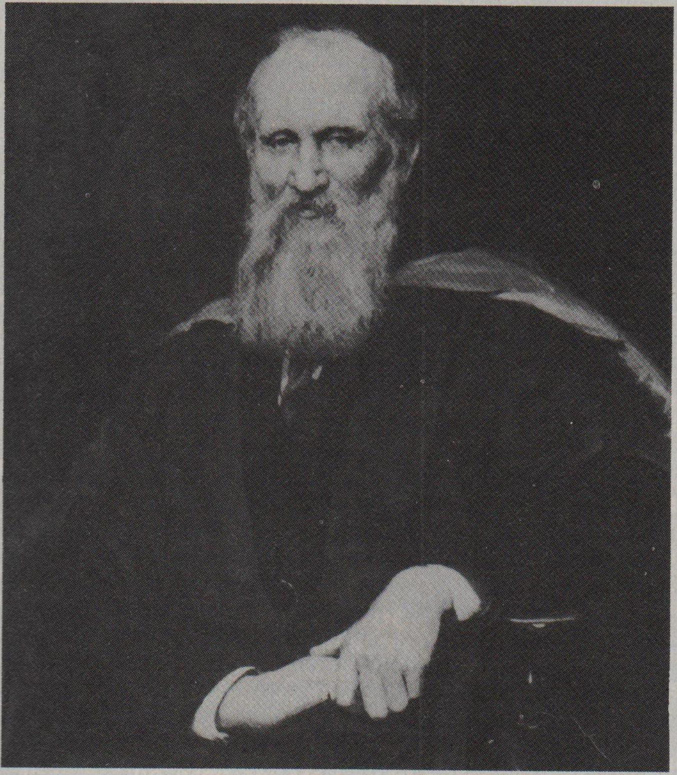
Pioneers

6. William Thomson, Lord Kelvin (1824-1907): mathematician, scientist and engineer.

W.A.ATHERTON



Institution of Electrical Engineers.

If only half of the praise heaped on to the memory of William Thomson is only half true then he was still a truly remarkable man.

Thomson, better known now as Lord Kelvin, was born in Belfast on June 26, 1824 the fourth of seven children of James and Margaret Thomson. His father was an eminent mathematician who, after the early death of his wife, devoted much attention to the personal tuition and encouragement of his children.

When William was seven years old his father was appointed Professor of Mathematics in Glasgow. With his brother James he attended some of his father's mathematics classes, where he displayed his prodigious mind at a tender age. On one occasion when no-one in the class could answer a question, William cried out, "Do, papa, let me answer."

In due course the two brothers became regular students at the university. When William was about 12 years old, a course in natural philosophy drew his attention to electricity; and his father ensured that the book learning was strengthened by practical work, something which was not then the norm. With his brother, William constructed frictional electrical machines and galvanic batteries, building whatever was needed from whatever was available. This 'activity' approach, as it might now be termed, helped develop the original and inventive mind that in later years was to be a driving force in electrical theory and practice.

In his final year at Glasgow, William Thomson's mind was captured by Fourier's theorem. This proved to be a cornerstone of some of his work on the transmission of electricity. He developed a great love for the French mathematicians.

After Glasgow University it was the turn of Cambridge, which he entered as an undergraduate at sixteen. His already-published paper on Fourier's Theorem caused a stir amongst fellow freshmen. He displayed musical talent, rowing skills and a zest for mathematics. One of his lifelong friends later described him at Cambridge as "a most engaging boy, brimful of fun and mischief." Shortage of money was often a problem: on one occasion Thomson wrote home explaining that he had only half-a-crown left.

After graduation in 1845 (he came second) he spent two months in Paris working in Regnault's laboratory, where he received a grounding in scientific research. (It was Regnault who calculated absolute zero to be −273°C.) Thomson met famous French mathematicians and studied Carnot's classic work on the motive power of heat. This helped to set him on the path to his own great work on thermodynamics.

Shortly afterwards he was appointed to the chair of Natural Philosophy at Glasgow, a position he was to retain for 53 years. There were many good candidates for it but the 22-year-old beat them all. His father's joy may be judged by a comment from a close friend: "The first announcement I had on the subject was your father's face as he came out of the hall where the election had been conducted. A countenance more expressive of delight was never witnessed."

For two years father and son held professorships in the same university, a happy situation ended untimely by a cholera outbreak in 1849.

Apparently Thomson was not an outstanding lecturer. His brilliant mind leaping through a problem would often leave his students exasperated. But according to one of them, his influence came from his magnetic personality.

One educational advance he introduced, however, was worth all manner of lecturing technique and that was his student laboratory – the first experimental laboratory for students in Britain. About 1850 he converted a disused wine cellar into a laboratory and there his students learned by doing. Later it became a research unit as he applied his own talents to solving technological problems. These efforts were rewarded by 70 patents, directorships, prestige and wealth. After his death the estate he left was valued at £162 000, a considerable sum in 1907.

Thomson made his mark in several fields of science and engineering. These included thermodynamics, electrical theory, submarine telegraphy, precision instruments, systems of units, and fundamental improvements to the marine compass. In the case of the compass he introduced magnets and soft iron to compensate for the effects of the ship's magnetism.

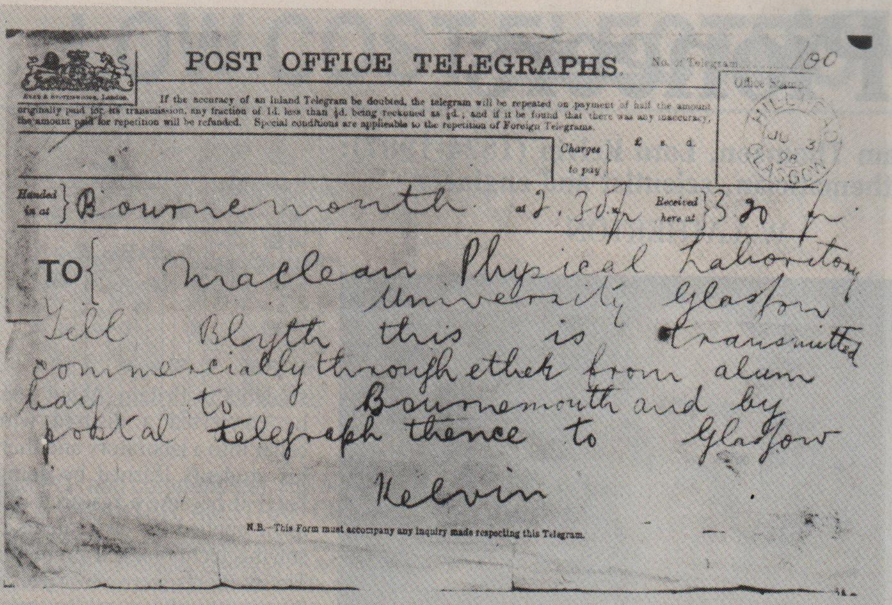
It is said that on seeing an early and crude version of the new compass the Astronomer Royal remarked "It won't do." "So much for the Astronomer Royal's opinion" was Thomson's comment.

Thomson helped establish thermodynamics as a pillar of science and his contributions there alone were enough to secure an honoured place in the history books. He championed J.P. Joule's work on the mechanical equivalent of heat at a time when Joule was finding it difficult to gain a hearing. He suggested the concept of zero energy of motion at −273°C and proposed the absolute temperature scale with zero at −273°C. In 1851 he proposed one of the two original versions of the Second Law of Thermodynamics (the more rigorous version was by R.J.E. Claussius, who gave us the word entropy). Five years later Thomson introduced the term kinetic energy.

THOMSON AND THE TELEGRAPH

But for those of us particularly interested in electrical and electronic engineering, Thomson's fame rests in the realm of electrical theory and practice, and in submarine telegraphy in particular.

By the mid-1850s telegraph engineers had turned their thoughts to spanning the Atlantic. This was to become one of the great engineering feats of the nineteenth century, akin to putting men on the Moon a century later. Thomson was an outstanding contributor to the eventual success of this project,



POST OFFICE TELEGRAPHS

If the accuracy of an Inland Telegram be doubted, the telegram will be repeated on payment of half the amount originally paid for its transmission, any fraction of 1d. less than ½d. being reckoned as ½d.; and if it be found that there was any inaccuracy, the amount paid for repetition will be refunded. Special conditions are applicable to the repetition of Foreign Telegrams.

Handed in at Bournemouth at 2.30 p Received here at 3.20 p

TO Maclean Physical Laboratory University Glasgow

Tell Blyth this is transmitted commercially through ether from alum bay to Bournemouth and by postal telegraph thence to Glasgow

Kelvin

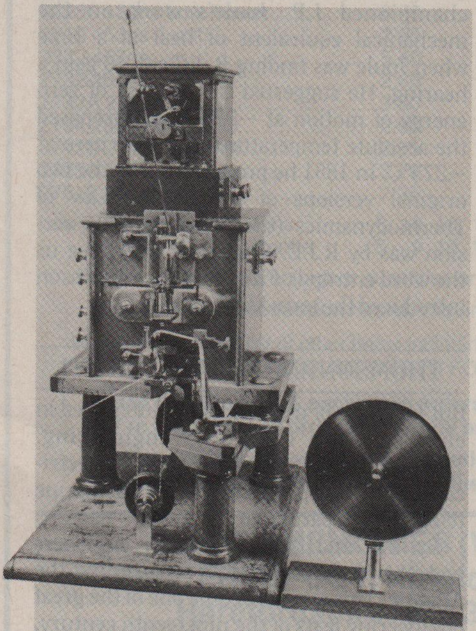
N.B.—This Form must accompany any inquiry made respecting this Telegram.

The first paid radio telegram: Thomson's message from Marconi's experimental station at Alum Bay on the Isle of Wight, 1898 (Marconi Company).

for which he was knighted in 1866.

The first submarine cables had revealed that the speed with which messages could be sent was less for an insulated cable laid in water than for an uninsulated land line of the same length. Siemens and Faraday showed that this was due to the capacitance and resistance of the cable. Sending a pulse into a long submarine cable was seen as rather like charging and discharging a very long capacitor.

Thomson worked out the mathematics and showed that the transmitted pulse took time to grow to its maximum and needed time to decay. Further, the time increased as the square of the cable length. The product of capacitance and resistance (the time constant) was of crucial importance; and one of the first tasks he assumed on becoming a director of the Atlantic Telegraph Company was to reduce both the resistance and capacitance of the cable under preparation. In some cases the copper content of the wire was as low as 50%.



The first ink-jet printer: Thomson's siphon recorder of 1867. Science Museum photograph, Crown copyright.

Thomson's mathematical ability enabled him to predict that the operation of the Atlantic cable would be slow but worthwhile. Normal telegraph instruments would be too insensitive for the job and so he devised his very clever (and justly famous) mirror galvanometer. This worked well during the laying of the 1858 cable. However, once the cable was operational, the low voltage transmitter and the mirror galvanometer detector were replaced against Thomson's advice with high voltage induction coils and conventional telegraph detectors. With something in the region of 2kV applied to it, the insulation failed.

This, with the failure of the Red Sea cable, culminated in the setting up of a British Government committee to examine the science and practice of submarine cables. The cable had been the first to be laid across the Atlantic, but was the third attempt at doing so. A lot of money had been lost.

The inquiry, of which Thomson and Wheatstone were members, reported in 1861. Of just over 11 000 miles of submarine cable laid, only about 3000 miles were working. Much was learned about the theory of electrical transmission, the effects of impurities on the conductivity of copper, and the design, manufacturing and handling of cables. With lessons learned, the prospects for a new try seemed good.

An attempt in 1865 failed with only 600 miles to go. The next year a new cable was laid successfully and the 1865 cable recovered, a new piece spliced on, and that cable also completed. Two cables linked Europe and America, as cables have continued to do to this day. Thomson, by the way, had sailed with every expedition.

Thomson invented two famous instruments for submarine telegraphy. They were the mirror galvanometer, mentioned above, and the siphon recorder.

The first was a moving-iron instrument. A tiny mirror, about a centimetre in diameter, was attached to a fine steel needle. Together they weighed 0.1g. A narrow beam of light reflected from the mirror was focused on to a screen so providing a very long and weightless pointer. A small deflection was easily visible, allowing tiny currents to be detected.

This instrument was so sensitive that Latimer Clark, a well known telegraph engineer of the time, used it to detect a signal sent through the two Atlantic cables in series. His battery was a single tiny cell consisting of a silver thimble, a bit of zinc, and a few drops of sulphuric acid.

The second of Thomson's instruments, the siphon recorder, gave a permanent record of the message and was patented in 1867. Ink in a capillary tube was charged such that it was ejected on to a moving strip of earthed paper. A moving-coil detector drove the capillary tube so that the received signal produced a wavy line on the paper. Thomson was one of the first to employ moving coils rather than moving iron in a meter.

His interest in measurement led him to suggest setting up a British Association committee to propose a system of 'absolute' electrical and magnetic units, continuing the earlier work of Gauss and Weber. The committee was formed in 1861. Various suggestions were lost along the way; 'ohm' for example was originally proposed as 'ohmad', the unit of electrical charge (coulomb) was once the 'weber'. It was Thomson who suggested the term 'mho' for conductance – now replaced by the siemens, which was once a unit of resistance!

Thomson was one of the famous men of the nineteenth century. He was made Baron Kelvin of Largs in 1892. He married twice, but had no children; yet the name Kelvin is perpetuated in our unit of absolute temperature. Many societies elected him as president, including the Royal Society and the Institution of Electrical Engineers. He became a Privy Councillor in 1902.

After his death in 1907 he was buried in Westminster Abbey, close to the remains of Newton. Not many electrical engineers have gained that honour.

Although a scientific revolutionary in his youth he became part of the establishment, so to speak, in his old age. He had doubts about Maxwell's theory of electromagnetism, once calling it "the hiding of ignorance under cover of a formula". He favoured d.c. mains systems to a.c. and once regarded commutators as "frightful". On the other hand he was one of the first to equip his home with the new electric light bulbs. And when visiting Marconi's experiments on the Isle of Wight in 1898 he sent a couple of messages to fellow engineers on the mainland for which he insisted on paying. These according to the Marconi company, were the first radio telegrams to be paid for.

Next in this series of pioneers of electrical communication: Alexander Graham Bell.

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