AST Trust

Advancing Steam Traction

NEWSLETTER No. 27 - JUNE 2025

The Greatest Gathering

CONTENTS

CHAIRMAN'S PIECE

John Hind

This year will be a significant in our history, as we are expecting greater exposure to the enthusiast community than we have before as we have a stand at the Great Gathering, more detail later.

Our own locomotive will be there, and I am expecting it will generate lots of interest, I am hoping mostly favourable but inevitably we should expect criticism from the steam pundits! It should be at the stage where it will look like just 'add boiler' and it is a runner. Like all new builds whatever size, the boiler represents the single largest cost. We have not gone out on enquiry for it, though we have estimated a cost. Once we have firm costs then we will be in a better position to look at financing options for it.

Thanks to the 111 members who have renewed their membership and hoping that this newsletter serves as prompt to the remaining twelve to do so. You know who you are!

It is with a great sadness that Chris reports the passing of Fred Rich. Fred was a professional engineer who started at Brighton in BR days and as part of his apprenticeship on the shop spent time building BR Standard 4 tanks. One of the apprentice jobs was chipping out the radii on the smokebox saddles where they fit onto the frames and every time, I see one, I wonder if it was one of Fred's. Fred then went into the Drawing Office at Brighton, then to Derby and then to the Rugby Testing Station, before leaving the railway industry to join the Ministry of Defence. It is only when they have gone do you think of the many questions you should have asked. He answered a couple of questions for me, and they were always beautifully clear and he knew some of the personalities involved in the Derby DO with the design of the BR Standards.

ASTT CONFERENCE
John Hind

4th/5th October – Hopetown, Darlington

The programme for the conference is being firmed up, with confirmed speakers and events but still with a couple of speaker slots to fill.

Paul Middleton, Engineering Director of the North Yorkshire Moors Railway is with us on Saturday to talk about the running steam in the 21st Century on a Heritage Railway. Paul is also known as 'Piglet' of Yorkshire Steam Railway fame and is an entertaining speaker, with great practical knowledge.

Another speaker is Daniela Fivola. She runs her own company providing technical services to the railway heritage sector. After working with the A1 Trust and David Elliot on the A1 and P2 she founded her own company Daniela Works and the talk will be about the challenges of steam locomotive engineering in the 21st century.

On the Sunday, we have a visit to see the P2 and guided tour of the A1 Trust's Darlington Locomotive Works Facility. The last time we were in Darlington, the A1 Trust were in their old workshop and the new one is an impressive modern building with wide open spaces.

Alex Powell will be talking about the practical application of Watertreatment and its use on Clan Line, which runs in the Southeast, an area where the water is good enough to drink but not good enough if you are a steam locomotive operator!

Hendrik Kapitein will be talking about locomotive boilers for the 21st century.

Andrew Hartland continues his series of talks on 'Why Did BR Give Up on Steam?' with one on lessons learned.

Jamie Keyte will be giving his ever popular and entertaining update on the build of Revolution. In a couple of years, the theme of Jamie's talk will change to testing of Revolution!

I will give a talk 'New Build Steam – the practicalities' not so much a technical talk, but one about things that the average enthusiast does not consider and highlighting some of the challenges that are not always apparent.

We still have two invitations out to speakers to complete the programme.

We had hoped to have a speaker from a company in the UK that is working with Nigel Day to offer a UK oil firing solution, but they would rather hold off until their first installation is complete, so they are pencilled in for future conferences.

The conference is at the Hopetown Museum in Darlington and is recognised as a Railway 200 event. Outline details can be found on the Railway 200 website https://railway200.co.uk/search-for-activities-and-events/

The conference fee is expected to be in the £100 to £110 range for 2 days' and £75 for a single day. Costs include meeting room hire; morning and afternoon teas and coffees; lunches; speakers' attendance fees; and a £300 donation to the A1 Trust after our Sunday visit.

The conference dinner is at the Bannatyne Hotel in Darlington, who are also offering discounted accommodation. The discounted rates for bed & breakfast are £70 per single occupancy room and £80 per Double or Twin room.

The conference dinner is £28 for three courses and in a private room. It is at 1830 because there is another group dining at 2030. This does mean getting to the bar earlier for after dinner conversations!!!

As in previous years there will be a menu in advance for pre-ordering.

Please book your room directly with the hotel, mentioning the ASTT discount. Early booking is recommended.

Their e-mail is reception.darlingtonhotel@bannatyne.co.uk

The hotel website is www.bannatyne.co.uk

Once the programme is confirmed, we will get out the Conference Flyer giving full details.

MEMBERSHIP MATTERS
Chris Newman

Committee Members

New Members:

Only one new member - Jeff Morfit from Virginia, USA - has joined since the start of the year. It is hoped that this unusual situation will be improved by ASTT's presence at the Greatest Gathering event to be held in Derby over the first weekend in August.

Not only have there been so few members joining so far this year, but 10 past members have so far failed to renew their subscriptions. Several of these have been habitually slow to resubscribe in the past, so it is hoped that they may do so if another reminder is circulated to the late-payers.

Fred Rich:

We are sad to record the death of Fred Rich who had been a member for the past five years. Fred was the author of a most interesting book titled "Yesterday Once More – the Story of Brighton Steam" published in 1996, which recounted stories of the railways of over a century ago – a very different world in which steam reigned supreme. Brighton was the birthplace of the Institution of Locomotive Engineers, the story of which Fred recounted in memorable detail. His book can still be bought on the second-hand market, Amazon having a copy for sale for £13 at the time of writing.

Membership Numbers

We currently have 124 members on our books, of whom 85 (67%) have paid their 2025 subscription. Others are reminded that subscriptions fell due on 1st January 2025. The current breakdown of 124 members is as follows (in the hope that all resubscribe!):

Full Members:	39	UK Members:	79	Age Ranges	Age Ranges
Associate Members:	74	EU: 18		Over 60	Approx. 46%
Student Members:	11	North America:	12	30 to 60	Approx. 40%
		South America:	1	Under 30	Approx. 15%
		Australasia: 11		Av. age	Approx. 56
		Asia & Africa:	3		

PUBLICATIONS PAGE

Chris Newman

Book Sales

Book sales, like membership numbers, have been disappointing so far this year, only 2 books being sold since the last newsletter was distributed. It is hoped that the publication of a 5th volume of Porta's papers (see overleaf) will see an increase in sales, but since this is likely to be the final volume in the series and since no new titles are in the pipeline, any improvement in sales is likely to be temporary.

Books sales since February 2025 have been as follows:

Publisher	Author	Title	Sales since N/L 26	Total Sales
ASTT	L.D. Porta	Porta's Papers Vol 1	0	152
	L.D. Porta	Porta's Papers Vol 2	0	143
	L.D. Porta	Porta's Papers Vol 3	0	111
	Martyn Bane	Porta's Papers Vol 4	0	78
	L.D. Porta	Porta's Papers Vol 5	0	0
	C. Newman (Editor)	Porta's Centenary Compendium Vol 1	0	88
	C. Newman (Editor)	Porta's Centenary Compendium Vol 2	0	47
	Ian Gaylor	Lyn Design Calculations	0	111
	David Wardale	5AT FDCs	0	223
	David Wardale	Reminiscences of a Trainspotter	0	43
	Alan Fozard	5AT Feasibility Study	0	47
Camden*	*David Wardale*	*The Red Devil and Other Tales from the Age of Steam*	*0*	*260*
	Phil Girdlestone	*Here be Dragons*	*0*	*33*
	Jos Koopmans	*The Fire Burns Better …*	*0*	*11*
	L.D. Porta	*Advanced Steam Design*	*0*	*5*
Crimson Lake	Adrian Tester	Physiology of the Loco Boiler – Part 1	1	35
	Adrian Tester	A Defence of the MR/LMS 4F 0-6-0	0	44
	Adrian Tester	Introduction to Large Lap Valves	1	24
		Total sales	2	1458
* Camden is now selling these titles in digital format, so they have been withdrawn from ASTT's website.				

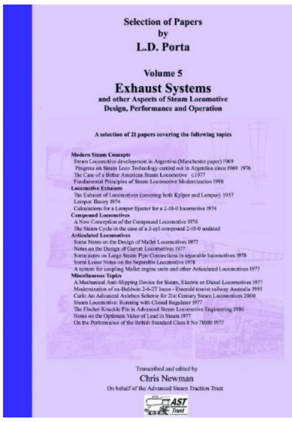
Book sales provide a valuable source of income to ASTT which helps to fund activities, not least our Revolution project. **Members are urged to support our endeavours by purchasing books from us.**

Note: We'd like to expand our book selection, so we welcome any suggestions for additional titles that we might be able to sell, or new texts that we might publish under ASTT's logo.

Selection of Papers by L.D. Porta – Volume 5

Exhaust Systems and Other Aspects of Steam Locomotive Design, Performance and Operation

ASTT's Latest title



This fifth volume subtitled "Exhaust Systems and Other Aspects of Steam Locomotive Design, Performance and Operation", includes 21 papers as follows:

Modern Steam Concepts

Fundamental Principles of Steam Locomotive Modernization	1998
Steam Locomotive development in Argentina (Manchester paper)	1969
Progress on Steam Loco Technology carried out in Argentina since 1969	1976
Modernization of ex-Baldwin 2-6-2T locos – Emerald tourist railway Australia	1995
The Case of a Better American Steam Locomotive	c.1977

Locomotive Exhausts

The Exhaust of Locomotives (covering both Kylpor and Lempor)	1957
Addendum – Notes and Clarifications by David Fryer and Martin Johnson	2025
Lempor Theory	1974
Calculations for a Lempor Ejector for a 2-10-0 locomotive	1974

Compound Locomotives

A New Conception of the Compound Locomotive	1976
The Steam Cycle in the case of a 3-cyl compound 2-10-0	undated

Articulated Locomotives

Some Notes on the Design of Mallet Locomotives	1977
Notes on the Design of Garratt Locomotives	1977
Some notes on Large Steam Pipe Connections in separable locomotives	1978
Some Loose Notes on the Separable Locomotive	1978
A system for coupling Mallet engine units and other Articulated Locomotives	1977

Miscellaneous Topics

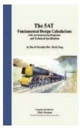
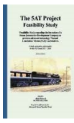
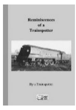
A Mechanical Anti-Slipping Device for Steam, Electric or Diesel Locomotives	1977
Cario – an Advanced Axlebox Scheme for 21st Century Steam Locomotives	2000
Steam Locomotive: Running with Closed Regulator	1977
The Fischer Knuckle Pin in Advanced Steam Locomotive Engineering	1986
Notes on the Optimum Value of Lead in Steam	1977
On the Performance of the British Standard Class 8 No 71000	1977

The book fills 340 A4 pages including an index (for the first time)**.**

Book price: £27.00 (less 20% discount to ASTT members) plus postage.

Note: A brief description of each paper can be downloaded from the book's page on ASTT's website.

Titles published by the Advanced Steam Traction Trust

	Year	Author	Title	Pages	RRP*
	2015	David Wardale	The 5AT Fundamental Design Calculations	556 (b&w)	£49.00
	2016	Alan Fozard and others	The 5AT Feasibility Study edited	230 (colour)	£35.00
	2018	Ian Gaylor	Steam Locomotive Design Specifications and Calculations for New Build Baldwin 2-4-2T 'LYN'	604 (colour)	£52.00
	2018	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 1 - Tribology and Lubrication	250 (b&w)	£25.00
	2019	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 2 - Adhesion, Compounding and the Tornado Proposal	256 (b&w)	£25.00
	2021	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 3 - - Steam Locomotive Boilers, Fireboxes and Combustion	290 (b&w)	£25.00
	2024	L.D. Porta and others Compiled by Martyn Bane	Selection of Papers by L.D. Porta - Vol 4 - Locomotive Boiler Water – Treatment, Circulation and Preheating	513 (colour)	£40.00 (£48 hard cover)
	2025	L.D. Porta transcribed and edited by Chris Newman	Selection of Papers by L.D. Porta – Vol 5 - - Exhaust Systems and Other Aspects of Loco Design, Performance and Operation	340 (some colour)	£27.00
	2022	Compiled and edited by Chris Newman	A Compendium of Articles and Papers to celebrate the Centenary of the birth of Livio Dante Porta - Volume 1	226 (colour)	£25.00
	2023	Compiled and edited by Chris Newman	A Compendium of Articles and Papers to celebrate the Centenary of the birth of Livio Dante Porta – Volume 2	331 (colour)	£27.00
	2023	David Wardale	Reminiscences of a Trainspotter	67 (b&w)	£16.00

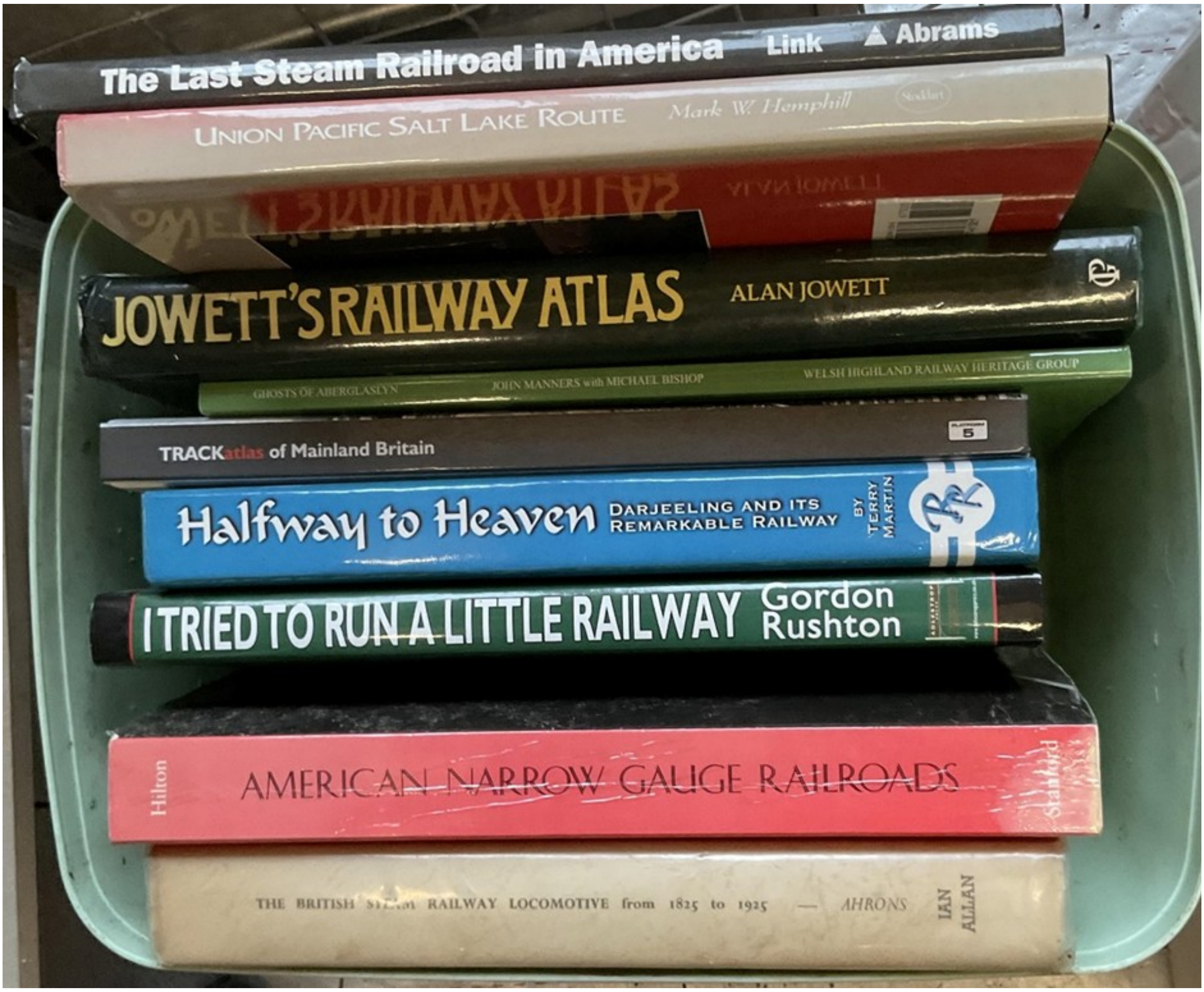
Second Hand Books For Sale

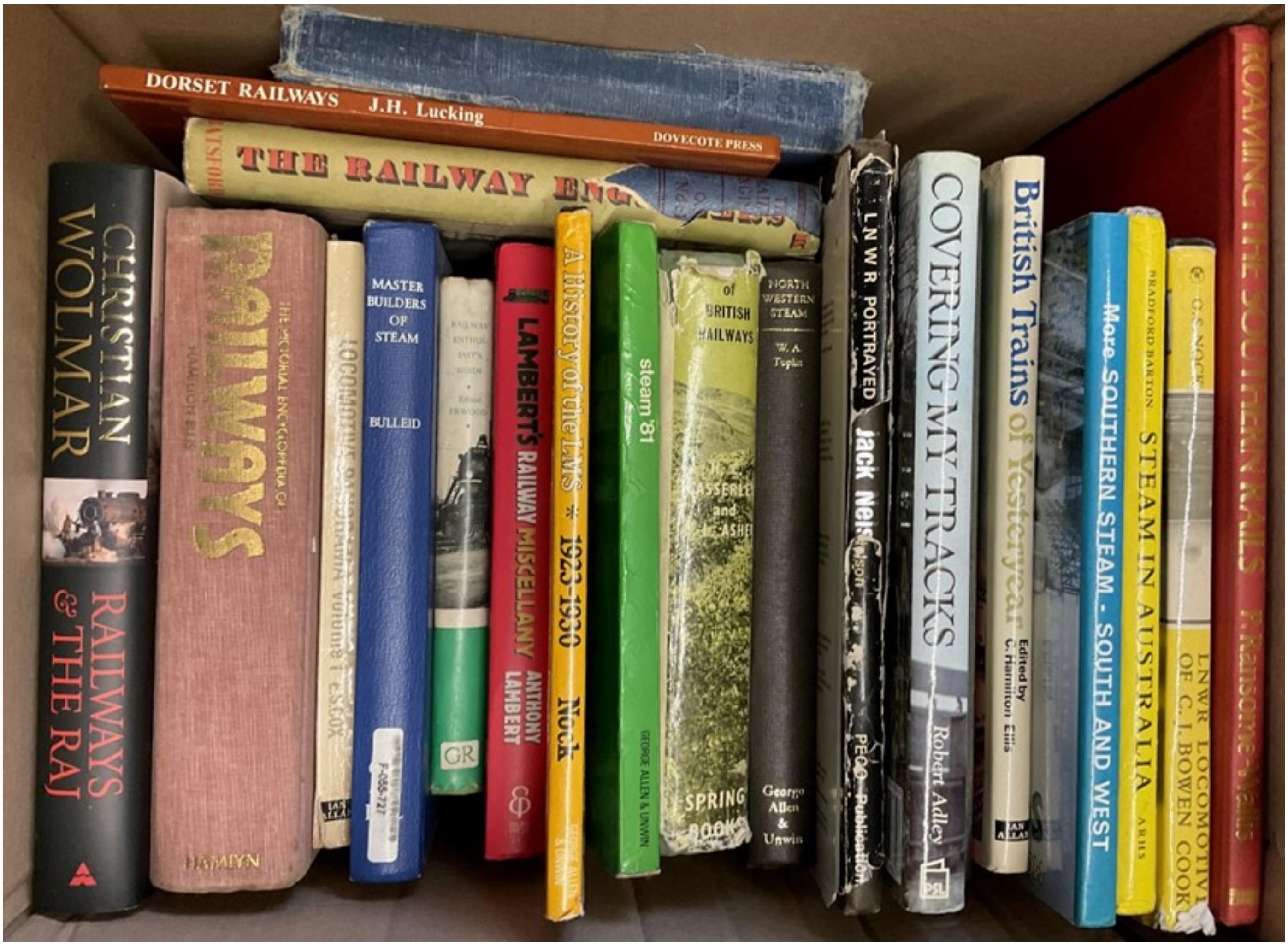
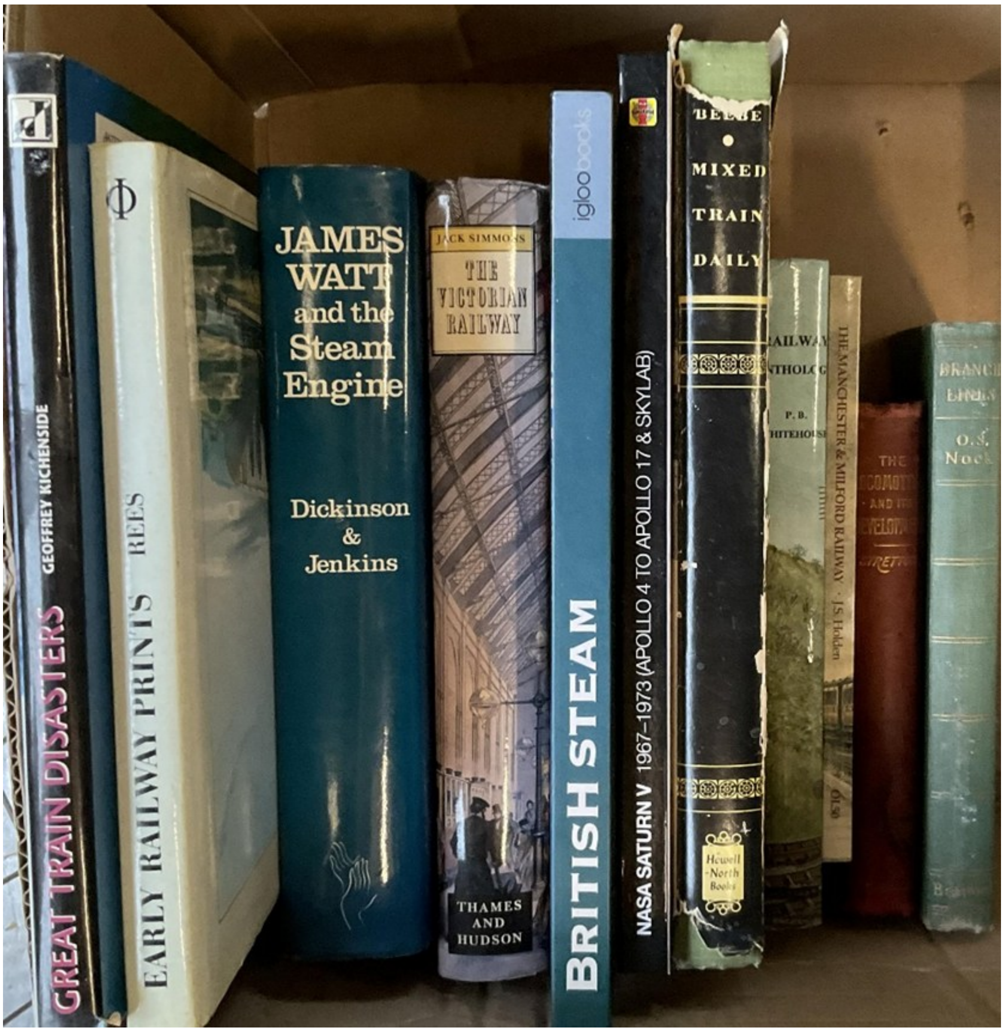
Our erstwhile Treasurer, Paul Hibberd, who passed away in 2022, has left us his collection of books and DVDs which we would like to sell to raise money for the *Revolution* project. The collection is being curated by Cedric Lodge (email janced@sky.com) who will provide further information to prospective buyers. Please contact Cedric if you are interested in any of the titles.

We are aware that some books are of higher value – e.g. 'Halfway to heaven' by Terry Martin. The cheapest listed on Abe Books is £110 ,so we will accept £100 first come, first served. We are inviting reasonable offers for the other books, relying on the goodwill and integrity of you - our members.

The total price must include postage, which will be calculated based on weight. Payments should be made to Advanced Steam Traction Services Ltd, sort code 20-73-26, Account No. 53896625, or via PayPal to info@adanced-steam.org. Please be aware that packing and posting may take time, so please be patient whilst your order is being processed.

See below for images of the books and DVDs that we have for sale.




DORSET RAILWAYS J.H. Lucking
DOVECOTE PRESS
THE RAILWAY ENG
CHRISTIAN WOLMAR
RAILWAYS & THE RAJ
RAILWAYS
HAMLYN
MASTER BUILDERS OF STEAM
BULLEID
LAMBERT'S RAILWAY MISCELLANY
ANTHONY LAMBERT
A History of the LMS 1923-1930 Nock
steam '81
GEORGE ALLEN & UNWIN
BRITISH RAILWAYS
SPRING BOOKS
NORTH WESTERN STEAM
W.A. Tuplin
George Allen & Unwin
L N W R PORTRAYED
Jack Nelson
PECO Publication
COVERING MY TRACKS
Robert Adley
British Trains of Yesteryear
Edited by C. Hamilton Ellis
More SOUTHERN STEAM - SOUTH AND WEST
BRADFORD BARTON
STEAM IN AUSTRALIA
ARHS
LNWR LOCOMOTIVES OF C.J. BOWEN COOKE
ROAMING THE SOUTHERN RAILS

GREAT TRAIN DISASTERS
GEOFFREY KICHENSIDE
EARLY RAILWAY PRINTS
REES
JAMES WATT and the Steam Engine
Dickinson & Jenkins
JACK SIMMONS
THE VICTORIAN RAILWAY
THAMES AND HUDSON
igloo books
BRITISH STEAM
NASA SATURN V 1967–1973 (APOLLO 4 TO APOLLO 17 & SKYLAB)
MIXED TRAIN DAILY
THE MANCHESTER & MILFORD RAILWAY
O.S. Nock


SCENIC RAILWAY JOURNEYS OF THE WORLD
RDV 087-881/3
SCENIC RAILWAY JOURNEYS OF THE WORLD
RDV 087-881/2
SCENIC RAILWAY JOURNEYS OF THE WORLD
RDV 087-881/1
Michael Palin's GREAT RAILWAY JOURNEY
BBCV 5223
PAL
PRESENTS
THE BIGGEST LITTLE RAILWAY IN THE WORLD
BRITAIN'S HERITAGE RAILWAYS Volume 4
SUN 9151
BRITAIN'S HERITAGE RAILWAYS Volume 6
SUN 9153
BRITAIN'S HERITAGE RAILWAYS Volume 5
SUN 9152
Steam around Bristol
FLYING SCOTSMAN
GRD2395
MICHAEL PALIN GREAT RAILWAY JOURNEYS
BBCDVD 1626
BBC
THE LOST RAILWAYS
THE BRANCH LINES of BRITAIN Volume Three
SUN 9206
THE BRANCH LINES of BRITAIN Volume Two
SUN 9205
THE BRANCH LINES of BRITAIN Volume One
SUN 9204

THE GREATEST GATHERING

John Hind

Thanks to Richard Coleby and his negotiating skills, we have secured a stand at The Greatest Gathering. In turn, that set off a few next steps for us. First was deciding what is going on the stand, who is supporting it, what handouts to have and what to wear!

Revolution will be there and, to the enthusiast, looking more like a locomotive, with a smokebox, cab and tender. Jamie is designing a stand, so that the engine is at waist height, making it easy to view.

We will be having pop up banners describing who we are, what we have done and what we do and potentially recruit more members and attract delegates to the 2025 conference.

Additionally, we will have an LCD display looping a video of what we have done.

Copies of our books will be on display, and we will take orders for them with a card reader.

With 10,000 people a day, there is potential to get greater publicity, though a lot will depend on where the stand is located.

Following the appeal in the last newsletter, Owen Jordan and Nigel Barnes volunteered to help man the stand and from the committee, Richard Coleby, Jamie Keyte, Alex Powell, Chris Newman, Gwion Clarke, Mike Stockbridge and I will be there on a rota basis. We are limited to six people per day on the stand.

Jamie is organising corporate workwear for us and I am looking into accommodation as it is going to involve overnight stays for several days for anyone not in commuting distance of Derby.

Richard is also involved with IMechE's Railway Challenge stand, similarly Jamie is also supporting the King George the Vth new build stand and I am supporting the Hengist new build Clan stand.

The Greatest Gathering

A VERIFICATION OF REPORT R13 FIGURE 18 46225 LOCOMOTIVE RESISTANCE CURVE

By Doug Landau

Introduction to Revised Edition March 2018

The first edition of this paper examining the veracity of the locomotive resistance (LR) curve contained in the 46225 *Duchess of Gloucester* test bulletin (Report R 13), dates from June 2010. The original paper, concluding that the LR curve withstood examination based on three lines of enquiry was not widely circulated at the time. As presented here, sheets 2 to 7, is to some degree in revised form with added detail covers the ground of the original report. Sheet 8 and Chart 1 are wholly new, introducing a new, and perhaps, clinching the line of enquiry.

Improbable Outcomes - Some Further Notes On Background

The early BR test bulletins included no specific information on locomotive resistance (LR). Such information could only be obtained by subtracting the DBHP from the IHP data. For the most part the results so obtained, improbably, returned constant locomotive resistance independent of power output. More seriously, the magnitude of locomotive resistances so revealed was of wildly disparate in magnitudes and form. The results for King 6001 revealed in Sam Ell's 1953 I.Loc.E paper, *Developments In Locomotive Testing*, was perhaps the classic example of excessively high resistance, additionally implying high sensitivity to effort.

The locomotive resistance curve derived from Test Bulletin No. 5 for the Britannia was absurdly, virtually constant independent of speed. Bulletin No. 4 for BR 4MT 4-6-0 75006 tested at Swindon returned specific resistance values (lb/ton), up to 46% higher than for Ivatt Mogul 43094 at low speed also tested at Swindon (Bulletin No.3). The 4-6-0 4MT was just 8% heavier than the 2-6-04MT. Swindon Bulletin 15 for 71000 included an LR curve 25% higher than the Duches R13 LR curve at 25 mph, Against this background of confusing and conflicting outcomes, the Duchess LR curve was dismissed by many as implausibly low. Such attitudes were aided and abetted by the considerably higher resistances reported for some continental locomotives, and in particular the Chapelon compounds. It was against this background, and on the grounds that at least notionally, the Rugby/Derby axis eventually ach testing facilities (as summarised under "The State of the Art?" on sheet 2), that the Duchess test data was subjected to close examination.

An Additional Test

Based on the assumption that published test bulletins were configured to represent an assumed environmental constant in regard to wind conditions, or a loosely defined "average" condition (Derby). It follows that the uncoupled locomotive vehicle resistance, VRU, should, at any given speed remain a constant regardless of effort. Such an outcome can only be determined when wheel rim horsepower test data is available as is the case with 46225, though only with sufficient data for 50mph. It passes this test (Figure 10 sheet 8), as have similar exercises carried out for the 9F and BR5.

Conclusions

The available empirical evidence withstands the various tests and scrutiny it has been subjected to. The veracity of Report R13 Figure18 stands. A fall-out of this exercise and a considerable body of other work, is that the Swindon controlled constant steam rate road test procedure was less controlled than supposed.

LMR Class 8 4-6-2 46225 Test Report R13

Preamble

The resistance of steam locomotives (LR), and a reliable general formula to estimate same, have proved an elusive objective down the decades. The magnitude of the problem can be amply demonstrated by applying published formulae to a common example. The application of 10 such formulae to an LMS Black 5 yields results ranging from 500 to 950 HP at 70 mph, with an average of 700. The maximum variation over the mean value of 725 was thus more than + or - 30%.

To a significant extent, the problem of accurate measurement of LR, is inherent when determining a relatively small difference between two large numbers. Suppose, for example, that the true indicated horsepower (IHP) of a locomotive is 2000, and the drawbar horsepower (DBHP) is 1700, then the LR is 300. But if, as is likely, the measurement of IHP and DBHP may be routinely subject to errors of +/- 2%, then the measured LR may appear to be anything from 226 to 374 HP, errors of about 25% in both cases.

In the normal way of things these measurement errors, provided enough readings are taken, may cancel out, and a reasonably sensible result obtained. However, judging by the conflicting formulae that have dropped out of such test data down the years, it would seem that "self-cancelling" errors can by no means be relied upon. The dependence on mechanical indicators for the measurement of IHP was always something of a challenge to instrument engineers, and their precision of measurement was inherently poor, with a bias to over record resulting from both mechanical considerations and human influence (confirmation bias: a natural welcome for apparently high cylinder efficiency). Errors could be systematic rather than random, such as a fixed or variable calibration error. IHP Errors in excess of 5% high have been demonstrated in comparative tests.

A further complication is that locomotive resistance is a variable, victim in particular to the influence of wind, which can bring about significant shifts in locomotive resistance at the top end of the speed range, both positive or negative. In these circumstances, the best that can expected of a resistance formula, is that it will reasonably approximate to reality under "average" or "typical" conditions. Where wind conditions are known an adjustment factor can be built into a resistance formula which will narrow the band of uncertainty, but it will not eliminate it. The quality of the track formation and curvature also affects resistance. Given this background it is hardly surprising that the picture regarding locomotive resistance is somewhat confused.

Locomotive Testing - The State of the Art?

Early in 1955 Stanier Pacific 46225 was the subject of performance and efficiency tests at Rugby Locomotive Test Station, and in the spring of 1956 underwent road tests over the Settle and Carlisle line. After reconciliation of the plant and road test data covered by internal report L109, the resulting test bulletin, Report R13, was probably the most accurate to emerge from the BR test programme. First commissioned in 1948, the Rugby test plant was the proverbial "last word" in locomotive test stations.

A possible rival opened in Moscow the same year remains an unknown quantity. In any event these were the last test stations to be built.

The Rugby plant drew heavily on the French test station at Vitry; some important modifications and refinements were incorporated. Significant of these was the incorporation of Bellville washers in the Amsler dynamometer draw gear and beefed up anchorage. (The Vitry plant had encountered resonance problems, disturbing the hydraulic dynamometer, a problem significantly curtailed when damping Bellville washers were retrofitted to the draw gear.) A 'Mediating Gear' servo mechanism monitored and corrected any shifts of the locomotive driving wheels from top dead centre above the test plant rollers. An additional damping dashpot proved dysfunctional, falsifying drawbar pull, and was eventually abandoned after numerous unsuccessful modifications and decommissioned at the end of 1950. The first run on the test plant was 26.11.1948 - WD 2-10-0 73798.

It was to be some years before operations at Rugby reached a satisfactory and consistent level of performance. Boiler efficiency plots for example, can almost be dated by the degree of scatter, which was noticeably higher in the early years.

The Farnbro indicator underwent significant development, in the early years mechanical failure was a constant problem, and there appears to have been a tendency to under record IHP. The indicators underwent continuous development and improvement until January 1955 at the start of the Duchess tests when "this produced the standard of diagram so long sought after."

The Rugby Farnbro indicator differed to the Derby pattern used on the road tests, the former was diaphragm operated and the latter piston operated. The cylinder efficiencies, recorded by the Derby indicator on road tests with Black 5 44764 in 1949, were too high to be credible. The unreliability of these results appear to have been quickly realised, they were given no publicity. Some comparative calibration tests were carried out at Rugby in 1953. The results were not very satisfactory, likewise Rugby v mechanical indicators the same year). Later comparative tests in 1955 on 9F 92050 showed closer agreement, by this time both versions of the indicator had undergone further development and improvement.

The 46225 road tests over the S & C in 1956 included constant speed working (MTU controlled) from 20 to 80 mph in increments of 5 mph. A number of additional tests at constant speed throughout were carried out at 20, 35 and 60 mph. Some reconciliation of the Rugby plant and road test results proved necessary; Hence Reports L109 and L109 supplement. Report R13 incorporated the reconciled data.

Fitting the R 13 LR Curve Figure 18 (Report R13 Fig 18 lb/ton LR curve for 46225)

Here a number of formulae are fitted to the R13 Figure 18 LR curve, various values of coefficients, in combination, will give an acceptable fit to the curve over its published range of 20 to 80 mph. Extrapolating beyond this range shows that varying degrees of divergence will occur. It is uncertain if Derby adopted Swindon's 2/3ds supplies LR criteria.

Table 1 R13 LR Lb/ton- Variations on a Theme How various coefficients give a tolerable curve fit.						**Report R13 Fig.18**		
MPH	DHL #	R13 Mod 1	R13 Mod 2	R13 Mod 3	R13 Mod 4	**LR lb/ton**	LR lb	LR lb 2/3 Supplies
20	9.2	9.1	9.4	9.2	9.8	9.2	1487	1401
30	10.5	10.4	10.7	10.6	10.8	10.7	1729	1630
40	12.2	12.1	12.4	12.3	12.3	12.5	2020	1904
50	14.2	14.1	14.4	14.2	14.1	14.4	2327	2193
60	16.5	16.5	16.7	16.5	16.3	16.6	2683	2528
70	19.2	19.3	19.3	19.2	19.0	19.2	3103	2924
80	22.2	22.5	22.2	22.1	22.1	22.0	3555	3351
90	25.5	26.0	25.4	25.4	25.5			
100	29.2	29.8	28.9	28.9	29.4			

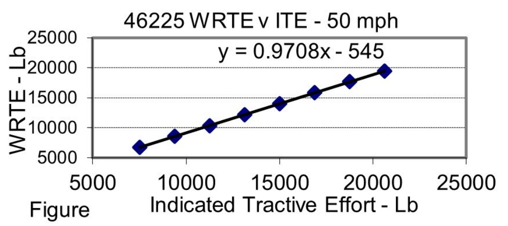
R13 figures above 80 mph extrapolated. Shaded cells equal or within 0.2 lb/ton of R13 Fig.18

R13 Figure 18	
MPH	LB/Ton
20	9.2
30	10.7
40	12.5
50	14.4
60	16.6
70	19.2
80	22.0

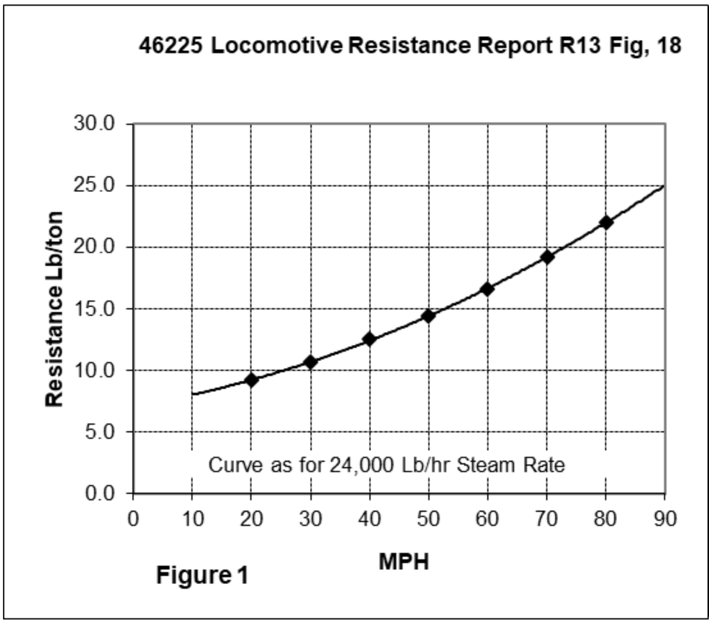
DHL formula derived from empiral data.

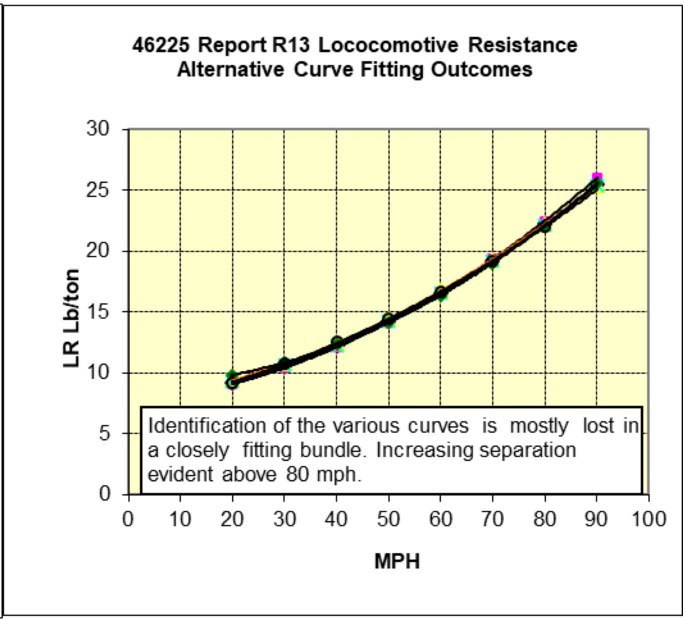
Table 2 Formula Used Above				LB/ton 80 MPH
Formula	1st Term	2nd Term	3rd Term	
DHL #	7.5	V/20	$V^2/600$	22.2
R13 Mod 1	7.5	V/24	$V^2/550$	22.5
R13 Mod 2	7.5	V/16	$V^2/660$	22,2
R13 Mod 3	7.5	V/18	$V^2/630$	22.1
R13 Mod 4	9.0	None	$V^2/490$	22.1
R13 Fig.18	Plots as Figure 18 Report R13			22.0

The lesson here is that a satisfactory formula, fitting experimentally derived resistance curves allow some flexibility in regard to both form and the coefficients adopted.



Figure





Notes

1 Figure 18 in report R13 gives the LR in Lb/ton for 46225 from 20 to 80 mph. See columns M & N above.

2 Table 5 columns C to D are the results for 5 different formulae that reasonably replicate the R13 data

3 Table 6 sets out the various coefficients assumed to replicate the R13 curve.

4 The three part formula of the form A + B/V + V^2/C notionally reflects the idea that some elements of resistance will be fixed, some a linear function of speed, and some a squared function of speed. The two part formula (R13 Mod 4) eliminates the middle term and still achieves a satisfactory fit, and likewise varying the 2nd and 3rd terms. The value of the coefficients adopted is therefore arbitary, any relationship with the causal reality, if any, is accordingly to some degree is fortuitous.

5 In reality there is some degee of increasing resisistance with rising effort.

6 WRTE at 50 mph = ITEx-C = 0.9708ITE -545 Lb. Ref Figure 3

Comparative Farnboro' v Mechanical Cylinder Indication

Early in 1953 the Rugby Farnbro indicating gear was subject to two series of comparative tests.

January 1953: 70025. Rugby 'Farnbro' balanced pressure indicators v Maihak & Dobbie-McInnes mechanical indicators provided and operated by Swindon test staff

Four test runs of 45 to 80 minutes duration at 50 mph returned differences of up to 10% for both mechanical indicator types relative to the Farnbro Indicator. Subsequent calibration checks at Swindon reduced the Maihak discrepancies, uniformly, to a little over 2%, but the Dobbie was still as high as 7% falling as an inverse function of effort to within 1% at the highest steam rate. The Rugby and the corrected mechanical results on an index basis are tabled below.

Table 3 BR7 - MEP% of RH Cylinder at 50 MPH

Run No.	Steamrate Lbs/hr	Farnboro'	Maihak		Dobbie McInnes	
			Initial Test	Recalibrated	Initial Test	Recalibrated
872	13900	100	104.9	102.29	110.4	107.20
871	17800	100	108.0	102.30	107.5	104.36
874	19800	100	109.8	102.30	106.5	103.39
873	23310	100	109.2	102.31	103.7	100.68

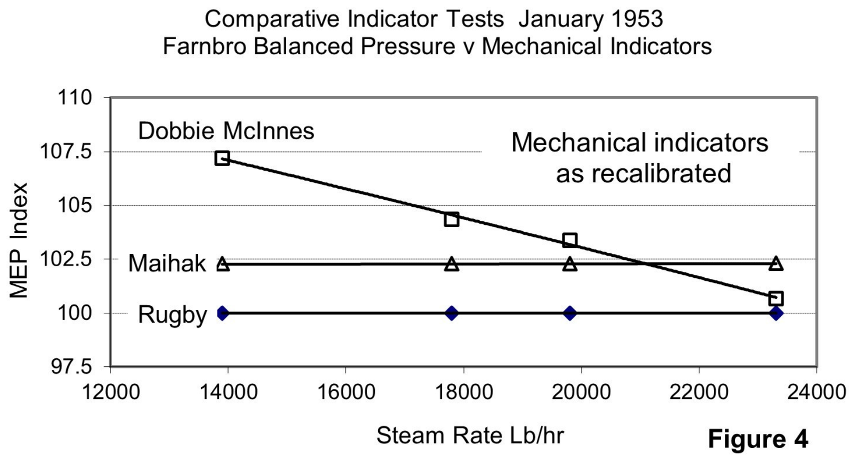


Figure 4

February 1953: 70025, Rugby v Derby 'Farnbro' Balanced Pressure Indicators

Simultaneous tests were carried out at Rugby test on the RH cylinder of 70025. The Derby indicator was piston operated, Rugby diaphragm operated. Both functioned on the "balanced pressure" principle.

The results were mixed, the Derby indicator returning greater discrepancies compared to Rugby at the back end, and widely adrift at both ends on test run 891. The test runs averaged 5 or 6 MEP readings at 5 minute intervals.

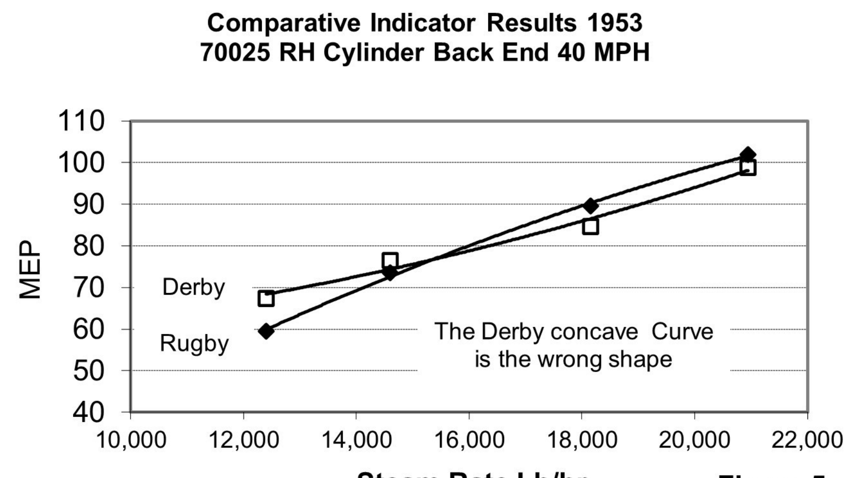


Figure 5

As plotted the Derby variance with Rugby was up to +13% - 3.4%. Full data sets are available for Rugby tests 872 to 882 immediately preceding these tests. Each test involved averaging up to 10 indicator diagrams. Maximum scatter was +/- 2.9%, averaging +/- 1.5%. Speeds covered 30, 50 and 70 mph.

Ron Pocklington took over operation of the Farnboro indicator at Rugby in 1952. He expressed concern on the accurate attainment of top dead centre. Any +ve or-ve shifts from same would either increase or diminish recorded MEP. "Snow storms" of scattered plots. Mechanical and electrical performance and durability was also problematical.

Comparative Rugby & Derby Farnbro Indicator Tests - 92050 Series 2 1957

These tests, which followed further refinements in the design of both the Rugby and Derby indicators were a notable improvement. The differences between the two indicators were no more than routinely obtained with the Rugby indicator when taking a sequence of readings under constant conditions. Data as Report L116 Figure 4

Table 4 92050 Series 2 Comparative Indicator Tests 1957

Steam Rate	IHP - Test Values					
	15 MPH		30 MPH		50 MPH	
	Rugby	Derby	Rugby	Derby	Rugby	Derby
11900	695					
12,300			785	795		
13,100	760	758				
14,900			1000	995		
15,500			1045	1053	1021	1003
16,150	964	950				
17,400					1203	1165
18,500			1290	1260		
18,900	1115	1080				
19,100			1310	1292		
19,500					1373	1402
19,750	1138	1133				
21,400					1510	1512
22,400	1254	1265	1520			
23,400			1556	1568	1633	1647

Table 5 Comparative Indicator tests IHP Indices 1957

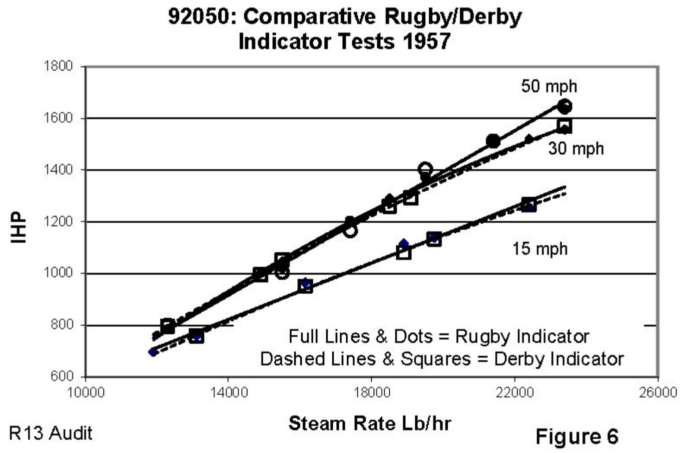
Steam Rate	IHP - Rugby-Derby Mean Value Indices					
	15 MPH		30 MPH		50 MPH	
	Rugby	Derby	Rugby	Derby	Rugby	Derby
12,300			100.6	99.4		
13,100	99.9	100.1				
14,900			99.8	100.3		
15,500			100.4	99.6	99.1	100.9
16,150	99.3	100.7				
17,400					98.4	101.6
18,500			98.8	101.2		
18,900	98.4	101.6				
19,100			99.3	100.7		
19,500					101.1	99.0
19,750	99.8	100.2				
21,400					100.1	99.9
22,400	100.4	99.6				
23,400			100.4	99.6	100.4	99.6
Averages	99.6	100.5	99.9	100.1	99.8	100.2
Averages	Rugby		99.75	Derby		100.26

Table 6 Test Series 1 & 2 IHP & WRHP Comparison - 50 mph

Steam Rate	IHP Willans 50 mph			WRHP Willans 50 mph		
	16,000	20,000	24,000	16,000	20,000	24,000
Series 1	1,170	1,500	1,770	1,090	1,415	1,680
Series 2	1,100	1,415	1,670	1,010	1,315	1,562
S2 Δ HP	-70	-85	-100	-80	-100	-118
S2 Δ HP %	-6.0%	-5.7%	-5.6%	-7.3%	-7.1%	-7.0%

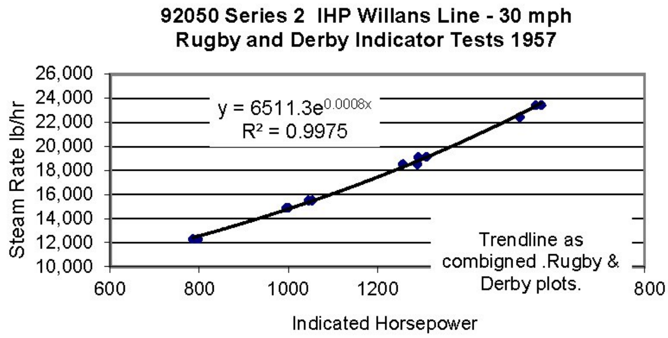
The Series 1 tests 1955, and the Series 2 1957 tests post dated the final improvementsto the Farnbro Indicator early in 1955.

The 92050 Series 2 tests at Rugby in 1957 returned reduced IHP and WRHP outcomes relative to the 1955 Series 1 tests. The Series 2 tests recorded higher exhaust steam temperatures for given steam rates at 30 and 50 mph. (Comparative data at other speeds unavailable). Such an outcome is symptomatic of steam leakage, The Series 2 tests also showed an increased specific steam consumption. 92050 was in traffic for 18 months between the test series and will have clocked up around 35,000 miles in the interim. The BR Standards with the 3 bar crosshead slidebar assembly were notorious for high piston valve ring and piston ring wear.



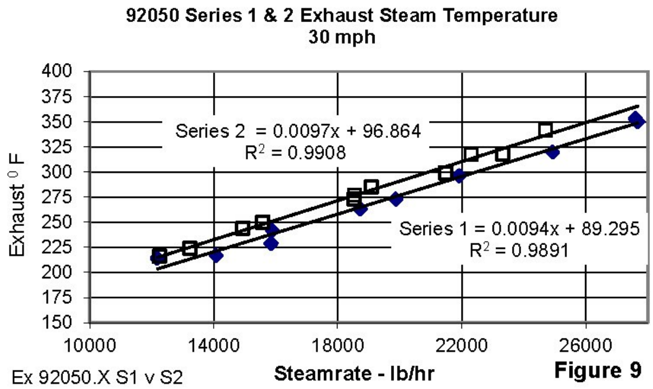
R13 Audit

Figure 6



R13 Audit 5

Figure 8



Ex 92050.X S1 v S2

Figure 9

Summary
That the comparative tests of the Rugby and Derby Farnbro indicators in 1957 returned average values within +/- 0.5% of the simultaneous mean values is a credit to the years of determined development work. The Rugby indicating equipment did not significantly change after early 1955.

R13 46225 DBHP Plot LR

Crosscheck One: Drawbar Horsepower Derived Locomotive Resistance

A method of approximating LR is from the zero root point of DBHP Vs Steamrate linear trendlines at given speeds, the root point (negative value) being representative of LR. See Figure 7 below . The proximity of these results to the R13 LR curve is striking - See Figures 8 & 9 below. The underlying theoretical point is that no horsepower appears at the drawbar until the locomotive resistance has been overcome. The linear projections represent the tangential mean of the recorded data. This example is atypically accurate suggesting that the R13 LR formula is likewise. Having explored this method extensively, the outcomes are very sensitive to the steam rate range selected to find a tenable data set. There is some scope for geometric mean solutions, in the case of the R13 data, this proved unnecessary, no weeding required. Theoretically, the perfect outcome from this process delivers the tangental mean LR. Under most circumstances outcomes will not be quite so focussed.

Table 7 46225 DBHP Vs Steam Rate - Report R13 L109 Supplement Ref Drg.							
Steam Rate	20 mph	30 mph	40 mph	50 mph	60 mph	70 mph	80 mph
16,000	827	839	791	690			
18,000	965	980	940	850	730		
20,000	1,080	1,120	1,090	1015	900	750	
22,000	1,200	1,260	1,250	1170	1060	925	765
24,000	1,320	1,390	1,380	1320	1220	1085	925
26,000	1,430	1,510	1,525	1485	1390	1255	1090
28,000	1,515	1,630	1,660	1630	1540	1410	1245
30,000		1,740	1,785	1780	1700	1570	1400
32,000		1,840	1,910	1900	1830	1705	1540
34,000			2,010	2010	1940	1830	1680
36,000			2,110	2120	2060	1960	1810
38,000			2,195	2195	2150	2060	1920
40,000				2260	2220	2140	2010

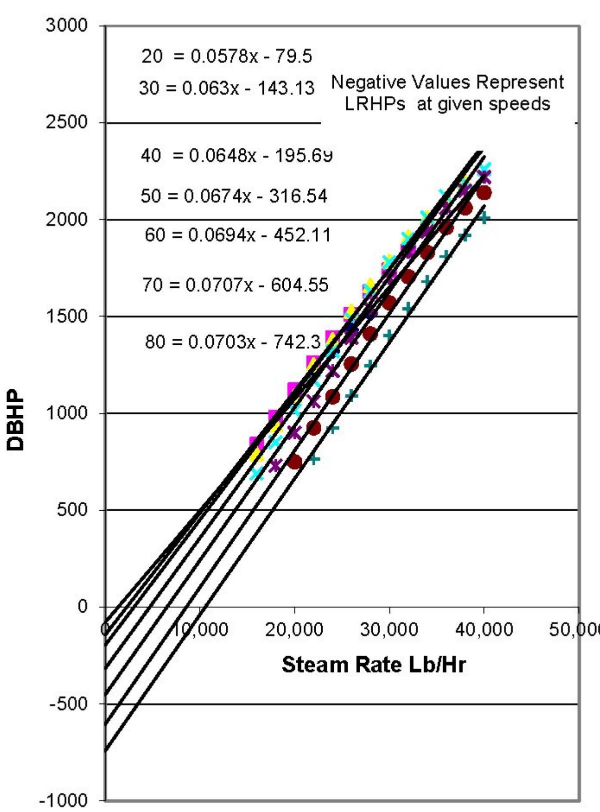


Figure 7

Table 8 R13 Vs DBHP LR Plot L109 Supplement						Smoothed DBHP
MPH	DBHPLR HP	DBHPLR Lb	R13 LR Lb	R13 LR HP		LR HP
20	80	1491	1476	79		78
30	143	1788	1691	135		138
40	196	1838	1959	209		217
50	317	2374	2281	304		316
60	452	2825	2657	425		438
70	605	3238	3086	576		585
80	742	3478	3569	761		761

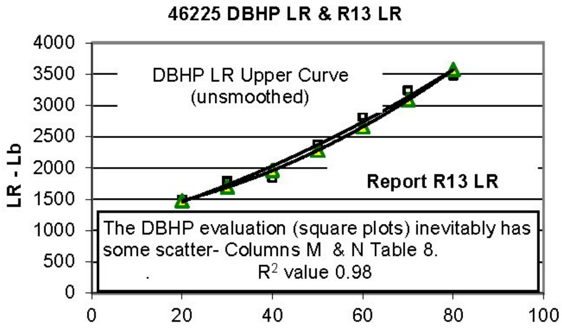


Figure 8

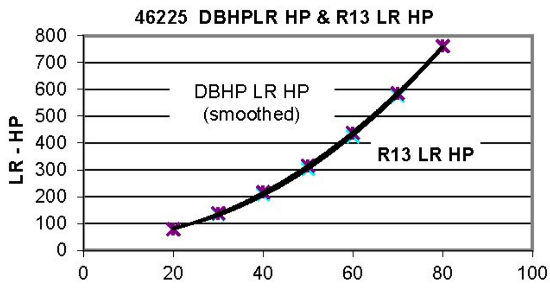


Figure 10

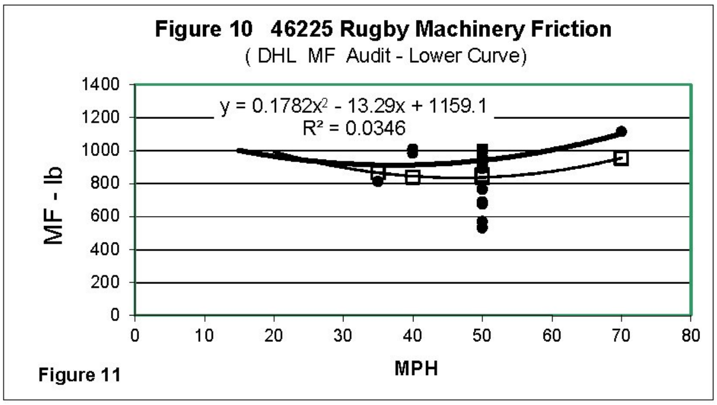
The smoothed Figure10 DBHP LR determination trend line and the R13 Fig.18 trend line are virtually indistnguishable.
The smoothed DBHP LR determinations (Table 8 & Figue 10) and the R13 Fig.18 values are within -2%/+3%

This method was inspired by reading Stanley Hooker's, autobiography "Not Much Of An Engineer"

Hooker was an engineer at Rolls Royce, initially specialising in superchargers. This backwards projection was used to determine the frictional losses in aero engines.

DBHP LR Crosscheck Two

Machinery friction data (MF) for 46225 is available from the Rugby tests. These values (along with same for other locos) can be tested by two methods; Firstly by a theoretical estimate of MF, and secondly by the 'stripping out exercise described below under "Crosscheck Three".



Rugb MF data for 46225 very limited at speeds other than 50 mph, Unbalanced outliers discarded at 35 mph (1), 60 (1), 65 (2).

DHL Audit Estimation

This exercise was carried out to ascertain the likely order of magnitude of locomotive Machinery Friction (MF). In other words was MF measured in hundreds or thousands of pounds?

The procedure was the summation of 'elemental approximations' MF compnents having been broken down into 9 theoretical modules. This exercise made no reference to Rugby MF data, but returned values of similar values generally in the order of hundreds of pounds. In other words, on a theoretical basis, the Rugby MF data appeared to be of plausible magnitude. Audits for 10 locomotive types were generally consistent with the Rugby data, forming a logical overall pattern. The audit correlation was not proof, or claim to great accuracy, but suggests that the Rugby MF data was within the bounds of probability. The audit MF modules erred on the pessimistic, or so I thought. Carling thought the dyanamometer was within the +/- 2% guarantee.

Crosscheck Three

It is possible to "strip out from the R13 LR curve estimated values for uncoupled vehicle resistance components, colletively (VRU): Carrying wheel losses including tender, track & ride losses (2nd term) and aerodynamic drag, plus an augment for the 2nd term adhesion weight losss peculiar to runing on track rather than rollers. At given speeds VRU is theoretically a constant independent of effort. An acid test,

Table 9	Duchess - VRUe Carrying Wheel Friction Audit - Loco & Tender 94.8 Tons									
Carrying Axles	No	D"	Journal d x L"	Axle Load tons	Journal lbs/sq.in	Ma	Cf	R lbs/ton	R Total lbs	Davis Formula
Bogie	2	36	6.5 x 10.5	10.75	176	5.54	0.014	5.7	122	96
Truck	1	45	7.5 x 11.875	16.8	211	6.1	0.0125	4.6	77	57
Tender	3	51	7.5 x 10.625	18.8	264	6.8	0.01	3.3	186	180
	Carrying Wheel Total			94.7			R Total Lbs		385	333
	Average Axle load			15.8			Mean Lbs/ton		4.08	3.52
							Average Lb/ton		3.8	

Table10 (R13Mod 3 LR = 7.5 + V/18 + V^2/630 Lb/ton), VRUe, & Estimated MF								46225 Rugby MF Fig.10	Machinery Friction HP Figure 11			
MPH	R13 LR Lb	Fixed VRUe Lb. Φ	V/18 LR (2/3ds) Ψ	Aero VRU #	R13 MF Lb Ω	DHL MF Audit Lb	DHL v Rugby Δ MF HP		MPH	R13 Fig. 18 (Dots)	DHL Audit (Squares)	Rugby (Triangles)
20	1490	360	120	117	893	1021	-4	964	20	48	54	
30	1710	360	180	238	932	896	1	920	30	75	72	74
40	1970	360	240	402	968	839	6	912	40	103	89	
50	2290	360	300	608	1022	836	11	940	50	136	111	125
60	2660	360	360	857	1084	878	13	1003	60	173	140	
70	3090	360	419	1148	1163	954	11	1101	70	217	178	206
80	3560	360	479	1482	1239	1100	1	1235	80	264	235	

\# 101.5 sq.ft, Cd 0.76, 3.5 mph HW as average wind record for test series.

Φ Carrying axles 3.8 Lb/ton as Table 8 average. (Notional LR VRU constant)

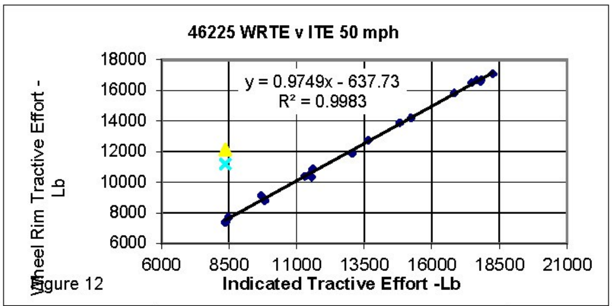
Δ MF (Col.I) is R13 MF HP(Col.G) - Rugby MF HP (Col.J)

Ψ V/18: AW Ride losses appear largely absent on the test plant: 2/3rds assumed. WRHP data for the Duchess, BR5 and 9F is consistent on this point.

Ω R13 MF = R13 LR - VRU (LR - (Φ + Ψ + #)

The Rugby MF data for 46225 appears generally compatible with the loco-motive resistance formula given in report R13. It would be unrealistic to expect the theoretical MF values as "stripped out" from the R13 curve in Table 9 to exactly fit the Rugby MF trend line given the inevitable experimental errors involved. Differences of potentially +/- 10 HP are probably uaavoidable.

Rugby 46225 MF test runs wrte substantialy concentrated at 50 mph.



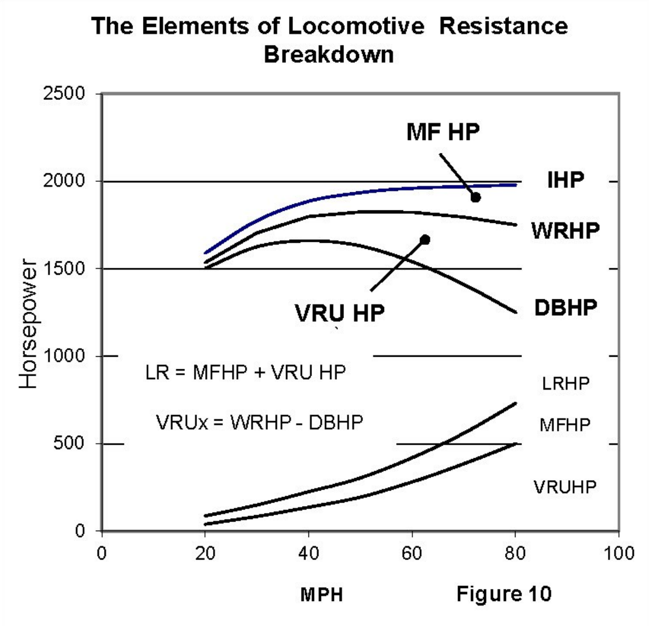
46225 MF 50 mph, 24000 lb/hr			
IHP	ITE	WRTE	MF lb
1620	12150	11207	943

Crosscheck Four: VRUx Verification of the Rugby Test Station WRHP Data

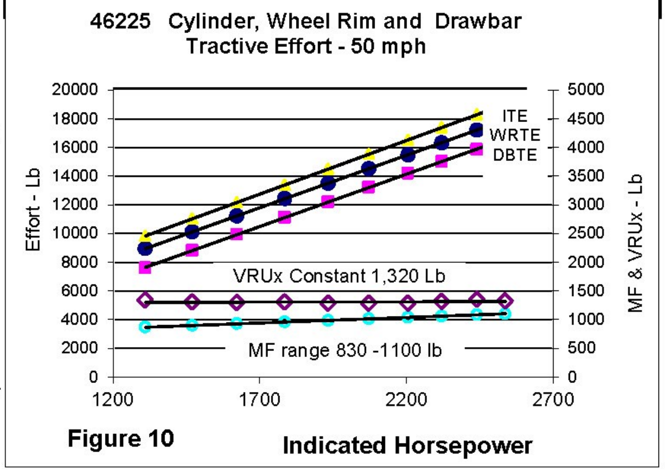
A Theoretical Litmus Test

The uncoupled vehicle resistance component of locomotive resistance, VRU, can be determined by deducting the drawbar horsepower (DBHP) as derived from road tests, from the wheelrim horsepower (WRHP) as recorded on the test plant. The plausibility of this result, defined here as VRUx, can be verified as to general sensibility by comparison with estimated values of VRU (VRUe) based on a body of empirical evidence in regard to the available experimental data and established technical data.

VRU as defined here excludes all locomotive machinary losses (LR) attributable to the coupled wheel power transmission frictional losses (MF). The estimated components of VRUe are the outcome of diverse forces and are also iprone to variables, such as changes in wind conditions and track condition/ride losses which affect VRU, and indicated tractive effort (ITE) which affects MF. The VRUe values calculated therefore represent the difference betwween test plant WETE and DBTE.. Where wind conditions pertaining for the road tests are known, as in the case here exampled, the 'band of possibility' can be narrowed down to some extent.



A characteristic power breakdown showing notional values



Vehicle Uncoupled Resistance - VRU

This comprises 3 elements:.

1 The rolling resistance of the locomotive and tender carrying wheels. This element is absent for locomotives without carrying wheels such as 0-6-0T or 0-6-0Ts..

2 Vehicle resistance is usually in the form: $R = A + V/B + V^2/C$ Lb/ton, where the 1st term A represents rolling resistance as 1 above, and is assumed, as a convenience, to be a fixed value independent of speed. The 2nd term is attributed to the ride losses resulting from the behaviour of the vehicle on and its interaction with the track. This term is usually derived as the remainder after the rolling resistance and aerodynamic drag (3rd term), has been deducted from the total resistance as established by experiment.

The extent to which the 2nd term losses are fully replicated at the coupled wheels when working on the test plant rollers is uncertain. It is probable that the losses will be reduced. The absence of percussive rail joint losses on the rollers is estimated to save about V/80 pounds per ton AW. Since the rollers are mounted on more solid foundations than track, further coupled wheel reductions are probable given the behaviour on the more flexible permanent way and track bed. In estimating VRUe; 1/2 to 2/3ds of adhesion weight (AW) 2nd term losses is the assumed range for VRUe assesment..

3 The 3rd term, an intrinsically squared function, is ascribed to aerodynamic drag in regard to rolling stock. Where locomotive resistance as determined by experiment is concerned, the 3rd term will also include an element attributable to the dynamic losses of the motion and windage, which will occur as part of the power transmission losses (MF), and not as part of the uncoupled vehicle resistance losses, VRU, as considered here.

Aerodynamic drag is problematical since it is a variable subject to the moods of wind, which can have a significant impact. Although aerodynamic drag can be sensibly estimated for an assumed set of conditions in regard to wind speed and direction, it will always remain an estimate. Wind conditions tend to vary by the hour if not the minute, and are constantly affected by the shifting local topography. Some of the Swindon derived test bulletins declared wind conditions: $7^1/_2$ mph, 45^0 headwind, and later 10 mph, but such information was absent from Rugby/Derby derived test bulletins and reports..the 46225 tests average $3^1/_2$ mph.

VRU is a Constant

If the DBHP test data is accurate VRU at given speeds will be a constant irrespective of effort... This should obtain whether it is VRUx as determined from deducting DBHP from the experimental WRHP, or estimated VRUe to crosscheck VRUx where available. Accurate WRHP data theoretically returns constant VRUx values at a given speed across the working range as exampled in Figure 10,

Notes on Chart

The constant VRUx values indicated (scatter +46/-20lb) satisfies the theoretical constancy litmus test within modest bounds of experimental error. Adequate IHP - WRHP test data is not available for 46225 at other than 50 mph. The LR (Figure 18) in Report R13 at 50 mph is 14.4 lb/ton, 2,330 lb in total, this equates to a steam rate of 24,000 lb/hr. The estimated VRUe outcome at 50 mph was close at 1,380 lb to the actual 1.320 lb. At 60 lb the difference is 8 HP.

GWR 1947 King LR Formula[1]

A Surprising Find

Swindon derived locomotive resistance data emerging from test bulletins and other sources in the 1950s delivered diverse outcomes in regard to magnitude and general trend. This was most evident at the lower end of the speed range, where specific resistances in lb/ton sometimes varied by over 100% for locomotives of similar size and weight. In particular, the tests with King 6001 in 1953 returned improbably high sensitivity to effort, increasing by 50% over the working range at 20 mph and 25% at 80 mph, LR at 30,000 lb/hr, 80 mph was over 1000HP. This sensitivity was wildly astray from the Duchess MF sensitivy to effort of 3% as determined at Rugby. The 1947 formula examined below tells a different story

The "1947" King Locomotive Resistance Formula

R = 9 + 0.034V + 0.0023 V^2 Lb/ton, *Castles & Kings at Work* - Michael Rutherford, Ian Allan. 1982

This formula quoted by Rutherford[1.] returns a similar order of magnitude to the Duchess R13 LR curve.
The King's higher LR at the top of the speed range will to some extent be attriutable to the indicator shelter fitted for the the road tests.
The King's DBHP derirved LR curve closely follows the 1947 formula.

Table 11 Locomotive Resistance HP - King & Duchess

MPH	Swindon 1947 King LR Curve	6001 Null Point DBHP LR #	Duchess R13 LR HP	Estimated Shelter HP penalty
20	77	71	79	
30	132	127	138	4
40	205	216	215	9
50	301	310	309	17
60	424	468	428	29
70	579	592	577	46
80	773	736	756	69

As derived from Ell's 1953 I.Loc.E paper, "Developments in Locomotive testing" 6001 carried an indicator shelter, this measurably increases aerodynamic drag at the top of the speed range. The origins of the test data supporting the 1947 formula are unknown.

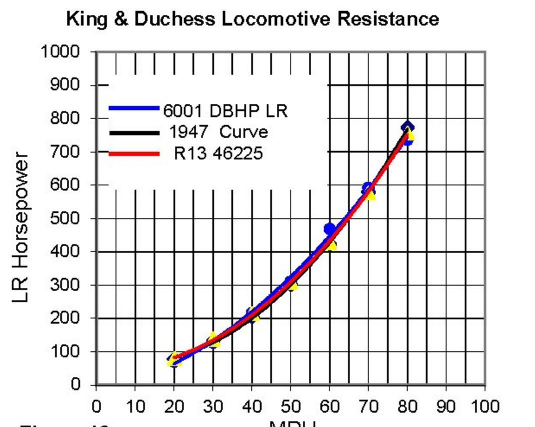


Figure 13

The King 1947 curve and 1953 6001 DBHP derived LR curve # form a close fit. Likewise the Duchess. (# File "DBHP LR)

General Note

The King formula is possibly based on tests with 6005 in 1931, when an indicator shelter was fitted. The heavier weight of the Duchess (24 tons) attributable to increased bogie, trailing and tender wheel axle loadings will increase the uncoupled vehicle resistance (VRU losses) by around 100 lb. Against this the Duchess will have around 4-5% reduced machinery friction on account of the greater mechanical advantage of the larger coupled wheels. The adhesion weights are similar. The Duchess drag coefficent will also be lower on account of its cleaner lines, vee fronted cab and higher tender..

This is apparent in Figue 13 up to about 50 mph, beyond which the drag penalty of an indicator shelter increasingly kicks in. The basic architecture of the King and Duchess with four cylinders and derived motion is similar. The King machinary friction will be around 5 or 6% higher on account of the smaller coupled wheels and inside eccentrics valve gear. Note Figure 14 DBHPLR.

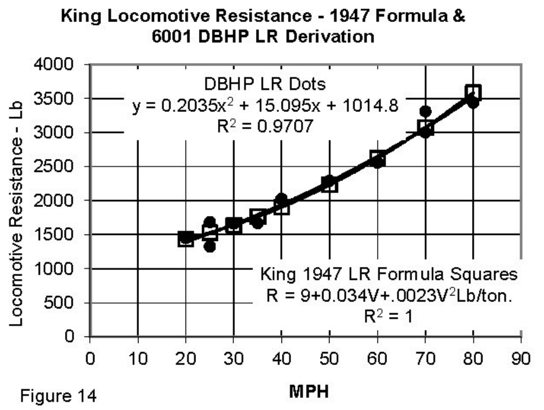


Figure 14

Refs

1 Castles & Kings At Work - Michael Rutherford, Ian Allan 1982

2 Railway Wind Tunnel Work - D W Peacock, I.Loc.E Paper 505, 1951

THIS NEWSLETTER IS WRITTEN BY YOU!

The content of the Newsletter entirely consists of articles and features submitted by you, the Membership. In the past, the Newsletter has been 70+ pages long, with a variety of interesting articles. The current stock of articles for the next issue is ZERO!

I send out reminders a month or so before the copy deadline, in the hope of soliciting more material, but I am aware that the time needed to write articles etc. is often longer than this. This means I am very worried about the content (or lack of it!) for the next Newsletter!

If you have it in mind to write something for the rest of the membership, PLEASE, PLEASE, PLEASE do so now! It can be short or long, technical or non-technical, but without material coming in, there will be no Newsletter going out…

Many Thanks in Advance for your support and assistance!

Iain (the Editor)