Liberté! Egalité! Télégraphie! The French Cable Station in Orleans, Massachusetts

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In a purely rational world, communications technology would progress smoothly. Newer and more efficient systems would completely replace old ones, and everyone would constantly benefit from the latest discoveries. While this description fits reality in many cases, other factors–such as government regulations, personal preferences, or even national pride–can intervene to preserve an outmoded technology long after technical considerations would dictate its demise. The town of Orleans, nestled in the elbow of Cape Cod, Massachusetts, harbors one such product of benign neglect: The French Cable Station Museum. This article describes the history of the telegraph-cable connections between France and the Cape, dating back to 1879, only thirteen years after the first permanently successful transatlantic cable was laid. As we shall see, French patriotism influenced the routing and operation of the cables as much as economics or engineering. The submarine telegraph cable was an interesting propagation medium in its own right. Even after intercontinental radio communications became practical, some of the best minds in the communications industry applied themselves to the problem of maximizing cable-transmission rates, with mixed results. I will review two significant technical advances in submarine-cable technology that occurred between 1900 and 1930. Finally, I will conduct an armchair tour of the French Cable Station Museum as it is today, one of the few communications museums in the country which preserves historic operating equipment at its original site.

1. "The Telegraphic Independence of France"

The rivalry between England and France, sometimes bitter, sometimes friendly, goes back at least to the exploits of William of Normandy, who conquered King Harold of England in 1066 A. D. By the nineteenth century, the two countries were at least on speaking terms. The first submarine telegraph cable ever laid in the open sea connected Dover, England, with Calais, France, across the English Channel, in 1851 [1]. Victorian England, in her efforts to expand the British Empire politically, also made sure to unite it telegraphically. English engineers and scientists, such as Sir William Thomson (Lord Kelvin), became the world leaders in submarine-cable-telegraph technology. Although the American, Cyrus Field, received much of the credit for laying the first successful transatlantic cable, in 1866 (an earlier cable failed after only a few weeks in 1858), most of the money, and all of the cables and instruments he used, were English in design and manufacture. By the 1870s, England was the hub of a largely British-owned communications network that extended westward to North and South America, and eastward to Russia and India.

The French were not entirely happy with this situation. It meant that whenever a Frenchman wished to communicate with the United States, his words had to pass through British hands, and he had to pay British tariffs.

So, perhaps, it is understandable that one Monsieur Pouyer-Quertier, Minister of Finance under President Thiers, established a company, in 1879, to "secure the telegraphic independence of France" [2]. M. Pouyer-Quertier faced an uphill battle. The shortest (great-circle) route directly from Brest, on the westernmost tip of France, to a point near a population center of the United States, ended on Cape Cod. But that distance, of over 5,300 km, was farther than any single undersea cable had successfully reached at the time. The distance to the customary North American terminus of transatlantic cables, Newfoundland, was considerably shorter. But Newfoundland was then British territory, and was therefore unacceptable as a landing site for a cable intended to secure the telegraphic independence of France.

The answer to this dilemma lay a mere 24 km off the southern coast of Newfoundland. The tiny islands of St. Pierre and Miquelon have a stormy history of their own. Along with Canada and other North American regions, they were claimed by both England and France at various times. Despite two intervals of British ownership since 1713, the Treaty of Ghent, in 1814, at last acknowledged their possession by France, which still claimed title to the islands in 1879. So a cable-relay station was erected on St. Pierre, and M. Pouyer-Quertier's company laid two cables, one from Brest to St. Pierre, and the other from that island to Cape Cod. When this system opened for business later in the year, the dream of an all-French pathway for transatlantic communications was realized at last.

Initially, the town of North Eastham, about halfway up the "forearm" of the Cape, received the St. Pierre cable from the Atlantic, where it terminated in the basement of the Nauset lighthouse keeper's home [3]. Later, a permanent station was erected, but the relative isolation of North Eastham favored the extension of the cable to the more populous town of Orleans, in 1891, when the existing French Cable Station building was built.

There was no practical method for automatic relaying of cable signals in the nineteenth century. The manual transcription and retransmission of messages in both directions caused delays and errors, so in 1895, the cable's operating company contracted with the French Government to lay a new cable all the way from Brest to Orleans. To ensure the financial well-being of the enterprise, the contract granted the Company a subsidy of 800,000 francs each year for the next thirty years. In addition, it promised that the national Administration of Posts and Telegraphs would use the new cable for all North American traffic, unless the sender specifically asked for another route [4]. One may assume that few Frenchmen would stoop to make such an unpatriotic request.

No one had laid a cable this long before. By the terms of the contract it had to be manufactured in France. To make sure it worked, the designers chose to use what may have been the thickest center conductor ever employed in telegraph-cable service: a copper core about 5 mm thick (B & S 4-gauge!) [5]. In 1898, the new cable was christened *Le Direct*, and went into operation. Its length of 5,876 km made it the longest telegraph cable laid up to that time. (René Salvador's claim [6] that it was the longest telegraph cable ever laid, however, is superseded by a 6,419-km British telegraph cable, installed in the Pacific in 1902, as part of a Canada-Australia link [7].) *Le Direct*'s service was interrupted thereafter only by mechanical damage or war.

As a primary communications link between two great countries, the French Cable Station inevitably played a minor but significant role in historical events. A few of these are recounted by the late Warren S. Darling, author of a 48-page tour book about the museum:

> On November 28, 1898, when they had barely finished laying "Le Direct," the passenger steamer *Portland* sank off Truro, Cape Cod, in the worst storm of the century. The first news to reach the world of the estimated 170 lives lost, in what older Cape Codders still call "The Portland Gale," was flashed from storm isolated Cape Cod to Brest, France. From there it was sent on to other cables to New York and the rest of the world. . ..
>
> All of the communiques to and from the American Expeditionary Forces of World War I were sent from here due to the privacy of cable communication. On July 21, 1918, during W. W. I, a German U-boat sank a tug and four barges off Nauset Bluffs and threw at least one shell into Orleans. It is suspected that the U-boat captain was trying to locate and break "Le Direct." He did not succeed. . ..
>
> On a happier note, news of aviator Charles Lindbergh's historic landing at LeBourget Field [May 21, 1927], after his solo flight across the Atlantic, first reached America from this station. Orleans baseball fans were the first to hear the good news. An operator going off-duty sped to Eldredge Park, where a game was in progress, and had the umpire make the announcement to the fans who scarcely 32 hours before, had heard his plane flying overhead [3, p. 13].

The Orleans cable station operated from 1891 until 1940, when German marines commandeered the companion station outside Brest, France, and the US Signal Corps put the American end into storage. In 1941, the British decided to "borrow" *Le Direct* to use it for a link between Canada and England. They successfully retrieved and diverted the western end from Orleans, Massachusetts, to Halifax, Nova Scotia, but German U-boat activity thwarted their plan to reroute the eastern end from France to England. Thus, for a time, German submarines inadvertently protected a French cable from interference by the British! In the heat of war, the French were not informed of these activities, and it was only through a chance 1949 meeting in Halifax, of French and English cable-ship officers, that the French learned the story [6, pp. 8-9]. With British assistance in locating the cable, it was finally restored to its original route and repaired in 1952. The station in Orleans was reassembled and operated for seven more years. When the British-American transatlantic telephone cable TAT-1 opened, in 1956, the greatly increased bandwidth made possible by its undersea vacuum-tube repeaters allowed for thirty-five voice channels. Only one of these voice channels was capable of carrying twenty-four teletype channels simultaneously. This exceeded the capacity of *Le Direct* by a factor of ten or more. After three more years of apparently dwindling business in the face of such competition, France bowed to the inevitable, and closed the station in 1959. The original operating company, however, is still in existence, at last report [8], although it now functions merely as a broker for international satellite and fiber-optic cable communications.

2. Telegraph cable technology, 1900-1930

At the dawn of the twentieth century, the world's attention focused on the new marvel of radio, which spanned the Atlantic at Marconi's bidding in 1903. As is well known, Marconi's grandest vision for radio, at the outset, was merely to replace the worldwide telegraph-cable network with a system of radio stations under his control. The idea of what is now termed "broadcasting" was simply not in the picture until several years later. While radio certainly competed with submarine cables for international-message traffic, radio had its own shortcomings when it came to long-distance point-to-point service. It depended on that fickle medium, the ionosphere, which meant that radio channels could become useless, without warning, for minutes or hours at a time. And radio, unlike cable, is intrinsically public by nature. Financiers, bankers, and diplomats, used to the nearly absolute security of an undersea cable, were apparently reluctant to trust their sensitive messages, even in cipher form, to a medium that could be overheard by anyone with a shortwave receiver. So the business of submarine-cable telegraphy remained viable, and even profitable, from the advent of radio until telephone cables with undersea repeaters came into use. Telegraph-cable technology received attention from a few engineers, who persisted in advancing the art despite the increasing competition from radio. Two of these were John R. Carson, of the United States, and Ernest S. Heurtley, of England.

2.1 J. R. Carson: Analysis of submarine-cable transmission characteristics

Although the second "T" of "AT&T" stands for "telegraph," the entity formerly known as the Bell System has few associations with telegraph technology. But an AT&T scientist, who made fundamental contributions to the growing field of radio, also studied problems in submarine-cable propagation. John R. Carson (1887-1940) joined AT&T in 1914, after an education at Princeton and a two-year stint at Westinghouse [9]. In the following year, he made essential contributions to single-sideband-modulation theory and the carrier-current system [10]. Carrier-current transmission squeezed dozens of simultaneous calls into each existing trunk-wire pair, and saved AT&T millions of dollars in the decades to follow. Interestingly, a 1922 paper of Carson's [11] discouraged nearly everyone but E. H. Armstrong from pursuing frequency modulation as a useful alternative to amplitude modulation for over a decade.

Carson was unquestionably a brilliant mathematician. Shortly after his successes with modulation theory, he and J. J. Gilbert turned to the problem of submarine-cable transmission [12]. In doing so, they followed in the footsteps of scientists such as Lord Kelvin and Oliver Heaviside [13], who had analyzed the cable as a simple distributed medium with four characteristic values. These were series inductance, series resistance, shunt capacitance, and shunt conductance, all per unit length. This model depended upon two assumptions: (1) the four values could be determined exactly

Figure 1. A deep-sea submarine telegraph cable, circa 1900, cut to show the cross-section (a cable in the collection of the French Cable Station Museum).

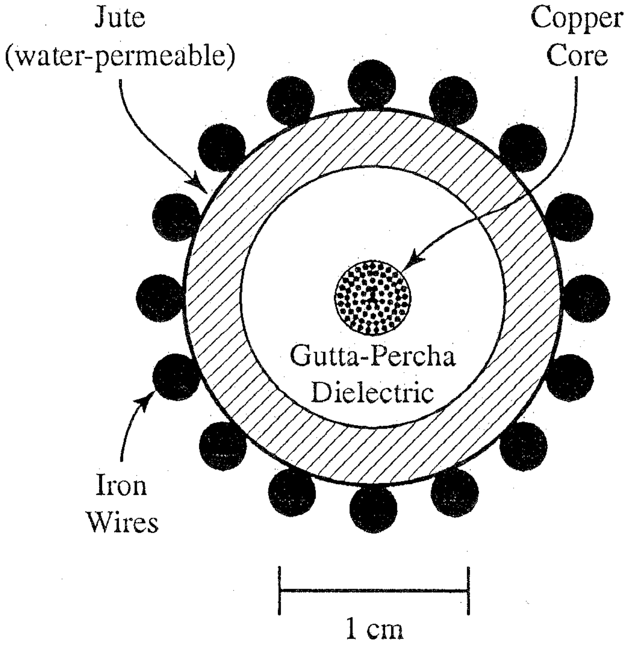

Figure 2. Carson and Gilbert's model of a typical submarine telegraph cable (adapted from [14]).

by simple analyses, and (2) they remained constant with frequency. In attempts to operate telegraph cables at higher rates, engineers found that neither assumption was correct. For this reason, Carson and Gilbert undertook a full-scale electromagnetic analysis of the submarine cable as a propagation medium. This turned out to be a surprisingly challenging task.

The challenge arose from the fact that, even as late as 1921, most existing submarine cables had been designed to meet the less-demanding needs of nineteenth-century telegraph technology. Low series resistance, reasonably low capacitance, good DC insulation, and high mechanical strength were the priorities then. Figure 1 is a photograph of the deep-sea portion of a typical telegraph cable, sectioned to show its interior. An outside jacket of heavy iron wires surround a second set of thinner iron wires. The copper center conductor is covered by a thick layer of insulation. Note the absence of any solid, continuous outer conductor.

Carson and Gilbert's model of a typical submarine-telegraph cable is shown in Figure 2. It is still very far from the clean, simple coaxial cable so dear to the writers of undergraduate electromagnetics texts. Beginning from the core, they modeled the typical bundle of copper strands as a uniform conducting cylinder. The dielectric surrounding the core was made of a natural rubber-like material, called gutta-percha, whose insulating characteristics far exceeded those of any other comparable substance, until the advent of synthetic plastics. However, gutta-percha's losses increase fairly rapidly with frequency. The real difficulties begin at the outer boundary of the gutta-percha insulation. Instead of a nice, highly conductive shield, there is a layer of saltwater-soaked jute. (Jute is a natural fiber resembling hemp.) Circumferentially disposed around the jute layer are a series of iron wires, which sometimes touch each other, and sometimes do not. These wires are what give mechanical strength to the cable. They also contribute resistive losses to the return current, and interact in a complex and lossy way with the cable's magnetic field. Modeling such a system even today would be a nontrivial task, and in 1921 the problem was almost impossibly difficult.

Nevertheless, armed with this model, Carson and Gilbert forged ahead, for thirty pages of densely reasoned mathematics. Near the end of the paper, they compared their resistance and inductance calculations over a range of 50-600 Hz with some experimental data taken by the US Signal Corps, on a cable that extended from Seattle, Washington, to Sitka, Alaska. They found that resistance per unit length rose and inductance fell significantly as frequency increased. This was in part because at higher frequencies, the return current concentrated more in the iron wires and less in the surrounding sea water. The dozen or so experimental data points they measured fell within about ten percent of their theoretical curves. It is unclear whether this work was used extensively by the cable-engineering community. Whatever its practical impact may have been, it represents an early triumph in the field of guided-wave-propagation analysis.

The greatest increase in telegraph-cable-transmission rates, before 1956, was achieved not by analyzing existing cables, but by installing new loaded ones. The same basic method of inductive loading, that had proven so helpful to the telephone industry in increasing the bandwidth of overland cables, also improved the performance of undersea cables. For mechanical reasons, continuous loading was preferred over lumped loading coils for submarine service. Loading was applied around the center conductor, in the form of a continuous strip or wire of highly permeable material, known by various brand names such as "Mumetal" and "Permalloy." Inductive loading raised the usable bandwidth so much that automatic equipment, capable of transmitting hundreds of words per minute, could be employed on many newer cables. But loading obviously could not be retrofitted to existing cables, and the high cost of laying new cables prevented many systems from installing loaded lines in transatlantic service.

2.2 E. S. Heurtley: The Heurtley magnifier

Before Claude Shannon derived his fundamental theorem that relates the maximum theoretical error-free transmission rate of a channel to bandwidth and noise, communications engineering was in a state similar to the science of thermodynamics, before the principle of energy conservation gained acceptance. There was nothing to prevent engineers from seeking the telegraphic equivalent of perpetual motion, namely, arbitrary increases in data rates without corresponding improvements in channel bandwidth or noise behavior. One such seeker, whose successes were modest, but nonetheless significant, was Ernest Sydney Heurtley, of England.

Mrs. Lenore Symons, archivist of the United Kingdom's Institution of Electrical Engineers, has furnished me the only biographical information I have been able to locate on Heurtley. His first listing as an IEE member appeared in 1913, and the last, in 1957 [14]. Judging by the evidence of US patents and technical papers, he "flourished," as the encyclopedias say, from around 1900 to at least 1930. In the 1920's, he was associated with the telegraph-equipment manufacturer Muirhead & Co. Ltd., and the consulting firm of Clarke, Ford, and Taylor, of London. He held four US patents from this period. Two of them describe increasingly sophisticated forms of an electromechanical amplifier that came to be called the Heurtley Magnifier.

The problem, as Heurtley seemed to envision it, was this. The standard method of "working" submarine cables around 1900 was to transmit a sequence of positive and negative pulses into the sending end, by means of a double-hand key. The voltage level of these pulses was limited by insulation considerations to about 60 V. At the receiving end, the signal emerged as a feeble current waveform, the rounded peaks of which rarely exceeded a few dozen microamperes. This signal went to a machine called a siphon recorder, invented by Lord Kelvin in 1870, and little modified since. Essentially a sensitive chart recorder, the siphon recorder got its name from a delicate glass siphon, which drew ink from a well onto a moving paper tape. A moving-coil mechanism, similar to the D'Arsonval movement in analog panel meters, deflected the siphon in response to the signal, tracing out a wavy line that was interpreted by skilled operators. One of several siphon recorders in the collection of the French Cable Station Museum is shown in Figure 3.

As the sending rate increased, the received waves became smaller, because of the high-frequency attenuation of the cable, until they ceased to actuate the siphon recorder. It was Heurtley's idea, around 1910, to magnify the received current to the point that the smaller, faster waves could once again be recorded and deciphered. At this point, the reader is perhaps wondering why the newly invented "audion" triode vacuum tube, patented in 1908 by Lee de Forest, was not immediately applied to the problem of amplifying cable signals. This was done eventually, but electronic amplifiers did not come into routine use for submarine-cable systems until about 1930. Problems with large levels of low-frequency noise, induced onto cables by geomagnetic disturbances, and the instability of early vacuum tubes, are two factors that probably delayed this development.

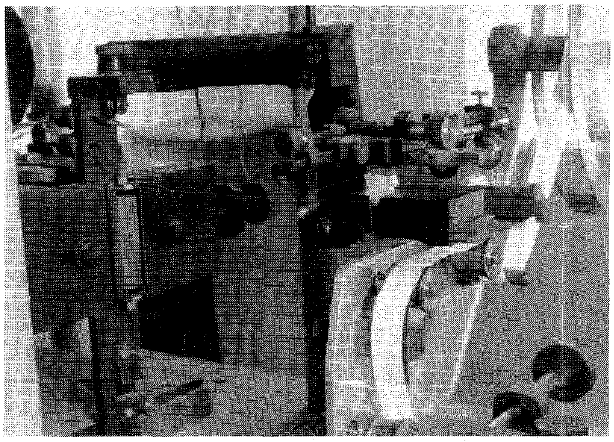

Figure 3. A siphon recorder, showing the moving coil between the large rectangular pole pieces on the left, threads that relay the coil movement to the glass siphon, and the paper tape on which the signal was recorded.

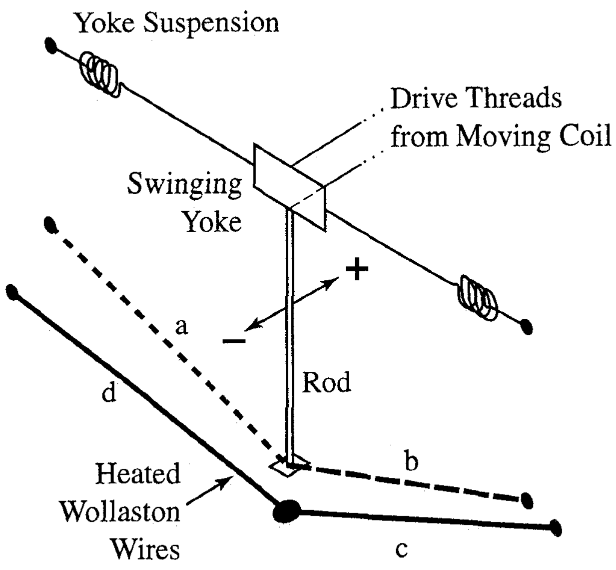

Figure 4. A simplified diagram of the hot-wire amplifier system of the Heurtley Magnifier. The incoming signal turns the moving coil (not shown), causing the threads to swing the yoke, which moves wires "a" and "b" (dashed lines) in relation to stationary wires "c" and "d" (solid lines). All four wires are heated by DC current flowing through them.

In the meantime, Heurtley was hard at work on the problem. The first version of the Magnifier to be patented in the US [15] relied upon a blast of cooling air or a tank of cooling liquid. Considering the inconvenience of either method, it is likely that this first embodiment did not receive wide acceptance. By 1919, Heurtley had refined his magnifier to work without flowing gases or liquid coolants. The heart of the most widespread version of the apparatus is diagrammed, in simplified form, in Figure 4 [16].

Heurtley found that if two very thin platinum wires, self-heated by a DC current, were brought into close proximity, their temperature (and thus resistance) increased rapidly as they came closer together. He based his instrument upon this mutual radiative heating effect of closely spaced thin wires.

Figure 4 shows how Heurtley arranged two pairs of hot wires, each suspended tautly in a V-shape, so that one pair rested slightly above the other. When a weak cable signal arrived, it actuated a moving coil attached to a pair of threads, similar to the arrangement in the siphon recorder of Figure 3. Instead of actuating a siphon, however, the threads caused a small yoke to swing about its horizontal axis. This swinging motion moved a rigid rod that is attached to hot wires "a" and "b" where they join, at point "J." The yoke thus swung the upper wires backward and forward horizontally, in response to the incoming signal.

The key to the instrument's operation lies in the fact that the lower stationary pair of wires "d" and "c" (solid lines in the figure) were set slightly skewed away from being exactly parallel with the upper movable pair "a" and "b" (dashed lines in the figure). All four wires were connected to form the four arms of a Wheatstone bridge. The current from the battery connected across the bridge both heated the wires and provided a signal-voltage output. In the absence of a signal, the wires were carefully adjusted so that the mutual heating of wire "a" and wire "d" was the same as that between wires "c" and "d." This made the four resistances equal, balanced the bridge, and produced a zero output voltage, as illustrated in Figure 5a.

Suppose a positive-going signal arrived. The yoke swung the upper wires so that "a" moved farther away from stationary wire "d" than before, and, conversely, wire "b" approached stationary wire "c." All four wires changed resistance in such a way as to produce the maximum change in the bridge-output voltage, as shown in Figure 5b. An incoming signal of the opposite polarity moved the yoke the other way, and gave a negative output signal, as Figure 5c illustrates.

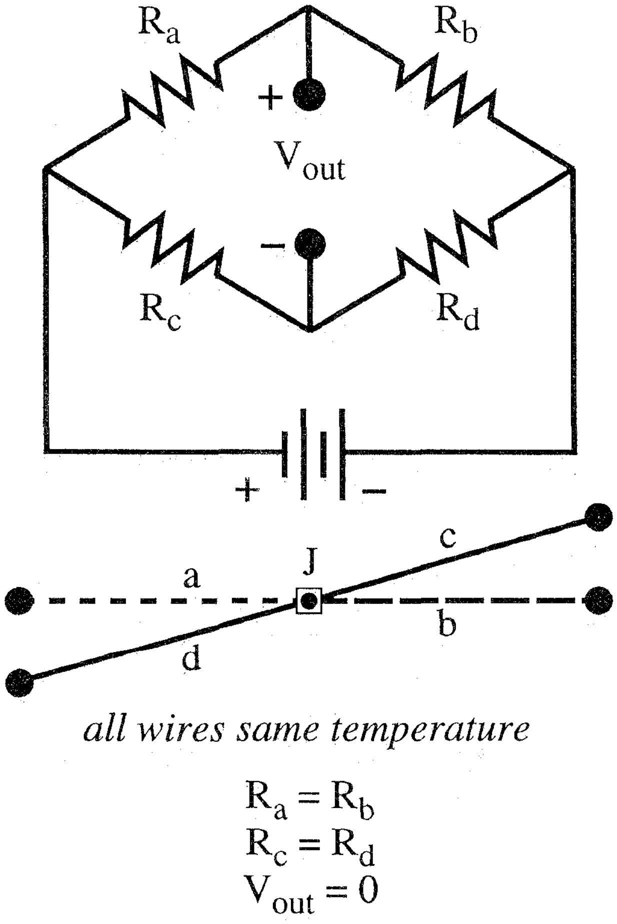

Figure 5a. The Wheatstone bridge circuit, and top views of the wire positions in the Heurtley Magnifier, upon reception of a zero signal.

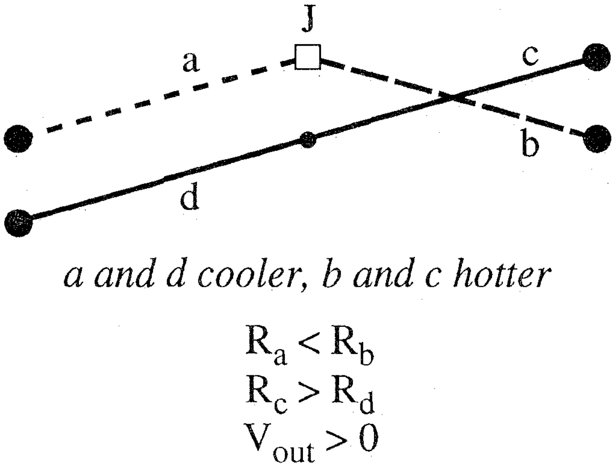

Figure 5b. The Wheatstone bridge circuit, and top views of the wire positions in the Heurtley Magnifier, upon reception of a positive signal.

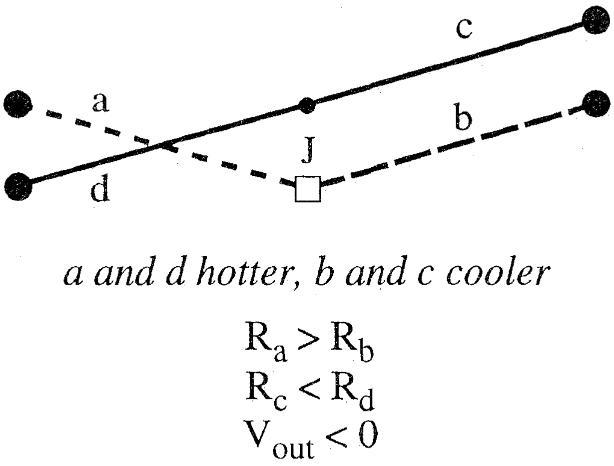

Figure 5c. The Wheatstone bridge circuit, and top views of the wire positions in the Heurtley Magnifier, upon reception of a negative signal.

As one might imagine, this amplifier was not easy to assemble or operate. The hot wires were made from Wollaston wire, which consisted of an extremely thin central platinum core, covered by a thicker silver coating. Once mounted in place, the silver coating was etched away with acid, to leave a platinum wire too thin to be handled. An inspection of the apparatus at the French Cable Station Museum revealed at least twenty-three separate mechanical adjustments, not to mention electrical ones that no doubt had to be made as well. The photograph of the Museum's unit in Figure 6 reveals its basic symmetry, but does not show the glass enclosure, which shielded the unit from dust and air currents under normal operation. Even with this precaution, the critical hot wires had to be enclosed by additional plastic or mica shields, which are the two large cylindrical objects in the photograph. (Regrettably, the wires themselves have not withstood the test of time, and the Museum's magnifier is no longer operational.)

Despite the elaborate and delicate nature of this apparatus, it found widespread use at cable installations around the world in the 1920s. Its gain was reportedly on the order of eighteen (whether voltage, power, or current is not known), and this was sufficient to allow a substantial increase in the signaling rate over what was pos-

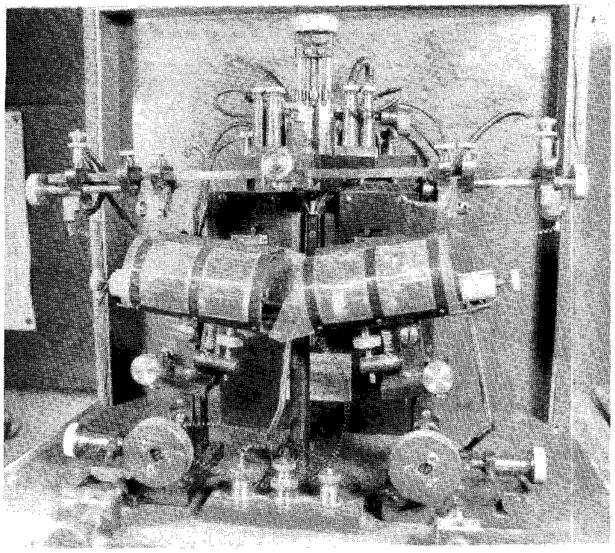

Figure 6. A photo of the Heurtley Magnifier, minus its glass case, at the French Cable Station Museum. The large cylindrical shields enclosed the hot wires, and numerous screw-motion positioners allowed for precise adjustments of the relative wire positions.

sible without it [17]. Its popularity was short-lived, however. By 1927, even Heurtley himself was reporting experiments with "various types of valve [i.e. vacuum-tube] amplifier" in connection with new Pacific Ocean cables [7, p. 350]. But in Orleans, Massachusetts, the magnifier, a mechanical hot-wire amplifier, continued to speed French diplomatic and financial cables on their way for many years.

3. The French cable station today

After the station was abandoned as a commercial enterprise, in 1959, historically-minded citizens of Orleans approached the French government with proposals to purchase and preserve it. According to Darling, "it is reported that the first attempts to buy this property for a Museum were rebuffed by the then French President, Charles de Gaulle, with the shout that he would 'never allow one square foot of French soil to be sold' or French words and gestures to that effect" [3, p. 45]. Whether or not this story is true, it is certainly in character. What is known for certain is that after De Gaulle's death, the land and property were sold to the local organization of interested citizens, who formed the French Cable Station Museum in Orleans, Inc. As much equipment as possible was restored to working condition, with financial assistance from the National Trust for Historic Preservation, and the help of personnel from the Smithsonian Institute. (One of these was Field Curry, whose grandfather, Cyrus Field, laid the first transatlantic cable.) The station reopened for business, this time as a museum, in 1972.

The outside view of Figure 7 shows that the white-painted frame structure, with two large bay windows, differs little in appearance from a typical Cape Cod home of the 1890s. On the left, as you enter, is the superintendent's office, complete with roll-top desk and framed prints of historic scenes pertaining to cable-laying and station history. Across the hall, to your right, is the operations room, dominated by a large table spread with a veritable feast of turn-of-the-century telegraphic apparatus. A narrow strip of paper runs along a track where the operator read it, as it emerged from the Muirhead siphon recorder. Near the recorder is a formidable panel of resistance- and capacitance-substitution networks: polished wooden boxes with black bakelite knobs and shiny brass contact points. This is the Apex Cabinet, so called because it formed the apex of a bridge circuit, used to duplex the cable. Duplexing (sending and receiving at the same time) required that the operators null out the 60-V transmitting impulses, so that the millivolt-level signal from France could be amplified and recorded. The duplex circuit balanced the impedance of *Le Direct* against the impedance of an artificial cable, composed of a large ladder network, housed in zinc-lined boxes in the basement to keep it at a uniform temperature. On good days, slight changes in the cable characteristics could be balanced out by above-ground adjustments. However, rapid ocean-temperature changes forced one operator to go downstairs and make major adjustments, while checking the results relayed by telephone from the receiving operator, above. Figure 8 shows Museum volunteer Donald Howe portraying the latter role at the Apex Cabinet.

Also in the operations room is a Kleinschmidt perforator, for the punched tape used in automatic transmission; a second siphon

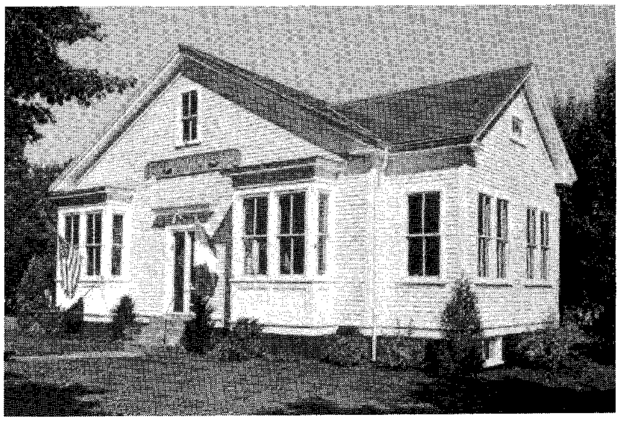

Figure 7. The French Cable Station Museum in Orleans, Massachusetts (courtesy of The French Cable Station Museum, Inc.).

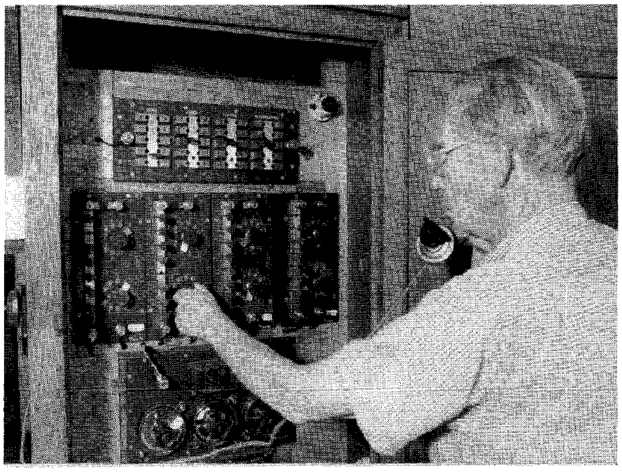

Figure 8. The Apex Cabinet, part of an artificial cable circuit used to null out the transmitted signal for duplex operation (Mr. Donald Howe at the controls).

recorder that used electrostatic charge to convey the ink from siphon to tape; and other pieces of related historic equipment too numerous to mention. The perforator, a Morse tape puller, and a model mirror galvanometer are all in working condition, and can be demonstrated during a tour.

Down the hall is the test room, which houses the Heurtley Magnifier, and test equipment that was used to detect and locate cable faults. In use, the magnifier's heavy iron base plate rested on four tennis balls, which in turn sat on a platform the steel support for which extended all the way through the ground floor, without touching it, into the basement foundation. Despite these precautions, operators could tell whenever a railway car dumped a load of coal at W. H. Snow's, a fuel dealer about a half-mile from the station, because the ground vibrations induced wild gyrations in the magnifier's output.

Much of the test equipment is in working condition and dates from the period 1900-1920. According to Mr. Howe, who served as my tour guide on visits in September of 1995 and August of 1996, the capacitance as well as the resistance of the cable was employed in tracing shorts and open circuits. In these days of automated test equipment, it is hard to realize that these tests were carried out with nothing more sophisticated than Wheatstone-bridge components and mirror galvanometers. The mirror galvanometer (also invented by Lord Kelvin!) used a lightweight mirror, suspended on a thread inside a coil of wire that carried the current to be measured. Magnetized iron wires attached to the mirror moved it under the influence of the net magnetic field present, which was the sum of the Earth's field, the coil's field, and the field from an adjustment magnet the position of which, on a pole above the coil, could be varied to suit conditions. Using this equipment was obviously not a straightforward enterprise, but somehow, breaks were located within a close enough distance to prevent too much fruitless searching by the repair ship.

Behind the test room is the repair shop. Transformers, wires, switches, and screws lie scattered about, as though a technician has just put down his tools to go to lunch. Parts drawers are labeled in both French and English to suit the bilingual nature of the staff. Static displays of various submarine cables, from the 1800s to the present day, round out the exhibits available for viewing.

The French Cable Station Museum is located at the corner of Cove Road and Route 28 in Orleans, Massachusetts, 02653. It is open to the public on a limited schedule (typically 2-4 p.m., except Sunday and Monday) during the months of June, July, and August only, plus Labor Day weekend. At the museum, you can buy the 48-page tour book by the late W. S. Darling, which describes its history and contents in detail, with photographs. Although no admission fee is charged, contributions (tax-exempt) are welcome. Since it is staffed entirely by volunteers, its hours of operation are subject to change, and visitors are encouraged to call either the Museum (508-240-1735) or the Orleans Chamber of Commerce (508-240-2484) to confirm the latest schedule.

4. Conclusions

In a slim volume, entitled *On the Teaching and Writing of History*, Bernard Bailyn points out one mistake commonly made by professionals who look at the history of their own discipline. They tend to "get involved in severe anachronisms, because they seem impelled to search the past for the seeds, the antecedents, of the present. . . ." [18]. We can see, in Carson's analysis of the submarine cable, a precursor of today's ingenious and increasingly successful attempts to cram more kilobytes per second through telephone-wire pairs that were installed years or decades ago. Heurtley's clever exploitation of bridge balance hints at the electronic differential amplifier to come. And anyone who has struggled to get the last 10 dB of isolation out of a cellular-phone duplexing filter will sympathize with the cable operator who manipulated the Apex Cabinet's controls to regain the 100 dB-plus isolation needed for duplex operation.

By placing this summary of the Museum's history in the context of contemporaneous technical developments, I hope I have avoided the error Bailyn warns about. The technical community has the town of Orleans and the state of France to thank for preserving this bit of communications history. Perhaps their example will inspire more such preservation efforts in the future.

5. Acknowledgments

I would like to thank the anonymous reviewers of this article for their helpful suggestions; Dr. William A. Ward, who kindly furnished me a copy of Darling's *The French Cable Station Museum Tour Book* and encouraged me to visit the museum; Mrs. Lenore Symons, archivist of the IEE; Pamela Stephan, who provided the artwork of Figures 4 and 5 upon short notice; and Mr. Donald Howe of Orleans, Massachusetts, tour guide and member of the Museum, who read the manuscript for accuracy and brought my attention to the excellent articles on the Museum in the Fall 1994 and Spring 1995 issues of the *IEEE Instrumentation and Measurement Society Newsletter*. A short review of the French Cable Station Museum, which included some material in this article, appeared in the April, 1996, *Antenna* newsletter of the Society for the History of Technology.

6. References

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17. *How Submarine Cables are Made, Laid, Operated and Repaired* (28-page pamphlet issued by Commercial Cable Company circa 1926), p. 18; gain figure from D. Howe, private communication.

18. B. Bailyn, *On the Teaching and Writing of History*, Hanover, New Hampshire, Dartmouth College, 1994, p. 88.

President's Message

Continued from page 6

Figure 2. Bill Imbriale and Stuart Long (l-r, in suits and masks), participating in the mask dance as part of the ISAP'96 Banquet.

hand, I have this sinking feeling that unless I come up with the right ransom for his blackmail, you may see this sight for yourself in an upcoming issue [Editor's note: Actually, this seemed of sufficient importance that a special effort was justified. The photos appear nearby. WRS]. Fortunately for me, the mask should provide the disguise necessary for me to remain anonymous, unless you somehow can distinguish me and my 6' 3" frame from my hosts and the children. Trust me on this one, it could not have been an attractive sight.

During each of my presentations and seminars, I tried to provide some humor for my hosts, by beginning my talks with a short opening paragraph in Japanese. Each time, I persuaded one of my Japanese-speaking friends to translate my opening lines into Japanese, and then to write them out phonetically. Despite practicing it many times, it was certainly severely butchered when delivered in my Texas accent, but it never failed to get an enthusiastic response from the audience. Of course, I never figured out exactly what they were really saying, but several later commented favorably about my attempt to speak their native tongue. (Remember the politeness feature of their culture 'though, so I am quite sure they would have been complimentary, whether or not they understood any of it.)

I did have one day to do some sightseeing in Tokyo. Although I saw most of the required temples, shrines, gardens, palaces, and shopping areas of Tokyo that appear on any good tourist's list, a couple of other places made even more vivid and indelible impressions. The first was coming out of the Shinjuku subway station in the evening, and being greeted by the largest crowd of people I have ever seen. It was an "ocean of humanity," unlike anything I had ever witnessed. The second was the basement level of the large Sogo Department Store, in Chiba. It was completely devoted to foods of all types, with many being processed or prepared in real time in front of your eyes (complete with free samples). I could have spent the whole day there.

This rather informal article is not meant to reflect negatively on any aspect of the experiences that I have tried to describe. The graciousness of my Japanese hosts cannot be overemphasized. I am most grateful to them for providing me with a multitude of memories that I will cherish and retell for the rest of my life. To all my new friends I say, "Arigotoo Gozaimasu."
