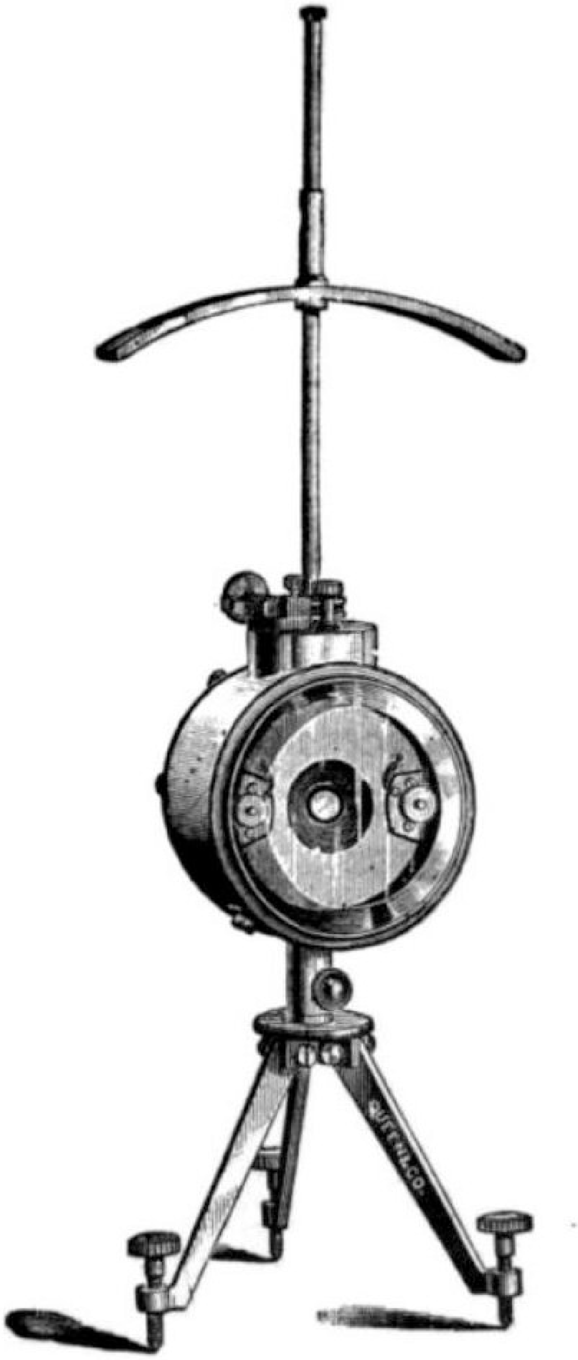
CATALOGUE ENTRY T8 | TRANSMISSION

A THOMSON-STYLE REFLECTING ASTATIC GALVANOMETER MADE BY ELLIOTT BROTHERS [1860-1870]

KING'S COLLEGE LONDON ARCHIVES. K/PP107/11/1/21



In 1858 the first telegraph cable connection was made between Ireland and Newfoundland. It was a decided flop. Messages sent down the line were, for the most part, unintelligible. It took 16 hours to send the 98 words of Queen Victoria's message and the line failed after just three weeks. Engineers struggled not only with manufacturing problems but also with a mystery phenomenon which scrambled the messages they were attempting to send.[1]

Sir William Thomson, 1st Baron Kelvin, is today one of the best remembered scientists of the Victorian era, credited with the first and second laws of thermodynamics and the determination of Absolute Zero. Back in 1854, plain William Thomson was a rising star of physics working on Michael Faraday's calculations for a possible Atlantic telegraph cable. He noted that the cable would be subject to the effects of induction. When a voltage is passed down a very long, thin wire it builds up a charge, much like a battery. This charge then interferes with the message signals being sent. The bigger the charge the longer it takes to clear the line and the more slowly the letter signals can be sent. Thomson concluded that the core of the proposed cable needed to be of greater diameter than planned to overcome this. As this was in opposition to the ideas of the Atlantic cable company's own chief engineer, Wildman Whitehouse, he rapidly came to the attention of the company. In 1856 they brought Thomson on board as scientific advisor for the first Atlantic cable laying attempt.

Whitehouse and Thomson soon found themselves at loggerheads over the best way to solve the message scrambling problem. Whitehouse saw it as a problem of resistance, which could be overcome with higher voltages to force the message through. Thomson argued that they must minimise induction effects and use only very small voltages and very sensitive equipment. Thomson went away and designed the mirror galvanometer to test this.

The mirror galvanometer uses an electrical phenomenon to detect very slight electrical signals. When a current passes down a wire it sets up a magnetic field. Thomson's galvanometer detects this and registers a message signal in the wire. Inside the galvanometer is a small mirror suspended by a silk thread. A tiny magnet is attached to the back. A spot of light is reflected off the mirror onto a cardboard scale some distance away. When a signal enters the wire and a magnetic field is generated it pulls the magnet towards it. The mirror moves on the thread and moves the spot of light on the scale. If a positive current is sent it moves the mirror in one direction. If a negative current is sent it moves in the other. Positive and negative deflections can therefore be used as a 'dot' and 'dash' to send messages by Morse code.[2]

Thomson was proved right; low voltages detected with the mirror galvanometer proved to be the only way to send signals down the short-lived 1858 Atlantic cable. Queen Victoria's congratulatory greeting to President Buchanan was sent via mirror galvanometer at ever decreasing speeds on the failing cable until the signal finally gave out forever. Thomson used the knowledge he had gained through the failure, to campaign for better cable design. Thanks in large part to Thomson, the successful cables of 1865 and 1866 had copper conductors of far higher purity with greater cross-sectional diameter and heavier, more perfect insulation. William Thomson was knighted in November 1866 for his contributions to the trans-Atlantic telegraph and went on to be made Baron Kelvin for his contribution to science.

CN

1. H. M. Field, *History of the Atlantic Telegraph to the Return of the Expedition of 1865* (printed only for private distribution, 1866).

2. M. Trainer, 'The Patents of William Thomson Lord Kelvin', *World Patent Information*, vol. 26, Elsevier Ltd, http://tinyurl.com/hv4c2lk (consulted 7 September 2016).

CATALOGUE ENTRY T9 | TRANSMISSION

CONCERTINA AND TELEGRAPH TRANSMITTER

KING'S COLLEGE LONDON ARCHIVES. K/PP107/11/5/1 AND K/PP107/11/1/7

Charles Wheatstone leads an amazing double life. In one he is a pioneering hero of the telegraph, in the other he is the precocious inventor of musical instruments; the finest and most famous of these being the Wheatstone Concertina. These lives are not so separate as might be imagined and the cross-over between his work with sound, his work with electricity and his flair for engineering instruments and machines is very clear. In the exhibition two instruments illustrate this very clearly the concertina and the prototype telegraph transmitter.

Wheatstone began his professional career at the age of 14 when he was apprenticed to his uncle, a musical instrument maker. The rural Gloucestershire lad moved to London to begin work in Uncle Charles' workshop on the Strand. In the day he works in the shop and workshop. In the evenings he prowls the many bookshops, buying up volumes on natural philosophy. The young Charles builds a home-made physics laboratory, complete with his self-designed version of the Voltaic pile (an early battery) built from salt water, blotting paper and pennies.[1]

At the age of 20 in 1822 he comes to the attention of the public with the first of his several acoustic 'shows' featuring the *Acoucryptophone* (translation: 'hearing a hidden sound') or *Enchanted Lyre*, an instrument which appeared to play 'of itself'. The *Enchanted Lyre* - now housed in the Horniman Museum – was a small, ornately decorated harp, suspended by a steel rod which passed through the ceiling above. In the room above, the rod was connected to the soundboards of a piano forte and a dulcimer. The Lyre appeared to play through sound conduction and the sympathetic resonance of strings.[2]

The Enchanted Lyre was a research experiment as well as a publicity stunt for the family firm, and Wheatstone went on to publish his findings on frequency, resonance and the conducting of sound in Thomson's *Annals of Philosophy* and the *Transactions of the Royal Society*. He soon became firm friends with fellow Royal Society member and physicist, Michael Faraday, who frequently delivered Wheatstone's lectures for him at the Royal Society (Wheatstone being famously shy when it came to public speaking). He continued to publish throughout the 1820s until his work led to his appointment in 1834 as the first Professor of Natural Philosophy (what we now call physics) at King's College London.

Wheatstone, like Faraday, was concerned with the scientific principles behind phenomena. Where he was exceptional was that he then took that newly acquired knowledge and designed new instruments – be they musical or scientific – that exploited that knowledge. This was the case with the discovery of resonant frequencies that led to the invention of the concertina in the late 1820s and the experimental measuring of the speed of electricity that led to the design of the first practical system of telegraphy.

Wheatstone continued to have an interest in the family music business, and indeed a lifelong 'admiration' for music.[3] Not only did his work in physics produce such instruments as the concertina and harmonium but his skill in, and connections with, precision instrument manufacturing fed directly into the design of the first telegraph transmitters. The sales ledgers from Wheatstone's commercial musical instrument workshop (digitised and available from the Horniman Museum) show that they were building experimental electrical apparatus for use at King's from the 1850s.[4]

The visual similarity between the concertina and prototype telegraph key is striking. But the polished mahogany, turned ivory buttons, delicate springs-loaded keys, and finely milled brass fittings underline much deeper connections between Wheatstone's passions: understanding and invention, music and physics, craftsmanship and engineering.

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1. B. Bowers, *Sir Charles Wheatstone FRS*, 1802-1875, IEE History of Technology Series, vol. 29 (London: The Science Museum, 2001).

2. N. Wayne, 'The Invention and evolution of the English Concertina', *Journal of the Galpin Society*, Vol. LXI (2009).

3. Wayne, 'English Concertina' (2009).

4. *Wheatstone & Co. Concertina Ledgers, 1839-1891*, http://www.horniman.info/ (consulted 7 September 2016).

CATALOGUE ENTRY T10 | TRANSMISSION

WHEATSTONE AUTOMATIC 'JACQUARD' TELEGRAPH TRANSMITTER [1858-1867]

KING'S COLLEGE LONDON ARCHIVES. K/PP107/11/1/8

Charles Wheatstone launched the Automatic or Jacquard telegraph in 1858 as part of his Universal Telegraph Company system. Where the ABC, or Universal Telegraph was designed to bring the telegraph into every home, the Automatic was designed to massively increase signalling speeds. Wheatstone had been experimenting with an automatic system for some time because, on land lines at least, the signalling speeds achieved by even the best telegraph operators were a long way below the maximum capacity of the lines. There was unexploited potential to increase traffic with the right machine.[1]

The Automatic system consisted of one (or several) Perforators, a Transmitter and a Receiver. Perforators were manually operated hole punches into which the operators punched holes, either to the left of the strip or the right, to stand for the dots or dashes of the message. The speed of the passage of the tape through the machine was controlled by the punching action. The tapes were then taken and threaded into the Automatic Transmitter. As the strip passed through the machine it passed underneath two delicate metal wires, one on the left for the dots, one on the right for the dashes. The metal wires were sprung so each time they passed over a hole in the tape they made contact with the metal surface beneath. Wheatstone used this contact to complete an electrical circuit and send either a dot or a dash down the line. At the other end were two pens, one operated by the dash signal and the other by the dot, which inked another continuous tape.

The Transmitter and Receiver could be run at up to 120 words per minute on landlines. Several telegraph clerks could be employed simultaneously perforating the message strips to be fed into one Automatic Transmitter, making the system five times faster than anything known at the time. The Automatic system was put to use in the very busiest of long-distance circuits, such as that between London and Manchester. It has been claimed that 'after the initial invention of the telegraph, the most important step in its development … was the introduction of the Wheatstone automatic system'.[2]

Wheatstone had been working on the design of the Automatic Telegraph since around 1850. The machine he launches with fanfare in 1858 is the product of several ideas and influences. As the name suggests it was particularly inspired by the Jacquard Loom, invented in 1801 by Joseph Marie Jacquard as a way of automating the weaving of complex patterns. The loom was the first programmable machine; it automatically pulled a chain of punch-cards through a reader to set each individual line of the weave. Alexander Bain's Mechanical Telegraph, though mechanically very different, is the acknowledged forerunner of the idea of every automatic telegraph. There is some debate over whether this complex device is a machine or a contraption.[3] Patented in 1841, Bain's machine used pulses of electricity to start and stop a clockwork type-wheel.

There is, however a third possible (and unexplored) source of inspiration in Charles Babbage's second difference engine; the Analytic Engine. The engine, like Jacquard's loom, used chains of cards as a way to create continuous loops of operations but it was also able to punch its own cards as a way of feeding back results. Babbage detailed this two-way operation in the mid-1830s and continued to work on the design for the machine into the late 1850s.[4] As Babbage and Wheatstone were contemporaries, both members of the Royal Society, and - through their respective lectures at the Royal Institution - keenly aware of each other's work, it seems likely that this exchange of ideas influenced both men's work.

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1. S. Roberts, *Distant Writing* (2012), http://tinyurl.com/grf3p2j (consulted 22/08/2016).

2. B. Bowers, *Sir Charles Wheatstone FRS, 1802-1875*, IEE History of Technology Series, Vol. 29 (London: The Science Museum, 2001), p.183.

3. S. Roberts, *Distant Writing* (2012)

4. J. Essinger, *Jacquard's Web: How a hand-loom led to the birth of the information age* (Oxford: Oxford University Press, 2004).

TRANSMISSION

from VICTORIANS DECODED: ART AND TELEGRAPHY

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