IEEE

Center for the History of Electrical Engineering

Newsletter No. 23 Spring 1990

Transcontinental Telegraph Named a Milestone

The Transcontinental Telegraph has been named a national Electrical Engineering Milestone by the IEEE. Built during 1861 by the Western Union Telegraph Co. and its associates, the line extended from Omaha, NE, to Carson City, NV, and then connected with local networks. This was the first high-speed link between the Atlantic and Pacific coasts, meeting a critical demand for rapid communication between the two regions. The original line operated until May 1869 when the transcontinental railroad was completed and the telegraph lines were moved to follow its route.

Western History Dept., Denver Public Library

Construction of the transcontinental telegraph line across the plains

The telegraph network had grown quickly in the East and Midwest and several companies came to dominate the business. Organized into eight geographic regions, these companies cooperated through a federation known as the North American Telegraph Association (NATA). At the annual meeting in August 1860, members of the NATA discussed construction of a transcontinental telegraph as outlined in the Pacific Telegraph Act passed by Congress two months earlier. The terms of the Act—a reduced subsidy and rate schedule from that originally proposed, along with a call for open bids on construction of the line—were not popular with the Association and its members voted to study the idea further and make recommendations for an amended act. A second resolution was passed as well, which allowed any member of the NATA to bid on the project independently. This opened the door for Western Union.

In a matter of days, Western Union president Hiram Sibley entered a bid for the contract. Though four bids were submitted at first, the three others were withdrawn. The contract was awarded to Sibley on 20 September 1860.

To build the telegraph line, Sibley had to coordinate the work of a number of companies as subcontractors. At the western end, Jeptha H. Wade, of Western Union, handled the consolidation of four rival companies into the California State Telegraph Co. This company in turn organized the Overland Telegraph Co. in April 1861 to take charge of the line from San Francisco to Salt Lake City. A similar arrangement had been made for the eastern section of the line; the Pacific Telegraph Co., a Western Union spin-off, was incorporated in January 1861.

Construction began in the summer of 1861 along the route surveyed by Edward Creighton, who was then appointed Superintendent of the Pacific Telegraph Co. Several factors combined to complicate the project. The burgeoning Civil War made demands on labor and supplies and, in one case, the political tensions led to destruction and subsequent re-routing of the line. Nature also seemed to be against the telegraph—the Great Plains are not known for their stands of timber from which to make poles, the Rocky Mountains and the Sierra Nevadas had to be crossed. As a counterbalance, financial provisions in the agreements between Western Union and its subcontractors and the prospect of spending the winter in the wilderness acted as incentives for the line's rapid completion.

On 18 October 1861, the workers of the Pacific Telegraph Co. reached Salt Lake City, completing the eastern section of the line. The western section, which was shorter but covered more difficult terrain, was finished by the Overland Telegraph Co. on 24 October. On that evening, the first messages were sent to President Abraham Lincoln. That from Horace

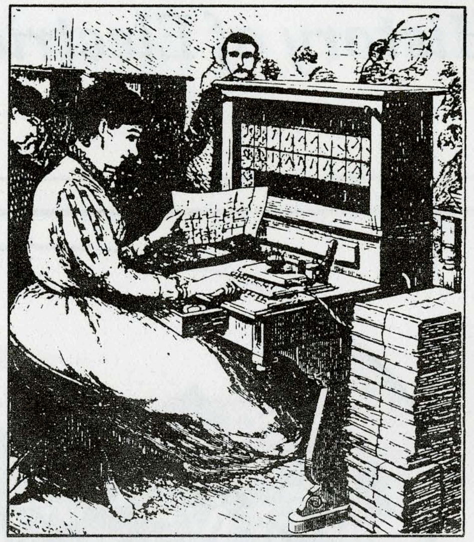
continued on page 8 . . .

Briefs . . .

Computing Before Computers

William Aspray, Director of the Center for the History of Electrical Engineering, has edited *Computing Before Computers*. (Ames, IA: Iowa State University Press, 1990). Contributors to the volume include Aspray, Allan Bromley, Martin Campbell-Kelly, Paul Ceruzzi, and Michael Williams, all historians or computer scientists who have been researching the history of computing for more than a decade.

Many people believe that computing technology began with the building of the ENIAC during World War II, or perhaps with one of the other electronic, digital calculators of about



Herman Hollerith's system for the 1890 census, including this "electrical counting machine," is discussed in **Computing Before Computers.** *From* **Scientific American, 30 August 1890.**

the same time. *Computing Before Computers* tries to change this notion by recounting the long history of computing technology prior to the introduction of the electronic, digital, stored-program computer. The story is traced back to antiquity, but the main focus is the one hundred years ending in 1950. Mechanical desk calculators, logic and syllogism machines, punched card tabulating systems, analog calculators, and other electromechanical and electronic digital calculators all feature in this story. The book strives to place these technological developments in their social context and to show how they converged in the modern computer of the post-war period. The book is written for a general audience and contains more than 100 illustrations.

Historical Radar Archive

The objectives of the Historical Radar Archive in Lincoln, United Kingdom, are to preserve radar history, enhance museum facilities, coordinate research and hardware preservation, and promote interest in radar history through exhibitions and lectures. Headed by RAF Squadron Leader Mike Dean, the Archive has a number of projects outlined for 1990. These include the construction of an archives building, restoration work on a number of radar sets, and collaboration with the Imperial War Museum on recommendations for the preservation of radar equipment. The Archive also undertakes historical research, ranging from oral history interviews to documentation of World II radar sites, and is compiling a directory of museums and archives interested in the history of radar.

For further information, contact Squadron Leader Michael S. Dean, Little Garth, High Street, Scampton, Lincoln LN1 2SD, United Kingdom (0522 73 0338).

Electrical Museum Seeks Artifacts

The Bolack Electromechanical Museum in Farmington, NM, is seeking 19th-century dc and 133-cycle ac meters and switching equipment, and 19th-century watt-hour meters of all frequencies. The privately-owned museum was opened to the public last fall and features myriad electrical devices, ranging from televisions to telephones to street lights. The collection also includes 170 linear feet of slate and marble power plant switchboards, along with transformers, meters, and insulators.

The museum is located on the 12,500-acre "B-Square" ranch, a multiple land-use project aimed at "better farm production and land use through a highly-diversified crop program, land reclamation, reforesting, game management and conservation practices." The entire complex is open to visitors, by appointment. Inquiries and information on artifacts should be sent to Tommy Bolack, Bolack Electromechanical Museum, 3901 Bloomfield Highway, Farmington, NM 87401 (505-325-7873).

The *Newsletter* reports on the activities of the Center and on new resources and projects in electrical history. It is published three times each year by the Center for the History of Electrical Engineering, Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017 (212-705-7501).

IEEE History Committee 1990

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Cavity Magnetron's 50th Celebrated

The 50th anniversary of John Randall and Henry Boot's work on the cavity magnetron was commemorated by a symposium and exhibition held at the University of Birmingham on 21 February 1990. The cavity magnetron was central to the development of air-, sea-, and land-based centimeter-radar systems.

Randall and Boot had been recruited by Mark Oliphant, head of the Physics Dept. at Birmingham, soon after his appointment in 1937. In 1939, Randall and Boot, like the other members of the Dept., were investigating uses of microwaves, a field stimulated by the invention of the klystron tube by Russell and Sigurd Varian. As Randall and Boot recalled, "We had been allocated the less spectacular task of making miniature Barkhausen-Kurz tubes as possible receivers and were also trying to excite cavities by gas discharge tubes. We were unsuccessful and disenchanted with this task."

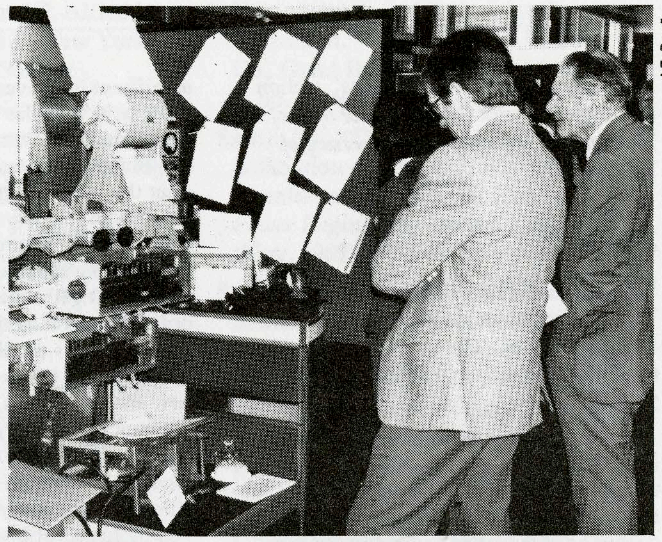
Their research led them to study the available split-anode magnetrons, which were inefficient, low-power generators of microwaves. Randall and Boot saw the possibilities for improving the power output of the magnetron and, in November 1939, "[W]e concentrated our thoughts on how we could combine the advantages of the klystron with what we believed to be the more favorable geometry of a magnetron." Their design modified Heinrich Hertz's wire-loop resonator into a slotted cylinder, grouped six of these cylinders around a central cavity to form the anode block, and used a tungsten-wire cathode. Randall and Boot described testing the magnetron.

> Powerful oscillations were obtained on the morning when all this equipment operated simultaneously and that was 21 February 1940. There was obviously a great deal of power being produced. Neon lamps could be lit some distance from the tube. Cigarettes could be lit off the output lead, leaving a self sustaining arc at the output. Successively larger filament lamps from motor car headlamps were burned out in attempts to estimate the power, which all agreed was several hundred watts. In fact, all agreed there was so much power that it could not possibly be microwaves . . . [T]he next few days were spent measuring the wavelength with a Lecher wire system some 10-12 ft. long . . . The wavelength was 9.8 cm!

Production models were developed at GEC Laboratories (General Electric Co., Great Britain) in Wembley, resulting in the E1189, the magnetron brought to the United States by the Tizard Mission in September 1940. By November, the Radiation Laboratory for radar research had been set up at the Massachusetts Institute of Technology and Bell Laboratories was producing copies of the cavity magnetron. Recognizing the importance of the Randall and Boot magnetron, the U.S. Office of Scientific Research and Development dubbed it "the most valuable cargo ever brought to our shores."

Speakers at the commemorative symposium included

- Sir Mark Oliphant, James Sayers, and Philip B. Moon, on the work at Birmingham.
- W.E. Willshaw, on GEC's work on magnetron development.
- E. Brian Callick, on receiver components.
- Sir Bernard Lovell, Reginald Batt, and J.R. Atkinson, on Royal Air Force applications of the magnetron, 1939-45.
- John F. Coales, on Royal Navy applications of the magnetron, 1939-45.
- D. H. Tomlin, on Army applications of the magnetron, 1939-45.
- John H. Bryant, on British, American, and Canadian collaboration.
- E.D.R. Shearman, on postwar applications of the magnetron.



The Royal Signals and Radar Establishment display at the "Fifty Years of the Cavity Magnetron" exhibit included a range of magnetrons from pre-Randall and Boot to current models.

In addition, Dr. Max J. Lazarus, University of Lancaster, presented a paper entitled, "Electromagnetic Radiation: Megahertz to Gigahertz. A Tribute to Heinrich Rudolf Hertz and John Turton Randall."

The exhibition hall featured Randall and Boot's first operating 10cm magnetron, now in the collections of the Science Museum, London, and included displays on the magnetron and its inventors, klystrons, early tubes, applications of the magnetron during World War II, and the development and uses of magnetrons since 1945. Inquiries concerning availability of the exhibition catalogue, symposium videotape, and forthcoming symposium proceedings should be directed to Ian F. Hunt, School of Physics and Space Research, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom (021414 6709).

Boot, Henry A.H., and John T. Randall. "Historical Notes on the Cavity Magnetron." *IEEE Transactions on Electron Devices* ED-23, no. 7 (July 1976): 724-729.

New Publications . . .

The Newsletter's *"Publications" section was prepared with the assistance of Prof. Thomas J. Higgins of the University of Wisconsin.*

Books

Richard F. Hirsh. *Technology and Transformation in the American Electric Utility Industry.* Cambridge, UK: Cambridge University Press, 1989. 274 pp.

In the mid-1960s, the American electric utility industry was at the height of its success. For more than 70 years, it had successfully managed technology to bring steady increases in power produced and thermal efficiency, and steady decreases in cost to the consumer. By the mid-1970s, there were serious recriminations from customers, lawmakers, and environmentalists about how the utility industry operated and managed itself, and whether it could provide energy reliably and at a reasonable price. Unlike others, who have explained this phenomenon in terms of the Oil Embargo of the 1970s or overregulation, Hirsh attributes the cause to *stasis*, which he defines as "the cessation of technical advances in an industrial process technology. Incremental improvements are no longer made, and the technology appears to have reached its limits" (p. 2).

The story he tells may be summarized as follows. By the 1930s, the basic structure of the American electric utility industry was in place. Management adopted a "grow-and-build" strategy for using advanced technology to create large monopolistic power systems, which were legitimated by state regulatory agencies. Holding companies were formed to raise the large capital needed to build these power plants. Growing up at the same time was a culture among utility managers which equated electrification with social and technological progress, and which was used to justify the grow-and-build philosophy and the use of advanced technology.

In the 1930s especially, there was tremendous progress in the development of technology for the electric utility industry. The results were seen primarily in the scaling up of machines and in significant improvements in thermal efficiency. In order to continue to meet the demands from utility managers for continued improvements in the technology after the war, manufacturers of power equipment employed a "design-by-extrapolation" approach which called for the same steady rate of improvement in equipment performance as in the past. In order to meet these goals, the manufacturers sacrificed extensive testing of equipment before deployment and used new analytical tools, such as computers, to cut back on the margin of safety built into their equipment ratings. In the face of escalating costs and plateaus in thermal efficiency, the utility managers were willing to accept these "minor" risks. In fact, because most of the utility managers were engineers rather than accountants, they often pushed the manufacturers to build cutting-edge technological products, even though it was known that these did not yield the best economies.

These traditional practices caused the utility industry serious problems in the late 1960s and 1970s, when confronted with technical limits to progress involving thermodynamics and metallurgy, environmental concerns over gaseous waste and thermal pollution from large power plants, and unreliability and complexity introduced through scaling up. At first, utility managers viewed lower productivity, rising costs, higher customer rates, and reduced benefits from load growth as anomalous, short-term phenomena, blaming these on unusual economic conditions and regulatory practice rather than technology.

As the situation steadily deteriorated in the 1970s, some utility companies began to rethink their build-and-grow philosophy and introduced energy conservation programs and load management. This has mitigated the problems, but continued (though slower) growth in energy consumption is making them seek alternative technological solutions, such as fuel cells and cogeneration. There is considerable resistance among the utility companies to these technologies, however, because they may lead to a restructuring of the industry away from large monopolistic companies once there is no longer a need for large, capital-intensive power plants.

Hirsh relies heavily on interviews with utility engineers, managers, and regulators. Although these interviews were all conducted ten or more years after the events recounted, he seems to have carefully checked the information received against historical and trade publications and against archival materials. The result is an impressive and convincing account that should interest technology and business historians, as well as policy analysts.

Richard F. Hirsh is Associate Professor of History at Virginia Polytechnic Institute and State University.

Other Recent Books

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The Magnetic Core Memory Collection at the MIT Institute Archives and Special Collections

MIT Institute Archives Staff

The invention of magnetic core memory by Jay Wright Forrester at MIT in the early 1950s was a major step forward in the development of high-speed digital computers. The story of Project Whirlwind and magnetic core memory is told in *Project Whirlwind: A Case History in Contemporary Technology*, by Kent C. Redmond and Thomas M. Smith (Bedford, MA: Digital Press, 1980). The book, however, does not discuss the extended litigation concerning Forrester's invention, a legal battle that lasted eight years and involved MIT and a host of corporations. The documentation assembled and produced by MIT and the law firm of Kenway and Jenney in the course of the suits is now available for research in the MIT Institute Archives and Special Collections.

The story of Forrester's invention of magnetic core memory began during World War II with a joint effort by MIT and the U.S. armed services to create an aircraft simulator, called the Aircraft Stability and Control Analyzer (ASCA). Forrester directed the ASCA project from its inception in 1944 until 1956. The ASCA itself was never built; instead, the emphasis shifted to the development of the computer mechanism which was the essential component of the simulator cockpit. In the course of this computer research, known as Project Whirlwind, a breakthrough in the way computers store information made high-speed digital computing possible.

In the early years of Project Whirlwind, Forrester became aware of the limitations of the electrostatic storage tubes then used for computer memory. His solution was the development of the storage system called magnetic core memory, which consisted of honeycombs of minute magnetic cores strung on wires through which information was read to electronic circuits in the computer. The system was fast and reliable, and, in May 1951, Forrester filed a patent claim for his invention.

The United States Patent Office issued Patent No. 2,736,880 to Forrester in 1956, acknowledging his invention of magnetic core computer storage. As soon as it was issued, the Forrester patent was contested by Dr. Jan Rajchman, an RCA researcher who had filed a similar patent application eight months before. Rajchman did not dispute that Forrester had been the first to conceive of the idea. Rather, his case revolved around two major claims: that Forrester had not reduced his idea to practice before filing his patent application and that he had not been "continuously diligent" in attempting to reduce his idea to practice during the time between Rajchman's patent filing date (September 1950) and Forrester's (May 1951). He contended specifically that work on the invention had come to a standstill between December 1950 and March 1951, and argued that work was resumed in March 1951 because one of Forrester's assistants, William Papian, discovered that Rajchman was working along the same lines.

Forrester and MIT were originally represented in the legal action by the Research Corp., a non-profit organization that handled inventions for universities. In March 1961, the Patent Office awarded priority of inventorship to Jan Rajchman. The Research Corp. appealed the decision and also charged RCA with infringement of the Forrester patent. The legal case later spread to include IBM. In 1952, MIT personnel had selected IBM to work with the Institute to augment the engineering design capability of the Whirlwind computer and to prepare for computer production. After IBM began manufacturing computers with magnetic core memory systems, disagreement arose regarding the amount of royalties that should be paid to MIT. In July 1962, the Research Corp. filed a suit charging IBM with infringement of the Forrester patent. Relations between the Research Corp. and MIT deteriorated over disagreements concerning the handling of the cases and, in March 1963, MIT terminated the relationship, bought the rights to the Forrester patent, and became a co-plaintiff in the RCA and IBM litigations.

To reverse the Patent Board's decision in the interference case, MIT needed to document the key period between December 1950 and March 1951. Joyce Jones Ericson and James Hastings of MIT's Patent Administration Office set about locating, collecting, and indexing documents relevant to this time period. The title of one of the memos in this collection is "Treasure Hunt," giving a good indication of the kind of activity involved. They sought to determine exactly what Rajchman knew of Forrester's work.

Ericson and Hastings compiled and analyzed a voluminous amount of material, including laboratory notebooks, office files, logs of visitors to Forrester's laboratory, purchase orders for Whirlwind computer components, travel vouchers, and even telephone bills, all of which is now part of the collection. The result was a comprehensive calendar which provided a day-by-day record of magnetic core research in the critical period. The calendar proved to be a decisive factor in establishing Forrester's claims. In 1964, the cases against RCA and IBM were settled out of court by negotiation, opening the way for settlements with other major companies that manufactured magnetic core memory systems.

The materials in the collection fully document the development of magnetic core memory and MIT's involvement in the patent litigation cases. Forrester's work is documented in laboratory notebooks, progress reports, correspondence, memoranda, and photographs; of special interest is Forrester's notebook No. 47 (1948-50), in which he drew his original plans and described magnetic core memory. A complete record of the development of magnetic core memory, assembled by lawyers at the MIT-retained legal firm of Kenway & Jenney, has been preserved as well.

The collection also includes materials on the administration and litigation of the Forrester patent pertaining to the IBM and RCA cases; to patent infringement suits against Fabritek, AMPEX, and NCR; and to licensing negotiations between MIT and Digital Equipment Corp., Honeywell, and Sperry Rand. There are legal documents and depositions, summaries of negotiations, theses, patents, floor plans, financial reports, correspondence, and memoranda. Complementing the collection are catalogued technical reports from Project Whirlwind and archival collections from MIT administrators and laboratories of the period.

MIT Museum

Jay Forrester holding magnetic core memory

For further information on the Magnetic Core Memory Collection, contact the Institute Archives, 14N-118, Massachusetts Institute of Technology, Cambridge, MA 02139 (617-253-5690).

Meetings . . .

International History Conference

The Association pour l'Histoire de l'Électricité en France will host the Second International Conference on the History of Electricity in Paris during 3-5 July 1990. The three conference themes are electricity before 1789, electrical and electrotechnical sciences, and the electrical industry throughout the world. For further information, contact the Association pour l'Histoire de l'Électricité en France, 9 Avenue Percier, 75008 Paris, France (1 40 42 5108; *FAX:* 1 40 42 2969).

1990 Tesla Symposium

The International Tesla Society will sponsor the 1990 Tesla Symposium, to be held in Colorado Springs, CO, on 26-29 July. Among the session topics on the tentative program are Tesla's life, electromagnetic theory, radio and telecommunications, nonconventional energy generation and transmission, and the social implications of Tesla technology. For details, contact the International Tesla Society, Inc., Attn: 1990 Tesla Symposium, 330-A West Uintah Street, Suite 215, Colorado Springs, CO 80905-1095 (719-392-6404).

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Exhibitions and Museums . . .

Le Téléphone au Fils du Temps, 1889-1989

"Le Téléphone au Fils du Temps, 1889-1989," an exhibition at the Musée d'Art Moderne de la Ville Paris from 12 December 1989 through 4 January 1990, examined the first hundred years of public telephone service in France. "Le Téléphone au Fils du Temps" was divided into four sections: "La téléphone de la Belle Epoque, 1889-1919"; "L'âge industriel du téléphone, 1920-1939"; "Un téléphone pour tous les Français, 1940-1978"; and "Du téléphone aux télécommunications, 1979-1989."

In the first section, "La téléphone de la Belle Epoque, 1889-1919," the story was taken from the first network organized in Paris by the Societé Génerale des Téléphones in 1877, through nationalization in 1889, and into developments in telecommunications technology in the early-20th century. "L'âge industriel du téléphone, 1920-1939," highlighted the development of radio communication as well as technical improvements (and their attendant problems) in telephony, such as the introduction of automatic switching and installation of the first long-distance telephone cable. Wartime research in radio and telephony, the advent of television, and the first telecommunications satellite were the focus of "Un téléphone pour tous les Français, 1940-1978." The final section of the exhibit, "Du téléphone aux télécommunications, 1979-1989," concentrated on the expanding world of telecommunications, ranging from facsimile transmission to high-definition television to cable and satellite networks, and also discussed the organizations that manage these systems. Throughout, the exhibit sought to balance the technical, economic, and social history of the development of telecommunications in France.

"Le Téléphone au Fils du Temps, 1889-1989" was curated by Catherine Bertho Lavenir and sponsored by France Telecom and the Ministére des Postes, des Télécommunications et de l'Espace. A lavishly-illustrated, 112-page catalogue, edited by Lavenir, accompanied the exhibit. Inquiries about the exhibit and catalogue should be directed to Ministére des Postes, des Télécommunications et de l'Espace, 20 Avenue de Ségur, 75700 Paris, France.

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W. Carpentier, president of the Overland Telegraph Co., read, "I announce to you that the telegraph to California has this day been completed. May it be a bond of perpetuity between the states of the Atlantic and those of the Pacific."*

The IEEE Denver Section will host the Milestone dedication ceremony on 5 August 1990 at the Fort Laramie National Historic Site. Fort Laramie served as a repeater station about midway between the ends of the line. The Fort was essential, therefore, to the successful transmission of transcontinental messages and also supplied vital information to the local area.

The IEEE Electrical Engineering Milestones Program serves to foster awareness of electrical engineering history and to preserve and document significant achievements in electrical and electronics engineering through Milestone site dedications. The Program is supervised by the IEEE History Committee and administered by the Center for the History of Electrical Engineering.

*Thompson, Robert Luther. *Wiring A Continent: The History of the Telegraph Industry in the United States, 1832-1866* (Princeton, NJ: Princeton University Press, 1947): 368.

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