Union Chain Bridge 1820 – its origin, significance and future

a talk to *THE BERWICKSHIRE NATURALISTS' CLUB*
at HUTTON PARISH HALL on 20 May 2015 by

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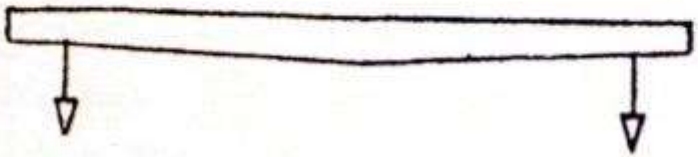
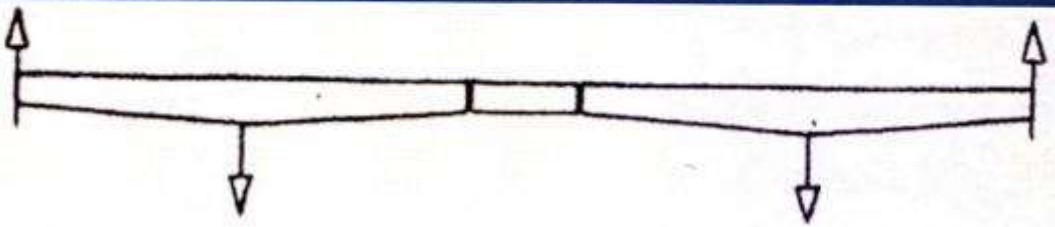
Ainslie's map 1789 showing multi-arch stone bridge crossings of R. Tweed then only at Coldstream [1767] and Berwick [1634]

MAIN BRIDGE TYPES

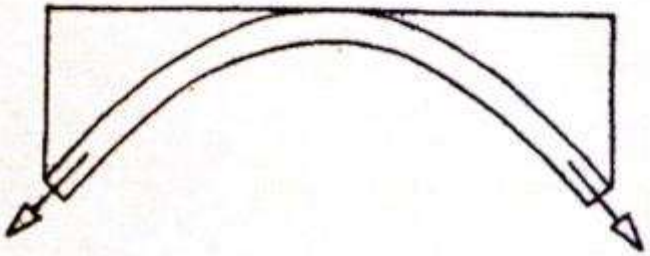
BEAM, ARCH, & SUSPENSION [and combinations]



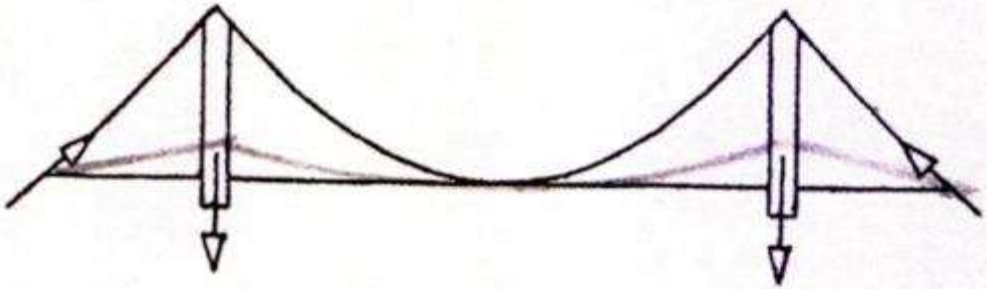
SIMPLE BEAM BRIDGE
Vertical weight only on ground



CANTILEVER BRIDGE
Vertical weight only on ground



ARCH BRIDGE
Outward thrust on abutment



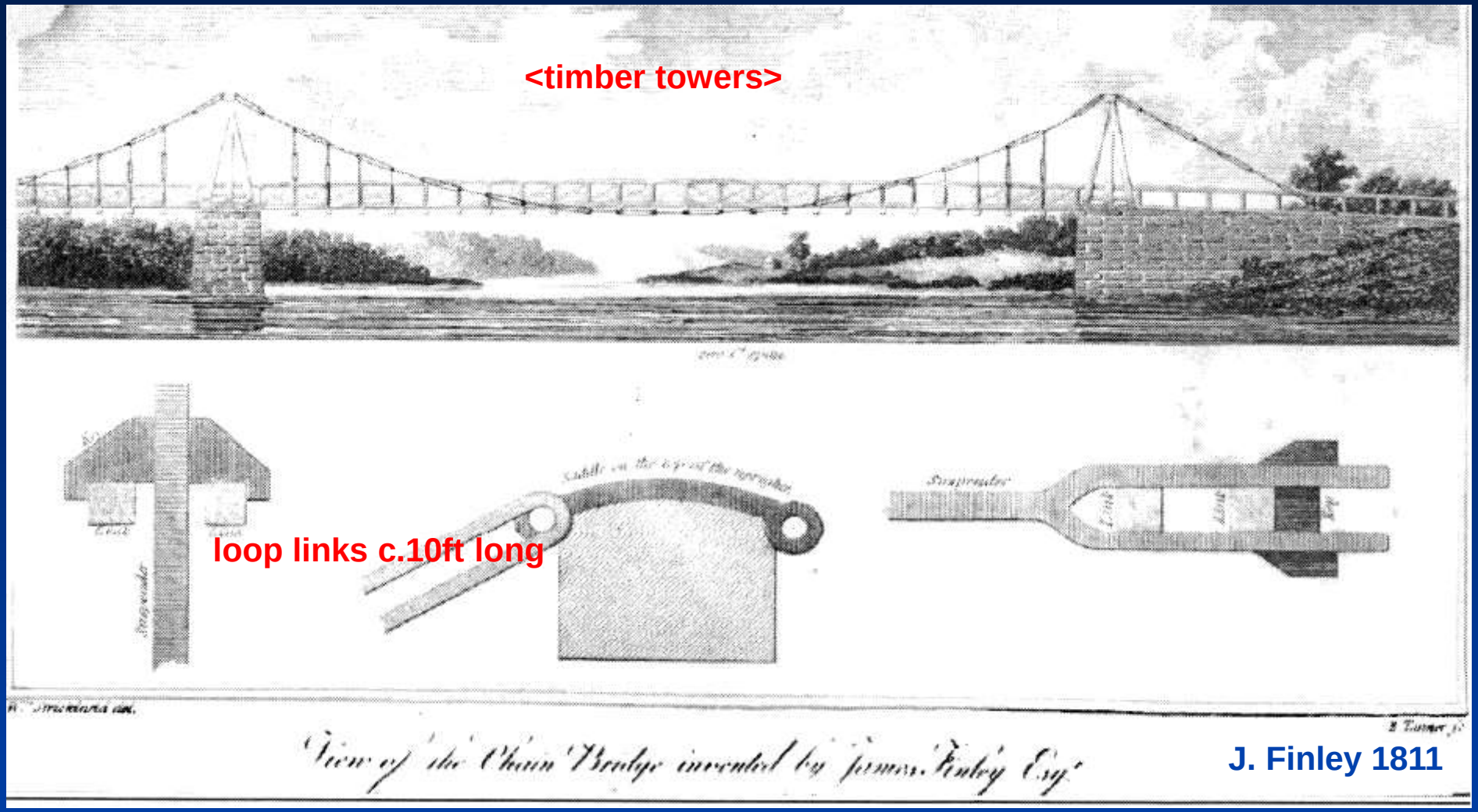
SUSPENSION BRIDGE
Inward pull on anchorage

Suspension bridges are important as the means of achieving the longest spans – iron types used in ancient China and from 1800 in USA by James Finley

UNION BRIDGE is a landmark in the progressive development of the world's longest iron spans i.e.

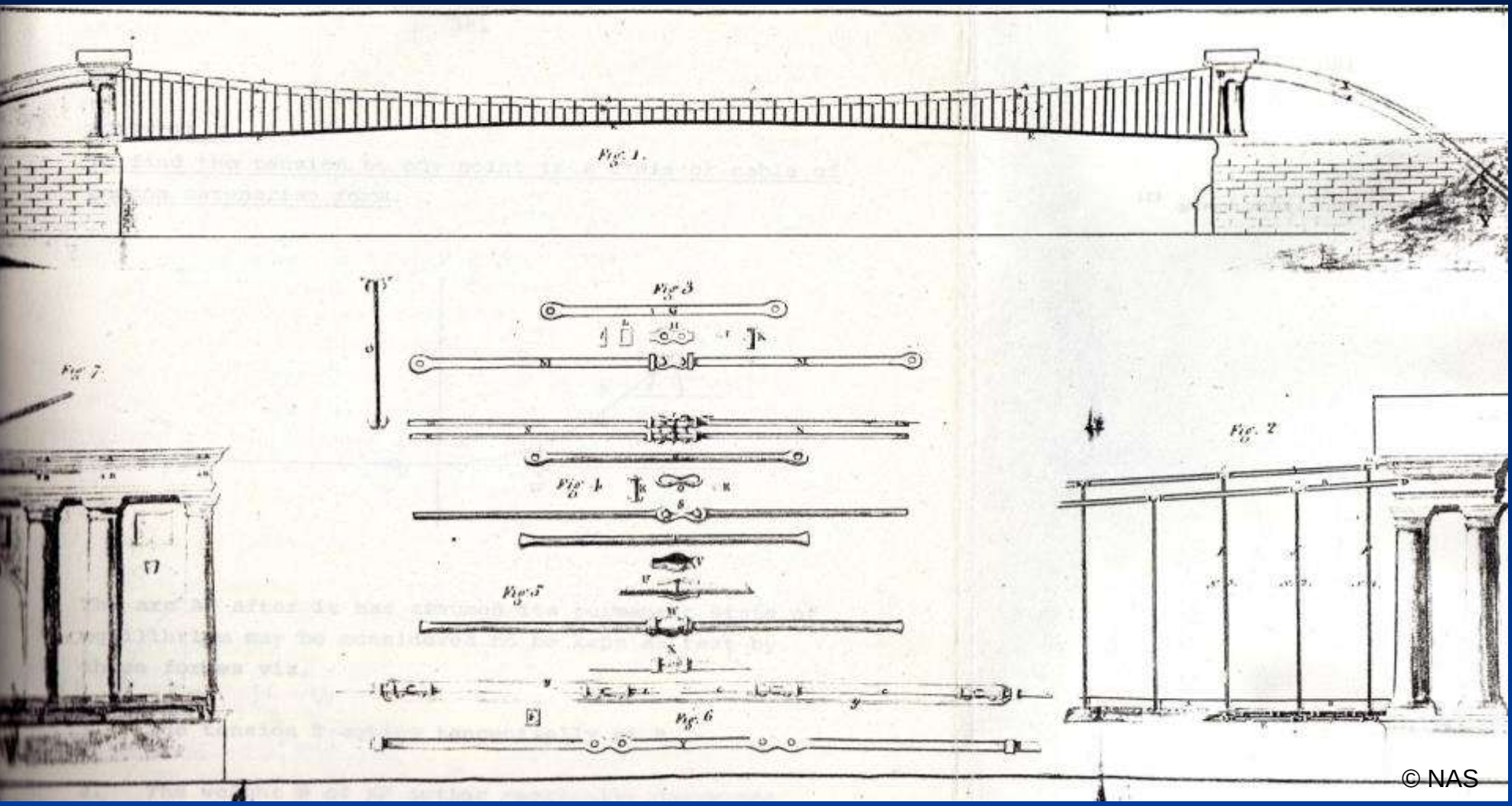
UNION, UK (1820) **437**ft, followed by:
MENAI, UK (1825) **580**ft [597ft between towers]
WHEELING, Ohio R, W.Virginia, USA (1849) **1010**ft
BROOKLYN, USA (1883) **1596**ft
FORTH [exceptionally a girder bridge] (1889) **1710**ft
GOLDEN GATE, USA (1937) **4200**ft
HUMBER, UK (1978) **4526**ft, and today,
AKASHI STRAITS, Japan (1998) **6532**ft

[*Guinness Book of Structures* – operational bridges]



J. Finley 1811

Numerous ingenious James Finley suspension bridges were erected in the USA from 1800 eg Merrimack Bridge, Newbury Port [1810] - span 244ft. Influenced Telford and Capt. Brown who were confident they could improve on Finley's practice

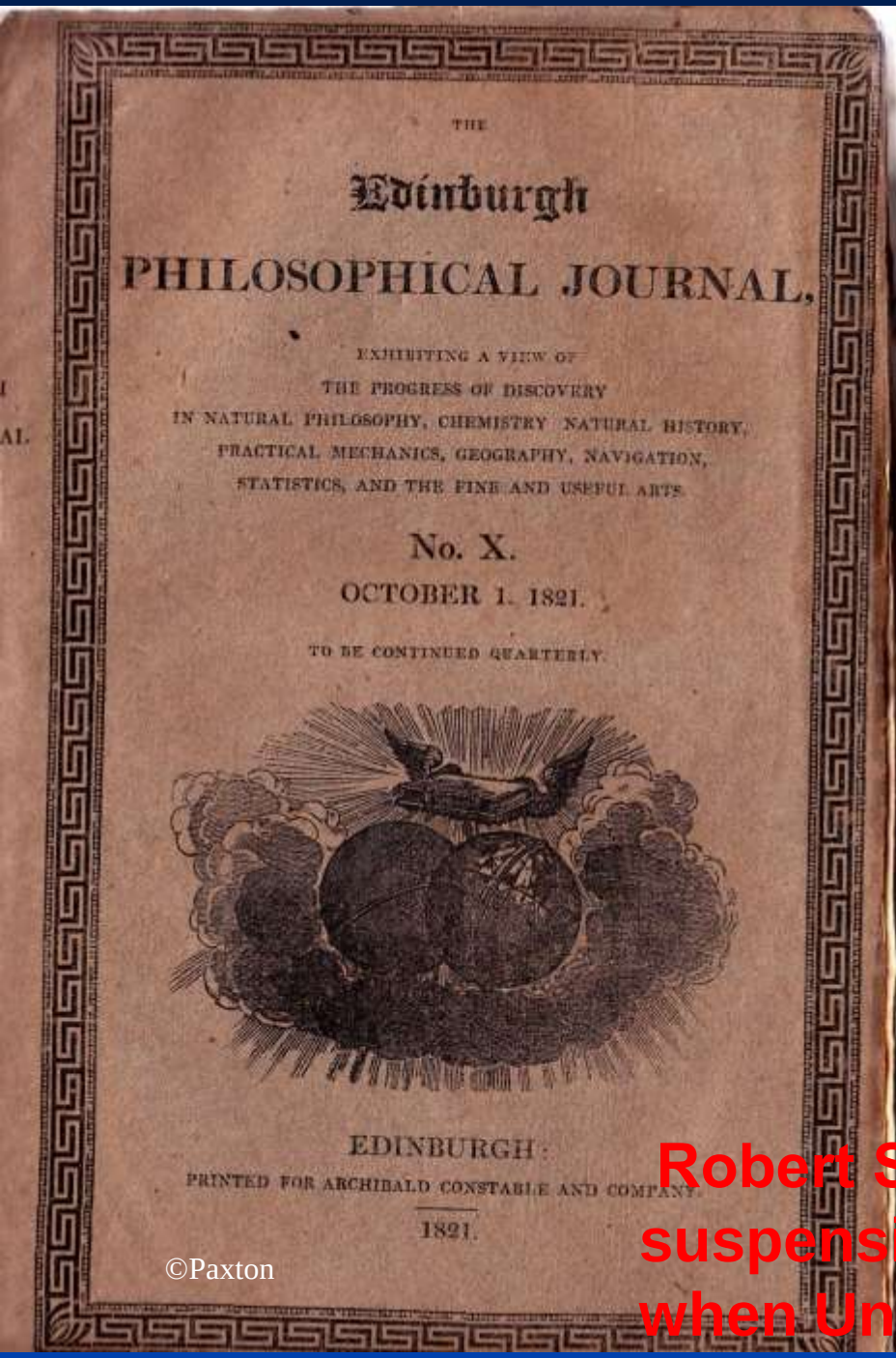


Brown's 1818 patent for using iron bar chains in suspension bridges. He became a leading exponent, erecting piers at Newhaven (Leith), and Brighton and bridges at Montrose, Aberdeen, Kalemouth and elsewhere. Re. bridge mechanics he took advice, in the case of Union Bridge, from John Rennie

Capt Samuel Brown (1774-1852) FRSE
Naval officer and chain manufacturer at London and Newbridge, South Wales

John Rennie (1761-1821) FRSE
Civil Engineer

UNION BRIDGE ENGINEERS



THE

Edinburgh

PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF
THE PROGRESS OF DISCOVERY
IN NATURAL PHILOSOPHY, CHEMISTRY, NATURAL HISTORY,
PRACTICAL MECHANICS, GEOGRAPHY, NAVIGATION,
STATISTICS, AND THE FINE AND USEFUL ARTS.

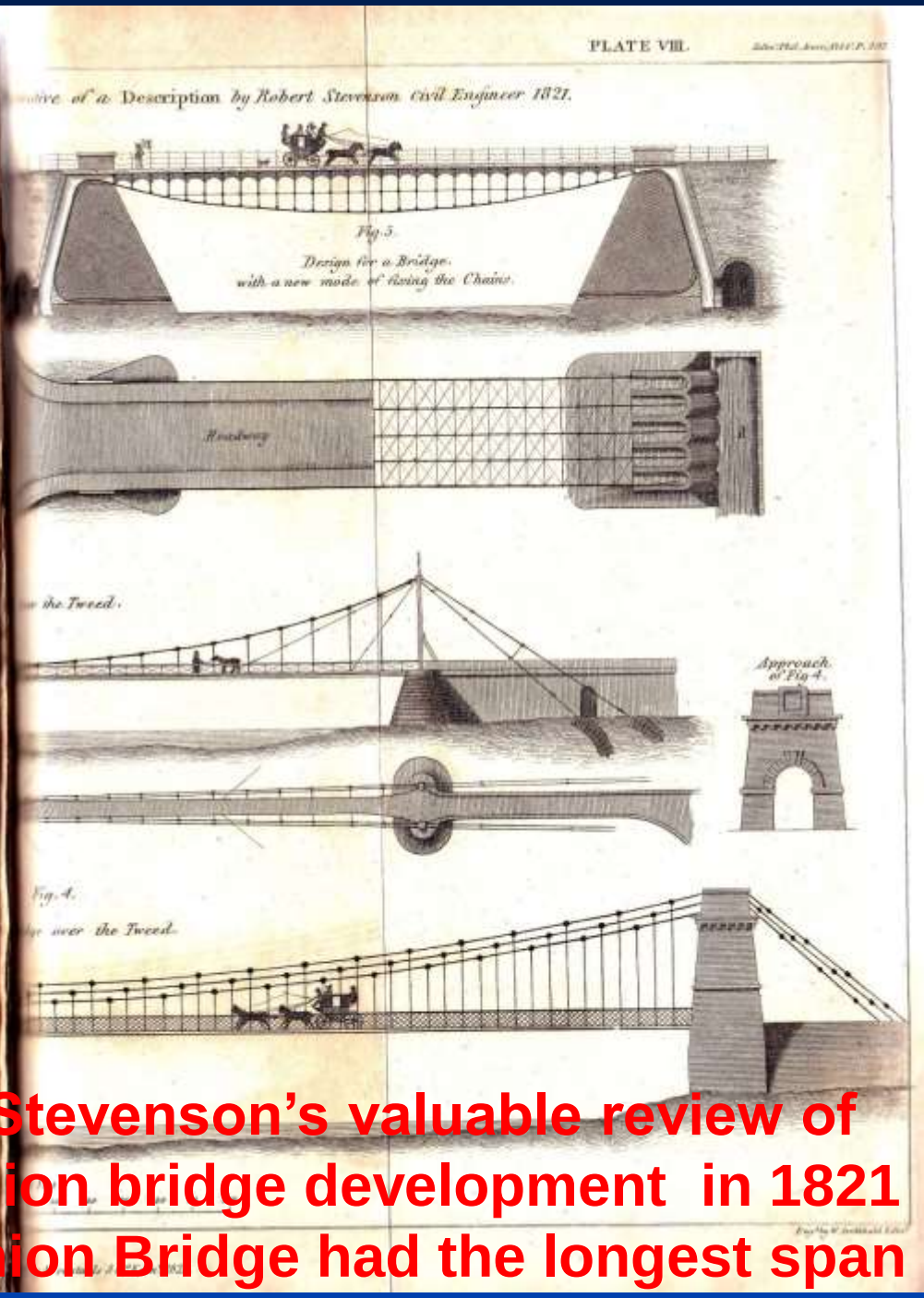
No. X.

OCTOBER 1. 1821.

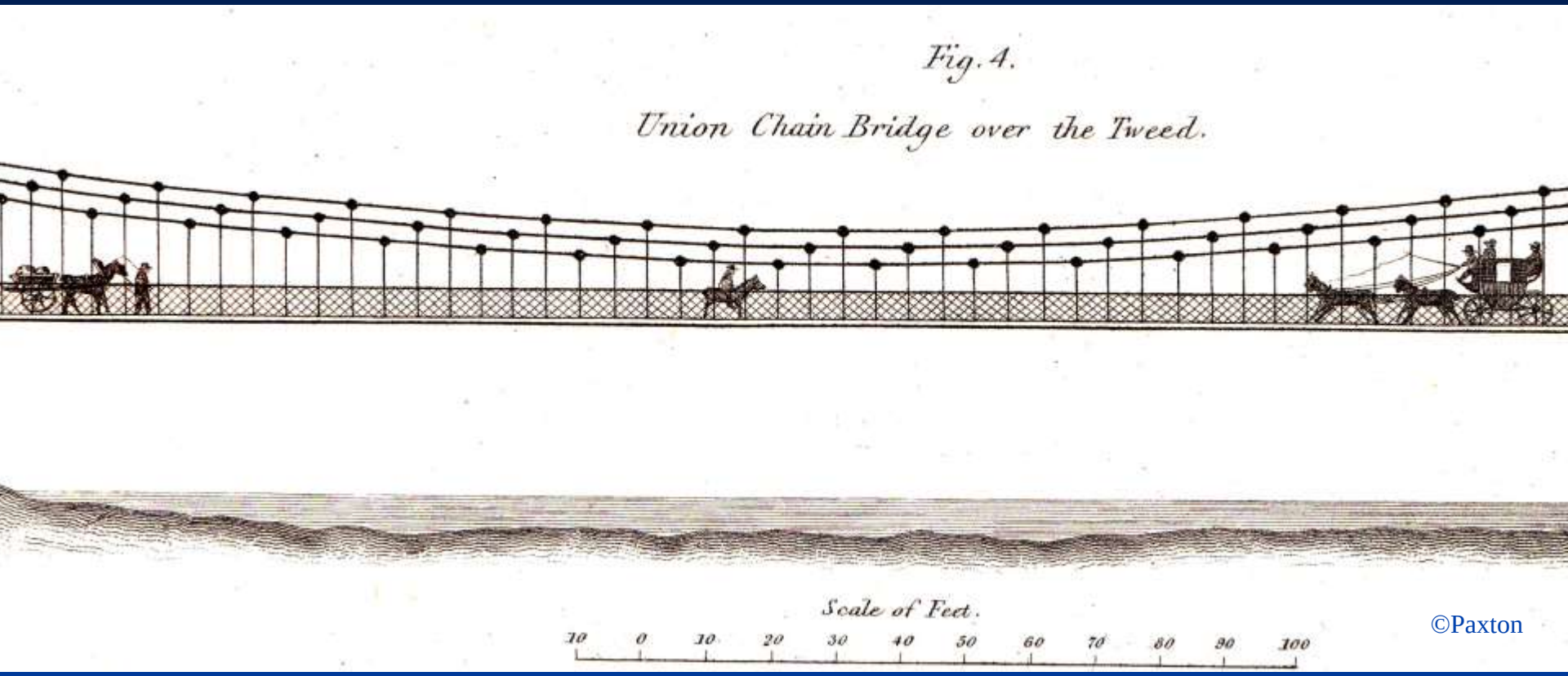
TO BE CONTINUED QUARTERLY.

EDINBURGH:
PRINTED FOR ARCHIBALD CONSTABLE AND COMPANY.

1821.



Robert Stevenson's valuable review of suspension bridge development in 1821 when Union Bridge had the longest span



Part of Stevenson's widely disseminated elevation of Union Bridge 1821, published in German, French and Polish by 1824

Innovative and cost saving

The Mirror

OF

LITERATURE, AMUSEMENT, AND INSTRUCTION.

No. XVIII.] SATURDAY, MARCH 1, 1823. [PRICE 2d.

Iron Suspension Bridge over the Tweed.

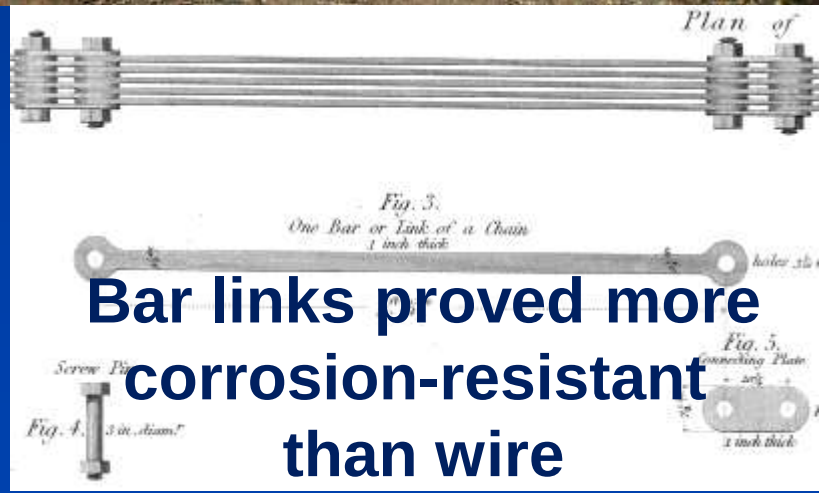
©Paxton

A popular account of 'one of those extraordinary results of mechanical science which particularly distinguish the age in which we live … the whole works of the Union-bridge were undertaken by Capt Brown for about £5,000 - a stone bridge must have cost at least four times that sum'

[*The Mirror* 1823 based on R. Stevenson's *Description* 1821]

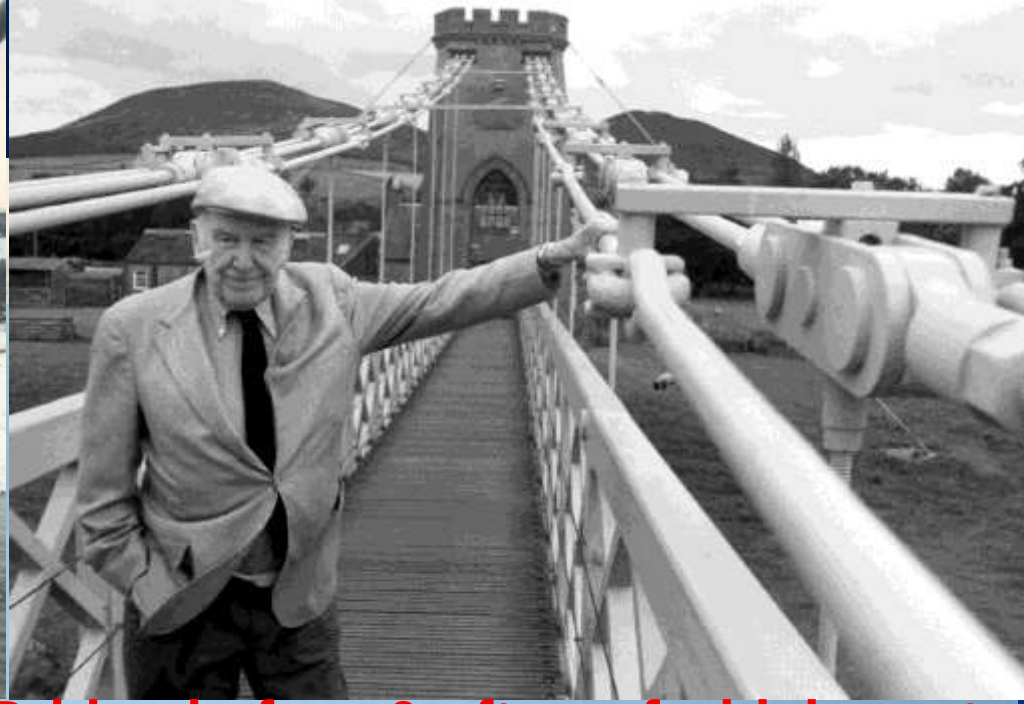
MENAI BRIDGE 1825

Brown's single bar, round-xsection links at Union Bridge influenced Telford's development at Menai of a 5 rectangular parallel bar link – a mode used later at Hammersmith, Clifton, Budapest and Glasgow bridges before use of steel cables

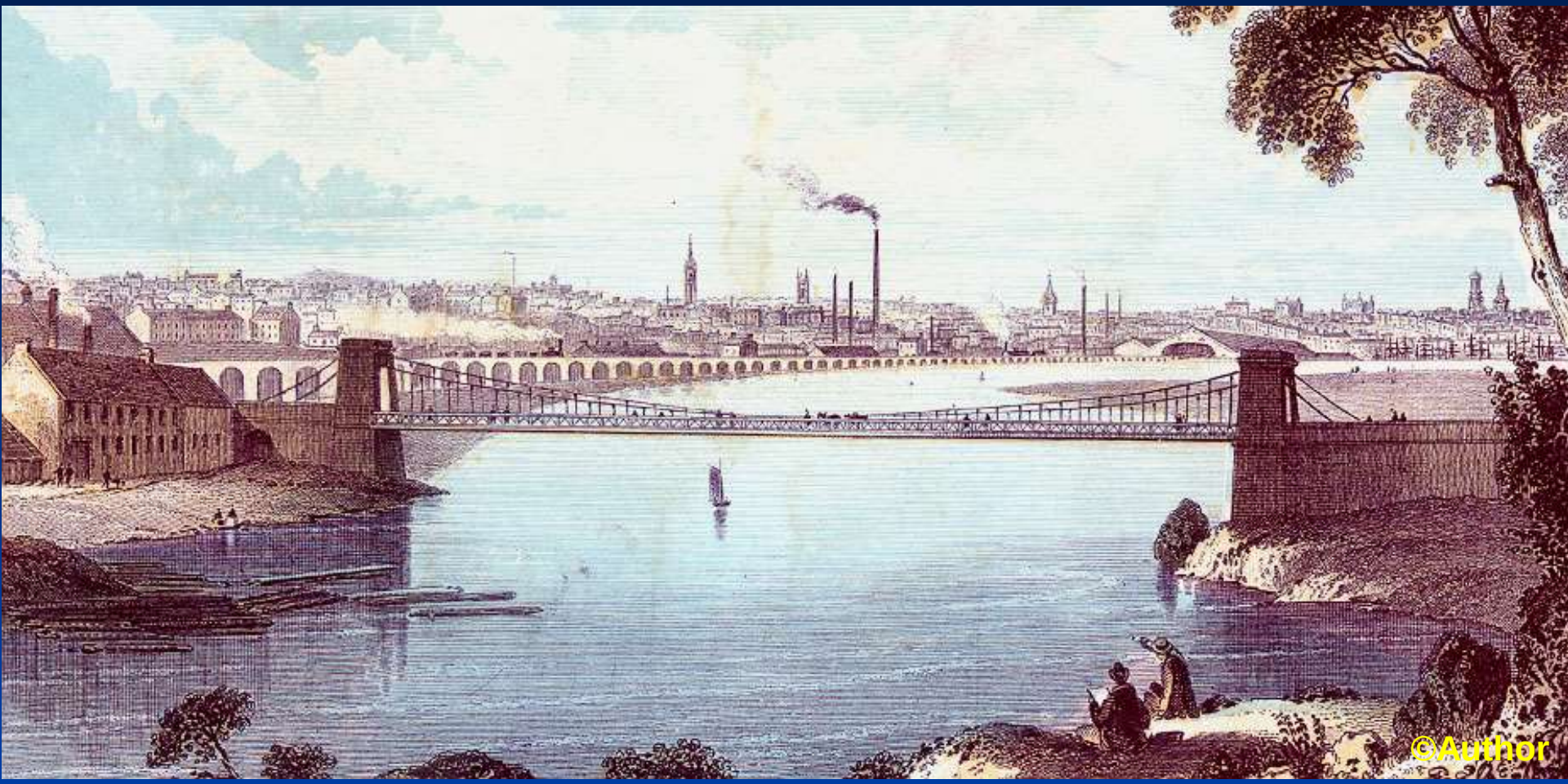


Bar links proved more corrosion-resistant than wire

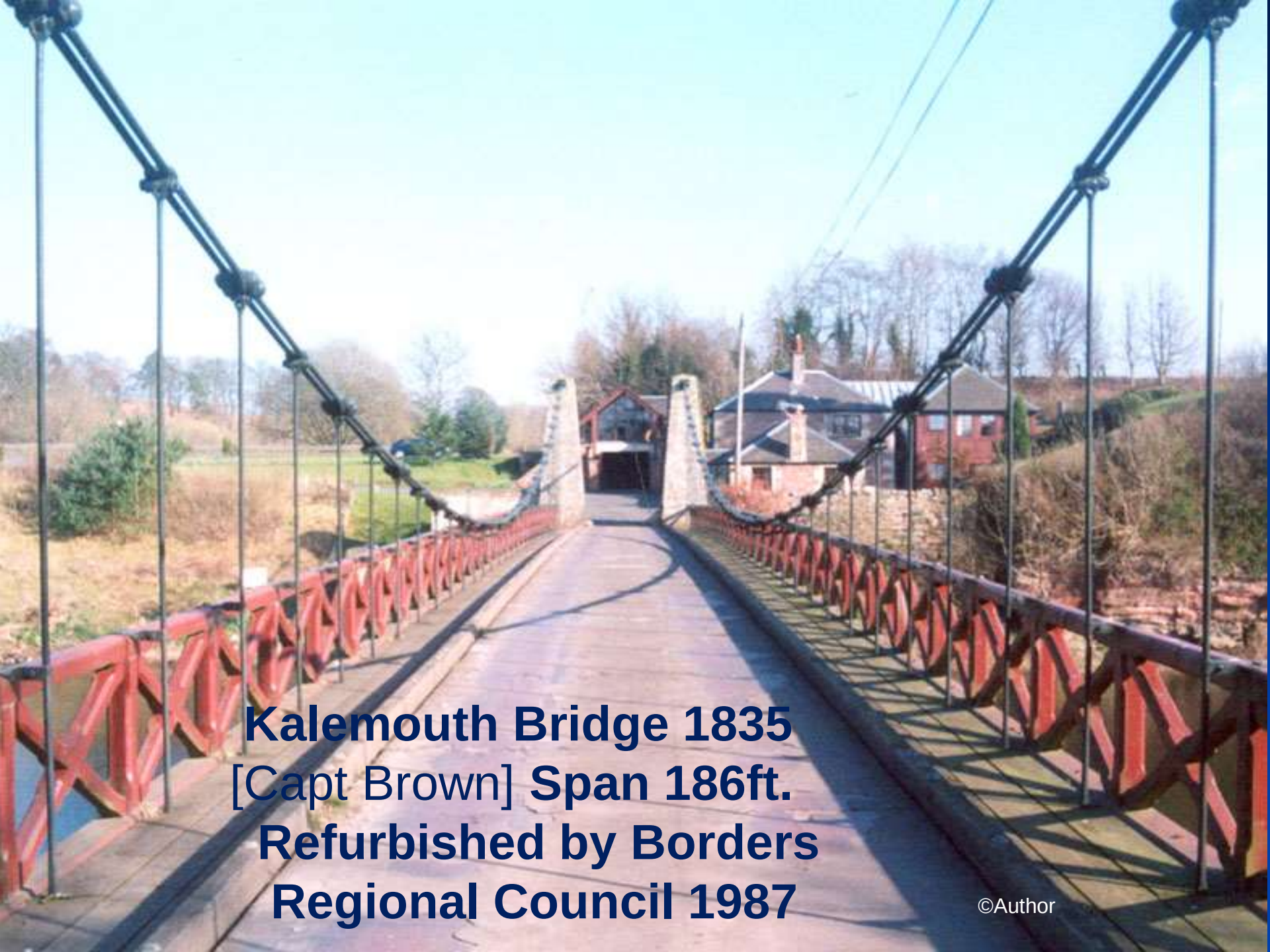
Akashi Straits, Japan 1998 – with high tensile steel cables and today's longest span [1¼ miles]



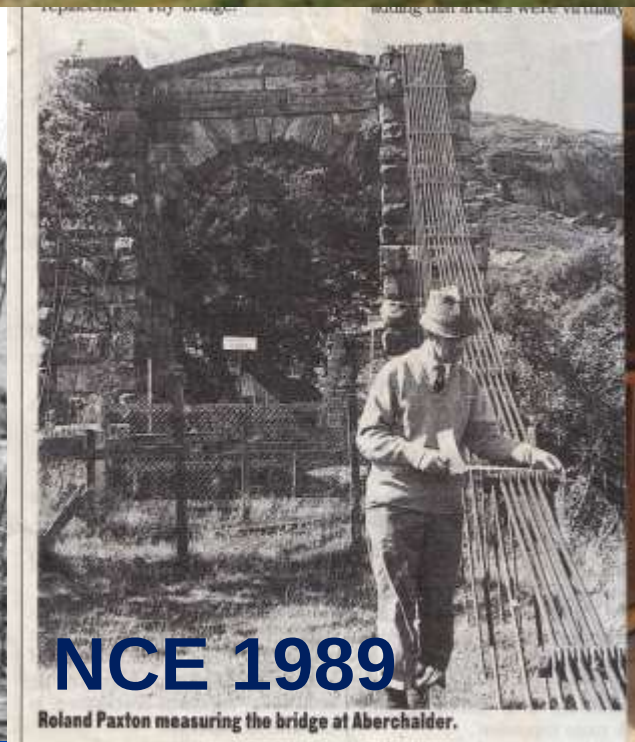
Gattonside Bridge before & after refurbishment 1990 & 1992 – some original ironwork preserved at ICE Scotland Museum, Heriot-Watt University



Wellington Bridge, Aberdeen 1830-1
[Capt. Brown] **Span 215ft.** Conserved for pedestrian use in 2005 by Aberdeen Council


Kalemouth Bridge 1835
[Capt Brown] Span 186ft.
Refurbished by Borders
Regional Council 1987
©Author

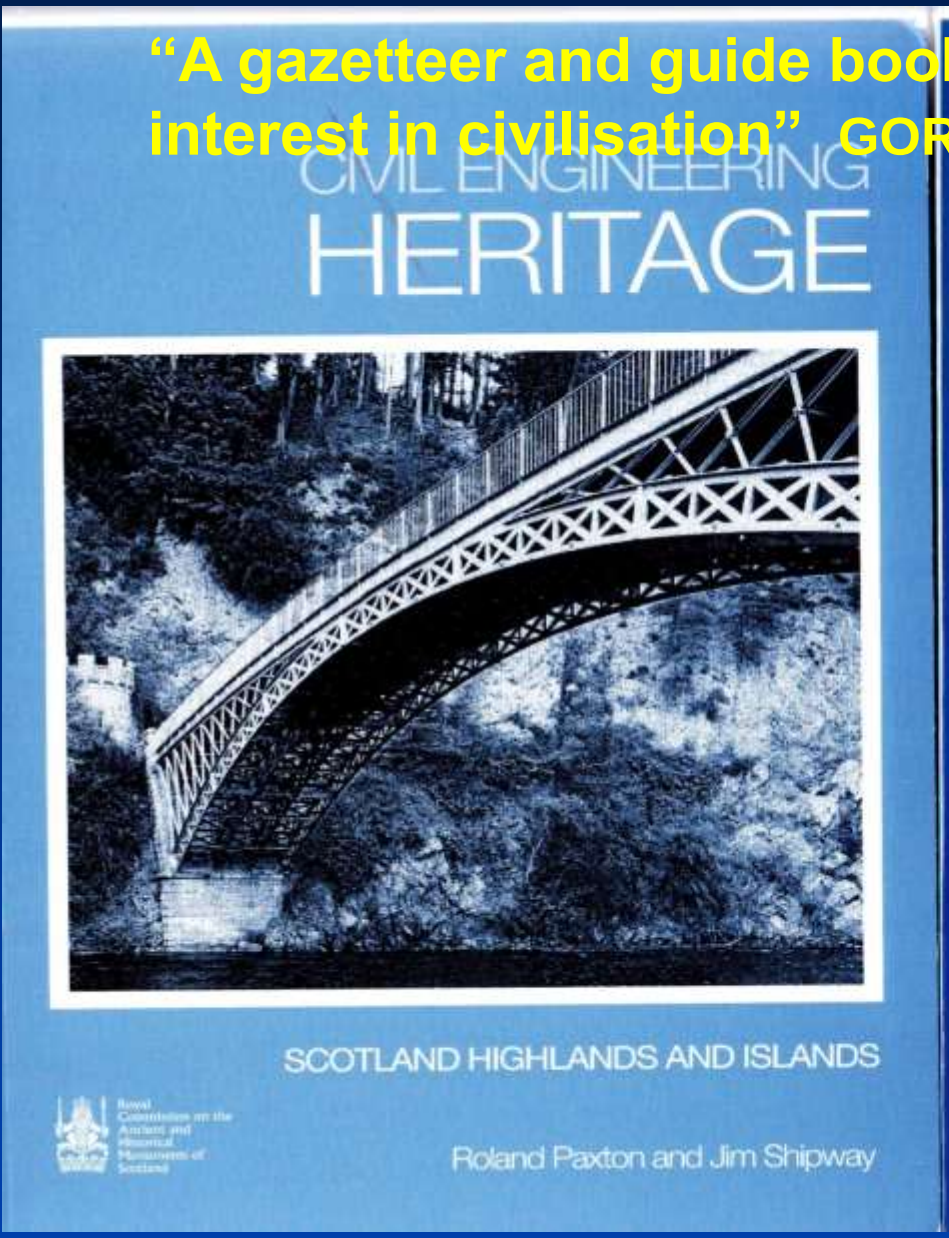
‘Bridge of Oich’ or Aberchalder Bridge 1850 by James Dredge. Span 155ft. Restored by Historic Scotland 1998 with ICE PHEW support

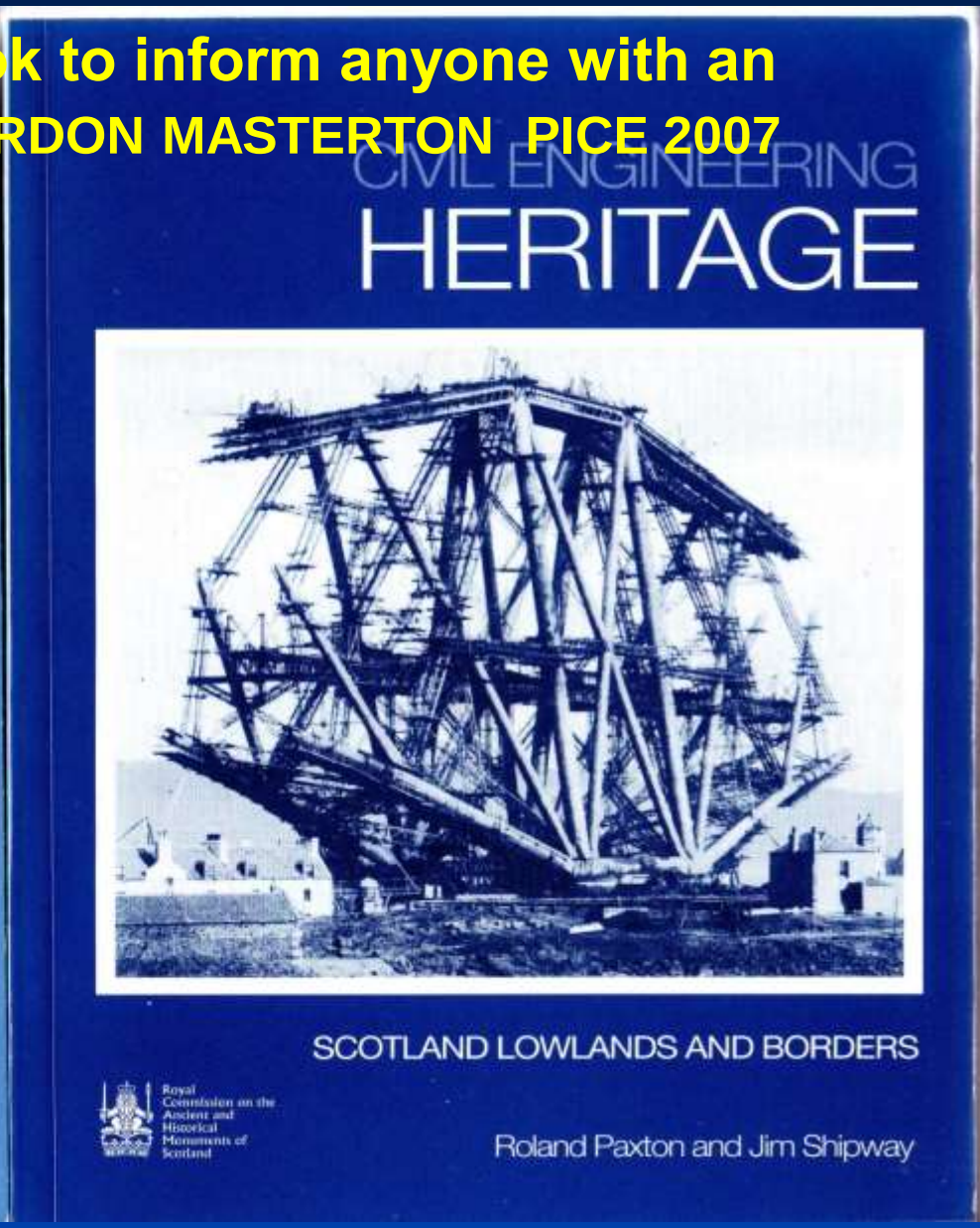


Society treasures the best of its built heritage. In the UK this is a matter for English Heritage, Historic Scotland, local authorities, owners and others. At Union Bridge where original traffic usage has much diminished additional funding is being sought to refurbish what is now a valuable historic monument

In 2013 deteriorating Union Bridge was placed on English Heritage's *History at Risk Register.* My support for its refurbishment is on behalf of the 197-years-old, 80,000-member, Institution of Civil Engineers via its Panel for Historical Engineering Works which records and encourages excellence in conserving the finest examples of such works

"A gazetteer and guide book to inform anyone with an interest in civilisation" GORDON MASTERTON PICE 2007





These Institution publications record c.500 significant Scottish Historical Engineering Works - including Union Bridge

Union Bridge's enhancement of the environment

Union Bridge in 2013
span 437ft
dip 26ft
2t weight limit

An ASCE/ICE IHCELandmark plaquing by Tom Jackson ASCE President and the Author in 2003 at Conwy Bridge, N. Wales [1826 - Telford, 327ft span] - now owned by the National Trust


1903 steel cable to support bridge if an original link fails
UNION BRIDGE Note state of bridge on 5 October 2013 and
< one of several recent replacement hangers and caps to chain pairs near mid-span
©Author

Professor Hiroshi Isohata of Nihon University, Tokyo inspecting Union Bridge with Gordon Miller and myself on 11 November 2014

存続の危機にあるユニオン吊橋（イギリス）

Union Suspension Bridge under Crisis of the Survival

五十畑（イソハタ） 弘（ヒロシ）*

1．はじめに

イギリスのユニオン吊橋(Union Chain Bridge)は、トーマス・テルフォードのメナイ吊橋よりも6年早く、1820年に開通した現存する世界最古の道路吊橋である(図-1)。この吊橋が今、存続の危機に瀕している。

建設後187年目の2007年に、ハンガーとチェインケーブルの定着部で破損が発見され、その後さらに4本のハンガーで同様の破損が見つかった。破損した5本のハンガーのうち4本はスパン中央部下流側で、破損個所は発見のつど応急処置が施されている。現在(2014.11)、通行車両は1度に1台と荷重制限がされているが、経過観察のもと供用下にある。しかし、交通量は少なく公共的な影響度が低いことから廃橋となる可能性もある。

この橋は、スコットランドとイングランドの両方から日本の重要文化財に相当する歴史的遺産として登録されているが、老朽化が進んでいることから、さらにイングリッシュ・ヘリテッジによって2013年に存続の危機にある遺産[1)]としても登録された。

図-1 ユニオン吊橋全景(2013.4)
ツィード川の上流側からのぞむユニオン吊橋（右がイングランド、左がスコットランド）

図-2 サミュエル・ブラウン（1774-1852）[2)]

2．ユニオン吊橋の概要と経過

ユニオン吊橋はサミュエル・ブラウン(Samuel Brown 1776-1852)によって1818年に設計が行われ、1820年に開通した初期のチェイン吊橋である(石造の塔はレニー(John Rennie 1761-1821)の設計)（図-2,3)。

この橋は、エジンバラから南東に80kmほどの場所にあり、スコットランドとイングランドの境界線をなす北海に注ぐツィード川の河口から10kmほどの場所に架かる(図-4)。

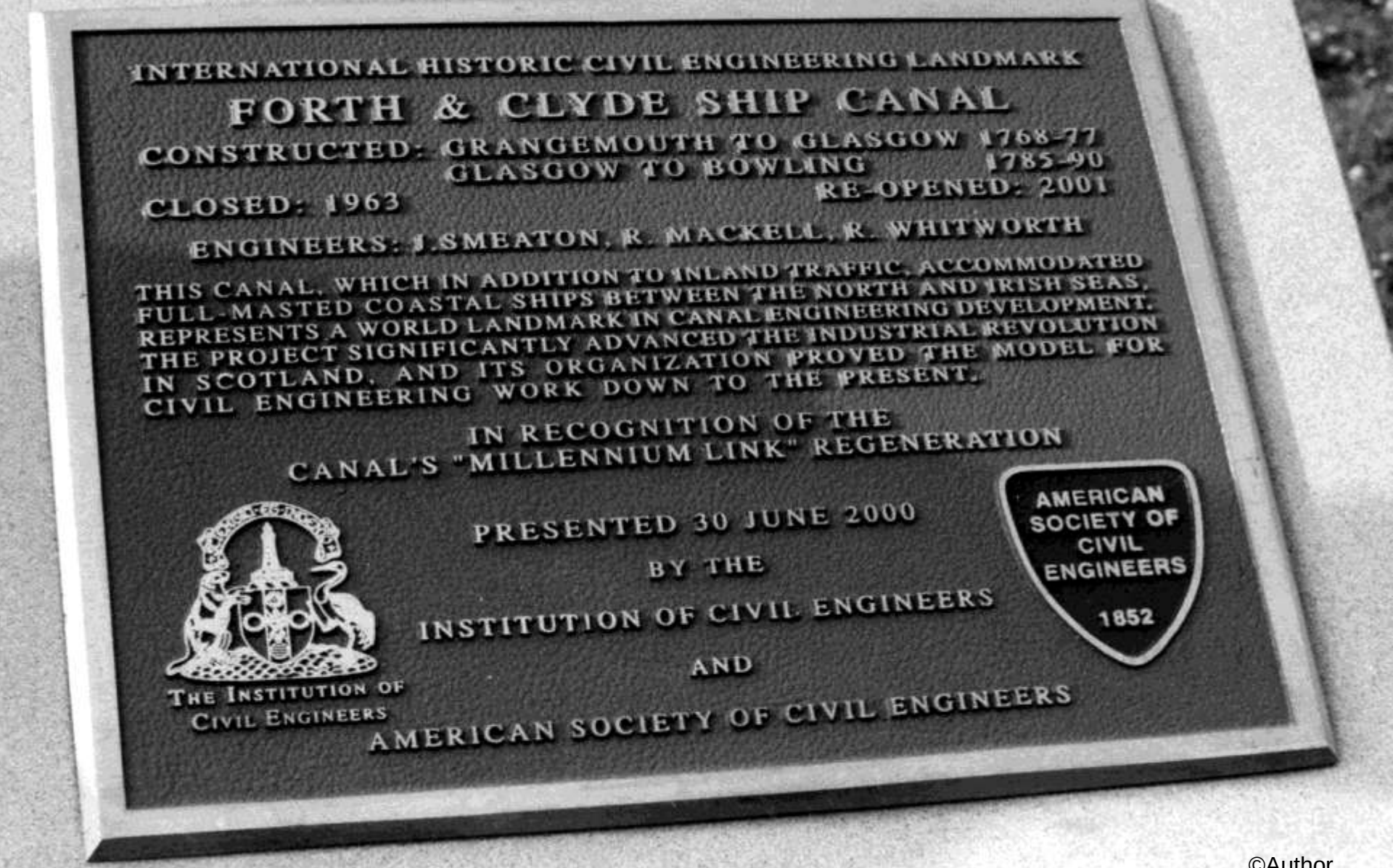
図-3 開通当時に描かれたユニオン吊橋

図-4 ユニオン吊橋の位置（Google Map より）
エジンバラから南東に80kmほどのペリック・アポン・ツィード付近（矢印）

幅員は5.5m、スパン132m(437ft)(ケーブルスパン：136m(449ft))は、錬鉄吊橋として当時世界最長であり、車両を通す吊橋としてもイギリスで最初であった。両岸から張り渡されたケーブルは、棒状の錬鉄のバーをピンで連結した3段のチェインで構成され、ハンガーで木製の床版を吊っている。左岸のスコットランド側には、高さ18mの石造の塔とその背後にアンカレッジがあるが(図-5)、イングランド側は川に迫る斜面にアンカーされている。

International recognition for Union Bridge's refurbishment by Prof Isohata's article in the Jan. 2015 issue of Japanese engineering magazine *'Bridge and Foundation'*

[Based on my PPP at Paxton House on 25 June 2014]



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The Forth and Tay Bridges, 'Titan' Crane, Forth & Clyde and Caledonian canals have been designated IHCELs at prestigious plaquing events. Union Bridge deserves to join them

Union Chain Bridge in addition to its local usefulness and enhancement of the environment deserves preservation as:

- a landmark in world bridge development

- the world's oldest operational suspension bridge - still carrying vehicles at 195 years of age, albeit with a 2t limit

- an outstanding example of the work of leading British bridge builders Capt Samuel Brown RN and John Rennie CE

- an accessible museum-piece treasure of social and technical history with valuable educational and visitor potential

These attributes reflect its high level listing of protection by *English Heritage* [Class 1] ; *Historic Scotland* [Category A]

NORTHUMBERLAND

Northumberland County Council

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Date: 27 January 2014

Dear Professor Paxton

Together with our colleagues from Scottish Borders Council we remain committed to securing the future of the structure with the ultimate goal of completing its refurbishment prior to the bicentennial celebration in 2020.

Extract from NCC letter re. Union Bridge 27 Jan. 2014

To conclude: The Institution of Civil Engineers [ICE] recognises Union Bridge's outstanding historical significance; strongly supports the Councils' aims as below; welcomes the formation of the 'Friends'; and plans, if its owners consent, to nominate the bridge as an *International Historic Civil Engineering Landmark*, with a view to an American Society of Civil Engineers/ICE presidential plaque unveiling at its bicentenary