‘In a parental position to our telegraph system’: Charles Wheatstone

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Abstract— **Prince Albert said that Wheatstone was ‘in a parental position to our telegraph system’. Was that description justified? The practical electric telegraph began with the work of Cooke and Wheatstone in Britain and of Morse in the USA. The first commercial installation was arranged by Cooke, using Wheatstone’s ‘five-needle’ instruments, on the Great Western Railway. It led to the formation of the Electric Telegraph Company and the rapid development of the telegraph network. When Morse came to London, seeking an English patent, he met Wheatstone, and probably also Cooke. They discussed possible co-operation, but the discussions came to nothing.**

Index Terms— **cables, history of technology, telegraphy, underwater communication cables.**

I. Introduction

The statement about Wheatstone in my title comes from a letter which Prince Albert, the husband of Queen Victoria, wrote in December 1860.

By 1860 the telegraph was well established on land, and there were reliable underwater cables linking Britain to France and Ireland, but there was no link with America. Attempts in 1857 and 1858 to lay a telegraph cable across the Atlantic failed, but the 1858 attempt came tantalizingly near to success. How to manufacture, lay, and operate such a long cable was a matter of intense interest both in scientific circles and in the commercial world. The British Government set up a ‘Committee of Inquiry on the construction of submarine telegraph cables’ which sat from December 1859 to September 1860. The eight members of the Committee included Charles Wheatstone. They questioned people involved, organized some experimental investigations, and produced a long report.

Prince Albert (1819-1861) took a great interest in matters of science and technology, including the telegraph. He knew Wheatstone and had seen some of his telegraphs demonstrated at King’s College London. In 1860 the Prince had an idea for a new way of making a submarine telegraph cable which he thought would be easy to manufacture and to lay. He wrote to Wheatstone explaining his idea and inviting Wheatstone’s opinion.

The actual letter[1] was written by Charles Ruland, the Royal Librarian at Windsor Castle, who said the Prince had

> often reflected upon the unsatisfactory results obtained by our submarine cables ... The bulk and weight of the cables, the want of elasticity, the difficulty of transporting them & spinning them out, and perhaps above all the difficulty of their manufacture on account of the incongruity of the many different substances of which they are composed, together with the great pressure exercised by the water upon them, may be looked upon as some of the most essential causes of failure.
>
> In reflecting upon how some of these might be overcome, the idea suggested itself to His Royal Highness, whether water itself could not be used as the conducting medium? A simple tube of caoutchouc, such as our flexible gas-tubes, might enclose and isolate a column of water, through which the spark might be sent. It would be cheap of manufacture, homogenious [*sic*] in material, flexible, light, and the outward pressure would be neutralised as the fluid inside would be the same as that outside.
>
> There may occur to you a thousand reasons, why this idea cannot be practically carried out; but His Royal Highness thought you would forgive the trouble if he asked you, who stand in such a parental position to our telegraph system, to let His Royal Highness have your opinion on it.

Among Wheatstone’s papers at King’s College London is a note that it would require a tube 9 feet (3m) in diameter to have the same conductivity, when filled with sea water, as a copper wire one sixteenth of an inch (1.5mm) in diameter. Clearly he gave some thought to the Prince’s idea, and he must have written a tactful response which, sadly, does not survive.

I like the Prince’s phrase ‘in a parental position’ to the telegraph. Parents give life to their offspring. Many inventors worked on the idea of communicating by electricity, but only a few may be said to have brought the telegraph to life. Three men have some claim to the title: Wheatstone, William Fothergill Cooke, and Samuel Finley Breese Morse. All three could have been found in Wheatstone’s laboratory at King’s College in 1838. Each of them had been working on an electric telegraph before they met. They had different ideas about how a telegraph should be arranged, but it was Wheatstone’s system which was used in the first working telegraph installation.

Let us look at these three individuals in turn.

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II. Charles Wheatstone (1802-1875)

The name of Wheatstone is best known today for the ‘bridge’ circuit which he described in 1843 in a paper on electrical measurements.[2] His reason for studying measurements was

> to ascertain the most advantageous conditions for the production of electric effects through circuits of great extent, in order to determine the practicability of communicating signals by means of electric currents to more considerable distances than had hitherto been attempted.

Wheatstone came from a family of musical instrument makers where he developed a skill in designing and making delicate mechanisms which was invaluable later when he came to design and manufacture telegraph instruments. Although a competent businessman, he was more interested in the physics of his instruments than in selling them. One question he investigated was how far sound could be transmitted through a solid body. In 1821 he set up a demonstration in his father’s shop in which a replica of a classical lyre was hung by a single brass wire which went through the ceiling to the room above where it connected with the sound boards of a piano and other instruments. Unseen musicians played, and visitors in the shop heard a concert coming from the lyre - and paid to hear it.

He thought about the possibility of a communications system using wooden rods or stretched wires and said if ‘the conducting-body possesses perfect homogeneity, and is uniform ... it would be as easy to transmit sounds through such conductors from Aberdeen to London, as it is now to establish a communication from one chamber to another.’

Wheatstone knew that sounds travel through solids more quickly than through air, and that sound is conveyed more faithfully through those substances in which it travels fastest. Electricity travels even faster than sound, so it was logical to try communicating by sending electrical signals along a wire. How fast did the electrical signal travel? Wheatstone devised an ingenious experiment to find out. At the Adelaide Gallery in London, a venue both for serious scientific research and for popular scientific exhibitions and lectures, he discharged a Leyden jar through a long circuit with a spark gap at each end and in the middle. The three spark gaps were close together. Wheatstone reasoned that if electricity were two ‘fluids’ which started out from opposite ends of the circuit then the spark at the middle gap would occur later in time than the sparks at the ends. If it were a single ‘fluid’, travelling from one end of the wire to the other, then the three sparks would occur one after the other. But all three sparks seemed simultaneous to the unaided eye. He had to stretch out time, which he did by viewing the sparks through a mirror revolving at high speed. If there were even a very small time interval between sparks then the images would be displaced, and he would be able to see that there was a difference in time.

His demonstration showed that the two end sparks were simultaneous, but the spark at the middle gap occurred later. Knowing the speed of the mirror, and the geometry of the situation, he worked out the time delay and derived a speed for the electric signal. His conclusion was that electricity travelled through the wire a little faster than light, whose speed was known by then from astronomical observations.

We would interpret the results differently, explaining the time difference between the sparks by reference to the inductance and capacitance of the circuit - concepts that were barely imagined at the time. The experiment attracted great interest in the scientific community. It was published in the *Philosophical Transactions* of the Royal Society in 1834. It established Wheatstone as a man of science, it got him a Fellowship of the Royal Society - and the Chair of Experimental Physics at King’s College London where he repeated his experiment using a wire four miles long. He never gave a precise answer to the speed question: the practical answer was ‘faster than anything else’. So he investigated electrical communication, initially on his own.

Wheatstone sometimes collaborated with other researchers. Michael Faraday, at the Royal Institution, gave lectures based on Wheatstone’s work, and his diary records several experiments conducted jointly with Wheatstone. In 1837 the Americans Joseph Henry and Alexander Bache visited London and conducted experiments with Wheatstone and J.F. Daniell, the professor of chemistry at King’s, using an inductance to obtain a spark from current produced by a thermopile. It was one of a series of experiments demonstrating that ‘electricity’ from different sources was in fact the same. Henry recorded in his journal that Faraday took part in some of the experiments, although Faraday’s diary is blank for the relevant days.

Wheatstone’s most significant collaborative work, however, was on the telegraph, with Cooke.

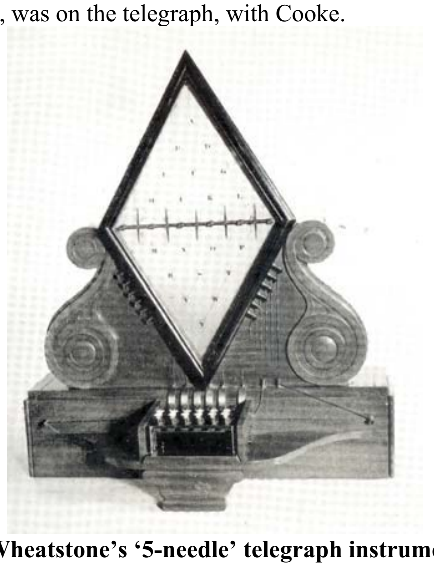

Fig. 1 Wheatstone’s ‘5-needle’ telegraph instrument

Wheatstone based his first telegraphs (Fig.1) on galvanometers. The instruments at each end had five galvanometers arranged in a line. By deflecting two of the five, one to the left and one to the right, one of twenty letters was indicated on a panel (Fig.2). The galvanometer circuits (Fig.3) were interconnected so that only five wires were needed and Wheatstone’s ‘permutating keyboard’ connected two of the five wires to a battery. Twenty letters are sufficient to transmit intelligible English. No codes are required and anyone who can read can use the system.

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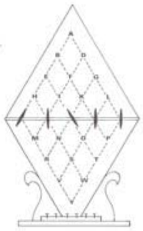

Fig.2 The face of Wheatstone's '5-needle' telegraph with two needles deflected to indicate the letter E.

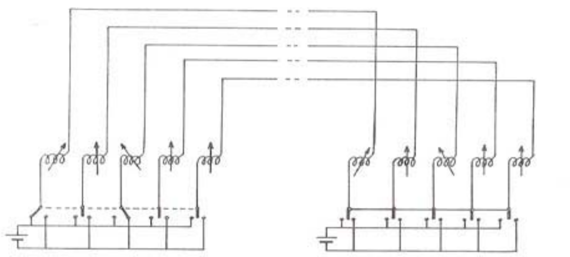

Fig.3 Circuit with two telegraph instruments connected together. The letter E, being sent from the telegraph on the left, is indicated on both instruments.

III. William Fothergill Cooke (1806-1879)

The son of a surgeon and teacher of anatomy, Cooke became an officer in the Indian Army, but resigned after a few years because of ill health. He studied anatomy at Paris and then Heidelberg, under Professor Münke, and found he had a talent for making the anatomical models, used in teaching anatomy. While at Heidelberg he saw a demonstration by Münke of a telegraphic apparatus. The equipment he saw was not practical, but Cooke realized that a more practical telegraph system would have commercial possibilities, especially with the various railway systems then being developed. He abandoned his anatomical studies and devoted himself entirely to telegraphy.

Cooke had little familiarity with mechanical things, but he understood the musical box in which a disc or drum rotates at a constant speed and plays a tune. He had the idea of putting letters around the disc and having a detent controlled by an electromagnet to stop the disc briefly when the required letter was indicated (Fig.4). The person receiving the message simply had to note the letter each time the disc stopped. There were two problems: keeping the speed of the drum constant so that the sender knew which letter was showing, and operating the electromagnet and detent through a long wire.

In 1836 he conducted experiments with the help of his friend and solicitor, Burton Lane, who allowed Cooke to set up a very long length of wire in his office. Cooke found that, although his apparatus worked across a room, it would not work through a mile of wire. He obtained introductions to Michael Faraday and Peter Roget; the Secretary of the Royal Society, to seek their help. Neither could assist directly, but Roget, who knew of Wheatstone's work, put Cooke and Wheatstone in touch.

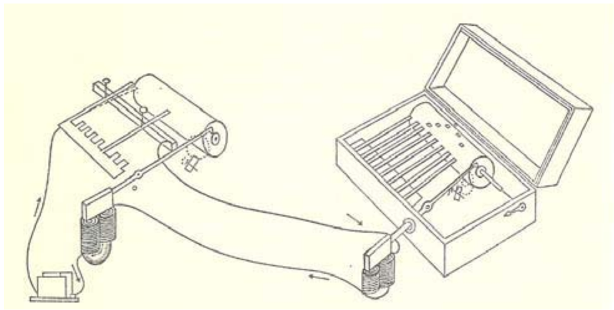

Fig.4 Cooke's idea for his 'mechanical' telegraph, based on a musical box, at the time he first met Wheatstone.

Cooke and Wheatstone first met on 27 February 1837, by which time Cooke was negotiating with the Liverpool and Manchester Railway Company to provide a telegraph. They soon formed what should have been an ideal partnership: Cooke had business ability, and Wheatstone could make the telegraph work. Sadly, disagreements arose and the partnership was dissolved a few years later. In the meantime, however, they obtained a patent and a contract to install a telegraph.

The patent, 'for improvements in giving signals and sounding alarms in distant places by means of electric currents transmitted through electric circuits', was signed by King William IV on 10 June 1837, and the specification enrolled six months later. The instruments described in the specification were of Wheatstone's design, but the partnership agreement established that Cooke was the business manager.

The contract was for the first commercial electric telegraph installation which ran for 13 miles (21 km) along the new Great Western Railway from Paddington to West Drayton, and began operation in April 1839. The equipment was Wheatstone's 5-needle system, and the installation was arranged by Cooke, who persuaded the Railway to pay.

They obtained several other patents. In 1843 the telegraph patents were assigned to Cooke, with the reservation of a mileage royalty to Wheatstone. Subsequently, Wheatstone sold all his rights in Great Britain, Ireland, and Belgium to Cooke for £30,000. In 1846 the Electric Telegraph Company was formed and bought all the patents from Cooke for £120,000.

Wheatstone continued to work on telegraphs for the rest of his life. His two main achievements were the high-speed automatic telegraph which transmitted messages previously prepared on punched paper tape, and the ABC telegraph which showed letters directly and enabled two people to communicate easily. Cooke subsequently had another change of career. He gave up his interest in the telegraph and then lost all the money he had made from it on unsuccessful mining ventures in North Wales.

IV. Samuel Finley Breese Morse (1791-1872)

Wheatstone had another American visitor in June 1838, when Samuel Morse came to London. It was not his first visit to England. He had lived there from 1811 to 1815, and then spent ten years as an itinerant artist. On the voyage back to America in 1832 he overheard a conversation about electromagnets, and was inspired by the possibility of an electric telegraph. He worked on the idea, and designed a

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telegraph receiver which printed marks on a moving paper tape (Fig.5).

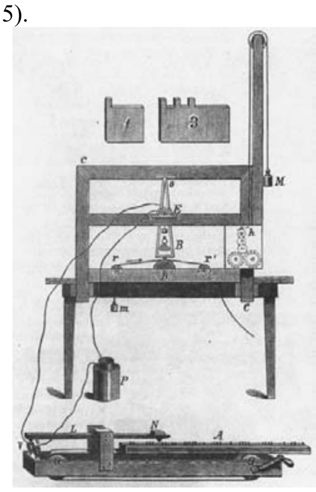

Fig.5 The telegraph for which Morse sought an English patent.

He returned to England to seek an English patent for his telegraph. The application was opposed by Wheatstone, and also by at least one other telegraph inventor, Edward Davy, who had made a telegraph receiver in which signals were printed on a chemically treated paper tape. The ground of opposition was that Morse's ideas had already been published in The *Mechanics' Magazine* a few months earlier. Morse apparently did not realize that it was impossible to get a patent in England for something that had already been published - a fact which he thought most unjust.

Although Morse failed in the main object of his visit he found his meeting with English telegraph workers useful, and he seems not to have had any hard feelings about his opponents. Morse later wrote

> Professor Wheatstone and Mr. Davy were my opponents. They have each very ingenious inventions of their own, particularly the former, who is a man of genius and one with whom I was personally much pleased. He has invented his, I believe, without knowing that I was engaged in an invention to produce a similar result; for, although he dates back into 1832, yet, as no publication of our thoughts was made by either, we are evidently independent of each other. My time has not been lost, however, for I have ascertained with certainty that the Telegraph of a single circuit and a recording apparatus is mine …
>
> I found also that both Mr. Wheatstone and Mr. Davy were endeavouring to simplify theirs by adding a recording apparatus and reducing theirs to a single circuit.

Surviving correspondence shows that Wheatstone maintained contact with his American visitors. In the Henry papers there is a draft letter to Wheatstone acknowledging receipt of his paper on the Physiology of Vision. This paper, published by the Royal Society in 1838, gave the first explanation of binocular vision and included a description of Wheatstone's stereoscope. Following that description Henry also made a stereoscope which he demonstrated to an audience of more than one thousand people in New York. He had also given a lecture on the transmission of sound in which he repeated another of Wheatstone's early experiments and arranged for the sound of an upright piano to be transmitted through a series of wooden rods fifty feet long.

In 1840 Morse considered a proposal by Wheatstone and Cooke that they should co-operate in America. Morse was tempted by the suggestion, but eventually declined it.

V. Conclusion

Who was most in a parental position to the telegraph? The practical electric telegraph began with the work of Cooke and Wheatstone in Britain and of Morse in the USA. Cooke and Wheatstone had not previously met, but their shared interest in the idea of an electric telegraph brought them together. Their joint efforts resulted in a practical telegraph sooner than either of them could have achieved it working alone. The world's first commercial telegraph installation was installed by Cooke on the Great Western Railway but used Wheatstone's five-needle instruments.

New-born infants grow into adults who look very different. The five-needle telegraph was followed by different systems requiring fewer wires and normally employing codes. It paved the way, however, for the Electric Telegraph Company and the rapid development of the world-wide telegraph network.

So Prince Albert was right: Wheatstone was in a parental position to the telegraph, and his contribution to the start of the telegraph is an appropriate subject to begin this conference.

References

For Wheatstone generally see Brian Bowers, *Sir Charles Wheatstone FRS, 1802-1875,* first edition, HMSO for the Science Museum, 1975, revised edition, Institution of Electrical Engineers, 2001.

The main sources for Cooke are his publications and papers in the Archives of the Institution of Engineering and Technology, which are well summarized in Geoffrey Hubbard, *Cooke and Wheatstone and the Invention of the Electric Telegraph,* London, 1965.

For Morse see Edward Lind Morse, *Samuel F.B. Morse: His Letters and Journals,* Boston and New York, 1914.

1. The original letter is in King's College London Archives, Wheatstone Collection, file W1/5. Wheatstone's note towards a reply is in file W1/3.
2. Charles Wheatstone, 'An account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit', *Phil. Trans.*vol.133, 1843, pp.303-27.

Brian Bowers PhD, BSc(Eng), CEng, FIET was awarded his doctorate for a thesis on the life and work of Charles Wheatstone. He has written and lectured in several countries on engineering history, mainly on electrical topics. Until retiring he was a Senior Curator in the Science Museum, London, and has been chairman of the History Group of the Institution of Electrical Engineers (now the IET). He has participated in many of the history conferences organized by the IEE and the IEEE, and spoke at the joint meeting held by British and French electrical engineers in Paris in 2004 marking the centenary of the Entente Cordiale. He currently chairs the Planning Group for the new Museum of Electrical Technology at Pavia, Italy.

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