Underseas Communication Cables of the World

by Lloyd Butler

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Electric Telegraphy via Submarine cable was first introduced in the 1850's. Today a multitude of Fibre Optic cables, carrying Communications and Digital Data, span the ocean floors of the world

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Introduction

The article is about world communications but specifically deals with the historic development of undersea communication cables around the world. These cables initially carried the electric telegraph, and then the electric telephone and other analogue sound channels and finally digitally encoded data. The first cables used for telegraphy contained cable pairs, then they changed to coaxial transmission lines to support higher frequencies, such as telephone carriers and digital data, and finally fibre optic transmission lines to support digitally encoded optical carriers.

Development of underseas cables in the eighteenth century commenced in the 1850's and cables of this era were confined to the electric telegraph. A short prelude is included on experiments and development of the electric telegraph prior to this date by inventors of electric telegraph systems such as Samuel Morse and his assistant Alfred Vale.

Information contained in the article was obtained from a number of sources and specifically those listed in the Appendix list at the end of the article.

Early development of the Electric Telegraph

Going back as far the the 17th Centre, there were experiments carried out to demonstrate telegraphy sent via an electrical system such as one suggested by Charles Marshall in 1973. And in 1787, there were experiments carried out in Spain using static electricity over wires stretched between Madrid and Aranjuez, a distance of around 42 kilometres.

Samuel Thomas Sommering demonstrated an electro-chemical telegraph to the Munich Academy of Science in 1809. His demonstration inspired a Russian nobleman Baron Pavel Schilling to take a lifelong interest into electric telegraphy. The ability off an electric current to deflect a compass needle was first noticed by Professor Oersted at the University of Copenhagen in 1820. Schilling developed a signalling code based on the swinging magnetic needle system controlled by the polarity of the electric circuit setting the mark or space in the telegraph code. The development removed the need for a separate telegraph wire for each character.

Englishman, William Fothergill Cooke, realised the potential value of Schilling' idea. He formed a partnership with Charles Wheatstone, a Professor of Natural Philosophy at Kings College. In1837 they were granted their first patent. Their five needle electromagnetic telegraph was demonstrated to the London-Birmingham Railway proving the effectiveness of the system. The directors were impressed and the inventors were invited to install a telegraph between their London terminal Paddington and West Drayton, a distance of 21 Km. This came into operation on July 9, 1839. It was the World's first electric telegraph.

The telegraph lines of Cooke and Wheatstone spread rapidly through Britain along with the railways, gradually reducing the number of needles used at each installation By 1845, due to the railway royalties, the partners were financially in good shape.

The work on the Electric Telegraph by Morse & Vale

Whilst the electric telegraph flourished in England, American inventor Samuel Morse was giving some thoughts to design of the telegraph. His concept included the idea that an electro-magnet could be used to move a pen across a moving strip of paper. In 1835, he was appointed as Professor of the Literature and arts at the University of New York, but spent spare time perfecting his ideas on the electric telegraph. In 1837, he took on a partner Alfred Vale, and together they developed the telegraph system which set a system design which became quite standard for systems around the world for many years to come.

Samuel Morse

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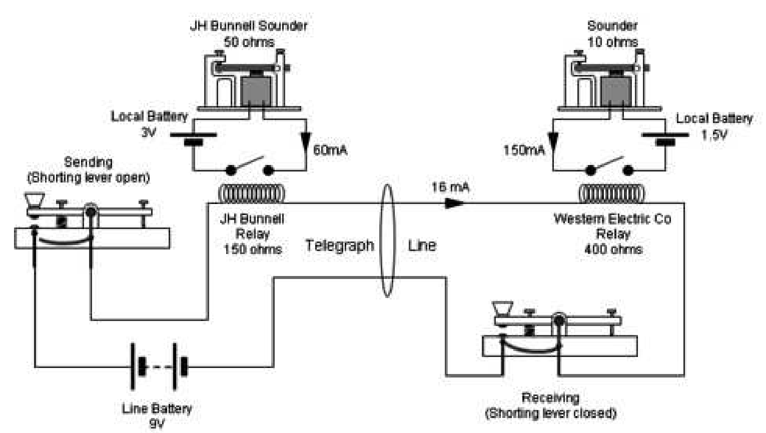
The basic circuit shown shows two wires connected between the two connected stations. However a feature of the Morse telegraph system was that it needed only one wire, the return circuit being provided by the earth. Transmission of the signals was effected simply by tapping a key so as to make and break the connection. The pen and moving strip of paper took the form of perforated paper tape to store the message which could later be used to regenerate the coded information. And it was found in practice that operators could read the messages at the receiving end by listening to the long and short buzzing sounds made by the receive instruments or the clicks generated by the magnetically operated sounders.

The basic circuit also uses a single pole battery. More advanced systems used a double polarity system so that switching from mark to space was a reverse of polarity rather than a switch of current flow between on and off. This reduced distortion of the mark to space signal transition and increased the transmission speed over a given distance set by repeater spacing.



Basic Telegraph Circuit

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Morse Key

Sounder

Telegraph Inker & Tape

Telegraph Relay

Components of Morse Telegraph System

Morse has been credited with the development of the telegraph code which takes his name. The development of the Morse telegraph system was the combined efforts of both Morse and Vale but quite a few historians insist that Vale was the one who actually developed the Morse Code (See Reference 12). Key transmission and the Morse code of dots and dashes has survived for many years before the introduction to automatic telegraphy and is still used for amateur communication. The telegraph system, as developed by Morse was as installed at communication centres, such as Post Offices and Railway stations around the world and on ships. It was not until well into the 19th Century, that keyboard operated machines, such as the teletype and teleprinter, replaced the manually keyed system.

Introduction of Undersea Telegraph Cables

In the early 1800's, there were thoughts that they might drop cables into the seas and enable telegraph communications over the oceans between continents and countries. but they found there were complications which had to be overcome. In 1842, Morse laid an experimental rubber insulated cable across a section of New York Harbour. The line went dead before the official opening ceremony. A fisherman angrily chopped through the cable because it had fouled his anchor. Interference from shipping proved to be one of the complications in laying cables over near shore shallow sections of the ocean.

In England, a retired antique dealer, John Watkins Brett formed a company called the General Electric and Subterranean Electric Printing Company to achieve a proposal suggested in 1840 by Professor Charles Wheatstone of King's Collage London. The proposal was to lay a cable across the English channel and a cable was manufactured by the Gutta-Percha Company. The cable consisted of a single copper wire surrounded by a 5mm thickness of gutta-percha insulation.

On August 28, 1850 a small steam tug, the Goliath paid out the cable from a huge drum on its deck and the cable end was landed at Cape Gris Nez near Calais in France. and that evening connected to the automatic telegraph printer of John Brett. In England, Brent attempted to send a message of greeting to Prince Louis Napoleon Bonaparte but recorded only unintelligible characters. By morning, the telegraph line was dead and this was again because a fisherman had interfered with it and cut out a section of the line as a sample.

But Brett tried again with support and guidance from railway engineer Thomas Crampton. The engineer designed a new cable of four conductors each insulated with gutta-percha. This was further protected by a sheath of tarred hemp and galvanised wires. The new cable was laid on September 23, 1851 and this proved to be successful. For the first time, these two countries separated by the sea, could communicate using the electric telegraph.

Over the of the 1850's, a boom of cable production and cable laying followed. Cables went into operation across the Irish Sea, the North Sea, the Mediterranean and even the Black Sea. And in 1857, India and Ceylon were linked.

And Australia wasn't far behind. In 1859, the first telegraph cable was laid under Bass Strait from Cape Otway in Victoria to King Island, by land across King island and then under sea again to Circular Head in Tasmania. With numerous failures on the way, this led to a saga of nine communication cables laid within Bass Strait between Victoria and Tasmania over the period of 1859 to 2003. The story of these cables is described in another OTN issue.

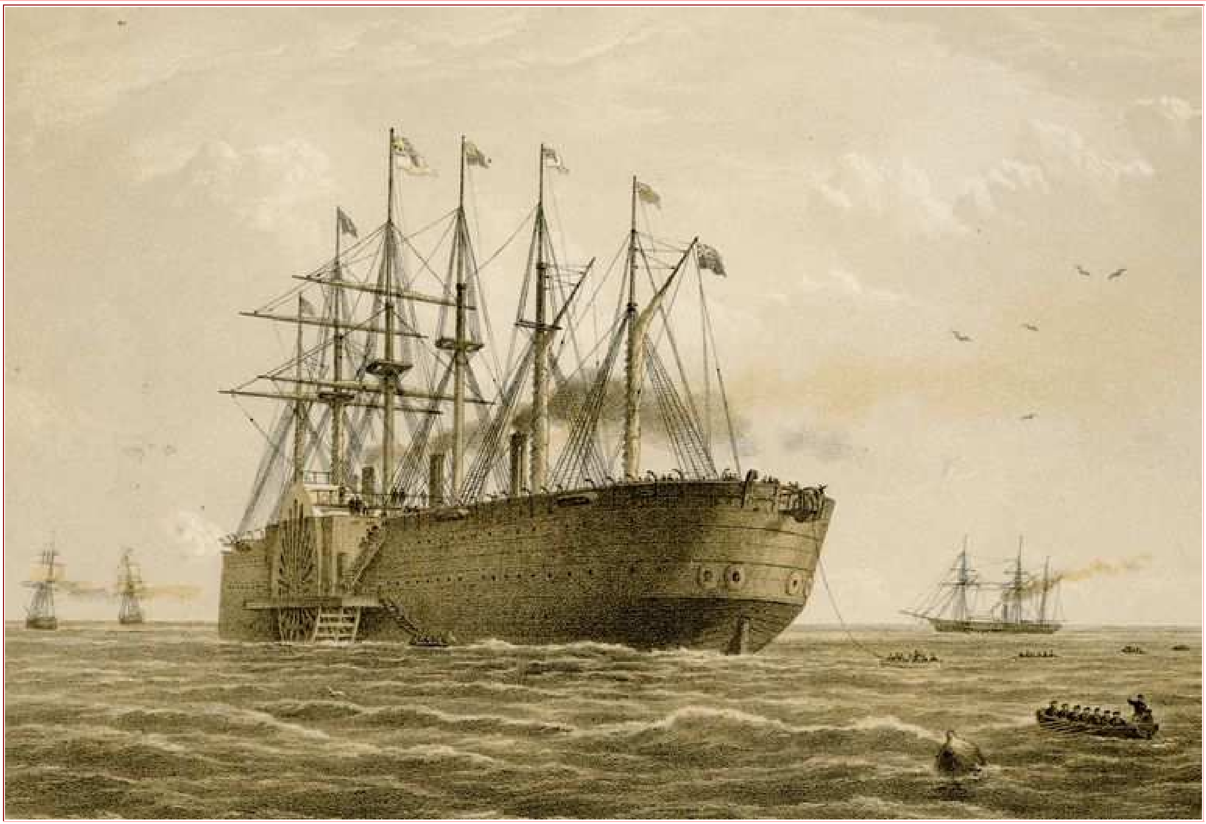
Cables across the Atlantic

The initial driving force to lay a cable across the Atlantic was American Cyrus Field. In 1856 he bought up the assets of bankrupt Newfoundland Electric Telegraph Company and travelled to England to find backers and practical support. Here he met up with submarine cable experts including John Brett.

The first meeting of the Atlantic Telegraph Company took place at Liverpool on November 2, 1856. Capital was raised in Britain and by August, 4000 Km of had been manufactured and loaded shared into two converted warships, one British and one American. The *USS Niagara*, laid the cable westward commencing from the coast of Ireland. Unfortunately it only lasted a few days, as the cable snapped at 480 km and the end disappearing into the ocean depths. So they had a second try, this time *Niagara* accompanied by the old wooden ship *HMS Agamemnon.* They started in mid-Atlantic, each ship splicing the ends of their respective halves of the cable together and steaming in opposite directions. But they kept getting electrical failures and on the third day the cable broke and the fleet again returned to port.

But there was a third attempt and it was successful. The ships were back in the Atlantic in 1858 and on August 5, that year, the first telegraph message crossed the Atlantic, from *Agamemnon*, at her anchorage inValencia Bay, Ireland, to *Niagara*, anchored in Trinity Bay, Newfoundland. Ten days later the telegraph cable link handled message traffic. Unfortunately, the circuit only lasted until September 1. It was not until July 29. 1866 that England and America again became linked by telegraph.

It was clear that engineers were going through a learning curve to establish how undersea telegraph cables must be made and how they were payed out into the ocean. But over the decade which followed, Cyrus Field pressed on, shuttling back and forth across the Atlantic, talking to investors into putting up more money, directing the design and manufacture of a new cable, and making shipping and naval support arrangements for a fourth expedition.



The manoeuvrable ocean going iron vessel "*The Great Eastern*"

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A turning point in the saga was the introduction to the project of the iron ship *Great Eastern,* 10in paddle wheels and 7m screw and the biggest and most manoeuvrable ocean going vessel afloat. The new improved cable, made in 1865, was the heaviest ever made. The ship was the only one of the day which could have carried the complete cable. The necessity to split the cable between two ships and bringing two ships together in mid-ocean to splice cable ends was thus removed.

Towards the end of June 1865, the *Great Eastern* left England carrying another 4100 km of cable on a fourth attempt to lay it across the Atlantic. During that trip, there were problems due to spikes of iron breaking off from the cable armouring and which damaged the cable insulation. There was also shifting of the heavy coils of cable in the storage tank and finally the cable snapped. Attempts to recover the broken cable ends failed and the expedition returned to Ireland.

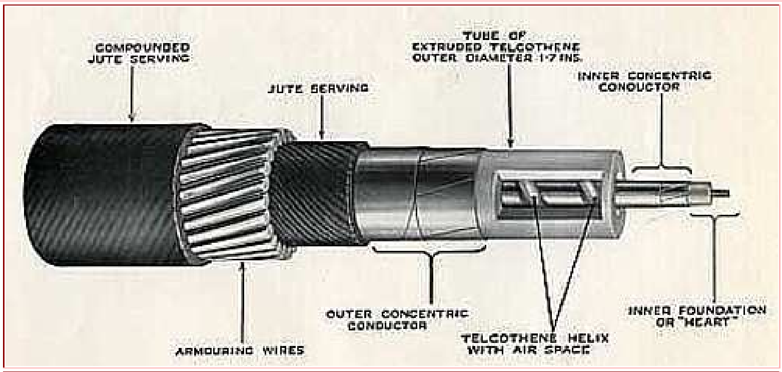
A year later on a fifth attempt in July 1866, the *Great Eastern* sailed western, with Cyrus Field on board, as with the previous attempts and with a further improved cable. After two weeks voyage without incident, the great ship anchored in Trinity Bay, Newfoundland, on July 27 and the cable end was hauled ashore. Two days later, New York and London were linked by a telegraph circuit and they were exchanging messages. From its first day the cable earned an income and the circuit continued to operate efficiently for five years before it needed repair.

Throughout the 1860s and 1870s, British cable expanded eastward, into the Mediterranean Sea and the Indian Ocean. An 1863 cable to Bombay, India (now Mumbai) provided a crucial link to Saudi Arabia. In 1870, the *Great Eastern* laid a cable across the Indian Ocean which linked London to Suez and Bombay. At the bequest of the British Government this was a combined operation by four cable companies. In 1872, these four companies were joined to form globe spanning Eastern Telegraph Company, owned by John Pender.

The final success led to the forming of further companies laying cables to the corners of the earth. In the late 1920's and early 1930's trans-ocean telephone circuits were established by radio systems. However the first undersea telephone cable to across the Atlantic was TAT-1, apparently the combined efforts of USA's Bell Telephone Laboratories and the British Post Office. This cable came into operation on September 25,1956, 90 years after the first telegraph across the Atlantic. Various under sea cables followed.

TAT-1 was actually two separate cables with with 36 two way voice circuits, with one working in each direction. initially. This led the field with two-way voice circuits and the first cables of the British Commonwealth submarine telephone cable network which were designed to carry up to 80 two way voice circuits.

A New Breed of Submarine Cable with Air Cored Coax



The 1947 Anglo-Dutch cable of the post WWII era with air spaced coax transmission line

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A new breed of cable was introduced around 1947 by the Telegraph Construction and Maintenance Company (Telcon) and which had the coaxial center but with an air dielectric rather than the solid insulated core. This cable, ultimately laid between Aldeburgh in Suffolk and Domburg in Holland, was a triumph of design and manufacturing skill, by the team at Telcon Works.

The cable incorporated an inner conductor 0.45" in diameter, composed of copper tapes on a Telcothene cord, and with another Telcothene cord 0.2" in diameter helically applied to the conductor. This cord supported a Telcothene tube of 0.4" wall thickness, thus producing a core of 1.7" diameter. The advantages of this construction lay in its lower shunt capacitance and lower attenuation, which enabled much higher carrier frequencies to be employed than with the solid insulated core. Hence a greater number of speech channels could be carried over the one coaxial line. (Telcothene was Telcon's name for their polythene dielectric material, first used by the company for cable insulation in 1938).

The 157Km Anglo-Dutch cable allowed simultaneous working of 84 telephone circuits, whilst a further 89 Km Anglo-Belgian cable, installed in 1948, allowed 216 telephone circuits. In 1964, the Anglo-Belgian cable was upgraded to 420 circuits by the insertion of two transistorised repeaters, the first use of this technology on any international cable.

However, it is also of interest that somewhat earlier in Australia in 1936, a 240 Km undersea cable with coaxial core was laid between Apollo Bay in Victoria and Stanley in Tasmania. It supported 5 telephone channels, one wideband broadcast channel and 14 telegraph channels. The dielectric of the coaxial core in this cable was solid so its attenuation characteristic would not have been quite as good as the air cored coax of the cables discussed in the previous paragraph. Never-the-less, it may have been the first undersea cable with coaxial conductor.

Telegraph connection of Australia to the world

After setting out first in 1858 on to three epic journeys, Scotch explorer John McDouall Stuart found a way from the south of Australia at Port Augusta to the north at Port Darwin by 1862. This set the route for the single telegraph wire across south to north which took two years to build and which was completed in 1872. The epic exploration across Australia and the subsequent construction of the overland line is a story on its own. North going section of the line left from Port Augusta and the south going section left from Darwin. They joined on August 22, 1872 at Frews Ponds, located between Newcastle Waters and Daly Waters.

The North going line was joined with the South going line at Frews Ponds on 22-9-1872

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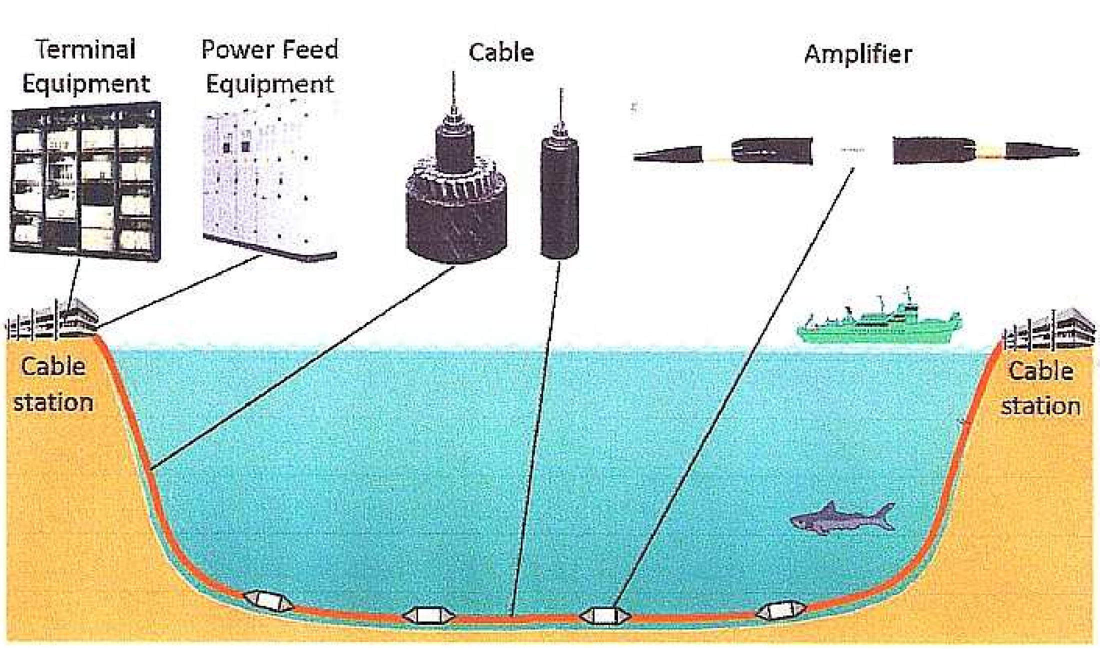
At this point and time, the Australian telegraph circuit was met by a submarine cable laid in the Timor sea by the British Australian Telegraph Company . This 1600 km of cable extended to Banjuwangi, at the eastern tip of Java, from where Dutch landlines ran to Batavia (Djkata). By October 1872, Australia could connect direct by telegram to England and other countries in the northern hemisphere. In 1876, New Zealand was also connected into the telegraph network circuit. I

Submarine cables across the Pacific

The first trans-pacific cables providing telegraph service were completed in 1902-03, linking the US mainland to Hawaii in 1902 and Guam to the Philippines in 1903. Canada, Australia, New Zealand and Fiji were also linked in 1902 with the trans-Pacific segment of the *All Red Line*. Japan was connected into the system in 1906. Service beyond Midway Atoll was abandoned in 1941 because of WWII, but the remainder remained in operation until 1951. The *All Red Line* was an informal name for the system of electric telegraphs that linked much of the British Empire. It was inaugurated on 31 October 1902. The name derives from the common practice of colouring the territory of the British Empire red or pink on many maps.

Cable CANTAT-1 was put into service between Britain and Canada in December 1961 and operated until 1986. It had 60 telephone channels. CANTAT-2 commenced in 1974 with 1840 telephone circuits. CANTAT-3 was a digital link with a capacity of 2.5Gbts. It operated between 1994 and 2010 when it eventually failed and was not returned to service.



Undersea Telephone Cable System

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CANTAT-2 Pacific Ocean Undersea Telephone Cable

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CANTAT-2 Pacific Ocean Undersea Telephone Cable - cross section

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The first trans-pacific telephone cable was laid from Hawaii to Japan in 1964, with an extension from Guam to the Philippines. Also in 1964, the Commonwealth Pacific (COMPAC) cable, with 80 telephone channel capacity, opened for traffic from Sydney to Vancouver, and in 1967 the South East Asia Commonwealth (SEACOM) system, with 160 telephone channel capacity, opened for traffic. This system used microwave radio from Sydney to Cairns (Queensland), the cable running from Cairns to Madang (now Papua New Guinea), Guam, Hong Kong, Kota Kinabalu (Sabah, Malaysia), Singapore, then overland by microwave radio to Kuala Lumpur.

In 1991, the North Pacific Cable System (NPC) was the first with undersea repeaters to completely cross the Pacific from the US mainland to Japan. The US portion of NPC was manufactured in Portland, Oregon, from 1989 to 1991 at STC Submarine Systems, and later Alcatel Submarine Networks. The cable system was laid by Cable & Wireless Marine by the *CS Cable Venture*.

Laid as a replacement for COMPAC, cable ANZCAN followed the same route from Australia and New Zealand to Canada, with the addition of a landing at Norfolk Island. The cable was 15000 Km long, with 1,213 repeaters and a capacity of 1,380 telephone circuits. Standard Telephone and Cables Ltd. manufactured all of the Vancouver - Sydney cable. Fujitsu manufactured the Norfolk Island - Auckland cable.

Cable operations on ANZCAN began in 1982. *CS Cable Venture* laid 11660 Km of cable from Vancouver to Sydney. *CS Mercury* laid the Norfolk Island - Auckland section of 1350 Km as well as 12260 Km in 1950 of the Vancouver - Sydney cable. *HMNZS Monowai* surveyed the route and *CS Retriever* undertook the re-routing of part of the Fiji - Auckland COMPAC cable. *CS Cable Enterprise* laid the shore ends at Hawaii, *CS Retriever* at the Fiji, *MV Chantik* at Norfolk Island and *CS Mercury* at Sydney and Auckland.

Loading Cable on board *CS Cable Venture*
for ANZCAN project

Cable Laying Ship *CS Mercury*
Used on ANZCAN Project

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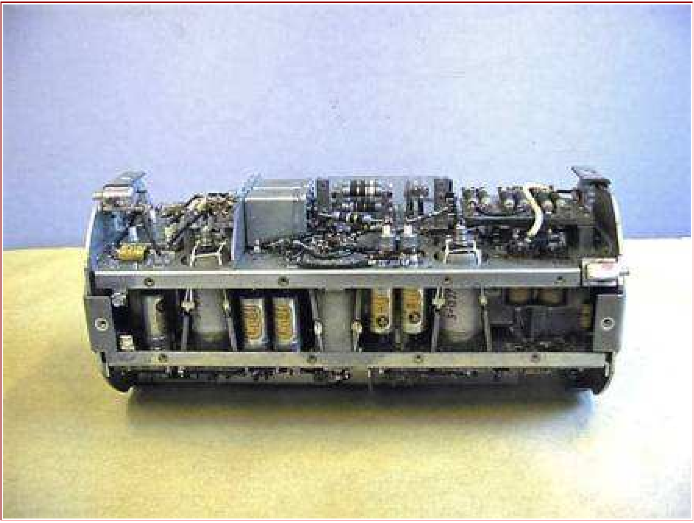
Undersea Repeaters

Transmitting signal over transmission lines involves attenuation of signal and for significant distance, in line amplification is needed to maintain signal above the noise floor. And for undersea cables of significant length, and certainly the long ocean links, numerous signal amplifiers, called repeaters, lay under the sea at intervals within the cable. For the early years of electric telegraph, circuit repeaters were electromagnetic relays or perhaps manually operated Repeater Stations manned by Telegraph Operators such as with the early Australian north-south telegraph link.

Miniature electron tubes were developed in the 1930's. They were small enough (less than an inch (or 2.5 cm) in diameter to be employed in amplifiers that could run through the cable-laying machinery, and rugged enough to survive at least 20 years under water without servicing. This led the way to electronic amplifying repeaters for the undersea cables.



An early Electron Tube Repeater

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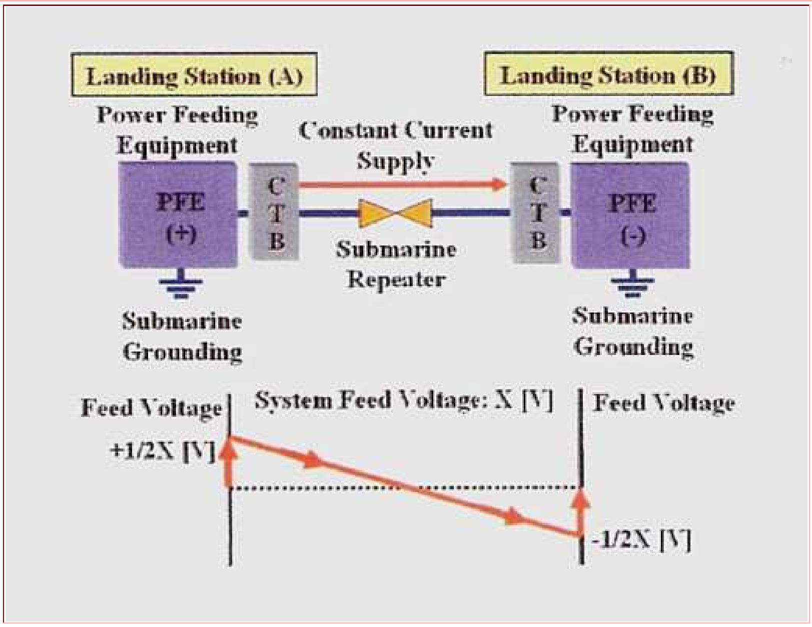
In parallel with submerged amplifier development, the ailing submarine telegraph industry was looking for ways to improve the performance of its cables. Western Union developed a submerged housing that contained thermionic valve circuitry to detect incoming telegraph signals and regenerate or 'Repeat' them, with newly generated outgoing signals. The first of these regenerators was successfully inserted in 1950 into an American Telegraph cable installed originally in 1881.

In 1955-56, the two-line trans-Atlantic telephone cable (TAT-1) was laid between Oban, Scotland, and Clarenville, Newfoundland. The British General Post Office (GPO), had developed larger two-way repeaters for shallow water. 51 narrow flexible repeaters were fitted about one every 30 miles (48 Km). An extension of a single line with 14 British repeaters was also fitted in shallow water from Clarenville to Sydney Mines, Nova Scotia. Most of the cable, manufactured in Britain, was capable of carrying 36 of 4KHz channels, and later 48 to 51 of 3KHz channels. The cable was laid by GPO ship *Monarch 4*.

In the late 1950s, transistor circuitry started to replace the electron tube and when transistors had proven themselves stable enough to be buried at sea unattended for many years, the more compact lower current transistor circuitry was used in the repeaters. In 1970, it was used in TAT-5, between New Jersey and Spain, with repeaters every 10 miles (16 Km) carrying 845 channels. The ultimate in this upward spiral was achieved by TAT-6 (Rhode Island to France) and in TAT-7 (New Jersey to Britain) which had 4000 channels and repeaters every 5 miles (8 Km) .

System capacity was initially designated by the number of voice channels, and then by the highest frequency transmitted. The 80 circuits of and TAT-1 soon became 160 circuits (1.2MHz), this was followed by system designs of 5MHz, 12MHz, 14MHz, 36MHz and finally 45MHz. The highest capacity submarine telephone system ever built was PENCAN 3, which was installed in 1977. The PECAN cable network essentially joins the Spainish mainland to the Canary Islands. PENCAN 3 was designed to support 71 supergroups or 5,680 x 3kHz voice channels. With the advent of fibre optic transmission, the repeaters used in these early systems became known as 'Analogue Repeaters'.

To energise electronic tube or transistor repeaters, constant current is fed down the cable to series feed the operating units, tapping off the required voltage at each unit. The quite high voltage is split between power units at each end of the cable. The two supplies, of course, have polarity opposite to its other end. All the later telephone system cables have been made with coaxial cable at the centre to support carrier telephone type systems. The inner copper conductor also carries the current of the series connected power.



High Voltage, Constant Current, is Series fed to Repeaters

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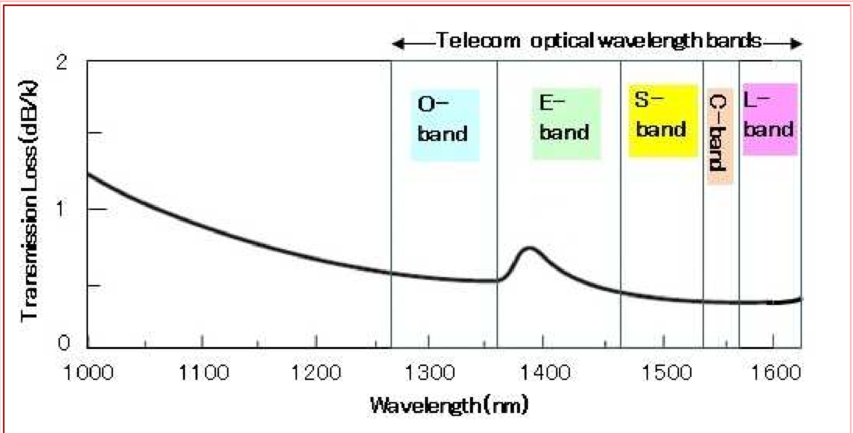
The first trans-Atlantic fibre optic cable cable was introduced in 1988 . The optical amplifier was introduced in the Atlantic cable (TAT-12) in 1996 The optical wavebands used for the undersea cable are shown in the following graph. Erbium-Doped Fiber Amplifier (EDFA) is an optical amplifier used in the C-band and L-band, where the transmission loss in the optical fibers is lowest over the telecommunication optical wavelength bands. Invented in 1987, an EDFA is now most commonly used to compensate the loss of an optical fiber in long-distance optical communication. Another important characteristic is that EDFA can amplify multiple optical signals simultaneously, and thus can be easily combined with Wavelength Division Multiplexing (WDM) technology. (Long-distance cables with WDM were first initiated in 1998).

Such optical fiber amplifiers provide in-line amplification of optical signals by effecting stimulated emission of photons by rare earth ions implanted in the core of the optical fiber. They provides in-line amplification of signal without requiring electronics and the optical signal does not need to be converted to electrical signal before amplification. And of course, no electrical power is needed down the line for repeaters.



Telecommunication Optical Wavelength Bands

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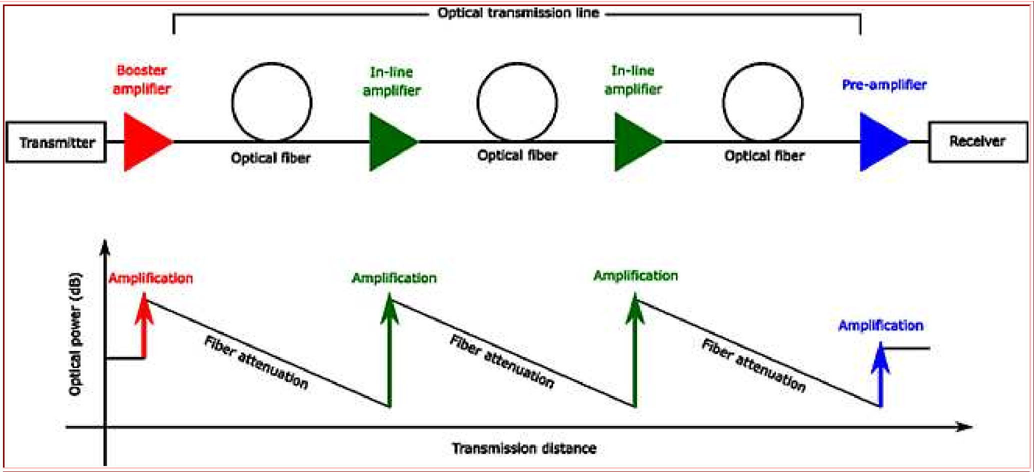
The capacity of optically regenerated systems developed over a decade and was characterised by the line rate. Initial system designs operated at a wavelength of 1,310nm (nanometers) and a line rate of 280Mbit/s (later increased to 420Mbit/s). The total system capacity was calculated as the line rate multiplied by the number of fibre pairs in the cable. By 1990 systems were operating at 1,550nm and a line rate of 560Mbit/s.

EDFAs are used as a booster, inline, and as a pre-amplifier in the optical transmission line, as shown in the diagram. The booster amplifier is placed just after the transmitter to increase the optical power launched to the transmission line. The inline amplifiers are placed in the transmission line, compensating the attenuation induced by the optical fiber. The pre-amplifier is placed just before the receiver, such that sufficient optical power is launched to the receiver. A typical distance between each of the EDFAs is several tens of kilometers. The first generation optical transmitters were 1,410nm pump lasers. Later 980nm pumps were introduced for higher power and greater reliability



Schematic showing Attenuation and Amplification in the Optical Transmission Line

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The first communications Satellite was launched in 1962 and it seems that for some years since, satellites have transmitted much of the circulating world data. But the first fiber optic cable TAT-8 connected Europe and America across the Atlantic in 1988. And now there are over 420 submarine cables in service, stretching around the world and transmitting data. According to information on the Internet, it would now appear that 99% of the data is being circulated by the fibre optic cables ,

The Overseas Telecommunications Commission OTC

As the article is about the history of World Communications, and in particular International Undersea operations, we cannot overlook the part played by OTC in representing Australian overview of those operations over the many years of the OTC appointment.

The Overseas Telecommunications Commission (OTC) originally inherited Australian international communication facilities in 1946 from Amalgamated Wireless of Australia (AWA) and British company Cable and Wireless Communications. Telecom Corporation Limited (Telecom Australia) was created in November 1975 from what was the Engineering Division of the Postmaster Generals Department (PMG), (essentially Australian telecommunications, national broadcast stations and control of commercial broadcasting licences, which they had controlled since the early days of the century).

OTC merged with Telecom Australia to form the Australia and Overseas Telecommunications Corporation (AOTC) in February 1992. The new company eventually was renamed Telstra, firstly overseas in 1993 and domestically in 1995. Whilst the companies OTC and Telecom Australia were owned by the National Government, the assets were sold and Telstra became a private company on the Australian Stock Exchange ASX.

As can be derived from the previous paragraphs, OTC operated over a period of 1946 to 1992 in its own name when it became a national identity as OTC, associated with much of the communications between Australia and overseas by radio and undersea cables and for maritime communications. Making long-term investments in technologies and networks, and becoming a major player in international cooperative efforts, it played a vital role in the provision of Australia's international communications.

Throughout rapid developments in undersea cable networks, global satellite systems and burgeoning digital technologies, OTC maintained a keen watch over its services to ensure continued quality. It also maintained and developed its links with maritime services, one of the initial arms of Australia's international telecommunications network. Over its 46 years of tenure, OTC played a vital role in the provision of Australia's international communications.

Summary

Experimentation with cables which could carry electrical communication under the sea commenced in the 1850's. A telegraph circuit spanning the Atlantic Ocean was achieved in 1866 but it was well into the low 1900's before telegraphs were well established across the Pacific Ocean. Carrier telephone systems were being developed in the 1930's, but it took until 1956 to establish the first undersea cable which supported carrier telephone systems across the Atlantic ocean and 1960 for the first across the Pacific Ocean.

The first communications satellite was launched in 1962. From then for a few years, satellites have dominated the movement of world data. But it appears that since the first optic fibre undersea cable in 1988, under sea fibre cables have taken over the world distribution of Internet data.

Hopefully, a picture has been assembled of over 150 years of undersea communication development. On the way, the developers have had problems to solve with their cables, such as damage from boat anchors, shark bite and sharp rocks on ocean floor. But they now seem to be getting long years of operation with their cables. The merits of satellites verses undersea cables seems like another interesting subject, but one for another day.

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