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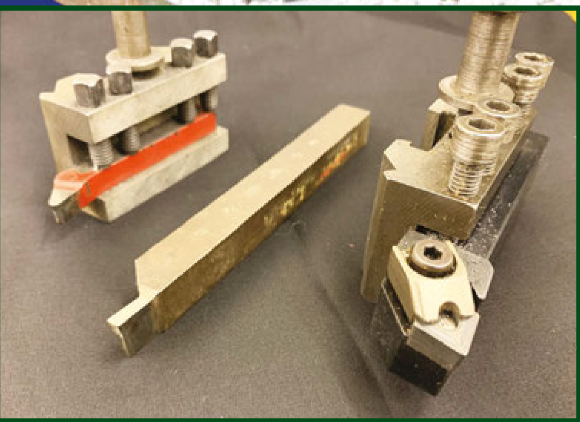
THE MAGAZINE FOR MODEL ENGINEERS

ENGINEERING in Miniature

MARCH 2021 | £4.50

Reviving a loco kit

Used bargain but a good first project?



New and novel ways to measure threads – in holes or on rods

TOOLS AND TIPS TO HELP A FIRST-TIME LATHE USER

CONTENTS

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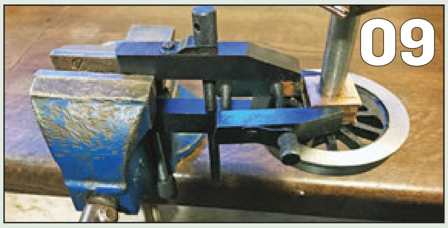

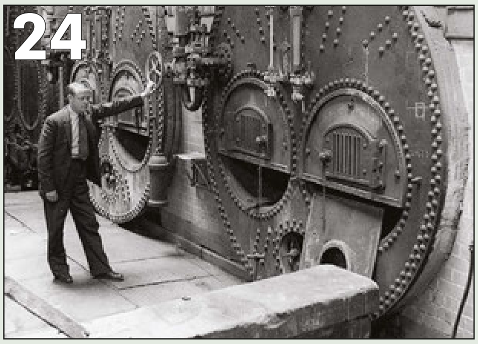

FRONT COVER

Youg model engineer Sam Ridley's first project, an unfinished Winson kit, was found for a very good price on the internet – but challenges awaited. Sam begins the story in this issue.

EDITORIAL

Respect to all – vital to the survival of our hobby

Welcome to the March EIM as we all continue to navigate our way through lockdown. I hope you are making the best of it in your workshops – I've certainly been creating more swarf than for a very long time in recent weeks.

It's not a happy subject that I address this month – I was very shocked to read on social media the totally justified disgust expressed by the head of one of our major suppliers, who has recently taken over the company in question and is working very hard to progress it in very difficult times. It seems a model engineer had been quite abusive on the phone simply because the voice that answered when he rang the company was female. The fact that this female has built engines of her own and knows what she is talking about apparently cut no ice with this particular dinosaur.

It continues to anger me that such attitudes remain in this day and age, though I'm glad to say they are among a rapidly shrinking minority. I've seen it myself – my daughter Megan's day job involves creating exquisite cakes but she's also a steam enthusiast and followed me onto a Welshpool & Llanfair footplate. Following her first trips a couple of drivers commented that Megan was so good with a shovel that they'd be happy to go out on the line with her without the fireman training her! Despite this an 'enthusiast' she was talking to one day felt it necessary to comment that the footplate was no place for a woman. I'm glad to say that Megan put his comments on her Facebook page and got thousands of supportive replies from across the world – many suggesting extra uses for her fireman's shovel...

No-one's capability should ever by judged by their gender. Megan for example is quite good with a welding torch, whereas I've never picked one up and wouldn't know where to start. There are many capable female model engineers, though not enough and such attitudes won't help grow the hobby when we need all the newcomers we can get, male and female...

This month we start another interesting series with another young engineer, learning his way by building and putting right a kit bought secondhand. Kits are an interesting subject in an age when many don't have the time or patience to build completely from scratch – we hope to look further into this part of the hobby later in the year.

Andrew Charman – Editor

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Rebuilding a Winson

Sam, a 16-year-old member of the Sussex Miniature Locomotive Society, describes how the used bargain of an unfinished kit from a defunct manufacturer provided his introduction to the model engineering hobby.

BY **SAM RIDLEY** Part 1 of a short series

Ever since I was a young child I have enjoyed watching and riding on trains, old or new, big or small. I also remember riding at the Beech Hurst Railway run by the Sussex Miniature Locomotive Society (SMLS) in Haywards Heath, West Sussex.

In the spring of 2017, I was given the chance to help run and maintain the miniature railway at Beech Hurst. I was very lucky to be able to drive locomotives with supervision round the track but also to meet very helpful and knowledgeable people at the club. It was clear to me that I really enjoyed this hobby and I wanted to try something new. I had shown interest in owning my very own locomotive but didn't really know where to start...

Introducing the 14xx

It was around November of 2018 when fellow club member and a good friend of mine, Andrew Brock, just happened to come across a 1999 Winson Engineering kit for a Great Western Railway 14xx 0-4-2T (**Photos 1-3**). I was not specifically looking for a loco at the time, but it just happened to suit me so well – it was almost as if the project found me!

ABOVE: Sam's Winson kit nears completion after a great deal of effort.

BELOW: Sam at work on his first project.

As I was just a beginner I didn't really want to start a scratchbuilt loco as such projects take lots of time and experience. The 14xx was going for a very low price and everything appeared to be in the kit including the boiler. I bought it for the low price advertised because I wanted to learn with this project.

The loco seemed to be a simple build, with its running chassis already made, but later on we found out that this was not going to be as simple as we thought, with the loco having several underlying problems that went unaccounted for when being sold.

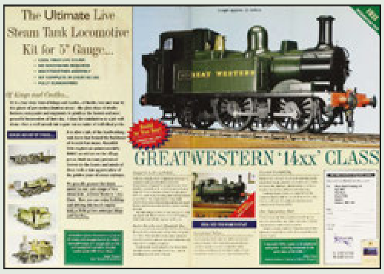
The issues included the wheel quartering, the slide valves not

What was Winson?

Winson Engineering was officially launched in 1990 and based initially in Porthmadog, close to the Ffestiniog Railway.

Over the next decade Winson produced a number of machined kits in 5-inch gauge, including the 14xx that is the subject of this series, the GWR 45xx Small Prairie, Pug 0-4-0T, Southern King Arthur class 4-6-0, LMS 4-6-0 'Galatea' and the BR standard 'Britannia' 4-6-2 and 2-10-0 'Evening Star'. The range available also included an American 'General' 4-4-0, industrials, road engines and portables.

Winson was even better known for its full-size output. Several of the 15-inch gauge Bure Valley Railway's locomotives were built by Winson, as were six carriages for the Welsh Highland Railway for its reopening. A new-build Falcon 0-4-2ST for the Corris Railway was in progress when Winson went into receivership and closed in 2001 – the loco was subsequently completed elsewhere.



Some of Winson's model engines re-emerged under a new company called Modelworks, but this in turn went into administration in 2008.

In the late 1990s Winson ads (above) were a familiar feature in the rail press. The Bure Valley Railway's 'Spitfire' (below) was among 15-inch gauge locos built by Winson. *Photo: Andrew Charman*

PHOTO 1: What appeared to be a complete running chassis hid some issues.

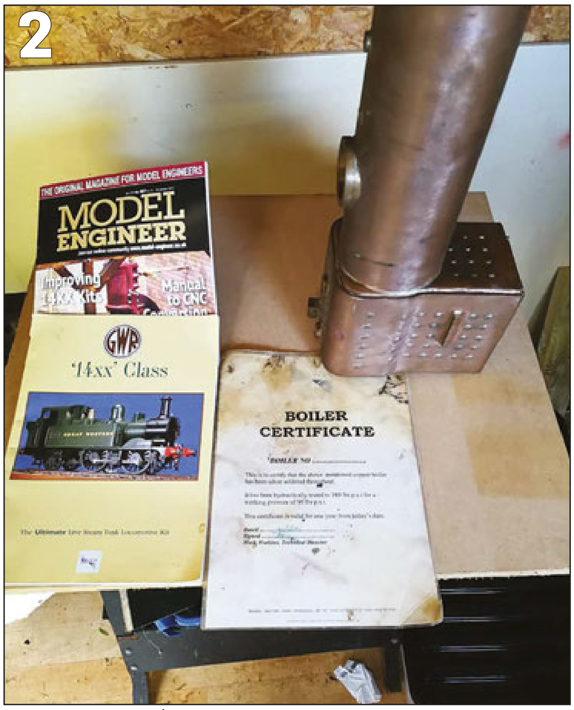


PHOTO 2: The boiler was included and passed its hydraulic test – a good start to the project.

seating, the eccentric pin heads fouling on the eccentrics and connecting rods that were too large.

It became apparent that this was going to be a larger project than I had expected but luckily with excellent help from other members of the club the build soon gained traction and I was to learn a great deal from the whole experience.

The prototype

Designed by GWR chief mechanical engineer Charles Collett and built in Swindon works from 1932 to 1936, the 1400 class locos were built for branch line work in the GWR and later BR (W) regions of the UK.

Originally classified as the '48xx' class, the locos were designed to run using the auto-coach system where the driver could drive from a cab in the leading coach. However, in 1946 these locos (4800-4874) were re-numbered to 14xx to make way for the 12 '28xx' class engines being converted to oil-burning so they could use the 48xx class number.

The 14xx locos could run on any of the GWR and BR(W) branch lines and were quite successful. But around this time diesel locos had started proving themselves and the lines on which 14xx locos ran were being closed by Dr. Beeching. As a result of this, the locos started to be withdrawn from service in 1956 and by the November of 1964 the final four had been retired.

There are currently four of the locomotives in preservation:

- No.1420 is stored at the South Devon Railway and as of 2021 not in service
- No.1442 is a static display loco at the Tiverton Museum in mid Devon
- No.1450 is now at the end of its 10-year boiler ticket and awaits overhaul at the Severn Valley Railway
- No.1466 is under overhaul at the Didcot Railway Centre in readiness for the Great Western Society 60th anniversary in 2021.

The beginning...

Very soon after purchasing the engine, it was decided to hydraulically test the boiler, however I needed some boiler bungs as the loco did not come with any. I was allowed to borrow some from a friend, but I was still three short. They all needed to be ⅜-inch diameter with a 32tpi thread and making these provided my first machining job on the lathe. With help, I got there.

I used a brass hexagon bar and mounted it in the lathe. I learnt how to 'zero' the dials and then turn the material until it was ⅜-inch diameter. Having turned each bung, I then set up a ⅜-inch x 32tpi die in a die stock – this was also my first time using a die properly on my own. I used the tailstock of the lathe to apply a small amount of pressure onto the die and bungs so it would cut a good, straight thread. Once all was set up, I was ready to start cutting the thread.

I used the lathe bed to stop the die holder from spinning and manually turned the lathe chuck to cut the thread (make sure the lathe is out of gear when you do this!). After a couple of full turns I released the pressure from the tailstock and unscrewed the die to break the bur and brush it off, I then applied pressure again and started to turn further up the bung.

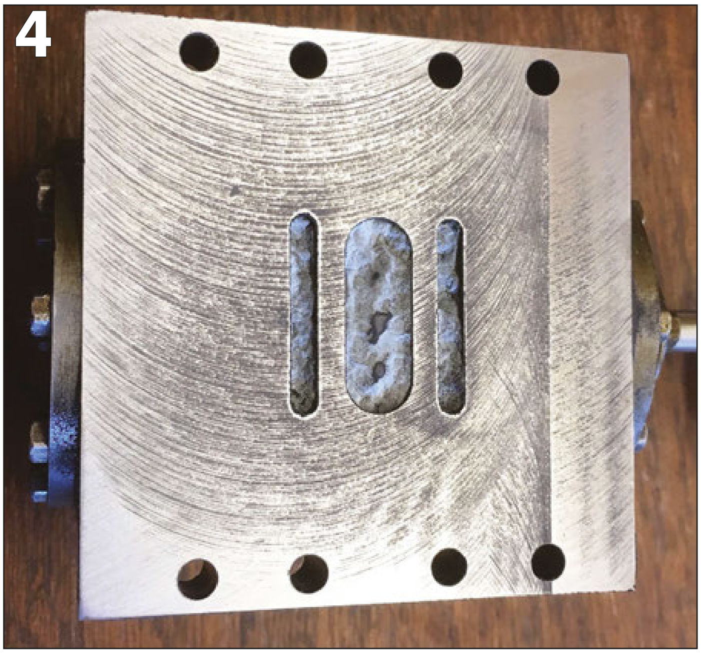
I repeated the process on the other two bungs and I now had all that was needed for a hydraulic test and before the test commenced, I wrapped the bungs in PTFE tape to stop any leaks that might occur through them.

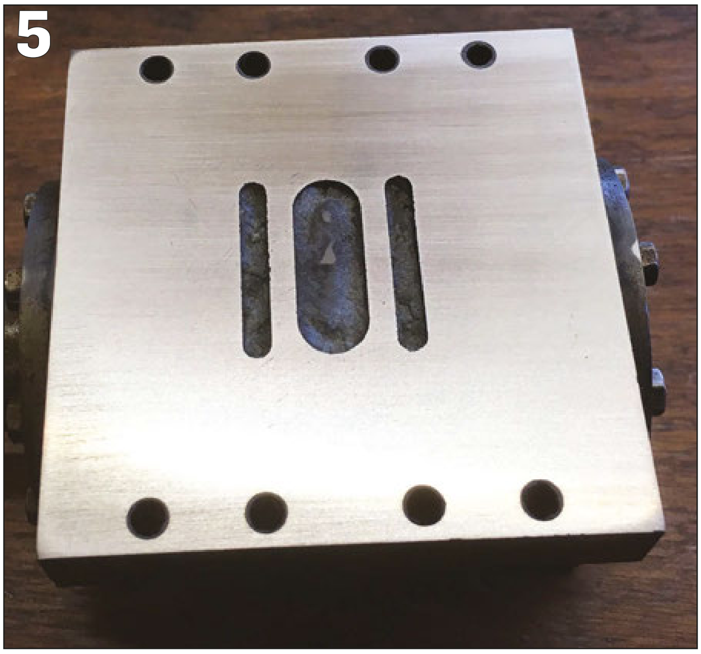
With the bungs in place the next thing to do was to measure the boiler capacity. The boiler ticket from the factory did not state a boiler capacity, only boiler pressure. So, with a measuring jug and a funnel we managed to measure the capacity – it was only a small boiler at 2.05 litres.

Now to commence the test! The boiler had been tested from the factory at 180psi hydraulic pressure (90psi steam pressure), so we replicated the test to that pressure – I didn't think such a smaller boiler would ever have to go to that pressure!

The boiler passed with flying colours with only a pinprick leak that let the smallest amount of water out. It was only a very well-made boiler with ▶

PHOTO 3: The purchased kit appeared to be complete, a great help to a young model engineer on his first build.





nothing to worry about – my project had made a good start…

However, this was where the restoration began. After some initial tests were carried out on the 'running chassis' it became apparent that the valve gear was out of time, numerous air leaks were discovered and the coupled wheel sets were not fitted properly to the axles.

Degrees of difficulty

To start with we had to check that the cranks and both wheel sets were quartered to 90 degrees. This was all checked on a Myford Super 7 lathe by holding the axles between dead centres and using the lathe bed, a ground vertical fixture and slip gauges to determine the size of the error, if there was one.

Unfortunately there was a problem because the original builder had keyed the front wheel set with an error of 0.008-inch. Because the left-hand side wheel was also loose, this measurement of 0.008-inch was at the 'good' end of the error and at this stage we could only assume this was where the left-hand wheel should be set. Before making any hasty decisions, we checked the rear (crank) wheel set and found this to have an error of 0.016-inch but with both wheels loose!

With this information known, the front right-hand wheel was removed, thoroughly cleaned, set up in a friend's quartering jig and fixed using Loctite 638. Once the Loctite was fully set, a 5BA stud was drilled into the axle and wheel to fully secure the two together. The process was then repeated on the left-hand wheel, so the front axle was complete.

Afterwards, the wheels on the crank axle (rear driving axle) were quartered using the same technique. Both wheels were then re-attached, again using Loctite 638 but were not pinned at this stage.

We then needed to make new bronze bushes for the coupling rods; this was because the original bushes had been elongated by 0.020-inch just to make the wheels turn!

With the wheels now set properly, quartered and back in the chassis and the new bushes turned, drilled and reamed to fit the crank pins, an initial test proved the wheels could now rotate 360 degrees with no compromises and only a very minor tight spot.

PHOTO 4-5: Before and after – the port face of the cylinder after diligent lapping.

PHOTO 6-7: A similar process had to be carried out on the valve faces – all good practice in fine finishes for a novice...

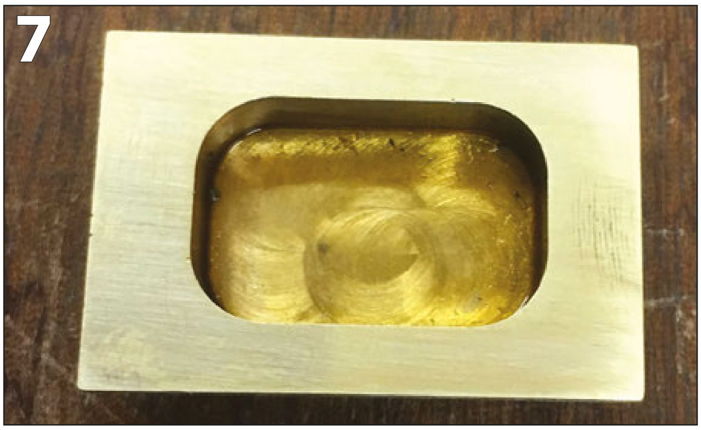
All photos in this feature by the author

The valve gear timing could now be checked. This showed the eccentrics to be at the correct position on the axle, however the pistons were just kissing the front cylinder covers as the connecting rods were too long. There was also a considerable air leak through the slide valves.

Making two new connecting rods would be too big of a task at this stage of the build, so a secondary solution was needed to solve the over-length issue. This solution involved cutting the existing rods, shortening them by $\frac{1}{16}$-inch and brazing them back together. This proved 100 per cent successful– the pistons now cleared the cylinder covers with no issue.

The cylinder covers were also relieved to allow for the bolt which was secured to the front of the piston rod. Furthermore, new gaskets were also made to seal the covers at both ends. However, there was still a significant air leak from the slide valves and investigating further, it was clear that the faces of both the valve chest and the valves themselves were unsatisfyingly rough.

To clean these faces we would need to remove the cylinder block from the chassis once more – one step



forwards, two steps back! While they were rough, the faces were good enough to not require any machining, we hand lapped them on a surface plate using various grades of emery paper. This process started with 120 grit, through 400 grit, 800 grit and finally finished using a 3000 grit paper for a smooth and mirror like finish, but essentially to stop any steam leaks coming through the crevasses in the material (**Photos 4-7**).

Once finished, the cylinder block was returned to the chassis and two temporary gudgeon pins were made from mild steel to secure the little end of the connecting rods to the crossheads. We planned to re-make these using either case-hardened steel or silver steel at a later date.

With these tasks now finished, the locomotive could now be tested on air again. The main cylinder block, gaskets and valve faces sealed well, however there were still minor leaks from the pistons and valve glands. To fix this, the old gland packing was removed and temporary split viton O-rings were added. This largely sealed the leaks.

Valve adjustment

Further air tests were successful but proved the valves themselves could not be adjusted equally about their mid-point, because the valve spindles were too long – another setback but we were still making progress!

With another job added to the 'to do' list the valve spindles were checked, removed from their buckles and shortened by ⅜-inch to allow the more or less equal adjustment about their mid-point. The thread on the buckle ends of the valve spindle was also reduced in length by 1⁄32-inch as it protruded beyond the thickness of the buckle and risked jamming the valve in the buckle.

Another task on the to-do list was to turn up, and thread, some draincock blanks. These would replace the auto draincocks that were supplied with the loco and which could be individually removed to help with testing.

Finally, with the to-do list finished and the valves re-assembled, a fully successful air test on the rebuilt chassis took place in late September of 2019, which coincided with the running season drawing to a close at Beech Hurst.

The chassis was now largely complete and running well in forwards and reverse. This meant it was now time for stripping, painting and the replacement of the temporary valve gear pins used during testing… EIM

■ Sam will continue the description of his rebuild in coming issues of EIM.

Uses for clamps

David demonstrates how versatile a simple tool can be...

BY **DAVID CONEY**

Toolmakers' clamps (sometimes called toolmakers' parallel clamps) are basically for 'what it says on the tin', clamping things together, but I have also found them very useful for work holding. They come in a range of sizes, imperial and metric, I have examples with 2-inch, 2½-inch and 4-inch jaw lengths.

First a tip for absolute beginners (not so long ago for me!) in the use of these clamps. The most important thing is to end up with the jaws as parallel as possible, otherwise the screws may become bent, and/or they will not provide the best clamping action. When I am using them I tend to tighten up the inner screw first, to leave them slightly off-parallel, then I do the final tightening with the outer screw to bring the jaws parallel, using a Tommy bar if necessary.

The other mode I use them more frequently for, is work holding. Sometimes with an awkward-shaped workpiece that needs some filing or whatever, it's not possible to directly hold the workpiece in the vice. But by using a toolmakers' clamp to hold the workpiece nearest to the work to be carried out, the clamp itself can then be held in the vice, providing a secure way of doing the job.

Photo 1 shows the cab of a 3½-inch gauge loco that needed some filing work, with the toolmakers' clamp holding the job near to where the work is to be carried out.

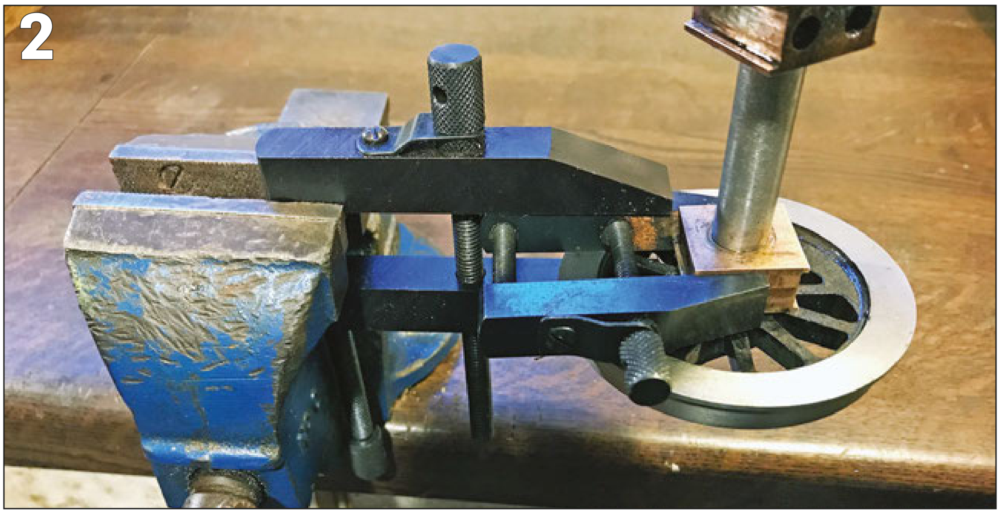
Other jobs have necessitated the use of two toolmakers' clamps, one holding the job, another, larger clamp holding the smaller one, and the larger one held in the vice.

Photo 2 shows the clamps being used on an loco axlebox that needed some grinding work to provide enough clearance against the valve gear. Here I could have probably just used the larger clamp, but I needed to hold the job a certain way up so I employed two clamps so I could then carry out the work satisfactorily. EIM

PHOTO 1: Using a clamp to provide a holding surface for work on a loco cab.

PHOTO 2: Two clamps can be used together to get the job just where one wants it...

Photos by the author



Threads laid bare

In this two-part feature Peter describes how to measure and identify any thread form on any bolt, nut,threaded rod or hole without removal or dipping into drawers of fasteners – it's all about a clever piece of scientific software, and it's free...

BY **PETER KENINGTON** Part one of two

So, you've trawled the dealer's websites, checked out ebay (risky, but perhaps housing a bargain…), maybe an auction or two, and taken the plunge: a shiny new (to you) steam locomotive sits proudly in your fledgling workshop and you gaze adoringly at its beautifully-made motion, its shiny brasswork and its slightly tired, but still gleaming, paintwork and dream of sunny days puffing around your local club track.

You look carefully and notice that one of the nuts is missing from the crosshead and a section of shiny thread protrudes, challenging you to make it complete. You look around the bench, the floor, the boot of your car, but the elusive nut remains just that, elusive. You conclude that it probably wasn't there in the first place and you hadn't noticed in the thrill of taking delivery of your pride and joy. "It's just a nut – I can replace it", you say to yourself, "how hard can it be?"

The answer is, of course, 'not very', assuming that you know what thread-type the elusive nut requires. That is where the fun starts…

Identity Crisis

We've probably all been there at some time or other, perhaps not with a steam locomotive but some piece of equipment we've needed to repair or refurbish. How do we identify the correct thread type in order to make or buy a nut, bolt or length of studding with which to effect a repair?

I was confronted with this problem when I bought my first loco, a Super Simplex – I've still got it and it's a real gem (Photo 1). It wasn't a missing crosshead nut, but we'll come on to that later. Experienced model engineers reading this will smugly point to a cupboard full of thread-gauges (Photo 2) and a full set of drawings for the loco, plus dozens of drawers of every conceivable type and size of nut, bolt and washer from the early bronze age to the present.

The newly-minted enthusiast, with a bench, a few screwdrivers and a lot of optimism, on the other hand, isn't in this position. In my case, I had a pretty well-equipped general workshop, but not a model engineer's one and not the first clue about ME (model engineer) threads, for starters.

PHOTO 1: Super-Simplex 'Roselea', with a very young Matthew Kenington, age 4¾. *Photo courtesy of Ross Wilkinson, who titled it 'Big Toy' when sending it to Peter!*

PHOTO 2: Thread gauges.

PHOTO 3: Measuring the threaded part of an M5 bolt.

PHOTO 4: Measuring the unthreaded shank of M5 bolt.

PHOTO 5: Testing a 0.8mm-pitch thread gauge on the 'unknown' M5 bolt.

PHOTO 6: Testing a 0.9mm-pitch thread gauge on the 'unknown' M5 bolt.

PHOTO 7: Set of taps and dies – this set has ME threads.

All photos by the author unless stated

But surely the drawings will provide all of the answers? You did obtain a set of drawings with the loco didn't you? They *may*, if the builder (who may well not have been the vendor) built the loco exactly to them. Many locos are 'based upon' a set of drawings, but often materials and parts to hand (or still available) are substituted for those specified by the drawings. In particular, nuts and bolts are often substituted with near-equivalents – perhaps modern metric examples replacing BA (British Association) parts, for instance, since some BA sizes are getting harder to source. In such cases, the drawings will be of limited use.

In my case, all those years ago, it was a troublesome boiler fitting – something I clearly didn't want to get wrong! The consequences of mangling the threads on a boiler bush didn't bear thinking about. Although I now know it is recoverable, it is still something very much to be avoided.

Thread gauges

You've just spent thousands on your loco; surely a few tens of pounds invested in every set of thread gauges you can lay your hands on makes sense? The simple answer is of course, yes, however thread gauges may not be available (or easily available) for all types. I'm not aware of anyone who produces thread gauges for ME threads, for example, although since these are based on Whitworth threads, using thread gauges for this thread type is an option. The only thread gauges I have are metric.

Thread gauges are also difficult to use to identify which thread type you have. If you know that a particular thread is, for example, metric, then it is relatively easy to use a set of metric thread gauges to find out precisely which 'M' thread it is (as we will see).

If, however, you have no idea what the thread type is, trying various gauges may not yield a convincing answer, just a narrower list of possibilities. For example, 9BA and M2 threads are very similar in most regards and a couple of sets of thread gauges would likely struggle to tell them apart.

Thread gauges are most useful, in my view, where the thread/bolt is of a known standard (such as metric) but the thread pitch (TPI) is unknown. Taking the example of a metric bolt (**Photo 3**); measuring its diameter (even if it wasn't known to be a metric bolt prior to measuring) makes it clear that this is likely to be an M5 bolt. Note that for a genuine bolt (as opposed to a machine screw), it is usually better to measure the unthreaded part (**Photo 4**) although, in this case, it makes very little difference (~0.02mm). Whilst this diameter should read 5.00mm, bolts are not (generally) precision-engineered parts, unless specifically made so, and will typically read a little under their stated diameter.

We have now, fairly convincingly, deduced that we have an M5 bolt, however which type of M5 bolt do we have? There are two thread pitches in (fairly) common use for M5: 0.8mm and 0.9mm (we will discuss and measure thread pitches in due course – for now, it is sufficient to note that they are different).

This is where a set of thread gauges comes in most useful, in my experience. It is relatively easy to tell these two thread pitches apart (see **Photo 5** and **Photo 6**) and thereby deduce the full specification of the bolt. In this case it is an M5 x 0.8mm threaded bolt. The only remaining parameters to specify are the head type, bolt length and thread length; again, we will return to these later.

It is evident, from Photo 5 and Photo 6, that even when a bolt is mostly 'known' (for example its standard, such as metric), and the likely thread parameters are known due to a given size of bolt only being manufactured in a couple of thread pitches, it is still not that easy to judge with absolute conviction that the right thread has been uncovered using a set of thread gauges (particularly if you are a complete beginner or your eyesight is not what it used to be...).

It becomes even more difficult if the bolt is completely unknown – which type of thread gauges should be tried? What happens if more than one standard/gauge looks like a plausible match? Techniques to help answer these questions are outlined below.

Nut Job

A first option is, of course, simply to try various candidate nuts (or bolts, as relevant) on the thread, until one seems to fit convincingly. This is fine so long as:

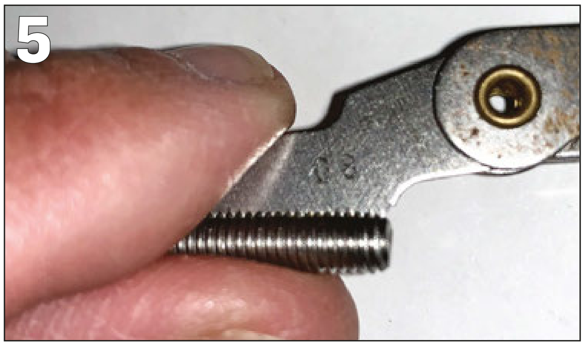
a) You either have a vast selection of nuts and bolts (those new to the hobby probably don't)...

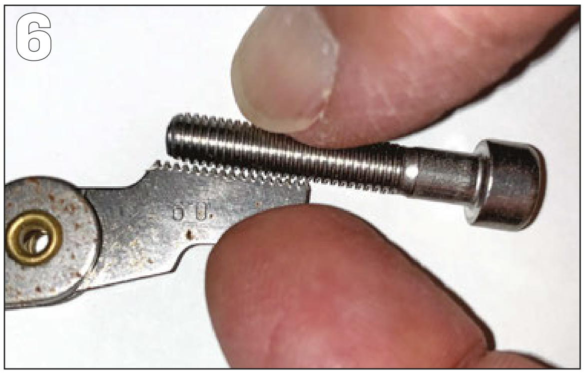
b) ...or you have a similarly vast selection of taps and dies (**Photo 7**), with which to make candidate nuts or threaded rod for trying out. Again, those new to the hobby probably don't.

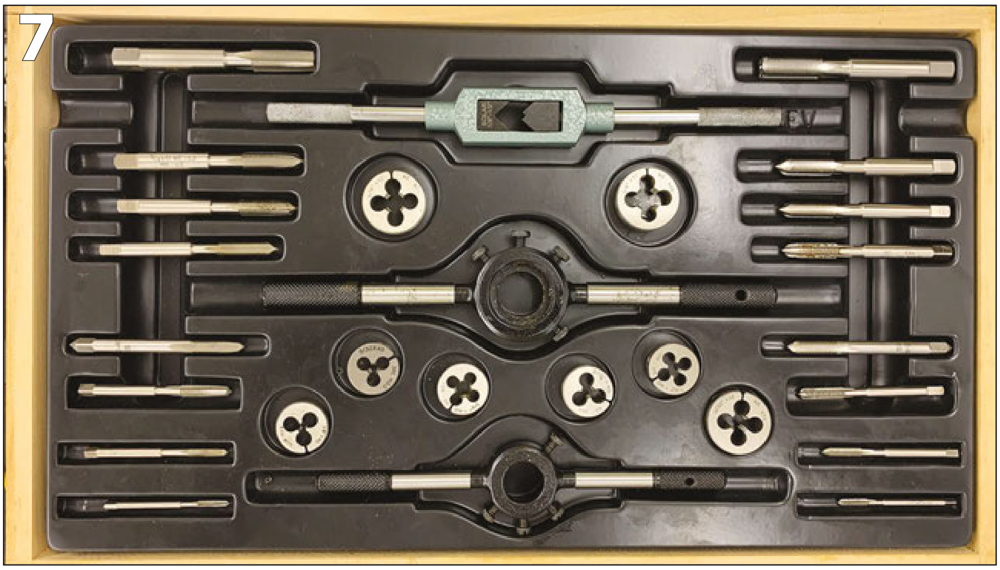
c) And the end of the thread (and, indeed, the whole thread) isn't damaged – if it is, even the correct nut (say) will either be stiff or not want to thread on at all.

"Materials and parts to hand are substituted for those on the drawings..."

Unless you know for certain which thread you are dealing with, applying a large amount of force to a nut (with the wrong thread) in an attempt to 'clean' or re-form the threads may well spell disaster for the bolt (say). If this is ▶







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Loctited-in to the motion, for example, or would require disassembly of half of the loco in order to replace, then it is best to be very sure of having the right thread before applying such force (or running the correct tap/die, as appropriate, along the thread).

If you either don't have access to the required nuts/bolts/thread gauges or are nervous of breaking your precious new loco (I still remember such feelings!), what do you do? The answer is to apply a little technology, as will now be described. And the best thing? It's all free…!

"There exists a bewildering array of thread types..."

Thread Types

There exists a bewildering array of thread types (the list in Table 1 is far from exhaustive) and a good number may be found on model locomotives – likely candidates are highlighted in bold in the table. Even within a standard, there are differing thread pitches for the same diameter of thread (as seen above with metric M, threads).

At least the thread taper generally used on the threads themselves is typically fairly standard across the most commonly-used types, at 55 or 60 degrees (with BA being a notable exception, at 47.5 degrees). These two angles are close enough that they may sometimes be interchanged, with caution. I know of a few model engineers who don't worry about this difference when thread-cutting on a lathe, for example.

TABLE 1: THREAD TYPES

Abbreviation	Thread name
ADM	Admiralty
ASME	ASME Thread
BA	**British Association**
Brass	**Brass thread**
BSF	**British Standard Fine**
BSP	**British Standard Pipe Thread**
BSPP	**British Standard Pipe Parallel**
BSPT	**British Standard Pipe Tapered**
BSW	**British Standard Whitworth** (also known simply as **Whitworth**)
BUTTON	Watch button threads
CEI	Cycle Engineers Institute
COND	Steel conduit thread (DIN 40430)
CROWN	Watch crown threads
Elgin	Elgin watch screw threads
GAS	Gas (Brass Pipe) Thread
HOLTZ	Holtzapfels Threads
LOEW	Loewenhertz Threads
L	Left-hand thread (appended to other thread-types)
M	**ISO Metric**
ME	**Model Engineer** (based on Whitworth)
NF	**National Fine** (see also UNF)
NPT	National standard Pipe Thread (US)
NPTF	National standard Pipe Thread Fuel (US)
PEND	Watch Pendant Thread
PROG	Progress Thread
SPARK	Spark Plug Threads
THURY	Swiss Screw Thread
UNF/UNC/UNEF	**Unified national Fine/Coarse/Extra-Fine**
WALTH	Waltham Thread
Whit	**Whitworth** (see BSW)
W.INS	Whitworth Instrument
W.Pipe	Whitworth Pipe Thread

Threads likely to be found in model engineering highlighted in bold

ME or Whitworth?

Whilst ME threads are based upon Whitworth threads, they typically differ in their thread depth and, almost always, in their TPI vs diameter. For example, a 40 tpi ME thread should have a thread depth of 0.016-inch irrespective of the thread diameter, which is much smaller than the equivalent Whitworth thread-depth in all cases but $\frac{1}{8}$-inch, where they are equal (as it is the only diameter of Whitworth thread which boasts 40 tpi).

The coarser ME thread, 32 tpi, has a thread depth based upon the BSF standard and again, the only thread density at which the two types are equal is the smallest size defined for BSF ($\frac{3}{32}$-inch). This diameter does not exist as an ME thread, however, making identification easy.

Bolt types

When specifying a bolt (or a machine screw), the following parameters are generally required:

1) Diameter – maximum outer diameter of the threads, in other words any sample bolt will fit through a hole of this size
2) Length – it is not always obvious how this is specified, see below
3) Threaded-length (for bolts)
4) Thread-type/standard (BA, M, ME, BSW and such like)
5) Head style (and sometimes diameter as well, if this differs from that specified in the relevant standard)
6) Head type, for example slotted, cross-head, posidrive or such.

At this point, it is worth distinguishing between a bolt and a machine screw. The former is only partially-threaded, in other words the end section is threaded but there will remain a section closer to the head which is plain and unthreaded. A machine screw, on the other hand, will be threaded right up to its head.

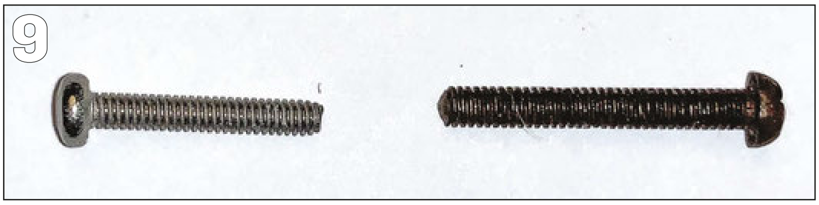
Photo 8 shows a selection of commonly-available bolt and machine-screw types – most of the examples in the photo are metric, although one is BA, can you guess which? (answer at the end). Working from left to right, these are:

1) Hexagonal-head (or hex-head) machine screw. Note that the term 'hex head' is sometimes (confusingly) used to refer to Allen-headed bolts
2) Cap-head Allen (or 'hexagon socket') bolt. Most cap-head bolts have Allen-key compatible heads
3) Flange-headed machine screw.
4) Countersunk machine screw – these are available with a variety of head types, such as Allen, slot, Torx and various types of cross-head
5) Cheese-head machine screw (with a slotted head)
6) Pan-head machine screw (this one is almost a halfway house between a true pan-head and a cheese-head)
7) A more conventional pan-head, slotted, bolt
8) Coach bolt

There are a couple of other common types which I didn't fall across in my rummage around for the photo...

- Raised-countersunk – as its name suggests, this is a countersunk-style bolt/machine screw with a raised rounded head
- Button (Allen) head – similar to a pan-head, but with a more rounded head (the profile forming part of the arc of a circle). Almost always designed for use with Allen keys.

There are other styles based upon these (such as types with both cross-head slots and hexagonal heads – often found on Jubilee-clips for example) and some more obscure types sufficiently rare to be ignored here. I've probably forgotten one or



two ‘obvious’ types – if so, I’m sure someone will write in to remind me!

Specifying Length

This is not obvious, or at least it wasn’t obvious to me when I started out. Those of you who served an apprenticeship and spent a career bolting things together will smile at my erstwhile naivety, however a career in the radio and microwave industry didn’t involve the specification of too many fasteners...

For most types of bolt, the length is defined from the furthest extent of the thread at the bottom of the bolt, to the underside of the bolt head. In other words, the length does not include the head. So far, so simple. When dealing with countersunk heads, however, the specified length includes the head!

The best way I have found to think about this (and it’s obvious when you do think about it) is that the length of a bolt is defined from the bottom of its thread to the upper-surface of the material into which it is inserted, when fully inserted and tightened. Based upon this definition, the fact that the length of a countersunk bolt includes its head, whereas that of a normal bolt (such as Hex or pan head) excludes its head, makes perfect sense.

Introducing ImageJ

What is ImageJ? It is a free, open-source, scientific image analysis software package originally written to perform tasks such as counting or measuring cells on a microscope slide, analysing growths in a petri dish and the like. It is a very powerful package and is useful for many aspects of model engineering. But despite its power, it is very easy to use (for the simple things we will be doing) – in effect, we are using a Le Mans supercar to pootle to the shops.

Examples of areas in which ImageJ could prove useful to a model engineer include:

1) Measuring thread-pitch and counting threads-per-inch (TPI), as discussed in this article

2) Accurately measuring small apertures, too small for a bore gauge to be used (or for any aperture, in the event that you don’t yet have a set of bore gauges – I’m still a little lacking in this area)

3) Accurately measuring loco components which are awkward to measure by conventional means (using callipers, micrometers and such like), even whilst they are still attached to the loco!

4) Accurately measuring components on full-size locos, in preparation for modelling. These would obviously still be attached to the loco, in most cases.

The last point is quite a powerful use of the package for a model engineer – most museums would take a dim view if you started climbing all over their precious exhibits with your ruler and tape measure, but are quite happy for you to take as many photos as you like.

A detailed discussion of items 2 and 3 is beyond the scope of this article, suffice to say that the quality of the photo is very important; not just its resolution, but the angle at which it is taken. Accurate results will only be obtained if the photo is taken square-on to the item. Views up to, or down to, the component in question will yield inaccurate answers.

One other point is that it helps enormously if at least one dimension in the photo is known (even to the extent of placing a ruler somewhere in the picture). This dimension can then be used to ‘calibrate’ the result.

As a final tip: if you can use a flat-bed scanner, then do so. This guarantees a 1:1 scaling and allows the resolution of the scanner to be used directly as a part of the measurement – we will discuss this in more detail in relation to threads, below. Perhaps I’ll get a chance to revisit the use of ImageJ on loco parts, in a future article, however for the present we’ll concentrate on thread-identification.

PHOTO 8: Common types of bolt and machine screw.

PHOTO 9: ‘Unknown’ machine screws, the picture taken using a smartphone with 12MP camera.

PHOTO 10: ‘Unknown’ bolts scanned using a 1200 dpi scanner.

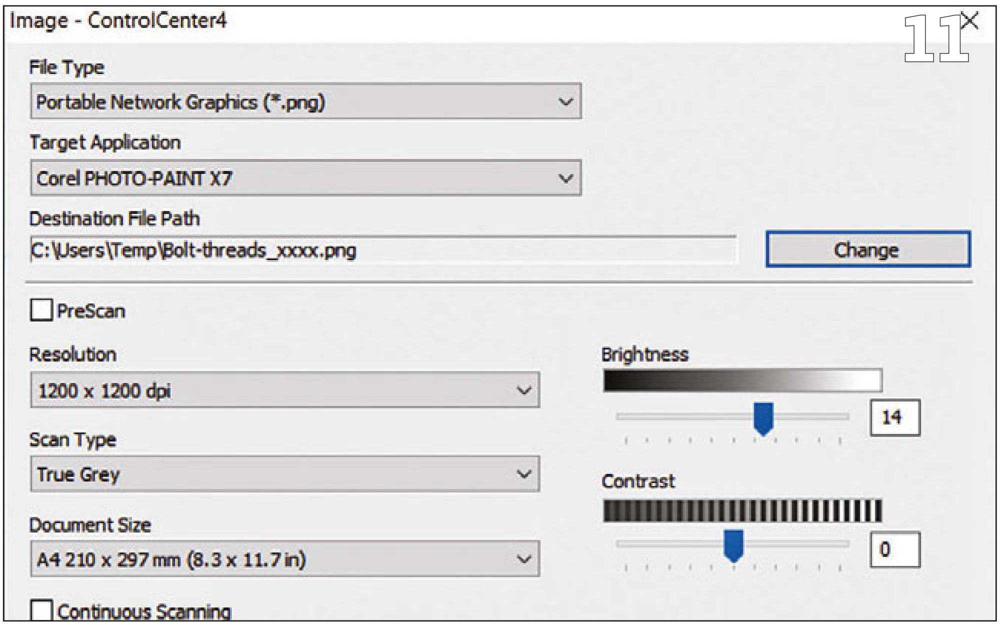
PHOTO 11: Scanner settings.

There are a number of variants of the package, but the one which is most commonly-recommended (and which I use) is called ‘Fiji’. It can be downloaded from ImageJ’s website at https://imagej.net/Fiji – this page contains download links for all of the main operating systems, including both 32 and 64-bit Windows systems, MacOS and Linux. I have only used the 64-bit Windows version, but I’m sure the others will work just as well.

Using the software

To demonstrate the use of this package, two similarly-sized machine screws but of differing standards were chosen from my (now reasonable) collection. For the purposes of this article, the images of these ‘unknown’ parts were obtained in two different ways: using a fairly high-resolution smartphone camera (12MP) with its flash turned on (Photo 9) and using a flat-bed computer scanner at 1200 dots-per-inch (DPI) (Photo 10).

The scanner settings used on the flatbed scanner are shown in Photo 11. ▶



Note that care should be taken with the scanner approach, as it would be easy for heavy-handed use of the lid (such as dropping it onto the bolts) to result in scratches of even cracking of the scanner glass.

Photo 10 also illustrates another minor problem with the scanner approach: the 'focus' of the scanner is set to the upper surface of the glass, thus making anything which is not actually touching the glass slightly out of focus. This can be seen, in particular, on the section of thread nearest to the head on the right-hand screw. This is not a huge issue, however, since any part of the thread may be used for measurement purposes and hence the bottom end of the thread, which is in focus, will prove adequate.

TABLE 2: MEASURED 'UNKNOWN' THREADS

Screw No	Diameter (mm)	Diameter (inches)
1	1.935	0.07615 (approx. 5/64)
2	2.179	0.08580 (between 5/64 and 3/32)

"It would be somewhat challenging to scan a 7¼-inch gauge Britannia on a domestic flatbed scanner..."

The key advantage of using a smartphone (or, indeed, any camera) is, however, its portability – it can be taken to the mystery bolt or thread on the loco, which can be photographed in-situ. In contrast, it would be somewhat challenging to scan a 7¼-inch gauge Britannia on a domestic flatbed scanner…

Start with the Diameter

The first step is simply to use a micrometer or callipers to measure the diameter of the unknown threads. If you have absolutely no idea of a bolt's provenance, measurements will need to be taken in both metric and imperial units – one or other will probably give an initial clue as to which is most likely to be correct, although it is best not to jump to conclusions at this stage!

For the two machine screws shown in Photo 9 and Photo 10, these measurements are shown in Photo 12 and Photo 13 for screw #1 and Photo 14 and Photo 15 for screw #2. In case these photos are too small to read when reproduced in the magazine, the values are shown in Table 2.

The values shown in Table 2 are not very convincing either way, particularly when it comes to the imperial values. Remember that a measured thread diameter will generally be a little smaller than its 'official' designation.

With this in mind, screw #1 could be 2mm metric and screw #2 could be 2.2mm metric. Equally, screw #1 could be 5/64"-inch imperial and screw #2 could even be 3/32"-inch imperial, although this might be a bit of a stretch. None of these measurements is conclusive, although they do narrow the field somewhat, by ruling out larger (such as 2.5mm) or smaller (such as 1/16-inch) threads. **EIM**

■ Next month Peter shows how to use ImageJ and a little Sherlock Holmes-style deduction to work out the thread type on any bolt, nut or other threaded component, whether or not it is still attached to your loco.

TABLE 2: The measured diameters of the 'unknown' threads.

PHOTO 12: Screw #1 measured in mm.

PHOTO 13: Screw #1 measured in inches.

PHOTO 14: Screw #2 measured in mm.

PHOTO 15: Screw #2 measured in inches.

Building a Ten-Wheeler

Plates occupy Jan-Eric in this month's episode of his 7¼-inch gauge loco build...

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

Our locomotives had their road number, class designation and the maximum allowed speed prominently displayed on the side of the cab, in a very distinctive typeface. Fortunately, I found the exact design in a book about old steam locomotives, so I could scan and print it on paper in the correct ⅛th scale size. Then, doing some fiddly work with a sharp knife, I cut out the letters and made a stencil that I could use to transfer the lettering to the cab.

Some years ago I had tried using ordinary spray paint with such paper stencils, with rather poor results – the thin paint spread uncontrollably under the stencil, destroying the shape of the letters. It may work in full scale, with larger-sized text, but even a spread of only a few tenths of a millimetre on letters not much higher than 6mm is very unsightly indeed.

So this time, I 'dabbed' some thicker enamel paint onto the cab wall through the stencil, using an almost dry brush. Then, I used a very fine watercolour brush to fill in the somewhat weak, mottled letters with the same paint, slightly diluted with paint thinner. The result can be seen in Photo 164. This was of course very exacting work, needing a steady hand.

Adhesive or rub-on

Another method is to use adhesive plastic letters, or 'rub-on' transfer letters of the Letraset type. The latter need a protective coat of special varnish, since they scratch easily. Plastic stick-on letters are more durable – they can be bought in stationery stores or, if no suitable size, colour or style can be found, cut to order by companies specializing in sign manufacturing. You need to choose a typeface from their catalogue, or pay extra to have a custom style.

Applying such self-adhesive letters is easy, since they are usually delivered on a waxed sheet that keeps them in the correct alignment as they are transferred.

"Having them made from brass would have caused extra expense, so in order to turn them more yellowish in colour, I heated them with a propane torch..."

On the side of the cab in Photo 164, you can also see the engine's road number, '999' – which was the actual number of the last locomotive built in this Ten-Wheeler class, in 1939. These numbers are made of 2mm thick metal, but not of brass as they were in the full-size prototype – instead they are stainless steel! I had them laser-cut at the same time as the stainless plates for the tender tank were cut, and of the same material.

Having them made from brass would have caused extra expense, so in order to turn them more yellowish in colour, I heated them with a propane torch (note: before attaching them!), until they adopted the straw-yellow colour you are familiar with, if you have ever hardened and tempered drill rod. This made them look almost like brass! They are epoxy-glued to the cab side.

Photo 165 shows the cab attached to the running boards. Only four wing nuts are needed, one in each corner. The nuts are completely hidden under the running boards. Also note the sliding doors in the rear of the cab – opening them, as in

PHOTO 164: Epoxy-glued metal road numbers, and class info painted on the cab.

PHOTO 165: The cab has sliding doors on its backsheet.

All photos in this feature by the author

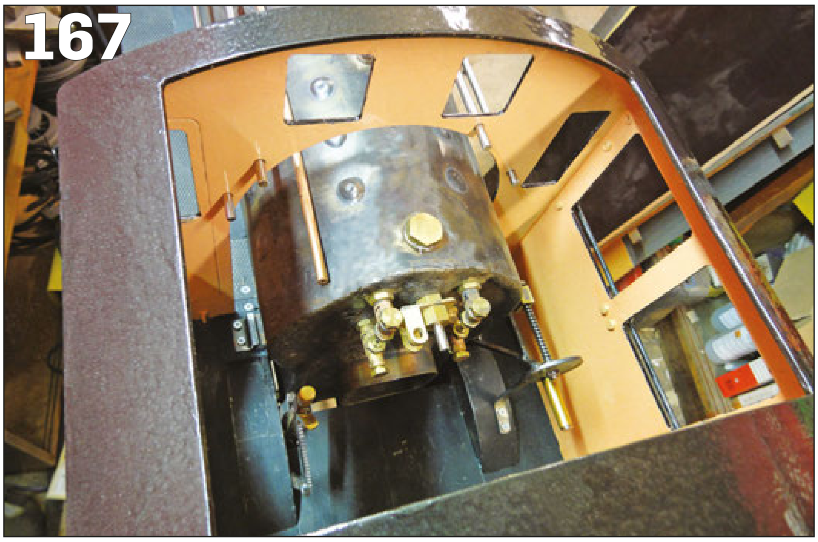


Photo 166, the loco driver can easily reach the reverser crank, as well as the ratcheted hand brake.

Through the doors, you can glimpse the backhead of the boiler, still in an unfinished state. The two water gauges are visible, and between them is the gland and clevis for the yet-to-be made throttle lever. The fire doors were also still missing when I took this photo.

An open roof

The 'cosmetic' roof of the cab (seen in place in Photo 165) is removable. This will make driving the engine much easier than reaching for the throttle through the cab doors. When sitting on the tender, the throttle lever is accessible through the roof opening.

In Photo 167 you can see the four handrail rods emerging through holes in the front wall. With handles, levers and linkages, these rods will control some of the fittings on the front of the loco, such as the drain cocks below the cylinders and the water-pump bypass valve.

The roof is painted with dark grey 'hammertone' paint, giving a slightly mottled surface that won't easily show small scratches and dents, as would a smoothly painted surface. The inside of the cab is painted a light orange-yellow, just like in the prototype.

On the left side of the boiler, on the floor, you can see a clamp holding the boiler in place, while still enabling it to move slightly back-and-forth during thermal expansion. There is a similar clamp on the other side. When firing up the boiler from cold to operating pressure, it will expand by more than 2.5 mm! If there is no allowance for this expansion, severe deformation or even breakage of the boiler fasteners might occur.

The 6mm copper tube seen under the window leads to the feedwater pump, attached to the smokebox. It was described in the July 2020 issue. The cab end of the tube will be connected to a steam valve, installed in the manifold that will be attached to the boiler with a 'banjo' union; for now, there is just a brass plug in the threaded bushing on top of the boiler. This manifold will have four steam valves: one each for the electric turbo-generator, the steam whistle, the water pump, and one for the blower in the smokebox.

Looking down into the cab, you see a handbrake lever on the left. This does not exist in the full-size prototype, but I decided to make an easily accessible and quickly applicable mechanical brake, instead of a steam or compressed air brake – these always have a slight time lag before they can brake effectively. The brass lever has a typical ratchet mechanism made of steel.

Also seen in the top view is the reverser crank with its left-hand-thread, coarse-pitch reverser screw, described in an earlier issue. The frame of the reversing mechanism is a simple weldment made of flat-iron strips, attached to the wheel guard on the running board. The crank handle is oversize – but so is the engineer!

A gas valve and a pressure regulator are on the cab floor, together with a pressure gauge for the propane gas, Photo 168. The six burners are

PHOTO 166: Opening cab doors reveals boiler backhead.

PHOTO 167: As-yet unfinished fittings in cab and on backhead.

PHOTO 168: Gas valve, regulator and pressure gauge.

PHOTO 169: Burner manifold in bottom of the firebox.

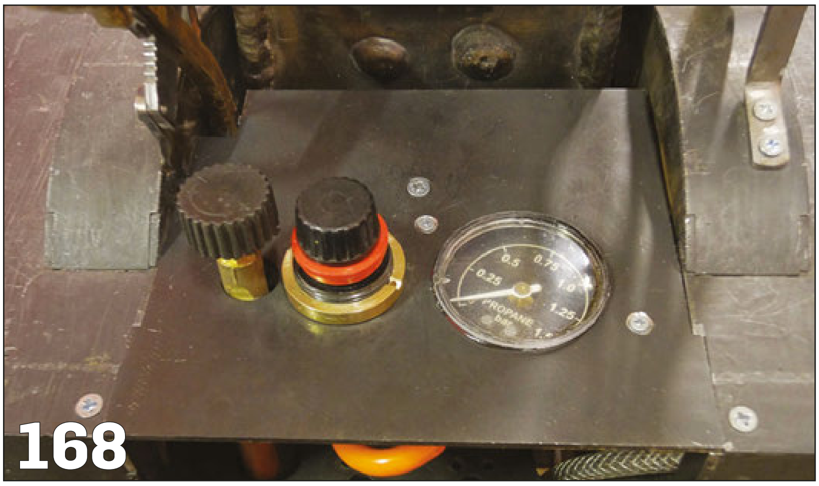


PHOTO 170: Original builder's plate and the design for the miniature loco.

PHOTO 171: Small plates cut from a magnesium printing plate.

installed in the firebox with the help of simple, removable braces, seen in Photo 169. A baffle plate closes most of the opening in the bottom of the firebox, there's only about 3mm of space around the baffle, as well as around the burners, best seen at the burner at top left in the photo of the firebox. If I want to fire this loco with coal or wood, the burners will be removed, and a grate installed instead. That's a big 'if', for sure – I like the simplicity of propane firing!

Platework...

One more addition to the cab is the 'builder's plate' on both cab sides, above the road number. This time, I've had them made (for about £30) by a company making old-style metal printing plates. It is quite a hassle to etch them yourself – I should know, getting yellow-stained fingers from the ferric chloride I used to etch the brass plates for my earlier 4-4-0 and 0-6-0! Fortunately, the discolouring wore away in a few weeks…

A friend gave me a real, full-size builder's plate for my 50th birthday (oh dear, almost 20 years ago – time sure flies!), see at the top in Photo 170. I've used that as a guide to prepare a graphic original for my miniature, seen below it.

The original plate is from a 2-8-0 engine, built by the Lokomo works in 1930. My Ten-Wheeler prototype was built by the same manufacturer nine years later. From the build numbers, we can deduce that Lokomo only made some 30 locomotives between 1930 and 1939.

Ordering printing plates of magnesium metal for use as builder's plates, it is very important to tell the company making the plates that the text should be correctly readable on the plates themselves – printing plates normally have the text displayed as a mirror image!

Photo 171 shows the result after I had sawed out the small plates, filed the edges smooth, and filled the depressions with appropriately coloured paint. After that, I rubbed the plates' front surfaces lightly on a piece of emery paper in order to get the raised letters free of any overflowed paint. Then, I used a yellowish lacquer on the silvery magnesium surface to imitate the brass in the original plates.

On the miniature, less than 5cm wide builder's plates, the smallest letters are only 2mm high, so I didn't really bother getting them exactly the same as the original, but used a standard typeface. The larger 'O/Y LOKOMO A/B' text had to be manually modified, since there was no matching typeface available on my computer, and I wanted to have at least that text matching the original as closely as possible.

In addition to these two plates, I made a small builder's plate of my own, with my name and the build years. This will be placed in a less conspicuous position compared to the other plates. The three smallest plates are for the tender, while the 999 plates ▶

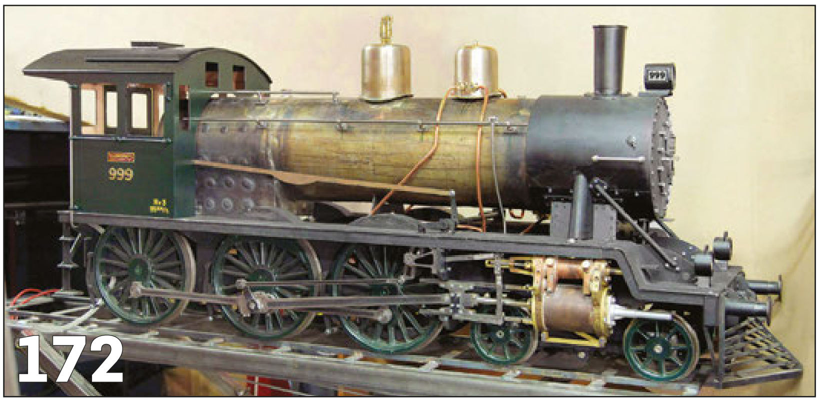


PHOTO 172: The almost finished loco on the workbench.

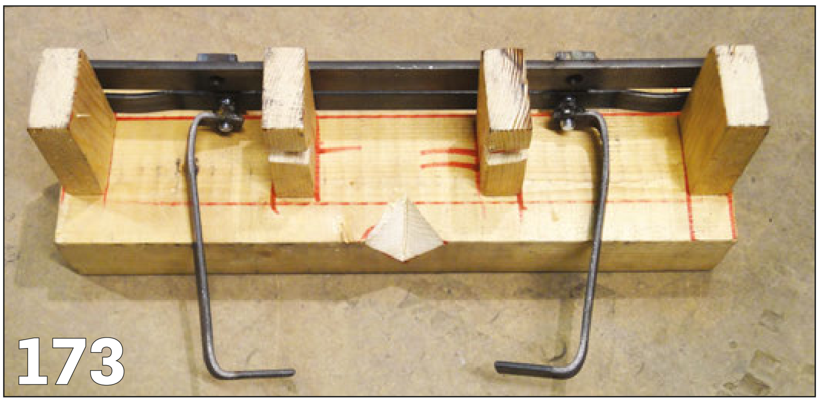


PHOTO 173: A clamp for the front of the loco.

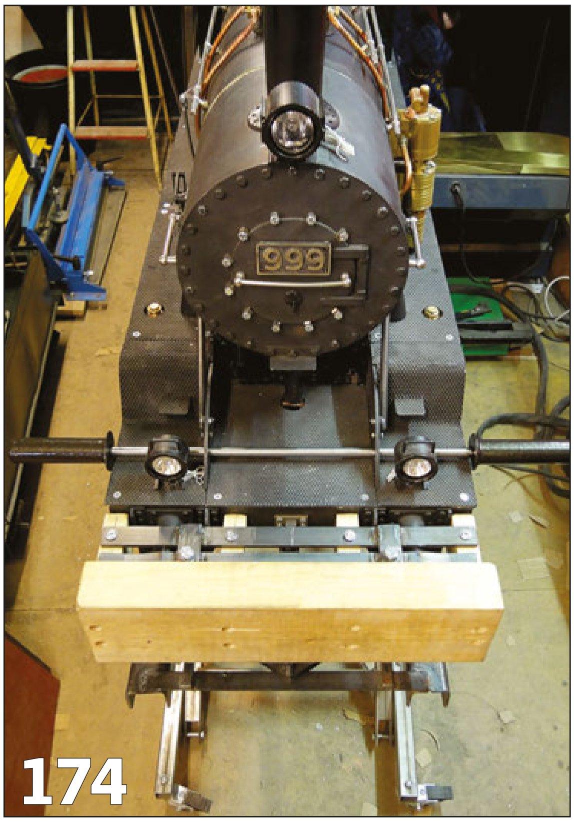
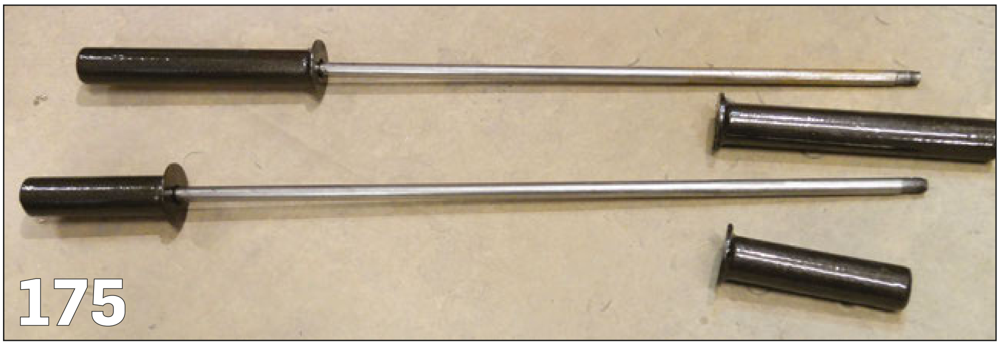


PHOTO 174: Loco front end securely fastened to workshop track.



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176

are for the loco's front headlight.

All in all at this stage, my Ten-Wheeler project was progressing slowly but surely – Photo 172 shows that the rest of the work yet to be done was mostly cosmetic, boiler and cylinder lagging, for instance.

In order to safely move and transport this heavy locomotive, weighing almost 200 kg, I built a 'cowcatcher protector', Photo 173, that enables me to clamp down the front of the loco to the track in my utility trailer – see the April 2019 issue of EIM for the details of how I modified the trailer. Photo 174 shows this simple clamp attached to my workshop 'track stand', enabling me to move the loco safely around the workshop without risking it rolling off the track.

For lifting the loco, I made two heavy 'handlebars', each having one end removable, Photo 175. Threading the bars through the loco frame front and aft, four people can easily lift the Ten-Wheeler and carry it a short distance, as in Photo 176, where the engine is lifted from my track into the storage shed. EIM

"I made a small builder's plate of my own, with my name and the build years..."

PHOTO 175: Simply made carrying handles for the loco.

PHOTO 176: Making use of the handles, four people can carry the engine.

■ Next month Jan-Eric tackles the final details of his Ten-Wheeler loco build project.

BENCH TALK

Simple vice modification

BY **HARRY BILLMORE**

Here is a simple modification I carried out to make life easier and quicker when needing to hold small components in my big milling vice.

I set the vice up true and square to the mill, then simply milled a ledge into the top of each vice jaw at the same height (Photo 1), about 3mm deep in both directions. The finished ledge can be seen in Photo 2.

In my case I also tidied up the jaws of the vice which with much use over many years had become quite significantly marked.

To ensure that the vice jaws are parallel when machining the moving jaw, close the jaw onto a parallel that is wide enough to allow your milling cutter to clear the fixed jaw.

Making this modification allows small parts to be held securely in a large vice without having to resort to balancing the part on parallels. EIM

1

2

PHOTO 1: Milling the 3mm slot in the vice.

PHOTO 2: The finished ledge, a boon to holding small parts in the vice.

Photos by the author

A first model engine for first-time model engineers

Matthew continues his series for novices describing his first model engineering project – an oscillating engine built when he was 12 years old. This month he makes the flywheel.

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

6

The flywheel is (probably) the most iconic part of any stationary steam engine and it is very important to get it to run true; achieving this demonstrates the engineer's care and attention to detail in their model engineering.

I was given a magnificent piece of phosphor bronze (it needs a display case in its own right) to make this part from. This material was lovely to machine and provides a fine golden lustre when polished (I could write poetry about this stuff). Though brass would work just as well, phosphor bronze will result in a more aesthetically pleasing model.

Having sold grandma and obtained your phosphor bronze, it's time to set to work on it. To start off you will need to find your hacksaw and get your muscles working, by cutting off a length of your chosen metal. It should ideally be quite a bit bigger (in both diameter and thickness) than the finished dimensions, as you will have to turn it down to size and it needs to be gripped in a lathe chuck.

You will also, inevitably, cut at a slight angle, when slicing the material to approximately the correct thickness and this fact needs to be taken into account when judging the cut. It is better to waste a little material (in machining off more thickness than might, ideally, have been the case) than to waste a large amount of material, by making a mistake with the initial cut.

"Be warned; these can cut at a slight angle and you would not want to ruin the lovely piece of metal that you sold grandma to obtain..."

PHOTO 6: Machining the flywheel for the oscillating engine on a Myford MLR7 lathe.

All photos and diagrams in this feature by Peter and Matthew Kenington

When I did this, it took me about half an hour but if you wanted to put your feet up and not do any work you could use a power hacksaw or a band saw (we have just achieved this level of luxury in our home workshop). But be warned; these can cut at a slight angle (particularly band saws) and you would not want to ruin the lovely piece of metal that you sold grandma to obtain! If in doubt, cut a piece of scrap wood first and judge the error based on that.

Machining the flywheel

Once you have had a rest and a cup of tea (an essential part of any model engineering project) it is time to head over to your lathe. I would recommend using a three-jaw chuck and a mid-size or larger lathe – a mini lathe won't cut it, quite literally. I used a Myford ML7 which I found was very capable for everything except the parting off (back to the hacksaw for this bit). The main issue (before I get letters) was the lack of availability of a suitably-long parting-tool blade at Hereford SME, at the time I needed it, and not the capability of the Myford.

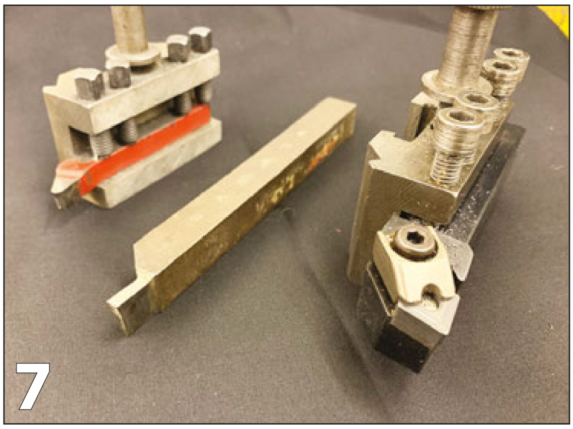
The trick to machining phosphor bronze (I have found) is to have a mid-range spindle speed, a few hundred rpm, and to take light cuts. Note: do not forget to tighten down your tool or your work will be ruined; a sad story, but one spotted in time – this is easy to forget when adding shim in the toolholder to set the correct tool height (see the panel on the next page).

Another point is to remember that the speed at which the lathe is running is the speed at the centre of your work, not on the outside; check your surface feet per minute, as you may find that you need to slow your lathe down. There is an article on Wikipedia which explains this quite well (https://en.wikipedia.org/wiki/Surface_feet_per_minute).

The first step it is to 'clean' the outside and end of the round bar by taking a series of light cuts using a standard left-hand turning tool (Photo 6). A tool ground for brass is ideal for turning phosphor bronze.

If you are not familiar with tool-grinding (and, as a beginner, this is highly likely to be the case), then there are a range of 'indexed' tools available very inexpensively these days (Photo 7). These incorporate a replaceable insert which is already shaped with the correct cutting angles.

The two main tools you will need in this project, a left-hand turning tool and a parting-off tool, are shown in



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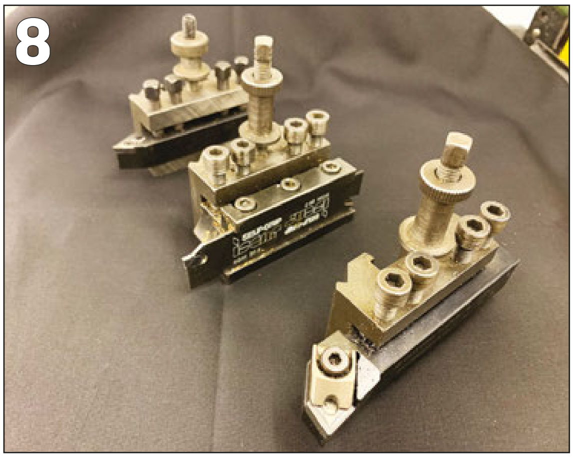

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Photo 8, together with a 'neutral' tool, which may also prove handy – as we will see shortly.

The end of the bar needs to be 'faced-off', in other words a cut needs to be taken across the end of the bar (or, more likely, multiple cuts). The aim here is to achieve a smooth, even, finish across the whole of the end face of the bar.

For the final cut (the 'finishing cut'), a little more care is needed in order to achieve a nice, smooth, finish. Firstly, ensure that this cut only removes a small amount of material. For example, if you need to remove 2mm in total, consider taking three 0.6mm cuts, followed by a 0.2mm finishing cut (most lathes should be capable of this severity of cuts).

If you have a beefier lathe, such as the Harrison M300 we have in our workshop, then fewer, deeper, cuts can be taken. The same principle applies, however: take a lighter cut as the finishing cut. In this case, since we are not yet at the stage of having to worry about precise dimensions, take cuts until the whole surface is shiny (indicating that all undulations, and any 'skew' in your hacksaw cut, have been removed). Finally, take the light 'finishing cut', as described below.

The second point needs a little practice – try to ensure that the tool does not stop in its lateral travel across the workpiece. This requires a little skill and dexterity (and two hands on the handwheel). The aim is for your second hand to start turning the handwheel before your first hand has run out of twisting ability, your first hand then taking over when your second hand is close to its rotational limit and so on. With a lifetime of practice, you will become quite good at this.

Why take so much trouble? The answer is that if the tool is allowed to pause at a point on the workpiece, it will leave a tiny score mark at that position. You will notice this mark and it will annoy you, being very obvious next to the beautifully-smooth finishes on either side. You can, of course, abrade this away with emery paper, but it is much better (and more accurate) not to have to do so.

Next, do the same on the outer surface of the bar – again, the aim is simply to achieve a uniform, smooth, surface, at this stage. The same hand-wheel technique is needed here.

Having achieved a uniform 'clean'

Setting tool heights on a lathe

It is important that the tip of a lathe tool is in vertical alignment with the centre of rotation of the lathe – too low and a parting-off tool (say) will not cut all of the way through the piece or a facing operation will result in a 'pimple' remaining, too high and no tool will cut correctly as the top of the tip on the tool will not be in contact with the material.

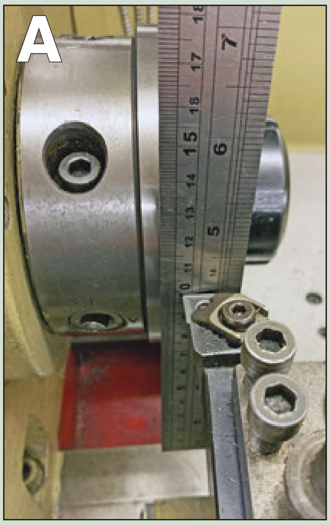
Fortunately, there is a simple way to do this, with the aid of a humble steel rule. This can be done on the lathe chuck (recommended if the unmachined workpiece is not circular) or the workpiece itself (acceptable if the workpiece is already round and merely needs reducing in diameter on the lathe). Photos A to D show the first method.

The tool height needs to be set such that when the ruler is lightly 'nipped' onto the workpiece or chuck by the tool (Photo A), it is exactly vertical. This is a near-magical technique – it is very simple to do, but very accurate.

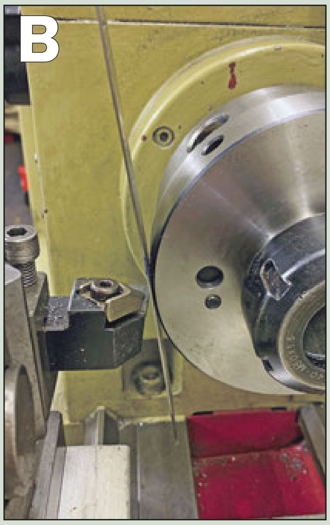
The height of the tool can either be adjusted using the adjustments available on the toolholder itself (for example if you are fortunate to have a Dickson-style toolholder, as is fitted to the Harrison shown in Photo B) or it can be adjusted by adding 'shim' (thin pieces of metal) underneath the tool, as needed, when mounting it in the toolholder (which is what I had to do on the Myford shown in Photo 6).

The great benefit of the Dickson style of toolholder is that once the tool-height has been set, it should never need re-adjusting (at least with an indexed tool – a ground tool may require minor re-adjustment after it has been re-ground/sharpened).

Note that in Photo A, the toolholder is (deliberately) not seated correctly – in this case it has been made 'too high', for illustrative purposes, simply by placing the adjustment collar on top of the clamp it is supposed to slot into. Needless to say, it should never be used in this position!

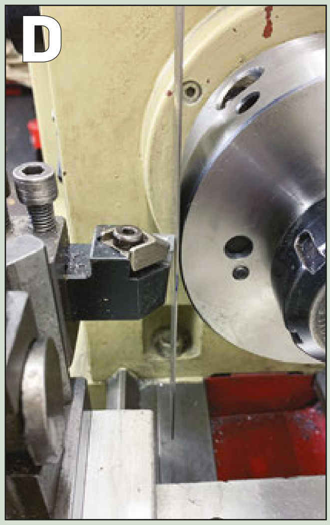


A: Position of the ruler and tool when setting the tool-height.



B: Setting tool height on Harrison M300 – here tool is too low.

C: Here tool is sloping towards chuck at top, showing it's too high.



D: Here the tool is just about right! (maybe a little high...)

finish, measure the outside diameter. If you are using callipers make sure they are exactly perpendicular to the machined outer face, and that the faces of the calliper blades are scrupulously clean, as neglecting either will lead to an inaccurate measurement (I am talking from experience here).

You are then ready to turn this down to the correct diameter (**Figure 3**). It is, of course, not necessary to apply a 'finishing cut' before turning down to the specified diameter, but it is good practice in learning and perfecting this aspect of machining.

Enhancements

You could leave out this next step out, but I think that the part looks a lot better with it – an indent in the face of the flywheel adds aesthetic interest to the finished model and is further, useful, lathe practice.

For machining the indent, you will need to change your tool; a reground parting-off tool will do the trick – you want something almost finger-like: narrow, with not too much depth but sufficient to provide strength.

An alternative is to use a 'neutral' turning tool (see Photo 8) – this is a simple option for a beginner (and one not yet comfortable with tool grinding!), but will result in sloped sides to the recess. This is not a problem, just an aesthetic difference from the prototype.

Don't forget to slow your lathe down, otherwise known as putting it in back gear, if you do not want chatter and the resulting poor finish. If you are still struggling, invert your ▶

PHOTO 7: Indexed (on right) and ground (at centre and left) lathe tools.

PHOTO 8: Lathe tools of type used in making the oscillating engine – left-hand turning tool (front), parting-off tool (centre) and neutral tool (rear).

FIGURE 3: General arrangement of flywheel (dimensions shown in mm).

FIGURE 4: Flywheel shaft and crank pin.

FIGURE 5: Flywheel shaft with under-cut on thread.

FIGURE 3
Reproduced approx full-size

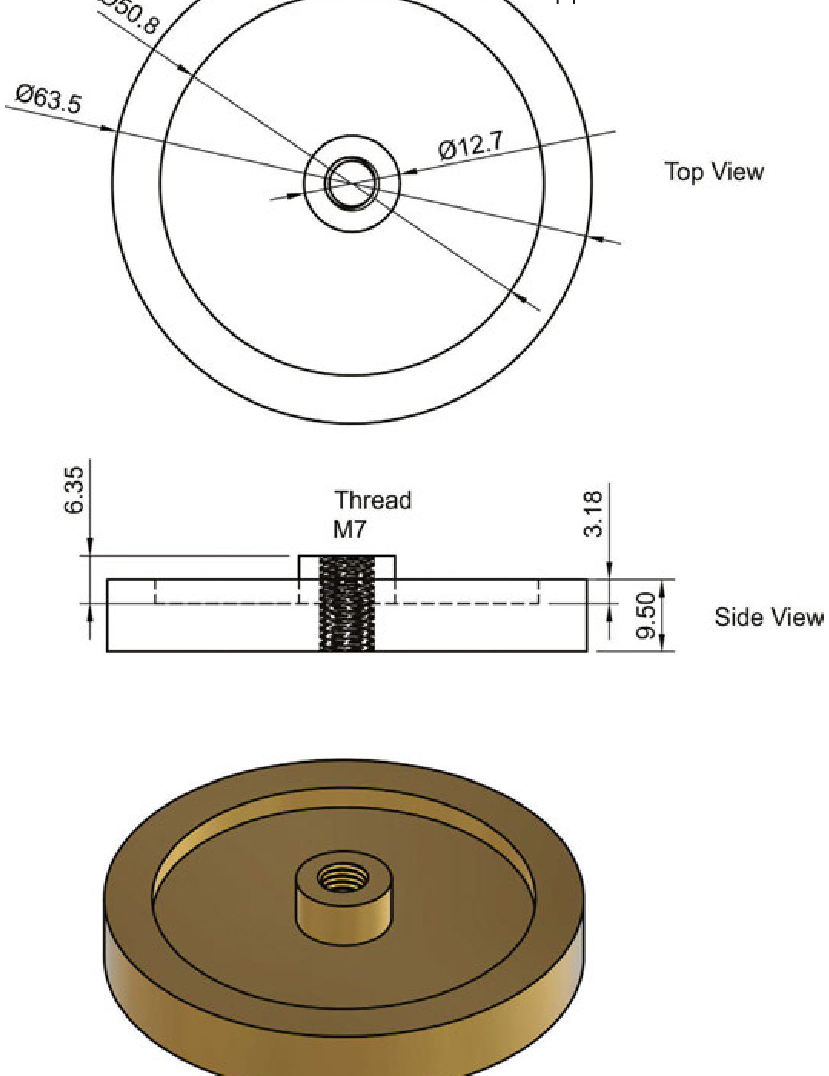


FIGURE 4
Reproduced approx twice full-size

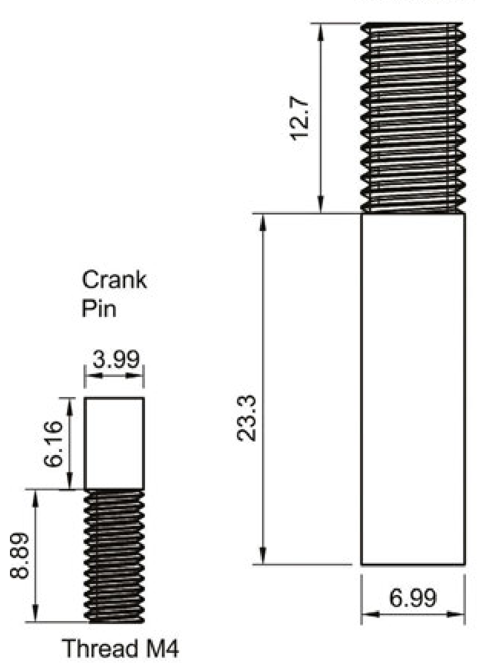


FIGURE 5
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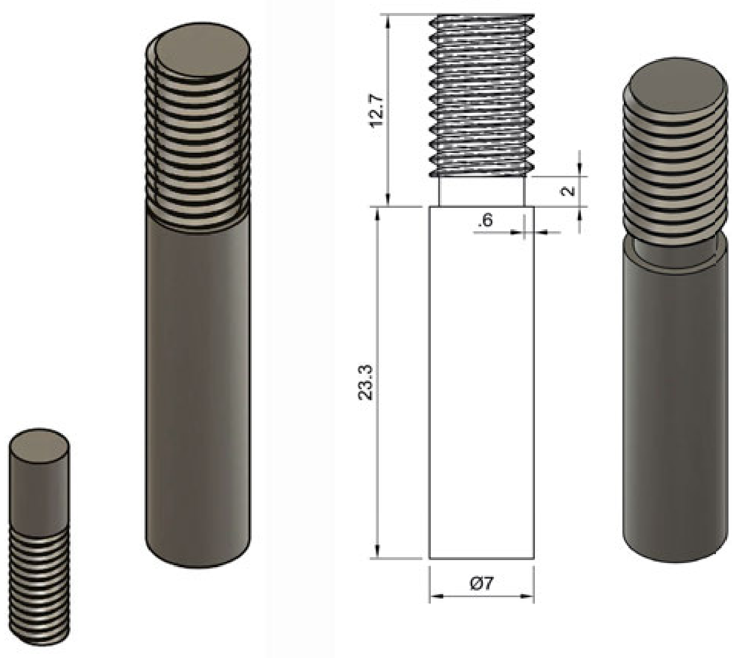

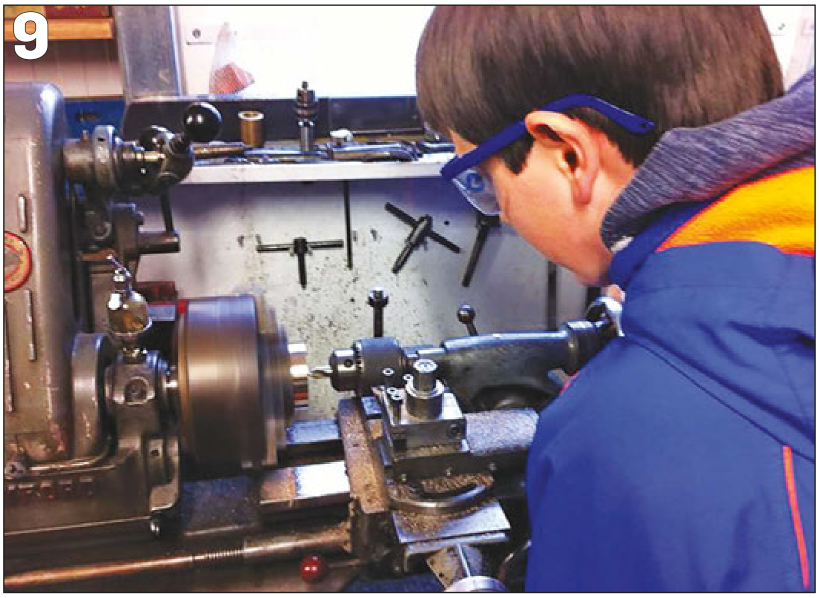

tool and move your toolholder to a rear tool-post, if your lathe supports such an option, then run your lathe in the opposite direction – the chatter should lessen or be eliminated.

The chatter lessens since when the lathe is running in the 'normal' direction the tool is trying to force the work and chuck up which results in chatter (if there is any play in the main bearing). If you run the lathe in the opposite direction and invert the tool in a rear tool-post (if you have this capability) the chuck and work will be forced down – a position they are already in, due to gravity. This improves the finish.

Finally, centre drill the flywheel, then drill it to 6.0mm diameter (**Photo 9**). Make sure your centre drill is quite a bit smaller than 6mm in the tip section, so you can use the chamfer on the larger diameter of the centre drill to help the larger twist-drill to locate. Finally, use a, preferably HSS (high-speed steel) tap to tap the hole to M7 for the flywheel shaft.

Don't forget to back-wind the tap and use plenty of oil or cutting compound so the tap does not catch and break. A turn or two forward, followed by half a turn or so backwards until the tap is free – you will feel the swarf 'break' – keep doing this all the way through. The use of a live centre in the lathe's tailstock is a handy way of ensuring that the tap is in line with the hole, if your tap-wrench has an indent in the rear for such a purpose (**Photo 10**).

The flywheel now needs parting-off from the remainder of the bar from which it was made. An indexed parting-off tool is ideal for this, as it will usually have a very long and uniformly narrow blade – something quite difficult to achieve by grinding. I didn't have this luxury at the time and so had to use a hacksaw.

Note that whilst the part can be held in the lathe chuck for this operation, resist the temptation to use a hacksaw as a 'poor-man's parting off tool', in other words with the lathe under power. This is quite dangerous, as it is easy to catch your fingers on the jaws of the lathe chuck and receive a very nasty injury! It is also easy for the saw to get caught by these same jaws; not a happy prospect.

If you use a parting-off tool, the finish may well be good enough to not require further machining, perhaps just some work with emery paper. If the hacksaw technique is adopted, the part will need returning to the chuck and facing-off with a left-hand turning tool. Spacers may be needed to ensure that the part runs true and sticks out beyond the chuck jaws – these spacers should be removed before starting the lathe (unless they are truly captive) – unedifying holes in the ceiling or, worse, the lathe operator, could otherwise result...

"Whilst the part can be held in the lathe chuck for this operation, resist the temptation to use a hacksaw as a 'poor-man's parting-off tool'..."

If you do need to turn the piece around, in order to face-off the reverse side, add some copper or brass shim to the chuck jaws in order to stop them from marking your beautifully-machined surface (see the September 2019 issue of **EIM** for details on how to make something suitable).

An alternative option is to make/use a mandrel – I have just used one in making the wheels for the tender on my current project, a 5-inch gauge Manor. However that is possibly a step too far for this beginner's series. If at all possible, avoid the use of a hacksaw and invest in a decent parting tool!

Now this part is complete, have a moment of quite reflection; you are one step closer to a steam engine!

Flywheel shaft

Silver steel rod was used for this part; this is the ideal material for the job as it is easier to machine than stainless, but it still has a good degree of rust resistance. If you go on to larger things in model engineering, then you will use this for axles and the like, so it is a good material to be familiar with.

As noted above, I used 'scrap' materials which were to hand and hence designed the engine to use a 7mm diameter silver-steel shaft which was lying around, thus saving me having to machine to this diameter – silver steel is usually supplied pre-ground and smoothed, to a good degree of precision. The diameter itself is not critical – anything between about 5 and 8mm could probably be made to work, with suitable modifications to the holes/screw threads in the adjoining components.

The first step is to set the shaft up in your lathe, again in a three-jaw chuck, but with only a small amount of 'stick-out' from the chuck. The end can then be faced-off using a normal left-hand turning tool, not forgetting to add a small chamfer to the edges/corner, as this helps the die to get seated on the work when it comes to cutting the M7 thread.

The shaft can then be threaded using an M7 die; you can use this either in a tailstock die holder or if you do not have this luxury, mount it in a normal die holder, push the tailstock up to the back of the die holder, then apply (gentle) force using the tail-stock

PHOTO 9: Centre drilling the flywheel.

PHOTO 10: Tap-wrenches with indents in the rear.

handwheel whilst rotating the chuck – using the chuck key is usually the easiest way of doing this (**Photo 11**). Finally, part off your work to the correct length (**Figure 4**) and then chamfer this end slightly (**Photo 12**).

The flywheel should now be assembled onto its shaft, to check that the threaded end of the shaft doesn't protrude from, or recess too far into, the flywheel boss. In the event of the former, the complete assembly can be put back into the lathe and the excess shaft trimmed with a conventional left-hand lathe tool. In the event of too much of a recess, then the cure is to thread the shaft a little further down its length. All being well, you should end up with something that looks like Photo 12 and **Photo 13**.

"The sharp corner created by the parting-off tool concentrates the stresses in that corner, potentially leading to cracking and failure..."

Thread concerns

There is a slight problem with the above method, which arises due to the shape of the die. In order to begin cutting a thread, a die must have a small taper to ensure that it sits centrally onto the shaft it is intended to thread and then only gently start to cut the thread. This end should obviously be used for the initial threading operation.

Once the thread has been cut to its end-point, the die can then be turned around and the opposite face now used, to ensure that the thread is cut to its full depth all the way to its end. Whilst this works well, in most cases, it is not perfect (although it was the method I used in the construction of my oscillating engine).

The problem is that the end of the thread is not very well defined and is often just visible where it enters the internally-threaded part (flywheel in this case) to which it must attach. This is not really obvious in Photo 12, but may be in some applications.

A better solution is to apply an undercut to the end of the thread, as shown in **Figure 5**, thereby giving the thread a clearly-defined endpoint, before the visible join between the flywheel centre-hole and the flywheel shaft. The flywheel will still sit at the same point on the thread/shaft, as it will come up against an unthreaded portion of the shaft, while the removal of 2mm of thread out of a total of 12.7mm will not impact the strength of the thread in any meaningful way, so there is no real downside to doing this.

This type of undercut is easy to achieve with a thin (2mm) parting-off tool, plunged to a just-sufficient depth to remove the thread entirely (a little extra depth is not a big issue). An even better approach is to arrange for the shaft to be thicker at the point where the shaft and flywheel abut, thereby creating a solid face against which to tighten the flywheel and a very well-defined end-point at which it can sit. This could simply be achieved by using an M6 thread, say, with the original 7mm diameter shaft. As I said, I didn't do this on the prototype and it still looks pretty good, this part being difficult to see anyway as it faces and lies close to the upright support. I don't think the judges noticed...

One point to note is that this approach can have a downside if it is applied to a wheel on an axle, say, which will be subject to large lateral forces (such as a train full of well-fed passengers). The diameter of the shaft has been reduced, thereby reducing its strength, and the sharp corner created by the parting-off tool concentrates the stresses in that corner, potentially leading to cracking and failure at this point. Neither of these is a concern in a small oscillating engine, however it is worth noting them for when you move on to more ambitious projects. EIM

■ Next month Matthew makes the crank and other components. Part 1 of this feature was published in last month's issue of EIM – you can download a digital back issue or order printed copies from www.world-of-railways.co.uk/store/back-issues/engineering-in-miniature or by calling 01778 392484.

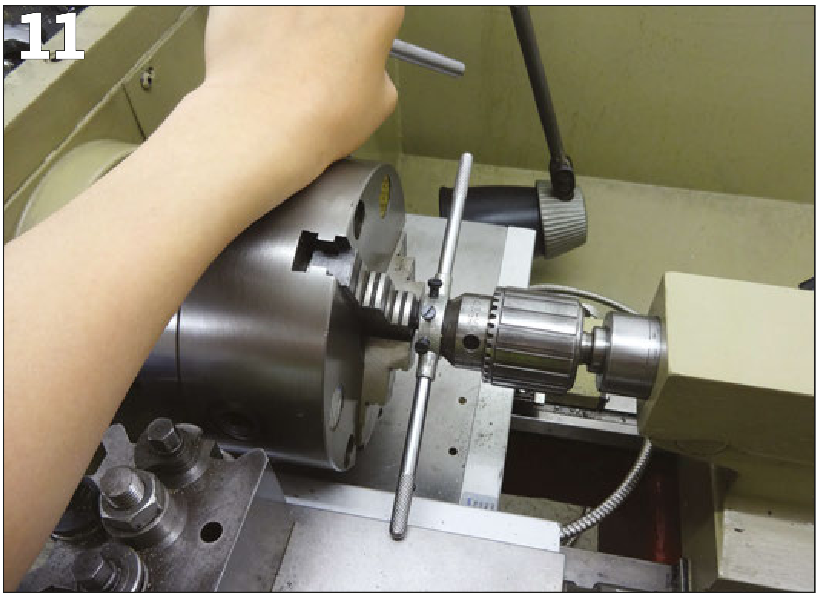

PHOTO 11: Threading the shaft, without using a tailstock die holder.

PHOTO 12: Rear of the flywheel and shaft – just a plane finish, which doesn't need to be perfect as it isn't seen (don't let on to the judges, though...).

PHOTO 13: The assembled flywheel and its shaft. Phosphor bronze really is beautiful stuff!

Powering Cottonopolis

Rodger describes how the expansion of the Lancashire cotton industry drove the development of more complex and efficient steam power for the mills.

BY **RODGER BRADLEY**

The century between 1790 and 1890 saw massive change in the way cloth, and especially cotton cloth, was spun and woven, driven – literally – by the technology uplift from the application of steam power.

In England's north west, Lancashire had been home to a textile industry for many years, individual weavers running what we today would call 'artisan' businesses. Lancashire's textile industry was not just based around cotton – indeed wool, silk, flax were the products of the water-driven industry in the western valleys and small towns of the Pennines.

The raw material, imported through ports such as Liverpool, was transported by the newly dug canals to the mill towns, including Accrington, Blackburn, Bolton, Burnley, Bury, Chorley, Oldham, Preston, Rochdale, Salford, and of course Manchester. The growth of the mills was supported by an equal growth in the supply chain, from iron foundries, to workshops making specialist gearing, ropes, steam engines and boilers, and all manner of related machinery.

As the 'Factory System' took hold during the last years of the 18th and early years of the 19th century the Lancashire mills grew in both number and size, and with it, an equal demand for more power, to produce ever greater quantities of textiles – especially cotton. By 1853 Lancashire was home to the greatest number of cotton mills in the world, and Manchester, the world's first industrial city, was awarded its title 'Cottonopolis' in 1854.

At the heart of this revolution, the innovators and pioneers were almost all Lancastrians – from Hargreaves (Oswaldtwistle), to Arkwright (Preston), Crompton (Bolton) and Kay (Bury) – and had been handloom weavers, yarn spinners, but closely allied to what was an industry driven by water. But those early inventions really benefited the handloom weavers, and it was not until the arrival of the power loom – accredited to Edmund Cartwright – that much greater changes took place.

The multi-floored mills of the Factory System provided the opportunity to have those power looms and multiple spindle spinning machines in one place. But they needed driving by a system of ropes, gears, belts and shafts to operate each of the many machines – step forward the coal burning boiler and rotating steam engine. Changes in steam engine design from simple vertical layouts and beam engines, to rotating machinery and reciprocating motion were critical to the industrial revolution that was taking place.

Manchester's Cottonopolis title remained firmly in place for the rest of the 19th century, and by the early 1890s, there were just under 1,800 cotton mills in Lancashire, including key locations such as Accrington, Bury, Burnley, Bolton, Manchester, Rochdale, Ramsbottom, Wigan, and many others. By the turn of the century all spinning and weaving was done with steam power, driving the looms and spinning machinery.

"At the pinnacle of the industry, more than 100,000 boilers were in daily use..."

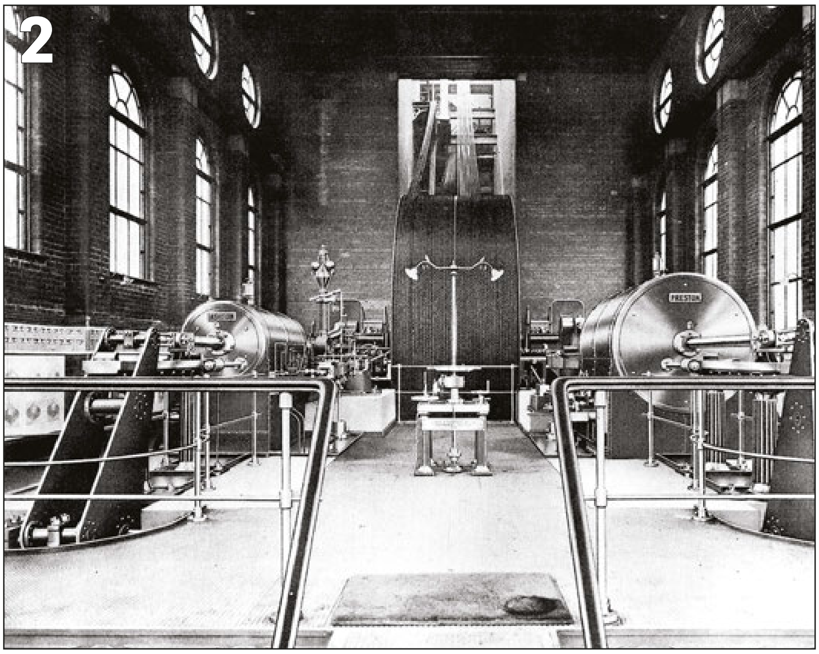

PHOTO 1: Tulketh Mill in Preston in 1984, a typical example of cotton mill architecture – the mill stands today, a major landmark alongside the main England-Scotland railway line, just north of the city.

PHOTO 2: Interior of the engine house at Tulketh Mill.

Photos: Preston Digital Archive

The Engine House

The engine house was the heart of the mill, and almost all of them were fitted with one or two double-flue Lancashire Boilers. This design was derived by William Fairbairn in 1844, and with two fire tubes provided a greater heating surface than the single-flue Cornish Boiler of Trevithick's design that had already been put to use in the mining industry. Alongside these steam producers were the engines that drove the line shafting across each of the floors, where spinning, roving, or weaving was carried out.

Sir William Fairbairn's treatise on *Mills and Millwork,* published in 1878, provided a detailed overview of the development of the mill machinery and the arrangement of factories, boilers, gearing, pulleys – from water wheels and turbines to steam engines. The segment on steam engines included descriptions of various designs and arrangements, from the simple beam engines to early horizontal and vertical machines, which enabled greater power output, especially when deployed with condensing equipment.

As a testament to the importance of steam engine, Fairbairn made the following observation:

"To the steam engine in the first place, and subsequently to the improved machinery and mill-work, we may attribute the present gigantic extent of our manufactures. The factory system, which has supplanted the cottage manufacture, has enlarged the resources of the country far beyond those of any former period. This island stands pre-eminent in productive industry; and it is a source of pride and gratification to find that these blessings, springing out of the application of physico-mechanical science, have been attained by the skill and indomitable perseverance of our own countrymen."

Lancashire engines

The majority of steam engines for the mills were built in Lancashire too, and the earliest of these came via a Scotsman named Alexander Petrie, who set up a foundry in Bury in 1792, later moving to Rochdale. There, as Alexander Petrie and Co., Ironfounders and Engineers, the company's 'Phoenix Works' built its first 8hp steam engine in 1819. In the following year another, rated at 20hp was constructed for a John Whitworth of Facit.

According to one report, in the early years of the 19th century there were only seven steam engines in use in and around Rochdale, and many of the early designs were beam engines, with single-acting cylinders. As time passed, the limitations of the approach were superseded by horizontal designs, capable of higher powers, with less physical footprint in the engine house.

Boiler Design

Wrought-iron plates were used in the various designs of boiler that were produced, until steel became widely available in the 1880s. This in turn allowed increased steam pressure in the boiler, which in turn provided greater power to be made available to drive the mill machinery. To provide a saleable product, the boiler makers also needed to show their designs and construction techniques that provided a cost-effective means of powering the steam engines that drove the mill machinery.

Some early designs of boiler included just one smoke tube – as in the Cornish boiler – from front to back, whilst others included a 'return flue', or the 'waggon top' design – the equivalent of the 'haystack' design used on early railway locomotives. But by far the most widely used design was the twin-tube Lancashire Boiler. The mills' boilers were manually fed with locally available coal as fuel – and compared to other designs these boilers made better use of the lower calorific value fuel from the Lancashire coal fields.

The Lancashire Boiler design remained the principal source of power for the cotton industry until electrification took over, and even then the many engineering companies and foundries in the country were still the main suppliers of drives and power systems. At the pinnacle of the industry, more than 100,000 boilers were in daily use, despite the arrival of more efficient multi-tube and Scotch Boilers.

Sometimes small detail design changes offered some of the best improvements, including feed water heating through the use of economisers, which together with the use of compounding and condensing for the mill engines allowed increased output and efficiency for the mills.

Perhaps the most famous of those early suppliers of boilers and steam engines for mill, mine and factory use was Boulton & Watt, but as the industry grew, many more names started to appear, some of which became globally renowned, including W and J Galloway & Sons, Anderton and Sons, Tinker, Shenton & Co, Oldham Boiler Works and Hick, Hargreaves and Co.

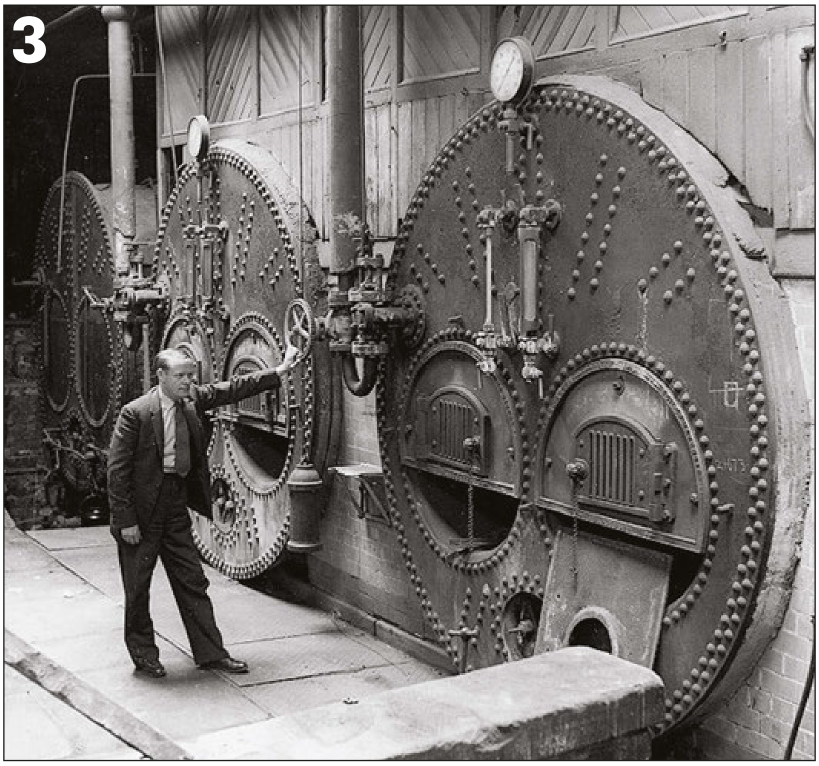

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PHOTO 3: Classic sharp end of the Lancashire boiler, showing two 'furnace tubes'. These three boiler were installed at Greenbank Mill, Preston, and photographed here just prior to demolition. They were manufactured by Fosters, Yates and Thom, Blackburn. *Photos: Preston Digital Archive*

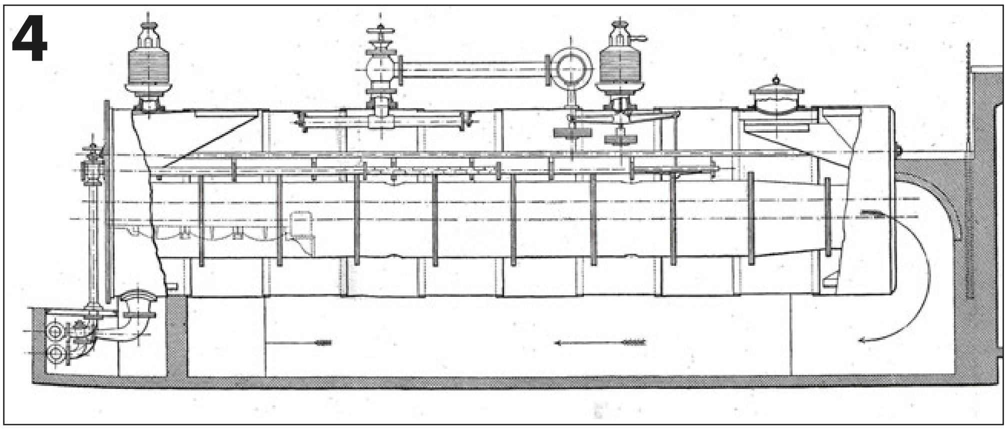

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PHOTO 4: Section through Lancashire boiler showing gas flow, and in dotted outline, firing grate at left-hand end. Steam collection and delivery to mill engines is through the top mounted valves. Also shown are safety valve and inspection hatch.

Drawing courtesy John Phillp, Northern Mill Engine Society

One typical boiler manufacturer was the Oldham Boiler Works Co., which had been in existence since 1814, and by the mid to late 1800s had become a major supplier. Hick, Hargreaves & Co., manufactured at the Soho Iron Works in Bolton – right in the heart of the cotton industry area. Another was Tinker, Shenton and Co of Hyde, whose product remains in use today – with only minor modifications – at the preserved Queen Street Mill in Burnley, where the first boiler was installed back in 1894.

In that same year, the Oldham Boiler Works Co supplied the boilers to the 'Lion Spinning Mill' at Royton. Today the Lion Mill is a Grade II listed building, and stands in Fitton Street, Royton. Directly behind it is the site of the former 'Bee Mill', now demolished and replaced with a range of small businesses.

"Almost every mill town in Lancashire had its own engine maker..."

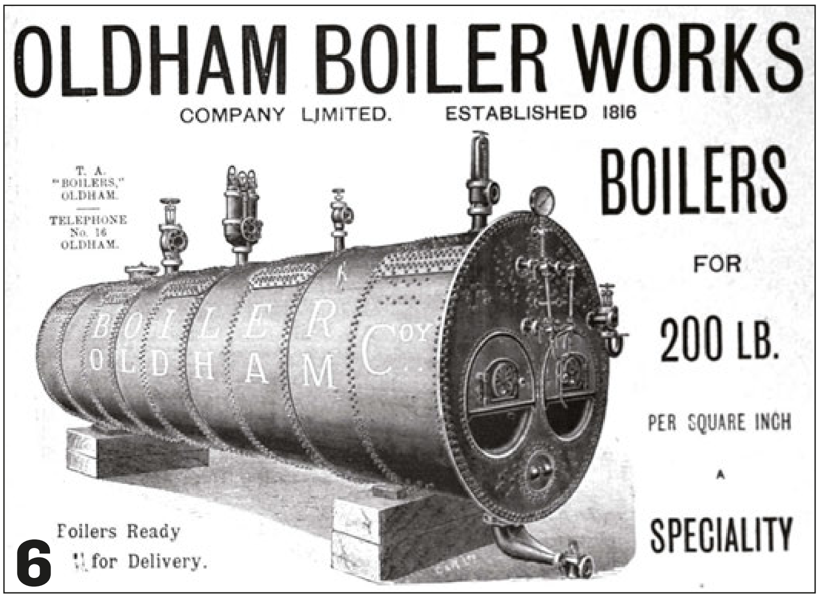


PHOTO 5/6: Typical examples of advertising by the major manufacturers of boilers.

PHOTO 7: Twin beam engine from Crossfield Mill, Wardle – only surviving textile mill example. During its life this engine was rebuilt with one new cylinder for higher pressure and subsequently ran as a single. Despite having two cylinders of different sizes it was never run as a compound. *Photo: Chris Allen (cc-by-sa/2.0)*

An important development in boiler design was the inclusion by W and J Galloway of 'Galloway Tubes', which were effectively water tubes that 'passed through' the two furnace tubes to increase the heating surface of the boiler. Galloway manufactured all manner of machines, from lifting jacks, to shears, non-condensing steam engines to, of course, Galloway Boilers. The company was based in Manchester, and survived until 1932, almost 100 years, when all the records, drawings and patterns were purchased by Hick, Hargreaves & Co. – another major firm based in Bolton.

Steam Engines

The stationary steam mill engine evolved from the beam engine of around 1790, but by 1890, high-speed horizontal and vertical types were in widespread use, persisting until after the end of World War 2. It has been said that almost every mill town in Lancashire had its corresponding engine maker, and upwards of 10,000 steam engines were in use across the region until the arrival of electricity.

Many different designs were adopted – from the beam engine, with its complex supporting pedestals (entablature), to a single horizontal cast iron bedplate, supporting a single cylinder to drive the flywheel. The layouts developed further to include inverted engines with cylinders that were essentially upside down, those in diagonal form and 'table' engines, to the more compact, 'enclosed' designs. All could be found in the engine houses of Lancashire's cotton mills.

The first beam engines were simple expansion designs, but at least one example can be found of a compound arrangement – the Cellarsclough Mill engine now preserved at the Bolton Steam Museum. This was based on an 1845 patent that doubled the power output by including a high-pressure cylinder between the flywheel crank and the centre pivot of the beam. The original cylinder then became the low-pressure cylinder.

Unsurprisingly Boulton & Watt was amongst the first makers of steam engines as well as boilers, but these were horizontal, reciprocating beam engine designs, providing the prime movers for most mills until around 1855-1860.

From around 1860 onwards the simple-expansion engine emerged, horizontally laid out and driving the attached flywheel from the crosshead, with an arrangement of links and levers to open and close the inlet and exhaust ports. Boulton & Watt also built the early compound beam engines, based on William

McNaught's 1845 patent. One of the benefits of McNaught's idea was that it could be retrofitted to existing simple-expansion beam engines.

For stationary engine use, the early simple-expansion designs needed to change, as increased power output and economy of operation were demanded by the mills, so designs turned to compounding. The obvious benefit was to use the steam twice, first under high pressure, which was then exhausted into a larger diameter lower pressure cylinder to employ the remaining energy in the steam. Numerous variations of the compound design were supplied, through triple and even quadruple expansion types, and either horizontal, vertical, or inverted vertical examples.

The difference in power demand depended mostly on whether spinning or weaving was being carried out. In a spinning mill, engines of 1,800 to 2,000hp would be needed, whilst a weaving shed might only need say 200 to 500hp – though these engines were still of a fair size.

When compounding arrived, further operational efficiencies were gained, along with greater power output, but although tandem compounds, with the cylinders in line on one side, provided some improvement, a smoother drive was possible with the cylinders on either side of the flywheel, the cross-compound. A variation of the design was the double cross-compound – the High Pressure (HP) and Low Pressure (LP) cylinders were in line (tandem), on the same engine bedplate, and another pair of HP and LP cylinders were mounted on the other side of the flywheel.

Valve gear

Controlling the engine in the early days involved 'gab' gear, and slip eccentrics, which could be engaged or disengaged by the operator to enable the steam and exhaust ports in the steam chest to be opened using a D-shaped block – the slide valve – on the steam chest. This type of valve gear was also adopted on the earliest steam locomotives and was improved by Stephenson to become the valve gear which carries his name today. But probably the most innovative development to operate the engine itself was the Corliss valve gear.

This was patented by one George Henry Corliss, an American who, in 1849 developed a design using rocking cylindrical valves – four to each cylinder – to allow steam to enter and exit the cylinder. It provided a greater degree of expansive operation and efficiency, and was soon adopted for stationary mill engines.

It was not until the 1867 Paris Exposition, however, that the Corliss Engine began to take a hold, and the British makers started to build them in greater numbers. Sometimes the Corliss valves were only fitted to the HP cylinders, with either slide or piston valves used on the LP side. Changes to the engine governor, to allow more responsive control of the inlet and exhaust, and the demand for higher-power engines was driven by the enormous growth in the cotton industry in particular.

Engine makers, as with boiler makers were many and varied, and some foundries and engineering works supplied everything from castings and gears to forged items, boilers, and complete steam engines. Names included J. and W. McNaught, J & E Wood, John Musgrave & Sons, Scott and Hodgson, Burnley Ironworks Co, Joseph Foster and Sons and W Roberts & Sons, some of which became globally renowned. The principal boiler makers became equally dominant in supplying steam engines for the mills, in particular Boulton & Watt and Hick, Hargreaves and Co.

"There was the clear danger of flat belts slipping, and some were retro-fitted with a layer of cork to try and prevent this happening..."

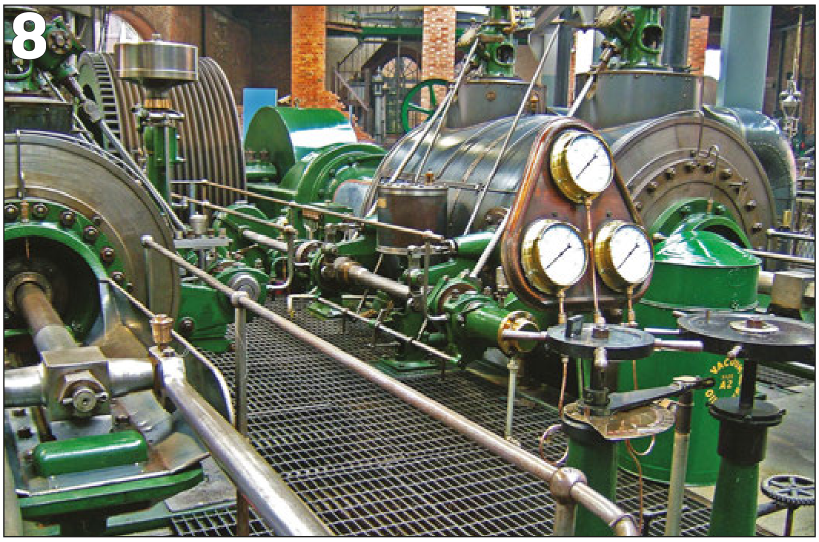


PHOTO 8: The last steam engine built to power a mill was appropriately produced by W & J Galloway & Sons in Manchester. This 600hp, cross-compound horizontal condensing engine for Elm Street Mill, Burnley, is now displayed in the Manchester Museum of Science & Industry (MOSI)

Power transfer

The next step in the mill's production process was of course to transfer the power generated to the spinning machines or looms. In the early days this was achieved by attaching a bevel gear to the mill wheel – in water powered mills – and linked to a vertical shaft reaching up the two, three or four floors of the building. At each floor a geared connection was made to horizontal line shafting, running the length of the floor, and with flat leather belts attached between the wheels mounted on the line shafts and the spinning machine or weaving loom.

Clearly the vertical shafting could also be used with bevel reduction gears attached to the steam engine's flywheel, but the wear and heat generated on the lowest part of the vertical shafting would have been enormous, and it was inefficient. An alternative arrangement appearing from around 1870 was to drive the line shafting through ropes – made of cotton of course.

Since the mills now possessed much more efficient and powerful ▶

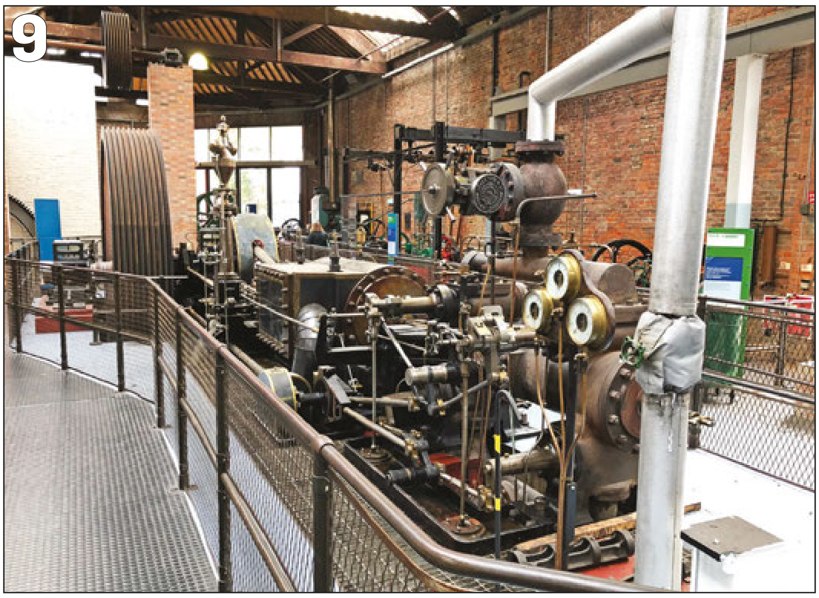


PHOTO 9: McNaught's of Rochdale tandem compound condensing engine. Grooved rope wheel is visible to rear. This example from Firgrove Mill is also preserved at MOSI in Manchester.

Photos: RPB Collection

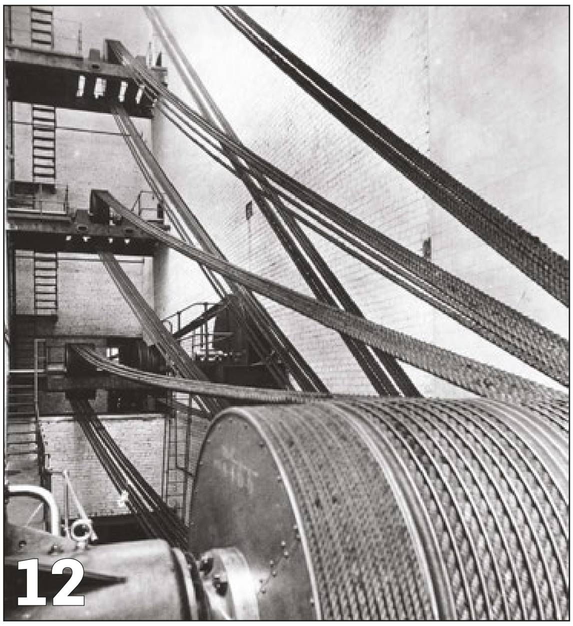
PHOTO 10: To increase the power output of an early beam engine, William McNaught introduced a second high pressure cylinder fitted at the crankshaft end. This modification was made to the Cellarsclough Mill engine, and the forerunner of true compounding. This McNaught beam engine is preserved in the extensive collection at the Bolton Steam Museum.

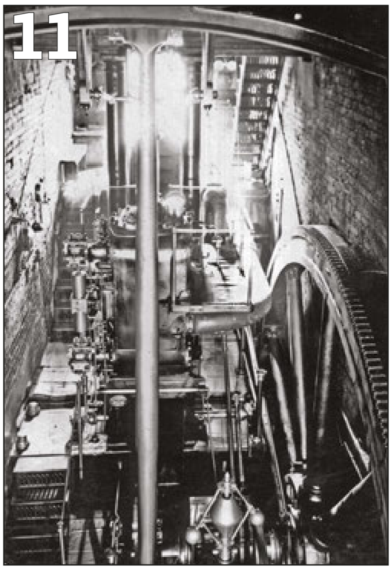
PHOTO 11: The engine at Holme Bank mill was installed in a very confined space as this view shows.

PHOTO 12: The rope race was the standard way of delivering power to the various floors in the mill, the ropes connecting with horizontal line shafting across each level. This example is from the Elk Mill in Royton, the flywheel in driven by a steam turbine.

PHOTO 13: 1500hp Scott & Hodgson engine from the Dee Mill at Shaw, Oldham. Its owners in 1968, Courtaulds, were keen to see the engine preserved, but sadly it never was.

Photos courtesy John Phillp, Northern Mill Engine Society





steam engines, getting the drive to the individual floors was achieved by providing a 'vee' grooved engine flywheel, to which the ropes were attached. Via the 'rope race', the power was transmitted to the horizontal line shafts on each floor.

This arrangement remained the standard method for many years, and of course, there were numerous specialist rope makers in the Lancashire mill towns. A 2-inch diameter rope could transmit between 40 and 50hp, and a 40-grooved flywheel would be fitted to an 1,800hp engine.

No belt and braces

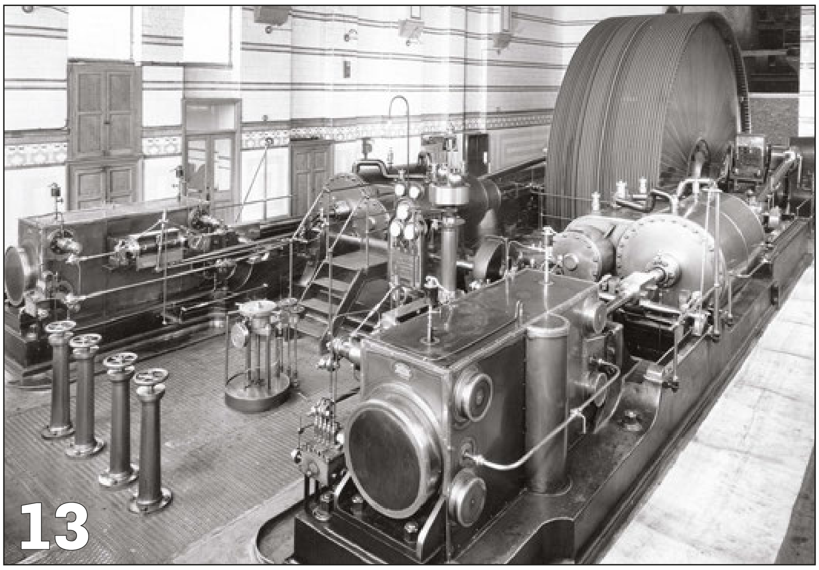
Some work was undertaken for a short time using flat belts with a composite or wide steel plate, but this did not see widespread use in the cotton mills. There was the clear danger of belts slipping, and where these flat belt drives were used, some were retro-fitted with a layer of cork to try and prevent this happening. Rope drives were reliable and were the industry-standard transmission – at least until electricity arrived.

The stationary steam engines were undoubtedly the beating heart of the mills of Lancashire for almost a century, and reinforced Manchester's title of 'Cottonopolis' for so long. In the mid-1800s the Lancashire cotton industry contributed some 40 per cent of the British economy, and Oldham and Bolton alone had more spinning capacity in their mills than the rest of the world combined.

Inevitably the decline eventually came, and it began in the 1930s. In, the post-World War 2 period the lack of investment and the arrival of man-made fabrics took their toll. Acquisitions, consolidation, mergers and cheap imports from the rest of the world saw the commercial demise of the Lancashire mill industry by the end of the 1960s.

Thanks to the efforts of many individuals and groups, and some far-sighted local and national organisations, today we can still see these amazing pieces of engineering design in museums, including many in operation. Numerous examples of the simple, compound, cross-compound, multi-cylinder horizontal, vertical enclosed and the machinery they drove have been preserved. These include – of course – working Lancashire boilers.

Many of these mill engine designs lend themselves well to the creative activity of our home workshops, and many models have been made in the past. Some, even the complex, compound double beam engines would make a great project to occupy the next year perhaps as we face spending even more time in our home workshops. I remember back at school (a fair few years ago!), when I did metalwork, our teacher offered us the opportunity to work on a model beam engine – a kit of castings by Stuart Turner I believe. Alas, I left school before the project was complete – maybe I should start again.... EIM



A change is as good as...

A find at the back of the workshop causes some head scratching for our Technical Editor...

BY **HARRY BILLMORE**

During the big tidy up of the workshop at the Fairbourne Railway that followed my appointment last Autumn as the 12¼-inch gauge mid-Wales line's engineer, I discovered tucked away at the back of a shelf, a quick-change tool post – complete with its central pivot pin and holding down bolt.

Handily it is a Colchester model, so assuming it would be a nice quick swap for the tool post on the smaller of the two Colchester lathes we have in the workshop, I took the existing one off.

At this point I discovered a completely different attachment method on the lathe, with sprung ball indents for locating the toolpost parallel and a couple of pegs too, along with a much wider base and a quarter-turn locking mechanism that absolutely would not fit the quick-change toolpost.

So having sat back for a while and compared the two, I eventually decided that the advantages of the quick-change toolpost outweighed the niceties of the old one, and figured out a way of attaching it.

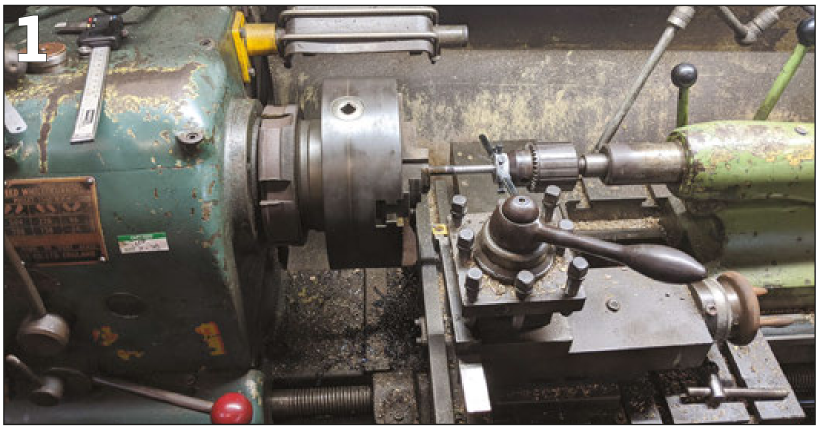
The first thing I did was to strip the cross slide off the lathe – this gave me access to the underside and thus allowed me to remove the mechanism for the quarter-turn lock and the sprung-loaded indents.

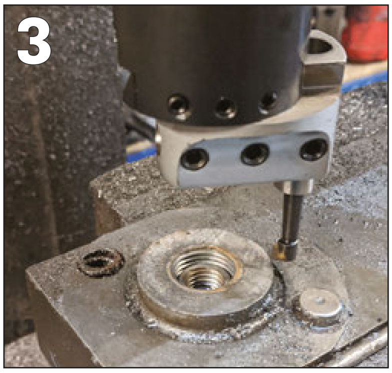
Tough customer

This operation also released the vertical pin that the handle attached to. My original intention was to modify this setup to accept the vertical pin of the replacement tool post, however it turned out to be extremely hard material.

There are a few ways around such problems, and the way I went was to heat the pin to cherry red and then to let it cool down very slowly, wrapped up in heatproof blankets. This tempered it enough for me to machine and tap a hole down the centre, this hole matching the threaded end of the new toolpost's centre pin.

I then mounted the cross slide into the mill and used a face cutter to take the height to the centre boss down to match the recess in the new toolpost's base. The next step was to clock up on the boss to centre it, and using a boring head, to machine the outer diameter to match.





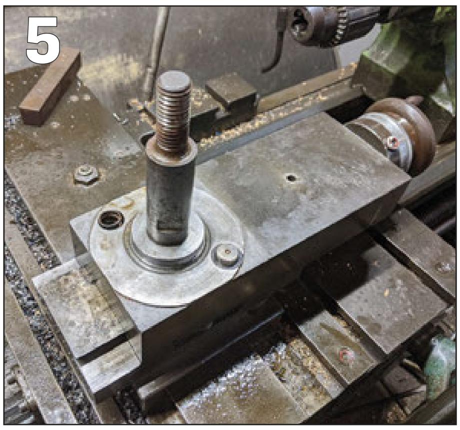


PHOTO 1: The old toolpost, which was functional but a pain when changing tools regularly.

PHOTO 2: A much better replacement – the quick change toolpost pictured in use.

PHOTO 3: Using boring head to machine outer diameter of base. Note modified original pin in centre of bore.

PHOTO 4: First test fit of new vertical pin to ensure correct height. Remains of spring indent top left. Pin at bottom right is sprung loaded which helps when turning the toolpost.

PHOTO 5: Completed modification back on lathe.

All photos by the author

All that remained was a simple assembly job, with some Loctite being used to secure the threaded adapter in the base.

As a result of a little work I now have available a quick-change tool post on a very nice lathe, which has already proved its worth in the many varied operations we carry out while maintaining the 6-inch scale stock on the line. EIM

■ For Harry's latest Fairbourne challenges see page 32

A Morse Taper Tapping Tool

Geoff describes another simple-to-make and highly useful workshop addition.

BY **GEOFF BALL**

Here is a little weekend project which creates a most useful tool. I made mine in 1996 and it has been in use very frequently ever since, in fact I would not like to be without it. Its most obvious use is in the lathe but I also use it in the pillar drill and in my mini milling machine.

The basis of the construction is a number two Morse Taper shank. Mine came from a basket of old tools at an antique (bric-a-brac rubbish) shop. The donor drill had obviously had a hard life, the working end was very short and the web of the drill was very thick. Reclamation attempts on an off-hand grinder had not had the desired effect and so it had ended up where I found it.

The shank was in quite good condition with only minor bruising which was easily stoned out. The drill shank close to the Morse Taper was soft and so readily sawn off.

The other main item of course is the drill chuck and here it is important that it has a screwed socket, not a Jacobs Taper. I have several small drill chucks with screwed sockets and they are all threaded 5/16-inch UNF.

Construction

We start construction with the handwheel, I made mine in aluminium and after many years of use I think that, due to its lower mass and therefore inertia, there is a better 'feel' when tapping very small holes. I used it to tap six 10BA holes in ¼-inch thick gauge plate from which I made the two cam rings for a radial i/c engine and I had no breakages.

Set a piece of 1¾-inch diameter material to run true in a four-jaw chuck, with sufficient protruding to enable a length of ¾-inch to be parted off (ultimately). Take a very light cut to just clean up the outside diameter and knurl about a ¾-inch length.

Next machine what will become Face A, ensuring that the ¾-inch diameter face has a good finish. Centre drill (BS 3), follow by a 7mm diameter drill to a depth of about an inch – a bit wasteful, but necessary to ensure a fully formed thread for the final thickness of ⅝-inch.

Tap the hole 5/16-inch UNF, supporting the tap with a centre in the tailstock and making sure that contact with the centre is not lost throughout. Finally part-off to 0.7-inch for finishing later.

The next item to make is the

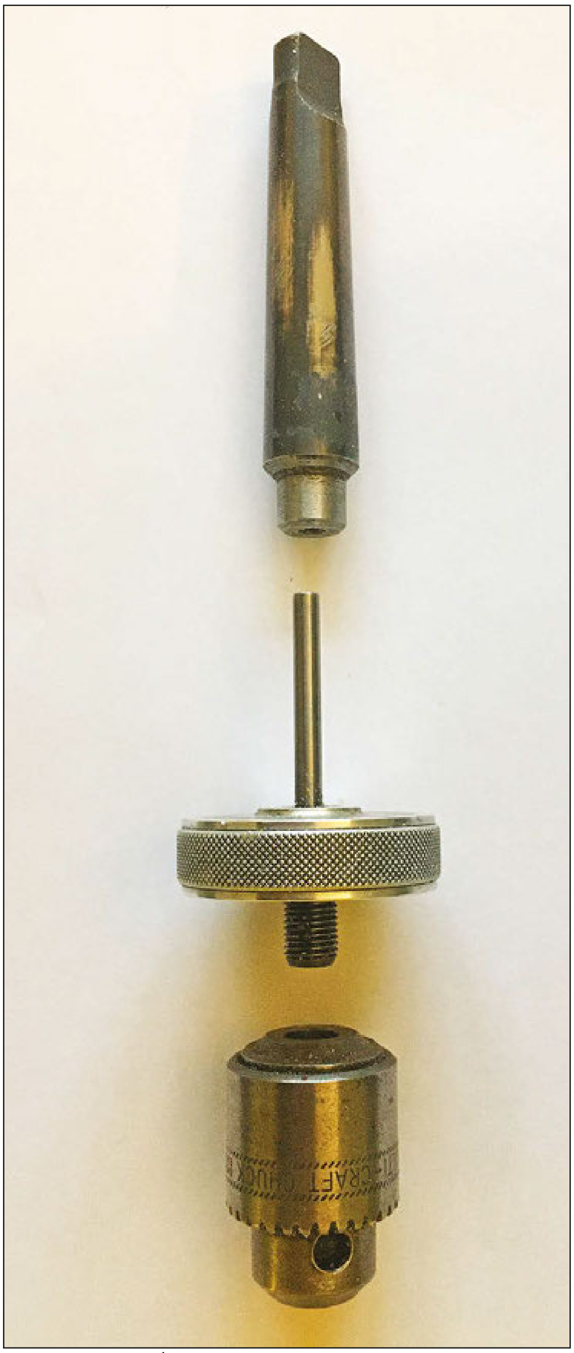
threaded stub, for this I used a 5/16-inch UNF cap-head screw. These are made from high-tensile steel and have rolled threads of excellent quality. As a bonus the material machines beautifully.

Cut off a threaded length of 1¼-inch. Dress the burr from the cut end for safety, but there is no need to machine it – yet. Clean it with methylated spirits or wash it with washing-up liquid.

Screw the original bolt end of the threaded stub into the handwheel from the unfinished side (what will be Face B) to a penetration of ½-inch, in other words still underflush on the finished side (Face A). Coat the remaining protruding threads with high-strength anaerobic adhesive and screw it into the handwheel to give a protrusion from Face A of ½-inch. Set aside to cure.

Whilst the handwheel assembly is curing, the Morse Taper arbour can be modified. If it is to be made from a salvaged drill, then the first job is to cut off the drill section.

The unknown bit is knowing where the transition from the hard



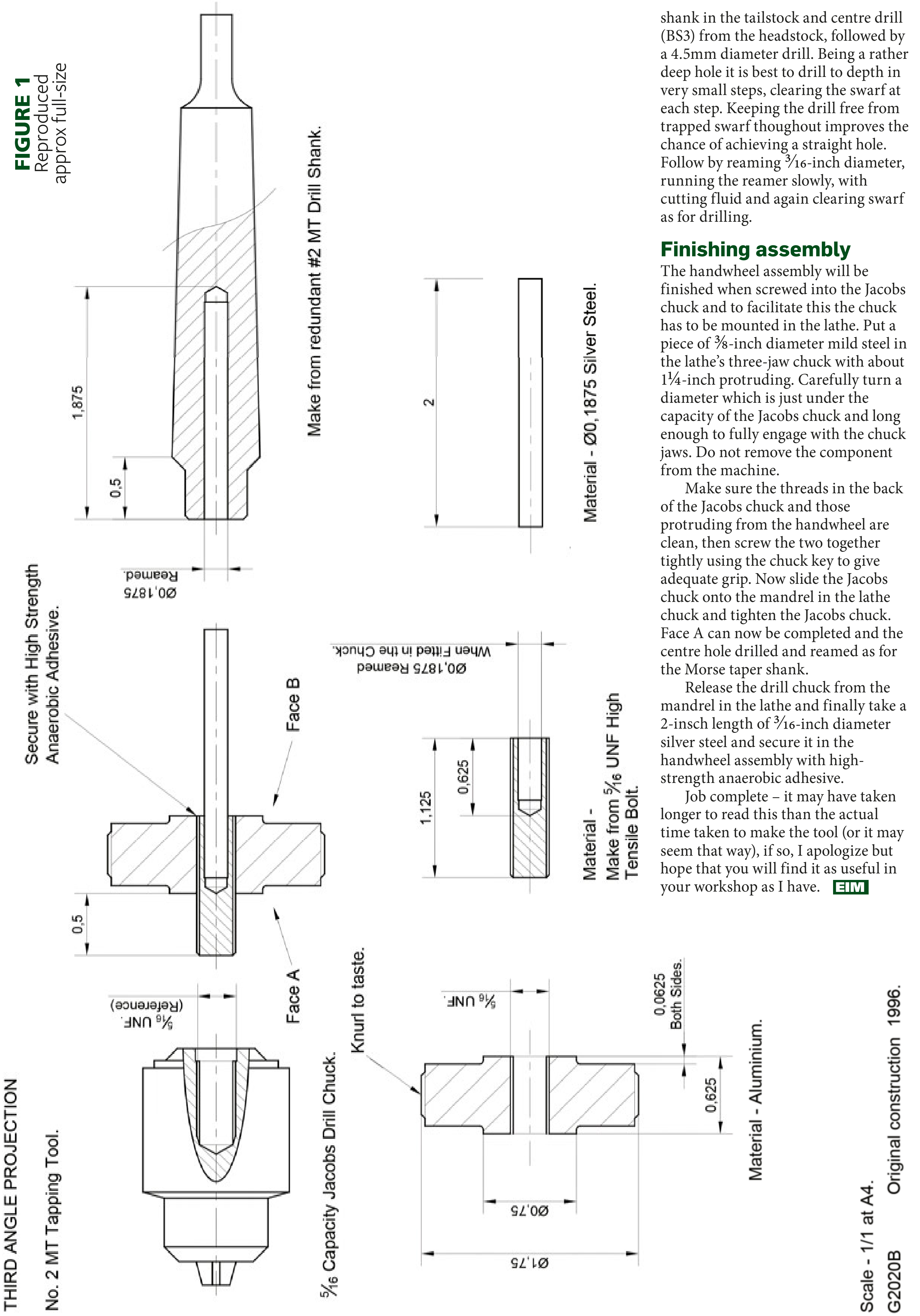
"Due to its lower mass and therefore inertia, there is a better 'feel' when tapping very small holes..."

drill shank to the machinable taper shank occurs, this is most easily established using the corner of a file (my taper shank came from a 9/16-inch diameter drill and the 'soft' section extended about ⅝ths of an inch from the top of the Morse taper).

Cut off the drill with a hacksaw leaving a short parallel section. Mount the Morse taper shank in the headstock spindle taper and clean up the sawn end (the ½-inch shown on the drawing is purely arbitrary – it happens to be what mine is).

Next mount the Morse taper

FIGURE 1 Reproduced approx full-size



shank in the tailstock and centre drill (BS3) from the headstock, followed by a 4.5mm diameter drill. Being a rather deep hole it is best to drill to depth in very small steps, clearing the swarf at each step. Keeping the drill free from trapped swarf thoughout improves the chance of achieving a straight hole. Follow by reaming 3⁄16-inch diameter, running the reamer slowly, with cutting fluid and again clearing swarf as for drilling.

Finishing assembly

The handwheel assembly will be finished when screwed into the Jacobs chuck and to facilitate this the chuck has to be mounted in the lathe. Put a piece of 3⁄8-inch diameter mild steel in the lathe's three-jaw chuck with about 1¼-inch protruding. Carefully turn a diameter which is just under the capacity of the Jacobs chuck and long enough to fully engage with the chuck jaws. Do not remove the component from the machine.

Make sure the threads in the back of the Jacobs chuck and those protruding from the handwheel are clean, then screw the two together tightly using the chuck key to give adequate grip. Now slide the Jacobs chuck onto the mandrel in the lathe chuck and tighten the Jacobs chuck. Face A can now be completed and the centre hole drilled and reamed as for the Morse taper shank.

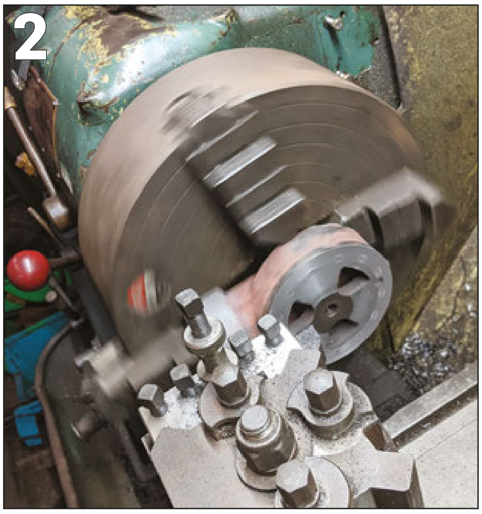
Release the drill chuck from the mandrel in the lathe and finally take a 2-insch length of 3⁄16-inch diameter silver steel and secure it in the handwheel assembly with high-strength anaerobic adhesive.

Job complete – it may have taken longer to read this than the actual time taken to make the tool (or it may seem that way), if so, I apologize but hope that you will find it as useful in your workshop as I have. EIM

Regulator refurbishment

Maintenance of a 6-inch scale go-valve occupies our resident engineer in this month's look behind the shed door at the Fairbourne Railway.

BY **HARRY BILLMORE**



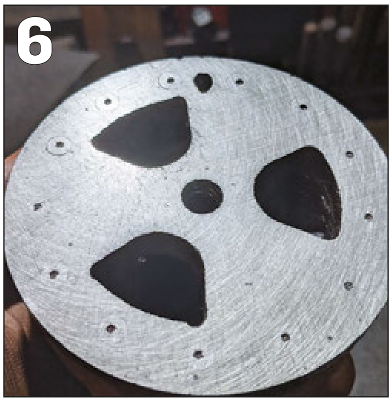


PHOTO 1: Start – bronze moving section of regulator as taken off boiler.

PHOTO 2: Turning casting face, only skim needed as shown by original face in centre.

PHOTO 3: Polishing casting face using coarse Wet and Dry on surface plate.

PHOTO 4: Results of coarse paper, note slight chatter where tool tip caught steel fasteners.

PHOTO 5: More time on coarse Wet and Dry improves surface.

PHOTO 6: Finish with coarse Wet and Dry.

PHOTO 7: Fine Wet and Dry used to polish to even finer finish.

PHOTO 8: Skim across bronze section turning face to speed up finishing.

The last few weeks in the lockdown-induced quiet surroundings of the Fairbourne Railway workshop have seen me mainly focusing on the continuing 10-year overhaul of our Darjeeling style 0-4-0ST 'Sherpa', and after disassembling the boiler and its internals, it was time to take a good look at the regulator.

Checking the maintenance records there had been no reports of a leaky regulator from the drivers over the past season so I wasn't expecting anything too bad, and this was confirmed after I stripped the regulator down fully – neither of the mating faces were particularly scored or pitted which was a good sign. There were just the usual wear marks from use, however with the regulator out of the boiler I took the opportunity to reface it and lap it in to hopefully give another 10 years of trouble-free use.

The design is a nice simple rotating disc regulator, with three teardrop ports spaced equally around the mating face, giving nice proportional control. There is a replaceable bronze insert in the moving half and the stationary section is a piece of cast iron, with a replaceable mating face too.

I started the job by setting up the stationary section in the four-jaw chuck of the lathe and faced across the sealing face of the regulator – this removed the little bit of pitting and grooving that had occurred.

Figure of eight

I then went over to the surface plate and with the usual figure-of-eight motion on some Wet and Dry paper, polished the machining marks out of the cast iron. Using a figure-eight motion prevents any bias occurring in the polishing, wearing down one side faster than another.

Unfortunately the countersunk screws that are used to hold the replaceable face on the valve are at the surface of the cast iron. Since these are harder than the iron they will wear the bronze more, but this shouldn't be an issue as it should simply wear a circular section of the bronze and not between any of the port faces.

To get an idea of how much material I would need to take off the bronze face, I quickly rubbed this over on the surface table as well and you can see the results in the pictures. This necessitated making a couple of passes on the lathe before it was back to the surface table for final finishing.

The regulator was then reassembled, remembering to put PTFE tape on the central pivot to prevent leaks as it goes between the steam space of the boiler and the regulator J-pipe. I tensioned the spring to ensure it held the faces together but still allowed for nice easy operation.

I then re-assembled this onto the components of the J-pipe that sits in the dome and set it aside until the boiler has been re-tubed.

Regulator gland

When I took the regulator gland off Sherpa, I discovered that it was past its best, with a corroded bore that had started to mark the stainless regulator rod, and a corroded end which squeezed the regulator gland packing out around the gland rather then compacting it to seal on the regulator rod.

All of this encouraged me to replace the gland, and to replace it with an SAE660 bronze one at that. Unfortunately we did not have any castings lying around for this gland so it would have to be machined from solid and again I ran into a problem – the only stock material we had that was big enough to machine the bolting flange from was not thick enough to machine the full length of the gland. As a result I was forced to fabricate the gland from two pieces.

The first task was to machine the centre section that the regulator rod runs through. I turned the outer diameter to fit into the gland housing before boring out the bore to be a good sliding fit on the regulator rod.

I machined the face that compresses the gland with a taper on, to help compress the packing material onto the regulator rod. Once this was complete, I turned it around and machined the main diameter down to 10mm bigger than the cored section of the large diameter bronze stock.

Safety step

I then machined a step into the front face of this so that if the braze ever did fail, the centre section that has the pressure acting on it would be held in place by the matching step on the outer bolt flange.

After the inner section was machined to size, including putting weld preps on the outer facing surfaces, I put the larger piece of bronze into the chuck, faced it off and then bored the middle to fit around the centre section, including the emergency step.

I couldn't do any more machining to this piece as it was too thin to turn ▶

PHOTO 9: First quick rub on coarse Wet and Dry reveals high spots.

PHOTO 10: More work on surface table shows deeper scores accross sealing face.

PHOTO 11: Back to surface plate to finish face – tool tip has polished a little, not a worry when hand finishing to be done after.

PHOTO 12: Final finish achieved.

PHOTO 13: The regulator reassembled and mounted back on upright section of J pipe.

PHOTO 14: Comparing the diameters of two pieces of bronze available to make new regulator gland. The upper one will form the bolting flange.

PHOTO 15: After parting off bulk of waste material from centre section.

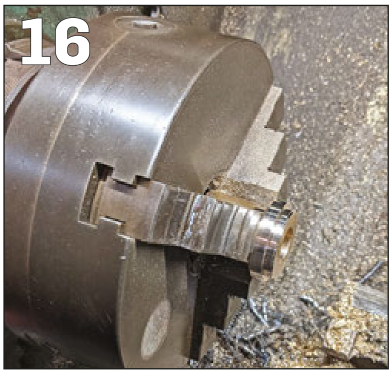


PHOTO 16: Machining a step in to take pressure in case weld ever fails.

PHOTO 17: Checking fit of centre piece, note weld prep.

PHOTO 18: The two parts ready to be welded together.

All photos in this feature by the author

PHOTO 19: First weld made on back of gland, note chamfer on centre piece to help seal gland packing.

PHOTO 20: Bolting flange machined to final thickness, note weld prep.

PHOTO 21: The front weld completed.

PHOTO 22: Machining back the front weld.

PHOTO 23: Front weld after machining back.

PHOTO 24: Bolt holes drilled on rotary table, original gland for comparison.

PHOTO 25: Lozenge shape machined mostly by eye, aiming for something that looks right.

PHOTO 26: Comparison between front of old and new gland, note oil hole in new one, this will extend life of packing material and make moving regulator easier.

PHOTO 27: Looking at rear, note shape of inner edge of original and the corrosion.

PHOTO 28: Turning regulator rod to clean it up, note corrosion caused by the old gland.

PHOTO 29: The final touch – regulator rod polished with emery cloth.

the outer diameter so I took the piece out of the lathe and then TIG-welded the back side of the gland up. This is a very similar technique to TIG-welding steel, it just happens to be in bronze in this case – you can use a variety of filler rod, but I used some SAE660 to be a perfect match with the base metal.

After completing the welding I put the gland back into the lathe, holding it on the outer bore of the smaller diameter, allowing me to machine the front face and outer diameter of the bolting flange.

I machined it down until the thickness of the flange matched the end of the centre section, with the small weld prep visible. I then TIG-welded the front face before cleaning this up on the lather again.

If it looks right...

Next job was to mount the flange in the rotary table on the mill and drill the two bolt holes into it, before milling it to the final shape that I liked onto the outside. I did this by drawing the shape I wanted with a Sharpie pen onto the bronze, then rotating the table until the drawing was perpendicular to the table.

Having machined this edge, I rotated the table by 180 degrees to get the parallel edge. I then added the angle the table was sat at to the original angle the table had been at to then produce the lozenge shape.

This was then further finished by roughing the radius at the top and bottom by determining by eye where the cutter touched the gland and using the table to machine the radius, then lowering the table, turning the table through 180 degrees and taking the same cut. Once this was done, I finished the radii off with a file, completing the new gland.

To go alongside the gland, I mounted the regulator rod in the lathe and skimmed the length that sits in the gland to remove the pitting and roughness left by the previous gland, finishing this off with a piece of emery cloth to leave a good polished surface for the new gland material to run on. Another job of the many in a 10-year overhaul done! EIM

Electrical information...

The article *Current Affairs* by Peter Kenington (EIM November 2020) was most illuminating. Peter mentioned a cable of 16 mm² cross-section area, capable of carrying a current of 62 Amps. This gives a current density of nearly 4 Amps per mm². However, he didn't mention the Skin Effect.

An electric current is a flow of electrons and, as they all have the same (negative) polarity, they repel each other, so they tend to travel through the cable nearer the edge than the centre.

An old RS Components catalogue shows a 16mm² cable with current-carrying capacity of 95 Amps! This is a density of nearly 6 Amps per mm², or 50 per cent more than that for the ordinary cable which Peter mentioned. The reason is that the 95Amp cable has 126 strands, which reduces the Skin Effect considerably.

On a related matter, I would ask people selling electrical items (such as colour-light signal heads, point motors and the like) to include not just the voltage but also the current (Amps) or power (Watts). This would enable purchasers to work out what size of cable to use for powering the equipment. I've added a table which should enable cable size to be calculated. I hope it's self-explanatory! ***Mike Hanscomb***

The Editor *replies:* Peter Kenington discusses Skin Effect, and a number of other queries raised by readers following his series, in a follow-up article stating on the next page.

Cable Volt Drop Chart for Copper @ 27°C

Wire Dia. (mm)	X-sec.area (sq.mm)	Ft. per Ohm	Maximum Cable length (ft) for different loads, assuming 10% loss				
			12v 24w	12v 12w	24v 24w	24v 12w	24v 5w
7/0.20	0.22	40	(24)	(48)	(97)	194	465
1/0.6	0.28	52	(31)	(62)	(125)	**250**	598
16/0.20	0.50	92	(55)	111	222	443	1063
1/0.9	0.64	117	(70)	140	280	561	1346
24/0.20	0.75	138	83	166	332	665	1595
32/0.20	1.00	185	111	222	443	886	2126
	1.5	275	165	331	661	1322	3173
	2.0	367	220	441	881	1763	4231
1/1.78	2.5	457	274	548	1097	2193	5264

To use this chart, choose a cable size (for example 1/0.6mm), look across to Volts and Watts rating of load to be energised (for example. signal lamp at 24v 5w) and read off the distance (for example 598ft.)

Notes

1) Wire diameter values: 32/0.2 (for example) means 32 strands each of 0.2mm diameter. This is a flexible cable. 1/0.6 means one strand of 0.6mm diameter. This is a 'solid' cable. Solid-cored cables are NOT flexible, and should never be used for connections to rails.
2) Cable distances are rounded to nearest whole Foot and calculated on assumption that one rail is used for the Return. These distances must be HALVED if Return is via the cable.
3) Any cable size or distance not entered in the table can be worked out in proportion.
4) The footage values in brackets are not recommended because they represent a current density of more than 3Amps per square mm. This is undesirable in a conductor which is not surrounded by 'free air', though this figure represents a large margin of safety.
5) Calculations are based on an allowance of a maximum of 10% voltage loss in the cable.

Additional information for interest The calculation of distances is as follows:

Ft/Ohm x [10% x $\frac{\text{Volts x Volts}}{\text{Watts}}$] ft – eg. 1/0.6mm cable feeding a 24v 12w load (*highlighted in chart*):

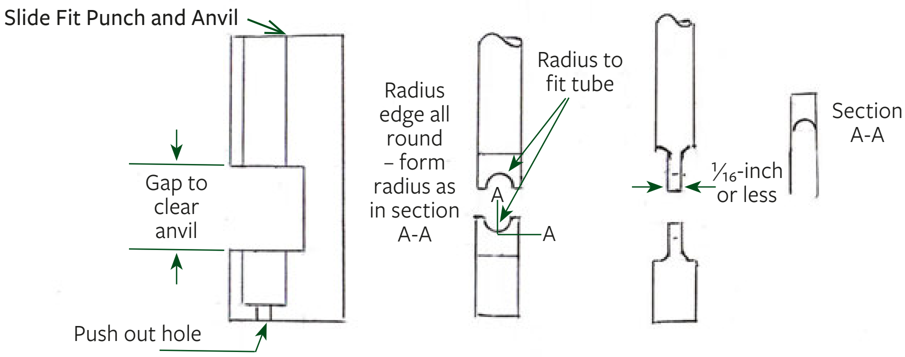
52ft/Ohm x [10% x $\frac{\text{24volts x 24volts}}{\text{12watts}}$] = 52 x 4.8 @250ft.

Having a bad bending day...

Can I add to the article by Rich Wightman in the December 2020 EIM on tube bending? I attach a sketch of a little gadget I made years ago when having a bad bending day similar to Photo 9 in the feature.

After bending the tube, anneal it then place between punch and anvil at the start of the bend – lightly tap the punch while feeding the tube through.

My apologies, I cannot find my original item or a sample tube to provide a photo of my device. ***D Stanton***



In need of some weighty advice

I hope you can help me. Much as I like Don Young's locomotive designs, he never appeared to cast in balance weights on his driving wheels (certainly not on his 3½-inch gauge GWR 43xx or 5-inch Precursor anyway) and I have been thinking about how best to fit them.

I was therefore pleased to see Jan-Eric Nyström show how he does this using polyester filler on page 21 of the October 2020 EIM. I would be very grateful if you could ask him which filler he uses as the results he obtained with it appear to be perfectly satisfactory. ***Alex Ellin***

Jan-Eric *replies:* The Ten-wheeler has two different types of counterweights on the wheels, but I decided to make just one pattern for the coupled wheels. In order to get the right prototypical look on the two drivers, I had to enlarge their counterweights accordingly.

Living in Finland, I am not familiar with the brands of polyester filler available in the UK, but I used a common two-component polyester (or epoxy) filler. There are several types, some intended for wood, some for marine glassfibre, and some for automobile fender repairs – I used the latter type.

It comes in a 500 gram jar, with a small tube of hardener paste (around 25cc or so). The hardener is mixed thoroughly in the correct proportion, which is not at all critical. There is actually more hardener than needed in the little tube.

The mixture is usable for only a few minutes before it becomes grainy and unworkable – the more hardener paste used, the shorter the working time. Thus, I mixed only enough for one wheel at a time.

When completely hardened (in about an hour or so), the filler is eminently workable with ordinary metal tools, for example filing, burring, milling and turning. It also accepts paints very well.

I will add an observation regarding counterweights in general: our small-scale engines do not need heavy counterweights, since the reciprocating masses (rods and pistons) are small. Even though my driving wheels' counterweights are mostly filler (with a much lower density than cast iron), I have not experienced any vibrations that could be attributed to unbalanced wheels, even running at a 'scale speed' of 150km/h...

Cables that leave you stranded

Peter follows up on his recent series on the electrical aspects of battery-powered locos to dispel a few myths which clearly persist regarding electrical cables.

BY **PETER KENINGTON**

When I wrote my recent series of articles on the electrical aspects of battery-electric locos (*Current Affairs*, **EIM** Nov 2020 – Feb 2021), I did wonder if they might cause the editorial mailbag to experience an obesity crisis. The articles were actually quite difficult to write, as they needed to include sufficient detail to enable 'experts' to understand the basis for my assertions (and hopefully be satisfied of their validity) but not so much detail that the average (non-electrical) reader would get lost and give up.

I have received some excellent feedback (many thanks to those who wrote in), some of which shows that there is still a little confusion out there on a couple of points, at least in part due to me trying to steer clear of delving too deeply into advanced electrical theory. The purpose of this follow-up article is to try and clear up these points.

Again, I will simplify things as much as possible and hope that those with relevant expertise will forgive my over-simplifications. It would be very easy to tip over into writing a full scientific journal paper (I have written well over 100 of these over the years), however I hope to teeter on the edge of that particular precipice and try to avoid falling in... This is, after all, a popular model engineering magazine (with, no doubt, ambitions to remain popular) and not an academic journal.

A Walk Along the Strand

Cable rating is one area in which it is easy to get confused. In the articles, I discussed a cross-sectional area of 16mm² for the main cables in a battery-electric loco, stating that they were adequately rated for a steady-state current of 62A. A quick consultation with the electrical expert, Dr Google, will reveal many entries advertising products that claim to be capable of handling well over 100A from this same cross-sectional area. So, who is right? The answer is, of course, that both are correct in their own circumstances.

The variables to consider are:

- For how long (continuously) will the cable be required to conduct its maximum current?
- Is the cable enclosed? How much cooling is available around the cable?
- What type of insulating material is used? If PVC, what type of PVC and at what temperature does it begin to lose strength?

There is a fallacy that car-battery cables (**Photo 2**), which typically have a large number of (small) strands for a given conductor cross-sectional area, can somehow defy physics and handle more current (all other things being equal) than can cables with the same conductor cross-sectional area and fewer strands. The reason normally given is the 'skin effect' (more on this below) which, whilst very real, is not relevant at DC.

The actual reason why car battery cables typically have large numbers of strands is that they need to be (relatively) flexible, to cope with both the bend-angles required in their vehicular application and also to cope with the inevitable (and constant) vibrations they will experience, plus the flexing due to occasional disconnection and re-connection for maintenance/replacement/charging. Cable failures due to metal fatigue would not go down too well with your typical motorist.

This is also a consideration in our locos and is a good reason to choose such multi-strand cabling, however increasing the number of strands will not magically increase their current-carrying capacity (for a given total cross-sectional area of the conductors). Indeed, arguably, the current carrying capacity will decrease slightly relative to that of a single, solid, conductor of a comparable overall diameter (or piece of copper bar stock as we model engineers would more commonly refer to it) – see below for an explanation as to why this is true.

The products highlighted by Dr Google, with their 100A plus current-ratings, will have one or all of the following characteristics:

- An insulating material rated to cope with a high temperature – this makes sense in a hot engine compartment anyway, even if the cable itself is not the source of most of the heat
- A rating which intentionally allows the conductor to run at a high temperature (e.g. 110A at 90 deg C – running a loco with cables at 90 deg C is probably not the wisest idea)
- A rating which is time-limited (for example the cable is capable of carrying 200A for up to two minutes)

In most automotive applications (let's ignore battery-electric vehicles for the present), a high current is only required to be passed for a short period of time, typically when the car is being started. The cable will therefore heat up, however its thermal inertia will ensure that it does not reach a temperature capable of melting its insulation before either **i**) the car starts successfully or **ii**) the battery is exhausted (or at least no longer capable of delivering greater than the cable's rated current).

"Running a loco with cables at 90 deg C is probably not the wisest idea..."

PHOTO 1: Battery-electric power in action – a 5-inch gauge 'Baby Deltic' raising money for good causes at a private railway in Monmouthshire.

PHOTO 2: Car battery cable with multiple strands.

All photos and diagrams by the author

Getting Under the Skin

We can now turn to 'skin depth' and the 'skin effect', which I have heard a number of times as a reason for adopting cables constructed using very high numbers of strands.

The skin effect refers to a phenomenon by which the current carried by a cylindrical conductor

FIGURE 1

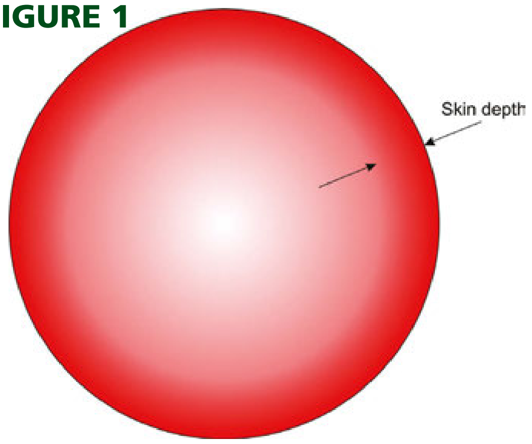


FIGURE 1: Skin depth in a conductor – current density shown as white = low to red = high.

(such as a strand of normal wire) can, in certain circumstances, be concentrated close to the surface of the conductor, with a lower current density in the centre (**Figure 1**). It therefore follows (so the fallacious explanation goes) that more, thinner, conductors equals more outer surface available to conduct the current which equals a higher overall current rating for the multi-strand cable. A detailed explanation of the physics as to why the skin effect occurs is probably beyond the scope of a model engineering magazine, however those interested can, in the first instance, obtain a good explanation from the relevant Wikipedia entry.

So, what is wrong with this theory? After all, the skin effect is a real physical phenomenon and in many circumstances needs to be considered and designed-around (radio-frequency circuits, for example, where I have spent much of my career). Let's look at the (simplified) form of the equation for skin depth (defined as: the depth from the conductor surface to that at which the current density falls to around 37 per cent of its value at the surface):

$$S = \sqrt{\frac{2P}{2\pi f \mu}}$$

Where:

P is the resistivity of the conductor (discussed in part 1 of my original series, **EIM** Nov 2020). For copper, this is 0.0178 Ohm.mm²/m.

"The answer is infinity and calculators struggle a little with this concept..."

f is the frequency of the current passing through the conductor (such as 50Hz for UK mains).

μ is the permeability of the conductor. Permeability is a parameter related to the magnetic properties of a conductor. For copper the value is very close to 1 (0.999994) whereas for iron, for example, it is very large (~5000).

This is one reason why iron (or steel) is a very bad choice as a conductor for anything other than pure DC (direct current) – and even then, it's not great – but why it is an excellent choice for the laminations in a transformer, for example.

The first thing to note about this equation is what happens if we set the frequency to 0Hz, representing the DC currents provided by a battery. The bottom line of the equation becomes zero and our metaphorical pocket calculator then gives an error; this is because the answer is infinity and calculators struggle a little with this concept (don't we all?).

In other words, at DC, the whole of the conductor will conduct the current, irrespective of the diameter of the conductors (strands), the number of conductors or even the material the conductors are made from.

Even if we set the frequency to 50Hz, to represent UK mains, the resulting skin depth is over 10mm, meaning that a solid conductor of 20mm diameter (i.e. >300mm² cross-sectional area) will (notionally) use all of its cross-sectional area to conduct the current. Any cable we are likely to encounter in a domestic situation is likely to be well under this size and so we can effectively ignore skin-depth here, too. Since its effect is either negligible or non-existent in domestic or vehicular applications, its effect is not considered, by manufacturers, when specifying the ratings for any domestic or office/light-industrial cables (other than communications cables, such as TV/satellite coax or Ethernet twisted-pair).

In conclusion, from the perspective of the cable ratings published by DC and mains cable manufacturers, no account will be taken of skin effect in arriving at their maximum current ratings for any cable we are likely to encounter as model engineers or amateur electricians.

So job done?

Not so fast... As discussed in the original articles, our loco controllers are not sources of pure DC. They use a high-frequency AC (say between 50 and 250kHz) pulse-width modulated (PWM) signal to control the motor speed. **Figure 2** illustrates a PWM waveform switching between 0V and 24V and its relationship to loco speed (making assumptions about a level track, no head or tailwinds and such). This is a simplified diagram, for clarity, and the frequency of the changes between 0V and 24V will be much higher in a real situation.

Bearing this in mind and therefore entering a frequency of, say, 100kHz into Equation 1, results in a skin depth of just under one quarter of a millimetre, so a conductor (strand) of greater than half a millimetre will begin to suffer a meaningful loss of current carrying capacity, assuming that little or no filtering takes place in the controller, prior to current entering the cable.

Filtering is used to remove the high-frequency component (100kHz, say), leaving only the quasi-DC voltage which ultimately governs the loco speed (giving us the blue line in Figure 2). Such filtering is not just a 'nice to have' as its absence will turn your loco into a radio transmitter! Radio 4 longwave broadcasts on 196kHz and your loco wiring will form a (somewhat inefficient) antenna.

There are many aspects of the system which can contribute to this filtering (not just components built into the PWM controller), for example the cable's inductance (notably if the cable runs adjacent to a steel loco frame) and the motor itself (its windings and magnetic components). In summary: it's complicated – hence my desire to avoid discussing it in the original series!

At this point, taking a simplistic view, it would be possible to conclude that the use of highly multi-stranded cables begins to make sense (in other words that the skin effect has some relevance), however even if we take this view their use will only restore us to the situation which we arrived at with DC, namely that we will get back to a cable rating which equates to that published by the manufacturer for a given cable cross-sectional area; we will not magically increase this! Based upon this argument, a 60A rated cable (as specified by the manufacturer, at DC) will, at best, be a 60A rated cable when conducting a PWM signal.

FIGURE 2

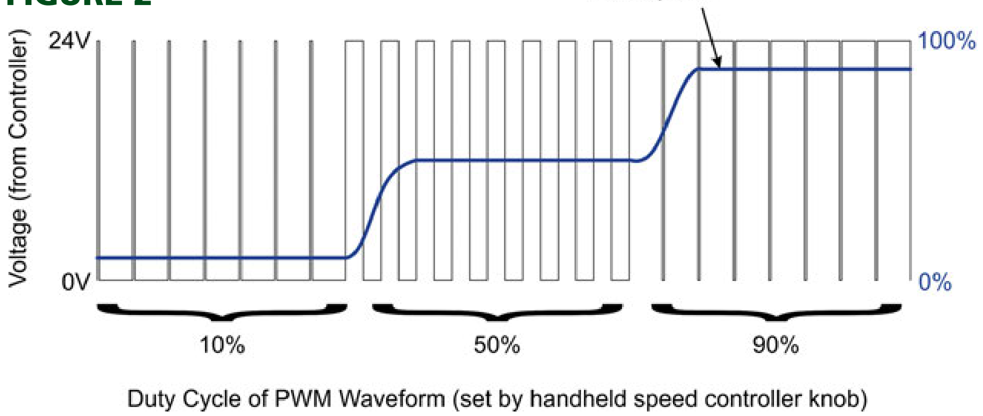


FIGURE 2: PWM for motor speed control in a model loco.

FIGURE 3A

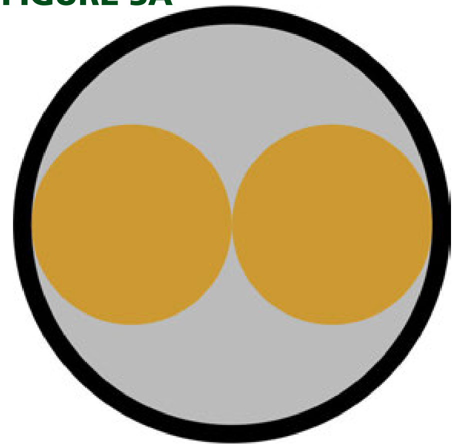
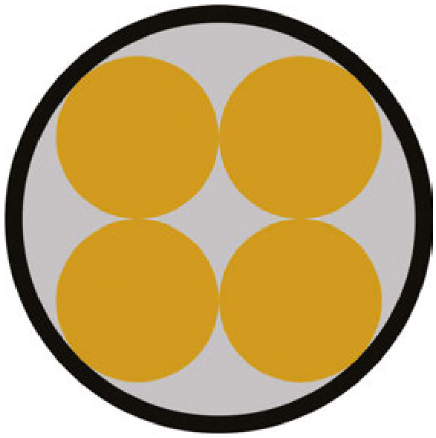


FIGURE 3B



Elephant in the Room

There is one more problem, however, which prevents us from making the above assumption, namely that of treating a multi-strand cable as a collection of individual strands, from the perspective of skin effect: the cable simply doesn't act that way! The reason is obvious, when you think about it...

Consider a 'multi strand' cable, consisting of just two strands (**Figure 3a**). In this case, it can easily be calculated that the percentage of the overall cable cross-sectional area which is covered by the conductors is 50 per cent.

If we now increase this to four conductors (**Figure 3b**), then the percentage area covered by the conductors also increases, to a little under 69 per cent. With seven conductors (**Figure 3c**), we get a coverage of just under 78 per cent – you can see a trend emerging here, although it is not entirely linear. For example, with 19 conductors (**Figure 3d**) the percentage is just over 80 per cent, however with 20 conductors (**Figure 3e**), this reduces to just over 76 per cent.

In the limit, with a near-infinite number of conductors, the packing density tends to a little over 90 per cent, which is very close to our piece of bar-stock discussed earlier, but almost 10 per cent smaller. In other words, even the best-packed multi-strand conductor will not be as good as a single, solid, conductor, for a given overall cable diameter.

"In our locos, we do have some handy-looking chunks of iron and, more commonly, steel with which to realise our conductors..."

This doesn't mean to say that I am advocating running solid copper bus-bars (as they are known) around our locos, however it does serve to illustrate that it is the total cross-sectional area of the copper conductors which matters and not the diameter of the cable itself. To be fair, this copper cross-sectional area is what most cable manufacturers specify, but this might not be the case with private sellers on ebay, for example, so be sure to check what you are buying.

So, back to our problem... If we assume that the copper strands contained within our cables are formed (in the factory) without corrosion and remain that way during use, then our multiple copper strands in our multi-strand cable will all be in electrical contact with each other (or at least with each touching neighbour) throughout their length. This is hopefully obvious from the latter diagrams in Figure 3.

The cable will thus behave as a single 'solid' conductor insofar as the skin effect is concerned and not as a series of separate, insulated, stand-alone conductors. A multi-strand cable of this type, for example any form of 'car battery' cable, will have no advantage over any other cable of a similar conductor cross-sectional area, from the perspective of the skin effect, no matter how many strands there are in the cable, even supposing such an effect is a factor in the first place.

Is our 'clean copper' assumption reasonable? The short answer is yes. For evidence, find an old length of cable which has been lying around in your workshop for years and strip off some insulation, say 1 inch from the current (probably corroded) end of the cable. This cable will almost certainly appear shiny and bright, despite having received no care or attention in its entire history. Even cables which run underground, in near-permanently damp conditions, will exhibit this property (although not those which have been filled with water, of course).

There do exist multi-strand cables which are deliberately constructed to enable the individual conductors to act independently of one another, hence enabling each to form its own 'skin' of current conduction. These are known as Litz wires and consist of a (typically large) number of strands, each of which is insulated from its neighbours by means of an enamel (or in the olden days, silk) coating, the conductors themselves often being silver plated. Remember, this has an even lower resistivity than copper and skin effect, where present, means that most of the current would then be conducted by this silver outer layer, so this extravagance makes sense.

I have never seen a high-current version of this type of wire, however, and even if such did exist, I dread to think what it would cost! Hi-Fi enthusiasts favour this type of wire and pay hundreds or even thousands of pounds for it, yet requiring it to conduct only milliamps at most.

Irons are Flat

The above discussion has focused on copper conductors. In our locos, we do have some handy-looking chunks of iron and, more commonly, steel with which to realise our conductors, in the form of the frames. In the articles, I did mention their possible use for this purpose and it is tempting to do so (they're large, handy and 'free'), however the use of a PWM controller may give cause for us to re-evaluate this idea (as hinted above).

The permeability of mild steel is in the region of 2000, although this figure varies a lot depending upon its precise composition. If we substitute this figure into Equation 1, the resulting skin depth when conducting our 100kHz PWM current is: 5µm (in other words, 5 thousandths of a mm)!

FIGURE 3A-E: Conductor packing in a multi-strand cable – see text for details.

PHOTO 3: Aluminium underground cable – not for use in locos!

FIGURE 3C

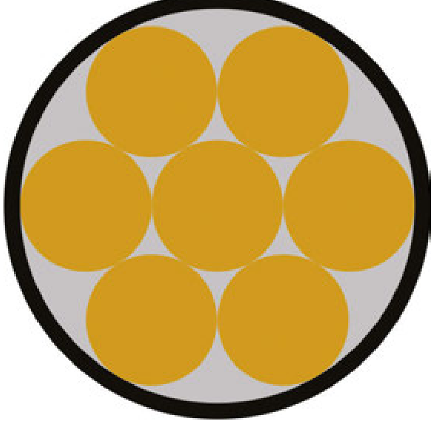


FIGURE 3D

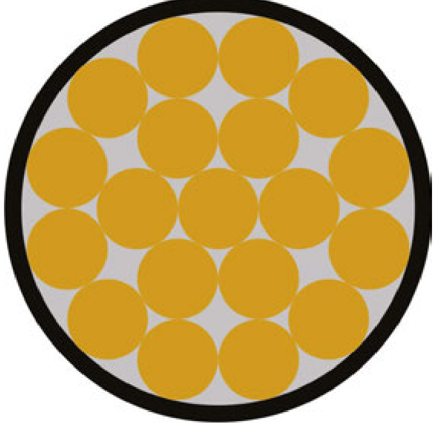
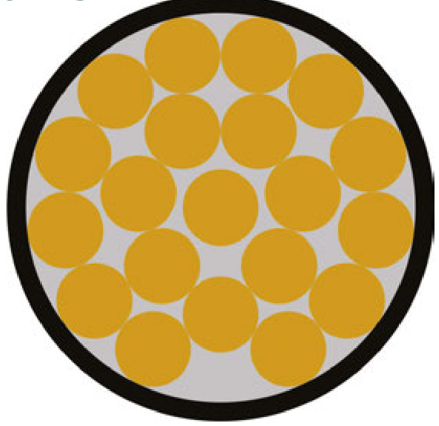


FIGURE 3E



Needless to say, this is tiny and using the frames for PWM conduction purposes would not be very sensible.

So, in the same way that irons are flat, anything containing iron should only be used for 'flat' (i.e. DC) currents. Hopefully this will make it easy to remember...

"For the small quantities we use in our locos the saving would not be worthwhile – we're not wiring up the National Grid..."

What does this mean?

I probably lost some of you somewhere around 'cylindrical conductor' and 'current density'. If that's you, don't worry, here are a few recommendations:

- Rate your cables based upon a conservative conductor area and a (relatively) small temperature rise. For example, 60-70A of continuous current through a $16mm^2$ cable is a reasonable maximum. This represents a current density of $4A/mm^2$. You may even want to be more conservative than this, using say $3A/mm^2$.
- Use multi-strand cable with many strands (for flexibility/reliability), but base its current rating upon the above figures, not the seller's claimed rating for automotive applications.
- Don't use iron or steel conductors for PWM controller signals, in other words don't use the frames of a loco as conductors for this type of controller!

There, that wasn't so hard, was it?

Aluminium Foiled

Another topic of discussion which has emerged is the use of aluminium in conductors – this was prompted by my inclusion of a photo of a section of underground mains cable in the first article (repeated here as Photo 3), plus its (brief) mention of the possible use of aluminium loco frames as a conductor (does anyone make frames from aluminium? – I've never seen any, but perhaps someone out there has?).

3

Firstly, if Photo 3 left the impression that aluminium cables are a good idea in model locos, then this was not intentional! The photo was intended as a tongue-in-cheek reference, to raise a smile, and not a serious proposal (it is a hugely-oversized cable, with a bend-radius larger than most 7¼-inch gauge locos). Aluminium has many disadvantages when considering its application in a cable for use by 'amateur' electricians:

- Its resistivity is a fair bit higher than copper (see the first article in the series)
- Whilst it is cheaper than copper, for the small quantities we use in our locos the saving would not be worthwhile – we're not wiring up the National Grid here (although it might feel like it at times...).
- It is actually pretty hard to get hold of wire of the size and (short) length we would need – your local motorist discount centre won't stock it.
- Making (good) connections will be a challenge.

The last point is a key one and was raised by one correspondent in particular. When aluminium corrodes, to form aluminium oxide, the result is a very good insulating layer – the last thing we need in a high-current connection! Aluminium also oxidises extremely quickly when exposed to air, making it difficult to form a good connection before oxidation sets in. Making a copper crimp terminal-to-aluminium chassis/frame connection is not quite so hard (a lot of radio-ham kit, high-end Hi-Fi equipment and such uses aluminium chassis and copper wiring for earthing/grounding). It is important, however, to thoroughly clean/abrade the aluminium, tighten the connection quickly and then apply some grease or paint in order to keep it air-tight.

Having said the above, it is still not an approach I would necessarily advocate for our purposes, although it remains an option, if needed.

Chasing Ratings

Another point which has been raised (and, I must admit, one I half-expected when writing the articles) is that of using the published/claimed ratings for cables and maybe applying a 'margin of safety' to these ratings. This could be viewed as a simple (almost no maths needed) way of specifying the required cable. There are a couple of things to bear in mind here:

- Not all cable ratings are created equally. A cable sourced from your local motorist discount centre or an unknown online supplier may be rated at 200A (say), however the expectation in arriving at this rating may be for short-term use (such as running a starter-motor for a minute) and it will probably not specify the temperature to which the cable will rise during long-term use at this (or any other) current. Likewise, it won't specify the temperature (or continuous current) at which its insulation will become weakened.
- Not all copper is pure – indeed, it could be argued that most 'copper' isn't. Many years ago, I worked for a cable manufacturer (of very high-power radio coax cables) and they were being undercut by a rival Chinese manufacturer. At the time, my employer was the largest buyer of copper on the planet (not just for cable use, but for any application), so they knew they were getting the lowest price for copper that was available. So how did the Chinese manufacturer undercut them?

A little was down to lower labour costs, but labour was a small part of the overall cost of the cable. The main answer was simple: impurities – the Chinese manufacturer added other (cheaper) metals to the copper, thereby reducing the overall cost of the raw material. This also (unsurprisingly) made it much more lossy. So, beware: 'cheap' copper cables, or those supposedly rated at X hundred amps (when others rate their cables lower), may not be all they seem.

Another way of looking at the first point is this: a 13A domestic mains fuse is rated for 13A of continuous current without failing, however I wouldn't want to live in a house cabled with 13A fuse wire!

The upshot of this is: do the maths (it's really very simple and compared to the amount of time you'll spend diagnosing/fixing faults on your loco, it's time wisely invested).

A Big Thank You

...to all who wrote in. It's nice to know that the articles were studied in detail, with such thoughtful points being raised. Your letters helped me see the articles through different (readers') eyes and hopefully this postscript has allowed some misunderstandings which may have arisen to be explained and corrected. EIM

■ For Peter's previous articles you can download digital back issues or order printed copies at www.world-of-railways.co.uk/store/back-issues/engineering-in-miniature or by calling 01778 392484.

Refurbishing a Kiwi mk 2

Stuart beats lockdown by resurrecting a petrol engine idle for more than half a century.

BY **STUART ROTHWELL**

In 1963 my father and I were members of a model boat club in Southport based on the marine lake. Although my father's main interest was steam locomotives he had seen a Sea Queen model boat and decided to build one and power it with an Edgar Westbury water-cooled Kiwi 15cc overhead -valve petrol engine.

He constructed the engine but never finished the model boat and so the engine has lain idle in his and subsequently my workshop ever since. Although I cannot remember seeing the Kiwi running I presume it had, albeit for only a short time since it was not fitted with petrol tank, float chamber, oiler or any cooling system.

I was looking round for my next project having just completed a large steam-driven tug boat (EIM, October 2020) and so decided to refurbish and finish the Kiwi. If the project was successful, and for something different, I planned to fit it into a small 3½-inch gauge early shunting engine.

Before I start recounting my experience during the process, I must explain that my knowledge of IC (internal combustion) engines is a little faded, since the last time I worked on them was also in the 1960s and they were full-size car and motorbike engines. Some of the issues I encountered might have been recognised and dealt with more easily by an experienced IC modeller, but my dialogue may be of some help to the first-timers.

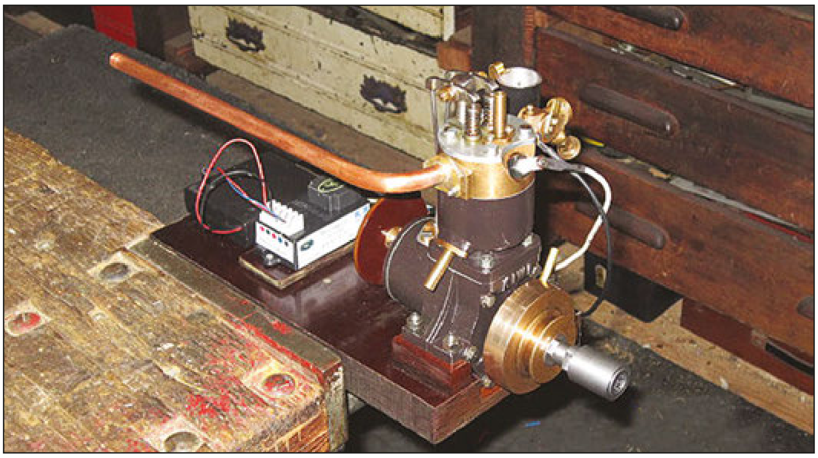
"The last time I worked on IC engines was in the 1960s and they were full-size car and motorbike engines...."

Ring cycle

The engine, having been left untouched for nearly 60 years, would not turn but once it was stripped down it soon became clear that the issue was the piston rings – the oil had dried and stuck the rings to the bore and slots in the piston. A gentle tap removed the piston from the bore, but while removing the rings from the piston one of them broke.

I ordered a new set from Hemmingway (www.hemingwaykits.com)as well as a float chamber casting. Butr the casting was out of stock so it took a month before it was delivered. I used the time to inspect, clean and paint the rest of the engine and did not find anything wrong so it all went together well, or so I thought...

I made a mechanism employing an electric drill to turn the engine over for starting. I later replaced this with a drive and housing utilising a roller clutch which proved a far better solution. However when the engine was spun it made no attempt to run.



ABOVE RIGHT: Stuart got his Kiwi petrol engine to run, but it took a lot of effort...

BELOW: Jig made up to turn flank radii on cams.

BELOW RIGHT: The jig in use on the lathe.

Photos by the author

I had previously checked that the original magneto produced a spark, so believing this to be okay I set about checking the valve timing against the timing diagrams in Edgar Westbury's articles. I found interpreting the diagrams awkward because my father had intended the engine to run anti-clockwise as viewed from the flywheel end – this was because it was common in the 1960s to drive model boats with left-hand propellers and the diagrams are drawn for clockwise rotation.

I eventually concluded that both valves were opening far too late and closing far too early – this had to be the problem, new cams were required. This was a new venture for me as I had never made cams before or cut internal keyways.

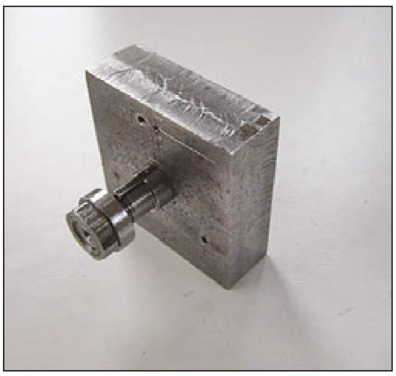
Studying the original articles it was clear that the engine will run in either direction by simply turning the valves round and that it would be easier for me to make the valves separately, not in one piece as drawn. With this design of cams the keyway is set at top-dead centre and was already in the engine camshaft so my keyway had to match both the cams and the jig used in the machining process,

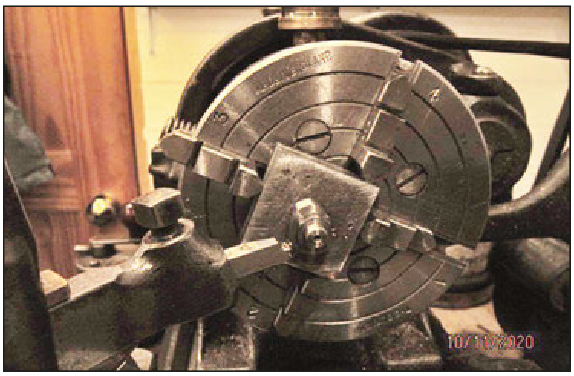
I found that a 1.5 mm slot drill cut the size exactly, a $\frac{1}{16}$-inch one as suggested by the drawing would with my equipment cut over-size, so the cutter that produces the internal keyway was ground to this size before starting on the blanks.

My advice when starting from scratch is to mill the keyway on the shaft first and make the internal cutter to match. Turning the blanks is now straightforward but it is important that the hole is reamed to exact size, not drilled.

Cutting the keyways is also straightforward, first making sure that the cutter is set accurately to centre height, and using the lathe as a horizontal shaping machine with plenty of cutting oil and tiny cuts.

To turn the flank radii I produced a jig that fitted into a four-jaw chuck – it is simply a piece of bar machined square and accurately marked out with the spigot position centre, a top-dead centre line, the other four radii centres for the flank angles and then spotted with a centre punch





exactly on the cross marks, making sure that the centres are marked for which cam they are to produce.

The jig was mounted in the four-jaw with the spigot centre running dead true. I reamed the hole for the spigot and with the top-dead centre line locked in the horizontal position cut a key way. The spigot is then keyed onto the jig so that the cam blanks are always in the correct and identical position.

I then set the jig to run true on the flank angle centres. Westbury tells you to measure the first flank across from the external diameter of the blank and when turning the second flank to go down to the cross-slide index. This did not produce the desired result, the thickness around the hole was different and so the first one was rejected as scrap.

If the radii is to produce a tangent intersect at the correct angle, then the edge distance across from the centre hole has to be exactly the same, so the flank angle dimensions were produced by measuring the thickness of material across to the hole. This has to be as the same as that produced by the base diameter when machined and was only made possible by being able to remove them from the jig and to refit them exactly.

The jig was then transferred to a rotary table set up on the milling machine so that the spigot was perfectly true. It is so easy to make a mistake and over run the angles so sticky tape was used to mark the start and end positions of the radii to be nibbled away. Again the cams could be taken off the jig so that the edge thickness could be measured and produced the same as for the flank angle curves – this way the tangents must be in the right place.

The cams were then polished and case hardened, the engine rebuilt, valve timing checked and all was well. This time she would surely start but no, she never even tried...

Ignition issues

My experience from years gone by told me that quite often when an engine did not even try to start the problem was ignition. I knew the coil, plug and points were at least 60 years old and that even though I was getting a spark outside the cylinder was I getting a strong enough one under compression? I ordered and fitted a new plug and condenser but still the little engine made no attempt to start, so I concluded it must be the coil.

I replaced the ignition system with a Minimag electronic system using a Hall sensor instead of conventional points mounted on a disc driven from the camshaft, but guess what, still no joy, this engine was not going to run.

RIGHT: Pair of new cams ready to be fitted.

FAR RIGHT: Discovering and fixing the issues with his engine certainly tested Stuart's model engineering prowess....

BELOW RIGHT: Another view of the completed engine, proving persistence pays.

By now I was starting to run out of ideas so I removed the carburettor for inspection and found that the primary air intake was missing. This is a small hole which bypasses the main intake and enters the body of the carb just prior to the jet. I made the modification and refitted it.

Shy plug

I also noticed at this point that the hole into which the spark plug screwed was not as deep as the drawings showed, which meant that the electrodes did not protrude into the compressed mixture space, so I set the head up in the lathe and corrected it.

Furthermore, the gap on the new spark plug had mysteriously disappeared. On investigation the earth electrode was a different shape to that on the original plug and when screwed in fully it fouled the couterbore in the hole and closed up. Everything was refitted but yet again the engine refused to make any attempt to run.

"The hole into which the spark plug screwed was not as deep as the drawings showed, which meant that the electrodes did not protrude into the compressed mixture space..."

By now I was clutching at straws and after talking to some members of my club I decided to check that the piston conformed to the design standards, but all seemed to be okay. However I realised at this point that Westbury never used gaskets – all his joints were metal to metal. Yet on my engine a fibre gasket of some 30 thou thick was fitted between the crankshaft casing and the cylinder, which with this size of engine must have reduced the compression ratio considerably.

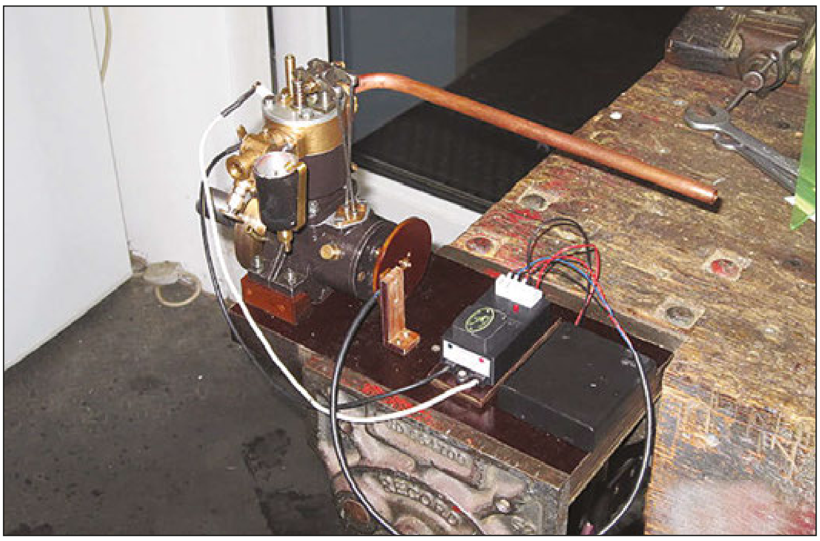
So I again reassembled the engine minus this gasket and when spun with the starter it fired up perfectly on every stroke!

This engine however still had a trick up its sleeve. When the starter was switched off the engine stopped – it would only run whilst being turned from an external source.

Whilst scratching my head I turned the engine over by hand with the flywheel and it seemed to slip when turning through the compression stroke. Westbury used a split taper collet to hold the flywheel in position and retightening this prevented the slip and bingo it fired up straight away and ran perfectly. It was time to put the kettle on or to have a stiff whisky...

I could only run the engine for a few seconds at a time because there was no cooling or oiler fitted, so the next stage will be to fit it to a test rig with the ancillary equipment and do the necessary adjustments before designing a model to fit it into.

The whole episode had taken me three months but the engine now runs and although some of the work done may not have been essential, I have to believe that the modifications I made will result in far more efficient running when fitted into a model. EIM



Twitter Steam Rally – the sequel...

In the June 2020 issue we described how young steam engineer Charlotte Coulls came up with a great idea to try and provide something for the hordes of enthusiasts stuck at home, as the Covid-19 pandemic caused the cancellation of a full season of steam rallies and events.

Charlotte, aged 14, created the 'Twitter Steam Rally', a virtual event held on 9th May and which aimed to fill social media feeds Twitter and Facebook with steam-related content. The response was unprecedented – within 48 hours of the event being launched more than 2000 internet users had signed up to be a part of it.

Over the rally weekend the net bulged with contributions, miniature and full-size steam, road, rail, stationary and more, vintage vehicles... you name it, if it had a steam rally connection it was there.

Charlotte's proud dad Anthony, a noted traction engine enthusiast and author and a senior curator at the National Railway Museum, told EIM that in the end more than 10,000 people took part in the virtual event and with such initiatives as merchandise sales more than £3,700 was raised for charity.

At the end of the year Charlotte's efforts saw her very deservedly named the Steam Apprentice of the Year by the Steam Apprentice Club, the trophy presented on Charlotte's birthday in December.

So what about a sequel? Back in the June 2020 issue we suggested that the rally should become an annual event but Anthony cautioned that it was strictly a one-off, responding to the unique situation we all found ourselves in through 2020. But of course neither he or any of us imagined that getting on for a year later we would still be in not much better of a situation, with swathes of public steam gatherings in 2021 being cancelled for a second year in succession.

So you guessed it, Twitter Steam Rally 2 is happening! It will be held on 1st May 2021 and we can do no better than repeat Anthony's words from the original; "We've created (the event) to allow more people to share their engines and vintage kit large and small for a seocnd time on 1st May.

"Photos, videos, live streaming, let's get it on Twitter and Facebook. Bring your own beer, chips and doughnuts and we shall enjoy our wonderful hobby hopefully across the world in our gardens, yards, fields and sheds!"

Can't say fairer than that – we hope many EIM readers will join the fun, perhaps sharing some of those excellent projects you have been working on during lockdown. It's really easy to sign up – simply enter the hashtag #TwitterSteamRally2 in the search feature on Twitter and Facebook. See you on the (virtual) rally field!

BELOW: Deserved Steam Apprentice of the Year accolade for Charlotte Coulls, and now she's doing the Twitter Steam Rally all over again... *Photo: Anthony Coulls*

Historic station for Thorpe line

A 15-inch gauge miniature railway revived just seven years ago is now planning to restore a waiting shelter from a historic but lost line.

The Thorpe Light Railway in County Durham owns Bossall station, the last remaining building from the 18-inch gauge incarnation of the Sand Hutton Light Railway near York.

The Sand Hutton line closed in 1932, but Bossall station building survived as a garden shed. It was then stored on a farm until around five years ago when it was acquired for the Thorpe line.

The Friends of the Railway feel that it is time that the building was restored – today it is nothing more than a set of walls needing a lot of love and a roof, but it is highly original and bears much graffiti scratched into its framework from former passengers. These include a set of initials 'SW', which some wonder could be from Sand Hutton line creator Sir Robert Walker's former wife, Synolda, after whom he named his 15-inch gauge locomotive before later converting the Sand Hutton line to 18-inch gauge.

The Friends of the Thorpe Light Railway, a registered charity, would love to have the shelter restored and on the station platform for the 50th anniversary of the current Thorpe line, which was formerly the Whorlton Lido Railway.

It is estimated that around £2000 would complete the project. Anyone who might be interested in helping, either practically or financially can email the chairman of the Friends, Anthony Coulls at ajcoulls@yahoo.co.uk. More information on the Thorpe line is available at www.thorpelightrailway.co.uk

BELOW: The 'flat-packed' remains of Bonsall station at the time it was being removed to safe storage by the Friends. *Photo: Anthony Coulls*

Drawings donation aids Colossus build

The Gigantic Locomotive Company, which is creating a new-build version of the 15-inch gauge the 4-6-2 Pacific commissioned from Bassett-Lowke in 1913 by Romney, Hythe & Dymchurch Railway founder Captain Howey, have been donated a set of drawings for the Barnes Atlantic – this was the final development of the Greenly Atlantic family of locomotives which the Pacific evolved from.

"This donation fills the gaps in the Basset-Lowke drawings GLC already possess, and therefore represent the final piece of the puzzle in researching the design," a spokesman said. As reported in the August 2020 EIM, support is currently being gathered to cut the new loco's frames.

Weathering the winter...

As if lockdown wasn't enough, more seasonal difficulties have also been affecting the clubs...

COMPILED BY **ANDREW CHARMAN**

ABOVE: Now that's flooding... Remarkable aerial shot of the Hereford SME track site in January. *Photo: John Arrowsmith*

We begin our March round-up from around the clubs still very much in the middle of nationwide Covid lockdowns, and as a result the scene is rather quiet. And as the remarkable picture heading this page shows, Covid is by no means the only challenge facing clubs at present with more seasonal and predictable difficulties also emerging.

Taken in mid January by regular EIM correspondent and former *Club News* editor John Arrowsmith, the picture shows the Broomy Hill Railway of the Hereford SME – or at least it would, if you could see it! The line runs around the field that is totally underwater in the centre of the picture – the totally cut-off building is the club's main station, with the clubhouse at right, above the building of the Hereford Waterworks Museum.

The Hereford club has been hit by flooding before, and remarkably John tells us that this flood was not as high as that a year ago in February 2020, and initial investigation suggested that no significant damage had been caused to the track.

Hereford SME is renowned for its healthy young engineers section – regular EIM writer Matthew Kenington being one noted member. John adds that due to Covid the section has not been operational at the club for almost 12 months; "but I do know that projects have been ongoing at home and it will be interesting to see what appears when we are allowed to get together again."

Indeed it will, a sentiment no doubt shared across the club scene. We were pleased on glancing at the Hereford website to see the club has published its planned season of 2021 open days. Okay, the first planned ones in April going ahead may be looking quite tenuous at present, but the mood music as vaccination numbers go up suggest that there really is light at the end of the tunnel – perhaps by the summer our club scene will be much more active than for a very long time.

Hereford has not been the only victim of flooding of course – we noticed on social media that the 15-inch gauge Saltburn Miniature Railway in Yorkshire was forced into clearing up after floods on 20th January, but the volunteer group that runs the line was defiantly reporting – "nothing that a brush and shovel can't sort out..." It's an interesting line this one, dating back to 1947 – more details are at www.saltburn-miniature-railway.org.uk

Global issue

It's not just in the UK either – the latest *Smokebox* from the Centurion SME in South Africa reports that club members completed new elevated storage for its stock at the beginning of December, but while they were busy moving all their locomotives to the new storage on the 22nd of the month, the flooding struck. "Water levels stopped just short of entering the workshop building and caretaker's

BELOW: Little and large at Grimsby, and both called Henrietta. *Photo: Neil Chamberlain/ Grimsby & Cleethorpes ME*

■ In these challenging times it's great to see a locomotive build project reach fruition and just that is evident in the latest *Maritzburg Matters*, newsletter of the **Pietermaritzburg ME** in South Africa, member Ray Teichmann successfully testing his new petrol/electric loco at the end of December before painting it.

Maritzburg club chairman and newsletter editor Martin Hampton told **EIM** that the loco performs "even better than I expected – very impressive", and added that it is loosely based on one of the South African Railways locos; "It is powered by an ancient 5hp Honda engine driving a 160amp alternator. Each axle on the two bogies has a 450w geared motor with a chain final drive. Ray has very ingeniously built all of his own controls and incorporated a braking system as well. There is also a hydraulic parking brake."

Ray kindly supplied us with some more details, saying that the loco was originally going to be powered by a single winch motor; "This all changed when the price of the winch motor went through the roof, and so the choice became a hydraulic unit."

At that point the planned design was for a three-axle loco, each being chain driven from one driven source. Having had lots of parts laser cut Ray started construction just before the first lockdown and realising that the permanent magnet-type motors he was switching to would not be as powerful as the winch motor, changed the design to four motors driving to a pair of two-axle bogies.

"We were still going to use the original design of an alternator supply to the motors," Ray added, but this was a 12-volt unit and the motors were 24v.

"By removing the regulator on the alternator and over exciting it you can get 30 volts out of the alternator and more if need be. But that is off-load voltage, so as soon as it is loaded the voltage drops away to way less than 12 volts."

Increasing engine rpm increases the voltage as well as also increasing the excitation but Ray adds that this has to be carefully done; "one can easily stall the 5hp engine by over exciting the alternator". But done carefully the result is smooth starting with a train; "You can also feel what the weight of the load is and how one needs to drive the loco."

According to Ray coming to gradients is a challenge as engine rpm has to be pushed to the max. "You have now to watch motor currents and voltage as when the engine rpm starts dropping towards stalling, one needs to decrease excitation which decreases speed and currents but will increase engine rpm again, so you have to juggle the controls." He admits a bigger engine would have been able to hold rpm and so would have been a lot easier to control the currents and speed, but he is surprised to see what the little 5hp engine is able to do.

The braking system employs the regenerative effect of the motors. If the train is moving under its own weight downhill and the voltage supply is removed, these motors will produce their own voltage. "The trick is to then use this voltage as a resistive bank – by decreasing the resistance one will cause these motors to brake themselves. Too small a value of resistance will throw the passengers off the carriages as it will brake harshly – I made a rotary selector switch which as one pulls the lever it decreases the resistance which increases the braking and is easy to control. I can also stop the train in an emergency very quickly."

The photos courtesy of *Martin Hampton* show (above) Ray and his unpainted loco under test, and below on duty following painting.

flat", editor Jon Shaw reported, adding that thanks was due to the hard work of members completing the final touches so the new and safer storage could be used; "We will definitely need lots of help to do a quick changeover as the track may prevent some of the old storage being used until they are also raised."

The *Smokebox* also includes details of the club's annual prizegiving and your editor rather liked the 'Rookie of the Year' award, as this is a phrase I'm very used to with my other great passion, American motorsport! New member Neil Webb won the award, described as a great asset to the club and among other talents having "acquired locomotives that did not run well and got them to run all day..."

Little and large

The front cover of the January *Blower* from the **Grimsby & Cleethorpes ME** sports a very impressive picture, reproduced on page 43 and clearly illustrating the variety in miniature railway engineering! Both engines are called 'Henrietta' and *Blower* editor Neil Chamberlain, who took the picture, explains that the larger one to the rear has quite a history.

A model of an American Hudson 4-6-4 express loco to a Henry Greenly design, the engine was completed in 1947 for a private 7¼-inch gauge railway in the grounds of Kenton Grange, Kenton, Middlesex. From there Henrietta's history took it to Cleethorpes, Littlehampton and Coniston, then back to Cleethorpes where it was intended to be run on a demonstration line alongside the 15-inch gauge line. Current caretakers of the loco, Ray Crome and Mark Atkins, are active and enthusiastic Grimsby members and Henrietta regularly appears on the club's track.

The Grimsby club opened its track extension late last year and the latest plans reported to the first members meeting for nine months (held using "that newfangled zoom thing"...) is a traction engine roadway, leading down to the lower field at the track site and including a level crossing.

Despite coping with the new technology members agreed that using zoom was a success and everyone is being encouraged to join in future meetings; "It helps us to maintain contact with each other and stay up to date on club life – Zoom is easy enough to download and you don't have to say anything, you can even switch your camera off if you don't want anyone to see you in your PJs!".

Patient pursuit of a plate

We are all having to be very patient at present and there is evidence that patience pays off, especially at the still young **Havering MRC** – construction of its 7¼-inch gauge line at Lodge Farm Park, Havering in Romford only started in 2016. Writing in the newsletter of the neighbouring **Chingford ME**, Tony Walker reports that the Havering club had been in negotiations to acquire a full-size loco nameplate with local connections.

The plate – 'London Borough of Havering Celebrating 40 years' was applied in 1995 to class 315 electric multiple unit no 315829, working the London Liverpool Street to Shenfield line on the national network.

With the unit approaching scrapping ahead of the opening of the Elizabeth Line (Crossrail), Havering MRC started negotiations first with Eversholt Leasing which owned the unit, and then Transport for London which leased it. But Crossrail's opening date was repeatedly delayed and the lease of the unit extended. Having been told it would continue running until May 2021, the club was surprised to learn in December that the EMU was off to the scrapyard.

Thankfully they had most recently been working with Ben Palmer, fleet manager of the Elizabeth Line and he ensured that the nameplates were removed from the unit before it felt the scrapman's torch. Ben duly presented the nameplate to club treasurer Bill Dadswell in a small ceremony on 18th December.

Good to note, by the way that mindful of the boredom factor induced by lockdown the Chingford club has followed many others in turning its newsletter into a fortnightly publication.

The Winter edition of the **Southampton ME**'s quarterly newsletter includes an intriguing tale, originally from the newsletter of the **Scunthorpe ME**, concerning a model of the Great Western Railway's only 4-6-2 Pacific 'The Great Bear'. In 1910 this model was commissioned at 1-inch to 1ft scale from Bassett Lowke by Sir Berkeley Sheffield, owner of Normanby Hall, close to Scunthorpe.

The completed loco was to 4¾-inch gauge (at 1-inch scale, 4¾-inch is a closer representation of the standard gauge of 4ft 8½-inch...) and ran on a line at the Hall until sold in the 1930s. It ran for some years as a club loco at Southampton, having been restored and regauged in the 1960s, before being sold to a member and ending up in Dorset, before eventually going back to Scunthorpe in 2006! How our locos can travel...

Bridging the gap

Always busy at the **Rugby ME** and the latest newsletter reveals that just a little work at the club site was possible in the new year before lockdown shut everything down again. And not content with building a new loco lift and various other projects featured in last month's **EIM**, chairman Aubyn Mee has been busy welding up a new gantry bridge that will connect the club's extended raised track to the existing section. The bridge will benefit from a host of laser-cut components – handy that fellow Rugby member Ed Parrott has become the owner of Model Engineer's Laser...

ABOVE: No small fabricating job is the new gantry bridge for the Rugby ME's raised track extension, being put together by chairman Aubyn Mee and including attractive components (above right) produced by Model Engineer's Laser. *Photos: Aubyn Mee, Rugby ME*

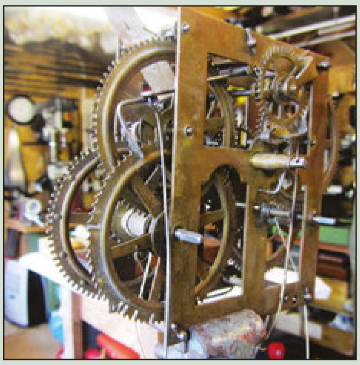
Last time we mentioned the lighthearted end-of-year quizzes popping up in club newsletters. Well the 'Holiday Special 2020-21 edition' of the **Bournemouth SME**'s *B&DSME News* certainly goes to town with first a railway geographical quiz which includes such delights as "Which of these is an actual junction on Network Rail: Cats Basket, Rats Nest, Stoats Nest or Rabbit Hole?" (The Ed knew that one as he often passed through Stoat's Nest Junction on trips to London when he lived 'darn sarth'...).

Bournemouth members also get to tackle a Christmas crossword and a somewhat different wordsearch, the 'Engineers Christmas Game' and are finally entertained with some strange photos of railwayania. These include a quite grotesque lump of ceramic pottery featuring a great railway engineer as a nocturnal farm bird and called 'Isambird Kingdom Brunowl'... Impressive – enough fun to last round to the next newsletter! EIM

■ EIM readers have been busy in their workshops during lockdown, none more so than Michael Malleson, whose projects have included Myford lathe turrets and toolposts and a pair of American wall clocks.

We will be publishing more on Michael's efforts next month, and meantime if you've completed a lockdown project, why not send it in for your fellow readers to enjoy? Include lots of detail as EIM readers like to know how something was done.

Meantime Michael's excellent clock efforts give us an opportunity to remind readers that we'd really like to see some more horology – something we rarely get to feature in the magazine. If you are a clockmaker with something other EIM readers might enjoy, then why not get in touch? Contact details are on page 3 and don't forget, we pay fees for features published in the magazine.



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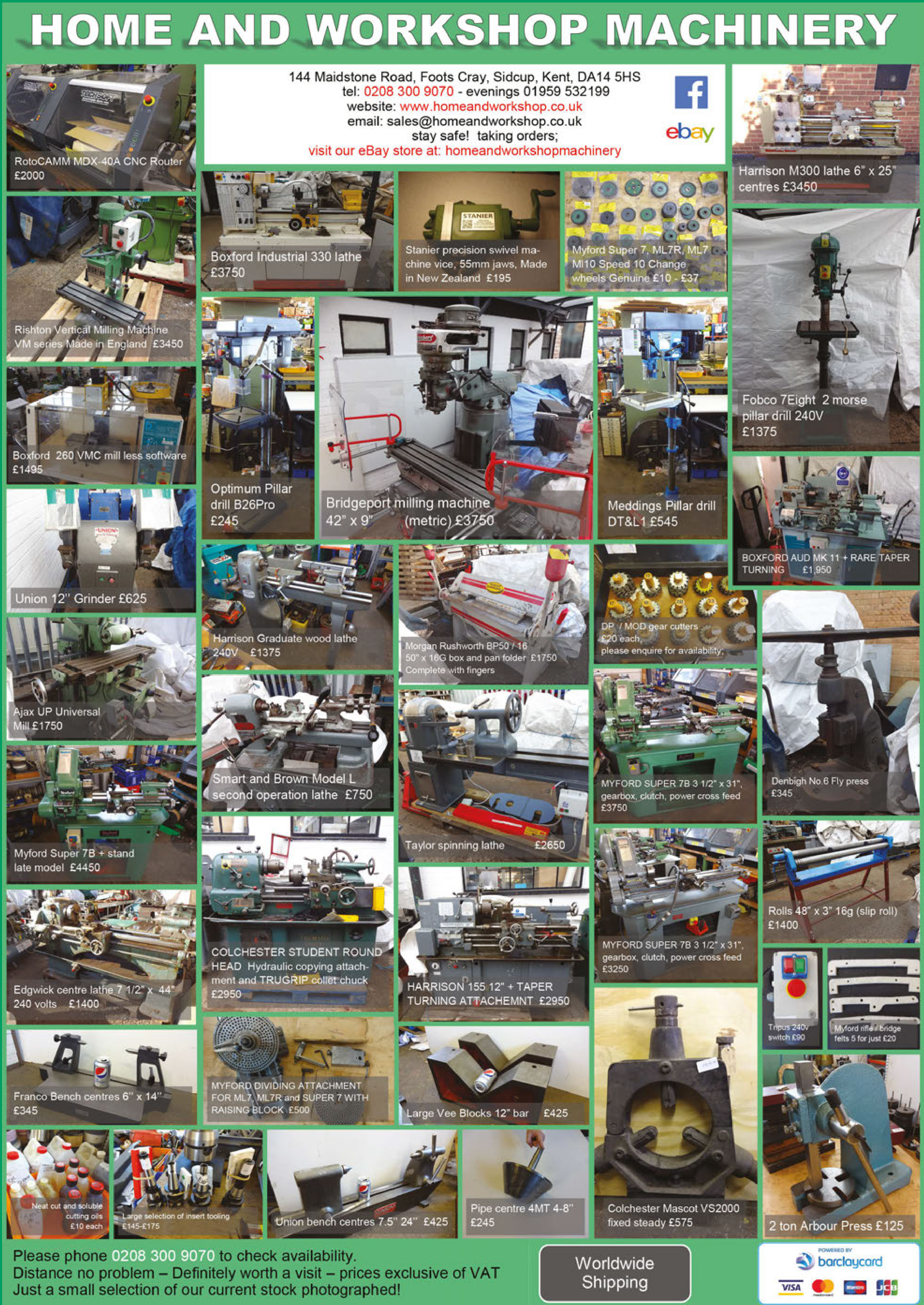
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