The LONDON MIDLAND and SCOTTISH RAILWAY

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RAILWAY BRAKES

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Much has been said about locomotives, rolling stock and signals etc, but not much about brakes. All the signals in the world are useless if the train cannot be quickly brought from high speed to rest at their command in the distances allowed. This booklet considers the evolution of railway brakes from their inception to the automatic vacuum brake adopted by the LMS.

Railway brakes and their evolution.

Contents.

Acknowledgments.
John Sadler.
Railway Year Books for1922, 1928 & 1966/7.
Safe Railway Working, C. E. Stretton.
Continuous Railway Brakes, M. Reynolds.
The Lancashire & Yorkshire Railway Vol.3, J. Marshall.
The National Archive, Kew.
R. J. Essery – LMS Society.

Chapter 1 - A Review

In 1833 Stephenson introduced a brake where steam acted on a piston and the retarding force was applied to the brake blocks through rods and levers. In 1832 he had already fitted a continuous brake acting through the medium of the buffing rods for the Liverpool and Manchester Railway. When the handbrake was applied the buffer spindles on the vehicles were pressed in, and through suitable gearing, applied the brake blocks to the wheels. Clearly this proved impractical when it became necessary to propel the train and so was quickly abandoned.

In 1839 the Nasmyth brake together with the Rollins Guerin brake was tried, but both worked on a similar principle. During 1844 Nasmyth and May introduced the first pneumatic brake, and in 1848 S. C. Lister (later Lord Masham) patented an air brake having an axle driven compressor that was, in principle, similar to the "straight air" brake of twenty-five years later. The apparatus consisted of an air chamber fixed below the framing of the carriage and containing a piston, by the rod of which the power was applied to the brake blocks by suitable gear. The air was forced into the chamber by pumps worked off a carriage axle. When an application of the brake was required, the guard opened the valves admitting the atmosphere to the pumps, a few strokes of which raised the air pressure within the receiver sufficiently to move the piston in the brake cylinder, so pressing the brake blocks against the wheels. A similar effect was produced utilizing the pumps to act as air exhausters instead of compressors, hence both a compressed air and a vacuum brake was contained in the Lister patent.

In 1849 Gooch introduced a sledge or skid brake fitted between the coupled wheels of a 4-4-0 tank engine. In application the skid was pressed against the rails to obtain a retarding effect, but the apparatus was abandoned due to the action tending to lift the rear end of the engine off the rails.

During this period, and in a few cases up to the first few years of the twentieth century, the only brake on the locomotive was the handbrake on the tender. Early locomotive engineers had a great aversion to the braking of coupled wheels, and for some time the trailing coupled wheels of the engine were the only coupled wheels with brakes. Eventually it was only the coupled wheels on the engine that were fitted with brakes, the tender handbrake being retained.

In 1852 James Newall patented a system of continuous brakes on the East Lancashire Railway consisting of a 2" diameter shaft running along the coach tops with arrangements for rotating it by the driver or guard. The shafts on the coaches were connected by the use of universal joints and square section shafts sliding in square tubes. The shafts were connected by a rack and pinion arrangement working against a spring to the brakes on each carriage.

The year of 1856 saw Charles Fay patent a screw brake system used on the LYR consisting of a shaft beneath each coach that operated the brakes by means of a wheel rotated by the guard with the connections being similar to Newall's brake.

Around 1858 McConnel applied a steam brake to the engine wheels, and at the same time the Fay & Newall brake made an appearance. The latter consisted of a square shaft connected by a universal joint between the coaches. The guard turned the shaft by means of a wheel in his van to put on the brakes, but the driver had no control over it, and trains so fitted usually had a second van and a guard when the train consisted of more than four coaches.

The Chain brake, one type of which was invented by Clark and Wilkins, was utilised from 1859 until the late 1880s. This was one of the more successful of the early attempts at providing a continuous brake. On each vehicle two brakes were hung in the usual manner, the brake being supported by a chain carried on sheaves along the centre of the train, united by coupling hooks at the end of each carriage. In the centre of each carriage the chain hung like a festoon and passed under two pulleys attached to pulling-rods fitted to the brake hangers. When the chain was tightened, the centre pulleys were raised and the blocks pulled on to the wheels with a force of three tons on each vehicle. When the chains were slackened the pulleys, that were assisted by a back weight, descended by gravity to their normal position thus releasing the brakes. The chain was tightened from either end of the train by means of two transverse axles driven by steel-faced friction-wheels twenty inches in diameter and screwed by manual power against the brake-van wheels. The momentum of the van was thus made to retard the whole train. To enable the enginemen to control the brake a cord was fixed on the footplate by means of which it could be applied to the front portion of the train, but the great drawback of the apparatus was, that until an automatic brake form was introduced in 1869 the whole mechanism was put out of action by the breaking of the chain. The Clark chain-brake was used on the Caledonian Railway until c.1888, and the LNWR used a form of chain brake for 15 years. The Midland Railway gave this form of brake a trial and considered it to be unsatisfactory.

In 1862 John McInnes invented a compressed air braking system used on the Caledonian railway where he was an engine driver, later becoming a CR brake inspector.

Two or three types of hydraulic brake appeared in the early1870s, with the LNWR using a type that consisted of a nine-inch cylinder with piston, the power being obtained from the water in the engine boiler forcing up the brake piston. When the brake was “off”, steam from the boiler had access to the top of the brake piston, keeping it down, and the brake was applied by cutting off the steam on top of the piston by a three way cock, when the water from the boiler forced up the piston from below to apply the brake, and the steam above the piston at the same time escaped into the water tank.

The counter pressure braking system, the principle of which consisted of reversing the engine into back gear while it was running forward with the regulator partially or fully open, was first introduced by Holt on the South Stafford Railway c.1856. Counter pressure was used in France and Spain during 1865 and became standard on many continental railways. In this country both the LNWR and the Midland Railways experimented with counter-pressure braking during 1869/70, the former having about twenty engines and the latter three. The Midland then experimented with the then new Westinghouse non-automatic (straight–air) brake. The North Eastern Railway applied the “Bouch’s” steam retarder, another form of counter-pressure brake, to a number of engines in 1870.

Chapter 2 – The Newark Brake Trials.

Under the direction of the Royal Commission on Railway Accidents, brake trials were carried out in June 1875 with each train consisting of an engine and fifteen vehicles, with the following railways taking part:-

1. LNWR with Clark and Webb’s Chain brake.
2. The Great Northern Railway with Smith’s Vacuum brake.
3. The Midland with Westinghouse Automatic brake, Clarke’s Hydraulic and Barker’s Hydraulic brake.
4. Caledonian with Steel McInnes Air brake.
5. Lancashire and Yorkshire Railway with Fay’s Brake.

6. The London Brighton and South Coast Railway with the Westinghouse Vacuum Brake.
7. The North Eastern Railway with Smith's Vacuum brake on engine and tender.

The line selected was part of the Nottingham and Lincoln Branch of the Midland Railway extending from near Newark to Thurgaton, later known as the Racecourse. Captain Douglass Strutt Galton was in charge of the trials.

The table below shows the systems tried together with the results obtained when everything was done to stop the train by the application of all available brake power including the use of sand, and the reversing of those engines not provided with brake blocks.

Those marked with an asterisk* had brakes applied to the engine wheels whilst the remainder did not.

Railway Company	Name of Brake	Speed MPH	Distance to stop in feet	Retarding force in percentage
Midland	*Westinghouse Automatic	51.50	825	10.64
L&YR	*Fay & Newall	57.25	1,385	7.94
LNWR	Clark & Webb	47.50	964	7.79
Midland	*Barker Hydrau;lic	50.25	1,101	7.64
L&YR	Fay and L&Y engine	45.50	913	7.60
GNR	Smith Vacuum	45.00	905	7.47
Caledonian	Steel McInnes	49.50	1,120	7.33
LBSCR	*Westinghouse vacuum	52.00	1,533	5.88

The table lists the order of merit as shown by the percentage recorded in the last column. The percentage was worked out as follows – supposing a train was to be stopped from 50 mph, on level track in 835 feet. Using the formula 3.34 x 50 squared divided by 835 = 10, meaning that the average brake force was 10%, or 10 tons for every 100 tons of the total weight of the train.

The story has been told that George Westinghouse paid a visit to the vast empire of Crewe Works that was presided over by Francis William Webb, the object of which was to interest Webb in his air brake. It seems that Webb was so incensed by the American bombast and attitude of Westinghouse that he was ordered off the premises. It is interesting to contemplate what might have happened if things had been different and the LNWR had adopted the air brake, as being the "Premier" line it is extremely likely Webb's decision would surely have influenced other railways. In the event as seen above Webb stuck to his Clark and Webb chain brake and, with a newly overhauled set of stock, performed sufficiently well to achieve third place.

Newark was not the only venue for brake trials as others followed on the North British Railway in December 1876, North Eastern in May and June 1877, Belgian State Railways in 1876 & 1877, Germany in August 1877, North Eastern Railway in October 1878, Paris Lyons Railway in April 1879, North Eastern Railway in July 1879 and the L&YR in July 1880.

Chapter 3 – The Board of Trade Specification and other company trials.

In August 1877, the Board of trade issued a circular stating that the essentials of a continuous brake should be:-

1. The brakes to be efficient in stopping trains, instantaneous in action and capable of being applied within difficulty by the engine driver and guard.
2. In case of accident, to be instantaneously self-acting.
3. The brake to be put on and taken off with facility on the engine and every vehicle on the train.
4. The brakes to be regularly used in everyday working.
5. The material employed to be of a durable character, so as to be easily maintained and kept in order.

The requirements are so obviously necessary one would hardly think it needed spelling out. The circular also went on to point out the advantages of having uniform brakes on all lines as the railway companies had made no attempt to agree on the essential requirements of a good continuous brake. The fact that several railways worked together exchanging rolling stock between them on a daily basis did not seem to influence the situation with the result that dual fitted stock was necessary rendering a portion of the brake power useless when in another company's train, not to mention the unnecessary expenditure in providing two set of brakes.

In the year following, the Railway Returns Continuous Brake Bill became law, and railways had to make six-monthly returns regarding the use of continuous brakes, showing the amount of rolling stock fitted.

North Eastern Railway Brake Trials at York.

On 14th and 15th July, 1879 Captain Galton conducted experiments with a train of sixteen vehicles fitted with the Westinghouse Automatic brake with a total weight of 207 tons 19cwt., 91.5% on braked wheels. Captain Galton conducted these trials on behalf of the Institution of Mechanical Engineers and also those on the LYR at Gisburn

Brake applied by driver

Speed MPH	Gradient	Stop in Yards	Time in Seconds	Retardation in percentage	Distance in yards that would have been run had the speed been 50 mph
51	1 in 1200 down	207	14.75	14.0	198
48	Level	189	14.5	13.5	206
50.5	Level	225	16.5	12.6	220
Train "slipped" Brake applied automatically					
52.5	Level	223	16.75	13.7	203
55	Level	208	15.5	16.1	172
59.5	Level	290	19.0	13.5	206
50	Level	173	13.25	16.0	173
52	1 in 200 up	187	14.75	15.6	178
58		260	16.75	14.4	193
Brake applied from van against engine with full steam on.					
27	Level	68	9	11.0	252

The Westinghouse brake did well, conforming to the BOT brake criteria and remained standard on the NER.

Lancashire and Yorkshire Brake Trials at Gisburn.
Captain Galton conducted a further series of tests on the L&YR in July, 1880.

	Stops by driver		Stops from van		Slip stops & automatic action	
Brake	**Distance in feet**	**Retardation in percentage**	**Distance in feet**	**Retardation in percentage**	**Distance in feet**	**Retardation in percentage**
Westinghouse,GNR train	727	11.49	-	-	441	18.94
Westinghouse LYR train	716	11.66	895	9.33	668	12.50
Eames vacuum	752	11.16	914	9.14	754	11.08
Sanders' vacuum	891	9.37	1111	7.19	722	11.57
Fay - Newall	817	10.22	-	-	-	-

Once again the Westinghouse brake gave the best results.
An American, Lovatt Eames, patented a vacuum brake, bringing an engine over from the USA for demonstration purposes. The engine was assembled at Newton Heath on the LYR.

Some railways remained reluctant to fit continuous brakes to their stock as shown by the Board of Trade returns for 1881 :

Type of brake	Engines Fitted	Vehicles Fitted
Westinghouse Automatic	184	1431
Sanders-Bolitho's Automatic Vacuum	155	691
Smiths Automatic Vacuum	14	79
Clark & Webb's Chain.	Nil	320
Smith's Vacuum.	75	305
Fay & Newall.	Nil	41
Parker Smith's	Nil	3

These figures reveal that compressed air and vacuum brakes were just beginning to find favour and during the next decade all the railway systems in this country adopted one or other of these two types of continuous brakes.

The Railways (Continuous Brake) Act of 1882 presented by the Earl de la Warr, made every company from February 1st 1885, use or cause to be used on every passenger train running on a railway, a continuous brake. Following this there were two standard brakes in use the world over, both of which complied in every way to the requirements laid down.

Stretton's Report
On 28th October 1886 Clement E. Stretton wrote a report on the situation at that time following his analysis of the Railways Continuous Brake return for the first half of 1886. He pointed out that the railways had fitted a considerable amount of rolling stock with inefficient non-automatic brakes making no attempt to fulfil the conditions laid down by the BOT in defiance of the Government and produced the following table.

	Engines fitted with brakes	Engines fitted with apparatus for working the brakes	Carriages etc fitted with brakes	Carriages etc fitted with pipes or chains only
Total amount of stock returned as fitted with brakes which appear to comply with the conditions of the BOT	2604	1376	22230	4623
Total fitted with brakes that do not comply	2126	1435	13111	3274
Total fitted	6631		43238	
Not fitted with any continuous brake	849		8552	
Total Passenger rolling stock therefore	**7480**		**51790**	

These figures showed that out of a total of 7480 engines and 51790 carriages etc only 2604 engines and 22230 vehicles have brakes that even "appear" to fulfil the BOT conditions. He then went on to say that further examination of some of the brakes returned as efficient were not so in practice. The BOT apparently were aware of this as the return stated*, "These totals are the numbers of engines and carriages fitted with continuous brakes. It will be observed however, that some of the brakes so returned but very imperfectly fulfil that designation".*
When studied further the return was so full of incorrect statements that for all practical purposes it was absolutely useless.

The North London Railway reported that the Webb and Clark brake fulfils the necessary conditions whereas the LNWR made no such claim. The Midland and GWR return included a large amount of rolling stock as fulfilling the conditions that was fitted with the dangerous "Leak-off" or two minute vacuum brake that was not efficient as numerous accidents had been caused by it with BOT accident reports proving it. The Midland had fitted 175 passenger engines and tenders with an automatic steam brake working in conjunction with the vacuum brake on the train that, although it worked well in ordinary circumstances, it was useless in case of disaster, as the moment the engine and tender parted, the steam pipe was broken and the so called automatic steam brake failed to act.

He then went on to point out other areas in which the return was incorrect and misleading e. g.
The totals given included engines fitted with apparatus for working the brakes, and vehicles that only had through pipes and no brake blocks. Such rolling stock did not fulfil any condition, as there could be no brake power when an engine only has the apparatus for working brakes on carriages and no blocks on the engine wheels, particularly when the carriages only had through pipes with no brake blocks. To give an example of this an engine with no blocks on its wheels was placed on a train of eighteen vehicles, fourteen of which only had through pipes. Such a train would be on the BOT return as working a number of miles with a continuous brake, a situation almost as bad with regard to stopping power, as a train without such a brake. At this time fish trucks and horseboxes were only piped and frequently included in passenger trains.

The LNWR policy in removing the Clark and Webb chain brake and substituting the simple vacuum brake did not comply with the conditions laid down and was a waste of money, as it would have to be removed or modified to come into line with the requirements.

The Manchester and Sheffield Railway's return showed that it was continuing to use the same Smith's vacuum brake that led to the death of twenty-four persons and sixty two injured at Penistone in 1884. This was followed by a further accident at Penistone in 1885 when part of an express ran back colliding with a wagon standing in a siding with twenty-four passengers injured, an accident that would have been prevented by an automatic brake.

The BOT required brake failures to be placed into any one of three categories as follows:-

1. Failure or partial failure of the continuous brakes to act when required in case of an accident to a train, or a collision between trains being imminent.
2. Failure or partial failure of the continuous brakes to act under ordinary circumstances to stop a train when required.
3. Delay in the working of trains in consequence of, the brakes, distinguishing whether they arose from neglect or inexperience of servants, or failure of machinery or material.

The returns relating to brake failures were equally incorrect with a large number not being reported at all with others placed under the wrong headings and many not stating where the incident occurred thus rendering it impossible to trace a case. As an example the Metropolitan Railway gave twelve cases in which a train overran a platform at a station through failure of the Smith's vacuum brake. The GER and GSWR also omitted the names of the stations.
The LYR reported an actual failure to act on 25th February 1886 at Hindley as one of delay when it overran the station. This should have been recorded under category 2 and not 1.
The same Company also recorded ball-valves and vacuum apparatus being out of order as belonging to the Westinghouse brake. The Midland and Great Western of Ireland reported three failures of Smith's vacuum brake simply as delays under category 3 when train ran past stations six, five and eleven carriage lengths respectively under category 2.

During that period three collisions were reported as being caused by failures of continuous brakes.

1. The vacuum brakes on a GNR train became uncoupled resulting in a collision with the buffer stops at Kirkstead.
2. An LNWR train ran into the buffer stops at Sutton Coldfield owing to the breakage of a stalk on the ejector of the vacuum brake.
3. The coupling of an LNWR engine broke near Birmingham, with the result the carriages ran into the engine, as the vacuum brake had failed to stop them.

None of these accidents would have occurred with an automatic brake.

Chapter 4 - The Railway Regulation Act, 1889.

Without this Act it is considered that certain railway companies would never have attempted to settle the brake question until compelled to do so.
The Act was passed in consequence of two very serious and disastrous accidents.
On 16th September 1887 a collision occurred on the Manchester, Sheffield and Lincolnshire railway at Hexthorpe with twenty-five fatalities and ninety-four injured. The block system had been suspended with a curve and a bridge obscuring the driver's view until he was 359 yards from another train. With a continuous brake the train would have stopped but with Smith's simple inefficient vacuum brake, failed to do so.
The terrible Armagh accident on 12th June 1889 when the rear portion of a passenger train ran back down an incline straight into a following train. The Smith's vacuum brake being non-automatic, led to eighty deaths and 260 injured passengers.
These two accidents hastened the Government to pass Mr. F. A. Channing's Bill with the Act passed on 30th August 1889.

Following this the BOT, under the powers granted issued a circular to the companies drawing attention to the fact that the block system, the interlocking of signals and points and the automatic continuous brake, and other requirements necessary, and that "The BOT propose that the time limited for compliance with the orders should not exceed
For adoption of block working – one year.
For adoption of interlocking - eighteen months.
For adoption of continuous brakes – eighteen months.
The brake requirement called for brakes being capable of operation by engine-drivers and guards and being self acting. This left three systems able to conform – Automatic Vacuum,

Steel McInnes and the Westinghouse Automatic, but with the Steel McInnes fitted on only a few CR engines there were effectively only two systems.
The following non complying systems were Clark's Chain, Clark & Webb's Chain, Fay's, Newall's, Parker Smith's Smith's Vacuum, Vacuum Webb's and the Westinghouse Non-automatic.

The number of vehicles fitted and unfitted is shown in the table below for the half year ending 30th June 1890.

	Engines	Vehicles
Fitted with efficient brakes fulfilling the BOT Conditions.	4749	38237
Fitted with brakes that did not fulfil the conditions.	539	5912
Fitted only with apparatus for working or connecting brakes, or through pipes, rods or chains.	4746	7644
Not fitted with either continuous brakes, apparatus, pipes or chains	410	2263
Total Stock	**10444**	**54056**

The table shows that the brakes on 539 engines and 5912 carriages will have to be changed from non-automatic to either of the two automatic systems. Also 4746 engines and 7644 vehicles with only pipes required to be fitted with brake blocks and 410 engines and 2263 coaches required a braking system to be fitted.

At Carlisle on 4th March 1890, a collision occurred in consequence of a vacuum brake failing to act on an LNWR express train due to its being frozen with four deaths and injuries to fifteen others. The train overshot the platform and collided with a CR engine. The driver used all means available to him to stop the train and was exonerated from blame, but the railway was censured for using a brake of uncertain and unreliable character. Regulations had been drawn up to overcome the problem of the brake freezing but the severe winter showed that the Automatic Vacuum Brake required great care and even then could not be relied upon in winter time as, without warning the main vacuum pipe, especially between the engine and tender, could become blocked with ice.

There were therefore only two braking systems that were at this time likely to come into permanent use, namely the Westinghouse automatic air brake and the Vacuum Company's or Gresham's automatic vacuum brake, both of which represented the best of their types. The action of the Westinghouse, or pressure system is based on the use of compressed air, or pressure greater than 15lbs of the atmosphere, whereas the vacuum system is applied by the force of the atmosphere acting on one side of a piston, from the opposite side of which about 12lbs of the atmospheric pressure has been purposely drawn out or removed.

The Compressed Air Brake.
Following the Lister patent of 1848, the next trace of compressed air being used for braking purposes in this country (other than the Westinghouse system) was on the Caledonian railway, where the Steel McInnes type was in use from 1871, replaced a few years later by the Westinghouse brake, that had changed from a "straight-air" type to the automatic form in 1872, with the invention of the triple valve.

The Westinghouse Automatic Brake was used on the following lines that were absorbed into the LMS on 1st January 1923.
Caledonian Railway some stock fitted with both vacuum and air brakes, also worked the Arbroath & Forfar; Brechin & Edzell District; Cathcart District; Callender & Oban; Dundee & Newtyle; Killin; Lanarkshire and Ayrshire Railway; Solway Junction.
At the LMS Board meeting on 26th March 1925 minute 1120 dealing with the Scottish Local Committee minute 2065 agreed to the unification of brakes stating that ***150*** engines to be equipped with the Vacuum Brake *in 1925* at estimated cost of £10,581. In March 1926 the Scottish Local Committee called for a further 75 engines to be equipped with vacuum brake

ejectors and piping during 1926 and a further 35 engines during 1927 at a total cost of £6,565.
Stratford & Midland Junction; Mersey Railway; LT&S Railway (Absorbed by the Midland Railway in 1912). Board minute 3006 made at the meeting on 26th April 1934, authorized the conversion of 254 coaches and 72 locomotives to be converted to the Vacuum Brake on account of the Hudd experiments then taking place and to avoid the need to fit the 2-6-4T engines currently being built for the LTS section with dual brakes.

The following general note appeared in Traffic Committee Minute 5684 stated that 2598 coaching vehicles were fitted with dual brakes of which only 65 were necessary "for use on certain Branch lines and certain excursion sets". The Minute called for the removal of the Westinghouse Brake from the 2533 vehicles for which it was not required. The Traffic Committee Minute 6032 26th July 1939 later called for the removal of Westinghouse through pipes from 1711 vehicles so fitted.

The Vacuum Brake.
Nasmyth and May introduced the first vacuum brake in 1844, and a few years later the Lister patent could also be similarly worked. The Smith non-automatic vacuum brake was first patented in this country in 1874. The Smith brake was used until about 1890. Aspinall also fitted a non-automatic vacuum brake in 1878, and later converted this into an automatic type on the Great Southern Railway (Ireland). The non-automatic vacuum brake generally employed collapsing cylinders or a vacuum chamber that was like an inverted basin closed at it's mouth, with an elastic diaphragm that carried metal discs secured by an eyebolt to which a link worked attached to the brake lever. When an application of the brake was required the air was exhausted from the vacuum chamber and the action of the atmosphere on the diaphragm caused it to collapse and apply the brake. The non-automatic brake had no reserve of power. If the diaphragm was damaged or a hose became disconnected, the brake was rendered useless.

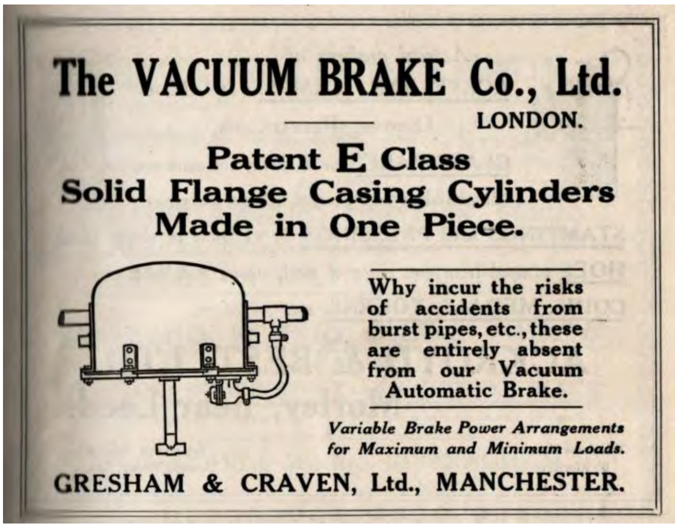
The automatic action of the vacuum brake was successfully accomplished by different systems of which the Eames, Hardy, Sanders & Bolitho and Smith types were the chief examples. The Sanders & Bolitho automatic brake was first used in 1877. The Smith non-automatic was improved by Hardy and made automatic. The outcome of these different systems became the standard automatic vacuum brake.

The Vacuum Automatic brake was utilized on the following lines that came into LMS ownership on 1st January 1923.
The ***LNWR*** (also worked the Birkenhead Railway with GWR; Charnwood Forest; Harbourne; Mold & Denbigh Junction: North & South Western Junction with Midland and NLR; Oldham, Ashton-under-Lyne & Guide Bridge with GCR; Shrewsbury and Hereford with GWR: Shropshire Union, partly with GWR; Tenbury with GWR; Vale of Towy with GWR; Victoria Station & Pimlico with GWR & SE&CR; West London with GWR also the ***LYR*** amalgamated in 1922.
Midland Railway (except LT&SR) also worked the Yorkshire Dales (Skipton to Grassington) and Northern Counties Committee and Belfast & County Down Railways in Ireland.
NSR also worked the Leek & Manifold; ***G&SWR*** some engines fitted with vacuum and air brakes***; HR*** some engines had vacuum & air bakes, also worked the Dornoch Light; Wick & Lybster Light Railway; ***S&DJR*** (joint with the Southern Railway until January 1930 when the LMS took responsibility for all locomotives); ***M&GN*** (Joint with the LNER)***; S&MJR*** (with some stock fitted with the Westinghouse brake)***; CLC*** (jointly with the LNER ex MR, GNR and GCR) also worked Southport & Cheshire Lines; ***NLR; Cleator & Workington Junction; Cockermouth Keswick & Penrith: Knott End: Maryport & Carlisle; Portpatrick & Wigtown*** (fitted with both Westinghouse and vacuum brakes dependent on which company was working the train) ***Tottenham & Forest Gate; Wirral Railway; Dundalk Newry & Greenore*** and many other subsidiary and joint companies

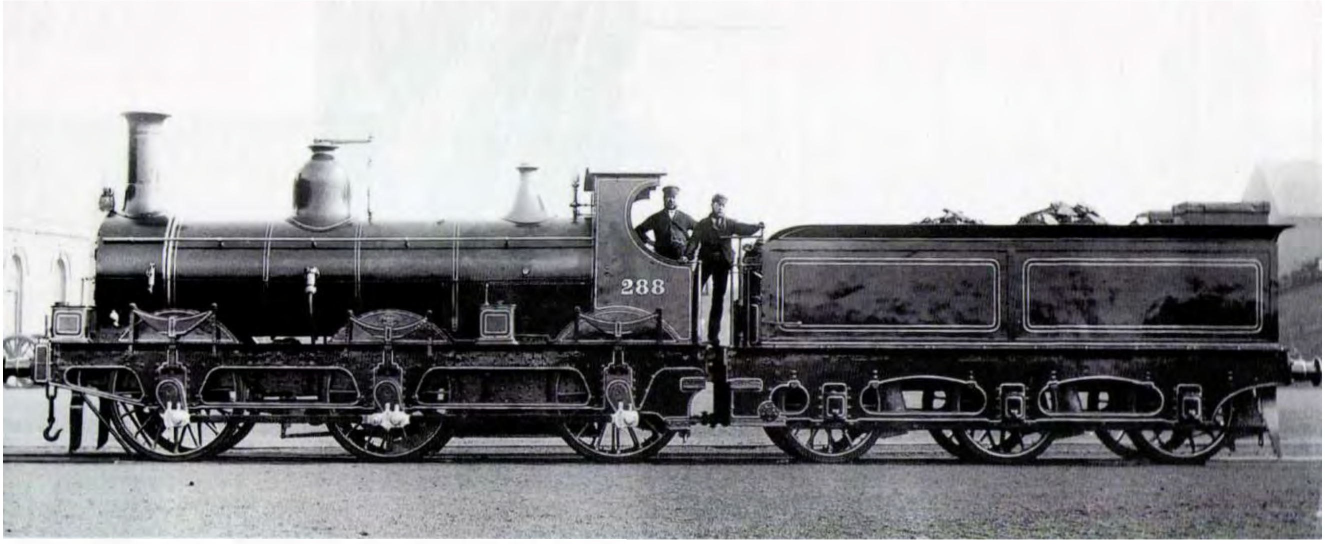
Dual Fitted Stock.
For working through trains from England to Scotland the LNWR and Caledonian Railways provided vehicles known as the West Coast Joint Stock. The Midland and North British Railways who's stock was known as Midland – North British Joint Stock and similarly there was the East Coast Joint Sock operating on the GNR, NBR and NER.

The Railway year Book for 1928 summarised the situation on the LMS stating that the Automatic Vacuum brake was standard throughout almost the whole of the Western and Midland Divisions except the LT&SR section that used the Westinghouse air brake, strangely there was no mention of the Northern (Scottish) Division

Clearly it would have been ideal had one type of brake been standardized on by the railways of Great Britain, but this was not to be until well into the Nationalized period when the 1966/7 Railway year book stated that all new British Railway's rolling stock will be fitted with air brakes.

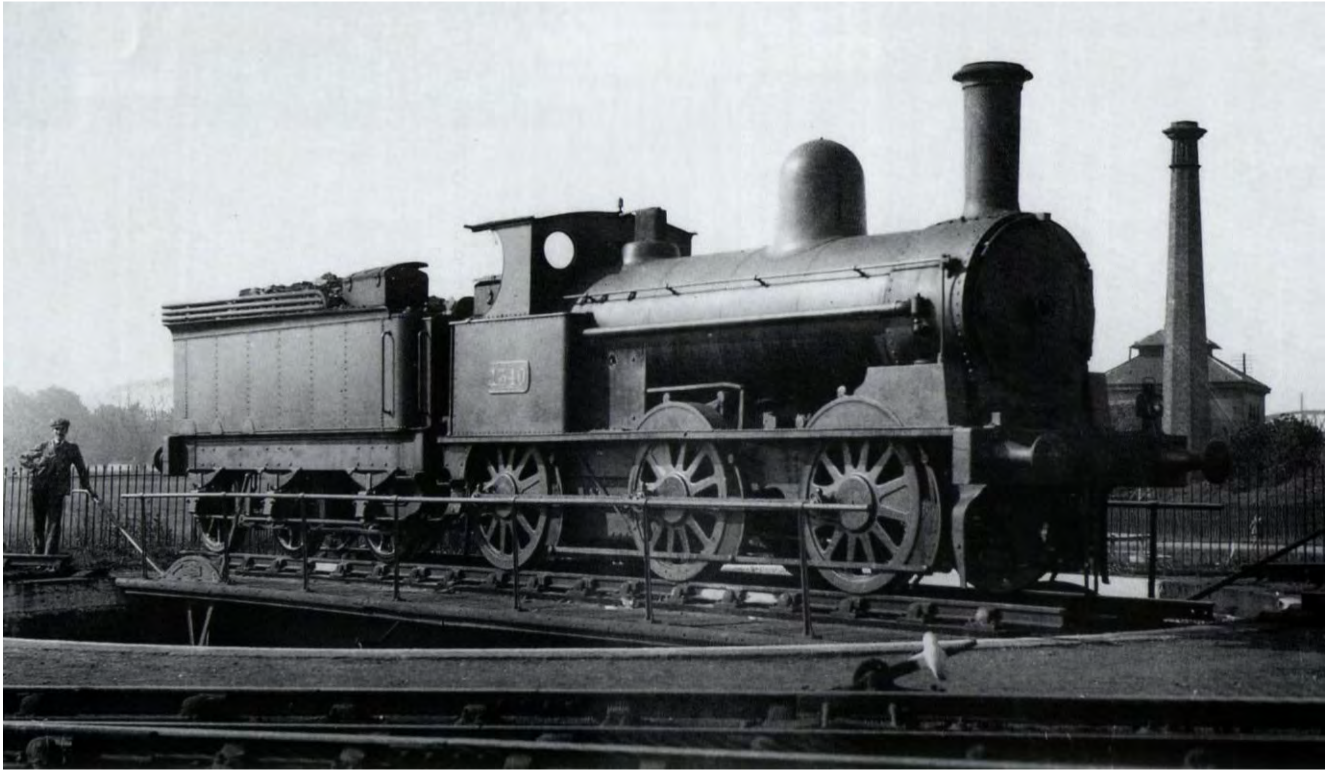


The Pictures and captions below were kindly supplied by fellow LMS Society member R. J. Essery.



Graham Warburton asked me if I could add some pictures with captions to 'round off' his article, and on reflection I felt that maybe a couple of early views supplemented with examples of LMS standard practice would be suitable. We begin with a picture that illustrates how things were during the early years of the Victorian steam railway, brakes on the tender but none on the locomotive. One can only admire the skill of the enginemen who worked fast trains over undulating gradients with such a primitive braking system. This picture shows No. 288, a Midland Railway double-frame goods engine, with no brakes on the locomotive wheels but a large wooden brake block behind each wheel of the tender. The brakes were applied by the fireman turning the brake handle; his left hand is seen resting on the vertical section of the handle and no doubt his strength was a major factor in making sure the maximum brake power was applied. The locomotive was built by Stephenson in September 1853 and rebuilt as seen in December 1876, being withdrawn in November 1898.
COLLECTION R. J. ESSERY

Whilst wooden brake blocks ceased to be used on the Midland, they remained in use on at least one LMS constituent company's locomotive stock until after the Grouping. To illustrate this point, I have included this picture of LNWR No. 1340, which became LMS 8285. My records show the LMS stock number was applied during January 1927, and this portrait was taken on the engine turntable at Peterborough LNWR shed on 7th May 1927. What we do not know is if the wooden brake blocks were replaced before the engine was withdrawn in 1932. A. W. CROUGHTON



Some of the early LMS-built locomotives entered service with pony or bogie brakes and in this picture of one of the first three Beyer Garratts to enter service in 1927, the clasp brakes can be seen. They were removed from all classes following the appointment of W. A. Stanier as CME of the LMS.
COLLECTION R. J. ESSERY

This picture shows the bogie clasp brakes fitted to the Horwich Moguls, or 'Crabs' as they are commonly known.
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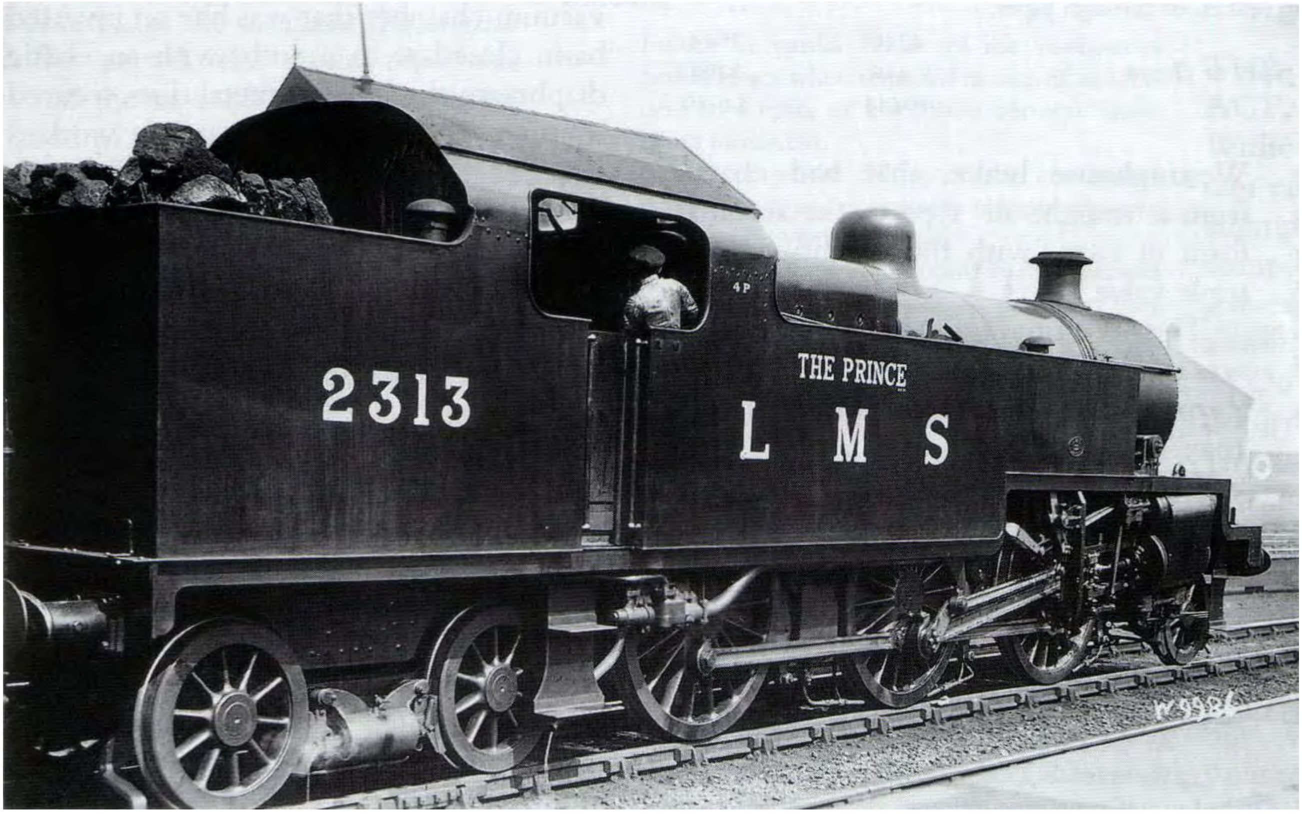

This picture illustrates the brakes fitted to the parallel-boiler 2–6–4Ts, numbered between 2300-2384. The pony truck was a swing-link type fitted with clasp brakes while the bogie truck brakes were operated via a system of linkage by a steam cylinder behind the truck pivot. This is a close-up view of the bogie brakes on No. 2313.

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Chapter 5 – Notes on early brake engineers

Fay, Charles
Born in 1812: apprenticed to Thomas Clarke Worsdell where coaches for L&MR were being produced. He was Carriage & Wagon Superintendent at Miles Platting/Newton Heath between 1846 and 1877. Charles Fay patented a screw brake in 1856 (Marshall states all papers lost in Miles Platting fire) with a shaft between each vehicle and tested it on Miles Platting incline. He was the discoverer of the important effect that skidding wheels are far less effective than revolving wheels for arresting the movement of vehicles He also made experimental use of containers for the movement of coal. He retired in 1877 and was replaced by Attock. He died in January 1900. Portrait on page 90 of Marshall Volume 2. See also Ottley 3206 & 3207: Fay and Newall doing battle with Galton over Newark brake trials..
Marshall, John. *The Lancashire & Yorkshire Railway.* Volumes 2 & 3.
Rowatt, T. Railway brakes. *Trans Newcomen Soc*.,1927, **8**, 19-32

Newall, James
James Newall was the inventive Carriage & Wagon Superintendent of the East Lancashire Railway at Bury and developed one of the first continuous brakes using a shaft system along the tops of carriages and connections between carriages by a system of universal joints and shafts. It was tested on the exdtremely steep Baxenden bank. These tests were viewed by William Fairbairn, Francis Trevithick and Samuel Barton Worthington. He also introduced gas lighting using a flexible container in the guard's compartment and flexible tubing along the roofs. See also Ottley 3206/7 Fay doing battle with Galton and Newall over Newark brake trials..

Marshall, John. *The Lancashire & Yorkshire Railway.* Volume 3.
Rowatt, T. Railway brakes. *Trans Newcomen Soc*.,1927, **8**, 19-32

Nasmyth, James
Marshall states was born in Edinburgh on 19 August 1808, son of Alexander Nasmyth, famous Scottish painter. Inventor of steam hammer and established locomotive builder. Died in London on 5 May 1890. Biography by R. Angus Buchanan with portrait in *Oxford Dictionary of National Biography*. Rowatt *Trans Newcomen Soc*.1927, **8**, 19 states that invented a vacuum brake with Charles May in 1844. Steam hammer patents: 9382/1842 (9 June 1842) and 9850?.

May, Charles
In 1844 inventor with James Nasmyth of vacuum brake Rowatt, T. Railway brakes. *Trans Newcomen Soc*.,1927, **8**, 19-32.

McInnes, John
Glasgow engine driver. Inventor of compressed air braking system in 1862: good enough to be tested in Newark trials. Rowatt, T. Railway brakes. *Trans Newcomen Soc*.,1927, **8**, 19-32. Pickersgill in his Presidential Address (*J. Instn Loco. Engrs*, 1920, **10**, 335-50. (Paper 85) noted that McInnes became a brake inspector on the CR.

Clark, John
Inventor of chain brake in 1862, adopted and developed by Webb of LNWR. Was working on NLR and Metropolitan Railway by 1866; also used on GNR, GWR and GIPR: Rowatt, T. Railway brakes. *Trans Newcomen Soc*.,1927, **8**, 19-32

Smith, John Y.
Inventor of Smith's vacuum brake: Smith was a Cumberland man who emigrated to America. and there invented his brake, which was for a time was used fairly widely in America. He

used an ejector on the engine and air pumps in the vans. The brakes were applied by collapsible India rubber bags below each vehicle. There were two train pipes, one of which went straight to the end of the train so that the vacuum was created on all vehicles, more or less, simultaneously. This brake met with considerable success in Britain and was used on the Great Northern, on the Metropolitan and St. John's Wood. and on the Midland Railways. It was not automatic. Smith obtained several patents improving the idea, and his brake was soon being used on several US Eastern railroads. It provided sufficient competition that George Westinghouse bought Smith's patents in 1875 or 1876 and produced vacuum brakes of Smith's design for several years under his own name. Rowatt, T. Railway brakes.*Trans Newcomen Soc*.,1927, **8**, 19-32.

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