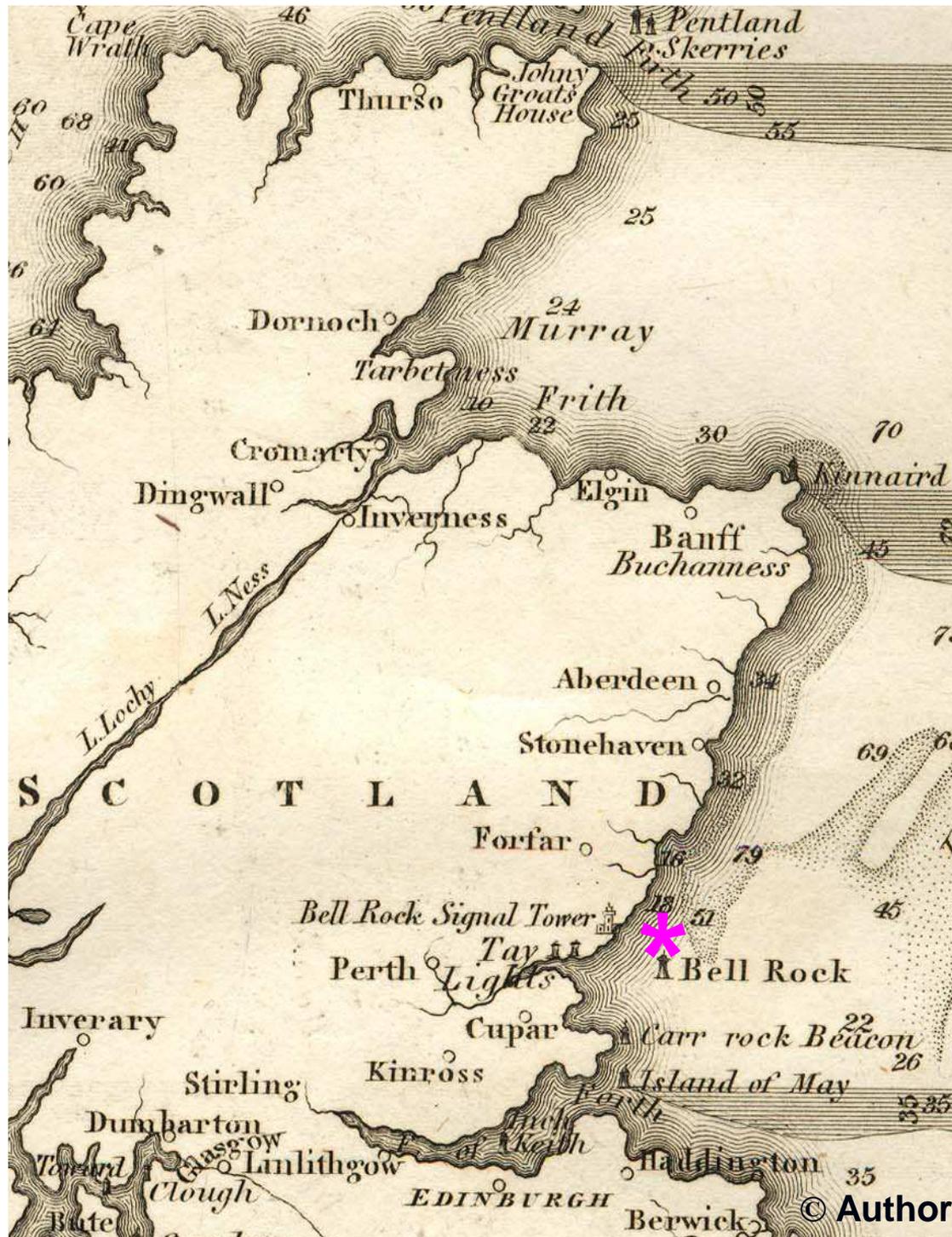


# THE BELL ROCK LIGHTHOUSE RAILWAY 1808 AND ITS SIGNIFICANCE

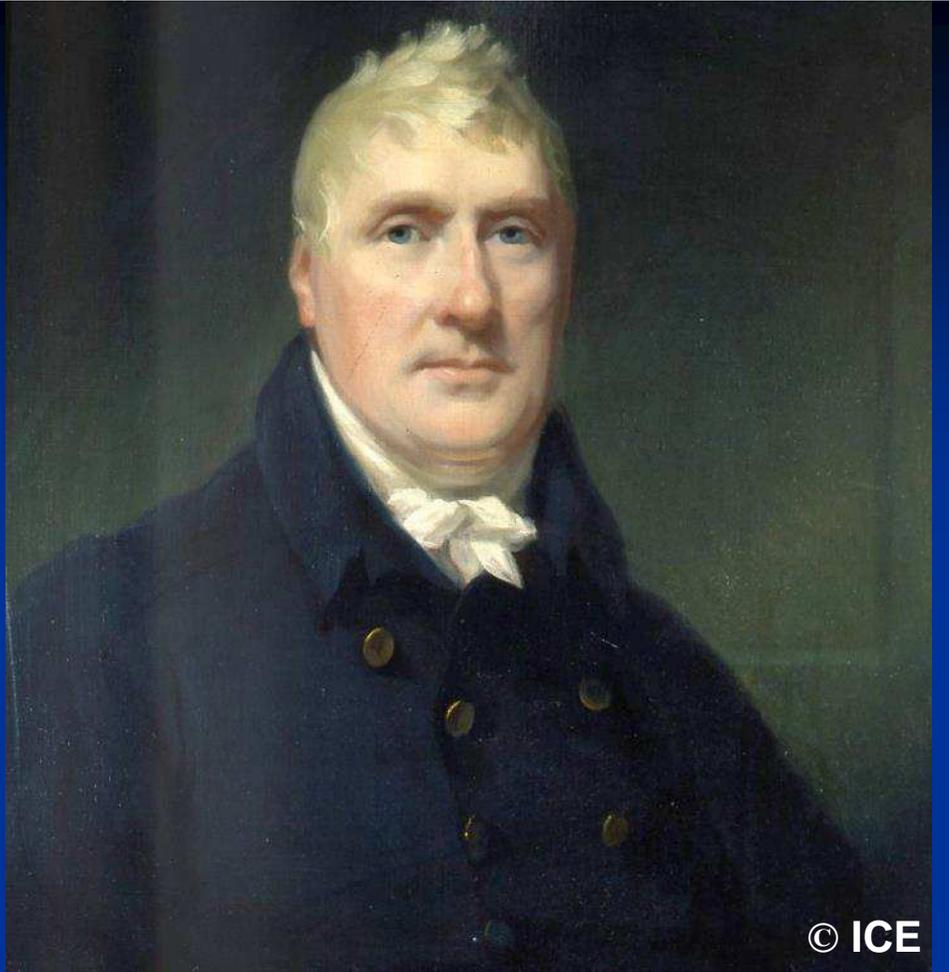
By Prof Dr Roland Paxton MBE FICE FRSE  
School of the Built Environment  
Heriot-Watt University, Edinburgh  
Vice-chairman ICE Panel for Historical  
Engineering Works

Railway 0-6 ft (1.8 m) above rock

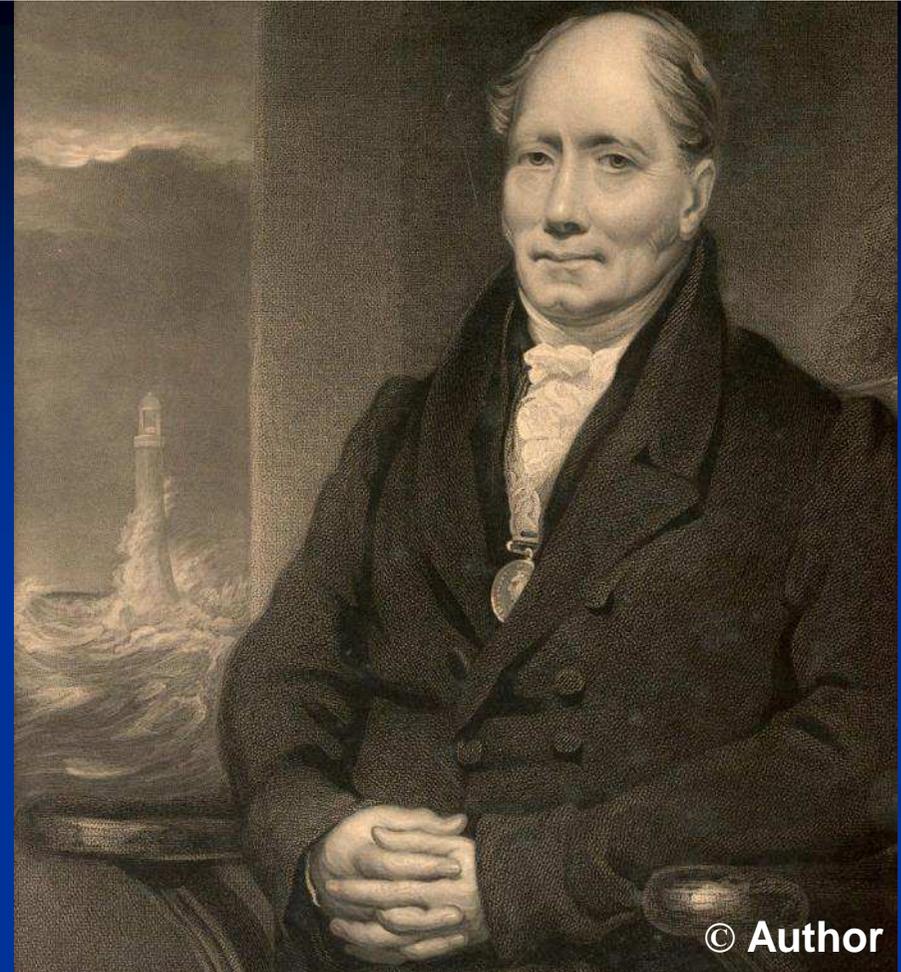
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The Northern Lighthouse Board was formed in 1786 to improve safety at sea. In 1799 about 70 vessels were stranded or lost on or near the Bell Rock – [11 miles off Arbroath] and Robert Stevenson proposed a stone lighthouse, a modified version of which was built under the direction of Rennie and himself from 1807-10 at a cost of £61,331.

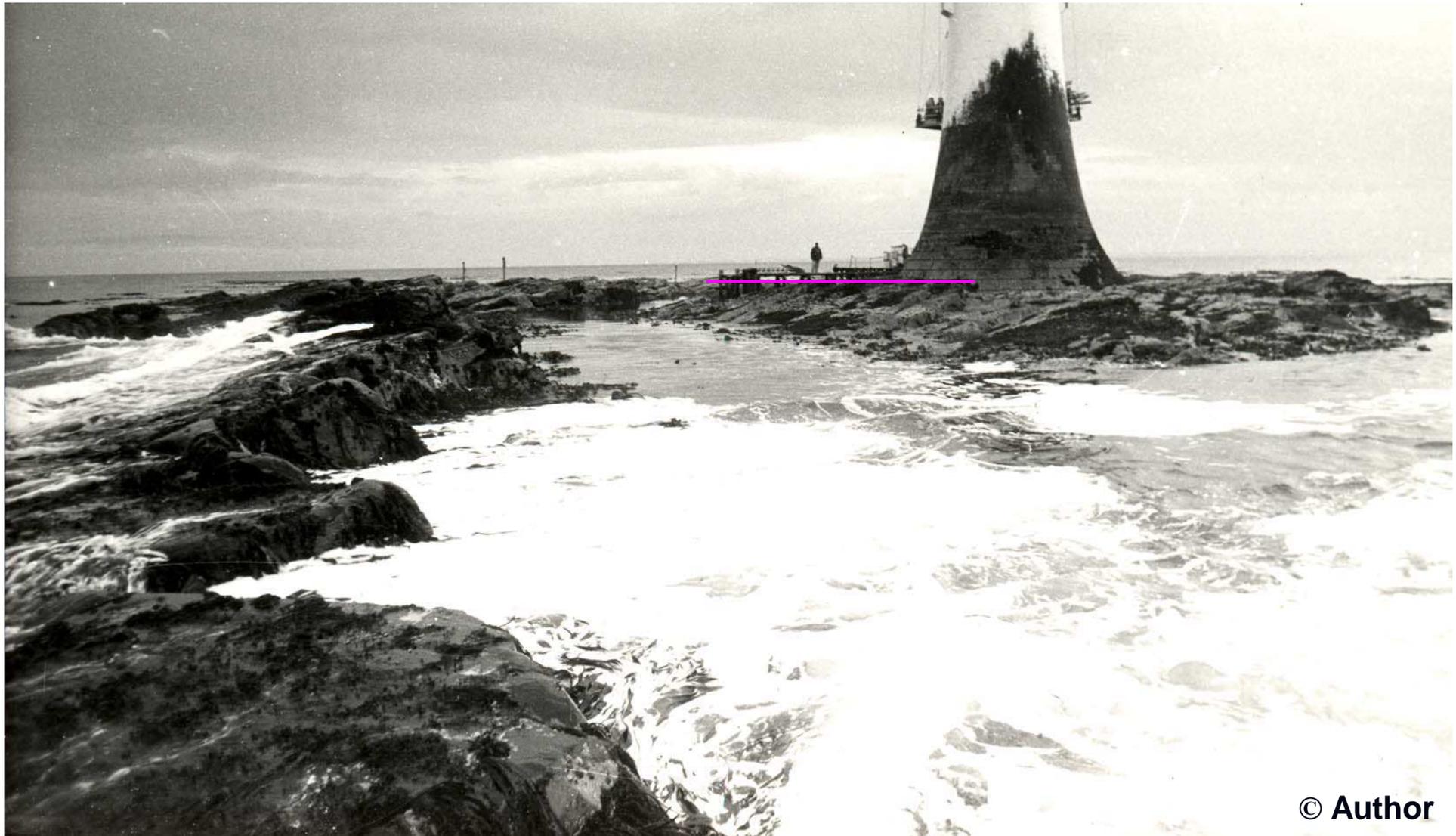


**John Rennie (1761-1821)**  
*Chief Engineer*



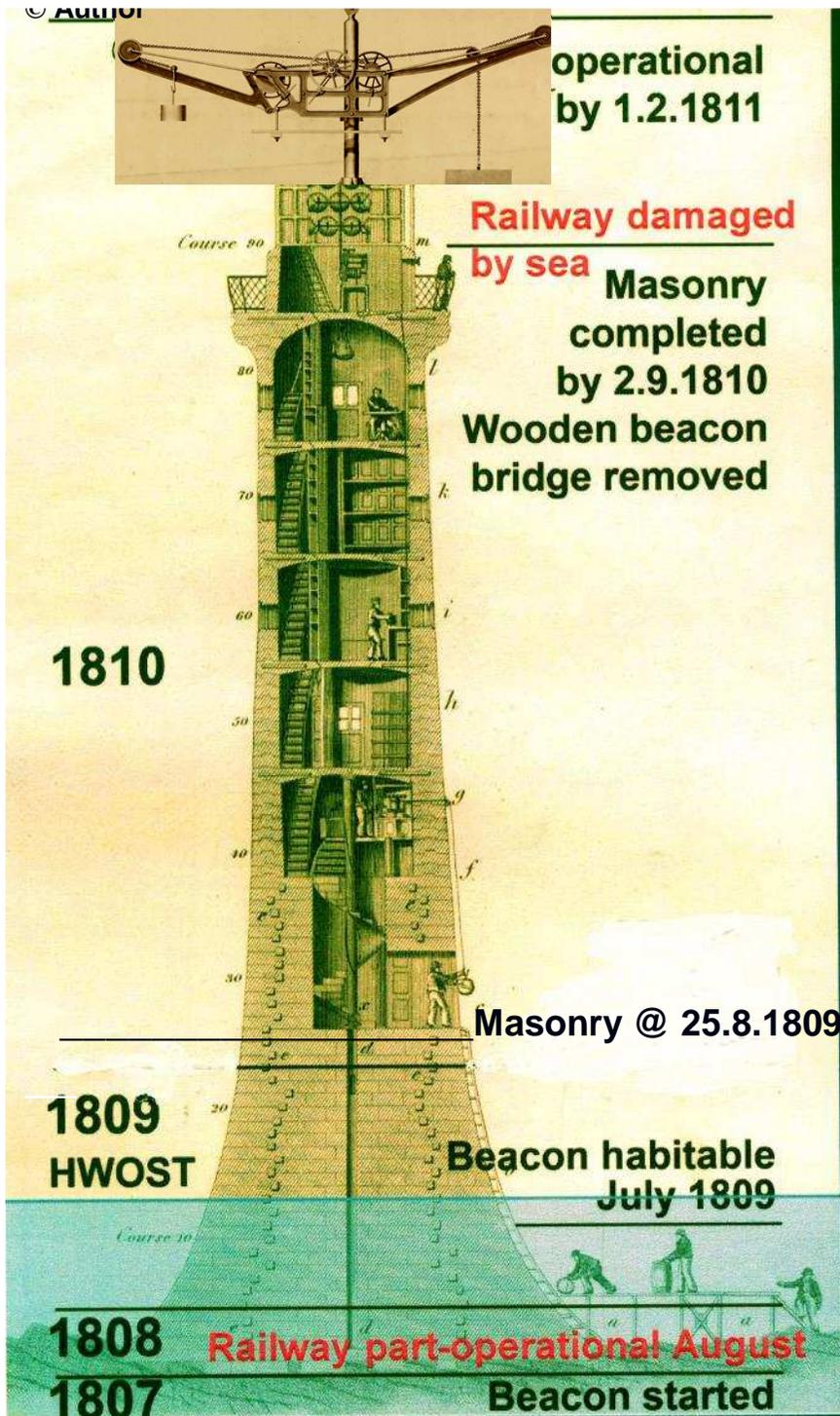
**Robert Stevenson (1772-1850)**  
*Resident Engineer*

**The lighthouse, an extraordinary engineering achievement, featured in a 2003 BBC2 documentary as one of ‘Seven Wonders of the Industrial World’ ... with Brooklyn Bridge, Panama Canal, Hoover Dam ...**



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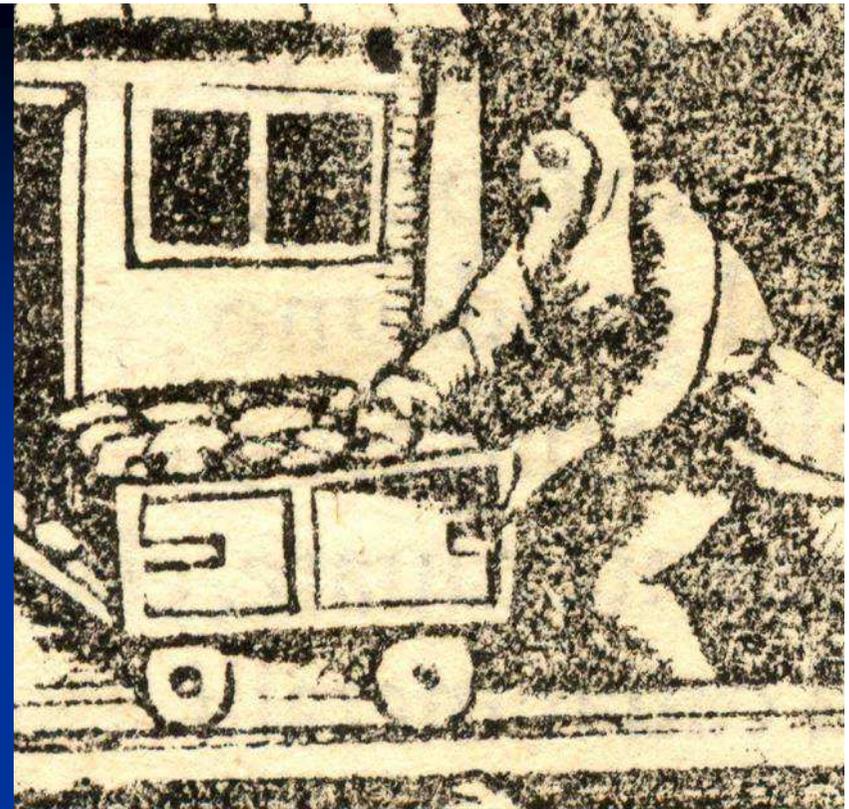
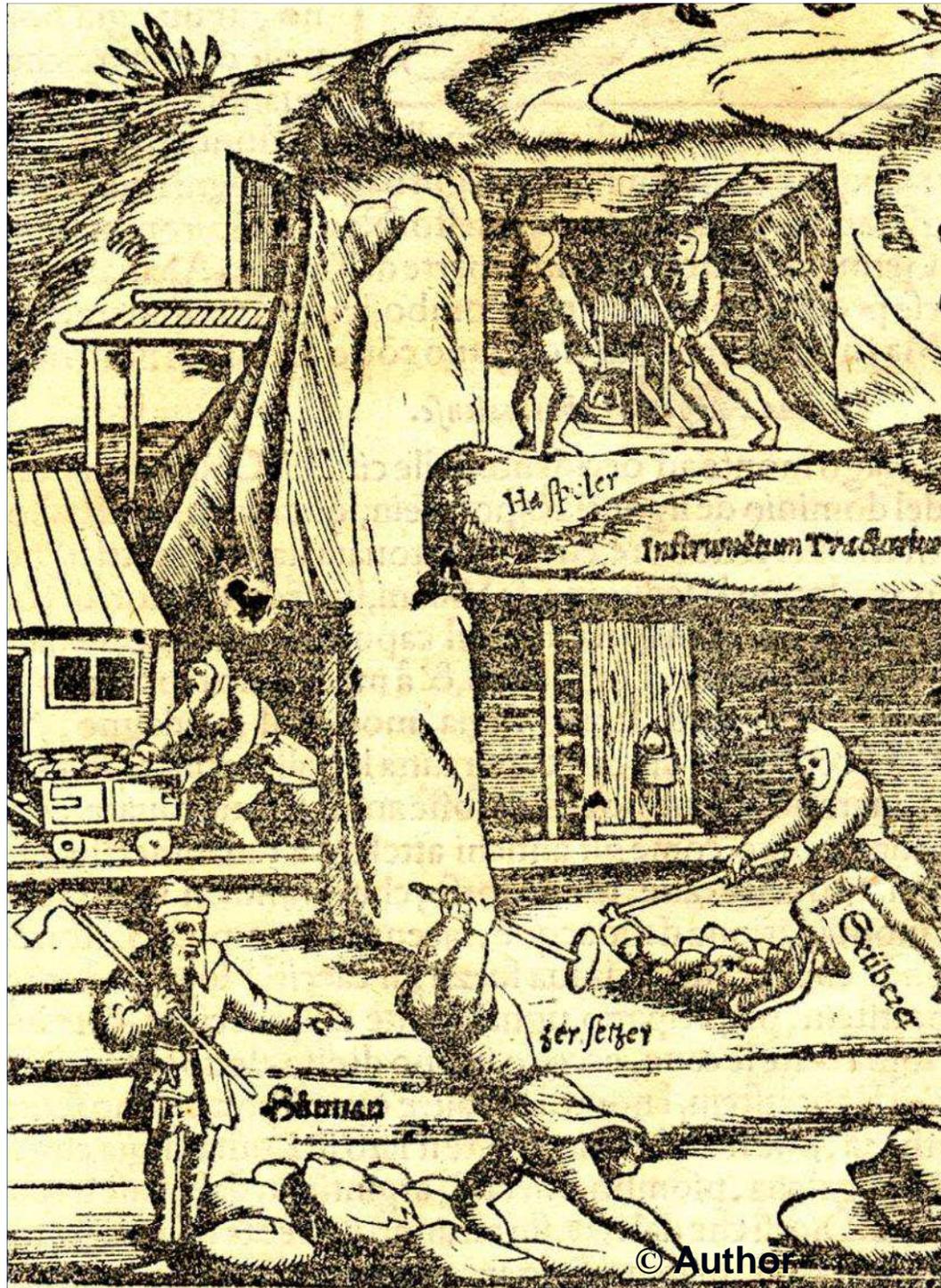
**Bell Rock reef at low tide from ‘Cunningham’s Ledge’ in 1986 – submerged up to 5 m at high tide. The railway, also an extraordinary achievement designed against sea effects , was an essential element in the project’s completion by 1810.**



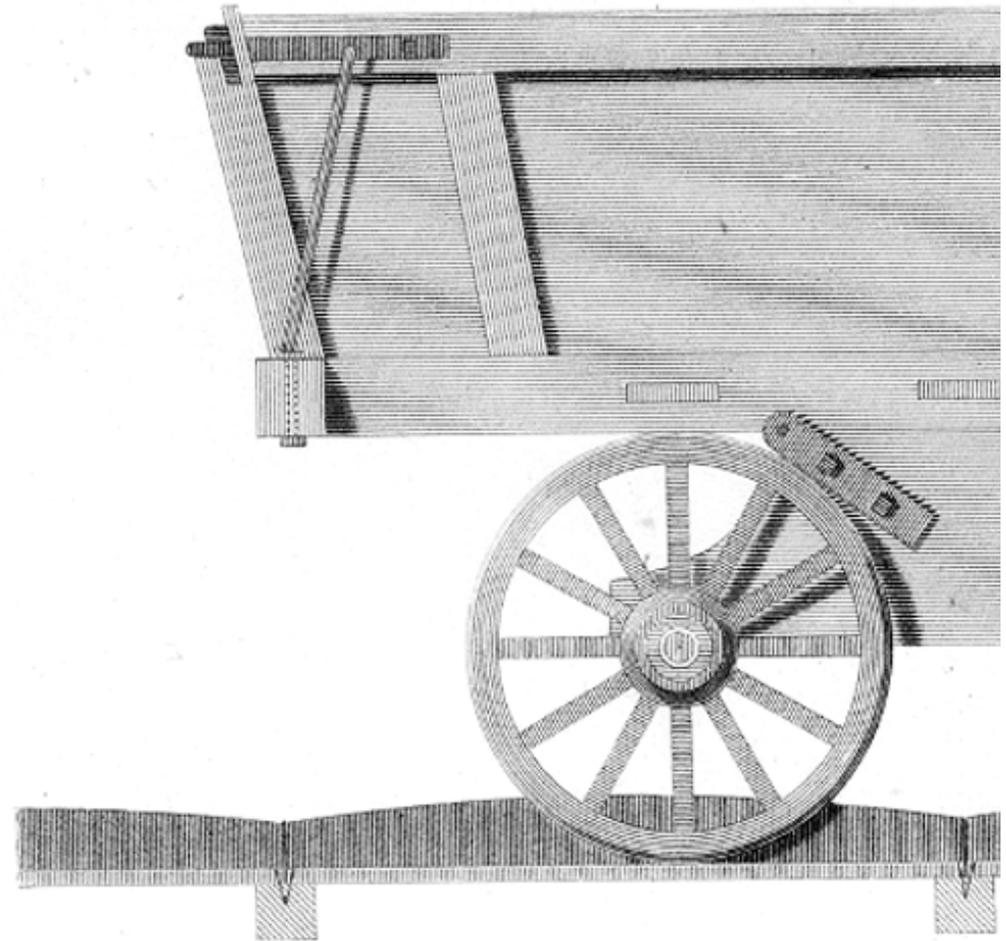
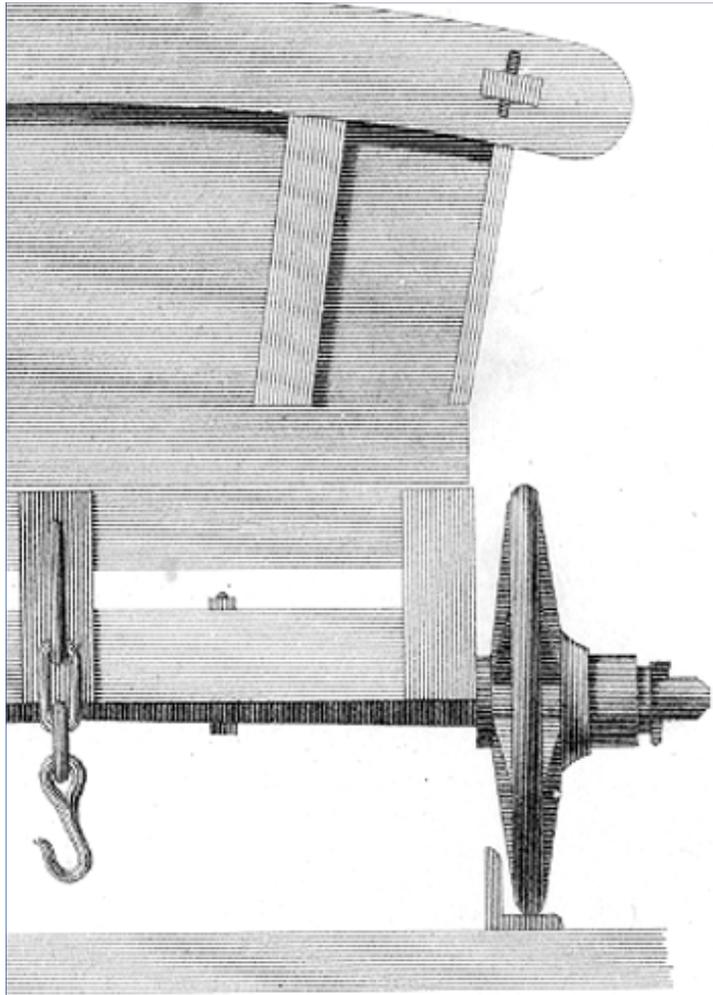
## Erection chronology.

Completion of the tower was achieved in 4 working seasons from 1807-1810. At first the work was carried out from ships which was inconvenient and time consuming.

Much faster progress was made after implementation of the innovative temporary expedients of the cranes, railway and beacon barrack alongside, designed and erected by foreman-millwright Francis Watt, who invented here the first iron balance crane for erecting tall towers. The railway operated 1808-10.



The basic idea of using railways and waggons was not new. Transporting ore on a wooden railway in a German mine c.1550 [Munster's *Cosmographia* 1575].

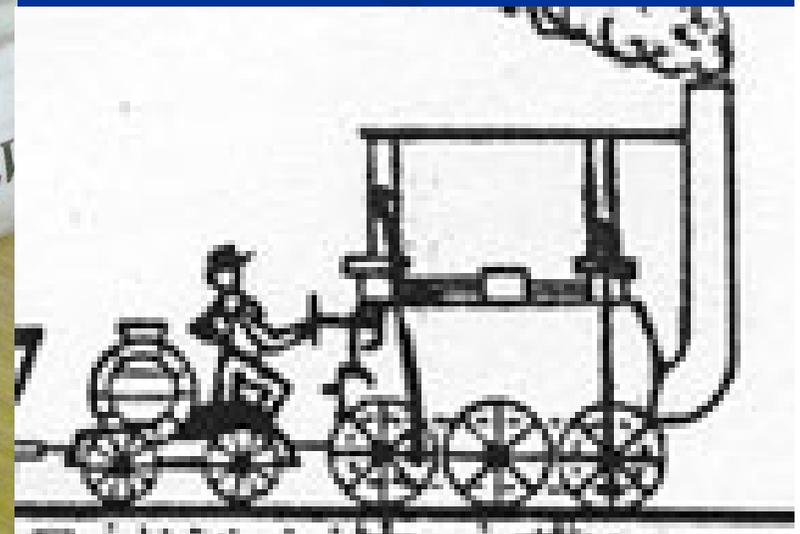


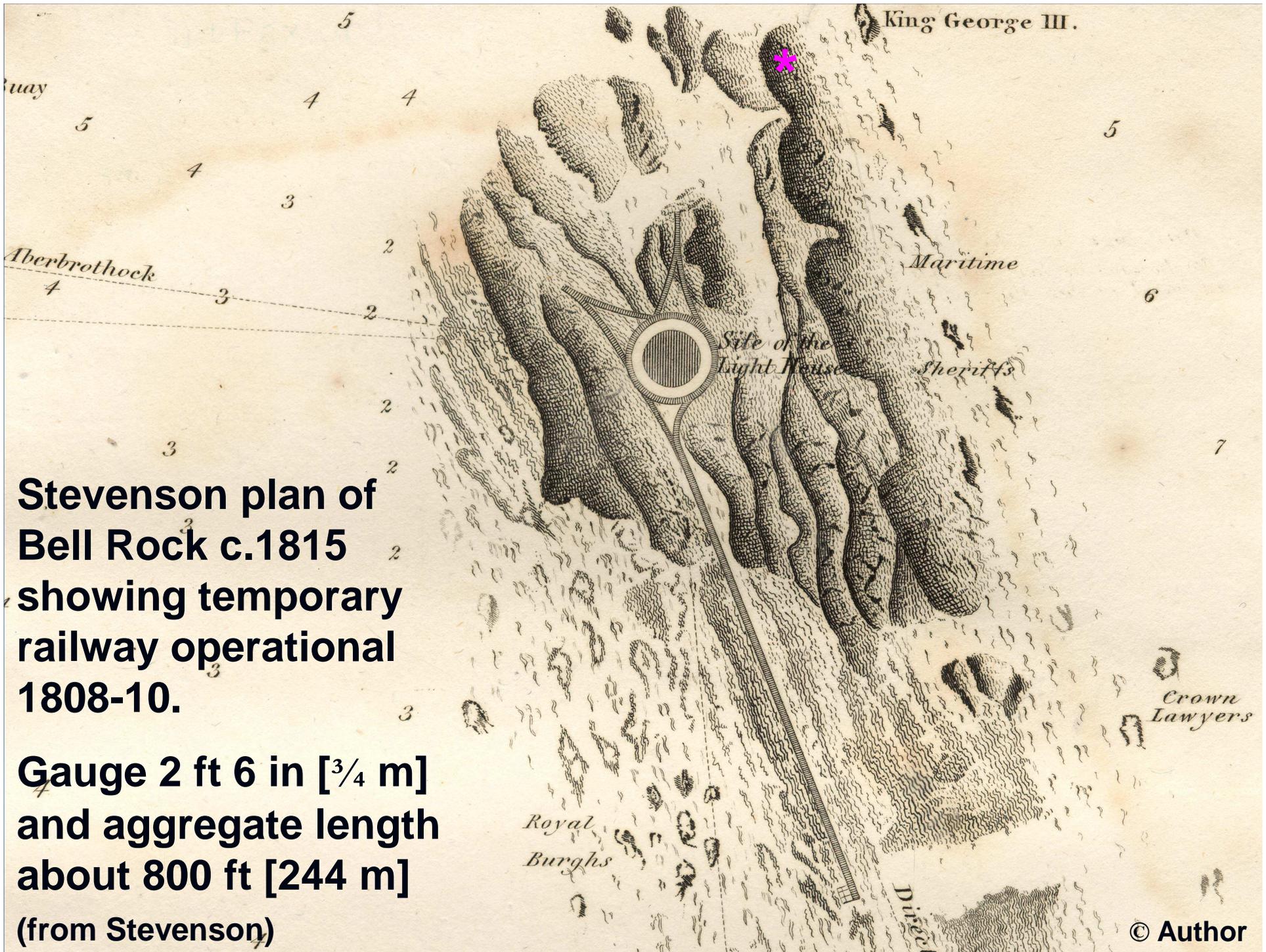
[Telford's *Life* 1838, pl. XX]. © Author

**Caledonian Canal state-of-the-art project [1804-22-]. Earth waggon on 4ft gauge, horse-traction iron plate-way with 3 ft long rails. Francis Watt, Bell Rock Railway ironwork designer, 1807-10, is believed to have worked at the Canal c.1806.**



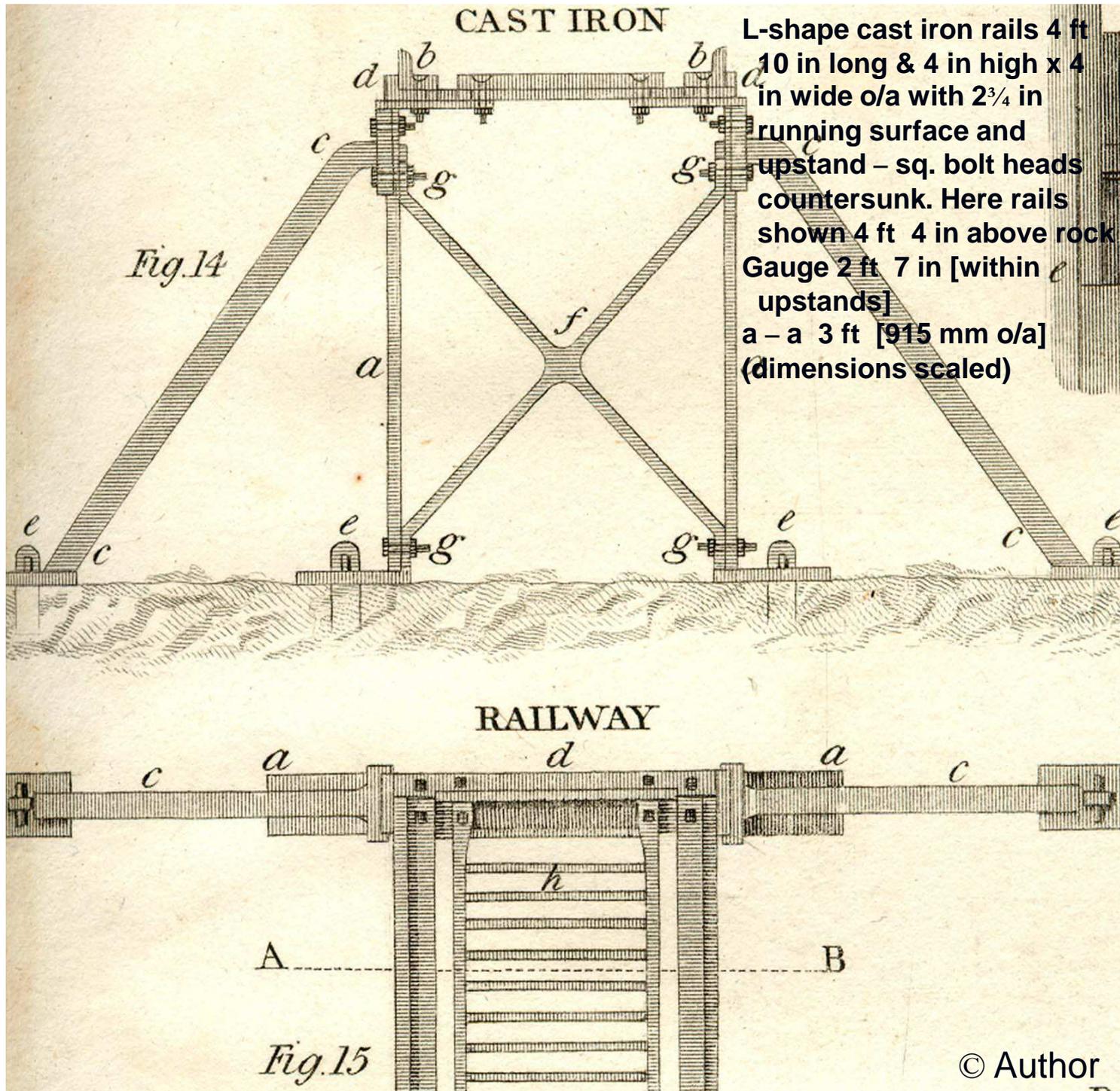
**Jessop [Butterley-cast?] rail from the Caledonian Canal works. 28 lb 11 oz.** [now at ICE Scotland Museum, Heriot-Watt University, Edinburgh]. **Similar to K&TR rails broken in c.1816 by 'The Duke' 'Killingworth' engine [sold to 7<sup>th</sup> Earl of Elgin at Charlestown for £70, 5 Nov. 1824] [ICE-PHEW Newsletter 103, Sept. 2004]**





**Stevenson plan of  
Bell Rock c.1815  
showing temporary  
railway operational  
1808-10.**

**Gauge 2 ft 6 in [ $\frac{3}{4}$  m]  
and aggregate length  
about 800 ft [244 m]  
(from Stevenson)**



CAST IRON

L-shape cast iron rails 4 ft 10 in long & 4 in high x 4 in wide o/a with 2¾ in running surface and upstand – sq. bolt heads countersunk. Here rails shown 4 ft 4 in above rock

Gauge 2 ft 7 in [within upstands]

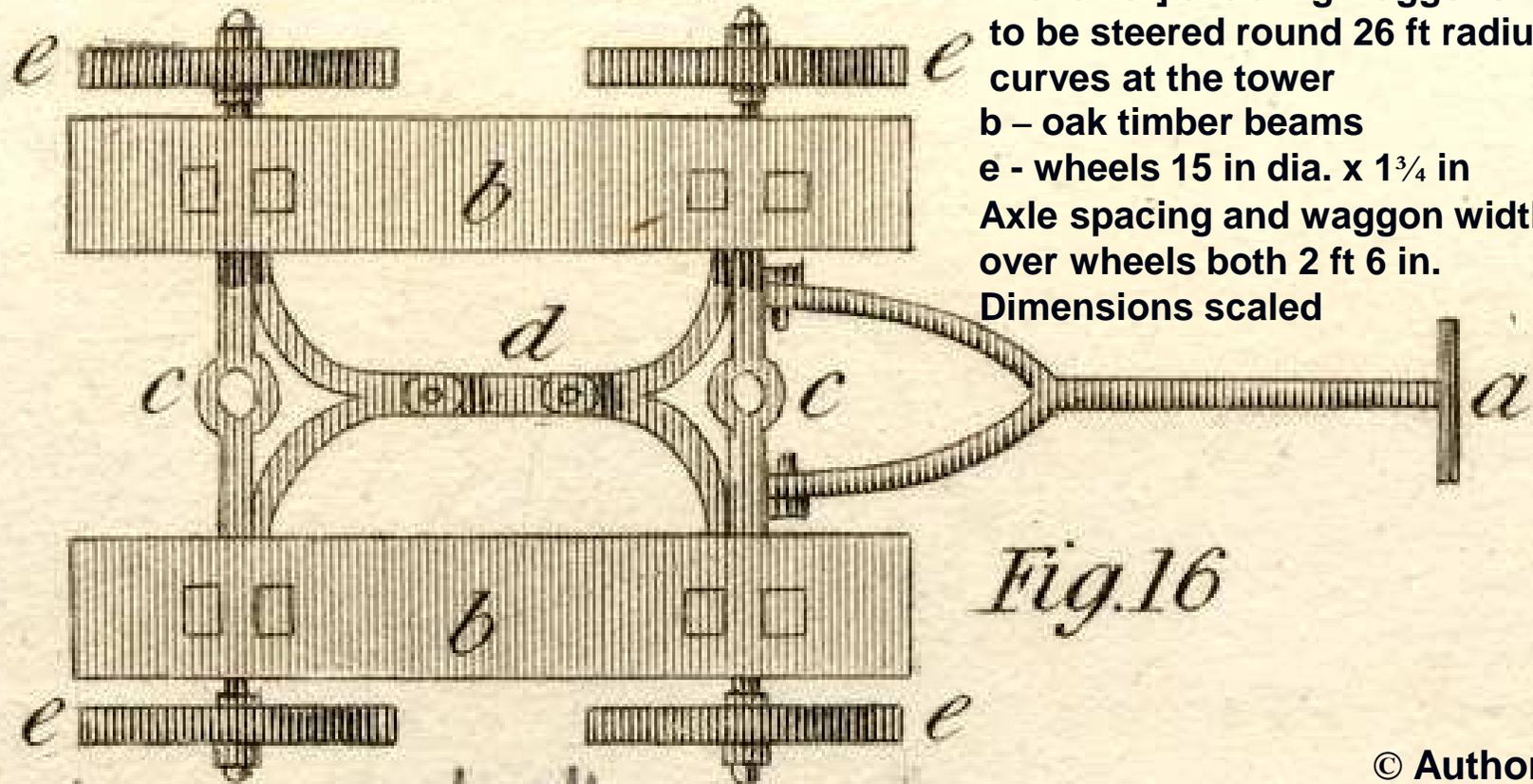
a – a 3 ft [915 mm o/a] (dimensions scaled)

**Railway 0 - 6 ft [0 - 1.8 m] above rock with cross-braced supports c. 5 ft [1.5m] apart.**

**Part (Watt's and Slight's reaches) made 'permanent' from 1815-19 - Stronger by addition of side stays.**

[Drawing c.1820]

# Railway Waggon



Swivel bolts at c and d through two frames [the upper sliding on the lower] enabling waggons to be steered round 26 ft radius curves at the tower  
b – oak timber beams  
e - wheels 15 in dia. x 1<sup>3</sup>/<sub>4</sub> in  
Axle spacing and waggon width over wheels both 2 ft 6 in.  
Dimensions scaled

*Fig. 16*

© Author

**Plan of Bell Rock railway waggon for transporting stone [G. C. Scott/Stevenson 1824] Weight about 2 cwt – Left upturned on the rock when the tide rose, but not moved much by the sea when the rock was inundated. Note two-frame chassis to accommodate some degree of turning.**



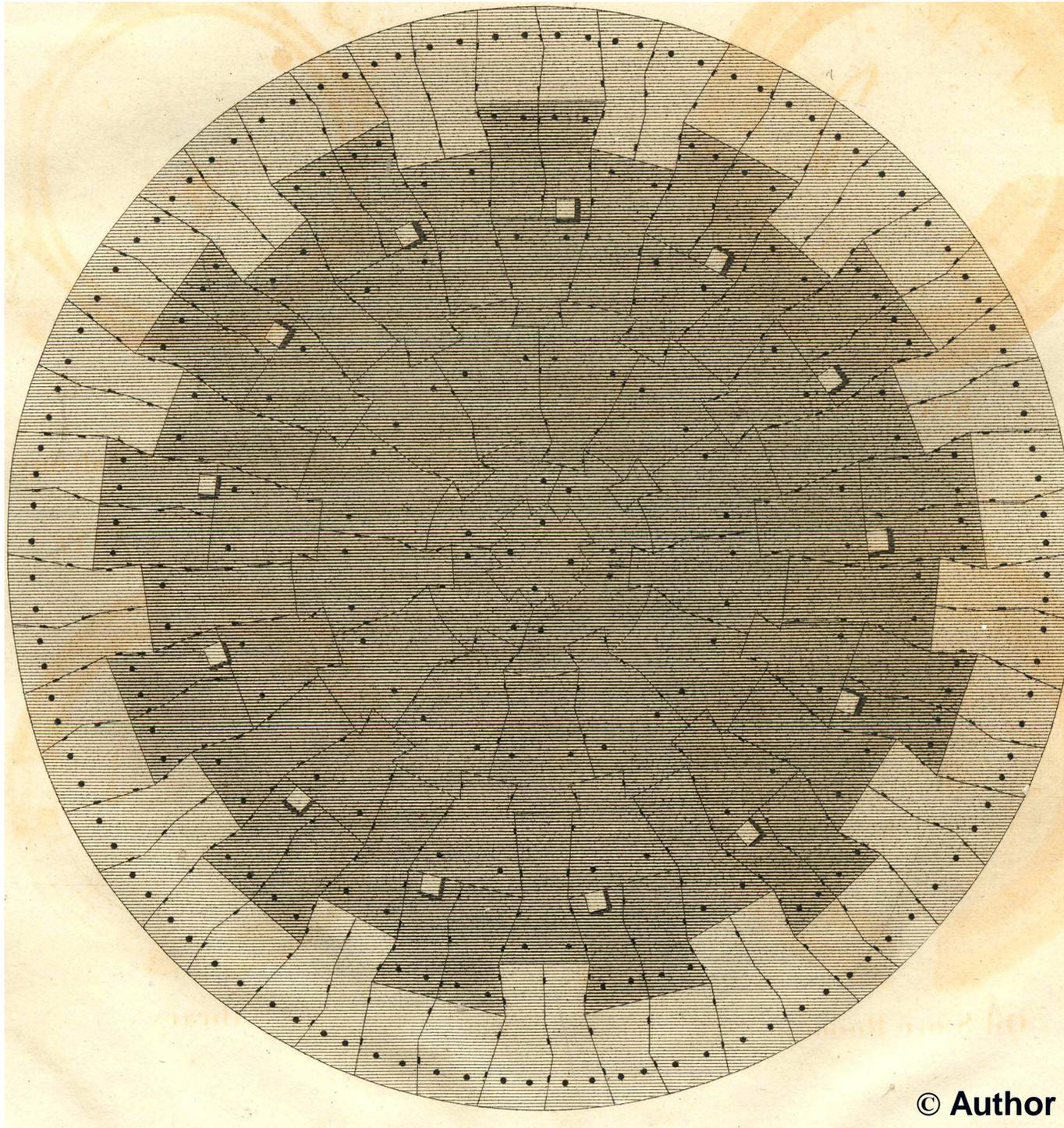
© Author, courtesy National Museums Scotland

**Model made by 1822 for Stevenson by James and Alex. Slight?  
indicative of railway operation c.1809 (from stone shape) but  
with some 1815-19 side-stays! NB - two-man waggon operation**

Another view.  
Note waggon  
end detail  
and railway  
construction



© Author, courtesy National Museums Scotland



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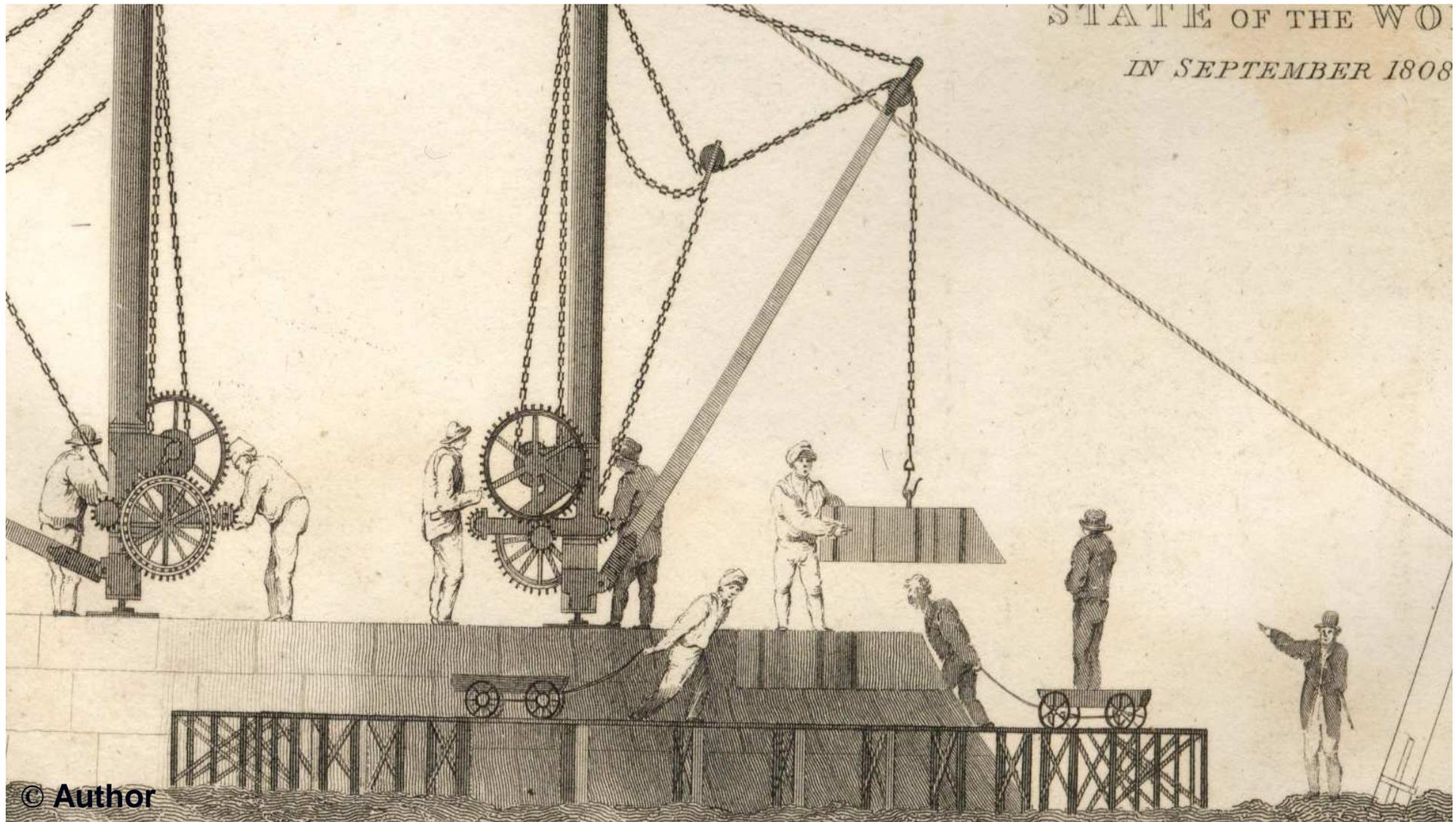
**First entire  
course [of 90]  
[1 ft x 42 ft dia.  
104 tons] 123  
stones from 11  
patterns.  
Outer stones  
Aberdeen  
granite, inner -  
Mylnefield  
sandstone –  
Average stone  
weight 17 cwt,  
some >1 ton .  
28,530 cu. ft.  
of stone in all.  
Total weight  
2076 tons.**



Courtesy National Library of Scotland

**Bell Rock – July 1810. On ‘Taylor’s Track’ and ‘Watt’s Reach’ [part] where rock surface was up to 6 ft below rail level and the iron supports offering minimal resistance to the sea were bolted to timber baulks. [Drawing by Stevenson’s assistant G.C. Scott]**

STATE OF THE WORLD  
IN SEPTEMBER 1808



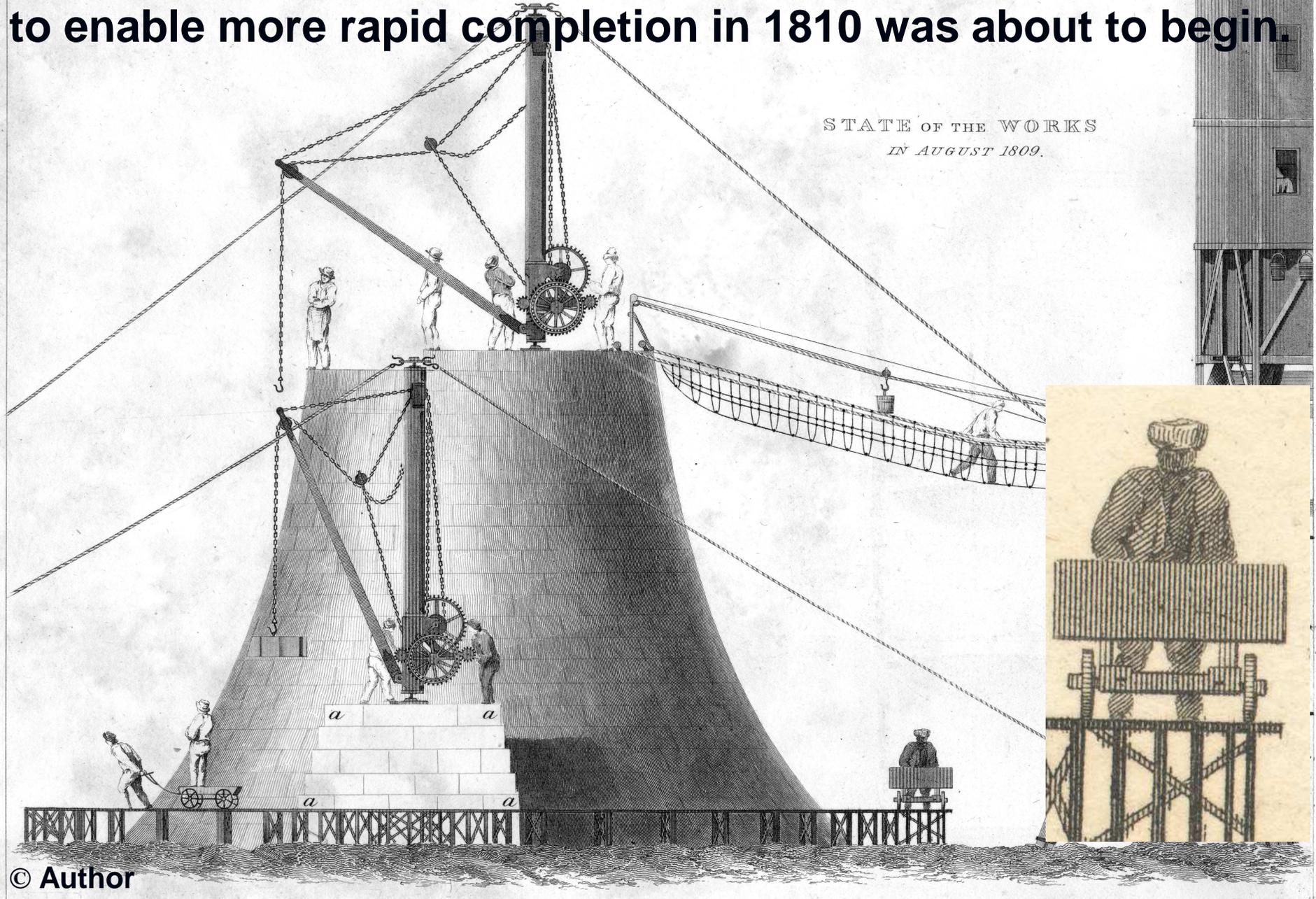
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**Operations in Sept. 1808 showing the partly completed railway to a 26 ft radius. As it was incomplete by 8 July 1808 when the foundation stone was placed, it and stones for the first full course had to be unloaded on site at or near high tide through the water – a difficult and unsatisfactory arrangement.**

**By 18 August 1809 the tower was 60% complete in mass and 30% in height. The railway extension to new northern wharfs to enable more rapid completion in 1810 was about to begin.**

PROGRESS OF

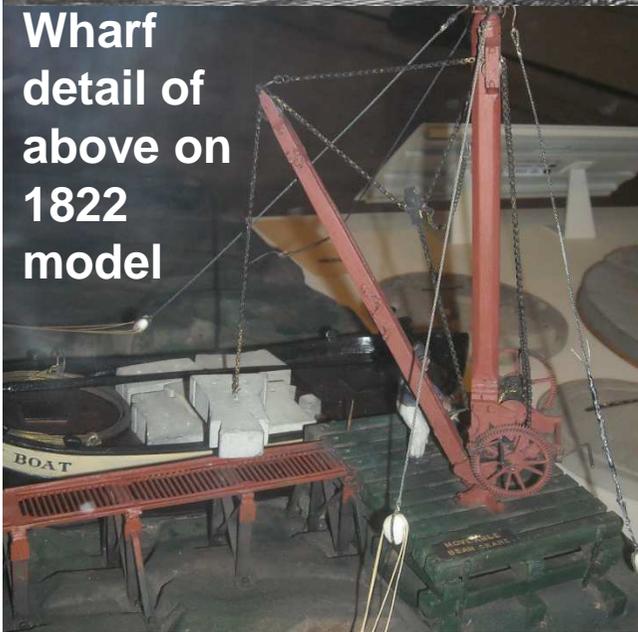
STATE OF THE WORKS  
IN AUGUST 1809.



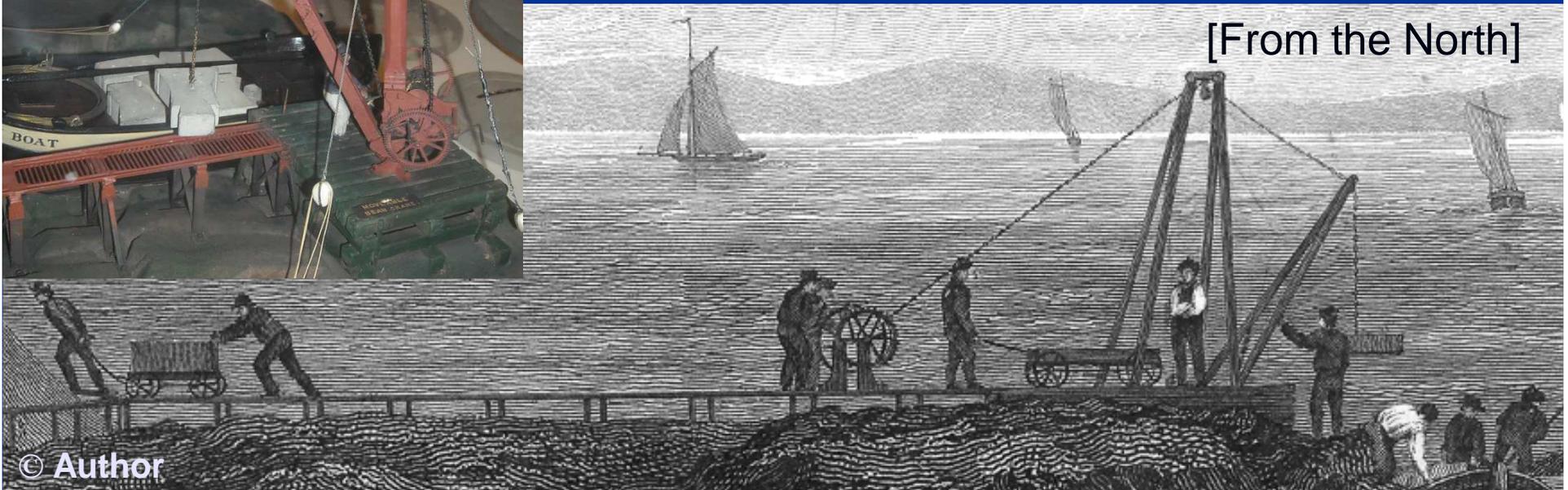
[From the South]



Wharf  
detail of  
above on  
1822  
model

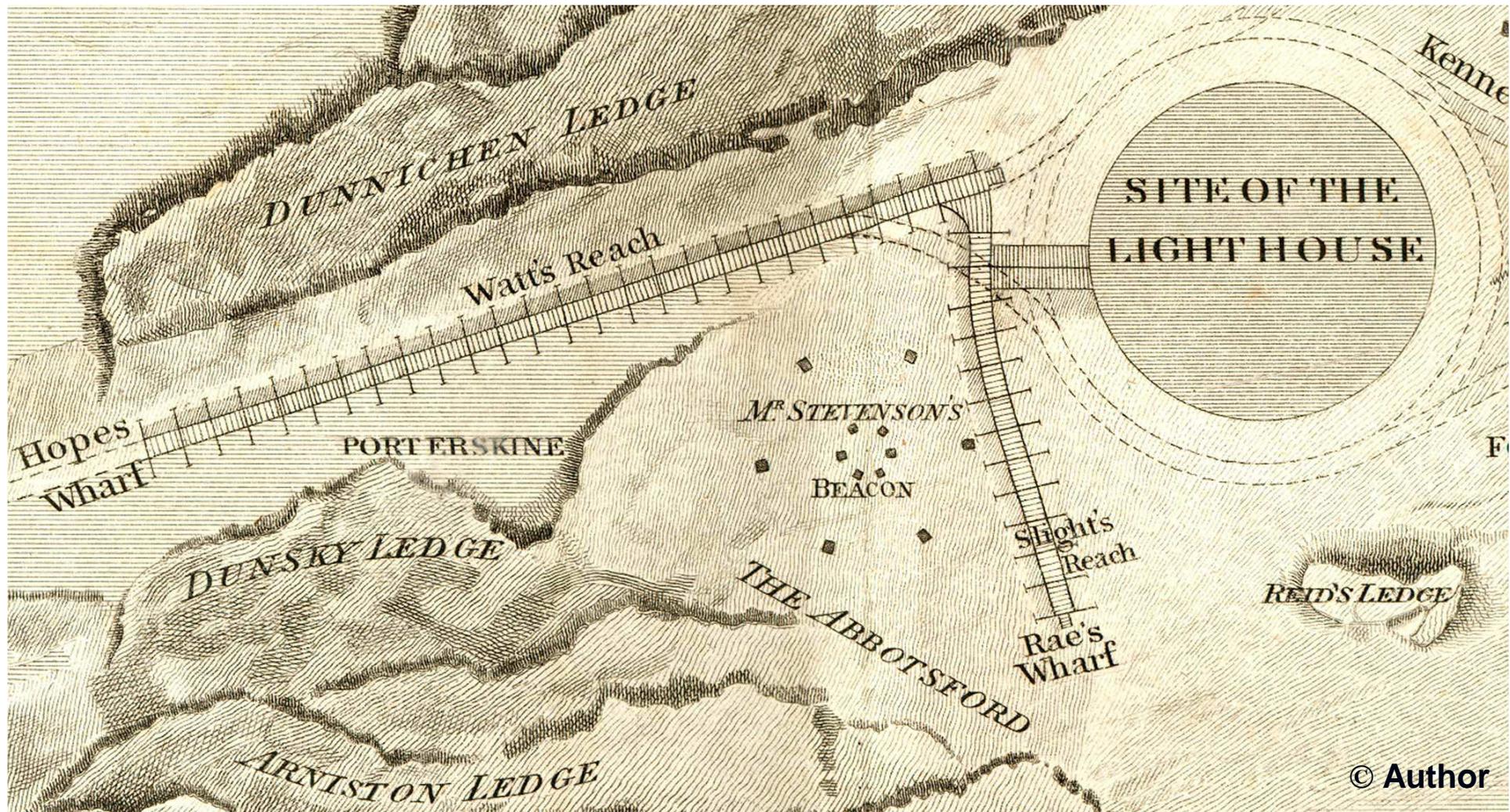


[From the North]

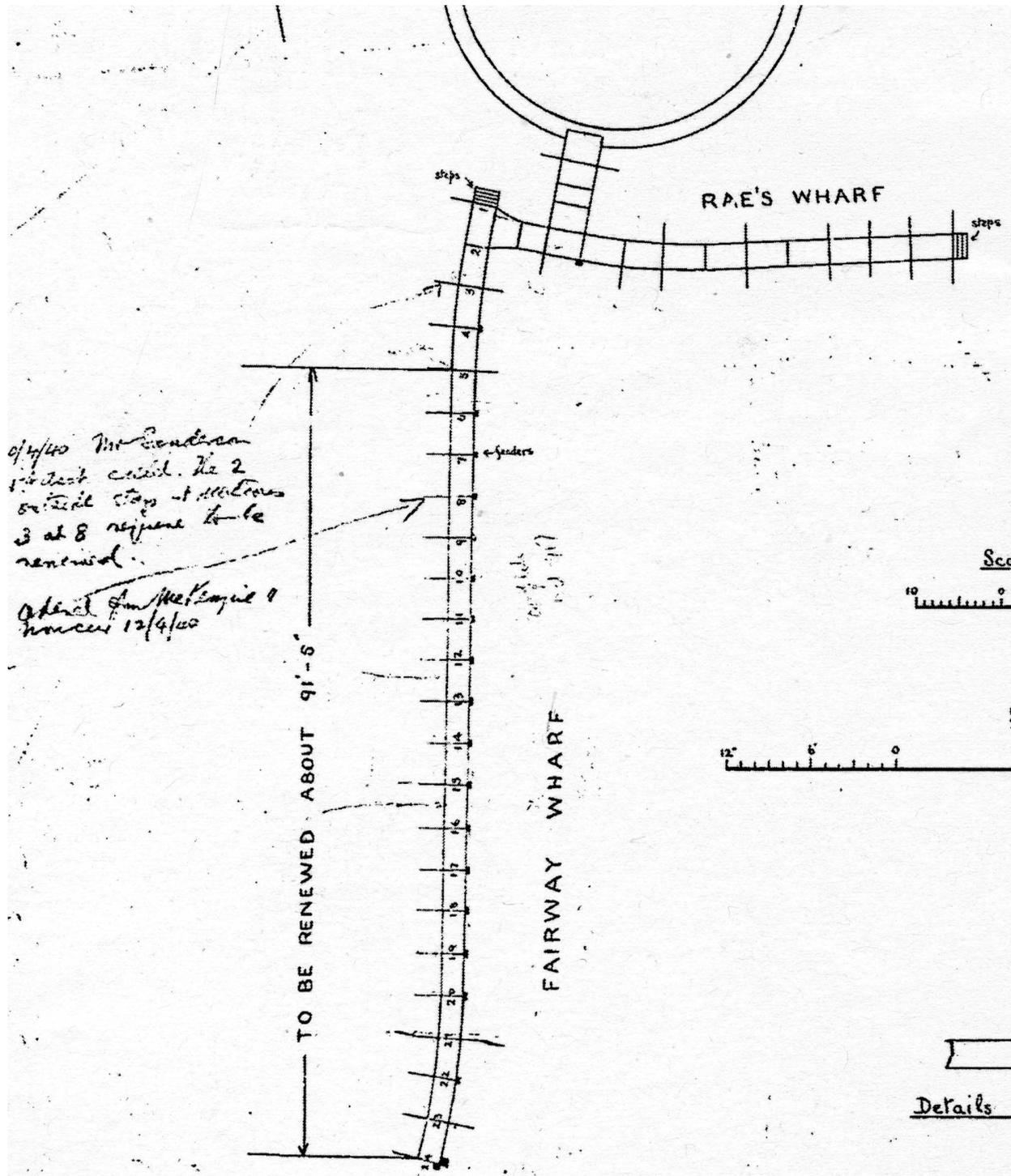


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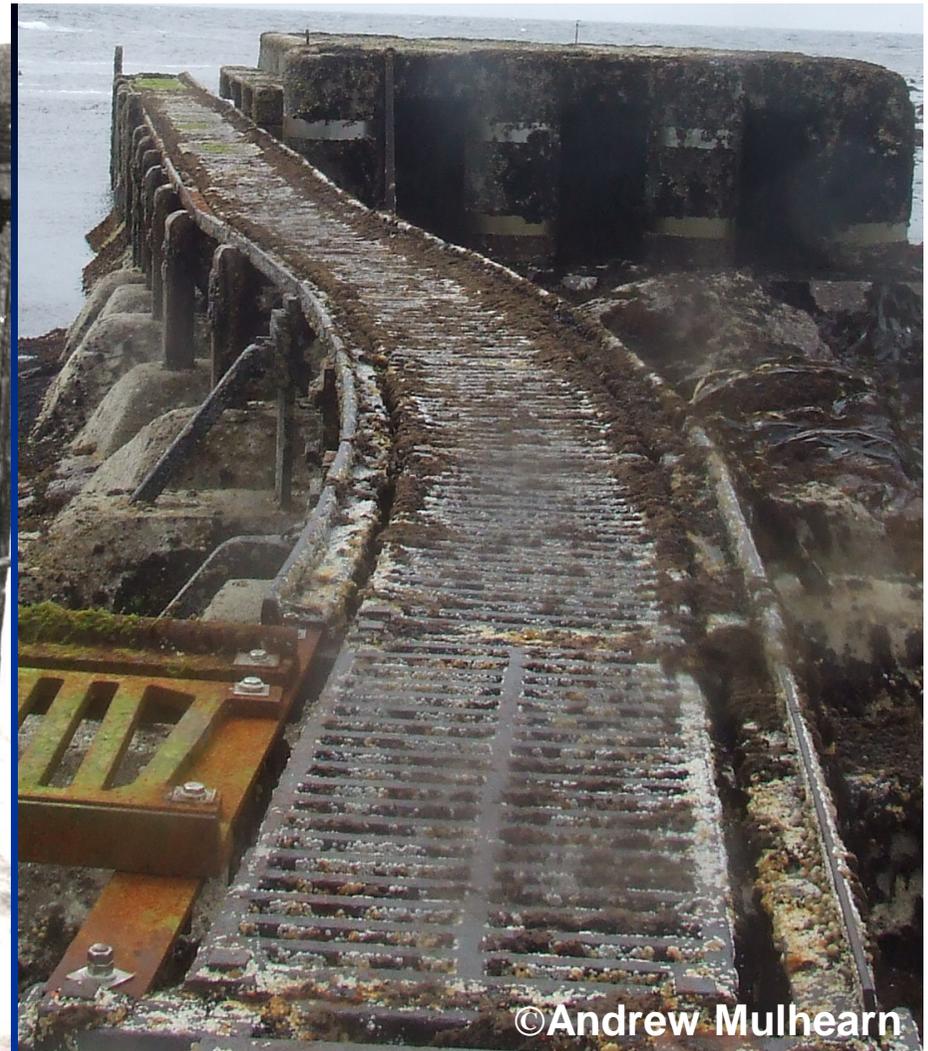
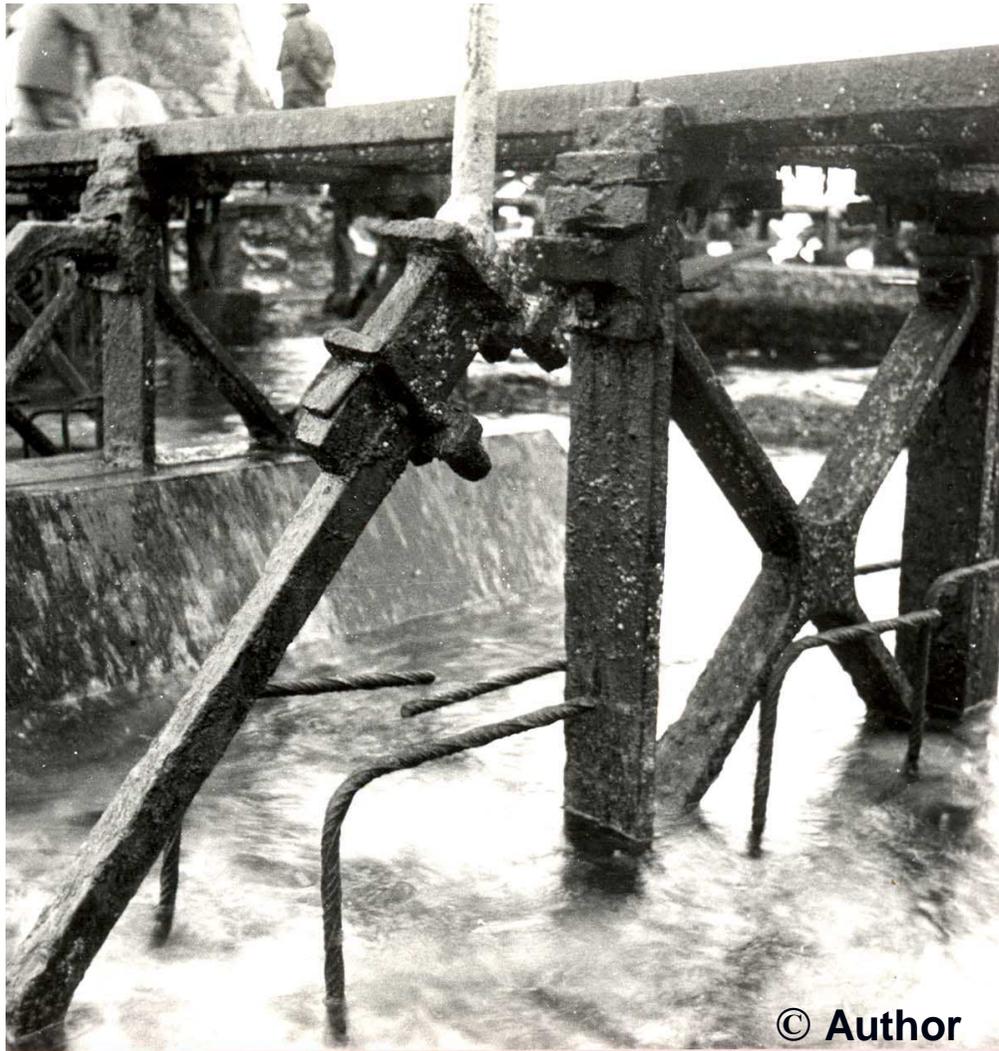
**Bell Rock Railway in full operation in July 2010 – near wharfs**



From 1815-19 the length of railway shown in solid lines on this 1824 plan, about 20% of the total, part strengthened and partly realigned, was made 'permanent' for lighthouse access. Since then, it has been repaired and painstakingly refurbished from time to time, notably in 1917 and recently.



Part of a D.A. Stevenson plan of 3/4/1917 showing most of Fairway Wharf carried away in a storm on 19/11/1916 [ by the action of travelling boulders] to be renewed so, very little, if any, of the 1819 railway now exists. Nevertheless the longevity of the cast iron has been remarkable.



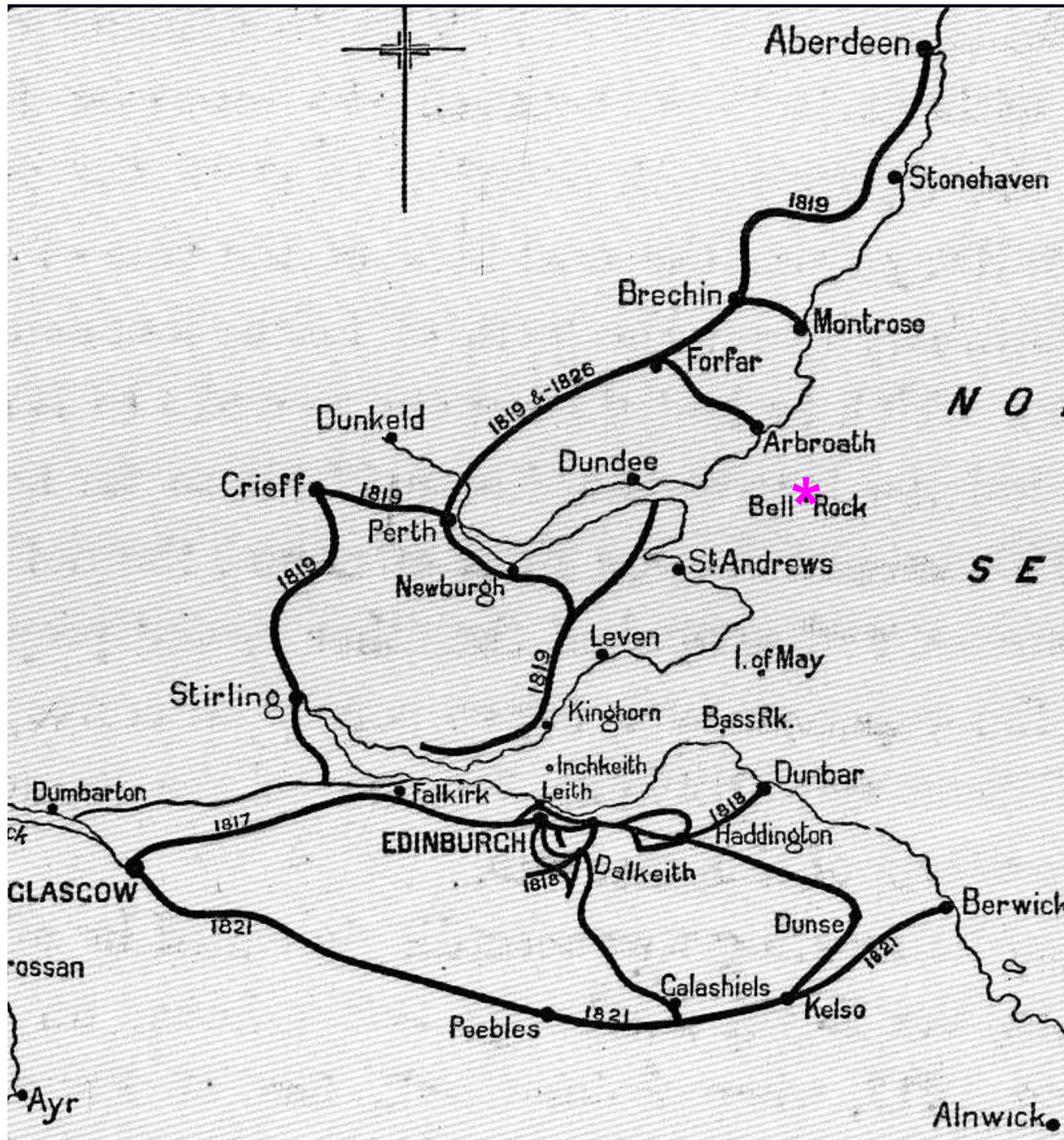
**(left) 'Watt's Reach' of the railway inspected by author in 1986. (right) 'Watt's Reach' in 2011, from near the lighthouse, now unmanned. Note some stronger supports with concrete encasement and recent track replacement by NLB (front left). The older work, probably 1917, is to the original dimensions.**

**Bell Rock 2011 showing  
'permanent' railway.**



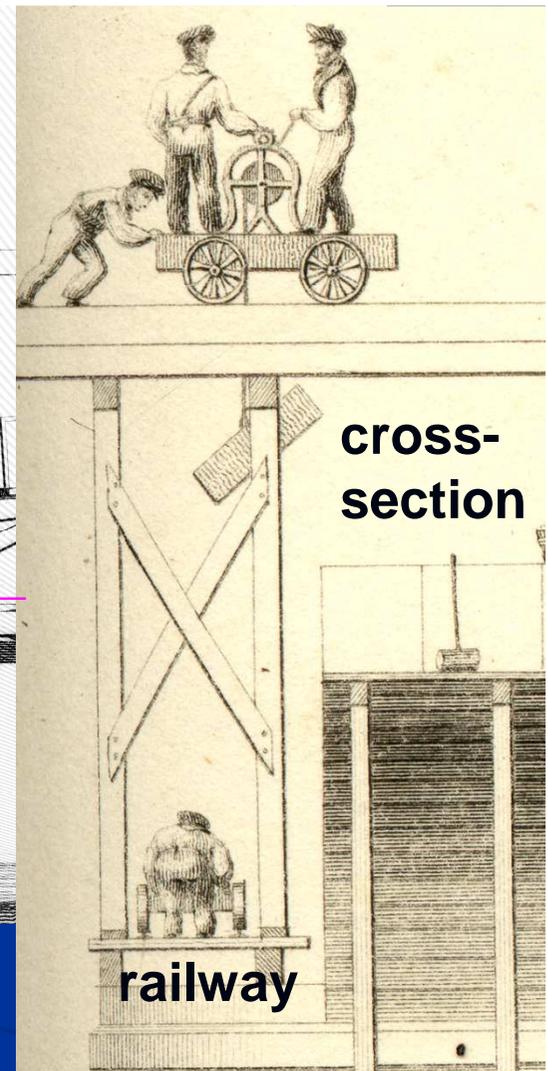
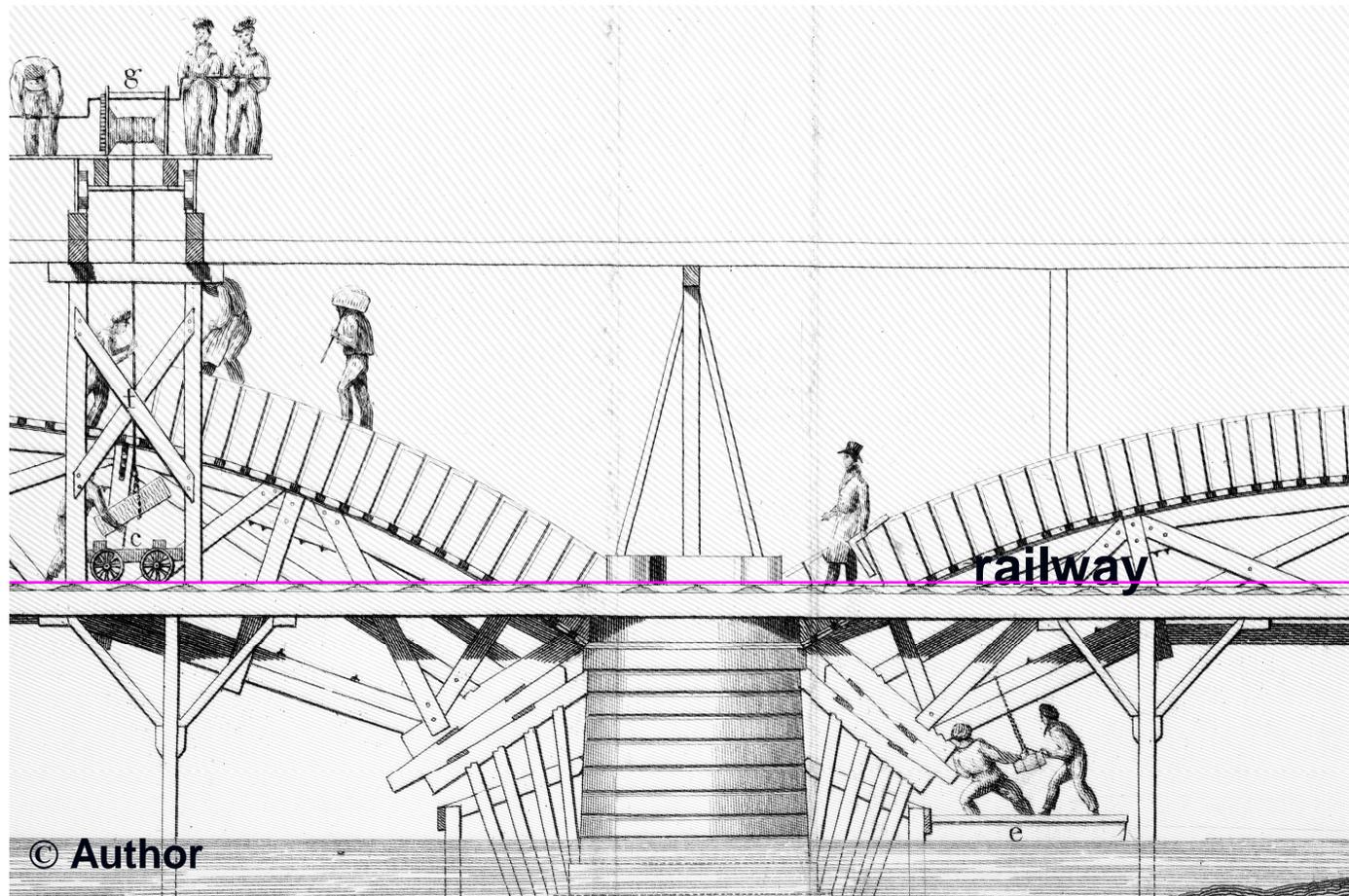
## Main Findings

- ❑ That this novel, man-traction, narrow-gauge plate-way, purpose designed by intuition and experience to carry stone and, exceptionally, to counter sea action, was essential to safe completion of an engineering wonder of the world by 1810.
- ❑ That the railway was designed and erected by foreman-millwright, Francis Watt, to the concept of and under the direction of Stevenson with the approval of Rennie. Its ironwork was made at Shotts and Shelf Iron Works, Bradford and cost, including erection, about £2800 [equivalent to about £2m now].
- ❑ That the railway's success was the catalyst to Stevenson becoming by 1820 a leading authority on pre-steam locomotive railways, promoting the edge rail and many Scottish lines which although unexecuted at the time developed later.
- ❑ That the railway, although not replicated elsewhere, influenced Stevenson projects, and through Weale's *Bridges* [1843] also encouraged the use of railways to facilitate construction.

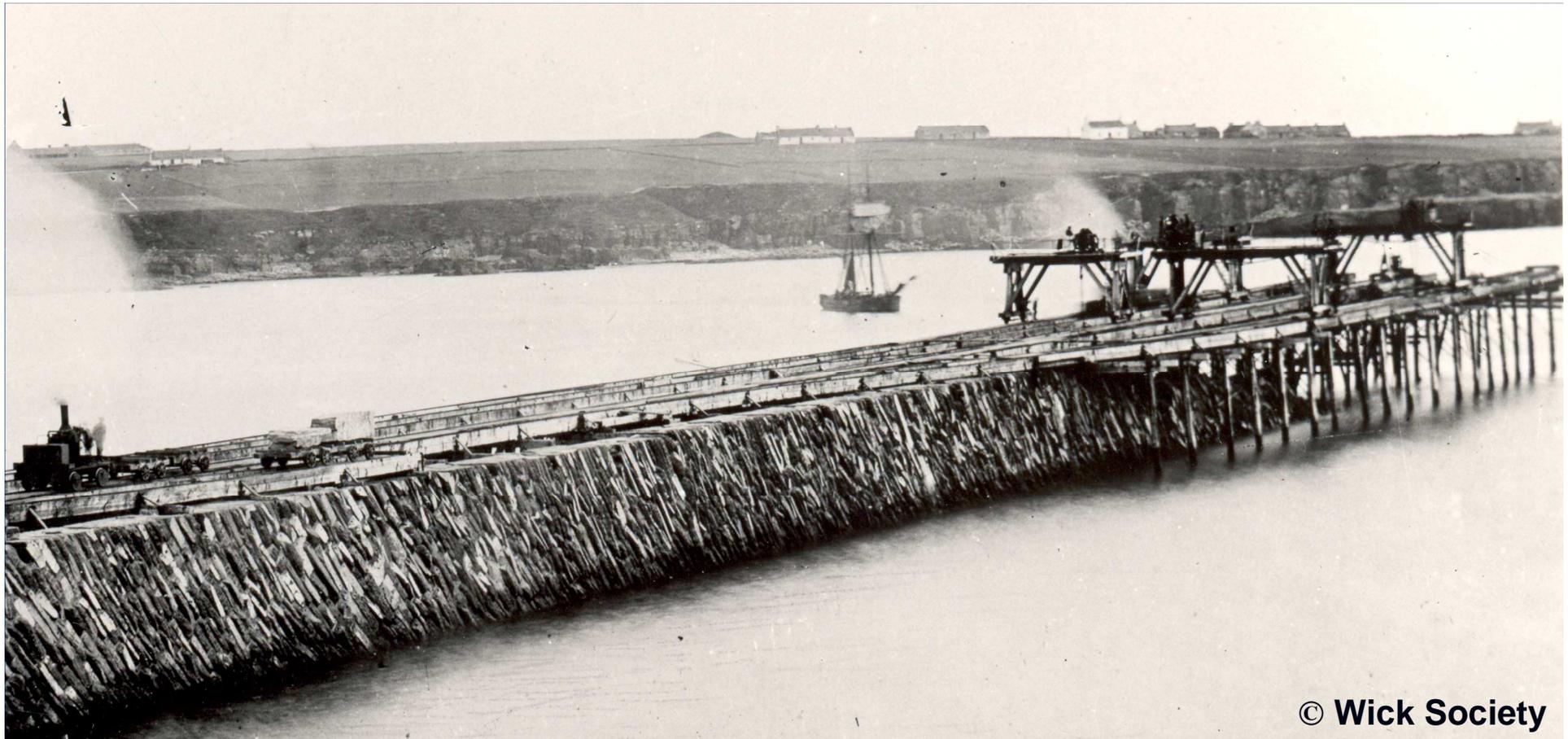


**Stevenson  
Railway  
proposals  
by 1826  
totalling about  
500 miles,  
although only 2  
short coal lines  
were built.**

**For Edinburgh  
- Haddington  
Railway 1818,  
12 ft long  
malleable iron  
edge rails were  
proposed.**



**Later usage of railways in construction. Hutcheson Bridge over the River Clyde, Glasgow 1831-34 to Stevenson's design showing temporary railways in operation. The contractor, John Steedman, was Stevenson's former chief assistant. [From an 1833 drawing by Steedman's apprentice, J. Andrews published in Weale's *Bridges* in 1843].**



© Wick Society

**Later examples:  
Wick Breakwater under construction in 1868.  
Engineers: D. & T. Stevenson – Extensive use of railways  
to carry stone from the quarry and place it as shown in the  
sea. An inclined tramway was used by the same engineers  
during the construction of Dhu Heartach Lighthouse in 1869.**