

# 19. *Engineering Empires: Chap 5, Conclusion*

## 1. "The most gigantic electrical experiment"

"In this chapter, our interest is in the 'reputation' of the telegraph, as much as in the reputation of its advocates; that is, we want to understand the simultaneous creation of a stable role (or roles) for the telegraph and an authoritative role (or roles) for its advocates." (MS05, pg. 179.)

- This involves the "fashioning of engineers and their artifacts":
  - *Assembling a new and valued identity.*
  - *Assembling a trustworthy and reliable technology with a well-defined meaning.*
- Heterogeneous engineering: not just construction of a technological system and its social worlds, but also the construction of the engineers themselves.



Claude Chappe  
(1763-1805)

*Refashioned  
as "telegraph  
engineer".*



William Cooke  
(1806-1879)

*Refashioned  
as "electrical  
telegrapher".*



Francis Ronalds  
(1788-1873)

*Refashioned as  
"founding father" of  
Society of Telegraph  
Engineers.*



Samuel Morse  
(1791-1872)

*Refashioned from  
artist to "economist  
of intelligence".*



William Thomson  
(1824-1907)

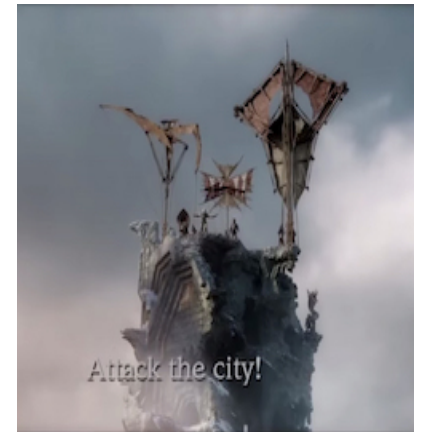
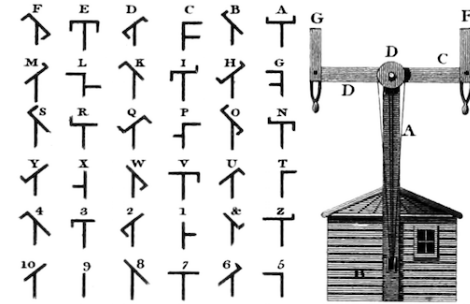
*Refashioned from  
Cambridge wrangler  
to expert on "electrical  
engineering".*

## (a) The Revolutionary Telegraph

- 1789. French revolution.
  - *Claude Chappe and brothers promote "tachy-graphe" as a crucial tool in a war effort.*
- 1794. Chappe made military lieutenant with title of "telegraph engineer".
- Chappe telegraph:
  - *Visual system based on both old and new forms of technology.*
  - *Old forms: stone towers/belfries, cranks, ropes, pulleys.*
  - *New forms: skilled operators with code books; social organization with low-paid "stationnaires" doing menial recording.*



*Claude Chappe*  
(1763-1805)

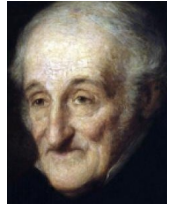
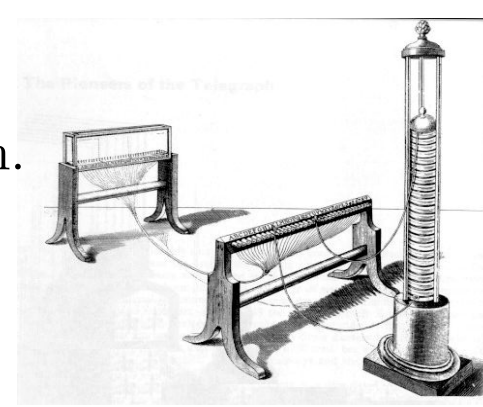


*semaphoring orcs*

"The credibility and stability of [telegraph lines in France and other nations]... depended on the intensity of fighting and, moreover, on the level of perceived threat which gave them meaning as military technologies. In times of peace that meaning evaporated and without a new and different promise, fulfilled or not, they were vulnerable to closure." (MS05, pg. 186.)

## (b) The Entrepreneurial Telegraph

- 1809. Samuel von Soemmering's electrochemical telegraph.
  - *One wire per letter/numeral (35).*
  - *Each wire immersed in tube of acid at receiver (2 miles away).*
  - *Current through wire produces hydrogen bubbles.*
- 1816. Francis Ronalds' static electric telegraph.\*
  - *8 miles of wire stretched between two wooden frames in backyard garden.*
  - *Leyden jar at sender builds up charge, which is dispersed through wire.*
  - *Two resin spheres suspended on silk threads at receiver.*
  - *Markets system to British Admiralty but is rejected.*
- 1820. Hans Christian Oersted observes compass needle deflected in presence of an electric "conflict".
- 1820. André-Marie Ampère's "galvanometer" ("current" detector).
  - *Suggests using galvanometers to transmit messages (one wire per galvanometer for each letter).*



Francis Ronalds  
(1788-1873)



"Hardly any of his experiments succeeded... He is dreadfully confused and is equally unskillful as an experimenter and as a debater."



H. C. Oersted  
(1777-1851)

\* Roberts, S. (2012) *Distant Writing*, pp. 4-5.

- 1820s-30s. Table-top "philosophical toys" and public demonstrations.

- Example: 1832-33. Paul Schilling's electric telegraph.

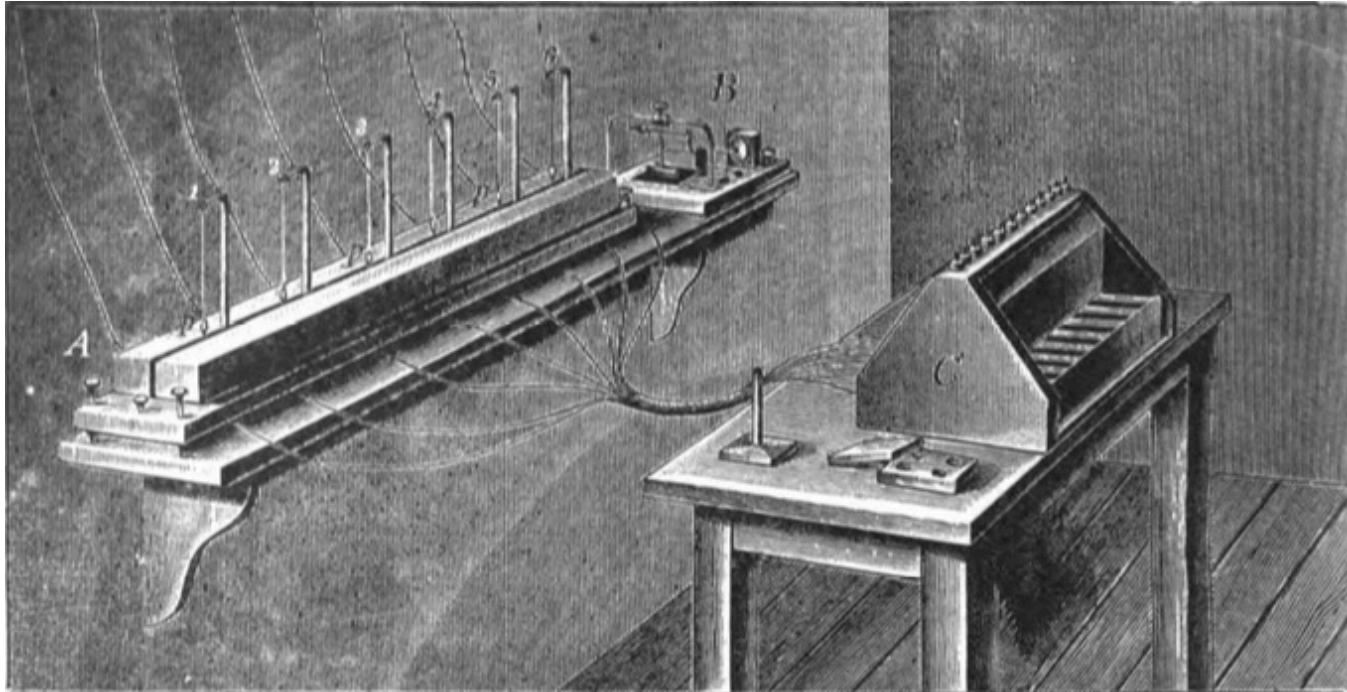
- *Set up in apartment in St. Petersburg.*

- *1835. Public demonstration.*

- *1836-37. Single needle version.*

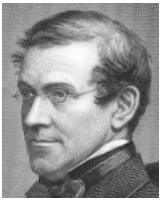


Baron Paul L. Schilling  
von Canstatt  
(1786-1837)



"Six magnetic needles hanging by silk threads were fitted with multiplying coils. These, together with a call apparatus (B), were connected by eight wires, one of which was for the return current. A keyboard (C) served to close the circuit. The movement of the needles was marked by little cardboard discs (*p*) fastened to the hooks on which the needles hung. When at rest these thin cardboard discs turned their sharp ends to the onlooker, but when deflected their flat sides, of which one was white and the other black."\*

\* Kolbe, B. & J. Skellon (tr.) (1908) *An Introduction to Electricity*, pp. 318-319.

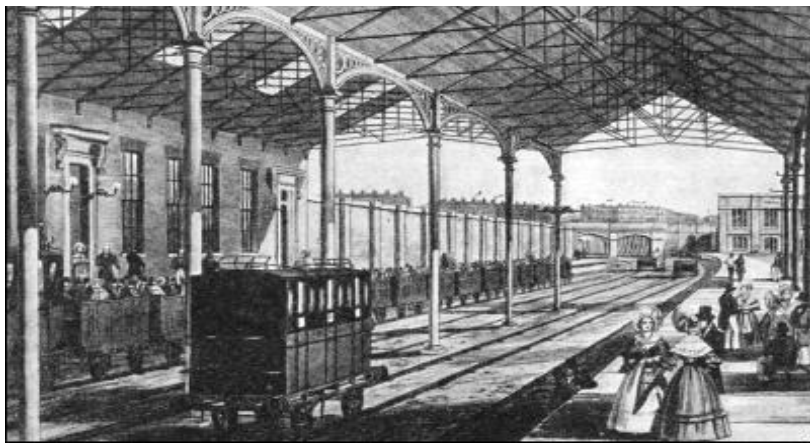


Charles Wheatstone (1802-1875)

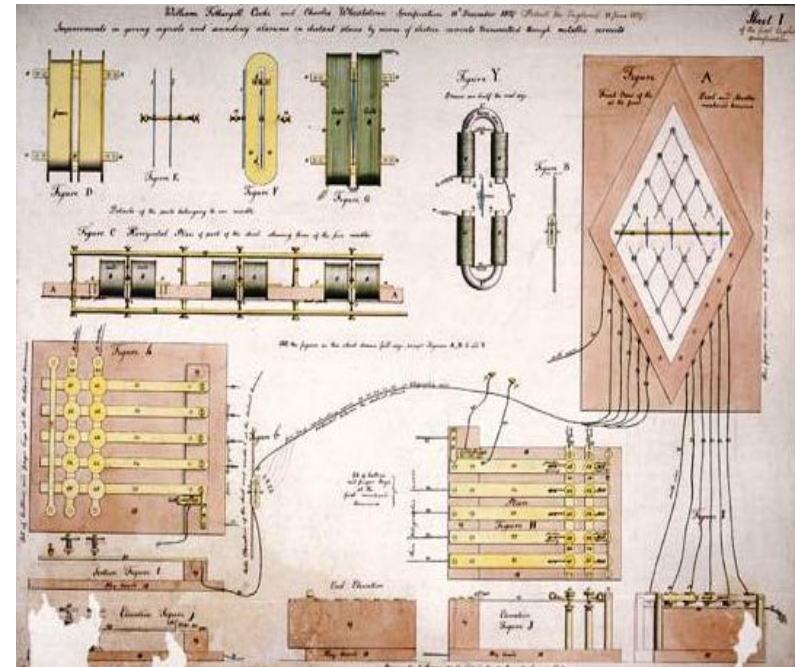


William Cooke (1806-1879)

- 1836. Charles Wheatstone becomes professor of "experimental natural philosophy" at King's College London.
  - 1829. King's College founded as Anglican response to secular London University.
  - To become key English center for the training of professional engineers.
- 1836. William Cooke, entrepreneur, markets telegraph to Liverpool & Manchester Railway as a signaling device.
  - Winding engine one mile up incline from Liverpool station.
  - L&MR reject proposal, relying on whistle signal.
- 1837. Cooke and Wheatstone patent for 5-needle electric telegraph.
  - Market device to London & Birmingham Railway for long-distance signalling.
  - Demonstrate telegraph works for up to 19 miles!
  - Obtain support of George Stephenson!
  - But: Rejected as too complicated.

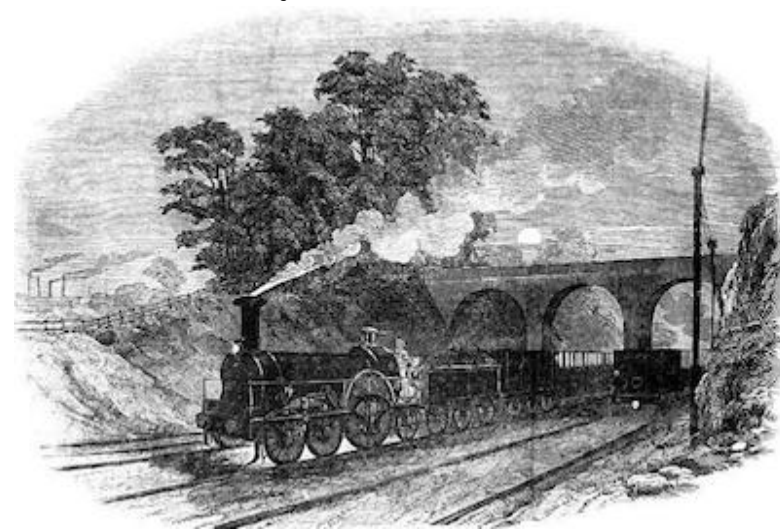


1837 Euston Station of L&BR: Trains run in and out over incline via cable operated from Camden (one mile away).



- 1838. Cooke markets telegraph to Great Western Railway.

- *Success! 13 mile experimental line from Paddington Station to West Drayton.*
- *Cooke extends line at own expense; suspends wires from poles to save money.*
- *1843. Line reaches Slough, near Windsor Castle.*



*Suspended telegraph wires as public symbol of progress.*

- 1844-45. Public relations successes:

- *Birth of Prince Alfred at Windsor reaches London by Cooke's telegraph.*
- *The "capture by telegraph" of the poisoner John Tawell.*

- Wheatstone and Cooke project new roles for telegraph:

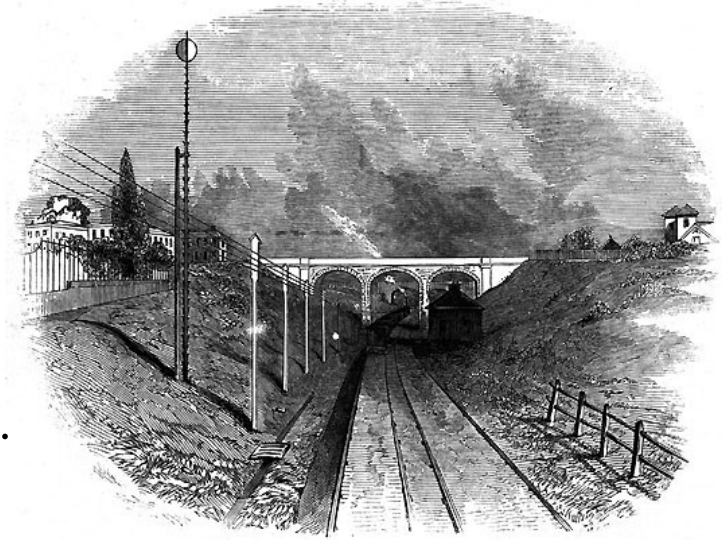
- *A "self-acting" means of regulating railway traffic more reliably than human operators, rather than just a signaling device.*

- But: GWR telegraph falls into disuse; discontinued in 1849.

"It was only later that the railway companies endorsed the particular meaning of the telegraph as regulator of railway traffic -- rather than rapid messenger boy for the elite." (MS05, pg. 196.)

- 1844. London & South-Western Railway constructs Cooke and Wheatstone telegraph line from London to Portsmouth.

- *Separate wires for Admiralty, Railway, and public use.*



THE ELECTRIC TELEGRAPH, ON THE SOUTH WESTERN RAILWAY.

- 1846. The Electric Telegraph Company (ETC).

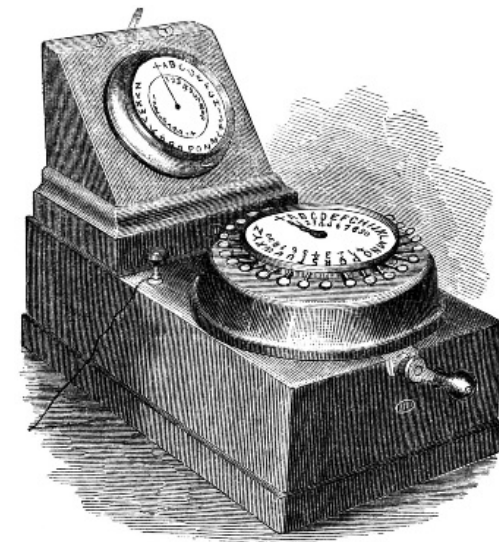
- Goal: *"To establish a complete system of Telegraphic communication, connecting the Metropolis with the different Ports and Cities of the Kingdom".*

- *4000 miles of telegraph along railway lines in 6 years!*

"These lines catered for a growing public thirst, manufactured in part by the companies, to communicate electrically." (MS05, pg. 196.)



- 1851. English and Irish Magnetic Telegraphic Company.
- 1857. Merges with ETC to form Magnetic Telegraph Company.
- 1859. London District Telegraph Company (LDT).
- 1860. Universal Private Telegraph Company.

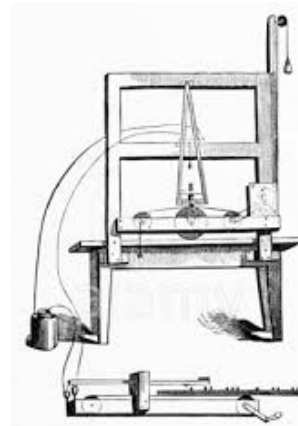


## (c) The New World Telegraph

- 1837. Samuel Morse, artist, obtains U.S. patent for electric telegraph.

"Morse's case shows how the creative, even ad hoc, assembly of common mechanical parts (from clocks) and readily available materials (from the printing trade) might launch a new technology and that no technology can succeed without effective marketing." (MS05, pg. 197.)

- 1838. Develops "Morse Code".
  - *Dots and dashes instead of Cooke and Wheatstone's alphabetic telegraphs.*
- 1843. "Morse Bill" allows construction of Morse telegraph lines in U.S.
  - *1844. First line; Baltimore to Washington, D.C.*
- 1840s. Small providers, intense competition.
  - *18,000 miles of wire across eastern U.S.*
- 1856. Western Union Telegraph Company.
  - *Entire U.S. linked by telegraph.*



Samuel Morse  
(1791-1872)

### International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.

|   |         |   |             |
|---|---------|---|-------------|
| A | • —     | U | • • —       |
| B | • • • • | V | • • • —     |
| C | • • — • | W | • — —       |
| D | • — • • | X | • — • •     |
| E | •       | Y | • • — —     |
| F | • • — • | Z | • — — •     |
| G | • — • • |   |             |
| H | • • • • |   |             |
| I | • •     |   |             |
| J | • — — — |   |             |
| K | • • — — | 1 | • — — — —   |
| L | • — • • | 2 | • • — — —   |
| M | • — —   | 3 | • • • — —   |
| N | • — •   | 4 | • • • • —   |
| O | • — — — | 5 | • • • • •   |
| P | • — — • | 6 | • • • • •   |
| Q | • — — — | 7 | • — — • •   |
| R | • • — • | 8 | • — — — •   |
| S | • • •   | 9 | • — — — — • |
| T | • —     | 0 | • — — — —   |

"Effective 2006-01-27, Western Union will discontinue all Telegram and Commercial Messaging services. We regret any inconvenience this may cause you, and we thank you for your loyal patronage. If you have any questions or concerns, please contact a customer service representative." (Western Union website, February 2006.)



## (d) The Submarine Telegraph

- 1849. Jacob & John W. Bret obtain concession from French government for telegraph cable between Dover and Calais.

- *Use gutta percha for insulation.*
- *Initial success but then fisherman breaks cable.*

- 1850s. Projectors discuss feasibility of trans-Atlantic cable.

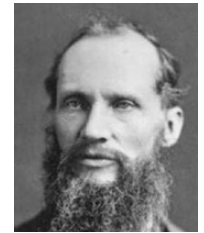
- Problem: *Length of insulated cable affects time of signal transit.*
- 1855. Thomson's "law of squares": *Retardation increases with both resistance and capacitance of cable, hence is proportional to square of length.*
- Prescription: *Increase both diameter of wire and insulator coating.*

- 1856. Atlantic Telegraph Company.

- *E. O. Wildman Whitehouse, chief electrician vs. Thomson, science advisor.*
- *Whitehouse suggests small diameter, high voltage cable.*
- 1857. *Attempt to lay cable between Newfoundland and Ireland, but breaks.*
- *1858 success after three more attempts.*
- But: *Retarded signals and eventual failure.*



THE NEW SIAMESE TWINS.



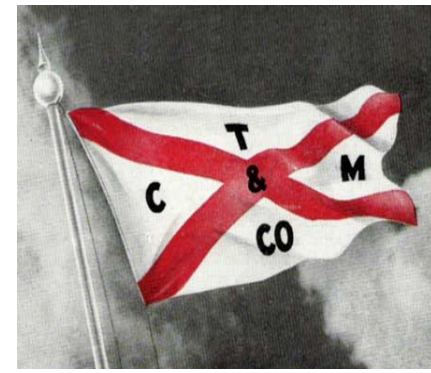
William Thomson  
(1824-1907)



E. O.  
Whitehouse  
(1816-1890)

- 1864. Telegraph Construction and Maintenance Company (TelCon).

- 1865. New attempt at trans-Atlantic cable using Great Eastern. Cable snaps.
- 1866. Further attempt succeeds with new cable and with grappling/connecting 1865 cable: Two working trans-Atlantic cables!



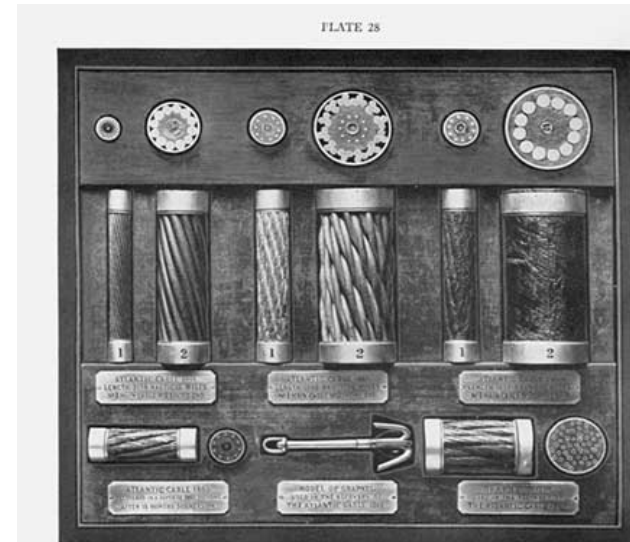
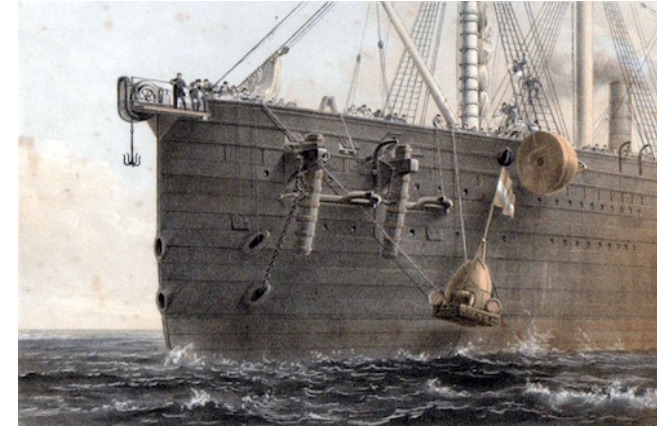
**THE EIGHTH WONDER OF THE WORLD.**

**THE ATLANTIC CABLE.**

*"Hearst's Contract, July 27<sup>th</sup> 1866.  
I hope that it will prove as blessing to England, and the United States,  
and increase the intercourse between our Country & the Eastern Hemisphere."  
Yours faithfully  
Cyrus W. Field.*

FOR BY KEMBLE & FOSTER 234 DE FINE LANE.

*Washington, July 29<sup>th</sup> 1866.  
To Cyrus W. Field, Hearst's Contract.  
May the Cable, under the sea tend, to promote harmony between the Republic  
at the West and the Governments of the Eastern Hemisphere.  
Andrew Johnson*



Atlantic cables of 1858, 1865, and 1866. A short length and a section of each

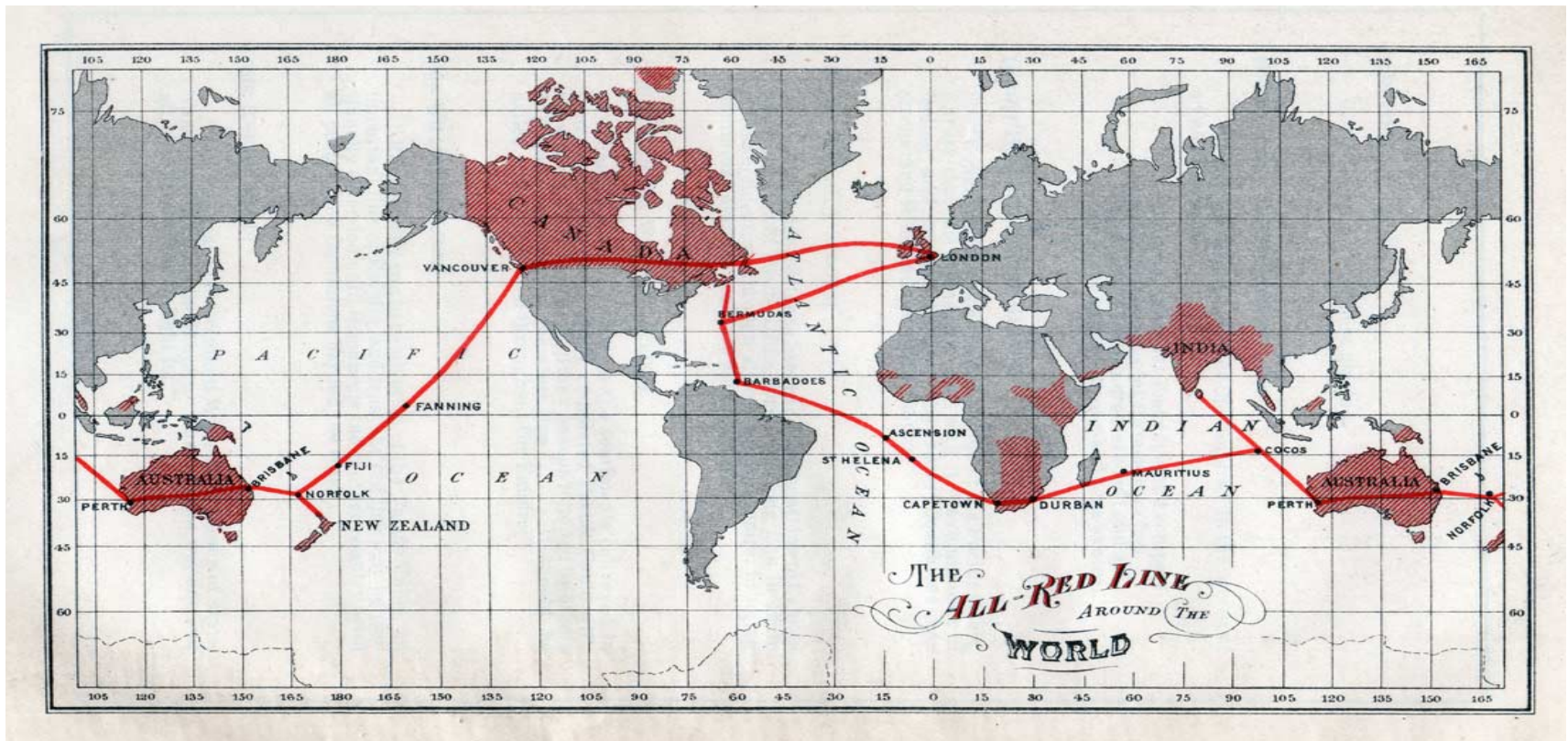
## (e) The Imperial Telegraph

"Disseminating British instruments, standards and practices throughout the Empire sustained and empowered that empire." (MS05, pg. 216.)

- 1866-1910s (WWI). Britain dominates submarine cable industry globally:
  - *expertise, cable-laying ships, manufacturing, standards.*

### Ex. 1: The All-Red Line.

- *telegraph cables passing only through British territories*

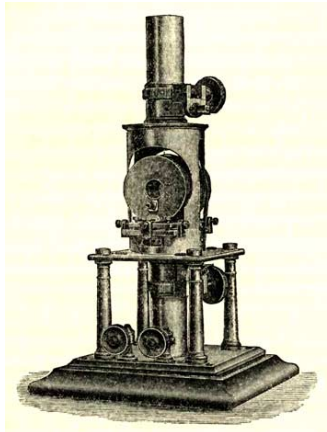


Ex. 2: *William Thomson's Univ. of Glasgow laboratory.*

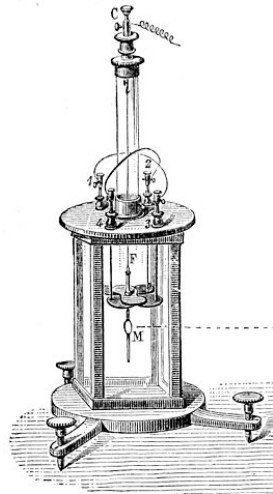
- "set standards of production and surveillance for a business of telegraphic engineering" (MS05, pg. 217.)

● Some Thomson patents:

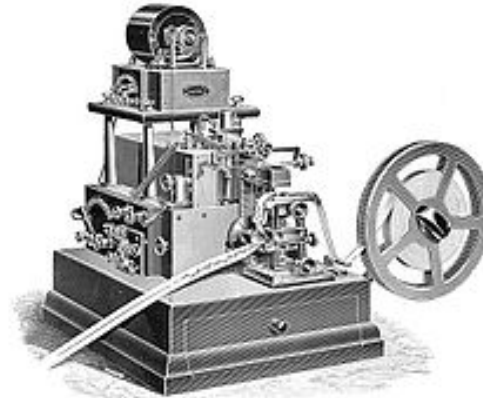
- 1858. *Marine-mirror galvanometer*
- 1867. *Quadrant electrometer*
- 1867. *Siphon recorder*



Marine-mirror galvanometer.  
Measures weak currents by deflection of light beam



Quadrant electrometer.  
Measures electric potential.



Siphon recorder.  
Records weak currents using ink on paper tape.

**Thomson's 70 Patents\***

- 12 patents associated with electric telegraphy (1854-1895).
- 25 patents for navigational apparatus (1876-1907).
- 29 patents for improvements in electrical instruments (1881-1902).
- 4 patents for improvements in valves for fluids (1889-1905).

● 1866. Thomson knighted as Baron Kelvin of Largs.

- *First natural philosopher to be elevated from commoner to House of Lords.*

\*Trainer, M. (2004) "The Patents of William Thomson (Lord Kelvin)", *World Patent Information* 26, 311-317.

### Ex. 3: *British Standard of Electric Resistance*

- 1851. German "force" proposal:

"...no special fundamental measure for electric resistance is needed if there are measures for electromotive force and for intensity of the current..."



*Wilhelm Weber*  
(1804-1891)

- Just use Ohm's Law: (*resistance*) = (*electromotive force*)/(*current intensity*)
- And: Measurements of electromotive force and current intensity can be based on an analysis of *magnetic forces*.

- *Electromotive force associated with a conductor = the force exerted by the earth's magnetism on it.*

- *Current intensity =*



"... the intensity of that current which, when it circulates through a plane of the magnitude of the unit of measure, exercises, according to electro-magnetic laws, the same action at a distance as a bar magnet which contains the unit of measure of bar magnetism."

- But: Weber's unit of resistance was "less than  $10^{-8}$  times the resistance of a mile of copper wire!"\*

\*Smith, C. (1998) *The Science of Energy*, Univ. Chicago Press, pg. 272.

- 1845. Thomson's "work" proposal (fresh out of Cambridge).
  - *Energy concepts (work, mechanical effect) versus action-at-a-distance forces.*
- The mechanical equivalent of electricity:



*James Joule*  
1818-1889

Heat produces  
mechanical effect.

So does electricity!

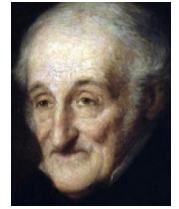


$$\left[ \begin{array}{l} \textit{The mechanical effect produced} \\ \textit{by a change of distance of two} \\ \textit{conducting spheres} \end{array} \right] = \left[ \begin{array}{l} \textit{The force exerted by} \\ \textit{each on the other} \end{array} \right] \times \left[ \begin{array}{l} \textit{The change} \\ \textit{in distance} \end{array} \right]$$

- 1863. Report of BAAS Committee on Standards of Electrical Resistance.
  - *Recommendation: Use Joule's Law ( $W = I^2 R t$ ) to derive measure of resistance.*
- 1881: First International Congress on Electrical Standards adopts BAAS standard for resistance.

## Ex. 4. Professional Societies

- 1871. Society of Telegraph Engineers.
  - Modeled after Institution of Civil Engineers (1818).
  - Father-figure Francis Ronalds.
  - 1889. Name changed to Institution of Electrical Engineers (IEE).
  - 2006. Merged with Institution of Incorporated Engineers to form current Institution of Engineering and Technology.



*Francis Ronalds*  
(1788-1873)



## 2. Cultures of 19th Century Technological Expertise

### (a) Technological Tourism and Exhibitionism

- 1825-1843. The Brunel Thames Tunnel.
  - *First tunnel under a river.*
- 1851. London's "Great Exhibition".
- 1853. New York's "Great Exhibition".



- Implicit in such exhibitionism: Two cultures.
  - *Natural philosophers (elite men of science). Oxford/Cambridge-educated.*
  - *"Practical men": Engineers, electricians, mechanics. Practice-based disciplines.*



## (b) Engineering Images

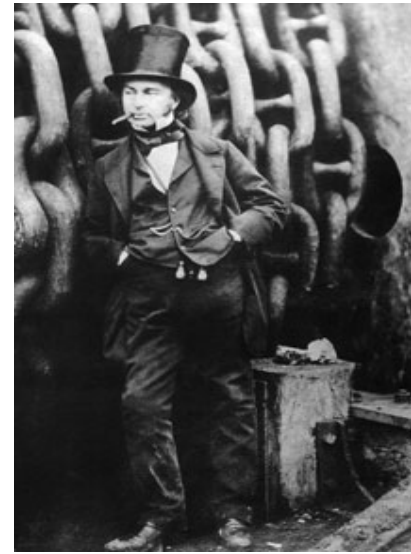
- Self-images in science:

- *Galileo. Promoted helio-centrism as adept courtier in Medici court.*
- *Robert Boyle. Public man of experimental science.*
- *Michael Faraday. Refashioned from lab technician to philosopher and sage.*



- Self-images in engineering:

- *William Thomson. Electrical engineer as professional/scientific type, versus self-taught men of practice (e.g., Whitehouse).*
- *I. K. Brunel. Engineer as masculine daring, risk-taking.*
- *Alfred Holt. Self-effacement and humility.*



- Images of machines:

- "the mere existence of an image of a machine did not imply the existence of a material artefact... for the engineers, images were the visual tokens of possible futures..."

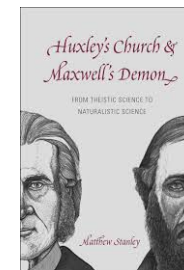
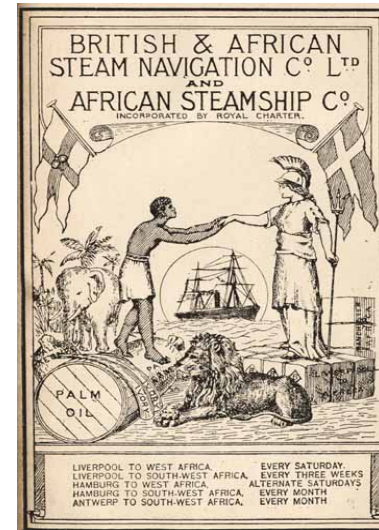
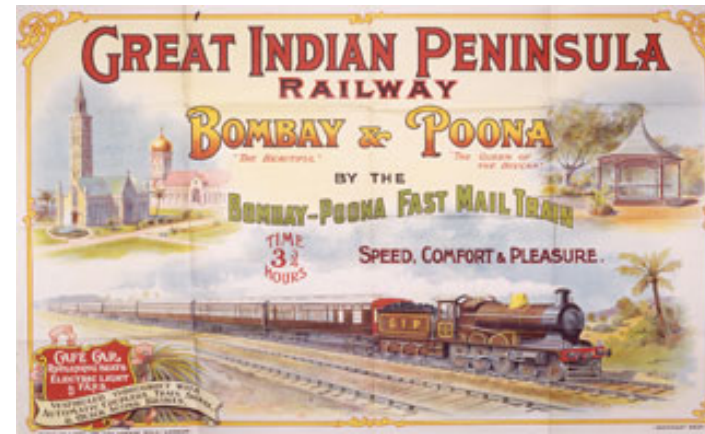
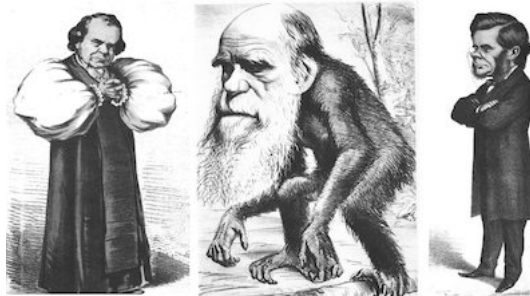


## (c) 19th Century Religion and Engineering

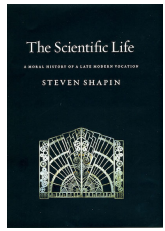
- Religion as mission of Empire.
  - *Steam as symbol of Western culture and civilization.*
- Religion as establishing trust in technologies.
  - *Cunard ships and their floating chapels.*
- Religion as underpinning engineering practice.
  - *Moral duty of eliminating waste.*
- Late 1800s. Thomas Huxley and scientific naturalism as new ideology of professional science.
  - *Theistic science versus naturalistic science.*



Thomas Huxley  
(1825-1895)



M. Stanley (2014)  
*Huxley's Church & Maxwell's Demon*



S. Shapin (2008)  
*The Scientific Life*

## (d) 19th Century Gentleman Engineers

- Early modern period. The "gentleman scholar".
  - *Problem of how to be both scholarly and virtuous, and yet practical and useful to society.*

- 19th century. Reworking of status as a product of merit and not birth.

*Ex. 1854. Brooklyn Polytechnic Institute founded as a finishing school for boys.*

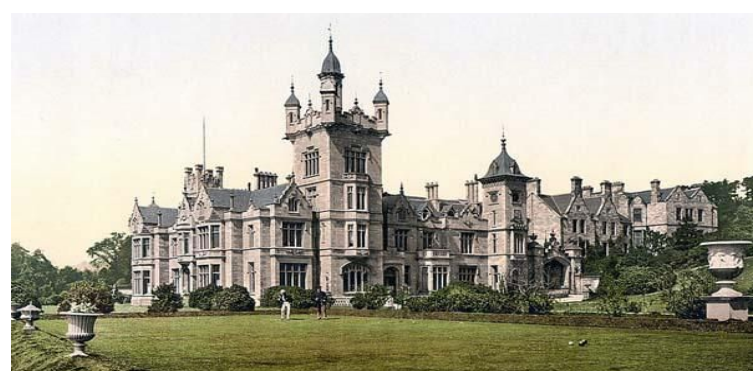
- The Country Homes of the Rich and Famous (engineers).



Watt's "Heathfield"



Brunel Manor



Napier's West Shandon