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ICE Cheshire Branch & the Historical Engineering SIG present:

The Paul Dunkerley Memorial Lecture - Modular Cast Iron Bridges & Their Significance

Date: Thursday 18th October 2012

Time: 18:30 (Refreshments from 18:00)

Venue: Chester College of Law, Pepper Street, Christleton, CH3 7AB

Speaker Professor Roland A, Paxton

Topic

ICE Cheshire Branch, together with the Historical Engineering Special Interest Group proudly present this years lecture in memory of Paul Dunkerley. The lecture will outline the origin and development of cast iron bridge-building from the first large iron bridge in 1780 at Coalbrookdale to the widespread adoption of the genre nationally by 1830. It will highlight the leading roles of Thomas Telford, William Hazledine and effective modular construction in this achievement, exemplified by the Mythe Bridge, Pontcysyllte Aqueduct and other works. Reference will also be made to the influence of the bridge type on subsequent development, surviving examples and recording and conservation of the best examples.

Please pre-register your attendance using the advanced booking system via the ICE website events page.

For further information contact: **Thomas Coon**

t 01925 542408 or e thomas.coon@environment-agency.gov.uk

www.ice.org.uk/cheshire for information and booking

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Further Information About the Speaker

Engineering Historian, Professor Roland Paxton, is a Fellow of the Institution of Civil Engineers and a Fellow of the Royal Society of Edinburgh. He is vice-chairman of the Institution of Civil Engineers' [ICE] Panel for Historical Engineering Works (chairman 1990-2003), a trustee of the James Clerk Maxwell Foundation, chairman of the ICE Scotland Museum and chairman of the Forth Bridges Visitor Centre Trust.

Since 1990, after a career in local government on the planning, design and construction of large public works, he has engaged in teaching, recording and research in engineering history and conservation at Heriot-Watt University as an Honorary Professor, lecturing as far afield as Japan and California. His awards include an MBE, the Institution of Civil Engineers' Garth Watson Medal, and the American Society of Civil Engineers' History and Heritage Award. From 1992-2002 he served on the Royal Commission on the Ancient and Historical Monuments of Scotland.

In hands-on pursuance of his favourite discipline, which has included advice to central and local government, he was instrumental in 1996 in saving from collapse the world's oldest viaduct on a public railway near Kilmarnock after negotiating its purchase for £2! Also, with *Radar World*, in laying a Highland legend, by locating horse and cart remains accidentally entombed within a concrete pier of Robert McAlpine's Loch-nan-Uamh Viaduct on the West Highland Railway during its construction in c.1899.

Of more than 100 publications those most relevant to engineering history are, *100 years of the Forth Bridge (1990)*, 11 *Oxford Dictionary of National Biography* articles; 10 on Telford's work; *Bright Lights - The Stevenson Engineers* (1999) (with the late Jean Leslie); *Civil Engineering Heritage Scotland Highlands and Islands* and *Lowlands and Borders* (2007) (with Dr Jim Shipway); an assessment of the Stevenson Wick Breakwater failures of 1870-77 (2009); *John Rennie* (2011); and *Dynasty of Engineers: The Stevensons and the Bell Rock* (2011). He has taken part in numerous conferences, and BBC TV and radio documentaries.

CPD: This event may be considered for contributing to a recognised Continuing Professional Development (CPD) scheme as part of personal development. Delegates should check their individual scheme requirements.

Thomas Telford
1757 - 1834

William Hazledine
1763 -1840

John Rennie
1761 - 1821

Pre-1830 modular cast iron bridges and their significance

By Professor Roland Paxton
School of the Built Environment, Heriot-Watt University, Edinburgh
Vice-Chairman Institution of Civil Engineers' Panel for Historical Engineering Works

- **'modular'** – composed of standardised elements – a term particularly applicable to the precision of casting, in the case of tonight's topic, in iron, the use of which, with improved manufacture as the Industrial Revolution developed had become available in large quantities of high quality at a cost affordable for bridge-making.
- **Cast iron bridges** offered an alternative to masonry ones, the largest practicable span then being about 100 ft, and to timber bridges which although cheaper and capable of larger spans had UK life of only about three decades.
- Emphasis tonight will be on civil engineering aspects and the role of cast iron in bridge practice and extending spans.

TRANSPORT LANDMARKS 1760-1900

Improvements sustaining the *Industrial Revolution*:

MAIN ROADS **Significantly improved by Abercrombie, Telford & McAdam 1800-30** (then inter-city decline until c.1905)

CANALS Ship and narrow boat (**extensive network by 1800 but declined in use from 1830s**) – Bridgewater 1760, Forth & Clyde 1790, Caledonian 1822 and Manchester Ship 1894

RAILWAYS Iron plate-ways c.1800 – Liverpool & Manchester **from 1830 [first inter-city] - developed nationally by 1890**

BRIDGES WERE AN ESSENTIAL COMPONENT OF ALL

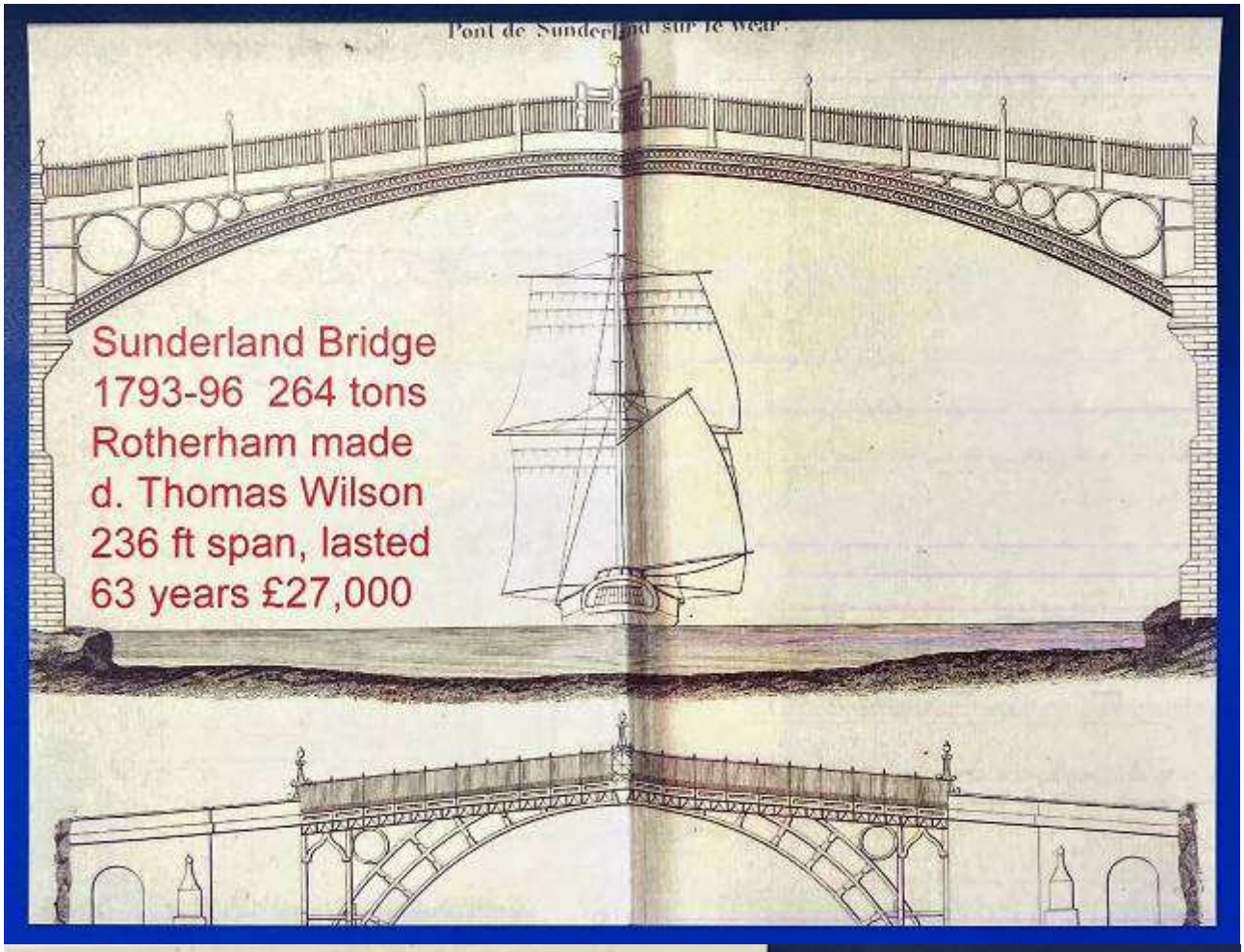
West Central England Iron-founding area.

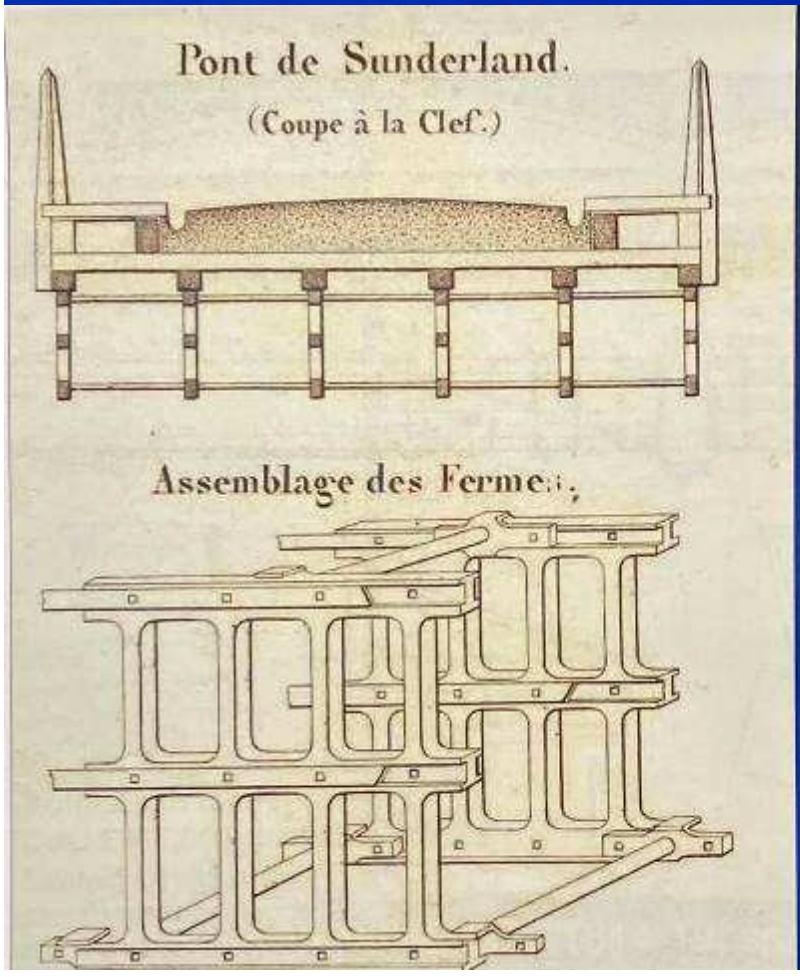
Ellesmere & Chester Canal

Note: Buildwas, Coalbrookdale Pont-y-cysyllte, Shropshire

The Iron Bridge, Coalbrookdale 1779 – 80 Span 100½ ft 380 ton
Designer: A. Darby III influenced by T. F. Pritchard architect
(Blackfriars Br., London 1769 had a 100 ft central stone span)

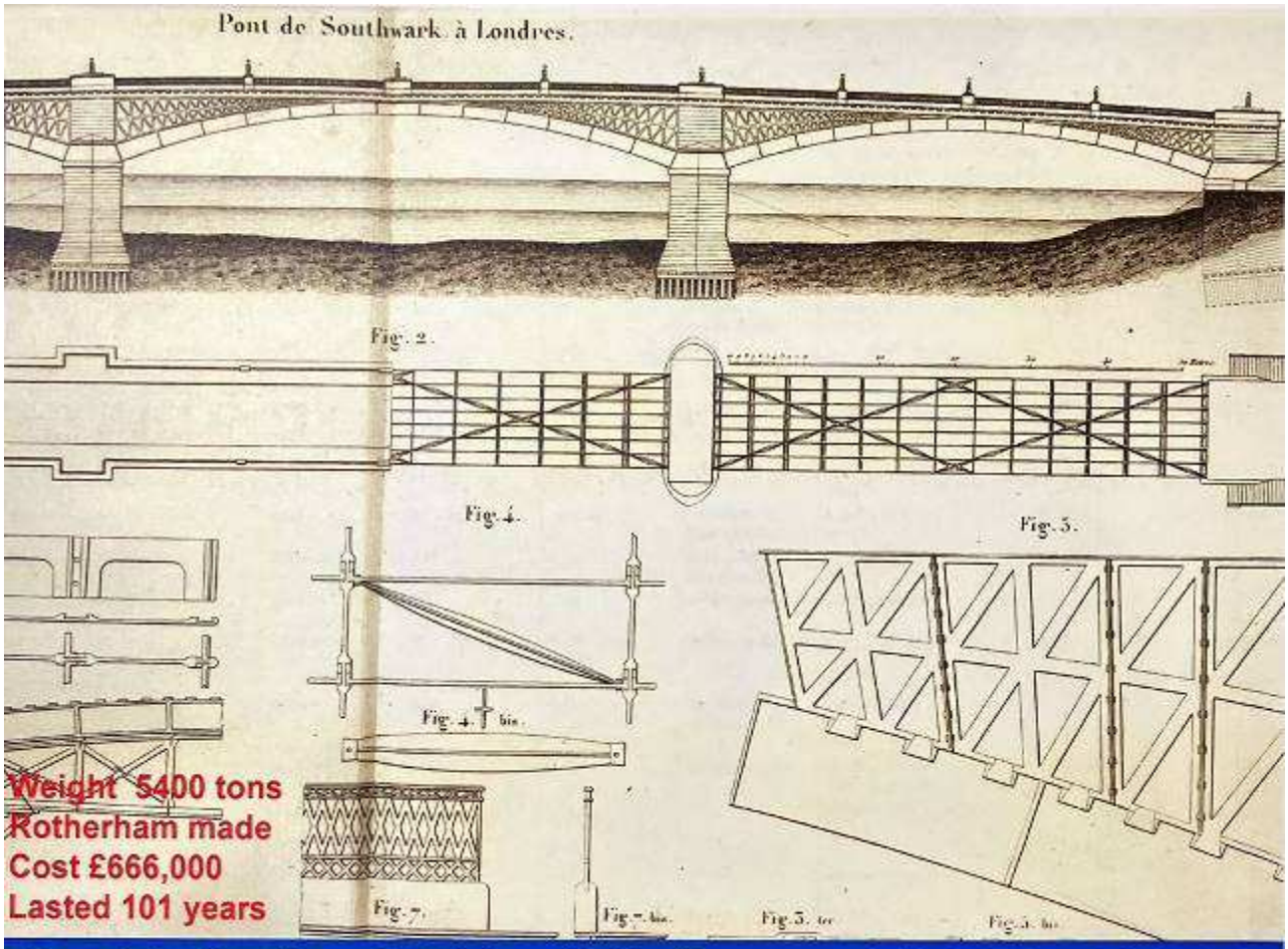
Buildwas Bridge, Salop, Telford 1796, had a 30%
greater span than the Iron Bridge for half its weight





Sunderland Bridge
1796
Engineer
Thomas Wilson

Rib castings
Held in place by horizontal straps – not a good idea as fracturing occurred - there were also sway problems, but these were fixed and the iron work lasted until the 1850s and the abutments until 1929



Weight 5400 tons
Rotherham made
Cost £666,000
Lasted 101 years

Rennie's Southwark Bridge 1814-19, spans 240 ft [73 m] & 210 ft

Table 1. A list of cast-iron bridges erected by 1830 with spans exceeding 32 m clearly indicates the dominance and durability of Telford's designs

Bridge	Engineer	Date built	Span: m	Rise-to-span ratio	Iron founder	Life	Cost: £	Weight of ironwork: t	St
Sunderland	Wilson	1793–96	70·7	0·144	Walkers, Rotherham	Perilous 1805 but fixed, lasted 132 years*	27 000 (modified 1859)	264	No
Buildwas	Telford	1795–96	39·6	0·13 & 0·26	Coalbrookdale Co.	Lasted 100 years	6444	176	No
Coalport	Onions	1799 & 1818	33·1		Banks & Onions	Weight limit 3 t	—	—	Yes
Staines	Wilson	1802–03	54·8	0·09	Walkers, Rotherham	Collapsed 1804	5660	274	No
Yarm	Wilson	1803–05	54·8	0·09	Walkers, Rotherham	Lasted 4 months	5660	274	No
Pont des Arts, Paris	Lemandé	1800–06	32·4	0·16	—	Lasted 48 years	—	—	No
Bridgnorth	Telford	1818–22	45·7	0·13	W Hazledine	Lasted 80 years	9736	183	No
Craigellachie	Telford	1812–14	45·7	0·13	W Hazledine	Strengthened 1964, pedestrianised since 1972	8200	183	Yes
Southwark	Rennie	1814–19	64·0 and 73·1	circa 0·1	Walkers, Rotherham	Lasted 101 years	666 486	5394	No
Chepstow	Rastrick	1815–16	34·1		R Hazledine/ Rastrick & Co.	Strengthened 1889	17 154	—	Yes
Betws-y-Coed	Telford	1815	32·1	0·10	W Hazledine	Strengthened 1923	—	—	Yes
Esk or Garrieston near Longtown	Telford	1820–22	32·1–32·1–45·7	0·10 – 0·10 – 0·13	W Hazledine	Lasted 94 years	12 827+		No
Eaton Hall Estate, near Chester	Crosley (Telford, design)	1824	45·7	0·13	W Hazledine/ W Stuttle (Jnr)	Weight limit 3 t	—	—	Yes
Mythe, Tewkesbury	Telford	1823–26	51·8	0·10	W Hazledine	Strengthened 1923 and 1992, weight limit 17·5 t	14 500	—	Yes
Cleveland, Bath	Goodridge	1827	33·5	0·10	W Hazledine	—	—	—	Yes
Holt Fleet, Ombersley	Telford	1827	45·7	0·13	W Hazledine	Strengthened 1923	—	—	Yes
Bigsweir, Wye	Hollis	1827–28	50·0	0·14	Bough & Smith, Merthyr Tydfil	Weight limit 17v5 t	—	—	Yes
Galton, Birmingham Canal	Telford	1829	45·7	0·10	Horsley Bridge Co.	Pedestrian use	—	345	Yes

Of 19 iron bridges in the world > 32 m by 1830, 18 in UK of which 9 to Telford's design (7 with Hazledine), 3 to Wilson's and 1 each to Rennie and others. 6 of Telford's still serve in some degree

Table 1. A list of cast-iron bridges erected by 1830 with spans exceeding 32 m clearly indicate

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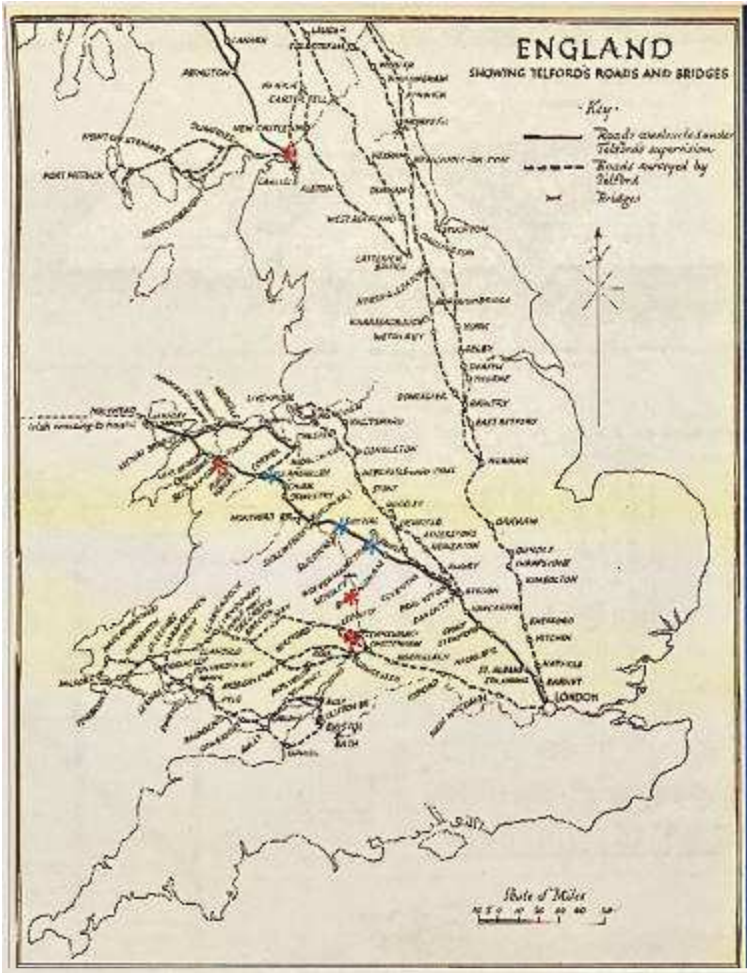
Sunderland	Wilson	1793–96	70·7	0·144	Walkers, Rotherham	
Buildwas	Telford	1795–96	39·6	0·13 & 0·26	Coalbrookdale Co.	
Coalport	Onions	1799 & 1818	33·1		Banks & Onions	
Staines	Wilson	1802–03	54·8	0·09	Walkers, Rotherham	
Yarm	Wilson	1803–05	54·8	0·09	Walkers, Rotherham	
Pont	Lamandé	1800–06	32·4	0·16	—	
d'Austerlitz, Paris	Ironfounders: WCEng+H 13: ECEng 4: SWales 1:France 1					
Bonar	Telford	1810–12	45·7	0·13	W Hazledine	
Craigellachie	Telford	1812–14	45·7	0·13	W Hazledine	
Southwark	Rennie	1814–19	64·0 and 73·1	circa 0·1	Walkers, Rotherham	
Chepstow	Rastrick	1815–16	34·1		R Hazledine/ Rastrick & Co.	
Betws-y-Coed	Telford	1815	32·1	0·10	W Hazledine	
Usk or Garrieston	Telford	1820–22	32·1–32·1–45·7	0·10 – 0·10 – 0·13	W Hazledine	
Eaton Hall Estate, near Chester	Crosley, (Telford, design)	1824	45·7	0·13	W Hazledine/ W Stuttle (Jnr)	Weight li
Mythe, Tewkesbury	Telford	1823–26	51·8	0·10	W Hazledine	Strength 1923 and weight li 17·5 t
Arch; rise/span 0.5 (1780); 0.13–0.144 (1796) to 0.10 by 1829						
Cleveland, Bath	Goodridge	1827	33·5	0·10	W Hazledine	—
Holt Fleet, Ombersley	Telford	1827	45·7	0·13	W Hazledine	Strength 1923
Bigsweir, Wye	Hollis	1827–28	50·0	0·14	Bough & Smith, Merthyr Tydfil	Weight 17v5 t
Galton, Birmingham Canal	Telford	1829	45·7	0·10	Horsley Bridge Co.	Pedestri
High Bridge, Handsacre	Potter	1829–30	42·7	0·10	Coalbrookdale Co.	Rehabili 1997

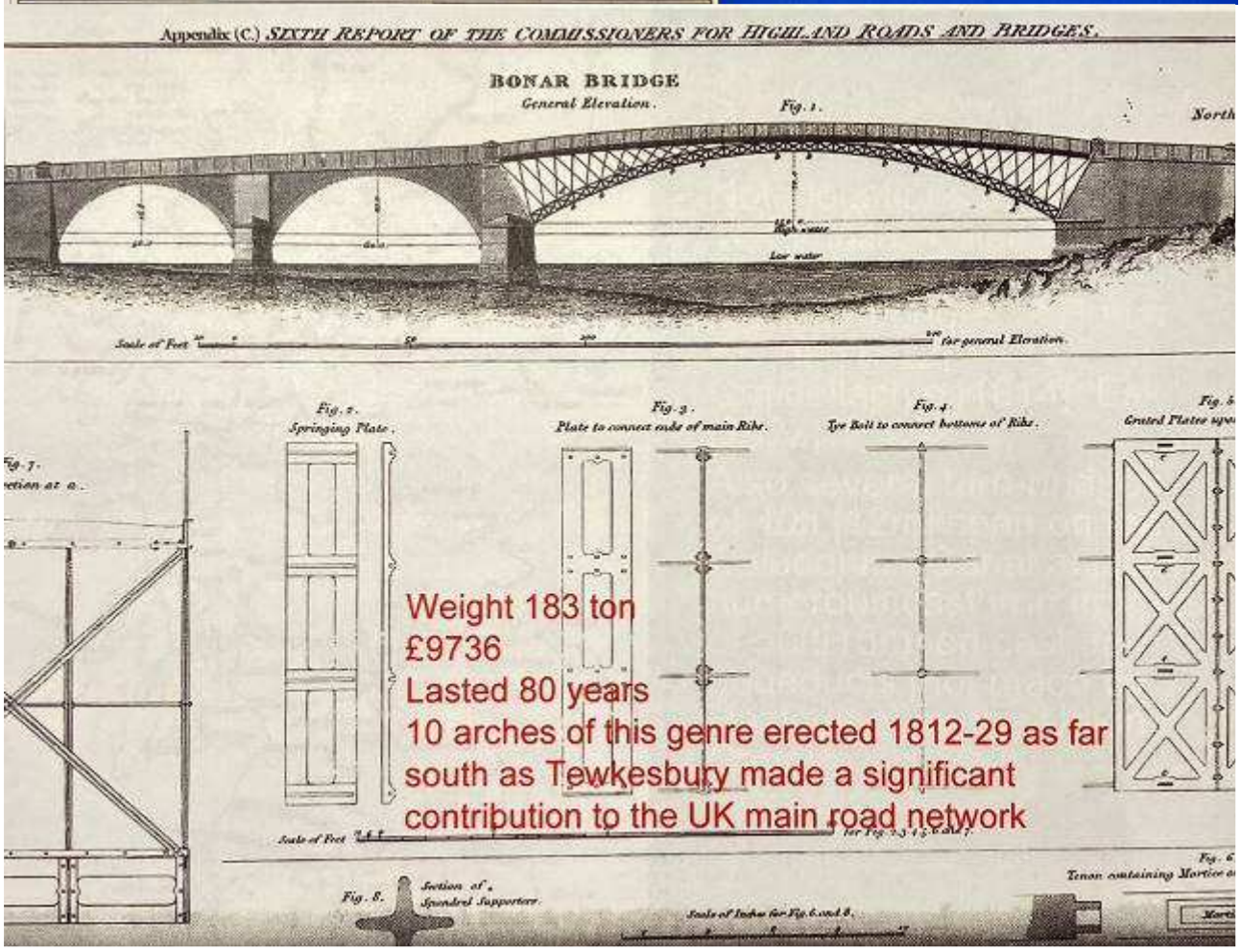
Notes
1. Excludes footbridges and bridges combined with timber or wrought iron (except fastenings).
2. Bridge costs and weights vary with sources and are provided only as an indication.
3. * A prototype of a 33·5 m promotional span to Paine's design was temporarily erected at Paddington Green in 1790.

Liffey ft/br 137¾ft span influenced by Telford's smaller iron bridges

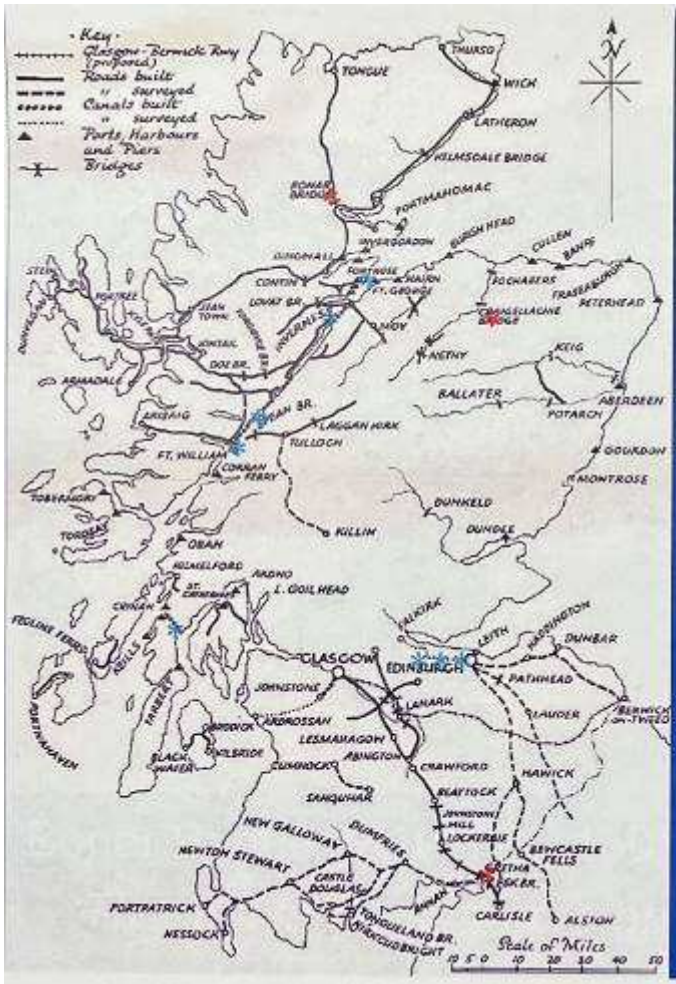


Telford was the Engineer for major parliamentary projects involving bridges in England, Wales and Scotland.

He was particularly interested in developing economical bridge spans, larger than practicable in stone, for difficult river crossings, where foundations in bad ground could be minimised or obviated



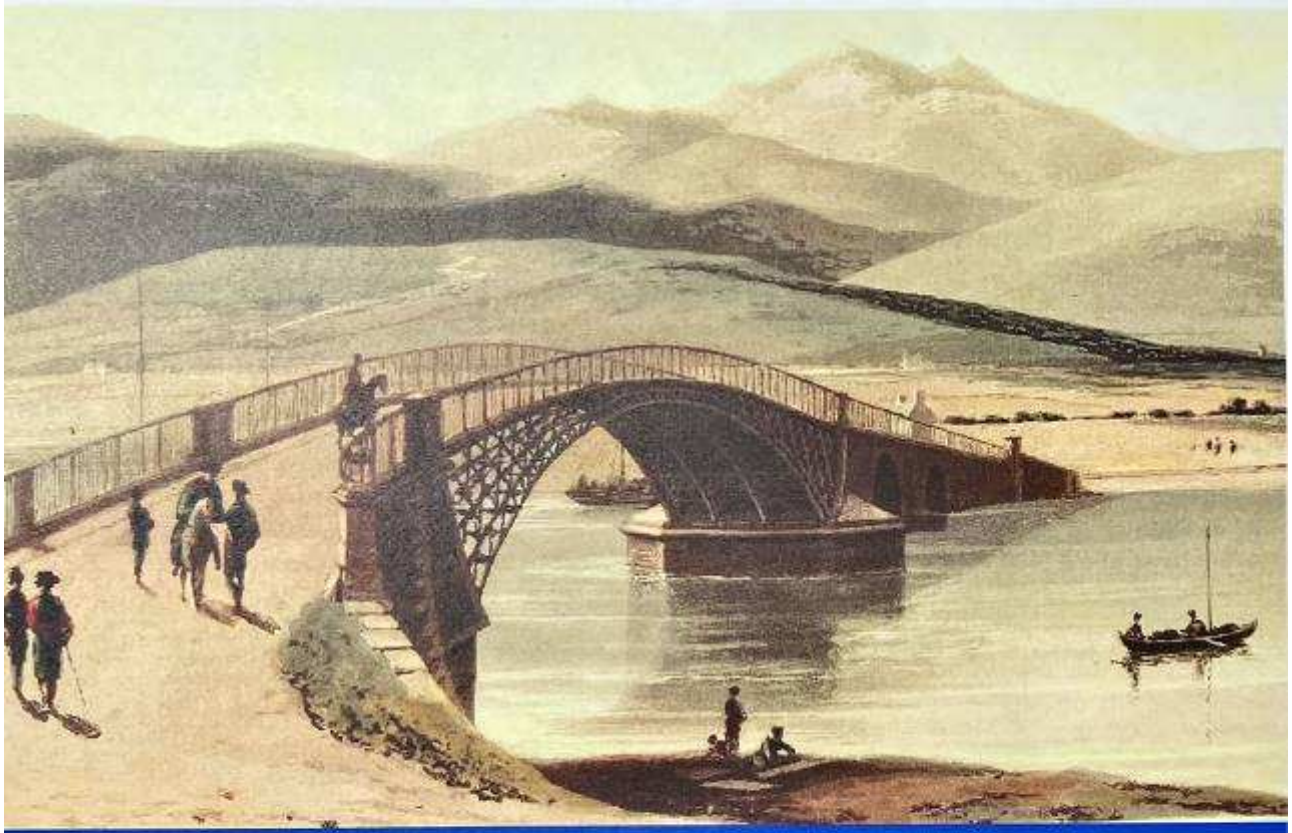
Weight 183 ton
£9736
Lasted 80 years
10 arches of this genre erected 1812-29 as far south as Tewkesbury made a significant contribution to the UK main road network



Scotland: Showing Telford works – [1790 -1834]

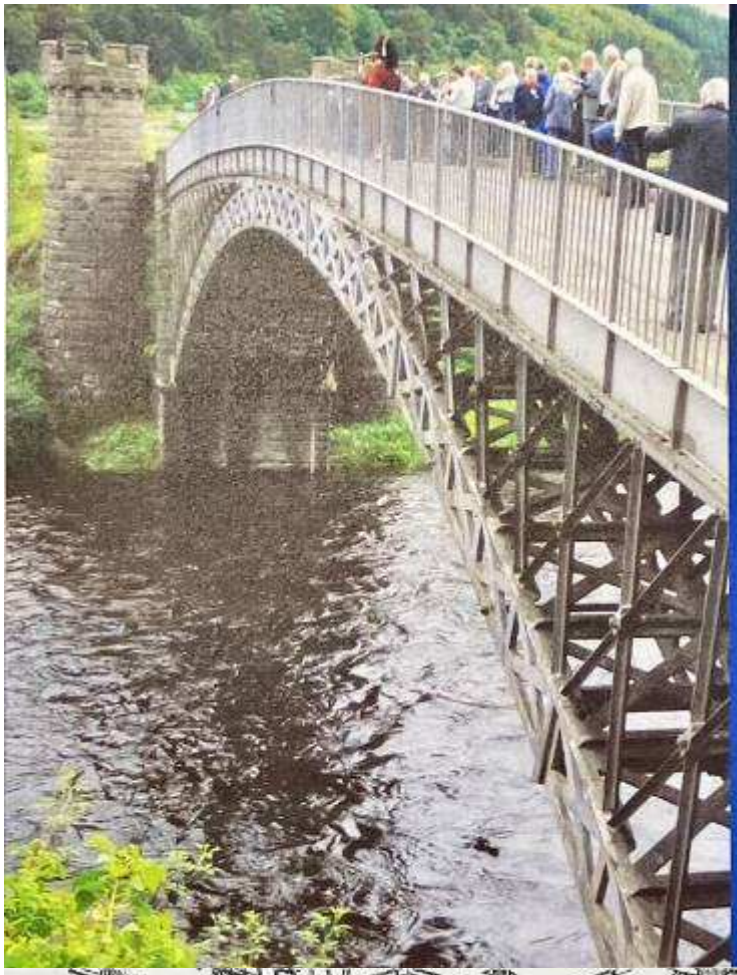
Note locations of Telford/Hazledine 150ft [46m] span cast iron modular bridges at Bonar Bridge [1812], Craigellachie [1814], Esk [1822]

Also several turn-bridges of 40ft [12m] span on the Caledonian Canal and numerous cast iron troughs of 50ft[15m] on cast iron aqueducts [not made by Hazledine] on the Union Canal



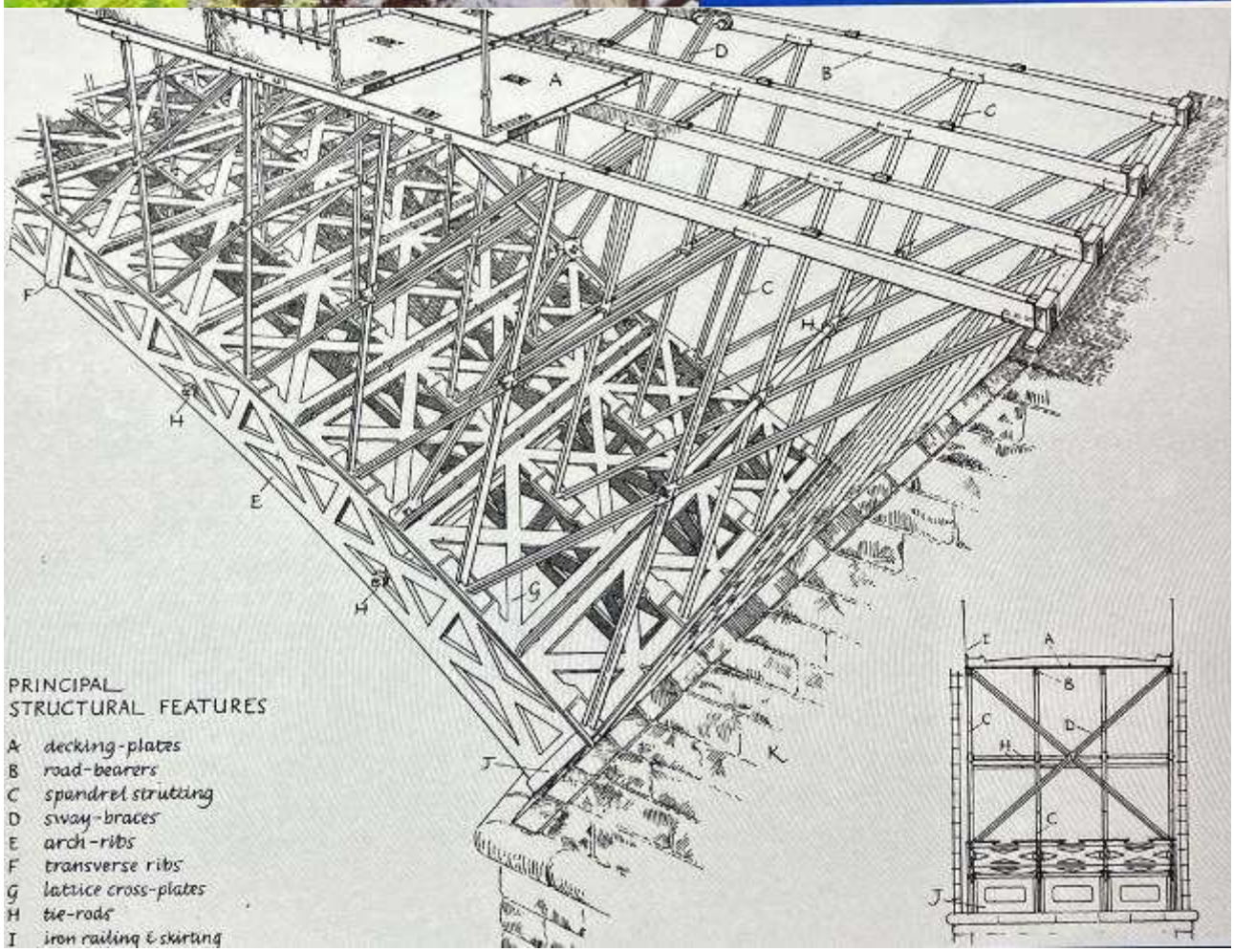
Bonar Bridge 1810-12 – 150 ft span (lasted until 1892)

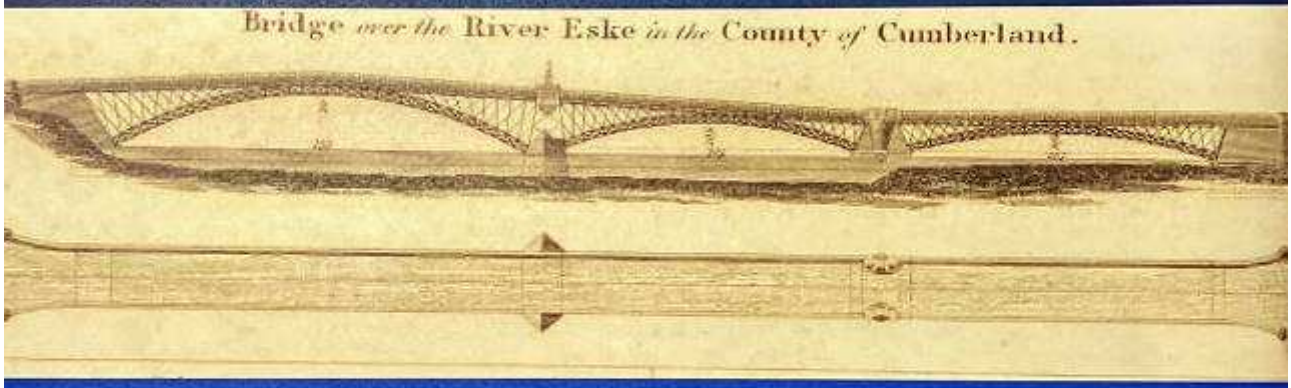
'The first large-span prefabricated cast iron bridge'



Craigellachie Bridge 1812-14, partly reconstructed 1964

'The earliest surviving prefabricated large-span cast iron bridge'

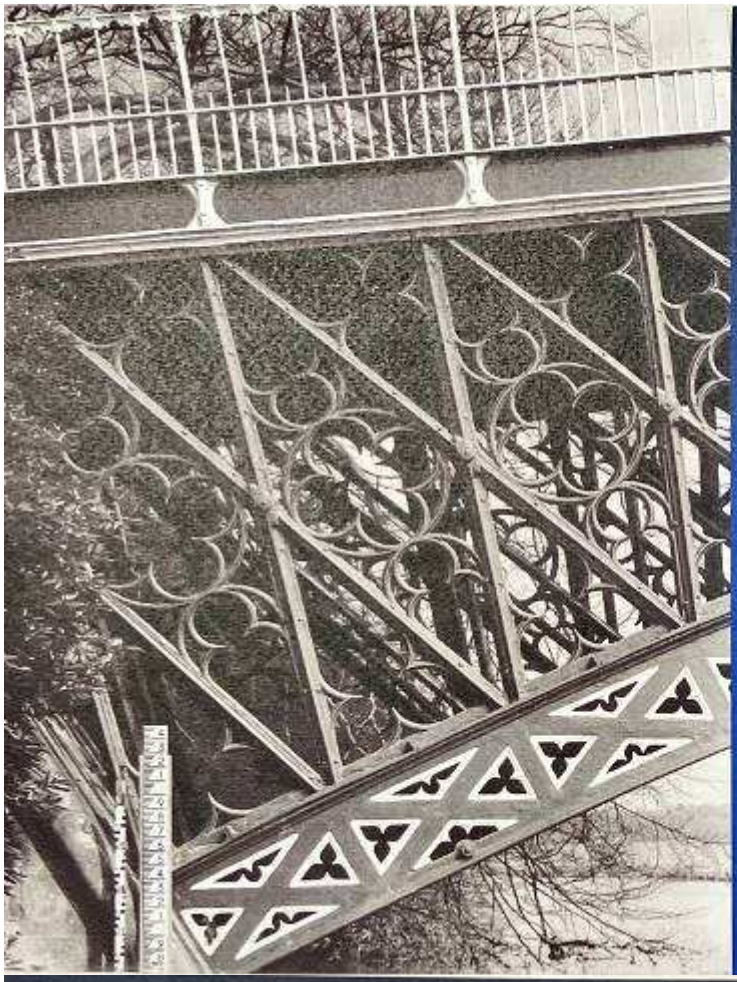




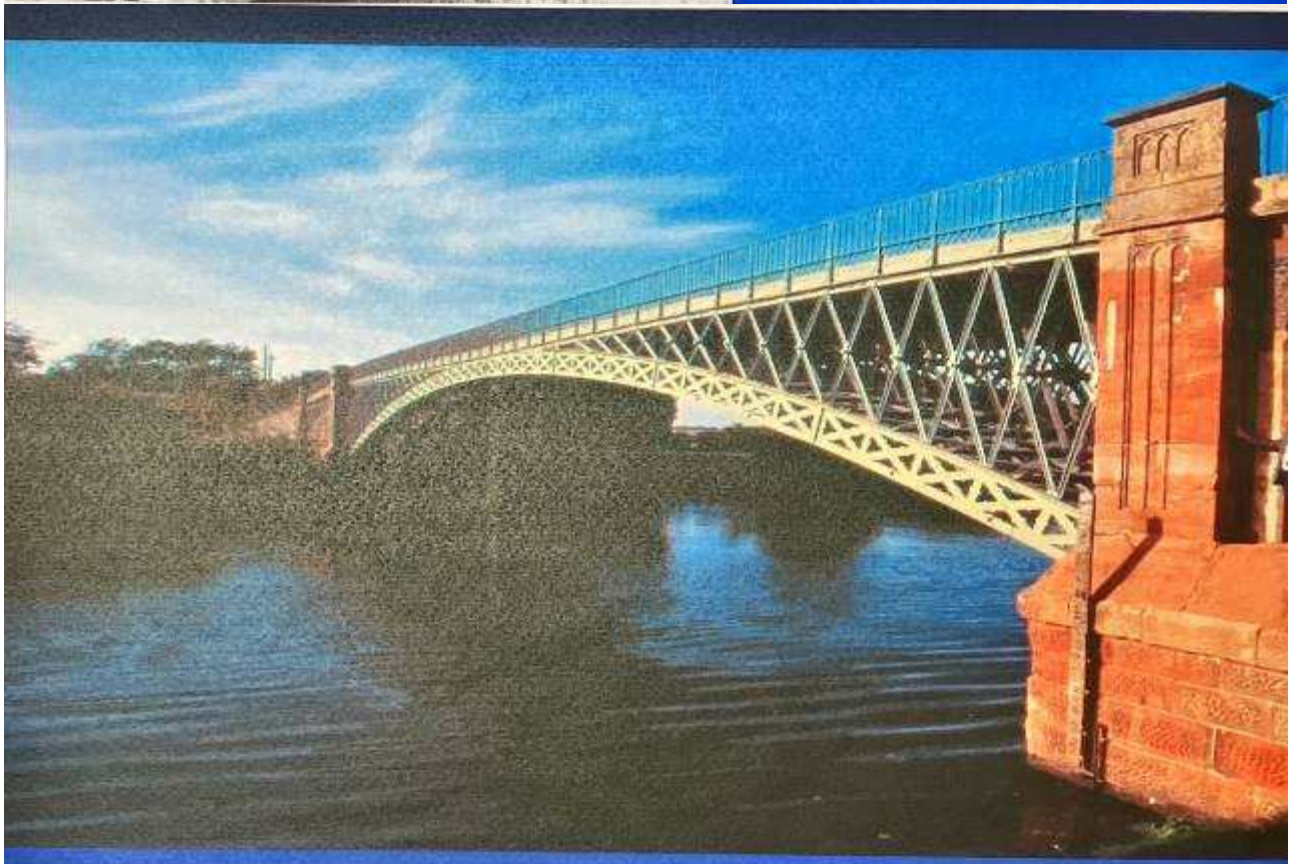
Glasgow and Carlisle Road 1815-25

Bridge erected over Esk 1820-22. £12827+

Near Metal Br Inn on A74.Lasted 94 years

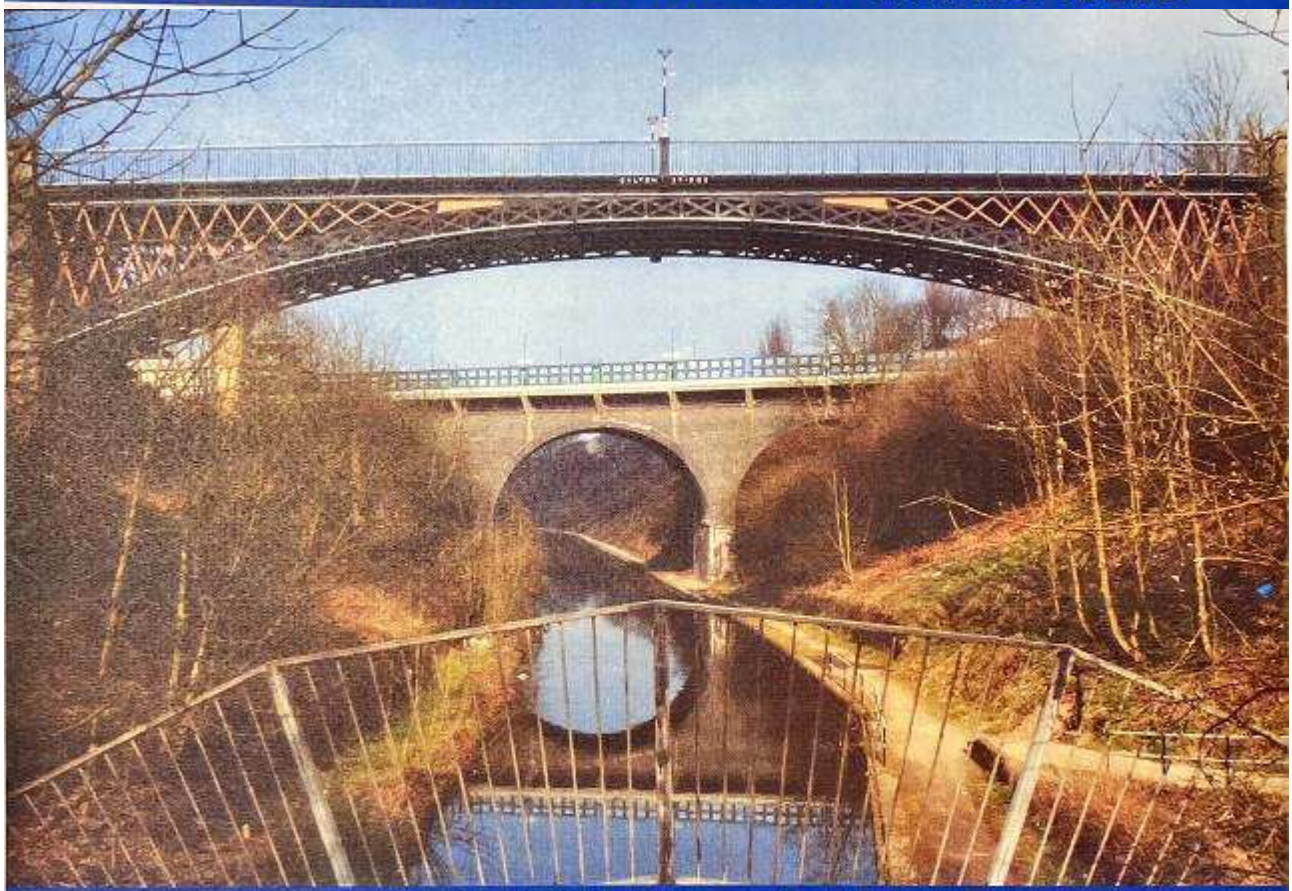


Eaton Hall Bridge
1824



Tewkesbury Bridge, R.Severn 1823-26 – On A438. Strengthened 1923, 1992. 17.5 t. Ultimate development of Bonar Bridge genre

London Bridge – Telford's proposed 600 ft cast iron span 1800-01, still under consideration until the 1820s

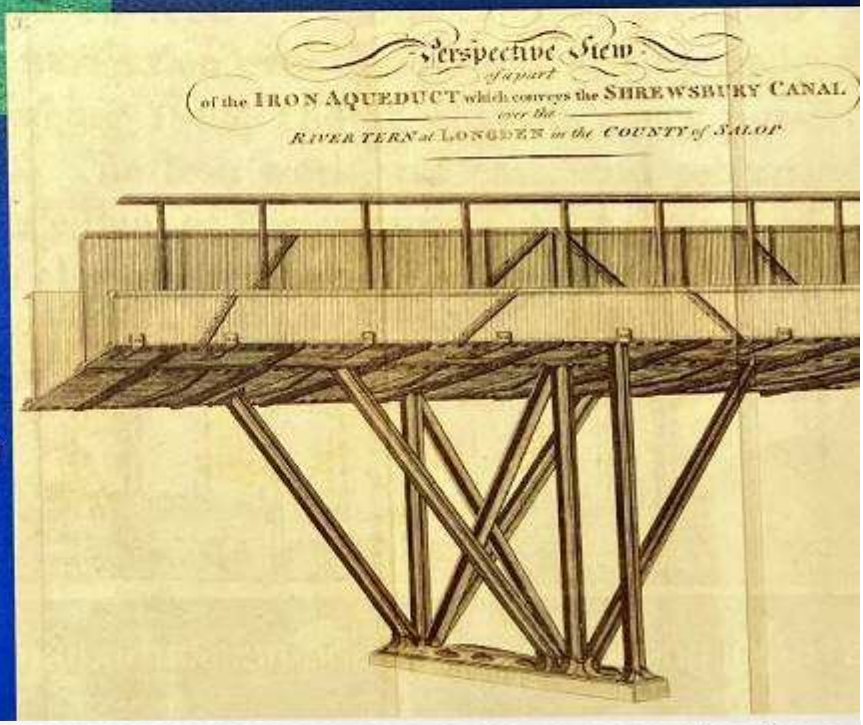


Galton Bridge - Telford 1829. Horseley Bridge Co. 345 tons

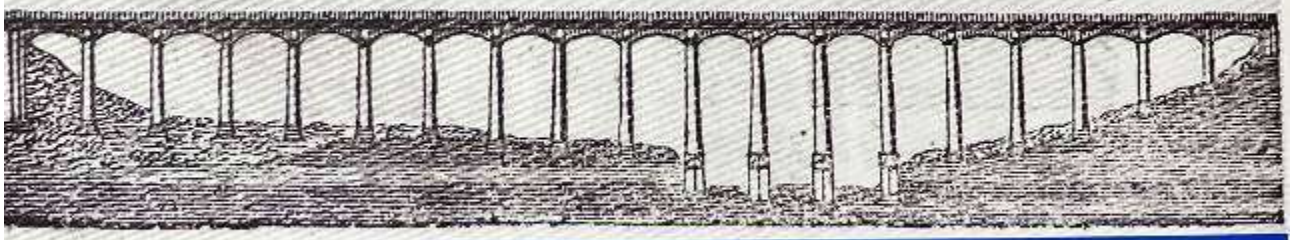
Longdon-on-Tern Aqueduct, Shrewsbury Canal 1795-96 .

Use of flanged joints to make flat arch, screw-bolts cruxiform cross-section struts.

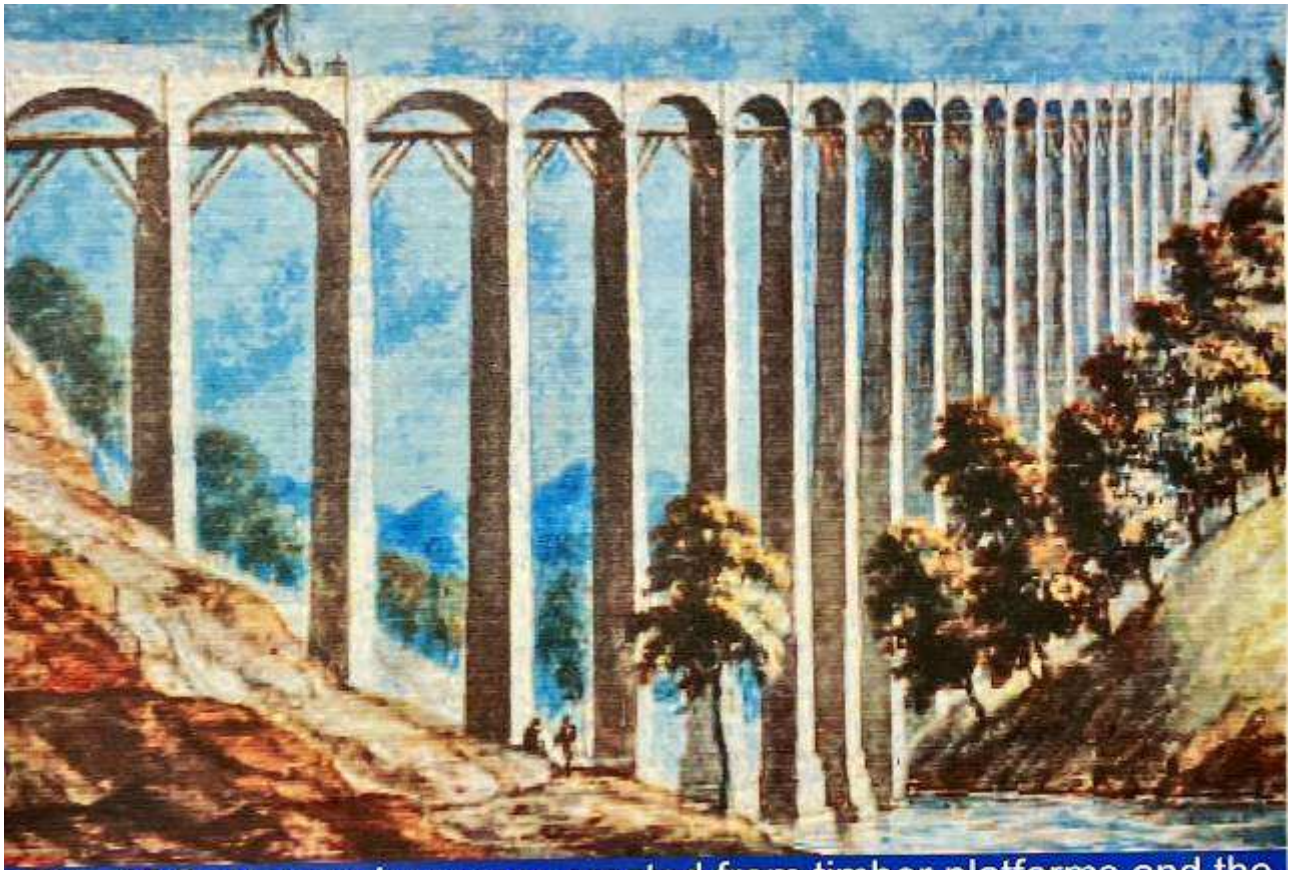
Wm Reynolds Ironfounder



Mr. Telford conceived the bold design of effecting this by means of an aqueduct constructed of cast iron, supported by stone pillars. These are 19 in number, including the abutments: the length of the aqueduct is 1020 feet, and the breadth across it 12 feet. It has been in constant use for the purposes of navigation ever since it was first opened, on the 26th of November 1805, and it answers every purpose perfectly well. The iron work was cast, and set up, by Mr. William Hazledine, of Shrewsbury. A small view of the elevation of this elegant structure is as here below.

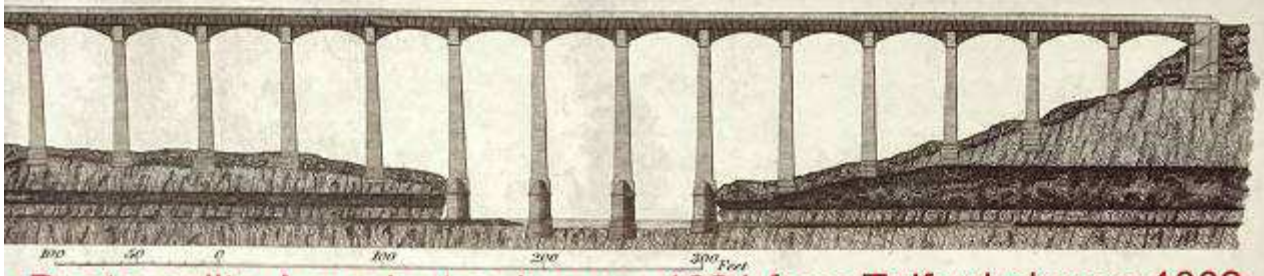


Charles Hutton FRS, mathematician and engineer, writing in 1812



The 45 ft span arches were erected from timber platforms and the trough was then assembled and built on top using a swivel-crane

Fig. 2. Pontcysylte Aqueduct.



Pontcysyllte Aqueduct redrawn c.1821 from Telford plans c.1802

Fig. 3. One Arch Pontcysylte.

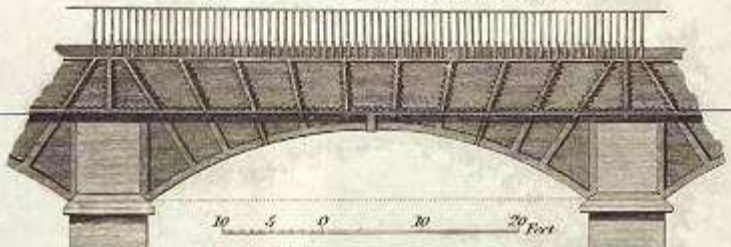
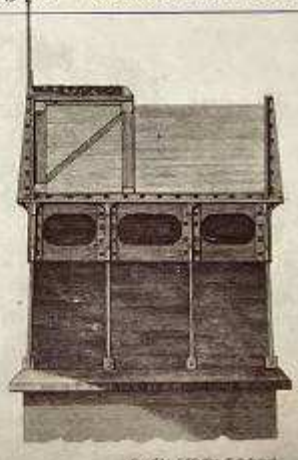


Fig. 4. Section Pontcysyl:

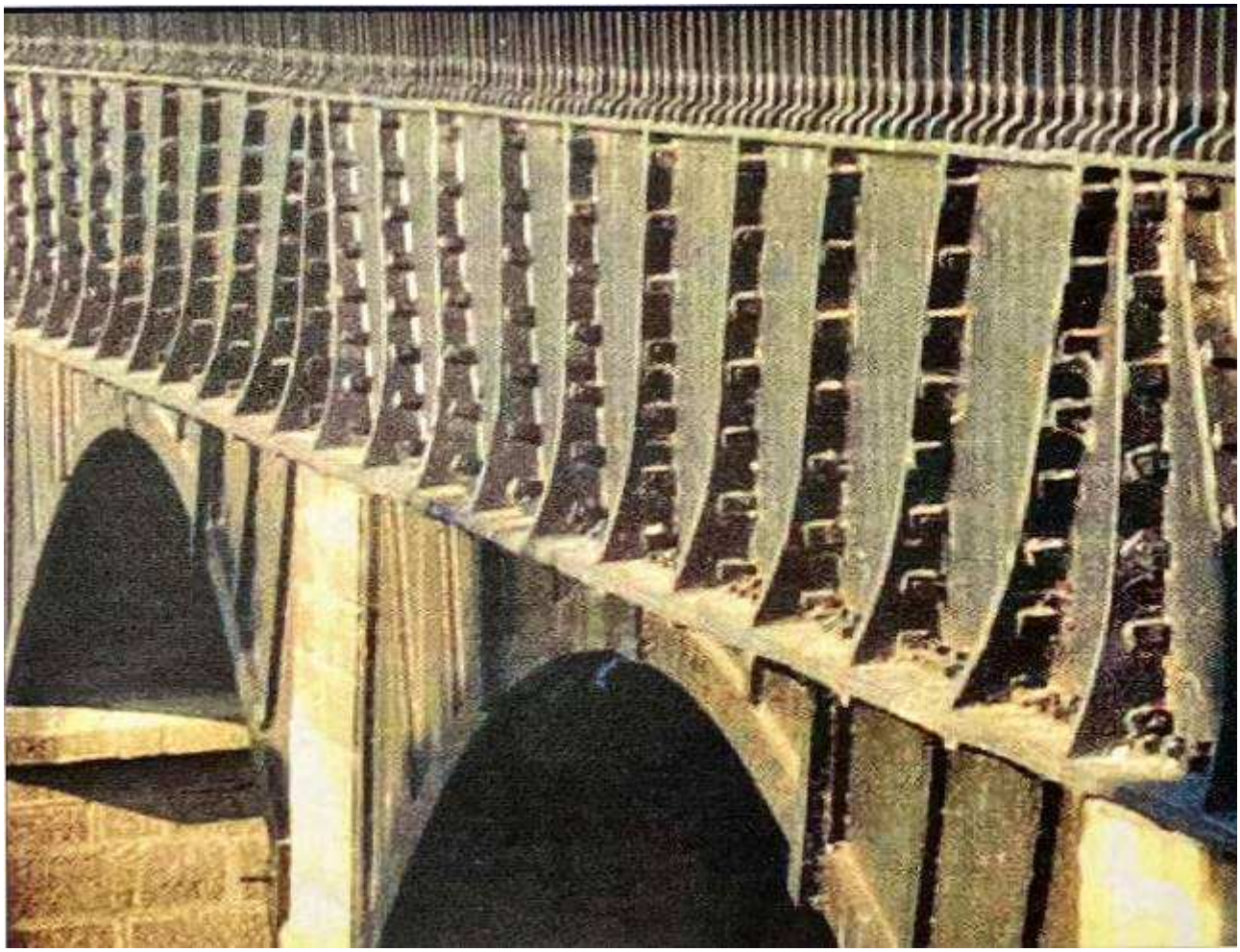


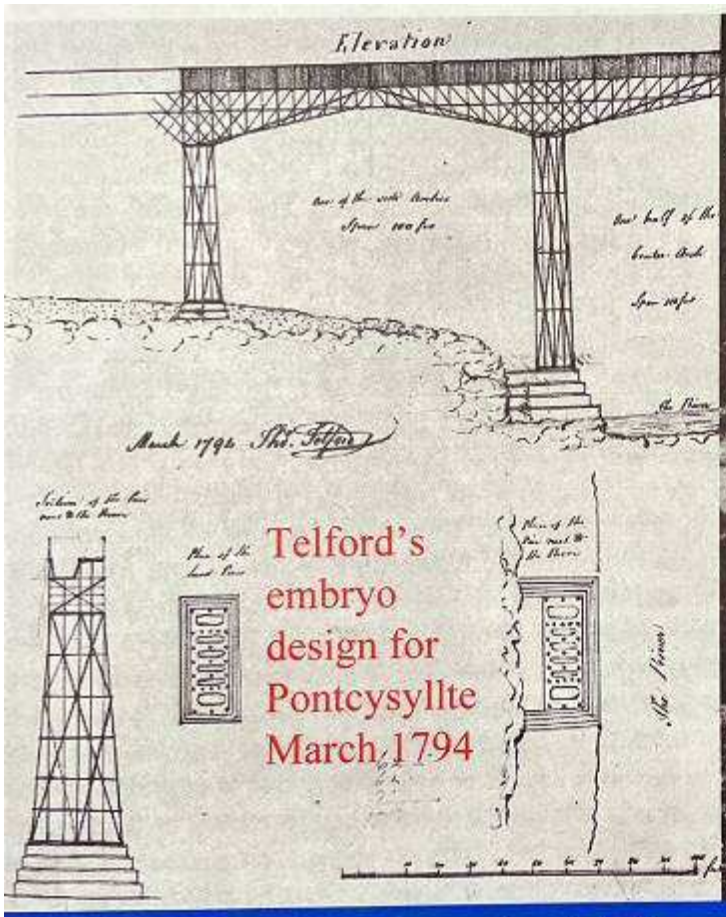
Span 44½ ft. Plates jointed with flannel coated with white lead, sides caulked with hemp rolled in tar

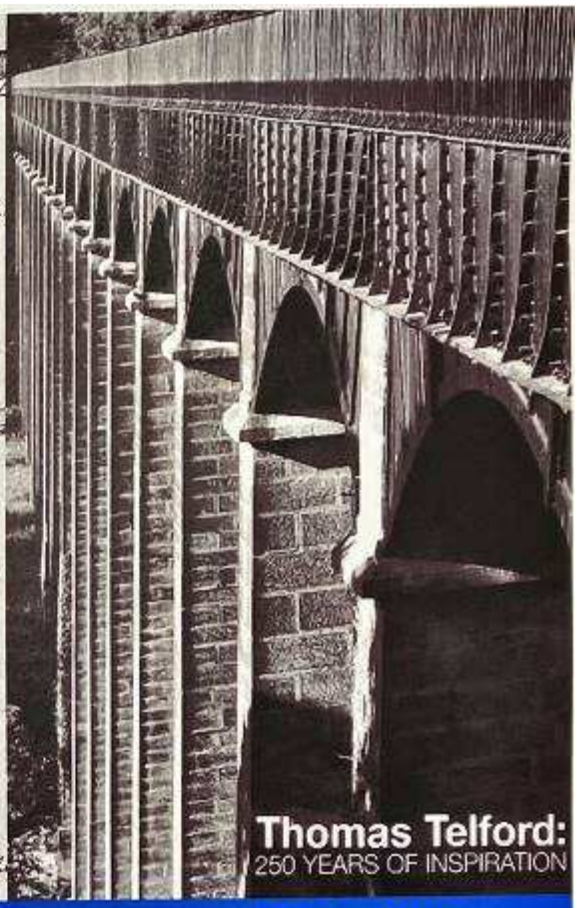
Pier at Springwood

Fig. 6. Cross tye Plate.

Fig. 7. Bottom Plate.







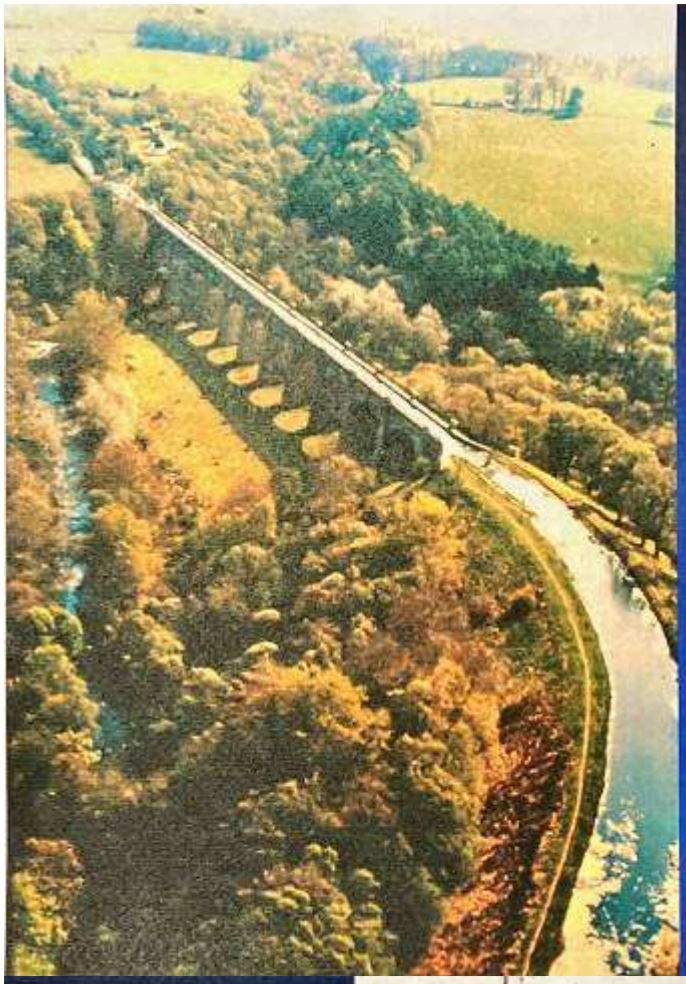
Pontcysyllte Aqueduct, Ellesmere Canal 1794-1805

Pontcysyllte Aqueduct, Ellesmere Canal 1795-1805

'Supreme structural achievement of the Canal Age'

Telford's wax seal 'TT' – on a letter of 1819

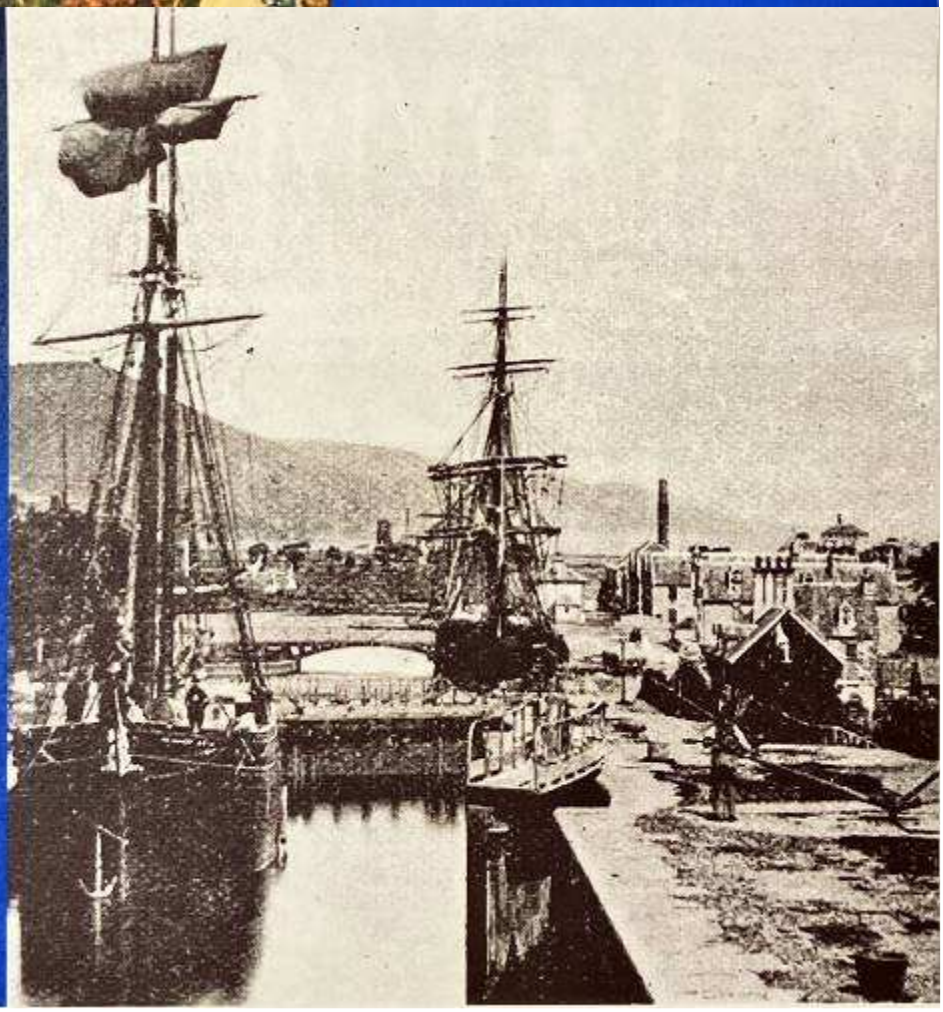
Birmingham & Liverpool Junction – Stretton Aqueduct



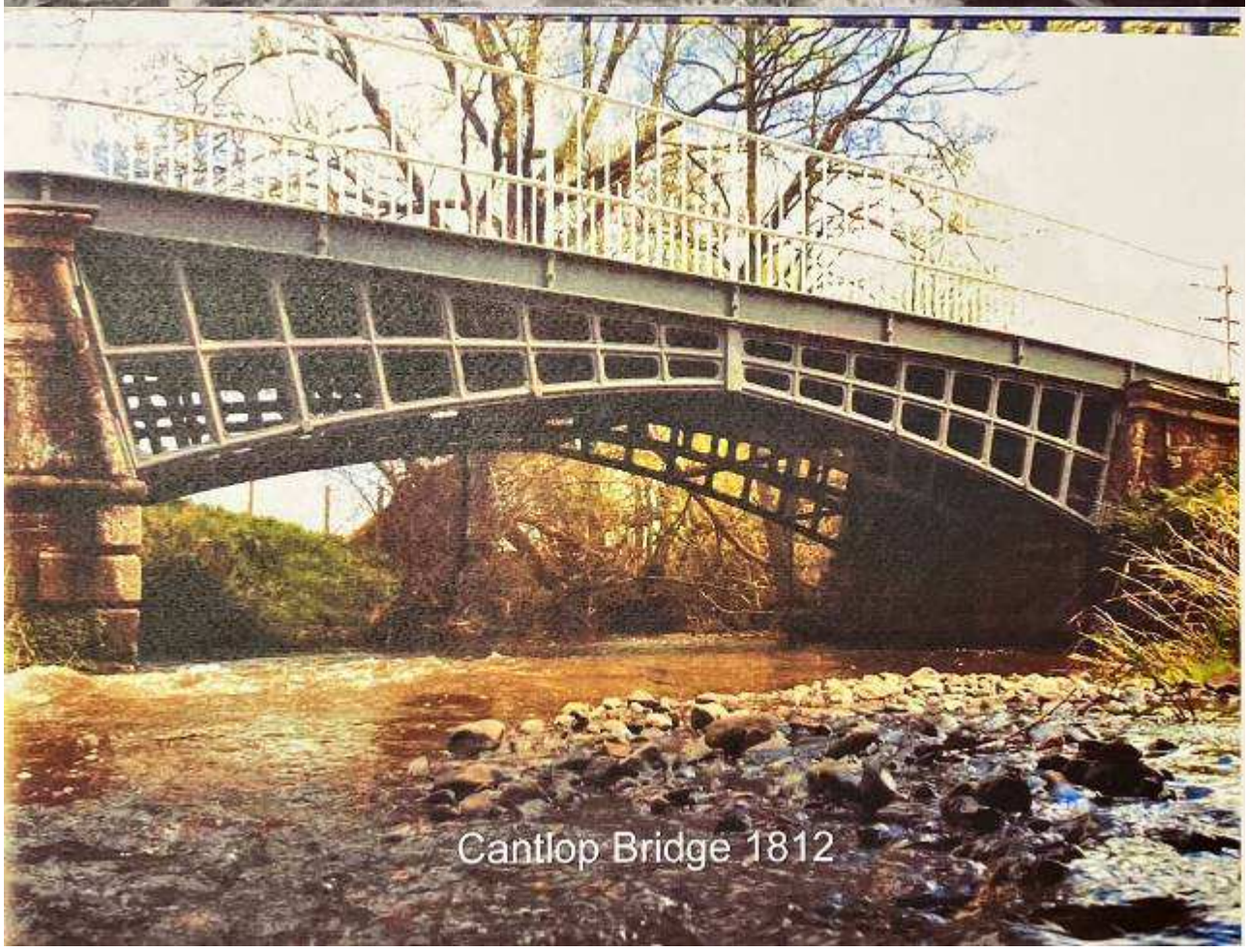
Edinburgh & Glasgow Union - Avon Aqueduct 1822

Telford was the consulting engineer. Hugh Baird - engineer

Caledonian Canal Muirtown Locks c. 1895




Moy Turn-bridge 1820
Caledonian Canal
Telford / Hazledine
40 ft span


Cantlop Bridge 1812

Liffey ft/br 137¾ft span influenced by Telford's smaller iron bridges

- Bonar Bridge 1810-12 with its lozenge-lattice spandrels was the epoch-making development in road bridge improvement before 1830. It also encouraged Rennie to change his practice and adopt plate ribs and lozenge-lattice spandrels in the world's longest cast iron span of 240 ft at Southwark.
- The Telford/Hazledine & Rennie/Walkers of Rotherham practice developed the iron bridge genre to the maximum practicable when, with the success of Menai Bridge (also a Telford/Hazledine masterpiece) wrought iron suspension and truss bridges began to take over the largest span role.
- Before 1830, Telford and Hazledine made a greater contribution than anyone else in applying prefabricated modular cast iron in main road bridge construction, and also, in 'the supreme structural achievement of the canal age'.
- After 1830, many smaller span cast iron bridges were built, often with larger elements, some with lozenge-lattice spandrels, until their demise with the advent of steel bridges.

Occasionally iron bridge appreciation takes on a more palatable form as evidenced by this 1861 whisky label!

FINIS