THE ORIGINAL MAGAZINE FOR MODEL ENGINEERS

Vol. 220 No. 4584 • 13 - 26 April 2018

MODEL ENGINEER

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DAG Brown on Repetition

Model Boiler Design

Wide-A-Wake Launched

COVER FEATURE

Newsham's Fire Engine

mytimemedia ENGINEERING GROUP
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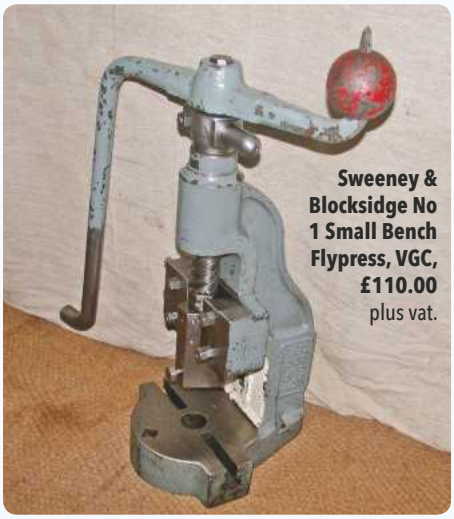
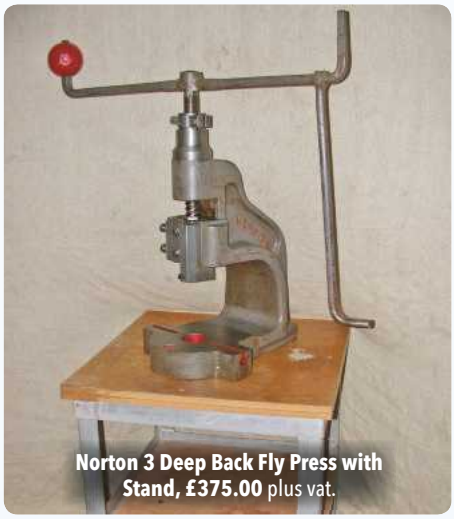
Colchester Bantam 1600 Lathe, Tooled, Inc Taper Turn, 3ph, **£1850.00** plus vat.



Sweeney & Blocksidge No 1 Small Bench Flypress, VGC, £110.00 plus vat.

Startrite 20RWF Bandsaw with Welder, 3ph, **£1000.00** plus vat.



Norton 3 Deep Back Fly Press with Stand, £375.00 plus vat.

Mec Brown 75 Pedestal Cut off Saw, 3ph, **£650.00** plus vat.

Wabeco F1210E Variable Speed Vertical Mill with Stand, VGC, 1ph, **£1850.00** plus vat.

RJH Bison Double Ended Pedestal Grinder, 3ph, **VGC, £285.00** plus vat.

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IN THIS ISSUE

Vol. 220 No. 4584 13 - 26 April 2018

ON THE COVER...

John Clarke's one sixth scale model of Richard Newsham's patented fire engine of 1721 (photo: John Clarke).

Machine Mart

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PC40	3.5HP	20Amps	£269.00	£322.80
PC60	5.5HP	32Amps	£319.00	£382.80

Clarke ARC / TIG INVERTER WELDERS

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- Efficient inverter technology
- Variable output current

AT165

MODEL	MIN/MAX OUTPUT CURRENT	ELECTRODE DIA. (MM)	EXC.VAT	INC.VAT
AT133	10A-130A	2.5/3.2	£129.98	£155.98
AT135	10A-130A	2.5/3.2	£169.98	£203.98
AT162	10A-160A	2.5/3.2/4.0	£149.98	£179.98
AT165	10A-160A	2.5/3.2/4.0	£199.98	£239.98

Clarke MIG WELDERS

135TE

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MODEL	VOLTAGE	HEAT OUTPUT KW	EXC.VAT	INC.VAT
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DEVIL 7005	400V	5	£84.99	£101.99
DEVIL 6009#	400V	4.5-9	£109.00	£130.80
DEVIL 6015†	400V	5-10-15	£169.00	£202.80
DEVIL 7025	400V	22	£299.00	£358.80
DEVIL 7030	400V	30	£349.00	£418.80

#was £142.80 inc.VAT †was £214.80 inc.VAT

Clarke METAL DRILLING MACHINE - CMD300

- Bench mountable, tilts 45° left & right from vertical
- Table travel 100x235mm
- Table Effective Size LxW: 92 x 400mm

CMD10

£579.00 EXC.VAT £694.80 INC.VAT

Clarke MICRO MILLING & DRILLING MACHINE

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- Bench mountable
- MT2 Spindle Taper
- Face mill capacity 20mm, end mill 10mm
- Table cross travel 90mm, longitudinal travel 180mm

MODEL	MOTOR	SPINDLE SPEED	EXC.VAT	INC.VAT
CMD10	150W/230V	100-2000rpm	£399.00	£478.80
CMD300	470W/230V	0-2500rpm	£579.00	£694.80

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BEST SELLER

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MODEL	JAW WIDTH	BASE	EXC.VAT	INC.VAT
CV75B	75mm	Fixed	£18.99	£22.79
CV100B	100mm	Fixed	£19.98	£23.98
CVR100B	100mm	Swivel	£23.99	£28.79
CV125B	125mm	Fixed	£29.98	£35.98
CVR125B	125mm	Swivel	£34.99	£41.99
CV150B	150mm	Fixed	£49.98	£59.98
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MODEL	MOTOR (W) SPEEDS	EXC. VAT	INC. VAT
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CDP152B	450 / 12	£149.98	£179.98
CDP202B	450 / 16	£189.00	£226.80
CDP452B	550 / 16	£229.00	£274.80
CDP10B	370 / 12	£198.99	£238.79
CDP352F	550 / 16	£229.00	£274.80
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8/250

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7/250	2 HP	7	24ltr	£94.99	£113.99
11/250	2.5HP	9.5	24ltr	£109.98	£131.98
8/510	2HP	7.5	50ltr	£119.98	£143.98
11/510	2.5HP	9.5	50ltr	£139.98	£167.98
16/510*	3 HP	14.5	50ltr	£209.00	£250.80
16/1010*	3 HP	14.5	100ltr	£259.98	£311.98

Clarke MEASURING EQUIPMENT

FROM ONLY £9.99 EXC.VAT £11.99 INC.VAT

MODEL	DESCRIPTION	EXC.VAT	INC.VAT
CM100	150mm/6" Vernier Caliper	£9.98	£11.98
CM180	0-25mm Micrometer	£10.99	£13.19
CM145	150mm/6" Digital Vernier	£17.99	£21.59
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- Min. Rolling Diameter 39mm
- Bending angle 0-90°

FROM ONLY £229.00 EXC.VAT £274.80 INC.VAT

SBR610

ROLLING

SHEARING

FOLDING

MODEL	BED WIDTH	EXC VAT	INC VAT
SBR305	305mm (12")	£229.00	£274.80
SBR610	610mm (24")	£429.00	£514.80
SBR760 NEW	760mm (30")	£499.00	£598.80

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CBB203B	3 Dr step up	£67.98	£81.58
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CBB213B	3 Dr Cabinet	£189.98	£227.98

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SIZE	SHAFT SPEED	EXC. VAT	INC.VAT
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⅓	4 pole	£59.98	£71.98
¾	4 pole	£79.98	£95.98
1	2 pole	£79.98	£95.98
2	2 pole	£89.98	£107.98
3	2 pole	£119.98	£143.98
4	2 pole	£129.98	£155.98

Clarke CONTRACTOR 18V BRUSHLESS COMBI DRILLS

NEW RANGE

- 2 forward and reverse gears

CON180LI

FROM ONLY £109.98 EXC.VAT £131.98 INC.VAT

powered by Li-ion

MODEL	VOLTS	BATTS	EXC. VAT	INC. VAT
CON18LIC	18V	2x 2.0Ah Li-Ion	£109.98	£131.98
CON180LI	18V	2x 4.0Ah Li-Ion	£169.98	£203.98

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- Overload safety valve

CFC100

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CBG6RSC	HD	150mm	£54.99	£65.99
CBG6SB#	PRO	150mm	£54.99	£65.99
CBG6RWC	HD	150mm	£59.98	£71.98
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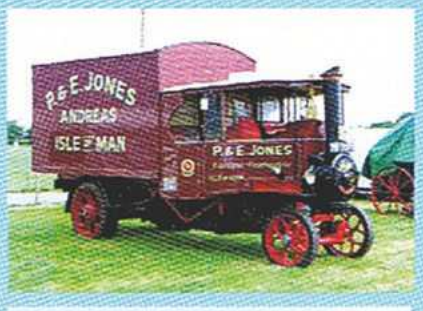

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SMOKE RINGS

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'Best Polly' prize awarded at SMEE AGM

Stephen Hall was awarded his prize for the best *Polly* model at SMEE's recent AGM. The winner was decided by course participants at SMEE's Christmas social.

The *Polly* course 'Building a simple steam engine' takes beginners through construction of a simple oscillating steam engine and boiler to the design of T.D. Walshaw, 'Tubal Cain'. The 2018 course restarts on 12th May. Now in its 13th year over 120 budding engineers have enjoyed the course. Most have gone on to build larger and more complex engines and gained valuable engineering skills.

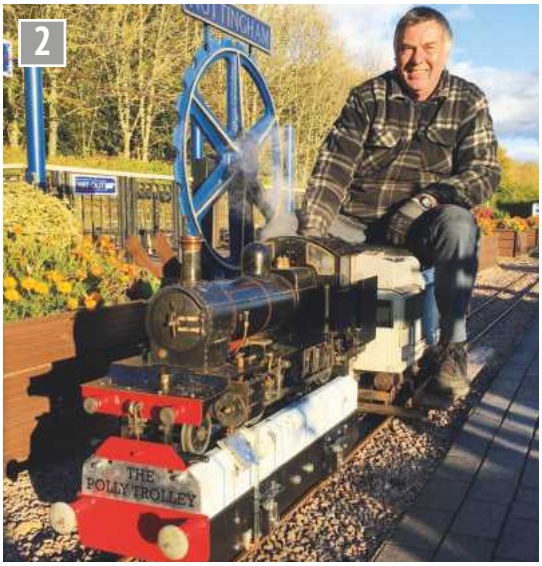
Stephen is a semi-retired chemical engineer who worked in the oil industry. He says "I wanted to start making things and the *Polly* course seemed a good practical start. Although it was challenging to do new things it was all interesting". He is now building a Gauge 1 steam locomotive.

Stephen praised the quality of teaching on the course. "The volunteer teachers are excellent demonstrators" he says, "They show a variety of metal working techniques including making small boilers using silver brazing, sheet metal work using soft soldering, safe use of hand tools to cut metal, turning parts using a lathe, drilling and shaping parts using a milling machine". Students then make parts in their own workshops in time for the next session. They enjoy the support of an active online community to help members solve any problems that may emerge in their model engineering.

The *Polly* course is open to all. SMEE also runs courses on milling and grinding (the latter for members only). Organiser Allen Berman is a keen model engineer who recently restored the late Ian Bradley's workshop engine shown on the SMEE stand at the London Model Engineering Exhibition. He says SMEE courses demonstrate basic metal work techniques now rarely taught in schools or evening classes.

Further information on the SMEE website www.sm-ee.co.uk or write to the SMEE Courses organiser at **courses@sm-ee.co.uk**

Mike Chrisp (left) awards Stephen Hall the Polly trophy at the SMEE AGM in March 2018 (photo courtesy of Richard Dedman).



Roy Hollingworth demonstrates his innovative 'Polly Trolley' (photo: Nick Harrison).

The Polly Trolley

Nick Harrison, chairman of Nottingham SME, reports: 'One of our members, Roy Hollingworth, arrived at Ruddington one day with his latest invention. He owns a 5 inch *Polly 6* but doesn't have a 7¼ inch steam locomotive. So, he set to and made an adaptor to enable him to run his locomotive on 7¼ inch gauge railways (**photo 2**). It has the ability to supply and control the axle pump water intake to the boiler. He can use the steam injector on the locomotive to top up the boiler but he has also included an electrical feed pump. This falls well into the experimental category of our hobby and gave a huge amount of satisfaction to Roy (as can be seen from the silly grin).'

Perhaps Nottingham should add the extra 'E' into their 'SME' to acknowledge Roy's experiment as a significant contribution to model engineering technology. If only Isambard Kingdom Brunel had been a member of the Nottingham SME and had met Roy! Imagine how the course of Great Western Railway history might have been changed. Swindon could have knocked up a few dozen standard/broad gauge Polly Trollies in no time at all and saved the Permanent Way department the trouble and expense of laying hundreds of miles of dual gauge track. And who knows? The broad gauge might yet still have been with us.

Martin R Evans
Acting Editor

Martin Evans can be contacted on the email below and would be delighted to receive your contributions, in the form of items of correspondence, comment or articles.
T. 07710 192953
mrevans@cantab.net

The 1721 Newsham Fire Engine

John Clarke constructs a miniature replica of Richard Newsham's 'new water engine', patented in 1721.

About a year ago I visited my local library and saw an old fire engine on display (**photo 1**). The library had recently also become a local museum and the fire engine was moved into it.

Seeing the engine sparked a memory from my past. As a child I had accompanied my mother to pay our rates at the local municipal building and I remembered seeing this old engine standing in the hall of the building.

As I then saw it again I was prompted to think about building a scale model of it (1:6 scale). Armed with my camera and a tape measure I was given permission to take numerous photographs and measurements. However, the actual mechanism for the pump was hidden from view inside a wooden casing so it was difficult to imagine exactly how it worked.

I made a list of materials that I thought I might require. As a keen recycler I went about gathering them together from boot fairs and society rummage sales. I then started to make a prototype from the photographs that I had taken and information gathered from the web. In fact, I made several prototypes of the mechanism but none of them appeared to work. At the Dartford Steam fair an old 20th century fire engine was parked outside our model display tent. The driver of this engine was persuaded to look at my latest attempt. He was the curator of the Kent Fire Museum at Ash. Subsequently, I was invited to visit the museum and at last I could get some answers to my questions about the pump mechanism and build a working demonstrator (**photo 2**).

Eventually, having built and tested the mechanical parts in a steel cistern, I decided to take a break and amuse myself by making small accompanying extras (**photo 3**). These were things like leather buckets, hoses, an axe, a rattle for warning people that buckets of water were required and, lastly, a beer barrel, carried on all engines, to quench the thirst of the men doing the pumping.

After this diversion, I went back to my engine model to build the wooden carriage parts for it. Having tested the mechanism in a metal cistern I now had to build a wooden cistern that had to be lined with copper to minimise leaks. The outward appearance of the engine (**photo 4**) was copied from pictures and photographs.

The 1721 Newsham Fire Engine.

A working demonstrator for the pump.

The various accessories supplied with the fire engine.

Engine with leather hoses.

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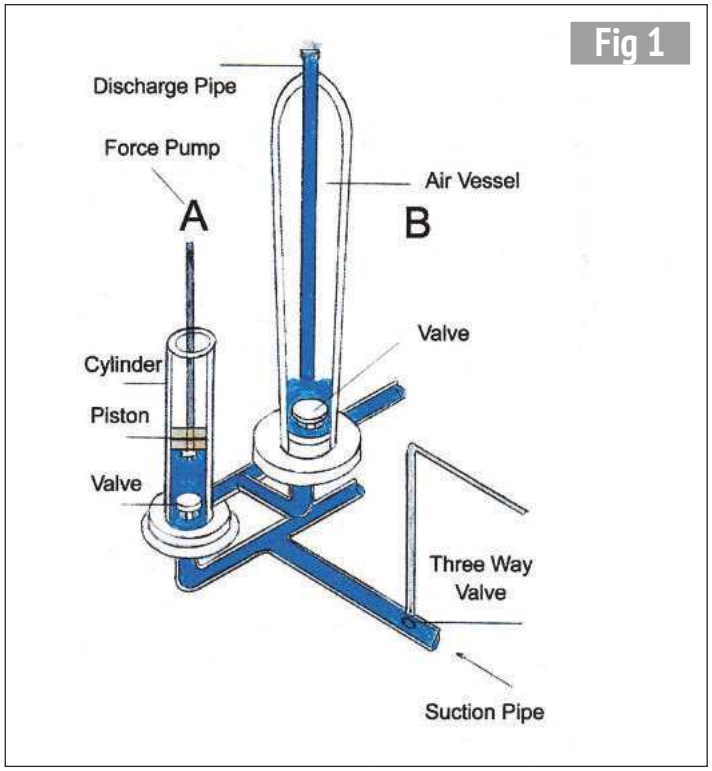
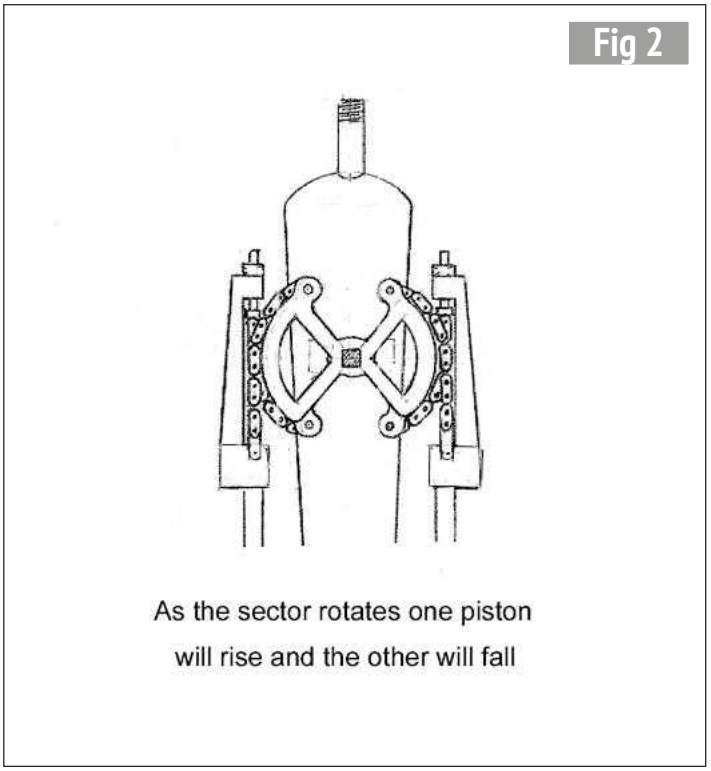




Newsham's invention explained

The Newsham engine (**fig 1**) has two force pumps **A** (only one shown) and an air vessel **B** inside an open-topped copper lined cistern. When the engine is at rest all valves are closed by their own weight but when the engine is working, the two pump valves are opened and shut alternately. Look at the construction of the pipe work and the air vessel. The action of this engine is simple; on raising the piston **A** a partial vacuum is produced in the cylinder causing the pressure of the atmosphere to force the water up the suction pipe through the valve lifting the valve into the cylinder. When the piston reaches the top of its stroke and begins to descend the valve closes and prevents the water, which has entered the cylinder, from returning by the way it came, being forced by the descent of the piston. The water is now driven along into the air vessel, raising its valve, which closes again the moment the water has all passed through. While this process has been going on, the other cylinder has become filled with water, which is now discharged in its turn into the air vessel and so on continuously.

The water enters the air vessel and some of the air is expelled but once the water rises to the bottom of the discharge pipe air can no longer escape. The air is driven by the flow of water into a smaller space than it originally occupied and the consequent pressure, acting on the surface of the water, drives the water up the discharge pipe with great velocity.

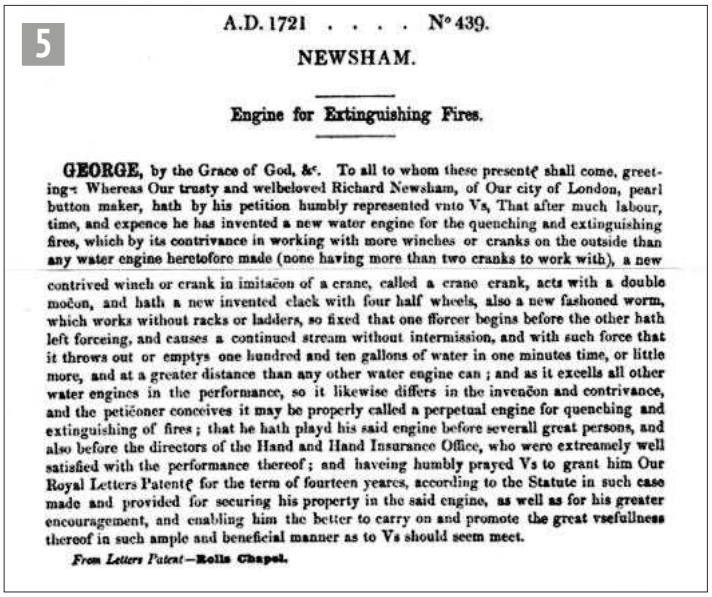
The improvements introduced by Newsham, notably the twin cylinders, were most important, converting a crude imperfect machine into one that was really efficient and suitable for the purpose and in which great skill and engineering knowledge had been brought to bear. Richard Newsham gained a patent for his invention in 1721 (**photo 5**).

Engine container

The case of the engine consists of a strong oak cistern, about three times as long as it is broad, mounted on four wheels and drawn by a handle and two ropes.

The front wheels are inset as the under part of the cistern is cut away. The rear axle is cranked to give the engine a low centre of gravity. To the rear end of the cistern sits a sloping sided case, enclosing the pumps and air vessel. This forms a platform on which the fireman stood to direct the jet of water coming from the branch pipe. This branch pipe is attached to the air vessel by two brass elbows, the first of which is screwed on the top of the air vessel and the second elbow is screwed to the first by a fine screw of several threads, turned to be perfectly water-tight in every direction. The first elbow revolves on the top of the air vessel horizontally while the second elbow revolves on the first vertically. The combination of these two motions, therefore, permits the branch pipe to be guided in every possible direction.

This branch pipe, however, soon became obsolete. For the model, I have produced both the branch and its replacement, which is a hose that can be used more efficiently on the ground (health and safety) or at a distance, allowing the engine to be kept away from the heat and fire.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A.D. 1721 . . . . N° 439.

NEWSHAM.

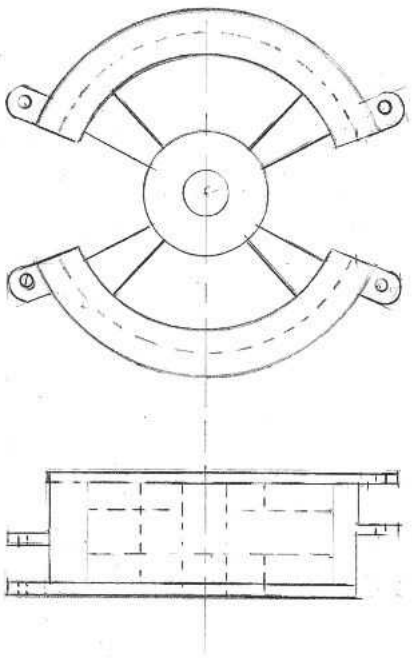
Engine for Extinguishing Fires.

GEORGE, by the Grace of God, &c. To all to whom these presents shall come, greeting: Whereas Our trusty and welbeloved Richard Newsham, of Our city of London, pearl button maker, hath by his petition humbly represented vnto Vs, That after much labour, time, and expence he has invented a new water engine for the quenching and extinguishing fires, which by its contrivance in working with more winches or cranks on the outside than any water engine heretofore made (none having more than two cranks to work with), a new contrived winch or crank in imitacon of a crane, called a crane crank, acts with a double mocon, and hath a new invented clack with four half wheels, also a new fashoned worm, which works without racks or ladders, so fixed that one forcer begins before the other hath left forceing, and causes a continued stream without intermission, and with such force that it throws out or emptys one hundred and ten gallons of water in one minutes time, or little more, and at a greater distance than any other water engine can; and as it excells all other water engines in the performance, so it likewise differs in the invencon and contrivance, and the peticoner conceives it may be properly called a perpetual engine for quenching and extinguishing of fires; that he hath playd his said engine before severall great persons, and also before the directors of the Hand and Hand Insurance Office, who were extreamely well satisfied with the performance thereof; and haveing humbly prayed Vs to grant him Our Royal Letters Patent for the term of fourteen yeares, according to the Statute in such case made and provided for securing his property in the said engine, as well as for his greater encouragement, and enabling him the better to carry on and promote the great vsefullness thereof in such ample and beneficial manner as to Vs should seem meet.

From Letters Patent—Rolls Chapel.

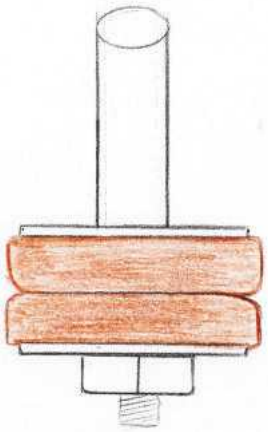
Richard Newsham's patent, granted by George I.

Fig 3



Double Sector

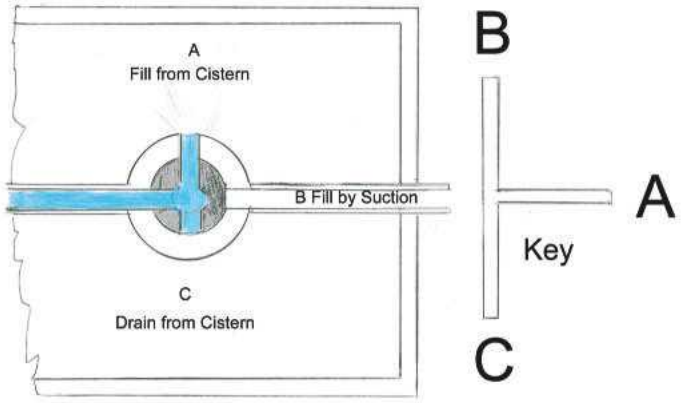
Fig 4



The pistons leather cups

Fig 5

The Three Way Valve



At the rear of the engine is seen a strong leather suction pipe (prevented from collapsing by a spiral piece of metal running throughout its length). One end of this can be attached to a brass nozzle which screws into the rear of the cistern. The other end has a strainer, which is immersed in the water supplied by a pond etc. The end part of the cistern has an added wooden trough with a copper grating to keep out stones etc. allowing the cistern to be supplied with water from buckets. There is also an open space left in the front end of the cistern with a copper grating.

Working parts

Between the sloping sided case and the front end of the engine, there is a strong iron shaft lying in a horizontal position over the middle of the cistern, lengthwise, and clamped in brass bushes at each end, one of which is placed between two uprights supporting the hand–rails. Upon this shaft are fitted two stout iron bars or levers, one at each end, which carry the cylindrical wooden handles, by which the engine is worked.

The pump mechanism

The double sector rocking mechanism uses the four attached flat link chains to convert the rocking motion into a pumping up and down movement for the pistons. This is rather like a rack and pinion (**figs 2** and **3**). This up and down movement is provided by at least eight strong volunteers who will raise and lower the long wooden handles attached each side of the engine.

There are two chains to each piston, one passing from the top of the sector to the lower end of the piston rod, the other from the top of the piston rod to the bottom of the sector. The chains are riveted to the sectors, and attached to the piston rods by screw nuts, which allow them to be kept constantly tight.

The pistons are formed of two brass plates smaller in diameter than the cylinder, put into stout leather cups, and fastened together by a nut, which screws on the piston-rod below the pistons (**fig 4**).

The three way valve

Over the rear trough there is a key which turns the three way valve situated beneath it. When the key is at position A (**fig 5**) water is drawn from the cistern that has been filled by buckets from each end of the engine. Copper gratings stop stones or other objects entering the pumps. If the key is now turned to position B the engine will work from water drawn through the suction hose from a pond, canal, lake etc. This hose has a strainer on the end. If the key is moved to the third position C the cistern will empty ready for the return home. An armband given to all pumpers at the start of the job may then be returned in exchange for one shilling.

Engine suction valves

In Newsham's engine, if one of the suction valves became damaged the cylinder had to be removed completely before the valve could be replaced. The cylinders are screwed down with brass screws on a leather valve and washer, which made a perfect joint. The leather valves are kept closed by a piece of metal having a tail, which passes through the leather and is cross-pinned under it. The top of the cylinders are above the level of the cistern so that when the latter is filled with water it may not run into the cylinders and wash away the oil with which the pistons are kept constantly covered.

●To be continued.

Next time I will provide a few details of the construction of the model.

The Southern Federation AGM

Taurus reports from the Cardiff Model Engineering Society.

David Goyder prepares his 5 inch Gauge Midland 4-4-0 for his time on the track.

The Southern Federation of Model Engineering Societies presentsv an annual Young Engineer of the Year award. This is intended to encourage young people who are active model engineers, or who are being trained in basic workshop activities by their clubs, to display their skills and work with the aim of being rewarded by the Federation.

The results of these endeavours are declared at the Federation's AGM. This year it was held at the Cardiff MES on March 10th when delegates and contestants assembled at the splendid clubhouse situated in Heath Park, Cardiff. As usual, the superb hospitality of the

A superb 7¼ inch Black 5 *waits to be fired up at Cardiff.*

This 5 inch gauge Super Simplex *has plenty of steam as it traverses the garden railway at Cardiff.*

host club was very much in evidence as coffee and tea, along with a selection of cakes and biscuits, were offered to all new arrivals. The track was open, although the number of active users was curtailed by the pouring rain for most of the morning. This cleared away later allowing some good running and atmospheric steaming because of the damp conditions. Before the AGM got underway a wonderful buffet lunch was provided by the hosts which was very popular and well received by all the attendees. With the inner man fully satisfied the meeting was able to continue.

There was a good attendance of representatives from various clubs so that the required quorum for the meeting was fully met. Chairman Bob Polley opened the proceedings with his report of the past year's activities and he again asked the meeting to be fully aware of the work the committee do during the year to ensure that all members of the Federation are aware of changes to different aspects of model engineering. He also asked the meeting to consider putting forward some new committee members as those presently in post are trying to spread the work over a larger number to ease the time they spend on Federation activities. Further reports came from the treasurer, who reported a healthy bank balance and the safety officer, who praised the overall excellent safety record of member societies. Tony Wood from the insurance brokers Walker Midgley provided a number of interesting statistics to emphasise the need for careful health and safety records to continue to be kept by clubs. He cited a number of minor incidents during the year which had been successfully defended by the clubs involved because they had kept good records, made on the day, of the incidents.

The meeting continued with the election of officers and committee members with as I said above a plea from the Chairman for more club involvement and support for activities, such as attending the major model engineering exhibitions and being prepared to perhaps help with the Federation display by looking after the stand while others have a break etc. It was also reported that there will be a change to the boiler test paperwork which will be sent out to all clubs in the near future and an additional plea was made to ensure that it is all fully completed. The boiler inspector said that after all this time he still receives boiler test result paperwork which is not fully completed. This means the test is not valid should a problem arise. For example, simple things like the tester's name are missed off.

When all the official aspects of the meeting had been completed Mike Chrisp, in his role as awards officer, took to the stage to report on the Young Engineers competition. He said he was delighted at the quality of the work and presentations submitted by the entrants and that he hoped there would be continued support for this competition by all clubs, as the involvement of younger members was essential for the continued existence of model engineering.

Mike then proceeded to list the contestants and to present the awards. The Young Engineer for 2018 was named as Noah Eggar, a fourteen year old member of the Hereford SME. Noah received the Southern Federation Trophy and Polly Model Engineering prize to the acclaim of the assembled members and guests. Four other young men from the Hereford Society were also recognised by the Federation and they too received their certificates from Mike. All in all, it was a very important day in their young lives and it is to be hoped that they will continue to progress their activities in model engineering. I know they will be given full support by all members at Hereford. I hope all other clubs will try to follow this example as young people like these will make a difference to your club activities and it is not as difficult as you might think.

The meeting concluded by the Chairman again thanking the host club, Cardiff, for their excellent hospitality and facilities by saying that it was very much appreciated by everyone attending.

ME

Noah receives his trophy from Bob Polley.

The prize winners with Mike Williams, chairman of Cardiff, and Mike Chrisp.

The prize winners with their families and mentors.

Noah proudly displays his trophy with examples of his work in the background.

An Engineer's Day Out

Roger Backhouse spends a day at the Denny ship model experiment tank, Dumbarton.

Denny's experimental ship model tank is one of the finest relics of Victorian engineering, now preserved by the Scottish Maritime Museum. It was a pioneer of using models in engineering science.

William Denny began building wooden ships and then composite (wood and iron) vessels. An example of an early ship's engine installed by Denny stands outside (**photo 1**). As William Denny and Brothers Ltd. they completed the *Cutty Sark* in 1869 when the previous builders closed.

The firm was forward looking. They introduced steel rather than wrought iron early and were among the first to adopt hydraulic riveting. They were socially progressive too, employing women early on in the drawing office.

With a restricted site at the foot of Dumbarton Castle Rock, Denny's specialised in smaller vessels such as cross channel ferries (**photo 2**). Large export orders included vessels of the Irrawaddy Flotilla Co., once claimed as the world's largest fleet.

Denny's sought a competitive advantage over other Clyde builders by testing hull forms before construction.

Believed to be the world's third oldest marine engine. Built by Robert Napier in 1824, his first marine steam engine, fitted in the paddle steamer Leven. *Single cylinder side lever type of 30 horsepower.*

This wasn't the first ship tank though. Alexander Hall of Aberdeen and the Duke of Portland at Troon built small scale tanks to test specific models. With Admiralty support the renowned William Froude built a tank built in 1872. An experimentalist, Froude developed a formula predicting the resistance of a vessel and could scale this from a model.

William Denny knew of Froude's work and persuaded his business partners to build an experimental ship tank to test hull forms. He defined the function as 'to determine with commercially acceptable accuracy the power required to achieve the contract speed and to reduce that power for any installation to a minimum'.

Denny's closure in 1963 ended years of shipbuilding innovation. After use by Vickers, who added a wind tunnel, the tank was saved through the National Maritime Museum and the Scottish Maritime Museum. Strathclyde University used the tank for a while for experiments but this use has now ceased.

The tank and carriage

The first tests in the tank (**photo 3**) ran in 1883. It was 73m long, 6.7m wide and 2.75m deep, lengthened after a fire in 1924 to 94.5m (307 feet). It had a uniform rectangular cross section with shallow docks at each end.

A narrow gauge railway (40 inches or 1016mm) suspended from the roof is reputedly cambered to match the earth's curvature so it was clearly intended for accurate measurements.

There have been seven different carriages. At first the

Turbine steamer Isle of Jersey *built by Denny for the Southern Railway in 1930. Typical of much of Denny's output.*

View along tank with walkways built over the tank on each side. Tow carriage and electric motor.

towing carriage was hauled by an endless rope hauled by two single cylinder Tangye steam engines. In 1908 this was replaced by electricity using a battery driven electric motor propelling the wheels. Later, mains electricity was used.

To test performance in different conditions the tank had a wave maker. The first was a board worked by a team of men to the beat of a drum! Later, vertical plungers made the waves. A weight catapult was installed to test the effects of rapid acceleration.

The first test for each model was to run it over a range of speeds to determine the resistance. Froude worked out that the total resistance, Rt, depended on skin friction, Rf (which depended on the wetted surface area and could be calculated), plus the wave making friction (also known as residual friction, Rr) so that Rt= Rf+Rr. He also worked out by experiment that for a full-size ship and a model of similar shapes corresponding speeds are in proportion to the square roots of their lengths. (So for a ship 150m long travelling at 15.5 knots a model of length 6m should travel at 15.5 √ 6/150 = 3.1knots.)

The second test involved running the model again with appendages (such as bilge keels and rudders). Finally, propellers would be fitted and self propulsion tests carried out. Tests in waves were carried out with the model held firm. Later, larger radio-controlled models were tested in the Gare Loch.

Instruments on the carriage measure power, speed, sinkage and trim of the model (**photo 4**). Model test tanks have a standard model hull run at intervals to ensure instruments are consistent. That for the Denny tank is brass and double ended (**photo 5**).

A Froude type screw dynamometer and its carriage was used to measure the torque and thrust of propellers, whether in open water or behind a hull. Latterly, a carriage mounted computer could be programmed to drive models at the required speeds, recording all data.

Tank testing changed hull design, notably the developing bulbous bow now almost universal (**photo 6**).

Instrumentation panel with hull model below (not normally accessible).

Each tank has its own standard hull - this for the Denny tank is double ended.

Bulbous bows developed through tank testing. Models show some types tested.

Paddle wheels and propellers

Denny's experimented with better designs for propellers. Craftsman made models, casting on site in Magnolia or Fry's metal. Models were then cleaned and tested (**photo 7**).

Denny's tested hundreds of propeller designs. Each took a skilled technician a week to make.

Dennys developed considerable expertise in paddle wheels design and testing. Paddlers were manoeuvrable, an important factor when ships had to dock quickly, as on Clyde services. There are examples of some of the paddle wheels tested.

Model cutting machine and preparation room

William Froude designed a machine to cut hull forms (**photo 8**). It was made by woodworking machinery makers John McDowell of Johnstone but worked well with wax. Two revolving cutters can be controlled to follow exactly the contours on the plan (**photo 9**).

Wooden models were tested initially but then refined paraffin wax was used. Models were made in a clay bed to the approximate outside shape with a clay covered lath former as core. Wax heated by steam coils was poured into the gap between the mould and core to produce an approximate shape. Once cooled, this went into the cutter for shaping. The hull form was then passed to the finishing room for smoothing off (**photo 10**), checking, polishing and weighing. In the tank it was ballasted to give the required trim and waterline.

Drawing office

In a fascinating glimpse of how ships were once designed there's a selection of instruments in the drawing office. A sophisticated Fuller calculator and other equipment helped designers draw plans and determine moments of area (**photo 11**) or areas enclosed (**photo 12**). The oddest is a machine for drawing graph paper (**photo 13**).

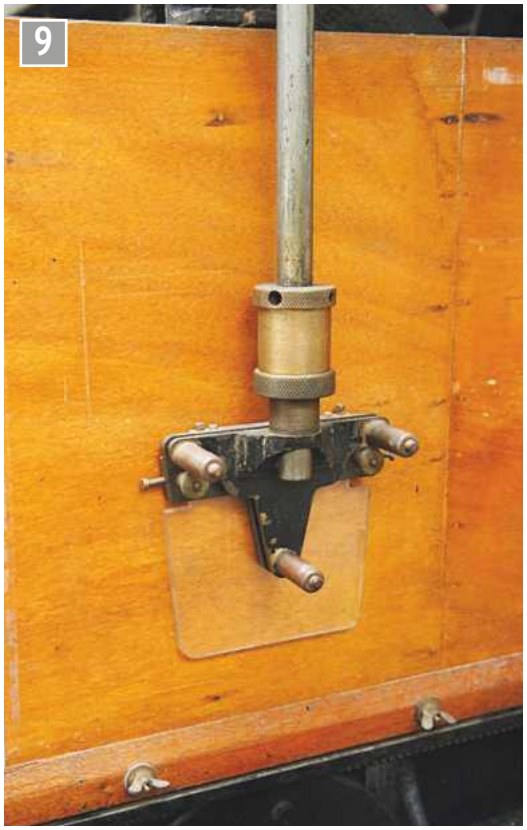
Further testing

Once launched and fitted out, ships were tested in the Clyde using carrier pigeons to send data back to the yard! There is a pallograph, used to measure vibrations, housed in the drawing office (**photo 14**). The *Queen Elizabeth 2*, launched by John Brown's yard, initially suffered badly from vibrations.

Denny innovations

Tank superintendent Edward Mumford, working with a Spaniard called Vergara, developed an experimental helicopter. He tested propellers underwater and then tried the design in a flying machine in 1905. At first engines had insufficient power but development continued with a final test in 1914 (**photo 15**). A final 40hp version with

Machine to cut hull forms, designed for wood cutting it then cut wax models. Revolving cutters hang below.



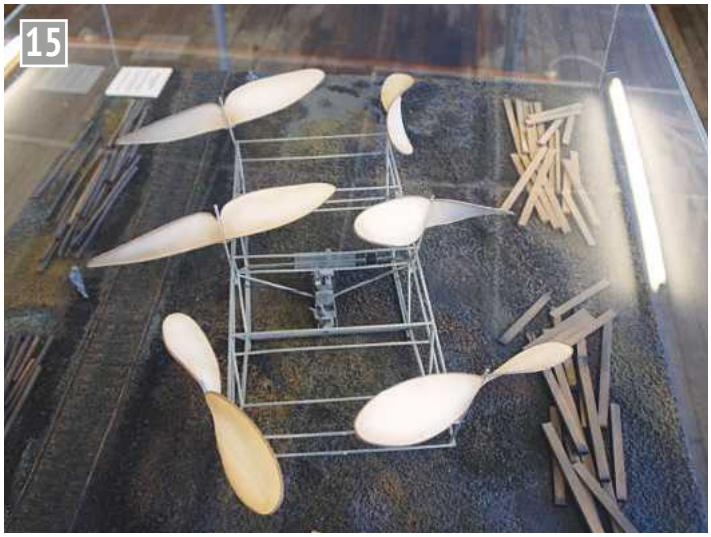
Tracer followed contour lines on plans so cutters would shape the model hull

Contoured hull after cutting, partly smoothed off.

Integrator used to determine moments of area about a particular axis on a ship lines plan

Planimeter used to determine areas enclosed by any shape.

Machine for printing graph paper.



Model of pioneering helicopter designed by tank superintendent Edward Mumford and Vergara and successfully trialled in 1914. First patent in 1905, later versions tested in 1909 to 1914.

floats was said to have been successfully tested on the river. Sadly, the First World War prevented further work.

Denny's developed the anti-roll fin stabiliser in collaboration with Brown Brothers and saw ideas adapted for warships by the Admiralty and in many passenger ships.

In the early 1960's the firm developed the Denny hovercraft. Although the D2 made the 800 mile journey to London the fixed skirts picked up Thames debris, damaging them and the propellers. It was briefly in commercial service between Barrow and Fleetwood carrying up to 70 passengers at 25 knots.

Other ship tanks

Ship tanks around the world followed Denny. The world's second was built at Nagasaki, Japan, in 1907. Custom has it that each new tank is 'christened' with a demijohn of water from the Denny 'mother tank'.

Getting there and contact details

Denny's tank was a world pioneer and makes a fascinating visit, especially in conjunction with the other attractions of Glasgow, the Clyde and Loch Lomond areas.

Address: Castle St, Dumbarton G82 1QS (about 10 minutes from Dumbarton Central Station)
Website: www.scottishmaritimemuseum.org.
Phone 01389 763444

Open daily 10am to 4pm. Small shop and café with a limited menu but remarkable value for money prices.

Thanks to Anne Hoben (Visitor Services Manager) and Laura McFettridge (Gallery Attendant) for their help and enabling access to areas not normally open. ME

Pallograph measured vibrations. This came from John Brown's test tank when that closed in 1970.

Other places of engineering interest:

Scottish Maritime Museum
Irvine, Ayrshire.
Includes the world's first passenger steam turbine in a Linthouse shipyard shed plus *Puffer*, *Spartan* and other vessels (see Model Engineer No 4221, 2004)
www.scottishmaritimemuseum.org

Paddle steamer *Waverley*
The last sea-going steam paddle steamer, built in 1948 for the LNER. Sails on the Clyde May to August with some calls at Helensburgh (with memorial to steamship pioneer Henry Bell). In autumn tours the English and Welsh coast (see Model Engineer No 4146, 2001).
www.waverleyexcursions.co.uk.

SS Sir Walter Scott
Original 1899 ship with triple expansion steam engines sails on Loch Katrine (see Model Engineer No 4343, 2009).
www.lochkatrine.com/wp-content/uploads/2017/01/Loch-Katrine-Download-Leaflet.pdf

Loch Lomond Outlet Stores - flamboyant former Argyll Motor Company factory in Alexandria. Car production failed and factory used to make torpedoes. Now a shopping centre with Scottish built cars displayed on occasions.

Riverside Museum and the Tall Ship
Riverside houses the Glasgow Transport Museum and more. Nearby barque *Glenlee* built on the Clyde in 1896 has been restored by volunteers.
www.glasgowlife.org.uk/museums/riverside/pages/default.aspx

Turbine Ship Queen Mary
Glasgow, 1933
Built by Dennys and used for Clyde coast services.
www.tsqueenmary.org.uk

Maid of the Loch
Last major paddle steamer built in Britain, currently undergoing restoration. Also working steam slipway. Loch Lomond Steamship Company, Pier Road, Balloch, G83 8QX
Tel 01389 711865.
www.maidoftheloch.org
Email mail@maidoftheloch.org

National Museum of Scotland (Edinburgh)
Many fine models including a sectioned model of Denny's *SS Nerbudda* built in 1883. Much industrial and engineering interest in this well displayed collection.

PART 13

Ferrabee Pillar Engine, 1862

Anthony Mount continues his construction series; an unusual stationary steam engine.

Continued from p.461
M.E. 4582, 16 March 2018

I was looking through some old technical books and came across an engine exhibited at the International Exhibition of 1862 (not to be confused with the Great Exhibition of 1851); I rather liked the look of it, thinking it would make an attractive model.

Expansion chamber to pump (Part 76)

We need to do some more machining in brass for the expansion chamber. I find that brass can have swarf like millions of tiny needles to catch the unwary fingers so, if you have some, preferably use bronze, where the swarf is more like little granules and far less sharp.

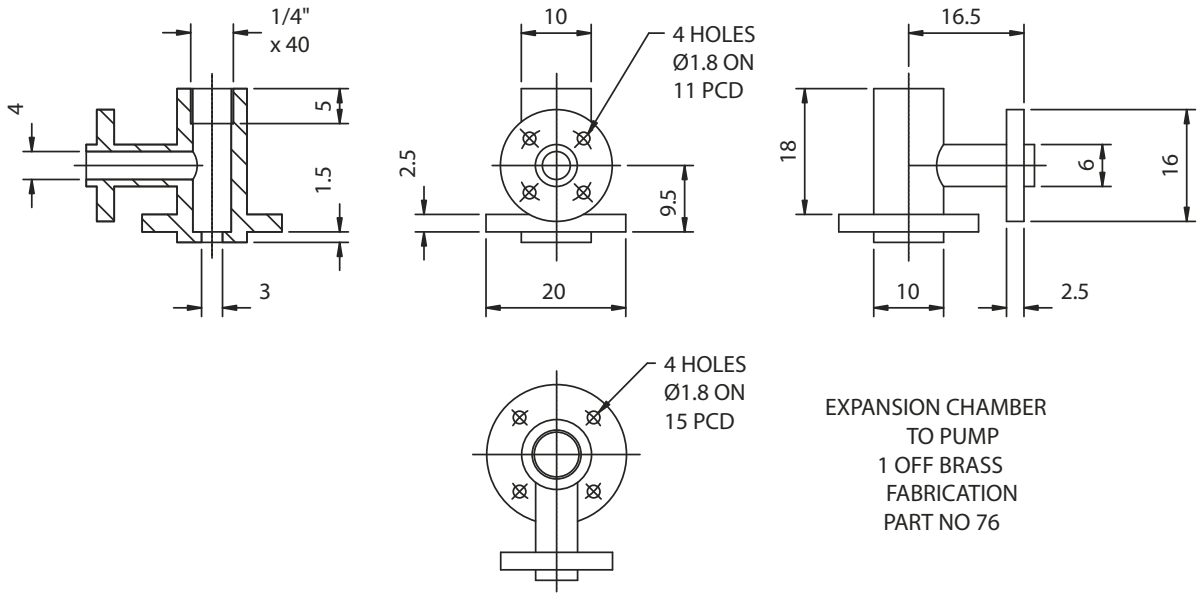
Using 20mm diameter material turn down the stem, drill through 3mm and open out with a flat-bottomed hole to tapping size for ¼ inch x 40tpi then tap for a depth of 5mm. Part off, reverse in the chuck and turn down the register to suit the pump body.

Cross drill and tap ¼ inch x 40 and then make up the separate flange and stem, threading the stem ¼ inch x 40 to screw into the cross drilled hole. The two parts can have the stud holes drilled using the dividing head, after which the two parts can be silver soldered together.

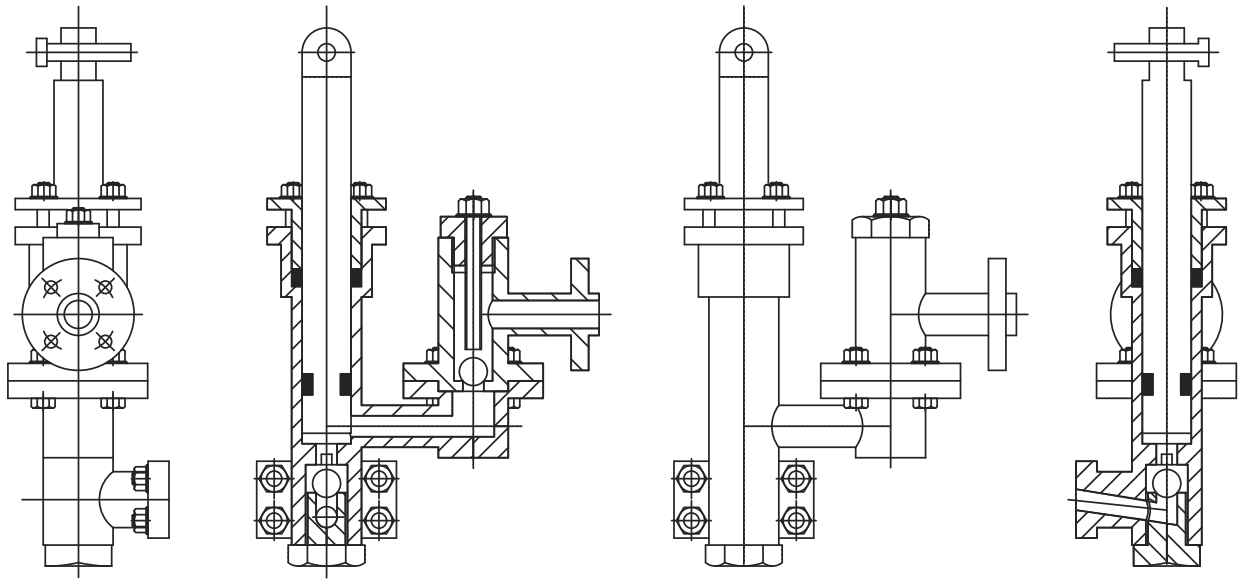
Pump body (Part 77)

The pump body is another brass fabrication, using 18mm stock to start with. The stem can be turned down to 10mm diameter followed by the bulge for the gland, then drill through at 3mm diameter and open out and tap ¼ inch x 40tpi. Part off leaving a flange at the top.

Fig 27



EXPANSION CHAMBER
TO PUMP
1 OFF BRASS
FABRICATION
PART NO 76



GENERAL ARRANGEMENT OF PUMP

FERRABEE'S COLUMN ENGINE 1862	FIRST ANGLE PROJECTION	Historic Engines South West
PUMP DETAILS	DRG NO 27 / REV'	
	SCALE 1:1 / DATE 26-07-13	
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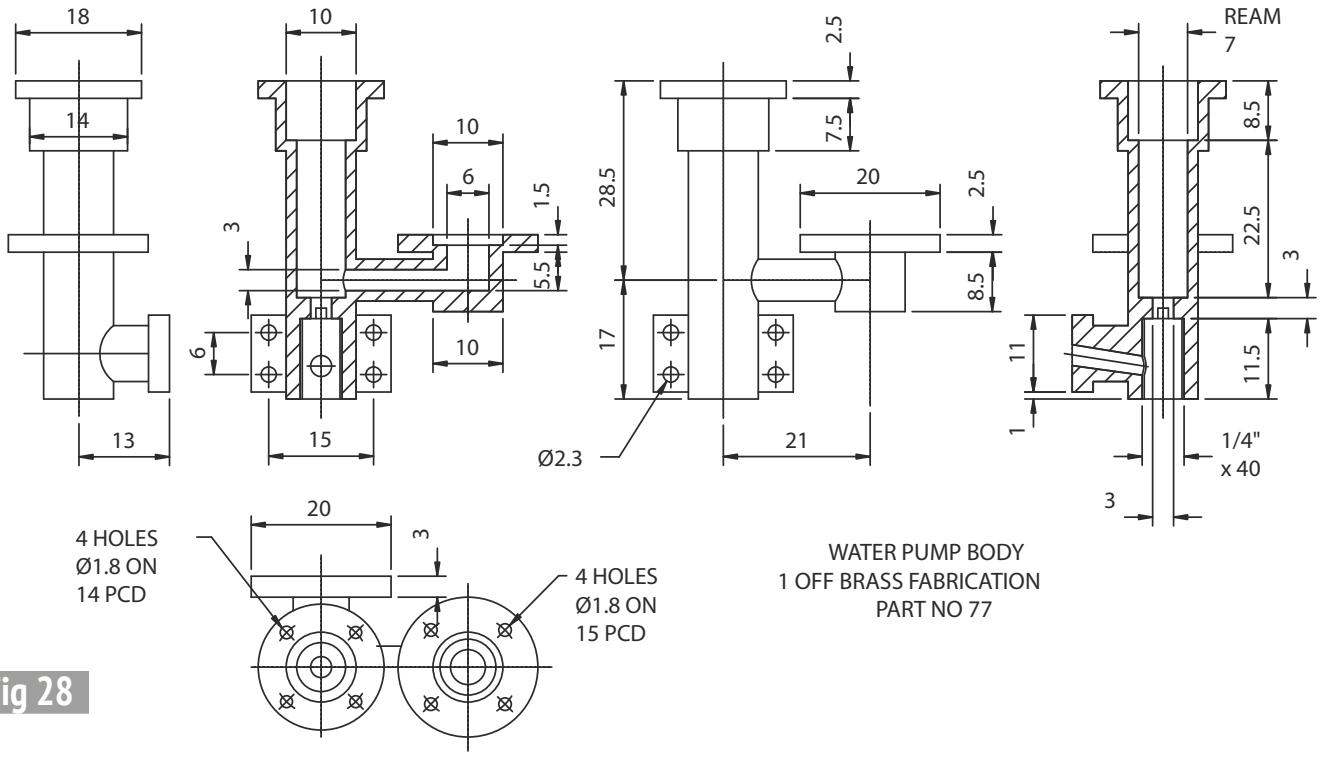
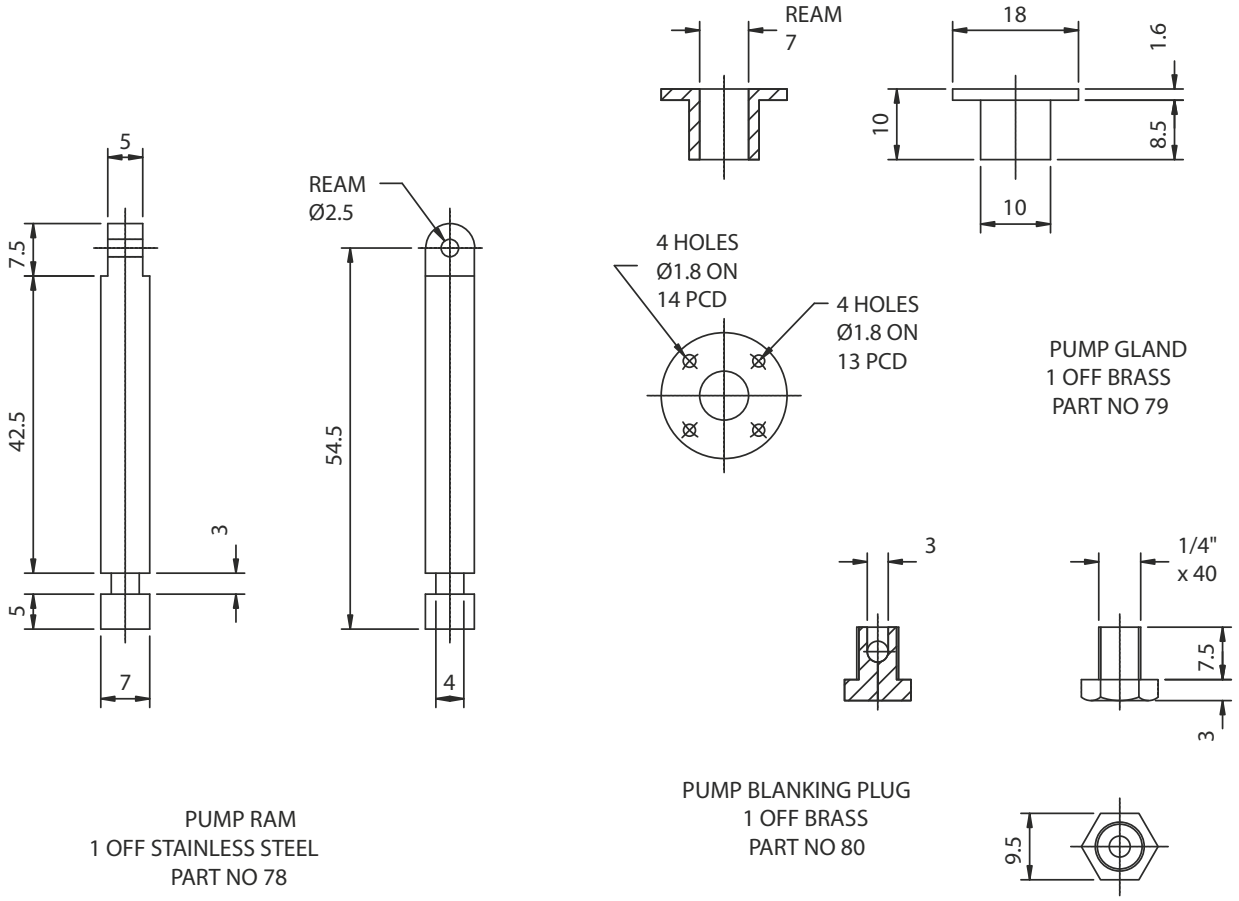


WATER PUMP BODY
1 OFF BRASS FABRICATION
PART NO 77

Fig 28



PUMP GLAND
1 OFF BRASS
PART NO 79

PUMP RAM
1 OFF STAINLESS STEEL
PART NO 78

PUMP BLANKING PLUG
1 OFF BRASS
PART NO 80

FERRABEE'S COLUMN ENGINE 1862	FIRST ANGLE PROJECTION	Historic Engines South West
PUMP DETAILS	DRG NO 28	REV'
	SCALE 1:1	DATE 26-07-13
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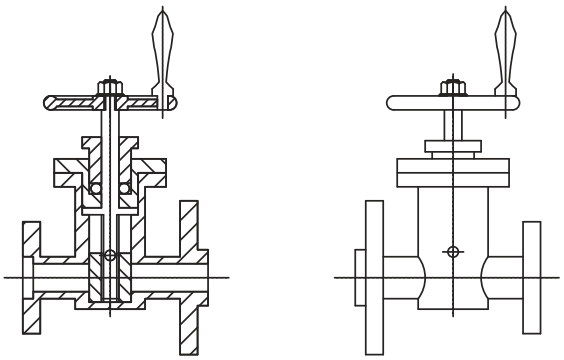
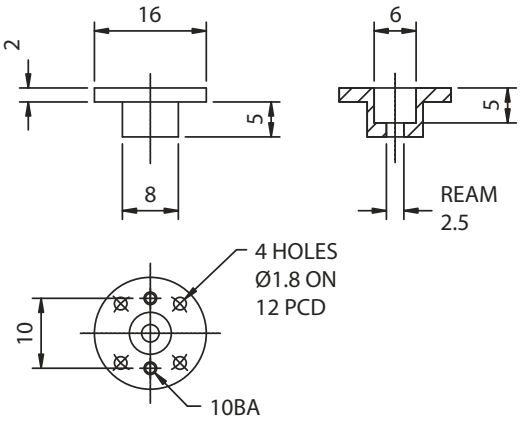
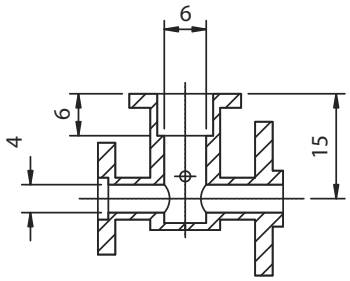
Fig 29



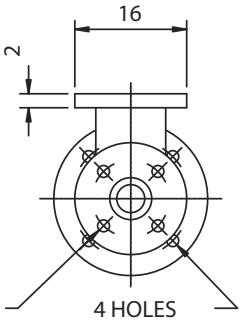
GENERAL ARRANGEMENT
OF CONDENSER VALVE



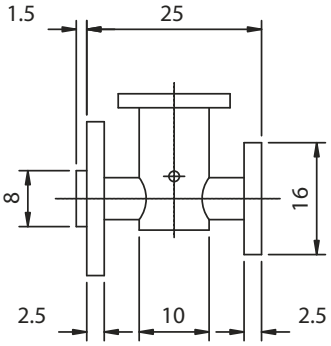
CONDENSER VALVE COVER
1 OFF STAINLESS STEEL
PART NO 81

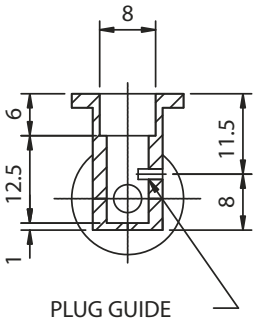


4 HOLES
Ø1.8 ON
11 PCD



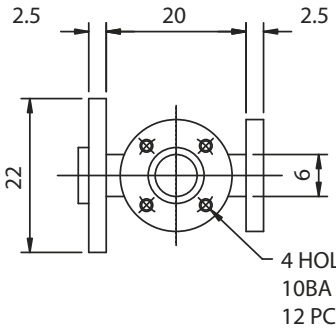
4 HOLES
Ø1.8 ON
17 PCD





PLUG GUIDE
PIN Ø1.5mm

CONDENSER VALVE BODY
1 OFF BRASS FABRICASTION
PART NO 82



FERRABEE'S COLUMN ENGINE 1862	FIRST ANGLE PROJECTION	Historic Engines South West
PUMP DETAILS	DRG NO 29	REV'
	SCALE 1:1	DATE 27-07-13
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Reverse in the chuck and drill and ream 7mm, opening out to 10mm at the top for the gland. Cross drill and tap ¼ inch x 40tpi for the side tube. Another little job is to make a couple of recesses in the bottom 3mm hole to stop the ball from sealing on the up stroke of the pump. I used a long series 3mm end mill with the body held in the machine vice of the mill to just put in a couple of recesses.

The side tube is just a straight length of brass rod, threaded each end ¼ inch x 40 and drilled through 4mm diameter.

The bottom support for the valve chamber is an inverted top hat section, drilled with an 8mm blind hole and a 10mm diameter register 1.5mm deep. It is also cross drilled ¼ inch x 40 for the side tube.

To bolt the pump to the column tank pad a rectangular flange is needed. Machine up a block of brass 20 x 11mm and set up in the four-jaw independent chuck turning down to 8mm diameter for 13mm. Thread the end ¼ inch x 40tpi, part off and reverse to face off the rectangular flange. Spot the centre at the same setting to give a start for the angled hole to be drilled later.

Drill the stud holes in the flange using co-ordinates and with the dividing head drill the stud holes in the circular flanges. Screw the parts together and silver solder, passing a reamer down to clean up the bottom of the pump ram cylinder.

Pump ram (Part 78)

For the pump ram a length of stainless steel can be used or nickel silver, the latter being easier to machine. Cross drill and ream for the pin hole and use an end mill to form the tongue. Round the end by filing. Change to the lathe, machining in the groove for the packing and then part off.

Pump gland (Part 79)

Using 18mm brass turn down a spigot a close fit in the bore of the pump body, drill through and ream 7mm then part off. Reverse to face off and then with the dividing head put in the stud holes.

Pump blanking plug (Part 80)

The bottom of the pump has a threaded hexagon plug, the top of which has a 3mm blind hole forming the seal for the ball valve. Screw this tightly into the bottom of the pump body and clamp in a drill vice for drilling the angled hole, from the pre-drilled centre in the rectangular flange into the hole in the plug.

Unscrew and seat the ball - a light squeeze in the bench vice will do. Assemble after painting with a stainless steel ball.

Condenser valve cover (Part 81)

There is a valve on the side of the column tank that would have let condensing water into the tank; in our situation it can do the opposite and let exhaust out of the tank, unless you have made provision in the bottom of the tank and the wooden base to let the exhaust out.

The valve cover is made from stainless steel 16mm diameter; turn it down to fit the valve body and part off. Reverse in the chuck and, after facing off, drill and ream 2.5mm diameter, then counterbore at 6mm diameter with a flat bottomed hole.

Set up the dividing head to drill the stud holes and the two holes for the gland, which are tapped 10BA.

Condenser valve body (Part 82)

For the condenser valve body start with a length of 16mm brass rod and turn down the body to 10mm diameter. Part off, forming the flange, face off the flange and drill down a flat bottomed blind hole 6mm diameter, counterbored to 8mm diameter. Cross drill right through and tap ¼ inch x 40tpi. Cross drill also on just one side the 1.5mm hole for the guide pin.

Turn up the two flanges and stems, threading the ends and put in the registers. Follow this with the stud holes using the dividing head to index them.

Screw the parts together, checking that the stud holes are orientated correctly and silver solder together. Clamp in the machine vice on the mill by the ends of the flanges and centre the hole to be able to clean out the bottom of the hole with a three-flute end mill.

Stop valve 0 ring (Part 83)

For the gland seal I used an 'O'-ring of 2.5mm section in Nitrile.

Condenser valve spindle (Part 84)

The spindle for the condenser valve is made from 8mm stainless steel. Turn down the end and thread 10BA, then turn down to 2.5mm section, leave full diameter material for the flange and, with a short parting type tool, turn down a further section to 2.5mm diameter behind the flange. Part off, reverse in the chuck and thread 7BA, ideally left hand (see below).

Condenser valve plug (Part 85)

As you can see from the general arrangement drawing of the valve the spindle is trapped in place by the valve cover but free to revolve. The plug therefore rises and falls when the spindle is turned. Ideally the thread would be left hand then turning the handle anti clockwise would open the valve.

The plug is a straight length of 6mm diameter material threaded 7BA left-hand and a small groove is machined in its side, then it is parted off. When assembled, the pin through the body of the valve locates in this groove and stops the plug from revolving while it is going up and down.

Condenser valve gland (Part 86)

The condenser valve gland has a roughly elliptical flange with a reamed hole for the spindle and is made a close fit in the valve cover counterbore. Two 10BA studs and nuts hold it in position on an 'O'-ring for sealing.

Studs to bearing pedestals (Part 87)

The bearing pedestals need bolting to the top of the column but one cannot get in from underneath so the studs are made with a small flange that acts as a bolt head, the tops of the holes in the pedestals being counterbored for these flanges. Above the flange the stud is, as normal, threaded at the top for the bearing caps.

Nameplate (Part 88)

All engines should have a nameplate. As I write this piece a friend has sent me some photographs of a really beautiful six column beam engine he has acquired, quite large, mostly in polished brass, with ebony base, superbly made, probably late 19th century but without any information - does it represent a model of an actual full-size engine, who made it and when?

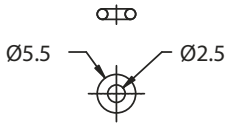
So, do put your name and details of the engine on a brass nameplate. In addition, do the same in paper and glue it to the underside of the engine base and the wooden base, as they do on the backs of paintings. You owe it to yourself that whoever owns your engine in the future (and who knows who that might be) will at least know what the engine represents and who built it.

Use engraving brass, not the usual brass plate model engineers use - your engraver will not be pleased with half hard brass - and get it engraved. Let it in flush in the wooden base, which looks better than screwing it on the face. It can be glued in with one of the modern adhesives.

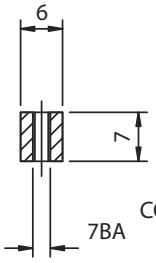
●To be continued.

Next time we will make a base for the engine and carry out the final painting and assembly.

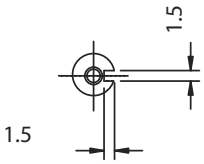
Fig 30

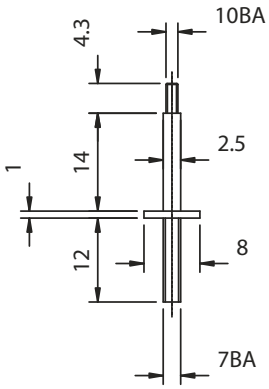


STOP VALVE
O RING
1 OFF NITRILE
PART NO 83

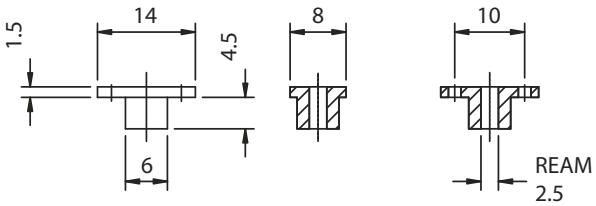


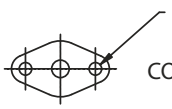
CONDENSER VALVE PLUG
1 OFF BRASS
PART NO 84



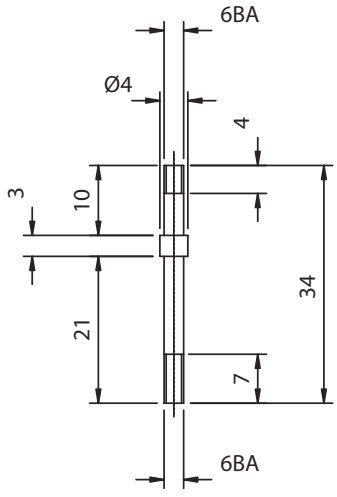


CONDENSER VALVE SPINDLE
1 OFF STAINLESS STEEL
PART NO 85

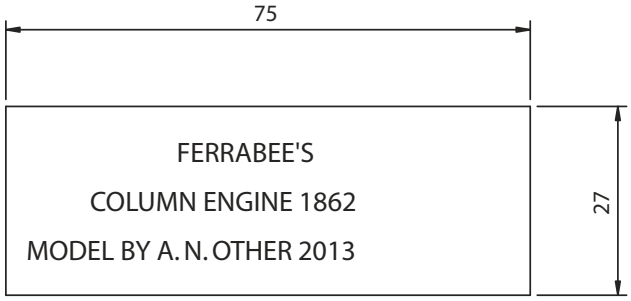




CONDENSOR VALVE GLAND
1 OFF BRASS
PART NO 86



STUDS TO BEARING PEDESTALS
4 OFF MILD STEEL
PART NO 87



NAMEPLATE
1 OFF ENGRAVING BRASS
PART NO 88

FERRABEE'S COLUMN ENGINE 1862	FIRST ANGLE PROJECTION	Historic Engines South West
CONDENSOR VALVE DETAILS	DRG NO 30 / REV'	
	SCALE 1:1 / DATE 29-07-13	
	z	

Ramon Wilson rebuilds the launch's Stuart Turner Double Ten steam engine.

Continued from p.435
M.E. 4582, 16 March 2018

Wide-A-Wake

PART 9

Wide-A-Wake **is a 2 inch scale model of a clinker built steam launch that plied the waters of Lough Erne in Ireland at the turn of the 19th Century. The model, designed by H. Croker and built in similar fashion to the full size, is powered by a Stuart Turner Double Ten engine and was first featured in the February 1972 issue of *Model Boats* magazine.**

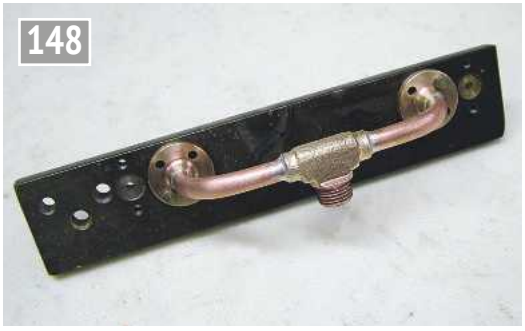
The pins for the reversing linkage were turned from steel and cross-drilled for split pin retainers. A simple cross drill jig was made from an offcut of steel to give the correct spacing between the head and hole position, allowing for the washers (**photo 147**).

Another simple aid was made from a scrap of mild steel bar to ensure the correct spacing and angular positioning of the inlet and exhaust flanges. The piping was silver soldered to the flanges *in situ* on the fixture, the finished parts not requiring any tweaking to fit the engine (**photo 148**).

Lagging was cut from a 6 x 1mm walnut strip bought from a local shop and a beading run down one edge similar to the boiler. This was stuck to a piece of 0.8mm ply cut to suit the cylinder recess. Rather than drill and tap the cast iron cylinder directly for the 14BA holding screws this was drilled to take small brass bushes. These had been tapped on the lathe - much safer and easier on such a small tap - and were carefully *Loctited* in position (**photo 149**).

The pipe-work could now be fitted and finally a test on air was carried out. The eccentrics required some slight movement that tested the idea of accessing the grub screw through the top strap oil hole. Once aligned, the hex key

The simple drill jig for cross drilling the linkage pins.



The jig for soldering the flanges in place. Holes to each side of the flanges are for the inlet. The other three holes are from a previous use.

was inserted, the screw eased and the crankshaft rotated by the flywheel a touch. This worked well and proved the principle. As said before it meant that the eccentrics could be kept much thinner, the straps held closely by the side walls and no boss to take the grub screw was required (**photos 150** and **151**).

The Inlet pipe work was lagged using cotton parcel string wrapped tightly around then, once satisfied with the appearance, it was liberally coated with thin super glue to fix and harden it. An oil separator tank was produced from a short length of brass pipe and mounted alongside the engine and the original ST displacement lubricator, bought at the outset in 1972, looked as if it finally might get pressed into action. It would turn out on first steaming that it was in just the right position and worked just as intended (**photo 152**).

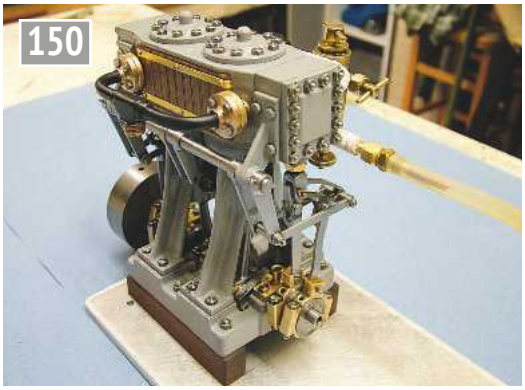
A small water pump was fabricated to the usual design and a 'casting' milled from aluminium to support the drive shaft. The helical gears were purchased from HPC and were modified to suit (**photo 153**).

With a combination of home-made and shop bought valves the whole plant was finally installed and plumbed in. Following a comment on the forum about string lagging being covered over with *Poly Filla* to smooth it out, white *Miliput*, an epoxy resin clay filled modelling putty, was applied over all the inlet piping and sanded smooth once cured (**photo 154**).

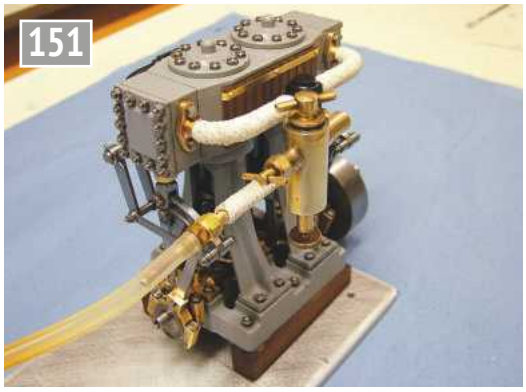
With the exhaust piping lagged and everything in place (**photo 155**) two servos were installed, one to move the throttle valve and the other the reversing gear. The necessary but rather out of keeping wiring was run through as unobtrusively as possible to the receiver in the aft cubby hole where the rudder servo is situated.

An anchor fabricated from nickel silver and a boat hook from brass (**photo 156**) plus some dummy rudder steering

The lagging and method of fixing - much safer than tapping the casting directly.

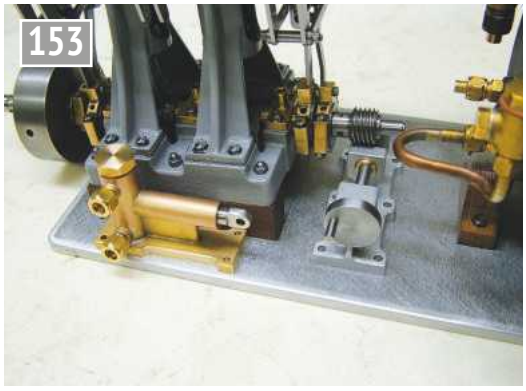


Ready to test - exhaust side.



Ready to test – inlet side. The temporary copper wire to hold linkage pins was later replaced with split pins.

The oil separator tank worked well in use despite being horizontal as opposed to the usual vertical set up.



The small fabricated water pump and drive set up.

The epoxy covering on the lagging stood up well to the first steaming although exhibiting minor cracking in places.

The finished installation. The exhaust lagging would later have a second layer of string applied – mainly for scale effect.

The boat hook and anchor proved a nice distraction from the general build.

Taken on the day the last item went on – the anchor rope.

Shame the sun would not be shining for the launch two days later.

Under the watchful eyes of 'Brian and Brian'. Note the overflow from the gauge glass valve leak to the bucket. Solved on the water by leading it into the water tank.

A happy moment making for a good laugh.

chains from the steering wheel added the small finishing touches and finally, courtesy of my good friend Peter Barnard, who had taken such a keen interest in the build right from the outset, a lovely piece of steamed pear wood with which to make a decent display stand.

Quite suddenly it seemed, after some forty four years of thinking about it and three years of some of the most enjoyable modelling time spent, it was at last ready for the water (**photos 157** and **158**).

Peter, aka 'Barney', arrived before the big day for a look. "I guess you have checked it sits on the water line" – "Err, no, I haven't!! - Haven't even thought about it!!!". You could say a slight 'sinking feeling' crept in. But, as it turned out, with full tanks and the boiler at the right mark, it was just a little down and, checking the 1972 article, just about the same as the original.

The day chosen was one of the Norwich Model Boat Club's Yachting Section 'Open Days'. Although it was rather a damp and dismal day there was, nevertheless, a good turn-out of members for the occasion - though I rather suspect it was the promise of some 'fizz' and cucumber sandwiches that did it.

Steam was soon raised that exposed two slight leaks, one on the whistle connection that had not had any pipe sealant applied, the other on the gauge glass quarter turn valve that was put down to differential expansion between body and valve. Neither was enough to prevent a head of steam however and the boat was soon ready for the water (**photo 159**).

Put up early on in the build by Barney to 'get in the spirit of it' my club colleagues were somewhat surprised by the attire but nowhere near so surprised as myself when my wife appeared the night before in what she had quietly been preparing behind the scenes (**photo 160**). It brought a good smile to everyone's face and added to the occasion. No launching would be right without some bunting on the vessel and this was made by a member's wife who volunteered for the job – thanks Eve – and those fenders, that proved not only in keeping but practical too with the boat alongside the pond wall, were made for it by Gill Collison, wife of another good friend.

With a few words from 'launch mistress' Eve and a few cheers and waves it was wet at last and steamed without a hitch (**photo 161**). Perhaps a little low with full tanks, it was however very stable with a good turn of speed, the throttle and reversing working very smoothly and much better than had been anticipated (**photo 162**). After being sailed by different members for some time the boat rested while we all retired to 'wet its head' with champagne (you are assured that none was wasted by pouring it on the boat!) accompanied by some tasty food prepared by the ever supportive wives - indeed a great occasion made special by all of those there (**photo 163**).

And that was it, three years of input, off and on and a whole lot of thinking about it at an end. Despite some intense effort over the building no project like this

Underway at last and a big grin can't be helped!

A little low but stable enough and more than adequate power at 60psi.

General rejoicing.

can be the result of just one person. So many friends and colleagues have taken an interest in this throughout its build and helped in some way. That, and the fantastic encouragement received from the management and instructors at the Oulton Broad Boat Building College, deserve a worthy acknowledgement. I can only say 'thank you' to all of you, whatever your input throughout this time, for it was much appreciated. Most of all, however, great thanks must go to my wife Sue, who tolerates my modelling adventures wherever they take me and, as always, was as supportive as ever from start to finish.

ME

PART 42

Garrett 4CD Tractor in 6 inch scale

Chris Gunn makes a towing eye for his six inch scale engine.

Continued from p.442
M.E. 4582, 16 March 2018

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.

By now I had accumulated a number of pictures of full-size engines and noticed that some were fitted with a towing eye which was fitted through the bolt hole on the front of the perch bracket. **Photograph 377** shows a rather dusty towing eye fitted to a 4CD at the Great Dorset Steam Fair. I have some other poorer quality pictures which show a very similar but chunkier eye. There is nothing shown on the drawings so I managed to scale something up from the pictures I had and produce a sketch. The sketch is shown in **fig 33**.

I decided to make the eye in five pieces and weld the lot together with generous fillets in all the corners which I could fettle up to look like a casting. I thought I would hold the end pieces to the centre piece with countersunk screws that would add some strength and be hidden by the welds. I made the sides of the eye from some oddments of ⅜ inch thick bar. The centre piece is made from a scrap of ⅝ inch or 15mm bar.

The pieces were marked out and the pin holes drilled before the pieces were cut to length. Then a short pin was used to line the pairs up while the ends were machined flat in the Bridgeport. While the small ends were in the vice the tapped holes were drilled and tapped. The centre piece was drilled and countersunk to match and the small clevis assembled. I milled a slot across each side of this clevis, and this was used to locate the remaining two pieces of the large end. These were held in place by two more countersunk screws and then the whole thing was welded together with plenty of amps and the biggest rods I had, building up the big fillets I referred to earlier.

It was a bit messy when I had finished but I felt there was enough deep weld to hold it all together. I could well be using this eye to pull the engine up the ramps into my van in due course. The towing eye was cleaned up and two pins made to go with it. **Photograph 378** shows the eye partially cleaned up and the two pins. Eventually the eye was polished up to give a better finish and painted black and the removable pin drilled for a 'P' clip to stop it jumping out.

Photograph 379 shows a rather rusty eye *in situ* on the finished engine.

Another couple of items that can be finalised now that the engine has been partially assembled in real life, which

The towing eye on the full-size engine.

The towing eye and pins, after welding up.

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

is running in front of the construction series, are the brake levers. The drawing showing the brake assembly has already been published in a previous episode that covered the manufacture of the brake parts apart from the levers carrying the brake shoes. I had reached a point in the assembly process where the engine was on its wheels and I could check the brake assembly and make the levers. I studied the drawings and it seemed to me that the levers were a straightforward fabrication job.

The right-hand lever looking from the back is shown with a flat web joining the two bosses and the left-hand lever is shown with a joggle in the web. The reason for this is that the right-hand lever has the brake operating lever on the inside of it which takes up some width on the brake shaft and the left-hand lever butts up against the brake shaft casting. As I had made the brake shaft plenty long enough 'just in case' I decided to make both levers the same and make a spacer to step out the left-hand lever to the right place - much easier than trying to bend the web. I know that it is not exactly as the real thing but I am sure no one will notice. It would not be a big job to make patterns for these levers and cast them complete with the joggle for authenticity.

To make my levers I adopted the same procedure as I have described elsewhere, which was to make two small and two large bosses out of non-leaded steel (EN3B was what I had) and make the webs from flat bar with a radius machined in each end to locate the respective bosses. The little end bosses I made 1 inch diameter by ½ inch bore (I will come back to the bore of the small end shortly) as I had both the material and a 1 inch diameter end mill to cut out the radius in the web. The other end I made 1¾ inches diameter as again I had a shell end mill of that diameter to plunge through the embryo web. I used 1¾ x ½ inch bar and cut the radii first, holding the bar flat in my big vice on the Bridgeport, and then trimmed the sides of the web to create the taper.

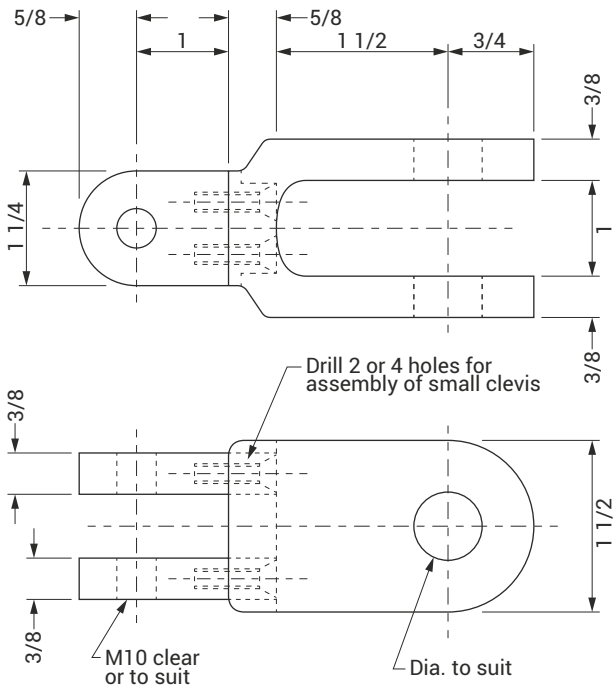
I drilled and tapped a couple of ½ inch Whitworth holes in another chunk of bar at the 3½ inch centres according to the drawing. I made a plug for the big end drilled ½ inch and with the outside diameter to match the big end boss bore. I then set the lever up with some packing holding the web in the right position, between the two bosses, and welded one side and let it cool before turning the job over and repeating the process. I managed to avoid any significant distortion in the result.

Coming back to the bore of the little end, the drawing shows a square shaft at that point and I assumed this was to keep the brake shoe aligned when the brake is applied and then released but it did not take long to realise out that this would not work in practice. I elected to put a round pin in to start, until I could try and determine what was intended. Once the levers were fettled up, I drilled and tapped a hole for a grub screw in each boss, which I would use to align the brake shoes. This should be positioned on the centreline in each end of the lever so it will not conflict with the taper pin which would be fitted on final assembly, as these holes would be drilled at right angles to the centre line of the levers.

I duly assembled the brake gear and I had to adjust the spacer and shaft slightly to get everything in the right place, which is why I always make this type of part overlong, as it does not take a moment to skim down a shaft or spacer but a lot longer to remake the part or add a bit on. I had the brake shoe fitted to a headed pin which was secured in the little end boss by a grub screw. This allowed the shoe to float but of course it also floated about when the brake was on and off and could dig in when the brake was supposed to be off. I had seen this happen on a 3 inch scale engine at one of my local rallies; it was new to the owner who was very disappointed on his first run to finish up with the brake gear in knots.

In the meantime life went on, and at one local rally a friend brought along his new Burrell miniature with all the brake gear in position and I noted that he had used a pair of leaf springs bearing on the brake shoe to keep the shoe off the wheel when the brakes were off, yet allow the shoe to pivot and seat itself on the brake ring when the brake was applied, with the spring compressing in the process. ≫

Fig 33



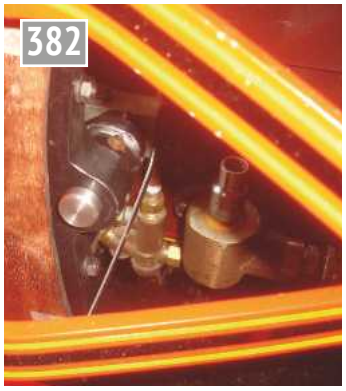
Towing Eye

Materials used:
1 1/4 x 3/8 x 1 3/4 lg. 2 off
1 1/2 x 3/8 x 2 7/8 lg. 2 off
5/8 x 1 1/2 x 1 1/2 lg. 1 off
or metric equivalents

The towing eye attached to the engine.

Splitting a spring block.

Finished spring assemblies.



Brake shoe assembly.

I felt this was the way to go in the absence of any other information, so I took a few pictures and when I got back in the workshop I had a look to see what I could do. On the Burrell there was a casting supplied for the job but I elected to make a block to carry a leaf spring and I also needed to make a longer headed pivot pin to carry this block plus the brake shoe. The new pin would be held in the brake lever and the brake shoe could then pivot on the pin, being retained by the head of the pin. The block to hold the spring would be held on the end of the same pin and retained by splitting the block and providing a pinching screw. I also needed a couple of leaf springs.

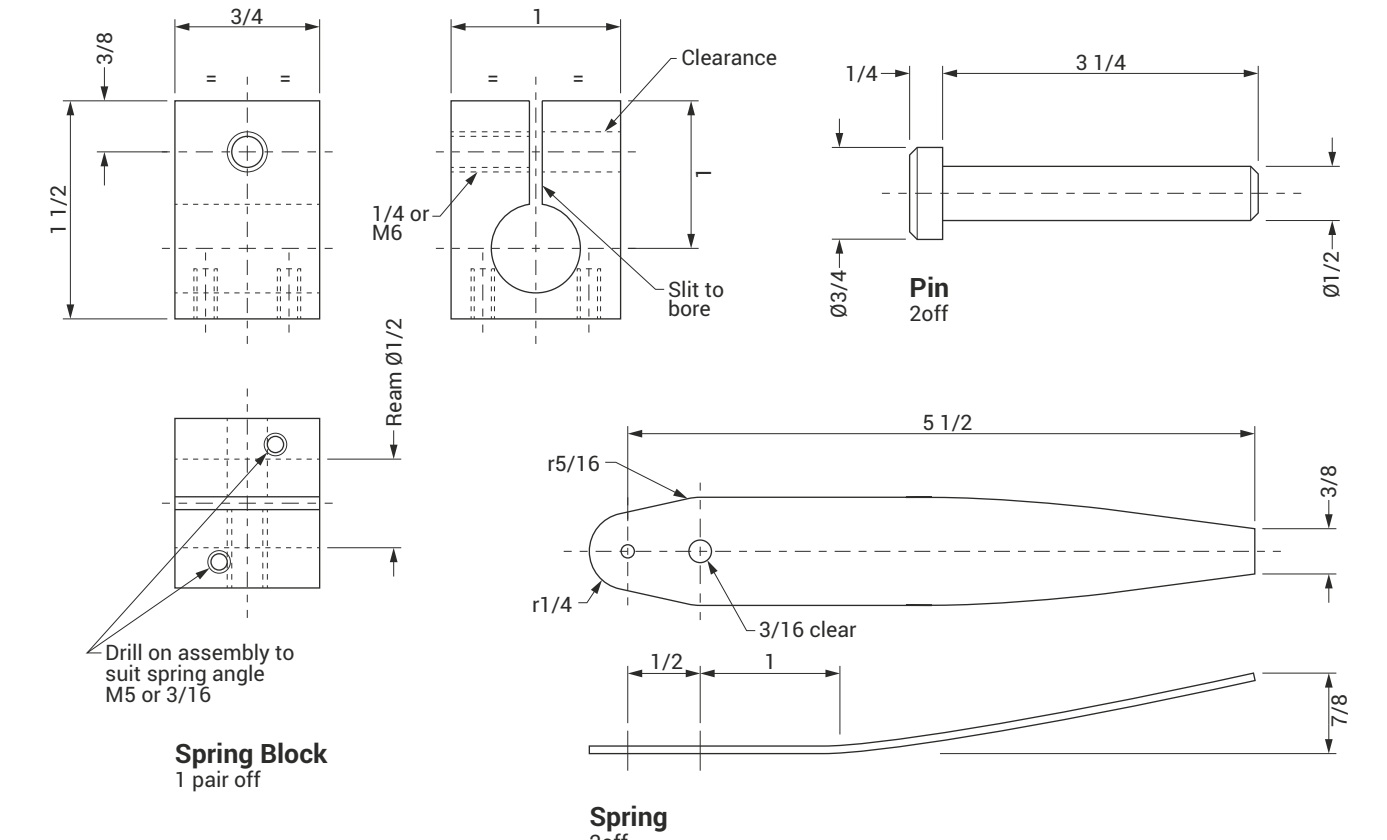
After I had a measure up, I realised that I could perhaps be able to use the leaf springs we used when I was working on the pallet nailing machines we produced before I retired. The older machines were equipped with chucks to receive the loose nails which were held in the chuck by a pair of jaws which were held by four blade springs about 5½ inches long, which seemed to be just right for the 4CD. I set off on the scrounge and found that the chucks I was familiar with were just about obsolete but there were some springs still in stock, so I was able to come away with two and a spare.

With springs to hand I could sketch up the block and the new pin, all as shown in **fig 34**.

The headed pin is a simple turning job and the split block was made from an oddment of rectangular section bar. The hole for the pin and the clamping screw holes were drilled first, followed by the holes for the spring, one tapped and one just 1/16 inch deep for the dimple in the spring to seat in. Once the holes were completed the block was split with a ⅛ inch thick side and face cutter as shown in **photo 380**.

Photograph 381 shows the pair of spring blocks with springs attached and **photo 382** shows the completed brake shoe assembled on the engine.

Next time I will continue with some more of the smaller details required.



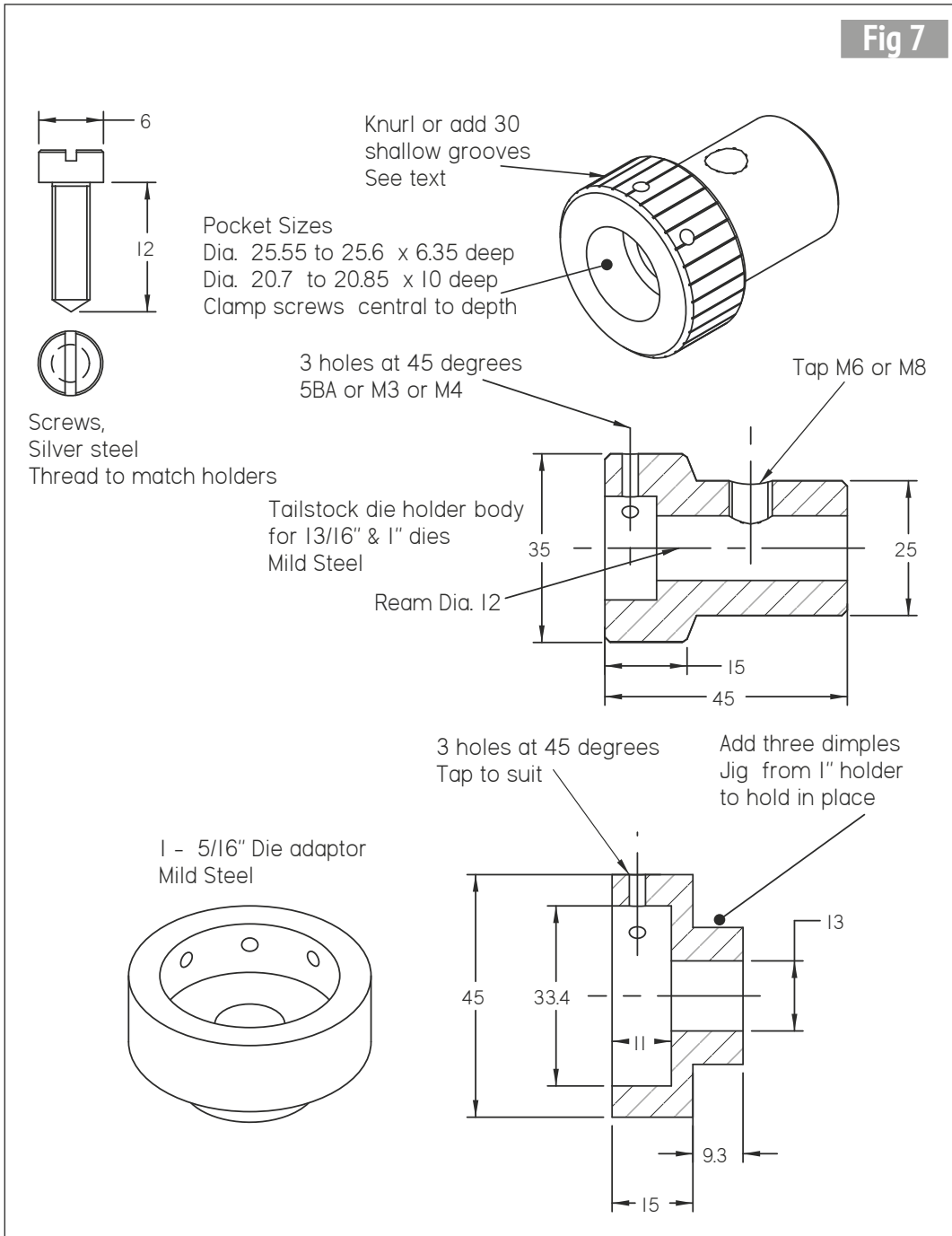
Brake Pin And Spring Holder

Fig 34

●To be continued.

PART 11

Lathes and more for Beginners



Tailstock die holder.

Graham Sadler describes how to make a tailstock die holder and a boring bar.

Continued from p.519
M.E. 4583, 30 March 2018

The tailstock die holder

I made my first die holder as one of our projects while teacher training. It's double ended, mounted on a Morse taper shank. A plain bar in the tailstock chuck will perform well enough though and is a lot easier to make! The double end is a bit of a pest as it tends to carry swarf over when switching ends. In addition, a big capacity chuck is needed to hold it so the form shown in **fig 7** is better and that's what we'll make.

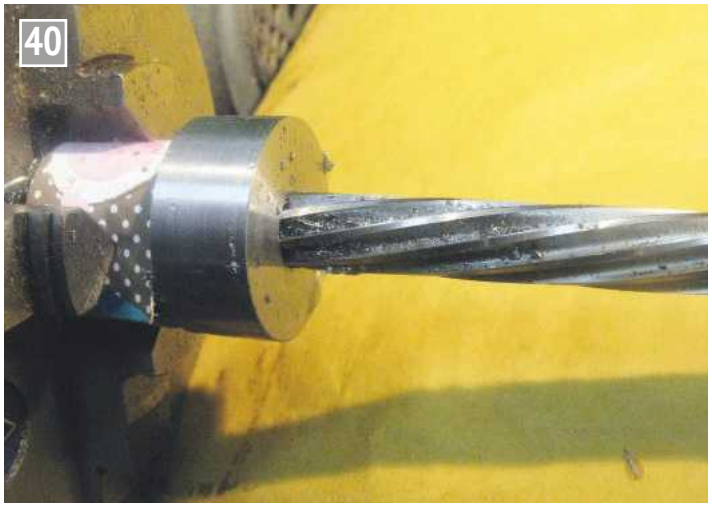
Photograph 37 shows some of my set of die holders, all different but essentially the same! For the handles, on the right is a redundant machine handle from my CNC

Four tailstock die holders; the three in the front are used most.

≫

Reducing the body diameter.

Drilling the hole.

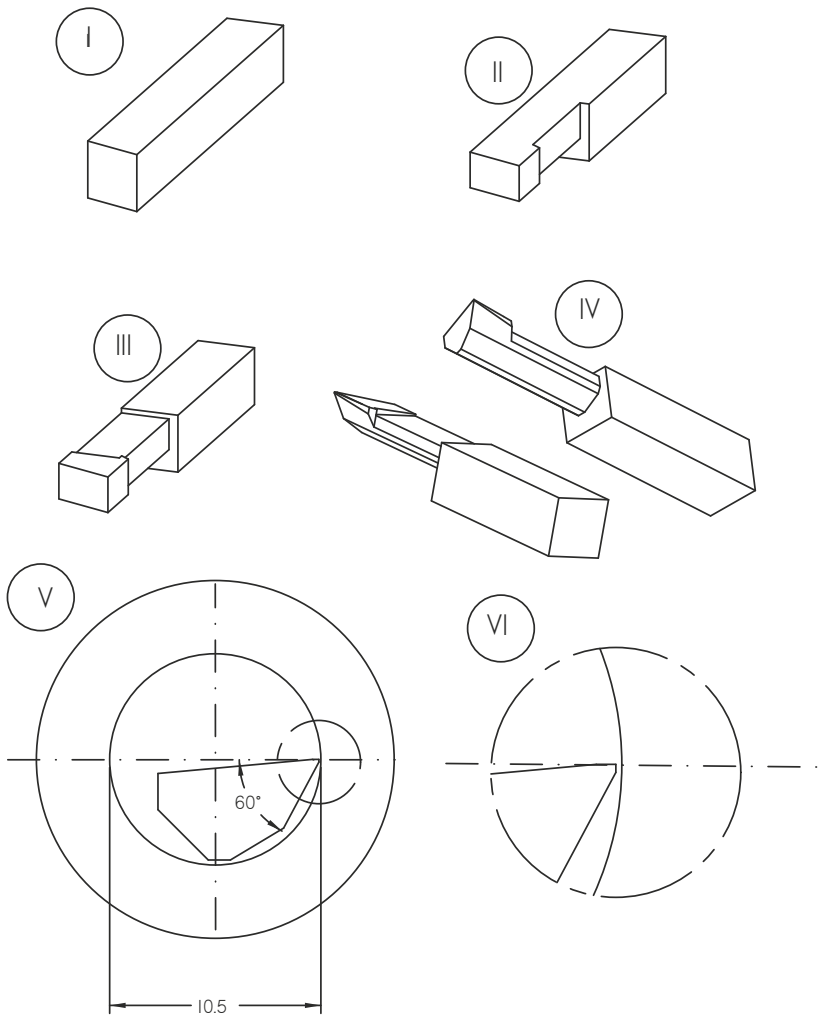


Reaming.

conversion, the left pair have a handle which happened to have a bore which is a close fit on the M8 stud, held in place by jamming with insulation tape - it does not have to be complicated... The top posh one was made as an exercise during my teacher training. I am advising all hardened screws as the ones in here caused problems getting damaged and jammed in place and they have since been replaced.

Cut off a length of 35mm diameter mild steel, 45mm long and face one end. Reverse in the chuck and, using your round nose tool, machine it down to about 25mm diameter for a length of 30mm (**photo 38**). Wrap a bit of card round this to protect the new surface, reverse in the chuck and reface. Centre drill and drill to 11.5mm (11.7mm is the correct diameter) for a 12mm hole then drop the speed to ⅓ of the drill speed and ream the hole if machine reaming (**photos 39** and **40**).

If using the pump centre with a hand reamer turn the chuck by hand as it would be highly dangerous to do this under power. The reamer could be pulled into the hole and off the pump centre and your hand is in the midst of all this… not good. Use plenty of lubricant and withdraw frequently to clear swarf. The 11.5mm hole is really too small so you will need to feed very slowly with frequent withdrawals as we are reaming away more than we should.



Making a boring tool:

I The basic bar with the end angled across the top for front clearance.
II Front (chuck side) relief and bottom relief (3–4mm).
III Top relief to form tool platform and front clearance at 6 degrees.
IV Rounding the bottom for clearance in the drilled hole.
V Primary clearance at the tip of the tool is 6-10 degrees, secondary clearance is at about 60 degrees. The hole shown is 10.5mm diameter - use a 10mm washer to check.
VI Here the effect of a primary clearance being too small is clear.

Fig 8

Making a boring bar

To produce the pocket for the die we will need a boring bar. Boring is an interesting process but the main difficulty is in seeing what is going on and removal of the swarf. We turn from the inside moving the tool towards us. A selection of boring bars is shown in **photo 41**.

Figure 8 shows how to grind our tool using the same method as for the tools we made before. **Photographs 42** and **43** show the reality and it is not quite so neat! If possible, use a long piece of 8mm HSS for this (I found difficulties in holding it when making the tool post ready for publication) and make it so it can cut to a depth of at least 27mm.

I used to make all my bars and many used tiny round cutters but they were a devil to grind before I made the holder we will cover in the grinding section. These days, I mainly use the inserted tip type, and **photo 44** shows one of its more useful features (perhaps not in all forms of bar) - the tip is angled downwards thus increasing the clearance under the bar and reducing the minimum size of hole they will fit in. The rake angles, I understand, are preserved by the geometry of the tip; all I know is that they work (many inserted tipped tools use negative rather than positive rake).

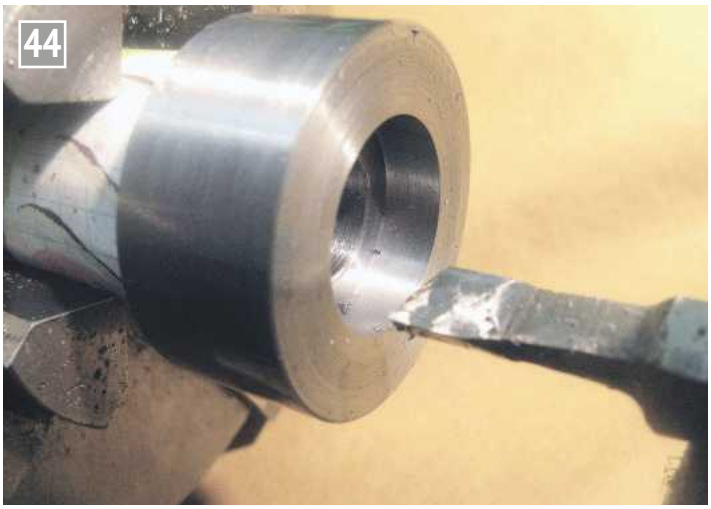
The others I commonly use for small stuff are the pre-formed HSS commercial bars based on round 6, 8 and 10mm bar. Making your first bar is not easy. I suggest you do a trial first on a piece of wood using a file as I did before grinding this one. Grind almost to the two working edges then finish with a coarse then fine oilstone. The primary clearance may need to be steeper if the tool doesn't cut. Do mark top and chuck side to avoid confusion.

To set at centre height, use another tool to lightly scribe the end of the work near the centre so it won't show then pack up to that height. In theory, you will need a single main piece of packing 9mm (⅜ inch) thick.

Boring tools, left to right: inserted bit in my tool holder, brazed small square bit for screw cutting, 10mm pocket cutting, 6mm through bar, silver steel 6mm shank, ⅜ inch carbide tipped (not now used), two small preformed bars, the one we will make.

Our bar stages I,II and II (fig 8).

Underneath thinning and rounding (stage IV).



Boring the die pocket.

Touch the tool on the inside of the hole and zero the dial. Repeat for the front face and zero the top slide dial - this of course assumes it is correctly set parallel to the lathe axis. 20.63mm is the metric diameter of the 13/16 inch die (do this one first as if it goes wrong it can be enlarged to the 1 inch size, 25.4mm). We will need the hole to be a bit bigger to enable the die to expand so aim for 20.7 to 20.85mm.

As with turning on the outside, we will ideally take a cleaning cut and measure it but firstly we need to rough out the pocket so there's something to get the callipers into. We can initially add a radial cut of 0.5 – 0.7mm (towards the chuck) with the tool in the existing hole, then feed inwards with the top slide for say 6mm. Once a few cuts have been done, use the apron hand wheel (or lead screw hand wheel if you have one), not the top slide (just in case it's not exactly parallel to the lathe axis), and take a skim cut along the inside of the bored hole to true it up for measurement. Measure the size and add cuts to bring the diameter to the required dimension not forgetting that the required cross slide dial movement when boring is negative or anticlockwise.

Incidentally, never rely on a single try when measuring with digital callipers, especially when gauging a bore. Try it two or three times to ensure the size is correct. On external measurements it's very easy to angle the jaws resulting in an increased diagonal size across the calliper jaws. Check the die is an easy but not rattling fit in the hole then face the bottom of the pocket to get the required 6.35mm depth. In reality it won't matter if the depth is up to 7mm but it's good to aim for a precise depth in order to gain skill – after all, it's always possible to face the end if you go too deep! Finally, angle the boring tool at 45 degrees and just remove the *arris* (a sharp corner edge when two surfaces meet) to make a nice chamfer – but keep this tiny!

That completes the main body of the tailstock die holder. Next time we will make the adjustment screws and discuss the process of hardening them.

●To be continued.

Repetitive Machining

Some thoughts on its application to injector components

DAG Brown ruminates on repetition and reveals ruses for raising the rate of reproduction.

I do not have to wait long for our worthy editor to bend my ear about various subjects in our hobby. And so it came to pass that we were talking about productivity in the home workshop. Much frustration arises from the failure to finish models in a reasonable time and precious hours are wasted in getting the size right during machining operations. There is often a better way of organizing work. A good example is where one has to produce multiple components of similar but not identical form. Tackling these as a group, performing similar operations on all of them in one session is a sensible way of working efficiently.

Great savings in time can result from careful application of batch production in a simplified form, without the need for bespoke equipment. The example which I am describing here illustrates the point. It is a number of years since I wrote my book on miniature injectors (*Miniature Injectors Inside and Out,* DAG Brown, TEE Publishing) but it is surprising how often I get asked if I can spare the odd example for a good cause and being of an obliging nature I normally weaken by donating a small brass artefact either from stock or after a batch of production.

Faced with the task of making a batch of injectors recently, I determined to examine the savings in time which I could make by applying simple batch machining principles to the job. I was surprised by the outcome of my application. I do have my set of drills correctly and keenly sharpened to the profile well known and associated with my name. I also carefully nurture my injector tools,

Set of injector tools by the author including those for experimental work.

which comprise taper reamers, bell mouth reamers, cone depthing mandrels and those special tools for removing cones from other people's injectors which find their way into my workshop from time to time. My collection (**photo 1**) is rather special to me and is the product of years of experimental work. Luckily machining brass does not cause any of these tools to get blunt so I can select and use any of them with confidence. The first task is to prepare the necessary lathe tools, which in this case comprised a knife tool, a narrow parting tool and a round-nosed tool.

Perhaps the most fiddly task in producing an injector is machining the cones, so I wanted to measure the productivity which I could achieve by applying batch production techniques but without setting up any dedicated equipment not normally found in the home workshop. It is essential that the tools be really sharp, as I was working to close tolerances (+/- 0.0001 inch on diameter).

I had made some injector bodies, all of which were reamed by the same 7/32 inch diameter reamer. This meant that their bores were all finished very closely to the same diameter. The challenge was to machine the cones to the correct interference fit, which was of necessity different from one cone to the next. Starting with the combining cones, these must be a press fit in the bodies, thus within a tolerance of 0.0002 inch.

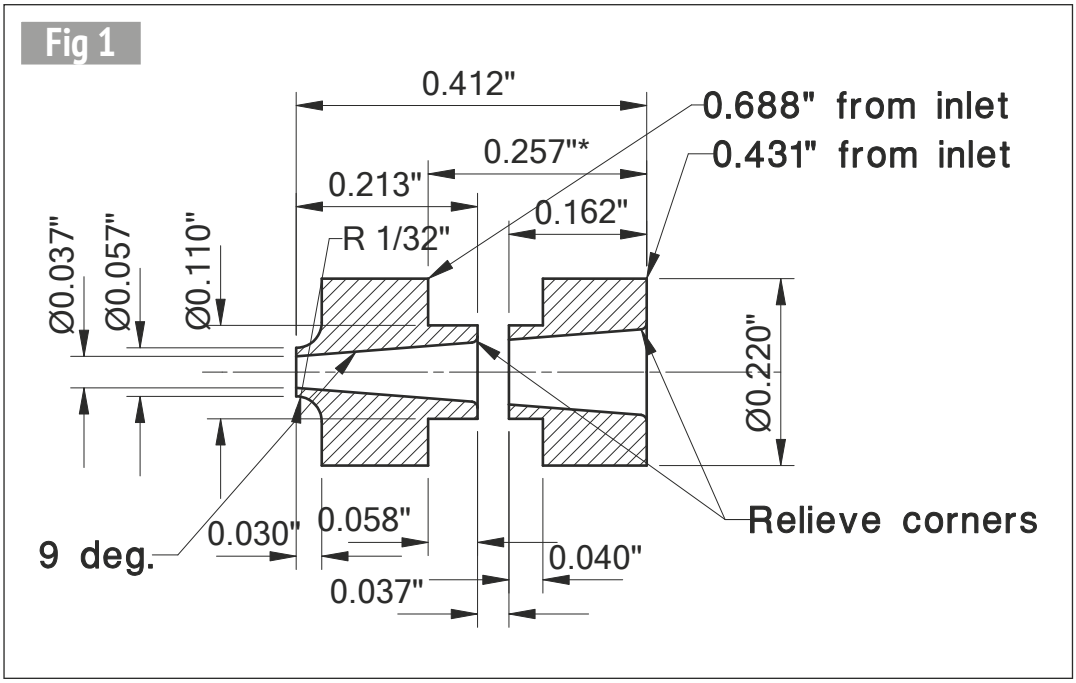
My trusty Myford *Super 7* is well capable of this sort of task, provided that the tools are really sharp. The quick-change toolpost certainly maintains true location with the surfaces kept clear of debris. I keep the top-slide locked and use the cross-slide dial to register depth of cut. The length of all cuts can be noted from the reading on the leadscrew handwheel.

A length of ¼ inch diameter brass was held in the chuck in such a position that a 0.030 inch wide parting tool just touched when the leadscrew handwheel read 120. Running the lathe at 1500rpm, the parting tool made its initial pass with the leadscrew dial set to 0. This became the

datum setting for the process; looking at the drawing of the combining cone (**fig 1**), you can interpret that the middle recessed section can be formed by multiple cuts with the parting tool advanced 0.070 inch beyond the point at which it touches the outside of the job, thus reducing the diameter to 0.110 inch. I next made some notes on a piece of sticky paper (to be stuck to a surface in front of the lathe). The notes were like this:

From datum parted @ 0:
Part at 1 turn + 27 to 0.070
Part at 2 turn + 7***
Eventual through @ 1 turn + 67 and 74
Final part @ 3 turn + 67
and so on!

Fig 1



You can see from this gobbledegook that I have written for my own benefit (never before shared with any other human being) a sort of G code which enables me to repeat accurate positioning for subsequent duplicate performances. Obviously, the small parting tool can easily be persuaded to fill in the spaces between the stated positions but this is done very quickly and with little mental effort.

Having formed the critical outside shape, the next task is to produce the tapered bore of the cone, with the diameter being 0.037 inch at a depth of 0.412 inch. I have a lovely ¼ inch *Albricht* chuck which is highly accurate. Fitted into the tailstock, its first task is to guide a No. 1 centre drill to start the centre hole. This is followed by a No. 65 drill (0.035 inch) to a depth of 0.450 inch (1½ turns of the tailstock handle). A 9° taper reamer is now used to open the bore to a smooth 9° until a 0.037 inch drill just enters the bore to the correct depth. When this is done a stop is locked on the taper reamer so that the operation can be repeated on subsequent components.

We now have the correctly shaped combining cone, apart from its outside diameter. This is completed with careful use of the knife tool, by trial and error, until the diameter is a press fit in the 7/32 inch bore of the injector body, to a tolerance of +/- 0.0001 inch. Admittedly this takes a bit of doing!

Before parting off a bell-mouth is reamed on the large end of the bore of the tapered section. The job is finished in two stages by the little parting tool at the leadscrew settings already discussed, not forgetting the bell-mouth relief of the second section before parting it off. This second relief operation is key to making sure that the injector will lift properly.

You should now find that the two-part cone unit can be pressed into the injector body using the two ends of the depthing tool to achieve the desired result.

Setting up this complicated sequence of operations originally took me about ¾ hour including making the above recordings and starting with my trusty set of prepared reamers and other tools. However, it was simple to repeat all the operations using the above logic and, by the second set of repeat operations I was achieving a 'floor to floor' time of less than 10 minutes. This is what the 'repetitive machining' process is all about. Analogous operations to form the steam and delivery cones resulted in repeat times of well under 10 minutes per component; thus the time to produce the cones for a complete injector dropped to under half an hour per unit (**photo 2**). The same repetitive logic applies to the injector bodies and I have normally made small batches of the little devices, in the sure knowledge that they will find good homes in the fullness of time (**photo 3**).

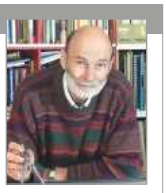
ME

Sets of finished cones and other components awaiting assembly.

Finished injectors looking for a home.

ME Vertical Boiler - Hand Pump

PART 5



A project aimed at beginners wishing to develop their skills or those requiring a robust vertical boiler for the running or testing of small steam engines. **Martin Gearing** lists the materials and other parts you will need.

Continued from p.450
M.E. 4582, 16 March 2018

To start with, you'll find here **figs 1** and **2**; the first because our editor forgot to include it last time (sorry! – Acting Ed.) and the second because I had mistakenly drawn a mirror image of the cutter. The original will of course work if used anti-clockwise but, failing that, you'll need to make a new one.

Apologies over, let's move on to the cylinder!

Cylinder – Item HP2

Ø12 x 40 Brass (**Figure 4**)

Hold a Ø12mm x 40 length of brass in a self-centring chuck with 10mm protruding and face off. Chamfer the edge 45° x 0.5mm. Turn around and hold with 15mm protruding, skim the end face, remove and measure to find how much needs to be faced off to bring to 38mm length. Replace in the chuck and remove the calculated amount.

Turn the diameter 10mm (+0.00 – 0.10) x 11.25mm, checking that it fits the hole machined in the pump body before removing any sharp edges. Centre drill, drill Ø7mm through the length. Using a small boring bar open the drilled hole out to Ø7.8mm before putting a Ø8mm reamer through at slow speed.

I find that using the traditional green *Swarfega* hand cleaner applied with a brush to the flutes as a lubricant improves the finish immensely, not only when reaming but also drilling and

Fig 1

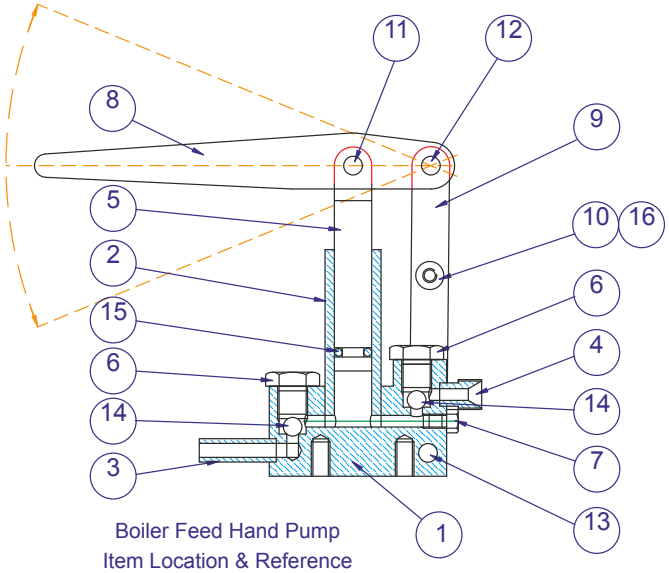


Fig 2

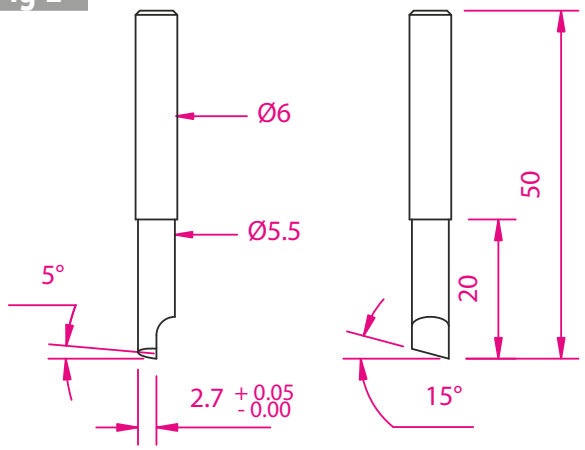
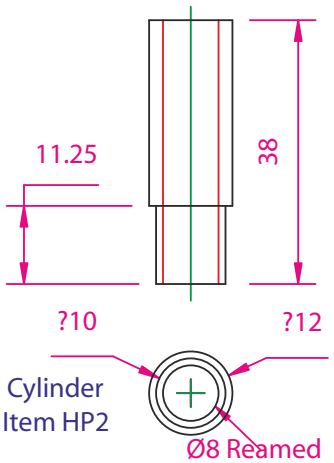


Fig 3



when using threading tools. I can't remember where I read about this tip but thank the person, whoever they may be. A major benefit of using *Swarfega* is that it doesn't cause any difficulties when the part has to be subsequently silver soldered unlike some cutting compounds. Remove the work from the chuck and with a scraper remove the sharp edges from the bore at each end.

Silver soldering

I would recommend that you purchase Keith Hale's recently published book *A Guide to Brazing and Soldering – Everything you wanted to know about Silver Soldering – but were afraid to ask!*

Failing that find time and make the effort to read the *Guide to Silver Soldering Best Practice*, also by Keith Hale. Details of both are on the CUP Alloys web page. In the absence of either, the following should enable the process to be well understood.

Silver soldering – the process

Silver soldering is not the black art most people believe – **provided** that you have access to the right equipment, the right attitude and understand what you are trying to achieve. Given the price of silver solder and the materials being joined it pays to get it right first time!

You will need heating equipment and for most this will be in the form of a propane fuelled torch. The quality end is made by Sievert, which is expensive but an excellent investment, followed by Bullfinch and similar companies, which are a little cheaper but do not offer such a comprehensive range of burners. To make a start, without breaking the bank, there is a three burner kit by Clarke to be found at Machine Mart, which I've used exclusively here to demonstrate that it is more than suitable for this and similar sized jobs.

Silver soldering needs to be done in an area away from anything combustible and on a surface able to resist extreme heat. Fire bricks are the best but for this job three or four aerated concrete blocks (trade names such as *Celcon* or *Thermalite*) will serve and are a lot cheaper - the downside is they don't reflect the heat back into the work as well or last as long. **Do not** be tempted to use the bricks from night storage heaters. They are designed to **absorb** heat and you will use most of your gas getting them up to temperature rather than your job!

Silver solder, if purchased for this job, will be cadmium free - if you are given some it may contain cadmium and must only be used in an area with plenty of ventilation. All joints for maximum strength need a gap of ideally 0.1mm (0.004 inch). Having two joint surfaces fitted tightly together will prevent any capillary action from taking place and result in a 'dry joint' which has no or little strength.

The last and most important is **cleanliness**. It won't do any harm to wear rubber or vinyl gloves at the final assembly stage to prevent any natural grease from your fingers contaminating the joint. The surfaces must be cleaned just prior to heating and fully coated/covered with the correct flux, which has a cleansing effect as the joint is heated. However, if the joint is kept hot for too long the flux loses its effect - so it pays to be organised. Also, be careful not to work on any surface on which soft soldering has been carried out as the flux residues and any traces of lead will contaminate the joint.

I recommend actually cleaning the silver solder rod itself before use with wire wool, as that also becomes 'dirty' if left for any length of time and should be considered part of the preparation process, particularly if the rod is from old stock.

The process I use is the 'Palette' method which is used by silversmiths and jewellery makers. I recommend it wholeheartedly – and unconditionally - particularly for the beginner, as it removes one of the dicier parts from the juggling act that one has to perform when silver soldering.

What must be understood is that it is the material either side of the joint which has to be brought up to temperature sufficient to melt the silver solder alone. The silver solder is not melted onto/into the joint, unless you want to waste a lot of expensive material and produce work that looks like it has had molten silver solder flicked all over it!

When the work is heated the first thing that happens is that the water is boiled off from the flux. This often results in the silver solder being displaced quite a distance from the original location. Returning it to the intended joint area is best done using a 'Scratch Stick'. This is made ideally from a length of Ø3mm stainless rod with one end machined/shaped to a 60° point and bent about 25mm from the point at 80°-90° and the other end formed into an eye/ring to make it easier to hold. Another function of the stick is to 'encourage' the molten silver solder to flow uphill when occasion demands!

There is a length of suitable material included in the metal pack.

For silver soldering the hand pump parts together you only need to use one grade of solder comprising of 55% silver, which has the feature of having one of the lowest melting points available and I suggest using Ø1.5mm and Ø0.7mm wire of that grade. To use it you will also need a compatible flux most usually referred to as *EF* or *Easy Flo* depending on the manufacturer/supplier.

When cooled the parts should be submerged in 'pickle', for between 10 – 15 minutes. Traditionally this was a solution of 10% sulphuric acid diluted with water, contained in an acid proof container, and this remains the most effective. The measured quantity of acid must **always** be added to the water whilst stirring continuously, **never** the other way round. These days there is some reluctance to using this type of pickle, mainly because of problems with disposal and storage, particularly where space is limited and small children are about. Alternatives are citric acid, available from home brew suppliers, or a specialist product obtainable from CUP Alloys or the suppliers listed, amongst others, which present far fewer problems with disposal and general safety.

After a suitable time wash the parts with clean water scrubbing the joint area with a stiff nail brush, before putting to one side.

The hand pump's construction will introduce you gently to a very useful phenomenon that occurs when using silver solder. Put in simple terms - when a piece of fluxed material is heated sufficiently hot to melt silver solder, the solder flows on the material and in doing so changes its composition slightly due to slight alloying of the solder to the base material. This slightly altered composition of the solder requires a slightly higher temperature to re-melt, and because of this allows a new joint to be made on a component that is made up of parts previously joined by silver soldering – **provided care is taken** not to heat the work beyond that just necessary to flow the silver solder on the new joint. When doing this, a very sensible precaution is to flux both the new joint and the previous joints which will save a previous joint should it actually begin to melt.

I should perhaps take this opportunity to sort out what is the correct (EXACT) terminology for the process that is commonly referred to as 'silver soldering'. It is unfortunate that there is a long accepted common interchange of terms which is guaranteed to cause great misunderstanding to any newcomer.

Referring to Johnson Matthey, one of the oldest ≫

Bringing up to temperature.

The solder after flowing.

suppliers of the product, you will find they say that 'soldering takes place below 450°C and brazing takes place above 450°C' and 'silver brazing uses filler materials containing silver that melt between 600°C and 900°C, below the melting point of the metals being joined'. Also – 'silver soldering/hard soldering are terms synonymous with silver brazing (not soldering)'. For my sins please forgive me for choosing to use the term 'silver soldering' throughout and not the technically correct 'silver brazing'. It is my reason for referring to 'silver solder/soldering' rather than just 'solder/soldering' which has a good chance of being misinterpreted in the beginners home workshop!

The fact that a previously silver soldered joint requires a slightly higher temperature than that used to flow the silver solder originally is accepted practice. This feature may be further enhanced by what is referred to as 'step silver soldering' and will be described in detail in the next section.

Silver soldering - part one

Wash in plain water both the cylinder and body and dry, before coating the bore in the body and the reduced diameter on the pump cylinder with *EF* flux before assembling the cylinder to the body. Set the assembly level on the brazing hearth and form a piece of Ø1.5mm low temperature (55%) silver solder to fit half way around the outside of the cylinder where it meets the body, then coat the silver solder and joint area with a little more flux. Using a medium-size burner heat the assembly up, directing the heat onto the greater mass of the body with occasional attention to the upper part of the cylinder but generally avoiding where the piece of silver solder is resting (**photo 7**). The flux will become transparent as the assembly nears the temperature at which the solder will flow. When the solder melts, encourage it to flow completely around the joint using a scratch stick if necessary. Maintain the heat for a few seconds to ensure full penetration (**photo 8**). Remove the heat and allow to cool for at least five minutes before placing in the pickle. Resist the temptation to plunge the assembly immediately into the pickle; while this definitely removes the flux residues much more quickly it also increases the risk of the joint fracturing and of you suffering acid burns if splashed. After ten minutes remove the part from the pickle, waiting to allow as much of the fluid to drain back into the container as possible before transferring the assembly into a container of plain cold water. It should be left there for an hour or so by which time all of the flux residues will be either removed or softened to the point that brushing with a nail brush or stiff toothbrush will clean any remaining trace of flux residue away.

Next time we will continue with the machining of the main body and cylinder.

●To be continued.

Table 1. Boiler hand feed pump materials list.

Item	Description	Material and Size
HP 1	Body	½ x 1 inch Brass
HP 2	Cylinder	Ø12mm CZ121 Brass
HP 3	Inlet Stub	Ø¼ inch CZ121 Brass
HP 4	Outlet Stub	Ø¼ inch CZ121 Brass
HP 5	Plunger	Ø8mm - 303 Stainless Steel
HP 6	Valve Plug x 2	10mmAF CZ121 Brass
HP 7	Drilling Plug	Ø¼ inch CZ121 Brass
HP 8	Handle	⅛ x ½ inch CZ121 Brass
HP 9	Handle Links x 2	1/16 x ⅜ inch CZ121 Brass
HP 10	Link Spacer	Ø¼ inch CZ121 Brass
HP 11	Plunger Pin	Ø6mm - 303 Stainless Steel
HP 12	Handle/Links Pin	Ø6mm - 303 Stainless Steel
HP 13	Links/Body Pin	Ø6mm - 303 Stainless Steel
HP 14	Inlet/Outlet Valve x 2	Ø5/32 inch Stainless Ball
HP 15	Piston 'O'-Ring	BS008
HP 16	Spacer Bolt x 2	M3 x 6 Bolt

Two Pistons and Three Con Rods PART 2

Wolfgang Tepper describes a water-cooled four-stroke opposed-piston engine.

Continued from p.423
M.E. 4582, 16 March 2018

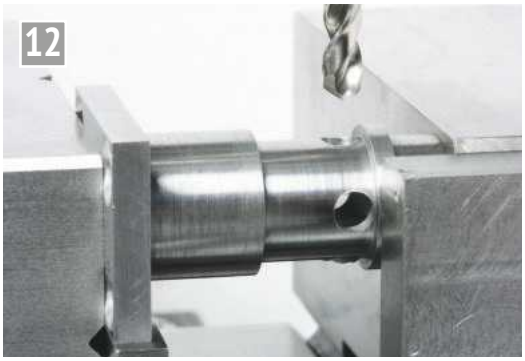
The figures showing the cylinder liner (**fig 3**) and the cylinder head (**fig 4**) were omitted last time so they are included here. We shall now move on to the valves and valve guides.

Valves and valve guides

Initially, for the four 45° bores at the cylinder head different inserts (**fig 5**) are manufactured from silver steel. They will hold the valves, the spark-plug and the blanking plug (**photos 12** and **13**). They are pressed against a copper sealing ring by means of four M3 screws each. Without these inserts there would be no way to form the valve guides, which are arranged radially at the midpoint of the cylinder.

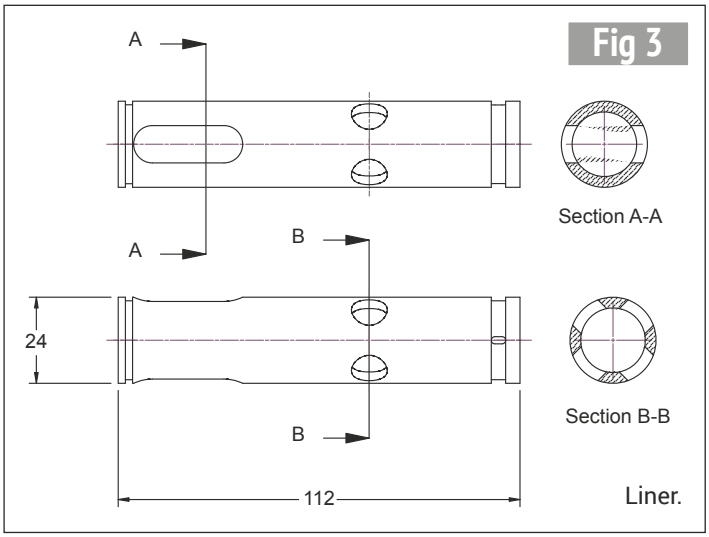
The two valve inserts are equipped with bronze bearing bushes (**photo 14**). After having been pressed in, they are bored and reamed on the lathe. The 45° valve seats are then turned at the same setting to ensure concentricity with the bore

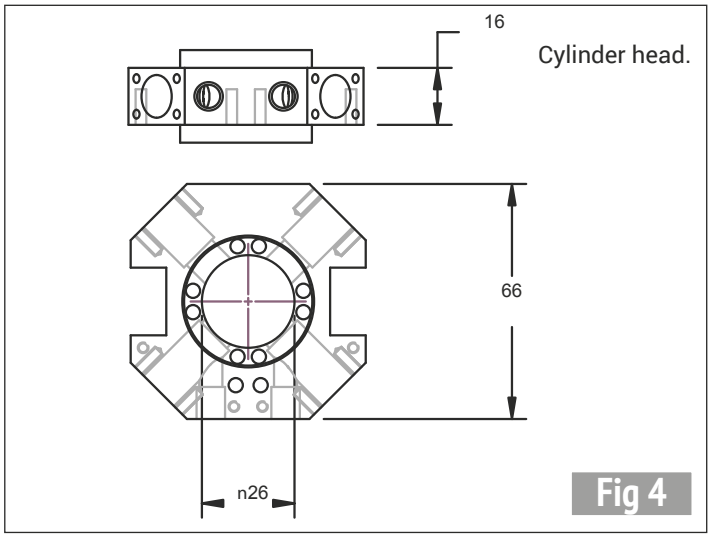
The completed engine.



A valve inset has just been equipped with the inlet/outlet bores.

The high compression blind-plug fits the inner cylinder radius.





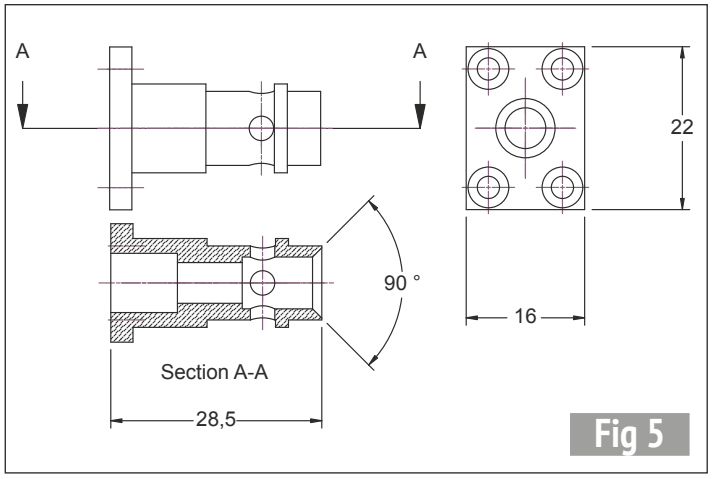


Fig 5

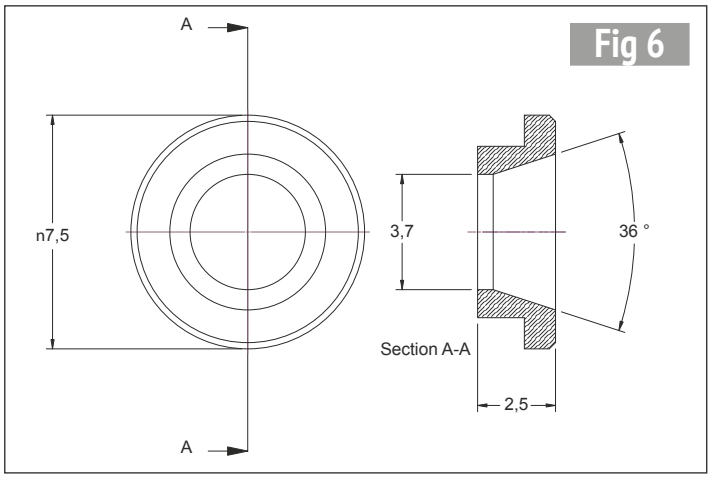


Fig 6

(**photo 15**). Here, the exact boring procedure is somewhat critical. The bore resides far back in the insert and cannot be reached by mini-boring tools so we have to do the job with an ordinary drill and a reamer.

The valves are turned in a stepwise manner (4-5mm length steps) out of a silver steel blank. Then the shafts are reduced to their final diameter by means of a lapping procedure (**photo 16**). Leaky valve seats are often the reason why four-stroke engines do not run, at least in


14

A bronze bush has been pressed into the valve inset from below but sufficient space remains in between to accommodate a valve spring.


15

The valve guide bore is already reamed and the seat has just been turned.


16

This is my lapping equipment: abrasive paper (up to 1000-grit) on one side, brass on the other side – and plenty of cutting oil.

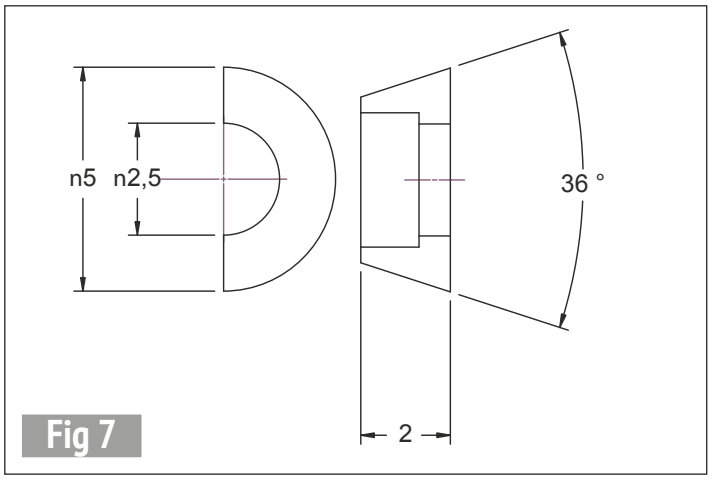
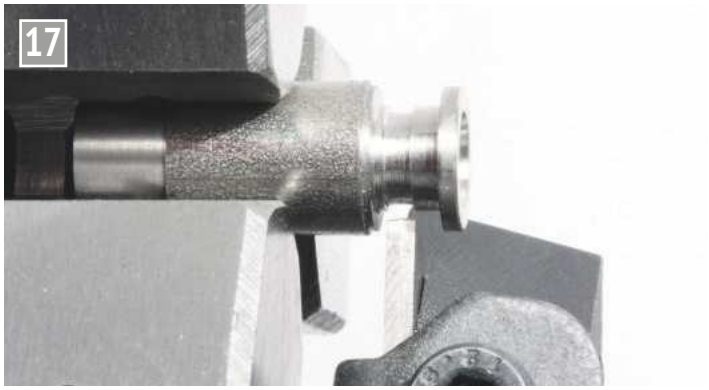


Fig 7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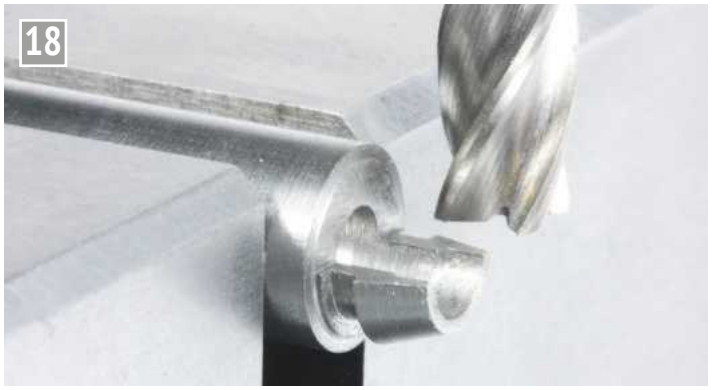
A valve spring plate is nearly finished.


18

Four small wedges like this are required for the valve spring caps.

my experience. As the bores are often not exactly concentric with the seats, there is some play needed between shaft and bore. This allows the valve to settle completely in its seat. At this point a hundredth of a millimeter makes the difference between 'it runs' and 'it does not run'.Later, when the cylinder is equipped with its pistons, a leak test can be performed - attach a thin transparent tube to the engines' inlet and suck up some water (about 1m) out of a bucket. Everything is okay when the liquid level can be maintained for several seconds.

Some bits and pieces are still missing (**fig 6, 7**): copper seal rings, valve springs, spring caps and spring cap wedges (**photos 17** and **18**). The valve springs should not be too strong; here I used 0.5mm piano wire (**photo 19**).

A fully assembled valve insert.

The rail case is still sufficiently solid to be chucked by three jaws.

This is the finished sliding rail case with its four silver steel rails pushed in.

These clamping rings will fix the rail case to the liner.

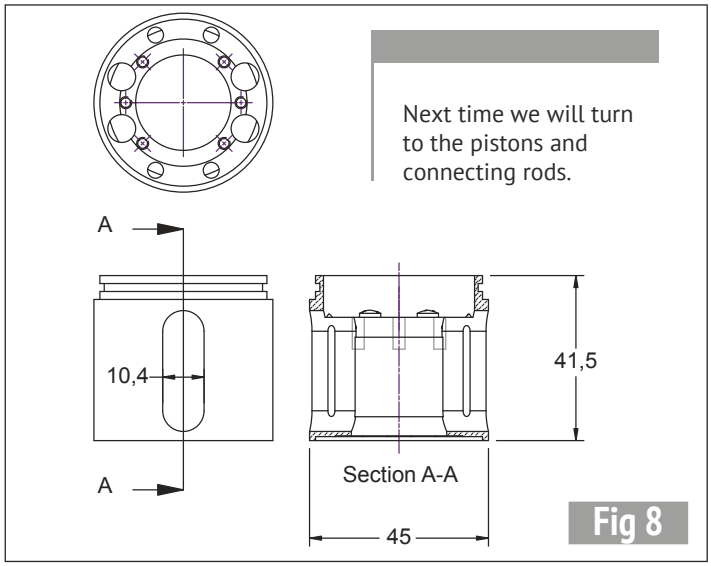
Sliding rail case

The upper piston pin is guided by sliding rails on both sides of the cylinder. The sliding rail case (**fig 8**) is implemented as a turned part with longitudinal slots (**photo 20**). In order to minimize friction and to achieve a well-defined support point, round silver steel rods (**photo 21**) are inserted (lightly pressed) into the case. These are the actual sliding rails. The other bores parallel to the cylinder axis are there just to reduce weight.

As this bulky stainless steel case loses a lot of material during all these turning and milling operations, it deforms slightly. That's why the final tenths of the inner diameter have to be bored at the very end. So that the sliding rail case may not wobble, it has to enclose the liner smoothly without any play.

The rail case is securely fixed at the upper end of the liner (**photos 22** and **23**) by two 120° clamp rings and another outer ring. An end cap covers the cylinder to keep oil splashes inside and it prevents possible finger injuries, too.

With the top cover plate removed the clamping arrangements become clear. The four bores are air passages which prevent the top cover being 'blown' off.



●To be continued.

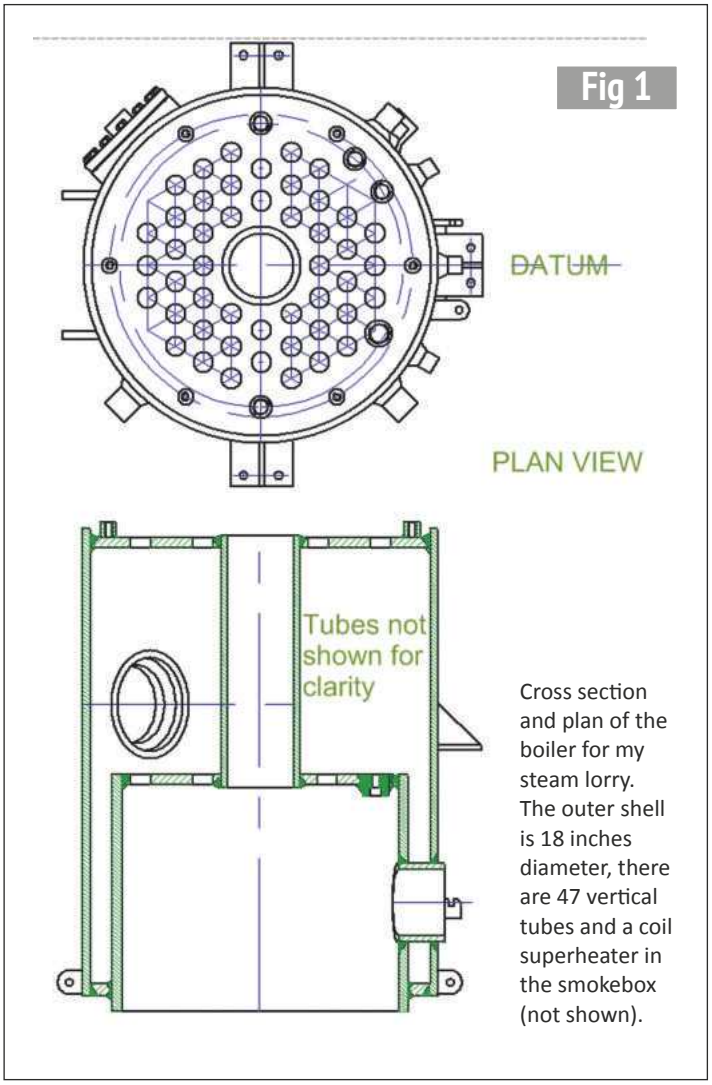
Designing Model Boilers
Or, The Truth About Model Boilers

Martin Johnson explains what really happens inside model boilers.

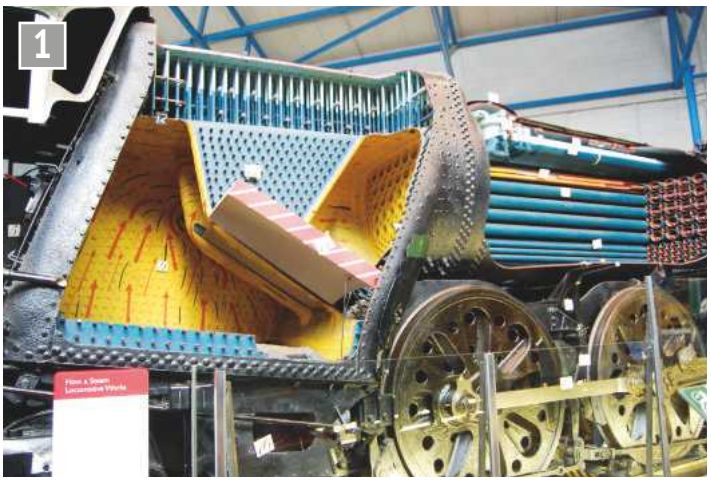
Introduction

It is a strange coincidence that when I first started reading *Model Engineer* back in 1971 such illustrious figures as D. E. Lawrence, Martin Evans, E.C. Martin and others were debating just how to design model boilers. I have to admit that I did not understand what these people were discussing at the time. Here I am, some 46 years later, discussing the same topic but in the intervening years computers have taken over from slide rules and I have had an engineering career concerned mostly with fluid flows so I now understand terms such as Reynolds number. I think we can do better than 46 years ago.

I am currently designing and building a coal fired boiler for my 7 inch scale miniature Fowler steam lorry, which is considerably larger than most 7¼ inch gauge locomotive boilers but not as large as full size. It is a vertical firetube type with a relatively large firebox, a large number of short tubes and the prototype had a smokebox superheater coil (**fig 1**). I found that the information available in the model press on proportioning boilers was very short of quantitative design rules and what did exist seemed dubious to say the least. Even much of the qualitative material seemed to be based on repeated assertion rather than fact. So, the only way forward was working from first principles.



Cross section and plan of the boiler for my steam lorry. The outer shell is 18 inches diameter, there are 47 vertical tubes and a coil superheater in the smokebox (not shown).



A complex boiler - but just how do you calculate firebox size, tube size and number and superheater details? (Photograph by P. Johnson)

This article deals with the thermal design of coal fired boilers in the 3½ inch to 7¼ inch gauge range. To avoid confusion with computer **modelling**, I have called them 'miniature' boilers throughout this article.

The ruling equations for

heat transfer in fireboxes and tubes are well known and can readily be solved with the massive computing power available to us all nowadays. There have been computational approaches to boiler design before, notably from Bill Hall. However, I decided to develop my own method and this article summarises some of what I have found out along the way. It will hopefully be of use to other designers of 'Stephenson' engines with small coal fired, fire tube boilers and of interest to users of such small engines – whether road, rail, marine or stationary.

I would like to acknowledge generous help in my researches from Duncan Webster who provided copies of previously published material, encouragement and occasional critique; also Roger Froud, who provided locomotive data and a chance to exercise my computer program for real.

Constructing a Mathematical Model of a Typical Locomotive Boiler

> If anyone wishes to flog his brains on heat transfer in ... superheaters, L.H. Fry's paper ... refers. The complex mathematics would probably give 99.9% of model engineers *rigor mortis* at first sight! In any case, I think these matters need not apply to our small engines. – D.E. Lawrence *M.E.* 3417

I am not the first to 'flog my brains out'. Some of the current work follows Bill Hall's methods. However, my program is constructed on the Excel spreadsheet platform (2002 Version) and will run on Open Office, whereas Hall's program was written in C making it a much less open platform for use and public development. Hall did not consider his boiler work 'complete'. A brief summary of the work was written up in an unpublished report (**ref 1**).

I have spent over two years developing my calculation, in which the geometry of a boiler can be entered along with the working conditions. The input data can be grouped as follows:

- Boiler Working Conditions - working pressure, pressure after regulator, firing rate, air ratio, fuel lost rate, fuel burnt on grate, combustion Efficiency, dryness fraction of steam leaving boiler.
- Boiler Geometry - grate area, firebox wall area, length of tube stack, number of firetubes, number of superheater flues, number of spearheads per superheater flue, internal diameter of firetubes, internal diameter of superheater flues, inside diameter of superheater elements, outside diameter of superheater elements, length of radiant superheater section, roughness of fire side surfaces, roughness of steam side surfaces, outside diameter of boiler barrel, overall length of boiler barrel, thickness of Insulation, conductivity of insulation.
- Coal Analysis - carbon, hydrogen, sulphur, water, ash, oxygen, nitrogen contents.
- Constants - firebed emissivity, specific heat of flue gas, absorbtion coefficient of flue gas.

The calculation involves some 14500 calculation steps, split roughly as follows:

Fire and Heat Release: 46
Firebox heat transfer: 1800
Firetube: 1900
Superheaters: 11000

The calculation produces the evaporative capacity of the boiler and superheat temperature of the steam. It also produces the temperature profiles along the length of the firetubes and superheater tubes. Typical results produced by the program will be discussed in relation to analysis of the boiler for LBSC's *Speedy* design.

I believe my work has advanced the state of the art in model boiler design in the following respects:

- More detailed analysis of the combustion process, in particular account of unburnt fuel, moisture content and coal analysis.
- A firebox radiant heat transfer model that includes the effect of absorbent/emissive flue gases.
- The option of considering wet steam generation.
- A section to calculate isenthalpic property changes across the regulator.
- Firetube performance calculation using well established correlations against Reynolds and Prandtl numbers
- Calculation of superheater performance.

The calculation is based on well-founded relationships for convective heat transfer in a tube, pressure drop along a tube, radiative heat transfer from a firebed to firebox walls, combustion process for coals, conservation of energy, etc. Empirical relationships, of which there are plenty, have been avoided because they usually apply to a limited range of full size practice. Readers (and the editor) will be pleased that I do not intend to reproduce all the fundamental equations involved, most of which are covered in thermodynamics or heat transfer textbooks or the website www.thermopedia.com However, it is worth summarising some of the difficulties encountered in putting the mathematical model together (**photo 1**).

The computer has to repeatedly calculate values of densities, viscosities, Prandtl number, enthalpy, entropy etc. over the range of temperatures and pressures likely to be encountered by wet steam, saturated steam, superheated steam and combustion gases. Therefore, a range of equations has been developed which will replicate published values of these data. Combustion gases are assumed to have the properties of dry air, which is the main constituent of combustion gas.

The combustion process is calculated using data contained in **ref 2**. This method will account for different quality coals. The calculation further accounts for:

- Some fuel being lost to ashpan, smokebox or chimney before being burned. This ratio is set by the user and tests have been analysed to determine realistic values for this quantity.
- The quantity of air drawn in to burn the coal tends to vary with grate loading. The ratio of air to coal is set by the user and tests have been analysed to determine realistic values for this quantity.
- Some carbon burns to produce carbon monoxide and this ratio is user settable.
- Some heat is trapped as latent heat in high temperature water vapour generated from combustion of hydrogen and evaporation of moisture in the coal – this heat is debited from the total generated, since it cannot be recovered in a non-condensing boiler.
- The heat generation can take place mostly in the firebed and partly above the firebed, the ratio depending on what parameters are set in the program. Heat release above the firebed would typically be due to volatiles burning in the firebox volume.

The heat released in the fire is assumed to heat the combustion products to the same temperature as the firebed and the combined heat increase in the gases plus the radiant heat emitted by the fire are equal to the energy released in the fire. The radiated energy from the firebed to the firebox is calculated using the Stefan Boltzmann equations. Some heat is radiated from the incandescent particles in the ≫

flames direct to the firebox surfaces. The ratio of 'firebed to firebox' heat transfer to 'flame to firebox' heat transfer depends on the emissivity and absorptivity of the firebox gas plus the dimensions of the firebox. The calculation also accounts for heat transfer by convection within the firebox, which is relatively small but significant. As gas passes through the firebox, the calculation reduces the gas temperature accordingly as heat is transferred into the boiler.

The flow in the firetubes is split into 25 stages along the firetube length. At each stage, the convective heat transfer to the boiler is calculated at the mean flue gas temperature in that stage and then the flue gas temperature leaving that stage is calculated as the input to the subsequent stage. The calculations take account of the formation of a boundary layer starting at the tube entrance and increasing along the tube length, plus the thickness of boundary layer based on correlations against Reynolds number. Thus, a reasonably accurate picture of the temperature profile along the tube is generated. An estimate of the superheater flue evaporation is made by assuming a similar temperature profile to the firetubes, the estimate being refined during the superheater calculation.

The regulator is usually placed before the superheater in a miniature and the program calculates the change in steam temperature and dryness due to the adiabatic pressure drop across the regulator.

The temperature profile in a superheater flue is calculated in a similar manner to the smoke tube calculation. However, the steam temperature in the superheater at entry to the firebox end of the superheater flue is not known so an iterative calculation is used to determine temperatures along the superheater. In addition, the evaporation from the superheaters is not known until the temperature profile has been calculated so another iteration process is needed to get over that difficulty.

The computer model does not account for thermal resistance through the metal of the boiler since it is actually very small compared to the resistance of the gas films. It would be a simple step to add this to the program, but there are more demanding areas of development.

The program has been constructed on a modular basis, so alternative configurations such as water tube boilers or smokebox coil superheaters can be constructed if needed.

For readers interested in learning more about the methods, the author can be contacted via the editor, and will be pleased to furnish the spreadsheet calculation, detailed equations, notes and references on request.

●To be continued.

Next time we will move on to discuss the validation of the computer model.

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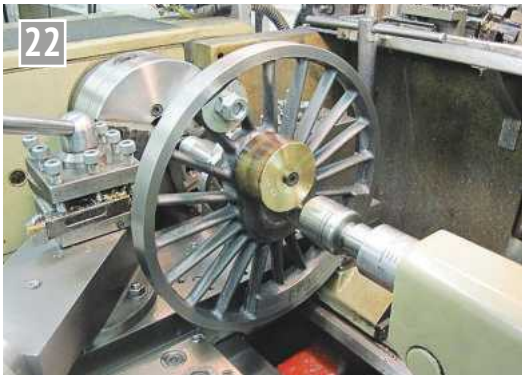
2. *Steam, Its Generation And Use* by Babcock & Wilcox Company – chapters 'Combustion' and 'Analysis of Flue Gases'. Can be found at www.gutenberg.org/files/22657/22657-h/22657-h.htm

PART 4

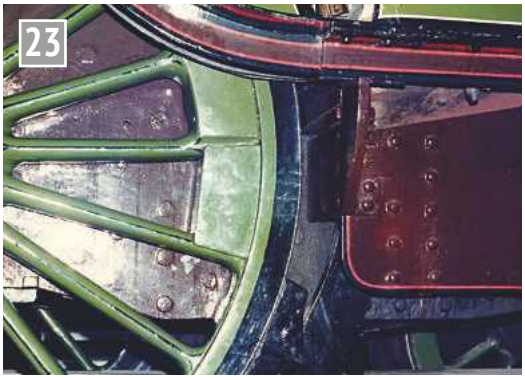
Making the Driving Wheels for 4457

Bob Bramson describes how he balanced his wheelsets and discusses the subtleties of wheel balancing.

Continued from p.455
M.E. 4582, 16 March 2018



Balancing trial.



GNR 251 showing supplementary wheel weight.

And now to wheel balancing. I have been threatening to produce a talk on this topic for some years now but it is not an easy one to explain and to do it justice without lots of tedious mathematics one really needs to produce some working 'props'. Regretfully, I have come to the conclusion that I simply don't have the time to do this and Professor Dalby's brilliant models, which do, may perhaps lie rotting

somewhere in the vaults of the IMechE. Let me just say that when I have encountered wheel slip driving on 7¼ inch gauge, most locomotives seem to want to change into *Concorde* and take off!

Out of balance forces increase in proportion to the square of the rotational speed so if you lose traction the effect of out of balance is felt 'big time'. There are two factors to be considered in balancing; one is due to the rotational and the other to the reciprocating masses. It should be possible to perfectly balance the rotational masses which include the wheel crank webs, crank pins, eccentrics, coupling rods and part of the connecting rods. The proportion of 'overbalance' required to balance the reciprocating masses of the other part of the connecting rod, crossheads, piston rods and pistons appears, I have to say, a bit of a black art.

The reciprocating masses set up forces which on short wheelbase engines lead to instability (hunting) and, on most locomotives, fore and aft pulsations. This effect is more pronounced on twin outside cylindered locomotives. The 'overbalance' masses added to the balance weights may well damp out the fore and aft pulsations but then cause other effects. These include 'hammer blow' and 'wheel lifting' - that is to say the additional weights put a force into the track when passing the rail and tend to lift the wheels off the track as they pass through the upper vertical centre line.

In models these forces are relatively low and non-injurious to the track and understructures. In over fifty years of model engineering, I have seldom experienced anybody mention them but I can assure you they do exist. The issue is just how much of the reciprocating mass do you need to balance? In full size this varied from 20% for high speed engines to 80% for slow speed short wheelbase locomotives.

Completed wheel sets.

I have often wondered how well scale size cast-in balance weights actually do the trick. In theory, the masses of the parts should scale well and I wanted to explore this. To do this, albeit rather crudely, I calculated the mass of the various parts to be balanced and made up an equivalent brass bob weight which I set at the crank pin radius on a spare wheel. This was mounted on a dummy axle together with its eccentrics and set on rotating centres in the lathe (**photo 22**). After rotating the wheel by hand, it was allowed to come to rest and then observed carefully to see if it always ended up in the same place - which it did, indicating it was out of balance.

I then added some weight in the form of a bolt and various washers opposite the balance weight until the wheel would stop in a random manner, indicating best balance. This additional weight then indicated an excess of mass existing in the balance weight and consequently a measure of the weight that could usefully be attributed to balancing the reciprocating mass. The total calculated mass of the reciprocating parts per side came out at 1.72lb. The weight of the bolt and washers was 0.164lb, thus contributing about 10% to the reciprocating balance. To increase the reciprocating balance to greater proportions would mean adding mass to the existing balance weights, which I was reluctant to do. Of course, calculations only give you an order of magnitude and to do the job properly I would need to weigh the 'as made' parts but I am not going to do that as I am satisfied there is nothing more that can be practically achieved.

Were that all that is concerned in balancing. Unfortunately, it is not as straightforward as that because I only assessed one half of the wheel and axle assembly. What actually happens is that one side of the wheels and its weights have an effect called a 'couple' on the other side. You will appreciate that it is not possible to give a full explanation here - in fact Dalby devotes several chapters to it! Suffice it to say that a force and vector diagram is produced to determine the magnitude and direction of the counterbalance weights to be added. From the vector diagram, another sketch is drawn which shows the position and magnitude of the balance weights relative to the crank masses. Current full-size practice employs computer modelling to solve balancing issues but this is way beyond my comprehension.

If you take a look at **photo 23** you will see that the LNER added a supplementary weight riveted-on to achieve the required balancing, possibly as a result of the poor ride performance of these engines (this I personally attribute more to the *diktat* of using a swing link bogie). I can only assume that Ivatt or his Chief Draughtsman overlooked the couples and, when the calculations were subsequently revised, the additional masses were added. Some of the 92 engines of the class were also fitted with small 'secondary' balance weights but space considerations preclude description of them and their mathematical derivation.

A habit I have adopted, dating from my watch keeping days as a marine engineer, is to log all the hours I spend working on the locomotive. So far the project has consumed approximately 1,600 hours out of an expected 4,000. Excluding the draughting work, the driving wheels took just over 150 hours and the painting 50.

Finally, I can honestly recall that designing and making the wheels and other related parts has been a very enjoyable and fulfilling experience. I have certainly learned a lot on the way and the final picture (**photo 24**) shows the wheelsets in their current form (supplementary balance weights to make and fit).

I do hope you have enjoyed my series on the wheels for 4457. Maybe there is something there that you have found useful for the future when designing and building your own locomotives.

ME

The Barclay Well Tanks of the Great War

PART 34

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

Continued from p.439
M.E. 4582, 16 March 2018

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.

Boiler construction

I don't see much point going into detailed boiler construction for this engine – for one thing it's all been covered before in this magazine and others (**refs 30, 31** and **32**) and I'm sure anyone tackling the project will already have plenty of experience under their belt. So, I'll just give the relevant measurements of the various components along with some tips for the tricky bits. First, however, I'll reiterate a few important facts with regard to procedures, along with some basic safety considerations.

Cleanliness is next to Godliness

Before and after silver soldering copper and copper alloys the metal should be cleaned in dilute acid to remove oxide layers/flux residues. The normal procedure is to soak components in dilute sulphuric acid of 5 to 10% strength – I use diluted battery acid available from most garages. A safer alternative is to use a hot solution of 10% citric acid.

Before carrying out work with copper and silver solder make sure that firebricks etc. in use are free from soft solder residues. These can alloy with copper and produce severe pitting in expensive boiler plates at silver soldering temperatures.

Silver soldering

All jointing alloys used in the construction of this boiler are silver-based but it is possible to use several grades of silver solder with different melting temperatures. For example, a higher melting temperature grade can be used for silver soldering the barrel followed by lower melting temperature alloys for further work on the inner firebox, tubes and stays. As I have no experience of this technique I will stick to doing the whole job with the lowest melting point material - *Silverflo 55* or its equivalent. In general, once the melted solder alloys with the base metal, the remelting temperature tends to be higher than the original melting temperature so this can help when using a single grade of solder.

Flux

For normal, relatively small, silver soldering jobs *Easyflo* flux is ideal and the residues are fairly easy to wash off afterwards. However, with a big job such as this, *Easyflo* flux fails on prolonged heating and therefore a more suitable flux is necessary. For extended operations use *Tenacity No. 4a* or *Tenacity No. 5*. The residues are more tenacious (pun intended) and difficult to remove compared with *Easyflo* but soaking in water overnight usually does the trick.

Mind the gaps

Another important tip is to make sure when using silver solder that all joints are pulled up tightish with no obvious gaps. These high silver content alloys are very fluid at melting temperatures and do not take kindly to bridging wide gaps or holes. It is therefore quite easy to lose valuable solder if it runs inside the boiler – LBSC called them 'stalactites'. Hence the use of a few small rivets here and there which will allow the plates to be pulled in tight. The firebox wrapper can be fixed using 3/32 inch diameter copper rivets.

Any larger gaps or holes, such as often occur when fitting a part such as the foundation ring, should be filled with tapered pieces of copper tapped in place *à la* LBSC. It is also tempting to gently tap plates together whilst the job is still hot but take care as molten solder can be ejected. LBSC used 3/32 inch diameter threaded copper rod to fix the outer wrapper in place over the backplate, which is inaccessible for rivets. These are screwed into the wrapper and backplate and cut off flush. Reading through his 'words and music' for making the fairly complicated boiler with combustion chamber needed for Maisie (**ref 33**), it all seems so easy. Moreover, he didn't

have the efficient propane burners that are available to us today. I can't imagine making a boiler with a heavy, five-pint paraffin blowlamp or an 'air-gas pipe' with a one inch nozzle, whatever that was! Other 'easy' tasks are hacksawing and filing up ¼ inch thick steel plates for the formers and using high melting point alloys such as *Sifbronze* for most of the job.

Safety first

Safety is discussed last here although it is, of course, of paramount importance and the difficult tasks of heating and silver soldering these big boilers are not to be undertaken lightly.

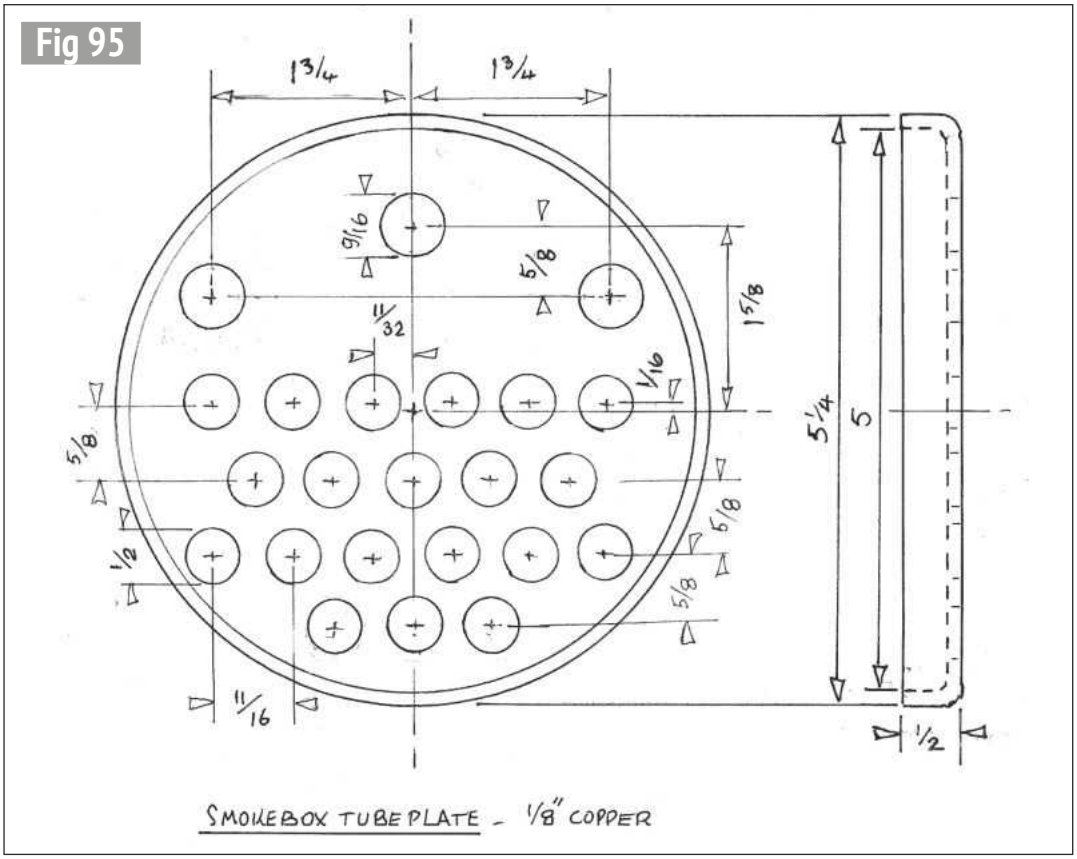
As far as silver soldering is concerned, ventilation is probably the biggest long-term safety issue, as the inhalation of various fumes (which includes the emission of cadmium vapour from silver/cadmium alloys) is a hazard with chronic implications regarding respiratory illness. Plenty of ventilation should be available and work should preferentially be carried out in the open air.

Safety must also be considered for operations that involve the use of butane/propane gas:

- check all gas hoses and connections;
- carry out the work away from any inflammable materials, with adequate ventilation and, wherever possible, outdoors;
- have a bucket of water handy and possibly a water supply 'just in case';
- wear suitable protective clothing/footwear and protect the eyes with goggles or safety glasses.

Finally, care is needed when handling sulphuric acid of any concentration and eye protection is most important. Splashes on the clothing are not life-threatening but may result in mysterious holes appearing several days later – a phenomenon not appreciated by 'er-indoors! If you should happen to start with concentrated sulphuric acid of 98% strength when preparing dilute acid, use rubber gloves and wear goggles and cautiously *add the acid to the water* with plenty of stirring and not the other way around. With commercially-available battery acid of approximately 40% H_2SO_4 it doesn't matter which way round you dilute it.

Fig 95



Smokebox tubeplate

A fairly straightforward component this (see **fig 95**) but note that the tube holes are half an inch in diameter – the three, 9/16 inch holes at the top are for the longitudinal stay bushes.

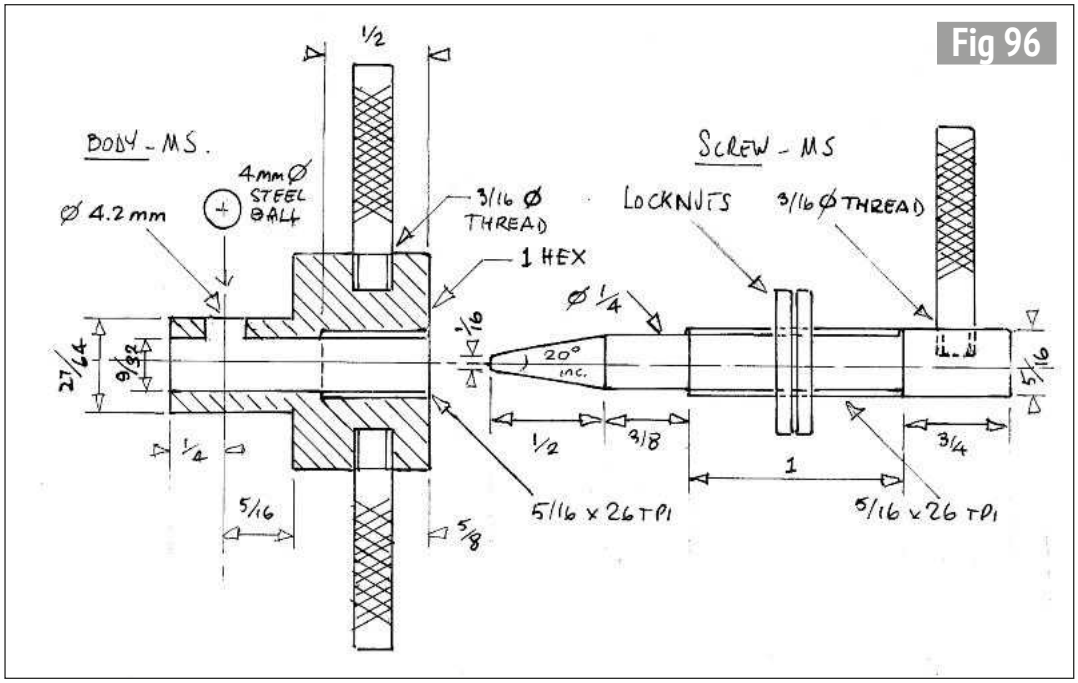
Unlike most boilers, there are no steam connections to be made from the smokebox tubeplate as the Barclay cylinders are provided with saturated steam from the dome/regulator via external pipes. Likewise, there is no hollow stay fitted to provide blower steam as, again, the blower supply is external and provided from the steam fountain in the cab. The blower pipe runs along the right-hand side of the boiler and is a prominent feature of these narrow gauge locomotives. Lay out the holes on the former and drill 31/64 inch; use this as a template to spot through into the flanged plate. Drill through the copper with a 31/64 inch diameter drill and ream ½ inch. Open out the three holes at the top to 9/16 inch diameter to take the longitudinal stay bushes. Note that the tubes are laid out with a vertical diamond pattern.

Fitting the tubes

The job of silver soldering the tubes in place is made a lot easier if a special tool is used to produce a raised annular ring on each end of the tube. See **photo 167**, which shows a test piece of tube with raised ferrules on each end and the expanding tool used to produce them. These rings or ferrules help maintain the tubeplates at the

Tube tooling.

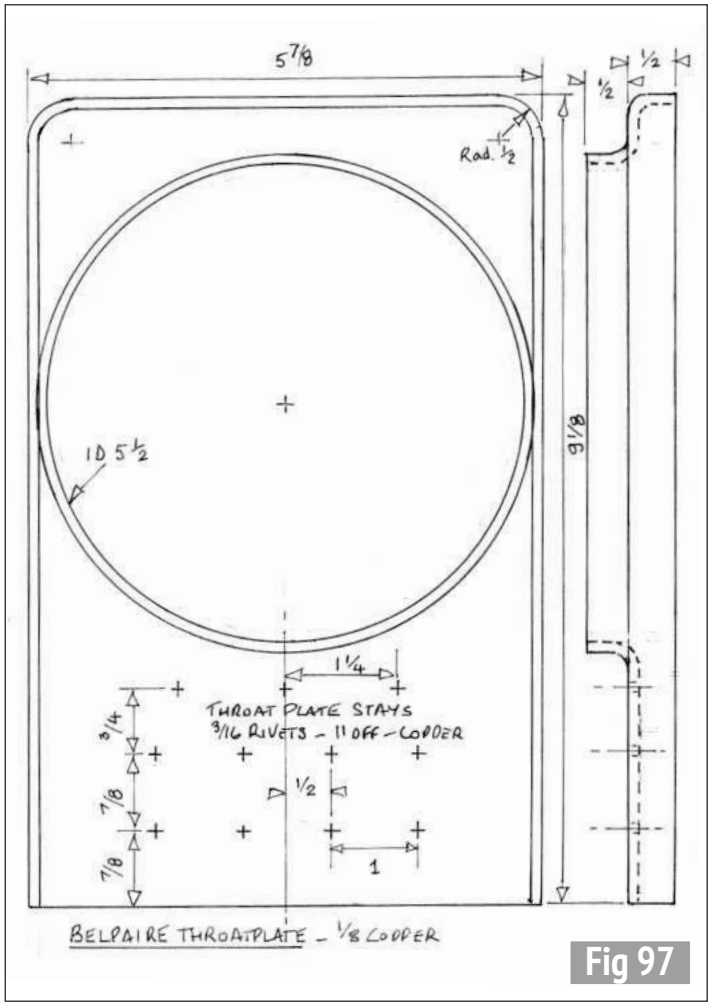
Another important tip is to make sure when using silver solder that all joints are pulled up tightish with no obvious gaps. These high silver content alloys are very fluid at melting temperatures and do not take kindly to bridging wide gaps or holes.

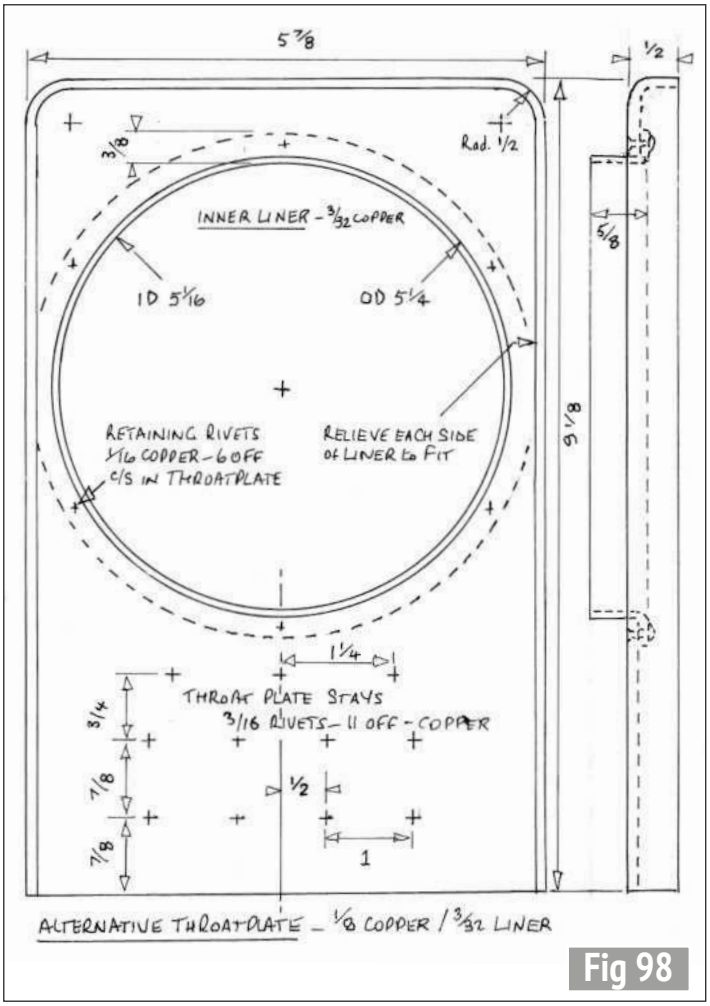


correct distance apart, during the difficult job of soldering. To ensure good fillets around each tube, I wind up rings of best quality silver solder and drop one over each tube on assembly.

Photograph 167 also shows a cone-cutting tool and depth gauge, which can be used to produce a number of holes, all of the same precise diameter. The cutting tool is a commercial item but the depth gauge is workshop-made and needs no elaboration.

The tube-expanding tool, for ½ inch diameter, 20-gauge tube, is shown in **fig 96** and from personal experience I can say that it does work well. The pair of locknuts allows the tool to be set to produce reproducible swages. The distance between the centre of the 4mm ball and the main body of the tool sets the position of the swage on the tube and the diameter of the front end should suit the boiler tube diameter. When





using the tool, a slight increase in the length of the tube shown in fig 94 may necessary and this should be determined by trial and error. Note that the 4mm ball bearing is not retained in the tool – so have a few spares ready!

Belpaire throatplate

This is the most difficult plate to make but there is an easier, two-part version. The two options are shown in **figs 97** and **98**. Note that, in fig 98, the liner is made from thinner, 3/32 inch thick copper and it fits inside the boiler barrel.

Backhead

The most complicated plate is the backhead, which is shown in **fig 99**. Most of the boiler bushes are located on the backhead and these can be silver soldered in when the backhead is finally fitted as the last major soldering job. The holes shown on the drawing, which seem a bit on the large size, are those required for fitting the various bushes. Note that on the boiler there are no fittings screwed directly into the copper plates. The four blind bushes are for fitting the sliding firedoor assembly. The firebox crown is 5/8 inch above the centre line of the boiler barrel.

Next time we will continue the boiler construction with the inner dome and firebox.

●To be continued.

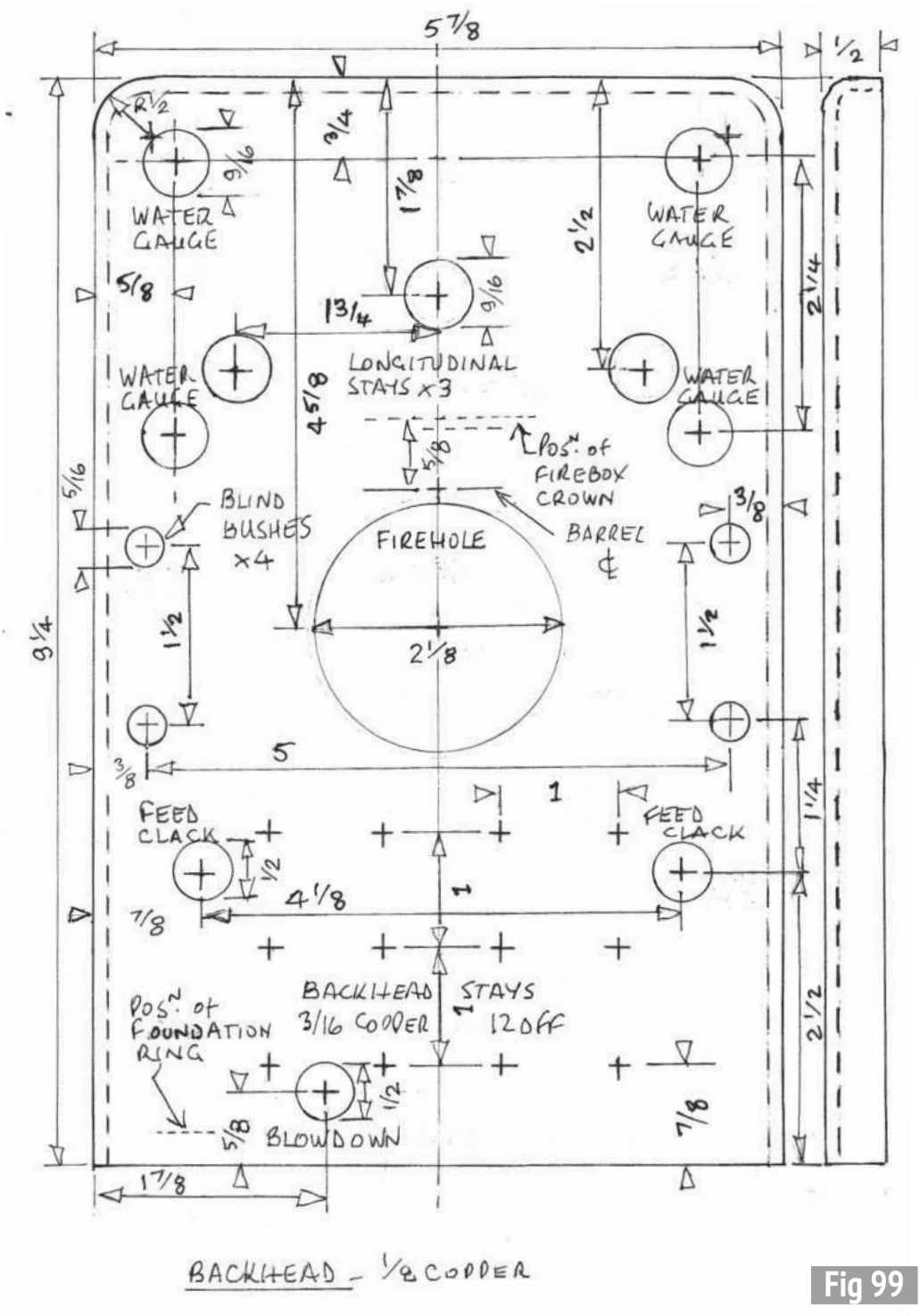


Fig 99

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30. Terence Holland, A Practical Approach to Boilermaking, Model Engineer, December 2009 to July 2011.
31. Julia Old, My First Boiler, Model Engineer, 2008.
32. John Jones, Boilermaking the Fairly Easy Way, Engineering in Miniature, 1996.
33. 'LBSC', Maisie - Words and Music, Percival Marshall, 1952.

CLUB NEWS

Geoff Theasby reports on the latest news from the Clubs.

There was an auction in Sheffield, offering several live-steam models, locomotives, traction engines, and many other smaller models, electrically powered, 'O' Gauge and below. Plus many Dinky, Corgi, Hornby, etc. There are a few of my favourite locomotive, the Midland/LMS 4F, but I dare not go because I'll BUY SOMETHING!!! This is not normally a problem, within reason, but I have overspent on radio equipment already and it's only February!

"I wish to return this body, it is faulty." "Sorry Sir, but it is out of guarantee, being 71".

To Horse! Well, to Word Processor...

In this issue, a Crunchie, liveries, a motorcycle, Queen's guides, a drilling problem, snails, gin, Aesop and Lombard.

Blast Pipe, February, from **Hutt Valley & Maidstone Model Engineering Societies**, relates how Ross Johnson began ship modelling; his first was a *Cromarty* oil rig supply ship. Spotting a real-life version at Lowestoft, UK, he introduced himself, explained his interest and showed a photograph of his model. For this he was given a tour of the ship. The club *Speedy* is being refurbished, starting with the boiler. Further work is scheduled, to be related in future issues. The Nelson Convention attracted over 300 registered visitors, with 75 locomotives, 16 traction engines and other road vehicles. The shunting challenge was organised by young Michael Gibbs and Hayley, his sister. They did a good job. A solitary rough shunt gained Colin Batt a *Crunchie* award... The winners were Sean Heenan and Logan Crook. Paddle steamer *Navy Lark* (capacity 4) was exercised but not allowed to carry the public unless they wore lifejackets. On a boating lake two feet deep (**photo 1**)!

W. www.hvmes.com

Reading Society of Model Engineers' *Prospectus*, February, begins with '61249' continuing his thoughts on improving *ThamesLink*. He found that spending on station car parks brought in more business than painting the stations. David Scott writes on *Heavy Metal*, meaning a Dore Westbury mill but opening with notes on the eponymous music classification. (I am just enjoying Andrew O'Neill's *The History of Heavy Metal* - and look up the E-B-BS rankings. (Hank Marvin's is 3)). 'Wolverton Pug' discusses the various liveries applied to (imposed on...?) rail transport of late, not forgetting the wallpapered locomotive at KWVR, and illustrated with many photographs.

W. www.rsme.co.uk

Navy Lark, *from* Blast Pipe *(photo courtesy of David Turner).*

Southampton Society of Model Engineers *Newsletter*, January, carries thanks from the mother of Hon. Member Sebastian, who is six and has cerebral palsy. Seb hugely enjoys his visits to the track and his parents are grateful for the ease with which the wheelchair carriage can be used. A visitor called at one meeting with a gas-fired flash steam hydroplane built by Fred Marsh. Fred made his own lathe using work facilities with permission and advice and later built an MR4 racing motorcycle using various proprietary parts and those of his own design, like the engine. This used Triumph *Terrier* heads and a Norton gearbox. The frame was a Douglas *Dragonfly* with Norton *Roadholder* forks. It can be seen today in the National Motorcycle Museum.

W. www.southamptonsme.org

The Blower, February, from **Grimsby & Cleethorpes Model Engineering Society**, opens with a photograph of the club site from atop the windmill. I was surprised to see many houses nearby as I always thought the mill was in open countryside (**photo 2**). The Ravenglass & Eskdale Railway ('L'al Ratty') has acquired a new locomotive, to them anyway. Built by Krauss in 1929, it has been dry stored since 1932. Recently intended for a railway in Spain, which did not come to fruition, it is now at the R&E. See www.trainfromspain.org (I like the low-loader too. Very smart – Geoff). A tip lifted from *16mm Today* concerns cleaning a gas jet. A member's wife suggested

Grimsby & CMES site from on high (photo courtesy of George Aisthorpe).

leaving it overnight in gin. (Well it works for jewellery.) It now seems that it works for gas jets too. This may be a waste of good gin, or not, as you wish (not Sir Robin of Locksley, I hope – Geoff) but it compares with the price of a new jet... Next, injectors???
W. www.gcmes.com

Welling & District Model Engineering Society *Magazine*, Feb-March, has Bob Underwood contemplating a slide-on/off smokebox for his GWR King since the contents are difficult of access due to the taper boiler, even in 7¼ inch gauge. Morecambe Bay Estuary can be a hazardous place for the unwary, says Fred Holdsworth. It was later served by the Furness Railway, which reduced the demand for the Queens Guide, who knew the way across to Cartmel. The guides were employed from 1501 at a salary of £5 per annum or a rent-free house. Bob Underwood describes an event in 1980, at Lake Peigneur, Louisiana, where drillers penetrated a salt cavern due to an error in surveying. This developed into a major event, draining the lake, flooding the salt mine and swallowing barges whole. No one was hurt but a couple of fishermen had to walk home... Editor Tony Riley visited the new London Bridge station when it reopened and was most impressed. Two things have not changed, however. It is still draughty and the trains are still late!
W. www.wdmes.co.uk

Erewash Valley Model Engineering Society, February newsletter, says that Keith Bostock has acquired an NER R1 (LNER D21) model, which was a 1939 'LBSC' *Miss Ten to Eight* design, which did not prove popular. He hopes to restore it to working order.

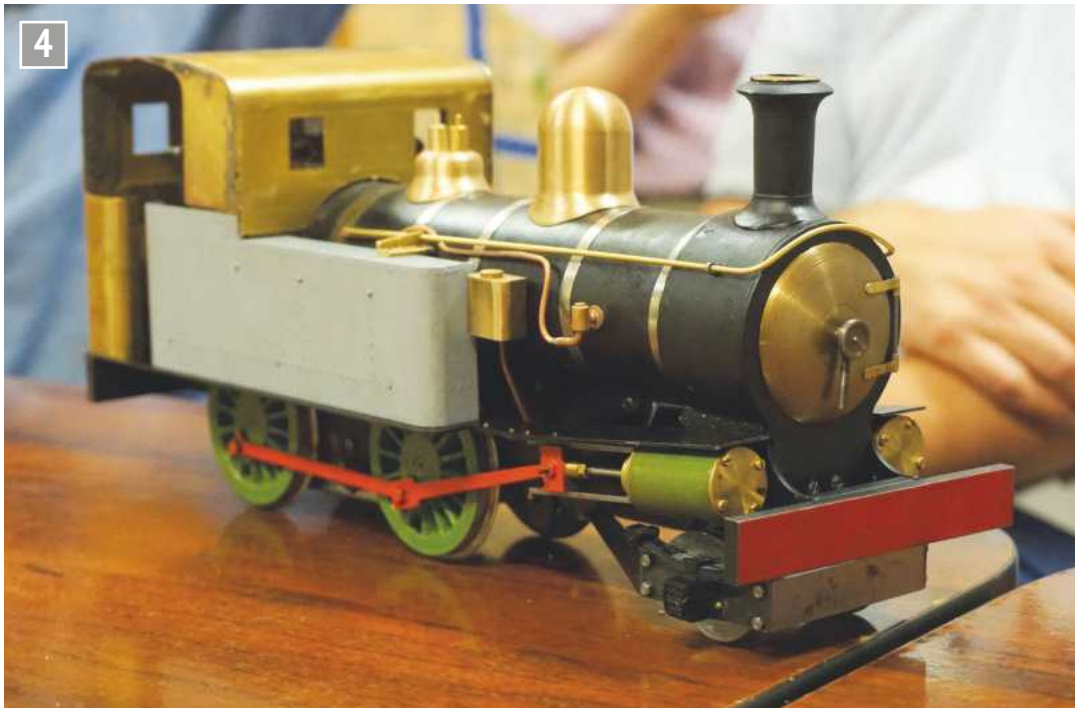
Doug Hewson sends another chatty missive, *The Occasional LMS Newsletter*, January, in which he says that a point motor failure was traced to a missing dummy hut in which the mechanism had been hidden. The hut had been eaten by snails! Removing the still-resident squatters revealed a detached wire, which was soon rectified, and the hut replaced by one made from indigestible plastic. (A wonderful headline in today's paper: 'Snail racing event cancelled as cold weather makes snails 'sluggish'' – Geoff.) Chris appeared on the Greatest Little Railway in the World, providing the steam locomotives, which covered the 71 miles with only a little wear on the valve gear pins and bushes.

Ray Taylor's 5 inch gauge wooden trains at Tonbridge MES (photo courtesy of Roy Robinson).

Tonbridge Model Engineering Society *Newsletter*, February, opens with a picture of Ray Taylor and one of his wooden 5 inch gauge radio controlled models. They were made for his grandchildren, have replaceable tops to resemble different locomotives and produce a regular 'chuff' obtained by producing 'white noise' electronically and breaking it into four using a LED and photocell separated by a slotted disc to turn it on and off, driven by the wheels. The models are constructed from 10mm uPVC sheet - this is not 'photographic grey' but its natural colour (**photo 3**). A new departure for the newsletter could be a cooking contest. However, this is not the sort of cooking meant. This is *Raspberry Pi* etc. These are readily understood by children and young people but there were none to hand so editor Robin Howard will have to do.

TSMEE News, from **Tyneside Society of Model & Experimental Engineers**, February, says that the Santa event worked well and the 32mm garden railway was declared open. The workshop is now operational, meaning that one cannot just amble in and use whatever takes one's eye. Proper training has to be given, on each machine. This is not 'More H&S'; it is for everyone's safety and protection. The carriage shed and sidings are complete and the new signal box should be up and working by the 1st of April.
W. www.tsmee.co.uk

Sydney Live Steam Locomotive Society's *Newsletter*, February, has James completing his coal-fired Gauge 1 Manx locomotive (**photo 4**). A change of superheater elements was required on Warwick Allison's *Butch*, where it was discovered that the stainless versions as fitted were considerably more difficult to remove than the new copper ones, which were easy to fit. It is suggested



James's G1 IoM 2-4-0 at SLSLS (photo courtesy of Nick Kane).

Lombard ***steam log hauler by Chris Rueby at OVLSME (photo courtesy of Chris Rueby).***

that the copper pipes 'give', where the SS ones don't. Extracting the old elements was performed by Neal, with the aid of large multigrips and great strength, who eventually prevailed. He would make a better dentist than a plumber... Neal had some difficulty relating this story to Jo, who was reduced to laughter at the thought of flat heads, wet heads, flogging pipes, 'D' bits and the filing of petticoats. James Sanders and his wife visited Victoria on holiday and the narrow gauge *Colac to Beech Forest*, which closed in 1962. Afterwards, they went to the 2 foot 6 inch gauge *Puffing Billy Railway*, where he was offered a shunting cab ride on 12A (NA Class 2-6-2, of 1912).
W. www.slsls.asn.au

North Wales Model Engineering Society *News Bulletin*, January, begins with an apology for its tardiness, due to a severe cold handed freely to chairman Dennis Postlethwaite by an anonymous donor. The West Shore site has been transformed by the hard work and dedication of all concerned but there is much to do in finishing off the details in time for their Grand Opening in midsummer. This has been achieved with the aid of good *bonhomie* and socialising. If you can help, go along and at least redistribute some topsoil... (No-one is secretly digging an escape tunnel, so you don't need baggy trousers, plus fours or great boots!)
W. www.nwmes.co.uk

The Link, from **Ottawa Valley Live Steamers and Model Engineers**, has lots of little snippets and, as Aesop said, one big thing (or something... 'The Fox & the Cat') ie, a model of a *Lombard* Steam Log Hauler. Editor, Graham Copley says it looks like a cross between a bulldozer and a steam engine, incorporating the worst bits of both (**photo 5**). Steering is not by skidding the caterpillar tracks but by a youth (omitting to take one step backwards when volunteers were requested?) sitting at the front holding a steering wheel connected to moving skids and wearing a rictus grin. No brakes! Look on YouTube for '*Lombard* MFLM 2017'. I had never seen nor heard of these before so I was delighted, nay fascinated, to learn of them. A similar situation prevailed when I unexpectedly encountered the working steam bus in Whitby, some years back. Chris first saw the *Lombard* on video only two years ago, and he was similarly smitten. This is the real thing but there are several others of the model.

Now some sad news: **Barnsley Model Engineers** are closing their track at Kirklees Light Railway, due to redevelopment. They were invited to create it in 1992 at the request of the then owner of the KLR. As there are only about 20 members of BME, with an average age in the mid-70s, they have pulled the plug and will close before September. There is 550 feet of track, four carriages, two driving trucks and two locomotives for disposal. Details from Graham Walker, 01226 763731. Graham is also chairman of **Wortley Top Forge Model Engineers** so we shall still see him for years to come.

Brandon & District Society of Model Engineers, Weeting, Norfolk, have rebuilt their club track, using 120 tons of ballast. New retaining walls have been built to keep the sandy soil, moles & other livestock off the track (**photo 6**). Previously, the site was grassed over.
W. www.brandonanddistrictsme.com

The Link, March, from **Model Engineers' Society (NI)** had an enjoyable visit to Crumlin Road Gaol. I hope they had been 'counted all out, and counted all back'. Maybe a few were 'reacquainted' with the building... An interesting item concerned the Hotham Valley Tourist Railway, which rose 'from the ashes', literally, on the tracks of the Dwellingup timber industry near Perth, Australia. The line ran from 1910 to 1984 but a disastrous fire in 1961 destroyed most of the industry. A preservation society was formed in 1974. A cartoon from *Off the Rails*, by Patrick Wright, is shown. This is my favourite from a book of about 50 similar and funny drawings, which feature magnificently-drawn locomotives, many in scrapyard condition but still instantly recognisable. I have a copy and there is one in the Sheffield SMEE club library. Thoroughly recommended.
W. www.mesni.co.uk

And finally, from Tonbridge MES: 'Note: please don't misconstrue my 14 jobs as 'job-hopping'. I have never quit a job'.

Contact:
geofftheasby@gmail.com

New track at Brandon & DMES (photo courtesy of Mick Wickens).

APRIL

12 **Cardiff MES.** Talk: 'My 49 Year Railway Career' – Dennis Flood. Contact Rob Matthews: 02920 255000.

12 **West Huntspill MES.** Quiz evening at Balliol Hall, 7pm. Contact Geoff Stait: 01278 794176 (eve).

12 **Worthing & District SME.** Club meeting 7.30pm. Contact Geoff Bashall: 01903 722973.

15 **Cardiff MES.** Steam up and family day. Contact Rob Matthews: 02920 255000.

15 **Grimsby & Cleethorpes MES.** Public running, Waltham Windmill, noon-4pm. Contact Dave Smith: 01507 605901.

15 **Guildford MES.** Public Open Afternoon 2-5pm. Contact Mike Sleigh: pr@gmes.org.uk

15 **Lancaster & Morecambe MES.** Public running at Cinderbarrow. Contact David Wilson: 07721 020489 or secretary@lmmes.co.uk.

15 **North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.

15 **Oxford (City of) SME.** Running Day. Contact: secretary@cosme.org.uk

15 **Portsmouth MES.** Public running, Bransbury Park, weather/participant dependant, 2-5pm. Contact Roger Doyle: doyle.roger@sky.com

15 **Plymouth Miniature Steam.** Public running, Goodwin Park (PL6 6RE), 2 – 4.30pm. Contact Malcolm Preen: 01752 778083.

16 **Peterborough SME.** Talk: 'Silver Soldering' – Keith Hale and Shaun Meakin, 7.30pm. Contact Terry Midgley: 01733 348385.

17 **Grimsby & Cleethorpes MES.** Monthly meeting, Waltham Windmill, 7.30pm. Contact Dave Smith: 01507 605901.

17 **Northampton SME.** Bits and pieces night, 7.30pm. Contact: secretary@nsme.co.uk / 07907 051388.

17 **Nottingham SMEE.** Talk – 'Gears and Gear Cutting', Derek Brown, 7.30pm. Contact Pete Towle: 0115 9879865.

17 **Romney Marsh MES.** Track meeting, 1pm. Contact Adrian Parker: 01303 894187.

18 **Bristol SMEE.** 'On the Table', 7.30pm. Contact Dave Gray: 01275 857746.

18 **Leeds SMEE.** Meeting night – 'Land Rover – Part 1 – The Early Years' – Jonathan Stockwell. Contact Geoff Shackleton: 01977 798138.

18 **Salisbury DMES.** Talk: 'Welworthy and Howlett, Piston Ring Manufacturers' – Mike Orman. Contact Jonathan Maxwell: 01722 320848.

20-22 **GL5MLA.** Cinderbarrow GL5 rally. Contact Peter Layfield: 01406 365472.

22 **Grimsby & Cleethorpes MES.** Public running, Waltham Windmill, noon-4pm. Contact Dave Smith: 01507 605901.

22 **North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.

22 **Pimlico Light Railway.** Public running 3-5pm. Contact John Roberts: 01280 850378

22 **Portsmouth MES.** Public running, Bransbury Park, weather/participant dependant, 2-5pm. Contact Roger Doyle: doyle.roger@sky.com

22 **Tiverton & District MES.** Running day at Rackenford track. Contact Bob Evenett: 01884 252691.

22 **Welling DMES.** Public running at Falconwood 2-5pm. Contact Martin Thompson: 01689 851413.

22 **Worthing & District SME.** Public running 2–5pm. Contact Geoff Bashall: 01903 722973.

24 **Romney Marsh MES.** Track meeting, 1pm visitors/spectators. Contact Adrian Parker: 01303 894187.

24 **Wigan DMES.** Presentation by Mike Crabtree on 'The Great Orme Tramway'. Contact Kevin Grundy: 01942 522303.

26 **Cardiff MES.** Talk: 'South Africa at War 1939-45' – Paul Clarke. Contact Rob Matthews: 02920 255000.

26 **Worthing & District SME.** Club meeting 7.30pm. Contact Geoff Bashall: 01903 722973.

26 **Sutton MEC.** Afternoon run from noon. Contact Paul Harding 0208 2544749.

28 **Romney Marsh MES.** Track meeting, noon. Contact Adrian Parker: 01303 894187.

29 **Cardiff MES.** Open day. Contact Rob Matthews: 02920 255000.

29 **Grimsby & Cleethorpes MES.** Public running and car boot sale, Waltham Windmill, noon-4pm. Contact Dave Smith: 01507 605901.

29 **Lancaster & Morecambe MES.** Public running at Cinderbarrow. Contact David Wilson: 07721 020489 or secretary@lmmes.co.uk.

29 **North Wiltshire MES.** Public running, Coate Water Country Park, Swindon, 11am-5pm. Contact Ken Parker: 07710 515507.

29 **Oxford (City of) SME.** Running day. Contact: secretary@cosme.org.uk

29 **Portsmouth MES.** Public running, Bransbury Park, weather/participant dependant, 2-5pm. Contact Roger Doyle: doyle.roger@sky.com

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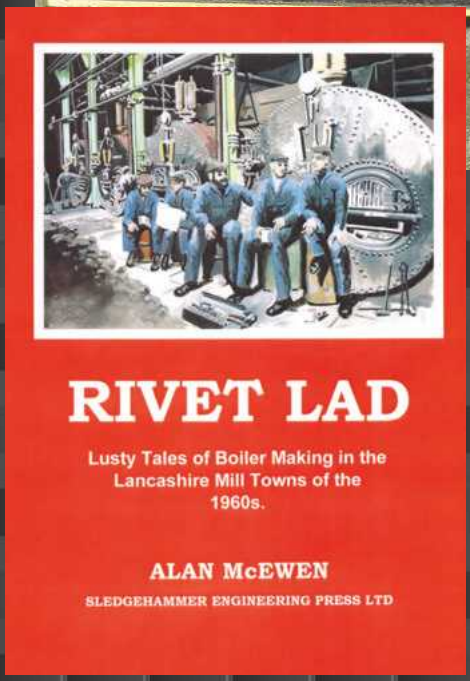

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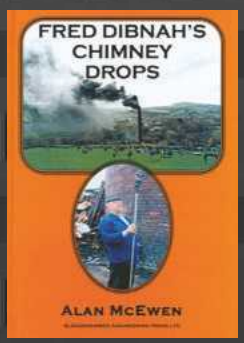

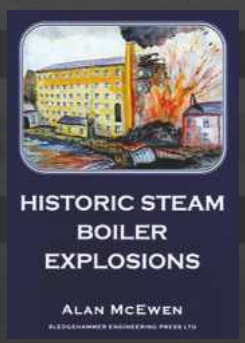

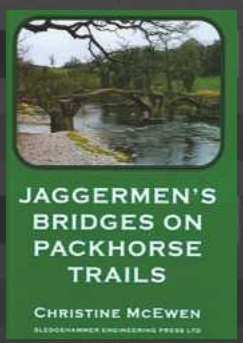

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