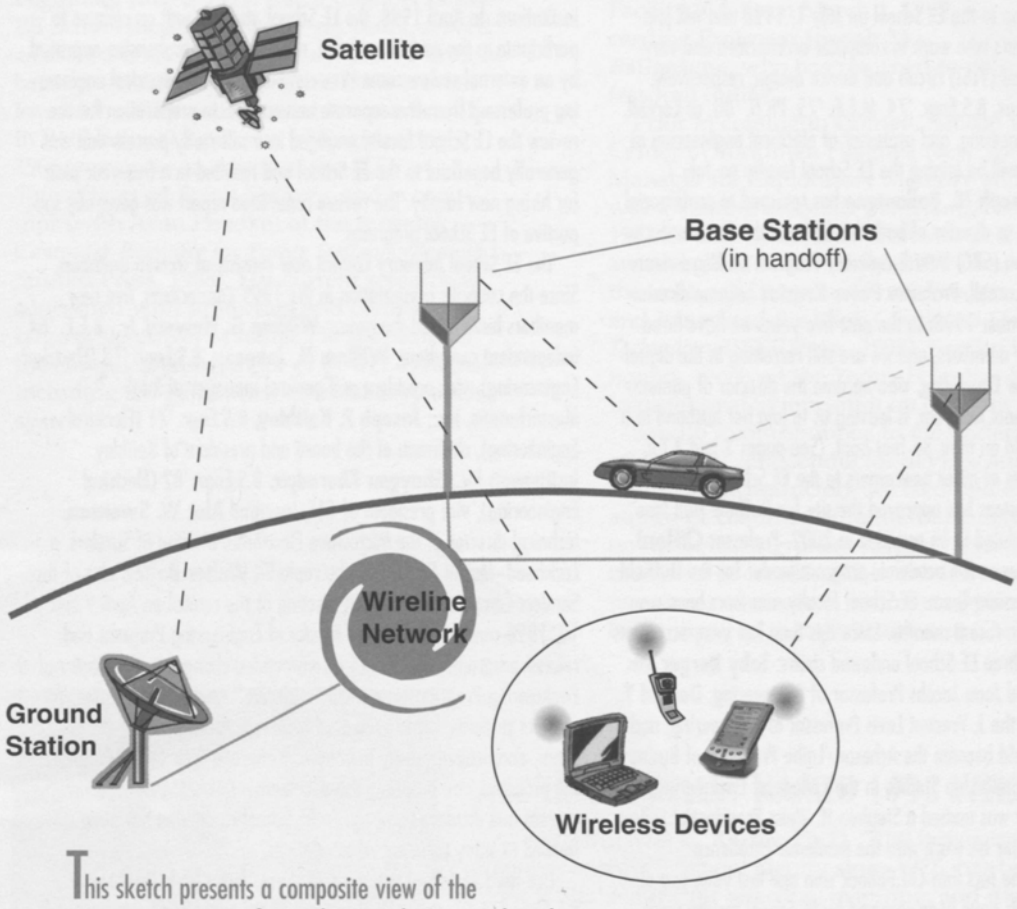
CONNECTIONS

A Report from the School of ELECTRICAL ENGINEERING • Cornell University

WIRELESS TECHNOLOGY RESEARCH

in the School of Electrical Engineering



This sketch presents a composite view of the major components of a modern wireless network and illustrates the various media devices that may be engaged in the communication of information among local, mobile, and stationary users, and from point-to-point around the globe. It may appear that in principle we may soon be able to speak to anyone, anywhere, at any time, because the number of communication towers (base stations), ground stations, and orbiting satellites is rapidly expanding, and the enormous wireline network is a firmly established and efficient entity. In reality, the complex modern networks that promote the growth of global communication have introduced new and complicated problems that must be studied and solved if wireless communication is to attain its potential. The articles on wireless technology research in this issue include discussion of communication theory, modulation coding, signal processing, networking, cryptographic procedures, device characteristics, and control circuitry, all topics that are integral to the ultimate success of wireless communication. (sketch courtesy of Starla Carpenter and Venugopal Veeravalli)

This eighth edition of *Connections* features the challenging research of our wireless technology research group, relates the history of wireless technology in the EE School, and considers the impact of new laboratories in this field on the EE School and the Department of Computer Science. The "Positive Feedback" section contains news of recent alumni activities. Other items of interest to alumni are listed below in the table of contents. Please fill out the information coupon on the last page of this newsletter, clip and mail it to us. We want to hear what you are up to.

Simpson (Sam) Linke, editor

SPRING 1999

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Report from the Director

James S. Thorp

Charles Harrington, Cornell University Photography

Our vigorous faculty recruiting program continues to be an important activity in the EE School. In the past year, we have hired four new professors. **Sandip Tiwari,** Ph.D. '80, joined the faculty on January 1, 1999 as a full professor, and on March 1, 1999 became the new director of the Cornell Nanofabrication Facility (CNF). Associate Professor **Lang Tong** joined the faculty on July 1, 1998 and will work closely with other members of the faculty who have interests in wireless telecommunication. Assistant Professors **Mark A. Heinrich** and **Rajit Manohar** both came to the EE School on July 1, 1998 and will join other faculty members who work in computer architecture and very-large-scale-integrated (VLSI) circuit and device design, respectively. **Michael G. Spencer,** B.S.Engr. '74, M.E.E. '75, Ph.D. '80, at Cornell, all in electrical engineering, and professor of electrical engineering at Howard University, will be joining the EE School faculty on July 1, 1999. Professor **Joseph M. Ballantyne** has returned to professorial duties after serving as director of both the CNF and the Semiconductor Research Corporation (SRC) Interdisciplinary Program on Microscience and Technology at Cornell. Professor **Peter Krusius** became director of the SRC in September 1998. In the past five years we have hired thirteen new faculty members, and we are still recruiting in the digital-systems area. **Diane Downing,** who became the director of administration in the EE School last year, is leaving us to join her husband in a sail around the world on their 36-foot boat. (See pages 3 and 4 for biographical sketches of other newcomers to the EE School.)

The Board of Trustees has approved the site for Duffield Hall (see page 16), now scheduled to be occupied in 2002. Professor **Clifford R. Pollock** continues as the academic program leader for the Duffield Hall Project Management Team. EE School faculty members have won prestigious awards in recent months. Since this time last year, occupants were appointed to three EE School endowed chairs: **Toby Berger** was named the Irwin and Joan Jacobs Professor of Engineering, **Donald T. Farley** was named the J. Preston Levis Professor of Engineering, and **Noel C. MacDonald** became the Acheson/Laibe Professor of Business Management and Leadership Studies in the College of Engineering. **Michael C. Kelley** was named a Stephen H. Weiss Presidential Fellow this year, primarily for his work with the Academic Excellence Workshops. Given the fact that Clif Pollock won one last year, two of these coveted awards have been received by EE School faculty members in consecutive years. Assistant Professor **Venugopal V. Veeravalli** received a National Science Foundation (NSF) Presidential Early Career Award for Scientists and Engineers (PECASE) in a ceremony at the White House on February 10, 1999, and Assistant Professor **Kevin T. Kornegay** won a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation in March 1999. Professor **Lester F. Eastman** received the 1999 IEEE Graduate Teaching Award. Professors **David F. Delchamps, David A. Hammer, Yu-Hwa Lo, H. C. Torng,** and **Stephen B. Wicker** won College of Engineering teaching awards. In the past five years EE School has won thirteen of the fifteen teaching awards we have been allowed to nominate.

In the 1997–98 academic year the University Senate initiated a campus-wide program of departmental reviews by visitors from other institutions. In April 1998, the EE School, the first unit on campus to participate in the review program, received a comprehensive appraisal by an external review committee composed of five electrical engineering professors from five separate universities. In preparation for the review the EE School faculty engaged in a self-study process that was generally beneficial to the EE School and resulted in a five-year plan for hiring new faculty. The review committee report was generally supportive of EE School programs.

The EE School Advisory Council now consists of sixteen members. Since the council's presentation in the 1995 *Connections,* five new members have joined the group: **William G. Howard Jr.,** B.E.E. '64, independent consultant; **William N. Johnson,** B.S.Engr. '73 (Electrical Engineering), vice president and general manager of Intel Massachusetts, Inc.; **Joseph P. Keithley,** B.S.Engr. '71 (Electrical Engineering), chairman of the board and president of Keithley Instruments Inc.; **Shaygan Kheradpir,** B.S.Engr. '82 (Electrical Engineering), vice president of GTE, Inc.; and **Alec W. Swenson,** technical director of the Microwave Electronics Division of Sanders, a Lockheed–Martin Company, who replaced **Walter Butler,** also of the Sanders Company. The annual meeting of the council on April 9 and 10, 1998 concentrated on the Master of Engineering Program and related programs. The council recommended changes in the Master of Engineering Program, suggested "exclusive" seminars and classes for masters students, urged enhanced corporate sponsorship of the program, encouraged faculty members to improve their attitudes toward the program, and proposed the development of professional short courses and distance learning. An EE School committee has been formed to study these recommendations.

Our third EE School astronaut in space, **Jay Clark Buckey,** B.S.Engr. '77 (Electrical Engineering), M.D., an associate professor of medicine at Dartmouth Medical School, returned to the campus on November 10, 1998 and presented an interesting talk on his study of the human nervous system in space during his sixteen-day flight aboard the Space Shuttle *Columbia* in April 1998.

Alumni who remember Professor **Joseph L. Rosson** will be pleased to learn of the establishment of an endowment to name a laboratory in the EE School in his honor and provide funds for its maintenance and operation. **Sarah Thole Fischell,** B.S.Engr. '78 (Electrical Engineering), M.E.E. '79, and her husband **David R. Fischell,** B.S.Engr. '75, M.S. '78, Ph.D. '80, all in applied and engineering physics, have initiated the fund and hope that other alumni will join in honoring Joe's memory.

James S. Thorp
Charles N. Mellowes Professor of Engineering and Director
School of Electrical Engineering

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Enrollment and Graduation Statistics

Undergraduate Program

year	*sophomores*	*juniors*	*seniors*	*degrees*
96–97	138	128	109	115
97–98	132	169	111	116
98–99	119	136	162	•

M.Eng. (Electrical) Degrees

August	*January*	*May*	*Total*
50	22	42	114
29	7	40	76
20	8	•	•

• Not available at press time.

M.S./Ph.D. Program

year	*applicants*	*admissions*	*total enrollment*	*degrees*
96–97	493	19	108	24 Ph.D., 6 M.S.
97–98	429	32	118	20 Ph.D., 6 M.S.
98–99	423	—	•	•

Note: Undergraduate students now affiliate with the EE School when the first term of sophomore mathematics and physics is completed.

These figures indicate that over the past three years, the undergraduate program has increased moderately, the M.Eng (Elec.) program has decreased significantly, and M.S./Ph.D enrollment has increased moderately.

JIM THORP REAPPOINTED EE SCHOOL DIRECTOR

James S. Thorp, B.E.E. '59, M.S. '61, Ph.D. '62 (all in electrical engineering from Cornell), the Charles N. Mellowes Professor of Engineering, has accepted reappointment as director of the EE School for three years, beginning July 1, 1999. Jim, a member of the EE School faculty for thirty-six years, served as associate director from July 1, 1991 until he became director on July 1, 1994. He is a fellow of the IEEE, was elected to membership in the National Academy of Engineering in 1996, serves as an editor of the *IEEE Transactions on Power Delivery,* and is coauthor (with Arun Phadke) of the textbook *Computer Relaying for Power Systems* (Research Studies Press, 1988). His current research is concerned with protection and control of large-scale power systems. He also studies the complicated behavior of power systems, including the generation of fractals by such systems.

SANDIP TIWARI

Nicola Kountoupes, Cornell University Photography

SANDIP TIWARI IS NEW DIRECTOR OF CNF

Professor **Sandip Tiwari,** B.Tech. '76 (Indian Institute of Technology, Kampur, India), M.Eng. '78 (Rensselaer Polytechnic Institute), Ph.D. '80 (Cornell University), all in electrical engineering, joined the EE School faculty on January 1, 1999 as a full professor, and was named the Lester B. Knight Director of the Knight Laboratory, Cornell Nanofabrication Facility (CNF) on March 1, 1999, succeeding Professor **Joseph M. Ballantyne,** who has returned to professorial duties.

Prior to coming to Cornell, Sandip was with the IBM T. J. Watson Research Center in Yorktown Heights, New York as a research staff member, and Manager for Exploratory Memory and Device Modeling. During 1988–89 he was a visiting associate professor at the University of Michigan and during 1993 he was an adjunct professor at Columbia University. He has been associate and guest editor of the *IEEE Transactions on Electron Devices,* is the author of the textbook *Compound Semiconductor Device Physics* (Academic Press, 1991), and has edited the book *Compound Semiconductor Transistors, Physics and Technology (*IEEE Press, 1993). Sandip is a fellow of the IEEE, and among other honors, received the Young Scientist Award of 1991 at the Eighteenth International Symposium on Gallium Arsenide and Related Compounds.

Sandip's contributions to the understanding and development of electronic and optical semiconductor devices and structures that use silicon and compound semiconductors are recorded extensively in the literature. He is the author or coauthor of numerous publications and patents. Asked to comment on his new assignment he said, "Nanostructures are now at one of those rare moments of creation. The next few decades will bring many more discoveries, new areas of research and new applications, and I look forward to helping bring many of them to fruition at CNF."

MICHAEL C. KELLEY

Engineering Publications

MICHAEL C. KELLEY NAMED 1998 WEISS FELLOW

Professor **Michael C. Kelley,** Ph.D. '70 (University of California at Berkeley [physics]), a member of the EE School faculty since 1975, has been named a 1998 Stephen H. Weiss Presidential Fellow for effective, inspiring, and distinguished teaching of undergraduate students. The award provides recipients $25,000 over five years. Since 1980, Mike has received five awards and recognitions related to undergraduate teaching and has made an outstanding contribution to undergraduate education at Cornell. He created a program called Academic Excellence Workshops (AEW), to reach freshmen and sophomores in their mathematics and physics courses who would normally be at risk within the College of Engineering. The program is based on the belief that students learn best from each other and will react positively to an expectation of excellence. These workshops reach some 200 mathematics students each year, and have been adopted by the Department of Physics for its large undergraduate courses.

In addition to his teaching duties and research on upper-atmospheric phenomena, Mike has accepted a half-time position in the College of Engineering as associate dean for professional development. He will guide the development of an initiative to improve the climate for work and study in the college.

Newcomers to the School

Lang Tong

B.S. '85 (Tsinghua University, Beijing, China), M.S. '88, Ph.D. '90. (both at the University of Notre Dame; all in electrical engineering), joined the EE School as an associate professor on July 1, 1998. Following a year as a postdoctoral research affiliate at Stanford University, he was an assistant professor at West Virginia University from 1991–93, an assistant professor at the University of Connecticut from 1993–97, followed by promotion to associate professor at Connecticut in 1997. Lang's teaching and research are in the fields of digital-signal processing algorithms; statistical signal processing; estimation theory; communication systems and networks; wireless communication systems: cellular, PCS (personal communication systems), high-frequency, high-definition television (HDTV); equalization and channel estimation; modulation techniques; and system identification. During his years at the University of Connecticut he was the principal investigator for more than a dozen sponsored research programs, which resulted in an impressive publication record. He is the author or coauthor of twenty-four refereed journal articles and book chapters, and seventy-five conference papers and invited talks that were presented in this country and abroad. In 1993 he won the Outstanding Young Author Award of the IEEE Circuits and Systems Society, and in 1996 he received the Office of Naval Research Young Investigator Award. In recent years his professional activities have involved several IEEE editorial positions, and IEEE conference organizational tasks. His personal hobbies include reading and enjoyment of music. Lang is looking forward to joining forces with the other members of the wireless network research group in the EE School.

William C. Mutch

Mark A. Heinrich

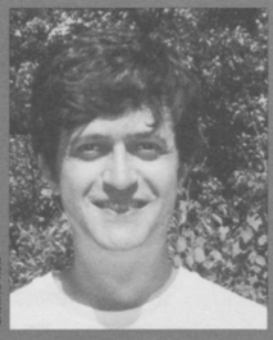
B.S.(EE/CS) '91 (Duke University), M.S. '93, Ph.D. '98 (both at Stanford University, in electrical engineering), joined the EE School as an assistant professor on July 1, 1998. Mark's teaching and research interests are in parallel and distributed computer architecture, distributed shared-memory cache-coherence protocols, programmable I/O and network subsystems, hardware/software codesign, and multiprocessor-performance evaluation and simulation methodology. While at Stanford he was a National Science Foundation graduate fellow and an original member of the Stanford FLASH (flexible architecture for shared memory) multiprocessor design team. In that capacity he made a number of contributions to the team, including design of portions of a hardware system node controller, development of software for a system-level simulator, design and implementation of protocols for the FLASH multiprocessor, and development of a model for analyzing the performance of multiprocessors throughout the design space of distributed shared-memory machines. He is the coauthor of one book, three refereed journal articles, and six conference papers. His current teaching assignments include courses in computer organization and parallel computer architecture. When spare time and family duties allow, Mark is a sports buff, collects sports memorabilia, and participates in softball, basketball, and racquetball.

William C. Mutch

Rajit Manohar

B.S. '94, M.S. '95, Ph.D. '98 (all at California Institute of Technology, in electrical engineering), joined the EE School as an assistant professor on July 1, 1998. Rajit's research and teaching interests are in asynchronous VLSI design, computer architecture, concurrency, distributed systems, parallel computing, and formal methods. While at Caltech he held a National Semiconductor Corporation graduate fellowship, was a research assistant on studies of asynchronous VLSI design and implementation of an asynchronous microprocessor, and as an instructor, taught a three-term graduate-level course, "Concurrency in Computation." He also served as a student volunteer for Caltech's high school teacher training program. He is the coauthor of three refereed journal articles, five conference papers and is coinventor of three pending patents. Rajit has been a referee at the Conference on Advanced Research in VLSI, an international parallel-processing symposium, a workshop on asynchronous design methodologies, and an international symposium on advanced research in asynchronous circuits and systems. His current teaching assignments include asynchronous VLSI design, computer architecture, and concurrency. In his spare time, Rajit enjoys badminton, and playing the harmonium and the piano.

William C. Mutch



Cristina Reis

Hercules P. Neves

Herc has joined the EE School as senior research associate with Professor **Noel C. MacDonald**'s group. He has been a visiting scientist in the EE School for the past year and has directed the work of the group while Noel is on leave in Washington, D.C. He received the B.S.E.-equivalent degree in electrical engineering from Federal University of Minas Gerais, Brazil in 1984, and the Ph.D. in electrical engineering/microelectronics from the University of Edinburgh, Scotland in 1991. Before coming to Cornell he was an associate professor of electrical engineering at the same institution in Brazil. Herc is a professional flutist in both baroque and modern music, and a woodworker who specializes in building harpsichords.

Wireless Technology in the EE School

After the famous Dempsey–Tunney boxing match in Chicago on the evening of September 12, 1927, Professor **William C. Ballard,** M.E. '10 met Instructor **True McLean,** E.E. '22 in Franklin Hall the following morning and asked him if he had heard the radio broadcast of the fight. "Sure did," answered True enthusiastically. "I was set up in the wireless lab to hear it. Reception was excellent. It's a good thing the fight was at night. In the daytime I would've heard only static from Station WGN, even with our long aerial."

Something like this imagined conversation may have actually occurred. True's comment about better reception at night referred to the "sky-wave," the skip-distance broadcast phenomenon known by that time to result from reflection of radio waves by the ionosphere.

In contrast to today's rapid scientific development, knowledge of long-distance radio-transmission behavior as well as a comprehensive understanding of wireless technology were slow in coming. Heinrich Hertz first demonstrated electromagnetic-wave propagation and detection in 1888, and Marconi followed with his invention of the wireless telegraph in 1896. In published course descriptions at Cornell, the earliest mention of wireless phenomena occurred in a graduate course, "Electrical Oscillations and Electrical Waves," offered in 1903 by physics Professor **Ernest Merritt.** The following year saw the advent of preliminary experimentation with wireless telegraphy in Franklin Hall.

A list of electrical-engineering laboratory equipment in the 1904–05 *Cornell Register* includes "a 30 kV 'inductorium' that provides current for wireless telegraphy." Before transferring from Cornell to Stanford in 1904, Professor **Harris J. Ryan** had developed an 80 kV power transformer and apparently contributed his expertise to the design of this high-voltage induction coil, which was used until 1908 by Professor Merritt in class demonstrations of Hertzian-wave phenomena. In 1909, the first course in wireless technology was introduced in the curriculum as an elective for EE School seniors. The course, E 27, "Wireless Telegraphy and Telephony," with one lecture and one laboratory session each week, was taught by Instructor **William H. Kroger.** The course was concerned with fundamental principles of wireless communication, and used laboratory experiments to supplement the lectures. The experiments applied the inductorium to the production and reception of electrical oscillations, included examination of station-tuning techniques to avoid interference with other stations, and considered use of Lee De Forest's "audion" as a detector and amplifier of wireless signals. From 1911 to 1913 the course was expanded to include study of the application of wireless principles, and the inductorium was converted into a 30 kV air-core transformer and combined with a capacitor and spark-gap apparatus to form a Marconi wireless system. When William Kroger departed from Cornell in 1913, instruction in wireless technology was absent from the curriculum until 1915 when Bill Ballard, who had joined the faculty in 1911, offered the course again in much the same form. In 1916 Ballard designed and built a spark-driven transmitter that operated at 5 kW and 706 kilocycles per second (kilohertz in modern nomenclature), and obtained a provisional license to operate it as an experimental wireless telegraphy station with the call letters "8YC." By the time Bill was promoted to assistant professor in 1918 he had upgraded the content of course E 27 to include vacuum-tube circuitry based on Howard Armstrong's regeneration and superheterodyne concepts. He also expanded the wireless-laboratory facilities to include (as paraphrased from the 1917–18 *Cornell Course Descriptions*) two spark-gap transmitters, both equipped with rotating-machine generators rated at input powers of 5 kW, 500 hertz (Hz) and 2 kW, 60 Hz, respectively. The receiving equipment included crystals, audions, and other detectors. A 500-foot aerial connected to a superheterodyne receiver allowed reception over a range of 5,000 miles. A pertinent quote from Morris Bishop's *A History of Cornell* illustrates the state-of-the-art on campus at the time:

"The game with Union on 16 October 1920 was noteworthy in that, apparently for the first time, a football match was reported from one city to

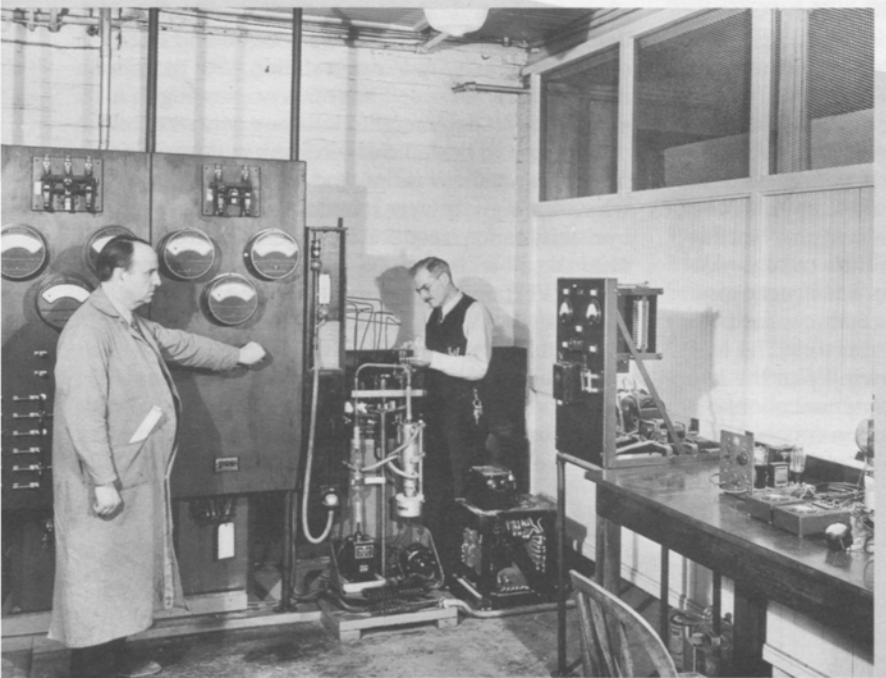


Figure 1.—Professors Bill Ballard, on the left, and B. K. Northrop, testing WEAI apparatus.

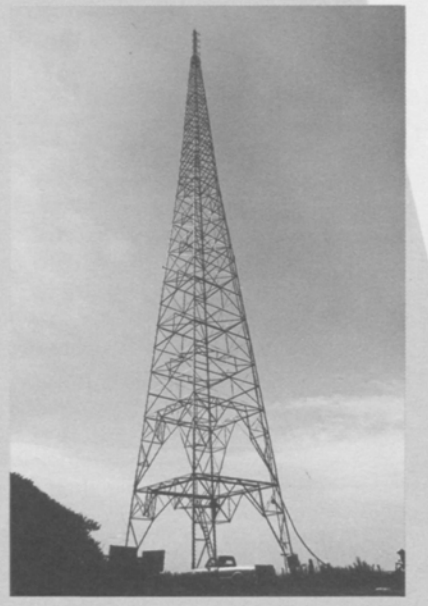
Division of Rare and Manuscript Collections, Kroch Library

another by radio. An R.O.T.C. operator at the field communicated the plays by telephone to Professor W. C. Ballard in Franklin Hall, and he relayed them by wireless telegraphy to Schenectady."

Radio-Technology Development

When the EE School became a separate entity in 1921, seniors could choose to enroll in either the electric power option or the electrical communications option. Students in the latter were required to take two new courses, E 26 and E 27, "Elementary and Advanced Electrical Communications," taught by Bill Ballard. Instructor **B. K. Northrop,** who had joined the faculty in 1920, was an assistant in these courses. The first course presented elementary principles involved in the electrical transmission of intelligence by telegraph, telephone, and radio, followed by the advanced course that offered detailed consideration of electrical communication systems, wave propagation and attenuation phenomena, telegraphy, telephony, carrier-wave telephony, various radio systems, and radio telephony. The course also included special emphasis on the theory of the electron tube and its practical applications. By 1923, the electrical communications laboratory had separate wire, telephone, and radio sections, with various transmitting and receiving sets including spark-telegraph, continuous-wave telegraph, and radiotelephone apparatus. Bill Ballard had also developed a vacuum-tube laboratory that contained unusually complete facilities for the manufacture and exhaustion of experimental tubes of various designs.

Figure 2.—View of WHCU tower on Mount Pleasant.



Both photos: Division of Rare and Manuscript Collections, Kroch Library

In 1923, as an adjunct to their courses, Bill Ballard and B. K. Northrop built a 500-watt transmitter and obtained a renewable provisional license to broadcast at 833 kHz. This station, called WEAI ("We Educate and Instruct") was the first AM radio station in Ithaca (see Figure 1). Bill also obtained a renewal of the provisional license to operate his experimental station but with new call letters "8XU," and at frequencies between 30 and 1,365 Khz. This FCC license only allowed operation after midnight "for the specific purpose of conducting experiments for the development of the science of radio communication or the apparatus pertaining thereto." Later that year True McLean was appointed as an instructor and joined Ballard and Northrop in their communications instruction and radio-broadcasting endeavors. The following year the two communications-option course numbers and titles were changed to EE 451, "Medium and High-Frequency Phenomena," and EE 452, "Electrical Communications Engineering." B. K. Northrop moved on to other concerns while Ballard and McLean, joined in 1925 by Instructor **M. G. Northrop,** continued to teach the two courses. They placed special emphasis on the theory and application of thermionic devices and use of their home-made radio station for demonstration purposes in the wireless laboratory.

Figure 3.—James L. Fly, chairman of the Federal Communications Commission, visits the WHCU control room. Professor True McLean, chief engineer, is second from the right.

A major change in EE School wireless technology occurred in 1927 with a gift—from the Westinghouse Corporation—of a 1,000-watt, crystal-controlled 100 percent–modulated transmitter. The equipment was housed in a special building at the present location of Hasbrouck Apartments off Pleasant Grove Road, and two 165-foot steel towers were erected to support the antenna. Studios were centrally located in West Sibley Hall. The station went on the air in August 1929 as WEAI, under the supervision of the Department of Electrical Communications in the EE School, with True McLean as radio engineer. Initial output power at 500 watts and 1,260 kHz was raised to 1,000 watts in January 1931. In later years an upgraded transmitter and associated towers were moved to Mount Pleasant to widen the reception area (see Figure 2). The broadcasting equipment and associated studio were used in regular communications-laboratory instruction and were available for special tests and radio research. Elaborate plans were made to use the new facilities for widespread educational activities and special programs that were to originate on the campus. After some initial success, it became evident that the economics of broadcasting were too stringent for the university budget. In 1932, cooperation with a commercial radio station in Elmira, New York, allowed the Cornell station to continue broadcasting with call letters WESG (*Elmira Star Gazette*). Unhappily, this cooperative venture ran afoul of some early FCC regulations that caused the arrangement to be abandoned in 1940 in favor of the establishment of WHCU-AM, a commercial radio station owned and operated by the university. True McLean, who had been promoted to assistant professor in 1930, was appointed chief engineer (see Figure 3). The station continued to operate as a Cornell entity until 1986, when it was sold to commercial interests. Also in 1940, several electrical-engineering students, in cooperation with other students, formed the Cornell Radio Guild and began operation of a "wired" radio station with reception limited to the campus. Programs originating in a studio in Willard Straight Hall were sent over telephone lines to designated receivers in dormitories, fraternities and sororities, and rooming houses where the signals were broadcast by low-power transmitters for reception by regular radio. The original call letters, "CRG," were changed eventually to WVBR, the "Voice of the Big Red."

Curiously, WHCU could only broadcast during daylight hours. Apparently the original license application was limited to operation from dawn to dusk under the assumption that few people would care to listen in the evening. Also, the original frequency allocation of 1,260 kHz was identical to that

of WWN, a 50 kW "clear-channel" station in New Orleans. During the day there was no conflict with the local station, but at night the skip-distance phenomenon often allowed WWN to come booming into Ithaca. Consequently, an application for extended hours of operation would have been to no avail. Eventually, WHCU-AM received its current frequency allocation of 870 kHz, and now the commercial station operates without interference at night.

[Pertinent information on the history of early radio at Cornell and in Ithaca was obtained (courtesy of the Division of Rare and Manuscript Collections, Carl A. Kroch Library) from "Radio Station Development—A Chronological Outline," prepared by Professor Emeritus ***Elmer S. Phillips*** *of the Department of Communication in the College of Agriculture and Life Sciences.—Ed.].*

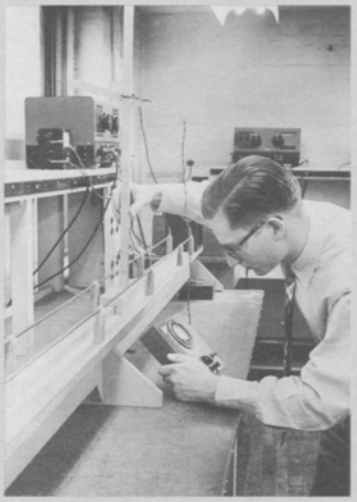
In the decade following the acquisition of the broadcast transmitter, major developments in the radio art had been gradually introduced into the communication courses offered in the EE School. In 1940, five elective courses were available to seniors: EE 451–52, "Electrical Communication Engineering," taught by Ballard and McLean; EE 453–54, "Theory of Communication Networks," taught by McLean; and EE 456, "Elements of Broadcast Engineering," taught by Instructor **William D. Moeder,** with laboratory sessions that included contact with WHCU equipment. By 1944, courses EE 451–52 had been broadened to include work in the rapidly expanding field of ultrahigh-frequency radio waves, which were of great importance in the war effort.

EE School courses offered in the Navy V-12 Program at Cornell during World War II included NEE [Naval Electrical Engineering] 7 and 8, "High-Frequency Circuit Theory I and II," taught by Professor Ballard, Associate Professor McLean, and Instructor **Charles L. Seeger III** '42; and NEE 7 and 8 laboratories, "High-Frequency Circuits Laboratory I and II," taught by McLean, Seeger, and assistant in electrical engineering **George Beck.** Topics in these courses included network theory, oscillations, cathode-ray tubes and circuits, modulation, demodulation, receivers, transmitters, high-frequency generators, transmission lines, waveguides, radiation, and propagation (see Figure 4).

Two young instructors, **Howard G. Smith** and **A. Berry Credle,** joined the communications group during Professor **W. A. Lewis**'s term as director of the EE School. When **Charles R. Burrows** became director in 1945, Smith and Credle, now both associate professors, joined with Ballard and McLean to form a new division in the EE School called "Radio and Communication." Establishment of the new five-year engineering-college curriculum inspired the division to offer thirteen specific communication courses in addition to the basic courses in the discipline. Under the new course numbers adopted by the EE School, the courses included: EE 4511–12, "Radio and Communication Theory," taught by Ballard and McLean; EE 4513, "Communication Networks," taught by McLean; EE 4516–17, "Radio and Communication Laboratory," taught by Credle and McLean; and EE 4521, "Radio Broadcasting," taught by Smith.

With WHCU-AM firmly established, members of the communications group began to consider the potential of frequency-modulation (FM) radio. Since True McLean was a classical-music enthusiast he was particularly excited about static-free reception that could be obtained by means of the new FM medium. Since FM is limited to line-of-sight transmission, it could not be used to receive the Manhattan-based classical-music station, WQXR, which could only be heard after dark in Ithaca, and even then the AM reception was relatively poor. This problem was solved by establishment of a series of line-of-sight FM relay stations across New York State, known as the Rural Radio Network, which allowed WQXR to come into Ithaca around the clock. True served as an enthusiastic consultant to this worthy project that delighted many Ithacans for years until economic difficulties caused its demise. Eventually, as an adjunct to AM broadcasts, WHCU developed an FM-stereo outlet that was devoted principally to classical music until both stations changed to popular music, sporting events, and rock after they were sold by the university. For a time WHCU-FM and its sister station, WVBR-FM, also broadcast classical music, but both eventually switched to popular-music formats. In Ithaca today, classical-music enthusiasts depend upon public broadcasting transmissions from direct-FM stations or cable and satellite services.

Figure 4.—An EE School graduate student conducting a high-frequency measurement in the radio laboratory in Franklin Hall.



Division of Rare and Manuscript Collections, Kroch Library

Toward Advanced Wireless Technology

The Radio and Communication Division enjoyed its most productive period in the EE School in the 1950s. Faculty and student interest in the electric-power option gradually gave way to study in the new areas of servomechanisms and power electronics, and enrollment in communication courses reached all-time highs. By the end of the period the division offered some twenty courses, which included not only traditional studies, but also new topics, such as radio aids to navigation, pulse techniques in radio and communication, radar, electromagnetic waves, wave propagation, microwaves, and applied acoustics. In addition to Professors Ballard, Credle, McLean, and Smith, the field attracted newcomers in the EE School including, **Paul Ankrum, Henry Booker, Clyde E. Ingalls, Walter Jones, Joseph C. Logue, Henry McGaughan,** and **Ben Nichols.** When the EE School moved to Phillips Hall in February 1955, the radio and communication laboratory was established on the fourth floor of the east wing. The 1956 issue of the College of Engineering course catalog included a description of existing radio and communication laboratory equipment and added a statement that in hindsight can be interpreted as a

forecast of new directions in radio and communication: "Facilities now available for instruction and research include the radio-astronomy laboratory (at the airport), engaged primarily in basic research, the antenna laboratory for the investigation of directional characteristics of antennas, and the ionospheric laboratory."

In 1963, the EE School curriculum was divided into "Systems" and "Electrophysics," with laboratory instruction in both. Upon completion of the required EE School courses, upper-class students could choose electives from specific areas in the EE School within a designated framework required for graduation. Courses in the former Radio and Communication Division were separated into "Communications Systems" and "Radio Science." A student could still specialize in wireless communication through the choice of suitable electives, but the old communications option was no longer available. The *Cornell Announcements* for 1963–64 carried the following description of the EE School Radio and Communication Laboratory: "Students have a choice of five different experiments from the fields of electronic circuits, networks, transmission lines, waveguides, and antennas. Experiments are selected to meet individual needs." By the time these curriculum changes had occurred, Henry Booker, Charles Burrows, and Berry Credle had left the EE School and over the next few years, the courses in radio science and communication systems were taught by Professors **Conrad Dalman, Lester Eastman, Bill Gordon, Lee Mackenzie, Paul R. McIsaac,** and **H. C. Torng.** True McLean was still active in the EE School and taught his course, "Radio Aids to Navigation," until his retirement in 1966.

In the following years, into the '70s, increased interest in technologies related to areas such as control systems, computers, integrated circuits, plasma physics, microwave circuits, and radio and radar astronomy gradually reduced the number of specific courses in radio communication and, as in other early disciplines, topics and laboratory exercises related to standard wireless technology were transferred from upper-level to undergraduate courses. The group of electives previously listed under "Radio Science" were placed under a new area called "Radio and Plasma Physics," and the "Communications" area offered electives in algebraic coding, principles of analog and digital communication, transmission of information, and decision and estimation theory. By 1975 the sole remaining specific radio-engineering course, EE 582, was described in the *Cornell Announcements* as concerned with, "electrical systems for communication, control, detection, and other purposes in which radio waves play a central role; system functions including generation, modulation, transmission, reception, and demodulation; guidance systems; and propagation of radio waves including transmission lines and waveguides, antenna systems, the effect of atmospheric inhomogeneity; and system-design problems."

Similar courses have been offered in subsequent years to upper-class and graduate students who maintain an interest in classic radio engineering. Current radio and radar research, and advanced instruction in the discipline are performed by members of the Space-Plasma Physics group, in conjunction with the radio-astronomy observatories in Arecibo, Puerto Rico and in Jicamarca, Peru (See the 1995 issue of *Connections).* In the 1997–98 academic year, two members of this group, Professor **Donald T. Farley** '56, and Lecturer **Wesley Swartz,** offered EE 487, "Introduction to Antennas and Radar," and EE 488, "RF Circuits and Systems." The strong student interest in these two courses bodes well for equal interest in study and research on the problems associated with the latest areas of wireless technology, the rapidly developing mobile-telephone and data-link systems.

A first glance at the "new wireless technology" could very well raise the question of what is really new. The standard radio principles of generation, modulation, signal transmission, detection, demodulation, and signal reproduction are all present in the new technology. Even FM and microwave techniques are certainly "old hat." An in-depth examination of the remarkable new cellular phones, however, reveals that their seemingly routine ability to allow worldwide communication from practically any point on the globe is heavily dependent on techniques such as information processing, optimization, and network analysis derived from other disciplines. The resulting highly complex systems, intricate networks, and elaborate computer protocols form the basis for the "common-air" medium required for wireless mobile communication systems.

The portable handsets and data-link devices are marvels of modern microprocessor and integrated-circuit design combined with efficient miniature radio transmitters and receivers. The cellular stations and their integration with associated telephone-cable and/or satellite-communication links require a high order of network design, and the problems posed by the enormous requirements for multiple access are solved by the application of sequential-code-acquisition techniques and error-control algorithms based upon information theory. The essential issues of privacy are addressed by application of cryptographic methods.

Associate Professors **Zygmunt J. Haas, Stephen B. Wicker,** and Assistant Professor **Venugopal V. Veeravalli** are recently appointed members of the EE School faculty who are actively engaged in research and teaching in this modern approach to wireless technology. Their specific interests and accomplishments are described elsewhere in this newsletter, together with those of other members of the faculty who are making contributions to the new discipline.

Sam Linke
Professor Emeritus
Electrical Engineering

THE WIRELESS NETWORK RESEARCH GROUP

The Wireless Network Research Group in the School of Electrical Engineering consists of two associate professors, **Zygmunt J. Haas** and **Stephen B. Wicker,** and an assistant professor, **Venugopal V. Veeravalli,** and some of their graduate students. Associate Professor **Lang Tong,** who specializes in signal processing for wireless networks, became associated with the group when he joined the EE School in the Fall 1998 semester. Wireless research in the EE School has been positively enhanced by the recent establishment in Rhodes Hall of the joint EE School and Department of Computer Science "virtual" PeopleSoft Laboratory, and the Wireless Systems Engineering (WiSE) Laboratory. Other members of the EE School faculty who contribute to the research of the group include Professor **Toby Berger,** with interests in code-division multiple-access and information theory for wireless networks, Professor **Terrence L. Fine,** who is looking into the applications of artificial intelligence to telecommunications networks, Professor **C. Richard Johnson Jr.,** who is concerned with adaptive and signal processes for wireless networks, and Assistant Professor **Sheila S. Hemami,** who performs research in visual communication. The principal research areas of the Wireless Network Research Group are described in the following three articles.

MOBILE AND WIRELESS NETWORK RESEARCH

Directed by Zygmunt J. Haas

Doug Hicks

In 1977 the Cornell Program on Science, Technology, and Society, now known as the Department of Science and Technology Studies, conducted an NSF-sponsored study on *Communications for a Mobile Society—An Assessment of a New Technology,* that resulted in the publication of a book of the same title (Sage Publications, 1978). Chapter 2 of that volume, entitled "Technologies for Land Mobile Communications: 900 MHz Systems," coauthored by **Jeffrey Frey,** B.E.E. '60, an associate professor in the EE School at the time, and his graduate student **Alfred M. Lee,** M.S. '75, Ph.D. '81, discussed general technical aspects of mobile communication, the technology of cellular and noncellular systems, and future developments in mobile land-communication technology. Although the overall study was concerned with the problems of Citizen's Band (CB) radio, Jeffrey concentrated on the elements of the emerging cellular communications system, and examined some of the problems that would arise when cellular systems entered into worldwide use. Now, twenty years after this initial study, the phenomenal growth of mobile and wireless communications systems has created, as predicted, major challenges for research in communication theory, information theory, networking, and associated technologies.

At present, wireless mobile communication systems provide facilities that are used primarily for voice transmission and reception. Projections for the next generation of systems include the availability of wider bandwidths, substantially higher data-transmission rates, and considerably increased flexibility. It may then be possible to have "global seamless roaming," widespread voice, data, and video services provided by means of interactive multimedia facilities, such as teleconferencing, and Internet access through coordinated systems including fixed-wireline, terrestrial-wireless, and satellite-wireless transmission. Mobile and wireless network research at Cornell is dedicated to achieving these objectives, thereby allowing development of applications such as virtual navigation, tele-medicine, tele-geoprocessing (combination of geographical and global positioning systems), crisis management during natural disasters, and education via the Internet.

For the past decade Associate Professor **Zygmunt J. Haas** has been a widely known investigator in the fields of data communication, wireless and mobile networks, personal communication service, high-speed communication protocols, and optical networks. At Cornell his research has addressed work in these fields, including macro-diversity techniques for narrow-band wireless systems, protocols for ad-hoc networking environments, mobility management in cellular networks, integrated (multimedia) medium-access-control protocols, channel allocation in cellular networks, adaptation of networking protocols to mobile environments, and design of multitier networks. His work in these areas is unique in the sense that it encompasses and integrates both the communication and networking aspects of the wireless and mobile networks.

Zygmunt received the B.Sc. degree in 1979 from the Technion (Israel Institute of Technology, Haifa, Israel), the M.Sc. degree in 1985 from Tel-Aviv University, and the Ph.D degree in 1989 from Stanford University (all in electrical engineering). From 1988 to 1994 he was a member of the technical staff of the AT&T Department of Network Research, and then spent a year in the AT&T Wireless Center of Excellence. At AT&T Bell Laboratories he led a research project that included implementation of protocols and applications for wireless and mobile local-area networks (LANs): in particular, network-layer protocols, transport-layer protocols, and applications supporting mobility in a workplace. In August 1995 he joined the EE School faculty as an associate professor. Zygmunt is a senior member of IEEE and a voting member of the Association for Computing Machinery. He is the author of

numerous technical papers, holds twelve patents in the fields of high-speed networking, wireless networks, and optical switching, and has filed two patent applications with the Cornell Research Foundation on "Multiply-Detected Macrodiversity, " and "Routing and Mobility Management Protocols for Ad-Hoc Networks." He has organized several workshops, delivered tutorials at major IEEE conferences, and serves on the editorial boards of several journals. He was guest editor of three issues of the *IEEE Journal on Selected Areas in Communications.* He has served on National Science Foundation (NSF) review panels and has been a reviewer of NSF proposals in his field of expertise. He has authored or coauthored twenty-seven articles that have appeared in refereed journals, six book chapters, and about seventy papers that have been published in conference proceedings, mostly on the communication and networking aspects of wireless and mobile networks.

Since his arrival in the EE School, Zygmunt and his graduate students and associates have been conducting research on the previously mentioned topics. One area of particular interest, macrodiversity techniques, is concerned with the maintenance of efficient and coherent mobile communication in a cellular network under a wide variety of possible conditions that may cause interference with desired system behavior. A novel scheme has been proposed and analyzed that allows significant improvement in the bit-error rate and reduction in the outage probability of faded mobile communication under realistic outdoor propagation conditions. The study has shown that system outages may be eliminated at least 45 percent of the time. As part of this work, a simple formula has been developed that can be used to make significant reductions in the complexity of wireless cellular network simulation, thereby allowing development of practical models of certain systems that could not be simulated using previous methods.

Trouble-free mobility management of cellular networks is another one of the sensitive features of wireless communication that must be provided to ensure satisfactory operation of the system. Current mobility-management schemes are nearly always handled through a centralized process in which every mobile unit notifies a database—the home location register (HLR)—that keeps track of the location of mobile units that are associated with that HLR. Zygmunt and his group have developed and proposed a novel alternative approach, based on quorum theory, that distributes the location-tracking operation among multiple locations. Quorums are sets that are formed from the databases in such a way that any two quorums overlap in at least one database. The mobile locations are reported to one quorum and are read from a different one. Since the quorums overlap, a read operation will always extract the current location of the mobile.

Zygmunt and his group plan to extend their current research and investigate new research directions that are appearing in the active field of wireless and mobile networks. He is especially enthusiastic about the trend toward collaboration between communication-oriented electrical engineers and computer scientists. This collaboration may produce far-reaching results, one of which is the new field of mobile computing.

WIRELESS INFORMATION NETWORK RESEARCH

Directed by Stephen B. Wicker

Engineering Publications

During the mid '60s, when terrestrial mobile wireless communication was in its infancy with relatively few users, telecommunication service was limited to voice transmission and reception over short distances. Problems of operation were primarily with finding suitable frequency allocations to minimize interference between individual transmitters. In contrast, present-day wireless communication exists in a completely different interactive environment. Unprecedented requirements exist for management and control of highly complex networks that must provide continuous multiple-access global telecommunication, high data-transfer rates, and flexible Internet connections operating under constraints introduced by simultaneous service to millions of users. Fixed-location telephone service in the wireless mode depends upon two factors not present in conventional wired telephone service: interference between units and the need to guarantee privacy of communication. Similar constraints occur under low-mobility conditions when users are walking on the street, riding elevators, or making short trips in automobiles, trains, and buses, except that the signals may be reflected from buildings and other moving vehicles. Additional problems occur in high-mobility conditions when users are traveling over long distances in high-speed automobiles, trains, or aircraft.

Wireless information network research is concerned with the development of control technology that can sort out this multitude of diverse broadcast signals, correct errors, and—by means of special codes built into the transmission media—allow every receiver to obtain an intelligible message. These systems will soon be governed by technology derived from information theory, artificial-intelligence theory, and coding theory. Privacy issues are addressed by the application of cryptographic procedures. Conversely, physical solutions to problems posed by wireless communication networks operating under these varied constraints are relatively straightforward. Signal strengths are maintained at low levels to minimize interference in both fixed and low-mobility situations. High-mobility conditions are managed by an approach in which the world is divided into small areas or cells with a multichannel carrier frequency designated for each cell. As people in several cells who are using these channels move between cells, they are switched from one frequency to another by computer-controlled monitors. This technique has given rise to the current widespread use of the term "cellular phone." Many of these techniques were developed for telecommunication in the deep-space satellite program and have been adapted for use in terrestrial systems. The first error-control system was launched into space aboard the *Pioneer 9* spacecraft on November 8, 1968. Since then, coding theory has advanced to the current state of the art, represented by the parallel concatenated-coding experiment aboard the *Cassini* spacecraft, which began its mission to Saturn on October 15, 1997.

Associate Professor **Stephen B. Wicker** is well-known in the wireless telecommunication field for his research in wireless information networks, digital communications systems, and error-control coding. He has focused on the development and application of advanced technologies for data links and multiple-access protocols in wireless networks, including the application of artificial intelligence and expert systems to the development of automatically configuring communications networks, turbo error control (*see definition below*), and iterative channel-estimation algorithms. Past results include the development of parallel turbo decoding, adaptive protocols for nonstationary chan-

nels, neural net-based decoders and equalizers, soft-output concatenated error-control systems for the deep-space network, the design of several digital signature schemes, and the cryptoanalysis (and "breaking") of several other digital signature schemes.

Steve received the B.S. degree from the University of Virginia in 1982, the M.S. degree from Purdue University in 1983, and the Ph.D. degree from the University of California at Los Angeles in 1987, all in electrical engineering. After working as a space and communications staff engineer in the Department of Information Science of the Hughes Aircraft Company in El Segundo, California from 1983–1987, he became a member of the faculty of the School of Electrical and Computer Engineering at the Georgia Institute of Technology. In 1992 he was named a visiting fellow of the British Columbia Advanced Systems Institute. He joined the Cornell faculty as an associate professor of electrical engineering in July 1996.

Over the years, Steve has been a consultant on error-control techniques and coding theory to about a dozen corporations. He is a senior member of the IEEE, a member of the IEEE Communications, Information Theory, and Vehicular Technology societies, and was elected to the board of governors of the IEEE Information Theory Society in 1996. Steve is the author of *Error Control Systems for Digital Communication and Storage* (Prentice Hall, 1995) and is the coauthor, with Associate Professor **Chris Heegard,** of *Turbo Coding* (Kluwer Academic Press, 1999). The latter work is the first book published on turbo coding, an advanced technique that decodes received information several times, compares the results to arrive at a consensus, and recalculates whatever cannot be resolved. He is also coauthor of a volume on Reed–Solomon codes, and of another book on error control, cryptology, and speech compression. He has contributed a chapter on "Deep-Space Applications" to the *Handbook of Coding Theory* (Elsevier, 1998), and to portions of other volumes on coding theory and coded protocols. He is the editor for coding theory and techniques for the *IEEE Transactions on Communications,* coeditor of *Reed–Solomon Codes and Their Applications* (IEEE Press, 1994), has authored or coauthored about thirty-two articles that have appeared in refereed journals and about seventy that have been published in conference proceedings, mostly on coding theory and error-control protocols. Steve and a colleague hold a patent on an analog neural-net Viterbi decoder, and, together with other colleagues, has several patents pending on related decoders.

Steve and his associates in the EE School and in the Department of Computer Science have established the PeopleSoft Lab, a joint "virtual" laboratory that uses state-of-the-art computers to simulate real wireless networks in real time (see Figure 5). The facility was funded by a $1 million grant from **David A. Duffield**, B.E.E. '63, M.B.A. '64, president and founder of PeopleSoft, Inc., in support of interdisciplinary efforts in telecommunication and information technology. The laboratory consists of two components, one for the EE School, in Rhodes Hall (the former Engineering and Theory Center building) and the Computer Science unit in Upson Hall, the two joined by a fiber-optics connection (see Figure 6). The EE School computational infrastructure consists of a high-speed/high-capacity server and twelve 200/300 MHz Sun Microsystems workstations joined by a 100 Mb-per-second Ethernet network that allows high-bandwidth video conferencing. The facility is now the focal point for several collaborative projects, including a joint EE/CS effort to study the application of artificial intelligence to communication networks through development of predictive algorithms that support random access, mobility management, and resource allocation in wireless networks. Steve calls the subject of this study "cognitive engineering," and considers it to be an excellent example of the benefits of faculty collaboration. In September 1997, the initial results of the study led to a $900,000 grant from the National Science Foundation to Steve and his colleagues, Professor of Electrical Engineering **Terrence L. Fine** and Professor of Computer Science **Joseph Halpern.** These funds, together with additional support from several corporations, have allowed the establishment of a wireless multimedia center in the EE School as a computational infrastructure for EE/CS wireless laboratories and programs that bodes well for the future of telecommunications research at Cornell.

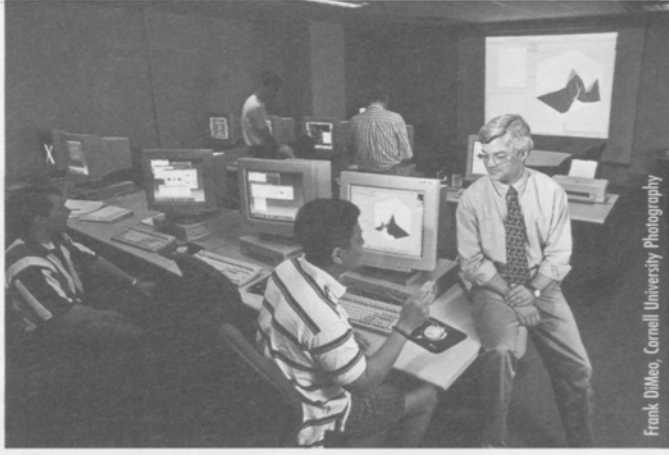
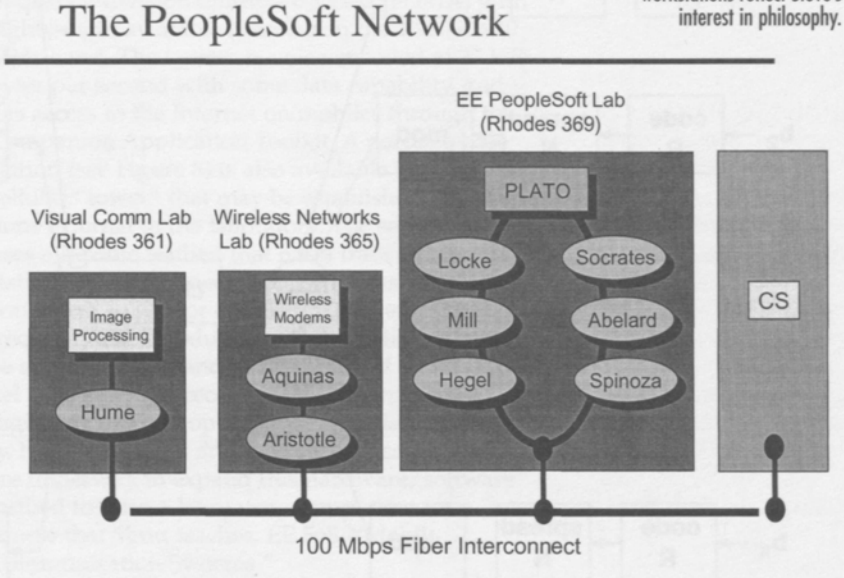

Frank DiMeo, Cornell University Photography

Figure 5.—View of the PeopleSoft Wireless Laboratory. Professor Wicker is at right conversing with graduate student Noah Henyon.

Figure 6.—Diagram of the PeopleSoft Interconnected Network. The names of the workstations reflect Steve's interest in philosophy.



WIRELESS SYSTEMS ENGINEERING (WiSE) LABORATORY

Directed by Venugopal V. Veeravalli

When telecommunications systems became technically and economically feasible, the popular use of the new facilities created an immediate need for multiple channels to meet the continually growing demand for telephone service. Tall wooden poles equipped with dozens of crossarms that held hundreds of wires aloft were soon erected along city streets and country roads. The duplex system that allowed two conversations on a single pair of wires was a welcome development, and was a forerunner of later techniques that would be used to expand the capability of a single channel. As open wires gave way to compact cables with increased numbers of individual wire lines, and, more recently, with wide-bandwidth fiber-optic lines, the continued demand for more and more channels stimulated development of sophisticated time-sharing techniques. For example, a cycle of an audio signal was split into many separate narrow pulses, and the space between pulses was filled with one or more additional sets of pulses from different signals, all of which were transmitted simultaneously on the same line. The technique works well for audio and music since the ear can fill in the missing pieces of the signal. Unfortunately, this time-sharing procedure is inadequate for data-link operation, so more complex error-control techniques have been developed.

Similar techniques have been applied to mobile wireless telecommunication systems, but with consideration of the difficulties inherent in cellular networks that require frequency-sensitive "handoff" procedures because the same limited bandwidth must be shared across cells as a user moves from cell to cell. Federal Communications Commission limitations on bandwidth allocations pose additional problems. As wireless systems have grown over the years, a number of these signal-compression schemes have been incorporated into wireless system operations with varying success. In early 1992, the introduction of digital technology into wireless systems created a major change in the cellular-telephone industry and in the procedures for maximizing the capability of telecommunication channels. An article in the August 1, 1993 issue of the *New York Times* contains a summary of the two major procedures now in general use. One scheme, known as time-division multiple-access (TDMA), condenses three conversations into one channel by breaking them into discrete fragments and transmitting one fragment from each conversation through the channel at precisely timed intervals that prevent overlap of the conversations. The three calls are recombined at the receiving end. The second procedure, called code-division multiple-access (CDMA), was conceived by an EE School alumnus, **Irwin M. Jacobs,** B.E.E. '56 (chairman of Qualcomm, Inc. of San Diego) and his colleagues. This method can transmit many conversations through a single channel, depending on the available bandwidth, by encoding each call with a unique electronic identifier and then breaking it into discrete fragments. The

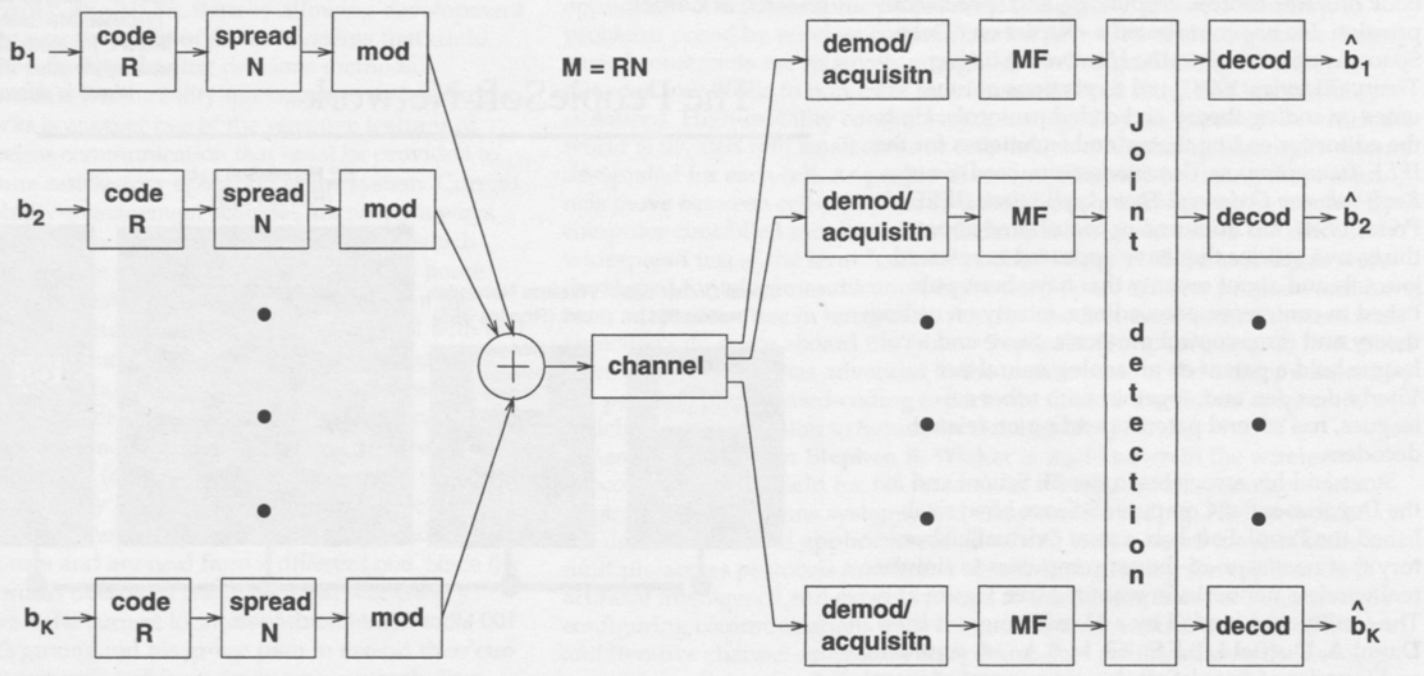


Figure 7.—Block diagram of a typical CDMA system.

Venugopal V. Veeravalli

fragments of all the conversations are transmitted simultaneously in haphazard fashion and recombined into the original messages at the receiving end. The *New York Times* article characterizes CDMA as a "multilane highway" in comparison with TDMA as a "country road."

Assistant Professor **Venugopal V. Veeravalli** conducts research in mobile and wireless communication systems and related topics in communication theory. Areas of current interest include accurate channel modeling for wireless systems that take spatial-frequency reuse into account, information theory and capacity analysis applied to wireless systems, dynamic radio-resource management, and optimization of CDMA systems for wireless access (see Figure 7). Ongoing research topics include cellular CDMA-network design, sequential code-acquisition and multiuser-detection techniques for CDMA systems, handoff and power-control algorithms for wireless networks, and coding-spreading tradeoff issues in CDMA systems. He is also working to develop a much-needed theoretical framework for the analysis of large-scale decentralized dynamic decision-making problems that could have applications not only in wireless communication, but also in other areas such as power systems and economic systems.

Venu received the B.S. degree in 1985 from the Indian Institute of Technology in Bombay, the M.S. degree in 1987 from Carnegie–Mellon University, and the Ph.D. in 1992 from the University of Illinois at Urbana–Champaign, all in electrical engineering. After serving as a postdoctoral fellow in 1992–93 at the Division of Applied Science at Harvard University, he was an assistant professor of electrical engineering at City College of New York in 1993–94, and a visiting assistant professor of electrical engineering at Rice University in 1994–96. He joined the EE School faculty in July 1996 as an assistant professor. In 1998 Venu received a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF), and in February 1999 he was selected—as one of twenty of the most meritorious recipients of that award—for the Presidential Early Career Award for Scientists and Engineers (PECASE). He has been a consultant on several industry projects, particularly in the wireless communication area. He is a senior member of the IEEE, the corecipient of the 1996 IEEE Browder J. Thompson Best Paper Award, and serves as a reviewer for several IEEE journals and other publications. He has authored or coauthored more than fifteen articles that have appeared in refereed journals, and over thirty that have been published in conference publications and proceedings, many on CDMA wireless systems and related topics. Venu and his associates have submitted four patent applications on wireless telecommunication systems.

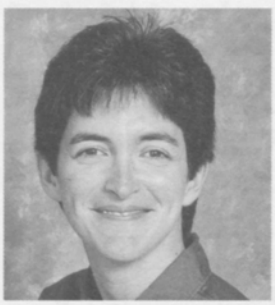
Research in wireless systems for Venu and his associates in the EE School is motivated by the desire to achieve high-quality wireless access that is ubiquitous, efficient, and cost effective. The primary goal of his research group, the Wireless Systems Engineering (WiSE) Laboratory in Rhodes Hall, is to meet this objective by developing techniques for optimizing the quality and capacity of wireless communication systems. At present, the research group consists of five M.S./Ph.D. candidates, four Master of Engineering (M.Eng.) candidates, and five undergraduate students. The laboratory also has two hardware projects at the undergraduate and M.Eng. levels. The first of these involves studies that use an indoor cellular testbed. The indoor unit contains six base stations, a controller, and a monitoring PC that supports time-division multiple-access (TDMA) and frequency-division multiplex-access (FDMA) with eighty-eight available channels in the 1,910–1,920 MHz band. The system is voice-encoded at 32 kilobytes per second with some data capability, and has access to the Internet on mobiles through the Companion Application Toolkit. A portable base station (see Figure 8) is also available for use as a cellular "tower" that may be established at locations external to the laboratory. The second project uses a flexible testbed that has a transmitter consisting of a PC connected to a wide-band arbitrary-waveform generator coupled to a tunable radio-frequency (RF) modulator. Channel distortion may be added in baseband or by means of an RF channel emulator. The receiver is a PC connected to a digitizing oscilloscope with demodulation capability, high resolution, and long record length. Plans are underway to expand this hardware/software testbed to form a laboratory component for a course that Venu teaches, EE 568, "Mobile Communication Systems."

Nicola Kountoupes, Cornell University Photography

Figure 8.—Professor Veeravalli shown with a portable base station from his laboratory.

A selection of pre-'90s EE School graduates who have distinguished themselves in industry and academia.

We invite suggestions of additional notable alumnae for future issues of *Connections.*



JENNIFER (TRUMAN) BERNHARD

JUDITH B. CARDELL

SARAH THOLE FISCHELL

SUSAN SPIRA HAKKARAINEN

MIRIAM LEESER

Jennifer (Truman) Bernhard, B.S.Engr. '88, received her baccalaureate degree in 1988 from Cornell University, and the M.S. and Ph.D. degrees from Duke University in 1990 and 1994, respectively, all in electrical engineering. In 1994–95 she was a postdoctoral research associate with the Departments of Radiation Oncology and Electrical Engineering at Duke. Since 1995, Jennifer has been an assistant professor in the Department of Electrical and Computer Engineering at the University of New Hampshire, where she holds the Class of 1944 Professorship. In 1977 she received a Sloan New Faculty Fellowship and won the 1997–1998 Teacher of the Year Award for the College of Engineering and Physical Sciences at UNH. At present she holds two grants from the National Science Foundation for research into wireless communication and integrated antennas. In the summer of 1999, Jennifer will be an American Society of Engineering Education Faculty Fellow at the NASA (National Aeronautics and Space Administration) John H. Glenn Research Center at Lewis Field in Cleveland, Ohio, and in the fall of 1999 she will join the Department of Electrical and Computer Engineering at the University of Illinois at Urbana–Champaign as an assistant professor. Jennifer writes that her Cornell experience fostered her interest in electromagnetics and established a strong background for her graduate work. She recalls Professors **Michael C. Kelley, Ralph Bolgiano,** and **Richard Compton** as having been excellent role models for research and teaching. Away from academic life, she enjoys traveling with her husband, reading murder mysteries, and playing an occasional game of squash.

Judith B. Cardell, B.S.Engr. '88, received her baccalaureate degree in electrical engineering and an A.B. degree in government from Cornell University in 1989. She obtained the M.S. and Ph.D. degrees from the Department of Electrical Engineering and Computer Science at Massachusetts Institute of Technology in the field of technology and policy in 1994 and 1997, respectively. While at Cornell she worked at Digital Equipment Corporation (DEC) under the Engineering Cooperative Program and continued with DEC after graduation on a VLSI-design team as a signal-integrity engineer. During her graduate studies Judith concentrated on the engineering and economic aspects of electric-utility operations and planning. In her current position as an electrical engineer in the Office of Economic Policy at the Federal Energy Regulatory Commission, Judith is part of a group that is developing a model to analyze the competitive and reliability effects of utility-industry restructuring and mergers. She is also involved in the development of principles for independent system operators, and of guidelines for approving market-based rates for ancillary services. Judith recalls her electrical-engineering undergraduate education as having been invaluable to both her professional and academic careers. In particular, the dual bachelors degree in electrical engineering and government eventually led to her current position with the Federal Government. Her hobbies include bicycling, piano, and a budding interest in gardening.

Sarah Thole Fischell, B.S.Engr. '78, obtained her baccalaureate degree in 1978 and her M.Eng. degree in 1979 from Cornell University, both in electrical engineering with specialization in communication and computer architecture. She joined AT&T Bell Laboratories in 1978 and worked for AT&T until 1998 in positions including member of technical staff, technical manager, and division manager. Some of her accomplishments (in chronological order) include: implementing network technology for AT&T's Primary Rate ISDN (integrated-services digital network) service; defining a novel mechanism for accessing customer information needed for real-time call processing; defining the network architecture and technology needed to implement at AT&T an initial local-service offering for business customers; managing AT&T's successful participation in the industry-mandated Local Number Portability Trial; and defining and implementing within her organization a well-defined systems-engineering process. She is a member of IEEE, holds two patents and four AT&T Architecture Awards, and serves on the board of directors for the Cornell Society of Engineers. Sarah writes that her EE School education at Cornell not only gave her a foundation for understanding telecommunication and computing technology issues and evolution in the last twenty years, but perhaps more importantly, provided her with critical experience in teamwork to define problems and to find solutions to those problems. Currently, she divides her time between telecommunications consulting, technology planning for the Fair Haven, New Jersey schools, and a variety of community and family activities. Sarah is married to **David R. Fischell,** B.S.Engr. '75, M.S. '78, Ph.D. '80 (all in applied and engineering physics at Cornell) and has two children. In her spare time, she enjoys skiing, gardening, and traveling with her family.

Susan Spira Hakkarainen, B.S.Engr. '82, received her baccalaureate and M.S. degrees in electrical engineering from Cornell University in 1982 and 1983, respectively, and her Ph.D. degree in applied plasma physics from Massachusetts Institute of Technology in 1989. She began her professional career with the Naval Research Laboratory and Raytheon Corporation in the thermonuclear-fusion program, and continued in that field as a visiting scientist at Toshiba Corporation's energy-science and technology laboratory in Tokyo, Japan. When Susan returned to the U.S. in 1990, she joined Lutron Electronics Company, the world's leading manufacturer of lighting controls, and started the company's Japanese Division with responsibility for developing initial marketing plans, establishing distribution, and creating products for the Japanese market. In 1995 she was promoted to director of Japan/Asia operations with management responsibilities for marketing throughout the Far East. She also became a member of Lutron's corporate strategic planning and patent administration teams. In 1996 Susan was promoted to vice president of international marketing. In 1998, she became the general manager of the visual-environment control-systems group, which is charged, among other responsibilities, with development of products for controlling and dimming fluorescent lighting. Susan writes that her engineering background taught her how to analyze and organize information and facts for business planning as well as for internal and external presentations, and helped her to learn varied disciplines such as accounting, foreign languages, and industrial and graphic design.

Susan delights in spending time with her children, and in her spare time, enjoys cooking and learning about other cultures.

Miriam Leeser, B.S.E.E. '80, associate professor of electrical engineering at Northeastern University, received her baccalaureate degree in electrical engineering from Cornell University in 1980, and the Diploma and Ph.D. from Cambridge University in England in 1984 and 1988, respectively, both in computer science. From 1980–84 she worked as a development engineer at Codex Corporation in Mansfield, Massachusetts. Miriam joined the EE School faculty at Cornell in 1988 as an assistant professor, was named a National Science Foundation Young Investigator in 1992, and was promoted to associate professor in 1995. In January 1996, she joined the electrical and computer-engineering faculty at Northeastern University, where she is also a member of the Center for Communications and Digital Signal Processing, head of the Rapid Prototyping Laboratory, and collaborates in research with Massachusetts Institute of Technology at Lincoln and Los Alamos National Laboratories. Her research interests include hardware-description languages, high-level synthesis, and reconfigurable computing for signal and image-processing applications. She is the author and coauthor of more than fifty refereed journal articles and conference papers, a senior member of the IEEE, and a member of the Society of Women Engineers, the Association for Computing Machinery, and the Society of Photo-Optical Instrumentation Engineers. Married with two children, Miriam also finds time for bicycling and cross-country skiing.

Jodi L. MacDonald

Jodi L. MacDonald, B.S.Engr. '81, received her baccalaureate degree in electrical engineering from Cornell University in 1981, joined Intel Corporation as a field application engineer, and gradually moved into a regional architecture specialist role. From 1991 to 1994 she was the Northeast applications manager with responsibility for thirteen field application engineers. In her present position as a program manager in Intel's Direct Contact Marketing Group, Jodi is responsible for coordinating and supporting activities for Intel's architecture managers (AMs). The AM group mission is to accelerate the adoption of new Intel technology in business as well as to collect and analyze key market trends that contribute to Intel's strategic business-planning process. A recent program encompassed the coordination of AM interaction with Internet service providers worldwide. Jodi writes that her engineering education at Cornell was an excellent foundation for the continual learning required by the fast-paced computer industry. Jodi has two children, aged four and two. Depending on the season, she enjoys skiing and gardening. In February, she and her husband traveled to South Africa for a memorable safari vacation.

Margaret Martonosi

Margaret Martonosi, B.S.Engr. '86, assistant professor of electrical engineering at Princeton University, obtained her baccalaureate degree in electrical engineering, with distinction, from Cornell University in 1986, received a National Science Foundation (NSF) Graduate Fellowship in the same year, and earned her M.S. and Ph.D. degrees from Stanford University in 1987 and 1993, respectively, both in electrical engineering. She joined the faculty of the Department of Electrical Engineering at Princeton in 1994 as an assistant professor. In 1995, Margaret received a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF), and in 1998 she was recognized for excellence in teaching and scholarship by the Howard B. Wentz Award from the Princeton School of Engineering and Applied Science. Her research interests are in computer systems with recent attention to application of performance analysis techniques to program customization and dynamic adaptive execution. She is a member of IEEE, the Association of Computing Machinery, and the IEEE Computer Society, and is the coauthor of eleven refereed journal articles and twenty-two conference papers. In her spare time, she enjoys hiking, skiing, and gardening. Margaret comments that the broad strength of the Cornell EE School undergraduate curriculum gave her a deep exposure to many different aspects of the field, and offered many options from which to choose a suitable area for further study.

Cheryl F. Newman

Cheryl F. Newman, B.S.Engr. '70, received her baccalaureate degree in 1970, the M.S. degree in 1972, and the Ph.D. degree in 1975, all from Cornell University and all in electrical engineering. She joined Bell Laboratories in October 1974 as a member of the technical staff, where she extended her electrical engineering background into communication-systems engineering and began her distinguished career in technical management. Cheryl left Bell Laboratories to join Bellcore in January 1984 as a member of the technical staff, and achieved the position of director of exploratory technical-data analysis. She transferred to Pacific Bell in October 1990 as director of special projects, and eventually became director of technical support for national accounts. She returned to Bellcore in April 1992, became director of a special project in education, and returned to AT&T in August 1995 as a member of the technical staff in the architecture area. Cheryl retired from AT&T in December 1998 as principal member of the technical staff. In January 1999 she joined Lucent Technologies as a distinguished member of the technical staff in offer assessment. Cheryl and her husband, Stagg, have shared their long-time hobby of one-day, one-hundred-mile, horseback endurance racing. Over the years they have brought their skills to world-class levels.

Elyse Rosenbaum

Elyse Rosenbaum, B.S.Engr. '84, received her baccalaureate degree (with distinction) from Cornell University in 1984, the M.S. degree from Stanford University in 1985, and the Ph.D. degree from the University of California at Berkeley in 1992, all in electrical engineering. From 1984 through 1987 she was a member of the technical staff of AT&T Bell Laboratories in Holmdel, New Jersey. In 1992 Elyse joined the faculty of the Department of Electrical and Computer Engineering at the University of Illinois at Urbana–Champaign, where she is currently an assistant professor. Her present research interests include modeling and simulation of electrostatic-discharge (ESD) protection circuits, thermal modeling of integrated circuits, gate-oxide reliability, hot-carrier reliability, and silicon-on-insulator technology. She is a member of IEEE and has authored or coauthored more than forty technical papers. She has been the recipient of a Best Student Paper Award from the International Electronic Devices Meeting (IEDM), a Technical Excellence Award from the Semiconductor Research Corporation (SRC), and a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF). Her favored pastimes include travel and cooking, neither of which has she had time for since the birth of her daughter Alana in November 1996.

Jaclyn A. Spear

Jaclyn A. Spear, B.S.Engr. '75 (Electrical Engineering), principal engineer and technical staff member at Westinghouse Savannah River Company in Aiken, South Carolina, joined the Water Reactors Division of Westinghouse in 1975. In her twenty-four years with the company she has served in positions of increasing responsibility in engineering and program management. In her current position she is responsible for providing technical, programmatic, and policy guidance for site personnel. In 1994–95, as national president of the Society of Women Engineers (SWE), Jaclyn developed an interest in technical policy issues. In 1997 she was selected as an IEEE Congressional Fellow and worked for the House International Relations Committee. Jaclyn continues her memberships in SWE and IEEE and chairs the SWE Archives Committee and the IEEE–USA Congressional Fellows Committee. Recently she was elected vice president for membership of the Cornell Society of Engineers, is active in the President's Council of Cornell Women, and is the Twenty-fifth Reunion Campaign Chair for the Class of 1974. Jaclyn and her family all have a long association with the EE School. Her father, the late **Edward D. Spear,** received the B.E.E. in 1947, her mother, **Amy Clark Spear** received her B.E.E. in 1948, and her sister, **Dorothy (DJ) Spear Oakes,** received the B.S.Engr. degree in electrical engineering in 1972. Amy, DJ, and Jaclyn have established the Edward D. Spear Scholarship to be awarded to women (preferably) in engineering.

Project Notes

Duffield Hall Update

On December 10, 1998, the University Board of Trustees unanimously approved a site on the Engineering Quadrangle west of Phillips Hall for the location of Duffield Hall. The new building will be adjacent and parallel to Phillips and will include an atrium to link Duffield to Phillips on the east and to Upson Hall on the south. The report of an Engineering College Siting Committee for Duffield Hall recommended the site and stated the committee's belief that "the Duffield program can move the college forward not only in a strategic research area (nanotechnology research), but also in a way that embraces the president's goal of integrating undergraduate education with research, and that furthers Cornell Engineering's commitment to undergraduate education." The college has established three broad-based committees for faculty input during the design process. One committee will advise on exterior aspects and connections to Phillips and Upson; a second will advise on interior design; and a third will be responsible for safety and management issues. Duffield Hall is tentatively scheduled to be occupied in 2002.

PSERC Receives $10 Million Research Grant

The Power Systems Engineering Research Center (PSERC), a consortium of universities led by Cornell, has received $10 million for research on minimizing failures in complex networks such as electric-power, communication, and distribution systems. The award is from the Electric Power Research Institute (EPRI) and the Army Research Office under the latter's Complex Interactive Network/Systems Initiative. Other members of the consortium include the University of California at Berkeley, the University of Illinois at Urbana–Champaign, George Washington University, Washington State University, and the University of Wisconsin at Madison. PSERC is a National Science Foundation (NSF) Industry–University Cooperative Research Center.

Professor of Electrical Engineering **Robert J. Thomas,** director of PSERC and principal investigator on the project, notes that the participating institutions collectively bring broad expertise to bear on power-system issues that include dynamic modeling and analysis, system protection, nonlinear system theory and control, hybrid systems, failure prediction, and analysis of large-scale systems. Consortium researchers will use the Cornell Theory Center's high-performance computing and visualization resources.

CNF Funding Renewed by NSF

On October 1, 1998, the National Science Foundation (NSF) renewed Cornell Nanofabrication Facility (CNF) funding for another five years. CNF is a member of the National Nanofabrication Users Network (NNUN) that provides nanofabrication facilities for about 1,000 users at Cornell, Howard University, Pennsylvania State University, Stanford University, and the University of California at Santa Barbara. NSF renewed NNUN's budget for a total of $23 million over five years, an increase of about 10 percent over the previous budget. The CNF share also increased to the amount requested in the renewal proposal.

The CNF, which operates state-of-the-art facilities for research into ultrasmall devices for medicine, high-speed communication, and automotive safety, is housed in the Knight Laboratory, which was built in the early 1980s with an endowment from **Lester B. Knight,** M.E. '29. The facility celebrated its twentieth anniversary with a symposium, in September 1998, that brought together university researchers, industry representatives, and government officials for a look into the future of nanotechnology. Their basic conclusion was that they must continue to work together to insure continued progress.

DOE Funds Cornell Fusion Research

The U.S. Department of Energy (DOE) has awarded Cornell its first major funding for thermonuclear-fusion research. In March 1998, DOE granted Cornell research support of $365,000 over two years, to be shared with collaborators at Imperial College, London, and the University of Nevada. A second grant was awarded in June 1998 for $150,000 per year over three years. The so-called inertial-confinement fusion-research program directed by Professor of Electrical Engineering **David A. Hammer,** Ph.D. '69, has been supported by a small grant from DOE's Sandia National Laboratories. (See the 1997 issue of *Connections* for a description of Dave's work on Z-pinches under that program). The new funding will support research at Sandia and Cornell in the development of a fusion system that uses high-power X-rays instead of laser beams to ignite pellets of hydrogen-fusion fuel. The powerful X-ray source is produced by the intense explosion of thin metallic wires to form a plasma that in turn is imploded along the axis of the wire by compression from the self-magnetic field of the current in the plasma (a Z-pinch). In addition to the study of X-ray sources, the Cornell researchers and their off-campus collaborators will test a theory that the imploding wires, as a result of the radiation they emit while imploding, become a thousand times more dense than a metal in its normal state.

Cornell Joins Focus Center Research Program

Cornell, as part of a consortium of seven universities, has been chosen to participate in an ambitious national semiconductor-research effort known as the Focus Center Research Program. The ultimate goal of the group is to develop a new generation of more powerful computer chips by devising new methods to interconnect microchip components. Cornell's partners in the consortium are the State University of New York (SUNY) at Albany, Georgia Institute of Technology, Massachusetts Institute of Technology, Rensselaer Polytechnic Institute, Stanford University, and SUNY at Stony Brook. The successful proposal for this research program, written by Professors of Electrical Engineering **Joseph M. Ballantyne** and **J. Peter Krusius,** resulted in an initial grant to Cornell of $3 million over a period of three years. Seven faculty members from several departments will be involved in the effort, and research support will be provided by the nanofabrication, electronic packaging, and Duffield Hall facilities.

Cornell's contribution will be primarily in the areas of photonics (using light waves to communicate on and between chips), and novel approaches for distributing information. Joe Ballantyne comments, "The primary purpose of the program is to do fundamental, long-range research to develop new ways of communication among the hundreds of millions of transistors on future generations of computer chips."

Recent Faculty Accomplishments

Note: Most of the listed awards were announced at the College of Engineering Fall 1998 Awards Ceremony and Faculty Reception on September 21, 1998.

• Professor **Joseph M. Ballantyne** (optoelectronic devices and materials), former director of the Semiconductor Research Corporation (SRC) Interdisciplinary Program on Microscience and Technology at Cornell, and the Cornell Nanofabrication Facility (CNF), led the SRC through a very difficult period of funding contraction. He coordinated preparation of two multiuniversity, multimillion-dollar proposals to rejuvenate the program: a proposed Center for Front-End Processing for Nanoscale CMOS (complementary metal-oxide semiconductors) that was judged best but was not funded, and a scaled-down version of a major proposal (with a Cornell/SUNY at Albany/Rensselaer Polytechnic Institute team and Professor **J. Peter Krusius** as principal investigator) that was submitted to the national effort known as the Focus Center Research Program, and was funded at $3 million for three years. Professor Ballantyne assumed leadership of the CNF in January 1998, led a successful effort to obtain a five-year renewal grant from NSF, initiated a twentieth anniversary celebration, recruited a new CNF director, hired two new staff members, and reorganized CNF safety activities. He was advisor to two doctoral candidates who completed their studies, and with the help of student **Mike Booth**, discovered a new electrically-controlled directional-switching effect in diode-ring lasers that is very strong, and shows large hysteresis. This discovery will significantly increase the fundamental understanding of these devices and has potentially exciting use in optical-logic and data-communication systems as a logic element and electrically controlled optical switch.

• Professor **Toby Berger** (information theory and communications, the Irwin and Joan Jacobs Professor of Engineering, directed the DISCOVER (digital-signal compression and video-encoding research) lab team to successfully produce a full-duplex software-only video coder–decoder that displays thirty frames per second (fps) of full-color, high-quality, quarter-standards of the National Television System Committee (Q-NTSC) on 200-MHz PCs that are running on Windows '95. Microsoft's widely acclaimed NetMeeting software-only video coder-decoder can send only 15 fps maximum, often less.

• Associate Professor **Adam W. Bojanczyk** (computer engineering, parallel architecture, and algorithms for signal and image processing) with the help of his graduate students developed algorithms and software to utilize variable-precision arithmetic in adaptive computations of digital-filter coefficients.

• Professor **Hsiao-Dong Chiang** (analysis and control of nonlinear systems with applications to electric-power networks) was promoted to full professor on July 1, 1998. He has been awarded the following U.S. patents:

"On-line Method for Determining Power-System Transient Stability," patent number 5,483,462, dated January 9, 1996 (Inventor: Hsiao-Dong Chiang).

"Method for Preventing Power Collapse in Electric-Power Systems," patent number 5,642,000, dated June 24, 1997 (Inventors: Rene Jean-Jumeau and Hsiao-Dong Chiang).

"Method for On-Line Dynamic Contingency Screening of Electric-Power Systems," patent number 5,719,787, dated February 16, 1998 (Inventors: Hsiao-Dong Chiang and Cheng-Shan Wang).

"System for Achieving Optimal Steady State in Power-Distribution Networks," patent number 5,734,586, dated March 31, 1998 (Inventors: Hsiao-Dong Chiang and Jin-Cheng Wang).

• Associate Professor **David F. Delchamps** (control and system theory), reports that his research program in intelligent and hybrid dynamic systems has led to some interesting new directions over the last two years. Such systems mix continuous and discrete variables, and often feature massively parallel architectures along with event-driven dynamics. His group has come to recognize the central importance of evolutionary computational approaches to the modeling, analysis, and control of such systems. Current research that applies dynamic systems techniques to problems in cognitive science and learning theory has also begun to play a role in their investigations. Dave was a 1998 recipient of the **J. P. and Mary Barger**, '50, College of Engineering Excellence in Teaching Award.

• Professor **Lester F. Eastman** (compound semiconductor materials, devices, and circuits), the Given Foundation Professor of Engineering, was the recipient of the 1999 IEEE Graduate Teaching Award. Lester reports that his research group is using a strained aluminum–gallium nitride/gallium-nitride(AlGaN/GaN) heterojunction to piezoelectrically induce a thin sheet of electrons in the GaN high-electron-mobility transistors that have been fabricated by electron-beam lithography, thereby achieving advances in the operating frequency and efficiency of the state of the art. A current gain limit of ~70 GHz and a power gain limit of ~140 GHz have been achieved, along with microwave amplification at 3 GHz with more than 70 percent efficiency.

• Professor **Donald T. Farley** (radiowave and upper-atmospheric physics), the J. Preston Levis Professor of Engineering, was part of a group that made a major contribution to the National Space Weather program by identifying severe atmospheric variations over Arecibo, Puerto Rico. The discovery was made with the Cornell Airglow Imager that is operated by a team of undergraduates.

• Professor **Terrence L. Fine** (information theory, inference and decision making in the presence of uncertainty) obtained new results that will be appearing in *Neural Computation*, on the long-run behavior of neural-network parameter estimates: these results established strong convergence but challenged the widespread belief that the errors would be asymptotically Gaussian. Terry continues to do research on sensor-assisted wireless mobile communication through the development of a propagation simulator that incorporates multipaths, and through the development of neural networks to estimate caller numbers and locations from the sensor data.

• Professor **Paul F. Goldsmith** (space sciences) completed a monograph covering both theoretical and practical aspects of Gaussian-beam quasioptical propagation. The book, *Quasioptical Systems*, was published in December 1997 by the IEEE Press. Paul also completed a study of gas and dust emission from giant molecular clouds in the Milky Way Galaxy, which showed that the gas-to-dust ratio and dust properties are not constant (*Astrophysical Journal* 491, pp. 615–637, Dec. 1997).

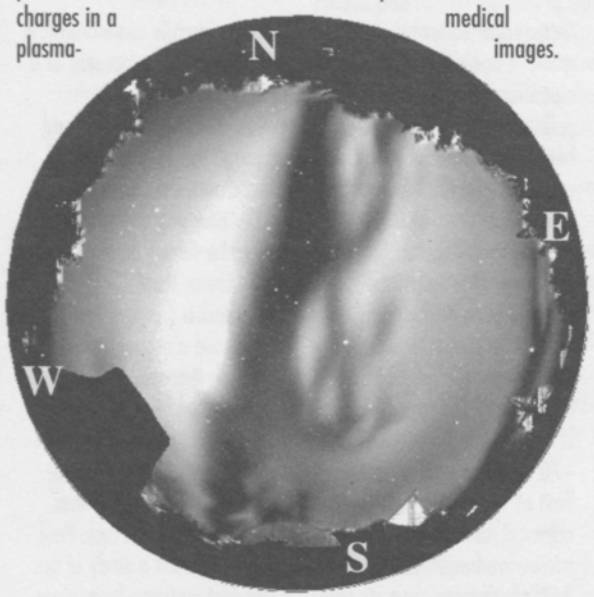
• Associate Professor **Zygmunt J. Haas** (wireless communication and networks, mobile systems) has introduced a novel medium-access control scheme, the "Dual Busy-Tone Multiple Access," that more than doubles the total network capacity with minimum overhead. Zygmunt is involved with the investigation of this new protocol and in its comparison with existing state-of-the-art schemes, such as "Medium-Access Collision-Avoidance" or "Medium-Access Collision-Avoidance Wireless." He has also proposed and studied dual mobile multicasting algorithms that allow reliable delivery of data in a highly mobile network.

• Professor **David A. Hammer** (plasma physics, con-

trolled fusion, intense ion beams), the J. Carlton Ward Jr. Professor of Nuclear Energy Engineering, reports that his sabbatical-year project at Applied Materials, Inc., in San Francisco, California, is producing the first detailed species spatial-distribution map of low-pressure chlorine discharges in a plasma-processing reactor. This result may facilitate development of new systems. Dave was a 1998 recipient of the **J. P. and Mary Barger**, '50 College of Engineering Excellence in Teaching Award.

• Associate Professor **Chris Heegard** (communication, information, and coding theory) continued his leave of absence during the 1998–99 academic year with the Alantro Company in Santa Rosa, California.

• Assistant Professor **Sheila S. Hemami** (application-specific compression techniques for packet networks, networking aspects of visual communication, and multirate coding and transmission) has developed several techniques for improving the performance of both JPEG (joint photographic experts group) and MPEG (moving pictures expert group) files; large gains in both signal-to-noise ratio and visual performance are obtained with minimal computational increases. Sheila has initiated a large-scale psychovisual study of quantization effects on subband-coded images at Cornell, and, jointly with Kodak Research Labs and the Cornell's Weill Medical School, of quantization effects on medical images.



Francisco García, Ph. D. '99

Figure 9.—Light emissions from 200 mile–high ion clouds in the night-time sky over the Arecibo Observatory in Puerto Rico.

• Professor **C. Richard Johnson, Jr.** (adaptive control and signal processing) reports that during the 1997–98 academic year he completed a multiyear effort in the development of a fundamental behavior theory for the most popular blind-equalization scheme in emerging wireless (and wired) broadcast and multiuser communication systems applications: the constant-modulus algorithm (CMA). "Products" supervised to completion in the past year include an invited CMA literature survey for the *Proceedings of the IEEE*, an invited chapter on CMA behavior theory in *Unsupervised Adaptive Learning* (Wiley), and journal publication of results from one M.S. thesis, two Ph.D. dissertations, and from collaborations with two postdoctoral visitors. Another byproduct is receipt of NSF support for his sabbatical leave in the 1998–99 academic year at a Silicon Valley communication-systems equipment developer and manufacturer.

• Assistant Professor **Edwin C. Kan** (modeling and fabrication of nanometer-scale devices) has proposed new interconnect structures for multigate electrically erasable programmable read-only memory (EEPROM), and is studying 3-D stack integrated-circuit integration issues.

• Professor **Michael C. Kelley** (upper atmospheric and ionospheric physics) was named a 1998 **Stephen H. Weiss**, '57, Presidential Fellow for effective, inspiring, and distinguished teaching of undergraduate students. Mike and his undergraduate research team discovered a new type of space-weather event in the Caribbean region. The team operates an all-sky imager that records light emissions from the night-time sky over the Arecibo Observatory in Puerto Rico (see Figure 9).

• Professor **Paul M. Kintner** (atmospheric plasma physics) completed the first year of service as the associate director of the EE School, during which tenure a variety of proposals and nominations were submitted. Of those acted on, all have been successful although many are outstanding and the 100 percent success rate can not continue. The digital systems courses were maintained and improved (especially the laboratory component), and two new faculty members were successfully integrated into the curriculum. Paul's course EE 416, "Global Positioning Systems," was continued and expanded. In the area of research, an Office of Naval Research proposal for $725,000 was accepted, the department's first Ph.D. in Global Positioning Systems graduated, and Paul was appointed to a high-level NASA science program committee.

• Associate Professor **Ronald M. Kline** (history of technology and electrical engineering) finished a draft of a book on the social history in the rural U.S. of the telephone, automobile, radio, electric input, and electric power.

• Assistant Professor **Kevin T. Kornegay** (computer-aided design for VLSI circuits) has received a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF) for his project, "A Wireless Sensor Instrumentation System for Harsh Environments."

• Professor **J. Peter Krusius** (solid-state electronics, semiconductor devices and systems, and electronic packaging) became the new director of the Semiconductor Research Corporation (SRC) in September 1998. He was awarded a $1 million grant in October 1997, under the NSF Major Research Instrumentation (MRI) program, for the construction of a precision-interconnect cluster tool (PICT). The goal in this three-year program is to construct a unique tool that can fabricate over 5,000 connections to integrated circuits chips. This is a ten-fold improvement over the present state-of-the-art. The tool will be placed in the Cornell Advanced Facility for Electronic Packaging. Peter and graduate student **Peter VanDerVoorn** have successfully fabricated the world's narrowest metallic-oxide semiconductor field-effect transistor (MOSFET) device using specialized equipment at the Cornell Nanofabrication Facility. These world-record shallow-trench isolated devices are only 50 nanometers wide, a size that the industry has targeted for manufacture in the year 2012, according to the National Roadmap for Semiconductors.

• Professor **Richard L. Liboff** (physics of microsemiconductor devices and solid-state plasmas) derived a residual resistivity for pure alkali and noble metals at 0° K. This finding is a breakthrough in solid-state technology.

• Associate Professor **Yu-Hwa Lo** (optoelectronic materials and devices, and integrated optoelectronic circuits) and his group have demonstrated methods of fabricating semiconductor compliant substrates to achieve very high-quality heteroepitaxial growth. The concepts and techniques may significantly advance the semiconductor technology. Yu-Hwa was a 1998 recipient of the James and Mary Tien College of Engineering Excellence in Teaching Award.

• Professor **Noel C. MacDonald** (microelectromechanical and nanoelectromechanical systems) the Acheson/Laibe Professor of Business Management and Leadership Studies in the College of Engineering, continued his leave of absence during the 1998–99 academic year in Washington, D.C. with the Defense Advanced Research Projects Agency (DARPA) as director of the Electronic Technology Office. During the year, Noel made frequent visits to the campus to consult with his graduate students.

• Professor **Paul R. McIsaac** (microwave theory and techniques) reports that his most important research contribution for 1997–98 was concerned with the study of the scattering matrix associated with an iris in a uniform waveguide containing reciprocal media. If the waveguides on either side of the iris have N propagating modes, then the scattering matrix for the iris has $4N^2$ elements. The study explored the role of the symmetry of the waveguide and the iris in determining which of the scattering matrix elements must be equal, and which must be zero.

• Assistant Professor **Bradley A. Minch** (analog and digital VLSI circuit design) has devised a novel way to implement log-domain filters, a class of large-signal linear, continuous-time, current-mode filters made from highly nonlinear elements. Bradley has demonstrated the technique experimentally.

• Professor **John A. Nation** (electromagnetic fields and waves) has continued the

development of ferroelectric cathodes. John now operates a 0.75" diameter cathode at 500 kV, 250 amperes, and 250 nanoseconds at 0.1 Hz in an electron gun.

• Professor **Thomas W. Parks** (signal theory and digital-signal processing) reports that his most important contribution during the Spring 1998 term was a course on wavelets that he taught to researchers while he was on sabbatical leave with Eastman Kodak in Rochester, New York.

• Associate Professor **Alfred Phillips Jr.** (quantum mechanical devices, optical switches, and process modeling) and his students have completed the empirical verification of his field-effect transistor (FET) theory by successfully modeling junction field-effect transistors (JFETs). Heretofore, metallic-oxide semiconductor field-effect transistors (MOSFETs), hetero-structure field-effect transistors (HFETs), and metal semiconductor field-effect transistors (MESFETs) were accurately modeled. The group has also created Lagrangian and Hamiltonian expressions for the FET, and submits that FET theory is essentially complete. Al and his group have also conceived a quantum computer with technologies currently available in Phillips Hall and the Cornell Nanofabrication Facility.

• Professor **Clifford R. Pollock** (lasers and optoelectronics) the Ilda and Charles Lee Professor of Engineering, spent the Fall 1997 semester on sabbatical leave at the Corning, Inc. Sullivan Park Research Facility, where he became involved with fiber-optic devices such as Bragg gratings. As a result of this activity, his research direction is changing from solid-state lasers toward fiber optics. During the 1998–99 academic year, Clif, as academic program leader of the Duffield Hall Project Management Team, was heavily involved in planning for the new building. On July 1, 1998, Clif became a member of the board of directors of Eta Kappa Nu, the EE honor society.

• Associate Professor **Anthony P. Reeves** (parallel computer systems, computer-vision algorithms) was involved with sabbatical leave activities that have resulted in several collaborations with other research projects having computer-vision components. New three-dimensional-shape features have been identified that can help determine the malignancy status of pulmonary nodules detected in helical CT scans of the lungs; this work was done in collaboration with the Department of Radiology at Cornell's Weill Medical College. Tony also collaborated with the Cornell's Department of Mechanical Engineering and NASA's Microgravity Science Division in the development of tracking techniques for video-image sequences, as part of a microgravity experiment exploring particle segregation in collisional shearing flows.

• Professor **Charles E. Seyler Jr.** (space-plasma physics, physics of relativistic electron beams), in recent publications in *Physical Review Letters* (PRL) and in *Physical Review Focus*, a general reader supplement to PRL, presents a remarkable experimental confirmation of a theory developed by Charles Seyler and his graduate student **Peter Schuck** on lower hybrid solitary structures (LHSS). Lower hybrid solitary structures have been known to space-plasma experimentalists for about thirteen years as a source of production of energetic ions in the ionosphere. Until the recent observations from PHAZE [Physics of Auroral Zone Electrons] 2, a sounding rocket launched by **Paul Kintner** and others, the nature of LHSS has been largely one of theoretical conjecture.

• Professor **James R. Shealy** (development of compound semiconductors) was promoted to full professor on July 1, 1998. Dick reports that in collaboration with Professor **Lester F. Eastman** and their graduate students, tests of gallium-nitride transistors have produced output powers of up to 2.2 watts per millimeter of length the transistor occupies on a chip, at a frequency of 4 GHz. Power outputs of 10 watts per millimeter are expected when improved test equipment is installed.

• Professor **Chung-Liang Tang** (lasers, optoelectric devices, nonlinear and coherent optical processes) the Spencer T. Olin Professor of Engineering, developed the first broadly tunable, femtosecond, optical-parametric oscillator in the mid-infrared (from about 1 micron to 5.4 microns) using the recently developed nonlinear optical material structure: periodically poled lithium niobate.

• Professor **Robert J. Thomas** (control techniques for large-scale networks, analysis of microelectromechanical systems) chaired the Curriculum and Standards Committee that recently revised the EE School's undergraduate core curriculum. Bob is the faculty advisor for the Hybrid Electric Vehicle (HEV) that has been built and entered in the national innovative-automobile competition. As part of his research activity, Bob reports on a new, first of its kind, approach to power-plant unit commitment with full ac power-flow constraints. Under his direction, the Power Systems Engineering Research Center (PSERC) continues to grow, with six schools of electrical engineering and twelve industry representatives now enrolled as members of the center.

• Professor **James S. Thorp** (estimation and control of discrete linear systems as applied to control of electric-power networks), the Charles N. Mellowes Professor of Engineering and director of the School of Electrical Engineering, reports that the problem of electromechanical oscillations in large electric-power systems has been modeled by considering the power system with its transmission lines, generators and loads to be a continuum. The resulting partial differential equation exhibits the traveling-wave behavior that has been observed in experiments with synchronized phasor measurements. Disturbances spread through the interconnected power system with a velocity of propagation that depends on parameters in the distributed model.

• Assistant **Professor Norman C. Tien** (micro-electromechanical systems [MEMS] for radio-frequency circuits and optoelectronics) has established MEMS programs in two application areas, wireless communication components and free-space microoptics. Norman's publication topics during the past year include an optically-sensed MEMS accelerometer, and copper encapsulation of polysilicon surface-micromachined structures that are intended for RF-passive elements. He also taught a revised MEMS course in which a laboratory for testing and design of MEMS devices has been added.

• Professor **H. C. Torng** (computer architecture applied to design of intelligent communications networks) was a recipient of the 1998 **Michael Tien** '72, College of Engineering Excellence in Teaching Award. H. C. has also made significant progress in completing the manuscripts on digital systems and ATM networks.

• Assistant Professor **Venugopal V. Veeravalli** (wireless communication, detection and estimation theory, and information theory) was the recipient of a Faculty Early Career Development Program (CAREER) Award from the National Science Foundation (NSF), followed in February 1998 by a NSF Presidential Early Career Award for Scientists and Engineers (PECASE). Venu is working on the analysis of the coding-spreading tradeoff in code-division multiple-access systems. He introduced a new undergraduate course in communications to train students for new opportunities in the telecommunications industry.

• Associate Professor **Stephen B. Wicker** (wireless information networks, digital communication systems, error-control coding, and cryptography) was a recipient of the 1998 **Michael Tien** '72, College of Engineering Excellence in Teaching Award. Steve, in conjunction with colleagues and students, developed a series of highly efficient random-access protocols that take advantage of user-location information. A patent on this technique is now pending. Steve and his students have also developed a series of soft-decision decoders for wireless systems, and developed a connection between iterative decoding and parameter estimation for hidden Markov chains.

EE School Research Funding

Total research funds expended in 1995–96	$12,921,520
Total research funds expended in 1996–97	$13,857,387
Percent increase	7.2 %
Total research funds for 1997–98 (as of June 30, 1998)	$13,370,224
Percent decrease	3.5%

In addition, approximately $450,000 has been received by the EE School in the past academic year in support of faculty research and special projects from Applied Signal Technology, Eastman Kodak, GTE, Lockheed–Martin, Lutron Foundation, Motorola, and Norstar. These generous grants from corporations and foundations, coupled with equally commendable gifts from many individuals, aid the recipients in their teaching and research and make it possible for the EE School to establish and maintain a leading edge in the discipline.


Jon Reis

William Harry Erickson

Professor Emeritus **William Harry Erickson** died at age 82 on October 21, 1998 in Ithaca, New York, after a short illness. After graduating with the B.S. degree in electrical engineering from the University of Pittsburgh in June 1938, Bill joined the Duquesne Light Company in Pittsburgh, Pennsylvania, where he became an electric-power transmission and distribution engineer specializing in the design of transmission facilities. During this period he was also a graduate student at Carnegie Institute of Technology. In 1942 he came to Cornell as a civilian instructor in steam engineering in the U.S. Navy V-12 officer-training program, as a specialist in motors and generators. He joined the School of Electrical Engineering as an assistant professor in 1945, received the M.S. degree in electrical engineering from Carnegie Tech in September 1946, became an associate professor in 1947, and attained full professorial rank in 1953. When **Charles R. Burrows** resigned as director of the EE School in 1957, Professor Erickson served as acting director for two years and as assistant director from 1959 to 1965. From 1965 to 1971, he was an associate dean of the College of Engineering. Bill returned to teaching duties in 1972 and also served two separate three-year terms (1972–75 and 1979–82) as a member of the administrative board of the Division of Unclassified Students, an Engineering College department that supervised undergraduates who were in academic difficulty. He retired as professor emeritus in July 1982. The major portion of Bill's forty-year academic career at Cornell was devoted to undergraduate education in the EE School and in the Engineering College, with emphasis on the application of engineering methods. He was also an ardent advocate of good technical writing and humanities studies in an engineering curriculum.

In 1946 and for years afterward, the large number of students who were enrolled in the Schools of Chemical, Civil, and Mechanical Engineering were required to take special courses in electrical engineering. Professor Erickson was given the task of organizing and teaching these "service courses," and served as a mentor to a group of graduate students who were appointed as his teaching assistants. Several of these young instructors later became members of the EE School faculty. Since a suitable textbook was not available, Bill wrote and distributed a series of class notes on basic electrical engineering and dc and ac machinery that he dubbed "Electrical Engineering for Non–Electrical Engineers." In collaboration with the late Professor **Nelson H. Bryant** who wrote the electronics component, the notes were expanded into a textbook entitled *Electrical Engineering, Theory and Practice.* The first edition of this popular text was published in 1952, a second edition came out in 1959, followed by a paperback edition in 1975.

Professor Erickson's background and expertise in electric-power systems and machinery were invaluable in the Naval training program, in the development of his text, and throughout his academic career. His familiarity with engineering practice allowed him to construct challenging, thought-provoking problems that were incorporated into his text. Unlike the usual rote exercises found in many textbooks, every problem in the text required a firm understanding of the principles involved for the student to achieve a correct solution. Bill often received requests for a solution manual from users of his text at other colleges but his typical response was "I've given you the correct answers. You'll learn something if you figure out the solutions by yourself."

In the early '50s, Bill helped initiate and taught many sessions of a required senior EE School engineering-reports course that featured preparation of technical articles and oral presentations. When the Division of Basic Studies was established in the College of Engineering in 1961, Bill initiated Eng 101 and Eng 102, "Engineering Problems and Methods," as introductory engineering courses at the freshman level. The courses featured consideration of major examples of modern engineering, emphasized the interrelationship of the several professional fields, and also described the role of the engineer in society. Bill taught these courses for ten years in addition to his duties as assistant director of the EE School and as associate dean of engineering. During those years he also continued his service-course management and teaching responsibilities, and served as class advisor at all class levels. Upon his return to active teaching without administrative responsibilities, and until his retirement, Bill applied his machinery and power-system expertise to introductory electrical engineering courses at the sophomore level, and particularly to the junior laboratory courses that came to be known over the years as "Super Lab." He was a junior and senior advisor throughout those years and also served as advisor for several Master of Engineering projects, including design of a Mars Rover, and a windmill power generator.

In addition to his classroom responsibilities, Bill was an active participant throughout the years in the work of many committees, including, among others, Long Range Planning, Financial Aids, Nominating, and Physical Education and Athletics committees, at the university level; the Core Curriculum, Professional Programs, Policy, and Academic Standards committees in the College of Engineering; and, in the EE School, as a multiterm member of the governing Faculty Committee. In off-campus activities, he was registered as a professional engineer in New York State, served as chairman of the Ithaca Section of the American Institute of Electrical Engineers (AIEE), and was the chairman of the AIEE Summer General Meeting held in Ithaca in 1961. Bill was named a Fellow of the AIEE in 1962 "for contributions to engineering education." When that organization became the Institute of Electrical and Electronic Engineers (IEEE), he continued his membership and became a Life Fellow of IEEE in 1981. He was elected to the engineering honor societies Tau Beta Pi, Eta Kappa Nu, and Sigma Tau, and was a member of the American Society for Engineering Education.

Bill was an avid golfer, had a keen interest in baseball, and organized the EE School's Franklin Hall Bowling League. But his particular long-time interest was in the "Sport of Kings." His overall gaming success with the horses is not known but he always maintained that his principal concern was with statistics. On several occasions he was a speaker at student-award banquets where he delivered a "lecture" that he called "Horse-Racing for Non-Horses" a corollary of "EE for non-EEs." On these occasions he would display his secret formula for track success: a long roll of paper covered with complex mathematical symbols.

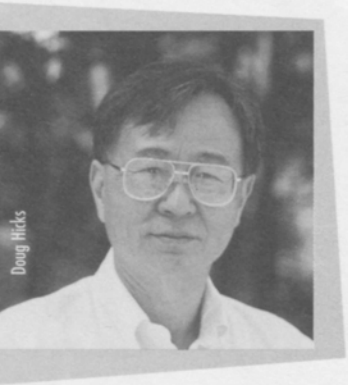
In 1955, Bill was elected president of the Exchange Club, an Ithaca branch of a national service club. Soon after assuming office, Bill discovered to his dismay that the constitution of the club contained a clause that banned nonwhite persons from membership. Under Bill's leadership the local club voted to withdraw from the national organization and form a new group, the Ithaca City Club, that is still in existence. On April 23, 1956, the *Ithaca Journal* reported that on the previous Saturday Bill was presented with a plaque that reads: "B'nai B'rith of Ithaca, New York honors William H. Erickson for outstanding achievement towards equality of man."

Many of Bill's major contributions to the College of Engineering occurred while he was associate dean of engineering. In his initial task of restructuring the engineering curriculum from a five-year to a four-year program he achieved a smooth and relatively trouble-free transfer to the new curriculum due in large part to his direct approach and clear-headed solutions to the problems that arose during the transition process. His strong belief in the need for engineers to have a thorough grounding in the humanities led to the establishment of an Engineering College requirement in the new program of at least thirty hours in the College of Arts and Sciences. During his tenure as associate dean, Bill was responsible for overall undergraduate affairs in the Engineering College, and was particularly effective in his work with the Academic Standards Committee, where his stern but eminently fair judgments administered to students in academic difficulties ultimately caused many of those students to improve their records and graduate successfully. In later years, these same students often expressed their gratitude to Bill for his positive impact on their successful careers.

Highly respected by his colleagues and students, Bill Erickson will be long remembered as a dedicated teacher and advisor, and as a man of exemplary honesty and integrity, who set high academic and professional standards for himself, his associates, and his students.

A distinguished alumnus, Professor **Thomas James Higgins,** E.E. '32 died at age 87 in Madison, Wisconsin on September 11, 1998. Dr. Higgins, professor emeritus of electrical engineering at the University of Wisconsin, had a long and productive career in academia and in technical publication. His major academic activity involved the teaching of graduate courses and the direction of graduate study and research of over 300 students at both the doctoral and masters levels in his many fields of interest. These included microwave theory, advanced electric-circuit theory, advanced automatic control theory, large-scale systems engineering, and others. He was the author of over 220 research papers that were published in scientific and technical journals in this country and abroad, edited the manuscripts of more than 120 textbooks, and published over 350 reviews of books and papers in electrical engineering. Throughout his career he was active in professional and honorary societies and was the recipient of many distinguished awards. He had a strong interest in the history of electrophysics and electrical engineering and published biographies and bibliographies on the lives and works of major contributors to these fields. He was working on a book-length history of the College of Engineering at the University of Wisconsin at the time of his death. The eminent quality of this outstanding career has brought honor to the electrical engineering profession, to the University of Wisconsin, and to Cornell.

H. C. Torng Retires


Doug Hicks

Hwa Chung Torng, a member of the EE School faculty for thirty-nine years became professor emeritus on January 1, 1999.

H. C. received the B.S. degree in electrical engineering from National Taiwan University in 1955, was awarded a prestigious Li Foundation Fellowship and came to Cornell for graduate study, where he received the M.S. degree in 1958 and the Ph.D. in 1960, both in electrical engineering. He joined the EE School faculty at Cornell as an assistant professor in 1960, was promoted to associate professor in 1963, became a full professor in 1971, and retired as professor emeritus in 1999.

H. C.'s tenure at Cornell has been devoted to teaching, research, and service to the EE School and the College of Engineering during a long and distinguished career in the field of computer architecture and communication networks. H. C. had written his doctoral dissertation on nonlinear sampled data-control systems under the late Professor **Wilbur E. Meserve,** and his first assignment as an assistant professor was to work for two years with Wilbur's servomechanism courses. Following Assistant Professor **Albert S. Jackson**'s departure from Cornell, H. C. took over Al's course in digital logic design and began his long association with computers and telecommunication systems. Two years later, in 1964, he published his first book, *Introduction to the Logical Design of Switching Systems* (Addison–Wesley) and followed up in 1972 with a more advanced volume, *Switching Circuits: Theory and Logical Design,* from the same publisher. At about this time he created and developed his two popular courses, "Computer Networks and Telecommunication" and "Processor Organization," devoted to methods and approaches in the design, analysis, and implementation of processors and computer networks. H. C. believed that seniors and graduate students who took these courses would have a clear understanding of telecommunication systems and computers. His many successful graduate students in these fields can attest to the accuracy of that assessment. In January 1995, the IEEE Computer Society Press published *Instruction-Level Parallel Processors,* a book coedited by H. C. and S. Vassilliadis of the IBM Glendale Laboratory. In the same year he offered course EE 546, "Architectures of High-Capacity Networks," for the first time. In 1997, H. C. turned his attention to improving the presentation of the study of digital systems at the engineering sophomore level. He reformulated course EE 230, "Introduction to Digital Systems," into EE 231, an engineering distribution course with the same title, and EE 232, a one-credit-hour laboratory course. New contents, flexibility, and emphasis have enhanced the appeal of the courses to electrical-engineering students and to students in other engineering disciplines.

H. C. is a vigorous and stimulating lecturer whose students admire his clear and well-organized presentations and use of real-world examples. He won many teaching awards during his career in the EE School, including Tau Beta Pi Commendations for Excellence in Teaching for various years, the IEEE Cornell Student Chapter "Best Professor" Awards in 1982, 1986, and 1997, the Ruth and Joel Spira Award for Excellence in Teaching in 1985, and the **Michael Tien,** '72, College of Engineering Award for Excellence in Teaching in 1995 and 1998.

In addition to those academic accomplishments, H. C. was the graduate field representative for the EE School from 1990 to 1993, introduced innovative recruiting and admission policies in the EE School graduate program, and took an active personal interest in the recruiting process. Following that term of office, he received a large grant in 1993 from the National Science Foundation, with matching funds from the university provost, to initiate a doctoral program for students from underrepresented groups in engineering. He was a member of many EE School committees, and for the College of Engineering he served as chairman of the ad-hoc Committee on Faculty Promotion in 1992–93, and was the affirmative-action facilitator from 1995 to 1997. He was a member of the Cornell Graduate School Fellowship Board for Physical Sciences from 1992 to 1994, and was a member of the University Senate from 1996 to 1997. During his career at Cornell he directed the research of seventeen Ph.D. and twenty-one M.S. candidates, wrote more than fifty-five publications in addition to his three books, and was a much sought-after class advisor. He has been awarded two patents: one for an integrated switching scheme, and the other for an instruction-issuing mechanism for computers, with special application for advanced reduced-instruction-set computers (RISCs).

H. C. was a visiting professor at National Taiwan University in 1966, a visiting professor at the University of Rochester in 1973, served as an outside doctoral examiner at the University of Toronto in 1978, and was also a visiting scientist at Lawrence Livermore National Laboratories in the same year. He was a member of the technical staff at Bell Laboratories in 1966–67 and also in 1980–81. In 1991 H. C. was named a Fellow of the IEEE "for contributions to the architecture and design of digital systems, and engineering education." He served as an IEEE Computer Society Distinguished Visitor from 1983 to 1986, received the Meritorious Service Award of the Society in 1991, and its Golden Core Member Award in 1996. He was editor of the *IEEE Transactions on Computers* from 1986 to 1990, and has been a member of various conference program committees. He is a member of the American Association for Computing Machinery, Sigma Xi, Eta Kappa Nu, Phi Kappa Phi, and is listed in *American Men and Women of Science.*

In 1982, H. C. invented an ingenious computer chip that had the potential to greatly increase the speed of computer operations. Initially unacceptable by the industry because of the then-impossible requirement for 250,000 transistors on a single chip, the device has come into its own now that many millions of transistors can be incorporated into a similar space. In traditional computer operation a microprocessor executes instructions in a rigid order. H. C.'s design allowed a processor to sort out instructions by rapidly evaluating their relationships to one another so that certain ones could be executed out of order without having to wait their normal turn. Cornell holds the patent on the invention and has licensed it to Intel for use in their Pentium chips. In recognition of this major achievement, Professor H. C. Torng has been named the first Intel Academic Research Fellow "for his contributions to the state of the art in high-speed instruction decoding and execution." A plaque was presented to H. C. in a ceremony on December 2, 1997 by a group of Intel executives that included **Justin R. Ratner,** B.S.Engr. '70 (Electrical Engineering).

In retirement, H. C. plans to remain in Ithaca for a couple of years until he completes two textbooks, one on an introduction to digital systems, and the other on computer networks. When these tasks are done he expects to transfer residence to San Francisco.

Kasia Azzara joined the EE School on August 18, 1998 as system programmer/analyst to assume the position vacated by **Pauline Helfenstein.** She received a B.S. degree in biomedical engineering from Boston University in 1994, and studied for the M.S. degree in the same field at the University of Texas in Arlington/Dallas, Texas. Kasia says she is enjoying the challenges of her job, her first professional position. Much of her spare time is spent with her one-and-a-half-year-old daughter, but she enjoys tennis and other outdoor sports and fine music, as time allows.

Sally Bird was appointed administrative assistant to Professor **Bob Thomas** and the PSERC Program on March 25, 1998. From October 1998 to her new assignment she held the Phillips Hall third-floor position vacated by **Carol Webster,** and previously had been administrative assistant to the space-plasma physics group for the past eleven years.

Amy Devaul joined the EE School in August 1998 as accounts representative. Prior to her present position she was an accounts representative for five years in the Department of Ecology and Systematics and worked previously in the office of the dean of the College of Architecture, Art, and Planning. She has a B.S. degree in management and finance from SUNY Empire State College at Auburn, New York, and an associate degree in accounting from Cayuga Community College. Amy likes her work in the EE School and says there is never a dull moment in her office. In her spare time she enjoys walking, reading, painting porcelain dolls, and occasionally playing the flute.

William F. Dougherty, building coordinator in Phillips Hall, retired on January, 1, 1999 after thirty-six years of service in the EE School. Bill began full-time employment in July 1961 on the High-Voltage Cable Testing Project with Professor **Joseph L. Rosson.** When the cable project ended in 1965, Bill was engaged in maintenance activities for the EE School in the Butler building workshop adjacent to the high-voltage laboratory on Mitchell Street, and eventually assumed his recent tasks in Phillips Hall. During retirement Bill plans to continue a maintenance program that he has performed for the Snyder Hill Cemetery for the past thirty years, work on repair of his house, and travel. Bill is a snowmobile enthusiast and will continue to engage in that sport. He entered the annual Quebec Snowmobile Tour for the eleventh time in April of this year. We wish him many happy retirement years.

Patricia Doxtater joined the EE School in November 1998 as administrative assistant in Rhodes Hall, in the position formerly held by Sally Bird. She has been employed in similar positions at Cornell for the past ten years. Before coming to the EE School, she was an assistant to the director of the Intensive English Program in the Department of Modern Languages, and held prior positions in several departments on campus. Patty is a native Ithacan, graduated from Ithaca High School, and earned an associate degree in secretarial services from Tompkins–Cortland Community College. She has a twenty-year-old daughter and a five-year-old son, and enjoys cooking and reading when time allows.

Lisa Gould has been appointed administrative assistant in Rhodes Hall to succeed **Tammie Van Buskirk,** who has resigned due to illness. Lisa has held administrative-aide positions at Cornell for twenty years in various departments on campus. She is a native Ithacan, graduated from Ithaca High School, and earned an administrative secretarial diploma from Buffalo Business School. Lisa sings alto in her church choir, likes to travel and to read, and enjoys the diversity of people at Cornell.

Susan Grover, accounts representative in the EE School for the past three years, has been promoted to accounts representative IV/human-resources assistant with responsibility for the nonacademic, non-exempt human-resources functions in the EE School.

Elke Schofield was appointed administrative assistant to Professor **Lester Eastman**'s group in April 1998, after serving in the same position for most of 1997 as a temporary replacement for **Elma Weaver,** who has since retired due to poor health. At Cornell she spent ten years as graduate field secretary to the Department of Psychology, after holding various secretarial positions on campus for the previous five years. Elke received her high school and business school education in Germany, held positions in Tokyo, and Darmstadt, Germany involving translation services, and for three years before coming to Ithaca in 1970 she was secretary to the director of telecommunication at Siemens in Munich, Germany. In her spare time on weekends she works as an English/German language interpreter for AT&T. She has been given the task of organizing a Gallium Nitride Electronic Device Workshop, a first-time event that will be held at Cornell on August 16–17, 1999. Elke enjoys travel, gardening, classical music, reading, and tennis when time allows.

More Tales from the Past

Your tales from the past are always welcome. Send us your favorite stories about professors, labs, classes, projects, stunts, or whatever you think made the EE School a special place. Further examples of the Matthews Criterion, as demonstrated at Cornell, are also of interest. We'll print 'em as space allows.

The "Matthews Criterion" expressed in the last issue of *Connections* has brought to mind several examples of alumni exploits that demonstrate an ability to "get the job done." One particularly exciting achievement is that of **Francis D. McLeod Jr.,** B.S.Engr. '65 (Electrical Engineering), who invented a directional Doppler-velocity meter that has become the primary vascular noninvasive diagnostic tool in the medical profession.

Fran, lecturer and manager of the undergraduate teaching laboratories in the EE School, has a distinguished career in the development of diagnostic blood-flow measurements and related bioengineering research. After obtaining his bachelor's degree, he was a research specialist in blood-flow measurements with the College of Veterinary Medicine at Cornell. Measurements of the period involved the use of uncomfortable invasive techniques, but Fran and his colleagues were hopeful that some form of electronic wizardry would appear to provide a means for performing noninvasive procedures. Consequently, great enthusiasm greeted a Japanese report of an ultrasonic Doppler-radar device that could measure blood flow with only a simple handheld probe applied externally to a pressure point on the body of an animal. Unfortunately, the Japanese device could only detect the presence of blood flow without reporting the vital information about direction of the flow. Blood flow in the body behaves in similar fashion to other wave phenomena. When the wave passes an obstacle such as a tributary blood vessel, a small reflected wave is established. If a major obstacle such as a blood clot or other physiological disturbance is encountered, the resulting reflected wave produces reverse flow which, if detected, provides evidence of the presence of the disturbance.

Francis D. McLeod Jr.

Figure 10.—A light touch over the carotid artery with the ultrasonic probe allows associated instruments to measure blood flow.

Fran conceived of a modified single-sideband phasing technique, based on the heterodyne principle, that in theory would allow measurement of directional blood flow in a laboratory animal when a small suitably designed electronic circuit was coupled to an ultrasonically driven probe. Unfortunately, the device did not work as planned. After several weeks of frustrating effort, Fran hit the "Ah-Ha" button. He realized that the ultrasonic carrier source was interacting with the blood flow, but was also impinging on adjacent stationary objects such as bone structures. The result was a large dc signal that swamped the desired Doppler-shifted pulse. When the dc signal was filtered out and some additional signal processing was added to the circuit, a voltage proportional to the Doppler shift was achieved. On February 1, 1967, Professor **Nelson H. Bryant,** E.E. '39 and Dean of the Graduate School **Paul Leurgans** witnessed a patent application that was assigned to Cornell. U.S. Patent 3,550,070, *Flowmeter,* was awarded to Francis D. McLeod Jr., on December 22, 1970. Elaborate laboratory and clinical equipment based on Fran's circuit is now being manufactured extensively, and is used in ultrasonic venography and diagnostics of carotid-artery disease in humans. Typical use of a noninvasive probe is shown in Figure 10 with the electronic equipment visible in the background.

Back in the early sixties when the five-year curriculum was winding down in the College of Engineering, **James O. Moore**, B.S.Engr. '64 (Electrical Engineering), consulted with his project advisor, Professor **Sam Linke**, and decided to do his required senior project on the design and operation of a high-speed direct-current interrupter. This would be a 200-volt, 100-ampere prototype for similar switches, which could be used in high-voltage dc power-transmission lines that operate in the range of 500 kV and 1,000 amperes. Standard interruption of direct current results in a long-drawn-out burning arc across circuit-breaker terminals because of the absence of the current-zero that is present in ac-circuit interruptions. Rapid interruption of a direct current without drawing an arc was to be accomplished by a circuit that would insert an opposing oscillatory current to create an artificial current zero when the test-switch terminals separated. Jim designed and built a circuit of resistance, inductance, and capacitance (RLC) in series with a normally-open auxiliary switch. This circuit was connected across the test-switch terminals, and the auxiliary switch was arranged to close when the test-switch terminals opened. Since solid-state components of those days had very low current capability, Jim used mercury-vapor thyratrons for the auxiliary switches. A sensing circuit fired the thyratrons when the current crossed zero. A separate dc source connected across the capacitor charged the RLC circuit through a normally closed switch that also opened in tandem with the test switch. The system worked well under initial tests except for minor sparking at the corroded terminals of the old ac contactor that Jim had used for the circuit breaker. Jim solved that problem by means of all-silver dimes (in probable violation of Federal laws!) soldered to the contacts.

As luck would have it at the time, Professor of Mechanical Engineering **David Dropkin,** M.E. '29, and his graduate student **Robert O. Pfahl Jr.,** B.M.E. '61, were in dire need of a fast dc switch to interrupt

an electric arc that was being used to study heat-transfer characteristics of satellite nose-cone material under reentry conditions. Their arc was produced by a large dc welding generator driven by an ac motor. Since the current was being interrupted by shutting off the ac supply to the motor, the arc would continue burning for an appreciable time as the machines coasted slowly to a halt. The resulting data were unacceptable since the test runs required instant removal of the arc. Jim applied his apparatus to the arc project and succeeded in producing arc interruptions that resulted in completely satisfactory data. Jim says that his experience with his senior project was an important factor in his 1987 decision to establish the Undergraduate Research Program in the College of Engineering.

The McIlroy Analyzer story in the 1997 *Connections* brought another interesting recollection from **Winfield L. Reese,** B.E.E. '50 who writes:

> I was surprised by the article covering the recollections of **Bob Rustay**, B.E.E. '50, about Professor McIlroy's pipeline analyzer. I too was employed by the professor just after the analyzer was built. It is my hope and belief that Bob will remember me as I do him.
>
> Some final assembly was needed when I first saw it. Professor McIlroy was setting up to analyze a city in New England at the time. Each "bulb" was tested and categorized according to its response to changes to each of its variables. These data were then used to develop special charts and graphs for the selection of bulbs to be installed as sections of pipe in the pipeline network, and to set the specifications for ordering new bulbs. Multiple bulbs, either in series or parallel, could be assembled, if necessary, to represent a section of pipeline.
>
> Bulb testing, calculating, plotting, selecting bulbs for the elements of a network, and network testing were the essence of the assistance that the professor needed. After assembly and during a network test, one could lie under the machine to change a bulb or actually "see" loaded as well as unloaded sections of pipeline when the system was wired to simulate a heavy fire or a leaking drain. It was my first look at a problem-solving analog machine, and I truly enjoyed doing these things for the professor.
>
> I have often thought of that first "technical" job I had, especially when I spent the forty years with IBM developing digital computers and terminals, and getting involved with reliability statistics and predictions. I often wondered whether anyone went on with the professor's idea for the analyzer and wrote programs that could be used to analyze pipeline networks. I would have liked to explore that avenue of creativity myself because I believed in the importance of the project. Your article reflected that of course studies are being done by computers today.

[Mac wrote a computer program himself, and tried it out on an early IBM card-programmed calculator. At the time, the machine was very slow, but Mac predicted that his analog device would be obsolete in a few years.—Ed.]

When **Mark G. Adamiak,** B.S.Engr. '75 (Electrical Engineering), decided to design and build a working power windmill for his Master of Engineering project, he found, as Professor **Joe Rosson** used to say, "He had a b'ar by the tail." Working under a limited budget, Mark and his collaborators, fellow EE School student **James R. Bolognue,** B.S.Engr. '75 (Electrical Engineering), and mechanical engineering grads **Robert D. G. Carter,** M.E.M. '77, **Jacques R. P. Charles,** B.S.Engr. '76, and **William D. Dougherty,** B.S.Engr. '75, combined their talents and built a unique wind-powered generator that had an estimated output of 1 kW for a wind speed of 22.5 miles per hour. Unlike typical horizontal-shaft propeller designs, this windmill had a vertical shaft with three sets of horizontal "blades" composed of two Savonius S-shaped rotors for starting, and a Darrieus two-vane "eggbeater" for power (see Figure 11). The metallic starter rotors were formed from 18" radius half-cylinders mounted on the vertical shaft to form an S configuration. The eggbeater vanes were shaped as airfoils composed of aluminum support members wrapped with foam and covered with molded epoxy and fiberglass to form a structure some 10' high and 8' wide. The final device, painted red, white, and blue, was mounted on top of the Phillips Hall tower and made an impressive sight, particularly at the 1976 Commencement, when 25,000 people in the Crescent observed it spinning merrily in the sunshine.

Sam Linke

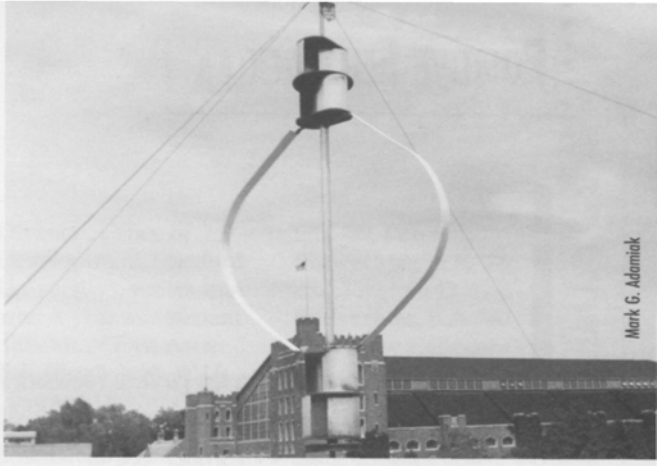


Figure 11.—The 1976 wind-power generator in action.

Alumni Breakfast

The annual EE School Alumni Breakfast was held on Saturday, June 12, 1999 from 7:45 to 9:30 a.m. in the Phillips Hall Lounge. Alumni, companions, and friends joined members of the EE School faculty and staff for an event that is always a festive and memorable occasion.

Positive Feedback

In this issue we are continuing the Positive Feedback feature of previous years. The first seven issues of *Connections* triggered a gratifying number of responses. We hope that this issue will stimulate even more returns of the coupon at the end of this newsletter. The dots (•) attached to some of the names in the following listing refer to respondents who are mentioned elsewhere in this issue.

Notice for Internet surfers: on the World Wide Web the EE School Home page may be found at <*www.ee.cornell.edu*>. The College of Engineering URL is <*www.engr.cornell.edu*>. The e-mail address for *Connections* is <*sl78@cornell.edu*>.

Note: Our alumni file is somewhat incomplete. If you know of EE School alumni who are not receiving Connections, please urge them to send their names and addresses to **Jeanne Subialka**, B.S. '99 (ILR), *Engineering Public Affairs, 248 Carpenter Hall, Ithaca, NY 14853-5401.*

Joseph C. Logue, B.E.E. '44, M.E.E. '49 (retired from IBM and now chairman of the board of Lorex Industries, Inc.), writes that alumni might like to read his memoir "From Vacuum Tubes to Very Large Scale Integration: A Personal Memoir," that appeared in the *IEEE Annals of the History of Computing* (Vol. 20, No. 3, 1998). Joe, an instructor and assistant professor in the EE School during and after his graduate study, relates several amusing stories about Professors **Bill Ballard, Everett M. Strong,** and **L. A. Burckmyer**, and provides a fascinating account of his distinguished career with IBM. Joe is a member of the National Academy of Engineering of the U.S., a Fellow of the IEEE, and a Fellow of the American Association for the Advancement of Science.

Burt E. Nichols, B.S.E.E. '44, writes that he is now retired and makes his home in Fairhope, Alabama.

Anatole Browde, B.E.E. '48 (retired from McDonnell–Douglas Electronic Systems), was a 1999 winner of the Frank H. T. Rhodes Exemplary Alumni Service Award given in recognition of extraordinary service to Cornell University. Tolly is currently studying for his Ph.D. degree in history at Washington University in St. Louis, Missouri.

• **Winfield L. Reese,** B.E.E. '50 (retired from IBM), writes that he was pleased to read recollections by his classmate, **Bob Rustay,** B.E.E. '50, about Professor McIlroy's pipeline analyzer, and recounts some of his own interesting experiences with Professor McIlroy and the analyzer (see page 25).

William J. Balet Jr., B.E.E. '59 (executive director, New York Power Pool in Schenectady, New York), spoke at the Cornell Energy Engineering Seminar on October 15, 1998, on "Deregulation and the New York Power Pool."

R. Sridhara Rao, M.E.E. '59 (retired professor of electrical engineering at institutions in India), spoke at a power-system seminar in Phillips Hall on May 29, 1998 on "Contraction Mapping Applied to Some Problems in Control and Power Systems."

Donald M. Kerr, B.E.E. '63, M.S. '64, Ph.D. '66, reports on his new position as assistant director, Laboratory Division, Federal Bureau of Investigation, Washington, D.C.

• **James O. Moore,** B.S.Engr. '64 (Electrical Engineering) (manager, research and development, Moore Products Company), recalls details of his unique senior project that allowed interruption of a large direct current without arcing at the circuit breaker terminals (see page 24).

• **Frances D. McLeod Jr.,** B.S.Engr. '65 (Electrical Engineering) (lecturer and manager of the Cornell EE School undergraduate teaching laboratory), outlines the basis of his invention of a velocity meter that has become the primary vascular noninvasive tool in the medical profession (see page 24).

Kailash C. Joshi, Ph.D. '68 (president and chief executive officer of Rainbow Displays, Inc., Endicott, New York), spoke at the EE School Colloquium on April 14, 1998 on "Large Electronic Flat Panel Displays: A Perspective from a Start-Up Company."

• **Mark G. Adamiak,** B.S.Engr. '75 (Electrical Engineering) (engineer, General Electric Company), recalls his M.Eng. project that involved design and construction of a 1,000-watt wind-powered generator (see page 25).

• **Jay C. Buckey Jr.,** B.S.Engr. '77 (Electrical Engineering), M.D. '81 (research associate professor of medicine at Dartmouth Medical School and a member of the space shuttle *Columbia* crew on the *Spacelab* flight from April 17 to May 3, 1998), spoke at the EE School colloquium on November 10, 1998 on "Neurolab, A Study of the Nervous System in Space." He described his work with the seven crew members who served as both subjects and operators for twenty-six individual life-science experiments that focused on the effects of microgravity on the brain and the

ee ON-LINE NEWS

New EE School Web Page is Now On-Line

The EE School Web site is in the process of being extensively modified with all planned changes to be completed by this summer. The current version contains a guide for enrolled and prospective students, an updated alumni section, and general information about the EE School and faculty. Check it out at ***www.ee.cornell.edu***

EE School Alumni On-Line Database

Alumni, click on the Alumni Database link on the above Web page.

nervous system (see page 2).

Augustus (Gus) K. Uht, B.S.Engr. '77 (Electrical Engineering), M.Eng. (Elec.) '78 (associate professor of electrical engineering at the University of Rhode Island), writes of his promotion with tenure on July 1, 1998, and his receipt of that college's Aurelio Lucci Award for Faculty Excellence in Electrical Engineering. *[Congratulations Gus, on both counts!—Ed.]* Gus performs research in instruction-level parallelism and computer architecture, notes that Professor **H. C. Torng** has been a wonderful source of support for him over the years, and congratulates H. C. on his receipt of the Intel Fellowship. Gus is also grateful to Cornell for a "superb education and experience."

William J. Schaff, B.S.Engr. '78 (Electrical Engineering), Ph.D. '84 (senior research associate in the EE School at Cornell), was notified in November 1998 that his graduate advisee, **Michael J. Murphy** was one of three winners in the competition for the Best Student Paper Award in the Seventeenth North American Molecular Beam Epitaxy Conference at Pennsylvania State University. Bill also received a plaque that recognized his contribution as Michael's advisor.

Cathy (Pietsch) House, M.E.E. '79, writes that she is now manager, instrument development at Lumenal Technologies, L.P. in Salt Lake City, Utah. The company develops patented diagnostic systems that optically measure biochemical compounds and microorganisms in liquid samples, including fluids from humans or animals.

Daniel J. Brea, B.S.Engr. '81 (Electrical Engineering) (engineering manager with Consolidated Edison Company in New York), visited Cornell in November 1998 on a recruiting trip. Dan was able to meet several of his professors and to observe the many changes that have occurred on campus since his graduation.

Harlow G. Russell, B.S.Engr. '83 (Electrical Engineering) (business consultant in Jakarta, Indonesia), should win an award for the most exciting trip to attend a reunion. On May 14, 1998, severe riots and violence erupted in Jakarta at about the time when Harlow and his wife, Jeanette, had planned to begin their 10,000-mile trip to Ithaca. After an intense, confused, and scary week, civil war was averted, President Suharto resigned on May 21, and soon thereafter Harlow and Jeanette were on their way to his fifteenth reunion. Harlow writes that they enjoyed their visit and "look forward to their twentieth, but without a revolution and CNN coverage."

Clifford L. Sayre III, M.E.E. '83 (distinguished member of technical staff of Phillips Consumer Communications, a Lucent Technologies/Phillips joint venture in consumer electronics), writes that he was recently promoted to his current position, and is working on code-division multiple-access (CDMA) personal communication system (PCS) phones and CDMA cellular phones for wireless networks.

Morris D. Brown, B.S.Engr. '85 (Electrical Engineering) (principal engineer at Raytheon in Tucson, Arizona), writes that he is enjoying *Connections* and keeping up with happenings at Cornell.

Scott F. Pesarcik, M.E.E. '88, writes that he is with Submarine Systems, Inc. and is living in Spring Lake Heights, New Jersey.

Tom Smith Tseng, B.S.Engr. '87 (Electrical Engineering) (associate director of development, Asian Operations Division, Office of Development, Stanford University), writes that after a year as assistant director of East Asian development at Harvard University, he has assumed his current position at the "Cornell of the West." Tom's new duties will include development of Stanford's interests and goals in Asia and the Pacific, and heading up the communications effort of the division.

Einwechter Family Fellowship Established

We are pleased to report that Mrs. Virginia D. Einwechter, whose husband was the late **William S. Einwechter** of the EE School Class of 1935, has made a thoughtful provision in her estate to establish the Einwechter Family Fellowship at Cornell University in honor of **William S. Einwechter,** E.E. '35, **Peter N. Einwechter,** A.B. '76, and **Virginia D. Einwechter,** B.A. '40 (Wellesley College). The income from the endowment will be used to provide assistance to students enrolled in the Master of Engineering Program in the School of Electrical Engineering in the College of Engineering. During his thirty-eight years with the Philadelphia Electric Company, Bill won electric utility industry recognition for his work as a power engineer and for his technical publications.

Alumni: Please fill out this coupon for the "Positive Feedback" feature and return to: Sam Linke, Cornell University, School of Engineering, 204 Phillips Hall, Ithaca, NY 14853-5401; e-mail: SL78@cornell.edu

Name: _____ class year

Position title: _____

I am employed by: _____

_____ street

_____ city state zip

My current activities are: _____

_____

_____

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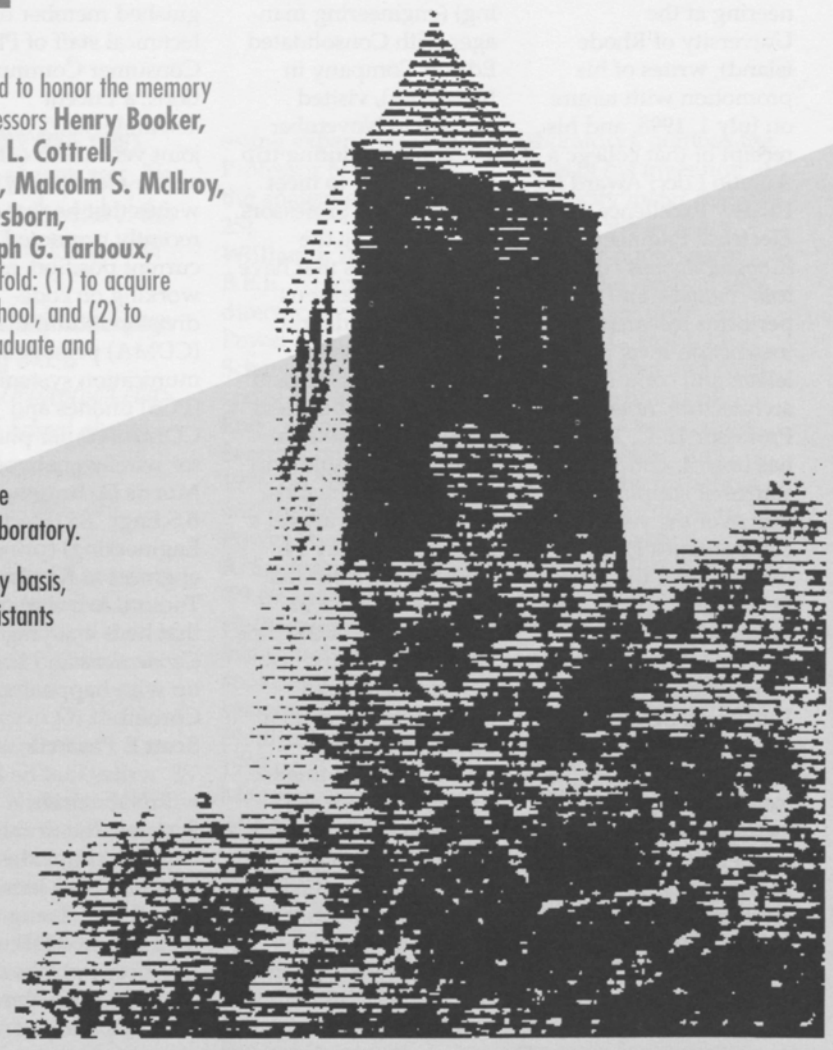
OPTIONAL

I would like to explore possibilites in the following areas:

- ❑ Contributions to the Eminent Professors' fund
- ❑ Contributions to the Joseph L. Rossen (Papa Joe) Memorial Fund
- ❑ Establishment of one-year fellowships professional masters students
- ❑ Engineering Cooperative Program
- ❑ Job placement of Cornell EE School seniors or graduate students
- ❑ Other _____

Eminent Professors' Fund

Seven years ago the EE School established the Eminent Professors' Fund to honor the memory of notable members of the EE School Faculty of past years such as Professors **Henry Booker, Nelson H. Bryant, L. A. Burckmyer, Walter W. Cotner, Casper L. Cottrell, William H. Erickson, Clyde E. Ingalls, M. Kim, Michel G. Malti, Malcolm S. McIlroy, Wilbur E. Meserve, True McLean, B. K. Northrop, Robert E. Osborn, Joseph L. Rosson, Howard G. Smith, Everett M. Strong, Joseph G. Tarboux,** and others whom alumni may recall. The objectives of the fund are twofold: (1) to acquire specific grants to improve laboratory and research facilities in the EE School, and (2) to establish endowments to provide ongoing financial support for undergraduate and graduate students.



The EE School has given high-priority status to the following goals:

- Establish an endowment fund to supplement the operating costs of the undergraduate computing center and the undergraduate teaching laboratory.
- Establish an endowment fund to provide financial support, on a yearly basis, for graduate and undergraduate students who serve as teaching assistants in our laboratories.
- Establish one-year fellowships to support candidates for the M.Eng. (Electrical) degree.
- Establish a fund to support M.Eng. (Electrical) research projects.

Alumni who would like to contribute to the Eminent Professors' Fund should contact Professor **James S. Thorp** in care of the School of Electrical Engineering, Room 224, Phillips Hall, Ithaca, NY 14853-5401.

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SCHOOL OF ELECTRICAL ENGINEERING
224 PHILLIPS HALL
ITHACA, NY 14853-5401