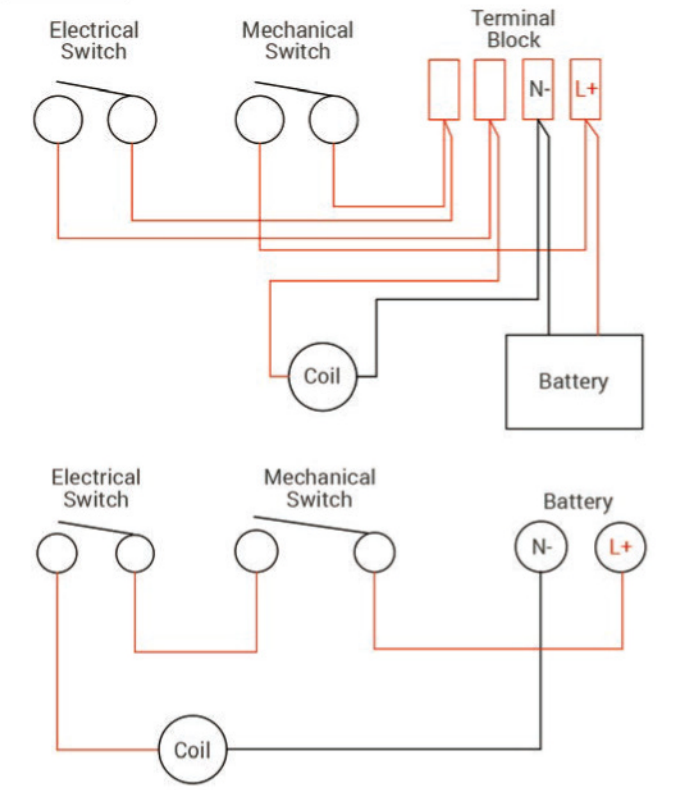
Shaping the ends of the acorn nuts.



A view of the wiring.

Plate to retain the battery.

Fig 19

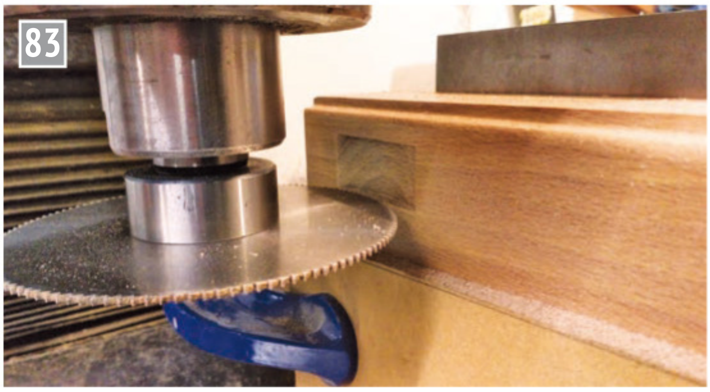


Wiring diagram.

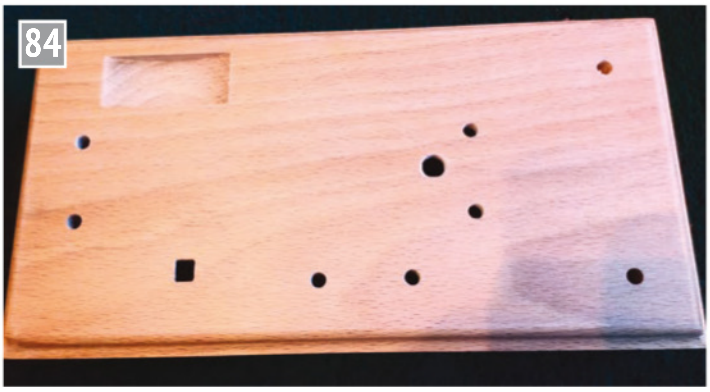
Assembly

Photograph 81 shows how the cables are connected and **fig 19** is the wiring diagram. The terminal connectors are screwed to a piece of Tufnell, scavenged from the back of an old Wylex consumer unit (another lesson - don't throw anything away as you never know when you will need it). Photograph 81 also shows the two M5 threaded extensions needed to fix the sub-base which holds the battery in place. **Photograph 82** shows this fitted - the other end is held in place by a groove cut into the inside of the wooden box.

Photographs 83 to **85** show the wooden base. The size is 225mm long x 115mm wide x 50mm deep and I was fortunate to have some wood this size. The bottom was drilled and milled out to size 195mm long x 95mm wide x 42mm deep. Also, as can be seen from photo 85, where the micro switch bracket and the cables to the coil go it was machined deeper. The bottom edge was also recessed 2mm deep for the base plate which is 1.7mm thick - another



Cutting the flywheel recess in the base.



Top view of the base.

The terminal connectors are screwed to a piece of Tufnell, scavenged from the back of an old Wylex consumer unit (another lesson - don't throw anything away as you never know when you will need it).

piece of the consumer unit back. **Figure 20** shows the positions of the holes in the wooden base.

Photograph 86 shows the connector block fitted to the board, with the hole to fix it to the threaded extension. **Photograph 87** shows the bracket and extension arm for the micro switch - the extension arm was made from brass 0.86mm thick. **Photograph 88** shows the two engines side by side.

Summary

I am pleased with the engines - the first engine with a coil wound with 0.8mm wire seems to go faster so I would use this size if possible.

It has taken me quite some time to write this up and learn the 'Turbo CAD' drawing package, having never done anything like this before. I hope this article helps someone or gives them an idea to make something. If someone finds a coil that works please let me know, through the editor.

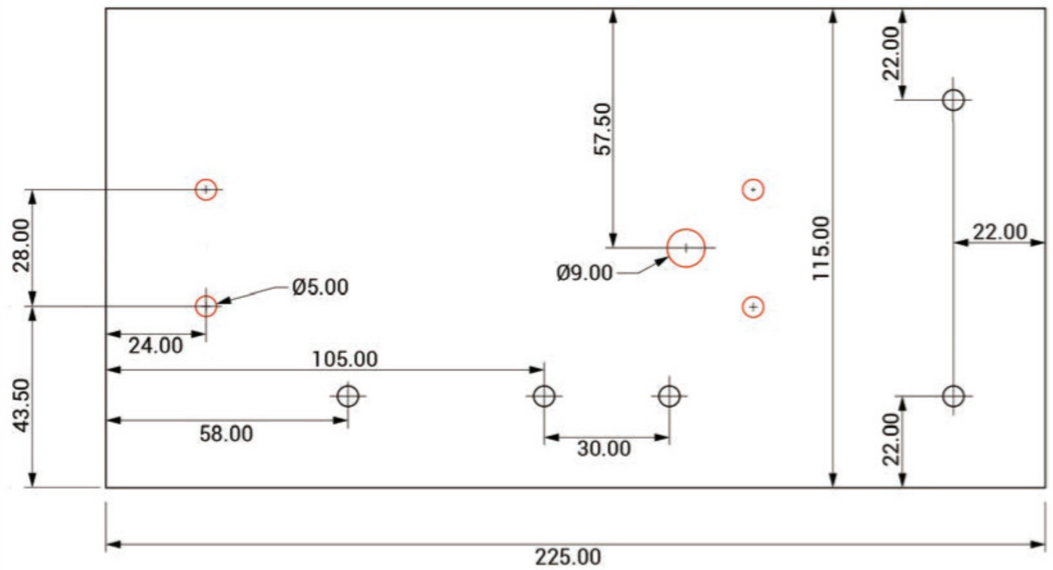
ME

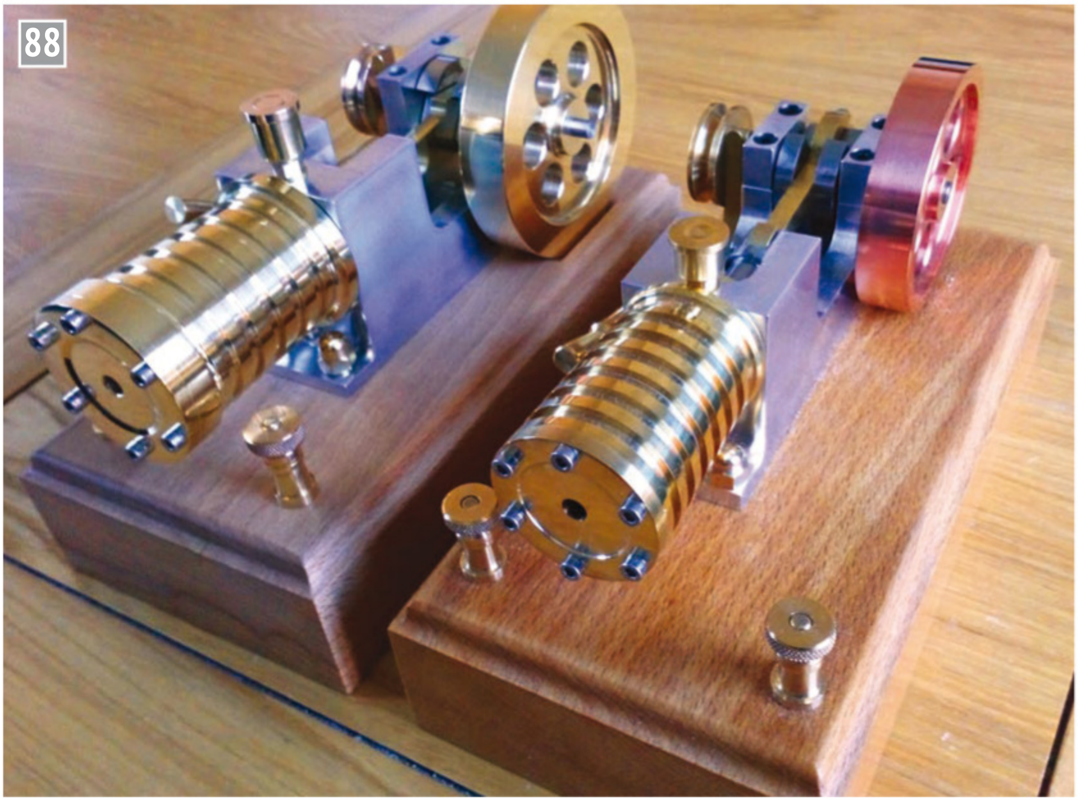
Micro switch bracket and extension arm.

Inside the base.

Connector block.

Fig 20 **Wooden base.**



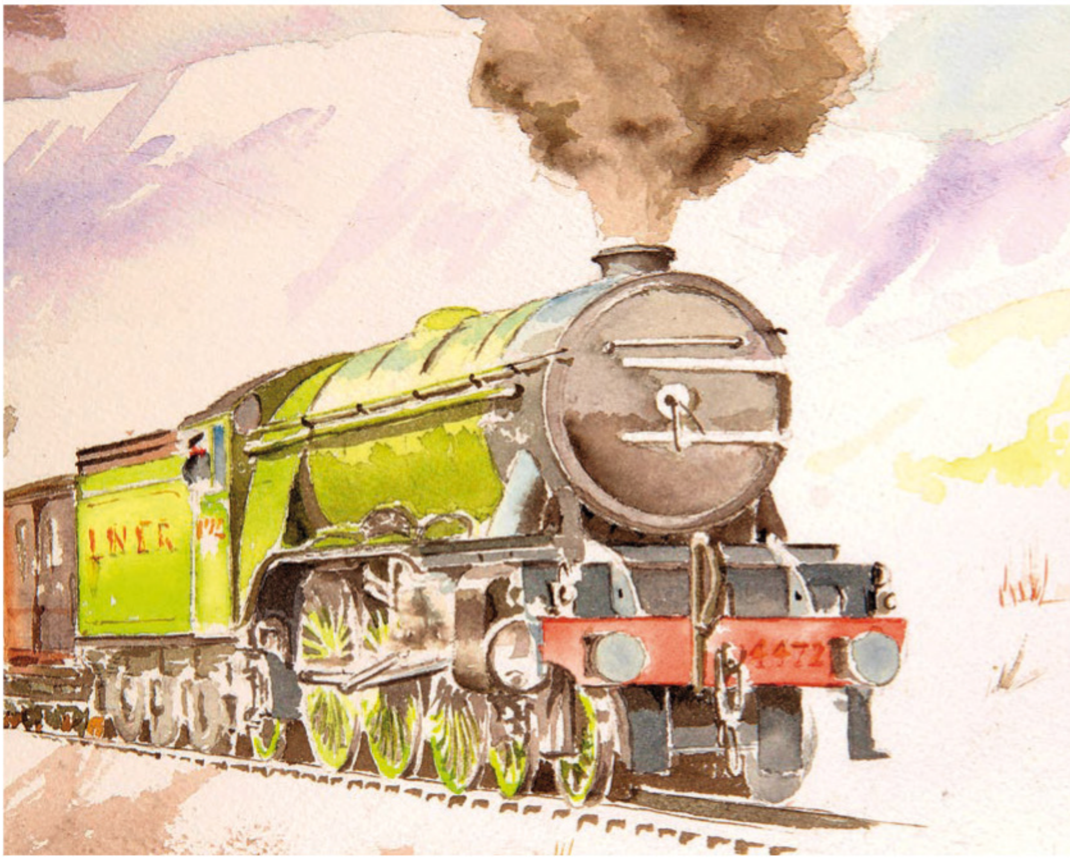


The two solenoid engines.

WHAT IS AVAXHOME?

Peter Seymour-Howell builds a fine, fully detailed model of Gresley's iconic locomotive to Don Young's drawings.

Continued from p.81
M.E. 4694, 1 July 2022



Painting by Diane Carney.

PART 39 – BOILER

Flying Scotsman in 5 Inch Gauge

1. Here is the backhead being fitted to the outer wrapper.

2. Dome bush, to a modified design.

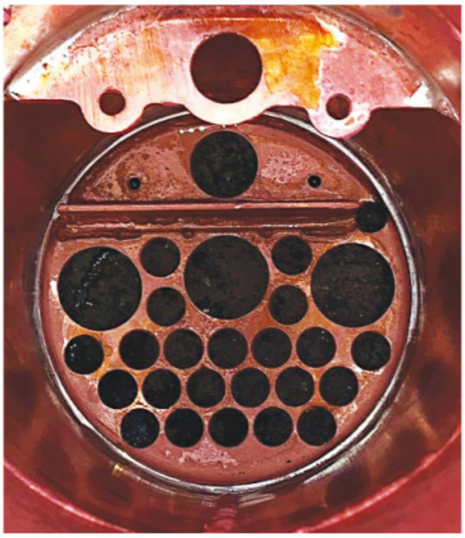
Boiler construction

I don't propose to give a blow-by-blow account of building a boiler as that has already been covered countless times in these pages. Instead I will provide photographs of the boiler at various stages of manufacture. My boiler was built for me by Paul Tompkins of Southern Boilers, whom I can recommend, both for quality and customer service.

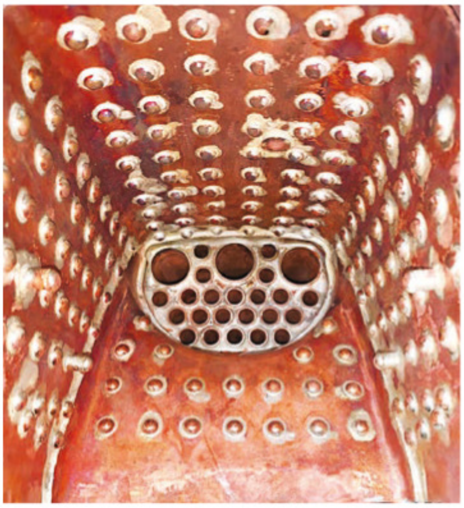
The boiler is, as you'd guess, mainly to Don Young's design but is stronger and has a higher working pressure of 100 psi versus Don's recommended 90 psi. The shell is a work of art, with the parallel barrel

3. These are the manifold and regulator bushes, machined from PB102 with M2 threads for studs. The manifold will have an 'O' ring for sealing.

4. Here are the combustion chamber tubes. Larger pipes have been installed for a better tube/grate ratio.



5. View inside to show the main steam pipe support and that of the two injector steam valve pipes too.



6. The inside of the firebox.

7. These pictures show the stay and firehole door penetration, all looking excellent.

8. Not much left to do – the stay ends will be trimmed, the boiler will be given a good clean and then tested at twice its working pressure for two hours.

9. The completed boiler.

blending in nicely with the taper and having no step thanks to TIG welding and it really does look like the full-size article in shape.

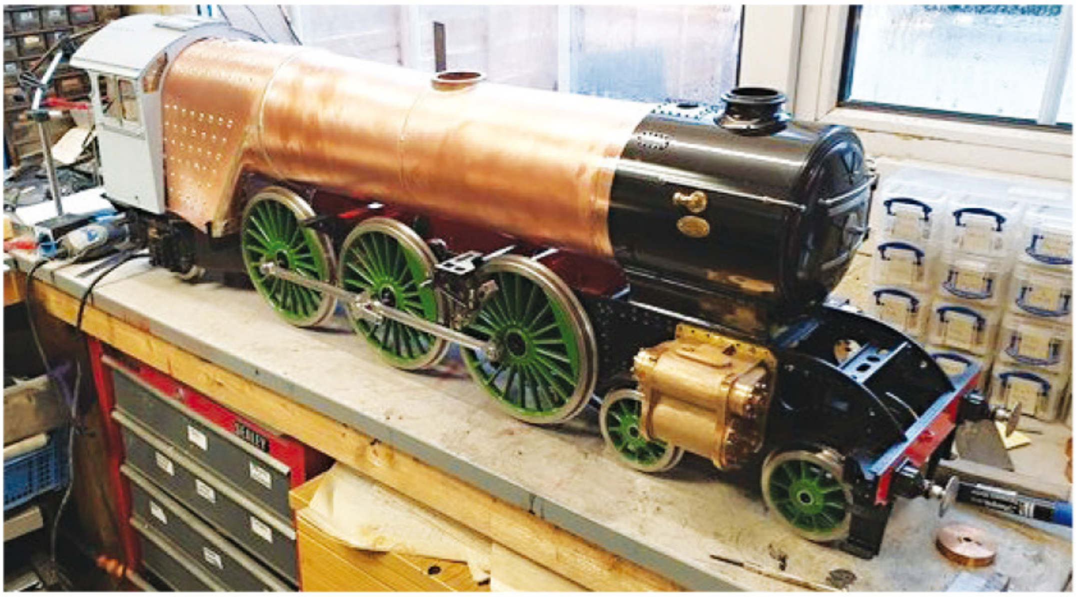
Boiler backhead

Now Don's backhead design is pretty good, very close to scale although fittings are slightly larger and spacing between the water gauge bushes is larger. I have kept the water gauge bushes as drawn as scale versions would give too small a window to view the water level. I will make the gauges as close to scale as possible, just with longer glass sections.

The steam valves will be to scale and I'll be using Adam's

»

10. Close up of the backhead.



11. Front three quarter view.

(Cro Fittings) castings to achieve this. The bore sizes for water and steam will follow the normal practice of 5/32 inch pipe for steam and 3/16 inch for water to match the injectors planned for the model - I can't recall which sizes I have chosen just now but it's written down somewhere. Bore sizes for the mounting pads are 3.2mm for steam and 3.8mm for water. I'm undecided on whether to try for working clacks within the steam valves themselves or to fit them independently below the cab floor. I'll see if it's feasible to get the clacks working first.

Manifold bush is to scale - this is to allow me to keep the bore size as drawn by Don. The manifold itself will again have castings supplied by Adam.

Paul has fitted four blind bushes into the backhead for me to secure the cladding when done - this will be very much to scale.

There are two extra water feed bushes along the bottom of the backhead, one of which will be used to fill the boiler using an electric pump. This will be able to feed water against boiler pressure if ever required, something I doubt will ever be needed but it's nice to have a back-up when there's no hand pump in the tender which, according to Don, would be undignified to have on this locomotive. There are also four washout plugs, two on the backhead lower corners and two on the front throatplate just above the foundation ring in each corner.

Paul has fitted larger tubes for a better tube/grate ratio - as drawn they are 1/2 inch but they are now 9/16 inch 18swg.

The steam header as drawn is threaded into a 3/4 inch x 26 tpi bush. Paul has modified this to have an 'O' ring with eight mounting bolts to secure it.

Also the dome bush has an added shelf with two holes for mounting the regulator body, which otherwise would just be held by the steam pipe.

The blower stay is what I would call a live stay. It's not a permanent fixture as drawn - Paul has followed full-size practice with a removable 1/4 inch tube that will be furled and beaded in to seal.

The upper steam area follows the Australian code with doubler plates, butt straps, whichever you prefer - this means rather than being 3mm thick on the tube plates as drawn it is, in fact, 6mm thickness of material and no longitudinal stays, which do little in a boiler of this length.

Last (I think) but not least is the fusible plug bush fitted into the firebox crown.

Boiler fitting

I then checked that the front barrel section was running parallel with the top of the frames, which it was so I then moved on to check the overall height of the firebox where it enters the cab. Next, I set up a rule across one of the safety valve bushes with a digital angle gauge attached. Once happy it was level I measured the distance from bench to rule. It was a fewmm over which is very good as the locomotive is sitting on its flanges - I am very happy with that.

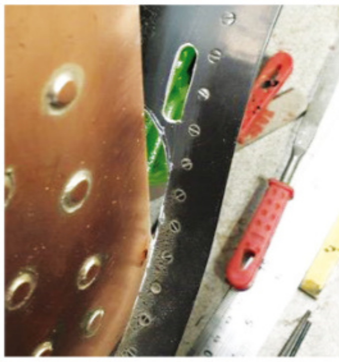
I now needed to check that the boiler was correct longitudinally, I decided the best way was to check the dome position in relation to the centre driving wheel.

Continuing with the final fit of the running boards, my first task was to remove a strip from the inside edge where it passes the firebox. This had been deliberately left oversize until after the boiler had been built. I used the Dremel and some cutting discs to cut the metal and then finish with a file and the sanding drum for the concave curve.

12. Checking the height of the boiler.

13. Splasher cut away for the insulation and cleading.


14. Lining up the slot in the running board for the reverser.


15. Reverser slot.

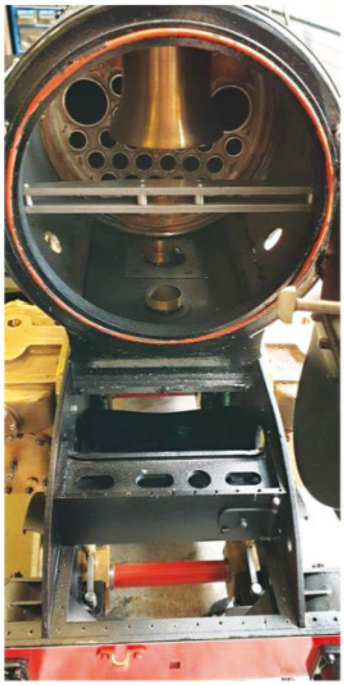
I needed to be able to remove the splashers now that the boiler is in place. This interfered with my plan to keep the running boards and their splashers as a single piece to make life easier during maintenance. I gave this a little thought and decided that it would be best to cut away part of the rear faces to allow the running boards and splashers to be fitted as one. Okay - it's stepping away from the prototype but you cannot see this at all - it's difficult now and once the cladding is attached you'd never know. The other reason for this decision is that it would be very difficult to reach the small countersunk screws which hold the splashers down. Worse still, if tried, it would most certainly mark the paintwork on the cladding around the boiler and that just wouldn't be acceptable so parts of the backs were cut off.

The rear quadrant of the rear splasher was ground off. Don advises to leave this open as a cover would foul the wheel, which it most certainly would plus, as he states, the cladding will be very close to this and it would never be seen - that's good enough for me.

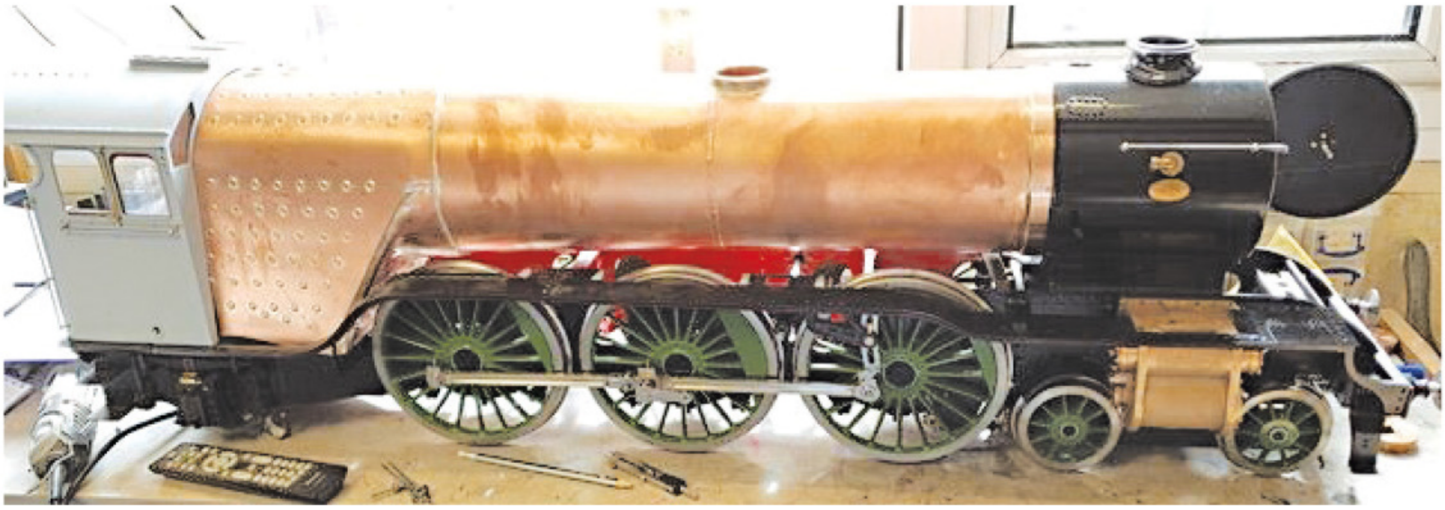
To get the reverser slot in its correct position (nothing shown on the drawings) I first calculated the height of the reverser pivot point for the rod and also used the full-size photograph as a guide. I finished the slot and placed a length of bar of the correct height (⅜ inch) through the slot and lined it up with the reverser pivot point marked on the cab - alas I didn't have any material long enough to meet the cab itself. I made the slot so that it has a sideplay movement of about 0.5mm - the rod is 3.96mm wide and the slot is 4.5mm wide. I can always open this up a little further on both axes if required.

Moving to the smokebox, here I needed to drill the two holes for the outside cylinder steam pipes. I have followed photographs of 4472 during the 30's rather than Don's words which state and show on his drawing the steam pipe covers being directly under the builder's plates but this is not correct, they are forward of this point. As it happens the hole centres were directly inline above the centre of the openings in the cylinder chests and you may recall that my smokebox was moved back ⅛ inch further than Don shows to match the prototype. If I hadn't done this, the steam pipe outlets would have been where Don has drawn them. As stated before, I think this all leads back to when the swing link bogie was replaced with the side control bogie as this moved the bogie scale wise by ⅛ inch. Anyway, I'm very glad that I followed my own nose on this one.


16. Holes in the smokebox for the steam pipes line up nicely with the cylinders.


17. The inside of the smokebox showing that both steam pipe holes have now been drilled.

●To be continued.


18. The boiler seated in the frames.

Ron Fitzgerald takes a look at the history and development of the stationary steam engine.

Continued from p.47
M.E. 4693, 17 June 2022

The Stationary Steam Engine

PART 35 – MATTHEW MURRAY AND THE ROUND FOUNDRY
The first buildings

If George Hawkes correctly assumed that the cylinder and air pump he saw at Low Moor Ironworks in July 1795 were intended for Murray's own works then it is possible that the close of ground known as the Leckeys was leased by the partners before they formally purchased it in February 1796. Building may have already commenced in anticipation of possession becoming absolute which makes the advertisement that that appeared in the *Leeds Mercury* on the day after the deed was entered seem less precipitate:

To IRON FOUNDERS. WANTED IMMEDIATELY, Two Sober, Steady and Active MEN, as GREEN SAND MOULDERS. Any Person answering the above Description will meet with constant Employ and good Wages, by applying to MURRAY & WOOD, HOLBECK, near LEEDS, February 17, 1796. None but good Workmen, and of good Character, need apply.

The foundry building must have been completed four months later when it was insured by the Royal Exchange Company (**ref 192** - numbers and letters in parentheses have been added by the author to give continuity between successive insurance policies):

Matthew Murray and David Wood of Leeds, in the County of York, Iron founders.

… a building, brick and slate, situated in Water Lane in Leeds … … used as an Iron Foundry **(1a)**, *Model Warehouse** **(1b)**, *Joiner's Shop* **(1c)** *and in which no fire is used for the drying of timber, £400. On utensils of trade and in trust in the same, £150, £550.*

*Foundry pattern store.

A month later a notice appeared in the *Mercury* announcing that the foundry was ready to cast metal (**ref 193**):

MURRAY and WOOD, DESIRE to inform their Friends and the Public in general, That they have erected and Opened a FOUNDRY, in Water-Lane, Leeds, for the Purpose of CASTING IRON, viz.

Engine Work of all Kinds, Ballance Wheels, Joints, Bosses and Steps, Crank and Octagon Wheels. Grate Bars, Bearers, Frames and Doors, Steam and Injection Boxes, Wheels, Segments, Tumbling-Shafts, Plummer Blocks, Coupling Boxes and Mill Work in general. … Tapet and Waggon Wheels, Waggon Rails and Tram Wheels, Rasp Barrels and Paper Rolls, Chip Plates, Oil Presses and Blocks, Callender Wheels and Plates, Tenter Posts, Press Tops and Bottoms, Press Ovens, Press and Singeing Plates, Cotton Spinning Plates, Cotton and Worsted Weights, Carding and Scribbling Engine Rims, Chain Wheels and Strap Pulleys, Malt Rollers, Pallisadoes, Weights, Clock and Sash Weights, &c.

Those who please to favour them with their Commands may depend upon them being well executed and on the lowest Terms.

N. B. As they cast Twice each Day, any Gentleman may be accommodated with Castings on the shortest Notice, in Cases of Emergency.

Marshall, of course, continued to press for textile machinery, a situation that had been greatly exacerbated by the need to re-equip B Mill after the fire. There is also evidence that Murray and Wood were beginning to supply other textile mill owners. Cast-iron was not extensively used in textile machinery at this period and the foundry was less significant than the work of the joiner and the forge, implying that Murray and Wood must have had a continuing need for buildings other than the foundry although it is possible that there was an overlap between the final tenure of the older Mill Green premises and the new site. There are also indications that the capacity for undertaking wider engineering work was growing. At least as early as April 1796, Murray and Wood had been buying boiler plates from Kirkstall Forge, possibly assembled into boilers by a subcontractor in Gildersome. The partners' first ventures into constructing for sale Watt style steam engines in the second half of 1797 have already been discussed and in October they advertised to smiths etc., for:

… Two Fire Men that can undertake Heavy Work in the Steam Line. Likewise One Good workman as a Green Sand Moulder in the foundry business and also a person who has been

accustomed to make Iron Boilers for Steam Engines.

Shortly after, Lawson confirmed in a letter to Watt Jnr. that by October 1797, Murray and Wood had a forge and other workshops in addition to the foundry:

… have built very large Smithies (6 or 8) *and other workshops - which are just covered in & seem to spare no expense….*

In the following month, Lawson saw an air pump and several other components lying in Murray's works yard which he assumed were intended for a steam engine intended to power Murray's works (it may be recalled that the cylinder for Fischer's engine seems to have been cast by Walker's of Rotherham but this was very large for the period. The Hull engine for Shipman was considerably smaller and could possibly have been cast in Leeds).

The next surviving insurance policy dates from 7 November 1798. It was taken out in connection with a mortgage that Murray and Wood raised from Richard Hargreaves, a joiner, Jonathan Cave and James Longley, both bricklayers, all three well-established in the locality as builders and probably responsible for the construction of Murray and Wood's building, as well as Marshall's. The mortgage applied to only part of the site but the buildings covered consisted of (**ref 194**):

(1a) *… a building used as an Iron Foundry situated in Water Lane in Leeds as tenants* (mortgagees) *Messrs. Murray & Co., 150*
(1b) *… a building adjacent not communicating used as a Model Warehouse only, 150*
… On Utensils of trade & in Trust therein, 200
(2) *… a building [new] used as a mill for casting Iron and*
(3) *Machine Makers Shops over, 400*
(3b) *… On the Steam Engine adjacent and communicating only by the aperture thro' the iron shaft passes, 100*
All Brick and slated

Items **(1a)** and **(1b),** are almost certainly the same as those included in the May 1796 policy but not including the joiners shop which would account for the reduction of £100 in the valuation. The second group of buildings **(2a)** and **(3)** are stated to be newly built in 1798 and distinguished as separate from the original foundry **(1a)** with its allied buildings. Item **(2)** is somewhat confusing in its description … *a mill for casting iron* … but later references confirm that the term *mill* almost certainly referred to a foundry. It is associated in the same sentence with … *Machine Makers Shops over …* . This also is ambiguous, at first reading it would seem that the machine shops were built over the foundry but this seems improbable. It is more reasonable to assume that '*over*' refers to a separate multi-storey building **(3)** close by with the qualification that a later policy cited below (**ref 195**) might be taken to endorse the original idea. The steam engine **(3b)** was adjacent to building **(3)** and power was transmitted by a shaft passing through the wall between the two buildings.

The mortgage transaction constituted a legal conveyance (*Lease and Release*) and the deed was registered at the West Riding Deed Registry (**ref 196**). The sum raised was £1,000. The recitation of properties involved re-states in general terms the content of the insurance policy:

All those….founderies, warehouses, fire Engine House, workshops & all other the several erections & buildings thereupon erected & built all which said premises are now in the Tenure or occupation of them the said Matthew Murray & David Wood.

Although Murray and Wood were undertaking heavy capital expenditure, both in terms of buildings and the costs of production, the mortgage need not necessarily indicate a straitened financial situation. It was commonly the practice amongst early factory owners to raise liquid capital on the basis of their fixed assets. The need to finance stocks and work in progress between customer payments was a recurrent problem and a mortgage on otherwise sterile real estate made sense providing that the return to invested capital took place at a higher rate than the customary 5% mortgage interest. Nevertheless the resources of the partnership must have been improved in August 1799 when the 42-year-old James Fenton became the third party in the engineering firm, bringing further financial resources.

There has been confusion surrounding Fenton's background. Frequently he has been said to have been part of the Fenton family of coal owners based in the Rothwell area of Leeds. Paul Murray Thompson's research dispelled this claim at the same time amending his pedigree (**ref 197**). James Fenton was in fact the younger brother of Samuel Fenton, the latter of whom was one of the members of John Marshall's first partnership in his spinning business. Their father, also called Samuel, was a partner of John Marshall's father in the earlier linen drapery business. James Fenton had also previously been a partner in Marshall's concern, something that Boulton and Watt also believed to be the case although Rimmer in a history of the Marshall enterprise makes no mention of him (**ref 198**). At the time that James Fenton entered into partnership with Murray and Wood his occupation is given as (leather) tanner of Walworth, Surrey and recent research by Paul Murray has established the linkages that led to his migration south after the earlier co-partnership with Marshall in the flax spinning business was dissolved in 1793. William, the third brother, was a Leeds attorney who frequently witnessed the legal transactions on behalf of both Marshall and Murray.

Twelve months after inducting Fenton as a partner, in March 1800, Fenton, Murray and Wood took out another insurance policy and the content reflects further additions to the building stock, probably financed in part by Fenton's contribution. The schedule comprised (**ref 199**):

(not located) *… two buildings adjacent & communicating, situated in Water Lane in Leeds aforesaid. Used as Model Warehouses only, 400*
(4a) *… a Building (new) used as a Mill for Boreing Iron with* **(4b)** *Machine Makers Shops over it and on the* **(4c)** *Steam Engine House adj. & comm. therewith only by an aperture in the Wall to Admit the shaft, 1,000*
(4c steam engine) *… Steam Engine near communicating with their adjacent Boreing Mill only by the aperture in the Wall through which the shaft passes, 150*

The earlier mortgages raised upon Hargrave, Longley and Cave matured in 1804 but the premises were remortgaged on 28 April 1804, the parties differing only in that William Hargrave, joiner, replaced his brother Richard, who had died intestate (**ref 200**). Again, insurance protection was taken out under two policies, one with the Royal Exchange Company and the other with the Sun Life Company. The Royal Exchange policy continued to cover the earliest group of buildings with additions (ref 195):

(1a) *Loam Foundry*
(part of 1a) *Brass foundry and*
(1b) *model chamber.*
(1c?) *… Four storey building used as joiner's shop.*
(2) *Iron foundry with four rooms above (model warehouse).*
(3) *… Building used for machine shops and model chamber (near fireproof).*
(3b) *… Steam engine house and steam engine.*
(6a) *Boiler maker's shop,* **(6b)** *a forge,* **(6c)** *another engine house, and engine.*

(9) *Building with four counting houses and a cottage.*

The Sun Life Insurance Company policy provided (additional?) cover for the first iron foundry with its pattern store (**ref 201**):

(1a) *... on their iron foundry with four chambers over, used as* **(1b)** *model warehouse, lettered 'F' , 1000*
(4c) *... On the steam engine house adjacent, 50*
On utensils & stock in trade therein, 500
Warranted that the steam engine house be divided from the iron foundry and chambers above by a brick wall carried to & through the roof and that there be no connection between the said buildings except by an aperture in the said wall to admit a shaft.
(3) *... On a building four stories high used as ... (Fitting up?) ... shops and machine shops, lettered 'B', 800*
On utensils of trade therein, 500
...... (illegible), 450
£4550
(7) *.....Another building used as machine shops with under chambers brick ... Fireproof, lettered 'H' nearby, 500*
On utensils & stocks therein, 500
(6a, 6b, 6c) *... Another engine house, boiler maker's shops and forge house adjacent Lettered 'I', 'K', 'L' and 'M', 150*
(6a engine) *... On the engine therein, 350*
£6050

Warranted that the engine house last mentioned and another smaller engine house not ... (?) ...situate on the other side of the building lettered 'H' be each divided from the said building by a brick wall carried to & through the roof and that neither of the said steam engine houses have any connection with the said building lettered 'H' than by an aperture in the wall to admit a shaft. All the said buildings are brick built and slated and situated on Water Lane near Leeds.

The Sun Policy was obviously compiled in connection with a plan to which the letters apply. Unfortunately this plan does not survive but the alphabetical letter series is clearly incomplete implying that by 1804 there were other buildings on the site which remain unaccounted for.

●To be continued.

NEXT TIME

We move to the Greensand Foundry.

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193. The Leeds Mercury, Saturday 9th July 1796.
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195. Royal Exchange policy 210457 of 29 April 1804.
196. W.Y.A. - Volume EB page 383 No. 536 Regd. 12 February 1799.
197. Murray Thompson ibid., p. 92.
198. W. G. Rimmer, *Marshalls of Leeds*, ibid
199. Royal Exchange Insurance Policies. Vol 37. Lady Day Quarter 1800. Policies 172611 and 172612
200. W.Y.A. - Volume ER page 224 No. 298.
201. Sun Life Insurance Company Michaelmas Quarter 1804. Policy 21645

NEXT ISSUE

Gilling Rally
John Arrowsmith enjoys a warm and sunny day at the mainline ground-level rally in Gilling, North Yorkshire.

Driving Truck
David Allen presents a timber framed four-wheel driving truck in 5 inch gauge.

Oscillator
Hotspur completes his three-cylinder oscillating engine with the addition of the reversing gear.

HIPP Clock
Carl Wilson explains how the parameters of the HIPP clock drive coil are calculated.

York Workshop
Roger Backhouse follows the construction of the York society's new workshop.

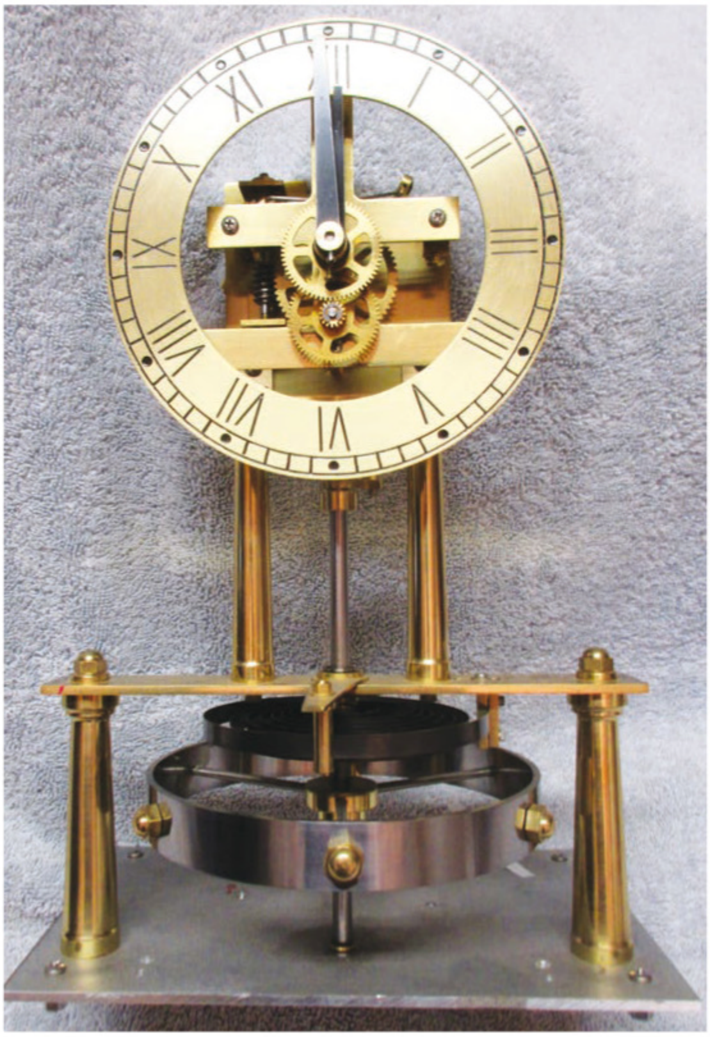
Content may be subject to change.

ON SALE 29 JULY 2022

Electronic Hipp Toggle Circuit PART 2

Carl Wilson applies 'hit and miss' principles to the drive for a balance wheel clock.

Continued from p.77
M.E. 4694, 1 July 2022



Large balance wheel clock.

Block Diagram

Figure 7 is the block diagram that corresponds to the schematic diagram. With our mental picture of the motion of the pendulum and the order of the opto signal inputs (fig 7), we may put the block diagram into operation. Pull the bob to the left of the centerline; then push it to the right and as the flag passes through the OFF opto, its output signal goes from low to high and back to low. Reading the block diagram to the right, at Node No. 1 the signal splits into two directions. Taking the vertical branch, the OFF signal goes to the Reset terminal of the MIN(IMUM) flip-flop resetting it and its notQ output is now high. Following the right-hand branch of the OFF signal at No. 1, the high OFF signal passes through the OR gate and branches at No. 3 into the Reset terminal of the ENA(BLE) and ON flip-flops, resetting them and their Q outputs will now be low. The OFF opto resets the three flip-flops.

Next, push the pendulum farther to the right and pass the flag through the ON opto. The pendulum is on the right going half beat, going away from the midline, and the coil must not be turned on in this

Block diagram.

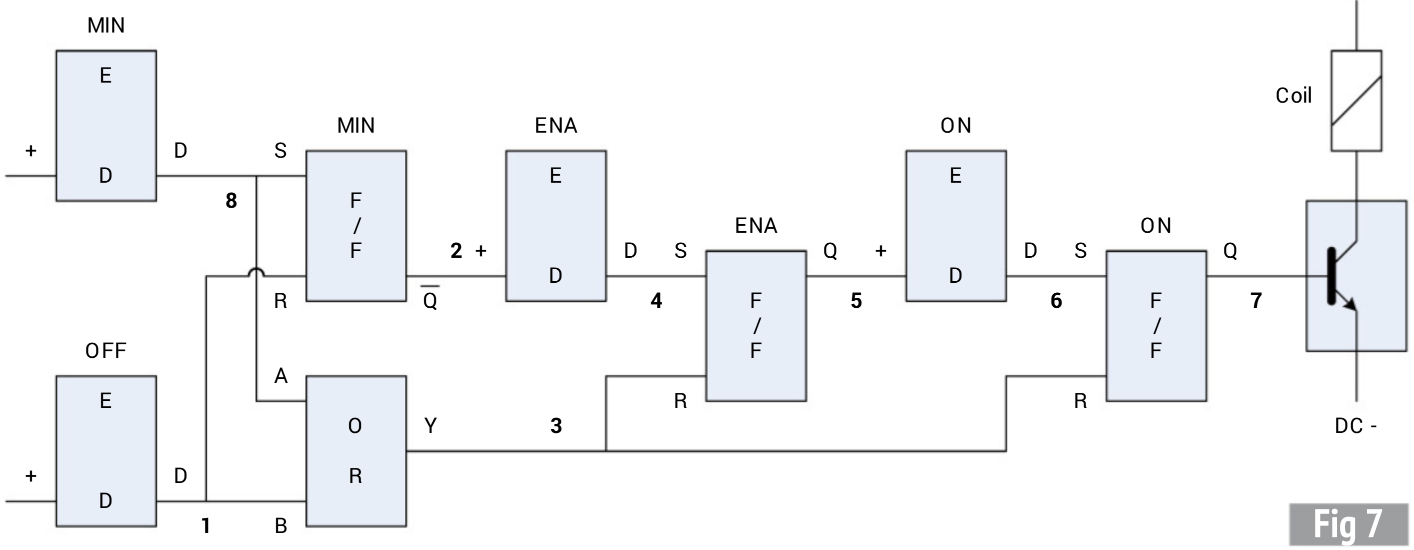


Fig 7

direction. This is accomplished by disabling the ON opto detector. The preceding ENA(BLE) flip-flop has been reset and its Q output is low so there is no DC+ power to the ON opto detector – it is disabled.

Then, pushing the pendulum farther to the right, the flag will now pass through the ENA(BLE) opto. Its detector has DC+ from the notQ output of the MIN(IMUM) flip-flop and the opto will output a momentary high signal to the ENA(BLE) flip-flop Set terminal. Setting this flip-flop will cause its Q output to go high and now the ON opto detector will have DC+ power. The ENA(BLE) circuit disables the ON opto during the right going half beat and enables it for the left going half beat.

Let's assume that the beat angle is low and that this will be a hit cycle. The pendulum reverses its direction and is now on the left going half beat. The flag does not interrupt the MIN(IMUM) opto light beam and its output remains low. The MIN(IMUM) flip-flop remains reset and its notQ output will be high. As the pendulum continues to the left, the flag once again passes through the ENA(BLE) opto which will output a high signal but as its flip-flop is set, no change in the circuit occurs.

The flag will now pass through the ON opto and its output goes high setting its flip-flop and sending a high signal to the power output block. The output transistor turns on and the drive coil is now energised. The coil will be energised until the flag passes through the OFF opto which resets all three flip-flops. The Q output of the ON flip-flop is now low and the coil is off.

The *miss* cycle is identical except that flag passes through the MIN(IMUM) opto optical path and when the light beam is interrupted its output goes high momentarily. This sets the MIN flip-flop and its notQ output goes low thereby disabling everything to the right. At the end of the left going half beat, the OFF flip-flop will be reset and the circuit made ready for the next right going half beat.

Application: The power block

When the ON opto is triggered: the ON flip/flop Q output goes high and this output is applied to the base of the power transistor, turning it on and effectively connecting its collector to its emitter. Current flows from DC+ through the coil, through the transistor and to DC-. The current flowing through the coil generates a magnetic field, attracts the NIB magnet thereby coupling energy into the pendulum and restoring its angle of swing. The TIP 120 power transistor specified in the schematic is over-rated for this application, but it works, is cheap and readily available – at least in the United States.

Diode D1 suppresses high voltage transients due to the collapse of the magnet field in the coil. The power indicating LED is optional. The fuse is also optional but it has a purpose. The coils may be over-driven – that is, their operating current may be greater than the recommended current for the wire size. Because the duty cycle is very low, in normal service the coil will not generate significant heat. However, while it is unlikely, it is possible for the pendulum or balance wheel to stop while the coil is energised and this could cause the coil or the transistor to overheat and burn out. Size the fuse for 125% of the current rating of the wire if possible (or the nearest size available) and install a time delay type.

Power supply

Transistor-Transistor-Logic operates at 5 VDC and any power supply that can deliver the current required by the drive coil at that voltage should suffice. A wall wart or package unit, if available, would be my first choice. Second choice would be to build a power supply but for most of us this this would require a transformer, rectifier and a voltage regulator plus some capacitors. This will take some volume which may not be available. A pendulum may be driven from a battery and depending upon the battery, this may require a voltage regulation circuit. A balance wheel may require more energy than a battery may conveniently supply and here I suggest a wall wart or package unit. These, particularly switching power supplies, will be much smaller than anything the amateur clock builder can construct and can be hidden somewhere.

Specification of the current rating of the power supply depends upon the current required by the drive coil, so this must first be designed.

Driving the pendulum or balance wheel

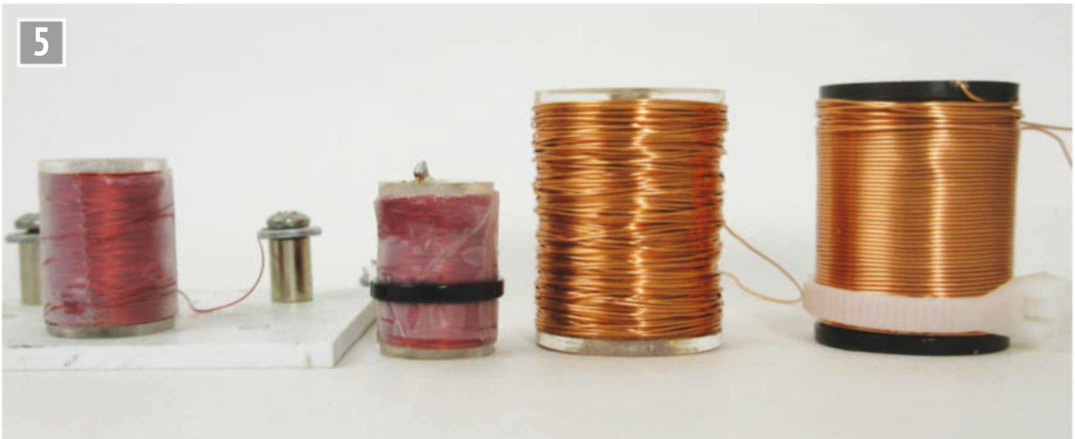
As the clock power requirement cannot be calculated from first principles and is derived from experiment, it is impossible to exactly match the coil design to the clock requirements. A coil with some reserve power should be wound and installed. The extra magnetic force may over-drive the angle of oscillation of a pendulum or balance wheel. A 10 ohm 10 turn trim potentiometer (R 11) reduces the supply voltage and current to control the angle of oscillation. This value should be suitable for most drive coils and is changeable if necessary.

There are other means of controlling the amplitude of the energy coupled into the system: the distance between the magnet and the drive coil may be changed, the duration of the drive pulse may be altered by changing the distance between the ON and OFF opto-interrupters, or the timing of the drive pulse may be changed by moving the ON and OFF opto together to initiate and terminate the power pulse at different angles of the pendulum or balance wheel.

A second power supply may be installed to operate the drive coil at a higher or lower voltage than the logic circuit. If a higher voltage is required for the drive coil, the logic may be implemented in CMOS integrated circuits which may be operated at higher voltages than the 5 vDC required for TTL. The power output circuit should be changed also, installing a MOSFET instead of a Darlington transistor.

Drive coils

The first coils that I used to drive the test pendulum were commercial items bought from surplus and they were all about



Test coils.

the same physical size. But I had no idea of their intended operating voltage, wire size and magnetic force. My first coil was about the same size as the commercial coils and wound with a fine gauge wire. It drove the pendulum, but not the balance wheel. I had a starting point, and now needed to know how to design a more powerful coil. I did not find useful information on the design of coils, so I am presenting my hard-won knowledge in some detail. I wound and tested four coils and **photo 5** shows them in order from left to right.

The two coils on the left are about 1 inch tall and ⅝ inch outside diameter and the one on the left was wound with 36 AWG wire. It would drive the test pendulum but not the balance wheel at any voltage. At this point I developed the method of designing the coil and with a method in hand I designed the subsequent coils. The second from the left was wound with 30 gauge wire and is about 400 ampere-turns. It too would drive the pendulum but the balance wheel required about 15 VDC. The next coil – third from the left – is about 1⅜ inch tall and 1 inch OD, scramble wound with 26 ga wire and is approximately 700 ampere-turns. It will drive the balance wheel at about 7.5 VDC. I wanted to be able to drive both the logic and power circuits from a 5 VDC power supply and wound the fourth coil on the same size bobbin but with 24 ga wire yielding about 1100 ampere-turns. This will drive the balance wheel at about 4.5 VDC. To reduce the coil voltage from 5 VDC, I added the 10 ohm potentiometer to the power block. I chose this method of controlling the coil voltage because the potentiometer adjustment screw will be accessible from outside the clock facilitating any adjustment that might be necessary in the future.

●To be continued.

Club Diary 15 July - 11 September 2022

July

15/16 Weeting Steam Rally
Fengate Farm, Weeting, Norfolk. See www.weetingrally.co.uk

17 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

20 Bristol SMEE
Zoom meeting – 'Fusion 360 Revisited'. Contact : secretary@bristolmodelengineers.co.uk

22-24 IMLEC 2022
Stoke Park, Guildford. See www.gmes.org.uk/events.htm

24 Bradford MES
Open Day, Northcliff Railway 13:30 – 16:00. Contact: Russ Coppin, 07815 048999

24 Bristol SMEE
Public running, Ashton Court Railway BS8 3PX noon - 17:00. Contact : secretary@bristolmodelengineers.co.uk

24 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

29-31 Welland Steam Rally
Woodside Farm, Welland. See wellandsteamrally.com

30 Cardiff Model Engineering Society
Steam-up and Family Day, Heath Park, Cardiff. See www.cardiffmes.co.uk

30/31 Fareham and District SME
Steam Railway Weekend, Club Track 10:30 – 17:00. Contact: info@fdsme.org.uk

31 Bristol SMEE
Public running, Ashton Court Railway BS8 3PX noon - 17:00. Contact : secretary@bristolmodelengineers.co.uk

31 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

31 York Model Engineers
Open Day. Contact: Bob Polley, 01653 618324

August

3 Bradford MES
Evening Running and Social Evening, Northcliff Railway 19:30. Contact: Russ Coppin, 07815 048999

3 Bristol SMEE
Auction, Begbrook Social Club BS16 1HY. Contact : secretary@bristolmodelengineers.co.uk

5-7 Gloucester Vintage and Country Extravaganza
South Cerney Airfield, Cirencester. See www.glosvintageextravaganza.co.uk

6 Wakefield SMEE
7¼ Inch Gauge Open Day, Club Track. Contact: Dennis Halstead, 01924 457690 or Blackgates, 01924 466000

7 Cardiff Model Engineering Society
Public running, Heath Park, Cardiff 13:00 - 17:00. See www.cardiffmes.co.uk

7 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

13/14 West Riding Small Locomotive Society
Rally/Open Weekend. Contact: Stuart Merton on 01132 523258 or wrslsec@gmail.com

14 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

20 Cardiff Model Engineering Society
Steam-up and Family Day, Heath Park, Cardiff. See www.cardiffmes.co.uk

20-21 Model Tram and Railway Exhibition
National Tramway Museum, Crich Tramway Village. See www.tramway.co.uk

21 Bradford MES
Running Day, Northcliff Railway 13:30 – 16:00. Contact: Russ Coppin, 07815 048999

21 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

25-29 Great Dorset Steam Fair
Tarrant Hinton, Blandford Forum. See www.gdsf.co.uk

28/29 Cardiff Model Engineering Society
Public running, Heath Park, Cardiff 13:00 - 17:00. See www.cardiffmes.co.uk

28/29 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

28 York Model Engineers
Open Day. Contact: Bob Polley, 01653 618324

September

3 Southport MEC
Small Gauges Day, Victoria Park 10:00 – 16:00. Contact: Gwen Baguley, gwenandderrick@yahoo.co.uk

4 North Wilts MES
Public Running, Coate Water Country Park, Swindon 11:00 – 17:00. Contact: Ken Parker, 07710 515507

7 Bradford MES
September Meeting, Saltaire Methodist Church 19:30. Contact: Russ Coppin, 07815 048999

8 Cardiff Model Engineering Society
Talk: Medieval Cardiff, Heath Park, Cardiff. See www.cardiffmes.co.uk

10 Cardiff Model Engineering Society
Steam-up and Family Day, Heath Park, Cardiff. See www.cardiffmes.co.uk

10 York Model Engineers
Evening Talk – 19:00. Contact: Bob Polley, 01653 618324

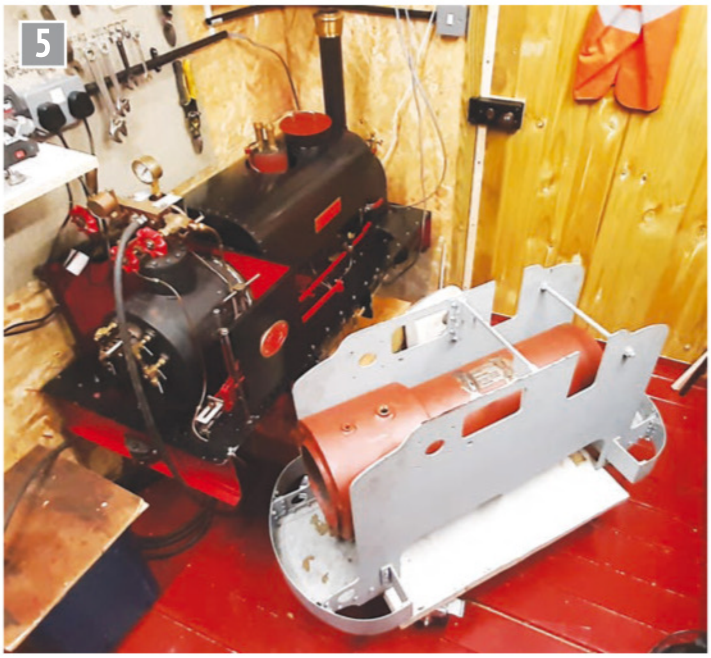
11 Ayesha Centenary Rally
Rugby MES 10:00 – 17:00. See www.n25ga.org

William Spence PART 11

Cliff Almond continues his description of a potential unusual narrow gauge 0-4-0T for 7¼ inch gauge.

Continued from p104
M.E. 4694, 1 July 2022

William Spence *boiler located between frames.*



William Spence *next to the author's 7¼ inch gauge Hunslet.*

In my last instalment I described the development of the, now completed, marine-type boiler for *William Spence*. Before moving on, I thought it may be interesting to describe a feature of the prototype locomotive that will be replicated on my version.

These locomotives were somewhat unique in that they were designed in such a way that the boiler could be removed from the frames for inspection and maintenance without disturbing much else, having the ability to be extracted from either one end or the other of the frames. Indeed, it may have been Samuel Geoghegan's requirement to have a relatively easily removable boiler that lead to the use of a marine-type boiler, given that the marine-type boiler has no deep firebox or associated water-jacketed wrapper protruding down between the frames, as found on almost all Locomotives. Instead, as the *William Spence* boiler consists, essentially, of two similar diameter tubes, this facilitates removal (**photos 4** and **5**).

As anyone who has designed a locomotive from original full-size drawings will know, there are certain parts of the original design that are either challenging to replicate, due to their size, making them either inefficient in operation or difficult to fit and maintain.

There is also, often, a trade-off between detracting from the original for the sake of reliability and robustness, while looking to design the locomotive as close to the original design as possible, and also achieving a locomotive capable of long term 'serious' operation.

As far as *William Spence* is concerned, there are two such areas of my design where I have deviated from the original, viz. the regulator and the axle boxes, with the former being a commercially available and externally mounted stainless-steel option and the axle boxes using commercially available sealed roller bearings.

It is the 'saga' of the axle box design I wish to describe next.

Axle boxes

The axle boxes on the prototype are of an unusual and quite complicated design. Where the normal practice was to mount the axle boxes within horn blocks, with the ability to accommodate a small amount of angular movement, the design of this item on the prototype was based around spherical bearings mounted within split housings, these being clamped between the bar frames with specially designed long bolt sets. This allowed the axle to roll several degrees, relative to the frames, whilst maintaining a sealed arrangement.

The environment these locomotives were designed to operate in and having to cope with (the tracks were laid to less than the exacting standards found on main-line railways) would today be seen as less than favourable conditions for a brewery - with the horse muck, mixed

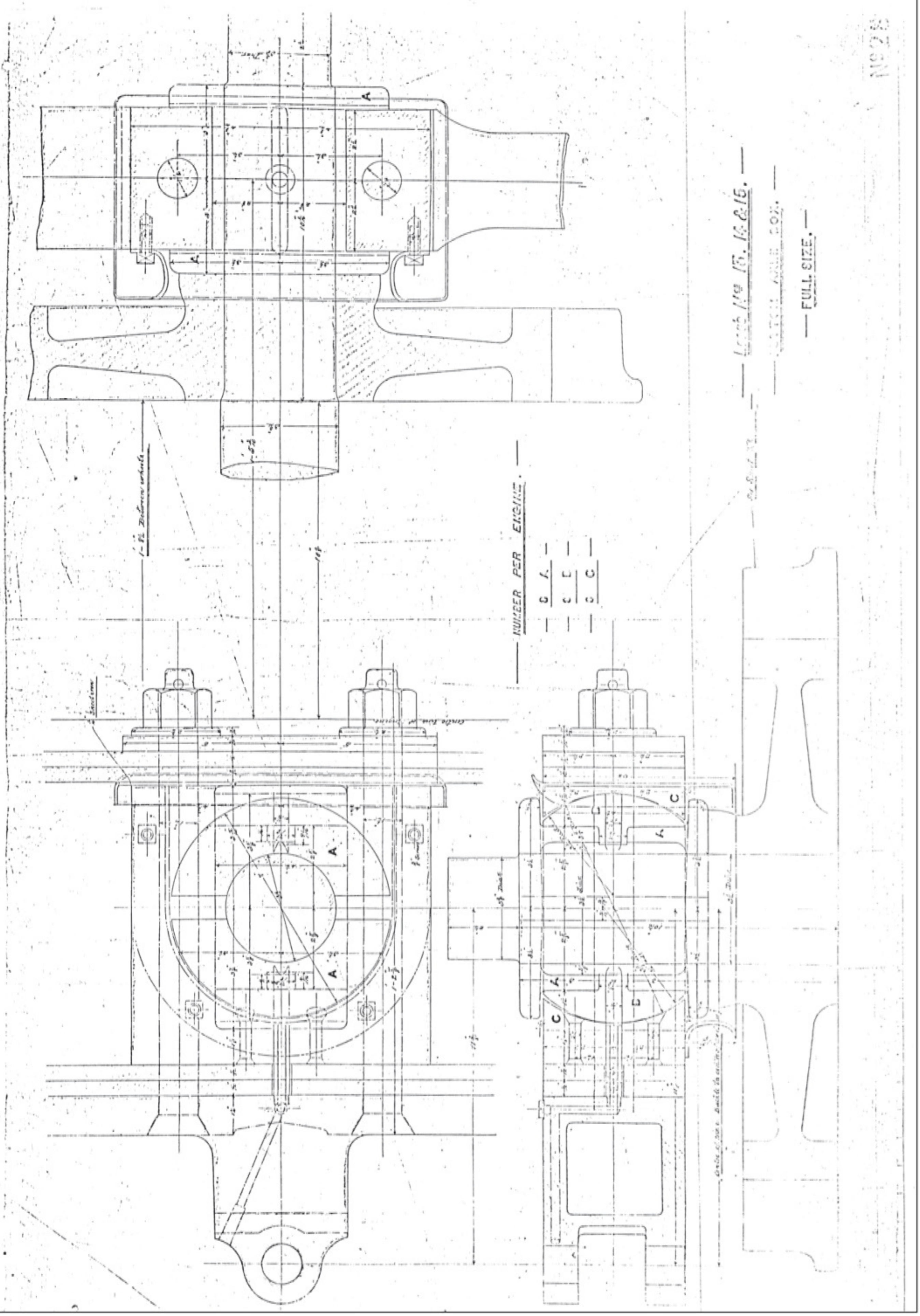


Fig 5

Original *William Spence* axle box.

with straw and grain around the site, forming a long-term corrosive mixture for an un-sealed and more basic design. This had proven to be one of the failures of previous designs of the locomotives trialled at the brewery (**fig 5**).

Initial design work to replicate the prototype went through several phases, ranging from copying the original design faithfully through to considering a much-simplified option - with much frustration in between!

I considered that any attempt to deviate too far away from the prototype would lead to a design that failed to capture many of the unique features Samuel Geoghegan had designed. So, having set myself a similar design challenge, the axle boxes have taken the most amount of 'midnight oil' to replicate so far!

Having spent several hours measuring and taking photographs of the prototype (No. 13), on display in the National Narrow Gauge Railway Museum, it was difficult from the surveys to ascertain exactly how the axle boxes fulfilled their function. It wasn't until I was able to see an original drawing of the axle box that I began to appreciate what (for the time) was an engineering achievement.

Although it was fairly easy to replicate the design in 7¼ inch gauge, it was quite a different matter to envisage how it could be machined in the average home workshop. Thoughts turned to making patterns to form the spherical housings but having rough castings then left the problem of accurately machining their bearing surfaces, let alone having to machine four split housings to such a degree of accuracy as to be able to take equally accurately machined spherical bearings.

Readers who may recall my earlier articles, with the description of how I obtained an almost complete copy of the original drawings, may recall reference to a part built 5 inch gauge version of the prototype I was shown. The designer of this version had obviously encountered the same problem as me. However, he had taken the decision to redesign the axle boxes to resemble those more akin to the type usually found on the majority of locomotive designs, i.e. square axle blocks bored to take the axle journal and machined to allow up and down movement within a hornblock, with a few degrees of roll. After some frustration I have to admit drawing up such a simplified arrangement for my version. However, trying to disguise this design to look, externally, like the prototype proved equally challenging.

After spending many hours trialling various design options on paper and then considering how they may be accurately machined, I started looking at commercially available sealed roller bearings that could be pressed or clamped into housings. Research on the Internet led me to such a bearing that could not only accommodate the axles already made but also allow several degrees of angular misalignment (**photo 6**). I purchased four of these, using them as the basis for the design of the axle boxes that, externally, accurately replicate the original design, right down to the ability to fit brass covers (**figs 6** and **7**).

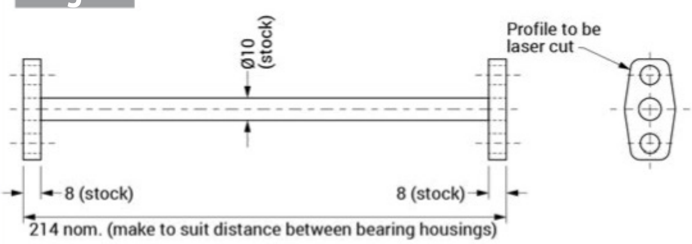
At the time of initially designing the axle box bearing housings, the plan was to machine these from stock aluminium bar, by clamping the top and bottom halves together, forming the bolt holes as close-fitting reamed holes to take the close-fitting bolts and then fitting these, before milling and boring them as four sets. The alternative (and more cost-effective decision) is now to make patterns and have top and bottom halves cast in cast iron. This will mean significantly less material needing to be machined away.

Whilst waiting for these to be cast, work continued with the parts for the bar frames and associated springs and brackets to house the axle box bearing housings.

In my next part, I shall describe the design of these on the prototype and how they are replicated on the model.

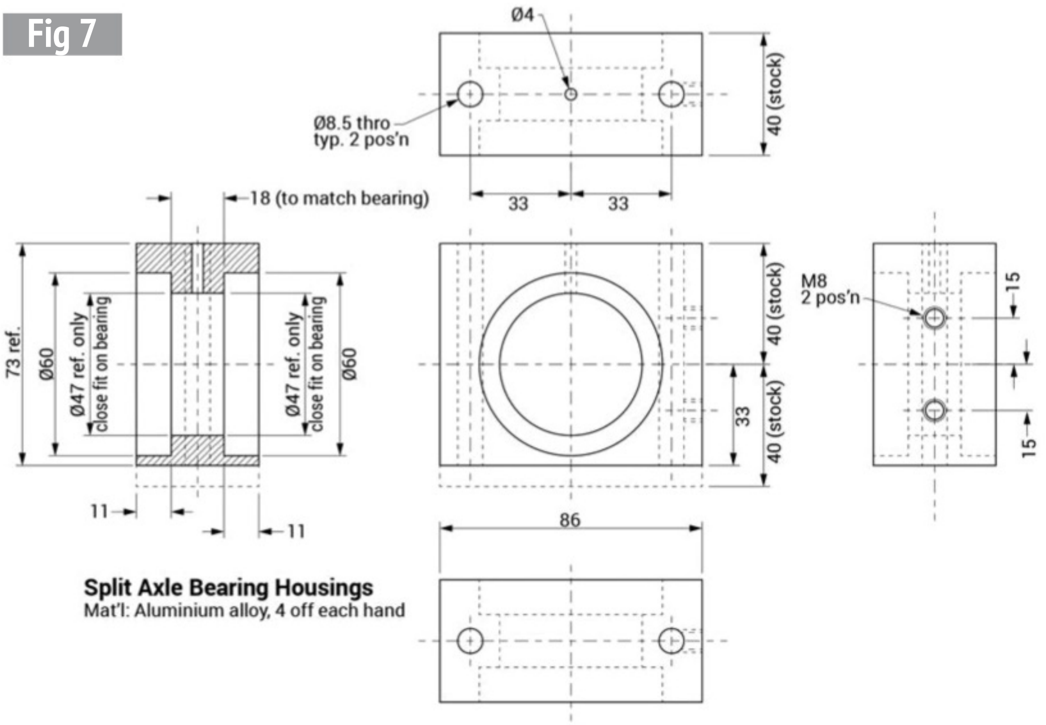
●To be continued.

Fig 6



Split Axle Bearing Housing Spacer
Mat'l: M.S, 2 off

Fig 7



Split Axle Bearing Housings
Mat'l: Aluminium alloy, 4 off each hand

Axle box roller bearings.

Obituary

Stan Bray

Stan was born in London in 1925 and trained as an engineer with an interest in communication equipment. When old enough he signed up to join the forces and passed his medical, only to have his application cancelled because his engineering experience classed him as a Reserved Occupation.

During the war, Stan would be provided with a set of drawings and sent to a factory outside normal working hours, to 'borrow' their machines and make equipment to support the forces. He was responsible for turning parts and grinding crystals for communication equipment. At the time he was not told why he was making these parts and later discovered that some may have been destined for Bletchley Park while others were for use in radar vans. This work was usually at night and involved cycling to various factories (Jameson's sweet factory in Tottenham was a particular favourite) so, to keep himself busy during the day, he also joined the ARP and Home Guard (Royal Fusiliers). Despite his valuable contribution, Stan felt that he hadn't played his part in the conflict that was WW2 so, shortly after VJ day, he applied for and was accepted in the Palestine Police Force. He journeyed to Palestine by train through a liberated but war-torn France. Seeing the damage first hand had a huge impact on him. Stan served in Palestine until 1948 before returning home to marry Dot. He worked for the Post Office before joining the Metropolitan Police Force. His son John was born in 1952, followed not long afterwards by David. During his time in the police, his enthusiasm for engineering continued, building his first home workshop and eventually purchasing his beloved Myford Lathe. He also became a founding member of the Lee Valley Railway club and most free time was spent constructing the club's live steam track. After 25 years' service in the police, Stan retired to take up teaching and also became a squash coach.

Along with his passion for engineering, Stan was an accomplished ballroom dancer, successfully participating in competitions with Dot. There were many family camping holidays touring Europe.

Stan was a passionate grower of fruit and vegetables and most meals featured something home grown - he could be very scathing of the lack of flavour in shop bought produce. He was a great advocate for growing organically and avoiding use of pesticides.

His writing career started when Stan was asked to write a book, which was done using a typewriter and 35mm camera with Dot checking and editing. They worked well as a team. Once the first book was published he was asked to write another and so it continued. He was a key contributor to *Model Engineer* magazine for many years. He also became involved in editing, becoming the first technical editor for Chris Deith's *Engineering in Miniature* magazine and founder editor of *Model Engineer's Workshop*. When Stan reached 95, his workshop became more difficult to access but this didn't stop him. With typical resourcefulness he moved one of the lathes into his study and continued to use it until he passed away.

Stan died peacefully at home on the 18th of June at the age of 97 years.

John Bray

Minnie *traction engine (photo: Howard Lewis).*

Tandem compound engine (photo: Howard Lewis).

CLUB NEWS

John Arrowsmith reports on the latest news from the Clubs.

It is nearly 12 months ago that I was press ganged ('gently coerced', please – *Ed.*) into writing these notes while Geoff went on holiday - well it has happened again so I will try and live up to Geoff's standard and have a look at the club scene in the current problematic world we all find ourselves in. Fortunately, there are lots of activities and rallies to look forward to this year if you are interested in model engineering.

I, like many others, was saddened to hear of the passing of Chris Deith in May whilst he was on holiday in Italy. Chris did so much for model engineering with the Midlands Model Engineering Exhibition at the Warwickshire Exhibition Centre being the jewel in his crown. I got to know him over a number of years with my involvement with both the *Engineering in Miniature* magazine when it was his publication and all his Model Engineering Exhibitions in London, at The Fosse and Manchester. Underneath that sometimes stern exterior he was a real family man and always treated me with great respect, which always helped in the bustle of managing both the magazine and exhibitions. He will be sadly missed and I sincerely hope that Avril and the team at WEC will be able to present a real tribute to Chris at the Midlands Exhibition in October. Hopefully, the event will attract lots of model engineers and I hope all the club display and competition stands will be groaning under the weight of all the new models that have been built over the last 3 years!! That will be a real tribute to Chris. I hope it will be well supported and that the attending traders will also enjoy a successful exhibition.

It is also good to see the number of club events that are planned for the year which will mean busy times for the members and which I hope will be well supported by the public. Early signs from the clubs that I have spoken to seem to indicate that it is going to be a bumper year for many of them.

At the end of April the **Ground Level 5 Inch Gauge Mainline Association (GL5)** enjoyed a weekend visit to the **East Somerset Society** where both shunting yards and mainline were put to good use with lots of interesting locomotive combinations and trains showing how interesting this section of the hobby can be. The one thing that stood out for me was the number of young people who were actively involved in the event. Now, if events like this can attract youngsters why is there such a problem at traditional model engineering events in getting young people involved? I don't mean school age youngsters but early twenties and thirties, thoroughly enjoying themselves. The youngest steam driver during the weekend was just five years old. I can hear the protests now, but I can tell you that this young man knew exactly what he was doing and could handle the small pannier tank he was driving without any problem whatsoever (**photo 1**).

In the spring edition of *The Kingpin*, the news magazine from the **Nottingham SMEE**, the club are mourning the loss of one of their oldest members, Stuart Copson, who passed away in the earlier part of 2022. Stuart was the chairman of the club and it was he who really pushed the club along to where it is today. He will be sadly missed for a long time ahead I suspect. They will be holding a Fun Day at Ruddington to enjoy all the facilities that were his ideas. He was the driving force behind many of the features members now enjoy. The track has been out of use for a while to allow the replacement of rotten wooden sleepers with the plastic variety on the section from the yard point through the tunnel and up to the signal box. The whole project was completed in just 2 months. Joe Hoy had a trip

1

Pannier tank with (almost) scale driver.

Alaska, the latest creation from Wally Sykes in Hereford.

to the Joys of Life Railway in Bethesda North Wales for the last steam up of 2021 in December. This little railway is a ground level operation and is run as far as possible like a full-size railway with all the usual railway features like section tokens and lower quadrant signalling. It was an enjoyable day out but as Joe says he would like to go back but perhaps on a nice warm summer's day! Another maintenance project undertaken at the club has been the refurbishment of the 7¼ inch gauge set of riding cars. The team of Bill Hall, Andy O'Brien, Rod Chamberlain and Roger Hopkins have made good progress, with two of them completed and looking very smart in their green and cream livery.

The **7¼ Inch Gauge Society** report the sad loss of their chairman Frank Cooper who passed away suddenly recently. Frank was a well-known gentleman who will be sorely missed by all who knew him. Janet T. Royston has taken over as acting chairman in order to maintain the group's activities. Their first-class society magazine carries a report about some new guidelines issued by the HSE regarding an incident in 2021 when a passenger had their leg trapped between the carriage and the raised track they were travelling on. Published in April this year, it identifies the possible risks on unguarded carriages so it might be a good idea for clubs who regularly carry members of the public to check out this document and see if they need to do anything to comply with the guidelines. Also in the current edition of the *7¼ Inch Gauge News*, Colin Edmonson illustrates the potential damage that can be done to wheels of both locomotives and rolling stock when using steel bar on edge as the track. He shows some excellent detail about how the wear takes place and how the use of the correct rail profile can reduce the wear and provide a much better ride for passengers. It is worth a read as he offers some excellent advice and tips which can easily be put into practice which will improve the overall riding qualities. Wally Sykes continues with his series on building a large American outline diesel locomotive, which is a powerful machine and really looks the part (**photo 2**). There is also a good selection of photographs showing the society's AGM at Echills Wood last year. The 2022 event was to be held at the Petit Train à Vapeur de Forest in Brussels but this has been cancelled due to the exorbitant cost of getting locomotives and stock to Europe these days to say nothing of the bureaucracy need as well. Instead they will be returning to the Echills Wood railway on the weekend of the 16th-18th September 2022.

In South Africa the **Centurion Society of Model Engineers** have been clearing up after some serious flooding took place at their site following a period of prolonged rainfall. Members have been getting rid of the thick clinging mud that was left as the waters receded. As a member of a club which experiences the same problems I can sympathise with the members there about these difficulties. However, they are getting things back to normal and they have had some new security flood lights installed along with some additional electrical repair work. The club is in the process of building a new raised track at their site. The support pillars have been delivered together with some track sections courtesy of the Gys de Vires family. We shall

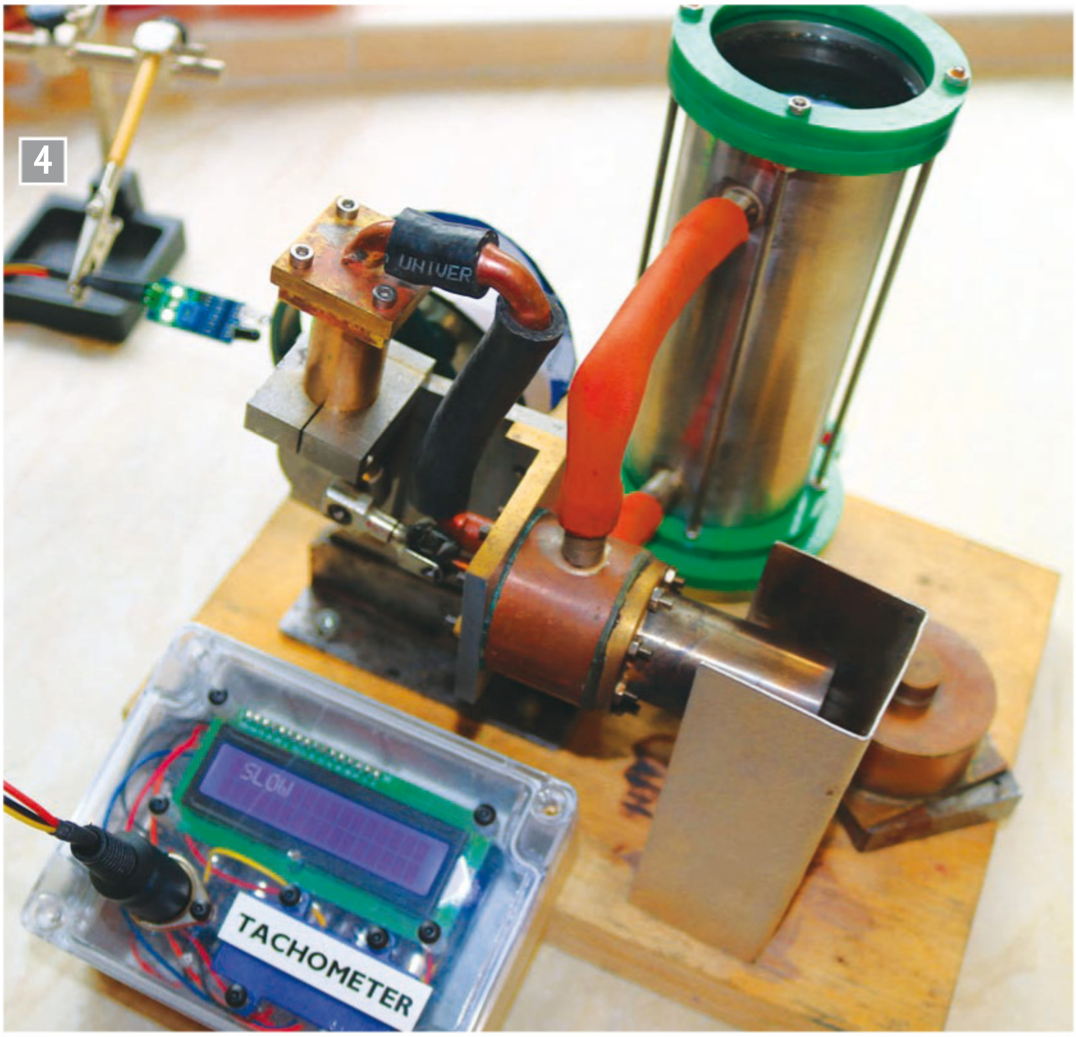
Centurion bridge (photo Hannes Paling).

look forward to hearing about this project as it develops. The track they have looks very impressive and the over and under bridge is a striking feature (**photo 3**).

Members at the **Sheffield SME** have been offered the option of having their club correspondence sent to them by email in order to try and reduce some of the club's overhead costs. This idea follows a discussion at the club's AGM and if adopted will help to reduce the annual postage costs. There was a Fish and Chip Run organised on Friday 13th May at their Abbeydale Railway and, looking at the video made on the day, there appeared to be a good selection of motive power in operation from large diesel locomotives to a 5 inch gauge WD 2-10-0 locomotive *Dame Vera Lynn* in action on the track. It was also good to see the number of young drivers being given the opportunity to try their hand at driving on this interesting track. At their annual Sheffield Children's Charity Fund raising day the club raised £2430 for the charity which was obviously gratefully received and in addition to that over £1000 was raised during their evening train rides at Christmas for the St Luke's Hospice in Sheffield. I think all the members at Sheffield should all be given a hearty round of applause for such excellent fund raising. Well Done.

The occasional journal from the **Stirling Engine Society** has quite a wide range of topics relating to this branch of model engineering. For several years the village hall at Brimpton near Reading has been the venue for member meetings and, having missed the last two years because of Covid, this year's meeting on the 3rd April included the Society AGM although most of the meeting was taken up by Stirling Engine topics.

Julian Woos the secretary describes the building of a solar powered engine using a parabolic reflector. Suitable 12 inch diameter reflectors are readily available from the trade. Julian describes how the system works and how the different parts of the engine need to be made and assembled. The engine mounting is another detail being described which will allow the engine to work as it should. Another interesting article by Bob Cannon describes the making of a simple Arduino tachometer which will enable you to see how fast your Stirling engine is running. A useful component list is included along with the program code for the Arduino *Nano* microcontroller. A good colour photograph shows the installation (**photo 4**). For the future the society will be attending the Midland Model Engineering Exhibition in October with another comprehensive display.



Tachometer built by Bob Cannon (photo Bob Cannon).

Members at the **Bradford MES** enjoyed a Spring Auction meeting on the 4th May with Godfrey Wormald acting as the auctioneer. A tidy sum was raised for club funds but the cost of some of the lots was eye watering!! For example, a nicely made *Atom Minor* I/C engine was sold for an amazing £1 - remarkable, but it was all in good fun and no doubt was a very enjoyable evening. With the new running season going well a new battery had to be obtained for the club's 5 inch gauge locomotive to help keep things ticking over. There are lots of events and functions planned for the rest of the year including the Rae Day Gala on Sunday July 3rd followed by the Steerage Competition on the 6th July. An interesting talk is planned for October 5th when Ian McKay will talk about things that go bang in the night or quite simply 'The History of Explosives'. I expect there may be a few incendiary questions at the end though!!

Dominic Scholes presented his test results for his trials with lithium-ion cell capacity testing which had some interesting results. The club's Annual Dinner/Lunch will be held on 14th October. I was very disappointed to have to cancel my visit to the club because I tested positive for Covid while I was in North Yorkshire and had to self-isolate. I was looking forward to going to see them as they always seem to have lots of activities ongoing all the time and they also seem to get great support from their members, I wanted to see what their secret was. Hopefully I will be able to re-arrange my visit later in the year and perhaps drop into some other clubs when I am in the area.

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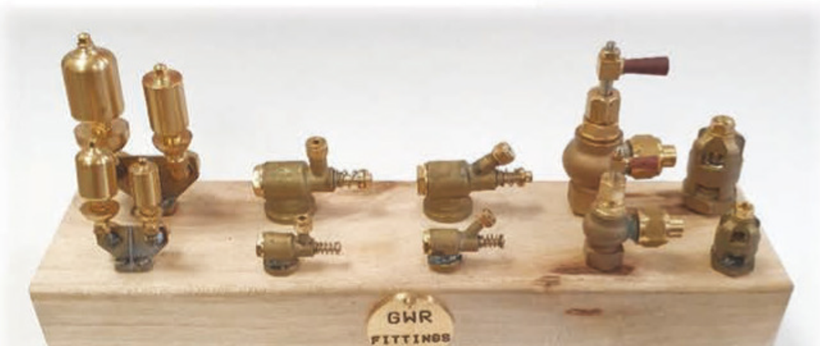

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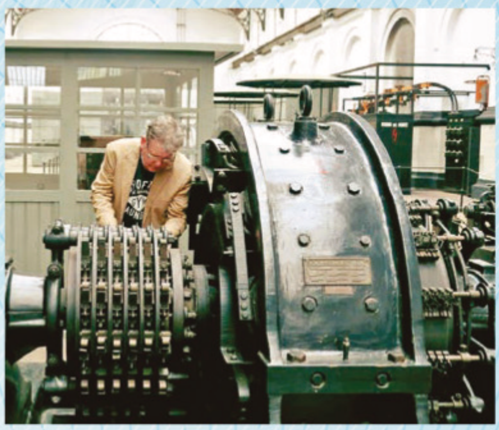

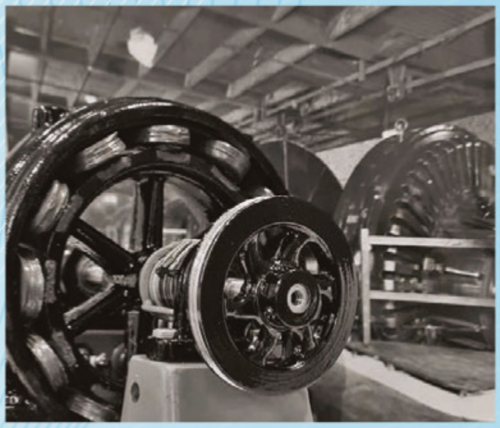

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