AST Trust
Advancing Steam Traction

Newsletter No. 5 - December 2017 - Editor: Cedric C Lodge

Preface:

As another year draws to a close it's time for another Newsletter.

The main event of since August when Newsletter No 4 was issued, was our annual Autumn Conference (described in a later section). For me, the highlight was the presentation by Colin Green of Ian Riley's on the work required to rectify 'Flying Scotsman'. Unless you download the relevant paper, it will be a long time before you see anything like it in print.

Contents

1 Chairman's Notes ... 2
2 Forthcoming events ... 3
3 ASTS Instrumentation Group needs volunteers ... 4
4 Visit to Riley and Son (E) Ltd ... 5
5 Website updates ... 5
6 Membership ... 6
7 Meetings and Conferences ... 7
8 Book Sales ... 7
9 Book review ... 8
10 New-build News ... 9
Technical Supplement ... 11
11 Dealing with clinker ... 11
12 Correspondence with Adrian Tester on Locomotive Boilers ... 14
12.1 On the Steaming Capacity of the 5AT Boiler ... 14
12.2 On Steel vs. Copper Fireboxes ... 17

1 Chairman's Notes

John Hind Chairman ASTT

Conference - A big thank you must go to the organiser, presenters and attendees of this year's event, which was a great success. A special thank you must go to Henrik Kaptein from Holland, Xavier Jiménez from Spain and Wolf Fengler from the USA, who went more than the extra mile to be with us. As well as a chance to learn about steam locomotives in the 21st Century, it was also a great opportunity for net-working and socialising. Next year will follow a similar formula.

As I write these notes, we are already thinking about next year's Conference and have set a date for it – Chris Newman gives more details later in the Newsletter. I hope that we can see you all next year. If you would like to present at next year's Conference please contact Chris Newman. If you have not made a presentation before, we can help you by giving help and tips.

AGM - Our annual AGM is a formality we have to go through. Next year's is on Saturday 8/3/2017 at Bury. Formal notification appears later. Once we have completed the formalities we usually close the day with a couple of presentations. Last year's was memorable for Richard Coleby's heartfelt plea for the future of mainline steam. This year I am proposing something slightly different:

The desire to improve the steam engine unites us and stimulates our inventiveness. This year I am set-ting a Chairman's Challenge for short talks on the theme of: 'If I was Chief Engineer……'. The aim should be 15 minutes max. of presentation with 5 minutes for Questions and Answers. It's your chance to stand in the shoes of Gresley, Stanier, Collet, Bulleid, Riddles (choose your favourite) and set down your mani-festo as Chief Engineer – the choice of subject is yours – after all you are Chief Engineer even if for just 20 minutes!

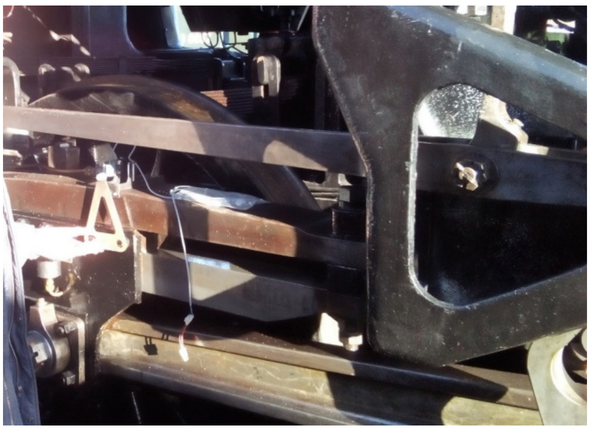
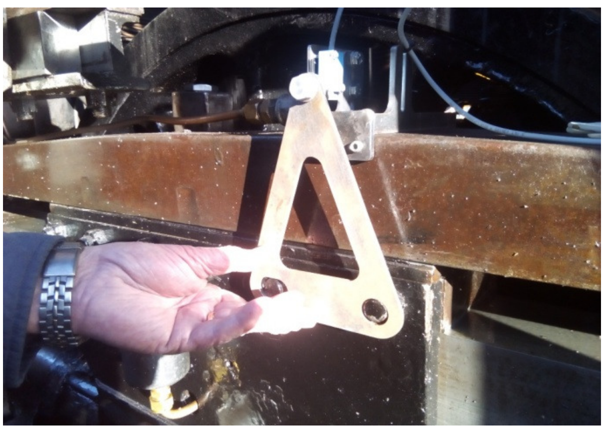
To stimulate interest and competition, there will be a Chairman's prize of one bottle wine for the best presentation and one bottle of wine for the best technical presentation. Of course, if you have a burning desire to give a longer presentation then please let us know.

Although it is the AGM, we try and make it an interesting day, so we hope to see you there.

S160 Locomotive Testing – at the Conference Mike Horne and Jamie Keyte showed various bits of kit that we have made for testing a pair of S160s, which perform differently. So that both can be brought up to the same standard, the owner would like to understand why they differ.

We are planning to measure smokebox vacuum, blast pipe pressure and temperature, main steam pipe pressure and temperature and take indicator diagrams.

Last week, we had chance to do a trial fit of them and the pictures show them in situ, but although both engines are S160's we have found detail differences between the two of them. In this case it was some-thing as simple as the method of locking the bolts holding the slidebar slippers – one uses split pins and the other lock nuts.

Crosshead position sensor (close-up on right)

As ever, when we can test is dependent on the railway, so we do not expect to be testing these till sometime in February 2018.

Help to run the ASTT (1): A recurring theme in the Newsletters has been requests for help with our back office tasks. I am a happy to say that **David Nicholson** has offered to help and will be working with Chris Newman who has multiple roles – Webmaster, Membership Secretary, Bookseller, Bookkeeper and Conference Organiser – I am sure I have left out one!

Help to run the ASTT (2): We are now at the stage with locomotive testing that we need help with all aspects of the work – right through from the practical side to the interpretation of the data that we are collecting. To give a chance to see what is involved we are planning a **One Day workshop at the Kirklees Light Railway** in the spring of 2018, this is before the railway becomes busy from Easter onwards. This is a chance to see what is involved in instrumenting an engine, collecting the data and analysing it. It has taken us a long time to get to this stage with some backward steps along the way! The aim of the day is to give Members the chance to get more involved in this side of our activities – whether that is the practical side of working with the engine or analysing the data. Our interest in locomotive testing came about because we wanted to test the performance of the Lempor Exhaust fitted to S160 5820, but as we have learnt and developed, we believe that testing could be a benefit to locomotive owners as it can be used as diagnostics tool to identify faults and help tune up a locomotive. Later in the Newsletter there is a separate section, written by Mike Horne that gives more detail.

Steam on the Mainline – the Railway Safety and Standards Board (RSSB) and the Office of the Rail Regulator (ORR) intend to hold a 1-day event at the NRM about certification requirements for all Heritage traction running on the National Network. A date for this has yet to be announced. We had intended to organise a similar event ourselves (following on from the Birmingham Workshop that we held in May), but pending the RSSB/ORR event we do not want to duplicate effort. We will be going along to the event as an attendee rather than an organiser.

Finally, on behalf of the Committee, may I wish you a happy Christmas and New Year, to you and your families.

Cedric Lodge

2 Forthcoming events

AGM: Notice is hereby given that the 3rd Annual General Meetings of the Advanced Steam Traction Trust Ltd. and Advanced Steam Traction Services Ltd. will be held on 3 Mar 2018, at the Museum of Transport, Bury, commencing at 11.30. This will be followed by lunch and a general meeting with presentations as described above.

Detailed Agendas will be issued nearer the date.

Conference 2018: ASTT's 2018 Autumn Conference will be held over the weekend of 29/30 Sept. 2018, at the Museum of Transport, Bury.

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3 ASTS Instrumentation Group needs volunteers

Mike Horne

The group are looking for other Members of ASTT with relevant skills to join the Group so that we can further our work on loco testing for the future.

Below are listed the skill sets required for this work. Please see if your own skills match any of these areas and if you are willing to become a member of the team please let us know

We plan to hold a one-day instrument experience seminar early 2018, probably at the Kirklees Light Railway where you can be shown the whole of the operations required and hopefully take a fully instrumented run up the line.

Plus side to all of this?

- Transducer plumbing and wiring: you get to get your hands dirty working on a variety of loco types connecting the system up and getting it all working
- Data Recording: you get the opportunity for carriage or footplate rides not normally available.
- Data Analysis: You get to keep in the warm and test your brains out working out what is going on and the satisfaction when your solution works.

Skills required are very varied and consist of:

Transducer plumbing and wiring

- Transducer selection for each measurement from the Omega PXM319 range of transducers, purchase approval and ordering where necessary.
- Keep control of all the data logger equipment and its security.
- Liaise with loco owners for the required fittings to be made to enable correct plumbing without interfering with loco operation.
- Building wiring looms to fit each loco and to connect the transducers to the Picolog interface board, ensuring that the cable harness does not interfere with loco operation or can be damaged by heat from the loco.

Data recording

- Before starting on to data recording you must be familiar with the transducer plumbing and wiring.
- Use of Picolog software and hardware. This requires computer skills and some training on the use of the Picolog software.
- Calibration of the software to the transducer outputs.
- Installation of the logging equipment and its batteries on to either the loco footplate or, where necessary, into the first carriage of the train
- Final installation and test on the loco prior to test runs.
- Recording of data during test runs.
- Fault finding the equipment when necessary if data does not appear to be correct or missing.
- Distribution of the recorded data file to those responsible for the data analysis.

Data Analysis

- Analyse the collected data to determine loco performance and any problem areas using a range of analysis software.
- Identify anomalies in the data that may indicate a problem area.
- Identify the cause of any know loco problems during analysis of the data.
- Prepare advice for the loco owner as to the identified problems and discuss with them the options for solutions.
- Identify post-rectification testing required to confirm the solution has worked with the Data Recording team.

4 Visit to Riley and Son (E) Ltd

Richard Coleby

The opportunity to have a tour round Riley and Son is not one that occurs very often and the visit arranged by the organisers of the ASTT Autumn Conference to see their new works did not disappoint. We were privileged to be among the first visitors to be given access to the premises.

Our Group was full of anticipation as we boarded the transport at the ELR museum for the five mile journey to Riley's new location in Heywood where we were ushered in to the reception area of a modern industrial building.

After a safety briefing by our guide Colin Green, a Company Director, we entered the machine shop area which is principally devoted to wheel and axle production although general repair and refurbishment work is also undertaken. Riley and Son are RISAS certificated to carry out this work which includes tyre turning and fitting, quartering and pressing. An impressive array of machinery, including a recently obtained new CHEMdynamic Wheel balancer is installed.

Also in this section of the works is the stay turning facility with a new Doosan CNC unit recently added to speed up production.

Moving on to the second bay we were greeted with the site of several boilers under different stages of repair. The company has considerable expertise in the sectional replacement repair techniques required for the refurbishment of old boilers and although the flanging and bending of plates and barrel sections is carried out elsewhere they have perfected the difficult assembly and welding methods needed to prolong the life of this fundamental component of the steam locomotive. Both copper and steel fireboxes can be catered for and it is in fact within the capability of the works to construct entirely new boilers.

Although the new facility is not rail connected there is road access to the cross bay connecting both sections of the works and which can accommodate an offloaded complete locomotive. Maneuverability of heavy components is carried out on air jacks - low slung hover trolleys - that allow for movement in any direction by no more than pushing by the operator!

Also on-site is a well organised and regulated control stores area seemingly well stocked with the essential items required for the cross section of work that is carried out here.

I think it is fair to say that by the end of our visit our Group was significantly impressed by both the standard of work being carried out and the professionalism of the management and workforce.

I would like to thank Colin Green for facilitating this visit which made a major contribution to the success of the ASTT Autumn Conference weekend.

5 Website updates

There has been little development of the website since August. The main changes have been two new pages reporting on the Autumn Conference: a general report on the conference and a password-protected page containing links to presentation files which is accessible to those who attended the conference, and to members who didn't attend who are invited to pay a contribution towards the conference costs (see conference report).

The Forum section has remained rather neglected by members. Feedback and suggestions for improving the forum facility will be welcomed.

As always, members are encouraged to offer suggestions for new pages for the website and to contribute content for them. Members' feedback, both constructive and critical, is also welcome. The website is not just a shop-front for ASTT, but a communication channel for its membership.

Help needed: ASTT is still dependent on one person to maintain its website. The workload is not large, but for long-term sustainability, we need someone to be trained up to take over if/when needed. The website has been developed on a WordPress platform (an industry standard), and while it involves a learning curve for those not familiar with it, it becomes easy to use with practice.

6 Membership

New Members: ASTT membership numbers have just reached the half-century, representing an increase of ten since August when the last newsletter was issued. New members are:

- **Geoff Ayres** from Bristol, a retired engineer who spent his career in aircraft and missile development.
- **David Smith** from East Sussex, who has a PhD in Mechanical Engineering. David was one of the first (or the first) person who, in 1999 or 2000, volunteered to assist David Wardale make a start on the design of components for the 5AT and who remained a supporter of the project for several years thereafter. His career to date has been in the design and development of large scale coal fired power generators.
- **Brendan Nickson** from Texas, USA.
- **Hendrik Kaptein** from Amsterdam, Netherlands, a Professor at Law with an interest in Engineering, financial and legal matters. Those of us who attended the Bury conference will remember meeting Hendrik there.
- **Reg Silk** from West Sussex, a model engineer who is currently building a 5 inch scale Black Five.
- **Niels Abildgaard** from Denmark, retired Associate Professor of Mechanical Engineering. Niels frequently expresses his views on the steam_tech@yahoogroups.com, most recently in discussion with Joe Cliffe talking about Chapelon's "economizer".
- **Neil Mortimer** from Middlesex, who has a BSc(Hons) in Biology and who in his spare time acts as boiler inspector for his local model engineering society
- **Sean McKercher** from Bradford.
- **David Palmer** who will be known to those who attended this year's Autumn Conference.
- **Manuel Ramos** from Spain who will be known to many and whose brief "bio" appears in the 5AT section of AST's website. Manuel is a veritable expert on steam locomotive operation, restoration and maintenance, having studied under L.D. Porta when Porta was engaged in a Spanish government project. For many years he has been owner- director of ARMF, Mantenimiento y Proyectos Ferroviarios, SL, the only workshop in Spain specialized in steam and historical railway equipment.

Current membership is spread out as follows:

- UK: 42 members distributed as per the map at right;
- EU: 7 members from Spain, Germany, Denmark, Switzerland and the Netherlands.
- USA: 1 member (two others have recently expressed interest).

Membership Renewal: Please be aware that memberships expire on 31st December. I'll be most grateful if those who wish to continue their membership (which I trust will be everyone) will set up a standing order with their banks to ensure that their annual subscriptions are paid automatically on 1st January as this will save me an immense amount of work. As membership numbers increase, the task of chasing membership fees becomes ever more onerous.

7 Meetings and Conferences

Chris Newman

2017 Autumn Conference: Much has already been written and spoken about this year's Autumn Conference held in the Bury Transport Museum over the weekend of 30th Sept - 1st Oct. The general opinions expressed by those who attended suggest that it was a great success, most credit being due to the ten excellent speakers who filled the two days with talks that were as interesting as they were diverse. A list of speakers and their topics can be found on the 2017 Autumn Conference page of the website (listed under the Members menu heading).

35 people attended the conference of whom 23 were ASTT members. As noted above, members who were unable to attend the conference can see the presenters' PPT files and recordings of their presentations by accessing the password-protected page that provides links to these, for which they are offered to make a £10 contribution towards the conference costs.

This contribution is invited because the conference attendance was below budget and attendance fees fell below the conference costs. ASTT is registered as a not-for-profit "charity" in return for which it is expected to provide educational opportunities, which the conference helps us to fulfil. It should therefore not be expected that ASTT should profit from such activities, however unless more members are able and willing to attend future events, the attendance fees will have to rise by £10 or £15 if it's to get close to covering costs.

2018 Meetings: Looking forward, we can look forward our AGM to be held in the Bury Transport Museum on Saturday March 3rd 2018. We also plan to hold our 2018 Autumn Conference in the same location over the weekend of September 29/30th 2018. Those who would prefer that we hold future meetings elsewhere other than Bury are invited to propose alternative locations, however it's important that venues are: (a) easy to access by public transport; (b) reasonably close to hotel accommodation, and have: (c) catering facilities close at hand; (d) meeting space sufficient and suitable for 50 attendees.

Bury has been chosen for our 2018 events because it meets all the above criteria, in addition to which Bury is reasonably close to the centre of gravity of ASTT's membership (though this is gradually shifting towards the southeast according to the membership map above). What's more, having held a successful event there and being on familiar terms with the Transport Museum's management and ELR's catering managers (and they having got to know us and our requirements), it will make organizing future events there easier and more assured.

It is expected that the March AGM will be followed by a General Meeting. The 2017 General Meeting took the form of a mini conference at which five excellent papers were presented. If the 2018 General Meeting is to take the same form, then a similar number of speakers will be needed. This will be a members-only event, so members are invited to offer proposals for 30 to 45 minute presentations at the event.

Chris Newman

8 Book Sales

Book sales have picked up in the last quarter not least because of purchases by conference-goers whose custom was (and is) greatly appreciated.

I'm not sure which books were included in the last count so I can't give accurate figures for the numbers sold. However, for what it's worth, 28 books have been sold since the beginning of October. What's more two additional Camden titles have been added to the book sales page. These are included in the summary below.

The current book sale status is as follows:

- **5AT FDCs** (pub. ASTT)**:** 6 extra copies have been supplied by Edinburgh Copyshop since August, of which five have been sold to Camden Miniature Steam and two to AST members, leaving 3 in stock.
- **5AT Feasibility Study** (pub. ASTT): 8 copies have been sold since August, five being bought by conference-goers and two by Camden Miniature Steam. Copies are printed on-demand by Lightning Source, so no stock is held.

- **Defence of the Midland/LMS Class 4 0-6-0** by Adrian Tester (pub. Crimson Lake): 6 copies have been sold to members, many of whom have offered very positive feedback.
- **Introduction to Large-Lap Valves & Their Use on the LMS** by Adrian Tester (pub. Crimson Lake): only one copy has been sold since August which is disappointing as it a most interesting and informative book.
- **The Physiology of Locomotive Boilers** by Adrian Tester (pub. Crimson Lake): Adrian expects that the first volume of his new book will be ready for publication early next year. It is expected that it will be made available through AST's website.
- **Here be Dragons** by Phil Girdlestone (pub. Camden Miniature Steam): This book is now available through AST's website and has been selling well, with 18 sales since publication in October.
- **The Red Devil and Other Tales from the Age of Steam** by Dave Wardale (pub. Camden Miniature Steam): This book continues to sell, eight copies being sold since the beginning of August.
- **Advanced Steam Locomotive Development** by L.D. Porta (pub. Camden Miniature Steam): this 2006 publication is now available through AST's website.
- **The Fire burns much better …** by J.J. Koopmans (pub. Camden Miniature Steam): this updated version of Dr Koopmans' 2004 thesis on locomotive exhausts is now available through AST's website.
- **Design Calculations for "Lyn"** by Ian Gaylor (to be published by ASTT): Ian is currently updating his calculations to incorporate last-minute design changes and hopes to have the text completed in the spring, ready for ASTT to publish on behalf of the 762 Club.
- **Porta Papers**: A draft printing of this three volume publication was on display at ASTT's conference and several attendees expressed interest in purchasing copies when they are published. No predictions can be made as to a publication date since this will depend on how quickly Shaun McMahon can finish proof-reading the drafts.

9 Book review

Cedic Lodge

At our autumn Conference, I was able to take a quick glance at the new publications on display:

- **'Defence of the Midland/LMS Class 4 0-6-0' by Adrian Tester**: The title is a little misleading, as it quickly became apparent that the book is a mine of information covering many aspects of steam loco design and operation. Adrian analyses service problems in relation to design philosophy, an approach rarely encountered in existing technical books on steam locos. The topics covered apply to a wider range of locos than the LMS 0-6-0s. Having enjoyed the opportunity of reading it at leisure, I find his style comfortable and engaging.
- **'Physiology of the Locomotive boiler'**: A pre-production copy was on display and again, all I could do was take a quick glance. This book looks as good as the former, and will complement it admirably. I have ordered a copy.
- **'Porta Papers'**: Some years ago, I met up with Shaun McMahon, and asked him about Porta's papers. All we had had up until then was the slender 'Advanced steam locomotive development', but surely, there must be a lot more? Shaun told me there were problems extricating the material, and the prospects for gaining access were not good. I was delighted therefore to see three volumes on display at our Conference. Flicking quickly through the pages, I alighted on an illustration - hand drawn, of a 'bent' firing shovel. This had been designed for a left-handed fireman! I fire left-handed, so the item had a special resonance for me. It also reminded me of my fire-irons; Porta is my kind of man, and I had no hesitation in ordering copies of the books. Chris Newman and Shaun McMahon have undertaken a monumental task in transcribing this material and presenting in book form. It is to their credit that these works are shortly to be available.

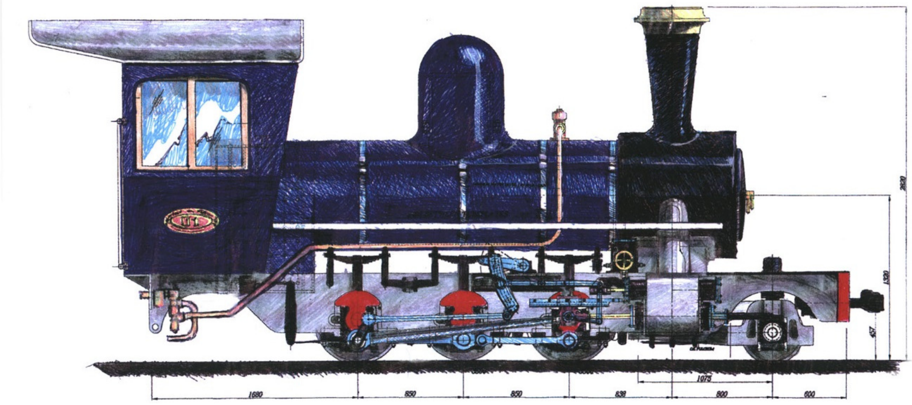
10 New-build News

Cedic Lodge

The standard gauge fraternity are fairly well reported in the national railway press, but developments on the narrow gauge are only reported when something special happens. But it is the narrow gauge which offers so much to those wishing to implement innovative designs in steam locos. The costs are a fraction of those for standard gauge locos.

Girdlestone (LSN) loco:

During the weekend of the Conference, I was joined by David Nicholson and Alex Powell to form a Group for taking the project forward. We have been further encouraged by the availability of drawings of the loco. by curtesy of Phil's brother. Until now, the only way of describing the loco. was by using the name of its designer. However, from the drawings and the In Memoriam, we learn that Phil described the loco. as the Class LSN, so that is the term by which it will be described in future. Having got a working Group established, I contacted the owner of the chassis to appraise him of our readiness to take the project on. Much to my dismay and disappointment, he told me he was undecided about whether to sell it. Still: "Never say never" in this business. In the meantime, we can peruse the drawings and familiarise ourselves with the details of construction.

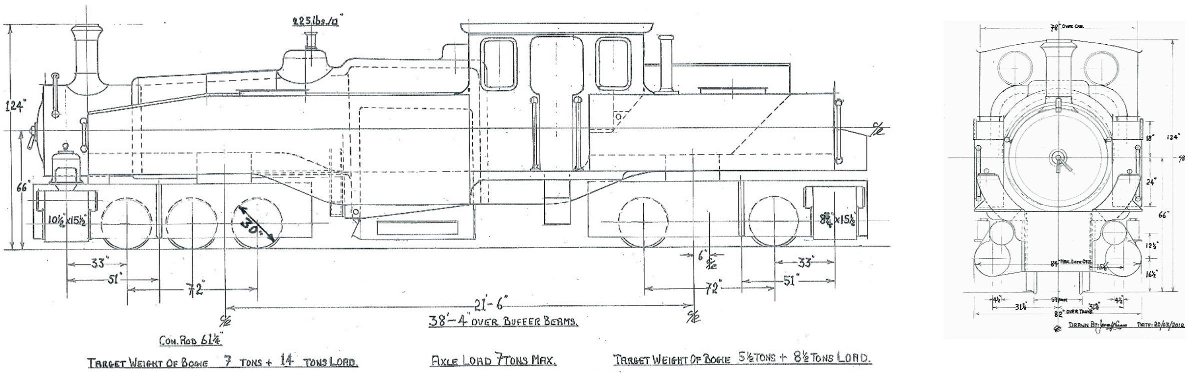


The Girdlestone Class LSN locomotive

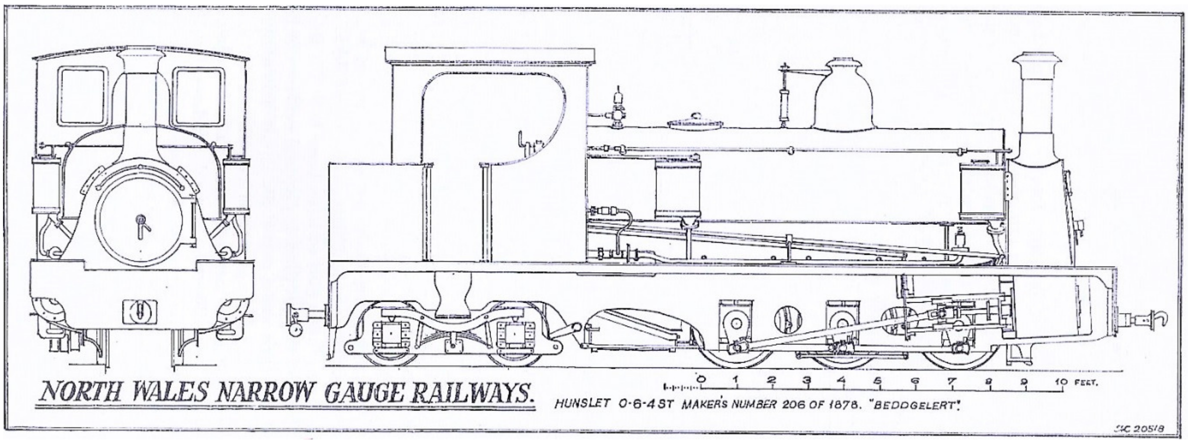
Other projects:

Whilst at the workshop of Alan Keefe in August to witness the first public steaming of 'Lyn', I met up with Colin Rainsbury. I have known Colin for many years, but had not seen him in a long time. He tells me he is launching a project to build a replica of a Darjeeling B Class loco, and has teamed up with James Evans in support of James' plan to build a 2ft gauge Meyer loco (although James describes it as a Super Fairlie). He also has aspirations to build replicas of the NWNGR loco. 'Beddgelert', and the contractors' locos. used in the construction of the L&BR.

We wish Colin well, and look forward to hearing more of his new-build programme in the future.



James Evans' Super Fairlie (looks like a Meyer to me. Ed.)



NWNGR 'Beddgelert'.

Technical Supplement

Cedric Lodge

11 Dealing with clinker

Clinker has been the bane of coal burning machinery since its appearance over 200 years ago. There is a mass of information about its formation and how to prevent it, to which I can add little. This article is concerned with what to do about it having got it.

My experience is firmly rooted in the Welsh Highland Railway, where I have been a fireman for the past 20 years. Our locos are NGG16 Garratts from South Africa. When I started, we were burning oil, and clinker did not feature. Then, about 10 years ago as the price of oil rose and the comparative cost of coal fell, we started burning coal. It was not long before we encountered clinker at the end of the day, and sometimes in between as well.

Ours is an 'up and over' line running between Caernarfon and Porthmadog, a distance of 25 miles. In either direction, we climb for about an hour, then coast for an hour. The tricky part is the turn-round at either end. On some diagrams we get 2 hours, on others a mere 30 minutes (if we are lucky). Before commencing the return journey, it is essential that the fire is cleaned to ensure we get up the hill. On the Caernarfon side, the gradient is less demanding, so a less than good fire can be tolerated; on the Pothmadog side, we have a steady 1 in 40 for 5½ miles with a stop after the first mile at Beddgelert where we take water. On a good day, we can make the summit in 16 minutes from Beddgelert, achieving a speed of 15 mph. On a bad day, it may be necessary to stop for a blow-up around Hafod Ruffydd-most humiliating!

Coal is variable. We have had it from various places: Russia, Poland, and South Wales. Currently, we are using South Wales coal, but even then, its quality varies considerably.

When we started burning coal, we had workable dampers. Come up the hill from Beddgelert, pass the summit, shut the damper and kill that roaring fire. I suppose it worked-of sorts, but it certainly made clinker. There have been occasions when I travelled the next 9 miles towards Caernarfon without touching the fire; everything had achieved a steady state. With the damper closed the fire, big though it was, was not producing much heat, so we could coast downhill without the safety valves lifting. Finally at Dinas, it was necessary to put a little coal on. At Caernarfon, it was evident a fair amount of clinker had formed. Since those early days, the dampers have been welded open and we have gained a bit of experience, so the formation of clinker on the downhill run has diminished.

Over time, we learned two lessons:

- it was better to adjust the firing up the hill so that on passing the summit, most of the fire had burned down.
- keep the damper open.

During the downhill run, some clinker would disappear through the bars. By having run the fire down for the downhill run, it was manageable. You could fire in response to the demand. On reaching Caernarfon, the aim would be to have a low fire and about half a glass of water. On many occasions, there would be clinker, but it was manageable. In those days, all three locos. had grates which rocked, and careful jiggling was sufficient to clear it; a full rock of either section would have lost most of half the fire. Wardale, recounting his experiences in China with the QJs, recorded the firemen giving the grate a jiggle every half hour or so when on the run to keep it clear of clinker. I believe some BR Standard locos.had a similar facility. The grates of the Garratts can only be rocked from the outside, so this option is not available to us. If the grate could not be rocked, cobs of clinker could be prised off the rear half of the grate and stacked at the front. The loco. will steam quite well as long as the air ways in the rear half of the grate are clear, and as I said earlier, the run up from Caernarfon is not as demanding as that from Beddgelert.

Shortly after we had commenced running the full length of the line, one day I found myself in difficulties at Porthmadog. Turn-round time was about an hour. I knew we had clinker on the run in, and had allowed the fire to burn down so I could deal with it. We unhooked, went for water, and parked opposite the station where I was to sort the fire out. When I looked in the box, to my dismay, most of the fire had gone! I had run it a bit too far down, taking into account the time to unhook and go for water. There remained a bit of flaming coal in the front LH corner, which I coaxed into life by careful additions of fresh coal. Of clinker, there was no sign; it had all dropped through. After suffering the embarrassment, a visit from the GM, and a 15 minute late start, we departed on our way. The Driver was very understanding, and I remain extremely grateful to him.

The only implement available to deal with clinker was something called a 'slice'. I remember seeing them on BR, but never had need to use one in action and I must confess to being ignorant of their function even now. They had a shaft about 8 ft. long with a spike at right angles at the end, about 6 ins. long; ours were similar. The shaft was ¾ in. bar, and the spike which started life at 6 in., has grown over the years to 12 in., so long that a diagonal tie is added to support it. It was a cumbersome tool at best, quite unsuitable for dealing with the clinker we were now experiencing. I often wondered why the shaft was ¾ in. dia? I could only surmise that when they were being made, 1 in. bar was unavailable!

But there must be a better way of doing things; the events just related triggered a train of thought which led to the present day.

From observations, there are three types of clinker:

- cow pat -great discs of glowing slag, lying on the bars but not adhering to them.
- toffee -a thin but glutinous layer covering a large area of the bars and adhering to them like toffee.
- gravel –a loose mobile mass of dead coal.

The tools I devised (although I do not claim them to be original) were a pair of fire irons comprising a rake and a clinker paddle.

The rake is a rectangular plate 5 in. x 7 in. set normal to a shaft of 12 mm. dia.

The clinker paddle is a plate of the same size, but set in line with a shaft of 16 mm. dia.

The prototype version had shafts of Rebar which, generally being of carbon steel, I figured would be a bit stronger than MS. However, this did not find favour with the management, and the production versions are of smooth MS.

In preparation for cleaning the fire, the injector is set going and the ashpan drench turned on and the blower on. This cools the grate somewhat and the clinker adhering to it.

When cleaning the fire, the procedure is to push as much of the fire as possible to the front using the rake, thus exposing the greater half of the rear of the grate. If clinker is of the cow pat variety, it can be prised off the bars and turned over. By careful manipulation of the paddle, it is possible to get the disc of clinker on to the paddle and withdraw it through the fire hole-rather like a pizza. One of the photos shows a large disc of clinker which has just been removed so. The prototype clinker paddle with Rebar shaft is still available, and I used it with good effect recently: as a disc of clinker was being withdrawn, the serrations of the Rebar enabled better control of the tool as the clinker was being withdrawn through the fire hole. If possible, it is far better to remove clinker completely than to leave it piled up at the front. If this procedure is being carried out during a turn-round, when the rear section of the grate is clear, the remaining fire can be pulled back by the rake and fresh coal added. The whole operation can be completed in about eight minutes.

If the clinker is of the toffee variety, we have to be a bit more cunning. Having cleared the rear section of the grate with the rake, it will be seen there is a thin skin covering the bars. It cannot be removed with the paddle in scraper mode until quite cool, for which there is usually insufficient time on a turn round. By turning the paddle on its edge, it can be used to clear the air ways by jabbing between the bars, taking care not to be tempted to use too much force, otherwise the bars could be damaged. It is possible to clear four or five rows of bars in this way, and that is sufficient for the return run.

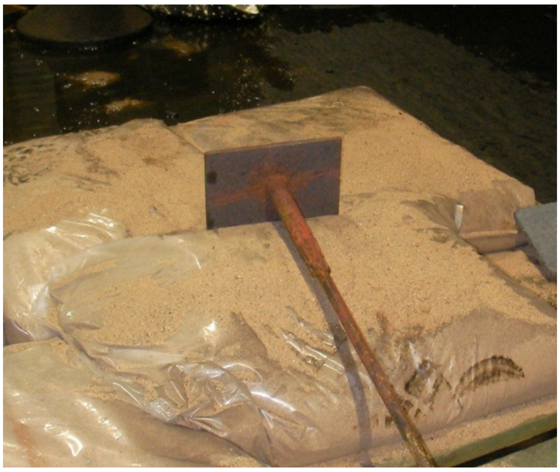
Recently, 143 had the RH half of the grate renewed. The LH half was not good, but still serviceable. This gave rise to a rather interesting phenomenon:

When it came to cleaning the grate at Disposal, the RH half cleaned up easily with no clinker remaining, most of the embers dropping through. The LH half was covered in a thin skin of toffee clinker, which had to be removed using the paddle. The LH half had become contaminated with clinker of the past, causing new clinker to adhere to it.

Gravel clinker is a bit more problematic. Thankfully, it does not occur very often, but when it does, it is usually on the run down hill or on the level. Its presence is detected by falling pressure although no steam is being used. Whilst the fire is relatively thick, it is dull and dead. I tend to regard it as a failure if we have to stop for a blow up. If gravel clinker is detected, get the rake in and push as much as possible forward, aiming to clear an area at the rear. Being what it is, it will not be easy, and all that may be achieved is a thinning of the layer at the rear. But that will be sufficient to allow the paddle to be jabbed between the bars to re-establish the air ways. Having done so, there may be time to work some of the clinker through the bars and get rid of it. When done, put fresh coal over the cleaned area and turn the blower up. With luck, it may not be necessary to stop.

Fire irons are the poor relation of the tools associated with the operation of steam locos. Whilst the instruction books refer to fire irons, I have been unable to find any illustrations or details of how they are to be used. They are so humble they do not warrant more attention, but my rake and paddle have transformed our ability to manipulate a fire. There was some reluctance in the earlier part of the year to use them, but I am gratified to hear more firemen ringing their praises. I knew they had been accepted when one day I saw my relieving fireman at Dinas walking down the platform with a clinker paddle on his shoulder!

The original fire iron.



The rake

The clinker paddle

Clinker Paddle coming into its own!

12 Correspondence with Adrian Tester on Locomotive Boilers

Chris Newman

Adrian Tester will publish the first volume of a new book to be titled "*The Physiology of Locomotive Boilers*" early in 2018. Those who heard Adrian's presentation at our autumn conference will have gained some fascinating insights into its content.

After hearing Adrian's talk, I engaged in email discussions with him on two topics relating to boilers. The first discussion started with a question about the 5AT's boiler capacity; the second with a question about copper vs. steel fireboxes. I thought Adrian's comments might be of interest to AST members so I thank for giving me permission to publish the following condensed compilation of the correspondence.

12.1 On the Steaming Capacity of the 5AT Boiler

CN to AT : I'd be very interested to hear your opinion as to whether Dave Wardale's predicted evaporation rate for the 5AT boiler (17,000 kg/hr) was unrealistically high. Some skepticism has been expressed as to whether such a small boiler would have been capable of generating so much steam, so I'd be interested to hear if you have a view on it. I asked Dave Wardale about it recently and he was adamant that the figure was realistic and achievable, and gave me a list of reasons why this was so which I've posted on the 5AT website – see https://www.advanced-steam.org/ufaqs/evaporation-rate/.

AT to CN: Please find attached a summary of the boiler performance *(reproduced overleaf)*. The units are Imperial - Btu/hr, degrees F, lbs/hr and inches of water.

As I suspected the evaporation is attainable more or less, but it is difficult to obtain the desired steam temperature. This I believe is due to the short barrel. Adding extra flues as DW contemplated increased the temperature but prompted a small fall in output. The evaporative tubular area is largely self-compensating so quite significant changes in gas flow or tube numbers don't have as much impact as one might expect[1].

DW adopted a high heat release of 58.4GJ/hr - equivalent to 55,363,200 Btu/hr. I have assumed this could be achieved with coal and based the calculations on that. I have already commented on possible firebox damage if this high heat release was sustained. No heating of the combustion air has been included but hot feed has.

Errors and assumptions on my part excepted, the results should be accurate to within a few per cent - certainly this is the case when tested against Rugby & Swindon data. The biggest departure tends to occur at the lowest steaming rate where flows are barely turbulent; the calculation method assumes turbulent flow.

[1] *From a later message responding to a question that I asked Adrian about Excess Air*: The excess air rate falls with rise in steam output. The fireman has some scope for adjusting excess air via damper openings. At lower steaming rates the excess air might be 60% but at the draughting limit - when S.O. Ell adjudged the smoke was becoming too much - it was typically around 20%. You are right in that an excess of excess air does cool flame temperature since heat that would have gone into the water instead heats up the extra combustion air. Thus the evaporative contribution from the firebox falls slightly since, being mostly radiant heat, it is very sensitive to temperature. In contrast, the heat transfer in the tubes and the superheater is by forced convection. Despite the slightly lower gas exit temperature from the firebox, the enhanced gas flow prompted by the excess excess air, increases the heat transfer in the barrel. Thus the superheat increases while the loss in evaporation from the firebox is almost compensated for by the increase from the tubes, so the total evaporation is hardly affected, falling by only by a small amount. These effects may be seen in the 5AT figures comparing the mean and maximum air flow results.

5AT

Revised version - November 2017

Variable gas properties | *Feed 221 deg F* | *3% Standing loss* | *Steam condition* | *x = 0.99*

35 flues | **146 tubes** | **Mean Excess Air**

Heat released	***13,889,988***	***20,834,982***	***27,779,976***	***34,724,970***	***41,669,964***	***48,614,958***	***55,559,952***
Steam rate	10,405	15,232	19,873	24,395	28,829	33,064	37,236
Firebox	6,095	8,480	10,559	12,405	14,098	15,577	16,973
Small tubes	2,088	3,317	4,640	6,081	7,615	9,077	10,553
Flues (empty section)	481	705	923	1,128	1,328	1,532	1,734
Flues (occupied portion)	1,741	2,730	3,751	4,782	5,788	6,878	7,976
Gas rate	16,215	22,903	29,591	36,279	42,967	49,655	56,343
Excess air	47.3	38.1	33.6	30.8	29.0	27.7	26.7
Gas apportion							
Tubes	6,016	8,474	11,008	13,713	16,542	19,117	21,692
Flues	10,199	14,429	18,583	22,566	26,425	30,538	34,651
Firebox gas exit	1,804	1,997	2,134	2,240	2,327	2,401	2,464
Small tubes	576	630	675	716	754	786	816
Steam temp.	611	646	671	689	704	720	734
Flues	591	648	694	733	768	800	830
Pressure drop	0.486	0.958	1.568	2.302	3.178	4.232	5.447

Maximum Excess Air

Steam rate	10,036	14,606	18,990	23,231	27,314	31,286	35,111
Firebox	5,432	7,360	8,956	10,298	11,444	12,432	13,213
Small tubes	2,215	3,560	5,035	6,628	8,145	9,716	11,309
Flues (empty section)	485	708	932	1,140	1,353	1,562	1,781
Flues (occupied portion)	1,904	2,978	4,067	5,166	6,372	7,576	8,808
Gas rate	18,534	26,382	34,230	42,078	49,926	57,774	65,621
Excess air	69.5	60.5	56.0	53.2	51.3	50.1	49.1
Gas apportion							
Tubes	6,876	9,840	12,973	16,242	19,222	22,243	25,264
Flues	11,658	16,542	21,257	25,836	30,704	35,531	40,357
Firebox gas exit	1,723	1,903	2,031	2,130	2,211	2,280	2,339
Small tubes	579	634	682	721	756	787	815
Steam temp.	627	666	693	714	735	753	771
Flues	596	652	697	736	771	804	833
Pressure drop	0.602	1.199	1.968	2.892	4.083	5.477	7.062

Maximum Excess Air

Variable gas properties | *Feed 221 deg F* | *3% Standing loss* | *Steam condition* | *x = 0.99*

40 flues | **100 tubes** | **Mean Excess Air**

Heat released	***13,889,988***	***20,834,982***	***27,779,976***	***34,724,970***	***41,669,964***	***48,614,958***	***55,559,952***
Steam rate	10,253	14,947	19,453	23,819	28,074	32,144	36,179
Firebox	6,095	8,480	10,559	12,405	14,098	15,577	16,973
Small tubes	1,467	2,334	3,283	4,299	5,381	6,415	7,462
Flues (empty section)	559	816	1,068	1,311	1,541	1,789	2,024
Flues (occupied portion)	2,132	3,317	4,543	5,805	7,054	8,363	9,720
Gas rate	16,215	22,903	29,591	36,279	42,967	49,655	56,343
Excess air	47.3	38.1	33.6	30.8	29.0	27.7	26.7
Gas apportion							
Tubes	4,232	5,978	7,812	9,723	11,730	13,556	15,382
Flues	11,983	16,925	21,779	26,556	31,237	36,099	40,961
Firebox gas exit	1,804	1,997	2,134	2,240	2,327	2,401	2,464
Small tubes	578	634	680	721	760	792	821
Steam temp.	639	681	711	735	755	774	791
Flues	596	653	700	740	776	809	839
Pressure drop	0.510	1.004	1.656	2.457	3.401	4.533	5.831

Maximum Excess Air

Steam rate	9,880	14,333	18,574	22,665	26,574	30,402	34,048
Firebox	5,432	7,360	8,956	10,298	11,444	12,432	13,213
Small tubes	1,560	2,514	3,577	4,678	5,761	6,894	8,024
Flues (empty section)	561	825	1,080	1,332	1,578	1,831	2,072
Flues (occupied portion)	2,327	3,634	4,961	6,358	7,791	9,245	10,739
Gas rate	18,534	26,382	34,230	42,078	49,926	57,774	65,621
Excess air	69.5	60.5	56.0	53.2	51.3	50.1	49.1
Gas apportion							
Tubes	4,856	6,965	9,242	11,487	13,630	15,830	17,980
Flues	13,678	19,417	24,988	30,591	36,296	41,944	47,641
Firebox gas exit	1,723	1,903	2,031	2,130	2,211	2,280	2,339
Small tubes	582	637	686	724	760	792	820
Steam temp.	654	702	735	763	788	810	831
Flues	600	658	704	743	780	813	843
Pressure drop	0.631	1.262	2.081	3.110	4.376	5.855	7.584

Two sets of excess air conditions are provided: mean excess air is what a skilled and interested fireman might achieve while maximum air is representative of a less skilled - even poor fireman. (The latter has been included because of the high gas rate DW used in his design.) Comparing these two sets of figures reveals under the latter conditions the evaporation is reduced by around 4-5% but this is offset to some extent by the higher steam temperature which slightly reduces the specific steam consumption.

Increasing the excess air does not make that much difference to the evaporation but because superheater performance is sensitive to gas flow it raises steam temperature *(see footnote 1 above)*. It also reduces the firebox evaporative contribution but because of the self-compensating action referred to above the indirect surfaces almost make up for it.

Incidentally, I have assumed the steam entering the superheater contains 1% moisture whereas DW has adopted dry saturated steam - i.e. his steam contains no moisture[2]. If I base my sums on dry saturated steam, the evaporation will reduce by approximately 1% whereas the steam temperature will rise by 15 deg F or so.

CN to AT: I'm impressed with the output from your simulation program which looks very comprehensive. I suspect it's just what lots of people have been waiting for – a means of accurately predicting boiler outputs to replace the rules of thumb that predominate on the one hand and complex calculations (like Wardale's) on the other. I'm also very pleased that your program produced results that come so close to Wardale's, and deduce that you've confirmed that Wardale's predictions are not fantasy.

I can see that you took into account feedwater heating when you set up your program, but I wonder if you also allowed for preheating the combustion air to 100°C - see Line 100 page 47 of the FDCs.

The FDCs are less clear about the incorporation of an economizer at the front end of the boiler – a partition plate which separates the "cold" feedwater from the hot end of the boiler by inhibiting movement of water from front to back. In Wardale's initial calculations, Line 94 of FDC 1.3 (original) includes the comment that "a considerably higher [feedwater] temperature [than 105°C] could be achieved by passing the feedwater through an economizer formed from the front section of the boiler barrel, this being an optional refinement at this stage". This sentence is deleted in his later calculations [FDC 1.3F (Final) on page 63], however he nevertheless increases the feedwater temperature to 110.5°C (= 231°F).

Does your simulator allow for incorporation of an economizer? If it does, I wonder if it suggests significant benefits (or otherwise).

On another point, in your earlier message you commented that "it is difficult to obtain the desired steam temperature ..... due to the short barrel". I guess there is an optimal length of barrel that will maximise the evaporation rate and steam temperature while minimising resistance to gas-flow. As I understand it, the Princess Royal's boiler was too long resulting in high flow resistance and also reduced steam temperature because combustion gas temperatures fell too low at the front end to the extent that they cooled the superheater elements. Presumably the introduction of a combustion chamber helped to resolve both problems, but either way, the shorter Duchess boiler was superior on both counts. Do your calculations suggest that the 5AT boiler is too short for optimum steaming? If so, can they be used to estimate what the optimum length would be?

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[2] *From a later message from Adrian*: DW struggled to obtain the high superheat he was aiming for in the 5AT. In the demonstration of the superheater booster appearing in the paper, despite pushing all the gas through the flues, the final steam temperature is lower than when that particular superheater is operated without a damper. Unlike the small tubes, superheater heat exchange is more sensitive to area, consequently to obtain high superheats it is not sufficient just to have high gas flow and a good temperature difference; you also need to have sufficient area. In other words you have to design a superheater, whereas the small tubes are much more forgiving - which is why engineers often had problems over their superheat.

AT to CN: As currently written the program assumes the combustion air is unheated since the vast majority of locomotives were not fitted with air heaters. I am intending to provide a version dealing with the E-type superheater, also the Crosti feedwater arrangements. These should be reasonably straightforward to include with the sums remaining simple. Chapelon's arrangement is more complicated - at the moment I am looking at ways of including it without sacrificing simplicity. Unfortunately the biggest problem for all of these variations is having the necessary boiler data/performance figures to check the programs against.

The two LMS Pacific boiler designs make a rather interesting comparison. Adding a combustion chamber reduces tube length so also reducing gas-side resistance. However the additional direct surface lowers the firebox gas exit temperature making superheat more difficult to attain. But this was offset to some extent by the still long elements fitted while the 6 x 1in diameter trifurcated units fitted consumed less of the free gas area through the flues - 26% as opposed to 33% with 4 x 1⅜ ins or nearly 40% with 4 x 1½. The Duchess of course had 40 flues whereas there were various boilers fitted to the Princesses the most common had 32 flues with 1⅜ or 1½ ins elements thereby compromising the superheat.

Each superheater has a maximum temperature it can attain. In most cases in locomotive work, this limit is virtual since it appears at a steam rate which is way beyond the maximum possible output of the boiler[3]. The analysis I have done on this to date, demonstrates that all things being equal the maximum steam temperature obtainable in a barrel say 13 feet long, with a 'conventional' number of flues for its size will be lower than that attainable in a longer one. However, raising the number of flues significantly to 40 as opposed to the 28 or 24 one might normally expect has brought the steam temperature up - as the attached demonstrates. Nevertheless at the maximum steam outputs more usually associated with this size of boiler (say 28,000lbs/hr), the superheat is around 760 deg F.

Increasing barrel length does not readily increase the steam output, since once you have a sufficiency of heating surface, i.e. enough to obtain a reasonable absorption efficiency - and the quantity can be quite small - then it becomes a law of diminishing return. Ever larger increases in heating surface area effect ever smaller increases in steam output. Meanwhile in pursuing this you introduce another 10-20 or more tons of boiler/loco weight to accommodate it. Superheating can gain from having elements longer than 13ft, which is why Chapelon's feedwater arrangement is potentially interesting.

12.2 On Steel vs. Copper Fireboxes

CN to AT: During his presentation, Colin Green expressed the opinion that fitting a steel firebox to Flying Scotsman would have resulted in all sorts of negative consequences and that copper fireboxes are altogether superior from the point of view of heat conduction and stress reduction (from its ductility), and perhaps other reasons that I've forgotten. He cited Tornado as an example of the sort of problems that can arise with steel fireboxes and as justification for sticking with copper in Flying Scotsman. I wonder if you have any views on the matter, given that most of the world's railways outside the UK seem to have managed successfully with steel fireboxes. By my understanding, Tornado's problems were due to the substitution of steel for copper without any dimensional changes - most notably without increasing the width of water jacket to give the stays greater flexibility.

[3] *From a later message*: The test bulletins from Rugby, Swindon and Altoona usually include a curve describing steam temperature. It exhibits a rising characteristic - steam temperature increases in line with steam output. However, the rate of rise in superheat is not constant; it reduces for equal increases in steam output. There is therefore a maximum steam temperature obtainable from each design. Through being able to replicate the curve we can extrapolate and predict accurately the steam temperature that will appear if a boiler has its evaporation increased through say improved draughting. I suppose being able to predict the curve to the point where it assumes a constant steam temperature is a bit of an academic exercise as it appears at impossibly high steam rates - but all the same it is interesting and pushes our understanding of the locomotive boiler a tiny bit further.

AT to CN: Explaining the differences between copper and steel fireboxes plus the advantages and disadvantages of the two materials is quite involved - quite a few pages in my book are devoted to exploring this. The following is therefore is very simplified. Steel can withstand higher wall temperatures although in part this is offset by its lower thermal conductivity. Thus the superior thermal conductivity of copper compared to steel results in a considerably lower (and less variation in) wall temperature for the same heat flux. But if a layer of scale is present on the water-side, due to its poor conductivity, this advantage is reduced or even lost. The lower limiting temperature for copper means it is not really suitable for boiler pressures above 250lbs or so.

The secret to both materials is good water treatment since this keeps the water-side surfaces clean allied with maintaining optimum pH (alkaline) conditions to prevent corrosion. I don't know the precise details of the problems with Tornado, but assuming it was not due to poor workmanship in Germany, I would be anticipating lack of adequate water treatment allied with the high heat fluxes demanded by high power outputs giving elevated plate temperatures resulting in cracking and bulging. Stays fail through fatigue but this can be accelerated ten-fold by poor water conditions giving rise to corrosion fatigue - stay life can then be embarrassingly short. If a copper box is pushed too hard, so that the wall temperature exceeds the limiting temperature, the 'grip' keeping the expanded tubes and the stays tight is lost, prompting leakage. Any scale present around the firebox tubeplate makes the tubes particularly susceptible should a greater effort be demanded from the boiler.

Since for a long and successful life both materials require good water treatment, it makes sense to use steel, not least because it's cheaper!

CN to AT: I wasn't aware that copper fireboxes were limited by steam temperature at pressures above 250 psi. Have I simply forgotten what I've learned, or have I never come across it in any of the books that I've read? (The last question is one that you won't know the answer to, other than perhaps to say whether it's common knowledge or not!)

As to Tornado's problems with firebox stay breakage, it was Dave Wardale's opinion that the breakages resulted from the design which retained the original firebox dimensions when steel was substituted for copper in the inner firebox, and that the width of water space should have been increased to reduce flexing stresses in the stays. In case you don't already have it, I attach a copy of his diagnosis of the problem[4]. I've no doubt that you're quite right in saying that inadequate water treatment could have been another factor in the failure.

AT to CN: When I said there was a limit of 250lbs for copper, this value is not written in tablets of stone as such but rather a 'sort of engineering consensus'. Certainly some engineers would not use it above that pressure - Bulleid stated he went to steel for his 280lb boilers (sat temp 416 deg F) because he thought it too high for copper. In contrast the LMS, after a report from the research team, intended to retain copper for the 300lbs boiler proposed for the 'super 4-6-4', but the stipulation was the water-side surfaces had to be regularly cleaned. The coppers then in general use started to soften above about 650 deg F, while the saturation temperature at 300lbs is 422 deg F and for 250lbs it is 406 deg F. Since metal temperatures of 650 deg F were measured in bad water districts, the loss of 16 deg F of 'reserve' through going to 300lbs was significant.

Thank you for the paper by DW which I read with interest. Despite agreeing with much of what he has written, I think the evidence does not support all of his findings. Hence:-

i. while wider water spaces reduce the bending stress in the stays, the success of many fireboxes fitted with narrow water spaces - as narrow for example as 2.5ins in ex-LSWR and Southern derived 4-6-0 classes - suggests it is beneficial not crucial. Sure this was in conjunction with a copper 'box, but I think the principle holds.

[4] Wardale's diagnosis is reproduced as an addendum to FDC 11.1. "Boiler: Principal Strength Calculations" as published in the 5AT Fundamental Design Calculations (pub. ASTT 2015 ISBN978-1-942748-13-7).

ii. as a general observation, wide fireboxes, due to their inherent proportions, tend to be less able to withstand elevated heat release rates and hence steam outputs, compared to narrow fireboxes.

iii. I suggest the supposed benefits from fitting Tross stays is not as clear-cut as DW suggests. P Girdlestone stated in his book on the SAR classes 25 N and NC that only some were fitted with Tross stays, and they were removed in the mid-1960s with ordinary screwed ones substituted. The reason being the appearance of cracks in the welding of the stays followed by cracks in the firebox plates. Although Tross stays were adopted successfully in Germany, the engines there were not worked hard. Unfortunately they were not used in America where the demands placed on its locomotives would have revealed how good they were!

iv. something quite similar to the Tross profile was tried in Britain before 1914. These were of course screwed copper stays but the profile was again intended to shift the bending away from adjacent the plate where the shear force is highest, instead moving it to the middle of the stay.

v. by the start of the Second World War with nearly 20 years experience of monel metal stays, Southern engineers could state no monel metal stay had broken, despite their having a profile similar to that of a conventional steel stay. I suggest the reason why monel metal stays were successful is not due to the greater ductility of the metal compared to steel, after all copper has higher ductility still, but rather the material's superior corrosion resistance.

Sure, stays eventually break through simple fatigue prompted by the relative movement between the inner and outer fireboxes, but the primary driver determining when this happens, for any chosen stay location, is corrosion fatigue, which in turn essentially depends on water quality. When the water is untreated, or when treated the correct levels are not maintained all of the time, then corrosion pits quickly form on the surface of the stays. These act as localised stress concentrations - and the rest you know. The time to fracture can be quite short!

I think the evidence of the French is very instructive. With TIA, consistently and correctly applied, boiler maintenance dropped to one-tenth what it had been previously. Stays no longer broke prematurely. This was despite the French using ordinary screwed stays in copper and steel fireboxes, roof sling stays, direct roof stays and girder stays. They made very little use of flexible stays.

I suggest if a 90% reduction in boiler maintenance requirements can be obtained from ordinary stays used in conventional firebox designs simply by adopting good water treatment, then the arguments DW put forward are for a secondary performance improver not the primary one, while in any case its success in service was mixed. In my opinion, the secret to good boiler life and minimum maintenance requirements is good boiler water treatment!