TELEGRAPHY

Until the electric telegraph was developed, all forms of telegraphy were based on visual signals. The Romans made wide use of towers for signalling purposes. The invention of the telescope made visual telegraphy more practicable, and in 1684 Robert Hooke (1635-1703) outlined the requirements of an effective visual telegraphy system. But little was done to implement a system.

It was the plight of France during the Revolution, 1793-4, that led to the first really effective system, that of Claude Chappe (1763-1805). He was a republican, and saw the need of rapid communication between armies and the capital. Hitherto a man on horseback was the fastest communication; he (after many initial experiments) established a telegraph system between Paris and Lille (144 miles) which transmitted a message in minutes. (First telegram sent 15th August 1794). He used wooden semaphores. One beam was pivoted at its centre, rotated in vertical plane. Other moveable arms at each end - giving quite a number of configurations.

Chappe's system grew: by 1852, when it was finally superseded by the electric telegraph, it had reached 3000 miles and 556 stations.

In Britain, a system with six moveable shutters was used. The various combinations gave 63 distinct signals. It was used for Admiralty purposes. The first chain, London - Deal, had 15 stations and was opened around 1797. Then 10 stations linking London to Portsmouth just before 1800. London - Plymouth 1806, London - Yarmouth 1807.

In U.S.A., first visual telegraph 1800 linking Martha's Vineyard to Boston.

1811-1814: shutter system in Britain replaced by Chappe system. The British systems only flourished in war; in peace they languished.

Visual systems, needing a lot of equipment and men at each station, with the requirement of spacing at around 8 miles, were very expensive, workable only by day in good visability. The electric telegraph, when it became a workable proposition, very easily displaced visual systems.

The Electric Telegraph (a) Using static electricity.

Some experience with static electricity had been obtained from ancient times, but significance only became attached to the subject when Wm Gilbert (1540-1603) of Colchester wrote his famous book "De magnete" in 1600. He coined the word "electric" from Greek "elektron" meaning amber. Otto von Guericke (1602-86) discovered the electric machine generator in 1660-3 by rotating a sulphur ball on a spindle and electrifying a suitable surface rubbing against it. Glass replaced sulphur - probably due to Newton in 1675. G. M. Bose (1710-61) introduced the prime conductor in 1738. Not until 1742 was a glass cylinder substituted for the sphere by Andrew Gordon (1712-51).

Electrical conduction and insulation was established by Stephen Gray in 1729. He was able to transmit electric charges over a distance of 300 yds by using an insulated conducting line. He used a down feather as the indicator or receiver, and without understanding why, he used an earth return.

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Many other schemes were tried. In 1816, Francis Ronalds demonstrated a synchronous system over 8 miles of wire. Synchronized clockwork-driven dials with a hole in them rotated over a disc with the letters of the alphabet appearing one after another in the hole. The line was charged up, and discharged by the operator at the sending end when the desired letter showed. At the receiving end, the operator would see his pith-ball indicator collapse and would note the letter showing at that moment.

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F. Ronalds also worked the system over an underground line 525 ft long, using copper wire in glass tubing. The Admiralty could not be got interested, and said "telegraphs of any kind are now wholly unnecessary". They expressed the same sentiment later on about the steam turbine.

(b) Using voltaic cells.

Current electricity generated by batteries was applied to telegraphy once the voltaic cell had been discovered. Galvani showed in 1791 that contact between metals and animal tissues often produced muscular contractions which appeared to be of electrical origin. This led Volta in 1800 to invent his "pile" of zinc and silver discs separated by pasteboard moistered with brine. Electrolytic decomposition of water was then demonstrated. Several electrochemical telegraphs were then proposed. Salvà in 1804 wanted to use a voltaic pile as source and hydrogen bubbles as indicator. S. T. von Soemmering in 1809 demonstrated a similar system at Munich and elsewhere and included an alarm bell! - 35 conductors involved. He greatly interested Baron Schilling (attaché at Russian Embassy at Munich), who worked on telegraph systems for the next 27 years, and laid the foundation for the successful Cooke and Wheatstone telegraph.

In 1819-20, Hans Christian Oersted (1777-1851) at Copenhagen discovered electromagnetism by noting that a magnetic needle deflected when a current flowed in a wire above it. This was the long-sought link between electricity and magnetism and was quickly taken up by Ampère and Arago in France, by Humphry Davy and Faraday and Sturgeon in England, by Schweigger in Germany, and by Henry in America. It was Schweigger who only a few months later discovered that the return conductor, if placed below the needle, added to the deflection, and that several turns of wire magnified the effect. Here was the galvanometer, and it provided the indicating instrument needed for effective telegraphy. Schilling exploited it, using either a single needle with a code (not unlike the Morse code to be developed later) or multiple needles.

The electric telegraph successful.

Yet no practical use seems to have been made of Schilling's systems until a year before his death (which was in 1837), and then he died before he could complete the plans. But in 1835 he had demonstrated his system to Moncke of Heidelberg, who made a copy for himself, and in 1836 this copy was seen by W. F. Cooke (born 1806). Cooke then devoted all his time to telegraphy, and constructed a system for the Liverpool and Manchester Rly, but met with some technical difficulties and called in Charles Wheatstone (1802-1875) Prof. at Kings Coll, London. They formed a partnership, got their first patent in 1837, and demonstrated their 5-needle telegraph to the directors of the London and Birmingham railway. The GW Rly installed the system in 1838 between Paddington and West Drayton (13 miles) and were so pleased that it was extended to Slough. This line used double-needle instruments, with a prearranged code.

Thereafter there was rapid expansion of telegraphy on the railway system. A sensational case in 1845 led to rapid expansion in other spheres. A suspected murderer was seen to board a train at Slough and was caught at Paddington thanks to telegraphed information.

In 1846 Cooke and Wheatstone formed the Electric Telegraph Co. Cooke was essentially the commercial director, and Wheatstone the technical man, but relations between them had been very strained ever since 1838, largely due to Wheatstone's habit of claiming all credit for the invention of the telegraph, whereas in reality Cooke had done more than anybody in bringing the telegraph to fruition.

In America, work on telegraphy was done by Samuel Morse, who was really an artist (Prof. of art in New York University since 1832). His work was technically poor, but he did introduce an electric telegraph in 1835, and with technical help from L. D. Gale, Joseph Henry (1797-1878) and Alfred Vail (1807-59) he developed a telegraph line between Washington and Baltimore, 40 miles, opened successfully in 1844. He is, of course, most famous for his Morse Code, which has been extensively used. It was based on the sound principle of using the fewest "bits" for the commonest letters, and for hand telegraph operating was immensely successful. For machines such as the teleprinter (introduced in comparatively recent times) a code of constant length is required - "short-stop" code - and the 5 or 7 unit code is used.

The first successful submarine telegraph cable was that laid by John and Jacob Brett across the Straits of Dover in 1851.

Attempts to work a telegraph cable across the Atlantic were at first not very successful. The first attempt was in 1857, but the cable broke after 350 miles had been laid and was lost. Second attempt Spring 1858 had fresh disasters. In Aug. 1858 the cable was completed, but had been so damaged that contact was lost after 4 weeks of rather poor operation. Then in 1865 a fresh cable was laid from the Great Eastern (Brunel's big ship); it was of improved design, but there were still many disasters and it finally broke and was lost in a depth of 4Km in mid-Atlantic. Finally on 27th July 1866 another fresh attempt, using the Great Eastern again, was successful. The cable ran from Valentia in Ireland to Trinity Bay in Newfoundland. The main credit for success lay with Cyrus W. Field (1819-92), an American who had worked untiringly on the project for 13 years.

Since then, thousands of cables have been laid in seas and oceans all round the world, including telephone cables, and, since the last war, submerged multi-channel telephone repeaters.

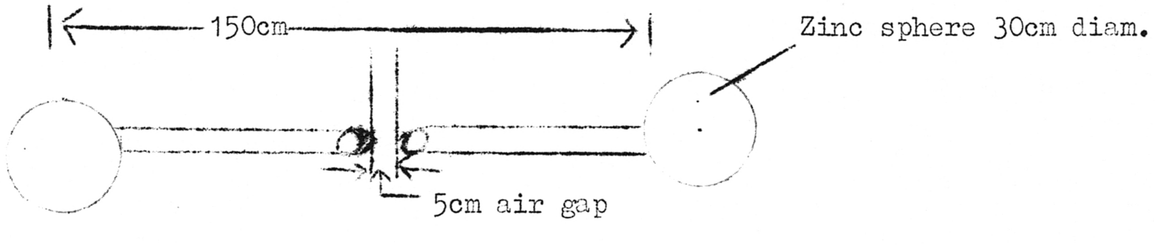
But for global communications (as also for internal comms) radio has come to be a serious competitor to the cable.

The origins of radio.

Faraday was one of our leading experimental scientists concerned with electromagnetism. He lived 1791-1867. He demonstrated electromagnetic effects in 1821. These led, in practical terms, more directly to the electrical generator than to radio, but many scientists of greater mathematical ability were led to investigate this matter of "action at a distance". Among them, one of the most important was James Clerk Maxwell, who combined mathematical and physical ability, and studied Faraday's work very carefully. He was born in Galloway (Scotland) in 1831, presented his first paper to the Royal Society at the age of 15, and published his first paper on electromagnetism in 1855. He took Faraday's work as his starting point, worked out a lot of mathematical theory, and tried to explain it in mechanical terms. But in 1864, with his paper "A Dynamical Theory of the Electromagnetic Field", he had laid out the electromagnetic theory of light. He and Faraday were always most generous in their references to one another, and both were modest men. But they were the two greatest contributors to the foundations of radio (and other branches of electrical engineering). Maxwell died in 1879, without ever realizing of course that radio was a possibility. Experimental techniques were just not available then for detecting waves.

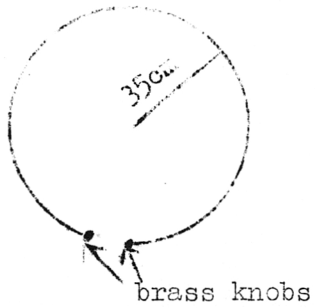
Maxwell postulated that insulators were the seat of electric action - what we now call displacement currents in dielectrics were postulated by him. Many physicists were sceptical about this. In 1879 the Berlin Acad of Sci offered a prize for an experiment to prove or disprove Maxwell's theory. It was necessary to show that energy passed through an insulating medium, such as air, at the speed of light, if Maxwell was to be proved correct. It was Heinrich Hertz who proved it in 1887. He noticed in 1886 that the accidental discharge of some very small Leyden jars across an air gap induced a current in a nearby coil. Energy had been transmitted across space. He had earlier realized that a very fast discharge would be necessary to generate oscillations of a sufficiently high frequency to set up waves; the air-gap now appeared to be the fast switch he had been looking for. He found that an electric wave took a finite time to pass from the spark gap to the coil, and clearly during that time energy had to exist in a medium.

His experiment as developed in 1887 had a transmitter and receiver. The transmitter was



When the voltage across the gap becomes high enough it produces a spark, which is the source of e.m. radiation.

The receiver was a loop of copper wire, 2 mm thick, 35cm radius, with an air gap, thus



The presence of e.m. waves was indicated by a spark across the gap.

Hertz was only 30 when he did this. He did not think his device could be used for telegraphy, mistakenly thinking that focusing of the radiation would be necessary.

Sir Wm Crookes, a British physicist, predicted in 1892 that e.m. waves would be used for wireless communication. Progress was made by the development of a more sensitive receiver using the "coherer". This was a tube of iron filings. As far back as 1866 it had been known that the resistance of such a tube was reduced suddenly by a spark. The principle was rediscovered by Edouard Branly, a French Physicist, in 1890 but still attracted no interest. It was Oliver Lodge who, in 1894, drew attention to the potential importance of the Branly tube as a detector of e.m. waves.

Now enters Guglielmo Marconi, an Italian amateur. He improved the Branly-Lodge coherer, and, most important, he altered the Hertz Xmitter arrangement by burying one of the plates (formerly spheres) and raising the other up a high mast. This was the first radio antenna or aerial. It is a mystery why Marconi should have done this, but it certainly worked. He offered his patent to the Italian Govt, but they refused it! So he came to England and got his British patent in 1896.

He covered a range of 4 miles on Salisbury Plain, and 8 miles over the Bristol Channel. Marconi WT Co. Ltd. incorporated 1897, with £100,000 capital, of which £75,000 was paid to Marconi for patent rights. Thereafter rapid expansion.

Signals across the Atlantic in 1901. Ship saved by radio message 1909. Wireless became compulsory on US passenger ships 1909.

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