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IN THIS ISSUE

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ON THE COVER...

Chris Gunn's 6 inch scale Garrett 4CD tractor – the account of its construction concludes in this issue (photograph – Chris Gunn).

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SMOKE RINGS

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Editor

DIANE CARNEY
Assistant Editor

YVETTE GREEN
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Model Engineers Laser

Malcolm High started his Model Engineers Laser business 15 years ago and, he tells me, he has since then sent out over 425,000 laser cut parts from a database of 22,500 designs to model engineers all over the world, as far away as Tasmania. He says his global reach could only have been further if Mr A. Penguin had decided to build a 'Simplex'. Of course, we all know that would be absurd – 'Simplex' castings are not available in Antarctica.

Malcolm has now decided to retire and focus on his many other interests, which include a 7¼ inch gauge 'Holmside' locomotive. The business, however, will continue, in the capable hands of Ed Parrott and his wife Holly. This will come as very good news for Malcolm's many customers and for the model engineering hobby in general. Ed Parrott writes: *'We plan to continue things as they are including offering all the same parts that are currently available, and the bespoke service offer. The only changes that we hope you will notice is that of a new logo, new (ish) faces, and the new bank account and VAT number. This said, we do have lots of exciting new products planned to complement the current range available. The first of which will be a kit for a 16mm Narrow Gauge Diesel, variable gauge to suit both 32mm and 45mm modellers. The prototype is at an advanced stage and we hope to launch the finished kit at the 16mm AGM in June, Covid-19 permitting. Other plans to tease you include a 10mm scale kit to suit Gauge 1 modellers, possibly to be matched with a 1/32 version and a number of sundry items to suit other scales.*

'To keep up to date with our new products, which shows we are going to, and general other news, you can follow the Facebook page that has been created - just search for 'Model Engineers Laser'.'

For me personally, it is a great relief to know that Model Engineers Laser will continue in business. Over the last several years I have made very good use of many parts produced by Malcolm, some from his 'standard' list but also many to my own drawings. The range of parts available is extremely extensive, covering a very wide range of gauges and scales, and if the part you want is not available it is very easy to draw up what you need and then send it to be cut. Some may say that using laser cut parts is somehow not 'authentic'. If that is so, then neither is hacksawing and filing locomotive frames (which were generally flame cut), machining coupling rods (which should be forged) or silver soldering boilers (which should be rivetted or welded). Model engineering (like 'real' engineering) must surely move with the times and in the 21st century a vital part of every model engineer's tool kit should be a draughting application. These are easy to use and many are available, in many cases at no cost. An additional incentive, beyond the saving of time, is that laser cut parts are generally not a great deal more expensive than the raw materials but the saving in time and effort is significant. That means you can build more locomotives or traction engines or whatever!

So – thank you, Malcolm, for all you have done for the hobby over the last 15 years and congratulations and good luck to Ed as he begins his new venture.

Stirling Engine

Roger Backhouse's article about LBSC and toy trains (M.E.4654, 18th December 2020) reminded reader Patrick Cubbon of a 'Caloric' gauge 1 locomotive he spotted on the Stamford Society's stand at the 2015 Spalding Model Engineering Exhibition. It is powered by a pencil gas torch and driven by a Stirling engine. To call it a 'Stirling engine', though, might cause confusion so perhaps it should be a 'Stirling Engine engine'.

The confusion between a Stirling Engine and a 'Stirling Engine engine' is rather more than coincidence as the two Stirlings involved were, of course, father and son. The Reverend Dr. Robert Stirling was a Presbyterian clergyman who was also interested, as many clergymen are, in things scientific and technical. He is well known as the inventor of the Stirling Engine. He had seven children, four of whom became locomotive or railway engineers. One of those was Patrick Stirling, designer of the beautiful and graceful Stirling Single locomotive.

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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PART 78

Garrett 4CD Tractor in 6 inch scale

Chris Gunn clears a few remaining issues with his engine and takes it for a second test run.

Continued from p.49
M.E. 4654, 18 December 2020

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.

I put everything back together in time for a test run at the next rally. In due course I steamed up and had the engine ticking over nicely. I got myself ready for a run around, had a good fire and it was full of water. I eased away from my spot and moved away but I had gone no further than 10 metres when the engine would not run and the timing seemed out; I could not do anything with it! I couldn't move it either, as the ground was damp and it had sunk in a bit. Then the disadvantage of a heavy engine comes home to roost. However, it did not take long for my fellow 'rallyers' to rally round and push the engine back to base where we could hold an inquest. We all felt the timing was out but with a blazing fire and a hot engine I could not do much with it for a few hours.

In the evening I had a chance to have a look. I stripped off the high pressure valve chest as we all thought the valve must have moved. It was clear that the valve had not moved, but after turning it over a few times, the penny eventually dropped. When I had put the engine back together, I had connected the high pressure valve rods the wrong way round. The top one was on the bottom and the bottom one on the top. It is easy to do this on the HP side as the rods are straight and will pass each other. On the LP side the rods are off-set and cannot be replaced the wrong way round. When the engine was ticking over I guess the low pressure cylinder was doing enough to turn the engine over. As soon as the HP cylinder was given some steam, the cylinders were fighting each other and I could go nowhere. I made the change, re-fitted the valve chest cover and went off in search of a much deserved beer or two.

Needless to say, in the morning I steamed up again and the engine was much quieter and seemed to run better. When I got back from that rally, I stamped the eccentric rods with a 'T' and a 'B' in the hope this would prevent a recurrence.

Now the engine was running quieter I could hear some more knocking and once again colleagues were quick to rally round and isolate the noise to the little ends. Once I was back home, I took one apart. The LP seemed to be the noisiest and I found there was slop between the crosshead and pin. I have to hold up my hand for this one, as I elected to ignore the drawing which shows a little end pin with a tapered head seated in a corresponding hole in the crosshead. I made a plain pin sitting in a plain hole and this was worn much more than I would have expected. Both pin and the crosshead were worn! The pin was fitted

Drawings, castings and machining services are available from A. N. Engineering: Email: **a.nutting@hotmail.co.uk** with a grease nipple and is greased at every steam up.

All I could do was remake the pin and reseat the crosshead for the pin. I was lucky in that I found a slot drill that had been modified to cut a taper for some special project or other, so I was able to open out the crosshead hole in one side and put a tapered hole in the other. I could then make a new pin. The taper was not the same as shown on the drawing, but it would do the job. I re-worked the crosshead and made the pin, which seemed a good fit, and put it back together for a test run under steam. The improvement was dramatic and showed up the noisy HP little end pin. When the engine had cooled down I re-made that as well and now the engine is pretty quiet although still has a slight knock - which I have narrowed down to the LP big end, which seems to be slapping from side to side a little. At this point I do not have a solution for this other than make the big end brasses a few thou wider.

Another problem I had was with the commercially bought blowdown valves. I found that these had a plastic plug on the end of the screw and when these were tightened, the plug extruded itself into the body of the blowdown valve and got stuck. When the boiler is blown down, the pressure blows the plug out of the hole to let the steam out.

I am in the habit of filling the boiler up to the brim between rallies and then draining the excess water out when I am ready to steam up. Under these circumstances there is no pressure in the boiler; the plug stays in the body and the water will not drain out. Removing the screw completely did not solve the problem, as the plug of plastic stayed in the valve. I managed to get the plug out with some probing and switched it for a stainless steel ball. I shortened the screw a little and the job was done.

I had to make a slightly longer bush to space the flywheel out from the guard as it was rubbing and I had to free off the brake shoes which rusted in place for some reason - maybe because I did not put an oil hole in the lever end. One problem I have making engines is that I was taught to make things to close tolerances so I tend to do that still. I will make a lever with a reamed hole and then put a pin in it with maybe a thou clearance, which is too fine for many applications. As soon as a drop of water gets near a joint like that it does not take much to rust it solid. I remade the pins and added an oil hole as well and that solved that problem.

I can also report that the polycarbonate water gauge protector glasses have started to craze now I am in the middle of the 2018 rally season. They will have lasted three years and will need replacing at the end of 2018. I could order toughened glass replacements, but have plenty of free polycarbonate to make some fresh ones.

I also had a couple of belts for the governor made by my local power transmission suppliers and that added a little more detail. Anyone who visited the Model Engineer exhibition at Brooklands in 2016 would have seen the engine with everything on it. **Photograph 668** shows the engine in all its glory before it was loaded for the exhibition.

I hope that this final instalment has been of interest, covering some of the trials and tribulations of putting the results of one's labours to work. I always thought I got my pleasure and satisfaction from *making* my miniatures, but I now get as much pleasure from taking them out, putting them through their paces and talking about them with the folks that attend the rallies. In addition, there is the social side of rallying and the companionship that goes with it.

As I edit this it has been three years since the 4CD has been completed and de-bugged, and in the meantime I have been catching up with some other small projects.

I am about ready to start on something else and I am looking at a 4 inch scale engine and a compound to boot! I am conscious that the 6 inch is going to get more difficult to handle as I get older and, if I start now, I could have something smaller ready when the 4CD is too heavy for me.

Before closing, I must thank my daughter-in-law, Keren, who has proof read all the text for me; she tells me she has learned a lot about devices to turn water on and off than she thought possible. She has plenty of spare commas left over if anyone needs them.

ME

In all its glory.

An Engineer's Day Out

Keeping Dutch Feet Dry

Roger Backhouse marvels at Holland's amazing land reclamation engineering.

When visiting the Netherlands, many engineers make a point of visiting the amazing Cruquius engine near Haarlem (**photo 1**). An article about this complex engine's operation appeared in *M.E.* 4646. The associated museum in the former boiler house displays the history of Dutch land reclamation, from simple windmills to sophisticated computer controlled electric pumps. Since visiting in 2019 the display has undergone a major revamp with many models replaced by interactive displays, although the machines described here remain.

General view of the Cruquius engine.

A model of the Netherlands, coloured to show the areas below sea level that could be flooded and then drained has now gone as it was life expired (**photo 2**). Nothing illustrated better how engineering - with major dykes, canals, drainage works and pumps - protects land from flooding. Some 65% of the Netherlands is below sea level and relies on pumped drainage. Nearby, Schiphol airport is 15 feet (4.5m) *below* sea level and was once part of the Haarlemmermeer, a large inland lake.

Whilst it is partly true that Holland was reclaimed from the sea, much land was reclaimed from marshes around the Rhine, Schelde and Maas estuaries. A dune barrier is still part of the defences against the North Sea. In the 13th Century a series of storms breached this barrier, drowning thousands and forming the Zuider Zee, bringing the sea far inland.

Model of the Netherlands showing land below sea level (in pale green). This model can be flooded and then drained. After decades of use it needed considerable maintenance and has been removed.

Wooden model of a post mill with scoop wheel. With their cloth sails, these dominated land drainage.

Early drainage

Monks attempted early drainage enclosing areas of land (a polder) with a dyke and sluice gate so that silt deposited inside. The first large scale work was in 1597 when the Netherlands were freed from Spanish rule. Again, land was enclosed with dykes but now windpumps lifted water into rivers or canals. This technique was shown by models in the museum (**photo 3**). Such technology ensured that wild marshes became productive farm land so that today the Dutch landscape is the most artificial in Europe.

Dutch engineers were celebrated so when English » landowners like the Duke of Bedford wanted to drain fenland they turned to men like Cornelius Vermuyden. He applied Dutch techniques to drain large areas of Eastern England, straightening and embanking rivers and creating washlands drained with windmills. First this became pasture but after drying out it became highly productive arable land. Wicken Fen (National Trust) in Cambridgeshire, England, shows how these lands once appeared and much of Holland was similar (**photo 4**).

Many Dutch merchants became rich from trade through the Dutch East India Company (VOC). These merchants often devoted surplus wealth to buying and draining land in Holland.

Windmill technology

Windmills pumped water into higher level canals or into rivers. As the lift of a scoop wheel was limited to about 4 feet 6 inches (1.5metres), sometimes several windmills were used in a chain, each lifting up to the next mill. The best-known survivor of this system is at Leidschendam.

Once a polder was drained, then more drainage ditches were dug across the polder and smaller portable windmills known as tjaskers were installed (**photo 5**). These small mills used Archimedean screws (**photo 6**). Other drainage mills employed are the smaller 'meadow mills', mostly used in North Holland to lift water from low lying parts to the general level of ditches in the polder.

At one time there were around 9000 windmills in Holland. Now about 1000 survive. Besides drainage there were corn mills, sawmills and even mills grinding paint pigments (**photo 7**). The Dutch claim to have invented the crank, used in sawmills. Although the Dutch pioneered windmills, nearly all retained cloth sails and required manpower to turn sails into the wind. This contrasts with Britain where fantails were often installed, turning mill sails to face the wind automatically. British millers

Partly drained fenland at Wicken Fen, Cambridgeshire, gives an idea of what the Dutch landscape was like before large scale drainage began.

Model of a small tjasker mill. These drained fields into higher level ditches using Archimedean screws.

Model of an Archimedean screw.

Classic Dutch windmill 'de Valk' in Leiden. Now open as a working museum, it once ground corn.

Early steam power used for drainage at Arkelse Dam. Built by John Cockerill of Belgium, it has Watt's parallel motion and Meyer slide valves. It once powered a scoop wheel of 7.5 metres diameter.

Model of a steam engine with scoop wheel, one of several fine models in the Cruquius Museum. This was built by Mr. A. M. W. Hoos in the 1880s.

also installed spring or patent sails to 'spill the wind' if it became too strong.

Windmill technology was proven and involved no energy costs. However, periods of high water didn't always coincide with the strongest winds so some drainage problems persisted.

Early steam pumping

One of the earlier steam engines for pumping was used at Arkelse Dam, powering a scoop wheel of 7.5 metres diameter via gearing. Built by John Cockerell of Belgium in 1826, it is fitted with Meyer slide valves and is the oldest surviving pump; it is now preserved in the museum (**photo 8**). Unfortunately, the scoop wheel was not saved. However, a Mr. A. M. W. Hoos made a fine model of a later horizontal steam engine with scoop wheel in the 1880s. There were other fine models made by apprentices at a Rotterdam Shipyard in the 1960s (**photo 9**).

Windmills continued in use and were cheap to run. At this time the Netherlands' coal deposits in Limburg had not been exploited so all coal had to be imported from England or Silesia.

Following the 1830 - 1831 Belgian-Dutch war in which the Netherlands lost territory, the new King Willem encouraged the draining of the large Haarlemmermeer between Haarlem, Amsterdam and Leiden, the largest drainage project ever attempted in Holland. His lead was followed by his son King Willem II (**photo 10**).

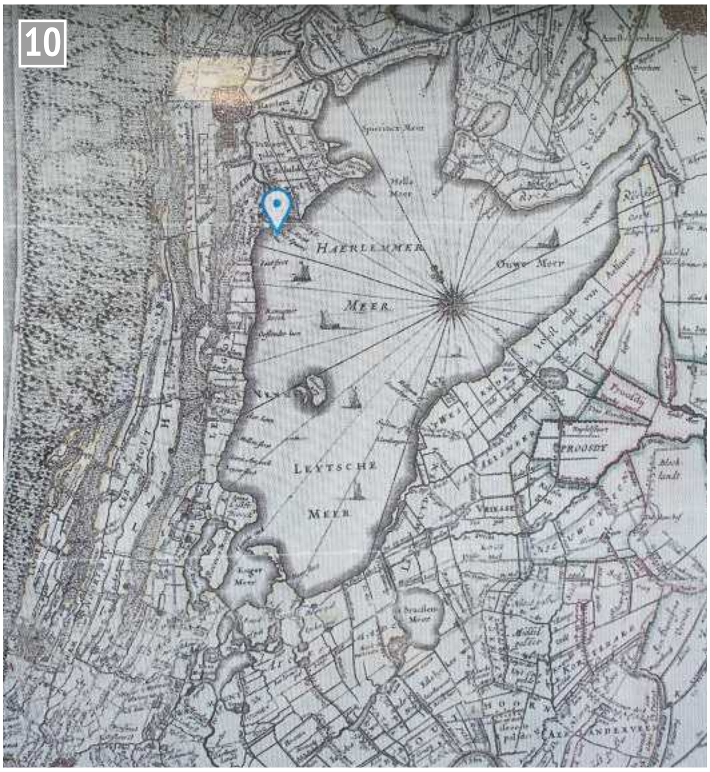
The Meer was formed from three natural lakes that expanded, through peat digging, to fuel Amsterdam and other nearby towns. The Norfolk Broads were similarly formed. Storms eroded banks and villages were swallowed up. It flooded often, threatening Amsterdam in storms that were known as the 'Water Wolf' so action was needed. Those wanting windmills with Archimedean screws and scoop wheels conflicted with those seeking steam power. Eighty windmills would be needed and drainage would take at least ten years.

King Willem II had studied at Oxford and was familiar with British steam power technology. With his encouragement the Drainage Commissioners decided to employ steam power exclusively and chose a radical engine design to drain the Meer.

The Meer was first surrounded by a ring dyke with a canal, known as the Ringvaart. Steam pumps drained the Meer into this ring canal, which fed to the sea at Katwijk. A museum model shows a classic polder arrangement with a ring dyke, but using a chain of scoop powered windmills (**photo 11**).

Three of these engines were built: Leeghwater, Lijnden and Cruquius. Only the last named survives and houses the present-day museum. All proved successful and the Meer was drained in three years.

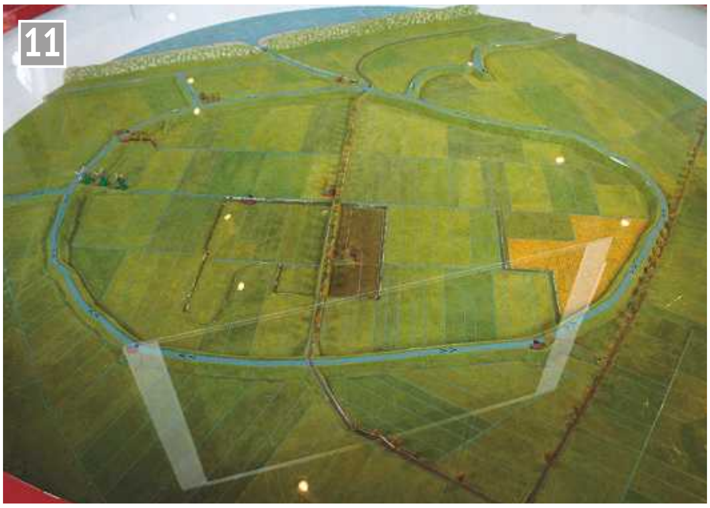
These were beam engines with vertical lift pumps. Built by Harveys of Hayle in Cornwall, the design was unlike anything else built by that company - or any other (**photo 12**)!



The Haarlemmermeer was formed from three natural lakes but spread through peat digging and erosion, eventually threatening Amsterdam. Many boats were wrecked in the north east corner, now the site of Schiphol airport. Marker shows Cruquius location.

Dyke construction and maintenance

The legend of the Dutch boy who stuck his finger in the dyke to stop a leak is of American



How a polder worked. The Harlemmermeer was drained like this, though on a larger scale. Pumped by a chain of windpumps (left) to a ring canal, water flows to the sea (top). Drainage ditches were then dug across the polder and farms built. (Unfortunately, it's not possible to avoid light reflection when photographing this informative model.)

Cruquius engine - an interior view showing the beams powered by an annular compound engine beneath the great cap. The annular compound has the high pressure cylinder within the low pressure.

Constructed by J. & H. Gwynne of Hammersmith around 1879, this engine and centrifugal pump was considered high speed when it was built. Adrian Strik stands alongside. He is a member of the 'Steam Team' and gave a fascinating tour of Cruquius.

Detail of the J. & H. Gwynne engine. It had adjustable Meyer slide valves and operated until 1959.

origin but ditch and dyke maintenance is a major task. Contrary to popular belief, dykes are rarely overtopped by water but are vulnerable to erosion from the sides. One surprising problem is burrowing by muskrats! They dig nests with underwater entrances in the banks. Finding and trapping muskrats is a vital job.

Holland's largest dike crosses the entrance to the former Zuider Zee, now the Ijsselmeer. This was built on a foundation of brushwood matting, loaded with boulder clay dredged from the sea and backed with dredged sand. Rock armour protects the dyke from the waves. Completed in 1932 it was intended to drain most of the Zuider Zee with polders but eventually only two were constructed (**ref 1**).

Another problem has been salt entering ground water. Preventing salt damage was one reason for building massive dykes and sluice gates in the Delta Project

SOME OTHER PLACES TO VISIT

(NB: The information given below applies to periods of normal operation. Please, always check before travelling.)

The Netherlands has many interesting historical engineering places away from Amsterdam. One advantage for the monoglot British visitor is that almost everyone speaks excellent English. Public transport by bus and train is usually very good (but note: buses take credit and pre-paid travel cards, *not cash*.)

D. F. Woudgemaal
Bezoekerscentrum Woudagemaal
Gemaalweg 1a, 8531 PS Lemmer.
Open February to December, Tuesday to Saturday, 10.00 - 17.00; Sundays and holidays, 13.00 - 17.00.
W. www.woudgemaal.nl

Keukenhof Gardens
These world-famous gardens display precision horticulture and are attractive for those who may not share engineering interests. In the heart of polder country the soil is suitable for growing bulbs (**photo 15**). This windmill must be the world's most photographed (**photo 16**)! A Dutch street organ usually plays for visitors (**photo 17**). Gardens can be busy, especially at Easter, but are quieter earlier in the week. Opening is usually from late March to early May.
W. www. keukenhof.nl/en/

Teylers Museum, Haarlem
A good museum of arts, natural history and science with early scientific instruments.
W. www.teylersmuseum.nl/haarlem/netherlands

Haarlem Railway Station
The first railway in the Netherlands ran from Haarlem to Amsterdam. The rebuilt station has a fine, overall roof with decorative tilework (**photo 18**).

Railway Museum, Utrecht
(see *Model Engineer* Vol. 202, No. 4342)
The evolution of Netherlands' Railways from using English steam locomotives to the present day. Well worth seeing.
W. www.spoorwegmusuem.nl

Open air museum Arnhem
(see *Model Engineer* Vol. 205, No. 4393)
Just outside Arnhem and ten minutes' walk from the Burgers Zoo trolleybus terminus. A fine collection of buildings, mills and artefacts from across Holland. Farm machinery and a tramway add engineering interest.
W. www.openairmuseum.nl/about-us/who-are-we/

Stoom Tram Hoorn - Medemblik
Preserved railway line with steam trains.
W. www.stoomtram.nl/en/

At Medemblik the Stoommachine Museum is housed in a former pumping station with a variety of steam engines often in steam.
W. www.steemmachinemuseum.nl

Leiden and the Boerhave Museum
Leiden is an attractive university town with excellent communications. Boerhaave Museum of Science and Medicine reminds us that Dutch and English scientists exchanged ideas as early as the 17th Century. The Leiden Jar, an early capacitor, was invented here. Two windmills include the corn mill de Valk, open to the public (**photo 17**).
W. www.rijksmuseumboerhaave.nl/engels/

Mr. and Mrs. Backhouse stayed at Leiden's d'Oude Morsche Boutique Hotel finding it central, clean, reasonably quiet and quirky! Eight minutes' walk from bus and railway stations.

Direct contact: d'Oude Morsch, Park de Put 1, 2312 BM Leiden, The Netherlands Tel +31(0)71 569 00 90.
Email addressinfo@hoteldeoudemorsch.nl

Typical polder landscape with drainage ditches seen from Keukenhof windmill. This lighter soil is now a major bulb growing area.

Keukenhof's windmill, perhaps the world's most photographed, was re-erected in the gardens. It turns but now has no useful function. Note the cloth sails and lack of a fantail.

Musical engineering - Dutch street organ at Keukenhof.

Haarlem station has a fine overall roof and decorative tiling; definitely one to see!

across western estuaries. This followed the disastrous floods of 1953, which also struck the East Coast of England. The 1954 Shell Film Unit's *View of Middelharnis* describes the works.

Pumping developments

Following the Cruquius engine, steam power was used for most land drainage. Pumping technology improved with the development of centrifugal pumps. The museum displays one made by J. & H. Gwynne of London around 1879. It operated until 1959 when it was replaced by a diesel pump. With sophisticated adjustable Meyer slide valves, it is directly coupled to the centrifugal pump via a common shaft and was considered a high speed engine (**photos 13** and **14**).

The biggest pumping station remains the D. F. Woudgemaal, opened in 1920 to drain Friesland, a UNESCO World Heritage site. This has four tandem compound reciprocating steam engines with poppet valves and uniflow exhaust driving eight centrifugal pumps. These are brought into service when the other main pumping station at Stavoren is used to capacity, usually on a few days each year.

Boilers were converted to oil firing in 1967. Pumping capacity is 4,000 cubic metres (880,000 UK gallons) per minute! Now almost all Netherlands pumps are diesel or electric powered.

ME

REFERENCE

1. *Triumphs of engineering*, Odhams Press, reprinted 1946. Unfortunately the book states that the Harlemmermeer was drained by windmills!

A New GWR Pannier PART 27

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

Continued from p.49
M.E.4654, 18 December 2020

We will now make a start on the steam brake valve which is an amazing piece of equipment (**photos 207** and **208**). I asked Harry Rawlins at the Dean Forest Railway if he had such a thing as a works drawing for such a thing and he said yes, so with that I had three copies of it in the post less than a week later. Now, I knew that this was a complicated piece of equipment but until I received Harry's drawing's I didn't realise quite how complicated it was. It was bad enough looking at it on the full-size drawings.

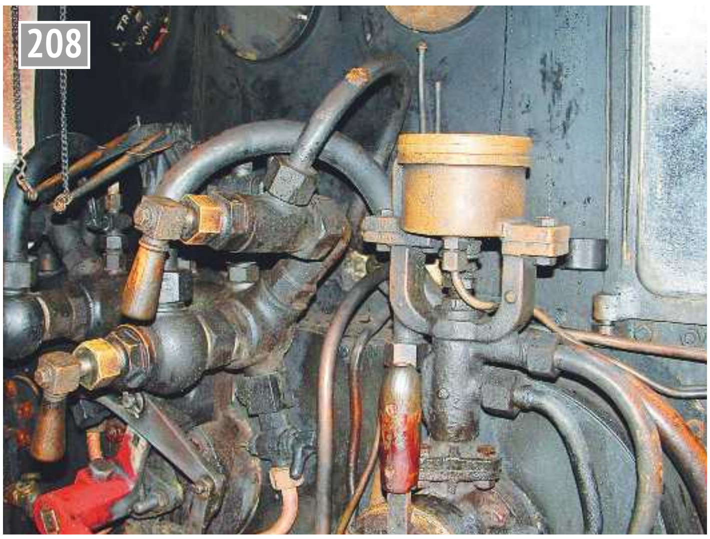
Anyway, as they say 'nothing ventured', so I set about making one to see if it would work but hardly before I had started I had this stroke which put the kibosh on my endeavours. I did however, get all the drawings done for it so I will just burden you with these to see how you can get on with it. I have to say here that Adam Cro makes the most exquisite set of castings for the valve (**photo 209**) but last I heard it is for the steam brake only although he is working on the vacuum side of it. I think that I have designed mine (**fig 49**) to do both the vacuum and steam brake except that I need someone to prove it so I will describe it as is and hope that this works. To make this valve you will need some 60 thread taps and dies.

A view of the brake valve.

To make a start on this valve you will need a chunk of brass ½ inch wide x 27/32 inch high x 19/32 inch deep. However, I used a piece of ⅝ inch round bar to start off with to make the upper part of the body. Mind you, I made a start on mine by drilling a hole in it with a 63/64 inch drill from the front 5/16 inch deep and tapped that ½ inch x 40 TPI. You then need to drill a little further (about 1/32 inch) with a 'D' bit so that you can drop a port face in there. You also need to mill out a couple of grooves with a ⅛ inch ball nosed slot drill just to the depth of the ball nose and about ⅛ inch long. Now when you come to do your silver soldering you can fit in a couple of pieces of ⅛ inch brass bar in there with the ends rounded off to make it look like a casting.

You need to drill some passageways in from the back of the valve. These are one at 3/16 inch and one at 7/32 inch above that, both ⅛ inch deep. From there you need to drill at an angle into the front hole which you drilled in the first place. It will also assist you if you drill from the front first and get the second drilling to meet up with it. From the hole at the bottom you need to drill it through with a No.54 drill straight through into the front cavity. You need this to get the steam to the front of the valve so that the steam is in the correct place to put pressure on the disc valve.

The third port needs drilling down directly from the top about 3/16 inch deep and No.54, then another one from the front of the cavity on a pitch circle of ¼ inch to meet it. On top of



Another view of the brake valve.

this you need to silver solder a triangular flange 3/64 inch thick, with a 1/32 inch spacer under it on there as shown on my drawing, with one long face to the left hand side. This needs spacing off the body by 1/32 inch. On the rear of the body you also need to fit a circular flange 3/64 inch thick to the rear of the body on the centre line of the hollow stay and not on the centre of the body.

There is one more passageway to drill and this one needs to come from the remaining hole on the port face 90 degrees to the left of centre on the face. This is for the steam brake drain when the brake is off. It also needs another hole drilling to meet up with that as I didn't want any chance of it clashing with the lower hole which is for the vacuum through the hollow stay. The upper hole is where the steam comes in from the boiler though the little pipe behind the bush for the brake valve.

If you have satisfactorily completed this little exercise you can now make the disc valve to go inside it. Use a piece of ½ inch brass bar and thread about 3/16 inch of it ½ inch x 40. Now you can drill it with a No.43 drill or so and ream it 3/32 inch. If you can't get the reamer in there, then drill it a little larger but only by one number of the drill (No.42). Drill it 3/32 inch deep using a 7/16 inch drill and then drill it 5/32 inch for 1/32 inch deep for an 'O' ring. You need to part this off leaving 5/32 inch of thread. You can now reverse this in a tapped bush and turn it down to 5/16 inch for a length of 1/32 inch. That should complete one of the inserts. The other insert is the port face disc.

This needs to be made from a piece of 7/16 inch brass bar and turned down a little way to fit into a recess in the body. The disc is 1/16 inch thick. The port face needs securing with a couple of 12BA brass screws and make sure that they are countersunk flush. Now you can drill the three holes in it for the port face on a ¼ inch pitch circle. You will also need a No.51 hole in the centre to accept the end of the spindle. The face of the port face needs to be an almost polished finish to fit in with the disc valve.

The disc valve can be made from a piece of ⅜ inch round bronze bar or at least a different type of brass to the port face. Part this off at 1/16 inch thick and then you need to mill two 90° grooves in the back of it with a 1mm ball nosed slot drill on a ¼ pitch circle as shown on the drawing. The port face needs a bit of a polish up too. This works on the same basis as the full size one, with the handle vertical for brake off; to the left it operates the steam brake and to the right the vacuum brake. You can also put a little radius around the edge of the disc. You need to make a square hole in the centre for the pivot but this hole needs a little bit of flexibility on the square for the disc so that it can bed in with the port face.

For the spindle you need a piece of 3/32 inch stainless steel rod turned down to 1/16 inch for about ⅛ inch long and then you need the square on it 1/16 inch long to fit the port disc and ¼ inch plain bar followed by 5/64 inch of 1/16 inch diameter to finish off. The square needs to be orientated at 45 degrees to the spindle otherwise it will not work properly.

The handle can be made from a piece of 20swg stainless steel to the shape shown and the centre piece needs a boss on it made up with another piece of 20swg stainless on the front and rear of it. This needs cross drilling for a 1/32 inch taper pin and a 12BA thread on the left-hand end. Shape the bottom end to a point and at the top you can fit a Tufnol handle.

I suppose now that you want to put a little face on the valve. For this you will need a piece of ¾ inch brass bar. Turn a recess in the front face 7/16 inch diameter and about 3/64 inch deep. On the face there are two stops for the brake lever and I think I would silver solder those on later, otherwise you

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Brake valve made using Adam Cro's castings.

can leave them on the face and make the recess a lot deeper and then mill the rest down to leave the two little protrusions for the stops. They need to be 1/16 inch deep. Now you can mill out the little slots. They need milling with a 1/32 inch end mill and want to be 1/16 inch long each end of where the radius begins, if you dare do that. You only need to do this 18 times though! The little pads for the text are raised so you can silver solder these on afterwards.

On the back of the face disc it needs a register turning on it to match the internal thread to fit in the front of body but that only needs to be 1/32 inch deep, if that. The centre needs drilling No.41. The holes either side need to be No.54 and the body needs tapping 12BA and if you can get any small headed 12BA screws all the better - good luck with that! If you don't want to tap the holes, then I would Loctite a couple of pieces of screw in there.

I think now that you can begin building up the body with a few nice little adornments. The first thing we need is the little outlet for the steam brake exhaust. This just consists of a piece of 18swg plate with a 3/32 inch elbow silver soldered on to it. The drain needs taking under the footplate for about a couple of inches and a little clip wouldn't go amiss.

The next piece to fit is the pillar on top. This begins with a triangular flange similar to the one which you have made before and then you need to turn this down to ⅛ inch diameter for 3/64 inch and then turn another 15/32 inch down to 3/16 inch diameter and then another 3/16 inch down to ⅛ inch diameter. You need to drill a hole up the centre of this ½ inch deep. To finish this part off you then need to drill a 3/32 inch hole in the side of it dead in the middle and then a 3/32 inch hole in it on the pointy side of it when you get the triangular plate on the bottom and then there is another branch 3/16 inch above the first one which needs a 3/32 inch hole drilling for it.

The branch is for the steam brake and so that needs an 5/32 inch union on the end of it and the rest of the pipe wants turning down to 3/32 inch. This also needs a 1/16 inch hole though it to meet up eventually »

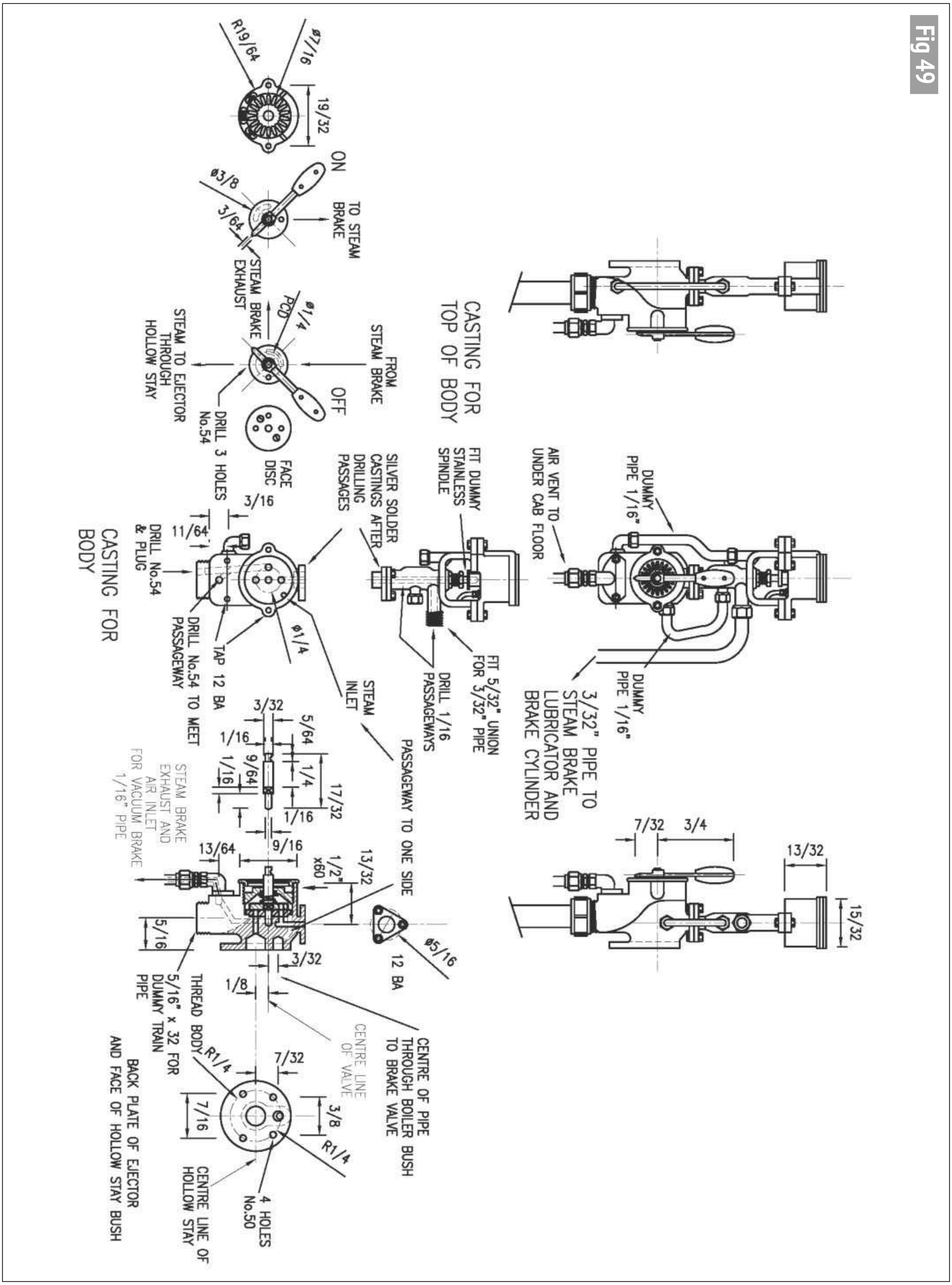


Fig 49
CASTING FOR TOP OF BODY
CASTING FOR BODY
R19/64
Ø7/16
19/32
ON
OFF
Ø3/8
3/64
TO STEAM BRAKE
STEAM BRAKE EXHAUST
FROM STEAM BRAKE
Ø1/4 PCD
STEAM TO EJECTOR THROUGH HOLLOW STAY
DRILL 3 HOLES No.54
FACE DISC
3/16
11/64
DRILL No.54 & PLUG
SILVER SOLDER CASTINGS AFTER DRILLING PASSAGES
FIT DUMMY STAINLESS SPINDLE
AIR VENT TO UNDER CAB FLOOR
DUMMY PIPE 1/16"
DUMMY PIPE 1/16"
3/32" PIPE TO STEAM BRAKE LUBRICATOR AND BRAKE CYLINDER
FIT 5/32" UNION FOR 3/32" PIPE
DRILL 1/16 PASSAGEWAYS
STEAM INLET
Ø1/4
TAP 12 BA
DRILL No.54 TO MEET PASSAGEWAY
PASSAGEWAY TO ONE SIDE
3/32
5/64
1/16
9/64
1/16
1/4
17/32
1/16
STEAM BRAKE EXHAUST AND AIR INLET FOR VACUUM BRAKE 1/16" PIPE
13/64
9/16
1/2" x60
13/32
5/16
3/32
1/8
Ø5/16
12 BA
THREAD BODY 5/16" x 32 FOR DUMMY TRAIN PIPE
CENTRE LINE OF VALVE
CENTRE OF PIPE THROUGH BOILER BUSH TO BRAKE VALVE
R1/4
7/32
7/16
3/8
R1/4
4 HOLES No.50
CENTRE LINE OF HOLLOW STAY
BACK PLATE OF EJECTOR AND FACE OF HOLLOW STAY BUSH
7/32
3/4
13/32
15/32

with the centre hole. Both ends of the body need turning down at about 45 degrees and then there is another small addition which is a piece of 1⁄16 inch material, which needs adding to the left hand side of the column and which also slopes in at both ends so the best thing to add this on is to mill a 1⁄16 inch slot down the side of the column and poke it in there.

You now need a ‘U’ shaped piece made from a piece of 16swg x 5⁄32 inch brass formed over a 13⁄32 inch former with rounded corners, which you will have to make. The depth of the ‘U’ needs to be 5⁄16 inch. This needs to be topped by a piece of 3⁄16 inch x 16swg straight across, for now, to aid the silver soldering job and that needs to be 13⁄16 inch wide. Make a little fillet shaped piece ⅛ inch wide and thread it over the protruding projection on the pillar once you have got the ‘U’ shape on there.

Before you get into silver soldering this lot together there is one more small addition and that is a 1⁄16 inch pipe to silver solder into the bottom left hand side of the ‘U’ shape and this needs a ⅛ inch dummy gland on the end. It needs to protrude about 3⁄16 inch from the bottom of the ‘U’. This can all be silver soldered now. Once you have done that you then need to cut the surplus off the top cross piece. This needs to be cut flush on the right-hand side and an equal amount left on the left-hand side as there is on the outside as there are two 12BA bolts on the left-hand side and only one on the right. You will also need to file a flat and the 5⁄32 inch union where it fits into the column but when that is all silver soldered you will not notice that.

The top part of the valve is all to do with applying the brakes momentarily on the locomotive before the train, so that the train is less likely to part company with the engine, especially if the train were to make an emergency stop. I have only included this as it is part of the valve.

To make the top half of this little piece you will need to start with a piece of ½ inch brass bar and turn this to form a little gland on the underside. If you just turn it down to 5⁄32 inch for 3⁄32 inch and then with a small parting tool you can reduce this down to ⅛ inch diameter but leave a flange on it 1⁄32 inch thick. Turn down to 9⁄16 inch for about ½ inch length and then another 9⁄32 inch to 13⁄32 inch length and then centre and drill down No.50 for about 3⁄16 inch and then you can part off at just over 15⁄32 inch long overall. Face the top of it to tidy it up. You can reverse in the chuck and turn two minute equally spaced grooves in the top. It would be advisable to mill a shallow groove down one side, 5⁄32 inch wide, and fit it with a piece of 16swg brass 5⁄32 inch wide and round that off at the top and silver solder it in there, in line with the lower part of the ‘U’.

You need to make what looks like a small gland in the bottom part of the ‘U’ and fit a ⅛ inch threaded portion with a thin nut on the top of it and drill it about ⅛ inch deep with a No.50 drill. This needs fitting with a loose piece of 1⁄16 inch rod to look like a piston rod.

To assemble this little lot, you need several 12BA nuts and bolts (preferably the ones with 2mm heads!) and a couple of lengths of 1⁄16 inch copper tube which go at either side of the body. They are both dummies. When you fit the port face you need to assemble it with some Loctite non setting sealer between the faces.

Now you can assemble the operating shaft with its port face on the square and put a 3⁄32 inch ‘O’ ring in there and then a fairly strongish spring to hold the disc onto its face. I would also fit it with a good blob of moly grease between the two faces. Screw the retaining ring into place and then you can fit the front cover with a couple more of those 12BA bolts and then the handle.

I was told on very good authority that there was no point in me trying to fit the ejector in there as well as the back pressure through the hollow stay would be just too much for it to work. He had tried it on his locomotive and it didn’t work so that is why mine is in the smoke box. I do hope that this little valve works and look forward to any reports!

●To be continued.

Are You Using the Right Firebrick?

R. Finch helps you to find the firebrick of your dreams.

An abbreviated version of this article was first published in the Bradford Model Engineering Society Monthly Bulletin No.151 for August 2020.

Introduction

Almost every model engineer will have a brazing hearth somewhere in their workshop. Do they have the right fire-bricks or did they scrounge some likely looking bricks from somewhere, not really knowing whether they were actually firebricks? If they were firebricks, were they the right sort of firebricks?

It is generally known that standard house bricks (the red ones that are made of clay) are totally unsuitable, but why? The answer is that the clay brick tends to absorbs some water and some is always held inside the brick all the time. If such a brick is heated quickly, the water turns to steam and, as it cannot escape easily through the small pores of the brick, the brick may well burst.

The reason it doesn't burst when it was originally being being manufactured is that the brick is fired in the kiln very slowly – typically taking two days to be heated up and fired (**photo 1**). Clearly such a brick is unsuitable for the home brazing hearth as we cannot all wait two days to heat up our brazing hearth.

The other problem with standard clay bricks is that under high temperatures, the brick becomes plastic and can deform under load. This is why large buildings that have experienced a fire usually have to be demolished as the walls are no longer structurally sound. In this article, a 'firebrick' is a material which comes in a block form and is capable of withstanding high temperatures.

1

A standard red clay 'house brick'.

2

A thermal storage brick (photo courtesy of Barry Gray, Gillingham).

The requirements

To select the right type of firebrick, it is first necessary to decide exactly what are the requirements are and what specific characteristics each type of firebrick has. The requirements are that it should be able to withstand many heating and cooling cycles, it should have a low specific heat so it would heat up quickly, a low density and it should have a low thermal conductivity. All are crucial for the best firebrick for a brazing hearth. Taking these characteristics in turn, the specific heat is the quantity of heat required to raise the temperature of one gram mass of the brick through one degree Celsius. Just to clarify terms, the 'degree Celsius' is used for actual temperatures only – where there is a temperature *difference*, the preferred term is the Kelvin, K, where 1 K is equal to one degree Celsius *difference*. Note that the symbol for Kelvin is just K, not °K. The density is the mass in grams per cm^3 – the lower the better as the specific heat is dependent on the density.

The thermal conductivity is a measure of how quickly the heat travels through the brick – and a low thermal conductivity is required so that the surface of the brick heats up quickly and the heat is not conducted away through the brick. There are three basic types of firebricks – thermal storage heater bricks; structural firebricks; insulating firebricks.

Thermal storage heaters

The most commonly thrown-out brick is the type used in domestic storage heaters. Thermal storage heaters are used for domestic heating in that the heater uses off-peak electricity to heat up the bricks inside during the night and then release the heat during the day. These heaters have a variety of names throughout the world, such as night storage heaters; heat banks; off-peak heaters; electric storage heaters etc. but are all basically the same. They consist of a large stack of shaped ceramic bricks where there is a depression in one face of the brick (**photo 2**). A couple of bricks are stacked together with the two depressions facing each other. The electric heating element fits loosely in the gap. The heater element gets red hot and heats up the ceramic bricks during the night using off-peak electricity, until they are at a temperature of typically 400 degrees C.

These bricks are made from a mixture of iron oxide and magnesium oxide (magnesia) bound with clay and fired to make it into a solid brick. The iron oxide makes the brick dense, so it is very heavy. The magnesia improves the thermal conductivity, so the heat from the electric element spreads more uniformly though the bricks when stored and releases easily when required. Different manufacturers use their own specific mixture of materials to form their bricks so they are not consistent in colour or other properties. The maximum design service temperature is around 600 degrees C, so is not designed to be heated directly by a flame and become red hot.

There is quite a second-hand market for these thermal storage bricks, varying from use in pizza ovens to making a wall on a greenhouse, so that the sun warms the bricks during the day absorbing heat, preventing the greenhouse becoming too hot during the day. The stored heat is then given out at night so that the greenhouse is prevented from becoming too cold during the night. One word of warning is that if these bricks come from a storage heater manufactured before 1975, then they may have been insulated with asbestos, so should be avoided. If the heater insulation is glass fibre matting, then the blocks are unlikely to have been used with asbestos.

A structural firebrick.

An insulating firebrick, Grade 26.

A 'non-firebrick'.

Structural firebricks

Next on the list is the typical firebrick used for building into a domestic fireplace. These bricks are structural in that they maintain their strength at high temperatures and are about the same weight as a standard house brick. They are made from high silica clay, sand and about 40% alumina (aluminium oxide) and then fired. The clay holds the alumina together and the alumina maintains strength at high temperatures. These bricks are typically yellow or a pale brown in colour due to the sand (**photo 3**). Whilst these will withstand repeated heating and cooling and are strong, their weight means that again, the torch is using most of the heat to heat up the firebrick and not the job being brazed. Whilst they do not have any fillers specifically designed to increase their thermal conductivity, they are not especially insulating being substantially solid.

This type of brick is also used for the main structure of the inside of pottery kilns as they are retain their strength at high temperatures. Whilst they withstand repeated heating and cooling, their weight means that they require quite a lot of heat to raise their temperature and take a long time to cool down.

Insulating firebricks

These are made to have specific insulating properties. They are made by mixing alumina (aluminium oxide) with a carefully graded particulate organic filler and a silica clay binder. The resultant brick is then fired at a high temperature and the organic filler burns out to leave a porous brick containing around 60% alumina. The pores mean that the brick has good insulating properties and the high alumina content ensures reasonable strength at high temperatures. They can withstand repeated heating and cooling but, as they are about one third of the weight of a yellow structural firebrick, they heat up and cool down quickly, so more of the heat from the brazing torch is available for heating the job being brazed. This type of brick is white and comes in several grades, the most commonly available being Grade 26 (**photo 4**). The small graded pores are visible in photo 4.

It is the same size as an ordinary house brick – 9 x 4½ x 3 inches (230mm x 115mm x 75mm) yet only weighs 1.6 kg, compared with 3.9 kg for a typical house brick. The grade number is the maximum service temperature in hundreds of degrees Fahrenheit, so a Grade 26 brick will withstand 2600 degrees F which is about 1426 degrees C. The brick is not as strong as a structural firebrick but still retains its shape when held at its maximum service temperature for a long time. The higher the Grade number, the stronger and denser the brick is. The recommended grade for home workshops is Grade 26 which has a low enough weight, yet is strong enough to withstand the rigours of the workshop.

Comparison of the three types

When the various characteristics are compared, it becomes clear which is the best firebrick for a brazing hearth. The typical values, which will vary from grade to grade and manufacturer to manufacturer, are given below in **table 1**. Whilst these values appear very specific, they have been taken as typical average figures, or mid-way within the range of values readily found on the Internet. The last column is the one which shows the real value of the insulating firebrick. This is the *volumetric* specific heat and is calculated by multiplying the density by the specific heat. The lower this value, the less heat is being put into the brick instead of the job being brazed.

It can be seen from the table that there is a clear 'winner' as far as heating up the firebrick is concerned. The lower volumetric specific heat value of 0.7 shows that the insulating firebrick not only heats up the quickest, but also does not allow the heat to travel readily through the brick due to the low thermal conductivity of 0.2 W/m.K. Consequently, the heat supplied by the brazing torch heats the job rather than the bricks – which is exactly what is required to avoid the brazing flux being exhausted by the heat.

A non-firebrick

Finally, there is a block used by some people, which is not a firebrick at all. This is the aerated concrete block or lightweight building block with a high insulation value (**photo 5**). They are correctly known as autoclaved aerated concrete blocks (AAC blocks). They are used on the inside of buildings to provide fire resistance and they do not fail by plastic deformation if heated and provide a good fire resistance in buildings (up to 4 hours or 2 hours if load bearing). Whilst they can be heated up providing that they are dry, they do not take well to repeated heating and cooling and eventually start to spall and fall apart where the flame has been impinging on the surface. This can become quite significant at brazing temperatures so the block may not withstand more than a few heat/cool cycles. If you don't often braze things, then the aerated concrete block may be an acceptable alternative.

Conclusion

For brazing hearths, the best type of firebrick to use is the Grade 26 insulating alumina-filled firebrick. This provides a long life, good hot strength and because it heats up quickly, provides a good heat-reflecting surface to promote quick heating of the job to be brazed.

ME

Table 1. Properties of various firebricks.

Type of brick	Specific Heat J/g.K	Density g/cm³	Thermal conductivity W/m.K	Volumetric specific heat J/cm³.K
Thermal storage	1.5	3.8	4.0	5.7
Structural firebrick	1.1	2.0	1.0	2.2
Insulating firebrick	1.0	0.7	0.2	0.7

Mick Knights thanks lockdown for getting a job out of the way.

Denford Novaturn.

A Myford Chuck Adaptor

I suspect that I'm not a lot different to the majority of shed dwellers in thinking of a useful addition to the tooling available, which wouldn't take that much effort to produce when the time allows, but never actually getting round to doing it. The particular piece of kit I've had in mind for a couple of years now is a simple adaptor to mount two small three jaw chucks to my Myford lathe spindle.

The story starts almost four years ago when I decided to complement my existing machining capacity with a bench top CNC lathe. Now I didn't exactly need a CNC lathe but when one reaches a certain age the word need is usually replaced by want!

I've had my little Sieg XK1 CNC mill for ten years now and wouldn't be without it. The control is now so familiar and simple to operate that I can machine one off's faster and to a higher standard than using my 'normal' mill/drill. Having operated a CNC lathe commercially, and also having been able to produce one off's faster than on a conventional lathe, I was hoping I could do the same on a bench top machine in my workshop.

The machine I purchased was a ten year old Denford Novaturn training lathe. Generally speaking, these machines wouldn't have had a particularly hard life as they would have been used in schools and colleges (**photo 1**).

Although every one is slightly different in some way I'm not exactly unfamiliar with finding my way around CNC controls, especially the earlier (basic) ones, but I did have my moments getting to grips with this particular setup, which is a story in itself and one for another day. Suffice it say that by the end of the learning curve I had replaced virtually every circuit board in the controller and had to buy a new operating licence but that is not the reason why we're all here today.

The lathe came with a sweet little Pratt three jaw chuck but unfortunately it only came with a set of reverse jaws. A set of jaws for this particular chuck weighed in at £125. A brand new three jaw chuck with two sets of jaws could be sourced for £65 and so there was no real problem in selecting the way forward.

Adaptor mounted to Novaturn spindle.

New three jaw mounted to the adaptor.

As for most of us, the Covid-19 situation has presented more than the usual amount of shed time and so there were no good reasons to put off producing the adaptor any longer.

Screw cut 1⅛ inch Whitworth thread.

Finish locating thread.

Locating register.

Second locating register.

Checking for run out.

Second chuck mounted on the adaptor.

The new chuck had a different mounting register and bolt hole pattern to the original chuck and so an adaptor needed to be produced before it could be used on the Novaturn (**photos 2** and **3**). Unfortunately, once the machine was up and running and with a comprehensive tool library established I still wasn't able to program and machine one offs and short batches faster on the CNC machine than on the trusty Myford. Although I did enjoy programming and setting the Novaturn, it has for the most part sat unused for the majority of its time in the workshop, which has left two useful chucks sitting on the shelf.

As for most of us, the Covid-19 situation has presented more than the usual amount of shed time and so there were no good reasons to put off producing the adaptor any longer.

As I've mentioned, each chuck has a different register and bolt hole pattern and so the ideal way forward was to produce one spindle adaptor with a different locating register on each face. By chance, I did have a suitable billet of 3 inch diameter aluminium in my 'it'll be useful one day' box. The first job was to produce a threaded bore and one spindle locating resister. The Myford spindle is 1⅛ inch x 12 tpi Whitworth and the register is 1¼ inches diameter. Although the thread and register need to be completely true to each, it's the locating register that provides the accurate location for the running of the chuck and so needs to be turned after the threaded bore just in case the billet shifts minutely in the chuck as a result of the screw cutting and thread chasing.

When producing spindle tooling for the Myford I tend to screw cut 0.005 inch shy of full thread depth and crest the thread using a second tap. The spindle is locked while the tap is supported by a back centre and rotated using a suitable spanner. I bought this set of 1⅛ x 12 Whit taps about six years ago for under £30 and they have proved extremely useful over the years in producing spindle mounted turning and milling fixtures that locate directly to the lathe and dividing head spindles (**photos 4** and **5**).

Once the thread has been screw cut and crested the spindle locating register and the first chuck register are produced (**photo 6**). The adaptor is then reversed and mounted directly to the lathe spindle. A series of 8mm diameter holes were machined around the outside diameter of the billet to take a Tommy bar so the adaptor can be secured fully home on the spindle register. The process of producing registers for the second chuck is repeated (**photo 7**). The fit between the adaptor and chuck needs to be positive but also allow easy separation.

To establish the bolt pattern I spotted through one hole in the chuck, drilled and tapped then, with the chuck secured to the adaptor by the one screw, spotted through to establish the two other screw positions.

Finally, came the acid test of mounting the chuck to the spindle and checking for run out against an indicator (**photos 8** and **9**). Both chucks ran completely true - but I'm afraid you'll have to take my word for that!

ME

James Buxton makes a skeleton clock to William Strutt's design.

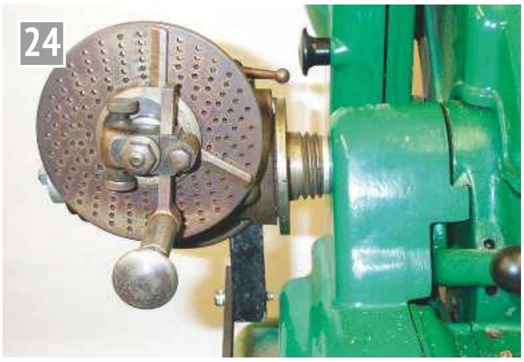
Continued from p.101
M.E. 4655, 1January 2021

The finished clock.

PART 2

Making an Epicyclic Clock

Making a lantern pinion.



Division system for the lathe.

Wheel blanks were turned using a 2MT mandrel, made up for the purpose.

The 2MT mandrel was then transferred to the dividing head on the miller for tooth cutting.

The planet system is made up of three wheels (gears) and one pinion. All the pinions in this clock are lantern pinions and I make these in the lathe, cutting the trundle holes with my 'Potts' type spindle (**photo 23**). Indexing is accomplished with a very old dividing mechanism adapted to fit the headstock of the lathe (**photo 24**). It has a direct dividing facility which makes this sort of job very straightforward.

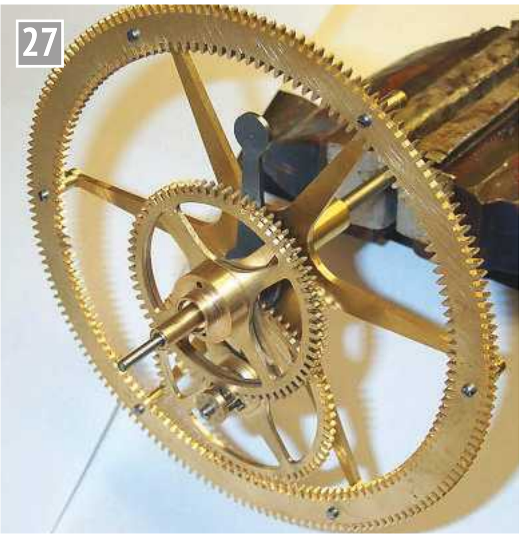
The three wheels are similar but different. That is what one would expect but two of them have different numbers of teeth although they are the same diameter. That is all to do with Ferguson's Paradox (see box). The diameters were turned in the usual way (**photo 25**) then the mandrel was transferred to the dividing head on the miller for cutting the teeth (**photo 26**). Because the centre distances of the wheels are fixed, there is no opportunity to 'depth' the wheels and pinions as one would when building a clock in the normal way. It just has to be hoped that all the calculations and the construction are absolutely correct.

Of the two wheels that share the same diameter, the front, outer, one is the 'sun' wheel and is fixed. The one behind is the hour wheel with more teeth. As the pinion rolls round the sun wheel, its trundles encourage the teeth to line up. So as the hour wheel is drawn round, as the tooth numbers dictate, the hour wheel rotates at one-twelfth the speed of the minute system. This is a working example of Ferguson's Paradox. The planet wheel and pinion combination is mounted on a counterbalanced arm with the wheel engaged with the internal teeth on the annulus (**photo 27**).

The dial is more than merely an indication of the hour. This clock has much of its mechanism outside the frame and the dial is actually the front bearing of the centre arbor as well as the mounting for the sun wheel. Smith offers two alternative options for the dial - Arabic numerals or Roman numerals. I did make a version with the Arabic numerals, with a lot of piercing, but I preferred the thought of Roman numerals. This system relied on the individual numerals spanning the gap between the inner and outer rims and these needed to be correctly placed and adhered in position from behind. The up side of this was that numerals were available commercially, but the down side was that the 'four' was of the form IV rather than the more usual IIII, which I prefer. So I made my own version of my preferred 'four' (**photos 28** and **29**). After construction, the minute markers were needed. These were applied with a pair of ball-nosed slot drills (**photo 30**).

Having got this far, there was still one more wheel needed - this was the escape wheel. I cut the teeth on this with a single point fly-cutter (**photo 31**) and again crossed out with the rotary table on the little CNC miller (**photo 32**). Again, I made use of double-sided adhesive tape and set the final depth to be just clear of the machine table and made the final cut with a craft knife.

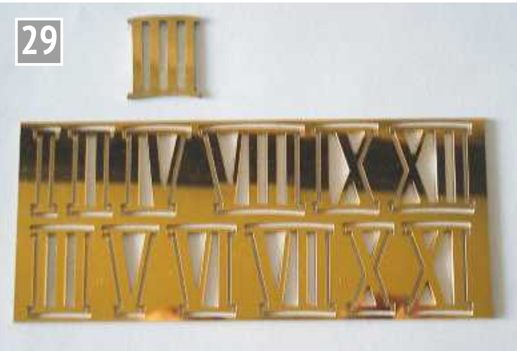
The escape wheel pinion engages with the outside teeth of the annulus wheel, which is of course outside the frame. So it needs a cock. This is made up from two pieces; a flat and an angle. The flat piece has the shape and was profiled on the little CNC miller (**photo 33**) and, after silver soldering, the overall shape was finished on the big miller (**photos 34** and **35**). Planting the cock requires the same sort of discipline as any depthing, so a particular operation was devised that would ensure that the cock would always be central to the frame member and with its axis vertical, wherever the


27

The assembled 'sun-and-planet' system.


28

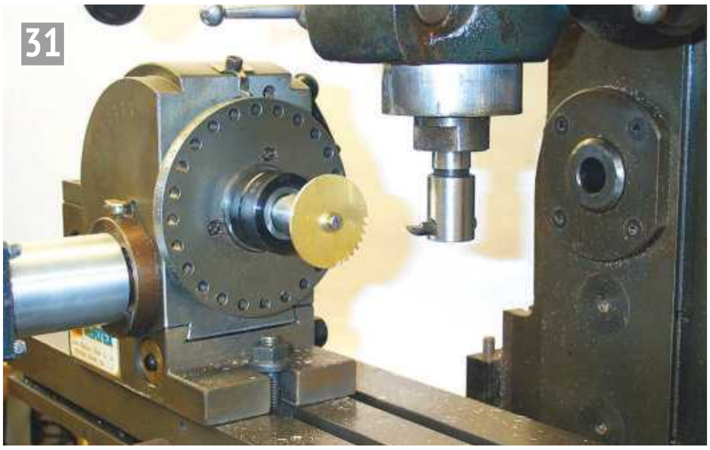
Cutting my alternative IIII.


29

The alternative explained.


30

Applying the 5-minute and 1-minute markers.

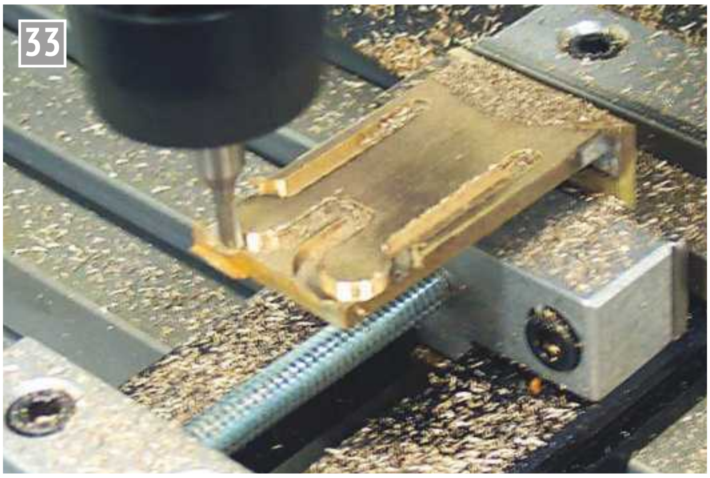

31

Fly-cutting the escape wheel.


32

Crossing out the escape wheel on double-sided tape.

Ferguson's Paradox consisted of a system where he drove three separate wheels of the same diameter but of different numbers of teeth on a common spindle, from a single, extra wide driver. Those wheels with more teeth than the driver revolved more slowly than the driver, those with the same number revolved at the same speed and those with fewer teeth revolved more quickly than the driver. One use was on an orrery, where planets where driven at different speeds.



Profiling for the front cock.

Shaping the front cock, after silver soldering.

The finished front cock.

Positioning the front cock.

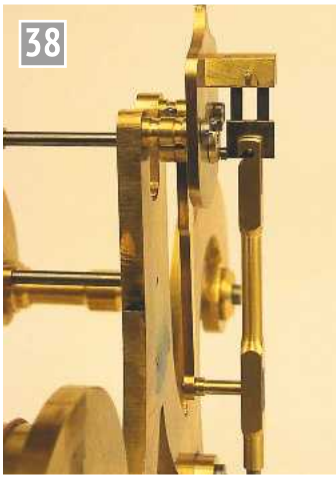
engagement depth required it to be (**photo 36**). With two steady pins, only a single fixing screw is required.

The pallets, pallet arbor and pendulum crutch were then completed (**photo 37**). The pendulum arm has a slot that engages with the crutch. The remainder of the parts needed for the back cock were then added (**photo 38**). The clock was set to run and the front cock set to allow best the possible depthing of the escape pinion with the annulus wheel. The annulus runs clockwise so the escape arbor runs counter-clockwise. The escape wheel therefor appears to be fitted bank-to-front, compared with what one might expect.

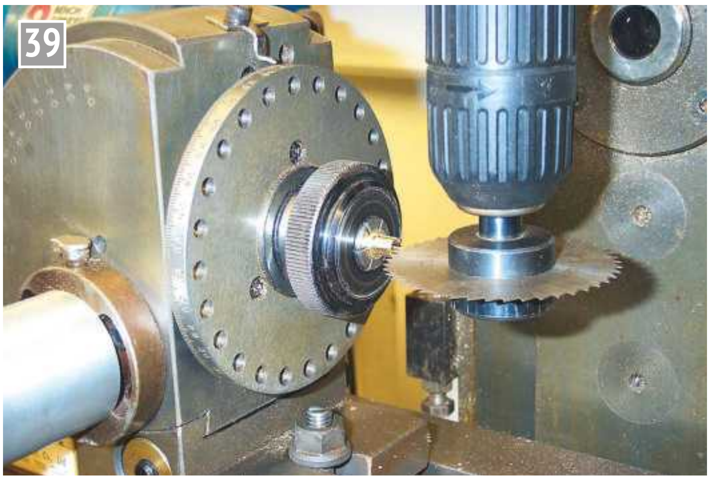
The hands were all that was now needed. There is another difference from 'normal' here. As there is no friction drive on the minute arbor and each hand is independent, each is fitted onto its own collet – but with a difference. Each collet is made to allow adjustment independently. They are fitted with pips internally designed to engage with grooves on collets on their arbors, both allowing location but the facility to be rotated for hand position. A fine slitting saw was used (**photo 39**) in order to make the small degree of spring flexibility required.

Photograph 40 shows the completed clock. ME

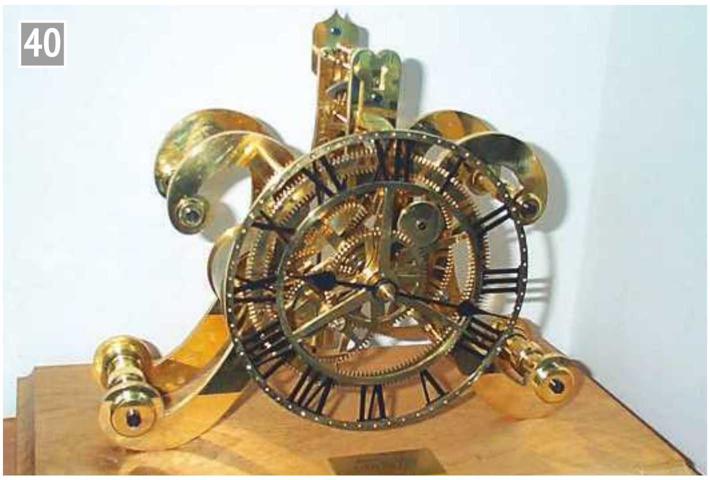
Pallets.



The pendulum suspension.



Using a fine slitting saw on a hand collet.



The completed clock.

POSTBAG

PCB Etching

Dear Martin,
By far the most efficient way to get PCBs today is to draw the circuit schematic in Eagle CAD, have it generate the PCB layout, send the files to China and then wait for a couple of days. Not too long ago, I had 100 small boards made for our club's signalling project. It took only a few hours to design the board.

It cost me about $60 US and they came back in 3 days, quicker than the electronic parts that were ordered at the same time from Texas (I live in Massachusetts). A quick check online shows the same firm is currently offering five 100mm square boards (double layer) for $5 plus $18 shipping to the US and 3-4 days delivery. In contrast, it would cost $40 to mail order a square foot of copper clad board and 500 ml of ferric chloride.

Assuming you are not *modeling* a PCB, why would you make them yourself, even if it were cheaper? I have made many PCBs since 1960, using crepe tape (professionally, no less!), nail varnish, and toner transfer as resist. I have used pre-sensitized boards and mylar masks, and milled boards in a CNC mill, up to 2 layers. I'm not doing any of that any more. The quality of the Chinese product is much better than I can manage, the cost is much lower and no nasty chemicals to deal with. And there are options such as flexible boards, multilayer boards and coatings that are almost impossible for the amateur.

However, if you object to buying from China, or you do need to do some other etching of copper, for instance for nameplates, don't use ferric chloride. It is nasty stuff and hard to dispose of. I am not a chemist, so this is not expert advice. I have most recently used cupric chloride, which is much more pleasant. I made my own etchant from scrap copper and muriatic (hydrochloric) acid. It's magic - used etchant can be regenerated by bubbling air into the etchant, or by adding hydrogen peroxide. The copper you etch turns into more etchant.

Possibly off-topic, but it is worth suggesting aluminium rather than copper in some etching applications (nameplates, say). I have etched aluminium with ferric chloride and sodium hydroxide. It seems to etch very rapidly and more deeply. The ferric chloride is very fast but scarily exothermic, so take care. I also think you can use hydrochloric acid but I have never done that myself.

Finally, may I suggest the use of 3D printing for nameplates and such-like? It is easy to make strong high resolution parts. Even if you don't have a printer, you can use on-line services. Naturally, you wouldn't use plastic parts on the side of a smokebox but newer materials are becoming available daily.

Jed Weare
(Massachusetts, USA)

Quarry Hunslets

Dear Martin,
Following Mark Smithers' series on the Hunslet narrow-gauge locomotives, I was very happy to see one example is *Cloister*, as I was one of its drivers for a short time. So I hope he won't mind my filling a small gap in its recent history.

Cloister did not go straight to Statfold Barn from its Hampshire Narrow Gauge Society home at Bursledon Brickworks. Instead it went via Purbeck Clay Mining Museum, at Norden, in SE Dorset; on loan there for about three years.

This small museum, associated with the preserved Swanage Railway, shows a flavour of the local ball-clay mining. The Norden plant, just West of Corfe Castle village station, collected clay from the open-cast and subterranean mines, via narrow-gauge railways, dried it, and transhipped it to the ex-SR Wareham - Swanage branch-line. Clay-mining continues, by open-cast and lorries.

Little trace remains of the clay-works' private sidings but a volunteer group laid a few hundred yards of narrow gauge line, restored several side-tipping wagons and serviced *Cloister* and two Ruston Diesel locomotives. We aimed to show the site's original purpose, with demonstration trains, but in practice one Ruston was busier on site works, and *Cloister* mainly on 'Driver For A Fiver' fund-raising events - £5 being the suggested donation.

The second Ruston, arriving later, had operated on the original clay system, which ceased in the 1960s.

The same group also rescued various mine artefacts from the surrounding country-side, for display.

The Swanage Railway has built a completely new station in Southern Railway / Region trim, with run-round loop, adjacent to the clay works, to act with a Council-run car-park also for the museum, as park-and-ride by rail. The up end of the branch survived BR closure to serve an oil and gas gathering station - on Britain's (largest?) terrestrial oil-field - and is connected and signalled to Network Rail's Wareham Station. So far though, only occasional specials and experimental public summer services have used the entire route and ex-Swanage normally terminates at Norden, well short of the 'golden fishplates'.

The Rustons are still at the museum and I gather have been overhauled, but being among several volunteers who left about two years ago, I do not know how the site is surviving the present duration.

Nigel Graham

Write to us

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Responses to published letters are forwarded as appropriate.

Stainless Steel Boilers

Dear Martin,
In issue M.E.4651 (6th November 2020) Joseph-Jean Pâques finds it a mystery that stainless steel boilers seem to be banned absolutely in Britain.

Some decades ago three of us were standing beside the elevated track of the Ottawa Valley Live Steamers and Model Engineers watching the trains go around. A visitor came up and asked why our boilers could not be made of stainless steel. The response surprised him greatly as it consisted of a chorus of "Chloride corrosion!" One of us (not I) was an engineer who had had his fill of stainless steel corrosion problems during his career and the remaining two of us were aware of the problem in a more general way.

The metallurgical and welding precautions that would have to be dealt with in fabricating a stainless steel boiler for models would be both extensive and expensive. I would not want one to be steamed near me without adequate technical documentation attesting to its reliability. Under the circumstances, a ban on stainless steel boilers is reasonable, especially to keep the inexperienced out of trouble.

Best regards, John Bauer (Ottawa, Canada)

Dear Martin,
Given the apparent rarity of the use of stainless steel in model boilers, in the UK at least, it was pleasing to see *Luker*'s article in M.E.4653 (4th December 2020) on the design and construction of such a boiler for his *Wahya* locomotive. I congratulate him for sticking his head above the parapet.

There seems to be no fundamental engineering reason why stainless steel should not be used more commonly, provided that materials and processes are correctly selected and implemented. I think that the potential for lower cost and greater longevity of the stainless steel boiler when compared with the equivalent copper boiler has for too long been largely neglected. Part of the reason may be the implicit discouragement of the use of stainless steel (although not of carbon steel) within boiler test codes published by the principal UK model engineering federations. It seems to me that the skill sets required in respect of design, manufacture and testing of stainless steel boilers are no more onerous than those required for carbon steel boilers. Of course, stainless steel is harder to work than copper but, as evidenced by *Luker*, this is not an insurmountable problem. I suspect that it is the welded joints that are at the root of the caution about the use of stainless steel. However, if the design is sound, the materials and techniques are appropriate and the welder's competence with the material is proven, there is no reason to suppose that a stainless steel boiler will be less safe than a carbon steel equivalent. It all comes down to the competencies of the designer, builder and inspector.

As *Luker* says, ASTM 316L (EN 1.4404 or EN 1.4432) is suitable for boilers and the mechanical properties, required for design, can be found in technical literature by manufacturers such as Outukumpu. Cold forming of this austenitic stainless steel significantly increases the proof (yield) and ultimate tensile strengths but although data can be found on the internet, the enhanced strengths should not be used for design. Also, cold forming may have an adverse effect on weldability. However, this property is used to achieve higher strength in some stainless steel products such as bolts. As a slight digression I offer a word of warning; what you get is not always what the supplier claims it is. I experienced two instances, in my professional career, where the actual mechanical properties of stainless steel bolts, as proven by customer testing, were significantly non-compliant with the properties claimed on the material certificates.

I am loath to criticise *Luker*'s design, which has been substantiated by testing to twice working pressure (and, unlike copper, the mechanical properties of stainless steel at room temperature are the same as at operating temperature) but I do feel that I should offer a few comments.

The welded joints at the perimeter of the backhead, the inner firebox doorplate and the firebox tubeplate appear to be specified as 3mm fillet welds which could, according to the normal calculation, have a throat thickness of only 2.1mm. This, in conjunction with the reduced allowable shear stress across the throat of a fillet weld, compared with the allowable tensile stress in the parent metal means that these welds are theoretically weaker than plates that they are joining. As a designer, I would want such important welded joints to match the strength of the weaker of the two plates being joined, an objective best achieved by the use of a full penetration butt weld.

The above comment also applies to the joint between the firebox wrapper plate and boiler barrel at the throatplate. Due to the change in diameters, the longitudinal tensile force in the barrel has to follow a 'dog leg' load path which sets up local bending moments in the plates. Each weld (both inner and outer) in this joint is therefore also subject to bending, as well as transverse shear force, across the throat. Cracking of boiler plates due to this type of behaviour was not unknown in full size boiler construction, for instance, some 'wagon top' boilers for Fairlie locomotives on the Ffestiniog Railway. In that case the problem was alleviated by the introduction of longitudinal stays. I would specify full penetration butt welds for these joints.

On the subject of butt welds, the structural integrity of the boiler 'as built' relies on three very important longitudinal butt welds; at the base of the barrel and at the outer firebox sideplates. Full penetration is really important for these welds as any lack of penetration will result in a local increase in tensile stress across the joint with consequent erosion of the design factor of safety. It is not always possible to get access to the back of the weld to check for penetration and/or do a sealing run, which places even greater importance on getting the welding procedure right. It is worth noting that in an industrial setting, testing to destruction of a test piece made with a full penetration weld would be deemed a failure if the fracture occurred anywhere other than in the parent metal.

The finding from the finite element (FE) model that the stresses (von Mises?) at the foundation ring are low is interesting. In the absence of stays directly connecting the firebox crownsheet to the outer wrapper, the forces that these stays would otherwise carry must be carried in shear and bending by the front, back and side stays, the foundation ring and the door ring, with possibly a very small proportion carried by the tube bank. It may be that the yielding of the inner firebox wrapper plate at the upper row of side stays is associated with a similar level of stress in those stays although, given the dictates of strain compatibility and uniform pressure on the plate, it is not clear to me why the stresses at the upper row should apparently be significantly higher than at the lower row. It may be because of the curvature of the inner and outer wrapper plates. I would also note that the stresses will be influenced by how the model represents the interfaces between the various components. Although it is not apparent from the FE stress plots, I would expect the square corners to be the sites of some of the highest von Mises stresses. I am sure that *Luker* would agree with me that the FE model (which I assume to be linear elastic) is only as good as the accuracy with which it reflects the intended construction and loading regime and that its results should always be assessed by the designer in the context of his or her critical engineering appreciation of where the load paths are. It is worth noting that strain hardening associated with redistribution of stress due to yield will increase the strength locally. This should not be relied on in design especially in the vicinity of welds.

I hope my comments will be accepted as a constructive contribution to the debate that *Luker* has invited and which I hope will happen. I have not prepared 'rigorous calculations' or quoted 'published literature' but I do draw on my experience from a career as a chartered engineer with responsibility for the analysis and design of many welded steel structures, although not of pressure vessels. I am not a welding engineer or a welder.

Lest it be thought that I am anti silver soldered copper boilers, I note that I have designed and installed two (with a third on order) for 5 inch gauge locomotives. I did, however, entrust the construction to more capable and better equipped individuals than myself.

Best Regards, Jeremy Buck

Luker responds:

Thanks for your letter - your comments were very welcome and I enjoyed reading your letter and responding! I was hoping the article on the boiler would generate a little debate. Manufacturing techniques have come a long way since the first model engineering boiler codes were scribed. I don't think TIG welding was common in those days (or electricity for that matter?) and stainless was still a new material and more expensive than copper. This is no longer the case. In short, I agree with most of your points and your very solid engineering discussion. Having done the calculations, I can elaborate a little on some of your points.

I'm going to try keep my response as non-technical as possible for the benefit of readers without a theoretical engineering background - unfortunately I can't do this with the FEA part of your letter. The presented plots are von Mises (or equivalent) stresses and although these stresses are more than adequate for ductile materials to point out possible weak spots in the design, it falls short in describing what's actually happening in those areas simply because it's a scalar value. A principal stress and vector plot gives a much better understanding of what's happening locally at elevated equivalent stresses. Interestingly enough you also need to extract the surface tensile stresses to check for corrosion sensitization specific to the austenitic grades of stainless. Focussing on your points: the stresses in the foundation ring are lower because the plate is thicker and the load is distributed by the stays, tubes etc. The top row of stays has higher stresses due to the relative deflection and geometry. Corner peak loads need to be checked to make sure these are not discretization errors, with mesh refinement done only for my own satisfaction to prove it was safe. The interfaces (mesh contacts) in the model vary depending on the position; typically this is mapped to the mesh to mimic the physics of the joint. There is no isotropic hardening (or any other non-linear material properties) in either model, which is of particular interest. I did a model of a smaller copper boiler a while back and it failed FEA dismally. In practice this boiler does work; the disparity was due to the work hardening of copper with a subsequent non-linear analysis proving this hypothesis. I agree totally that the accuracy of the model is only as good as the setup and boundary conditions but my methods have been scrupulously checked by a roomful of engineers and professors. I was invited to present one of my boiler FEA's at an engineering conference some time back. The presentation included a coupled static structural-thermal analysis of a boiler at 1.5 working pressure and, even after a rather in depth presentation with a number of plots showing all the assumptions and methods used, I still had a number of very interesting questions most of which were focused on the thermal boundary conditions. The point is - I would need to fill these pages with far more than one or two plots to have a meaningful discussion on the FEA results, which I think would put a number of readers (and me) to sleep.

A butt-weld on any of the wrapper to tube-plate etc. joints is practically very difficult. Lining the wrappers up to the plates would require a friction grip and you would not be able to use the thicker plates as a former for tacking. A butt weld here would also invite distortion and weld sensitization due to the heat input to the thinner wrapper where, if welded like the drawings, the thicker (backing) plate helps to dissipate the heat. You would also need to back purge to prevent over-penetration and weld sensitization. Where possible all welds were designed to limit the need to back purge, with only a backing plate required for the boiler barrel and outer wrapper butt weld. All welds were checked with hand calculations and were found to have a very large safety factor. No weld root dimensions (this is normally taken as full penetration welds for any 'V'-preps) or post weld grinding is specified and as long as this is followed the welds will be more than adequate. The welds between the throat-plate, boiler barrel and outer wrapper will see low stresses because of the stiff 6mm throat-plate, which when scaled to full size would be just shy of 60mm. This is why longitudinal stays aren't required and if such thick plate was used in the full scale 'Fairlie' they probably also wouldn't have needed stays.

As part of my welding procedure I weld the standard test 'V'-pieces and do the bend tests in a vice with, as you say, all the welds good after the bend with no cracking. These test pieces are kept with the material certificates and welding procedures by our boiler inspector with all the weld prep photos and general construction photos.

I agree that sometimes you don't get the correct specification of material you ordered but this is less likely if you insist on a material certificate with the correct batch number. All my calculations are based on the proof stress and not supplier given values, which is typically higher.

I have made two copper boilers, one silver soldered and one copper TIG welded, both passing all the necessary tests. The one that I kept is still giving me loads of fun on our track; the other (which was sold to finance my next locomotive) is sadly sitting on a display stand. I have no particular love for stainless but I have built a number of locomotives and intend to build many more. If this hobby was not to lead me into a life of abject poverty I needed to come up with alternative ways to make the hobby more affordable for me. Let's be honest, who can afford to make a silver soldered copper boiler in these tumultuous times?

Thanks for taking the time to comment.

Luker

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

Continued from p.71
M.E. 4655, 1 January 2021

Painting by Diane Carney.

Flying Scotsman in 5 Inch Gauge PART 2

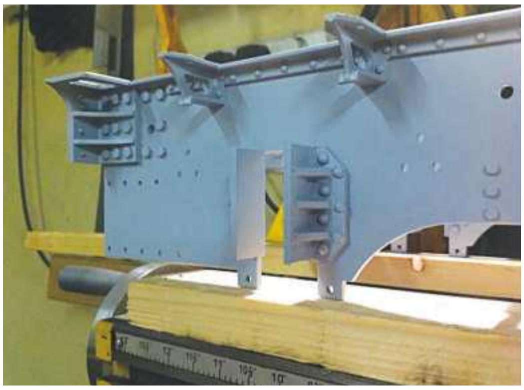
In this picture the chassis is held square on the mill bed while I changed the bolts. I was very happy that the chassis remained true with no rock.

So far, the chassis had been temporary held together with mostly oversize head bolts and screws. I used these because during this time the chassis was dismantled many times thus marking the heads; it has now reached the stage where I could use scale sized heads for which I used Loctite to secure.

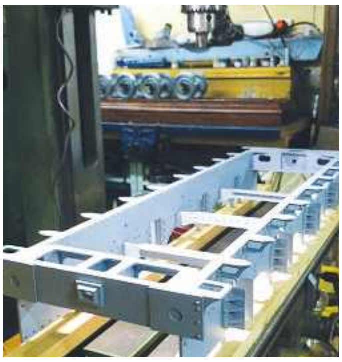
Now that I was happy with the chassis it was time to Loctite the wheels to their axles. I have set up one of the axles between centres and used the toolpost to check alignment. These wheels have two small holes that Don Young said were there to stop the wheels ringing. When it comes to building the model they are perfect for holding the wheel onto the faceplate (alas I have no picture of that stage).

●To be continued.

I wasn't sure if these were supposed to be inline across the axles or not but decided to do so anyway, hence why there is studding being used to help align them. I was amazed at how quickly the Loctite set; luckily for me it didn't catch me out.



The chassis now had the outriggers brazed up and attached using 1/16 inch rivets to the frames. The ¼ x ¼ x 1/16 inch brass angle has also been riveted in between the outriggers. I then sprayed the chassis with Upol acid 8 etch primer.



The chassis at that stage. In the background you can see the wheels with axle boxes fitted awaiting refitting to the chassis.

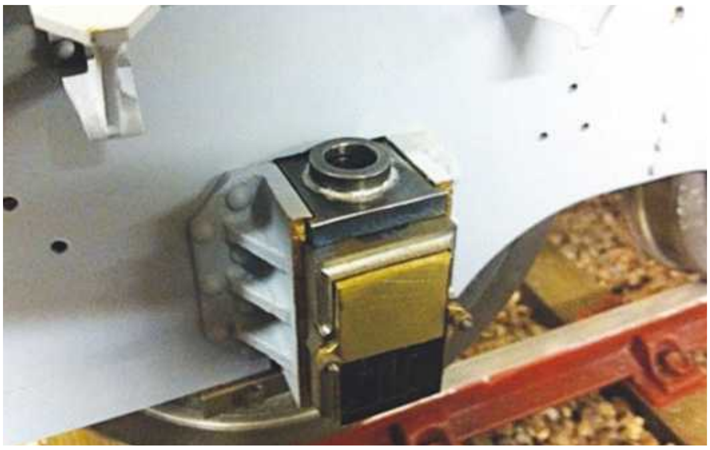
A picture of Tornado's tender chassis at a similar stage which I have used for reference.

Spring plates; naturally there are eight of these, four intermediates with extra allowance for axle movement and the lead and trailing plates which have less movement. I gang machined these in batches of four. Here the intermediates are having their slots machined.

The plates have rings brazed to them for the spring buckle to sit into. I decided that an easy way to ensure the rings went on centrally and also to hold said ring while being brazed together was to drill holes into the plate for temporarily holding the rings in place using bolts. Here four of the plates are being drilled together for this.

Starting to look the part. Next I'll make a start on the body.

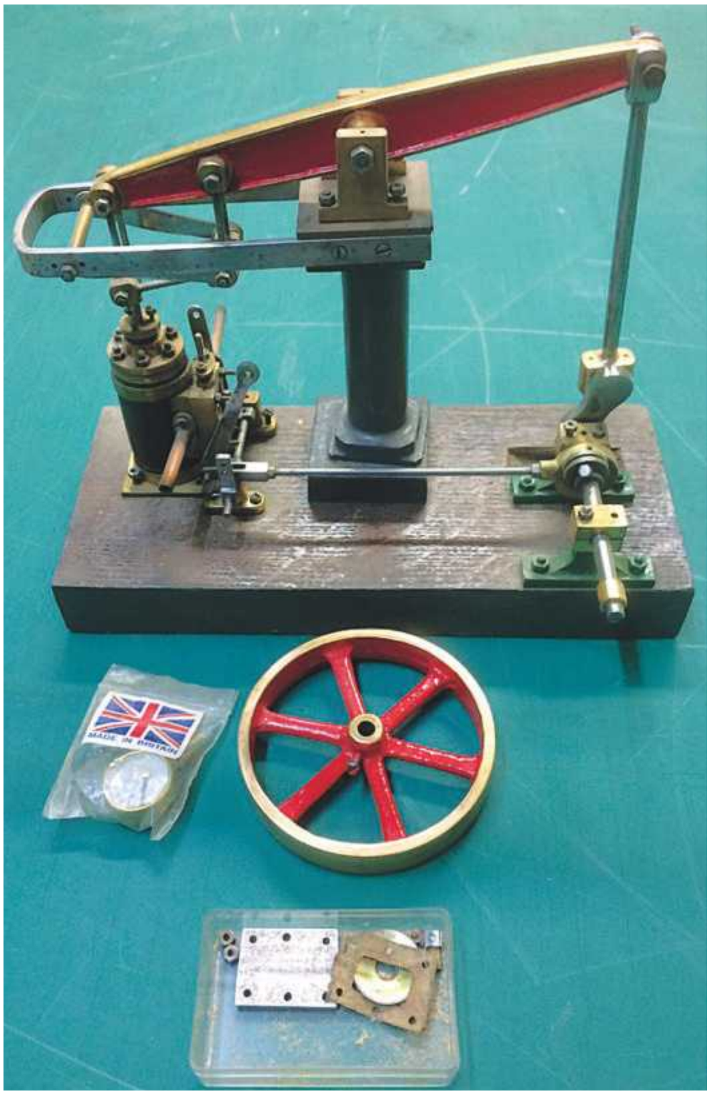
Plates and rings ready for brazing. The rings were a simple turning exercise; the parts were held together using 8mm bolts/nuts.



One of the finished spring plates in situ.

Restoring an Old Model Beam Engine

PART 1



Tony Bird turns a pile of nondescript bits into a working engine.

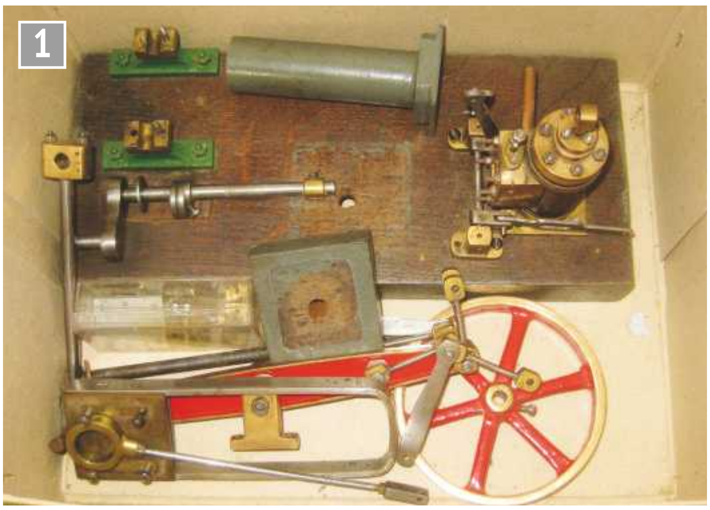
A few months ago, a friend made the author the gift of a model beam engine saying, ‘I am sure you can do something with it’. Some people are eternally optimistic! The story was that the friend had been given it by a curator of a Portsmouth museum. The model had been passed round various members of the museum staff before the friend received it; it was said to have hailed from the docks as an apprentice piece but whether it had ever worked or not wasn’t known. The friend had had it for several years, had taken it apart and had not got around to doing anything to it.

The model wasn’t that well made but superficially it didn’t look as if it shouldn’t work. It is unlikely that it was an apprentice piece; if it was, he had been poorly supervised and didn’t have access to much in the way of materials. The model came in a cardboard box (**photo 1**) and was mostly in pieces, only the crank shaft bearings and cylinder still being attached to the wooden base. Having checked to see if there were any major parts missing - which there weren’t - the bearings and cylinder were removed from the base. The loose parts of the model were then stored in three plastic bags:

(1) The beam, column and their fittings.
(2) The crankshaft, flywheel and their fittings.
(3) The cylinder and piston assembly.

The author has finished quite a few of other people’s models and restored many others. He usually tries not to re-engineer too many parts unless it is necessary to make the model work; he has had various degrees of success in doing this!

A start was made on the only part not in a bag - the model’s wooden base. Alas, it was very rough, filled with putty on one corner and, more importantly, slightly warped (**photo 2**). It would have been easier and possibly more sensible to replace it, but hey-ho, it was original. The author is no wood worker but does own a milling machine. This was just as well as there were several hidden nails in the wood which would have damaged a plane or a wood working machine. The oak base board was flattened and squared and all the original securing holes were drilled then plugged with dowels (**photo 3**). To improve the look of the crank recess in the wooden base a milling cutting was used to clean it out. As some nuts and bolts would be used to replace some threaded nails that had been



The contents of the cardboard box.

used to secure the bearings and cylinder to the wooden base, and as these new fixings would need some clearance, feet were made from a piece of oak and glued in place (**photo 4**). Before any further work was done to it, the wooden base was varnished to protect it from oil and the like whilst further work was carried out (**photo 5**).

Column and beam assembly

Next, the first plastic bag was opened and a start was made on restoring and fitting the column and beam assembly to the wooden base (**photo 6**). The column was supported on a square, mahogany base. The column itself consisted of a steel tube with a brazed-on brass base (this piece of brass having been recycled from something else). The capital to which the beam's bearings and parallel motion bracket were fitted consisted of two square brass plates with a square of mahogany sandwiched between them. All of the parts of the column were held to the wooden base by a long bolt with a castellated nut (another recycle) but, unfortunately, there were no registers between each part of the column so it could move and turn in any direction.

To correct this problem three spacers were made and fitted to the column so it could only rotate and not move side to side. First, the mahogany column base was cleaned up, plugged and drilled with the same size hole as in the oak base. A mushroom shaped brass spacer to locate the mahogany column base to the main oak base was then made (**photo 7**). Later, this column base would be glued to the oak base. The steel column's brass base had a recess turned in it for a push fit spacer (**photos 8** and **9**). A loose stepped spacer was fitted into the top of the steel tube to centre it under the capital (**photo 10**). Holes had been drilled in the tube's brass base for screws that would be fitted later to stop it from rotating (**photo 11**). As the accurate height of the column wasn't known yet it was left to be adjusted later; it would probably be too high and could be corrected by either by turning back the top spacer or thinning the column's mahogany base.

The parallel motion bracket which screwed to the wooden part of the column's capital had been made in two parts that had not been joined so these parts were hard soldered together (**photos 12** and **13**).

The two pieces of square brass sheet sandwiching a square piece of mahogany that

The wooden base.

Drilling and plugging various holes.

New feet.

Restored and varnished base.

Column and beam parts.

Locating spacer for the base.

Machining a recess in the base of the column.

Push fit spacer fitted.

Some readers might be wondering, 'why bother?' Couldn't I just cut another piece of wood or metal? Retrospectively, so did the author!

the parallel motion bracket was screwed to was taken apart (**photo 14**). The mahogany was machined square and all its holes were drilled and plugged with dowel - after which it was found to be too narrow when fitted between the arms of the parallel motion bracket so some thin pieces of plywood were glued to either side of it (**photo 15**). Some readers might be wondering, 'why bother?' Couldn't I just cut another piece of wood or metal? Retrospectively, so did the author! The beam itself turned out to be fabricated and not a casting so, after removing its parallel motion it just needed cleaning. All that was done to the parallel motion arms themselves was to take them apart, clean and assemble them again on the beam.

On assembly it was found that the parallel motion support bracket was out of square so the relevant holes in the two brass sheets were filled and new holes drilled. The beam's bearings after cleaning were fitted to the top of the column's capital and it was then found that the beam wasn't parallel to the parallel motion bracket (**photo 16**). Some more holes were duly plugged and drilled! The column was sprayed with undercoat and the beam and parallel motion assembled on it. As all the bearings of the parallel motion arms were soldered to their rods it was good to find out that the parallel motion turned out to be parallel and moved up and down easily with the beam; if it hadn't there would have been no easy adjustment (**photo 17**)!

●To be continued.

Centring spacer for locating the capital.

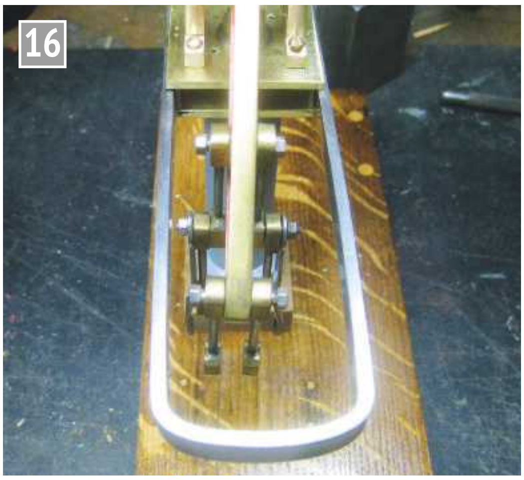
Column assembly.

Original state of the motion bracket.

Motion bracket after repair.

Attachment for the motion bracket.

Improved attachment.



Original alignment of the motion bracket.

Restored beam and motion bracket assembly.

Recycling and Model Engineering

Luker **says there's no excuse for not being a green engineer.**

Introduction

Society and fashion trends move in weird and wonderful ways. For example, it was fashionable to wear pants that unzipped into shorts a couple of years ago (I loved those; very functional). More recently global warming and environmental issues are in the forefront of trending hash-tags especially with recent world events.

Greta Thunberg has once again reminded us that we need to look after the word around us, not just for our generation but the next. I actually have a lot of respect for that young lady and her cause. It takes a lot of guts to stand up in front of a crowd on a good day; but standing up and wagging the proverbial finger at a bunch of politicians is my type of person. I just hope nobody points out that although taking a wind powered yacht is incredibly clean and green the pollution over the whole product life cycle is a completely different matter; especially the manufacture and disposal. That little bit of perspective might knock the wind out of her sails.

You can of course lie down and do nothing - that will lower your carbon footprint - but I think that is a harrowing prospect for most model engineers. Any partner that has ever taken one of us on a lazy beach holiday might attest to this. I do, however, strongly believe there is hope for our kind.

Model engineers have been recycling since time memorial with the pioneers of model engineering fashioning boilers from old copper fire extinguishers and the tubes scavenged from copper radiators. Most model engineers aren't scared to dive into their box of forgotten treasures (the scrap box) to finish the odd project that requires a sliver of material too small to spoil a good sheet. That very simple action is more than what most people do to save their ecosystem. Having said that, the art of true recycling, and not just sorting, requires the refashioning of materials or changing discarded materials completely to serve a new and useful purpose, with of course little to no wastage.

Safety valve cover made from an appliance motor and a candle stick.

I get asked by the public on our club open days where I get the parts for some of my locomotives and when I answer that a large percentage of the components are made from discarded appliances like vacuum cleaners and the like the enquirer thinks I'm trying to be funny but this is not the case. The safety valve cover on my Stirling single, my favourite example (**photo 1**), was made from a discarded appliance motor and a candle stick holder. For those interested, this is my story of workshop recycling…

The used-car-oil furnace

Having the ability to melt and mix alloys drastically increases the recycling warrior's arsenal. Normally, the cost of small furnaces is prohibitive with the induction type furnace defeating the object of saving money and the ecosystem and the gas fired furnace costly in terms of gas. It is possible to make a furnace that runs on used car oil (from when I service my car) able to melt anything from the aluminium alloys, brasses and bronzes to the cast irons.

The furnace itself was designed for primary and secondary combustion essentially eliminating smoke which is a very good indicator of poor combustion and pollution. As irony would have it, I burn less waste oil when melting brass and gunmetal shavings to make bar stock

>>

than fuel when taking a drive to my closest non-ferrous supplier. The furnace itself was made from a scrapped 50 litre compressor (**photo 2**) with nearly all the steel used for the construction from the treasure box. Even the wheels were cast from the compressor heads.

I buy FeSi, which is a cast iron inoculant, and the graphite crucibles from trade; pretty much everything else is scavenged or repurposed to cut costs and wastage. The sand for the moulds comes from my local river, a brisk walk from my humble home, where mother nature is kind enough to wash and sort the sand for me. Copper, which is the base metal for all the bronzes and brasses, is found from discarded motors and plumbing lying around waiting for another chance at greatness. You should see the looks I get from my lovely wife when I stop the car to look through some building rubble on our way to a fancy do dressed in our best - but what's life without a little whimsy?

Aluminium is a handy alloying element with copper to make tough grades of Al bronze. Pewter is a good source of tin for the more common gunmetal and bearing bronzes. Then of course all those non-ferrous metal shavings we like to generate in the home workshop can be collected, melted and cast into rods to be used again.

All the cleaning solvents like paraffin and thinners are mixed with the oil to start the furnace, one of the more environmentally friendly ways to dispose of them. I also use the dirty paraffin in an oil lamp to light the blow torch during soldering. The small amount of smoke from the flame helps keep the mosquitos at bay, especially around the dark brazing hearth where they like to lay in wait to suck you dry when the solder is just about to start to run.

While I'm on the topic of casting, some of my wood patterns are made from fine grain pressed-board typically used for shop fittings in my area. Normally the discarded board is left out for anyone that can find a use for it. With a scroll saw, some wood glue and a little patience respectable patterns can be made. The saw dust is kept to soak up oil spills in and around the workshop, and no this does not end up in the refuse! The oiled saw dust is thrown into the furnace, with the pattern offcuts, for an easy start-up.

Workshop tooling from recycled car disk brakes

One particularly handy tool I made from my wife's car's disk brakes was a 'V'-block set that can also be used as a small angle plate. The disk brakes are made from some of the best cast iron money doesn't need to buy, easy to machine and ductile enough for machine tooling. Not to stray too far from the topic, but casting the two pieces as one (**photo 3**) and splitting them only after the 'V'-angle and sides have been skimmed leaves you with a matching set (**photo 4**). Because they cost nothing and are easy to make drilling into them for the specific job on hand is not heart breaking (**photo 5**).

The oil fired furnace in action.

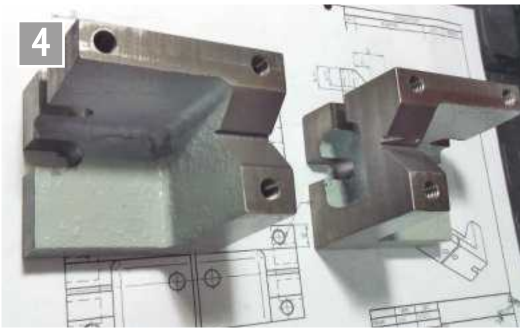
The paperless workshop

The catch phrase 'paperless office' was banded about by HR in one of the companies I used to work for. I thought at the time that the printed plan of action defeated the point a little and I wasn't very popular when I pointed that out. The paperless workshop on the other hand is actually worthwhile. I'm embarrassed to say the plans and articles for my very first locomotive were printed out and clamped to the splash plate of the lathe ready at a glance while machining. Currently I have my laptop mounted on a swivel base above the lathe easily visible from any working area by a simple flick of the swivel (**photo 6**). The advantage of the computer, even if PDF's are used, is the zoom function and quick access to other literature and resources at the click of a button. It's particularly handy if you do your own designs, making updates and adding machine/operation specific dimensions as you go.

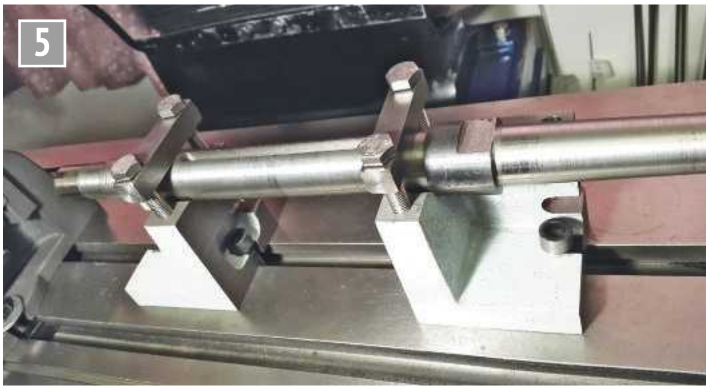
Reusing tipped tools

Inserts (and tipped tools) need to be discarded very carefully. They shouldn't find their way into the garbage because they can do a lot of damage to the waste sorting machines. They also don't melt easily so the scrap recyclers can't do much

Angle 'V'-Block mould.



Machined angle 'V'-Block.



V'-block set-up for mandrel slot milling.

The computer on the swivel.

with them unless they have very specialised furnaces. Lucky they can be reused in more than one way. Like a dodgy person's undergarment, they can be flipped around and used again to cut brass if it has a neutral rake or plastic if it has a negative rake. The bottoms of the tips generally don't have a radius like the top which is perfect for those two material groups.

My favourite use for them is to silver solder them to a piece of bar either to be used for boring or for a shaping tool (**photo 7**). The green grinding wheel will shape them as needed, or failing that a diamond tile cutter on an angle grinder. When you use the tile cutter you need to take your time and be very light on the pressure or the carbide gets too hot resulting in the carbide cracking or chipping.

Discarded printers

I have a pet hate for home use printer brands with a business model aimed at making money off the printer cartridges. They're not selling printers, they're selling plastic to fill refuse dumps. Be that as it may, the motors, gears and particularly the shafts are well worth stripping and salvaging. When family friends hear that I can use discarded printers for model engineering they are more than eager to drop off their unused printers. Generally speaking, all the shafts and spindles are made from polished free-machining rod, which works very well for all sorts of components and shafts on the locomotive frames.

If the printer is one of those combo units with a top scanner the glass can be fixed to a piece of wood and used as a gauge plate, especially handy when lapping valve surfaces.

Welding gloves, electronic chargers and plastic

For some reason I seem to always have an abundance of these items so I decided to find a use for them. Welding gloves make pretty good fibre washers or fibre seal replacements, provided they don't see appreciable heat. I once used a piece of welding glove as a bearing for a little toy I made as a gift for a friend's little one. It was wrapped around a shaft with a strap holding it in place and connecting it to the connecting rod of a wobbler type engine. The leather was well oiled and worked like a charm.

I generally use the normal gauntlet welding gloves for furnace work but I do sew a flap from an old welding glove from the palm to the finger tips to improve heat resistance and make the gloves last a little longer. For TIG welding I roll a good piece of an old glove and sew it in the form of a leather ring to fit over my TIG welding gloves so that I can rest my welding hand on the job without burning myself through the thinner TIG gloves.

I have a treasure box full of old electronic chargers that come in handy for all sorts of projects. These chargers are used for everything from electro-stripping tanks to electroplating and even LED lighting for the workshop. Most of my LED lighting designs are based on the electronic charger I want to use, with the number of LED's and resistor to suit the voltage.

Plastic is not something that is used very often in my home workshop but when it is needed I prefer making my own bars as opposed to buying new. This can be done by stuffing some plastic bits into a copper tube and melting the lot slowly and carefully with a blow torch. A weighted steel bar will press the bits into a usable plastic bar. This needs to be done in a well-ventilated area, keeping the temperature low (if you hear a popping sound it's getting too hot) to prevent any fuming, which is poisonous.

In closing

Back to the Stirling safety valve cover; by mixing copper from the windings of a motor with a die cast candle stick holder (typically made from die cast zinc to make it feel heavy and costly) a little lead from sinkers or tyre weights in the right quantities, and you have ornamental brass. See, I wasn't being disingenuous!

Model engineers leave more than their fine models for the next generation; we also leave a carbon footprint when we walk on this fragile living planet. A workshop and foundry doesn't need to be a dirty place. A mere two meters from my furnace I have a veggie garden and a goldfish pond with all manner of animals visiting my garden and workshop (**photo 8**). This tells me I can't be doing too badly.

ME

Silver soldered insert tips.

A regular workshop visitor.

The Barclay Well Tanks of the Great War

PART 70

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

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.

Continued from p.25
M.E. 4654, 4 December 2020

Current progress

I think it might be a good idea to reinstate 'Current Progress' now that work has restarted on the 0-6-0. The boiler, made by John Gaunt in Devon, is now with me thanks to an efficient and inexpensive, door-to-door delivery; Devon to Andalucía arranged by Eurosender. See **photo 320**, which shows the boiler in its plastic box and packaging. I've told 'er-indoors it's a three-dimensional horse brass for an iron horse and she's promised (very kindly) to add it to all her other, once a week, polishing jobs!

Now I'm in possession of the boiler (it is the first one I've not made myself and, in retrospect, it's a surprise I've never set fire to my shed!) I find that I am freshly motivated and have decided to fit out the boiler independently and carry out the steam test. All of the parts to be made, such as smokebox, grate, ashpan, water gauges etc. will be needed anyway.

Tank filler and oil-box

Looking at the front view of the engine (photo 302, M.E.4644, 31st July 2020) I

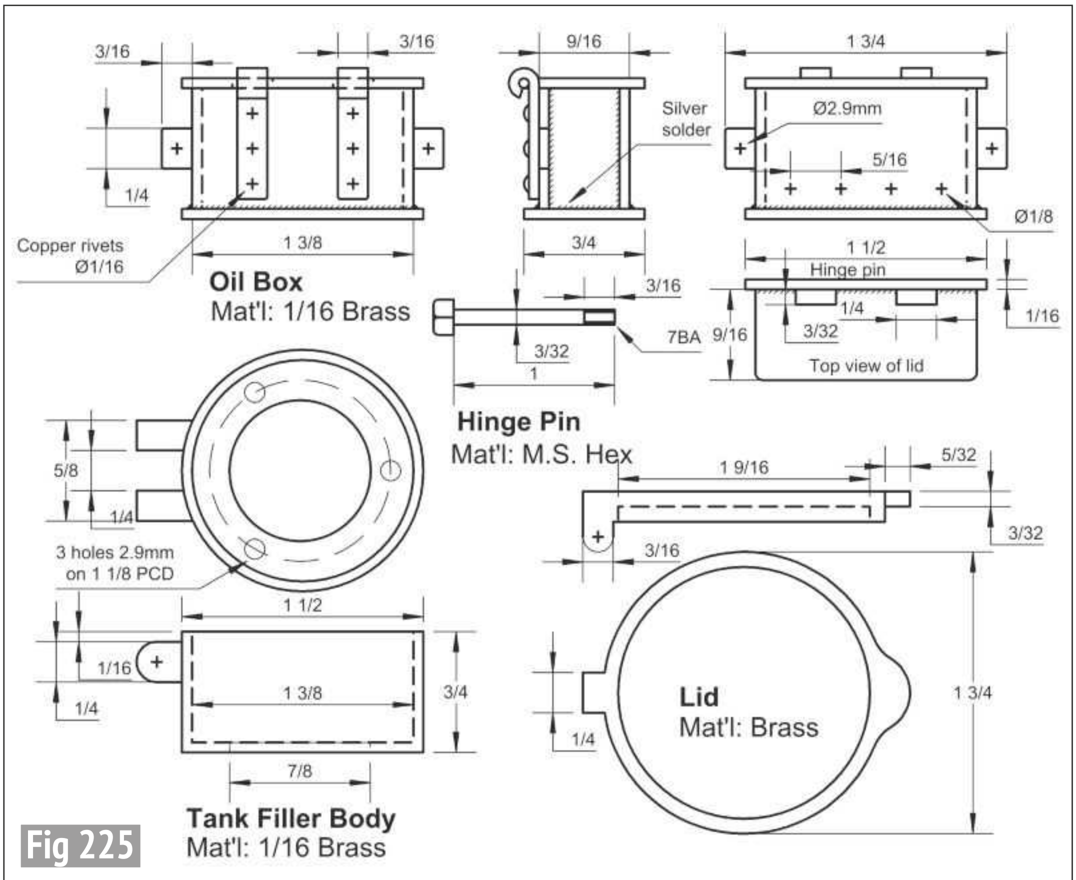


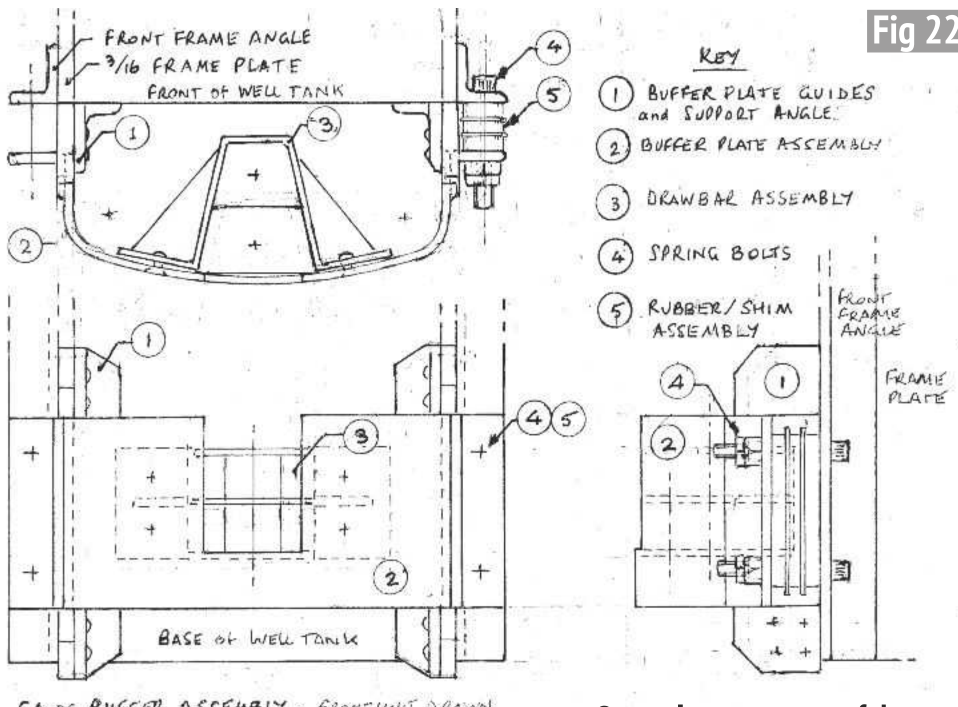
Fig 225

Now I'm in possession of the boiler (it is the first one I've not made myself and, in retrospect, it's a surprise I've never set fire to my shed!) I find that I am freshly motivated.

was struck that the well tank filler presented an attractive feature on the front of the tank. So, as a bit of an aside to the main work, I decided to have a go at making it. **Figure 225** presents its dimensions. The job's a bit fiddly but with plenty of scrap brass available, along with careful silver soldering, it came out well – see **photo 321** which shows the prototype filler.

Once painted, of course, a multitude of sins becomes hidden! The original brass work is shown in **photo 322** and the finished item in **photo 323**. To provide a good key for the paint I etched it in concentrated hydrochloric acid containing a dash of hydrogen peroxide . Over here in Spain concentrated hydrochloric acid is available in any grocery store and is called *agua fuerte,* which translates as 'strong water' – a bit of an understatement I always think! And, in the shop, it sits on the shelf next to the caustic soda...

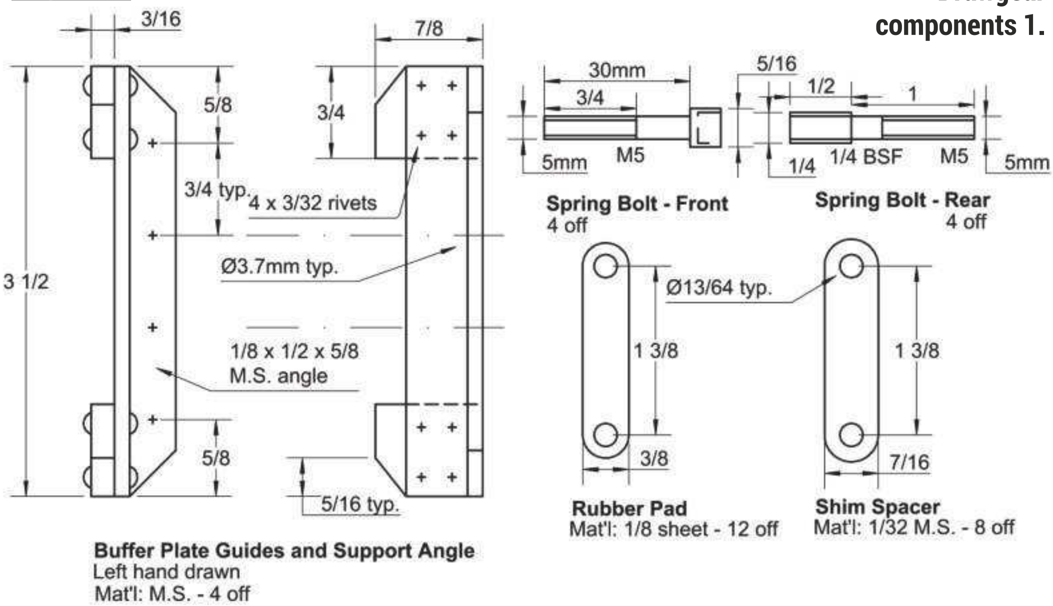
Fig 226



General arrangement of drawgear.

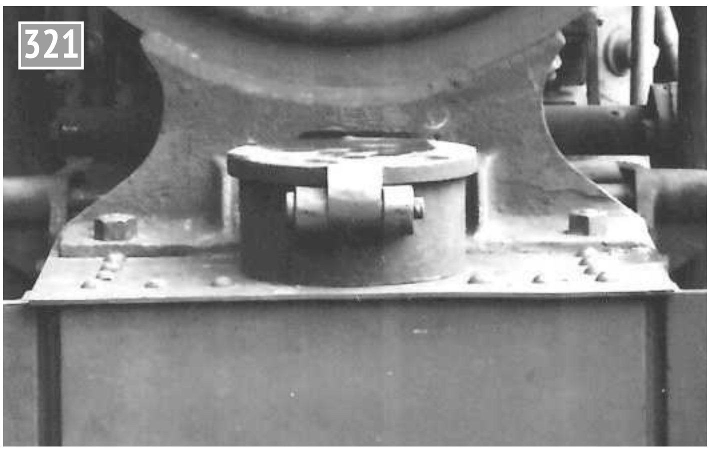
Fig 227

Drawgear components 1.



320

321



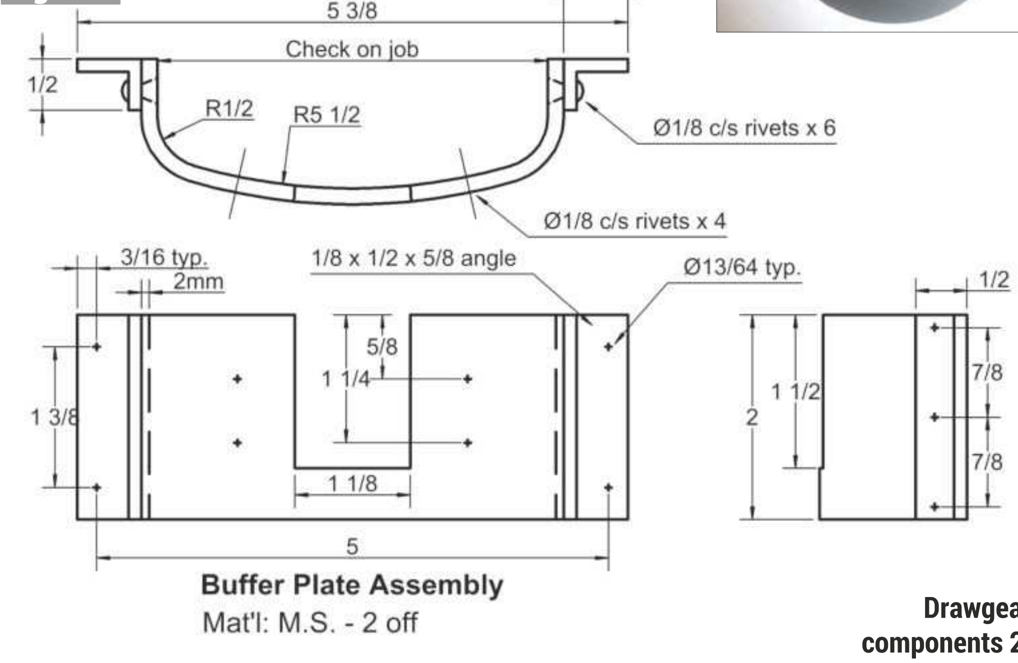
LEFT: Receipt of the boiler. RIGHT: The water filler (author's collection).

322

323

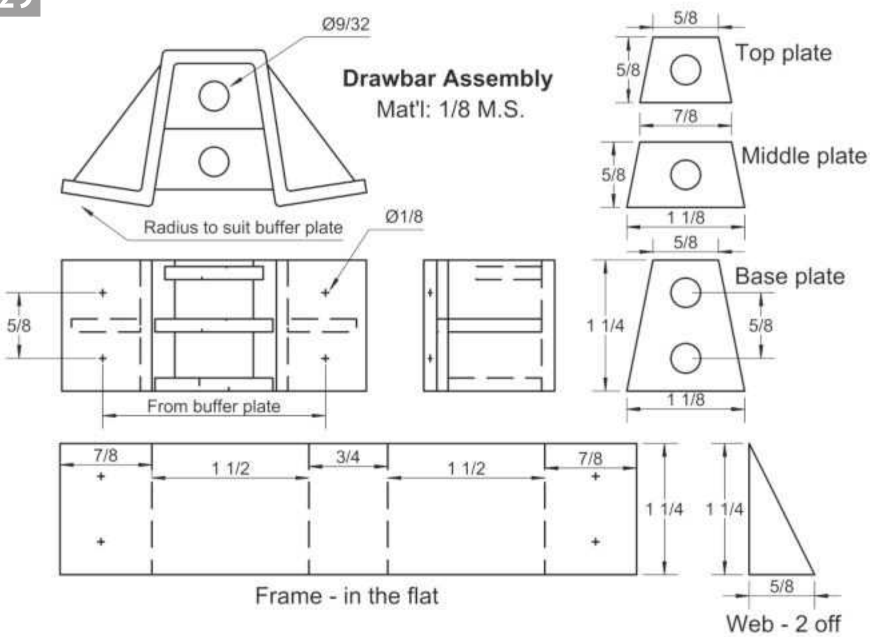
LEFT: Water filler components. RIGHT: The finished item.

Fig 228



Drawgear components 2.

Fig 229



Drawgear components 3.

Note that the original hinge was fitted with a plain rod held in place with a split pin – this is a bit small fitted to a $^3/_{32}$ inch diameter shaft so I have used a custom-made 7BA bolt turned from 8BA hexagon stock. The filler assembly bolts down to the well tank lid with three 6BA bolts on the inside of the filler body. A $^1/_{32}$ inch thick gasket will seal it to the tank lid. Figure 225 also gives the dimensions of the oil-box – as illustrated in figure 224 (M.E.4654, 18th December 2020). The box is drilled with ⅛ inch holes for connecting the six ⅛ inch diameter feed pipes using silver solder. The assembly will be fitted before the lid is in place, so the plumbing is hidden once the lid is fitted. Alternatively, small unions could be soldered into the box for connecting the pipes if one prefers to 'gild the lily'! The lid is to the original LBSC design; it's easy to open for filling and impossible to lose.

Drawgear

A Plasticard mockup of the drawgear was shown in photos 309 and 310 (M.E. 4648, 25th September 2020). It was difficult to determine the internal details of the drawbar assembly; numbered 3 in the general arrangement drawing (**fig 226**). I checked all the various reference books I have relating to the use of 60 cm railway rolling stock in WW1, but photo 308 was the only relevant picture I could find and that was of little use. And, as mentioned earlier, I finally concluded that the design allows for the connection of various heights and lengths of drawgear to the locomotives, in conjunction with a variety of pins and rods; which were most likely carried on the locomotive.

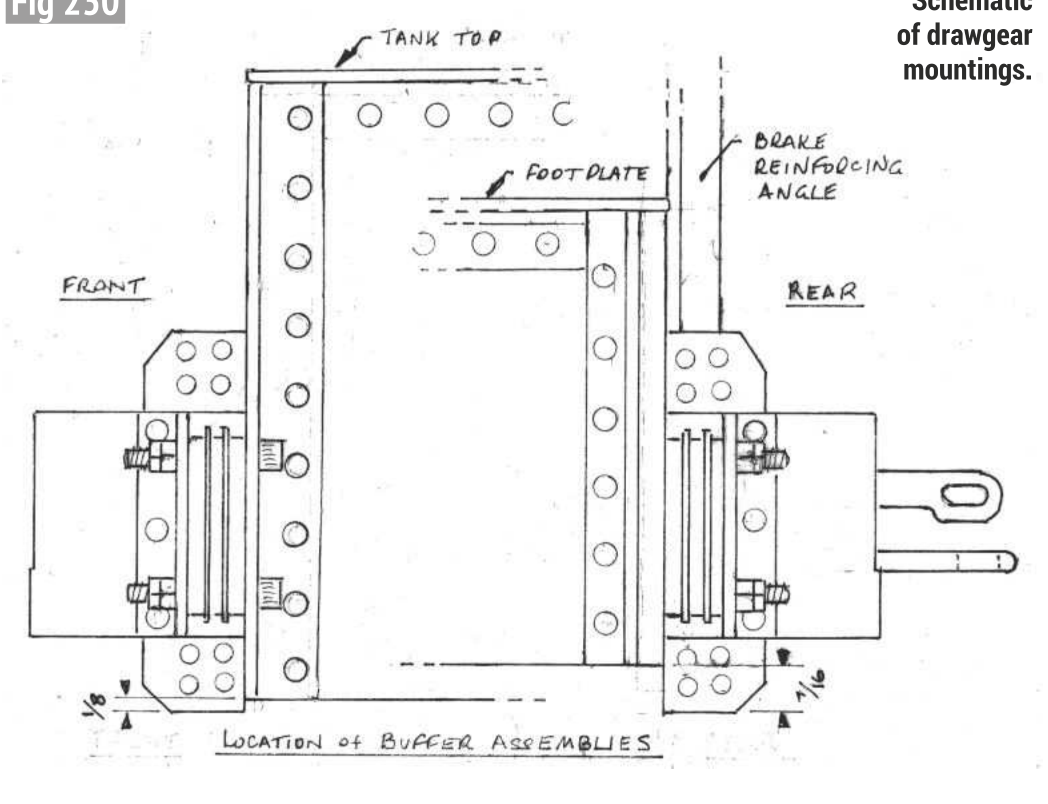
I would imagine that the internal component of the full-size assembly would have been a cast item bolted with studs to the inside of the buffer plate. For our purposes a fabrication will be required; made from mild steel and silver soldered together. Fixing it to the buffer plate is not straightforward, as no fixings show on the face of the beam, so the easy way is to use iron rivets with the heads countersunk on the buffer plate, finishing off by grinding or filing them flush with the plate.

Bending up the buffer plate will not be an easy task as it has to slide comfortably over the two guides, one on each side. Therefore, it is probably best to fit the guides first and then make the buffer plate to fit. The radii shown are not critical as long as both front and rear plates are the same. The most difficult part is probably the drawbar assembly as this will need silver soldering – and with so many parts, not an easy task. **Figures 227** and **228** detail the various parts and the sketch in **fig 229** gives some idea of how it all fits together. I would make the frame first, cutting through partially at the joints and then reinforcing these with silver solder or brazing alloy after bending. I note that the dimensions here are not critical, as long as the front opening is wider than the opening in the buffer plate. Once the frame is made all the other pieces can be silver soldered to it, after wiring on with rusty iron wire.

During the preparation of **fig 230** it became obvious that there is a minor error in the depth of the rear beam. Quarter of an inch needs to be removed from the bottom of the beam. This means that the fixing holes for the rear drawgear, shown on figure 217 (M.E.4652, 20th November 2020), are ¼ inch too low, but this should not prove to be a problem as these need to be spotted through from the buffer plate and positioned as shown in the figure.

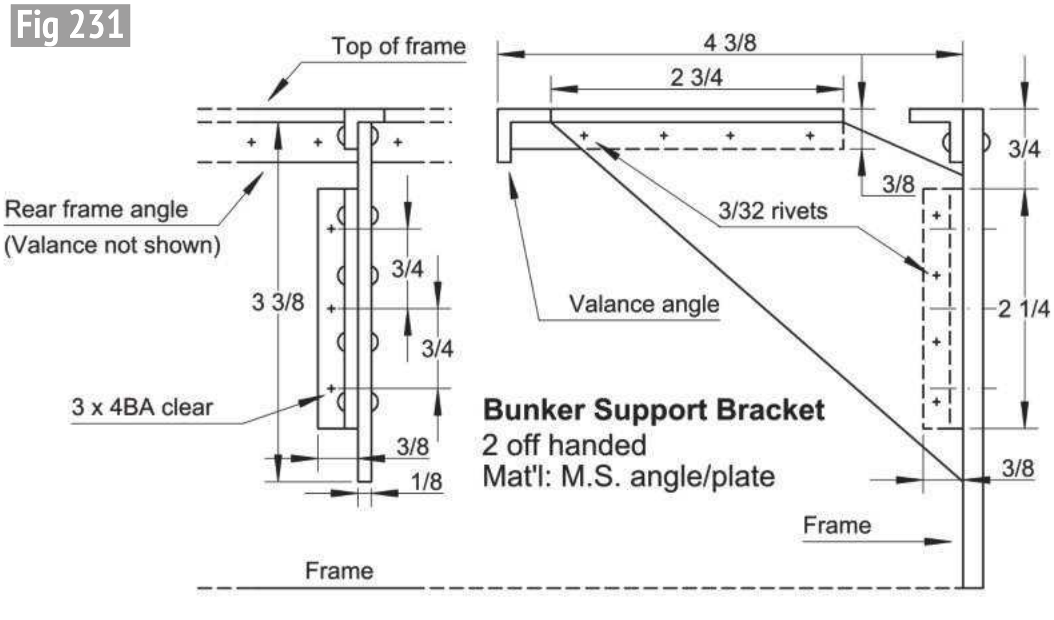
A cosmetic improvement can be made to the two front angles on the well tank. These may be made from ½ x ¾ x ⅛ inch angle; i.e. the part that is riveted to the frame should be increased from ⅝ inch to ¾ inch. This will give a bit more clearance around the rivet heads.

Fig 230



Schematic of drawgear mountings.

Fig 231



Bunker support brackets

These two brackets (**fig 231**) carry out the same function as those on *Douglas*; i.e. they support the front of the bunkers and the cab structure. The main difference, when compared with the 0-4-0, is that the two acute angles are not truncated (see fig 21, M.E. 4517, September 2015). Note that they are handed.

●To be continued.

NEXT TIME

We consider the springing of the locomotive.

A vessel moored in Vigo harbor in Spain.

Realistic Rust

Ron Wright perfects a technique to give an authentic appearance to a marine model.

I was very impressed (going back some years now) with Ray McMahon's superb model of a steam drifter (*Model Engineer,* 26 August 2011), not least by the weathering which is so clearly evident.

Some years ago I took **photos 1** and **2** of vessels moored in Vigo harbour in Spain whilst on holiday. This was for research for a kit-built model coaster, *Talacre* in 1:48 scale, by Caldercraft, which I have now just about completed.

My intention has been to construct this model to show how the real craft would most probably have appeared after several years of service, bearing in mind that ships of this kind were often operated with minimum crew numbers to reduce costs to rock bottom, thereby allowing very little time for maintenance and painting etc. I think that the two photos do show just how extreme the results of this policy could be.

A closer view of the rust I am trying to recreate.

One problem with depicting rust on a model is that real rust has a very definite rough surface texture which I have found quite difficult to realistically reproduce using just paint alone. Also, real rust expands to rise above the surface on which it has formed. **Photograph 3**, which was taken


Deck rust painted over.

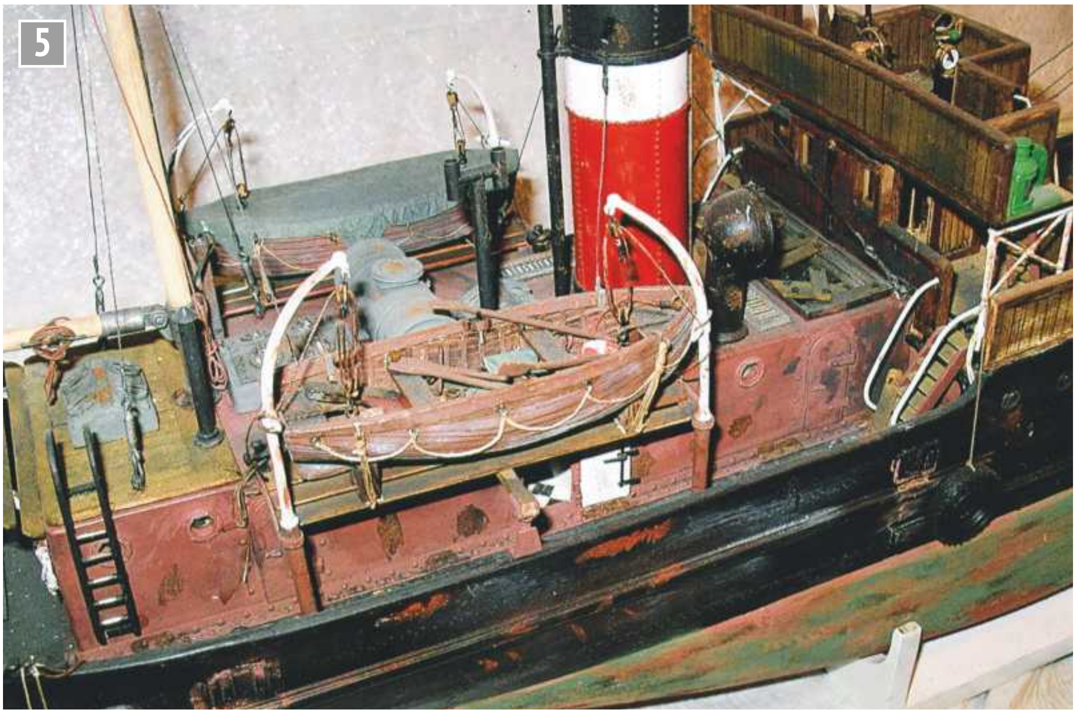

My finished model.

on the coaster, *Robin* when on view in St. Katherine's dock at Tower Bridge, shows this; where although the rust has been painted over, the 'bulging' profile above the surface is readily apparent.

All this, of course, makes the problem of realistic re-creation even more difficult, but I managed to evolve the process described below which reliably produced a rough and raised texture. **Photographs 4, 5** and **6** are general shots of the finished model and photo 6 is a close up of one of the rust patches created as follows:

Firstly, the surface is painted the desired colour and then weathered to a dull and faded appearance, then the patches where the rust is desired to be are brushed with clear matt varnish. Following this, 'dust', in the form of crushed and ground chalk of an appropriate colour, is blown on to the wet varnish, as shown in the posed **photo 7** (no laughing please!).

A small quantity of the dust is held in a little spoon, or spatula, and then 'puffed' on to the surface where it will adhere to the varnish. For this I used an empty plastic glue bottle with a fine spout which, when firmly squeezed in at the sides, worked well - i.e. it 'puffed' very well indeed!


Surface rust on the hull.

Also, of course, when dry, more layers can easily be added to raise the rust patch to any desired level above the surface. This method can also be used for applying under-water marine growth using suitably coloured chalk dust, as this too has a very uneven surface. However, on a working model this might have an adverse effect on performance; my model is for display only so this is of no consequence. **ME**

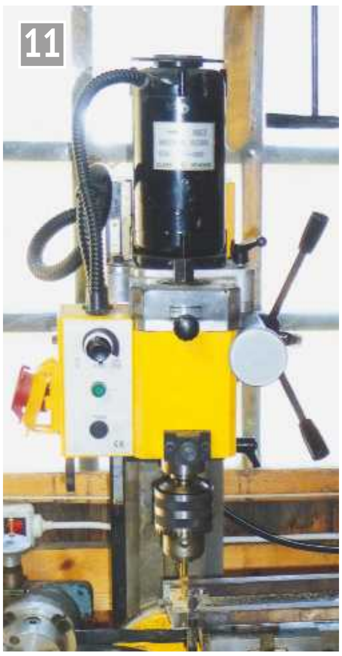

General 'neglect' on the deck.


The 'puffing' technique.

Trials and Tribulations with a Mini Mill PART 2

Terence Holland gets tooled up.

Continued from p.88
M.E. 4654, 1 January 2021



Close-up of the belt conversion.

A Mini Mill discovered

On discovering the Mini Mill I assumed I'd found some sort of engineering elixir. It was fairly small and not too heavy but the bed was long enough to machine items such as locomotive coupling and connecting rods etc. After much deliberation (and carefully avoiding the moths flying out of my wallet) I decided to buy one. So there it sat in my workshop. Beautiful, all bright and shiny, 'brand spankers' as they say, and ready to solve a lifetime's problems. Or so I thought…

I used it a couple of times on light jobs when, suddenly, there seemed to be no connection between motor and chuck. Odd, I thought, but I wasn't prepared for the shock I received on opening up the gearbox – PLASTIC GEARS with no teeth! Well that was it, I'd couriered the machine from the UK to Spain so I couldn't just pop it back to the shop. Several emails to the company went unanswered so, for a while, it was back to the Rodney. An Internet search revealed that this was a common occurrence – no one had told me at the time that it wasn't a mill but a child's toy! All was not lost, however, as I found a very helpful company in the USA who made a belt drive replacement kit for the so-called 'gearbox' and promptly ordered one.

And for several years things were perfect. The belt drive kit was inexpensive, easy to fit, nice and quiet in operation and enabled the machine

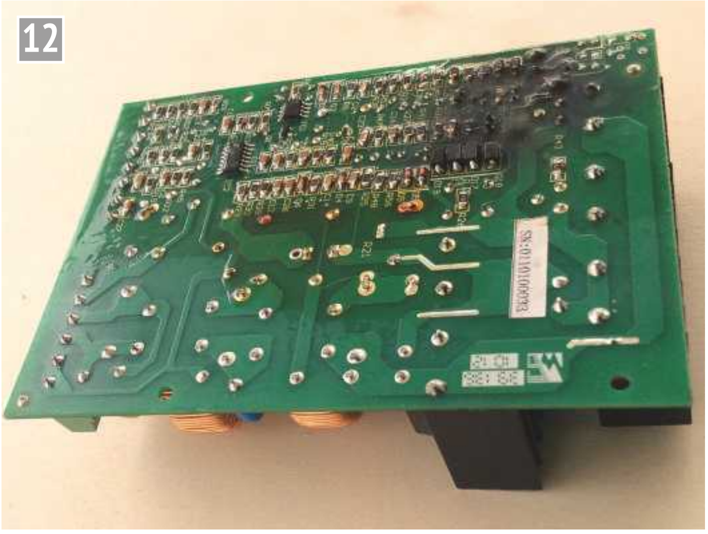
Mini-mill with belt drive conversion.

to carry out useful work. **Photographs 10** and **11** show the mini-mill fitted with the belt drive conversion - there are no photographs of the initial 'gear' problem because I was so disgusted that I forgot to take any!

Disaster strikes - again

Well there I was a few years later, happily milling away, when there was a popping noise accompanied by the emission of some smoke. Suddenly the mill would only work at full speed – which doesn't do the cutters much good. Now I'm old enough to know that when a piece of electronics emits smoke 'fings ain't wot they used t'be son' – as Max Bygraves might have said. And, of course, I was correct – see **photo 12**, which shows the back of the control board complete with black stain. Once again, it was back to the Rodney.

'Enough's enough', I thought and being the old geezer that I am I decided to get back to basics, do away with the fancy DC motor and fit



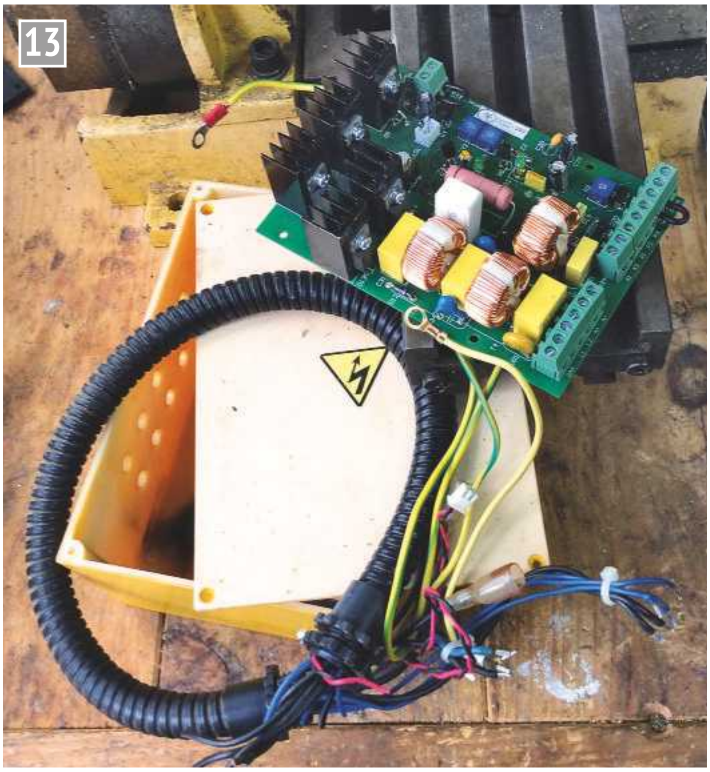
Damaged control board.

an old fashioned one, with a reduction gearbox driving the existing belt drive. Some drastic surgery was called for and **photo 13** (unlucky for the mill) shows all the bits that aren't going back – no new-fangled stuff for me and, as we all know, you can't make omelettes without breaking eggs or, to use another idiom, you have to be cruel to be kind!

Old-fangled mods

Having made the decision to proceed with major modifications (as opposed to installing an expensive, new electronics board) it was necessary to decide what gear reduction was needed to feed the two-speed belt drive. That was when things started to get a bit complicated!

I happened to have a fair, old collection of Myford gears acquired over the years, so using a couple of these seemed a good starting point. I sorted out two sets, each with the same centre distances, with teeth ratios of 28:70 and 45:55. I had a useful 230 volt, ¼ horse power motor from an old, redundant pillar drill with a



Collateral damage.

motor speed of 1,200 rpm. And I was retaining the 'retrofit' belt drive, which gave me a choice of two speed reductions: 1.25 and 3.5.

So, this gave me three options with the motor:

1 - Direct drive to the belt
i.e. no gears
2 - Gear reduction (45/55) of 1.2
3 - Gear reduction (28/70) of 2.5

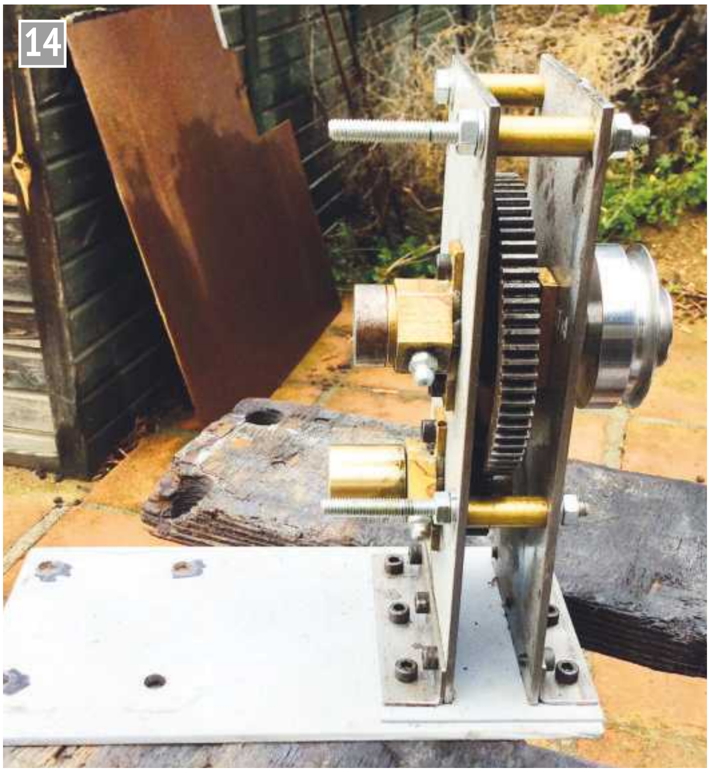
With the belt reduction options of 1.25 and 3.5 and a motor speed of 1,200 rpm this gives the following approximate speeds at the cutting tool:

1 - No gears – 340/960 rpm
2 - Gear box
45/55 – 290/800 rpm
3 - Gear box 2
8/70 – 140/380 rpm

There is a wide range of recommended cutter speeds for various materials, so I made a compromise and used the recommended speed of 60 foot per minute for cutting mild steel with an HSS cutter. This gives the following approximate speeds for different cutter diameters:

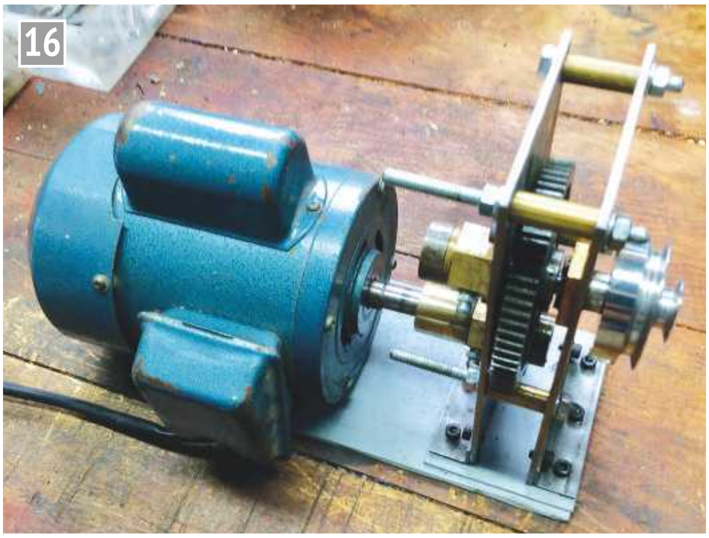
¼ inch - 920 rpm
½ inch – 460 rpm
1¼ inch fly cutter – 180 rpm

From this I decided that option 1, direct drive, would be correct for small diameter cutters and option 3 for slow feeds and fly cutting. I therefore went for the 28/70-tooth gear option giving me a choice of 140 or 380 rpm but, if I want to, I can change the Myford gears and obtain 290/800 rpm, which is not that far off direct drive. I pays me money and makes me choice… »



The gearbox with belt drive pulley on the right.

The gearbox with endplate removed to show gears.



The gearbox and motor connected.

The Oldham coupling.

Final set-up.

To conclude

With all these variables (including what selection of gears is available) I haven't included any drawings of my gearbox, as I don't think they would help that much. However, **photos 14**, **15** and **16** should give some idea of what's needed.

The only problem I had with the project was connecting the motor to the gearbox without everything tightening up. I cured this by making an Oldham coupling, with the centre section machined from a chunk of nylon I've had for years – just waiting for such an application. I was going to use PTFE but nylon is a lot tougher and less likely to shear. These couplings are easy to make (as long as you have a milling machine!) and solved the problem perfectly (**photo 17**).

Photograph 18 shows the final set-up with the safety guard removed so the moving parts can be seen. Note the use of 6mm threaded rod which enables a support to be put in for the motor overhang, as well as providing somewhere to fit a guard. The end plates are made from ⅛ inch mild steel and the two shafts run in plain brass bearings.

It works fine – it's a bit noisy perhaps but at least it's functional and there is nothing that can go wrong that I can't fix. I like things to be under my control, although I 'm not daft enough to say that to 'er-indoors… **ME**

NEXT ISSUE

Bridget Boiler

Jon Edney makes a copper boiler for his 7¼ inch gauge Ken Swan locomotive Bridget, previously described in these pages.

Whittle Turbofans

Ralph Oliver looks at Frank Whittle's early work on fanjets, creating a much quieter and more efficient jet engine.

Making Tee Section

Nigel Bennett goes into mass production of brass Tee section for the cab of his Isle of Wight 0-4-4T '02' locomotive.

Model Frame Saw

Peter Evans models a reciprocating frame saw, of the type used for sawing up planks under steam power.

Content may be subject to change.

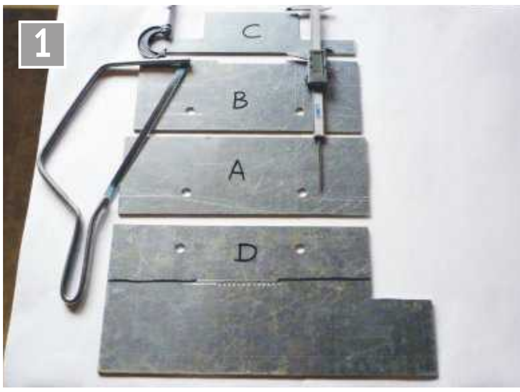
ON SALE 29 JANUARY 2021

Rodney Oldfield constructs another of Bob Middleton's small but interesting engines.

The Middleton 'Monitor' Type Engine

PART 1

Once again Bob Middleton has designed a very good looking engine, interesting with lots of moving parts and low slung. The initial idea came from a feature and one photograph of a group of people in the USA who found the remains of the *USS Monitor* ship in the mud of a river bed. It had both left and right cylinders cast in one solid block. This boat was one of the first iron clad ships in the American Civil War.



Engine frame plates.

I first built the 'Monitor' type engine in 2012 and, because it is such a strong, robust and appealing engine, I thought it would be an ideal model to make for my grandson Jake which he could fiddle with and turn the fly wheel on to his heart's content. Whilst I built this model I took some photos and made some notes.

Why build a stationary engine? – because Bob's engines can be built from scratch with bits and pieces you already have, pieces from your local scrap man and stock from your local metal merchants. They can be built in four to five months and you can at least lift it by yourself when finished.

Working from Bob's drawings you can always add bits and modify them to your own design and wishes. So, please have a think about building a 'Monitor' engine and use whatever screws you have available to the nearest size (BA, Metric, Whitworth, Button heads, Cheese heads, and Hexagon heads) as long as they look in keeping – size wise and cosmetically.

I have written the following notes the way I built my engine and in the order I built the 'Monitor' engine. I am not saying you should do the same but it may be a starting point and a guide.

I have deviated on the outer profiles on some of the parts from the original drawings, e.g. vibrating arm and rocker arm, and where I have done so I have tried to indicate and state why.

The drawings for this engine are available at **www.modelengineeringwebsite.com/USS_Monitor_engine.html**

Engine base frame plates

When I build a model I usually start with the base or, in this case, the frames (**photo 1**). This way, as you

»

Base tie rod bushes.

Drilling the frame plates.

go along making the different pieces, you can add them straightaway making sure that everything fits and runs freely. Having no plate available, I went to see my friendly local scrap merchant and was able to buy three pieces of plate 3mm thick.

Now we all know that cutting plate is not easy unless you have a miller big enough and want to use it. Anyway, I cut mine out by hand just to prove a point. I started out by marking out a strip $3\frac{1}{16}$ x 14 inches long, using my trusty hacksaw, which I made when I was a 15 year old apprentice and which is very handy because it has a 5 inch throat. Keeping just to the right side of the line, saw down from either end, then drill a series of small holes across the middle as on plate 'D' in photo 1, then with a pad saw separate the plates.

You will eventually end up with four plates, 14 inches long by 3 inches wide. From the centre of the plate mark 3 inches either side, 2 inches down from the top then mark 1 inch up from the bottom to the outside. From the corner of the scribed line mark ¼ inch out and ¼ inch up, centre punch and drill a small pilot hole through, then open it out to a ½ inch hole as in photo 1. Next, saw accurately down the scribed lines and file to size using digital read out callipers, as on plate C in photo 1. Using this as a template, mark out the outlines of the remaining three plates, drill ½ inch holes and cut out and file up accurately.

Once all four plates are cut to size, stamp in the correct length order: A, B, C and D. Remember plates B and C are shorter on the 1 inch thick leg. Using a piece of scrap plate material cut a 2 x 1½ inch square plate for the bearing pad. Mark out and drill for the rivet holes (do not drill the centre hole). On the inside of plate D rivet the thrust pad into place. Mark out all the holes as accurately as possible. I used 3BA countersunk screws for the six top holes because I have plenty but use whatever you have. With great care line up all four plates using a packing piece between C and D because of the rivets. Clamp together very carefully and drill through all four plates using the correct diameter drills (**photo 2**).

I have not got a ¾ inch reamer so with a bit bigger pilot hole I drilled through with a ¾ inch drill and was satisfied with the result. Remember you are turning the thrust bearings so you can always adjust.

Only drill the four holes on the end of the 1 inch strips on plates A and C to the size of the screws you are using.

Cylinder mounting plate

I machined two pieces of aluminium 1 inch wide exactly by 6 inches long but they were 0.030 inch down on the ½ inch size. However, it does not matter. On one mounting plate I drilled four holes on top for the cylinders.

I used ¼ inch Allen cap screws because it is easier to tighten them up onto the cylinders.

(Note: **do not** drill both plates as I did!) Remember this goes between plates A and B.

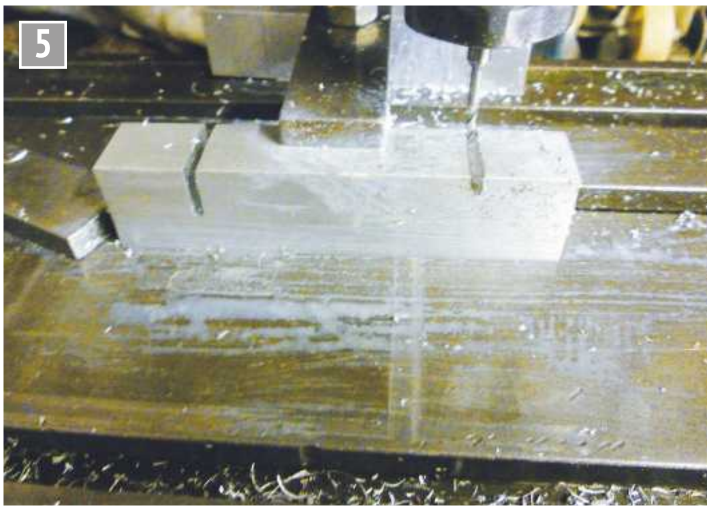
Next machine four 1 inch base tie rod bushes out of ⅜ inch steel bar with a 2BA clearance drill through as in **photo 3**.

Using these pieces, with the mounting plates lined up exactly on top, clamp together plates A and B as in **photo 4**, check that everything is square and spot through, drill and tap both sides. I used 3BA countersunk screws (because I have lots). Repeat for plates C and D. Then I machined two pieces of ⅜ inch diameter bar exactly 2⅞ long tapped 2BA at both ends.

Outrigger base

Taking two pieces of 1 inch square aluminium bar I machined them down to 5⅛ inches exactly and I marked them 1 inch in from both ends. Then, placing them in the miller with a ⅛ inch ball ended slot drill accurately on the line

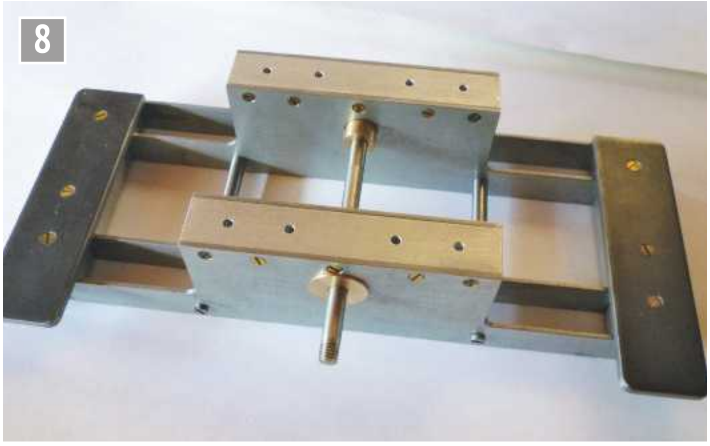
Spotting through the frame plates.



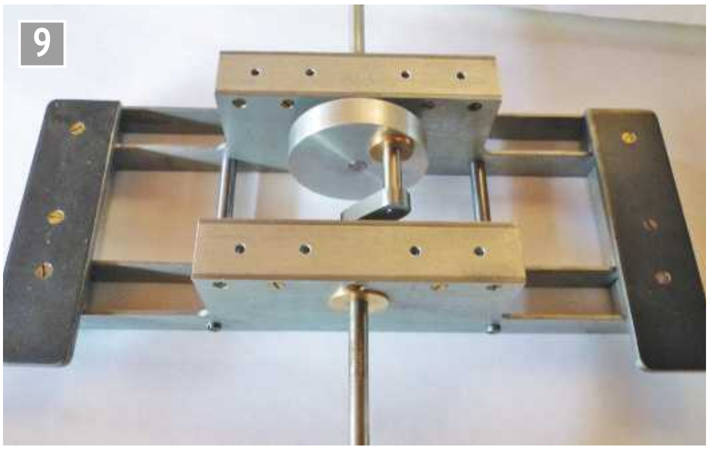
Machining the outrigger base.

Construction of the frame.

Thrust and front bearings.



Aligning the bearings.



Crank and crank pin assembly.

I milled the slots ½ inch deep (**photo 5**).

Build it up as **photo 6** making sure the tops of the plates and the bar are level and everything is square. Spot through the four end holes, drill and tap. I use cheese-head screws - make your own decision.

Then, turning the frame over, mark off ½ inch in from the ends and ⅝ inch in from the front and back frames.

Drill and tap all four corners - these are for the feet. I used 2BA, but use whatever is available to you.

Thrust and front bearings

Make as drawings. The piece of brass I had was $1\frac{3}{16}$ inches, which was ideal for me because I wanted to place a small counter sunkscrew in the flange to locate it whilst I was building it all up. Turn the ¾ inch diameter down to size making sure it goes through the frames with a good fit and approximately ⅛ inch longer, drill and ream, part off, turn around and face off the flange to width (**photo 7**).

Place into the frames and line up with a piece of ⅜ inch bar through the bearings. If they do not line up don't be afraid to tap the bar with a soft hammer and run a reamer through both bearings - I had to do this (this is where the 8BA screw comes in handy). **DO NOT MOVE ON** until the bar is running free (**photo 8**).

Outrigger top plate

Machine to drawing size and drill through the three holes marked 'A'. I used 3BA countersunk screws because I have plenty, but use whatever you have. Clamp it onto the top frame, spot though, drill to tapping size and tap. Remember the ⅜ inch overhang.

Inner flywheel

I was fortunate enough to have a 3¼ x 1 inch thick piece of aluminium. I turned it down to size and reamed a ⅜ inch hole through, taking great care to get everything running true. Next I machined down to size the crank making sure it was perfectly flat. I marked out the 1" centres accurately then drilled and reamed the ⅜ inch hole through. Then, placing it onto the fly wheel with a ⅜ inch stud through the centre, I clamped it onto the milling machine. After locking everything down I drilled an 8mm tapping size hole through the crank and through the flywheel. Whilst everything was nipped up and square I started tapping the crank 8mm. Making sure the flywheel didn't move I took the crank off and drilled through and reamed the fly wheel ⅝ inch diameter then made the flywheel insert to suit. Machine and thread the crank pin to drawing sizes, being extra careful to keep everything square whilst screwing it together.

Place the crank and crank pin in the fly wheel, slip it between the frames and push the ⅜ inch bars into the fly wheel and the crank (**photo 9**). Hopefully it will turn - mine was quite tight but, with a bit of tapping using a soft hammer and help of a well-placed reamer, a scraper and a few swear words, I finally got there.

Drill and tap the inner fly wheel and crank for grub screws so that they will nip onto the ⅜ inch shafts.

When all is built up, measure the inner crank pin, which should be 1 inch long. To achieve this, machine the appropriate amounts off the thrust and inner bearings. When all is to your satisfaction turn the retaining rings for the thrust and front bearings, then drill and tap for grub screws.

●To be continued.

CLUB NEWS

Geoff Theasby reports on the latest news from the Clubs.

Evening All!
Several items have been held over due to the plethora of interesting contributions. I hope it didn't spoil Readers' enjoyment of Club News, if, indeed, they can conceive that state....

One reader in particular will receive a pleasant surprise, so *Schtumm* for now.

Paul Ohannesian, editor of the **British Columbia Society of Model Engineer**'s *The Whistle*, had his ego recently polished, as an item on his locomotive, *Phoenix,* was published in the *Live Steam* magazine November/December 2020.

In this issue.... Rationalisation, a 'gas' lamp, a Skeoch, a school locomotive, a J63, sprockets and A. G. Bell.

The Newsletter, November, from **York City & District Model Engineers,** begins with a photograph which is definitely not of York. A clue is that the subject, *Blanche*, was built in Yorkshire, and another is that York member Paul Martin is a regular driver, and 'she' is his favourite. Mike Waters compares vice jaws; soft, for the gentle holding of, and, having made several sets, in brass, aluminium or fibre, concludes that those magnetically held into the vice are the best. (I agree – Geoff.

Zero MP Alfreton (photo courtesy of Derby Heritage).

– Must get some – Ed.). Paul Tanner writes on the making of a zero milepost. It is in the style of the famous example at York Station, not that of Alfreton, Derbyshire (**photo 1**). Fittingly, for a newsletter beginning with a locomotive, it ends with a guards van. Editor Roger Backhouse is pictured with friends in said van on the occasion of Titley Open Day 2004, the 40th Anniversary of the closing of the Kington to Leominster branch.

W. www.yorkmodelengineers.co.uk

Model and Experimental Engineers, Auckland's *Newsletter* for October, bears a brief explanation of why North America went for 7½ inch gauge, rather than the 7¼ used in 'the old country'. 7½ was chosen as being more accurately 'scale' to the 4 foot 8½ inches of the standard gauge. Graham Quayle has had to give up his business for health reasons. His retirement village has agreed that his glass-cased Showman's engine can be displayed at the entrance. His collection of small models is being found good homes and his business activities have gone to a friend in a similar line of work. (A friend of mine is rationalising his lifetime's collection of amateur radio gear. Some will be sold, some will be kept to remain in use and some will be given away to innocent victims (club members)– Geoff. Murray Lane has produced several aids to help him see his work. These include a headband magnifier and better illumination.

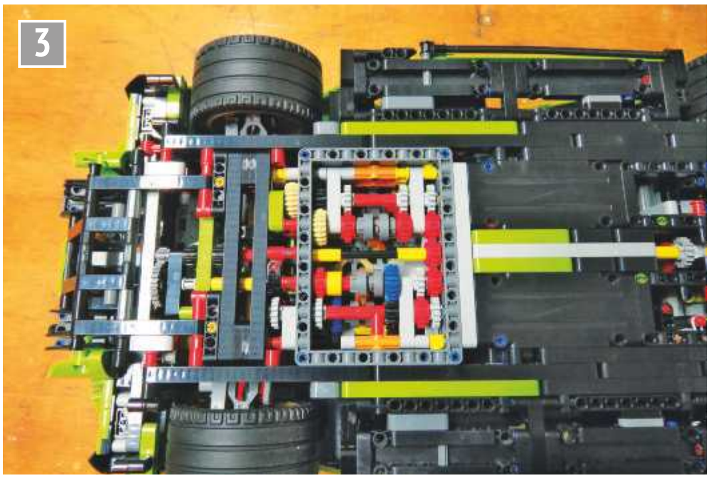
The Cam, October, an eccentric newsletter from **Cambridge and District Model Engineering Society**, reports that co-editor Tim Coles is to make an LBSCR, 2-2-2 *Grosvenor,* inspired by the runner-up in the recent LittleLEC competition. That locomotive, by Carl Jones, despite being a single-driver, pulled a scale weight (Carl...) of 300 tons on a wet rail. Co-editor Helen Hale has recently completed and steamed a kit locomotive, by no means easy with no engineering background or training. This was completed, together with a similar machine, by Pete Smith, another member. Helen found numerous problems and ill-fitting parts but was comforted by the fact that Pete, building the other, had similar problems. Alan Denney, years ago, rescued a gas lamp from Audley End Station, now closed, and has reacquired it after its sojourn at Saffron Walden club whose track at Audley End (Lord Braybrooke) has also had to close. Alan has a clockwork timer and gas jet, but incorporated 50 LEDs in a 'gas mantle' which looks authentic.

W. www.cambridgemes.co.uk

UK Men's Sheds Association's *Shoulder to Shoulder*, November, reports that Dalbeattie Men's Shed is attempting to replicate a Skeoch cycle car from 1920, using the original blueprints. Tragically, the original project failed due to a fire shortly after it began, in 1921. The Shed has raised over £20,000 towards the project, which is now almost complete. See it in action on YouTube, under 'Dalbeattie Skeoch Cart'.

Leeds Lines, November, from **Leeds Society of Model and Experimental Engineers**, begins with Chairman, Jack Salter, reporting on the various activities of the members under Covid restrictions. One forward thinking gentleman is rebuilding his workshop using engineering bricks, 'because they last longer'. He's nearly 80. There's optimism! The new owners of the Eggborough site are said to be favourable to a track being built there. Geoff Shackleton, about to embark on painting his Atlantic locomotive, says that all paints are not the same. The 'trade' paints are typically denser, and cover better. 'Motorists' shop' aerosol paints are not among them. Mark Batchelor writes on *Thunderbolt*. Originally built by Leeds Grammar School pupils in 1960, it has since fallen into disrepair and is now being refurbished by Mark, described by him as

Miniature silver chair (photo courtesy of Alan MacDonald).



Lamborghini gearbox (photo courtesy of editor Stephen Sandford).

a 'Heavy General' overhaul. Alan Macdonald, watching TV's 'Bargain Hunt' with his wife, found that his boon companion had conceived a liking for a miniature silver rocking chair. "You could make me one of those" came the 'request'. Now that he has finished it, it does look rather fine (**photo 2**). Bargain Hunt is no longer watched in the Macdonald household...

W. www.leedssmee.btck.co.uk

At this point, a slight contretemps occurred when I tried to join a discussion on Jit.si (An alternative to Zoom, M'Lud). Something took a dislike to something else and the computer sulked and threw a wobbly. It took ALL Sunday afternoon to get it up and running again. Consequently, I didn't write a word all day. A lighter moment came in a later Jit.si assembly, when passwords were being discussed. In an inspired burst of uncharacteristic wit, I suggested 'Jit.si Rose Lee'.

Chingford and District Model Engineering Society remembers the summer of 1950, when a portable track and a few exhibits were taken to the annual fete, on a day of glorious weather. George Wills' model motorcycle was awarded a One Guinea prize for the Best Model in Show. Mrs. Leiper was given special thanks for the gallons of tea for which the exhibitors always seem to develop a keen thirst on these occasions. Ted Jolliffe has a mill sporting a chunk missing from the table, where an irresistible force met an immovable object and the 'T' nut pulled out. Ted recommends junking the 'T' nuts and using 'T' bars instead to spread the load over a wider area. Ted suggests making them such that they are as long as the width of the vice normally used.

W. www.chingford-model-engineering.com

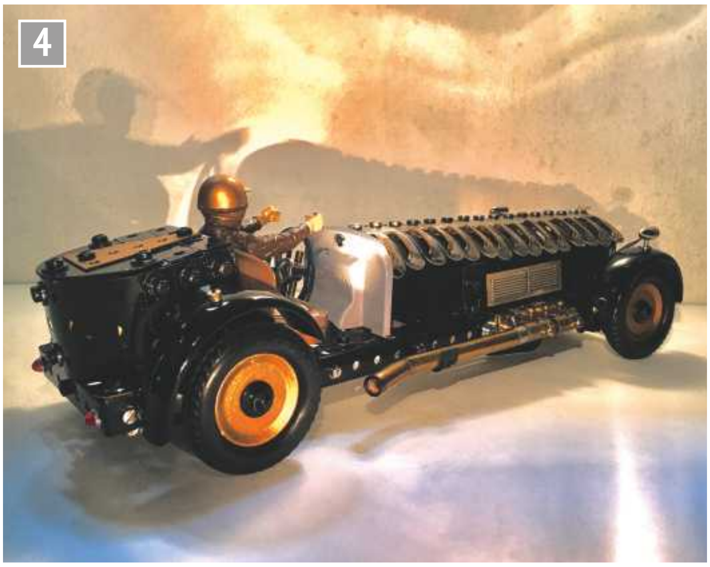
Blastpipe, November, from **Hutt Valley and Maidstone Model Engineering Societies,** goes to town on Roy Hamilton's Lego Lamborghini Sian, which isn't just ANY model Lamborghini, but needs almost as much assembly as the real thing. Here is a photo of the gearbox from below. Everything that can move, does so - doors open, the steering works, as does the drive train; and two assembly manuals, yes, two of them, are provided, as this is Lego on another plane, so to speak (**photo 3**).

W. www.hvmes.com

My 5 inch gauge locomotive *Deborah* has been treated to a starter motor from a motorcycle and this was coupled with a controller, a 24 volt YIYUN YK31C, which cost only about £10, and is claimed to handle 15 amps. Then I encountered a problem with these low voltage, high current circuits - contact resistance! The value of the resistance is not relevant here but the voltage drop across the connectors and along the wires is. The controller is intended for R/C models and came along with the correct polarised connectors. FOR R/C! I couldn't match any of them so I cut them all off and built a controller panel to test it. There is little information online but look for SPD-24100 for connections details in English. For measuring the contact resistance, i.e. voltage drop, a good electronic testmeter, or digital multimeter, by Fluke, for example, will be required. I found that the ¼ inch spade connectors in the motor leads lost 2.2 mV across each, that's 4.4 mV there and back. The wires to the ammeter lost 32mV each and 10mV is lost across the ammeter itself. All this adds up and could reach 1 volt, which should be going to the motor. The 24 volt battery meanwhile dropped only 900mV on load as measured at the terminals. So, every joint must be solid, well soldered or well bolted up.

I also found a motor sprocket of nearly the right bore, for the chain that came with the rolling chassis, but I made a sprocket for the drive axle from Acetal sheet, by drilling a circle of holes to match the chain pitch and turning away the outer part to leave a circle of half-holes. The drive sprocket needed a shim (cut from a drinks can) to achieve a better fit to the motor shaft, which looked rather hamfistedly done. My sister Catherine would have done it better.

Henk de Ruiter in Holland has a new model. He says, 'It is a Märklin/Meccano car built on a ladder-chassis using Meccano girders, Märklin Metall suspension, Märklin front radiator and Märklin wind-up motor.' In addition, Henk designed the background and lighting for the model (**photo 4**).



Henk de Ruiter's latest model (photo courtesy of Henk de Ruiter).

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Bristol Society of Model and Experimental Engineers sends this extra edition of *The Bristol Model Engineer*, to keep members up to date in a rapidly changing world. Opening with a good picture of president Bernard North on the Society's newly-acquired 'Romulus', it goes on to discuss John Whale's intention to build a model of the widely-travelled last survivor of the Yorktown class, now at the Chasewater railway. It was originally introduced in 1909 by Peckett's of Bristol, of which it was once said of the UK railway preservation movement, 'Everybody has a Peckett'. Then, the text of a talk given by Richard Lunn, via Zoom, regarding the story of the historic locomotive, *Lion*. Peter Pearson writes entertainingly of how the twice seized turntable was repaired. Various options were considered, like hitting it wiv a big 'ammer, even bigger 'ammers, an angle grinder, gas axle, or leaving BSMEE and joining another club, but eventually, a small plate was discovered, which, when undone, revealed a large and dirty ball bearing…

W. www.bristolmodelengineers.co.uk

Inside Motion, from **Tyneside Society of Model & Experimental Engineers**, November, says that a new section has been added to the club website, which is self-explanatory: www.tsmee.co.uk/members-projects-2.


5

Bonus photo of Tor's locomotive (photo courtesy of Paul Ohannesian).

Sam Yeeles, mentioned in the Spring issue, a budding railway photographer, has had one of his compositions used on the front cover of the October *Heritage Railway* and two more on the A1 Locomotive Steam Trust's website.

W. www.tsmee.co.uk

The November issue of **Bradford Model Engineering Society's**, *Monthly Bulletin*, arrives. (Would that the Royal Mail were so prompt with their deliveries. I became so fed up with the late delivery of ME 4650 that I untrousered a coin of the realm for a back number. This week it is *Practical Wireless* which was four days late.) 'Old Harry's' 'Thought for the Month' is – 'I have accumulated over the years an impressive bank of model engineering knowledge and experience. Unfortunately I have lost the key.' A final note from the editor, Graham Astbury (as amended by Geoff T) reminds us that keeping in touch with other members does not need e-mail, Messenger, Skype, Zoom etc. as there is this nearly obsolete technology called the telephone, by which people may converse without the aid of a computer. Don't wait for him to ring you, he might be doing the same. Quill pens, anyone? We radio amateurs have other means, of course, as do CB'ers.

W. www.bradfordmes.co.uk

Here is a gratuitous picture of Tor's locomotive. Well done (**photo 5**)!

Ryedale Society of Model Engineers, *Newsletter,* October, begins 'Diary empty'. Nevertheless, members got stuck into the maintenance tasks that befall every club. One locomotive new to Gilling was a nicely weathered J63. It certainly looks the part. Editor, Bill Putman, encourages the submission of further activities which are not illegal, immoral or fattening but if one feels compelled to contribute, especially the 'immoral' bit, anonymity is guaranteed!

W. www.rsme.org.uk

In what passes for topicality in a column written 6 weeks before publication, here is Network Rail's idea for a diorama, right on my doorstep (**photo 6**).

And finally, what word can you make using only the top row of keys on a computer keyboard? 'Typewriter'. No, you can't make anything out of Esc/F1/F2/F3/F4 etc…


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'Scoop' Theasby's latest coup.

CONTACT

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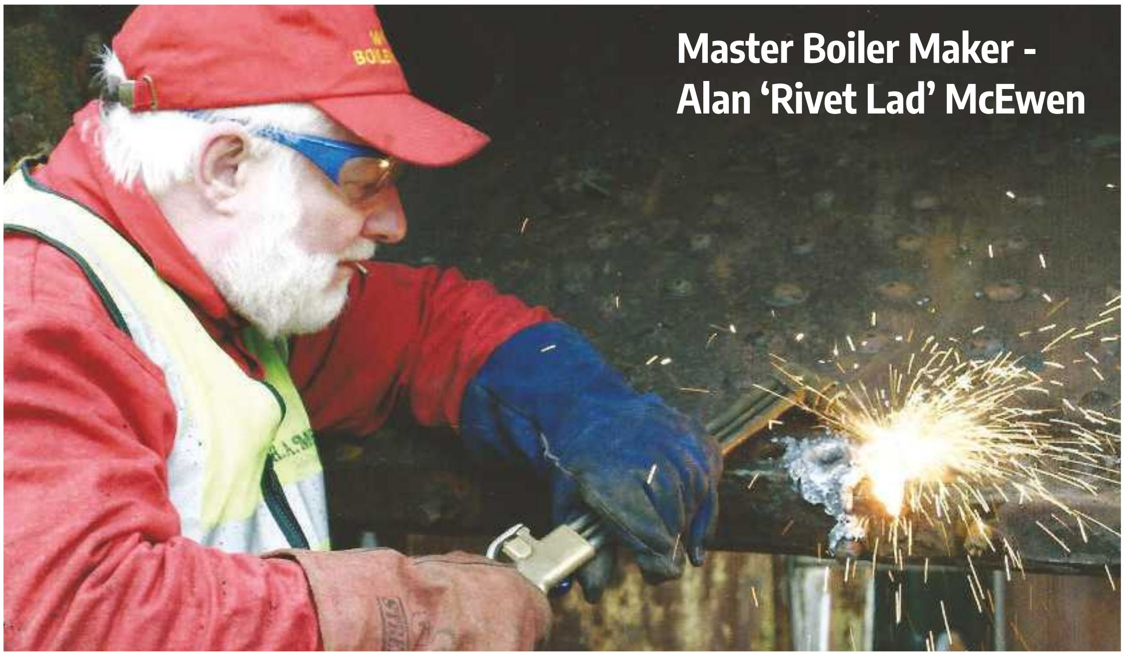
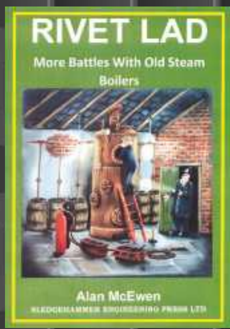
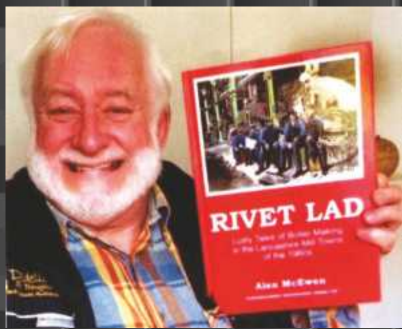
Bringing British industrial history to life



Master Boiler Maker -
Alan 'Rivet Lad' McEwen





When Master Boiler Maker and author, Alan McEwen was a young sprog, he loved banging and hammering on rusty old boilers; now that he is an old hog, he just prefers others to bang and hammer!

Alan McEwen's Boiler Making adventures and also 'potted histories' of several Lancashire and Yorkshire Boiler Making firms, can be read in **RIVET LAD** - *Lusty Tales of Boiler Making in the Lancashire Mill Towns of the 1960s.* The book is crammed with 'hands on' technical information of how Lancashire, Locomotive, Economic, and Cochran Vertical boilers were repaired over 50 years ago. The book's larger-than-life characters, the hard as nails, ale-supping, chain-smoking Boiler Makers: Carrot Crampthorn, Reuben 'Iron Man' Ramsbottom, Teddy Tulip, genial Irishman Paddy O'Boyle, and not least Alan himself, are, to a man, throw-backs to times gone by when British industry was the envy of the world.

Alan McEwen's first RIVET LAD book: *RIVET LAD – Lusty Tales of Boiler Making in the Lancashire Mill Towns of the Sixties* published September 2017 is now priced at £25 plus £3.00 postage and packing to UK addresses.

Alan's second RIVET LAD book: *RIVET LAD – More Battles With Old Steam Boilers* was published in September 2018. **Now priced** at £25 including postage and packing to UK addresses.

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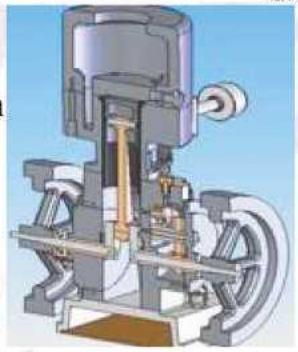
The Junior

Castings and drawings for home machining

Our Junior model takes its inspiration from the well known Lister Model A. The model runs on the 4 stoke Otto cycle using a glow plug for ignition but can be converted to spark ignition if desired.



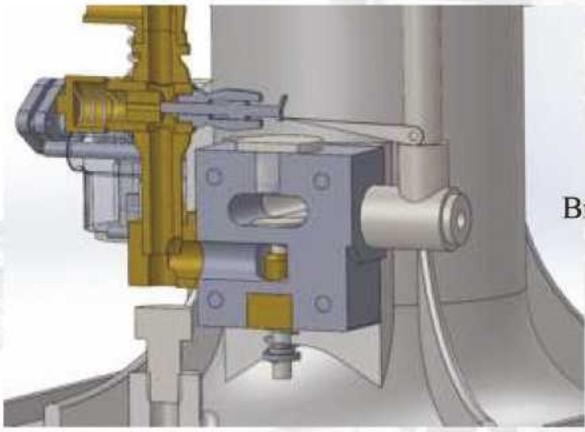
8 Castings brass & steel material pack inc. 3 profiles

The drawings are supplied in a book format, each component is printed on one A4 page, there are exploded diagrams, section views and parts lists to help make construction easier to

December offer

A copy of an reprinted Lister hand book published by **Internal Fire Museum** will be included for **free**.

The Otto



Supplied as 8 raw castings, 2 pre cut gears, some raw material, a glow plug and 3 profiles. The Otto inverted D6 engine will build into an impressive model approximately 266 mm tall with a 199 mm diameter cast iron flywheel. The drawings are in book format with a single page per part, parts lists and exploded diagrams with some guidance notes.

Brass nameplates (2) now available £49.50 inc UK P & P

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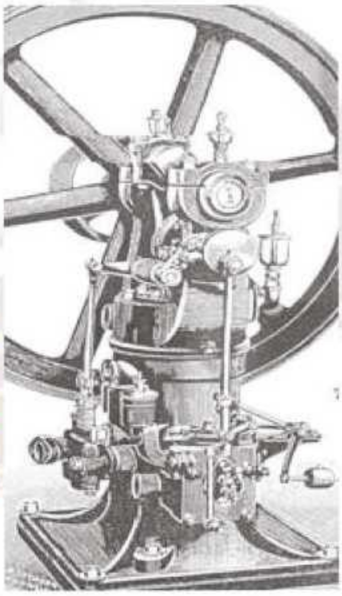

Hubbard

An interesting 2 stroke marine engine these castings will build into a model of a two stroke marine boat engine based on the 1912 Hubbard engine. The model is run on glow fuel with ignition by glow plug. It has a capacity of approximately 12cc. The flywheel is iron, the remaining castings are in aluminium.

The drawings are traditional format with various views on the same sheet. There are 8 sheets of drawings. Approximately 150 mm tall. 86 mm diameter flywheel. This is an ideal model for those with smaller machinery.

Offer

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