1. Belief in Steamers

- Was iron steamship technology inevitable in the 19th century?

  - *Standard accounts*: Yes! Iron and steam's success produced a revolution in shipping with major consequences for 19th European empires.

"this chapter challenges these traditional assumptions with a historiographical narrative that integrates in local contexts the often-ignored 'failures' that counteract a story of heroic and progressive 'success'". (MS05, pg. 89.)

No assurance that steam would prevail:

- 1854 steamship accidents:
  - *City of Glasgow* lost with 480 passengers.
  - *City of Philadelphia* runs aground.
  - *Artic* lost with 350 passengers.

- 1874 stats: 593 of 11,569 British ships lost.

- 1850-1874. Increases in tonnage of *both* steam and sailing ships.

- Early 20th century "wind-jammers" (iron-clad sailing ships): continued use through WWII.

- 1801. William Symington's *Charlotte Dundas*.
  - *Steam-powered canal boat in Scotland*

- 1807. Robert Fulton's *Clermont*.
  - *Steam-powered riverboat on the Hudson, from Brooklyn to Albany!*

- Centers of steamship development:
  - *Glasgow on the River Clyde.*
  - *London on the River Thames.*

- 1818. First cross-channel steam service (Glasgow and Belfast).

- 1821. David Napier establishes Glasgow shipyard.
  - *Cultural context:* "...a tightly knit Glasgow business community with strong Presbyterian values of hard, useful work and disciplined Sabbath observance..."

ROBERT FULTON'S CLERMONT - 1809
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Ex: George Burns (Napier associate):
- *Insists on sailing on Friday so as not to violate the Sabbath.*
- *Chaplains must accompany voyages that can't avoid this.*

- 1840s. American-built and -owned clipper ships dominate China tea trade.
  - *Scottish Clyde-built clippers compete.*
  - *Slow steamships offer low prospects.*

- Issue of scientific credibility in steamships.
  - *Recall BAAS concern: Will compasses work on iron-hulled steamers?*

- *But more importantly*: Issue of public trust in steamships.

> *Ex*. 1819. Maiden voyage of steam-aided sailing ship *Savannah*, U.S. to England.
> - *But*: No passengers!
> - *And*: President James Monroe refuses to ride even from Charleston to Savannah.

I. K. Brunel's steamship "experiments"

- ## 1830s. *Great Western.*
  - *First purpose-built Atlantic steamer.*

- ## 1845. *Great Britian.*
  - *Maiden voyage takes 60 (out of 360 cap.) passengers 15 days to travel from Liverpool to New York.*
  - *Fifth voyage ends in stranding.*

- ## 1850s. *Great Eastern.*
  - *Delayed launches, bankrupcy, death of Brunel.*
  - *1859. Initial launch results in explosion and 5 deaths.*
  - *1860. Maiden voyage with 35 passengers, 418 crew. Public confidence never recovers.*
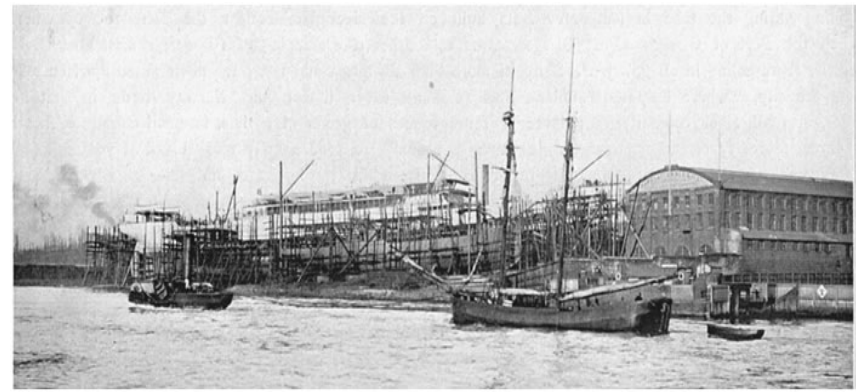 - *Later reconfigured for manual labor on trans-Atlantic telegraph cable project.*

The Three Great Ships
PS *Great Western* 112ft, SS *Great Britain* 212ft, and the PSS *Great Eastern* 692ft.

Clyde shipyards: Establishment of trust

> "..no inevitability about the Clyde's rise to pre-eminence in iron shipbuilding."

> *Claim*: Clyde dominance was due to the *local* cultural context.

- *A social network of Glasgow engineers, industrialists, and clergy established public trust based on Presbytarian values, work-ethic, and a "moral economy" of minimizing waste.*

- 1830s. Robert Napier gets contract for mail steamer for East India Company.

- 1839. Samuel Cunard gets Royal Mail contract.
  - *Partners with Napier to form British & North American Steam Packet Company (later Cunard Line).*
  - *Emphasis on safety and reliability, not "experimentation".*

> "Never in advance of the times, but never far behind them; never experimenting, but always ready to adopt any improvement thoroughly tested by others; avoiding equally extravagance and parsimony... the success of this Company, taking all things into the account, has never been equalled." (1864, *North American Review*.)

- Contrast with Brunel's (reckless?) "culture of experiment" associated with BAAS Section G as integral to science-based engineering practice.

- 1854. Liverpool meeting of BAAS: No consensus on the best design of ocean vessels, with respect to size, speed, material or engines.
  - *Debate over whether high temperature or high pressure should be considered in choosing the best type of working fluid for a heat engine.*

- Macquorn Rankine presents paper on air engines and efficiency based on emerging theory of thermodynamics.
  - *Temperature difference between heat source and exhaust solely determines efficiency.*
  - *Suggests air engines can be made more efficient than steam engines.*
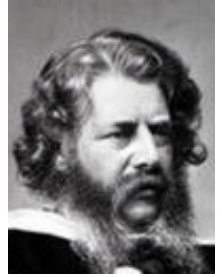
Macquorn Rankine (1829-1872)

- <u>*But*</u>: Projectors did not invest in air engine projects.
 - *Too experimental and unproven.*
  - *Associated with extravagant personalities (e.g., Ericcson).*

- Rankine's analysis suggests double-acting steam engines can be made more efficient (from 4 lb. of coal per horse-power/hr. to 2.5 lb.).
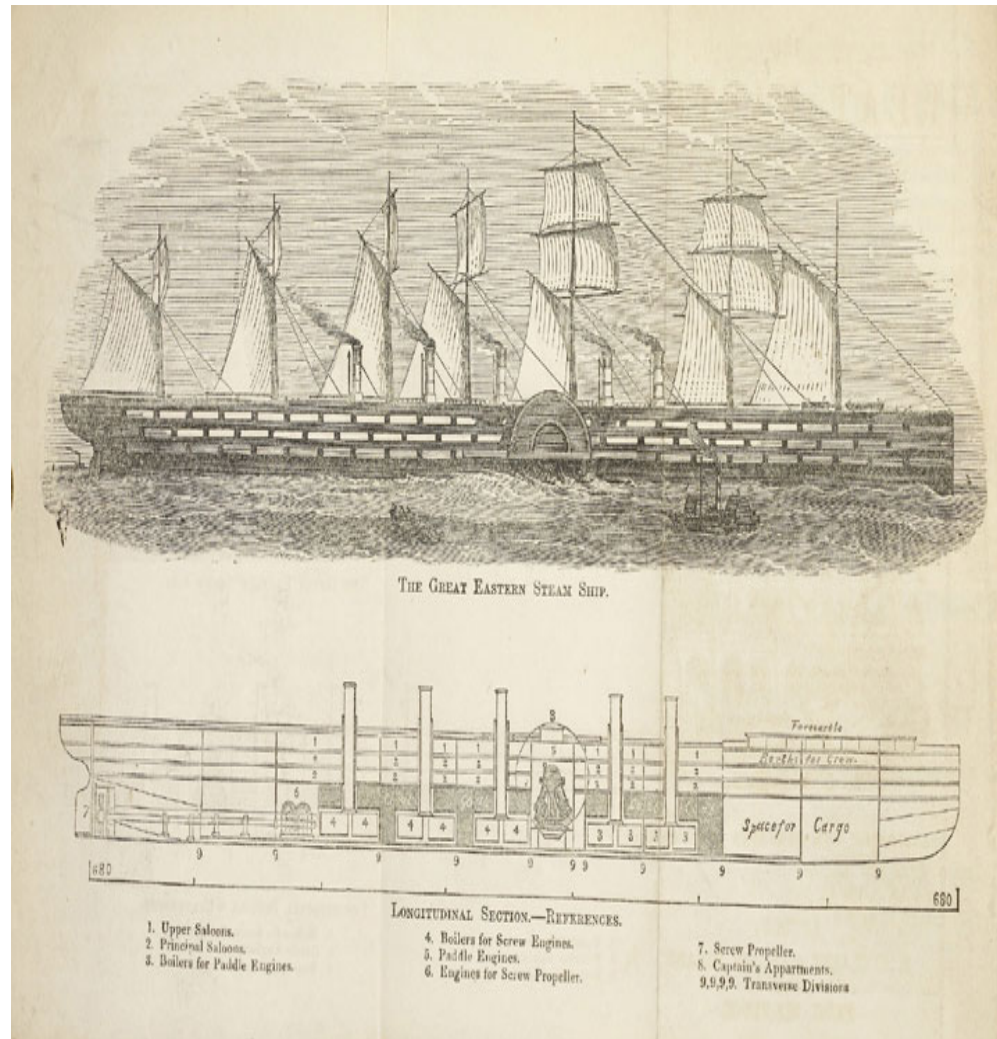 - *1854. John Elder's compound engine with efficiency of 3.25 lb.*
  - *New generation of compound engine steamships: Inca, 2.5 lb.; Valparasio, 3 lb.; Thetis, 1 lb.*

Early Compound Marine Engines for the Paddle Steamer "Valparaiso."
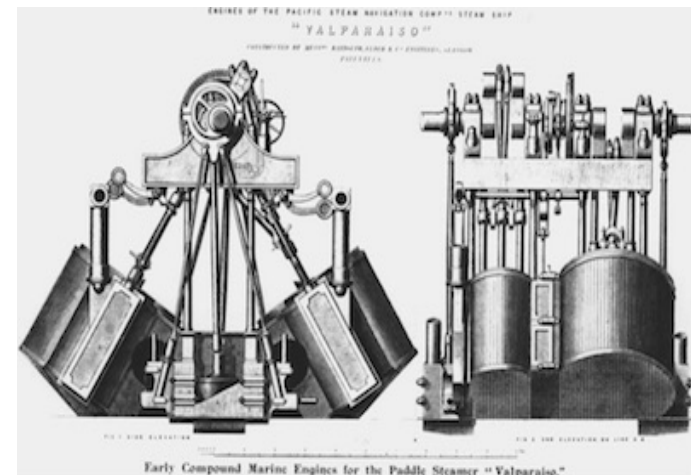
Standard view: "The more fuel-efficient, compound (high-pressure) steam engine was 'needed' before steamers could displace sailing ships on long-distance ocean trades and before steamships could compete without expensive subisdies." (MS05, pg. 119.)

- *But*: Fuel efficiency not always prized as a competitive virtue.
  - *Brunel's Great Eastern was supposed to be large enough to carry enough coal and passengers to be competitive with sailing ships (assumption: British coal is cheap).*

- *And*: When prized, fuel efficiency was not simply a technical constraint.
  - *Claim: Fuel efficiency embodied a Presbytarian/Unitarian moral economy of minimizing waste.*

THE GREAT EASTERN STEAM SHIP.

LONGITUDINAL SECTION.—REFERENCES.

1. Upper Saloons.
2. Principal Saloons.
3. Boilers for Paddle Engines.
4. Boilers for Screw Engines.
5. Paddle Engines.
6. Engines for Screw Propeller.
7. Screw Propeller.
8. Captain's Appartments.
9,9,9,9. Transverse Divisions

Case of Alfred Holt

- Renshaw Street Chapel Unitarian social network of Liverpool.

- 1864. Persuades investors to back Ocean Steamship Company (later Blue Funnel Line).

> "...striving to eliminate waste was not merely driven by commercial pressures to reduce costs or by physical concerns to avoid exhausting bunkers on long ocean voyages. It was indeed for him a universal moral concern, coinciding with the values of the Renshaw Street network in particular..." (MS05, pg. 123.)

- Highly successful company (to 1988) with reputation for safety and reliability.

- Very different experience from Brunel.
  - *BAAS-backing, but dismal track record and little public trust.*
  - *Unitarianism of Holts allowed them to "...handle their local audiences of investors and shippers with consummante skill".*
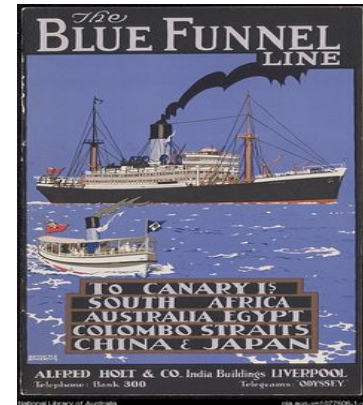
General Moral: Success of steamship technology was not inevitable; rather, it was contingent on culturally determined factors: the establishment of trust among relevant social groups (shippers, investors, public) and the adoption of a *moral* economy of efficiency, reliability, and the minimization of waste.

2. Building Railway Empires

Three themes:

1. The growth of railways from "highly localized interests" in the early 19th century to "vast networks, often on continental scales, serving goals of nation- and empire-building".

2. The growth of railways as "a series of contested historical processes in which neither the L&MR [Liverpool & Manchester Railway] nor any of its rivals such as the Great Western acted unproblematically as fixed templates for later developments".

3. The growth of railways as a construction not only of "networks of iron and steam but also new cultural systems".
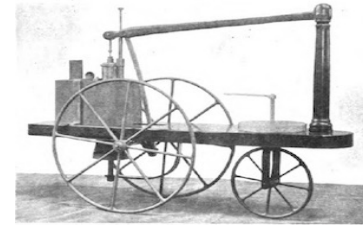
- Late 18th century England.
  - *Coaches carry mail and passengers on road system.*
  - *Canal system links ports with inland manufacturing centers.*

- Experiments with steam-driven carriages.
  - *1769. Nicolas Cugnot's 3-wheeled steam wagon.*
  - *1785. William Murdock's experimental carriage.*
  - *Early 1800s. Goldsworthy Gurney's patents (1825, 1827, 1829).*

- 1831. Steam carriage service from Glouchester to Cheltenham.
  - *Opposition from railroad magnates, turnpike trust, stagecoach operators, suppliers/feeders of horses, and coaching inns.*

"Local feeling, however, was strongly antagonistic to the innovation, and various obstacles were placed in the way of the project, heaps of stones were piled on the road, with the result that an axle broke" (Jenkins*, pg. 76.)

  - *Act of Parliment increases tolls on steam-carriages.*
  - *Service lasts only 4 months.*

"The case of the steam-carriage indicates that there were many imagined transport possibilities, none of them clearly destined to win out in the bustling technological marketplace of the early 19th century." (MS05, pg. 134.)

*Jenkins, R. (1902) *Motor Cars and the Application of Mechanical Power to Road Vehicles*

- One imagined transport possibility: place steam-carriage on its own separate railway.
  - *Fixed rails in mines from 16th century in North-east England and Wales.*
  - *1801. Richard Trevithick's locomotive.*
  - *1812. John Blenkinsop's toothed wheel locomotive.*
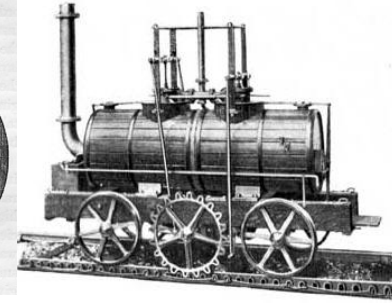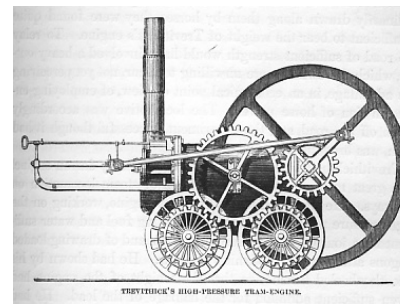
- <u>*Another*</u>: Horse-drawn carriages on own separate railway.
  - *1803. Surrey Iron Railway (South London).*
  - *1838. Innocent Railway (Edinburgh).*

- 1821. George Stephenson appointed engineer for Stockton and Darlington railway.
  - *Tasked with replacing horse-drawn system with steam-powered "Locomotion".*
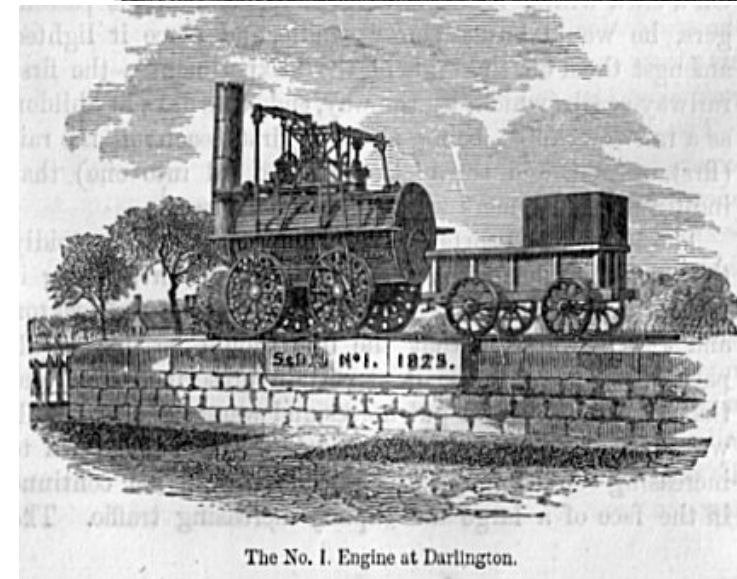 - *Chooses 4 ft 8.5 inch gauge.*

George Stephenson
(1781-1848)

"...the result of the accident that certain tram-roads adjacent to mines were of that width." (1864)

Charles Babbage
(1792-1871)

The No. 1. Engine at Darlington.

The Liverpool and Manchester Railway (L&MR)

- Late 1820s. Investors seek railway line between Liverpool and Manchester.
  - *Enlist George Stephenson.*
  - *Neutralize opposition; get act of Parliment passed allowing line.*

- 1829. Company report: Which transport technology to adopt?
  - *Chief contenders:* *horse, stationary engine, "loco-motive" engine.*
  - *Public fear exploding steam engines hurtling across the country-side belching smoke!*
  - *Solution:* *Public trials for loco-motive option at Rainhill.*
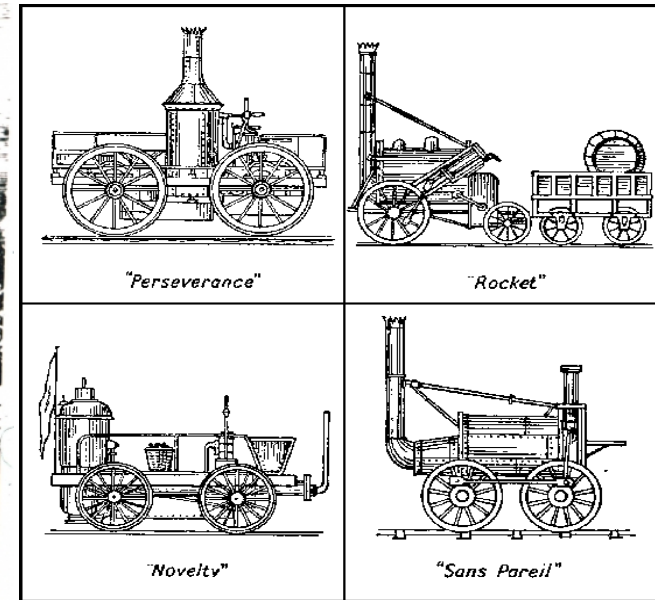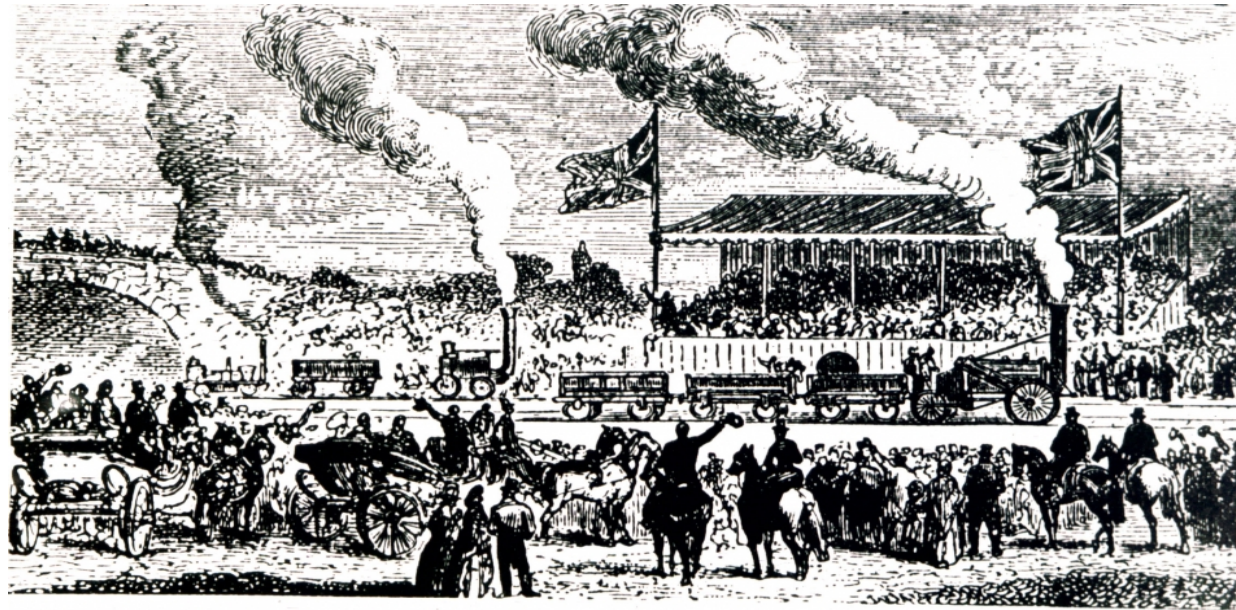
- level 1.75 mile track
- engine pressure of no more than 50 psi
- average speed of at least 10 mph over 35 miles (10 roundtrips)
- must "consume their own smoke"
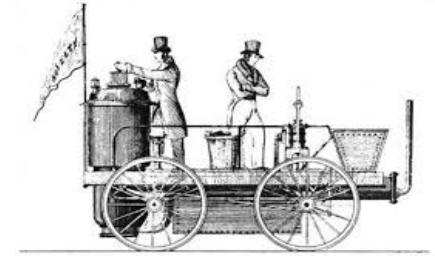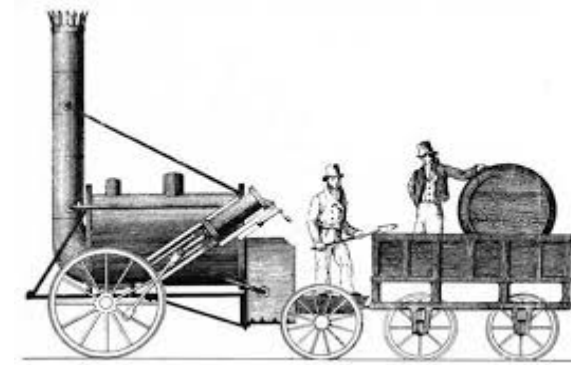
- *But*: John Ericcson's *Novelty* gets short shift:
  - *Faster than Rocket but more erratic.*
  - *Rule change mid-way through to include assessment of time required to get boilers up to pressure (favors Rocket).*
  - *Engines allowed to strip down to ferry passengers at max speed (shows that Rocket can get up to speed).*

More generally: "...the public rhetoric of exhibition, as much as any unequivocal technical demonstration internal to an engineering profession, had been at play." (MS05, pg. 141.)

- 1830. L&MR line officially opens.
  - *MP William Huskisson mangled to death in machinery!*
  - *Charles Babbage runs damage control.*

"Stephen the Rocket"

"Babbage saw [the L&MR] as a technology which might be rendered safer by 'mechanical science'... as the guarantor of innovative engineering projects' trustworthiness." (MS05, pg. 144.)

- BAAS launched within a year of L&MR: Section G established in part as response to railway construction.

The Great Western Railway

Standard account: L&MR seen as model for future development.
- *Combined pre-existing systems of technology: stage couches, canal infrastructure, legal procedures for land procurement, mine rail technology.*
- *Parallel tracks; fixed, reliable timetables; passengers charged by class and mile; purpose-built stations.*

- *But*: The L&MR did not constitute the fixed and final template.

"Rather, the railways were sites for continued variation, innovation -- and experiment." (MS05, pg. 144.)

- *Example*: 1833. I. K. Brunel's Great Western Railway (GWR).

  - *Larger engines, broad 7 ft. gauge for greater speed, enhanced comfort.*
  - *Main trunk line between London and Bristol.*
  - *Great Western steamship (1837) extends GWR westward to US.*
  - *Distinct GWR "culture": broad gauge, large engines, ethos of luxury and speed, prestigious architecture (Paddington and Bristol Temple Meads Stations).*

- **1843. Second surge in railway construction mania.**
  - *Many competing companies, each with separate standards.*
  - *Projectors willing to adopt new innovations without hindsight of rigorous testing.*


> *Example*. Atmospheric propulsion.
> - *Piston propelled through tube down length of track by compressed air generated by pumping stations.*
> - *Carriage attached to piston through slot along top of tube.*
> - *Requires air-tight valve.*
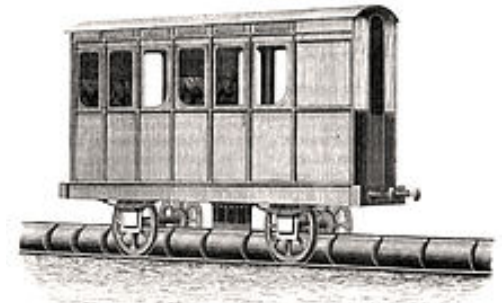
- **1844, March. First atmospheric line: Kingstown & Dalkey Railway, Dublin (1.75 miles long).**

- **1844, August. Brunel convinces directors of South Devon Railway to build atmospheric line.**

> "I have no hesitation in taking upon myself the full and entire responsibility of recommending the adoption of the atmospheric system on the South Devon Railway..."*
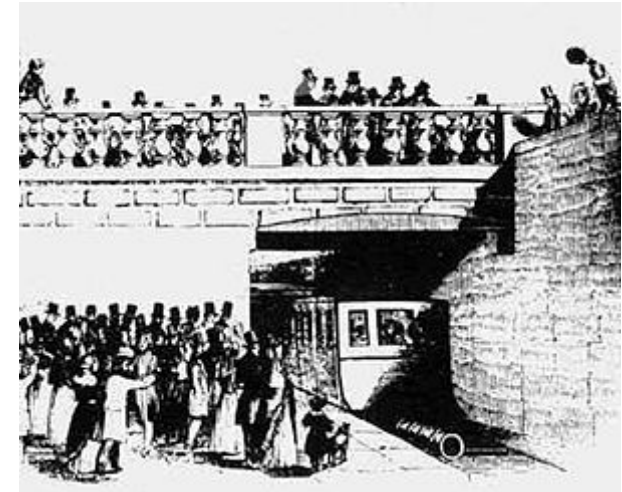
- **1848. Atmospheric line abandoned (converted into steam line).**
  - *Erratic pumping and faulty valves.*
  - *End of mania and tolerance for innovations that were not returning investments.*

Quoted in Buchanan, R. (1992) "The Atmospheric Railway of I. K. Brunel", *Soc. Stud. Sci. 22*, pg. 235.

The Battle of the Gauges

- 1835-37. 88 new companies absorbing venture capital of ~£70,000,000.
- Should there be a standard gauge, and if so, what?

> *Babbage's 4 questions*:
> 1. What would be the best gauge in the absence of tradition and any existing system?
> 2. What is the best gauge based on past experience?
> 3. Should government impose a single standard, as opposed to a free market solution?
> 4. If the free market, then what would be the best imposition to promote national interest?

- 1838. Brunel helps Babbage persuade directors of GWR to allow Babbage to collect data on railways to answer questions.
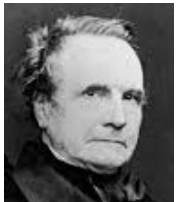
Babbage

Would you continue to advise 4 ft. 8.5 in. based on past experience?

"Not exactly that gauge... I would take a few inches more, but a very few."

Stephenson

- 1845. National debate: No clear technical choice.
- 1846. Gauge Act. Mandates narrow gauge (4ft., 8.5in.) on all new lines.

> "The eventual winners in disputes such as this cannot simply be understood as those with 'the best' technology according to universaly agreed criteria... the final victory of the narrow gauge cannot be seen as merely the result of inevitable rational, or practical, choice." (MS05, pg. 155.)

Cultural Constructs

> "To augment the familiar trustworthiness of the railways, interest groups, including gentlemen of science, entrepreneurs and engineers, and cultural commentators participated in the creation of attractive, rich -- and safe -- railway cultures in diverse forms." (MS05, pg. 156.)

- *Recall*: Heterogeneous engineering = simultaneous construction of technological systems and social worlds.

- Representations of railway culture in visual media

  - *Images of locomotives (like portraits of stallions) signified power, pedigree, progress.*

  - *Images of railway infrastructure in bucolic settings displayed the "naturalness" of railway technology.*

  - *Images of the architecture (Classical, Moorish, Tudor, Gothic, Egyptian) of bridges, tunnels, and stations associated railway technology with Western aesthetics.*

- Joseph Turner's *Rain, Steam and Speed: the Great Western Railway* (1844).

- *A representation of the loss of 'Old England' to steam culture?*
- *A symbol of human progress challenging nature's elemental forces?*

"It cut a modern technological corridor through a previously unspoilt landscape replete with pastoral classical resonance -- and thus signalled a culture, literally, in transition." (MS05, pg. 157.)

- Representations of railway culture in print media
  - *Literary railway culture as a new mode of seeing.*

"The panoramic gaze of the train traveler"*

- Train travel as disruptive of traditional modes of seeing:

"In travelling on most of the railways, the face of nature, the beautiful prospects of hill and dale, are lost or distorted to our view. The alternation of high and low ground, the healthful breeze, and all those exhilarating associations connected with 'the Road', are lost or changed to doleful cuttings, dismal tunnels, and the noxious effluvia of the screaming engine." (Anonymous, 1844.)

- Train travel as an innovative new "panoramic" mode of seeing:

"Nothing by the way requires study, or demands meditation, and though objects immediately at hand seem tearing wildly by, yet the distant fields and scattered trees, are not so bent on eluding observation, but dwell long enough in the eye to leave their undying impression. Every thing is so quiet, so fresh, so full of home, and destitute of prominent objects to detain the eye, or distract the attention from the charming whole, that I love to dream through these placid beauties whilst sailing in the air, quick, as if astride a tornado." (M. Ward, 1853.)

"In a few hours, it shows you all of France, and before your eyes it unrolls its infinite panorama, a vast succession of charming tableaux, of novel surprises. Of a landscape it shows you only the great outlines, being an artist versed in the ways of the masters. Don't ask it for details, but for the living whole." (J. Clarétie, 1865, pg. 61.)

*Quotes from Schivelbusch, W. (1977) *The Railway Journey*, pp. 54, 60, 61.

- Railway culture's role in the construction of new social spaces.

  "Travellers quickly rediscovered reading as a mechanism by which to avoid embarrassment in the new social space of the railway carriage." (MS05, pg. 158.)

  - *Universal time standard based at Greenwich.*

  - *Subsequent social distinction between work and leisure.*

  - *Physical distinction between urban and suburban.*

  - *Development of urban cultural and commercial centers (trip into town).*

  - *Creation of leisure resorts for newly mobile masses (trip out of town).*

Brighton Beach, early 19th cent.

- New professions and academic fields:

  - *Late 1830s. Durham University establishes academic rank of "civil engineer".*

  - *1841. Trinity College Dublin establishes School of Engineering.*

  - *1847. George Stephenson forms Institution of Mechanical Engineers (breaks away from Institution of Civil Engineers dominated by older generation of canal engineers).*

Stephenson