HMS Agamemnon strikes heavy weather during the laying of the Atlantic cable of 1857.

The story of undersea cables-2

The history of telecommunications is full of stirring tales, but perhaps none more so than the story of the development of the globe-girdling network of cables which carry telegrams and the spoken word beneath the seas. Continued from last month, this article traces events up to the present.

One of the most heroic sagas of telecommunications history is found in the story of the first bridging of the Atlantic by the telegraph. It is a story of 10 years of continuous, courageous effort in the face of repeated failure, of fortunes being gambled on what must have seemed to most a lost cause, of men braving great physical dangers as well as public ridicule time and time again, and persisting until success was at last achieved.

The project brought together some of the most remarkable men of a remarkable era. The promoter of the scheme and the main driving force behind it was an American, Cyrus Field. Although only 34 years old when he first become fired with the ambition to link the USA and Britain by submarine telegraph, he had already retired from the New York business world with a comfortable fortune. In 1856, having been persuaded to buy up the assets of the bankrupt Newfoundland Electric Telegraph Company, he took passage to England in search of backers and practical support for his bold scheme. There he met the leading submarine cable experts of the day, including John Brett of Channel cable fame.

The odds against success were great and were made even greater by the haste with which the over-eager directors pushed the project forward. The first meeting of the Atlantic Telegraph Company took place at Liverpool on November 2, 1856. Within a few days, £350,000 had been subscribed, mostly by British investors. By the following August, 4000 kilometres of cable had been manufactured and loaded into two specially converted warships, one British and one American. No ship then afloat could have carried the whole cable. Laying, from the USS *Niagara*, steaming slowly westward from the coast of Ireland, lasted only a few days. After 480 kilometres the cable snapped, the end disappearing into the ocean depths.

After raising more capital, Field persuaded the British and American navies to assist him again the following June. This time, *Niagara* and the old wooden warship HMS *Agamemnon*, started in mid-Atlantic, splicing the ends of their respective halves of the cable together and steaming in opposite directions. Three times in two days they came together, spliced ends and commenced laying. Each time, the cable failed electrically, or parted. On the third day the break came after 300 kilometres had been paid out. Foiled once more, the fleet returned again to port.

Field, refusing to be beaten, asked his directors to back another attempt. Several resigned. But the ships were back in mid-Atlantic by July 29. This time, after many setbacks the operation ended successfully. On August 5, 1858, the first telegraph message crossed the Atlantic. From *Agamemnon*, at her anchorage in Valentia Bay, Ireland, to *Niagara*, anchored in Trinity Bay, Newfoundland. It reported that the shore end had been safely landed.

Although a further 10 days passed before the line handled any traffic, wild enthusiasm greeted the news of its completion. Queen Victoria telegraphed congratulations to President Buchanan. (It is recorded that transmission of this message took 16 hours.) Charles Bright, the Atlantic Telegraph Company's 26-year-old Chief Engineer, received a knighthood. A banquet in New York honoured Cyrus Field.

The rejoicing, however, proved to be premature. A message addressed to

Field from London on the very day of the banquet turned out to be the last one carried by the cable. The line died on September 1. Another eight years would pass before England and America communicated by telegraph once more.

Committee of Enquiry

A committee appointed jointly by the British Government and the Atlantic Telegraph Company conducted a lengthy enquiry into the whole problem of submarine cable failures. The Government had become involved since sinking £800,000 of public money into a cable laid through the Red Sea to India, which had also failed. The simple truth was that the engineers were having to build up their knowledge of this new technology by a process of trial and error.

Considering the primitive state of electrical science at that time, it is amazing that telegraphic messages had been transmitted across the Atlantic at all. Few of those who worked with electricity had more than a superficial understanding of its properties. No agreed units existed for measuring current, potential difference, or resistance. George Ohm had recently died (1854), bequeathing to the world his law on the constant relationship between these three characteristics of an electrical circuit but the law was not generally known. One of the "expert" witnesses who addressed the committee of enquiry stated that he "dissented entirely" from the "theory of circuits."

The American States, between 1861 and 1865, passed through the Civil War. Still, the indefatigable Cyrus Field pressed on, shuttling back and forth across the Atlantic, talking investors into putting up more money, directing the design and manufacture of a new cable, making shipping and naval support arrangements for a fourth expedition. Towards the end of June 1865 (a few weeks after the assassination of President Lincoln), the *Great Eastern* left England carrying another 4100 kilometre length of cable.

The Great Eastern

The great iron ship, with its 18m paddle wheels and 7m screw, was the biggest and most manoeuvrable ocean-going vessel afloat. Conversion of this leviathan into a cable layer rescued both its owners and the cable promoters from embarrassment. Since its launching, the ship had steadily lost money for a succession of owners. Yet its availability at this time came as a great stroke of luck for the Atlantic Telegraph Company. It was the only ship of the day which could have carried the complete cable. The necessity for bringing two ships together in mid-ocean to splice cable ends was thus removed.

Much had been learnt by the engineers. This 1865 cable was the heaviest so far made, more than 3cm thick and heavily armoured. Yet further lessons remained to be learnt. Further disappointments lay ahead.

Several electrical faults were found during paying out. Each one necessitated stopping the ship, laboriously manhandling the suspended cable around from the stern to the bow, turning the ship about and steaming in the reverse direction, heaving cable inboard until the fault had been brought in. Several times, a spike of iron was discovered embedded in the cable, arousing the suspicion that someone among the crew was a saboteur. Later, the spikes were found to be pieces of the armouring wire from the cable itself, broken off and driven through the insulation by the motion of the ship and the shifting of the heavy coils of cable in the storage tank.

With two-thirds of the distance covered and only 1000 kilometres left to go, a fault was observed. The procedure of picking up cable, by now regarded as routine, turned difficult as the huge ship began to veer in a wind. The cable snapped. The end sank from sight into two thousand fathoms of water.

Valiant efforts were made to raise the lost wire, using a five-pronged grapnel on an improvised 8 kilometre length of line. For nine days the ship drifted silently with the mid-ocean breeze, shifted position and drifted again, dragging the grapnel along the ocean bottom. Fogs and unfavourable winds caused long interruptions. Three times the long probe encountered something on the sea-bed, hauling in began – and the rope broke. After the third attempt, with insufficient rope left to reach bottom, Chief Engineer Canning admitted defeat. The expedition returned to Ireland.

A year later, in July 1866, *Great Eastern* and her escorts sailed westward once more carrying yet another improved cable, festooning it along the Atlantic bed as they went. Aboard the ship, sharing the nerve-wracking tension, as on all the earlier expeditions, were Cyrus Field and one of his co-directors, Professor William Thomson of Glasgow University (later to become Lord Kelvin). After a fortnight's voyage without incident, the great ship anchored in Trinity Bay, Newfoundland, on July 27. The end was hauled ashore at a place appropriately called Heart's Content. Two days later, New York and London were linked by wire and exchanging messages. This time, the operation had succeeded splendidly. Never again would the two sides of the North Atlantic be remote from one another.

The trans-Atlantic telegraph cable earned £1000 on its first day of operation. And it continued to operate for five years, with high efficiency, before it needed any repair. Soon, groups of British businessmen were forming companies to lay cables to the farthest corners of the earth. In 1870, the *Great Eastern* laid a cable across the Indian Ocean which linked Suez and Bombay. Further cables laid in that same year joined Madras (connected to Bombay by the Indian landline), Penang and Singapore. The British Australian Telegraph Company, formed in London in January 1870, put a cable between Singapore and Batavia (present-day Djakarta). Australia's long isolation was about to be ended.

Overland Telegraph officers Little, Patterson, Todd and Mitchell pose next to a supply wagon near the Roper River, NT 1872.

The Australian scene

During the years of the struggle to establish the Atlantic telegraph, explorers in Australia were giving their lives to find ways across the inhospitable inland of the empty continent. Burke and Wills perished on their way back to Melbourne from the Gulf of Carpentaria in 1861. Scotsman John McDouall Stuart, who had made a profession of exploring, set out upon the first of his three epic journeys to find a way from south to north in 1858 – just as Englishmen on the far side of the world were loading cable into the *Niagara* and the *Agamemnon*. On April 22, 1860, Stuart wrote in his diary: "I am now camped in the centre of Australia. I have marked a tree and planted the British flag." In 1862, his ambition achieved, he was carried back to South Australia on a stretcher by his companions. Blind and ailing, but triumphant, he retired to England where he died two years later.

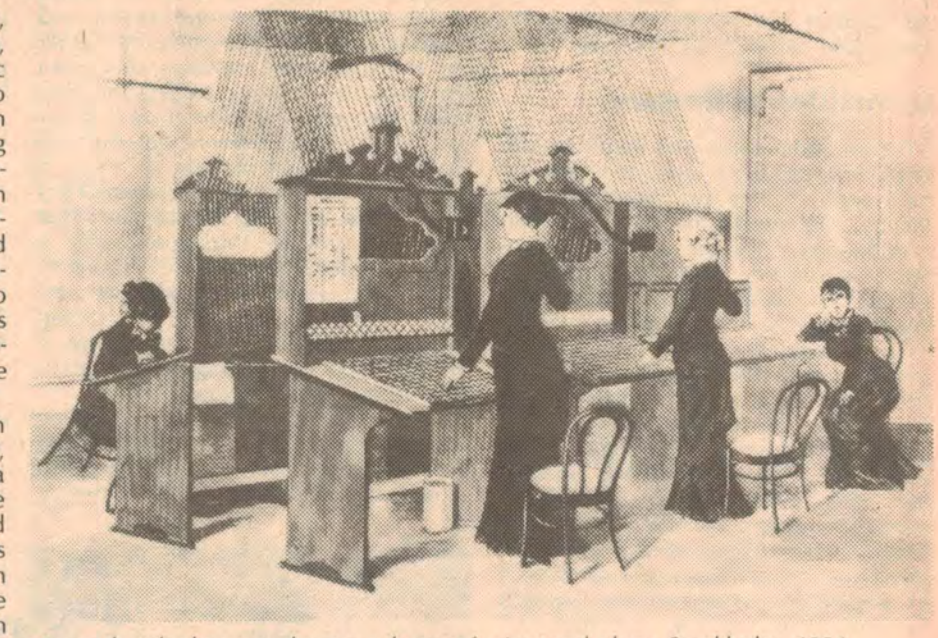
Within another ten years, a telegraph wire followed the route blazed by Stuart, reaching all the way from Port Augusta across the Centre to Port Darwin. There the wire met a submarine cable laid across the Timor Sea in 1871 by ships under contract to the British Australian Telegraph Co. This 1600 kilometre cable extended to Banjuwangi, at the eastern tip of Java, from where Dutch landlines ran to Batavia. So, in the 84th year since the founding of the settlement at Sydney Cove, Australia became linked with the outside world by telegraph.

The overland telegraph line from South Australia to the shore of Port Darwin took two years to build and cost six men's lives. The history of its construction is another of the great sagas of the 19th century.

The citizens of the major cities of the southern and eastern colonies found themselves able to communicate by telegram direct with England and most other principal overseas countries from October 1872. Messages could now be exchanged with London in hours instead of weeks. This liberation from "the tyranny of distance" (to borrow a vivid phrase from author Geoffrey Blainey) was greeted with great excitement and rejoicing. Businessmen, newspapermen and administrators hailed the advent of the international telegraph as though it marked the dawn of the millennium. Typically, a speaker at an official banquet in Sydney on November 15 referred to the opening of the line three weeks before as " . . . the greatest and by far the most wonderful event that has ever occurred in the history of this country."

International telephone

Four years later, Australia and New Zealand were linked by telegraph cable. That was 1876, the year in which Alexander Graham Bell patented and demonstrated his telephone. Before long, the cable engineers were thinking in terms of girdling the earth with a magic chain that could carry speech. But another three-quarters of a century would pass before this became possible.



An early telephone exchange, a loom of wires and plugs, Stockholm, 1884.

Whilst the use of the telephone grew very rapidly, especially in America, Britain and the countries of Europe, development of a satisfactory submarine telephone cable to span all but the shortest underwater distances proved enormously difficult. Not until the arrival of the electronic age did the engineers have any means of overcoming the major problem, which was loss of signal strength over long lengths of cable. The first trans-oceanic telephone circuits were radio circuits, opened in the late 1920s and early '30s. But research engineers within two great organisations on opposite sides of the Atlantic were by this time patiently working, in co-operation with British and American manufacturing concerns, on the invention which was to make long-distance submarine telepathy possible: the submersible repeater.

No longer is the story of communications technology a romantic legend of individual achievement, as in the days of the 19th-century pioneers. No longer is it a game for the dedicated amateur working in a back room with little capital and some makeshift equipment, guided by the spark of genius. Now we step into the present-day world of the professional communications engineer. The two bodies mainly responsible for the successful development of the submarine telephone cables were the USA's Bell Telephone Laboratories and the British Post Office. These two institutions, after years of research, and many trials with repeatered telephone cables in this respective home waters, pooled their technological resources in the 1950s to design a cable that would carry speech across the Atlantic. This cable, TAT-1, came into operation on September 25, 1956 – just 90 years and two months after the opening of the first commercially successful trans-Atlantic telegraph cable.

The advent of high-quality trans-oceanic telephony triggered an explosion in public demand for international telecommunications facilities which continues to test the resourcefulness of national administrations throughout the world – as it does the ingenuity of the engineers. To enable international networks to keep pace with demand, it has been necessary for submarine cables of ever greater capacity to be produced.

The record is astonishing. That first Atlantic telephone cable, TAT-1 (actually two separate cables, one working in each direction), initially led the field with 36 two-way voice circuits. The first cables of the British Commonwealth submarine telephone cable network were designed to carry 80 two-way voice circuits. These included CANTAT-1, between Britain and Canada, opened December 1961, and COMPAC, joining Canada, New Zealand and Australia, opened December 1963. CANTAT-2, laid in 1974, has 1840 voice circuits. In 1976, a cable was laid across the Atlantic providing 4000 circuits. And another, planned for laying in the 1980s, may be able to handle 16,000 simultaneous telephone conversations.

Submersible repeaters, like the coaxial submarine cables into which they are spliced, must be as near to flawless as it is possible for human skills to make them. They must operate continuously, with complete reliability, whilst lying on the ocean floor for periods of 20 years or more. (TAT-1 has already been in service for 20 years. A North Sea cable with seven repeaters has been working since 1954.) Throughout that time they must function with unflagging efficiency, each one amplifying the signals in the line several thousand times, so that the sound of each speaker's voice is received at the other end undistorted, without fading, sounding utterly natural.

Seabed surveys

When men first began to lay telegraph cables beneath the seas, in the middle of the 19th century, they found themselves confronted by a completely unexplored region of the earth; the oceanic depths. Before that time, geography had stopped just beyond the shoreline. Until the development of modern diving techniques, most of this vast region – more than seven-tenths of the earth's surface – remained as inaccessible as the most distant planet. Information about the depth of water in the open seas was sketchy and unreliable for it originated from random soundings taken by sailors with weighted, hand-hauled lines. The nature of the terrain at the bottom of those seas remained a mystery.

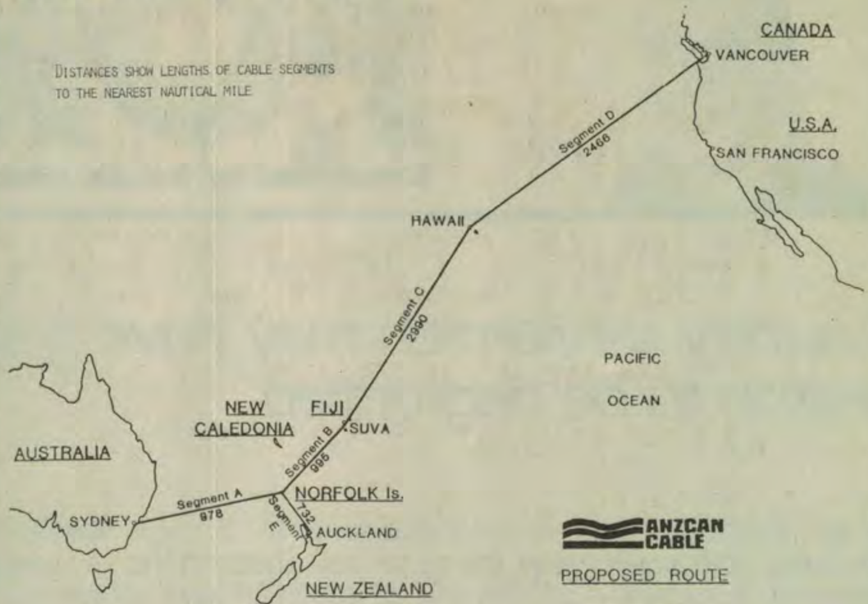
These days, when telecommunications engineers plan the route for a new trans-oceanic cable, they start by collecting detailed information about the terrain. Usually this means carrying out oceanographic surveys. They need to know exactly where they will encounter underwater mountains and such possible causes of trouble as deep trenches. Apart from the risk of earthquake activity, however, the major hazards to submarine cables are man-caused. In the relatively shallow waters above the continental shelves, cables are vulnerable to damage by ships' anchors or trawling gear. Techniques have been developed for burying cables in the sea-bed, using a special plough to gouge a channel. Such ploughs are highly sophisticated pieces of equipment, sometimes carrying television cameras and underwater lighting so that the route may be visually surveyed. Where a rocky bottom makes cable burial impossible, particularly in coastal waters, armoured cable is used.

Despite the dynamic and unpredictable nature of the environment in which they must operate, submarine cables have proved to an outstandingly durable and reliable medium. When you consider that there are scores of thousands of kilometres of cable draped along the sea-beds, all operating day and night, continuously, year in and year out, the achievement of the cable engineers is nothing less than astounding.

Repeaters in a modern cable may be as much as 2.5 metres long and contain more than 300 components, all of which must be thoroughly tested to ensure a working life of (usually) 25 years. A repeater, snug in its polythene sleeve and encased in a brass cylinder, may be more than 20cm thick – by contrast with the usual cable diameter of about 4cm yet it must be led through the paying-out gear of the cable layer without interrupting the steady progress of the laying operation. And it must be strong enough to withstand the great pressure of water at the ocean bottom – as much as 62000kPa at a depth of 6000 metres. The whole system must be mechanically robust enough to stand being hooked by grapnels and lifted from the depths, in heavy loops several kilometres long, when repairs are necessary.

What other servant of man can match the submarine cable for service? Once it has been made, it is lowered into the darkness of the ocean depths to perform its task unseen for perhaps a quarter of a century. Think of the cable, lying there, the next time you talk to someone overseas by phone or read a report supplied to your newspaper by an overseas "wire service". ❧

ANZCAN — THE BIGGEST YET



Australia's Overseas Telecommunications Commission (OTC) will play a major role in the world's largest undersea cable project, the ANZCAN Submarine Telephone Cable System.

The 15,000 kilometre cable will link Australia to Vancouver, Canada, passing through Norfolk Island, Fiji and Hawaii, with a "spur line" to Auckland. The United States and several other countries will use the ANZCAN cable as an international link, carrying telephone, telex, facsimile and digital data communications.

The cable will be capable of handling over 1300 simultaneous telephone calls, 16 times as many as the COMPAC cable, which was laid in 1962 and is now nearing the end of its service.

As well as providing links to Norfolk Island, New Zealand, Fiji and Hawaii, the cable will provide direct access from Australia to communications networks in the United States, and through further microwave and cable links to Europe.

Repeaters will be used to boost signal levels along the cable, at intervals of about 13 kilometres. The repeaters will be manufactured at a plant set up by UK company Standard Telephone and Cable Ltd, at Liverpool on the outskirts of Sydney.

Work has already begun on the $A400 million cable, which is expected to be operational by late 1984. ANZCAN will serve Australia's growing need for international communications links — currently increasing at around 30% a year.

The cable will cross the Pacific at depths of up to six kilometres.

Contracts have been signed with two companies, Standard Telephone and Cables Ltd and Nippon Electric Co Ltd for the manufacture and laying of the cable system. Each contract includes the design of the system, supply of equipment and cables, laying operations and training of technical staff.

Cables and satellites complement each other in the international network, and provide backup for each other in case of emergencies.

The ANZCAN cable will be the biggest telecommunications project in the world, even in this age of satellites. Cables will continue to share world communications traffic with satellites for many years to come.