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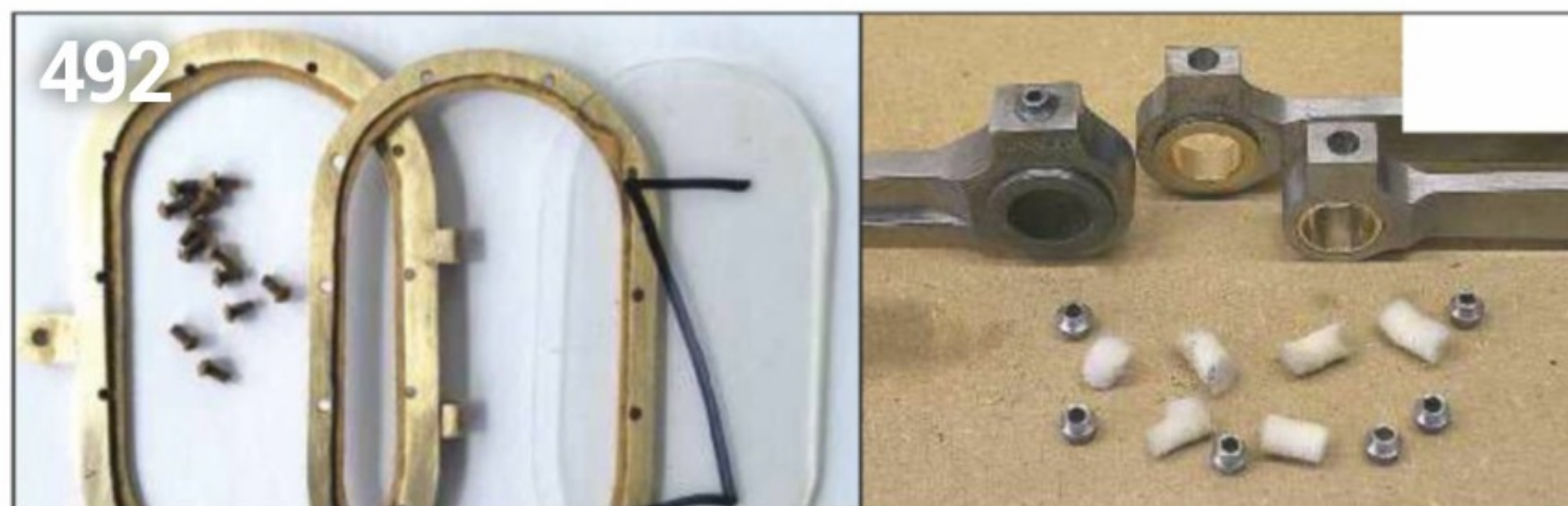


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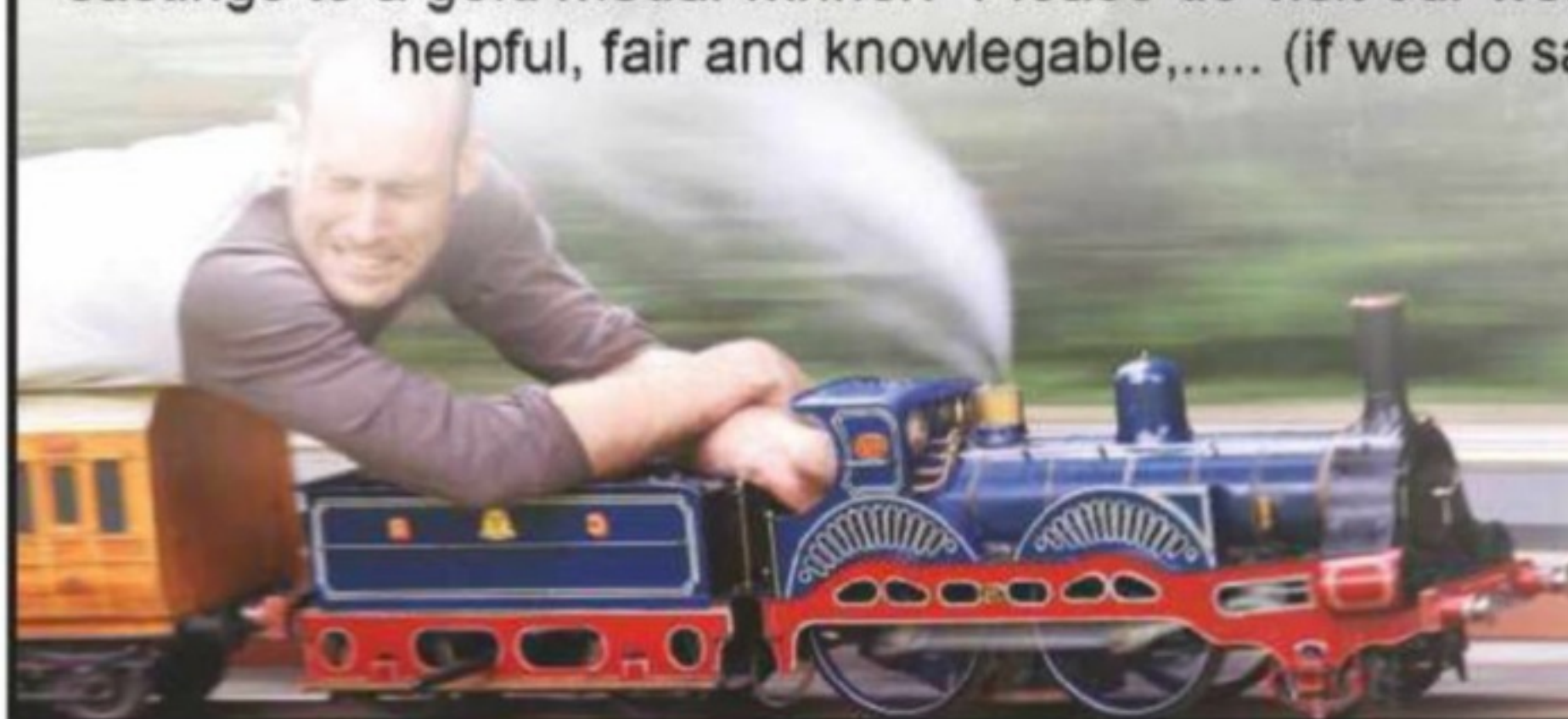
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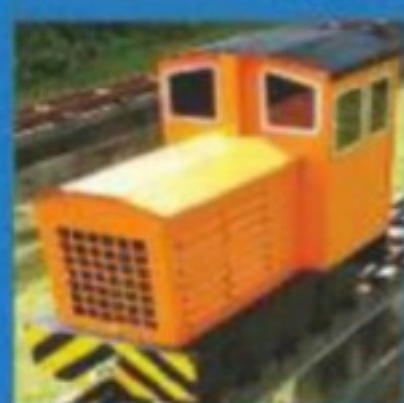
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Scaling Models

After pondering the question of the maximum attainable size of a steam locomotive (Smoke Rings, issue 4620) I turned to wondering how our model locomotives scale as far as performance is concerned. Speculation on this question was encouraged by a look at the IMLEC results table (issue 4620 again), which represents a reasonably good database of model locomotive performance.

I suppose tractive effort is a good place to start. As I stated in my 'How Big' speculation, this depends on the product of boiler pressure, piston area and the ratio of the crankpin throw to the wheel diameter. If we suppose that our models and the 1:1 versions have the same geometry, as far as wheels and cranks go, the tractive effort should therefore scale with boiler pressure and piston area. If we stick to standard gauge 5 inch gauge models for the sake of this discussion (scale 1:11.3) then the piston area will scale by a factor of $1:11.3^2$, which is roughly 1:120. We run our models at about one third of prototypical boiler pressure (80psi versus 250psi) so tractive effort should, ideally, scale by 1:360.

However, there is a limit to the actual maximum tractive effort that a locomotive can exert and that is determined by the product of the weight of the locomotive and the coefficient of friction between wheel and rail. This coefficient is typically about 0.25 (in good conditions) but can be assumed to be same for a model and the full-sized article. We can expect maximum possible tractive effort, therefore, to scale with weight. The weight of models scales fairly closely to the cube of the scale (e.g. a full-sized Thompson B1 weighs about 160,000lb which, scaled by $1:11.3^3$ - roughly 1:1400 - is 110lb, a little lighter than the actual weight of a 5 inch model).

Now we can make an interesting observation. We find that the maximum theoretical

tractive effort of a 5 inch model scales by 1:360 but the maximum attainable tractive effort (limited by the weight of the locomotive) scales by 1:1400. A reasonable conclusion is that the tractive effort of a model is limited much more by locomotive weight than the ability of the locomotive to deliver the required force. This implies that achieving wheel slip in a model is rather easier than it is in full size (for a properly scaled load, of course). I wonder if that is what is found in practice - perhaps someone can pronounce on that?

Now let us consider drawbar pull while running. This is not the same as tractive effort, defined as the maximum possible drawbar pull. Presumably this latter is achieved with the locomotive in full gear, with the regulator wide open and the locomotive hardly moving. None of these conditions applies when the locomotive is running normally. When the locomotive is 'notched up' the average cylinder pressure will be rather less than the boiler pressure, perhaps half, and the regulator will not normally be wide open, reducing the pressure even further. Let us suppose then that the drawbar pull, when running normally, is about 25% of the claimed maximum. This is a bit 'finger in the air' but I reckon it is realistic (50% for notching up and 50% for the regulator!).

Turning now to the IMLEC results, let's look at the winning locomotive, Marcus Peel's B1 (hence my choice of example above!). A full-sized B1 has a tractive effort of 27000lbf. If we divide this by 360 we get 75lbf, which we may suppose is the maximum tractive effort of the model. Marcus achieved an average drawbar pull of 21lbf. Sure enough, this is about 25% of the maximum. The model and the full-sized locomotive thus appear 'true to scale' as far as drawbar pull is concerned.

Power to weight ratio is another interesting performance parameter. Power is the product of force and speed (the 'dot product' of force and velocity for the pedants!). Marcus Peel's

average speed was 9 miles per hour (about $4\frac{1}{2}$ miles in 30 minutes) and his drawbar pull averaged 21lbf. His power was thus about 190lbf.miles per hour (in ME units!). A full sized B1 doing equivalent work might typically achieve 45mph with a drawbar pull of 7000lbf (25% of maximum) - a power of about 31500lbf.miles per hour. Scaling this by weight gives us 225lbf.miles per hour. This is not far from Marcus's power to weight ratio for his B1. We can therefore conclude that power to weight is also reasonably 'true to scale'.

Lastly, let's turn to coal consumption. One ton of coal will typically take a full-sized express locomotive 40 miles. That's 50lb per mile. Marcus Peel used 1.47lb and travelled $4\frac{1}{2}$ miles, or $\frac{1}{3}$ lb per mile. If we divide by drawbar pull (to get 'coal used per lbf.mile') we get respectively 1/140 and 1/63. It seems then that the efficiency of the model, in terms of coal consumption, is less than half that of the full-sized locomotive. This is borne out by the efficiency figure of 3% given in the IMLEC results, compared to a typical full-sized locomotive efficiency of 6-7%.

So, it appears that our models are more or less true to scale in performance in most respects except efficiency. The key is clearly the boiler, which converts the energy in the coal to steam. Of all the parts of a steam locomotive this is the one part which doesn't scale in a straightforward way - we're at the mercy of fluid mechanics. So, is the boiler of the locomotive one of the major factors which make an IMLEC winner? Is IMLEC really a 'battle of the boilers'?

Martin Evans can be contacted on the mobile number or email below and would be delighted to receive your contributions, in the form of items of correspondence, comment or articles.
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Model Engineering's Heroes - James C. Crebbin

Roger Backhouse celebrates an early pioneer of model engineering.

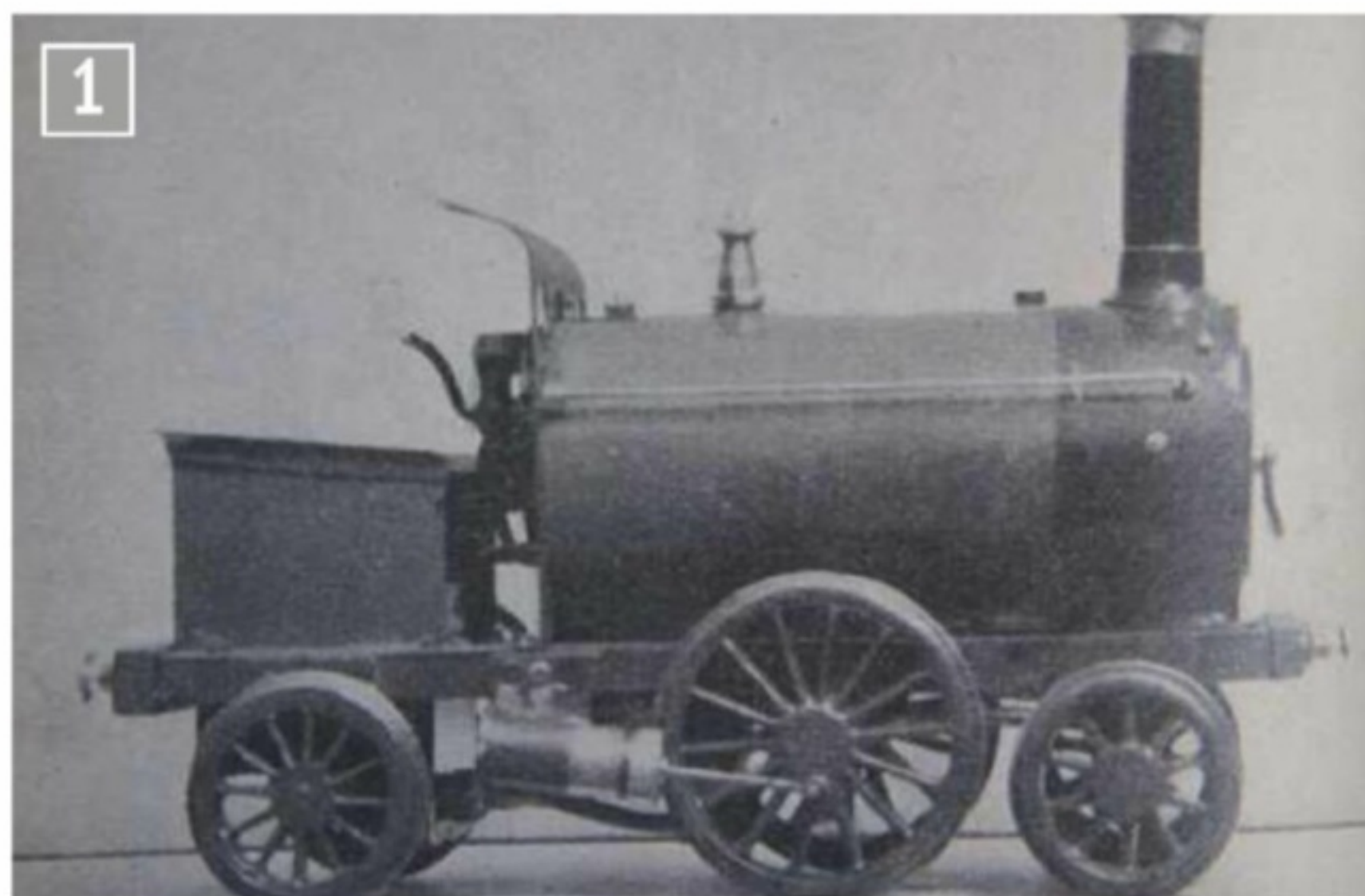


Writing in 1969 K. N. Harris noted that fewer than twenty working model compound locomotives had been made since 1898 and one man, James Charles Crebbin, was among the few makers. 'Uncle Jim' not only made compound locomotives but was also a great experimenter in locomotive and boiler design during his life, from 1875 to 1950.

His engine *Cosmo Bonsor* was a pioneer in model locomotive engineering. It will be seen by a new audience at an exhibition in the National Railway Museum York from September and then at the Science Museum London from May 2020.

Jim Crebbin was born in 1875 in Bromley by Bow, Poplar, near the River Lea. Success did not come easily. His father discouraged engineering as a hobby and career thinking it would be bad for his health. Some of the family were involved in local shipbuilding and this may have sparked Jim Crebbin's first interests in model boats. As a boy Jim was a regular visitor to model shops including that of H. J. Wood on Oxford Street where he saw locomotives made in the workshop there.

At just ten years old Jim Crebbin was sent to Australia for the good of his health. He sailed on a five masted sailing ship, knowing no-one on board. He went to Ballarat College for four years before returning to his family, now moved to Islington where his father managed a gin distillery. Here he built a workshop secretly in a garret, screwing boards to the rafters so as not to make a noise.



Jim Crebbin's first model locomotive, built when he was about 15 years old (© Model Engineer).

He was now building model locomotives with early efforts much like the commercial 'Ajax' types then available, with a pot boiler and meths fired. He seems to have built his first by the age of 16 or 17 (photo 1). How he acquired his engineering skills is not known but those who knew him commented on his determination.

An early job in a drapers led to a health breakdown because of the long hours. Fortunately he was able to obtain a clerk's post in the Bank of England where he remained, rising to become a supervisor in the dividend department, until retirement after forty years service.

The family moved again to Hornsey where Jim Crebbin built a garden railway. Here he began to develop ideas about compounding and improvements to boilers. In the late 19th century most model locomotives were spirit or oil fired. They were not intended for passenger haulage. Only richer men could afford ground level 9½ inch gauge tracks for coal fired 'ride-on' trains and locomotives.

Jim Crebbin had been working on his own and he sympathised with 'lone hands' throughout his life. His contacts were transformed by publication of *The Model Engineer and Electrician* in 1898 with the first editor, Percival Marshall, realising the potential market among gentlemen amateur engineers. He proposed a society for amateur engineers and one of the first to respond was Jim Crebbin.

Jim was an early member of the Society of Model Engineers which grew rapidly, establishing branches in several towns. The name was changed to Society of Model and Experimental Engineers in 1910. This gave him many new links and the opportunity to exchange ideas with others involved in SME and *Model Engineer* including Henry Greenly and Charles Lake.

One of his earlier engines used frames given to him by a Colonel Ricardo plus parts from a second hand shop. From these frames he built first one with a toy like appearance but then rebuilt it again to look more like a proper model locomotive. This



Jim Crebbin with a new Cosmo Bonsor at his parent's home in Hornsey. He became known worldwide for this engine which ran at most Model Engineer Exhibitions until his death in 1950 (© SMEE 2019).

he rebuilt yet again to make the engine *Boorman*, named after a fellow member of SME who'd built the society's portable track. This engine was his first compound. He also used a superheater, possibly the first in a model locomotive, and used a brick arch made of bent steel sheet coated with Pyruma fire cement, again perhaps a first.

Jim Crebbin experimented with spirit firing, trying different configurations of burners and boilers for best results. He also tried using paraffin, experimenting with different types of burner. Perhaps drawing from his experience with model boats he used water tube (flash steam) boilers in locomotives trying several different arrangements. From his experiments he advocated dry steam, though not necessarily superheated.

From the late 19th century Jim Crebbin travelled extensively in the UK and abroad, having a particular liking for the Great Western where G. J. Churchward was carrying out a radical overhaul of locomotive

stock. He came to know and admire Churchward and held footplate passes on many railways, also riding on many Continental locomotives. This gave him detailed knowledge of the de Glehn compounds and contacts with Karl Golsdorf, whom he admired. His knowledge of compound locomotives and their working led to speaking engagements at SMEE and the Junior Engineers Section of the Swindon Mechanics Institution. Later, his friend J. N. Maskelyne said he advised Great Western drivers on the introduction of compound locomotives *La France* and *President*.

His next engine *Cosmo Bonsor* developed from his earlier engines. Completed in 1903, it hauled the first train at the first Model Engineer Exhibition in 1907 and became arguably the most famous model locomotive in the world. It was built to 4½ inch gauge and was oil fired with an Atlantic wheel arrangement. As built it had four cylinders – i.e. two tandem compounds fitted between the frames (**photo**

2). Later, he changed this to a 4-6-0 wheel arrangement, replaced oil with coal firing and removed the compound arrangement, running it as a four cylinder simple expansion locomotive instead.

By 1914 he'd started work on a compound 4-6-2 to be called *Charles Aldington* (now *Conversion*), not completed until 1922 (**photo 3**). He also developed his interest in model yachting becoming Chairman of the Model Yacht Racing Association and President of the Victoria Model Steamboat Club.

In 1916, at the age of 40, he married a Belgian refugee eighteen years his junior. They had a son, Roger Louis Edward Crebbin. Alas, the marriage ended in divorce in 1921 though he retained custody of his son. By this time he had moved to 'Mostyn', Bramber Road, Friern Barnet, where he lived until his death in 1950. Here he had a garden workshop and later built a miniature railway track.

Divorce was a blow, but worse followed. In 1925 he spent three months in the King Edward VII Sanatorium near Midhurst suffering from tuberculosis. Perhaps as part of his convalescence he went for a cruise on the SS *Oronsay*, dressing as a tramp for a fancy dress dance on board! He took regular cruises to the Mediterranean and elsewhere, later visiting Madeira, Brazil and Argentina, meeting model engineers *en route*.

His next engine *Sir Felix Pole* was a 4-8-0 compound. Model engineers commented on how easy it was to drive this and other Crebbin engines, noting their free steaming on limited coal, rapid acceleration and excellent adhesion. Their

maker was a great believer in good springing.

He followed with two more models - *James Milne*, a 4-6-0 mixed traffic locomotive, and *Old Bill*, a 0-6-0 simple expansion locomotive in 5 inch gauge. By this time he was again active in SMEE, elected President and improving relations with other model engineering societies. He also joined the North London Society of Model Engineers when that formed in 1944.

Though divorced, Jim Crebbin was no misogynist and liked seeing women drive his engines, promoting women's membership of SMEE. One, whom he met on a cruise, Betty Colebrook, wrote an enthusiastic account of driving at the Model Engineer Exhibition in 1926 (**photo 4**).

On retirement from the Bank of England he did even more travelling abroad including a visit to Vitry to see Gresley's *Cock o' the North* on the testing plant there. Unfortunately he was knocked over by a motor bike near home and spent time in Finchley Cottage Hospital. Here he invented improvements to a surgical instrument, not the only one he'd devised.

In the Second World War his son Roger was taken prisoner at Dunkirk. Jim Crebbin ran his *James Milne* engine at a local fête, raising money for prisoner's welfare, and also appeared briefly in a film for the Ministry of Information. 'Transfer of Skill' describes how craftsmen used their skills in other ways to help the war effort. The film shows him driving his rebuilt Santa Fe Mallett and in his workshop but gives little other information.

Given boyhood visits to H. J. Wood's shop it is appropriate that one of his last projects was restoring a model of a Great Northern single made there. The restoration was for the conductor and founder of the Promenade Concerts, Sir Henry Wood, H.J. Wood's son (**photo 5**). Jim Crebbin and



Conversion, formerly Charles Aldington, as it is today. Though outwardly little changed this was built as a four cylinder compound but later altered to simple expansion (© SMEE 2019).



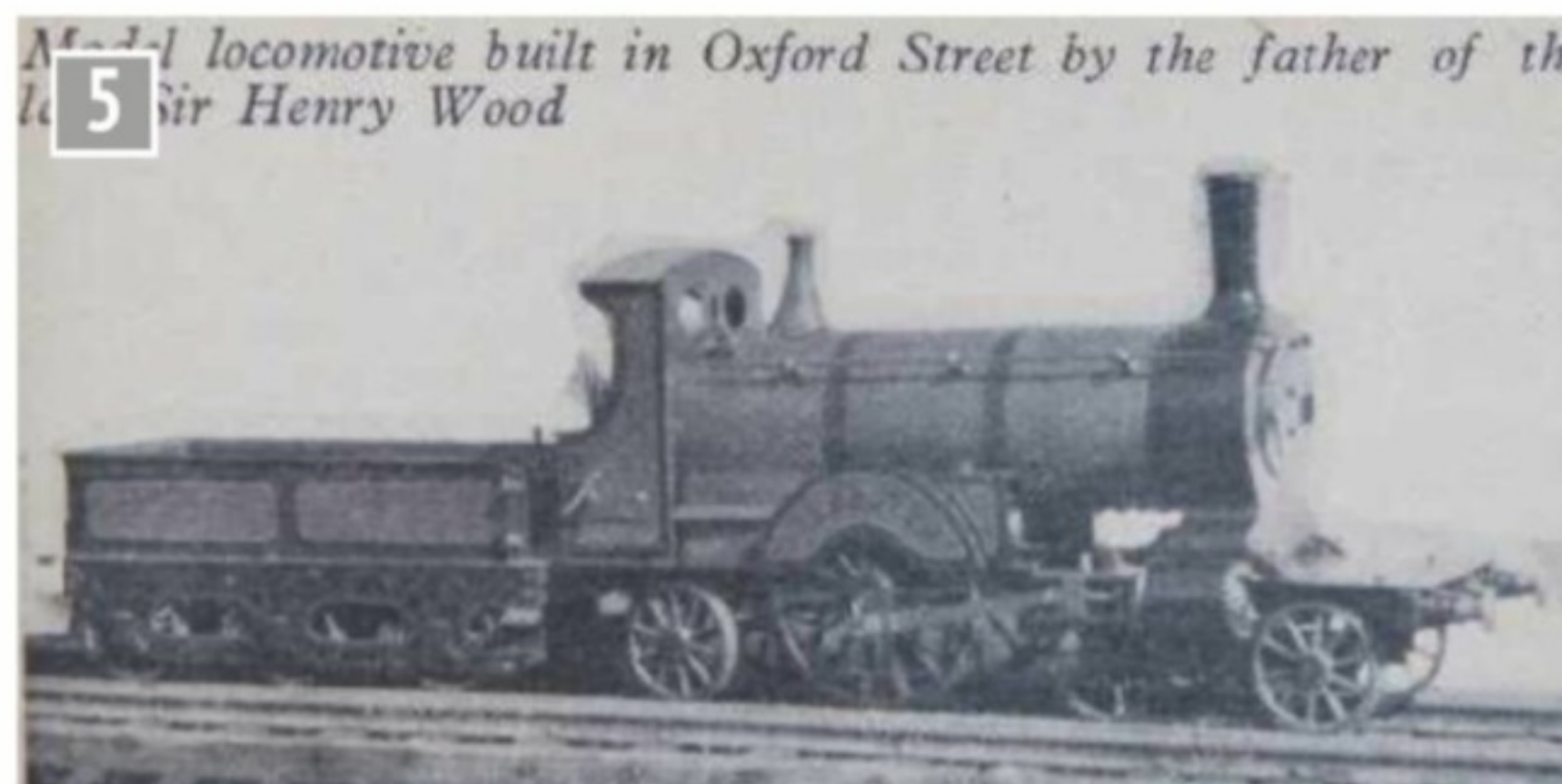
4 The 4-8-0 compound Sir Felix Pole driven by Miss Lettice Holder at a Model Engineer Exhibition. Jim Crebbin stands on the left, pipe in hand. He liked seeing women drive his engines - and guess which boy wants to be an engine driver? (© SMEE 2019).

Henry Wood were friends and Jim said music was one of his hobbies, often attending Promenade Concerts.

On his death in 1950 his friend J. N. Maskelyne said of him "nobody has worked harder in the cause of model engineering". It was one fitting tribute among many. His generous donations to

societies were many, and the Crebbin Trophy, now awarded at the National Model Engineering Exhibition, commemorates a great model and experimental engineer.

ME



5 Model locomotive built in Oxford Street by the father of the late Sir Henry Wood
Great Northern Railway single driver model restored by Jim Crebbin for his friend Sir Henry Wood, the conductor and founder of the Promenade Concerts (© Model Engineer).

FORTHCOMING BOOK

Roger Backhouse, 'The Remarkable Jim Crebbin and his Experimental Locomotives', Society of Model and Experimental Engineers. Published 24th September 2019.

84 pages. £14 plus £2.50 UK postage and packing.

ISBN 978 1 5272 4532 7

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'Transfer of Skill' is available on DVD from Panamint Cinema, Abercorn Schoolhouse, By Newton, Broxburn, West Lothian, EH52 6PZ www.panamint.co.uk

SHOWCASE

Kempton Park Kerr-Stuart Locomotives

Two 7¼ inch gauge models of the Metropolitan Water Board railway at Kempton Park, London, made their first appearance together at the Coate Water Railway track of the North Wilts SME, Swindon on Sunday 2nd June 2019.

The model of *Hampton* was built to works drawings by Alain Foote of Rugby and first steamed about 6 years ago. The model of *Kempton* was built by Brian Minter of Market Lavington using only copies of two works drawings and a minimal number of castings and was completed in 2018.

Both locomotives performed well on this busy railway until rain stopped play in the mid-afternoon.

Simon Bowditch



If you would like to see your model in the 'Showcase' please send a photograph and a brief description to the editor.

The Barclay Well Tanks of the Great War

PART 53

Terence Holland describes and constructs two appealing, century old locomotives.



Continued from p.390
M.E. 4620, 30 August 2019

This constructional series addresses Andrew Barclay 0-4-0 and 0-6-0 narrow gauge locomotives supplied for use in the First World War. Built without the use of castings, the 0-4-0 design is described as two versions; as-built for the British Admiralty in 1918 and as rebuilt and currently running on the Talyllyn Railway as their locomotive No.6, *Douglas*. The 0-6-0 engines described were built in 1917 and operated on 60 centimetre gauge track at the Western Front in France. These were small, spartan machines of which only 25 were supplied and none have survived into preservation.

Finishing off *Douglas*

There is not much work left now to complete *Douglas* and then it's on to the modifications (and simplification) required to create the engine in its original state - *Airservice Constructional Corps No.1*.



Cab/boiler angle iron.

Spectacle plate/firebox angle iron

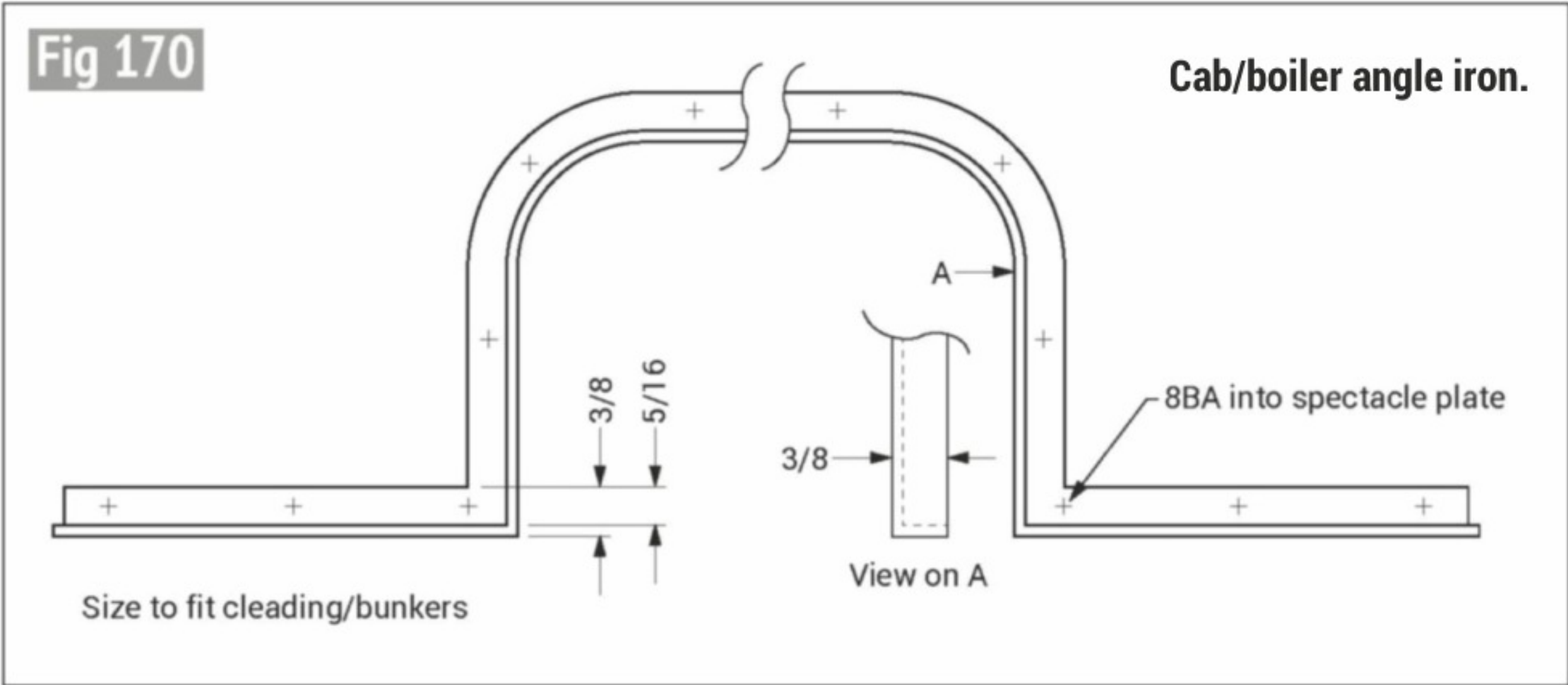
This is another fairly simple component but, nevertheless, difficult to make. It connects the cab to the boiler and tidies up the joint (see fig 170 and photo 242). Note the cut-outs in photo 242, which are needed for the blower pipe and regulator rod. My engine has several cut-outs on the cab front resulting from various accessories added in the past, such as steam donkey pump, chime whistles etc. I should really have filled these in when rebuilding as *Douglas*, but it

was one of those relatively insignificant jobs that was easily forgotten and, as they say, 'life's too short'! Dimensions are not given in fig 170 (apart from those of the brass angle itself) as the item needs to be made to fit around the boiler cleading and across the bunkers, once the various parts are fitted. I don't see any problem with this, as this item would have been used on the original locomotive to cover minor discrepancies.

Window frames

Again, these are not easy parts to make and, if building *Douglas*, four pairs of frames are needed. They should be a precise fit in the spectacle plate openings as the windows can be opened from the inside. They are well worth the effort involved in manufacture, however, as they are a prominent feature of the engine - and several more items of brass to polish! One advantage of building the 0-6-0 F Class engine is that window frames are not required.

The frames are cut from 1/16 inch thick brass sheet,



as shown in **figs 171, 172** and **photo 243**. As they are constructed from relatively thin sheet, they will need to be soft soldered to a suitable backing plate so that the recesses can be milled to take the glass. Another tricky job but only eight are required! At the top left of the inner frame in photo 243 a milling 'excursion' can be seen which almost resulted in a 'scraper'! Fortunately, it is on the inside and therefore not visible.

The outer frames (fig 171) should be drilled and tapped 8BA and spotted through to the inner frames, which should then be drilled 8BA clear. The glass should be cut to fit from suitable glass of slightly under 1/16 inch thickness.

As with the spectacle plate openings, CNC machining would make the job easy – but, as mentioned earlier, it's way above my pay grade! Another option would be to turn the ends from brass bar complete with rebates, part off and cut these in half with a piercing saw. Silver solder these semi-circular sections on to machined straight pieces, which have been suitably rebated.

Roof

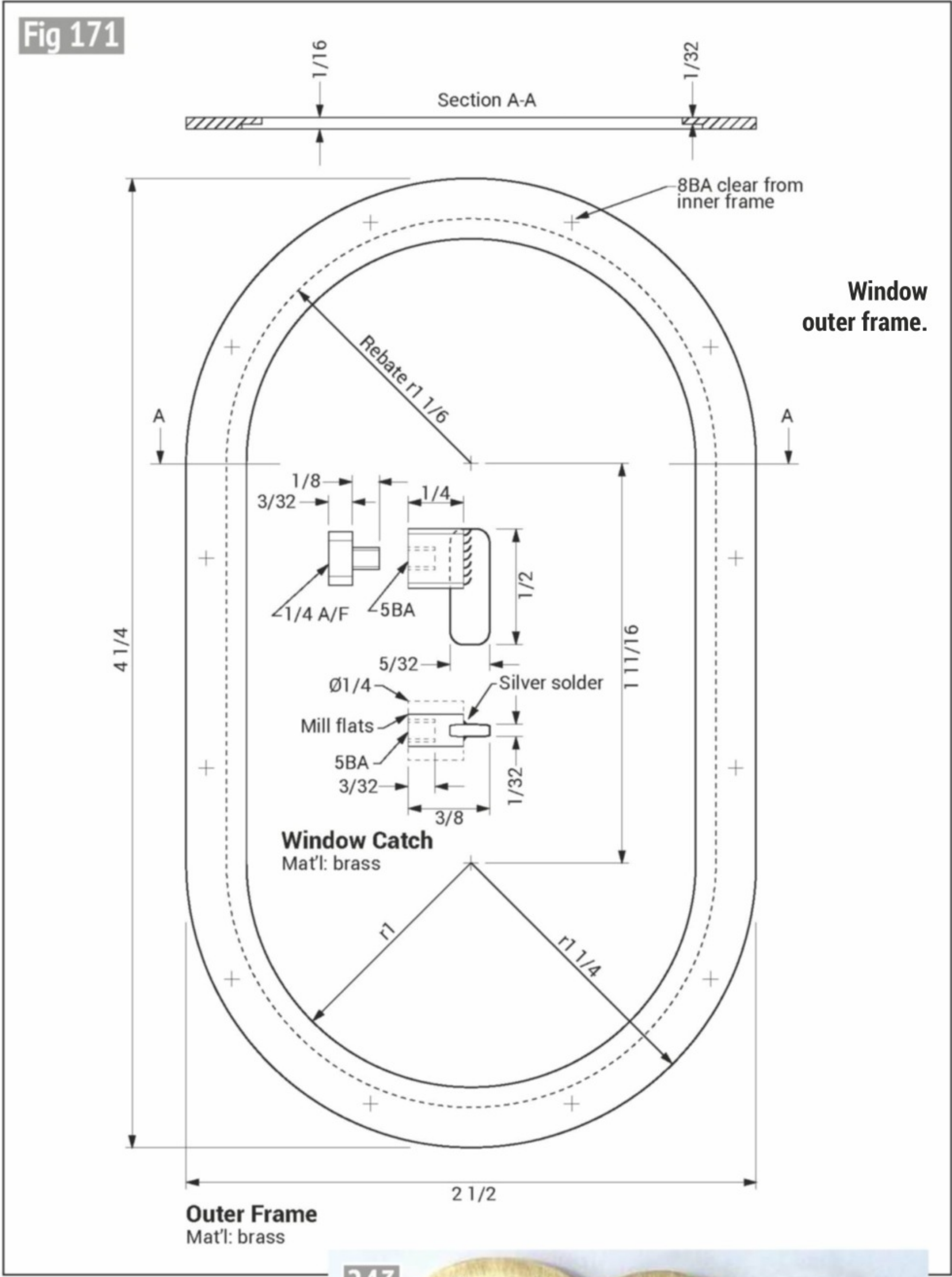
Working out the curve for the roof of the locomotive is easy when you have the formula; it is just a matter of calculating the radius from the dimensions of a chord. The only measurements needed are the height of the chord *H* and its width *W*. The formula is as follows:

Radius, $r = H/2 + W^2/8H$

However, for our purposes, with cab rooves (or roofs depending on your preference) as *H* is small compared with *W*, *H*/2 is insignificant and can be ignored and therefore $r = W^2/8H$

Incidentally, the word chord comes from the Latin *chorda* meaning bowstring – useful information for anyone involved in a pub quiz!

The roof panel 'in the flat' is approximately 13 3/4 inches wide. Note that the roof for *Douglas* is longer than that of



Window frame components.

Fig 172

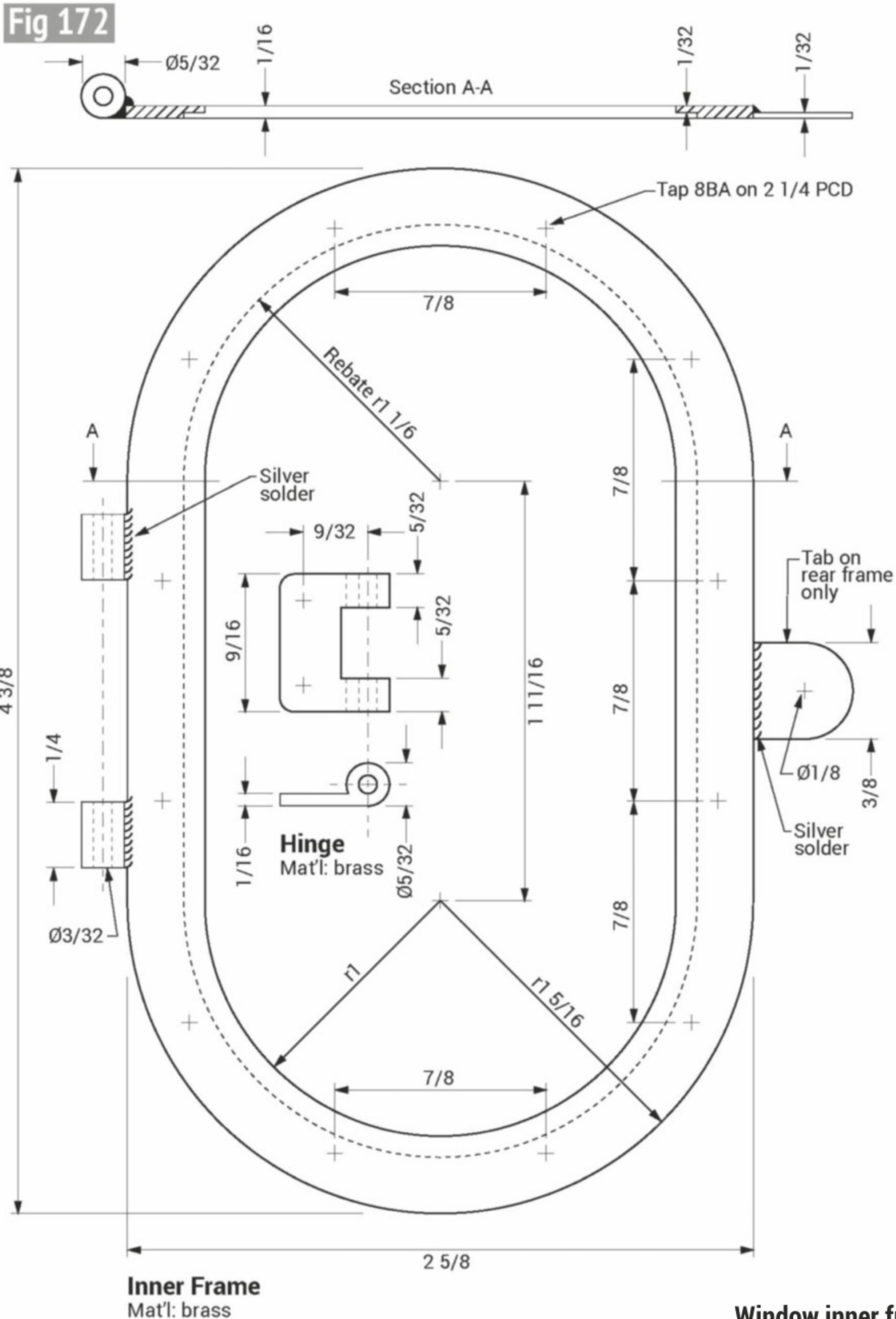
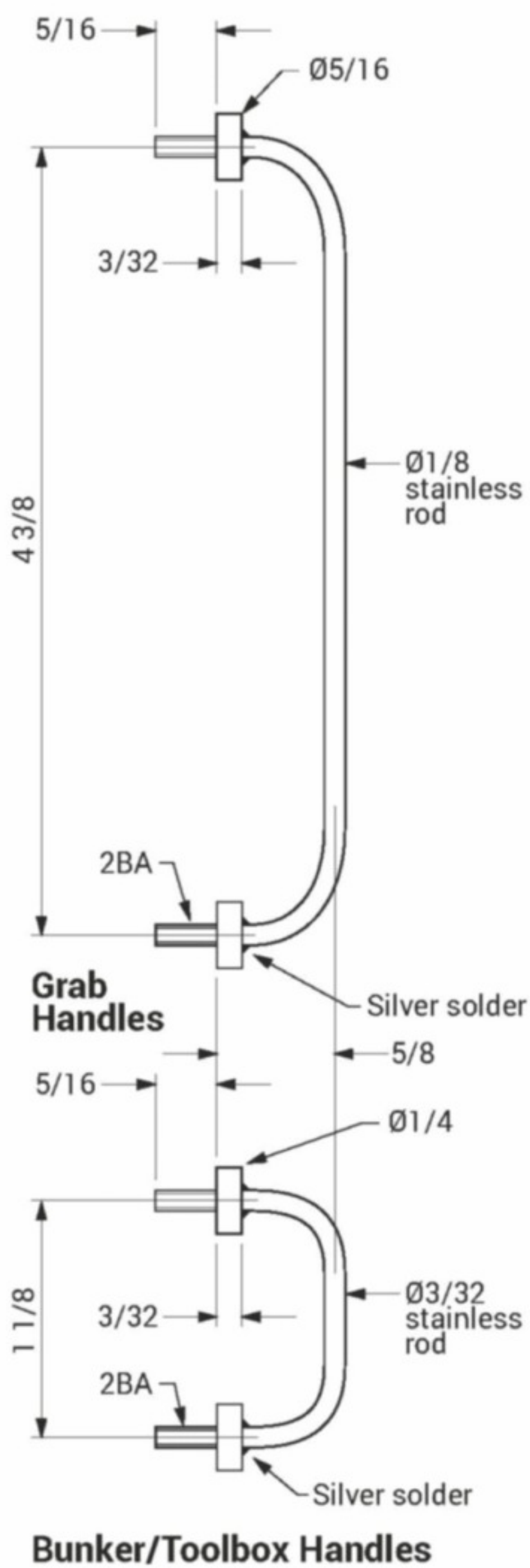


Fig 173



with the slots machined off and made special nuts from ¼ inch hexagon brass. It would, however, be no more difficult to turn 'em up from brass rod.



Sliding roof panel.

of *Douglas* came from sister engine 1432 and may well have the number stamped on them somewhere. The roof panel is shown partly removed in **photo 244**.

Grab handles

Four of these are needed, one each side of the cab access opening – see **fig 173**. I made mine the easy way by bending up 1/8 inch stainless rod and silver soldering these to 2BA brass cheese-head screws

Toolbox and bunker lid handles

These are similar to the grab handles but smaller; mine were made the same way as the bigger ones, using $\frac{3}{32}$ inch diameter stainless rod and 2BA screws with the slots removed. Again, see fig 173. All these handles look good with the heads painted black and the stainless left bright.

●To be continued.

Five Inch Gauge Garden Railway Design and Construction

PART 2

Stephen Wessel considers the best way to achieve a stable and durable track bed for his garden railway.



Continued from p.441
M.E. 4621, 13 September 2019

The first part of this series set out to illustrate some of the shortcomings of the typical 5 inch ground level railway using either wooden or plastic sleepers with aluminium rail. I write as a long-term owner of such a railway, ever seeking to reduce the maintenance hours while improving both its safety and longevity. I hinted before at a way forward and now, in this second article, I shall discuss the use of a concrete bed as a means of increasing the stability of our small tracks.

I should add that the processes that disturb and degrade our railways are not so much caused by trains as by continual unseen movement and decay caused by the weather.

For any permanent track concrete can be used in two ways, either separately or together.

1. As a solid ribbon about 3 – 4 inches thick running continuously under the track, which is screwed down to it at intervals.
2. For sleepers. I have carried out much experimental work on these and will be giving a detailed report in part 3.



A newly laid section on concrete (just visible in foreground).

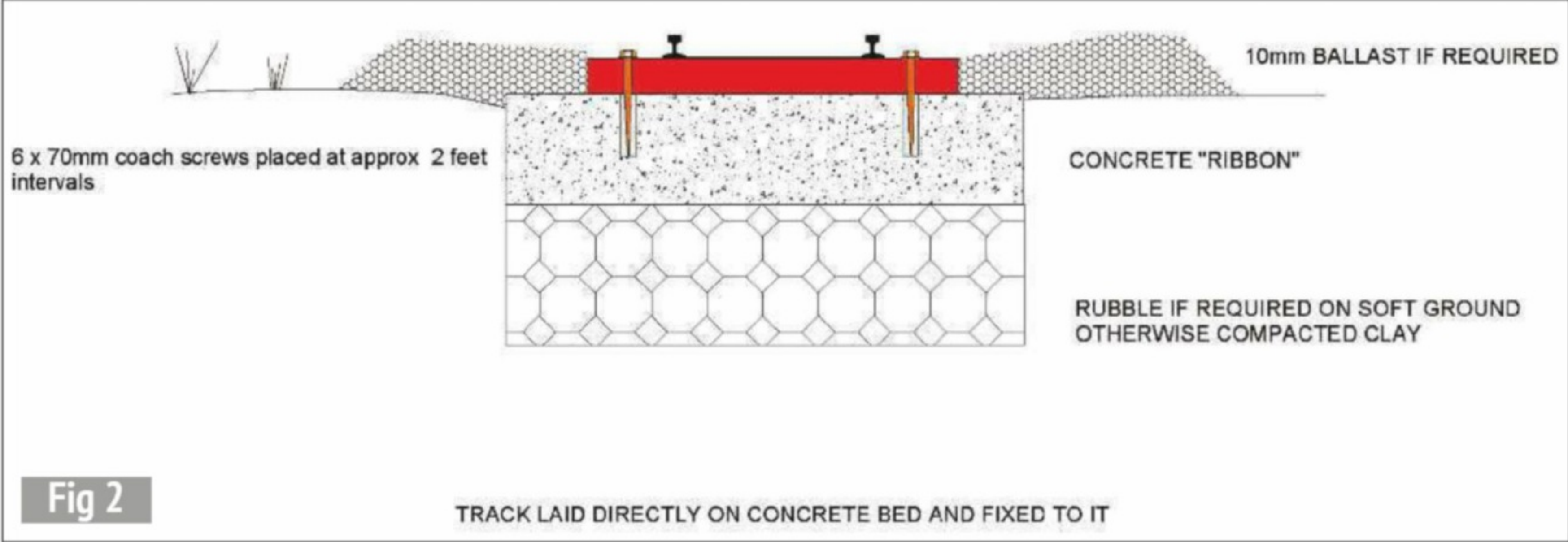
It has often occurred to me that a good solution would be to use concrete sleepers, if a way to cast them successfully, complete with fixings, and the necessary strength could be found. I have now developed a method which shows great promise.

Most of my railway uses the first method. The concrete has been in service now for about 20 years, underlying about 90% of the route, which extends to 1/2 mile. Stability of the ride has been fairly good with very little regular maintenance apart from sleeper replacement,

which becomes an ever increasing issue as the years pass (photo 7).

Contrary to advice given elsewhere the concrete should in my opinion be kept relatively thin, 3 inches being quite thick enough (fig 2).

A long length of this thickness has some flexibility and will move with the ground – a thicker section, especially if attempts are made to reinforce it with steel, may well break up into blocks causing sudden gradient changes. The principle behind the concrete bed is that the track, by being attached to it, acquires weight. I have found



expansion gaps in the concrete to be quite unnecessary as the temperature of the bed remains uniformly cold throughout the year. Here are the pros and cons:

Pros

- 1. The amount of excavation and foundation material may be reduced depending on the type of ground. Much of mine is laid directly on to compacted clay subsoil. Where the ground was softer, I put in a layer of rubble first. No membrane is needed. Remember the pressure imposed by a passing train is tiny, the load being well spread by sleepers and concrete. Think of Chat Moss.
- 2. Setting out curves is much easier because this is done at shuttering board stage. Levelling and superelevation on curves (if required) are put in at the same time, before any concrete is poured.
- 3. Provided the concrete is screeded off flat and smooth, laying the track is very easy.
- 4. The need for constant ballast tamping to ensure track is free of bumps,

hollows and twists is entirely eliminated. The track remains stable and is consequently much safer.

Cons

- 1. Concrete in large quantity is expensive and may be difficult to handle and move around on site.
- 2. Drainage is a major issue leading to shorter sleeper life if they are of wood. Surface water and silt tend to collect around sleepers.
- 3. The hold-down screws often shear off due to extreme lateral forces on the track during hot weather. Installing a sufficient number of them is a major, somewhat back-breaking task involving percussion drills and plastic plugs. Wooden sleepers shrink in thickness becoming loose around the fixing screw.
- 4. Large tree roots passing under the bed gradually expand and can lift it. It is advisable to leave a gap in the concrete at such points, filling it with ballast, so the root has room to move.
- 5. A largely imagined worry about a concrete bed is hardness of the ride and noise. In practice, after a

year or two, fine silt collects under every sleeper which has a softening effect.

Some of my older track is still just lying in plain ballast but all of it has been given extra weighting by attaching blobs of rough concrete, approx. 6 inch hemispheres, to the ends of every other sleeper. This was something of a panic response to improve stability quickly at minimum cost without the need to lift track. It doesn't look very pretty and over time many of the blobs have worked out of the ballast or been kicked accidentally into the verges. However, as a system the idea was sound and certainly reduces the tendency of track either to lift or move laterally with temperature changes.

Installing a concrete bed

Sadly, I have no photographs of this process so a brief description will have to serve. Shuttering boards should be 4 x 1 inch sawn timber in 4.8m lengths. I connect three of these together with 'fishplates' of the same material into one long length getting it straight by eye. These are set in the previously dug trench using a number of 2 x 2 inch pegs

wacked in on the outside of each board (**fig 3**). On curves, the inner board is set first, pegging and bending it to achieve a smooth curve complete with a natural transition from straight. Gradients are attended to at the same time using whatever surveying instruments come to hand. I used a water level. The outer board can be given a slight cant or super-elevation by raising it slightly relative to the opposite one. Once all is securely fixed a general-purpose concrete can be poured, tamped and screeded off, taking care that the surface is smooth and flat. The process is fun for a small team and thoroughly good exercise for cool spring days! This method was also used exactly as described to lay the Bath & West Railway by the East Somerset SMEE and has served well.

Other types of foundation

As an alternative to continuous concrete I have tried longitudinal timbers tied together with 5 inch spacers. These units of 4.8m length rest on deep concrete supports at suitable intervals. Track is screwed down to them. The

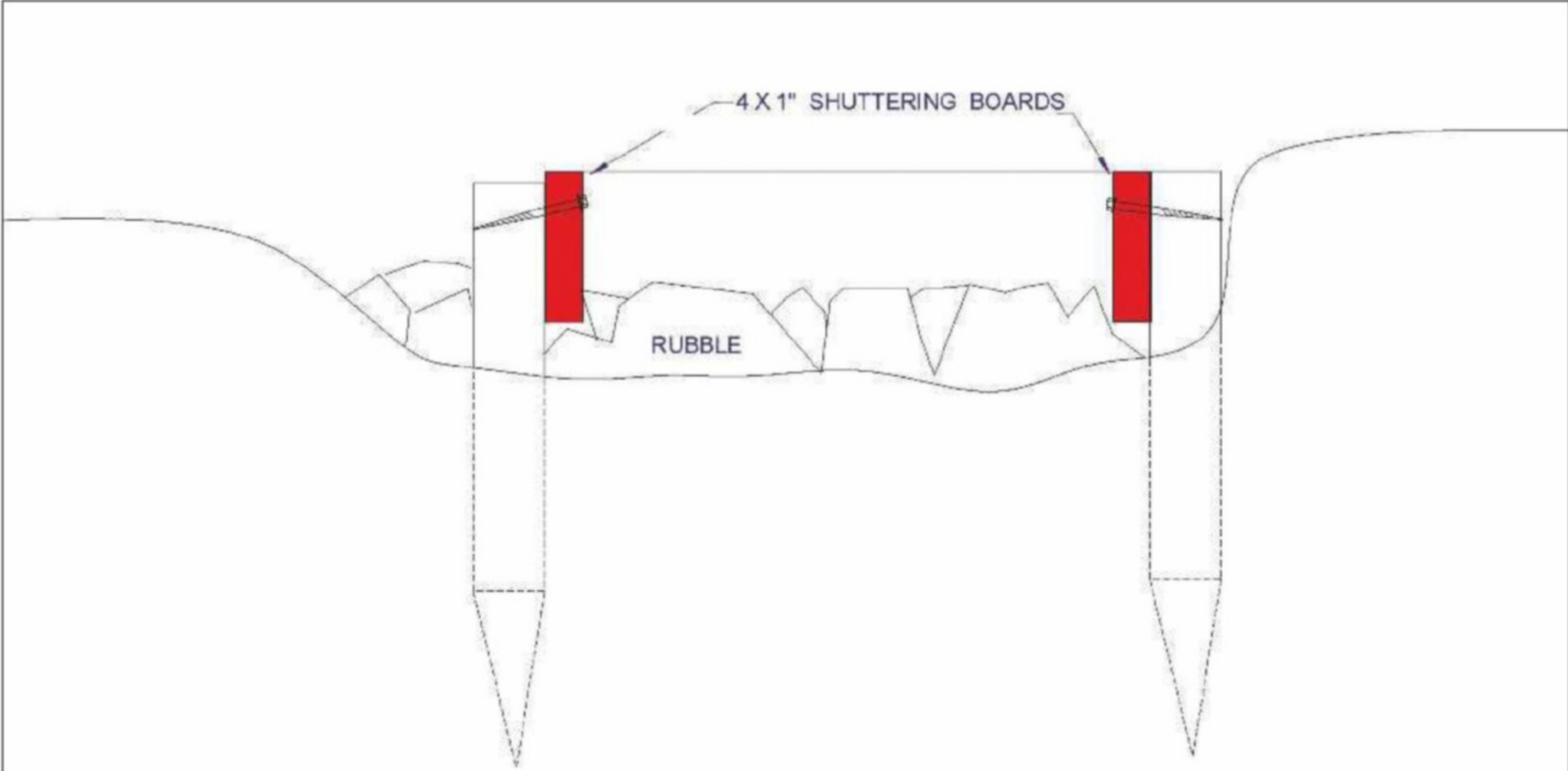


Fig 3



Some rail fixings. The coach screw at left is now favoured mainly for its hexagon head. Flat screwdriver slots are a pain while posidrive slots soon fill with silt making them hard to remove. Note there is no need for stainless steel. Some of these fixings are more than 30 years old.

system is fine for straight sections and can be used on gentle curves although proper super-elevation isn't really possible. I made the mistake of back filling around the timbers with clay and rubble, which remains constantly wet so their life has been relatively short at 15 years. The replacements recently installed were left partially exposed and given a thick coating of bitumen paint. The system was employed over soft ground close to a river bank.

I have also used scaffold poles in a similar way.

Rail fixings

I must have tried everything - wood screws with various heads, a huge batch of surplus OBA set screws, coach screws and even roofing nails (**photo 8**). In days gone by, screws were relatively expensive but prices have since plummeted, even for stainless steel, and there is a huge variety available. I have no doubt that BZP coach screws with hex heads and an integral washer are the best. I use 6mm x 25mm now obtainable everywhere for about £3 per 100.

Pre-drilling the sleepers is vital to reduce later splitting despite some of these modern screws having self-drilling tips. It also speeds up assembly. It is still necessary to use some sort of gauging tool as assembly proceeds because screws always push the rail over as they tighten. But any type of screw will stress the

surrounding material which will eventually cause a split to develop. Constant movement of the wood with changing seasons will inevitably result in screws losing their initial tightness but then how tight *should* they be? This is a simple question that drives right to the heart of track stability.

Track rigidity

When laying brand new or re-sleepered track it is tempting to do up the rail screws hard, as once both rails are secured the panel gains lateral rigidity and curves are locked in place. Panels may be assembled on a bench in this way then brought to site, connected up and ballasted. The sad truth however is that the many factors outlined in part 1 soon get to work and, before you know it, the only job the sleepers are doing effectively is maintaining an approximate gauge. Most of them will be loose in the ballast and many loose on the rail; you then have a situation where, instead of firmly holding the rail where it should be, they are simply dangling from it. This happens whether the railway is laid on a concrete bed or not. Hold-down screws also loosen as sleeper thickness reduces with age. Steel sleepers either bolted firmly or welded to the rail would certainly keep the panel rigid but may be an expensive or impractical solution for most.

This situation should be much improved by using plastic

sleepers but screws under any sideways loading will gradually cause the surrounding plastic material to creep, especially in hot weather. It is perhaps too soon in the story of plastic sleepers to make a final judgement on this point.

It has long been recognised in the full size world that rail needs to be able to move relative to sleepers while *their* job is to remain locked in the ballast with sufficient weight to hold the track down and maintain lateral alignment. This movement should neither compromise gauge nor result in obvious looseness. Expecting our little ones, without chairs, to behave in the same way is too much. So whatever degree of tightness screws are given initially, many of them will loosen if in softwood.

Rail

For my own railway I have only used aluminium, mostly 20 x 20mm section but some in 16 x 16mm. Its over-riding advantages for an occasionally used railway are lack of corrosion and kindness to wheels, which are generally harder to replace than rail, should you have to. It is the 'wrong' colour of course and doesn't ring like steel but one puts up with that. It is also a better conductor of track circuitry than rusty steel. As mentioned above, its expansion is much greater than that of steel, so gaps need to be bigger and fishplates need to accommodate them.

Fishplates and bolts

Mine are mostly home made from mild steel strip and unplated. They are no more rusted now than the zinc plated commercial ones I started with. I have used both plain nuts and Nylocs. All of them quickly corrode to the point where a positive effort is needed to remove them (like hammer and chisel!) so the advantage of the locking type is virtually nil. Assembly with grease and 'just tight' by hand seems about right.

Strictly speaking, every joint should be regreased at

intervals of say 5 years but who is actually going to do that? Some rail gaps tend to fill with mud and detritus but I find on the whole that rail expansion movement does take place, despite the odds. On curves it is tempting to use the relative stiffness of the plates and very tight bolts to reduce or eliminate the inevitable 'threepenny bit' kink; this is lazy and doesn't work. Instead the rail should be properly bent, or tweaked, right up to its end. If laying track on concrete, extra hold-down screws can be used near rail joints.

One major advantage of aluminium over steel for an occasionally used railway is its ability to make track circuitry reliable. I have a lot of this and it always works provided the rail joints are properly connected by wire – rusty fishplates behave as insulators!

Wear and tear

Aluminium rail does wear on the inside of the head as you would expect but I have never had to replace a single rail for this reason alone. Slivers of metal get planed off on very tight curves and pointwork while derailments usually carve up the top surface a bit but not badly enough to warrant replacement. I would rather my rail took the brunt of this than wheels.

Conclusion

A very good combination would be to use recycled plastic sleepers screwed down to a continuous concrete bed. This need be no thicker than 3 inches and should not be reinforced. Unfortunately, this is likely to be the most expensive option and still does not entirely solve the problem of stability as hold-down screws do shear off in time allowing the track freedom to wander.

●To be continued.

NEXT ISSUE

I will discuss the use of engineering concrete for the sleepers themselves.

Sieg SX2 Plus Miller CNC Conversion

Graham Sadler explains how he converted his Sieg milling machine to CNC operation.

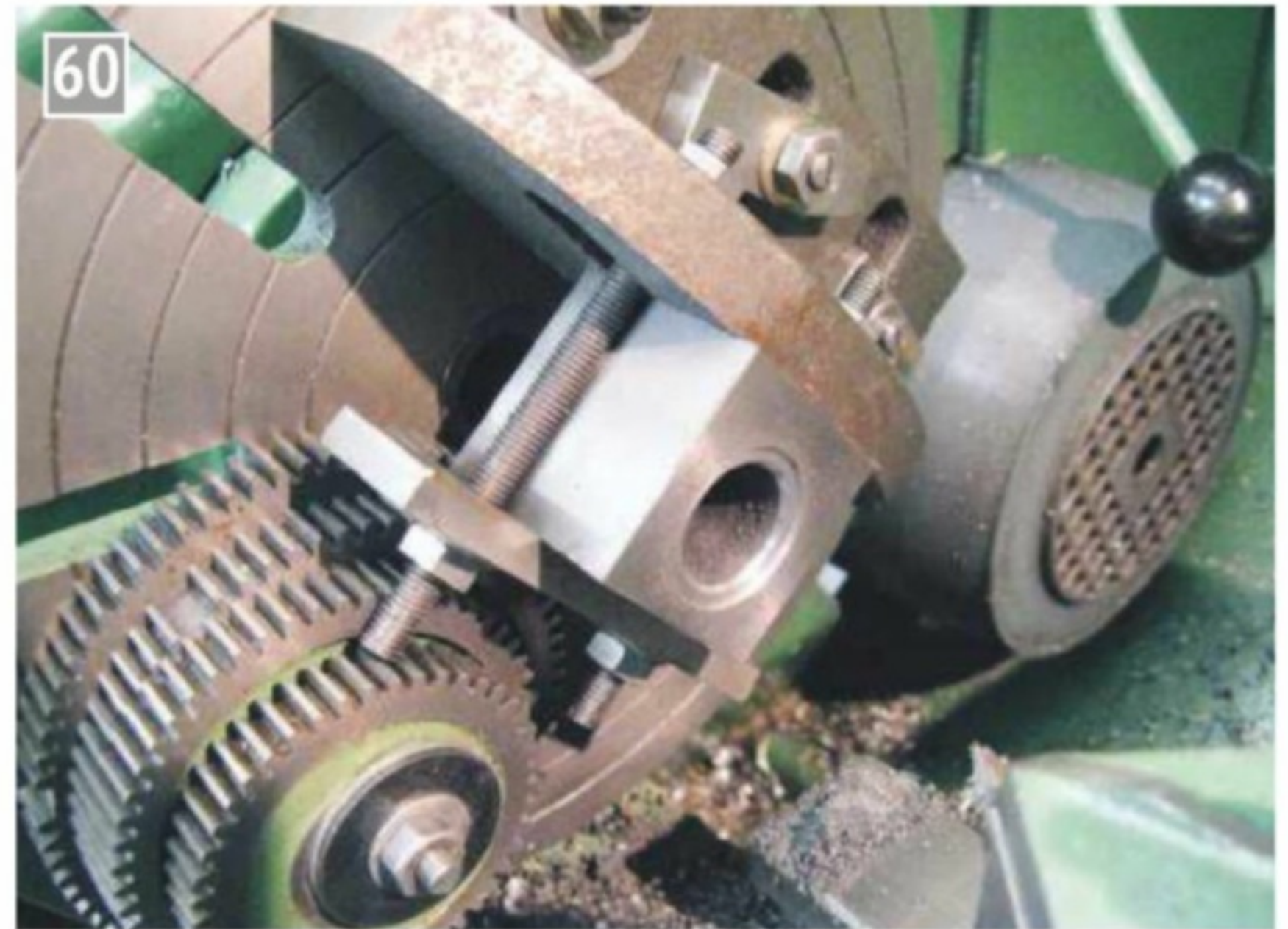


Continued from p.385
M.E. 4620, 30 August 2019

The next problem to be solved (in this account at least) was the obvious need for setting the length offset. If possible, this should be done off the machine to avoid the extreme care needed with the tool having to be brought into contact with the setting block. This can be easily achieved with a block with a true $\frac{3}{4}$ inch hole into which the tool is inserted and stood upright. A digital height gauge is then zeroed at the top of the block and the height of the tool end is measured. I have a very good non-digital vernier height gauge, and I won't consider buying another, but the reading of it and the subtraction of the block height I felt would lead to errors.

After a bit of head scratching an alternative dedicated system was devised using a left hand calliper purchased for lathe use, but very rarely used. This would make a great basis for the overall setting jig; this could be kept close to the machine and make it quicker to use but with a horizontal rather than vertical system.

After considering various mounting possibilities, the calliper was dismantled, the back of which is in stainless steel. It was drilled for very small countersunk screws to fix it to an aluminium block which itself is fixed to a 10mm thick aluminium plate, taking due



Boring the setting jig tool block holder.

care to get it perfectly parallel with the edge of the plate. So they wouldn't get in the way, the surplus internal measuring blades were cut off with the Dremel and a diamond.

A $\frac{3}{4}$ inch hole was bored in a small lump of continuous cast iron for a slide fit with the tool holders (**photo 60**). This was then bolted to the plate, being careful to get it parallel to the edge, but in a place where the centre of the hole is about 3mm inside the edge of the end of the calliper (**photos 61 and 62**). No diagrams are needed as the photograph makes the construction clear, although a taller block would have been better - I had to mill a slot for clearance for the drill chuck, although I used what I had in the scrap box and enlarged the existing hole in it! In use the end of the calliper is zeroed on the block and fully opened. A tool is gently but firmly pushed into contact with the block and the calliper end brought into contact with the tool. The length can then be recorded and put into the Mach3 tool table.

For setting drills, the chuck must be fitted first then the drill goes into it. My calliper was a standard 150mm version - a 200mm version would be better as it's a bit tight to get it in but entirely satisfactory.

Organising tools

You need to be organised about where you put the tools when working on a job, so a rack for each, where it lives permanently except when in use, is critical. In addition the holders should be numbered, perhaps by CNC engraving or punching the rack. The (I hope) logical numbering system I use is shown in **table 3**, starting with 1 for the setting tool and 2-9 for specials.

So, for instance, tool 17 is a 7mm cutter on a 10mm shank, 141 is a 4.1mm drill and there will be the same drill in 222 (2BA tapping) - these latter high numbers are an aid to save looking up the size in a table. Just type the appropriate BA number in and the diameter will be displayed in the tool offset box. It is not necessary to put all the drill data in at the start - just as each drill is used for the first time. For drills, the length setting is of less importance for spot on accuracy and, probably, a rule dimension will be good enough from the face of the drill chuck, added to the drill chuck offset.

Setting the work offset

Lastly, we need to establish the work height in relation to the spindle. For this a number of very nice but expensive tools are available. Many are



Setting the block parallel on the jig.

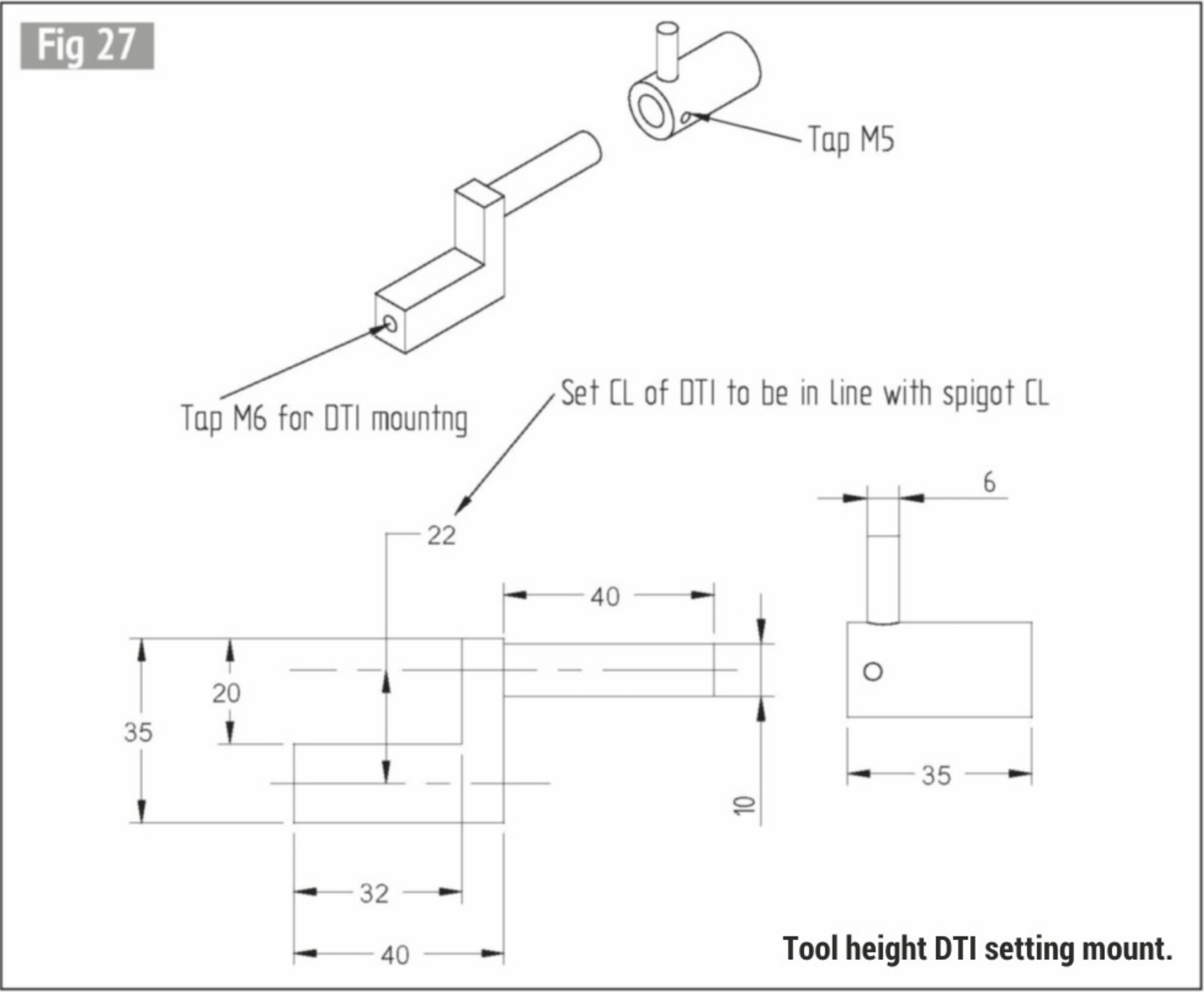


Setting the gauge scale parallel.

in the form of a cube with a sensing plate on the top, working an indicator built into it. In use the tool is inserted and the device is sat on the work before jogging down onto the top plate, and then further until the clock reads zero. The tool is now a known distance from the work (often 2 inches). It is accurate but it's really an industrial tool and, for stability, needs a large surface to sit on. I realised the process could be inverted. The photographs will make my device clear - it uses a good quality clock gauge mounted on a special adjustable holder (**fig 27**). I purchased my gauge a very long time ago and since graduating to the vastly superior lever type DTI it has very rarely been used.

To make this gadget , I used a single piece of bar by sawing the bulk of the material away, then turning the stem to 10mm in the four jaw chuck. The 'L' shape was chain drilled, sawn out and milled smooth (**photos 63 and 64**). A fabrication would be equally sound but the billet I found in my scrap box was the correct size and, in any case, it was an enjoyable bit of machining. The shape may need to be varied relative to the mounting on the back of your clock gauge. Ensure your gauge is mounted close to the centreline of the spindle. The setting pin is positioned so that the overall length in the working position is about 115mm. In addition, leave at least 5mm clearance between the silver steel holder and the spigot face for adjustment.

Table 3. Tool numbering system.			
Tool Number	Function	Tool number	Function
1	DTI for work offset	76-89	overflow
3	Centre drill	90-99	specials
4	Facing cutter	100-199	Drills 1-10mm x 0.1mm
5-9	Fly cutter	200-219	Drills 10 + 1-9 x 1mm
10-19	10mm shank cutters	210-219	Drills 10 + 1 x 0.5mm
20-29	12mm shank cutters	220-229	BA tapping size
30-39	3/8 inch shank cutters	230-239	BA clearance size
40-49	1/4 inch shank cutters	240-249	Counterbore pilot sizes
50-59	1/2 inch shank cutters	OR 200 +	Imperial drills
60-69	6mm shank cutters		
70-75	3mm shank cutters		



Turning the spigot on the DTI mount.



Chain drilling the waste.



How to set the Indicator to size.

To set it to an exact 115mm, loosen the grub screw locking the gauge to its mounting arm into the setting jig and adjust it by pushing the DTI plunger in for one full turn plus enough to get the reading on the jig calliper to be approximately zero. Hold the plunger in place with a bit of tape. Check the calliper still reads 115mm then lock the grub screws holding the mounting arm. Remove the tape and adjust the bezel on the dial to read zero and again check the calliper still reads 115mm (it moves on its own easily at this stage). This setting has to be spot on. If your DTI has a locking screw on the bezel, tighten it. A mirror is essential for this task as the device has to be mounted upside down for clearance (**photos 65 and 66**).

The work offset can then be set as follows:

1. In the tool portion of the machine window, enter tool no. 1 to obtain the correct offset length.
2. Mount the DTI tool in the spindle.
3. Jog down until the DTI reads zero after one full turn.
4. Zero the Z DRO.
5. All future tool lengths can now be taken directly by the part program from the values entered in the tool table.

The spindle reference point is now exactly 115mm above the work but the machine 'thinks' (as if it could!) that the reference is at the work piece i.e. 115mm down from where it is so now select tool 1 offset.

For example, tool 4 is a 25mm diameter tipped facing tool and is recorded in the tool list as being 51.9mm long. Mount it in the machine and in the MDI line type:

G43 H5
followed by the 'enter' key.
With this tool, the Z DRO now reads 63.1mm i.e. 115-51.9 and zero with the tool just touching the work. Type:
F200
G90
Z 5

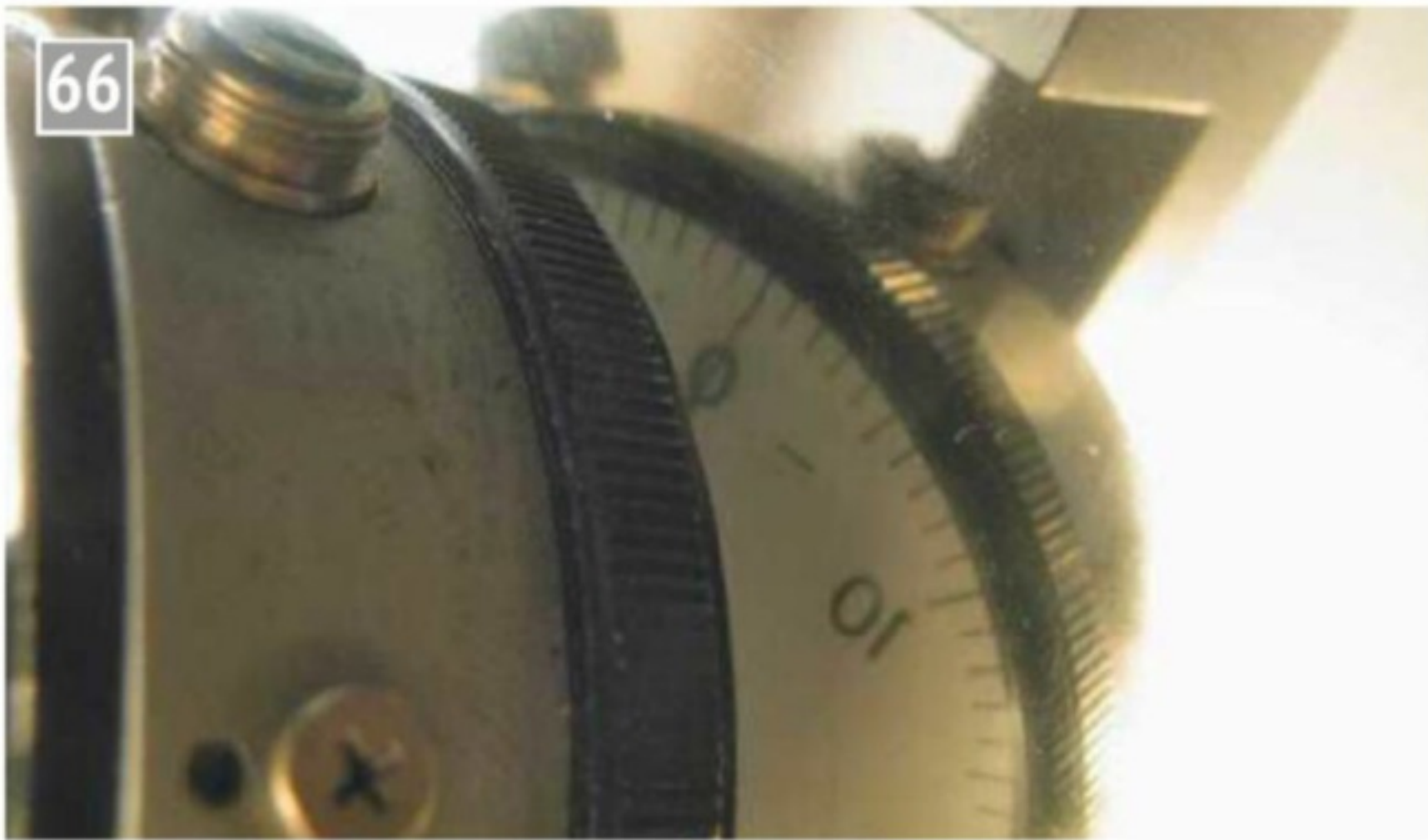
The tool will slowly drop to 5mm above the work. The process uses the DTI tool but the same result is obtained by jogging the spindle down until it touches the work and the Z axis zeroed. However, this is a sure way of damaging the machine with even a momentary lack of concentration.

The device is similar in principle to the industrial setting tool mentioned earlier but so much smaller for our small work. The only drawback is the need to change the tool in the spindle to set the offset.

Along with the use of the tool table, each tool holder will need to be numbered and replaced in a dedicated hole in a tool rack to ensure that they don't get mixed up. This is shown in **photo 67**, while **photo 68** shows the system and some of the elements described.

Testing

With the system completed it was time to put it to the test. At first, I had inconsistent results - the touch tool was used but I couldn't get the correct reading by the shim



Close up of setting the indicator.

trial method to verify results. There was always an error, small but annoying. Eventually, this was traced to a peculiar feature. When the tool pin is pushed against the spindle collar and the draw bar is ready to be tightened, it was found that, in doing so, the R8 collet is pulled into the spindle *and the tool holder slug moves up as well!* The touch tool revealed this to be a consistent 5 thou. Disaster!

I could find no movement of the spindle collar or within the tool holder itself. The solution was therefore to add onto the tool offset, or find another way. Now, when a tool is put in the spindle, a 5 thou shim is trapped between the collar and tool pin and the drawbar is gently finger tightened to hold in place. The shim is then pulled out and the collet fully tightened but to a position where the spanner hits the motor housing, giving

repeatable torque on the drawbar. This pulls the pin just in contact with the collar and gives repeatable positioning. Eventually unbelievable and consistent results of 0.005mm were obtained.

●To be continued.



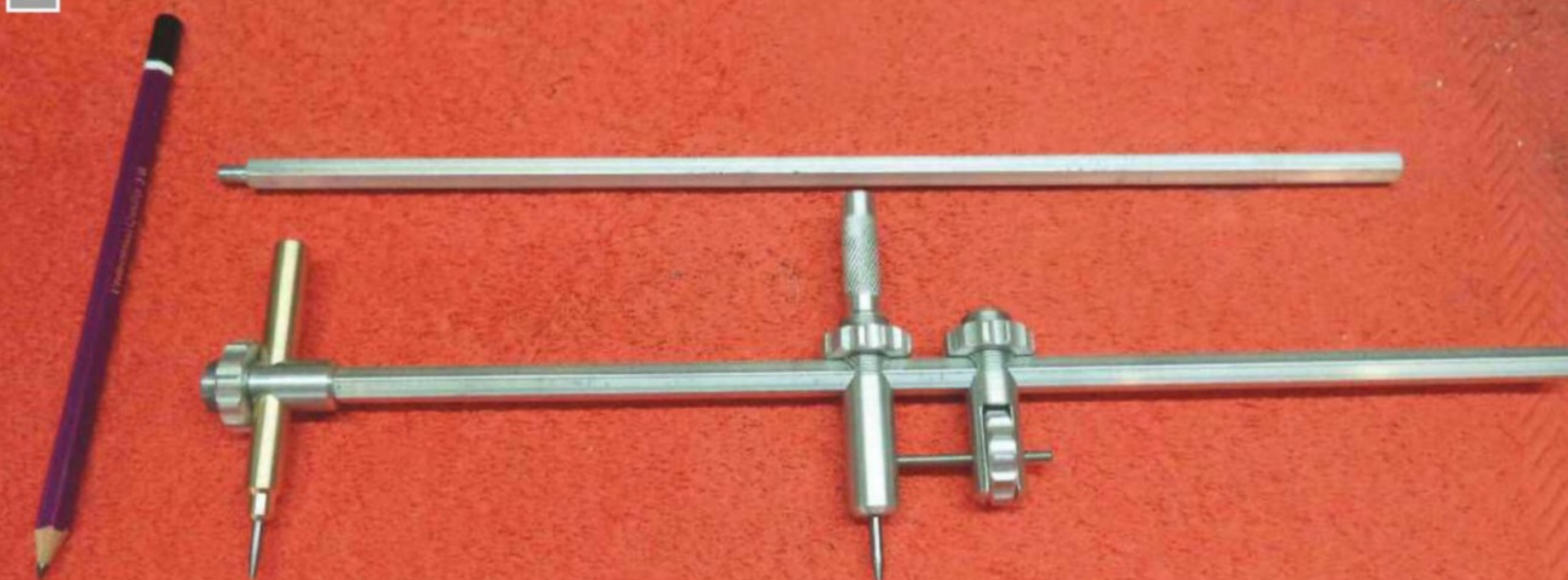
The CNC tool drawer, mounted in filing cabinet type runners directly under the miller.



The complete system. Setting jig with tool holder being measured, fitted with my tool no. 4 (6mm end mill), indicator setting probe, drill chuck and spindle box spanner. Note the hammer weight on the spanner, which is stored in a tube on the miller head.

1

Beam compass.



Beam Compass

PART 1

Stewart Hart describes a useful but simply made marking out tool.



2



Threading $\frac{1}{2}$ inch x 32ME.

3



Drill and tap M5.

4



Drill 9mm cross hole.

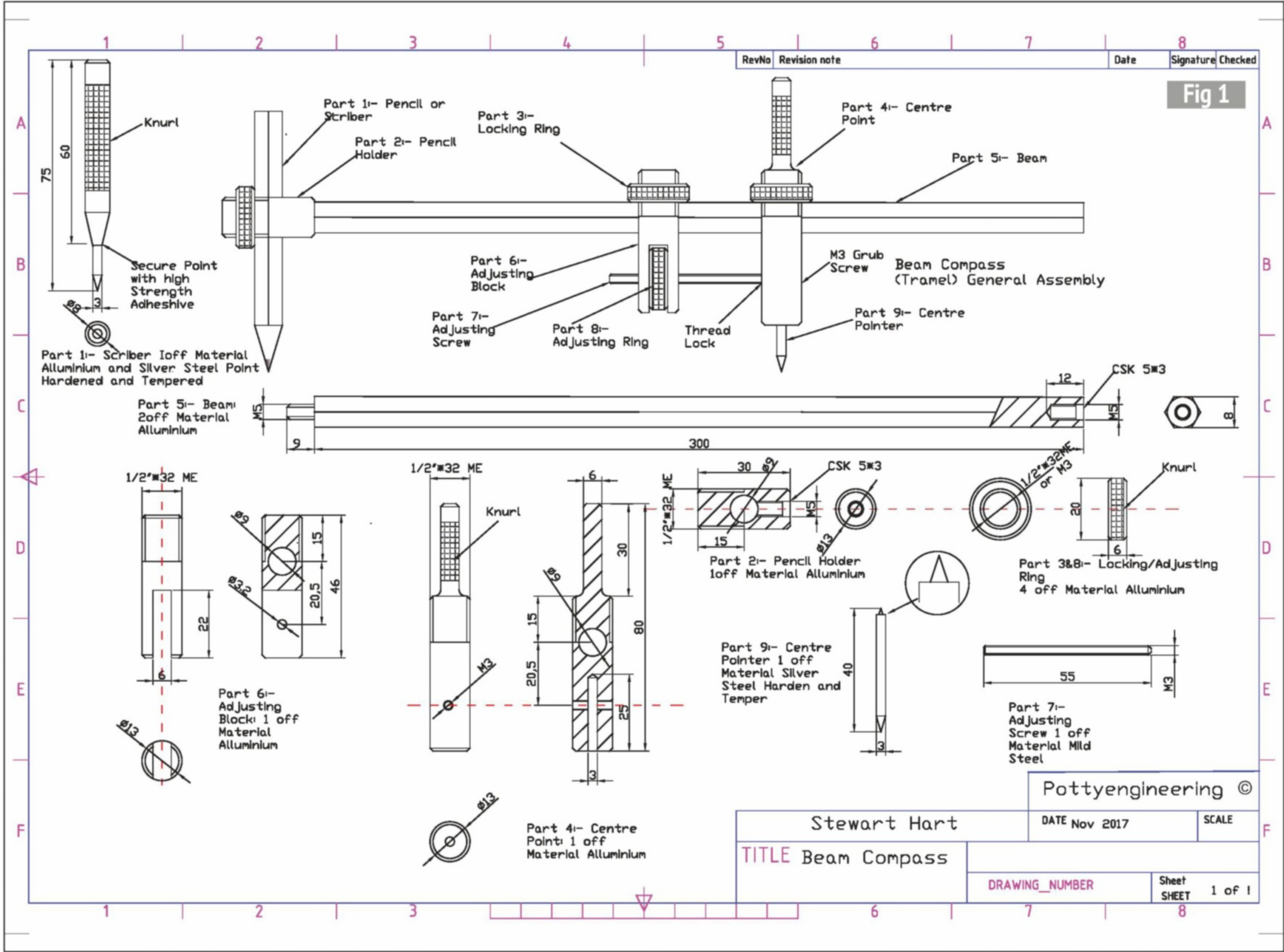
Beam compass or - as we used to call them - 'trammels', but I think 'beam compass' is a better description - as the man said, does exactly what it says on the tin. You may be wondering what use this old fashion drawing and marking out instrument has in this modern age of computers. Well, the answer to that is quite simple. In order to model the valve gear of the 5 inch gauge locomotive I'm building I needed to draw large arcs and my lap top is just too small to be able to see what's going on at the intersections. Moreover, my pension just doesn't run to buying a large monitor, so its good old pen and paper to the rescue (**photo 1**).

I have a second-hand set of old drawing instruments but, to be honest, they are far from being accurate enough for the job in hand. What I wanted was something that would be robust enough to draw an accurate 12 inch radius without wobbling about and losing accuracy. The design I came up with is based around a $\frac{5}{16}$ inch (8mm) hexagon beam. I chose an hexagon beam because it will have a ready-made flat down its length for clamping the pointers to (**fig 1**).

I made my compass from aluminium but brass or steel will do just as well - in fact I can remember the marking out table in our heavy machining department having a trammel with a hardwood beam.

As I was waiting for the delivery of the hexagon bar I made a start on part 2 (the pencil holder). This is made from $\frac{1}{2}$ inch aluminium. Face the bar off and thread $\frac{1}{2}$ inch x 32ME for a length of 15mm, part off, face to length and drill and tap M5. Then add a nice deep 5mm countersink so that the beam will screw up against the face. Then over onto the drill and on the centre line drill through 9mm diameter (**photos 2, 3 and 4**).

Part 4 (the centre point) is made of the same $\frac{1}{2}$ inch bar. Centre drill and, using a running steady, turn down to 6mm for a length of 30mm and give it a medium knurl - if you don't have a knurling tool it won't harm to omit the knurl.



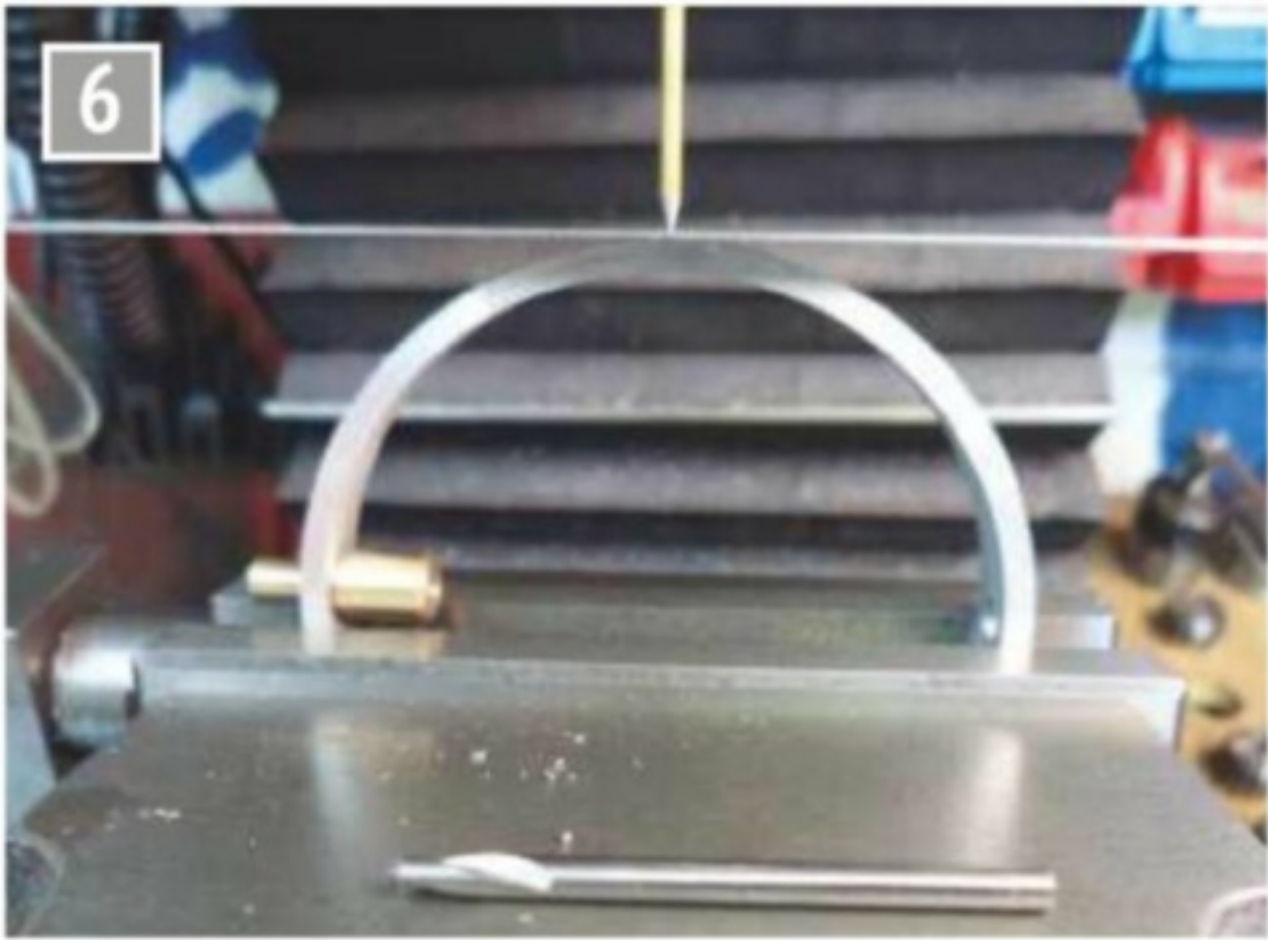
Part off and face to length, centre drill and drill 3mm x 25mm deep. Onto the drill and drill the 9mm cross hole and, without removing from the vice, drill and tap the M3 cross hole (photo 5).

Here's a little trick you may not have seen before for finding the centre of a bar - all you have to do is balance a steel rule on the bar and trap it down with a point and adjust until it looks level to the Mk1 eyeball. You'd be amazed at how accurate this method is (photo 6).

Part 6 (adjusting block) is similar to the first two parts so you should be getting good at them by now. Face and thread ½ inch x 32ME, part off, face to length and drill the two cross holes. To cut the 6mm slot so that it is correctly aligned with the cross holes all you have to do is pass a piece of bar through one of the cross holes and rest it across the vice jaws. You can level it up by eye as that isn't too critical. On the centre line, put in a number of evenly spaced centre drills



Knurl the handle.



Finding the centre using a ruler and pointer.



Chain drilling.



Milling the slot.

then follow these up with a 5mm drill and finish off with a 6mm slot drill. If you don't

have the luxury of a mill, you can simply drill through and then with an hacksaw and files

cut the slot out - it's not too fussy (photos 7 and 8).

●To be continued.

ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT I E NEXT ISSUE NEXT ISSUE NEXT ISSUE NEXT ISSUE

- **Four Bar Linkages**
Nick Feast explores the applications of these rather ingenious mechanisms.
- **Oxford Club**
John Arrowsmith continues on his travels and visits the Oxford Club to observe their preparations for their recent 'Dreaming Spires' rally.
- **Wax Chuck**
Tony Bird explains how to make and use wax chucks.
- **Tram Truck**
Ashley Best describes the Brill 22E tram truck, widely used on British tramways.
- **Lions Meet**
Mick Baker goes down to Bournemouth to observe a pride of Lions, in 5 and 7¼ inch gauge, and meet their proud owners.

Content may be subject to change.



ON SALE 11 OCTOBER 2019

Garrett 4CD Tractor PART 61

in 6 inch scale

Chris Gunn
begins
the final
assembly,
painting and lining.



Continued from p.367
M.E. 4620, 30 August 2019

This article has been written to guide the builder through the construction of the 6 inch scale Garrett 4CD tractor designed by Chris d'Alquen. The writer has previously built a 4 inch scale Garrett and a 6 inch scale Foden wagon so has the benefit of considerable experience in larger scale modelling. Most machining can be done in the average home workshop but the supplier from whom the castings and drawings are currently available is able to provide a machining service for the largest items if required.

Air test and final assembly

At this stage I had made virtually all of the parts that would be needed to run the engine and I had fitted most of the items that were needed to complete the engine. Some were in place but some had been made and fitted and removed after trial assembly. The crankshaft and the motion were fitted, with the block painted and in position on the boiler. I decided to finally assemble the rest of the block, sealing all the covers and packing all the glands. I fitted the reversing lever and taper pinned all the levers after a kind gentleman found me a few suitable taper pins after I'd lost mine. The crankshaft could be turned over by hand and was stiff but not tight enough for me to think something was amiss. I decided it was time to try and run the engine on air to see if it worked. Once the air test was completed I could then start the final assembly sequence.



I had thought long and hard about this and conferred with some of my fellow club members. My dilemma was whether to build the engine, steam it and then take it apart and paint it, or to paint it as I went along and steam it after painting and assembly. The consensus was that painting the engine as I went along was the way to go, as cleaning it well enough to paint after several steam ups is very hard to do - and not only that, it is time consuming. I knew this already as I had fully built my 4 inch Garrett, run it on air then steamed it several times before fully stripping it again, cleaning it and painting it. I was working then and had access to a steam cleaner which was a big help in shifting the oil; nevertheless, it was a long job. It was hard to go through all that and the time it took before being able to run it again.

This time I realised that much of the visible painting

could be done off the engine. Items like the wheels, guards and covers, the cladding the tender and belly tank could all be done off the engine, as could many of the other smaller items. Once it was steamed and had passed the steam test, then I would be in business straight away.

Having made the decision, the next step was to make the boiler airtight and give it a try. I made a blanking plate to fit over the regulator pocket, which would be required again when the engine was hydraulically tested. I plugged all the holes in the boiler. All were tapped $\frac{3}{8}$ or $\frac{1}{2}$ inch BSP so I was able to use some of the commercially made plugs I had accumulated. I fitted a temporary pressure gauge and added the flywheel and I was ready to go after oiling all the motion and squirting some oil into the block. One of our club members owns a larger than usual air compressor, a 2hp model with a big tank

Drawings, castings and machining services are available from A. N. Engineering: Email: a.nutting@hotmail.co.uk

on it. I was able to borrow this and I left it in the back of my van during the testing. I connected the air, switched the compressor on and watched the pressure build as the tank and boiler were filled to about 110psi, and then I opened the throttle and I was tickled to death when it ran first time. It was remarkably even and ran equally well in reverse and I was pleased that the more scientific approach I took to set the valve eccentrics paid off. I let it run as long as the air held out which was about 4 or 5 minutes. The pistons in the compressor were not as big as the pistons in my engine. **Photograph 510** shows the engine under test.

I continued for about 30 minutes until the compressor cylinder head was hot enough to fry eggs and then let everything have a rest and cool down. Once it had cooled I had another session. At this stage I was just letting the engine turn the crankshaft and, after a few days of running in, I added the drive gears and drove the motion down to the cannon shaft and ran it like that for a day or two, taking care to keep clear of the unguarded gears. I carried on like this for a few more days and then added the differential so I was driving the back axle. After a couple of weeks, I had got to the point where the engine would run at about 20psi and would run a bit more after that if I opened the pop valve. The motion was noticeably freer when the process had finished and I was happy to stop at that point. The compressor was taken to test a 6 inch Ruston and Proctor and I returned to contemplate my next move.

Painting and lining

I had decided to paint the engine in Garrett chocolate brown and duly popped over to Craftmaster paints to get the primer, undercoat, top coat and a set of de-luxe brushes.

I stripped off the tender and removed the crankshaft, leaving the valve rods still attached to the block assembly. The cannon shaft



Engine under test.

and all the back-axle assembly were also removed, leaving just the block on the engine. This was already painted with high temperature black paint.

I then embarked on a long journey painting the engine. For convenience sake I will describe the highlights of the painting process item by item but in practice some of the painting was done concurrently and in the order in which it could be re-assembled.

Hornplates and boiler

Having stripped everything off the horn-plates, these were cleaned with solvent, degreaser, and detergent. Luckily this was done in the summer so the boiler and horn-plates soon dried off. The same procedure was adopted at the front end and the smoke box and chimney saddle were cleaned also. The tops of the horn-plates were masked off, at the point where the horn-plates separated from the boiler. The bottom sections of the horn-plates were painted black using BBQ paint from a rattle can. These used to be called aerosol cans but rattle is easier to spell. The smoke box was dealt with in the same way and the instructions on the can were followed, noting that the paint would harden off once exposed to a high temperature. It would be about 18 months before this paint felt the heat but I can report now that it seems to be fine.

Once the black paint had a chance to go off, the masking

was reversed on the horn-plates and the top section was brush painted with a coat of primer, then undercoat and finally several coats of top coat. **Photograph 511** shows the primed hornplates.

I struggled a bit with the top coat as it tended to sag despite me brushing it out as much as I felt I could. This paint is labelled 'for professional use' and, as I was not a professional coach painter, I guess I had not got the right technique. In the end the finish was reasonable and thankfully most of what I had painted would be covered by bits and pieces so the saggy bits would be unseen. I was told this paint could not be thinned and sprayed so did not attempt this but much later, in fact too late for me, I talked to a couple of engine builders who had used the same paint and thinned it and sprayed it

with complete success; so you pay your money and you take your choice.

I think one problem I have is that once I have the paint I want to start painting and start with the project in hand instead of practising on something else to get the technique right for the particular paint. That said I did think about it but could not find much to practise on so ploughed on.

Axles

I had removed all the parts from the engine for fettling and painting, and these were dealt with in some semblance of order, with the items to go back on the engine first painted first. I started with the front axle so I could get it back on the engine and then refit the wheels. The axle was primed and several coats of top coat applied after masking the wheel journals. This needed lining out, so this would be my first try with the lining tape supplied by Craftmaster. I wanted to flare the lines out to a point.

Using the tape to create a fine line means placing the tape and then getting hold of the end of the carrier tape and peeling it away. I found it almost impossible to place it then insert my scalpel and peel back the carrier tape. I sought advice and I was told to peel the brown tapes back a little and I did this with a scalpel with a new blade, taking care not to cut the end off my finger again. I also folded the ends of each of the brown tapes back

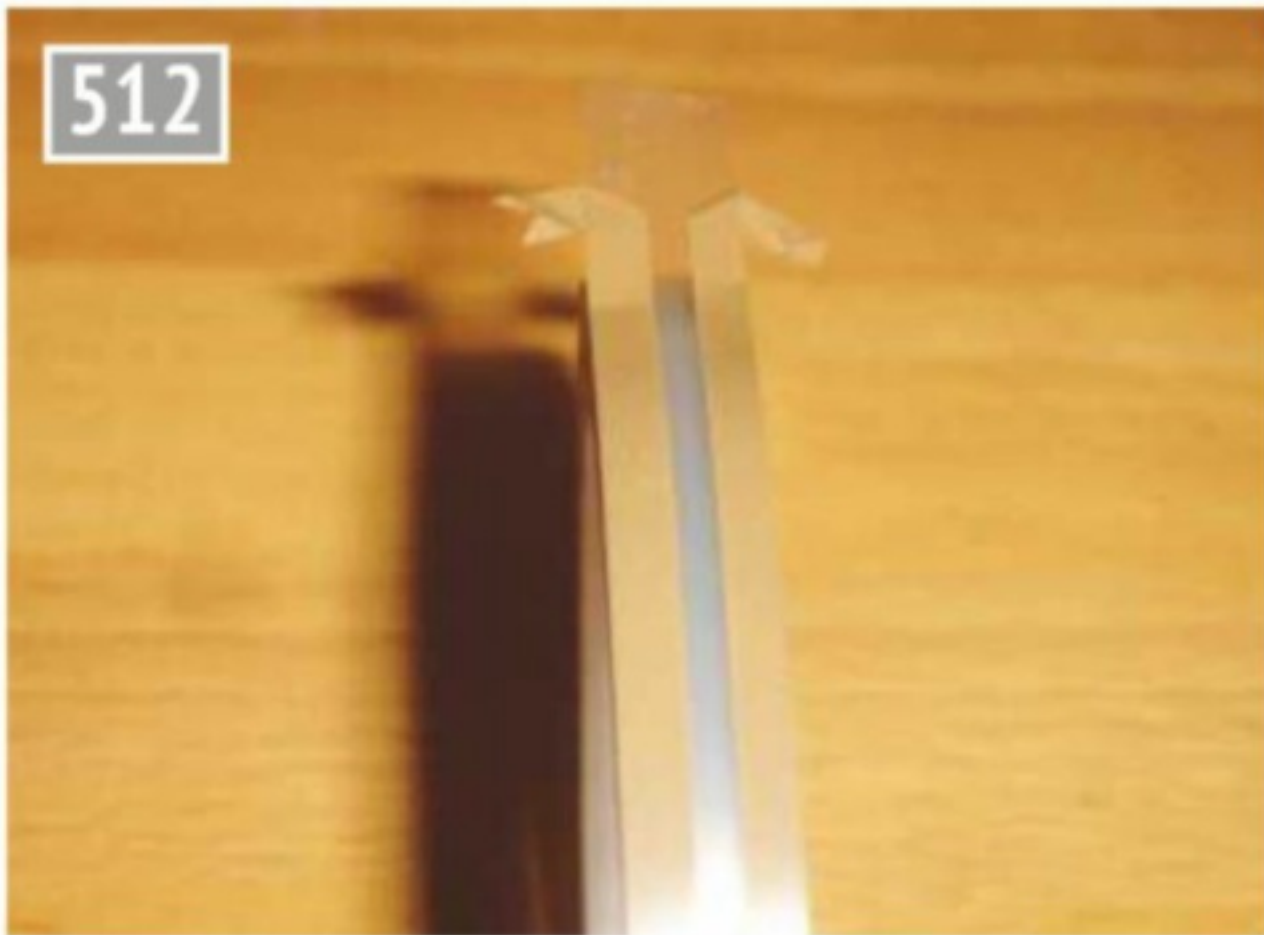


Primed hornplates.

on themselves. **Photograph 512** shows the tape end semi-peeled and ready to apply. The tape was positioned with the peeled section beyond where it should be at one end. Then I was able to burnish up and down the working section of the tape and then pull the loose end of the carrier tape back dead in line with itself using a pair of tweezers.

In order to create the curves I wanted I had to grab hold of the ends of the thin brown masking tapes and move them to create the flared end of the line. I already knew this would not be easy, as the lining tape could crinkle on the edge of the curve. The edge in tension would stretch around the curve but the edge in compression would tend to ruckle up. However, I carried on regardless and I picked up the end of one of the tapes with tweezers and moved it to create the curve while smoothing the tape into position. I tried to do this in one go, as the tape did not stick as well if it was continually lifted and repositioned. It is harder to describe what I did than to do once I had some practice. **Photograph 513** shows the masking on the end of an axle.

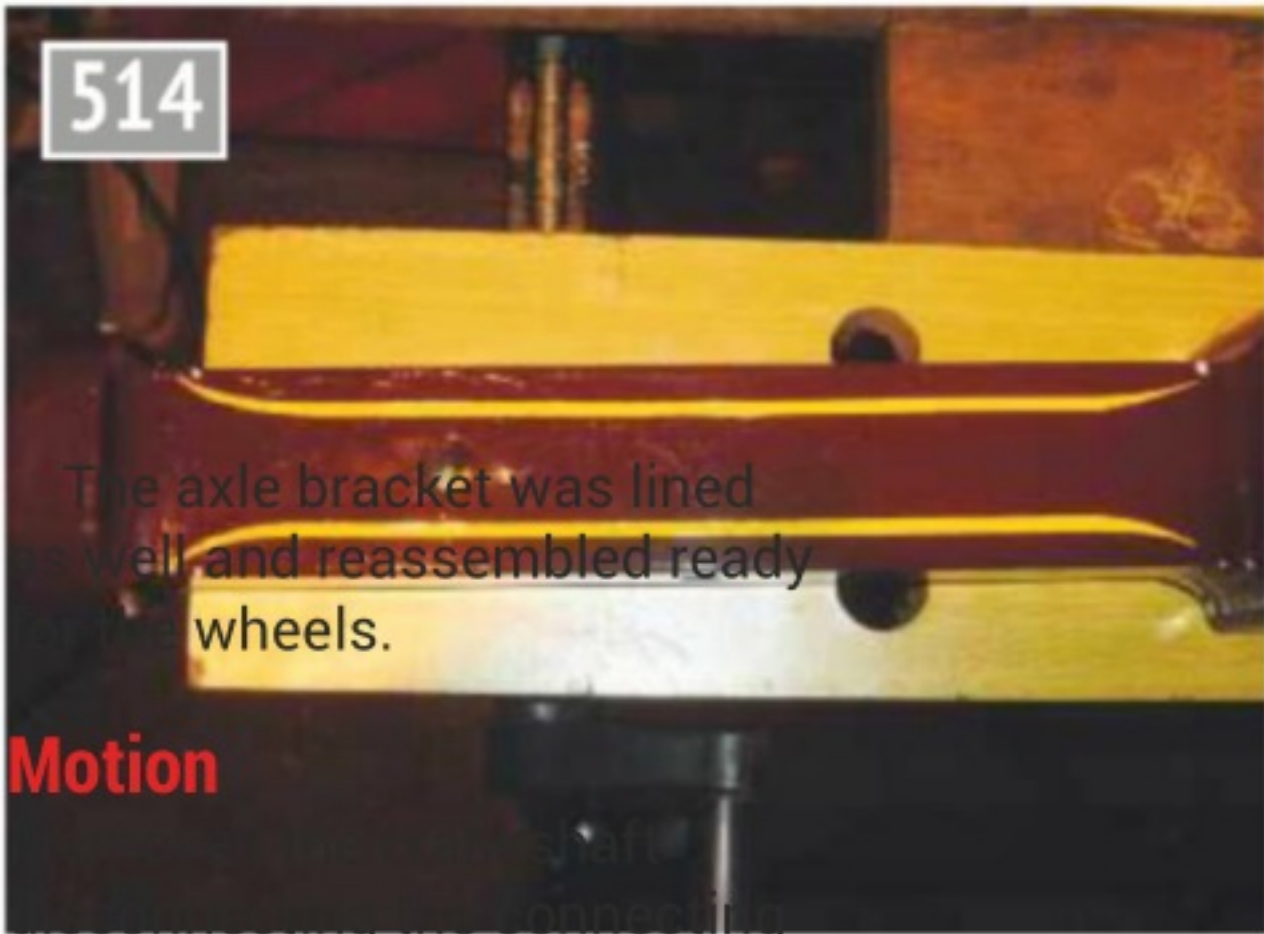
I did this pretty well by eye, knowing where the end of the line should end up. The bend on the ends of the axle were not too great and the results, as shown in **photo 514**, were reasonable.



Tape end.



Masked axle.



Motion
The axle bracket was lined as well and reassembled ready for wheels.

and valve rods, leaving them connected at the cylinder end. The eccentric sheaves were removed and the crankshaft masked and painted red, as were the sheaves, then everything was re-assembled in reverse order. I set to work on many of the castings. These needed some fettling and cleaning up and I set about the castings with my new power file, which is shown in **photo 515**. This was really good for getting rid of the flash and could get into all the corners. I did this outside and with a face mask to deal



Power file.

with the dust. A few days later some of my shrubs turned brown and on inspection I found that the cast iron dust had settled on the leaves and then gone rusty. I managed to bluff my way out of that one.

All the castings were fettled then blown down to remove the dust, wiped down with thinners and then hand painted. I reassembled them working from the top down. I finished by fitting the back-axle bearings, the back-axle with the keys and fitting the right

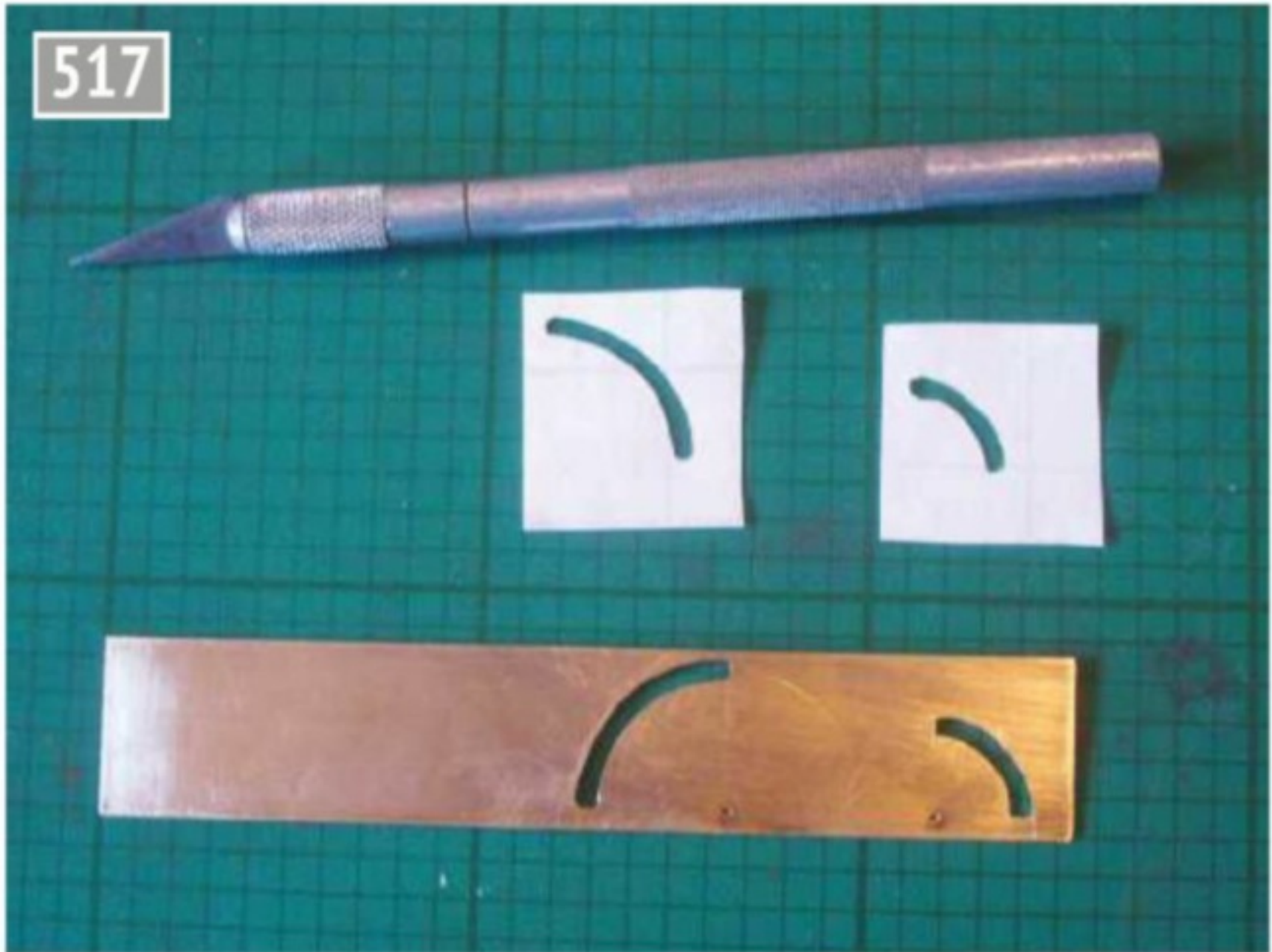
hand wheel spacer and the differential and brake drum on the opposite side. **Photograph 516** shows some of the parts drying in the sun.

Tool box

I also made a tool box as I planned to make the canopy later on. This was duly painted and I wanted to try lining this, which would need radiused corners. As I had been working away I noticed a thread on the *Model Engineer* website where someone had asked for



Parts drying.



Radius templates.



Toolbox masking.



Finished tool box.

assistance in lining, including corners, and I read this with interest. One technique mentioned was the use of frisket film, something I had never come across before. I duly searched for this on Google, found all the details, and it seemed just the thing I needed. I bought some from Amazon, (other search engines and online retailers are available) and I decided to practise on the tool box. I fiddled about with a scalpel and plastic templates for a while but the scalpel dug in to the edge of the plastic and in the end I made a brass template from a scrap of brass about

20 thou thick. I made this by marking out a set of $\frac{3}{32}$ inch diameter holes on a suitable radius and chain drilled them. I cleaned the template up with needle files. The template shown in **photo 517** shows two radii, the smaller used on the toolbox and the larger on the belly tank.

The frisket carrier paper is printed with grid lines, so I was able to line up my corner template with a pair of lines and then use the scalpel to cut carefully round the template. The blade I used is shown in photo 517 and this style of blade was needed to cut across the ends of the radius.

I cut through the carrier sheet and into the film, and that seemed to give me a cleaner cut. The templates are also shown in photo 517.

I cut four templates and marked out the tool box with a soft pencil then set the frisket template to the marked-out lines. I found I could lift the template a couple of times if I did not get it right. Once I was happy, the template was burnished down and then a corner of the carrier tape was lifted with the scalpel and peeled off. As the template was cut from a flat sheet the edges did not ruckle up. The line was painted and left for 20 minutes

again before the frisket was peeled off and the results were good. Once all four corners were done, the lining paint was left to dry overnight and then the lining masking tape was laid out to complete the square. **Photograph 518** shows the masking in progress, and **photo 519** shows the finished article.

●To be continued.

NEXT TIME

We tackle the major task of painting and lining the wheels.

No.286

MODEL ENGINEERS' WORKSHOP

October's issue, number 286, will have some great builds:



Mogens Kilde starts a step-by-step guide to building a Scroll Saw.



Andrew Johnston gives an introduction to his Bridgeport Mill.



Make **Keith Johnson's** Pointmaster jig for sharpening small drills.

On Sale 4th October

A New GWR Pannier

PART 10

Doug Hewson decides that LBSC's well-known GWR pannier tank design needs a make-over.



Continued from p.395
M.E. 4620, 30 August 2019



GWR 5786 photographed at the South Devon Railway.

Once again, I can only apologise for not having made the coupling rods for the pannier tank so for the machining I will have to use some of the photos taken at the time I was building the Y4 again. The coupling rods can be made from 1 x 1/4 inch steel bar and it is best to use some black bar if you can get hold of it.

Imperial sizes are freely available if you have a look around, particularly if you have a look on the M Machine stand. I got all I needed for a fiver. I use it all the time; I

generally keep a good stock of BMS bar in both round and rectangular and it soon seems to dwindle. Have a look in Yellow Pages under steel stockholders. All the ones I have tried are only too willing to help, especially if you tell them what you are doing. If you use metric bar I think you may have to use some 8mm and mill it down to the required size as the 6mm is too small. If you wish to build a little closer to scale, then you can mill the rods from 3/4 x 1/4 inch bar as, in this case,

the oil boxes are pressed in separately. Generally speaking, the coupling rods on full size locomotives have oil boxes which have a reservoir built into the boss which is packed with felt packing which helps retain the oil and allows it to drip out as the day goes by. I copied this on my BR Standard designs, so I thought, why not treat the Pannier to similar rods? We will come to these oil boxes later. **Photograph 78** is a very nice photo of 5786 (and I can't remember who sent it to me but if the gentleman recognises it, I would certainly like to hear from him so that I can credit it correctly. The same applies to another gentleman who sent me all the black and white photos by email also – a Mr. Colin Tickle). **Photograph 79** is one of my own photos taken of 7754 at Llangollen and it shows the 'big end' of the coupling rod with its bronze bush and white metal lining.

Photograph 80 shows me using the drilling machine to drill the mounting angle for making the coupling rods. And **photo 81** shows the rod



Coupling rod from GWR 7754.

mounted on the angle and a start made on the milling. You can use bright bar, but you need to watch out for distortion. Mine was fine. My only problem was that I did not have any $\frac{3}{4}$ inch wide bar in stock so I had to mill down some $1\frac{1}{4}$ inch bar before I could make a start. *C'est la vie!* The first thing to do is to mark out the shape of the rod on both faces of each rod but not to worry about the edge profile at this stage. If you do use bright bar, then it is as well to coat it with engineer's marking ink first. Some of our advertisers and exhibition traders sell this in small bottles.

First of all, I mounted a 4 inch vice on the milling table and then checked to see it was parallel to the movement of the table by holding a stout piece of BMS bar in the vice and then running it along and measuring the distance between a piece of rod in the chuck and the back edge of the bar using a digital calliper. Once you are happy with this you can drill the holes for the crank pin bushes at $7\frac{1}{4}$ inches and another one at $8\frac{1}{8}$ inch centres in your bar using the dials on the milling machine. However, having been happy with the way in which the wheels revolved on my chassis with my temporary rods on, I used these as jigs to drill my mounting bars. In fact, I drilled one of the holes and then used one of the temporary rods bolted to the bar to drill the second one in each case.

The best thing to do next is to make the trailing rods from your drilled jig and then drill the knuckle hole afterwards.

The free leg was then gripped in the machine vice with the coupling rod bar laid flat on top, and again I ran the table along and back just to make sure the movement was again parallel to the edge of the bar. Incidentally, I also put $\frac{1}{8}$ inch thick washers under the rod to be worked on just to keep it clear of the angle so that the milling cutter could run along the edge being machined without gouging along the angle. To cut the profile of these rods I would suggest that you work out some co-ordinates of the curve of the fish belly so that you can work along each rod with say 5 thou at a time and then, starting at the centre of each rod, you can drop the cutter down so that you produce the necessary steps and then file the belly to shape.

I did not have a cutter large enough to form the radii and the ends of the rod where it meets the bosses so I used a $\frac{3}{8}$ inch solid carbide slot drill, which was wonderful, and worked as near to the curved lines as I could and then ran along the edge with cuts of about 40 thou at a time until I was about 5 thou short of my marked line. I thought this would be just enough for finishing off with a file later. I ran right to the end of the cut and then again milled as



Making a coupling rod drilling jig from a piece of angle.

near as I could to the marked curve where the centre of the rod sweeps up to the boss. Once down near enough to the marked line I then turned the whole fixture through 180 degrees (in plan) with the rod still fastened to it to mill the other side. This may sound a bit long winded but in fact the whole job thus far took less than an hour for the two sides.

The rods now need the centre part thinning down (**photo 82**). For this the angle needs to be held with the other edge held vertically in the vice, but this time it can be bolted directly to the face of the angle to give a solid backing; drop some spacers in between the rod and the angle as this prevents it from flexing mid-cut as you go along. Before I remounted the rod on the fixture I also made a cut-out

in the upstanding leg of the angle so that I could check the thickness of the rod using my micrometer between cuts. The first operation was to use the same slot drill to machine along the centre parallel part of the face to a depth of about 45 thou (in 20 thou cuts). This was where the slot in the back of the angle came in useful, so I could check the amount that I had removed with the first cut. For milling the end curves I used the mill in 'quill mode' so that I could use the up and down movement like a drilling machine to mill up to the line at the edge of the boss at each end. These rods have some very nicely shaped little oil boxes but the edges need removing with an $\frac{1}{8}$ inch ball nosed slot drill and that will give the required radius where the box meets the main part



Starting to form the outside shape of a coupling rod.



The rod is turned through 90 degrees to be thinned down.



Roughing out completed.

of the rod. This is the kind of thing which just makes all the difference to a proper looking engine. **Photograph 83** shows the final roughing out done on the rod.

Once the milling was done, I finished the rods by filing and this needs some care to make a nice job. The requisite tools here are some 'smooth' 6 inch and 8 inch hand files, a 6 inch half round smooth file and a 6 inch smooth round one. I began by using the half round file to finish off the upper and lower curves to the bosses and this is where you need to be careful as it is very easy to go over the edge and ruin the nice sharp corner where the boss meets the narrower main part of the rod. Some soft jaws for the vice are essential for this job and I make mine from a couple of off-cuts of ½ inch brass angle.

When they wear out you can just bin them and cut another couple of pieces. **Photograph 84** shows the method for draw filing these rods.

Grip one of the bosses in the vice such that the corner of the boss is dead level with the tops of the brass jaws and angle the rod up at about 45 degrees. This way you can file the curve to shape without fear of the file slipping over the edge and marking the top of the boss. **Photograph 85** will hopefully explain this much more clearly (a picture and a thousand words ... etc!).

Once I had got the top and bottom nicely blended in I then used the round file to finish off the curves on each side. This needs even more care not to slip over the edge. You can ruin the job in a trice if not careful. To this end I



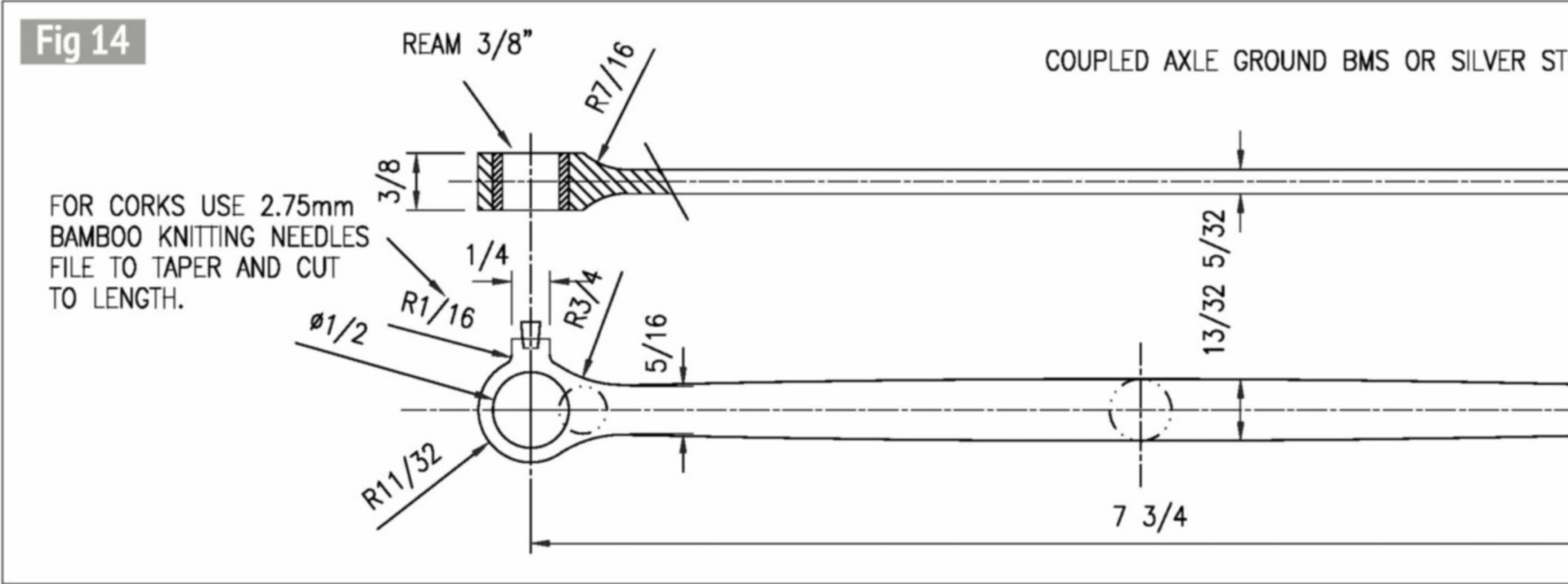
Draw filing a rod.

used the file more like draw filing and then twisting the file in my fingers as I ran up the slope towards the boss. Then I used needle files as draw files to remove the last of the machining marks. It is better to take more time than have to begin again.

Now, just a little word about polishing. To finish off I have a selection of emery tape in my workshop in coarse, medium and fine. The grit sizes are 100, 180 and 220. You can, of course, use sheet and tear off strips as you need it but the rolls of tape seem to last



Rod gripped carefully in the vice for shaping the end.





Polishing stick in action.

forever and they can be picked up on the exhibition stands at bargain prices. The last rolls I bought were at least ten years ago and some are still going strong. Once you have removed the worst of the machining marks draw file the end bosses making sure that the file does not rock from side to side to keep all edges nice and square. You can then go onto the main part of the rods down to fine emery. You can wrap some emery cloth around a hand file as that helps keep it flat but the other useful tool to make is a polishing stick. It was a very good toolmaker friend of mine who showed me how to do this. I made mine from a piece of $\frac{1}{2} \times \frac{1}{8}$ inch flat steel bar. It is shown in **photo 86** and is held in the palm of the hand with the emery tape wrapped round the end. It is very useful for

polishing along the rod and into the fillet at the ends. For that reason, I rounded the underside edge of mine. When the tape wears down you can just pull another piece around the end and grip it with your index finger. It may seem a funny thing to say but the better the finish on your rods the better they will keep. A wipe over with an oily rag should keep them in good condition. I do not aim for a high polish but I do like to see to see a nice clean finish with a semi-polish shine. When I was happy that mine were looking ship shape I did just finish them off with some 1200 grit wet and dry paper. I have seen some rods polished to death but I have to admit it looks wrong and I hate to see that.

I usually fit cast iron bushes in coupling rods but I didn't have any the correct size



Felt punchings nicked from the Severn Valley Railway.

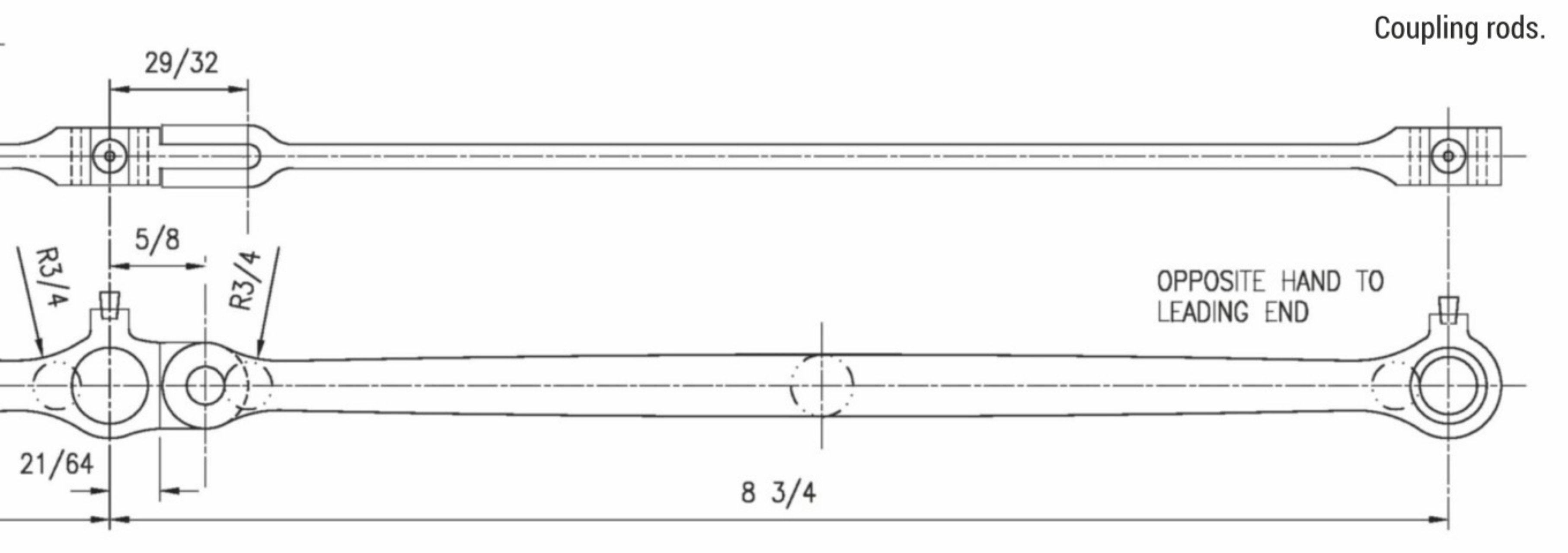
(without turning the bushes from 2 inch bar!) but for the purpose of this exercise I used bronze so that I could complete the job in hand. We regularly run four Y4s and they all have cast iron bushes in both the coupling and connecting rods - they outlast bronze by at least five to one. At the first opportunity (or when they wear out) they will be replaced with cast iron bushes. The bushes need to be a good push fit in the rods and having made the axles you will know how to do this now. Remember to drill the oil hole in the bushes when pressed in. Finally, I made the little oil boxes which are a light press fit in the rods. I used Worsted tapestry wool to fill my oil boxes and just to put the icing on the cake I fitted some little corks as seen on the full size locomotives; these

were made from a No. 9 cane knitting needle by tapering them in the lathe with a fine file until they just pushed in. Worsted wool (tapestry wool) was used to fill the little oil boxes. Finally, **photo 87** shows the oil box tops and the felt punchings which, I have to say, I nicked from the Severn Valley Railway when I was doing the very same thing on 75069 when I was finishing its overhaul off - the *first* overhaul! They were only some small offcuts though, so I hope they didn't mind. This was done under the guidance of the late, great Ray Tranter!

●To be continued.

NEXT TIME

It's on to the connecting rods and slide bars.



Soldering Timer PART 2

Les Kerr
describes a
microprocessor
based timer
which will
extend the life of the bit of
your soldering iron.



Continued from p.379
M.E. 4620, 30 August 2019

Software outline

Once power is supplied to the microprocessor an output on GP5 is provided that switches on the soldering iron via the power relay. A second output GP4 switches the front panel LED on for 500ms then off for 500ms in a continuous loop that takes one second to process. The number of one second loops is counted until the programmed on time is reached. The soldering iron and power to the microprocessor is then switched off. For example, if the programmed time is 1 hour, which equates to 3600 seconds, then 3600 loops are counted before the soldering iron is switched off. The required time is entered as a binary coded decimal into GP0, GP1 and GP2.

Details

The software is written using the PIC BASIC Pro compiler (see listing below). If you are not interested in this then skip this section. Listed below are the steps taken to write the firmware that is used to the program the 12F617 microprocessor.

1. We initially have to configure the device. This is done at the beginning of all programs. Code protection is switched off so that the program on

the chip can be copied. BOR off (brown out) stops the program from working if the voltage falls - not needed in this case so it is switched off. MCLE on (master clear reset) - by switching it on the software can be sent back to the beginning by setting GP3 to zero. This is used in fault finding. WDT off (watch dog timer) - if a large program stops working then after a period of time the watch dog timer will reset it. Not needed for such a simple program. PWRT on (power up timer) is used to provide a delay to enable the microprocessor to settle down when first switched on. INTRC OSC NOCLKOUT (internal oscillator no clock out) on - we are going to use the internal resistance capacitance oscillator with no external output for the clock. This saves adding components for an external oscillator. IOSCFC 4 MHz - internal oscillator frequency set to 4MHz. WRT off - enables the program to write to the program memory

2. The oscillator in 12F617 is factory calibrated to give a high degree of accuracy. However, to get this to work you need to load its value into the microprocessor. The ASM program does this.
3. Define OSC 4. 4MHz oscillator is used for the clock.
4. CMCON0.7 = 0. The microprocessor has built in comparators that are not needed in this application. This command switches them off.
5. VRCON = 0. The microprocessor contains a reference voltage

generator for the comparator. Again in this application it isn't needed so is switched off.

6. ADCON0 = 0. The microprocessor has several built in analogue to digital convertors. In this application they are not needed and are switched off.
7. ANSEL = %00000000. As there are no analogue signal connected to the input/output ports of the microprocessor so we make them all digital (all ports 0).
8. INTCON.7 = 0. The microprocessor has the ability to interrupt the program when a special event occurs. These are called interrupts and are not needed for this project and are switched off.
9. INTCON.6 = 0. Another type of interrupt is a peripheral one. Again, this isn't needed for this application and is switched off.
10. OPTION REG.7 = 0. To save having to add external resistors to inputs to pull them up to 5V (logic 1), the microprocessor has them built in. As we need them for GP0, GP1, and GP2 (timer program inputs) we switch this on.
11. TRISIO = %00001111. We have to tell the microprocessor which ports are inputs and which are outputs. Setting a 1 makes it an input and 0 makes it an output. The ports are read from the right so GP0, GP1, GP2 and GP3 are inputs and GP4 and GP5 are outputs.
12. GPIO.5 = 1. When you first switch on the microprocessor GP5 is set to 5V (logic 1). This means that the transistor is on and the relay contacts are closed.
13. a var word. We need somewhere to store the number of 1 second loops the program has been through. 'a' is used for this.
14. b var word. Again we need to store the required number of loops (seconds) for the timer to run through to reach the programmed soldering iron on time. 'b' is used for this.
15. Start: This is the label for the start of the program.
16. GPIO.4 = 1. GP4 is at 5V (logic 1), switching LED1 on.
17. Pause 500. 500ms delay before next step.
18. GPIO.4 = 0. GP4 is at 0V (logic 0), switching LED1 off.
19. Pause 500. 500ms delay before next step.
20. You'll remember we need to tell the microprocessor how long the soldering iron is to be switched on for. This is done by adding various links for different times. If you add a link then the corresponding input is at 0V (logic 0). If you leave out a link then the built-in pull-ups will take the corresponding input to +5V (logic 1). The next 8 lines tell the microprocessor what time you want. For example, say we want seven hours then from the circuit diagram LINK 1 and LJNK 2 are added and LINK 3 is left out. This means that GP0 is at logic 0 and GP1 is at logic 0 and GP2 at logic 1. If you look at the 8 options then you will see that the 7th line is the only one that meets these criteria. The result is that variable 'b' is set to 25200 seconds which equates to 7 hours.
21. GPIO.5 = 1. GP5 is at 5V (logic 1) which turns the transistor on, which closes the relay contacts

- providing power to the soldering iron.
22. $a = a + 1$. Add 1 to a. Initially $a = 0$ so it now is 1 (a delay of 1 sec) and the next time we go round it increments to 2 (2 sec). It keeps going round until it reaches the programmed on time in seconds.
23. If $a < b$ then goto Start. If a is less than b then go to the start of the program. In this case $a = 1$ and we have set the time to 7 hours then b from the above is 25200 which means that the program goes back to start. The next time $a = 2$ (2 sec delay). It keeps going around the loop incrementing 1 sec each time.
24. If $a \geq b$ then goto Cutout. If a is greater or equal to b then go to a new label called 'Cutout'. For the above example 7 hours b equals 25200 so on the 25200th loop a will equal b (7 hour delay) and the program goes to the new label 'Cutout'.
25. $GPIO.5 = 0$. Make GP5 0v (logic 0). This removes the base current to the transistor switching it and the relay off. The relay contacts are now open removing the 240V AC from the soldering iron and mains transformer. The soldering iron and the microprocessor are now off.
26. End. Stop here. We are now back to how it was before the start button was pressed.

Final test

Before applying power check the wiring for any errors and make sure the terminal screws are tight and are making contact with their wires. Plug in the soldering iron and apply power then press the start switch. As before, you should hear the relay switch on and the LED flash. The soldering iron should heat up and remain hot until the program time has elapsed. If all goes well screw the lid on the box.

ME

SOFTWARE LISTING:

```
' cutout soldering iron SC
'Started....9-01-19
'Microcontroller used: Microchip Technology 12F617
'microchip.com
' PicBasic Pro Code: Micro-Engineering Labs, Inc.
'melabs.com
'-----Program Description-----
' If the soldering iron is on for more than a programmed time (1 to 8Hrs) then the power is switched
off
#CONFIG
_CONFIG_CP_OFF & _BOR_OFF & _MCLRE_ON & _WDT_OFF & _PWRTE_ON & _INTRC_OSC_
NOCLKOUT & _IOSCF5_4MHZ & _WRT_OFF
#ENDCONFIG
ASM
    bsf          STATUS,RP0      ; bank 1
    movlw        0x00            ; set oscillator to factory calibrated frequency
    movwf        OSCTUNE
    bcf          STATUS,RP0
ENDASM
Define OSC 4
    CMCON0.7 = 0      'comparator off
    VRCON.7 = 0       'comparator voltage ref off
    ADCON0.0 = 0      'ADC off
    ANSEL = %00000000 'all digital
    INTCON.7 = 0      'disable interrupt
    INTCON.6 = 0
    OPTION_REG.7 = 0  'pull ups on

    TRISIO = %00001111 'all ports inputs except GP4 and GP5
    GPIO.5 = 1         'power on
    GPIO.4 = 0         'led off
a    var word         'number of 1 second intervals counted
b    var word         'number of 1 second intervals require (on time in seconds)
    a = 0
    b = 0

Start:
    GPIO.4 = 1         'switch LED on
    pause 500          'pause 500ms
    GPIO.4 = 0         'switch LED off
    pause 500          'pause 500ms

    if GPIO.0 = 1 and GPIO.1 = 1 and GPIO.2 = 1 then b = 3600      ' 60 minutes
    if GPIO.0 = 1 and GPIO.1 = 1 and GPIO.2 = 0 then b = 7200      ' 120 minutes
    if GPIO.0 = 1 and GPIO.1 = 0 and GPIO.2 = 1 then b = 10800     ' 180 minutes
    if GPIO.0 = 1 and GPIO.1 = 0 and GPIO.2 = 0 then b = 14400     ' 240 minutes
    if GPIO.0 = 0 and GPIO.1 = 1 and GPIO.2 = 1 then b = 18000     ' 300 minutes
    if GPIO.0 = 0 and GPIO.1 = 1 and GPIO.2 = 0 then b = 21600     ' 360 minutes
    if GPIO.0 = 0 and GPIO.1 = 0 and GPIO.2 = 1 then b = 25200     ' 420 minutes
    if GPIO.0 = 0 and GPIO.1 = 0 and GPIO.2 = 0 then b = 28800     ' 480 minutes

    GPIO.5 = 1 'power on

    a = 1 + a
    if a < b then goto start
    if a >= b then goto Cutout

Cutout:
    GPIO.5 = 0         'switch power off
END
```


Lathes and More PART 49

for Beginners

Graham Sadler

makes a couple of faceplates designed for repeatable holding of workpieces.



Continued from p.435
M.E. 4621, 13 September 2019

For the angle bar, cut off a length of 25mm square bar about 100mm long. The key to this component is to have two faces really square to each other. The other two won't matter. Square aluminium bar is never perfectly square or has flat faces, so will need machining. Put this in the miller vice and use a fly-cutter to skim it flat. This will form the mounting face. Avoid using multiple cuts with say an end mill to finish it flat as it's important to ensure there is a complete absence of ridges which can form if your miller spindle isn't completely vertical. Mill the tenon slot across the 25mm width in the centre of the bar, again in two stages, and set out the two M6 tapped holes

for the mounting bolts. Ensure they are correctly spaced from the central slot.

The next bit is important as the finished bar must be square. Assuming that your vice is in good condition, the machined face, suitably protected with thin card, is placed against the vice fixed jaw. Use parallels under the work to set it just above the vice jaws, but here is the key - don't use the moving jaw directly onto the work as this back face is un-machined and may cause the block to have a slight tilt. What you do is use a pusher of say 15mm diameter steel between the moving jaw and the work. This gives a line contact and ensures the work is really firm and true against the fixed jaw. Now mill the long

tenon slot along its length and drill and tap (4.1mm) for the two 2BA clamps which need to be in the centre of the tenon slot. Deburr.

In the lathe, the production is a bit more tricky. Begin by packing up on the cross slide for fly cutting one face. Check that the bar is parallel to the chuck by removing the chuck jaws then pushing the bar hard against the face of the chuck before tightening the clamps. Now fly cut the first face, then cut the long tenon slot approximately in the centre of the bar. Rotate and machine the second face. The tenon slot across the 25mm width is achieved by clamping onto the vertical slide using an engineer's square to set the bar vertical (**photo 255**).



Setting the bar vertical to machine the tenon slot.



One setup for finishing the angle bar true. The setting plate is well used! This would be better done by clamping the bar onto the cross slide.

If you are intending to use the long tenon slot, then drill and tap the M6 mounting screws but go all the way through and bolt to a machining plate (this one is well used!) and thus onto the slide. I used cap screws here which had to have their heads turned down a little so they were a clearance fit in the 'T' slot. The holes mounting the plate onto the slide have to be positioned correctly. **Photograph 256** shows this as a mock up - fly cutting the front face then cutting the cross tenon slot first then the top. In the end though I decided this was a bad idea and feel the second face mounting is better cut by clamping onto the cross slide.

The larger angle plate

Here, I thought something more like a standard angle plate would be better. It is asymmetric, with a 32mm and a 45mm face. It is produced in a very similar way to the simple bar. Do not carve out the centre until the faces are completed as it will be easier to hold. The slots seen in photo 253 (M.E.4621, 13th September) on the 45mm face are redundant. In addition, it's not worth doing the cross tenon, horizontal in photo 253. I intended to use this for the 32mm wide face on the angle plate but I have never used this setup.

Clamp the angle plate onto 30mm packing, which will enable the face to be fly cut, then the long tenon can be cut more or less in the central position wherever this happens to be - the work mounting plate can be altered to suit (**photo 257**). Rotate and machine the 32mm face then produce the tenon slot in the same way as for the square bar. Of course, **photo 258** shows how I actually produced this on the miller - a much simpler task. As before, use a piece of round so there is a line contact between it and the work, thus pressing it hard against the fixed jaw.

To carve out to make the angle plate shape, use a large diameter end mill to



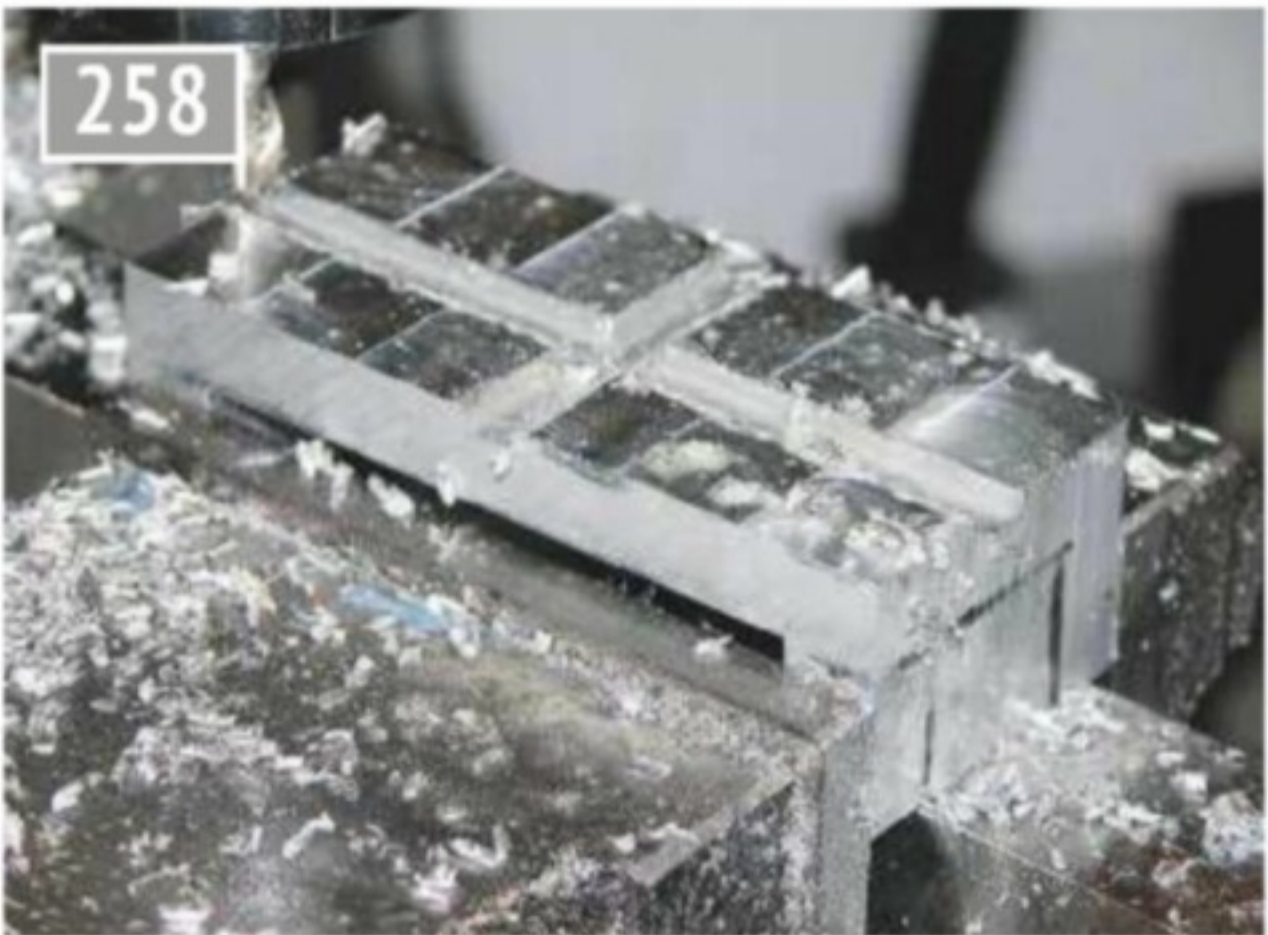
Facing then cutting the tenon slots in the angle plate - do this before cutting the pocket.



It's a lot easier in the miller (b)!

carve out the back, which is intended to reduce the mass and thus balancing weights - dimensions here aren't critical at all. Do set table stops for this as, even with a DRO, it's too easy to mill too far. On the vertical slide you will need several different setups

to carve this out but it's not necessary to obtain a perfect matching of the cuts. It's all about reducing the mass of the angle plate (**photos 259 and 260**).



It's a lot easier in the miller (a)!



Removing mass from the large angle plate. This will need several setups and perhaps finishing by hand.

●To be continued.

NEXT TIME
We need to make several work mounting plates.

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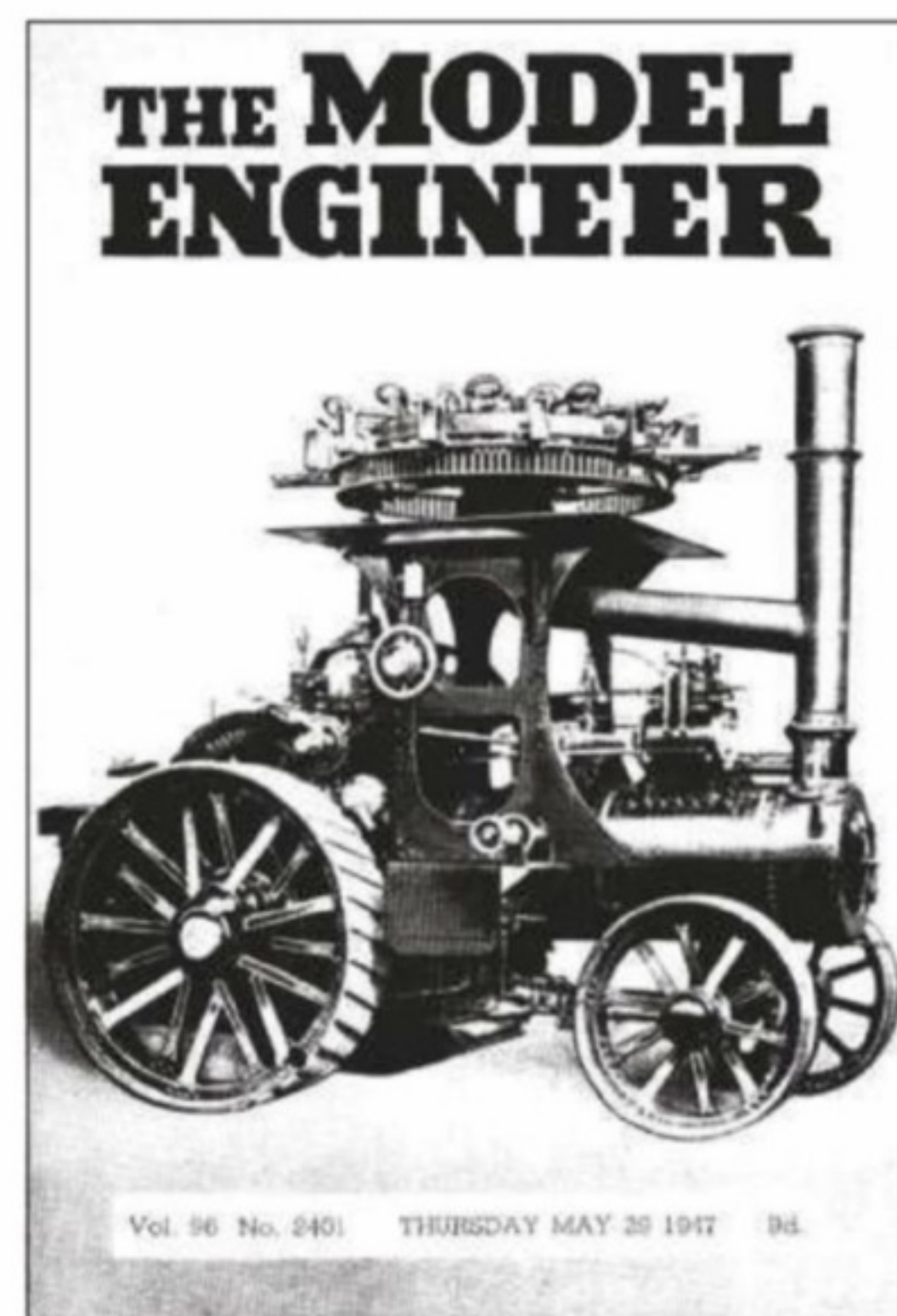
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A Brand New Bagnall for Groudle Glen

PART 2

Mark Smithers features a new Bagnall locomotive built at the Scarborough North Bay Railway.



Continued from p.432
M.E. 4621, 13 September 2019



Otter's chassis was photographed again in the Scarborough Erecting Shop on 26 May 2017 and this front left three-quarter view makes an interesting comparison with the corresponding view of four months earlier. By this stage, the cylinders had been fitted, along with the motion brackets, weighshaft bearings, handbrake cross-shaft, coupling rods and much of the valve motion. At this stage it had been intended to name the locomotive Wendy, although with hindsight this would probably not have been a good move, given the fact that a 'Bullhead' Bagnall with this name already exists in preservation.

Although it was originally envisaged that the new locomotive would be named *Wendy*, the powers that be at the Groudle Glen Railway had other ideas and, in keeping

with the naming policy of the other Bagnall locomotives presently and formerly owned by the G.G.R. (*Sea Lion*, *Polar Bear* and new-build, *Brown Bear*) the name *Otter* was

eventually chosen. The G.G.R. policy of giving its locomotives different liveries has also been followed and *Otter* has been turned out in a garter blue livery similar to the scheme used on the L. & N.E.R. A4 Pacifics. Certain refinements have been introduced that were not present in the original specification, including steam operated cylinder draincocks, a mechanical lubricator and roller bearings for the axles. The ability of these latter components to reduce rolling resistance is very evident from the locomotive's free running properties. Some of the components that would have been castings on the original design are steel fabrications on the new locomotive. In most respects, however, *Otter's* design closely follows the



A close-up view of the left hand cylinder. This was cast from the same pattern used to produce the cylinders for the G.G.R.'s other new Bagnall-pattern steam locomotive, 2-4-0T Brown Bear.



A close-up view of the left hand motion bracket and weighshaft bearing.

General Arrangement drawing in that the mainframe length is 8 feet 6 inches overall (2 foot 6 inches + 2 foot 6 inches + 3 foot 6 inches), namely the dimension that corresponds to the smallest variety of the *Sipat* specification. The cylinder dimensions, however, are 5 inch bore by 7½ inches stroke, which corresponds to the largest variety of the class, which had an overall frame length of 9 foot 6 inches. The new locomotive does, therefore, incorporate an element of 'customisation' but this was not uncommon in the days of widespread construction of narrow gauge locomotives for revenue-earning service.

At the time of writing, it was intended to deliver *Otter* to the G.G.R. on the Isle of Man by Easter with a formal commissioning ceremony, in conjunction with 2-4-0T *Brown Bear*, being scheduled for July 24th 2019.



By May 2017, the eccentric rods had been connected up to the bellcranks carried by the 'wobble' (combination) bearings associated with Bagnall-Price valve gear. This is the right hand eccentric, eccentric rod, bellcrank and 'wobble' bearing.



The external parts of the Bagnall-Price valve gear had yet to be fully assembled at this stage, but in this left-hand view the expansion link and combination arm (fixed to the 'wobble' bearing) can be seen.



The rear portion of the firebox stretcher can be seen to advantage in this view, together with the leading central part of the footplate and ash shield. With this type of boiler, ash can only be removed from the rear of the firebox.



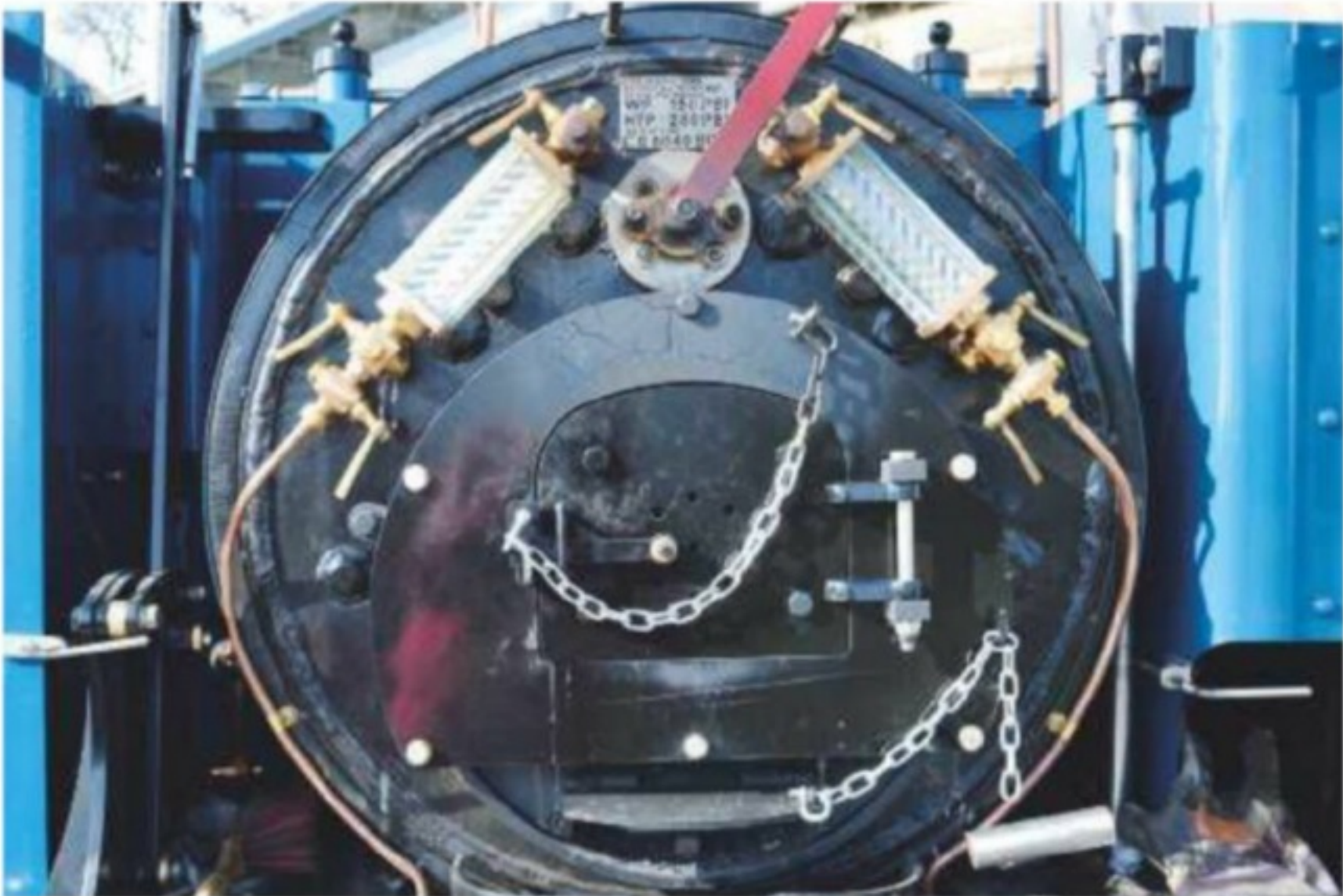
Unlike the original *Sipat* design, *Otter* is fitted with steam operated cylinder draincocks. The pipework for these is seen in this view, taken on 21 April 2019. Also visible in this view is the pipework for blower and the tank level equalisation and drain pipe.



This is a close-up view of Otter's worksplate. In line with N.B.R.E.S.L.'s normal practice, no maker's number has been allocated.



This is a close-up view of the left hand external components of Otter's Bagnall-Price valve gear. From top to bottom, we have the weighshaft bellcrank; the drop-link; the expansion link; the die block (with 'wobble' bearing behind) and valve rod; the combination arm; the crosshead, correcting link and connecting and coupling rods. Note that the general design philosophy of this valve gear is very similar to Walschaert's with its reliance on a primary eccentric (or return crank) driven motion 'combined' with a crosshead driven correcting (lap/lead) motion. Note also the shape of the connecting rod in the big end region – there is blank metal where a cotter pin spit bearing would have been on the original *Sipat* design.



This view shows the classic 'Bullhead' backhead found on many small Bagnall locomotives. Note the upper (firehole) and lower (damper) doors.



The steam manifold is shown in this view, attached to the rear column of the safety valve casting. The lower pair of take-offs are for the injector steam feeds, whereas uppermost we have (L to R) the blower; the whistle and the steam draincock feed (the latter certainly a non-original feature).



A close-up of the injector pipework, reach rod and upper part of the valve motion on the left hand side.



This mechanical lubricator, fitted on the right hand side close to the leading wheelset, was not a feature of the original design.



The original plans of the Sipat mainframes were followed closely with the result that this set (mirrored on the other frame) can be seen at the rear end. They should be noted by prospective modellers of the original design as they originally carried the bearings for the hand-worked cylinder draincock control cross-shaft.



A posed view of the completed Otter with three Robert Hudson V-skips taken on the day of the locomotive's first running test on 21 April 2019.



Otter moves off away from the test track's watering facilities following the re-filling of its 35 gallon capacity saddle tank.



Otter is seen here with (L) David Humphreys of North Bay Engineering Services Ltd. and (on footplate) Jonathon Kennaugh of the Groudle Glen Railway.

Muncaster's 'Simple' Entablature Engine

PART 5

Jason Ballamy presents a rarely modelled engine suitable for a beginner.



Continued from p.459
M.E. 4621, 13 September 2019

Crosshead guides (fig 8)

Ideally these should be made from $\frac{1}{4}$ inch thick cold rolled steel that can be pickled before skimming down to 6mm thick and milling to overall size. If you are using bright bar then there is a slight risk that the metal may move but a few tweaks after machining should have things straightened out. Mark out the two blanks and saw away most of the waste material before holding on the vice on parallels. Touch off on the top of the work and zero the Z-axis, feed down 6.2mm and then, working from the sawn end, mill until you are left with the 3mm thickness required for the top leg (**photo 39**).

Now, touch off on what will be the bottom and mill inwards 55.3mm until you have a 3mm thickness left in the vice which will become the vertical leg (**photo 40**). Using two equal diameter rods to support the work, mill down to your layout line to form the inside sloping edge (**photo 41**). With that done turn the work over with



Milling the top leg of the guide.

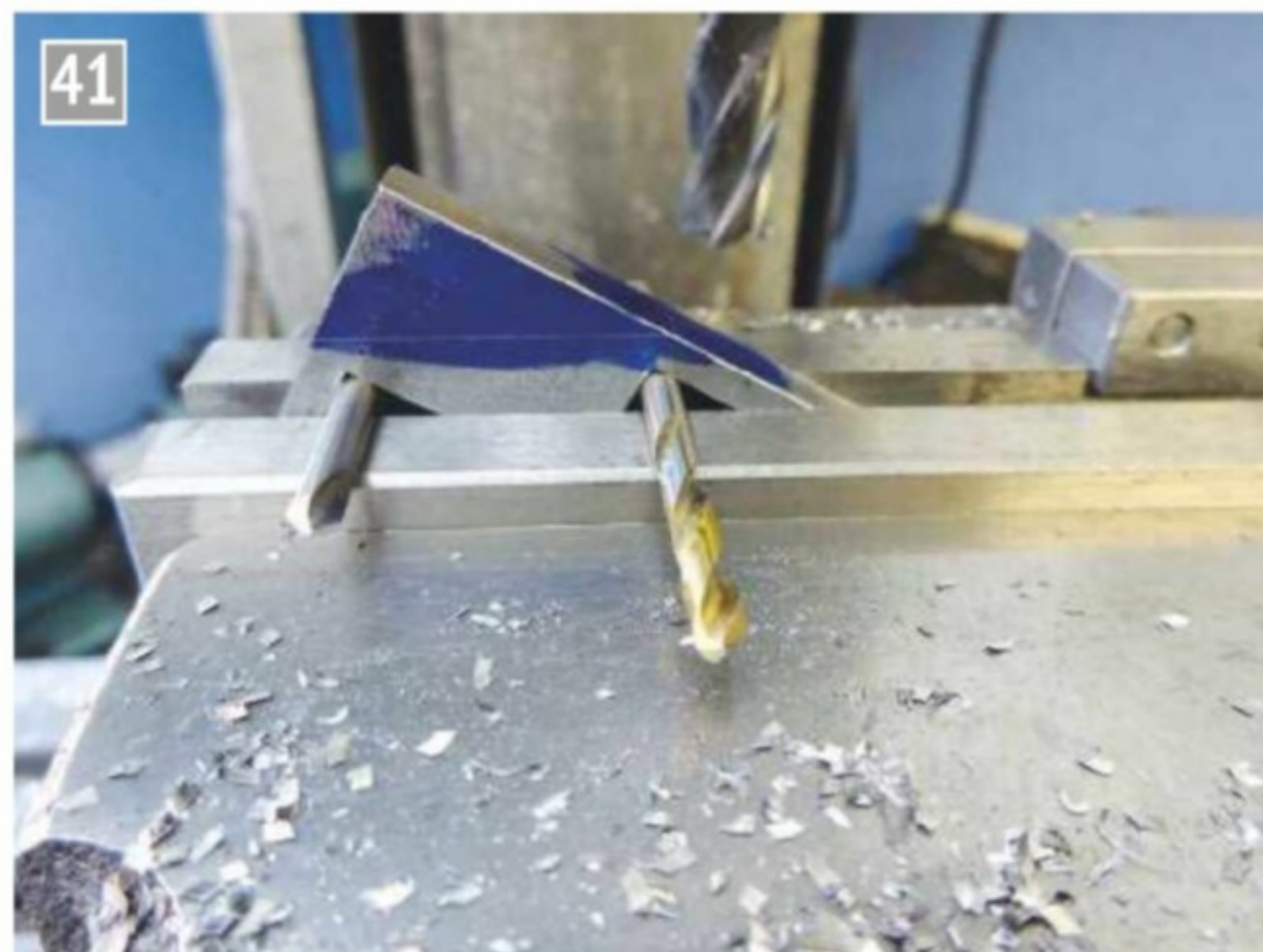
the edge just machined resting on parallels and mill down until the 3mm thickness is reached. The last machining job is to drill the holes at either end. With some fine emery wrapped around a file use a draw filing action to clean away any tooling marks paying particular attention to the inner face and sides that the crosshead will run against.

Crosshead (fig 9)

If you have a means of indexing or collet blocks then the crosshead can be made from round stock; if not start with 20mm square bar and use its sides for indexing. The first job is to turn the spigot on the end and drill and tap for the piston rod, metric fine if you have it. Transferring to the mill, first form the basic

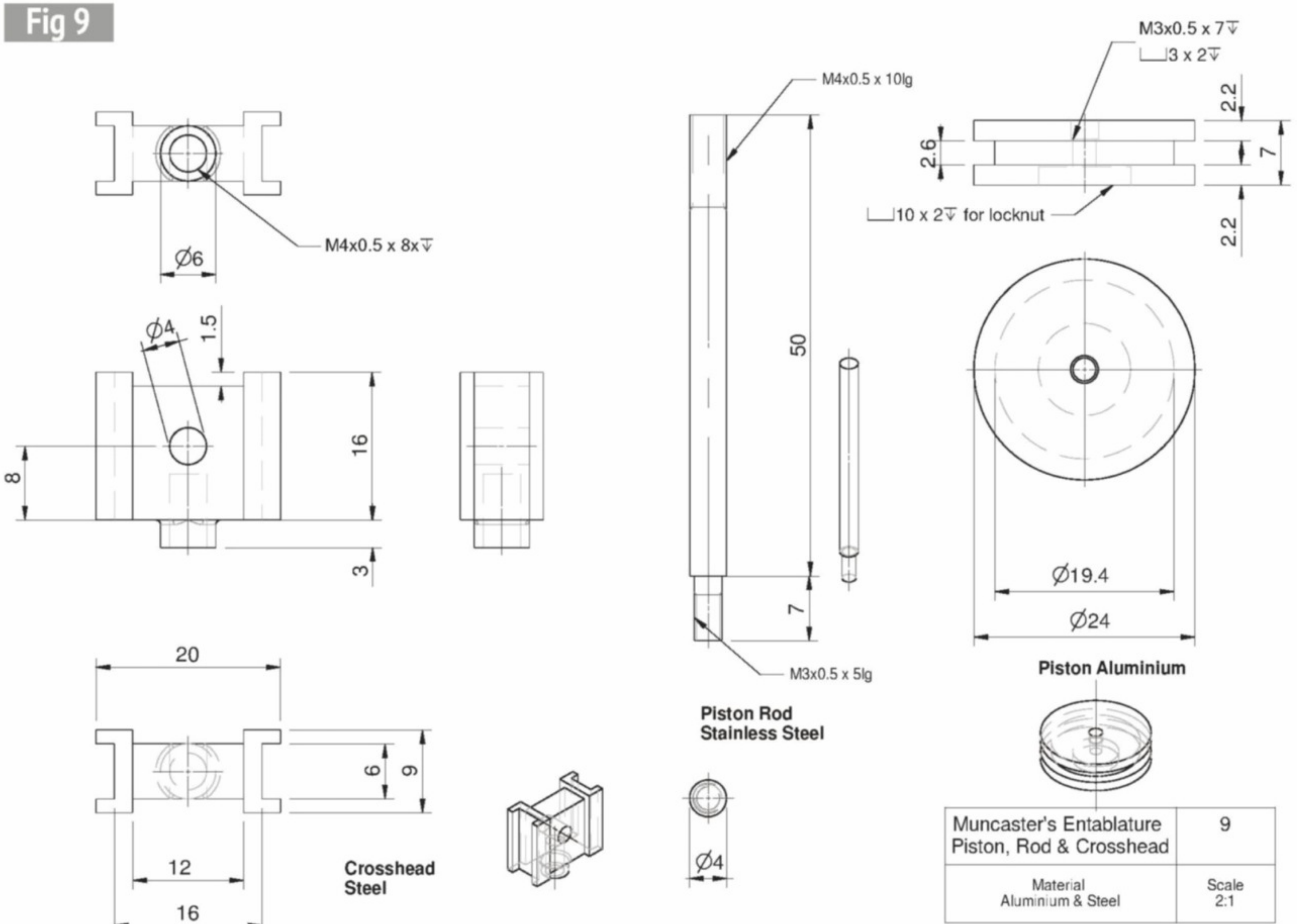


Milling the lower leg of the guide to thickness.



Milling the angled face using drills as support.

Fig 9



Reaming the crosshead pin hole after milling.

20 x 9mm rectangular section followed by the side recesses and finally the two 6mm slots that fit around the guides. Use a smaller cutter for these, say 5mm diameter, so that you can fine tune the finished width to suit your bars. Then drill and ream for the pin (photo 42). Lastly cut off from the main bar, mill to length and add the

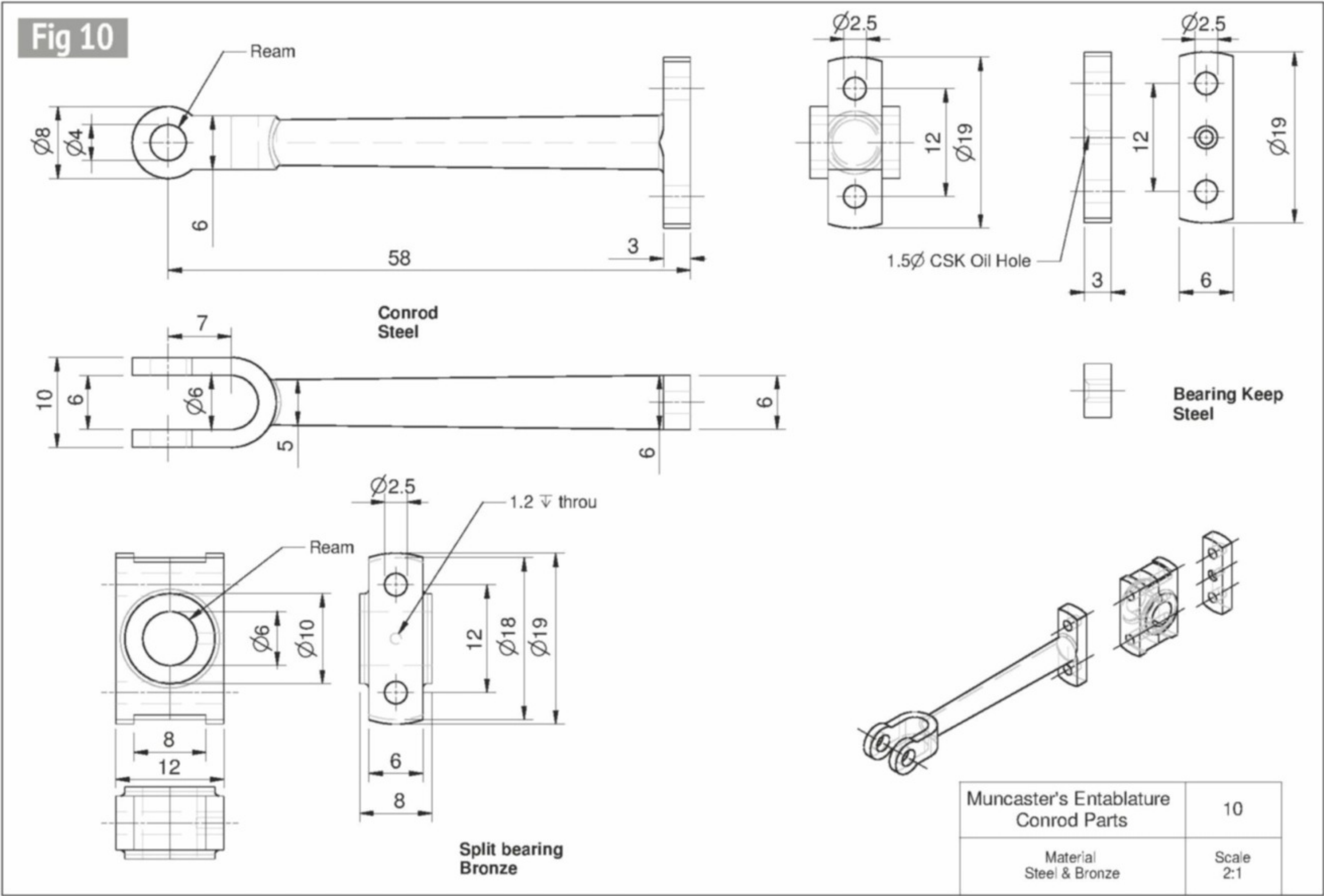
1.5mm recess in what will be the bottom. If you intend to do a lot of running under load then it may be worthwhile case hardening the crosshead to reduce the risk of it picking up on the guide rails but I have not found this necessary on my engine which has done quite a lot of display running - just keeping it oiled.



Initial turning of the piston.

Piston rod (fig 9) This is a fairly straightforward turning job. The main thing to watch is getting the 3mm reduced diameter and thread nice and concentric to the outside. The other end should be threaded to match whatever you used in the crosshead.

Piston (fig 9) Start by skimming down some 25mm or 1 inch stock to say 24.5mm diameter; face off, drill 2.5mm, counterbore 3mm for 2mm depth and thread M3. Then, using a sharp parting tool, cut the piston ring groove making sure to remember to allow for the fact you have an over diameter piston at this



stage (**photo 43**). Part off, face to thickness and with a small boring bar or end of a 10mm diameter milling cutter, form the 2mm deep counterbore for the locknut to fit inside.

To finish turn the piston set the rod running as true as possible either in a collet, split bush or using the four jaw, then screw the piston tightly onto it and fit a locknut. Now using light cuts trim the diameter

back to a sliding fit in the cylinder using that as a gauge once you start to get close, rather than measuring. The piston should not be removed from the rod after this.

The groove sizes shown on the drawing will suit a 2.4mm section 19.4mm internal diameter Vitron O-ring but you could also fill it with graphite yarn or - if you only want a display engine and you have

got your fits right - it will happily run on a couple of psi of air at a very slow tick over with nothing in the groove which does reduce friction and help with the slow running.

Connecting rod (fig 10) Machine up a piece of steel 10 x 20 and about 25mm longer than needed; square off one end and then measure up 58mm from that end to drill

and ream for the crosshead pin (**photo 44**). Stand on end to drill the two 2.5mm holes and while you are at it, add a small centre drill hole to aid turning later. Now mill 6mm off each side leaving 3mm at the end for the bearing to fix to, followed by milling the central slot (**photo 45**). Then remove a further 1mm to leave 6mm in the middle which is the thickness of the fork (**photo 46**). With the



Reaming the conrod for the crosshead pin.



Milling a fork slot in the conrod.



Reducing fork thickness.



Cutting the palm down to thickness.



Rough turning prior to doing the taper.



Rounding the assembled big end parts.

rod back onto its side the palm can have 2mm removed from each face (**photo 47**). Set the conrod to one side for now.

Big end bearing (fig 10)

There is no real reason to make this a split bearing unless you expect it to have a hard life so start by milling a piece of bronze to 20 x 8 x 12mm then, holding in the four jaw chuck, drill and ream the central hole after which the raised boss can be turned with a round nosed tool. Reverse in the chuck and add the boss on the opposite side. Finally drill the two through holes for studs and the small oil hole. Keep in mind that bronze is quite soft so don't be too heavy handed with the chuck key and risk distorting the part.

Bearing cap (fig 10)

A fairly straightforward job from a piece of 20 x 6 x 3mm steel with two clearance and one centre drilled hole.

Holding the conrod by the spare material at the end, get it to run true in the four jaw with additional support from the tailstock and turn the shank round to start with using a general purpose turning tool, then swap to a round ended tool to turn the final taper leaving fillets at each end for strength (**photo 48**). Without removing the rod from the chuck, assemble the bearing and cap onto its end then bring the tailstock back into position in the cap. Using light cuts reduce the 20mm material to a 19mm diameter and then again with the round nose tool cut

If you intend to do a lot of running under load then it may be worthwhile case hardening the crosshead to reduce the risk of it picking up on the guide rails but I have not found this necessary on my engine which has done quite a lot of display running - just keeping it oiled.

the 18mm waste around the bearing (**photo 49**). Mark the parts so they go back together the same way before taking apart then saw off the chucking block and using filing buttons, round the ends of the fork.

●To be continued.

NEXT TIME

We shall make the valve and eccentric.

Additional content and discussion about this build can be found at www.model-engineer.co.uk/forums/postings.asp?th=139596

The Brushless Brute

Jon Freeman describes a powerful, dual gauge petrol-electric locomotive using brushless motors for tractive power.



Continued from p.463
M.E. 4621, 13 September 2019



Preparing for an early test run at Bristol in 2017.

Suspension

Coil springs for the primary suspension were specified with the help of some simple calculations, after some thought as to how to get this right, or right enough. The logic developed thus.

At rest on a level surface, the sixteen springs should equally share the load of 'sprung mass', that is the weight load of the whole locomotive minus the 'unsprung mass' of the wheels, axles and a proportion of the motor weights. In this rest state, the axle-boxes should all be about half way between the upper and lower limits of movement. The springs are required to offer at least some resistance over the whole movement range but this resistance should increase significantly and steadily as deflection increases. Similarly, resistance should reduce with reducing load, offering little or almost no force when the axle-box is at the lower limit, resting on the keep. Therefore, the unloaded spring length, or free length, is just long enough to not rattle loose when both axle-boxes are at the lower limit. This settles the length 'L'.

Knowing the maximum vertical axle-box travel, the spring deflection at rest is half this. Let the at rest deflection distance = 'd'. This is best measured in millimetres as most of the web sites searchable for springs use metric. Having an idea of the locomotive sprung weight 'W' in kg, the force in units of newtons due to weight is the weight W in kg multiplied by the 'standard gravity' factor of 9.81. This divided by sixteen gives the force on one spring. The 'spring rate' R in units of newtons per millimetre is then:

$$R = W \times 9.81 / 16 / d \text{ N/mm}$$
 [Eqn 7]

Choice of outside or inside diameters is largely a matter of cosmetics and what fits; it's not critical, so with the free length 'L' and the spring rate 'R' determined, the search for springs may begin. One suitable source was found at www.flexosprings.com. Varying this design, for instance using more than one spring per wheel, gives more options. Using half the number of springs rated at 2R would be just as good or, if the exact spring required cannot

be found, they may be used in pairs of different ratings adding to 2R.

Time was spent machining the motor mounting plates, in particular the recesses to fit the motor registers. The register is there to fix the position of the motor on the plate and it is worth the effort machining this to a good fit with no shake. The through hole should be a good clearance for the pinion gear; this and the recess are probably best machined using a lathe and faceplate or four jaw chuck before finishing the hole for the axle bearing. The distance between motor and axle centres needs to be accurate enough to ensure proper gear meshing. With this project, the larger set were machined first with the distance between centres fixed such that the gears were fully meshed with no clearance allowed for. While this works, the gears make a clearly audible growl at low speeds, quietening down as the speed increases. For the smaller 5 inch gauge set, a clearance of about 0.3mm was designed in; these run smoothly and almost

silently. The assemblies were built with the intention of staying together so all screws were secured using a thread locking compound.

Whether push-fitted or secured using Loctite, motor mount assembly axle bearings should accommodate a small clearance over the finished axle size. 0.1mm clearance feels about right but clearances up to about 0.25mm would do no harm - the main point is to avoid binding and tight spots, leaving some space for the grease or oil. The larger bogies were fitted with roller bearings but this was probably a waste of time, money and effort. Plain bronze or cast iron would have been sufficient to carry the small load of part of the motor mass.

Fixing the large gear to the wheel required some rethinking. The first attempt used three countersunk screws and, despite time and effort being put in to ensure every hole and thread were within a couple of thou or 0.05mm, the gear was obviously off centre by a far greater, clearly unacceptable margin. After some head scratching, some new screws were obtained from a supplier of quality engineering materials. These at least had the conical heads more or less concentric with the threads, unlike the cheap rubbish screw from the local hardware shop! The result was

much better but still judged to be not quite good enough. Next, using the same methods and accuracy in positioning, a pair of holes was drilled and reamed through both the gear and the wheel. Silver steel dowels were then fitted to locate the parts accurately, all held together with quality screws and Loctite.

Early trials

Photograph 45 is from an early trial run on the 7¼ inch ground level track at Bristol. At this point there was no automatic engine speed control. Before pulling away the engine control lever was set to 'rev' the engine to 'quite fast'. This worked but it soon became a bore setting back to tickover when stationary. It was also possible to stall the engine when driving hard with the revs not high enough. A keen observer might note that the larger pulley was fitted to the generator, and the smaller to the engine. One shaft was 19mm and the other was ¾ inch. Not much difference but enough when not checking thoroughly before boring out the pulleys! Everything worked but having the wrong pulleys on the wrong shafts explained why the generator output voltage was about 20% lower than calculated (new pulley subsequently ordered, bored correctly this time, sorted).

The 7¼ inch bogies were originally fitted with an older design of brushless motor



Bogie parts gathered together for assembly.

controller. These worked and proved the basic design but were later replaced by the new STM3 boards. This designed out one or two potential problems and simplified the communication protocol between the driver's touch-screen controller and the motor controllers – deep technical stuff, such is development.

Photograph 45 shows a stage in development of the chassis. The large cross member at the front is a piece of 4 x 1 inch steel. It provides a solid fixing to the frames and buffer beam and probably weighs about the same as all the electrical stuff at the back. The rear panel forms part of

an assembly of aluminium panels all much thicker than they need to be for any reason of mechanics. The idea was to provide an efficient means of conducting heat away from the electronic brake gear fitted on the rear panel. In normal public running service to date, the rear panel temperature rise is seldom noticeable.

Photographs 46 to 48 show the 5 inch gauge bogies under construction.

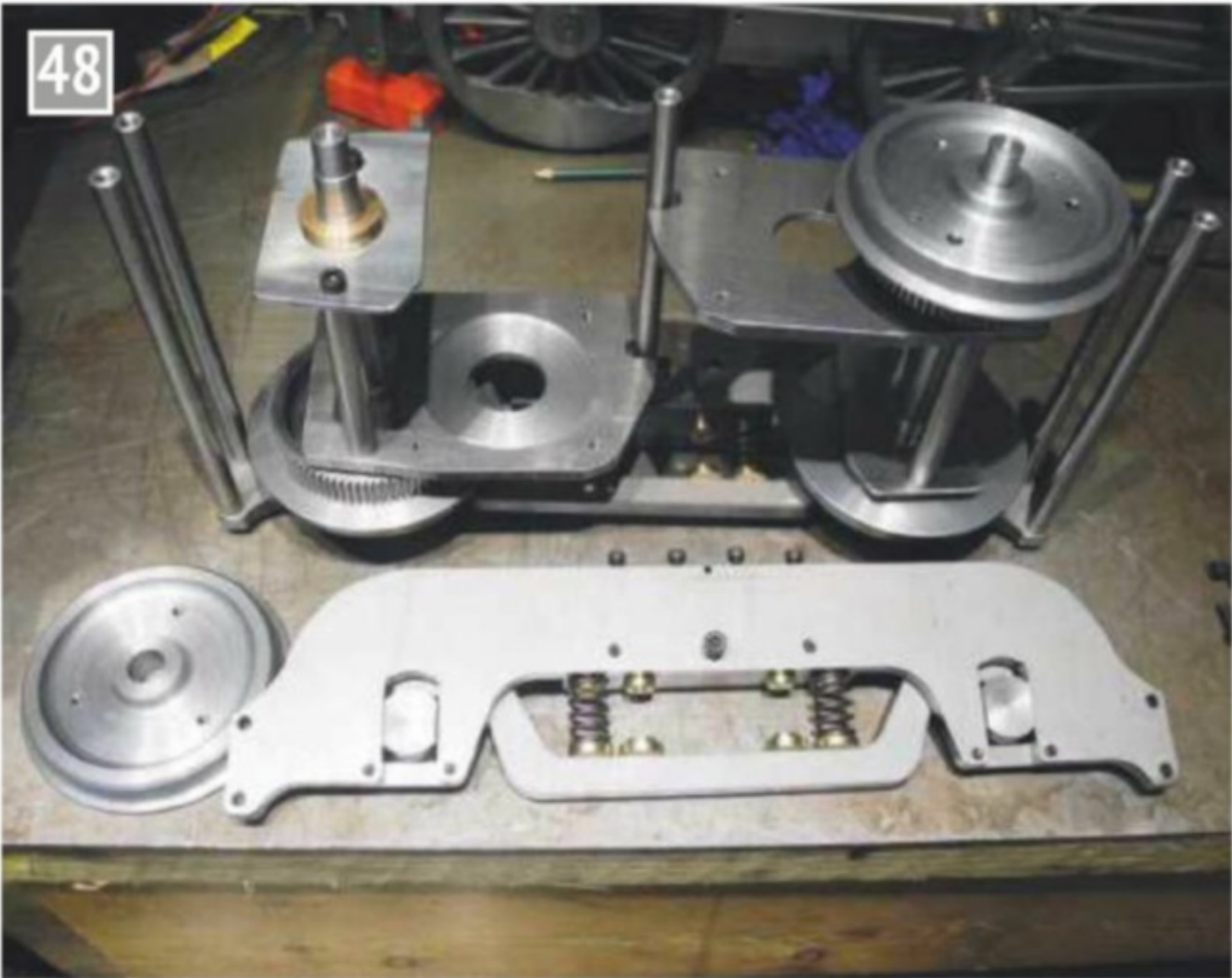
●To be continued.

NEXT TIME

We conclude by looking at the electronics and software.



Early stage of assembly.



Assembly of the bogies is nearly complete.



One Giant Leap

Dear Martin,
Like millions of others of my generation I too was glued to the TV back in July 1969 watching Armstrong and Aldrin on the Moon. We had been brought up on Dan Dare, gawped fascinated at '2001' on the big screen and were looking forward to promises of the 'space age' and our weekend sightseeing jaunt in low earth orbit. As we know the 'future' started to unravel after Apollo 17 - the taxpayers in the US were becoming disinterested and their economy was becoming overstretched. So, yes, money was and is a problem but there is another more technical reason for the failure of the space age to impact the lives of us ordinary folks in the direct way we had fondly imagined. The Energy Density (ED) of the chemical fuels we are stuck with is just very much too low. And this is especially so in rocketry - here the rocket weight is

Ford Museum

Hi Martin,
Your correspondents are correct about the spelling and the wheel arrangement of the Allegheny locomotive. I must have got myself confused when writing it up once I got home. It is still a somewhat enormous locomotive. However, on the numbering, as can be seen from the photograph the one in the Henry Ford museum is number 1601. Number 1604 is also preserved and after a somewhat eventful preservation history is in the Baltimore and Ohio museum in Baltimore.

Regards, John Olsen

(The confusion about duplex and triplex perhaps arises because the 2-6-6-6 might at first sight suggest a triplex but the last '6' in fact refers to the 6 trailing wheels under the firebox. If it were a triplex it would be 2-6-6-6-0 - Ed.)

mostly the fuel (over 90% in the case of the Saturn V used for the Apollo launches), with the added burden of carrying aloft the oxygen required for combustion.

Take the Saturn V first stage, for example. It was powered by kerosene and LOX (Liquid Oxygen). The ED of kerosene is similar to diesel at about 45 MJ/kg but the need to haul the oxygen aloft as well attenuates

this to an unimpressive 6.1 MJ/kg. The second stage used hydrogen and LOX, which combines to 19.4 MJ/kg. Better, but still well short of the base ED (45 MJ/kg) that drives cars, buses, aeroplanes etc (as the oxygen comes free weight-wise - it's all around you).

The oxygen deadweight can be alleviated to a degree by carrying the rocket aloft using a more or less conventional aeroplane, as was the case with the X-15 programme in the 1950s and 60s (Neil Armstrong was one of the pilots) and more recently the Virgin Galactica project. But the energy (ED) deficit limited - and limits - these to flights of about 50-60 mile altitude and speeds far short of that needed to achieve orbit. As Isaac Asimov wrote in his 1988 collection of essays (The Relativity of Wrong - Sail On! Sail On!) 'Unless there is a richer source of energy than chemical reactions, then interstellar travel is hopeless'. And I'm afraid this applies too to travel within our own solar system, at least in the take off and away Dan Dare style.

I fear none of us will see weekend in orbit special offer posters in our local travel agent's window anytime soon. And I, for one, am greatly disappointed - the 'One Small Step for (a) Man' didn't really turn into a Giant Leap for Mankind.

Mike Gray (Louth, Lincs)

Boilers

Dear Martin,
Bob Bramson tells us that he is unaware of Bill Hall's work on measurement of condensation, so it is safe to say he hasn't read it. Despite this he doesn't believe it! Let me assure him that Bill was absolutely meticulous in his experimental work and as a retired Professor of Nuclear Engineering he did have long experience of both theoretical work and experiments to confirm it. He did in fact measure a 'steam ratio' of ~2.5 for an engine running at 500 rpm, steam chest pressure 50 psi, 40% cut off with no superheat. These are typical of our conditions, and he used a *Speedy* cylinder. He checked carefully for leaks, both by running on compressed air and measuring the air flow, and by increasing the superheat and watching the steam ratio decrease towards unity.

I also have in front of me a textbook by Prof. John Perry, published in 1909, in which he quotes an engine 18 inch bore, 30 inch stroke running at 120 rpm. The 'missing quantity' is 17.2%, equivalent to a 'steam ratio' of 1.172, but the area/volume ratio of this big engine is roughly 12 times higher than our little ones, so a lower figure would be expected.

For anyone interested in improving the breed, Bill's papers are available at www.advanced-steam.org/uFAQs/prof-bill-hall-papers-and-locomotive-simulation-software

Regards, Duncan Webster

Write to us

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Steam Turbines

Large and Miniature

PART 18

What is the best type of turbine to build?

Mike Tilby explores the technology, history and modelling of steam turbines.



Continued from p.371
M.E. 4620, 30 August 2019

This question has appeared occasionally on modelling forums etc. and it is something that I have been wondering about myself for a number of years. In the absence of any recent guidance for the amateur on turbine design, it seemed necessary to study theory and past models as closely as possible, then make a best guess and then 'have a go', not forgetting to keep fingers crossed. Over the last few years I have been working on the design and construction, firstly of the tools needed to make the parts and, more recently, an actual turbine.

Of course, there is no single answer to the above question and in this and subsequent articles you will find a discussion of merits and drawbacks of various design options and an explanation of the choices I made for my own design. Also, you will find a discussion of the best designs for blades and nozzles, based on available evidence, plus information about how the parts can be made. However, only a small part of the guidance can be based on that most valuable commodity, direct practical experience, since my own model is not yet completed and tested.

In case you are thinking that I should have waited to attain more practical experience before writing these articles, I'd like to say that I would not have had the temerity to submit any of this series for publication if it were not for the fact that it is well over

100 years since any general guidance for the amateur has been published concerning the principles of steam turbines and how to design models of them. Furthermore, some recent books and articles give me the impression that, outside the sphere of professional engineers, there is a general lack of understanding of how steam turbines work and how they were developed. Therefore, I felt that an updated explanation of the history, theory and design options might be worthwhile.

Another justification is that I've been working on my model turbine for several years and at this rate of progress, fate could well deny me the possibility of ever completing and testing it. On the other hand, it is just possible that the ideas will be of interest to some readers and might assist anyone who intends to design and build their own model turbine.

Aims

Before embarking on discussion of the various design options, it seems sensible to ask: 'What is one's aim in building a model steam turbine?' If it is simply to build a stationary steam engine that spins round and makes that lovely turbine noise then there is no need to bother with all the details in the following discussion since the series by Mr E. T. Westbury (ref 50) or past descriptions of other model turbines will provide all the information needed. However, if it is to power a

model passenger-hauling locomotive, then it seems that any improvement in efficiency that can be achieved would be advantageous. If it is to power a model boat, then carefully designed De Laval type turbines have successfully propelled some models but steam consumption has been higher, or power developed lower, than for model reciprocating engines. So, improved efficiency would again be of benefit and that will require experimentation.

My own primary aims are simply to see if I can build a model turbine that is more efficient than has been achieved previously and to see if it can be made at least as efficient as typical model reciprocators. The secondary aim would be to install it in a model ship.

Reasons to be hopeful

There are a number of reasons to think that model steam turbines with improved efficiency are possible. Fairly good efficiencies were achieved with the turbines of Prof. Chaddock, Mr. Elkind and Mr. Bamford (see parts 7 and 14) despite the following serious problems that are associated with their choice of turbine design – namely single stage impulse turbines:

- 1 De Laval type (convergent-divergent) nozzles were used and these seem to have a very low efficiency (see part 12).
- 2 At any moment, only a few blades were transmitting

power to the rotor while most were acting as brakes (see part 17).

- 3 The very high steam and rotor speeds used caused high frictional losses with additional losses if supersonic steam velocities were actually attained (see parts 11 and 13).
- 4 Despite the high rotor speeds, blade velocities were still much too low to attain the ideal ratio to steam velocity (see part 6).
- 5 Blade shape was probably poorly matched to the actual steam velocities and directions, especially since blade design did not reflect the latest developments in impulse blade shape (this will be discussed in a later article).

If the severity of at least some of these problems could be reduced, then a model turbine with improved efficiency seems a distinct possibility.

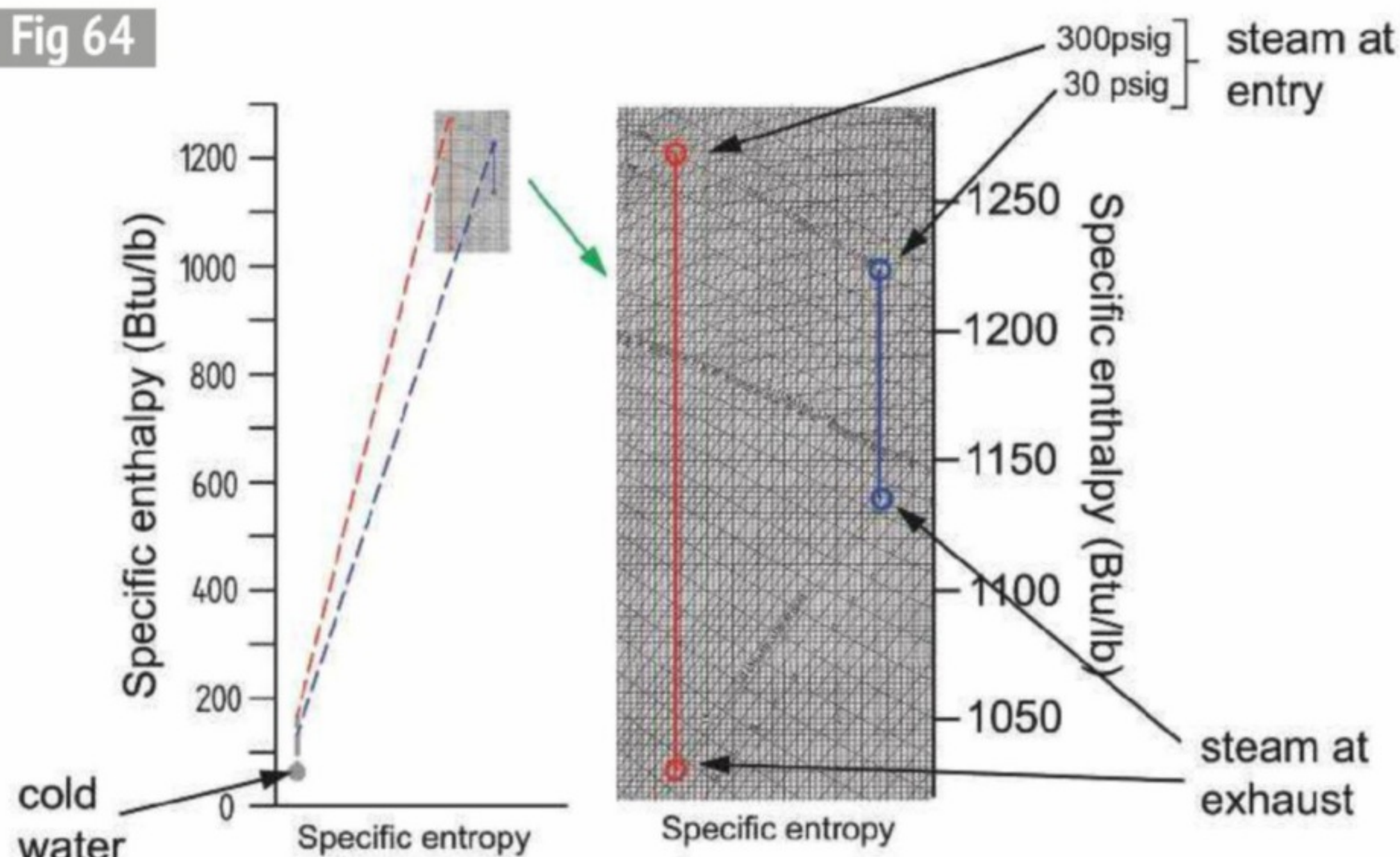
An advantage of turbines is that they can make good use of the expansion of steam whereas it seems that in many model reciprocators cut-off is quite late so that there is little opportunity for expansive working. Lastly, steam temperature in any part of a turbine is constant but, as Professor Bill Hall showed, cycles of heat transfer between steam and the cylinder wall can be a serious cause of inefficiency for small reciprocating steam engines (ref 51). Therefore, it seems possible that a turbine could be developed that has better efficiency and better power to weight ratio than good model reciprocating engines.

Choice of steam pressure

In these articles, two different measures of turbine efficiency have been discussed:

- 1 The amount of steam that a turbine needs to use in order to produce the equivalent of 1 hp for an hour (lb / hp.hr).
- 2 The power output as a percentage of the power that is theoretically available

Fig 64



Mollier diagram showing changes in internal energy (enthalpy) of water as it is converted to steam and then expanded to atmospheric pressure in a perfectly efficient engine. Initial steam pressures: 30 psig (blue lines), 300 psig (red lines).

in the steam (isentropic efficiency).

However, in general it is the performance of the whole steam plant that really matters and one or more of the following characteristics will be of particular importance:

- 1 Overall thermal efficiency, which is the power output as a percentage of the rate of heat energy input to the boiler.
- 2 Power output in relation to size or weight of the whole plant.
- 3 Maximum permissible steam pressure and temperature.

Increasing the efficiency by which available energy in steam is utilised by a turbine (or reciprocator) should improve overall thermal efficiency of the whole plant but it is possible that the best overall thermal efficiency might be attained by adopting a higher steam pressure, even if that means the turbine itself could only utilise a smaller proportion of the available energy (i.e. it had **lower** isentropic efficiency). The reason for this is illustrated by **fig 64** which shows how

the internal thermal energy (enthalpy) changes as feed-water is converted to steam and is then expanded in an engine. This diagram compares steam at pressures of 30 and 300 psig. In both cases the steam is initially superheated by 100°F but a similar pattern is seen when there is no superheat. The left-hand side of fig 64 shows the large increase in enthalpy that is needed to convert cold feed-water into steam. A very small part of this increase results from pressurisation by the feed-pump and the overwhelming majority of the energy comes from heat conducted through the boiler wall.

As explained in part 5, the energy theoretically available from steam for a perfectly efficient engine can be found by drawing a vertical line on the Mollier chart starting at the point denoting the inlet pressure and temperature. The line should drop down to the exhaust pressure which, in this case, is atmospheric pressure and it shows the decrease in enthalpy which occurs in an ideal engine. The small central part of fig 64 and its enlargement on the right

show these drops in enthalpy. It can be seen that **increasing the pressure from 30 to 300 psig requires very little extra input energy but it results in the available output energy increasing by about 2.5 fold.** (As explained in parts 13 and 14, at higher pressures, more of the internal energy in steam is available for doing work i.e. the level of entropy is lower.)

Also clear from fig 64 is how little of the energy needed to produce the steam is available for conversion to output power. In practice, of course, the actual output will be an even smaller proportion of the input because a real engine will have an efficiency much less than 100%.

Reduction in steam consumption for the same output power means a reduced rate of water evaporation is needed. Consequently, less energy is needed to convert water into steam and the size and weight of the boiler and ancillary plant can be reduced. But, to take full advantage of the increased energy available per pound of steam at higher pressure, an engine must be capable of handling a large degree of expansion in steam

volume and turbines are far better than reciprocators at achieving this. However, of course, in the world of model engineering, steam pressures of several hundred psi require the use of a flash (mono-tube) type boiler. My choice has been to aim for a steam pressure of 60 psig because if a reasonably efficient turbine design could be developed for this working pressure then it would have wider application than a turbine that relied on a flash boiler. Also, use of higher steam pressures increases the difficulty of making an efficient turbine. However, my long-term aim is a steam plant for a model boat with a monotube boiler and so, if attempts to develop sufficient power at 60 psi fail, then, as a last resort, the boiler and turbine could be run at a higher pressure.

Design options

In starting out to design a new model steam turbine we are faced with the following six key questions.

1 Single-stage or pressure compounded?

Almost all working model turbines built so far have consisted of a single pressure stage and one can imagine why this was so. Firstly, in the world of full-size engineering, turbines at the lower end of the size and power range were of this type. However, this does not necessarily mean that in small sizes of turbine, the single stage machine is more efficient. Instead, it could reflect the need to balance manufacturing and maintenance costs against the extent of cost savings that come from any increase in efficiency. It seems that some of the simple small De Laval turbines ran on waste steam from a large process plant or exhausted into a heating system. In those circumstances efficiency of steam use would not have been very important. It seems relevant that the micro-scale steam turbine with a 4mm diameter rotor described in part 17 was pressure compounded.

Secondly, single-stage turbines are far easier to design than multi-stage ones and they are also much easier to construct. However, if one is to reduce the losses associated with De Laval type turbines, as listed above, then one must use small pressure drop(s) across the nozzle(s), thereby reducing steam velocity. This means either running a single stage turbine on very low-pressure steam or adopting a multi-stage design. Use of low-pressure steam was the route advocated by Mr Johnson in 1945 and was criticised by Mr Elkin (see part 7). As discussed above, although low steam pressures could help to achieve a high isentropic efficiency, the available energy per lb of steam would be so low that the steam consumption per hp.hr would be high and that would reduce the overall efficiency and the power to weight ratio of the whole steam plant because large quantities of water would have to be evaporated for a relatively small power output.

A multi-stage design would allow both higher inlet steam pressure and low pressure drops per stage. This would avoid the need for super-sonic steam velocities and improve the ratio of blade to steam speed. The lower pressure drops per stage would also mean that convergent-divergent nozzles could be replaced by the more efficient simple nozzles. Lastly, in the lower pressure stages, the nozzle size and/or the number of nozzles would be increased. As a result, the proportion of blades contributing to power output at any moment would be increased.

A multi-stage model turbine would be more challenging to design and construct. Also, there is the risk that the added friction resulting from the extra components might exceed the efficiency gains listed above. Anyway, my choice has been to bite the bullet and try to build such a turbine, initially with three or four pressure stages.

2 Tesla disc or bladed turbine?

It seems to be accepted that, as the size of bladed turbines is decreased, losses become greater. This is understandable because, for example, as passage widths become narrow, frictional losses (as a percentage of energy in the steam) increase. Also, as blade length is decreased, leakage of steam past the ends of unshrouded blades becomes more significant since there is a practical limit to the extent that clearances can be reduced. In a Tesla rotor, friction is a necessary part of the energy transfer process, so reduction in size of passages in the rotor would aid that energy transfer. However, in Tesla turbines, frictional losses in small nozzles and in high speed bearings and gears will be the same as for other types of turbine. Tesla turbines are easier to construct and it may be possible to devise a design for a small turbine that has good efficiency. But, as discussed in parts 15 and 16, currently it seems that, without skills and facilities to perform advanced computational fluid dynamic analyses, it is impossible to rationally predict the best design for a Tesla turbine for any chosen steam conditions and flow rate. Thus, any attempt to build such a turbine would seem to be very much a shot in the dark. A recent paper reported a theoretical analysis which indicated that, as turbine size is reduced, Tesla turbines do become more efficient than bladed turbines. However, in this analysis that only occurred when the rotor diameter was reduced to below 4mm.

Another consideration is that if multiple pressure stages are to be used, then the design of a Tesla turbine would become very cumbersome. Therefore, I have opted for a bladed design. Also, a bladed design appeals to me because the model is more likely to show at least some resemblance to the construction and outward appearance of full-sized turbines such as were used to power ships.

3 Impulse or reaction?

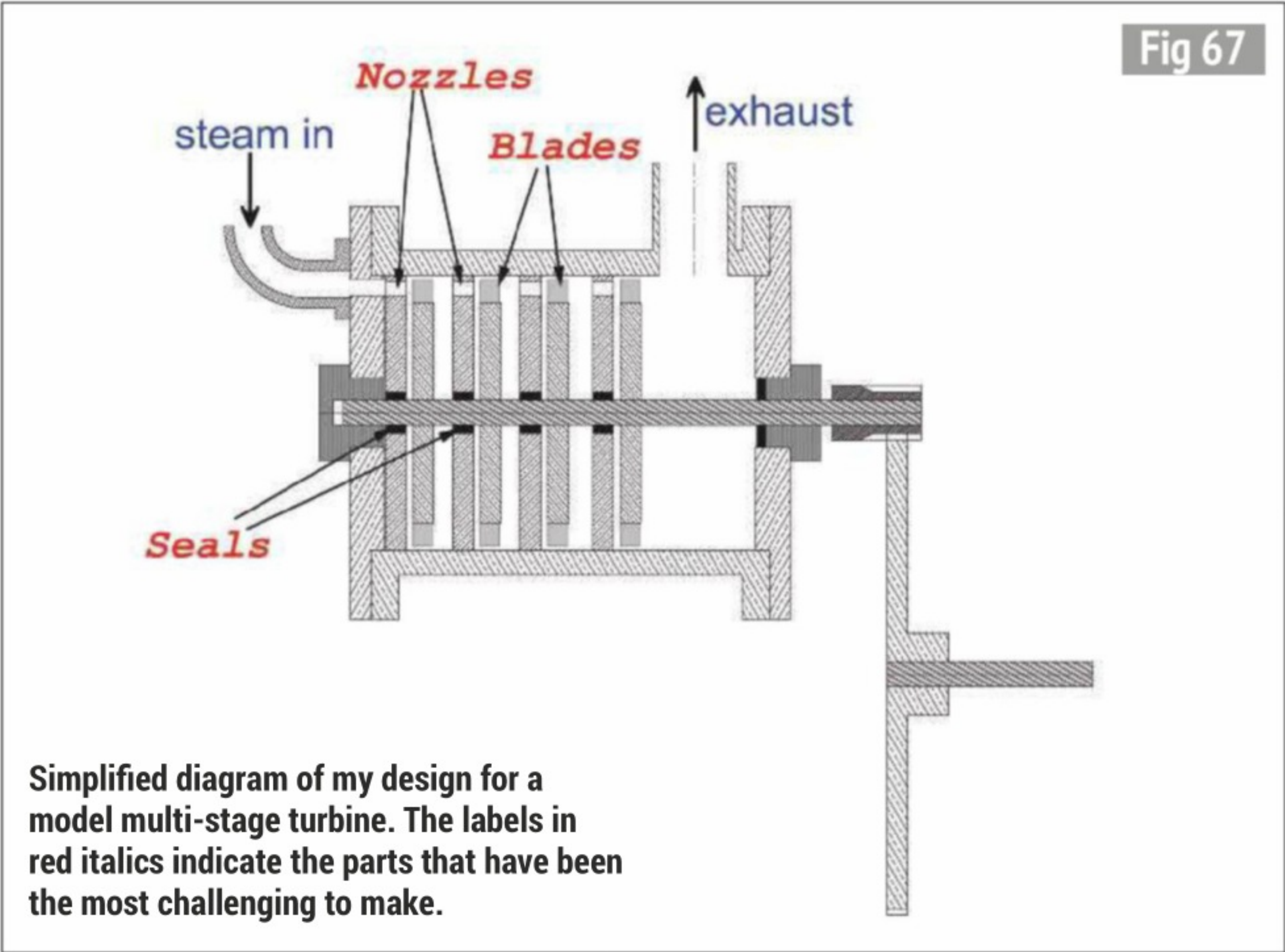
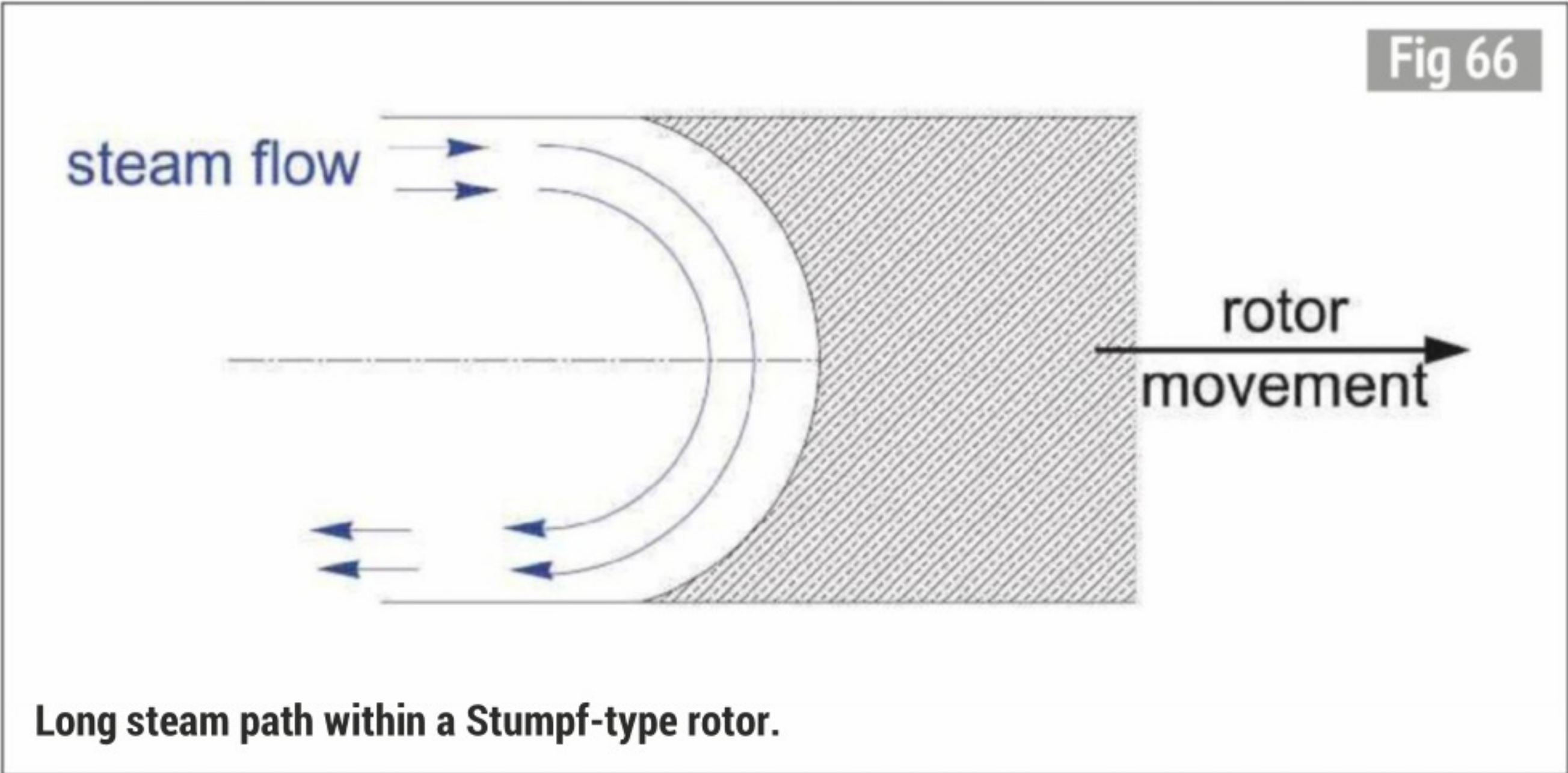
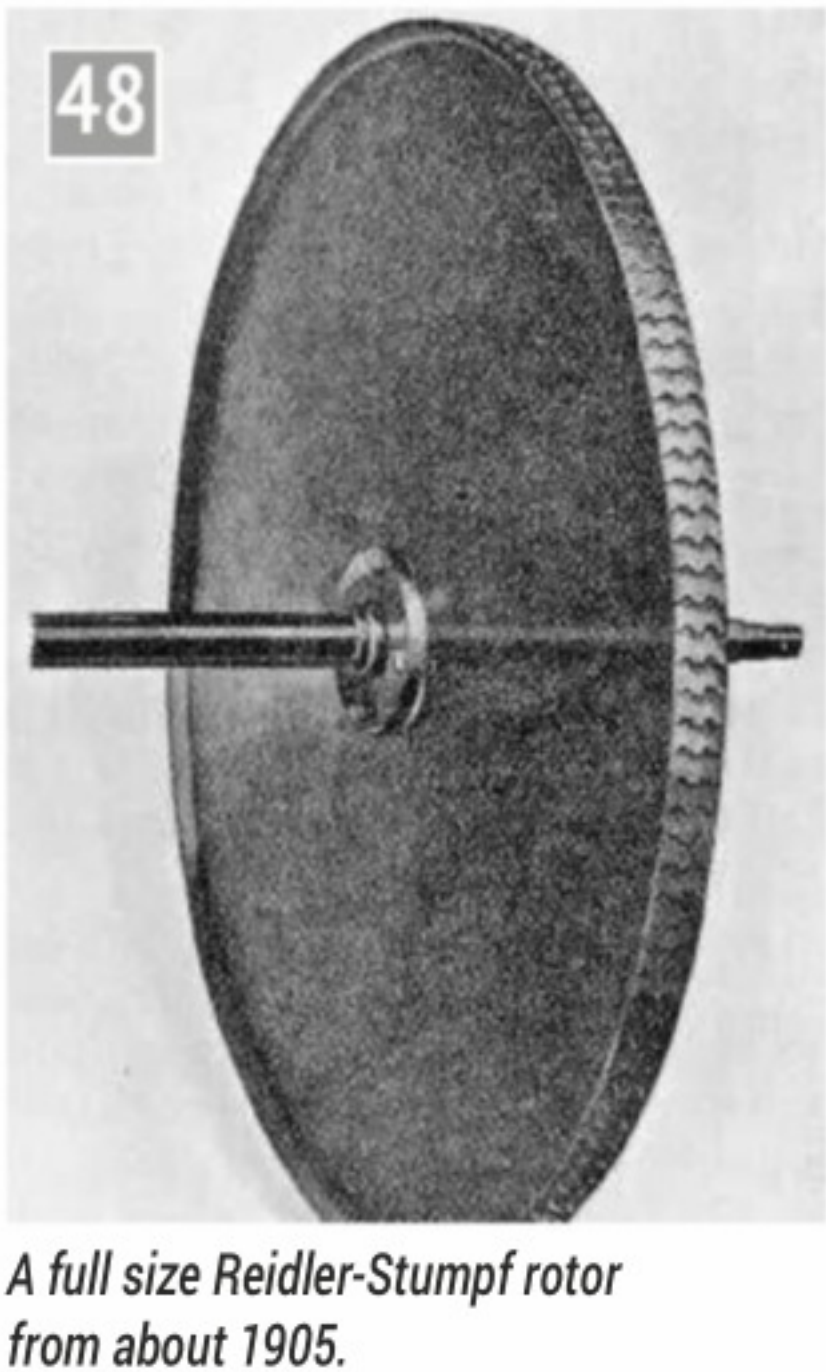
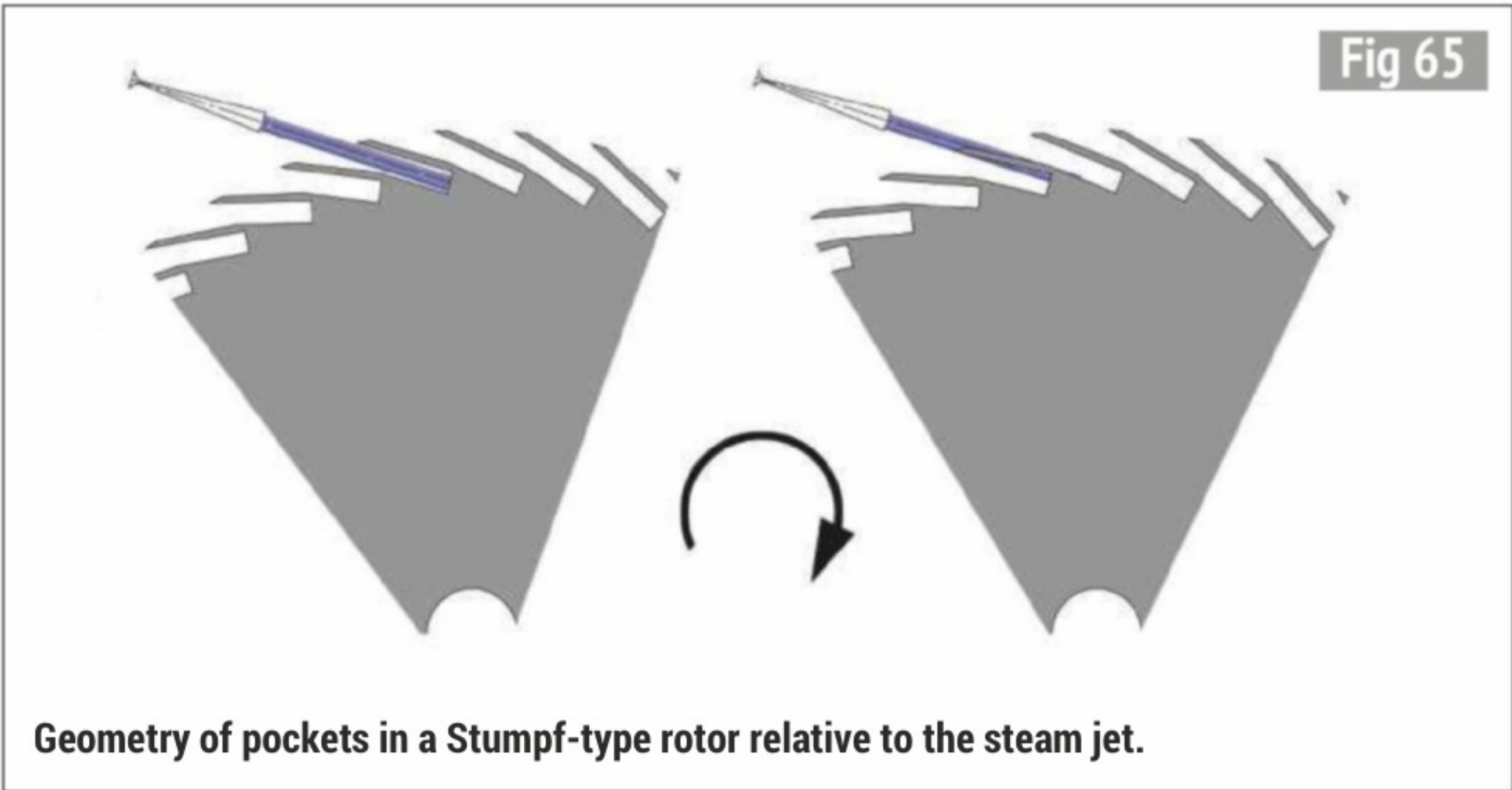
In all reaction turbines, a pressure drop is necessary across each set of rotor blades (see part 8). On a small scale it is extremely difficult to prevent significant leakage of steam past the blade tips, especially when the blade height is small compared to the rotor diameter, because the clearance would have to be vanishingly small. Also, as discussed in part 17, in a model steam turbine it seems necessary for steam admission to be restricted to a small fraction of the rotor circumference. As discussed in part 9, this is not consistent with a reaction-type design. Therefore, I have opted for an impulse turbine.

4 Axial or radial flow?

Single stage radial flow turbines are used in some gas turbine engines and in many superchargers but, for a number of reasons, this design is not very suitable for steam turbines. Apart from the Electra turbine mentioned in part 10, radial flow steam turbines, whether large or micro in scale, have been of the multi-stage reaction type, consisting of opposed discs carrying concentric rings of blades with steam flowing outwards. Although exhibiting the same problems for a model as other reaction turbines this design seems to have the advantage of being very compact, thereby avoiding problems associated with balancing a long rotor.

5 Bladed or Stumpf-type rotor?

In a Stumpf-type rotor the steam jet is directed onto the edge of the rotor where it enters buckets tangentially. This design has been used in quite a large number of models and Mr. Westbury gave detailed instructions for building a simple turbine of this type (ref 50). These rotors are robust and relatively easy to make using common workshop equipment but there are a few weaknesses in the design. When steam enters tangentially there is only a very



narrow range of rotation over which the steam jet is properly aligned with the bucket. Outside that range, the steam jet becomes obstructed as the bucket effectively disappears 'over the horizon' (**fig 65**). In original full-sized Reidler-Stumpf turbines (**photo 48**), the rotor had a large diameter and carried a very large number of relatively small buckets, resulting in much better overall geometry of steam jet relative to buckets. Another weakness relates to frictional loss as the steam flows through the rotor. Blades of conventional turbines are quite narrow so as to minimise the distance over which frictional loss in the steam occurs. However, in a Stumpf-type bucket, the periphery of the recess is much longer (**fig 66**) and also friction occurs with its upper and lower surfaces. Lastly, the Stumpf design is not well suited to pressure compounding. Thus, I have opted for a bladed rotor. However, where high efficiency is less important than robustness and ease of construction, then this type of turbine seems a good choice, such as in small turbogenerators on larger locomotives as in **refs 52 and 53**.

6 Velocity compounding?
In full-sized turbines, velocity compounding was once widely used (see article 10). This provided a means to

optimize the ratio between steam and blade velocities whilst avoiding the need for a large number of pressure stages. However, velocity compounding was associated with sub-optimal efficiency of each stage because high, often supersonic, initial steam velocities were used and the high velocity steam had to negotiate several sets of blades with their attendant losses. In many cases the advantages to be gained from employing one or two velocity-compounded stages outweighed the loss of efficiency but these advantages were from problems with use of very high temperature and high pressure steam and the need to reduce the length of the turbines. In miniature turbines such advantages are not present and losses associated with friction are likely to be even more significant than in large turbines. In a description of an experimental velocity compounded model turbine (**ref 54**), Mr. Jan Hook presented results showing that this was more efficient than a simple impulse turbine. However, he concluded that this difference was largely due to an artefact related to the pattern of steam flow within the turbines. For better or worse, I decided against the use of velocity compounding.

My choice of design

Overall, my personal preference is to attempt to build a multi-stage pressure compounded impulse turbine. This type is generally known as a Rateau turbine (see part 9). **Figure 67** is a simplified diagram to show the main features of the model that, so far, is partly built (**photo 49**), with a rotor diameter of 1.25 in.

The design is for inlet steam to be at 60 psig and at least 100°F superheat. With these inlet conditions, the steam should remain dry after expansion in the first two stages and the maximum velocity that could be attained by the steam in each stage is less than Mach 1, thereby



Partly constructed multi-stage turbine.

simplifying nozzle design and hopefully maximising nozzle efficiency.

However, this design does entail a number of challenges, the main ones being:

- 1 Making properly shaped nozzles in the diaphragms between each rotor disc.
- 2 Making numerous small carefully shaped blades in the periphery of each rotor disc.
- 3 Designing nozzles with sizes that give the required steam flow through each diaphragm, allowing for the expansion of steam that occurs in each pressure stage.
- 4 Making high speed low friction rotating seals for the points where the shaft passes through each diaphragm.
- 5 Balancing a relatively long high speed rotor.

● To be continued.

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50. Westbury, E. T. (1954), 'A Simple geared Impulse Turbine, Part 1', *Model Engineer* 111 (2778): 228 – 230.
51. Hall, W. B. (2002), 'The Effect of Superheat on Cylinder Condensation', *Model Engineer* 187 (4161): 592 – 594.
52. McMahon, R. (2008), 'A Miniature Steam Turbine Turbo Generator, Parts 1 and 2', *Model Engineer* 201 (4332): 211-213; (4334): 329 – 331.
53. Rowbottom, E. (1954a), 'Miniature Steam Turbo-Generators, Parts 1 and 2', *Model Engineer* 111(2790): 576 – 578; 111(2791): 602 - 604.
54. Hook, J. (1988), 'Is Compounding Worth the Trouble? Part 2', *Model Engineer* 160 (3818): 164 - 165.

NEXT TIME

The next article will start describing how to design model turbines of multi-stage bladed and single stage bladed and Stumpf-type designs. Subsequent articles will discuss past and present possibilities for making the various specialised components.

Geoff Theasby reports on the latest news from the Clubs.



Thomas Pawley raises the tone, with Sir Walter Scott (a bit o' Cultcha!) in writing to me: 'Is there a man with soul so dead, that he has not to himself said, *'This is my own, my Henley Solon'*? Indeed, barely a day passes that I do not ask myself this very question... Solon was one of the Seven (S)ages, of which I might be the 'lean and slippered pantaloons', or even in my 'second childishness...' Gosh! The Bard, yet. (Resists the temptation to quote from that interminable literary canon, *The Rime of the Ancient Mariner*.)

I am currently having a day off, feeling unaccountably weary and taken to my chaise, consumed several violet creams and a cheeky Eccles cake, even extending to some dark chocolate digestives.

More time spent working on my 'Bolide', named after the New York car company of 1969, although I don't think Jerry Lee Lewis would have had such a hit in 1957 had he sung, *'Goodness Gracious, Great Bolides...!!!'* (see - <https://www.undiscoveredclassics.com/forgotten-fiberglass/the-1970-can-am-1-by-bolide-motors-%E2%80%93-an-extension-of-borg-warner-and-the-crv/>) To me, it looks like a cross between a Lister Jaguar and a DeLorean. Anyway, the seat (from IKEA via Sheffield Freegle) is now fitted and I will have to reposition the motor below, rather than behind, it. Time for some slogans... 'Running in, Please pass' perhaps, or, from Deborah, 'Don't collide with my Bolide'.

In this issue: Arson, making points, an old boiler reused, a company song, classic cars, celebrations and a 'Hexagon'.

I discovered the May *Frimley Flyer* hiding in a pile of radio magazines so, tearing myself away from the siren calls and blandishments of the Wild Waves, I can report on the activities at **Frimley & Ascot Locomotive Club**. The new club locomotive is *Baldrick* and in the light of trial runs, the exhaust is to be redirected, as

it currently blows dust all over the drive system. Brian Garland describes his turnover jig, which greatly helps his ageing back. This design uses two scissor jacks, relying on the pivot at the top, which allows lifting even when not 'square' to the load. It supports Brian's 7¼ inch gauge B1 with ease. A sad ending to one little boy's day occurred when his offer to swap his plastic 'Thomas' for Don Faulkner's blue 'Rob Roy' was declined...

W. www.flmr.org

Reading Society of Model Engineers sends the August *Prospectus*, beginning with an arresting picture of a round-topped firebox which has been transformed into an outside loo (**photo 1**) seen at Bodmin Central by John Billard. In response to '61249's musings on HSTs, '3450' offers his thoughts on the technical aspects of these trains' power cars, including a cut-away drawing. A 17 tonne axle loading and 4000 HP was the specification, met by having two power cars each with a 1100 HP small Paxman engine, but turbocharged to double the power output. This weighed less than half the normal diesel locomotive equipment. Brakes were disc-type rather than cast iron blocks on the train, blocks being retained for the power cars. Also, the method of applying the brakes was improved so that there was no 'lag' in applying them, as the brake pipe pressure



Firebox loo at Bodmin & Wenford Rly. (Photo courtesy of John Beddows.)

equalised all along the train. A visit to the private 7¼ inch gauge Spinney Railway is planned for September.

W. www.prospectparkrailway.co.uk

On Track, August, from **Richmond Hill Live Steamers**, had a successful Doors Open event, with more than 800 visitors, with 97 trains departing from the ground level station. There has been activity at the Kentucky Steam Heritage Corporation, as C&O 2-8-4, 2716 was towed from Kentucky Railway Museum to KSHC. See www.kentuckysteam.org W. www.richmond-hill-live-steamers.tripod.com.

Graham Astbury adds more to the panoply/growing range of info/ on the **Henley Solon Owners Club**, suggesting several group names, like a Melt/Fusion/Alloy/Eutectic/Power or Therm of enthusiasts. He goes on: 'For the Club itself, rather than an Association, a Chapter, Club, etc, I think that it would be a local "Joint", which could be in the local pub (a good joint) or at the local M.E. Club (a dry joint). Maybe in your case, it should be a "Shack".'

Ho-Ho! I do like that and also the term 'Fusion' as a collective noun. 'Do not hold hot end.'

Blast Pipe, August, from **Hutt Valley and Maidstone Model Engineering Societies**, relates that the *Speedy* boiler, taken out of service with leaks having been discovered, has been pronounced very poorly constructed and not worth repairing. David Grant-Taylor goes into radial axleboxes and pony trucks. Here is NZR Class 36 on the turntable at a private railway in Queensland (**photo 2**) and three models of NZR A8 locomotives in 2½, 3½ and 5 inch gauges at the Blenheim models day (**photo 3**).

W. www.hvmes.com

Steam Whistle, July, from **Sheffield & District Society of Model & Experimental Engineers**, now counts TWO Thomas II locomotives, *Centurion* and *Ross*. (I don't think builder, Mick Savage



NZR Class 36 on turntable at a Queensland private railway.
(Photo courtesy of Rick Satherley.)

will swap his either – Geoff.) Included is a supplement covering the Sweet Pea Rally held here in June. A noticeable visitor was Paul Godin from Potters Bar and his GWR-style 5 inch gauge Metre Maid, *Housty*, spotted both by John Arrowsmith and me as worthy of note.

W. www.sheffieldmodelengineers.com

Ashpan, Spring, from **Ickenham & District Society of Model Engineers**, has Graeme Vickery recreating Marlow goods shed and station, all scratch built and taking 16 months. 35 years ago, the clubhouse was severely damaged by a fire started deliberately. Police attendance increased and one picture shows PC Fuller interviewing a suspicious-looking character who turned out to be the chairman. Interestingly, PC Fuller went on to become the chairman himself...

W. www.idsme.co.uk

Kingpin, Summer, from **Nottingham Society of Model & Experimental Engineers**, says that John Pownell has died. He was an active member and anonymous benefactor to the club. He ran a Tinkerbell and more recently a Hunslet quarry locomotive, plus he had one of a pair of IoW engines by David Aitken, which he said were 'too good to run'. He was interested in golf, sailing and football, owned a local golf course and kept a yacht on the South coast and also a vintage steamboat, *Bramble*. This vessel had a hull of teak, a Merryweather boiler and a Simpson Strickland Quad

engine. One year he took *Bramble* to Windermere, an overnight journey, but travelling by road strained the hull, which leaked ever after. John studiously avoided official status in the Society but always had its best interests at heart. Reinstalled Chairman, Nick Harrison says that the new website has been well received and the extension track is now complete but there is still lots to do. Parkgate remodelling, landscaping and signalling to name but three. A supporter bought a very highly detailed locomotive, 46222 *Queen Mary* from a dealer, but couldn't wait to try it out and stopped at NSMEE on his way home. See: YouTube, '46222 *Queen Mary* at Ruddington'.

W. www.nsmee.org.uk

Port Bay Express, August September, from **Portarlington Bayside Miniature Railway**, has two pages of good railway jokes, ending with a system for dealing with complaints. The next complainant is to take an interview number (attached to the pin of a Mills Bomb (hand grenade)). The passenger traffic continues to increase, up 84% for July, over July 2018 and 19% annually.

W. www.miniaturerailway.com.au

The Link, July-August, from **Ottawa Valley Live Steamers & Model Engineers**, mentions two lots for sale, an 'LBSC' 3½ inch gauge, 0-6-0, *P V Baker*, designed 1945, with two boilers (no certificates) and a 5 inch gauge OS 0-6-0 Super 6, from a kit. Also, castings for a 2 inch scale Clayton steam wagon. Editor, Graham Copley,



Three NZR A8 locos at Blenheim. (Photo courtesy of Robert Farquhar.)

writes on track activities, mainly involving the High Line and the manufacture of a set of pointwork. Designed by John Bryant using CAD, there are six straight and six curved pieces of rail, three frogs, three switch blades and 30 sleepers. The first machinist found the job too much for his facilities, but a backup has been found.

Bradford Model Engineering Society's Monthly Bulletin, August-September, says that Richard Randell has died. He worked at Horace Greens near Skipton in WWII, Company song – 'We make dynamos, excitors and alternators'. (Not, 'See you later, Alternator' then? - Geoff.) David Jackson, in *Road Vehicle News*, discovered a model he did not recognise on the G&C stand at Doncaster. It turned out to be a model of a Simplex armoured rail tractor 'Tin Turtle'. It had once run at BMES' Northcliff track, though David had missed it.

W. www.bradfordmes.co.uk

Following on from this, BMES also exhibited in *Modelmania* at Bradford Industrial Museum, so my glamorous assistant Deborah and I set off for the Metropolis at an unearthly hour on 10th August, a day in which Sheffield and Leeds were to meet at football. I shall draw a veil over our train journeys there *and* back. We arrived at Moorside Mills to find a Jowett Owners' Club meeting in progress, with some superb examples of Bradford's finest automotive products on show. Inside, we quickly found the BMES exhibits and met Ken Shipley, who was demonstrating the building of an O-gauge locomotive. In a range of other models was this chassis, which, due to the remaining front bodywork, I mistakenly thought was of a Jowett. Luckily, Martin Birch (of Snaefell tram fame) was on hand to fill me in, particularly in view of the four cylinder inline



Misleading for Geoff at BIM.



Model tappet loom, BIM.



Wharfedale printing press model, BIM.

engine, which was definitely *not* a Jowett ‘flat four’ (photo 4). This was probably an instructional model, not of any specific vehicle. I also liked the model tappet loom (photo 5), one of the museum’s exhibits and the model Wharfedale printing press (likewise, (photo 6), especially since the full-sized original was also in the museum. More exhibition pictures later. Returning to

central Bradford, we had an excellent lunch at The Avenue, in the Great Victoria Hotel just opposite the Interchange. **Ryedale Society of Model Engineers**, *Monthly Newssheet*, July, informs us that the site was very quiet when Editor, Bill Putman arrived on 4 July to find everyone lolling about, busy doing nothing... Inside the clubhouse it was rather livelier, something to

do with our colonial friends’ celebrations for ‘134 years ago’ (Eh? What happened in 1885? - Geoff.) W. www.rsme.org.uk The previous Sunday I was happily writing away and surfing social media when a posting caught my eye. ‘Classic cars on The Moor today!’ So, leaving Debs a message (she was out) I hot-footed it across town. Good

decision! I got some great photos. The 1920 Sheffield Simplex is one of only three left. It belonged to the 7th Earl Rockingham, his modest crest still on the doors. A 1957 Chevrolet Bel Air, with Dagmars and kidney cutters was displayed. I preferred the curvy 1947 Triumph Roadster. Also, there were a US Nash Rambler, a Reliant - I think; I failed to note the details save that it was rebuilt on a Reliant Kitten chassis with Yellow Top performance engine. Rolls Royce Silver Spur (long wheelbase Silver Spirit), 1932 Austin 7, Robin Hood Engineering, ‘Caterham 7’-type, kit car and many others. This car is a bit of a puzzle; an MG TC, I think, post WWII, by Naylor Garages of Shipley (photo 7). DVLA says it is a TA Motor Company Vanden Plas product but I can find no proof, photos or other connection with that company, now known as Findhorn Cars. The dashboard design, MG badge and overall appearance suggests a TC. I cannot verify the Vanden Plas connection on the rear. Again, more pictures later. And finally, a mathematicians’ joke: What is Satan’s address? Answer - Apt. 29A. (Think about it.)



MG ‘TC’ at the Moor, Sheffield.

Contact:
geofftheasby@gmail.com

SEPTEMBER

- 28 Romney Marsh MES.** Track meeting, noon onwards. Contact Adrian Parker: 01303 894187.
- 29 Newton Abbot & District MES.** Running day at Lindridge Hill. Contact Ted Head: 07941 504498.
- 29 North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.
- 29 Oxford (City of) SME.** Running Day, 1.30-5pm. Contact: secretary@cosme.org.uk
- 29 Portsmouth MES.** Public running, 2-5pm, Bransbury Park. Contact Roger Doyle: doyle.roger@sky.com

OCTOBER

- 1 Romney Marsh MES.** Track meeting, 11am onwards. Contact Adrian Parker: 01303 894187.
- 2 Bradford MES.** Talk: 'Electricity Before Electricity. Water Hydraulic Power in the 19th Century' – Ron Fitzgerald, 7:30-10pm, Saltaire Methodist Church. Contact: Russ Coppin, 07815 048999.
- 2 Brandon DSME.** Meeting at The Ram Hotel, Brandon, 7.45pm. Contact Mick Wickens: 01842 813707.
- 2 Bristol SMEE.** Talk: 'Modernising our Rolling Stock' – Gary Locock and Bert Roberts. Contact Dave Gray: 01275 857746.
- 3 Cardiff MES.** Talk: 'Steam Launches' – Richard Harvard. Contact Rob Matthews: 02920 255000.
- 3 Leeds SMEE.** Meeting night – 'Land Rover – the Troubled 1970's and

- Beyond' – Jonathan Stockwell. Contact Geoff Shackleton: 01977 798138.
- 3 South Lakeland MES.** Meeting in the pavilion, 7.30pm. Contact Adrian Dixon: 01229 869915.
- 4 North London SME.** Work in progress evening. Contact Ian Johnston: 0208 4490693.
- 4 Portsmouth MES.** Club night: 'Around the Cans' – RC model yachts, 7.30pm, Tesco Fratton Community Centre. Contact Roger Doyle: doyle.roger@sky.com
- 5 Tiverton & District MES.** Running day at Rackenford track. Contact Chris Catley: 01884 798370.
- 5/6 North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.
- 6 Cardiff MES.** Open Day. Contact Rob Matthews: 02920 255000.
- 6 Guildford MES.** SMSEG open meeting 2-5pm. Contact Mike Sleight: pr@gmes.org.uk
- 6 Oxford (City of) SME.** Running Day, 1.30-5pm. Contact: secretary@cosme.org.uk
- 6 Plymouth Miniature Steam.** Public running, Goodwin Park (PL6 6RE), 2 – 4pm. Contact Rob Hitchcock: 01822 852479.
- 6 Portsmouth MES.** Public running, 2-5pm, Bransbury Park. Contact Roger Doyle: doyle.roger@sky.com
- 6 Welling DMES.** Public running at Falconwood 2-5pm. Contact Martin Thompson: 01689 851413.

- 7 Newton Abbot & District MES.** Running day at Lindridge Hill. Contact Ted Head: 07941 504498.
- 8 Romney Marsh MES.** Track meeting, 11am onwards. Contact Adrian Parker: 01303 894187.
- 10 Cardiff MES.** Bring and buy. Contact Rob Matthews: 02920 255000.
- 11 Tiverton & District MES.** Club meeting at Old Heathcoat Community Centre, Tiverton, 7.30pm. Contact Chris Catley: 01884 798370.
- 13 Bedford MES.** Public running, from 10.30am at Summerfields Miniature Railways. Contact Brian Walton: 07498 869902.
- 13 North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.
- 13 Portsmouth MES.** Public running, 2-5pm, Bransbury Park. Contact Roger Doyle: doyle.roger@sky.com
- 14 Newton Abbot & District MES.** Running day at Lindridge Hill. Contact Ted Head: 07941 504498.
- 15 Romney Marsh MES.** Track meeting, 11am onwards. Contact Adrian Parker: 01303 894187.
- 16 Bristol SMEE.** Members' night – 'On the Table'. Contact Dave Gray: 01275 857746.
- 17 Leeds SMEE.** AGM. Contact Geoff Shackleton: 01977 798138.
- 18 Rochdale SMEE.** Talk: 'The Corris Railway' – John Schofield, at Castleton Community Centre, 7.30pm. Contact Rod Hartley 07801 705193.

- 20 Guildford MES.** Public open afternoon 2-5pm. Contact Mike Sleight: pr@gmes.org.uk
- 20 North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.
- 20 Oxford (City of) SME.** Running Day, 1.30-5pm. Contact: secretary@cosme.org.uk
- 20 Plymouth Miniature Steam.** Public running, Goodwin Park (PL6 6RE), 2 – 4pm. Contact Rob Hitchcock: 01822 852479.
- 20 Portsmouth MES.** Public running, 2-5pm, Bransbury Park. Contact Roger Doyle: doyle.roger@sky.com
- 20 Rugby MES.** Public running 2-5pm – visiting locos welcome with boiler certificate. More info. at rugbymes.co.uk.
- 20 Tiverton & District MES.** Running day and autumn BBQ at Rackenford track. Contact Chris Catley: 01884 798370.
- 20 Westland & Yeovil DMES.** Track running day 11am – 4.30pm. Contact Bob Perkins: 07984 931993.
- 21 Newton Abbot & District MES.** Running day at Lindridge Hill. Contact Ted Head: 07941 504498.
- 22 Romney Marsh MES.** Track meeting, 11am onwards. Contact Adrian Parker: 01303 894187.
- 23 Bedford MES.** Public running, from 10.30am at Summerfields Miniature Railways. Contact Brian Walton: 07498 869902.
- 24 Cardiff MES.** AGM. Contact Rob Matthews: 02920 255000.



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Right Hand Point	SLE695	£45.00
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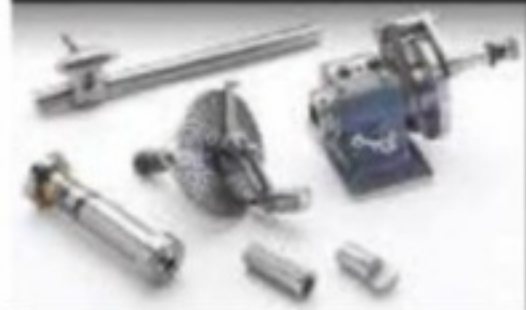
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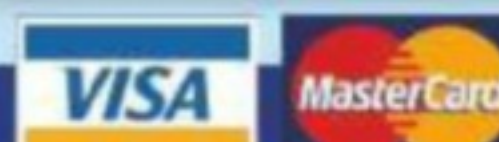
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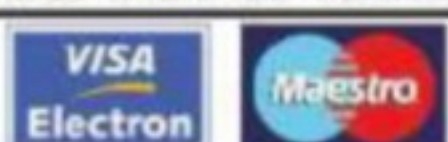
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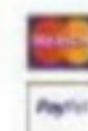
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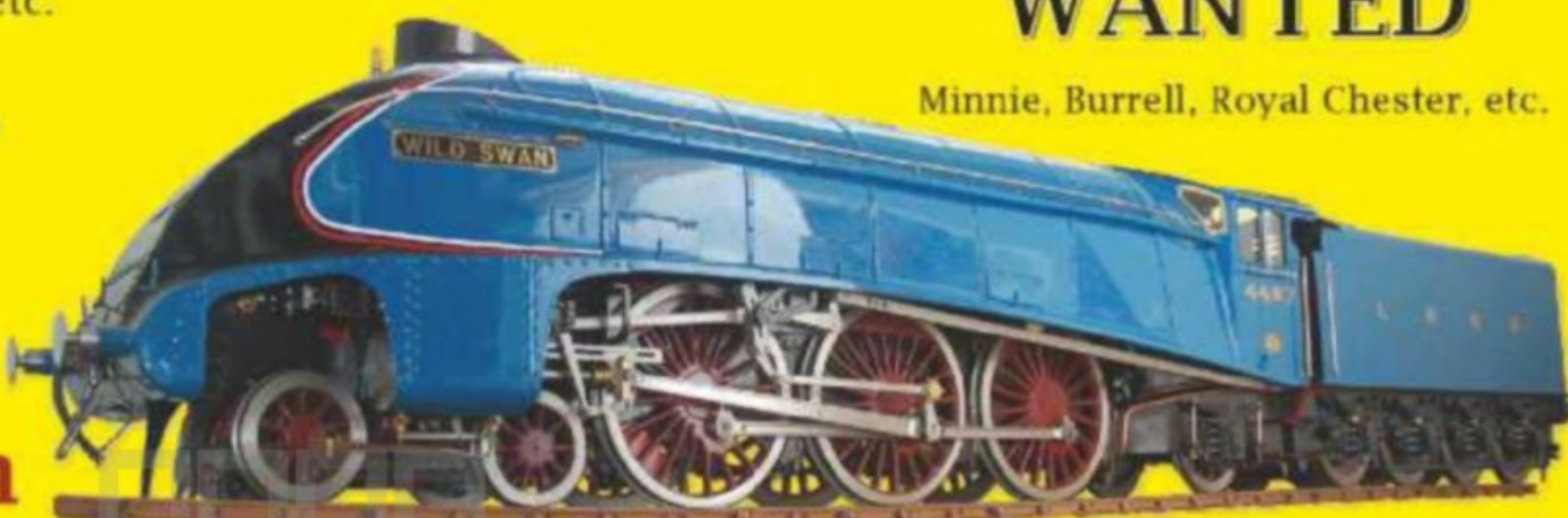
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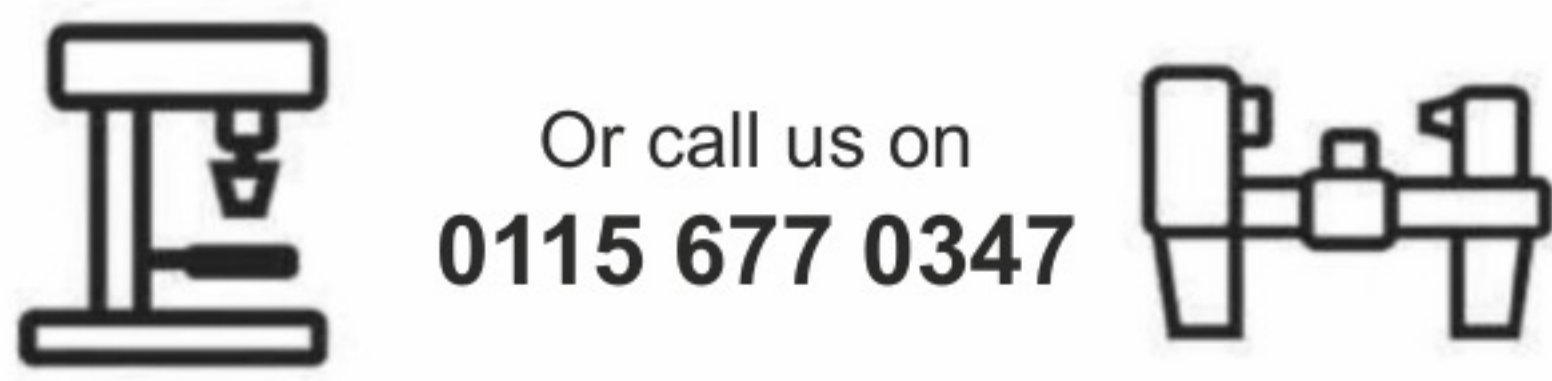
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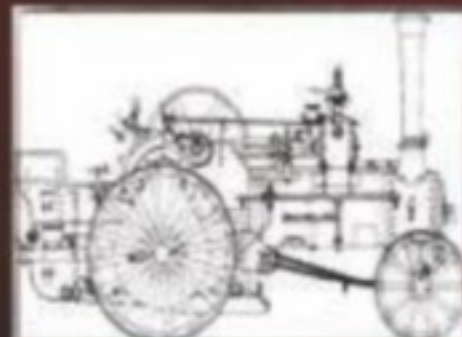
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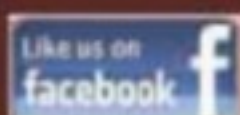
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King John

5" Gauge live steam four cylinder tender locomotive. It has been on display for nearly 20 years. Requires re commissioning. Boiler history nice detail and finish with display track.

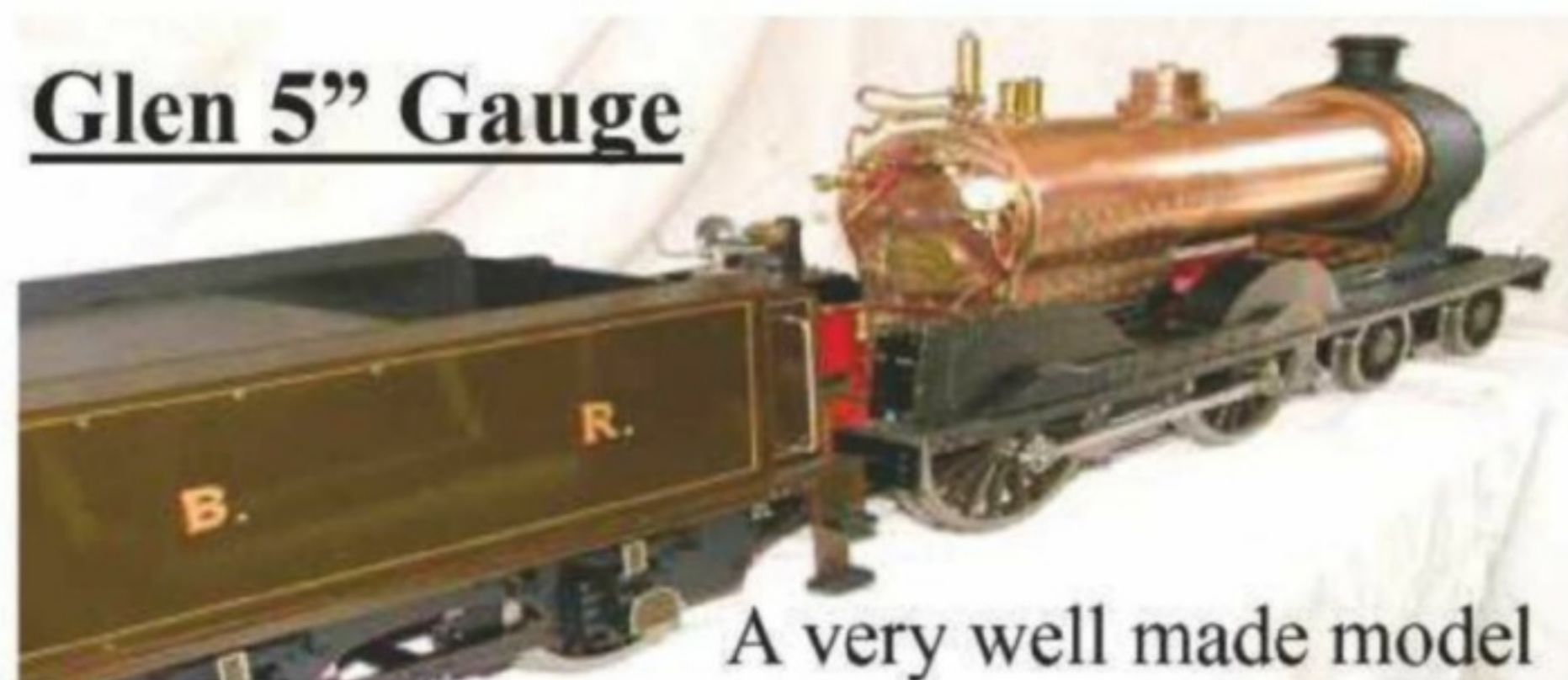


GWR 1400 5" Gauge



14xx this locomotive has been on display since it was built. Never steamed, nicely presented on display track. Good paint and plate work. Copper boiler, requires commissioning.

Glen 5" Gauge



A very well made model

almost finished, inc cab cladding, small parts and drawings (Don Young) included.

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