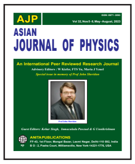

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Preservation of communication heritage

Derek Cassidy

University College Dublin, School of Architecture and Engineering, Clonskeagh, Co. Dublin, Ireland

Dedicated in memory of Prof John Sheridan

Telegraph and telephone communication heritage is at the historical heart of University College Dublin. Many artifacts from the Engineering world are on display including support examples of mechanical, electrical, and electronic pieces. However, here we investigate the forgotten link to Valentia Island and its place in submarine telegraph cable history. The examples of forgotten artifacts and one mans dream to finally preserve this cultural heritage so that history itself can come to life.

Keywords: Telegraph, Mirror Galvanometer, Needle Telegraph.

1 Introduction

Valentia Island Telegraph Submarine Cable Station is on the Irish tentative list for World Heritage Status [1]. This is an ongoing process and is expected to be adjudicated by the United Nations UNESCO World Heritage Centre in Paris. John Sheridan was very aware of this and was keen in supporting this. John was also aware that UCD were the custodians of many artifacts that were of historical importance that were associated with the first successful trans-Atlantic submarine telegraph cable and the history of telegraphy. John had a desire to keep these items in a secure but presentable state and was hoping to develop a museum so that UCD could showcase these technological historical masterpieces. It is by understanding why Valentia Island is so important to development of long-distance telegraph transmission and the opening of long-distance telegraph transmission will help us to understand the history of telegraphy and the importance of Valentia Island Telegraph Submarine Cable Station.

2 The birth of telegraph communication

Telegraph communication or the telegraph was first patented in England in 1837 by William Cooke and Charles Wheatstone [2]. but it had a long evolutionary process of investigation by many others who would also be applauded for their work and revolutionary ideas.

The telegraph could only have been possible by three major discoveries in electricity. The first was the discovery of electrical conduction and induction by Stephen Grey [3] in the 18th century, the second major discovery was energy storage and the invention of the battery by Volta [4] in 1800 and third discovery was the relationship between electricity and magnetism by Oersted [5] in 1820. These three discoveries, although independent of each other made the possibility of electrical communication over wire, or telegraph communication, possible.

It was not just down to the investigations by Cooke and Wheatstone and their achievements that made telegraph communication possible. We need to understand the developments and discoveries by Samuel

Corresponding author

e mail: derek.cassidy@ucdconnect.ie (Derek Cassidy)

Morse, Alfred Vail & Leonard Gale in the United States [6] , William Brooke O'Shaughnessy in India [7], and Werner von Siemens working with the Prussian Army Telegraph [8].

Each working in different parts of the world, working separately and without knowledge of each other's investigations, had undertaken research in communications by using electrical charge. Morse had come across the development in electrical magnetism and its association with conductivity on a trans-Atlantic crossing in 1832 and was very interested in these ideas [9]. It was this chance meeting on the ship that got him interested in the concept of communication by electrical circuit over a single wire. On his arrival in the United States, he went to work on his idea of the telegraph with Gale and Vail [9].

William Cooke who was studying medicine in Paris came across the idea of the electric telegraph when one of his professors used an apparatus that worked just like a telegraph in his lectures. It was only an experimental form of the electric telegraph, and it immediately grabbed his attention. He gave up medicine and returned to England on the preposition of putting the ideas of the electric telegraph into operation. However, he needed help and consulted many academics about his ideas which lead him to meet Charles Wheatstone in 1836 and together they started to work on their telegraph principles. Cooke and Wheatstone turned to the railway, who were looking for a new way to communicate between stations, stops and siding so that safe locomotive transport could be achieved. In 1837 they built the first telegraph network between two railways stations, and this has been established as the first commercial telegraph network in operation and they were granted a patent for their telegraph and signaling method in June 1837 [10].

Photo: William Brook O'Shaughnessy (Courtesy: Biography of Sir William Brooke O'Shaughnessy - Red Historia)

In India, William O'Shaughnessy, a doctor working for the East India Company pondered the idea of a communications network covering the Indian sub-continent [7]. The East India Company was a commercial trading company set up in 1600 but became the ruling authority over many parts in India in 1757 [11]. As the East India Company grew in operation, control, and authority by the middle of the 19th century there was a need to have an efficient communication network, specifically for the Militia or standing military arm of the East India Company. It was this need for a new communication network and some recent information and correspondence that O'Shaughnessy came across that turned his attention to the new developments in telegraphy. He knew that the sub-continent needed a new communication network that could transmit and receive messages faster than the standard horse and rider method. As India was being ruled by a semi-military company the need to have fast communications so that its industrial and economic infrastructure would thrive, especially between military, Government and Administration. O'Shaughnessy set about working on a primitive telegraph network that soon spawned a new technological development in telegraphy and the ideas of insulation were also researched. The electric telegraph was introduced into India in 1837 [12] and during this stage O'Shaughnessy also looked at the issues around insulation due to the humidity of the Indian climate. He came up with the idea of Gutta-percha, which was just being introduced into the European market but was well known in eastern Asia and on the Indian Sub-Continent for its supple, malleable form and its water repellent properties [13]. He soon developed a rudimentary insulation telegraph system that was also deployed across rivers, making O'Shaughnessy the first person to install a submarine telegraph cable across rivers with proper insulation.

In East Prussia, also with a view to fast communications for the military, Werner von Siemens, who was an officer in the East Prussian Army, had a very keen interest in the new technology of telegraph communications. He had been assigned a military role in the deployment of telegraph as a subterranean and submarine communications systems so that the army could deploy the telegraph as an operational communication system, and this led him to the use of Gutta-percha as the material for insulation. However, as this research and investigation was initially for the purpose of military communications, the need to develop a commercial telegraph for public use was always on the horizon. Soon after leaving the army and the establishment of his company, Siemens, his investigations, and deep interest in the telegraph turned towards commercial deployments and activity [14].

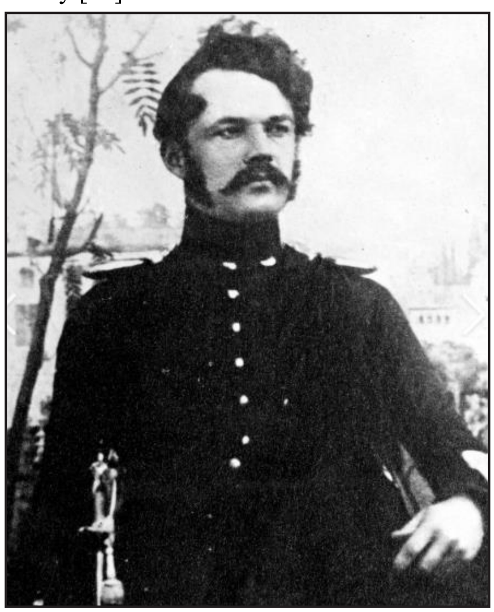

Photo: Werner Von Siemens as an officer in the Prussian Army,1843 before he set up the Telegraphen-Bauanstalt von Siemens & Halske in 1847 (Photo: Siemens Historical Institute).

It was by these separate developments that culminated in the development of the telegraph and the submarine telegraph cable. However, we must also look at other factors such as the coding methods, developments in insulation, following on from O'Shaughnessy's research and the ability to transmit across long distances. We need to discuss these factors so that we can fully understand the development of the telegraph and the first telegraph company, Electric Telegraph Company. This will lead onto the first telegraph networks and the need to cross the oceans and the technology needed to complete this. Valentia and its place in the first successful commercial trans-Atlantic Telegraph Submarine Cable and its effect on society, the economy and technology.

3 Coding Methods

Cooke and Wheatstone initially looked at a way to send and receive the telegraph with the use of an instrument that would indicate the presence of electrical current by the movement of needles and their first trials included a complex 60 coded system which proved too complicated. So, a less complicated system was devised and introduced as the 5-needle telegraph, which over time was reduced to a one needle system that lasted on the railways for well into the 1930s [15].

Their original and subsequent designs for the telegraph system on the railways helped to develop different scenarios for the railways including block work and single line right of ways which delivered a safer system of work. The telegraph idea itself was not seen by the public as a necessity, however, after the arrest of Thwall on the 1st of January 1845 [16] and its publication across the press that public interest began to increase. Soon the need for telegraph systems across the UK was seen as a need and was soon finding its place as a means of communication in society. In 1846 Cooke and John Ricardo, a wealthy businessman who had a financial interest in the Cooke and Wheatstone patents, established the Electric Telegraph Company [17], the first telegraph company in the world.

Wheatstone also developed other coding techniques for the telegraph and some of these were used on private wires and experimental purposes only, however it proved that the electric telegraph could operate with any number of coding techniques that Cooke and Wheatstone could throw at it, if the codes and the instruments used followed certain principles.

Another coding form used for the telegraph and one that would last well into the 21st century, its initial development was first undertaken by Samuel Morse, Alfred Vail & Leonard Gale in 1832 [18], when Morse was credited with the invention of the telegraph, however no commercial working telegraph had yet gone into production. In 1838, Morse and Gail had finally come up with a working code, called the Morse code, which was patented in 1840. By 1844 they had built a telegraph between Baltimore and Washington, and it was on the 24th of May 1844 when the first long distance Morse code was successfully transmitted [18].

Hamburg, 1848, Friedrich Clemens Gerke took Morse Code and by changing some of the codes and technically making it a bit easier, his innovation or interpretation of the original Morse code was called the Hamburg Telegraph [19]. In 1851 at an International Telegraph Conference the Gerke version of the Morse code was adopted internationally, while America and Canada still used the American Morse Code version (Samuel Morse version). However, in 1865 the International Telegraph Union, which was established in Paris that year, adopted a new version of Morse code that was a variant of Gerke's original version. This new ITU code is the Morse code heard and transmitted today [20].

Dublin 1845, Charles Hancock was looking for a solution that would help him produce bottle stoppers. When he was introduced to Gutta-percha by his brother Thomas, he was immediately taken to the flexible and mouldable attributes of this new natural rubber. Charles took out a patent on his new idea of Gutta-percha bottle stoppers and set up a company with Henry Bewley, a Dublin Chemist, who was producing soda. This company was called the Gutta Percha Company [18]. In 1848 Henry Bewley came up with the idea of extruding Gutta-percha into pipe moulds. This new way of moulding Gutta-percha into a pipe was soon introduced to the telegraphic world and research was done on a way to insulate copper wire for underground telegraphic cables. Henry Bewley took out a patent on his new method of extruding Gutta-percha over copper wires, something that had a direct impact on the future of telegraphy, submarine cables [21,22].

As we can see the two events mentioned above, happened in two different countries and without any interlinking communication. They were very closely united in the common purpose of driving the ideas of telegraphy further, incorporating these developments with the use of Gutta-percha as the insulation, due to its malleable and water repellant properties [23]. It is interesting to note that these two separate companies were both producing Gutta-percha insulated telegraphic wires, but with different insulating techniques. As Henry Bewley and the Gutta-percha company were now producing insulated telegraphic wire for the commercial market, Siemens were producing them for the military but set up "Telegraphen-Bauanstalt von Siemens & Halske" or Siemens and Halske Telegraph Company. Two separate markets, one allowing patents to be filed and ownership of the research (Gutta-percha Company) and the other (Siemens and Halske Telegraph Company) being established in a military research environment that did not allow patents to be pursued and so could not claim any rights to or claim infringements on patents as its development was for military use. However, the company soon developed into commercial operation [24].

But as the 1840s ended and with the telegraph already undergoing a revolutionary change in design and technology, the next steps in this evolutionary process would lead to a new leap in the development of submerged or submarine telegraph cable design and deployment. These new developments would push telegraphy into the next generation and totally revolutionize telegraph communications in a way that was only thought off and even thought impossible a few years earlier.

4 The new era in Telegraph communication: Submarine Cable Telegraphy

In 1847, John Watkins Brett and Jacob Brett had received a license from the French Government to lay a submarine cable across the English Channel and land it in France. However, the license lapsed in 1849 but they managed to get it renewed again for ten years if they managed to lay a submarine cable by September 1850 [24]. They came up with a plan and in the early part of 1850 the English Channel Submarine Telegraph Company was set up [18,21]. They ordered for 25 miles of no.14-gauge copper wire to be covered with Gutta-percha from the Gutta-Percha Company. The cable, although only having the constituents' parts of Gutta-percha and centre copper core was the first submarine Telegraph cable built for a commercial purpose. The cable, when being laid, needed lead weights to keep it on the bottom of the channel. The cable was successfully laid on the 28th of August 1850, just about completing it with the time allowed under their licence agreement. But even though it was the first submarine telegraph cable ever laid connecting two countries, it also has the notoriety of being the first submarine telegraph cable to be damaged while in operation [25]. It was lifted off the sea floor by a French fisherman who thought that his fishing tackle had got caught on some seaweed and cut it away. This was the first case of submarine cable damage caused by fishing. It was also the start of the age of submarine cable telegraphy which directly led to the many innovations in submarine cable technology and the submarine cable designs we have today. This has been labelled as the first leap in submarine cable design technology [25].

Fig 1. Copper wire covered with Gutta-Percha for insualtion, 1850 Dover to Calais cable.

In 1851, the Brett Brothers set another company called the Submarine Telegraph Company [26], it was successful until it was nationalised and subsumed by the GPO in 1890. This company set about redesigning a new cable design and ordered a new telegraph wire coated with the Gutta-percha insulation from the Gutta-Percha company. However, this cable had four telegraph cores, each one covered in Gutta-percha. However, the main design change was that the cable was to be covered by a wire wrap, or armouring cable. It is interesting to note that this posed a large problem for the cable handlers as no telegraph cable had ever been protected by armouring wire before. The Gutta-Percha company handed over the four lengths of Gutta-percha covered telegraph copper cores to a rope making company who would install the wire armouring and infill to form the cable. But issues arose with the technique being used by E Weatherley & Co who were originally rope makers but who had been contracted to make the cable. The technique they were using was one originally patented by R S Newall & Co. There was a disagreement, and it was finally resolved when as R S Newall & Co were given the contract to complete the cable build, however they had to complete it at the premises and factory that E Weatherley & Co. So, it was agreed that R S Newall & company would carry out the manufacture of the armoured cable with the Gutta-percha cores inside. The main reason why R S Newall was selected was that their wire rope deigns include a hemp inner core, which would be replaced by the Gutta-percha core(s) and so producing an armoured submarine cable [27].

The Submarine Telegraph Company successfully laid the cable on the 13th of November 1851, it became operational, and it lasted for well over 30 years. This is the second leap in submarine cable design in that it was designed with armouring wire for protection against outside aggression. It was also the first submarine telegraph cable to go into commercial service [28]. For the next seven years telegraph communication spread across the globe like a spider's web, across mountains, rivers, lakes, and seas. However, there was still one obstacle that was out of reach, Connecting Europe with America. But this prospect was seen as a prize to be won by people who were driven with the idea that the Atlantic Ocean could someday be conquered by a telegraph submarine cable capable of connecting the old and new worlds. Cyrus Field led a handpicked team of Engineers and Scientists. They set about getting the funds to fulfil their dream on connecting Europe and America and set about designing and manufacturing the cable required.

5 The First Trans-Atlantic Telegraph -Valentia Island to Newfoundland

In 1858 after 3 attempts to cross the Atlantic Ocean, the third attempt finally succeeded. But it failed after 30 days due to the use of high voltage and current [29] used to drive the electrical signals across the long-distance cable and with the added failure of the insulation [30]. This failure increased engineering ideas and technological innovation that kept powering the telegraph age and submarine telegraphy. The 1857-8 trans-Atlantic cable did prove that it was possible for a telegraph cable to span long distances and that the technologies proven during these installations opened a new world of long-distance telegraphy. Soon submarine telegraph cables were spanning distance up to hundreds of miles. In 1859 the Gutta-percha Company supplied a telegraph core covered with Gutta-percha and R S Newall & Co completed the submarine telegraph cable build. This new telegraph cable had a total length of 632 miles as it was being laid between Singapore and Jakarta via Banca or the Bangka Islands [18]. The cable although in two lengths, as it was connecting islands, did show that telegraph connectivity over these long distances was only possible due to the advances in technologies that were used for the first trans-Atlantic telegraph cable [31]. Cable armour design, insulation, and storage were some of the innovative changes that can be directly attributable to the first Valentia cable. Other innovations such as electrical connectivity, Morse code receivers such as the mirror galvanometer, batteries and power supply voltages used for the electrical current needed to transmit the telegraph pulses across these great distances [32].

Even though the first real attempts to lay a trans-Atlantic cable between Valentia and Newfoundland was not a success [33], the discoveries and innovations that were derived from the team in Valentia had a very profound effect on telegraph communication for many more years to come and would have a direct effect on the future trans-Atlantic attempts from Valentia to Newfoundland.

William Thompson mirror galvanometer: William Thompson (elevated to 1st Baron Kelvin in 1892 by Queen Victoria) had investigated the issues surrounding the transmission of electrical signal over the full length of the trans-Atlantic telegraph cable [34]. He was aware that an existing instrument, the galvanometer, could help with the receiving of signals over this distance, but its use as a telegraph instrument was one that was never put into practice and as such there was no real way of reading the electrical signals. After the failure of the 1857 expedition, he went about researching the use of needle inflection and its uses for current detection, just like the instrument that Cooke and Wheatstone used. However, upon investigation and further research and upon happenstance he noticed that a mirror suspended by a fine wire could also be deflected with very small amounts of electrical current.

In 1858, before the next attempt to lay the trans-Atlantic cable [28], William Thompson perfected the instrument, tested it on submarine telegraph cables in the Bay of Biscay and then used it on the next attempt in June 1858. When the cable was finally landed on the 5th of August 1858 and connectivity was made, he used his new instrument, the mirror galvanometer [35], as the receiver of the electrical signals across the cable. This new devise, one that would change the history of long-range telegraphy, was connected at each end, the words finally came through. The mirror galvanometer was patented that year by William Thompson and until a newer technology was invented this devise was used the world over on all long-distance submarine and overland telegraph cables.

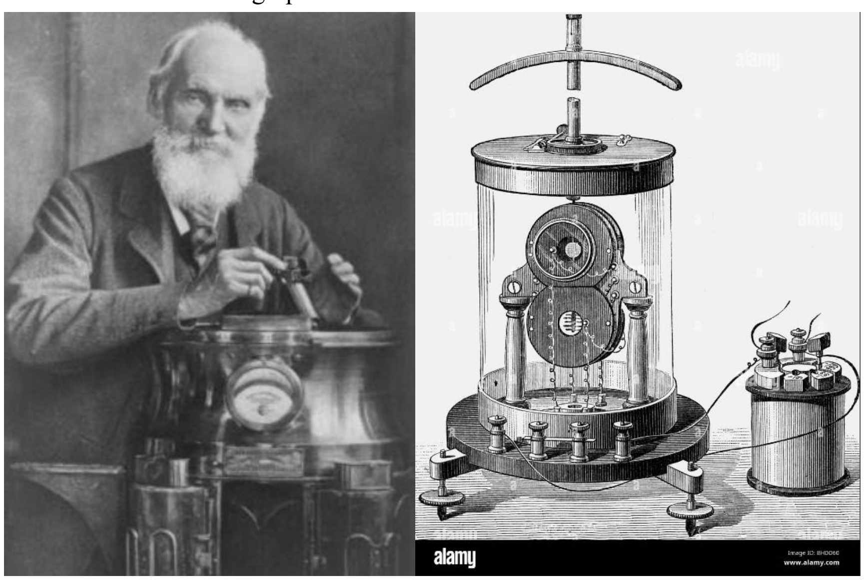

Fig 2. William Thompson (left) and his Mirror Galvanometer (Right) replica, in UCD.

The cable armouring: The cable armour being made of seven strands would around a central strand and making up eighteen bundles was to become the armouring wire for the main section of the cable. This design was inspired by a conversation between Isambard Kingdom Brunel and Cyrus Field as they meet one evening in London in 1856 [36]. This design, although great for tensioning wire or wire rope is good when multiples of this design are used together to lift or hold an object in tension. However, using this wire rope design, acting as a submarine cable armour, other stresses effect the wire rope due to the submarine cable laying process. On a wire rope when force is applied the force or tension is along the axis of the rope and all parts of the metal rope work in unison to counteract the force. However, in the armour of the cable, when the cable is being laid on the seabed the force applied is spread about around the central axis of the cable and the armour takes different levels of force depending on its positioning at that point. With solid wire armour the force is applied evenly to the wire, however in armouring designed by Brunel the force is not even due to the strands. The total cross-sectional area of a solid wire of the same diameter as the total number of strands per seven wire bundle is not the same. The solid wire has a bigger cross-sectional area and therefore bigger counteraction to the force applied. The armour of the first trans-Atlantic cable was too weak to be able to hold the cable section is suspension under the ships over a long distance proved fatal. To overcome this design, flaw all future submarine cables armouring wires were solid and wound in the same direction along the full length of the cable [37].

Telegraph transmission: The transmission speed of the first submarine telegraph cable was very slow and it would take an extra ordinate amount of tie to send a message. With the use of the mirror galvanometer the speed increased to about two to two and half words a minute. Which was fast across such an expanse of water. However, with the research carried out by Thompson in making the mirror galvanometer a better devise the increase speed across the Atlantic in 1866 was eight words a minute [29]. Also, with the ability to try new technologies across newer long distance submarine cables the increase in word transmission had increased so much that by 1900 the word transmission speed could be as fast as fifty words a minute and with duplexing and quad duplexing techniques employed three hundred words a minute could be successfully transmitted [33].

Cable braking system: The cable braking system is a design used to help lay submarine cables from the back of ships and slows down the paying out of the cable. It was designed by Charles Tilson Bright, and it was based upon the original designs used for cables that were laid by the British and Irish Magnetic Telegraph Company and with consultation with C.S Varley from the Electric Telegraph Company and John Brett from the Submarine Telegraph Company. The first cable paying out system and braking system, used on the 1857 cable expedition, proved difficult to measure the force applied when the cable was in suspension under and behind the ship. In 1858 when the next attempt was carried out Charles Bright made a few changes to the equipment that allowed for a graduated brake which would apply a small amount of force and it could also be measured [34]. However, after the cable was finally landed and connectivity was made. Charles Bright dismantled the cable laying equipment and redesigned it so that all moving parts had the ability to have their applied force measured. The force itself was also graduated so that the force could be applied and removed even with the cable was being laid, without causing damage to the cable. This design was to become the blueprint for all future designs and its next use was for the submarine cables being laid across the Mediterranean and the next trans-Atlantic telegraph expeditions [38].

Deep sea cable laying: Deep-sea cable laying had not been carried out before the adventures associated with the 1857-58 submarine telegraph cable and re-engineered during the 1865 and 66 cable expeditions. Everything that was done to lay the cable on the seabed was done out of engineering designs that were produced and manufactured specifically for these projects. There were no other previous attempts undertaken, therefore there was no information that could be used to help design these solutions to get over the engineering challenges. This also proved somewhat difficult because without anything to go on the success of laying the submarine cable was solely based upon the solutions that Charles Bright managed to conjure up to help with the cable lay [39]. But the successful laying of the trans-Atlantic telegraph cable in 1858 did prove that it could be done, and it was also the starting point for all other deep sea submarine cable laying operations that can trace their historical lineage all the way back to the successful laying of the 1858 trans-Atlantic telegraph cable, specifically the 1866 trans-Atlantic cable [40].

6 Valentia and its legacy

In the history of telegraph transmission, no other place has had more of an impact or effect on submarine telegraph cable transmission than the Valentia Island Cable Station. With the 1857-58 trans-Atlantic cable the Cable Station was in the Slate Yard in Knightstown because the cable was landed just beside the harbour. However, as the 1865-66 cables were landed at Foilhummerum Bay, at the opposite end of the island, there was a small cable hut in a field opposite the landing site and from here an inland cable was laid to the Slate Yard in Knightstown, technically an extension of the submarine telegraph cable. This inland cable was the same design as the 1865 cable shore end with an inner and outer armour, sometimes called rock armour in today's submarine cable terminology, it had 6 telegraph cores between the two armoring wires and two telegraph cores in the centre of the cable. Each telegraph copper wire core (seven stranded copper wire) was coated with Gutta-percha insulation. This is the first time this type of cable was used with the capability to offer extra connectivity [41]. Technically this land section could connect eight different submarine telegraph cables. When the 1866 cable was landed and the 1865 was finally connected the two centre telegraph cores of the land section were used for these two cables. The extra six telegraph cores were kept for other submarine cables that were to be connected. The cable was in use up to the late 1930s..

The 1866 trans-Atlantic submarine telegraph cable was the first successful commercial cable, and it helped the telegraph industry to develop long distance communication across oceans. The final frontier or oceanic submarine telegraphy was now finally conquered by the new trans-Atlantic cable of 1866. This act alone helped Engineers and Telegraphers look to finally connecting India with a long-distance submarine Telegraph Cable. As India was already connected by 1864, but this was across land and was not a stable service. On the 23rd of June 1870. Charles Bright who was so instrumental in the original 1857-58 trans-Atlantic cable was the Chief Engineer on the new submarine telegraph cable form Britain to India, which was a success. It was through the technologies and innovations surrounding the trans-Atlantic telegraph cable that enabled the opening of long-distance submarine cable telegraphy [18,37,42].

Fig 3. 1858, 1865 and 1866 submarine telegraph cable samples.

As Valentia opened the world to long distance submarine telegraph transmission and along with the different technological achievements that came with the cable, the ability to connect Europe and America also had a very positive effect on the economy and markets, both financial and stocks markets. With regards to the economic advantages associated with the 1866 cable was the ability of stock markets to have an even better view of the stocks and shares being sold on the New York Stock Exchange and then compare these with their financial dealings taking place on the London Stock Exchange. The availability of these stock prices, for all sorts of goods, helped create a true global economic revival and was the start of what we call the global economy [43].

Valentia was also central for establishing the European Arc of longitude, which was central to the establishing of Greenwich Mean Time across Great Britain and for navigational purposes. Today we see Ireland and Britain as in one time zone sharing the same time, yet within different longitudes. The first changes to the use of common time came in 1847 when the railways established a common time for all railways, which became known as railway time. This new time was also the start of the common railway time schedules, which was only possible due to the telegraph connecting most stations and enabling this rollout of the new common railway timetables we use today. This railway time became the common time across the Island of Britain. Work to investigate longitudinal time was carried out on Valentia Island in 1862. Using telegraph communication, the European Arc of Longitude between Valentia Island, the western most point of Europe, and the Ural Mountains being the eastern most point of Europe. Longitude between these two pints and across Europe was properly measured. This also helped to establish the correct times across various countries across Europe. Valentia Island also went on to finally solve the longitudinal question across the North Atlantic, this was only possible using the trans-Atlantic cable of 1866, which was pivotal in solving this question. Again, Valentia was not only at the center of the world for bringing America and Europe together through the new trans-Atlantic cable, but it was also the answer to the final longitudinal question [44].

It was because the question of longitude across Europe was answered the British Government establishment of Greenwich Mean Time across Britain in 1880, followed by Ireland in 1916, which had been formally designated Dublin time since 1880. All these changes in time were only possible due to the establishment of the telegraph network and especially the trans-Atlantic cable from Valentia to Heart's Content [45].

7 Telegraph Speed

It can also be seen that the speed at which telegraph messages could be transmitted had also increased between the first telegraphs of 1837 and the new age in long distance telegraphy in 1866. For example, for the first few years of telegraphy the transmission speed was measured in letters per minute and in 1858 the average speed of transmission of about words a minute, but the 1858 trans-Atlantic telegraph cable could only operate at about two words a minute. This had increased to eight words a minute on the 1866 trans-Atlantic telegraph cable and in 1870 the average words per-minute had increased to ten words. However, the technological changes that were taking place such as duplexing and better batteries and telegraph keys meant that the words per minute had now increased to about thirty words per minute in 1900. With the addition of duplexing and multiplexing it would increase this word count to a maximum average of three hundred words per minute by 1910. However, as the telegraph was dependent on the manual input of Morse code as the coding method of the day, some technologists looked at the idea of mechanical input of Morse code which would increase the word count even more, however that was not common practice amongst the telegraph companies [33].

8 New technical innovations

With communications there is always some sort of change or evolution such as the coined phrase "communication evolution", which the telegraph was a milestone in such a revolutionary change. New technologies within the field of telegraphy include the introduction of duplex telegraph transmission, multiplexing techniques and even telegraph signal amplification through the act of induction, which the telephone system used with their induction coils along their transmission paths, years later. A lot of these technologies were researched first on the long-distance submarine telegraph cable systems. Even the idea of measuring the earth's magnetic field and the movement of the Earth's crust in seismic movements [46], although the tectonic plates were not actually discovered until the late 20th century. These and other innovational and scientific investigations were accrued out and researched by James Graves from Valentia Telegraph Cable Station with work carried out on the trans-Atlantic cables. James Graves would also come up with the testing protocols for submarine telegraph cable repairs as he could also identify the distance to breaks in submarine cables by applying the laws of electrical resistance etc. to calculate the distance to the fault, something that is still used today on shunt faults by using the same formulas [46,47]. The foundations of seismic testing and sensing were first investigated by James Graves from the Valentia Island Telegraph

Cable Station. His work, in its infancy within this area of research, has been widely referenced and researched as it formed the basic foundation of these new technologies in cable sensing and are now used in optical fibre sensing [48]. His work on understanding cable earthing techniques was also investigated and even solved problems on the 1865 and 1866 cables. His research into these issues and the solutions found are still used today and are one of the major testing techniques used to monitor submarine cables, such as the Tinsley system used on modern optical submarine cables can trace its history right back to James Graves research [48].

9 The growth of long-distance telegraphy

It cannot be said that the successful delivery of the 1866 trans-Atlantic submarine telegraph cable had no influence on the world of submarine telegraphy, the success of the 1866 trans-Atlantic submarine telegraph cable immediately set in motion the project to deliver the France to America cable that was delivered in 1869, by the French Company La Société du Câble Transatlantique Française. This cable went from Brest to St. Pierre in Newfoundland and then on to Cape Cod, Massachusetts and it was laid by the SS Great Eastern. This cable was called the French Atlantic Telegraph Cable and it was a successful one. The issues and problems that the original trans-Atlantic telegraph cables in 1857-58 and 1865-66 encountered were overcome by solutions that were found by Charles Bright, C F Varley, and William Thompson with regard to the electrical current and power needed to feed the telegraph cable with its many messages and new improvements in words per minute were also achieved [49]. The age of trans-Atlantic telegraphy had arrived, and many new cables were planed and laid across the ocean connecting Europe and America. New cable stations were also required for these new cables as they were not all operated by the same company.

10 Conclusion and preserving the past for the future

UCD established in 1854, primarily teaching subjects within the following areas: Science, Engineering, and the Arts. This put the university in a position to obtain the newest technologies to be used in educational research. Being established amid a communication revolution put it centre stage in helping to develop and launch innovation at its best. To this end many examples of historical pieces of technology such as William Thompson's Mirror Galvanometer, Cooke and Wheatstone's Needle Telegraph receiver, telegraph submarine cable samples and other pieces such as batteries, electrical instruments used for measurements are kept onsite. It was not widely known but John (Sean) Sheridan had a very keen interest in preserving the technological past. John knew of the existence of these pieces and tried to keep them safe for future generations. His goal was to set up a museum to showcase these very important artifacts and to keep them save. He was aware of the place in communication history that Valentia Island had placed itself, and the on-going bid to get World Heritage Status. He had an energy and enthusiasm that could easily be seen when someone mentioned the historical pieces that UCD were the custodians off. John truly wanted to promote the knowledge around them and to promote the establishment of a proper home within UCD that would be acknowledged. John also wanted to share the knowledge and understanding surrounding these inventions and innovations in communication and technology.

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Derek Cassidy is doing a PhD in the field of Optical Engineering; Photopolymers, Self-Written Waveguides, and Wavelength manipulation with UCD, under the late John Sheridan. He is a Chartered Engineer with the IET and Past-Chair of IET Ireland. He is Chairman of the Irish Communications Research Group. He is also currently researching the Communication History of Ireland. He is a member of SPIE, OPTICA, IET, IEEE and Engineers Ireland. He holds patents, in the area, of Mechanical Engineering and author of over 30 papers on Submarine Cable Technology, Communications and Optical Engineering. He has been working in the telecommunications industry for over 29 years managing submarine networks and technical lead on optical projects, both nationally and internationally. Derek holds the following Degrees: BSc (Physics/Optical Engineering), BSc (Engineering Design), BEng (Structural/Mechanical Engineering), MEng (Structural, Mechanical, and Forensic Engineering) and MSc (Optical Engineering).