THE EVOLUTION OF EARLY RAILWAYS IN WINSTANLEY, ORRELL AND PEMBERTON, LANCASHIRE, ENGLAND, 1770S TO 1870S

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INTRODUCTION

From the 1770s to the 1870s at least 12 early railways operated in the townships of Winstanley, Orrell and Pemberton to the west of Wigan in Lancashire, England (Fig 1). I present a synthesis of the evolution of these early railways in time and space, including documentation of relevant aspects of geology, topography, coal mining, economics, advances in engineering and sources of capital.[1]

The jewel was a rack locomotive, known as the Walking Horse or Yorkshire Horse, built in 1812 at Haigh Foundry near Wigan by Robert Daglish.[2] For almost two centuries, many chroniclers have ignored the contributions to early railway development by the locomotive's owner John Clarke and his colliery manager and engineer Daglish.[3] In 2012, the

1 J H M Bankes, 'Records of mining in Winstanley and Orrell, near Wigan from the 16th century to the 19th century', *Transactions of the Lancashire and Cheshire Antiquarian Society.* LIV (1939), 31-64; . Anderson, *The Orrell Coalfield, Lancashire 1740-1850* (Buxton, 1975), 111-14; D. Anderson, *Blundell's Collieries 1776-1966* (Wigan, 1986); D Anderson, *Winstanley Hall III: Coal Mining in the Winstanley Estate*, Wigan Public Library [WPL], WCS 1491, W3.B2, undated; D Anderson, *Jonathan Blundell and Son*, WPL, WTW 623 L2 A5, undated; B Newby, 'Tramways in the Douglas Valley', *North Western Society for Industrial Archaeology and History* 2 (1977), 9-13; C H A Townley, F D Smith and J A Peden, *The Industrial Railways of the Wigan Coalfield: Part One, West and South of Wigan* (Cheltenham, 1991); C H A Townley, F D Smith and J A Peden, *The Industrial Railways of the Wigan Coalfield: Part Two, North and East of Wigan* (Cheltenham, 1992); R Daglish, 'A Yorkshire Horse', *Journal of the Railway and Canal Historical Society* 31(3), (1993), 123-31; G L Crowther, *National Atlas Showing Canals Navigable Rivers Mineral Tramroads Railways and Street Tramways, Vol. 2F-762* (WPL, undated); Ordnance Survey map, 1849

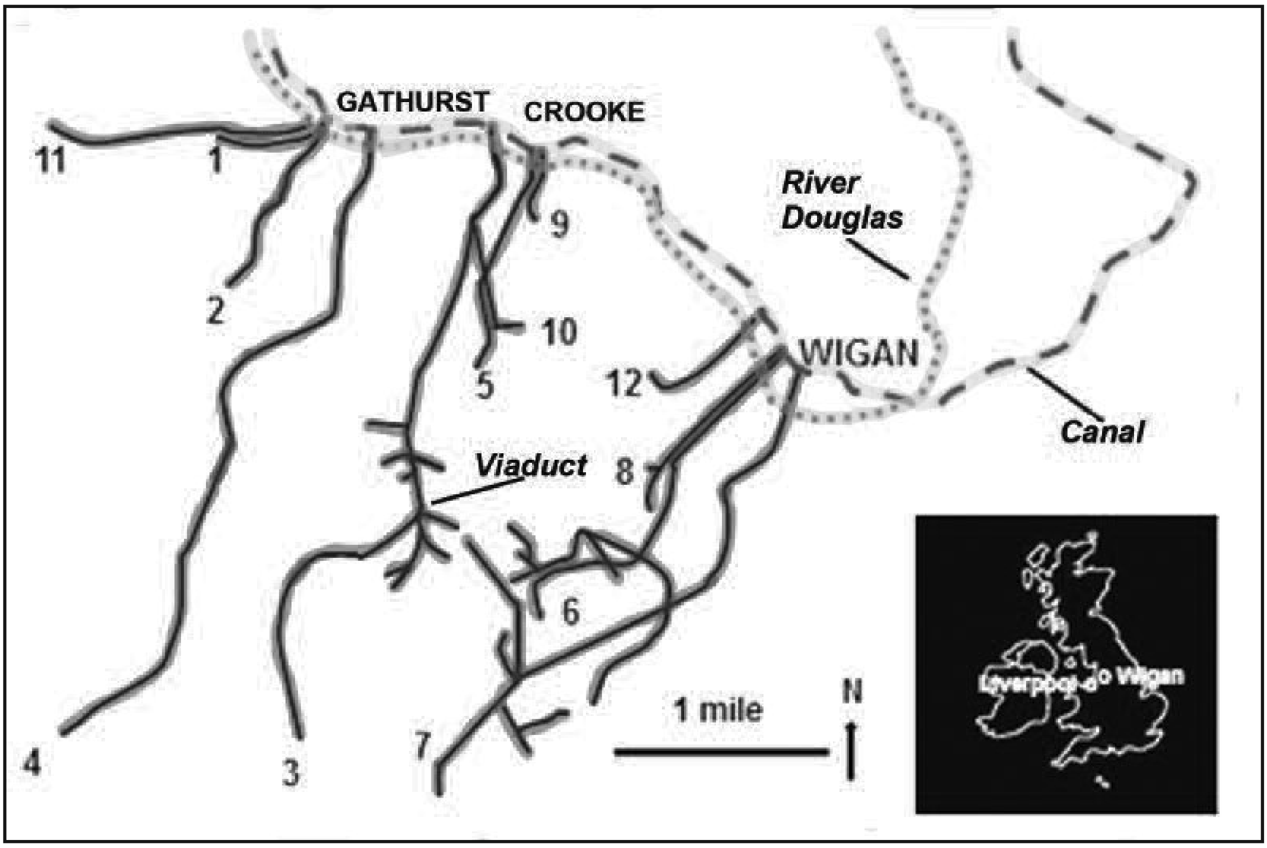

Fig 1. Geographical location of waterways and colliery railways (see Fig 5 for names of railways)

bicentennial year of construction of the Walking Horse, it is fitting and proper to highlight substantial contributions to early railway development by Clarke and Daglish.

GEOLOGY AND COAL MINING

These early railways were private colliery railways, and an understanding of geology and coal mining opens the door to understanding their evolution.

In the Wigan area, coal measures occur in a basin with the oldest rocks outcropping at an elevation of about 500 ft along Billinge Ridge in the west (Fig

2 R Daglish, 1856 letter to Mr. Jones, Liverpool, Wigan Record Office at Leigh, reproduced in R Daglish, 'A Yorkshire Horse', *Journal of the Railway and Canal Historical Society* 31(3), (1993), 123-31; Institution of Civil Engineers (ICE), Minutes, *Proceedings of the Institution of Civil Engineers.* 26 (1886/7) in Daglish 1993.

3 N Wood, *A practical treatise on rail-roads, and interior communication in general* (London, 1825); W Strickland, *Report on Canals, Railways, Roads and other Projects, made to the Pennsylvania Society for the Promotion of Internal Improvements* (Philadelphia, 1826); W Laxton, 'The Civil Engineer and Architects Journal', *Scientific and Railway Gazette* XII (1849), 68-70; C J Bowen-Cooke, *British locomotives: their history, construction and modern development* (London, 1893); E K Scott (ed.), *Matthew Murray, Pioneer Engineer: Records from 1765 to 1862* (Warwickshire, 1928)

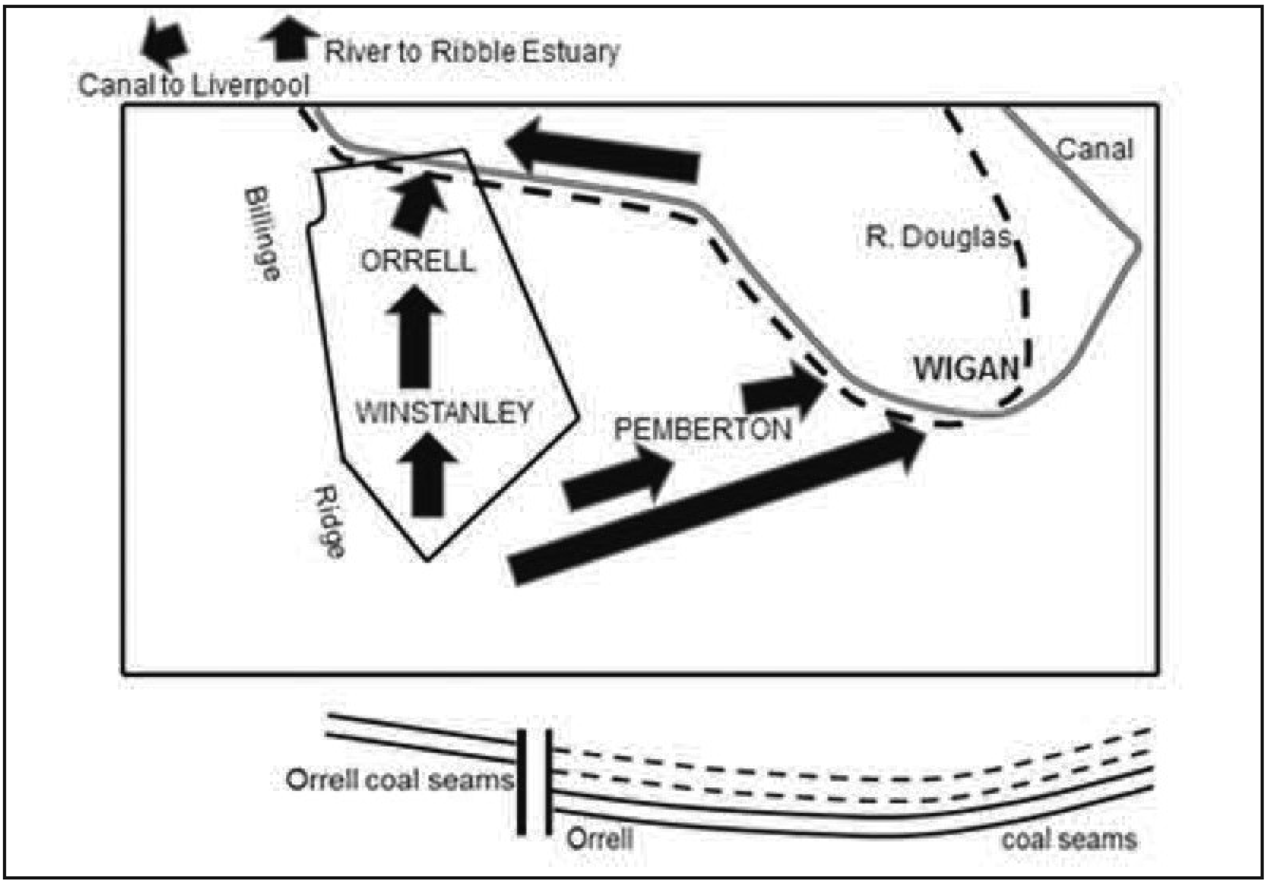

Fig 2. Mining and transport of coal prior to mainline railways

2). Over millennia, rock strata have been severely faulted and eroded and fault lines delineate the southern and eastern boundaries of the Winstanley & Orrell Coalfield (W&OC). These faults throw rock strata downward to the south and east: in the W&OC the two Orrell coal seams occur at shallow depths, but in Pemberton the Orrell seams occur almost 2,000 feet below the surface with a bonanza of some 70 feet of coal in multiple seams above.[4]

Geologically, the history of coal mining is from the outcrop down the dip, *ie*, from the surface to deep underground; technically it is from the easiest to the hardest; and economically it is from the least expensive to the more expensive. In the 1770s, the Orrell Five Feet and Four Feet coal seams in the W&OC were mined near the River Douglas and the Leeds and Liverpool Canal (L&LC) and over the next seven decades at increasing distances southwards from the canal. The Orrell seams were mined first in the W&OC for two reasons: i) they were high quality coals, second only to the famed cannel, and commanded premium prices; and ii) they could be exploited with relatively simple mining technologies.

4 Anderson 1975; R Winstanley and D Winstanley, Founded on Coal (Wigan, 1981)(DCO http://www.wiganworld.co.uk/stuff/foundedoncoal.pdf, accessed 15 January, 2012)

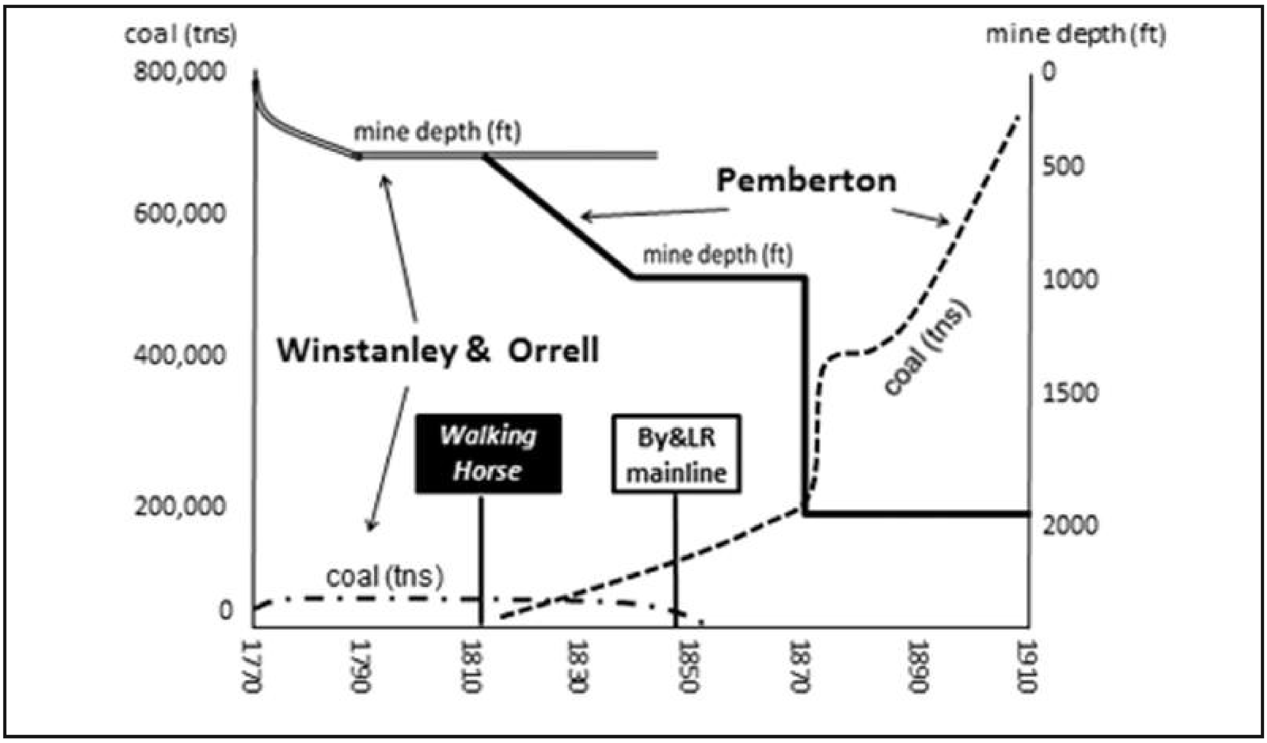

Fig 3. Mine depths and coal production at large collieries in the Winstanley and Orrell Coalfield and at Blundell's Pemberton Colliery 1770-1910.

Prior to the L&LC opening to Gathurst in 1774, the largest colliery produced about 5,000 tons of coal per year and production from the entire area was about 36,000 tons.[5] By 1792, Jonathan Blundell's Orrell Colliery alone produced about 55,000 tons of coal, as did Clarke's Colliery in 1810-15.[6] Thus, geology and mining techniques dictated that large-scale coal production and early railways to the west of Wigan would occur first within the W&OC. Coal seams in the W&OC were largely exhausted *c* 1850.[7]

From Orrell, Blundell's activities moved to Pemberton, outside the W&OC. From 1815 to 1845 shafts were sunk to about 1,000 feet and coal production at Pemberton Colliery increased to 96,000 tons. After shafts were sunk almost 2,000 feet down to the Orrell seams in 1869, coal production from multiple coal seams rocketed to a peak of 738,000 tons in 1913 (Fig 3), when it was the largest colliery in Lancashire.8 The Bankes, Woodcock, German and later the Orrell, Daglishs', Roby Mill and Newtown Collieries also were developed outside the W&OC.9

5 J Langton, *Geographical Change and Industrial Revolution: Coalmining in South West Lancashire 1590-1799* (Cambridge, 1979); Anderson 1975, 177
6 Anderson 1975, 177; Anderson 1986, 45
7 Anderson 1975, 200
8 Anderson 1986, 1
9 Anderson 1975; Anderson 1986

EVOLUTION OF RAILWAYS

The evolution of early railways followed this sequence of coal mining dictated by geology, topography and engineering capabilities and shaped by investment decisions.

As will become relevant, in north-eastern England large-scale coal mining flourished and wealth accumulated much earlier than in Lancashire: as early as 1334 Newcastle was the fourth wealthiest town in England.[10] By the end of the eighteenth century, annual coal production on the Great Northern coalfield was about three million tons.[11] Horses and gravity powered the transport of coal in largely controlled descents along wagonways from the mines to major rivers, from where water and wind power were harnessed to transport coal ships out to sea and south to London and Europe; haulage of loaded wagons uphill was to be avoided.[12] The W&OC, however, remained essentially landlocked and largely undeveloped well into the eighteenth century; horses pulled carts of coal, gangs of 30 to 40 pack horses carried coal and roads were atrocious.[13] Development of the W&OC required larger markets, a new transportation system and an infusion of capital.

Population in Liverpool increased from about 6,000 in 1700 to 149,000 in 1821 and ship tonnage increased from about 9,000 to 840,000.[14] The expanding heart and lungs of Liverpool demanded more coal for homes, businesses, industries and a booming export trade. This demand for coal was the stimulus for investors to open up the W&OC.

The first substantial artery was the Douglas Navigation in 1742, making the River Douglas navigable for vessels of 34 to 44 tons from Wigan to the Ribble Estuary.[15] Even greater efficiencies in transport were demonstrated to the south of Wigan when the Sankey Canal opened in 1757.[16] What really transformed the W&OC was the opening of the L&LC to Gathurst in 1774 and to Wigan in 1780.[17] By the end of the century, over a quarter of a million tons of coal per year were shipped via this artery.[18] The River Douglas and the L&LC are shown in Figs 1 and 2.

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10 D Simpson, *Coal and Industry, 2009* (DCO http://www.englandsnortheast.co.uk/CoalMiningandRailways.html, accessed 8 March, 2012)
11 Anderson 1975, 14
12 A Guy and J Rees, *Early Railways 1569-1830* (Oxford, 2011)
13 Langton 1979, 176; Whuttle in *Wigan Coal and Iron*, D Anderson and A A France (Wigan, 1994), 198
14 C Williams, *Old Liverpool* (DCO http://www.old-liverpool.co.uk/Timeline.html, 1998-2008, accessed 17 January, 2012)
15 Anderson 1975, 27-39
16 G O Holt, *A Regional History of the Railways of Great Britain, Volume 10 the North West* (Newton Abbot, 1978)
17 Townley 1991,16
18 Langton 1979 170

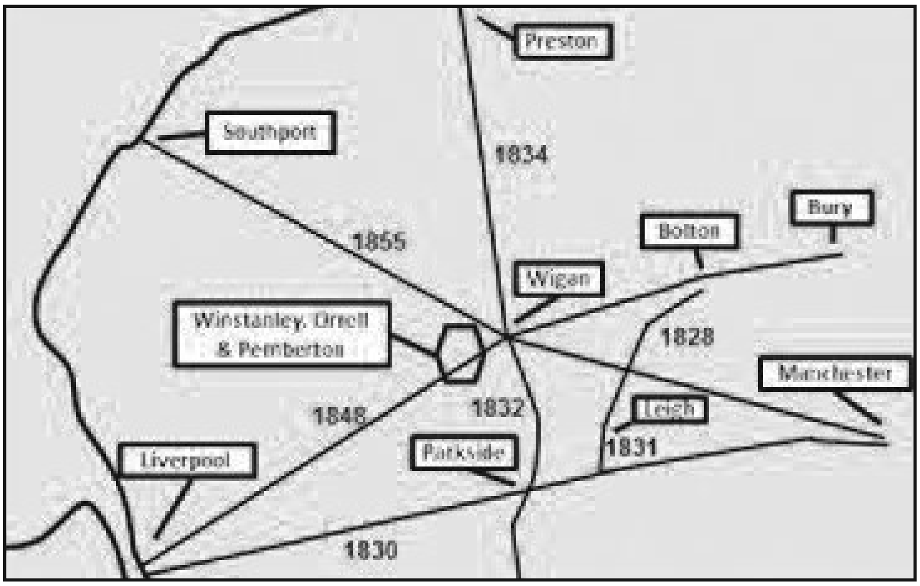


Fig 4. Mainline railways 1828-1855.

Narrow-gauge, horse-powered wagonways were constructed as veins to transport coal to the main artery — the L&LC — with capillaries, or branch lines, transporting coal from individual pits to the veins. Starting in January 1813, a narrow-gauge, steam locomotive operating in Winstanley and Orrell began to transform the feeder system to the L&LC and later new arteries were developed. In 1828 the Bolton and Leigh Railway (B&LR), laid out by Robert Daglish a few miles east of Wigan, followed by the Liverpool and Manchester Railway (L&MR) a few miles south of Wigan in 1830, the line from Wigan to Parkside connecting with the L&MR in 1832 and the Wigan to Preston line in 1834 signaled the start of standard-gauge, steam-powered, public railways as new arteries (Fig 4).[19] To the west of Wigan, the Bury & Liverpool Railway (By&LR) in 1848 and the Wigan & Southport Railway (W&SR) in 1855 provided new arteries for the transport of coal, cotton and other goods.[20] In 1869, the Pemberton Branch of the Lancashire Union Railway opened, providing another outlet for coal from Blundell's and Bankes' collieries.[21] The spatial evolution of these waterways and railways is shown in Fig 1 and their temporal evolution in Fig 5.

There was no blueprint to guide a transition from harnessing the power of gravity and horses to steam locomotives. Blundell made private, standard-gauge sidings to connect his Pemberton Colliery Railway to the By&LR soon after it opened in 1848 and introduced three steam locomotives by 1852.[22] However, details of the interplay between horses and steam locomotives on

19 Holt 1978 14-15, 15-22; Townley 1991, 19

20 Anderson 1975 12

21 J H M Bankes, 'A nineteenth-century colliery railway', *Transactions of the Historical Society of Lancashire and Cheshire.* 114 (1962), 155-88; Townley 1991, 62, 71, 75

22 Anderson 1986, 150

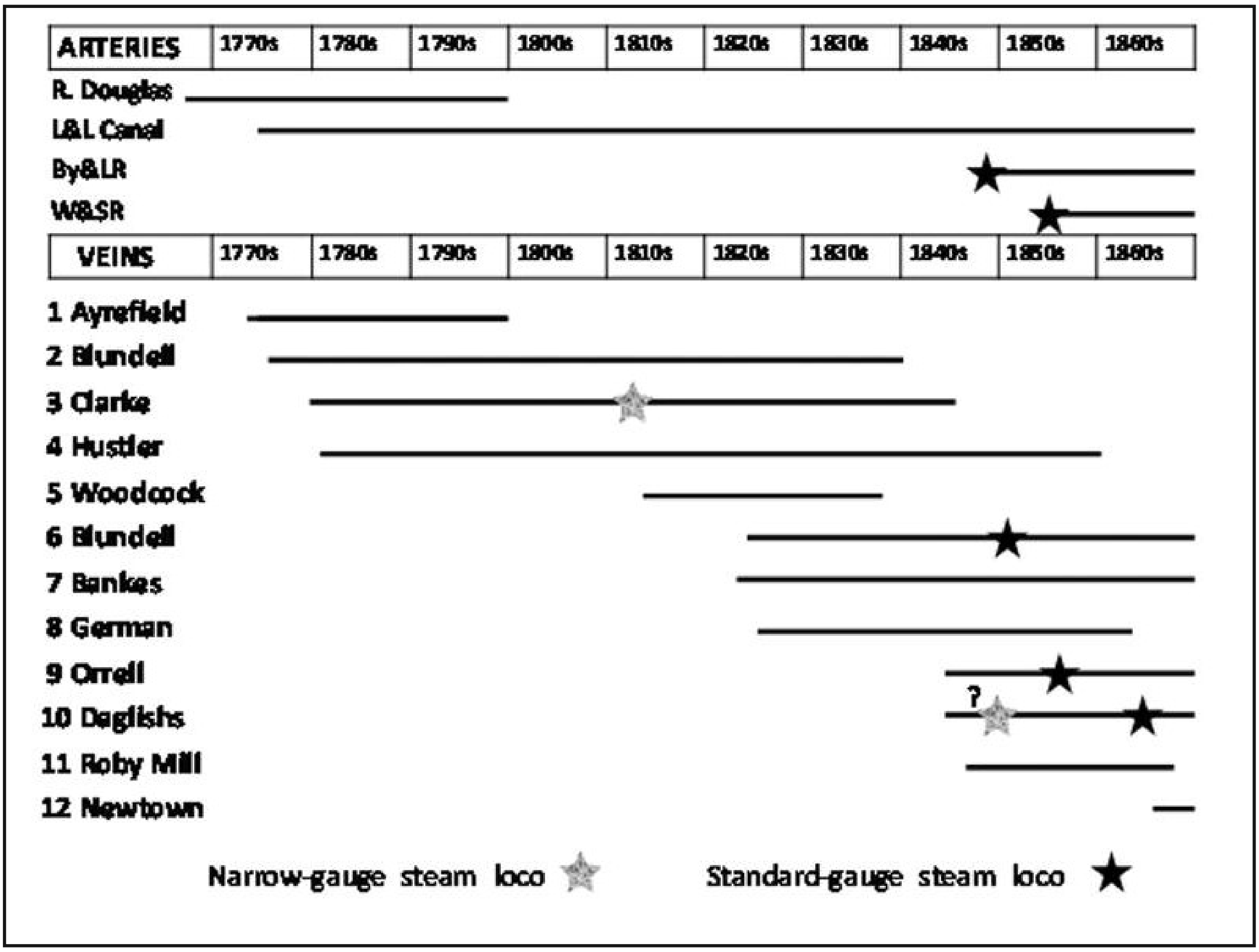


Fig 5. Timeline of development of waterways and railways (railways are numbered and data sources are the same as in Fig 1).

mixed-gauge tracks is not known; neither is it known if Blundell's Pemberton Colliery connected to the L&MR or operated steam locomotives pre-1848. Blundell was authorized to operate his own locomotives from his Amberswood Colliery, southeast of Wigan, to Liverpool utilizing the Wigan to Parkside Railway and the L&MR. In the early 1840s Blundell's Mesnes Colliery in Wigan had a private connection to Preston via the North Union Railway.[23] Annual coal production at Pemberton Colliery in 1850 was about 100,000 tons.[24] Bankes conveyed coal to the canal and the L&MR; although no information on the L&MR connection is provided, perhaps it was under an agreement with Blundell via the Wigan to Parkside line.[25]

At collieries where smaller amounts of coal continued to be produced, gravity- and horse-powered, narrow-gauge railways continued to be an effective form of transport and the transition to standard-gauge and steam

23 Townley 1991, 73, 163
24 Anderson 1986, 45
25 Bankes 1939, 61

locomotives was much slower, and in some cases did not occur. Hustler added a narrow-gauge spur to allow transfer of coal to the mainline, but never adopted standard-gauge or steam locomotion. The German and Roby Mill Railways continued to operate narrow-gauge, horse-powered railways to the canal.[26] Clarke's Colliery was exhausted before the W&SR opened in 1855 and his railway remained narrow gauge. Daglishs' Railway at Norley Hall in Pemberton was worked by horses and a stationary steam engine, but may have used Clarke's narrow-gauge steam locomotives *c* 1850 before switching to standard-gauge steam locomotives about 1860. Orrell Railway adopted standard-gauge, steam locomotives *c* 1855, but the Newtown Railway appears to have been narrow gauge from its inception *c* 1865.[27]

Bankes' railway appears to have had three sections with inclined planes: near the top, a half mile descent had an average gradient of 5.3 per cent; the middle section had an average gradient of 2.4 per cent; and the lower section had an average gradient of 0.35 per cent. The top section operated as a self-acting inclined plane, but there are no reports of the other two inclined planes being self acting. Two brakesmen worked on the railway and two horse wagons carried horses and horsemen down to the canal in a 'dandy cart' and horses hauled empty wagons back up the incline. In 1867 Bankes added a third steel rail to the lines near his pits to allow standard-gauge wagons to his post-1848 By&LR sidings, while narrow-gauge wagons continued on the line to the canal. He added standard-gauge, four coupled-saddle-tank engines in 1878 and a 4 ft 0 in gauge engine down to the canal in 1882.[28] The terminus of Bankes' Railway was a promontory by the side of the canal in Wigan, where coal was tippled from wagons into canal barges. This promontory gained notoriety as the pier in George Orwell's *The Road to Wigan Pier,* so the road to Wigan Pier can be interpreted to have been Bankes' Railway from Winstanley.[29]

TOPOGRAPHY AND DRAINAGE

In the W&OC, the Smithy Brook valley is incised between Winstanley and Orrell and posed a significant challenge for Clarke to transport coal northwards from Winstanley. Fig 6 shows elevation profiles for four early railways to the west of Wigan. The general trend is of two per cent gradients of decreasing elevation in favour of loaded wagons from the mines to the canal. The one exception is the profile for Clarke's railway, which crossed Smithy Brook and then ascended some forty five feet up to Oldham's Fold before descending to the canal.

26 Townley 1991, 59-60
27 Townley 1992, 350-1
28 Bankes 1962, 162
29 G Orwell, *The Road to Wigan Pier* (London, 1937)

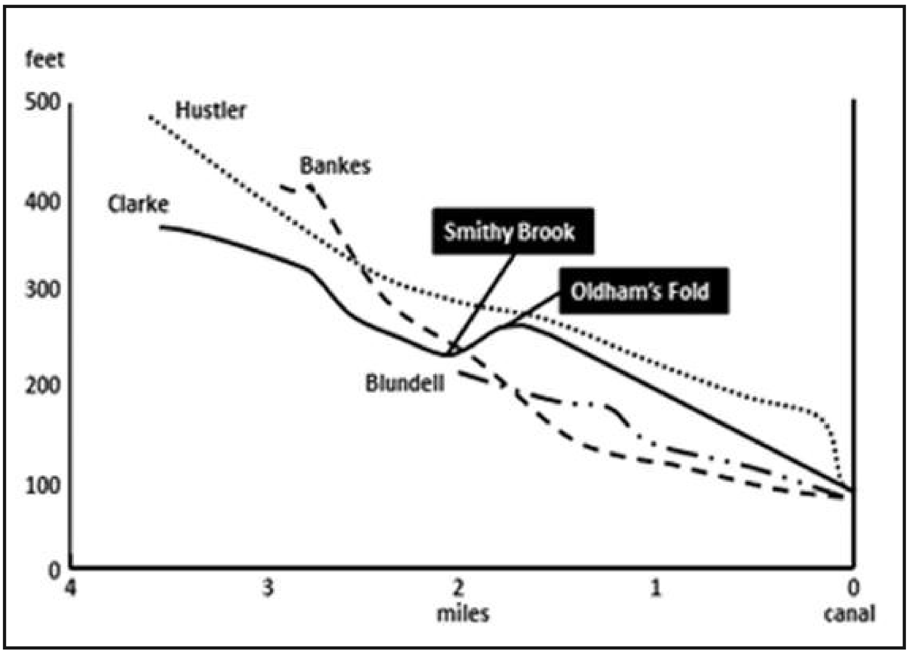


Fig 6 (left). Elevation profiles for four early railways west of Wigan.

Fig 7 (right above). Etching of the Arches Viaduct across Smithy Brook Valley *c* 1790s. *[Anderson 1975, 116]*

Fig 8 (right below). Route of Clarke's railway up the north side of Smithy Brook valley, 2012.

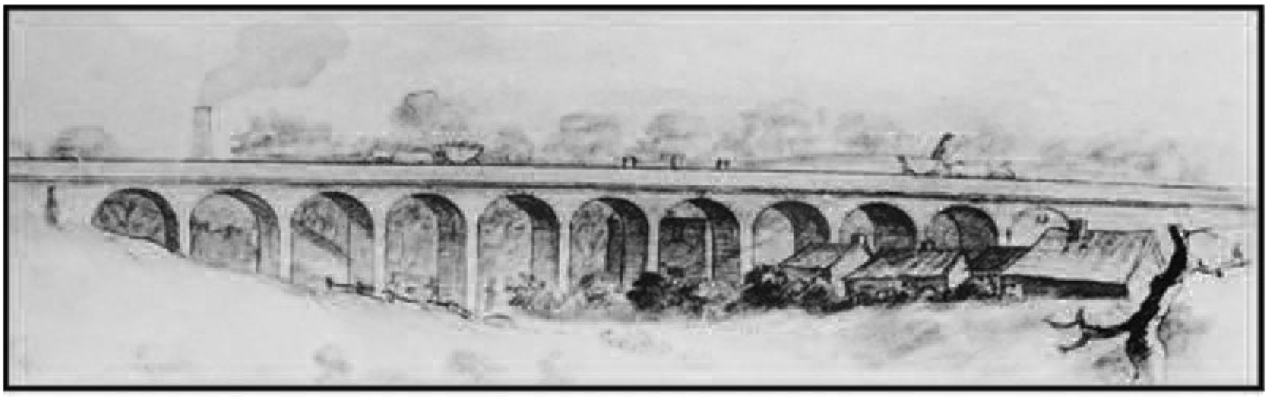
Anderson provides some documentation of Clarke's railway.[30] From 1779, Clarke and partners leased and/or purchased land progressively further south from the canal at Crooke; they had their eyes on the large undeveloped part of the coalfield in Winstanley. One strategic action was to obtain a narrow corridor of land on which to extend his railway southward into Winstanley and in so doing he had to negotiate the significant incline from Smithy Brook up to Oldham's Fold.

Clarke and German first leased mineral rights and land in Winstanley in 1792 and it was probably soon after this that they constructed The Arches Viaduct across Smithy Brook. Anderson reproduces an etching of the viaduct held in 1975 by Wigan Public Library (Fig 7).[31] The viaduct with eleven arches appears to have been about 150 yards long, about twelve feet high and built of stone. The chimney shown at the left (north) is shown as a lime kiln on the 1849 Ordnance Survey map. It is evident that there was a double road across the viaduct with a horse-drawn wagon travelling north and one travelling south.

Clarke appointed Daglish manager of his Winstanley and Orrell Colliery *c* 1810, after Daglish had served as engineer at Haigh Foundry from 1804.[32] Pumping and winding engines built by Daglish at Haigh Foundry were 'celebrated in their day as improved and efficient machines'.[33]

An early nineteenth century plan shows a double-track wagonway from some 600 yards to the southwest of the viaduct down to the canal, with single-

30 Anderson 1975, 111-8
31 Anderson 1975, 116
32 Anderson 1975, 111, 176
33 Anderson 1975, 95



road branches feeding from individual pits to the wagonway. In 1812, a new 30-year lease was drawn up for mining coal further to the west, towards Longshaw, and the railway was extended.[34]

Daglish reports that coal wagons were drawn up an altitude of one inch to a yard (2.78 per cent). According to Google Earth, this is the average gradient from Smithy Brook to Oldham's Fold, but just north of the viaduct the gradient exceeds 4.0 per cent and ground truth confirms this (Fig 8).

STEAM ENGINES

The first stationary steam engine on the W&OC was installed in 1769 and at least 15 other pumping engines were used on the W&OC before the *Walking Horse* became operational in January 1813.[35] Pumping engines remained very costly; in 1815 a 50 horse-power engine cost £1,870 and Blundell's 200 horse-power engine would be much more expensive.[36] That many of these engines were purchased reflects the necessity of paying high prices for technologies to pump large quantities of water from increasingly deep mines — there was no alternative.

At Middleton Colliery near Leeds, two locomotives were at work on the near-level sections of the railway by the end of 1812; connecting these two sections was a self-acting inclined plane (Calvert 1999).[37] The locomotives were

34 Anderson 1975, 113-7

35 Anderson 1975, 84, 201

36 Anderson 1975, 89

37 S Bye, Historian and Archivist, Middleton Railway Museum, personal contacts 8, 9 January, 14 February 2010, 12 March 2012; J B Calvert, *Strickland's Reports* (DCO http://mysite.du.edu/~jcalvert/railway/strickla.htm, accessed 13 March, 2012)

designed by Mathew Murray and built by Fenton, Murray and Wood in Holbeck. Murray's design was based on Richard Trevithick's patent for a high-pressure steam engine, incorporating for the first time two double-acting cylinders and adapted to use Blenkinsop's mechanism of a pinion working in a rack rail to increase the tractive force).[38] *Salamanca*, most probably the first steam locomotive at Middleton, exploded early in 1818 and the line reverted to horse power in 1835.[39]

The Walking Horse

There are no contemporary drawings or photographs of the *Walking Horse*, but it appears that many historians have assumed erroneously that it was simply a copy of the Middleton locomotives and not worthy of much further discussion — hence the name the *Yorkshire Horse.* Anderson and Townley state erroneously that the engine was based on a design by Blenkinsop.[40] However, Blenkinsop's patent for rack locomotion did not include any form of power and he did not design or build a locomotive.[41] Eli Bankes of Pemberton constructed a working model of the *Walking Horse* based on drawings of Murray/Blenkinsop's engine supplied by the Science Museum (item 1910-21) and the model now resides in the Beamish Museum (item NEG86494). Thomas Scherer has produced a detailed drawing of the *Walking Horse* (reproduced in Fig 9 with kind permission) based on specifications in the literature.

Like Murray's first two locomotives, the Walking Horse had two cylinders and utilized Blenkinsop's rack system, but Table 1 shows that Daglish made significant improvements. the *Walking Horse* was built more powerful to haul loaded wagons up a significant incline: it had an eight horse power engine, a larger wrought-iron boiler, a wider and tapered wrought-iron chimney, a brass feed pump and it used more coal and water. The track was made stronger by using larger stone sleepers and longer and heavier rails with heavier pedestals bolted through stone sleepers. The reported pressure of 55 psi for Murray's engine was greater than that for Daglish's at 32 psi, but as Daglish's engine required considerable pulling power to haul loaded wagons up a significant incline, it is evident that 32 psi was sufficient. Anderson reports that later engines had toothed driving wheels on both sides, but does not provide a reference.[42] In 1834 Daglish won a national competition for the best form of parallel rail and pedestal.[43]

38 Bowen-Cooke 1894, 5; Scott 1928, 69
39 Bye 2010; Scott 1928, 70
40 Anderson 1975, 118; Townley 1991, 58
41 R L Galloway, *The Steam Engine and Its Inventors; A Historical Sketch* (London, 1881)
42 Anderson 1975, 111
43 C F D Marshall, *A History of Railway Locomotives down to the end of the year 1831* (London, 1953)

Table 1. Some specifications of Murray/Blenkinsop locomotives (operational June-December 2012) and Daglish/Blenkinsop locomotive (operational January 1813).[44]

	Murray/Blenkinsop 1812	Daglish/Blenkinsop 1812
Weight	4-5 tn	6-7 tn
Engine	4-6 hp	8 hp
Cylinders	2	2
Stroke	20-24 in	24 in; 40-50per min
Piston diameter	8 in	8 in
Boiler (oval)	114x37x32 in; cast iron	108x51x38 in; wrought iron
Chimney dia	14 in	20 in (bottom) to 16 in (top) wrought iron
Chimney height	?	14 ft
Feed pump	No	Brass: dia 2 in; stroke 4 in
Safety valve	Yes	Yes
Coal consumption (lb/hr)	84	140
Water evaporation (gal/lb coal)	0.5	0.25
Pressure	55 psi	32 psi
Carriage wheels dia	35 in	36 in; 4.25 broad on rim; 2.25 in bearing on rail
Cog wheels	37-38.25 in; 20 hollow teeth pitch 6 in	Pitch 6 in
Wheel base	88 in	86 in
Gauge	4 ft 1 in (2 in)	4 ft 0 in
Length of rails	3 ft?; 4 ft? some 6 ft; cast iron, rack on left; fish belly?	4 ft; cast iron, rack on left; fish belly
Rail weight (per yard)	Plain 40 lb; cog 56 lb	Plain 49.5 lb; cog 58.5 lb
Pedestal	Plain 6 lb; cog 14 lb	Plain 12 lb; cog 18 lb
Stone sleepers	18-20x20.5-22x8.5-11 in	30-36 in sq & 8 in thick, &/or 27x22 in & 9-10 in thick; chairs fixed to sleeper by through bolts
Operational performance	On level haul 74-94 tn at 3-5 mph	On level haul 90 ton plus own weight at 3-6 mph; haul 27-36 tn + own weight up 4% incline at 2-4 mph

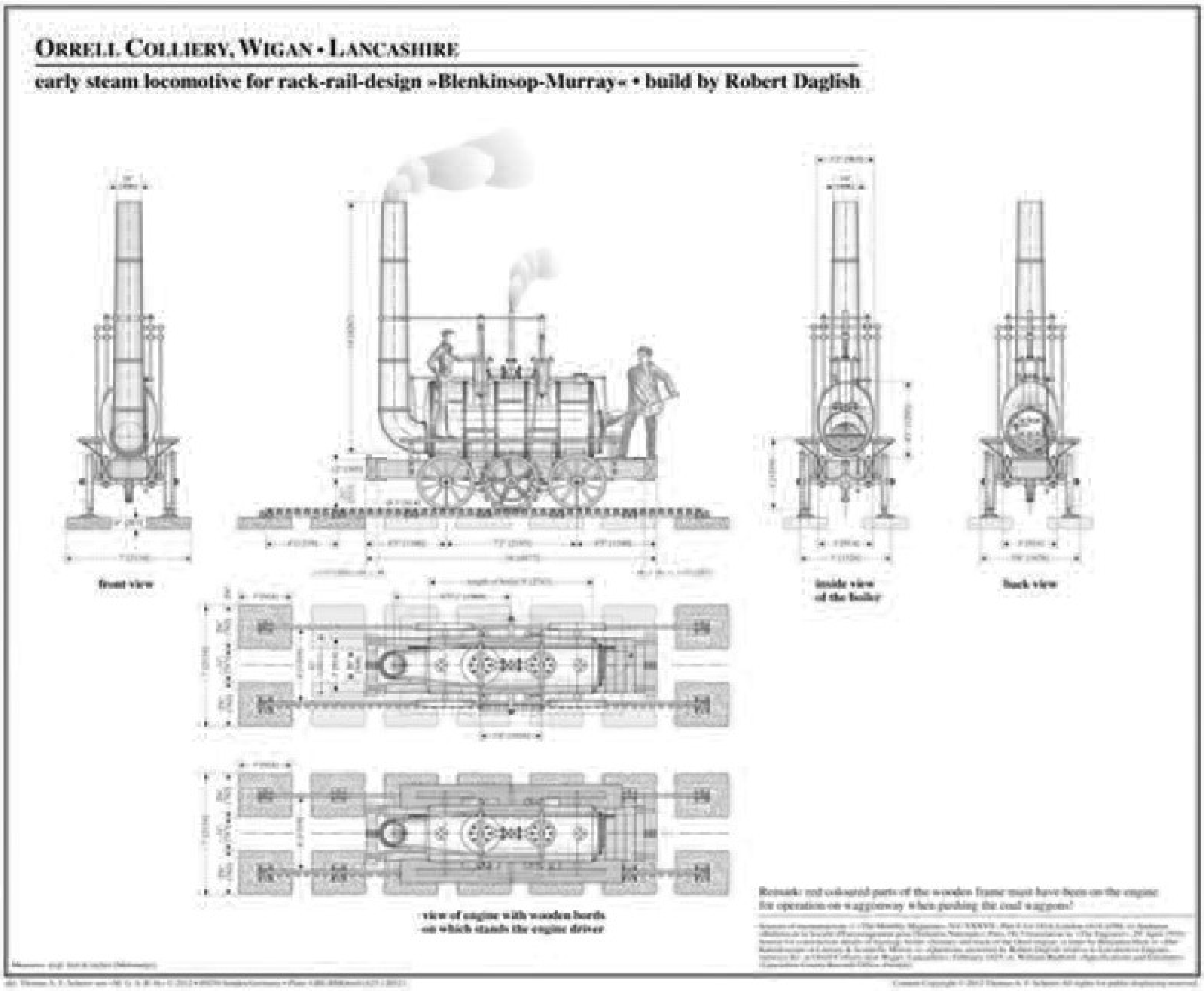


Fig 9. Drawings of the *Walking Horse*

*[del Thomas Scherer sen. (M.G.S.R.H) © 20130].**

* Daglish 1825; B Hick, letter to the editor, *Kaleidoscope,* No 118, Vol.III (1822) in Anderson 1975, 117; Andrieux, *Bulletin de la Société d'Encouragement pour l'Industrie Nationale* (Paris, 1815, translation in *The Engineer* 29 [1910]); J. Blenkinsop, letter, Monthly Magazine 37 (1814), 394-5

There is conflicting and incomplete information on which sections of Clarke's Railway the *Walking Horse,* a second cog locomotive and an adhesion locomotive operated. Daglish (1825) provides information on materials and

44 J Blenkinsop, letter to John Watson, August 2, 1812 cited by Marshall 1953; Blenkinsop 1814; Hick 1822; W. Simmons, 'On Steam Carriages', letter in *London Journal of Arts and Sciences* III (XVI), (March 16, 1822), 196-199; Daglish 1825; T Gray, *Observations on a General Iron-Railway* (London, 5th edition, 1825); Laxton 1849; Bowen-Cooke 1893; G F Tyas, *Matthew Murray, A Centenary Appreciation, Part 1* (Science Museum, South Kensington, 24 February, 1926), cited in Scott 1928, 7-44; Scott 1928; E A Forward, *Description of Murray's Locomotive*, in Scott 1928, 62-63; Marshall 1953, 29-53; Anderson 1975, 111-8; Townley 1991, 57-9; Townley 1992, 500-501; Bye 2010, 2012; Grace's Guide, *Middleton Colliery Railway* (DCO http://www.graces-guide.co.uk/Middleton_Colliery_Railway, accessed 14 January, 2012); M White, Librarian (Acting), Search Engine, National Railway Museum, Science Museum, pers. comm., 1 April, 2012; Guy and Rees 2011, 35.

costs for 'one mile of steam carriageway complete'. We do not know if only one mile of railway was completed initially, up the incline to Oldham's Fold, or whether the materials and costs should be multiplied by up to 3.6 for the total length of the railway. Bankes states that the *Walking Horse* operated up the incline to Oldham's Ford and down to the Baiting Point, from where loaded wagons went by gravity to the canal; horses then pulled empty wagons up to the Baiting Point.[45] According to Bankes' description, the *Walking Horse* must have pulled empty wagons back up to Oldham's Ford and then descended into Winstanley. Hick states that an engine pulled loaded wagons up the incline to Oldham's Ford where another engine took over down to the canal.[46] It thus appears that steam locomotives hauled loaded and empty wagons up and down inclines. It is not known whether the second cog locomotive served only as a backup to the *Walking Horse* on the ascent, what the specifications of the second rack locomotive and the adhesion locomotive were, or on which sections of the railway they operated. Operations probably changed over time.

The pre-1812 horse-drawn railway from inside Winstanley to the canal was double track (Photo 1).[47] However, Anderson's 1970s photographs show a single-track wagon road and it is evident from Daglish's list of materials and costs for one mile of railway that these were for a single track.[48] I conclude, therefore, that from 1812 the railway probably was single-track for its entire length. The locomotives operated successfully until *c* 1850.[49]

ECONOMICS

According to many, but without much evidence, it was a dramatic rise in the price of animal fodder that created the imperative that made the locomotive an economic proposition.[50] Although there are not sufficient data for detailed economic analysis, insights can be gleaned from fragmentary records. From 1802 to 1815 England was engaged in wars in Europe and grain prices surged 90 percent from 1800 to 1812.[51] If we assume that each railway horse ate as much as the average military horse, then each horse consumed 8 lb of oats and 12 lb of hay each day.[52] A colliery operating 15 horses thus had to provide

45 Bankes 1939, 58
46 Hick 1822
47 Anderson 1975, 113-5
48 Anderson 1975, 113, 114; Daglish 1825.
49 Daglish 1856
50 Guy and Rees 2011, 35
51 J Baten, D Crayen, D and H-J. Voth, *Poor, Hungry and Stupid: Numeracy and the Impact of High Food Prices in Industrializing Britain, 1790-1840* (DCO http://www.econ.upf.edu/~voth/h_s_p.pdf, undated, accessed 8 January, 2012)
52 G J Morris, *Battlefield Anomalies,1812 – the Turning Point* [DCO http://www.battlefieldanomalies.com/1812/index.htm,2004, accessed 11 January 2012]

nearly fifty tons of fodder each year, together with men to feed and operate them. From the accounts of Blundell's Colliery in Orrell, provisions for horses amounted to 35 percent of the cost of working the colliery in 1800.[53]

Daglish stated that compared to horses, savings by the *Walking Horse* were regulated by the price of oats and hay and cited oats at 3-4s per bushel and hay at £4-5 per ton.[54] Immediately preceding the wars, oats were 2s 2d per bushel, so there is evidence that *c* 1813 Daglish paid 38-85 percent more for oats in Winstanley than the prevailing price two decades earlier.[55] Further, there is evidence that the price of horses also increased: at Middleton Colliery the average price for a horse rose from £14 in 1771-89 to £26 in the early nineteenth century.[56] Although costs increased, the price of coal delivered at Liverpool doubled from 1790 to 1815, so a more detailed economic analysis of the effects of increases in the prices of fodder and horses on the development of steam locomotives also would have to consider increases in the value of the delivered product — coal.[57]

According to Daglish, the cost of one mile of steam carriage railway in 1812 was £1,775 16s 0d and a steam locomotive cost £420, but we do not know precisely how many miles of railway were built.[58] It is evident, however, that the capital outlay for a one mile railway and a rack locomotive was about the same as for a large pumping engine. Using data in Daglish, it can be shown that the cost of the *Walking Horse* was the same as buying sixteen horses or the yearly wages of eight men.[59] The stated savings of £300-500 per annum compared with horses and drivers etc. appear to be for one mile of railway and one steam locomotive.[60] From limited available evidence, there is no doubt that profit from investment in steam locomotion contributed to the overall average Clarke Colliery profit of £11,000 per year from 1804 to 1815.[61] Profit probably was the reason Daglish built and operated another rack locomotive and an adhesion locomotive by 1816.[62] In 1816, however, there was commercial panic owing to the great fall in prices at the conclusion of the Napoleonic War and Clarke became bankrupt.[63] These unfavourable commercial conditions also

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53 Anderson 1975, 156
54 Daglish 1993, 129
55 Dennison in 'The Penny Loaf and the Bank of England', *Liverpool Mercury*, 2 (83) (29 January 1813), 246
56 D Fraser, *A History of Modern Leeds* (DCO http://books.google.com, accessed 7 February, 2012)
57 Anderson 1975, 106
58 Daglish 1825, 128
59 Daglish 1993, 124
60 Daglish 1825, 128; Daglish 1856.
61 Anderson (Winstanley Hall) undated
62 Daglish 1856
63 J Hughes, *Liverpool Banks & Bankers*, 1760-1837 (London, 1906) (DCO http://books.google.com, accessed 20 March 2012)

probably served as a disincentive to railway development for some time.

In 1845, Meyrick Bankes paid £3,787 for three pumping steam engines (one 30 horsepower and two 20 horsepower) and construction materials, £9,420 for construction of a gravity-and-horse-powered, narrow-gauge railway to the canal and £1,566 for 46 coal wagons and six horse wagons. One year's toll paid by Bankes to the mainline railways totaled £2,080 0s 8d. Bankes' first steam locomotive in 1878 cost £1,000 and was, therefore, well within the range of other colliery expenses.[64]

The only stationary steam engines reported to have operated on inclines to the west of Wigan before 1880 were at Bankes' Number 4 pit and Daglishs' Norley Colliery; Bankes' sidings to the W&LR may have been operated by a stationary engine.[65]

Sources of capital

Through the late eighteenth century, landowners, merchants, bankers, lawyers and manufacturers supplied capital to finance relatively small-scale mining and quarrying operations.[66] Of the owners and investors, Woodcock, Berry, Jackson, Laithwaite, Townsend, Brimilow, Stephen, Whaley, the Germans and Claughton fall into this category, to whom Longhbotham, Chadwick, Haliburton and the Daglishs could be added by including engineers and ironmasters. However, as Langton concludes, large infusions of capital were needed to sustain and expand coal production and many of these people were incapable of making the necessary investments.[67] So, where did large amounts of new capital come from?

Hustler and Hardcastle — Bradford wool staplers and merchants — and Blundell, Earle and Hollinshead — Liverpool merchants — were members of the Leeds–Liverpool Canal Committee and some of the earliest 'foreigners' to make substantial investments to develop waterways, railways and collieries.[68] It is reported that the Blundells and Earles, together with the Branckers and Clarkes, also were members of the cohort of leading Liverpool slave merchants and that other leading slave traders such as Leyland and Chaffers partnered with Clarke in Liverpool banking, as did Roscoe, an abolitionist.

From 1695 to 1807, 5,300 voyages to Africa from Liverpool transported about one and a half million slaves.[69] By 1787, 37 of the 41 members of Liverpool Council were involved in slavery. Further, all of Liverpool's 20

65 Townley 1991, 61, 87

66 Anderson 1975; Langton 1979.

67 Langton 1979, 220-1

68 Anderson 1975, 39-45

69 A Tibbles, *Ports of the Transatlantic slave trade* (International Slavery Museum, TextPorts Conference, April 2000) (DCO http://www.liverpoolmuseums.org.uk/ism/resources/slave_trade_ports.aspx, accessed 7 March, 2012)

mayors who held office between 1787 and 1807 were involved. Liverpool's net proceeds from the African trade in 1783-93 were said to be £12,294,116.[70]

There is much evidence to document the deep and lucrative involvement in the slave trade by Blundell, Leyland, Earle, and Chaffers.[71] It is not clear if Clarke was directly involved in the slave trade, but there is no doubt that as a major Liverpool banker he benefited greatly from the slave trade and his partners, Leyland, Earle and Chaffers, were slave traders. I have found no evidence that the Bankes family was directly involved in the slave trade, but there is no doubt they and other land owners benefited greatly from leasing land to Liverpool merchants and bankers. Using wealth accumulated largely from leases, the Bankes family developed its own colliery and railway in the 1840s.

The *Walking Horse* was built at Haigh Foundry, so it is also important to identify sources of capital for the foundry. In the late 1770s, the Earl of Balcarres found Haigh Estate to be in decay and he was in great debt.[72] But in 1788 the Earl, his brother, Robert Lindsay and James Corbett purchased Brock Mill forge and combined it with two new blast furnaces at Leyland Mill to form Haigh Foundry. Iron works on the site date from the seventeenth century.[73] By 1789, the foundry began to construct steam engines, sugar mills and other complex heavy machinery.[74] Anderson considers it most probable that post-1790 steam engines at collieries to the west of Wigan were made at Haigh Foundry and I consider it likely that Haigh Foundry produced steam engines before Boulton

70 *Breaking the Silence: Slave Routes* (DCO http://www.saylor.org/site/wp-content/uploads/2011/04/United-Kingdom.pdf)

71 L S Walsh, Liverpool's Slave Trade to the Colonial Chesapeake: Slaving on the Periphery (DCO http://www.hslc.org.uk/downloads/walsh_paper.pdf, 2005, accessed 31 January, 2012); E E Williams, Capitalism and Slavery (University of North Carolina Press, 1944); S S Friedman, Jews and the American slave trade (Transaction Publishers, New Brunswick, New Jersey, 1998) (DCO http://books.google.com, accessed 21 December, 2009); Microform Academic Publishers, *Records relating to the slave trade in the Liverpool Record Office: a guide to the microfilm edition with an introduction by Professor Kenneth Morgan, Brunel University*, Wakefield, 2007 (DCO http://www.microform.co.uk/guides/R51361.pdf, accessed 10 December, 2011); Richardson 2007, 28, 32, 98, 194, 196, 198, 202, 208-10, 209, 219, 231, 232; Hughes 1906, 172; A E Phillips, *Leyland and Bullins* (British Banking History Society, 2010) (DCO http://www.banking-history.co.uk/leyland.html, accessed 12 December, 2011); Tibbles 2000; Merseyside Maritime Museum, *Liverpool and the Transatlantic Slave Trade* (DCO http://www.liverpoolmuseums.org.uk/maritime/archive/info-sheet.aspx?sheetid=3, accessed 19 February, 2012); G Williams, *History of the Liverpool Privateers and Letters of Marque with an Account of the Liverpool Slave Trade* (Liverpool, 1897) (DCO http://books.google.com, accessed 20 February, 2012)

72 Daglish 1993, 124; Anderson and France 1994, 52

73 Langton 1979, 97

74 A Birch, 'The Haigh Ironworks 1789-1856; a nobleman's enterprise during the industrial revolution', *Bulletin of the John Rylands Library* 35 (1953), 316-34

and Watt made all the components for steam engines at their Soho Foundry and Fenton, Murray and Wood at their Round Foundry.[75]

There is strong evidence that much of the capital to renovate Haigh Estate and enhance the foundry came from the slave trade. King George III named the Earl of Balcarres Lieutenant Governor of Jamaica, where he served from 1794 to 1801.[76] In Jamaica he purchased plantations, employed hundreds of slaves and received thousands of pounds in compensation for his slaves.[77] It is reasonable to assume that he also profited from the sale of coffee and sugar produced on his plantations and that Haigh Foundry supplied iron goods to the plantations. On returning to Haigh in 1803, the Earl established an 'Aggrandising Fund' for the purpose of accumulating wealth for his family and in 1804 he appointed Daglish engineer at Haigh Foundry.[78] From 1835 to 1856, 114 locomotives were built at Haigh Foundry.[79] The Earl's Haigh and Holland Collieries, the Kirkless Hall Coal and Iron Co Ltd. and two smaller concerns formed the nucleus of the vast Wigan Coal and Iron Company established in 1865 as the largest joint-stock company in the country, excluding railways.[80]

To the east of the Pennines, landed gentry, London businessmen and local entrepreneurs had accumulated sufficient wealth to capitalize increasingly large collieries and early railways through the early nineteenth century.[81] Around Wigan, landed gentry and entrepreneurs had sufficient capital to get the ball rolling, but insufficient resources to capitalize large collieries and railways. Liverpool merchants and bankers, who had become wealthy from the slave trade, stepped in.

CONCLUSIONS

Geology was the major factor determining the location and sequence of collieries and, hence, railways. Local sources of funding soon became inadequate to finance ever larger operations and the Liverpool slave trade became a major source of capital for construction of the L&LC, collieries,

75 Anderson 1975, 201; R L Hills, *James Watt Volume 3: Triumph through adversity, 1785-1819* (Ashbourne, 2006); H Gomersall, 'The Round Foundry of Leeds', in *Early Railways 3: Papers from the Third International Railway Conference*, ed M R Bailey (Sudbury, 2006), 260-9

76 Daglish 1993, 124

77 Williams 1944, 94; D Alvarado, R Crick and E Figueroa, Jr., *The application of field geophysics for reconnaissance of a Jamaican slave village and the surrounding area* (DCO http://keckgeology.org/files/pdf/symvol/; U B Phillips, *American Negro Slavery* (D Appleton and Company, New York and London, 1918) (DCO http://books.google.com, accessed 2 January, 2012)

78 Anderson and France 1994, 52; Daglish 1993, 123

79 Birch 1953, 332

80 Anderson and France 1994, 64, 89

81 L Turnbull, The Montagu Family of East Denton Hall (DCO http://www.mininginstitute.org.uk/papers/TurnbullMontagu.html, 2003-7, accessed 3 March, 2012); L. Turnbull personal contact 8 March 2012

private railways and the *Walking Horse*. It was the unique challenge of negotiating an incised valley, perhaps stimulated by high prices for horses and fodder, that led Clarke to finance construction of The Arches Viaduct, the *Walking Horse*, two other locomotives and a rack railway.

Clarke undoubtedly had full knowledge of Daglish's skills, enthusiasm and creativity and hired him as his colliery manager *c* 1810. Daglish built the *Walking Horse* and had it working by January 1813, when it became the third commercially successful steam locomotive in the world, the first steam locomotive to be built and operate in Lancashire, the first commercially successful steam locomotive in the world to cross a viaduct and the first successful steam locomotive in the world to haul fully-loaded wagons up a four per cent incline. The previous earliest date I can find for a steam locomotive possibly crossing a viaduct is 1816/7, when *The Duke* was set on the rails of the Kilmarnock and Troon Railway, part of which crossed the masonry Laigh Milton Viaduct.[82] The *Walking Horse* also was the first commercially successful locomotive in the world to have a wrought-iron boiler and chimney and a feed pump.

The Arches Viaduct, built by Clarke *c* 1790s, probably was the first masonry railway viaduct in the world: Risca Viaduct opened in 1805 and Laigh Milton Viaduct in 1811.[83]

Haigh Foundry was the second foundry in the world to construct a commercially successful steam locomotive. Haigh was the first foundry and Daglish the first engineer and colliery manager in the world to construct a steam locomotive that operated successfully for four decades. Clarke's Colliery was the first industrial enterprise to operate a steam locomotive successfully for four decades. Many tales in Winstanley and Orrell describe the *Walking Horse* as also carrying passengers.

The *Walking Horse* was not a simple replica of the first two Murray/Blenkinsop locomotives at Middleton Colliery and clearly incorporated independent engineering designs and developments by Daglish. There is a letter from Blenkinsop to Clarke regarding a royalty for using his rack system, but I have found no documentation of Murray and Daglish discussing engine design.[84] Scott states that Murray must have had the order for the locomotives in 1810 for him to deliver them in 1812.[85] Applying the same logic, Daglish also must have had an order for a locomotive *c* 1810 to

82 R Paxton, 'An Engineering Assessment of the Kilmarnock & Troon Railway 1807-46 ', in *Early Railways: A Selection of Papers from the First International Early Railways Conference*, eds A Guy and J Rees (Newcomen Society, 2001), 95-100

83 T Jukes, *The development of Risca* (DCO http://www.riscamuseum.org.uk/risca.html, 2004-2011, accessed March 19, 2012); Paxton 2001

84 J Blenkinsop, letter, 22 February 1813 cited by Daglish 1993, 126

85 Scott 1928, 69

operate it on a new railway in January 1813, just one month after the second locomotive became operational at Middleton Colliery.[86] And it is also important to note that some of Daglish's advances were evident in subsequent design recommendations and railway developments to the east of the Pennines: in June 1813, Blenkinsop recommended a wrought-iron boiler; in 1814 George Stephenson incorporated a wrought iron boiler and a 20 in diameter flue tube in his first locomotive at Killingworth Colliery; and in 1825 Middleton Colliery Railway had four-feet rails.[87]

In summary, the *Walking Horse* and its railway demonstrated advances in steam locomotion, especially improvements in power, reliability and stamina, the major benefits of which were realized with development of a new generation of railways in the 1820s and the opening of the M&LR in 1830. One of the three locomotives Daglish built and operated by 1816 was an adhesion locomotive and this must have been one of the first successful adhesion steam locomotives in the world.[88]

I conclude that cost probably was not a major deterrent to adopting early steam locomotives on Hustler's, Blundell's, Bankes' and German's Railways. These railways worked well with low-cost and low-risk gravity and horse power, and profits generally were high; with favourable gradients for loaded wagons all the way to the canal, there was a lack of incentive to adopt new and risky steam locomotives. At Clarke's Colliery, the adoption of early steam locomotives can be described as an adventurous and cost-effective luxury, as loaded wagons had been and could still have been hauled by horses. Stationary steam engines, on the other hand, although expensive, were necessary for pumping water from ever deeper mines. A new generation of more powerful locomotives became necessary when coal production became centralized in large collieries and greatly exceeded 100,000 tons per year. Other industries and population growth also added to the demand for new arteries to transport large quantities of goods. Of course, synergies between new technologies, increasing coal production and improved transportation were the hallmark of the Industrial Revolution and new arteries and mining technologies also made possible much higher coal output from large collieries with deeper mines.

86 Bye 2012
87 Marshall 1953, 46; Scott 1928, 64; Calvert 1999
88 Daglish 1856